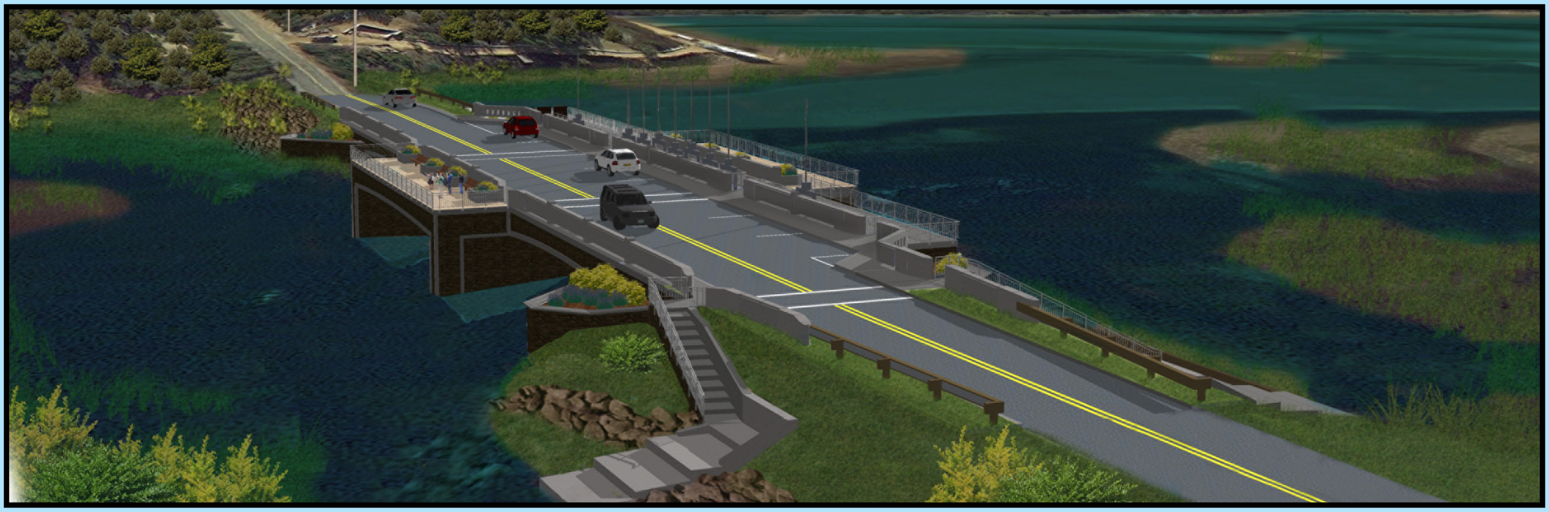
National Park Service
U.S. Department of the Interior
Cape Cod National Seashore

Town of Wellfleet
Town of Truro
Herring River Restoration Committee

Herring River Restoration Project

Final Environmental Impact Statement / Environmental Impact Report, May 2016



Cover Photos:
Top: *Chequessett Neck Road, Day Before Closing, 1909 – Wellfleet Historical Society & Museum*
Middle: *Chequessett Neck Road Dike present day – Friends of Herring River*
Bottom: *Water Access – Fuss & O'Neill, Inc.*

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
AND HERRING RIVER RESTORATION COMMITTEE
HERRING RIVER RESTORATION PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT/ ENVIRONMENTAL IMPACT REPORT

This *Herring River Restoration Project, Final Environmental Impact Statement/Environmental Impact Report* (final EIS/EIR) evaluates alternatives for tidal restoration of large portions of the Herring River flood plain in and adjacent to Cape Cod National Seashore (the Seashore). The EIS/EIR assesses the impacts that could result from continuing current management (the no action alternative) or implementing any of the three action alternatives.

Three action alternatives have been developed for the restoration of the Herring River. These three alternatives are intended to represent a range of desirable endpoints to be achieved through incremental restoration of tidal exchange and adaptive management. The alternatives are distinguished primarily by the long-term configuration of a new dike and tide control structure at Chequessett Neck Road and the resulting degree of tidal exchange. These alternatives represent the “bookends” of the minimum and maximum tidal exchange restoration necessary to meet project objectives, where alternative B achieves the minimally acceptable tidal restoration with the least impacts, and alternative D achieves the maximum practicable tidal restoration possible with more impacts, given the limitations of present day land use in the Herring River flood plain.

The Herring River flood plain is a large and complex area that has been impacted by more than 150 years of human manipulation, the most substantial being the construction of the Chequessett Neck Road dike at the mouth of the river in 1909. Just as the current degraded state of the river is the combined effect of many alterations occurring over many years, restoration of the river will also require multiple, combined actions to return it to a more fully functioning natural system.

The review period for the draft document ended 60 days after publication of the U.S. Environmental Protection Agency Notice of Availability in the Federal Register on October 12, 2012, and publication of the availability of the EIR in the Environmental Monitor. During the 60-day comment period, comments were accepted electronically through the National Park Service (NPS) Planning, Environment and Public Comment (PEPC) website and in hard copy delivered by the U.S. Postal Service or other mail delivery service or hand-delivered to the address below. Oral statements and written comments were also accepted during public meetings on the draft EIS/EIR. Comments were not accepted by fax, email, or in any other way than those specified above. Bulk comments in any format (hard copy or electronic) submitted on behalf of others were not accepted.

To comment on the final EIS/EIR, or for further information, visit http://parkplanning.nps.gov/caco or contact:

Cape Cod National Seashore and the Herring River Restoration Committee
Herring River Restoration Project, Final EIS/EIR
99 Marconi Site Road
Wellfleet, MA 02667

The Secretary of Energy & Environmental Affairs accepts written comments on projects currently under Massachusetts Environmental Policy Act (MEPA) review. Comments may be submitted electronically, by mail, via fax, or by hand delivery. Please note that comments submitted on MEPA documents are public records.

On EIRs, any agency or person may submit written comments concerning the project, its alternatives, its potential environmental impacts, mitigation measures, and the adequacy of the EIR, provided that the subject matter of the comments are within the scope. For this project only, comments must be filed within 60 days of the publication of the availability of the EIR in the Environmental Monitor, unless the public comment period is extended.

The mailing address for comments on the EIR is:

Secretary Matthew A. Beaton
Executive Office of Energy and Environmental Affairs (EEA)
Attn: MEPA Office
Holly Johnson, EEA No. 14272
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Herring River Restoration Project Final Environmental Impact Statement/ Environmental Impact Report

May 2016

EXECUTIVE SUMMARY

This *Herring River Restoration Project, Final Environmental Impact Statement/Environmental Impact Report* (final EIS/EIR) has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), the Council on Environmental Quality (CEQ) regulations implementing NEPA (40 CFR 1500–1508) and the National Park Service (NPS) Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-Making*, the Massachusetts Environmental Policy Act (MEPA), and the Cape Cod Regional Policy Plan.

This final EIS/EIR evaluates alternatives for tidal restoration of large portions of the Herring River flood plain in and adjacent to Cape Cod National Seashore (the Seashore) and addresses comments received in response to the draft EIS/EIR issued on October 12, 2012. The EIS/EIR assesses the impacts that could result from continuing current management (the no action alternative) or implementing any of the three action alternatives.

Upon conclusion of this final EIS/EIR and subsequent decision-making process, the preferred alternative, with its various restoration components, will provide a strategy for long-term, systematic monitoring, management, and restoration of the Herring River estuary.

BACKGROUND

Historically, the Herring River estuary and flood plain was the largest tidal river and 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 at the mouth of the Herring River to reduce 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.

By the mid-1930s, the Herring River, now flowing with freshwater, was channelized and straightened. Between 1929 and 1933, developers of the Chequessett Yacht and Country Club (CYCC) constructed a nine-hole golf course in the adjoining Mill Creek flood plain. Several homes also have been built at low elevations in the flood plain.

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 voted to repair the leaking tides to protect private properties. The Massachusetts Department of Public Works rebuilt the dike in 1974 (HRTC 2007). Following reconstruction, tidal monitoring showed that the Town had not opened an adjustable sluice gate high enough to allow the tidal range required by an Order of Conditions issued by the Conservation Commission. 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). Despite this, conditions in the estuary continued to degrade after the tide gates were repaired.

In 1980, a large die-off of American eel (*Anguilla rostrata*) and other fish focused attention on the poor water quality in the Herring River. The Massachusetts Division of Marine Fisheries and the 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 took steps to protect river herring by blocking their emigration from upstream ponds to prevent the fish from entering low oxygen 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 although mosquitoes (*Ochlerotatus cantator* and *O. canadensis*) were breeding abundantly in the Herring River, estuarine fish, which are important mosquito larvae predators, could not access mosquito breeding areas because of low tidal range, low salinity, and high acidity (Portnoy 1984a). In 1984, the town increased the sluice gate opening to 24 inches, where it has since remained (HRTC 2007).

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 the MassDEP to list Herring River as "impaired" under the federal Clean Water Act (CWA) 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).

In addition, 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 animal waste and atmospheric deposition, exacerbated by the lack of tidal flushing, which has allowed nutrients to accumulate in the Herring River.

Pesticides have likely been used throughout the Herring River watershed, including long-term use for mosquito control. Pesticide concentrations (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 the NOAA ERL (effects range low) guideline values, whereas PCBs and DDT were found to be above NOAA ERL guidelines. Sediment sampling performed in 2014 by the Seashore detected pesticide concentrations that exceed the effects range median (ERM) value of 46.1 parts-per-billion (ppb) at two locations (see chapter 3 for discussion). These concentrations appear to be consistent with previously detected background conditions within the Seashore.

Because tidal restrictions radically affect the process of sedimentation on the salt marsh, much of the diked Herring River flood plain has subsided up to 3 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 effectively blocked sediment from reaching the Herring River flood plain. In addition, drainage has increased the rate of organic peat decomposition by aerating the sediment and caused sediment pore spaces to collapse. All of these processes have contributed to severe historic and continuing subsidence in the Herring River's diked wetlands.

PURPOSE OF THIS PROJECT

The purpose of this project is to restore self-sustaining coastal habitats on a large portion of the 1,100-acre Herring River estuary in Wellfleet and Truro, Massachusetts. While the ecological goal is to restore the full natural tidal range in as much of the Herring River flood plain as practicable, tidal flooding in certain areas must be controlled to protect existing land uses. Where these considerations are relevant, the goal is to balance tidal restoration objectives with flood control by allowing the highest tide range practicable while also ensuring flood proofing and protection of vulnerable properties.

NEED FOR ACTION

The Herring 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 impacts include the following:

- Tidal restriction (lack of tidal inflow and outflow)
- Plant community changes (including loss of salt marsh vegetation and increase in non-native, invasive species)
- Loss of estuarine habitat and degradation of water quality
- Alteration of natural sediment processes and increased salt marsh surface subsidence
- Nuisance mosquito production
- Impediments to river herring migration.

This EIS/EIR has been prepared in accordance with NEPA, CEQ regulations implementing NEPA (40 CFR 1500–1508) and NPS Director's Order 12: *Conservation Planning, Environmental Impact Analysis, and Decision-Making*, the MEPA, and the Cape Cod Regional Policy Plan.

OBJECTIVES IN TAKING ACTION

Objectives are "what must be achieved to a large degree for the action to be considered a success" (NPS 2011b). All alternatives selected for detailed analysis must meet project objectives to a large degree and resolve the purpose of and need for action. Objectives must be grounded in the enabling legislation, purpose, and mission goals of the Seashore, and must be compatible with the Seashore's General Management Plan direction and guidance, water resources plan, NPS *Management Policies 2006*, and/or other NPS management guidance. The NPS and Herring River Restoration Committee (HRRC) identified the following objectives for developing this final EIS/EIR.

- To the extent practicable, given adjacent infrastructure and other social constraints, re-establish the natural tidal range, salinity distribution, and sedimentation patterns of the 1,100-acre estuary.
- Improve estuarine water quality for resident estuarine and migratory animals including fish, shellfish, and waterbirds.
- Protect and enhance harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Bay.

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

IMPACT TOPICS

Seashore staff, Wellfleet and Truro, members of the HRRC, and the public identified impact topics associated with tidal restoration in the Herring River. The full rationale for analyzing the following impact topics in detail is provided in chapter 1. These impact topics provide the organizational structure for the description of the affected environment in chapter 3 and the analysis of environmental consequences in chapter 4 of this final EIS/EIR.

SALINITY OF SURFACE WATERS

Increased tidal exchange and increased salinity levels affect species occurrence and distribution. Salt-intolerant vegetation in areas subject to frequent tidal inundation would be expected to die out, allowing colonization of tidal marsh species. In addition, support for estuarine fauna would also depend on salinity concentrations and water depths.

WATER AND SEDIMENT QUALITY

One of the more important hydrologic functions of tidal flushing and wetlands is water quality improvement. Poor water quality in the river has led to fish kills and closure of shellfish beds at the river's mouth. Water quality parameters to be addressed in this final EIS/EIR include dissolved oxygen, pH and sulfates, metal concentrations, nutrient levels, pesticides and other organic compounds, and fecal coliform.

SEDIMENT TRANSPORT AND SOILS

Much of the tidal marsh plain of the Herring River upstream of the dike has subsided up to 3 feet below its pre-dike elevation and below the surface of existing salt marsh seaward of the dike. Restored tidal range would lead to higher sediment transport and deposition onto the wetland surface. Higher tidal velocities will increase the width and depth of tidal channels and the quantity of sediment mobilized in those channels. Tidal inundation of soils will initiate changes in terms of increased pore spacing, increased pH, and increased organic content.

WETLAND HABITATS AND VEGETATION

Wetlands in the project area would change from degraded habitats influenced by freshwater to tidal marsh habitats influenced by varying degrees of salt water. Increased tidal range would restore an estuarine salinity gradient and allow for colonization of native tidal marsh plants.

AQUATIC SPECIES

Improved water quality and increased salinity would increase the extent and value of the Herring River as a nursery for estuarine fish species, improve estuarine habitat conditions and access to spawning ponds for anadromous and catadromous fish, and increase habitat for shellfish and other invertebrates.

STATE-LISTED RARE, THREATENED, AND ENDANGERED SPECIES

Restoration of the Herring River estuary could beneficially or adversely impact several state-listed species and their habitats in the estuary, including American Bittern, Least Bittern, Northern Harrier, Eastern Box Turtle, Water-Willow Stem Borer, and Diamondback Terrapin.

TERRESTRIAL WILDLIFE

Restoration of the Herring River estuary could beneficially or adversely impact birds, mammals, reptiles, and amphibians by affecting habitat conditions and habitat distribution.

CULTURAL RESOURCES

Restoration of the Herring River estuary could impact pre-contact and post-contact archeological sites through direct disturbance and possibly through inundation. Some historic structure may also be affected. These cultural resources will be subject to ongoing site-specific evaluation as the project is implemented.

SOCIOECONOMICS

Social and economic conditions may also be affected by reducing nuisance mosquitoes, improving recreational and commercial shellfishing, improving finfishing, creating potential flood risk for low-lying roads and properties, opening scenic viewscapes, improving recreational access and quality, and improving regional employment conditions.

ALTERNATIVES

The NEPA requires federal agencies to consider and fully evaluate a range of reasonable alternatives that address the purpose of and need for the action. Reasonable action alternatives must be economically and technically feasible and demonstrate common sense. The CEQ regulations (40 CFR 1502.14) also require that federal agencies analyze a "no action" alternative; this alternative evaluates future conditions under existing management plans or practices and allows the public to evaluate what would happen if no project were implemented.

The MEPA (301 CMR 11.06 and 11.07) requires that the action proponent present a reasonably complete and stand-alone description and analysis of the project and its alternatives. Alternatives include: 1) all feasible alternatives; 2) the alternative of not undertaking the project (no action) for the purpose of establishing a baseline in relation to which the alternatives can be described, analyzed, and potential environmental impacts and mitigation measures can be assessed; 3) an analysis of the feasible alternatives in light of the project objectives and the mission of participating agencies; 4) an analysis of the principal differences among the feasible alternatives under consideration, particularly regarding potential environmental impacts; and 5) a brief discussion of any alternatives no longer under consideration including the reasons for no longer considering these alternatives.

The project alternatives include adaptive management strategies for varying degrees of tidal exchange, as well as infrastructure and flood mitigation elements. How each of these alternatives meets the objectives of the EIS/EIR is detailed in "Chapter 2: Alternatives," table 2-4. The full range of impacts anticipated to result from implementation of the proposed alternatives is detailed in both table ES-1 and "Chapter 4: Environmental Consequences" of the EIS/EIR.

ELEMENTS COMMON TO ALL ALTERNATIVES

The following management actions are common to all alternatives. The HRRC will implement these actions upon adoption of the final Record of Decision (ROD) regardless of which alternative is adopted.

INCREMENTAL TIDAL RESTORATION AND ADAPTIVE MANAGEMENT

Since the early planning stages of the Herring River Restoration Project (HRRP), reintroduction of tidal influence has been understood as a long-term, phased process that would occur over several years. The key to restoration, and an element common to all action alternatives, is the construction of a new dike at Chequessett Neck Road with adjustable tide gates. Gradual opening of adjustable tide gates would incrementally increase the tidal range in the river. The primary reason to implement the project in this manner is to allow monitoring of the system so that unexpected and/or undesirable responses could be detected and appropriate response actions taken. In addition, the complexity of the proposed project also dictates use of an adaptive management approach. Among these are a large and divergent group of stakeholders, multiple and overlapping objectives, and the need for phased and recurrent decisions through an extended period of time.

Adaptive management is a formal, iterative process where (1) a problem is assessed, (2) potential management actions are designed and implemented, (3) actions and resource responses are monitored over time, (4) data are evaluated, and (5) actions are adjusted as necessary to better achieve desired management outcomes. Details of this process and its application to the Herring River project are described in "Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project."

MONITORING

Field monitoring is frequently used in ecological restoration to measure the success of restorative activities. When part of an adaptive management process, field monitoring needs to be carefully designed to measure progress toward objectives and assumptions built into conceptual models. In contrast to standard ecological monitoring and other data gathering efforts, monitoring for adaptive management is not carried out primarily for scientific interest. Instead, adaptive management monitoring studies are designed and carried out to specifically support management decision-making and assessment. Adaptive management monitoring could be a subset of a broader monitoring program, but adaptive management monitoring activities must be specifically tied to project objectives and be cost/time-efficient and sustainable for the duration of the adaptive management plan.

VEGETATION MANAGEMENT

The increased tidal exchange between the Herring River estuary and Cape Cod Bay would be achieved in incremental steps over a number of years and would change many characteristics of the flood plain. One of the most important, 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 range, frequency and duration of tidal flooding, soil saturation, and, most notably, salinity. Predominantly shrubland and woodland plant communities exist on areas of the river flood plain that were once vegetated with salt-marsh plants including salt meadow grass (*Spartina patens*), smooth cordgrass (*S. alterniflora*), black grass (*Juncus gerardii*), and spike grass (*Distichlis spicata*). Most woody plants will not tolerate flooding with salt water, however gradually these impacts occur, and flooding will likely result in many acres of standing dead trees and shrubs covering a large portion of the flood plain.

Vegetation Management Objectives

Management of flood plain vegetation, specifically the removal of shrubs and trees before salt water reaches them, would have the following objectives:

- Encourage re-establishment of tidal marsh.
- Remove woody debris that might impede fish passage.
- Remove large trees that will eventually die, topple and leave holes on the wetland surface where mosquitoes might breed.

Vegetation Management Options

Potential techniques for dealing with woody vegetation include cutting, chipping, burning, and targeted herbicide application. A combination of these techniques will be part of a flexible approach to vegetation management.

The vegetation management activities would consist of primary and secondary management techniques. Primary management is cutting of the vegetation. This 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.

Secondary management is the processing and removal of the biomass that has been cut. This would be accomplished by a number of techniques including the use of cut hardwood (i.e., as firewood), removal of wood chips, and burning brush and branches. Woody vegetation with diameters of 3 or more inches could be used for biofuel, either as chips or logs. Natural decomposition of dead woody material as a management technique would be considered in some areas of the restored Herring River flood plain. Appropriate options for smaller diameter cut woody vegetation would be developed. Access, substrate type, and other factors would need to be considered to determine the most appropriate vegetation management techniques for specific areas and conditions.

Vegetation management actions would be of the same type and would be implemented in an identical manner under each of the action alternatives; however the spatial extent and timing of when actions would be taken might vary. See “Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project” for a more complete discussion.

RESTORATION OF TIDAL CHANNEL AND MARSH SURFACE ELEVATION

Although reintroduction of tidal exchange and salinity is the primary component and main driver for restoration of the Herring River flood plain, several other actions would likely be necessary to reverse other previous direct and indirect alterations of the system’s topography, bathymetry, and drainage capacity. Diking and drainage have caused subsidence of the former salt marsh by up to 3 feet in some locations, 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). After tidal restoration is initiated, these factors could limit or delay progress toward meeting the project objectives by inhibiting circulation of salt water, preventing recolonization of tidal 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 the project’s adaptive management plan. In summary, these potential actions 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 and 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.

LOW-LYING ROAD CROSSINGS 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 2007a). To prevent this, the road surfaces and culverts would need to be elevated or relocated. 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. 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 might be feasible with lower costs. Additional engineering studies and traffic analyses are needed to fully evaluate both of these options (CLE 2011).

LOW LYING PROPERTIES

Minimizing and mitigating impacts to low-lying properties is an important objective of the HRRP. Generally, these measures could include limiting water levels across entire sub-basins, elevating or relocating driveways and landscaping, moving wells, building small berms or flood walls, and moving or elevating structures.

Within the boundary of Cape Cod National Seashore in the Lower Herring River basin, there are two private properties with buildings that would be flooded by restoring tidal flow to the main river basin. These properties are at very low elevations and would be affected early on in the restoration process. Unlike potentially affected structures in other basins, there are no tide control structures between them and the Chequessett Neck Road dike that can minimize high tide levels. In these cases, where no other flood mitigation measures are feasible, in the absence of a willing seller, NPS could consider an eminent domain taking. At present, a voluntary exchange is being negotiated for one of these two properties.

PUBLIC ACCESS AND RECREATION OPPORTUNITIES

The Herring River estuary is included in the Seashore's natural zone, and is managed to protect natural processes with limited infrastructure. Given this National Seashore planning objective, it is anticipated that any development of public access points or visitor facilities would occur at the discretion of adjacent landowners or stakeholders, such as the Towns of Wellfleet and Truro, Wellfleet Conservation Trust, or the Friends of Herring River.

For example, the new Chequessett Neck Road dike would be designed to include safe fishing access points, launch sites on the upstream and downstream sides of the new dike, and a safe portage route between those launch sites (see "Section 4.11, Potential Long-Term Use of Chequessett Neck Road Dike Staging Area and Adjacent Wetlands for Canoe/Kayak Access," for more detail). Launches for canoes or kayaks could also be provided at other points in the estuary. Walking trails could include access to the variety of habitats established by the restoration process. Over the long term, access to recreational shellfishing areas could also be considered once the shellfish resource is sustainable and capable of supporting harvest. The NPS would work with adjacent land managers by providing guidance on resource protection and interpretation.

ALTERNATIVE A: NO ACTION – RETAIN EXISTING TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK

NEPA and MEPA regulations require measuring all alternatives against a future condition without the project. In this case, no action means that the existing 18-foot-wide structure composed of two flap gates and an adjustable tide gate would remain in place, and no tidal restoration would occur. Although no changes to infrastructure would occur, it is important to emphasize that "no action" is not a steady state from an environmental perspective.

ACTION ALTERNATIVES

The three action alternatives are differentiated primarily by the extent of restored tidal range throughout the estuary. The beneficial and adverse impacts of all alternative elements, including elements common to all, are described and analyzed in detail in "Chapter 4: Environmental Consequences."

ALTERNATIVE B: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – NO DIKE AT MILL CREEK

Following the "bookend" concept, alternative B provides the lowest high tide water surface elevations needed to achieve the project objectives. Under this alternative, 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 at the location of the Chequessett Neck Road dike to allow passage of Wellfleet Harbor tides (an element common to all alternatives—see section 2.3 in chapter 2). The tide gates would be opened gradually according to guidelines set forth in the Adaptive Management Plan with an objective to ultimately reach a mean high spring tide of 4.8 feet and a maximum coastal storm driven tide of 6.0 feet in the Lower Herring River. These elevations reflect the maximum restoration possible without the need to install a secondary tide control structure at Mill Creek to protect private properties 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 3 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.

This alternative would provide a uniform degree of restoration in all sub-basins and would not require the construction or cost of a dike at Mill Creek. Flood proofing actions undertaken throughout the estuary would be designed to accommodate maximum coastal storm driven high tides 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 require flood proofing measures for the CYCC golf course and other low-lying properties throughout the Herring River flood plain. Also, alternative B would forego the ability to pursue higher inundation levels in the estuary as part of an adaptive management process. This alternative would limit the total area of tidal wetland habitat that could be realized with tidal restoration.

Mill Creek Sub-basin

Under alternative B, the Mill Creek sub-basin would be left open to the Herring River, thereby subjecting the sub-basin to a limited tide regime controlled at Chequessett Neck Road Dike. However, the tide gates at Chequessett Neck Road dike would remain partly closed to limit mean high water spring tides to a maximum of 4.8 feet and coastal storm events to a maximum of 6.0 feet in the Lower Herring River. This would equate to a maximum mean high water spring tide elevation of 4.7 feet and a maximum coastal storm driven tidal event elevation of 5.9 feet in Mill Creek. As a result, this alternative would not require the construction or cost of a dike at Mill Creek if flood protection measures are in place.

Chequessett Yacht and Country Club

Hydrodynamic modeling has shown that several areas of the CYCC golf course would be affected by inundation levels proposed under alternative B. There are two options for addressing the impacts to the CYCC:

- 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. Approximately 30 acres of long-term upland disturbance would be generated under this option. One fairway would not be able to be relocated because of its proximity to the clubhouse and would require filling and regrading.
- Elevate the affected portions of the facility by providing necessary quantities of fill, regrading, and replanting the areas. Initial design concept plans for this effort include approximately 150,000 cubic yards of fill and 32 acres of disturbance for grading and site preparation. Portions of five low-lying golf holes would be reconstructed to a minimum elevation of 6.7 feet, which is 2 feet above the mean spring tide in Mill Creek.

ALTERNATIVE C: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT EXCLUDES TIDAL FLOW

Chequessett Neck Road Dike

Like the other action alternatives, tide gates at a rebuilt Chequessett Neck Road dike would be opened gradually and according 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. Following the "bookend" concept, alternative C provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain; however, a tidal exclusion dike would be constructed at the mouth of Mill Creek in order to avoid flood impacts to low-lying private properties within this sub-basin. 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.

Mill Creek Sub-basin

In contrast to alternative B, under alternative C a new dike at the mouth of Mill Creek would need to be constructed to *eliminate* tidal influence to the sub-basin. Based on the results of hydrodynamic modeling, the minimum recommended crest height of this dike is 2 feet above the projected maximum coastal storm tidal surge elevation, or 9.5 feet (based on the modeled elevation of 7.5 feet in the Lower Herring River). Construction of this structure would require approximately 2,900 cubic yards of fill and would permanently impact 12,500 square feet of wetland. In addition, a construction work area encompassing approximately 105,000 square feet (2.4 acres) of vegetated wetlands would likely be required for dewatering and other associated work and would be impacted temporarily.

A one-way, flapper-style tide gate would need to be installed within the dike to allow freshwater to drain from the basin toward the Herring River while blocking seawater from passing upstream of the dike. Given the generally flat land surface of the flood plain and naturally occurring high water table, mechanical pumping may be necessary at times to facilitate freshwater drainage.

Chequessett Yacht and Country Club

Because a dike would eliminate tidal influence from the Mill Creek sub-basin, no additional flood protection measures would be required for CYCC or other Mill Creek properties.

ALTERNATIVE D: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT PARTIALLY RESTORES TIDAL FLOW

Chequessett Neck Road Dike

Like the other action alternatives, tide gates at a rebuilt Chequessett Neck Road dike would be opened gradually and according to guidelines set forth in the Adaptive Management Plan. The objective for 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. Following the "bookend" concept, alternative D provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain. Tides in the upstream sub-basins would be lower because of natural tide attenuation. With the exception of Mill Creek, flood protection actions undertaken throughout the estuary would be designed to accommodate flooding up to these maximum tidal elevations.

Since publication and release of the draft EIS/EIR in 2012, the HRRC has continued design and planning work on several key project components, including design of the proposed new Chequessett Neck Road dike and development of design options for the Mill Creek dike. In response to agency and public comment several other aspects of the project have been clarified and incorporated into the descriptions of the alternatives. These address options for preventing tidal flow impacts to High Toss Road and building a tide control structure at the Pole Dike Creek Road culvert. They are each described and analyzed in detail in “Chapter 4: Environmental Consequences.”

Mill Creek Sub-basin

Similar to alternative C, a new dike at the mouth of Mill Creek would need to be constructed under alternative D. However, under alternative D, the one-way flapper style tide gate would be replaced with an adjustable, two-way tide gate which would be managed to partially restore tidal flow to the sub-basin. Mean high spring tides would be limited to 4.7 feet and coastal storm tidal events to a maximum of 5.9 feet in Mill Creek. In contrast to alternative C, the same flood proofing measures and related costs specified under alternative B would be required for Mill Creek (e.g., golf course and private property flood proofing, and well relocation) as well as the cost of Mill Creek Dike construction.

Chequessett Yacht and Country Club

As described for alternative B, two options for protecting the CYCC golf course would be possible under alternative D: (Option 1) relocating portions of multiple low-lying golf holes to upland areas currently owned by the CYCC or (Option 2) elevating the affected areas in place by filling and regrading.

NPS AND HRRC PREFERRED ALTERNATIVE

To identify the preferred alternative, each alternative was evaluated based on its ability to meet the plan objectives (see “Chapter 2: Alternatives,” table 2-4) and their potential impacts on the environment (see “Chapter 4: Environmental Consequences” of this document). An initial screening of the alternatives was accomplished by the project team through the Value Analysis/Choosing by Advantages process held June 1–3, 2011 (Kirk Associates 2011). The Value Analysis/Choosing by Advantages process considered the advantages of the three proposed action alternatives, including the Mill Creek options for alternatives B and D. Each of the three alternatives was evaluated against three factors:

- Restore natural and cultural resources.
- Improve operational efficiency, reliability, and sustainability.
- Enhance and maintain socioeconomic benefits.

The HRRC evaluated the benefit or “importance of advantage” for each of the alternatives. Not considering the cost, alternative D, with Mill Creek Option 2 which includes installation of new tidal control structure at Chequessett Neck and a dike at Mill Creek that partially restores tidal flow and elevates the fairways and practice area at the CYCC, would provide the greatest importance of advantage based on benefit points. Relative initial cost estimates for the alternatives were developed and the relative benefits and costs of the alternatives were graphed. This cost-benefit ratio also showed that alternative D with Mill Creek Option 2, elevation of the CYCC golf course, would offer the best value, with the highest benefit to cost ratio. Thus, in the Value Analysis/Choosing by Advantages process, alternative D with elevation of the CYCC golf course was selected as the preferred alternative.

ENVIRONMENTAL CONSEQUENCES

For each impact topic, methods were identified to measure the change in the Herring River flood plain’s resources that would occur with the implementation of each management alternative. Each management alternative was compared to baseline conditions (Alternative A: No Action) to determine the context, duration, and intensity of resource impacts. Table ES-1 summarizes the results of the impact analysis for the impact topics that were assessed. The full impact analysis is in “Chapter 4, Environmental Consequences.”

TABLE ES-1: SUMMARY OF THE IMPACTS OF THE ALTERNATIVES

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Salinity of Surface Waters	The existing Chequessett Neck Road Dike would continue to limit tidal influence in the estuary. Seawater would not reach areas upstream of High Toss Road. The lowest reaches of the Lower Herring River would continue to receive some influence from tidally driven seawater.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 4.8 feet and a maximum coastal storm driven tide of 6.0 feet in the Lower Herring River. Salinity penetration would increase in most sub-basins.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 5.6 feet and a maximum coastal storm driven tide of 7.5 feet in the Lower Herring River. A new dike managed to exclude tides would be constructed at the mouth of Mill Creek. Salinity penetration would increase in all sub-basins beyond that achieved in alternative B, but no change would occur in Mill Creek.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 5.6 feet and a maximum coastal storm driven tide of 7.5 feet in the Lower Herring River. A new dike managed to control tides would be constructed at the mouth of Mill Creek. Salinity penetration would increase in all sub-basins to the same extent as alternative C, but salinity penetration in Mill Creek would be comparable to that of alternative B.
	Salinity ranges of specific sub-basins would be as follows: (0 parts per thousand (ppt) = freshwater, ~35 ppt = seawater): • Lower Herring River: 0-26 ppt • Middle Herring River: 0 ppt • Upper Herring River: 0 ppt • Duck Harbor: 0 ppt • Lower Pole Dike Creek: 0 ppt • Upper Pole Dike Creek: 0 ppt • Lower Bound Brook: 0 ppt • Upper Bound Brook: 0 ppt • Mill Creek: 0 ppt	Salinity ranges of specific sub-basins would be as follows: (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 22-29 ppt • Middle Herring River: 7-29 ppt • Upper Herring River: 0-1 ppt • Duck Harbor: 0-25 ppt • Lower Pole Dike Creek: 15-30 ppt • Upper Pole Dike Creek: 0-14 ppt • Lower Bound Brook: 2-24 ppt • Upper Bound Brook: 0-3 ppt • Mill Creek: 0-30 ppt	Salinity ranges of specific sub-basins would be as follows: (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 25-30 ppt • Middle Herring River: 12-29 ppt • Upper Herring River: 0-17 ppt • Duck Harbor: 3-24 ppt • Lower Pole Dike Creek: 17-30 ppt • Upper Pole Dike Creek: 0-20 ppt • Lower Bound Brook: 7-27 ppt • Upper Bound Brook: 0-15 ppt • Mill Creek: 0 ppt	Salinity ranges of specific sub-basins would be as follows: (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 25-30 ppt • Middle Herring River: 12-29 ppt • Upper Herring River: 0-17 ppt • Duck Harbor: 3-24 ppt • Lower Pole Dike Creek: 17-30 ppt • Upper Pole Dike Creek: 0-20 ppt • Lower Bound Brook: 7-27 ppt • Upper Bound Brook: 0-15 ppt • Mill Creek: 0-30 ppt

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Water and Sediment Quality	Lack of tidal flushing would continue to impact water and sediment quality by lowering the pH of porewater and surface water, leaching iron and aluminum, reducing summer dissolved oxygen concentrations to levels dangerous to fish and invertebrates, and concentrating fecal coliform.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to approximately 800 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to approximately 830 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates. No water quality improvements would occur to Mill Creek.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to 889 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates.
	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence Time under current conditions is approximately 200 days.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence time would be reduced to 8 days.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence time would be reduced to 6 days, but Mill Creek sub-basin would be excluded.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence Time would be reduced to 6 days.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Sediment Transport	Tidal flows would continue to be restricted by the existing Chequessett Neck Road Dike, limiting upstream sediment transport. Channel width, depth, and capacity would remain restricted. Insufficient delivery of sediment to marsh surfaces, pore space collapse, and decomposition of organic matter would cause continued subsidence of the marsh surface.	Enlarging the dike opening would result in accretion of sediment on the marsh. The degree and rate of sediment mobilization would be determined by the amount of tidal influence and rate of incremental opening of the tide gates. Restoration of marsh surface elevations may proceed for decades.	Same as alternative B.	Same as alternative B.
	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under current conditions: • Normal Tides: 56 acres • Storm Tides: 154 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative B: • Normal Tides: 144 acres • Storm Tides: 349 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative C: • Normal Tides: 156 acres • Storm Tides: 447 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative D: • Normal Tides: 156 acres • Storm Tides: 447 acres
Soils	The soils would continue to evolve as they have since the dike was built, as there would be no predicted changes in soil chemistry, structure, or organic content. Soil conditions would continue to reflect past adverse impacts of tidal exclusion.	Tidal restoration would result in estuary-wide, beneficial changes to hydric soils by increasing pore space, soil pH, and organic content as these soils are subjected to tidal inundation. Various local changes in soil texture are also expected as soils are subjected to different erosional and/or depositional forces that alter the sand, silt, or clay content.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Wetland Habitats and Vegetation	Degraded freshwater conditions would persist in over 1000 acres of former salt marsh habitats due to tidal restriction. The following habitat conditions are currently present for each cover type: • 75 acres wet deciduous forest • 7 acres dry deciduous forest • 26 acres pine woodland • 231 acres dry deciduous woodland • 288 acres wet shrubland • 1 acre dry shrubland • 18 acres old field herbaceous mix • 172 acres freshwater marsh (non-tidal) • 36 acres brackish marsh (tidal) • 13 acres salt marsh (tidal) • 20 acres heathland • 1 acre dune grassland • 94 acres water • 24 acres developed	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following cover type habitat conditions would undergo habitat change: • 44 acres wet deciduous forest • 2 acres dry deciduous forest • 22 acres pine woodland • 10 acres dry deciduous woodland • 122 acres wet shrubland • 2 acres old field herbaceous mix • 127 acres freshwater marsh (tidal) • 183 acres brackish marsh (tidal) • 358 acres salt marsh (tidal) • 11 acres heathland • 1 acres dune grassland • 86 acres water • 12 acres developed • 26 acres misc. non-tidal**	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following cover type habitat conditions would undergo habitat change: • 2 acres pine woodland • 67 acres wet shrubland • 99 acres freshwater marsh (tidal) • 98 acres brackish marsh (tidal) • 551 acres salt marsh (tidal) • 80 acres water • 24 acres developed • 57 acres misc. non-tidal**	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following cover type habitat conditions would undergo habitat change: • 2 acres pine woodland • 67 acres wet shrubland • 99 acres freshwater marsh (tidal) • 98 acres brackish marsh (tidal) • 585 acres salt marsh (tidal) • 86 acres water • 12 acres developed • 57 acres misc. non-tidal**
	** Misc. Non-tidal habitats include varied wetland and upland areas expected to persist along the periphery of the project and other isolated areas.			

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Aquatic Species	The Herring River estuarine system would remain degraded with diminished abundance of resident estuarine fish, marine migrant species, and macroinvertebrate species in the estuary, and limited use of fresh water spawning grounds by anadromous/catadromous species.	Restored estuarine waters and salt marsh would provide substantially more spawning and nursery habitat for both resident and transient fish species and for estuarine macroinvertebrates, increasing their abundance. Improved water quality and access to the head waters of the river would enlarge the river herring run.	Same as alternative B.	Same as alternative B.
	Total estuarine habitat would be limited to 70 acres within Lower Herring river.	Total estuarine habitat would increase to 790-800 acres.	Total estuarine habitat would increase to 822 acres.	Total estuarine habitat would increase to 878-885 acres.
State-listed Rare, Threatened, and Endangered Species	<u>Northern Harrier</u> • 96 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 251 acres of Foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 659 acres unsuitable habitat	<u>Northern Harrier</u> • 60 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 668 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 278 acres unsuitable habitat	<u>Northern Harrier</u> Impacts associated with alternative C are not addressed for this resource here because, compared to the preferred alternative, it only excludes the Mill Creek sub-basin from the project. Therefore, alternative C impacts are the same as, or only slightly less than, the preferred alternative.	<u>Northern Harrier</u> • 49 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 782 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 175 acres unsuitable habitat
	<u>American Bittern and Least Bittern</u> • 208 acres potential nesting habitat (83% fresh marsh; 17% brackish marsh) • 13 acres potential Foraging, roosting, and migratory habitat (salt marsh) • 785 acres unsuitable habitat	<u>American Bittern and Least Bittern</u> • 310 acres potential nesting habitat (40% fresh; 60% brackish) • 327 acres potential foraging, roosting, and migratory habitat (salt marsh) • 369 acres unsuitable habitat	<u>American Bittern and Least Bittern</u> Impacts are the same as, or only slightly less than, alternative D.	<u>American Bittern and Least Bittern</u> • 197 acres potential nesting habitat (50% fresh; 50% brackish) • 585 acres potential Foraging, roosting, and migratory habitat (salt marsh) • 224 acres unsuitable habitat

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	<u>Diamondback Terrapin</u> • 84 acres habitat with limited availability (tidal barrier; salt and brackish marsh, water) • 922 acres unsuitable habitat	<u>Diamondback Terrapin</u> • 627 acres available habitat (salt and brackish marsh, water) • 379 acres unsuitable habitat	<u>Diamondback Terrapin</u> Impacts are the same as, or only slightly less than, alternative D.	<u>Diamondback Terrapin</u> • 769 acres available habitat (salt and brackish marsh, water) • 237 acres unsuitable habitat
	<u>Eastern Box Turtle</u> • 88 acres principal habitat (dry and wet deciduous forest, dry shrubland, dry dunes); • 611 acres occasional habitat (dry deciduous woodland, heathland grass, old field, pine woodland, wet shrubland) • 307 acres unsuitable habitat • 3,870 acres immediately adjacent to project area within Cape Cod National Seashore	<u>Eastern Box Turtle</u> • 47 acres principal habitat • 145 acres occasional (misc. non-tidal*, pine woodland, wet shrubland) • 814 acres unsuitable habitat • 3,870 acres immediately adjacent to project area within Cape Cod National Seashore • * Misc. non-tidal habitats include varied wetland and upland areas expected to persist along the periphery of the project and other isolated areas.	<u>Eastern Box Turtle</u> Impacts are the same as, or only slightly less than, alternative D.	<u>Eastern Box Turtle</u> • 0 acres principal habitat • 123 acres occasional (misc. non-tidal*, pine woodland, wet shrubland) • 883 acres unsuitable habitat • 3,870 acres immediately adjacent to project area within Cape Cod National Seashore
	<u>Water-Willow Stem Borer</u> • 386 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 620 acres unsuitable habitat • 265 acres adjacent to project area	<u>Water-Willow Stem Borer</u> • 171 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 835 acres unsuitable habitat • 265 acres adjacent to project area	<u>Water-Willow Stem Borer</u> Impacts are the same as, or only slightly less than, alternative D.	<u>Water-Willow Stem Borer</u> • 131 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 875 acres unsuitable habitat • 265 acres adjacent to project area

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Federally listed Threatened and Endangered Species	<u>Rufa Red Knot</u> • 13 acres of potential red knot habitat (salt marsh [tidal]). • 993 acres of unsuitable habitat	<u>Rufa Red Knot</u> • 358 acres of potential red knot habitat (salt marsh [tidal]). • 648 acres of unsuitable habitat	<u>Rufa Red Knot</u> Impacts are the same as, or only slightly less than, alternative D.	<u>Rufa Red Knot</u> • 585 acres of potential red knot habitat (salt marsh [tidal]). • 421 acres of unsuitable habitat
	<u>Northern Long-eared Bat</u> • 339 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 667 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.	<u>Northern Long-eared Bat</u> • 78 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 978 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.	<u>Northern Long-eared Bat</u> Impacts are the same as, or only slightly less than, alternative D.	<u>Northern Long-eared Bat</u> • 2 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 1,004 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.
Terrestrial Wildlife	<u>Birds</u> Salt marsh species would remain limited to 13 acres in Lower Herring River. For other wetland species, 264 acres of freshwater/brackish habitat would remain available. For upland and other bird species, 723 acres of woodland, shrubland, and heathland habitat would remain in the project area.	<u>Birds</u> For salt marsh species, 393 acres of habitat would be restored in Lower Herring River, Mill Creek, Middle Herring River, and Lower Pole Dike Creek. For other wetland species, 407 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats.	<u>Birds</u> For salt marsh species, 346 acres of habitat would be restored in Lower Herring River, Middle Herring River, and Lower Pole Dike Creek. For other wetland species, 484 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats. No change would occur in Mill Creek.	<u>Birds</u> For salt marsh species, 399 acres of habitat would be restored in Lower Herring River, Mill Creek, Middle Herring River, Duck Harbor, and Lower Pole Dike Creek. For other wetland species, 491 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	<u>Mammals</u> Mammals would remain widespread throughout the 1000+ acre project area.	<u>Mammals</u> Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	<u>Mammals</u> Most species would relocate to the estuary periphery and to the upper extents of the 830-acre area affected by mean high spring tide. No change would occur in Mill Creek.	<u>Mammals</u> Most species would relocate to the estuary periphery and to the upper extents of the 890-acre area affected by mean high spring tide.
	<u>Reptiles and Amphibians</u> Reptiles and amphibians would remain widespread throughout the 1000+ acre project area.	<u>Reptiles and Amphibians</u> Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	<u>Reptiles and Amphibians</u> Most species would relocate to the estuary periphery and to the upper extents of the 830-acre area affected by mean high spring tide. No change would occur in Mill Creek.	<u>Reptiles and Amphibians</u> Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.
Cultural Resources	No impacts to cultural resources or archeological resources would occur as a result of the no-action alternative, as existing conditions would be maintained.	There is a potential for adverse effects to archeological resources in the APE from construction or other ground-disturbance. Additional archeological assessment would occur prior to construction. Higher tides would not impact archeological resources because any inundation would be gradual. Erosion from increased tidal flows could impact transportation corridors across river channels, but these impacts would be mitigated by culvert replacement and other erosion control measures. Depending on the golf course flood proofing option implemented, either 5 or 30 acres (approximately) of sensitive uplands could be disturbed.	Same as alternative B, but with approximately 30 additional acres under tidal exchange; no tidal influence or disturbance in Mill Creek.	Same as alternative B, but with approximately 90 additional acres of tidal exchange, including in Mill Creek. Depending on the golf course flood proofing option implemented, either 5 or 30 acres (approximately) of sensitive uplands could be disturbed.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Socioeconomics Nuisance Mosquitoes	The Herring River would remain a productive mosquito habitat, particularly between High Toss Road and Route 6. The dominant mosquito species is *Ochlerotatus cantator.*	A shift in species is expected as salinity is increased, with a long-term decline of freshwater and generalist species such as *O. cantator* and *O. canadensis*, with replacement by salt marsh mosquito species such as *O. solicitans* in the lower marsh. Because of the greater success in controlling this species, a decrease in the mosquito nuisance is expected. These impacts are expected in 801 restored acres.	The same species shift is expected as in alternative B. These impacts are expected in 830 restored acres. No changes would occur in Mill Creek.	The same species shift is expected as in alternative B. These impacts are expected in 890 restored acres.
Shellfishing	Recreational and commercial shellfish harvest would remain permanently closed immediately downstream of the Chequessett Neck Road Dike, due to fecal coliform contamination.	Shellfish populations and shellfish harvest are expected to increase. Decreased fecal coliform levels would allow the closed area downstream of the Chequessett Neck Road Dike to be reopened; other areas of Wellfleet Harbor that are only conditionally opened could be opened year-round.	Same as alternative B.	Same as alternative B.
Finfishing	No improvement to recreational or commercial finfishing would occur. Ongoing estuary degradation and obstructed access would contribute to continued regional population declines of estuary-dependent fisheries.	Improvements to habitat and water quality in the estuary and Wellfleet Harbor would benefit populations of finfish and commercial finfishing industries. Restoring connectivity with Wellfleet Harbor for the full range of fish species formerly found in the estuary would provide a corresponding improvement to the recreational fishery.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Low-lying Properties	Properties in the project area would rely on the continued operation of the Chequessett Neck Road Dike for protection from tidal impacts. Certain properties may need to obtain flood insurance if the Chequessett Neck Road Dike is not upgraded to comply with FEMA design guidelines.	Increased tidal exchange would result in beneficial and adverse impacts to low-lying properties. Beneficial impacts would include transition to open marsh and water vistas, potentially increasing property values. Adverse impacts could include flooding of low-lying structures and cultivated vegetation. Flood proofing measures would mitigate flood impacts. Compared to the other action alternatives, this alternative has the least impact in terms of the number of properties affected and the degree of impact.	The types of impacts are the same as alternative B. This alternative would have more impact in terms of the number of properties affected and the degree of impact than alternative B, but less than alternative D, because there would be no change in Mill Creek.	The types of impacts are the same as alternative B. This alternative would have more impact in terms of the number of properties affected and the degree of impact than alternatives B and C.
Low-lying Roads	Present road conditions would persist under the no action alternative. None of the roads have serious flooding issues.	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 7,394 feet Sand/fire roads: 10,332 feet	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 8,694 feet Sand/fire roads: 10,332 feet	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 9,397 feet Sand/fire roads: 10,727 feet

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Viewscapes	The current natural features and landscape character, and therefore viewscapes, would not change.	Long-term viewscape benefits would result from expanding intertidal habitat and open vistas. Intertidal habitats would vary by basin, but would be mostly open water, broad salt meadows, and salt water marshes. More native wildlife may also be observed. Wooded areas within the flood plain would decrease, reducing obstructions to viewscapes. In the short term, some dead or dying vegetation could reduce the quality of the viewscape until the transition is complete.	Same as alternative B, except that slightly more wooded area in the upper sub-basins would be removed, and Mill Creek sub-basin would be unaffected.	Same as alternative B, except that slightly more wooded area in the upper sub-basins would be removed.
Recreational Experience and Public Access	Public access points would remain unaffected and the physical character of the estuary would be unchanged.	Some low-lying access points could be impacted in the short term, but in the long term these could be replaced with better access points. After restoration, there would be improvements to recreational shellfishing, finfishing, wildlife viewing, boating, and visual aesthetics. There would be no net loss in public access.	Same as alternative B, except that no change would occur in Mill Creek.	Same as alternative B.
Regional Economic Conditions	There would be no project expenditures. Current regional economic conditions and trends are expected to continue.	Regional economic conditions would benefit from engineering, construction, and related spending that would support jobs and increase economic activity.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Construction Impacts Chequessett Neck Road Dike	No construction would occur.	The Chequessett Neck Road Dike would be reconstructed, temporarily impacting approximately 103,200 square feet (2.4 acres) comprised of the current dike footprint and adjacent inter- and sub-tidal wetland areas.	Same as alternative B.	Same as alternative B.
Mill Creek Dike	No construction would occur.	No construction would occur.	This structure would require approximately 2,900 cubic yards of fill and would permanently impact 12,500 square feet of wetland. In addition, a work area of approximately 105,000 square feet (2.4 acres) of wetlands would be impacted temporarily for dewatering and other associated work.	Same as alternative C.
High Toss Road		If the road is reconstructed above high tide line, there would be a permanent loss of approximately 13,000 square feet of vegetated wetland. Alternatively, if High Toss Road were removed, approximately 12,000 square feet of additional wetland area would be restored.	Same as alternative B.	Same as alternative B.
Pole Dike/ Bound Brook Island Roads		Elevating the roads above the maximum coastal storm driven tidal elevation would fill approximately 4,000 square feet of adjacent wetlands. Elevating the roads above annual high water (AHW) would fill approximately 2,300 square feet.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
CYCC Golf Course Flood Proofing		Two options exist for flood proofing low-lying golf holes: Option 1 (relocation) and Option 2 (elevation). Under the relocation option, most of the low-lying golf holes would be relocated to an approximately 30-acre adjacent upland area. One hole would be elevated in its current location, resulting in a wetland loss of about 89,000 square feet. For the elevation option, approximately 360,000 square feet (8.3 acres) of wetland would be filled and elevated above the high tide line. Most of this wetland is now a developed part of the golf course. Fill may be generated from an approximately 5-acre borrow area on adjacent uplands for both options. The upland area is highly sensitive for pre-contact archeological resources.	No flood proofing measures are required.	Same as alternative B.
Residential Flood Proofing		Several low-lying residential properties could be impacted by restored tides, requiring actions such as constructing a small berm or wall to protect a residential parcel, adding fill to a low driveway or lawn, or relocating a well. Some of these actions may have limited wetland impacts.	No flood proofing measures are required in Mill Creek. In other areas, impacts would be similar to alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Secondary Restoration Actions / Minor Road Improvements		These actions may include direct vegetation management, sediment management, channel improvements, and planting of vegetation. Impacts are expected to include work within wetland areas to remove trees and shrubs, dredge and/or deposit of sediment, excavation or fill of channels, and other actions to improve tidal circulation. Some actions may include access for heavy equipment.	Same as alternative B, except that no restoration would occur in Mill Creek.	Same as alternative B.

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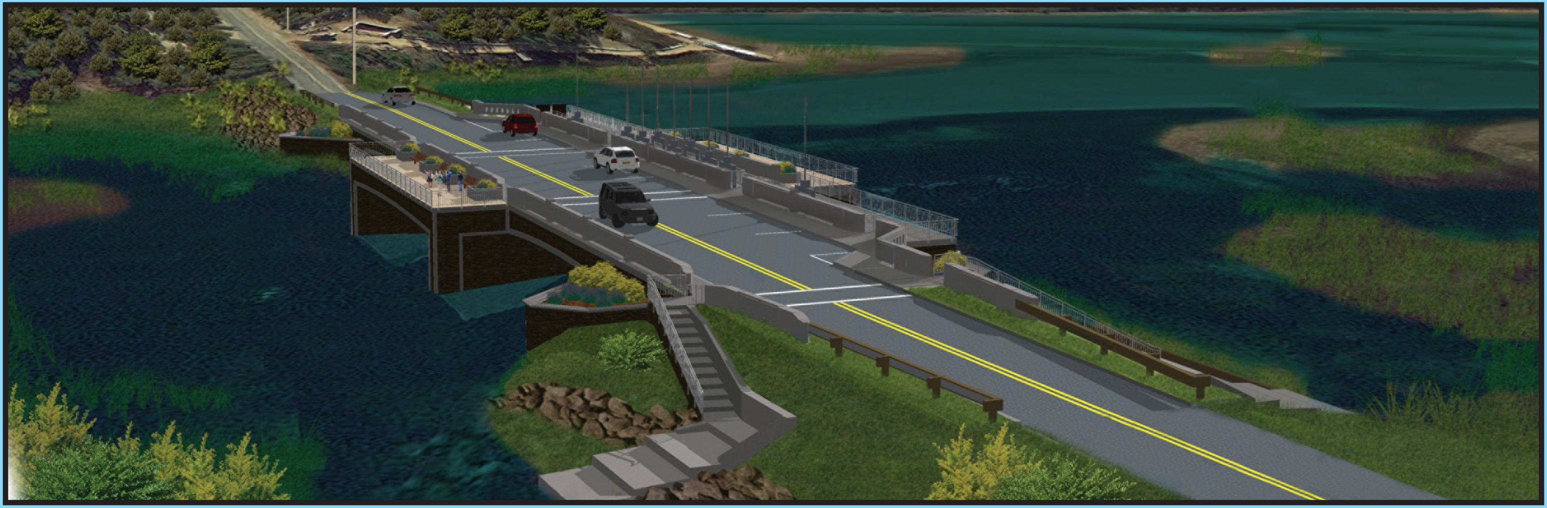
Acronyms and Abbreviations

ACEC	areas of critical environmental concern
AHW	annual high water
APE	area of potential effect
BMP	best management practice
BVW	Bordering Vegetation Wetlands
CCC	Cape Cod Commission
CCMCP	Cape Cod Mosquito Control Project
CEQ	Council on Environmental Quality
CRP	Conceptual Restoration Plan
CWA	Clean Water Act
CYCC	Chequessett Yacht and Country Club
CZM	Coastal Zone Management
DDT	dichlorodiphenyltrichloroethane
DRI	Development of Regional Impact
EFH	essential fish habitat
EIR	environmental impact report
EIS	environmental impact statement
EIS/EIR	Herring River Restoration Environmental Impact Statement / Environmental Impact Report
ENF	environmental notification form
ERL	effects range low
ERM	effects range median
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
GIS	Geographic Information System
HRRC	Herring River Restoration Committee
HRRP	Herring River Restoration Project
HRTC	Herring River Technical Committee
LCS	List of Classified Structures
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MHC	Massachusetts Historical Commission
MHW	mean high water
MLW	mean low water
MOU	Memorandum of Understanding
National Register	National Register of Historic Places
NEPA	National Environmental Policy Act

NHESP	Natural Heritage and Endangered Species Program
NHPA	National Historic Preservation Act of 1966
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PA	programmatic agreement
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEPC	Planning, Environment, and Public Comment
PEL	probable effects level
ROD	Record of Decision
Seashore	Cape Cod National Seashore
SHPO	State Historic Preservation Officer
TEL	threshold effects level
THPO	Tribal Historic Preservation Officer
TPH	total petroleum hydrocarbons
TWG	Technical Working Group
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WPA	Wetlands Protection Act

Chapter 1:
Purpose and Need



CHAPTER 1: PURPOSE AND NEED

1.1 INTRODUCTION

The Herring River Restoration Committee (HRRC) and the National Park Service (NPS) propose to restore native tidal wetland habitat to large portions of the Herring River flood plain in and adjacent to Cape Cod National Seashore (the Seashore) (figure 1-1), by re-establishing tidal exchange in the river basin and its connected sub-basins. Tidal exchange would be increased incrementally, over time, using an adaptive management approach, to achieve desired conditions for native estuarine habitats.

The HRRC and NPS have prepared this *Herring River Restoration Project, Final Environmental Impact Statement/Environmental Impact Report* (final EIS/EIR) for the Herring River Restoration Project to (HRRP) assist the public, the Seashore, and the Towns of Wellfleet and Truro in developing a tidal restoration project for the Herring River. This final EIS/EIR has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), the Massachusetts Environmental Policy Act (MEPA), and the Cape Cod Regional Policy Plan. For this project, the Towns of Wellfleet and Truro are the lead agencies for MEPA and the Cape Cod Commission (CCC); the NPS is the lead agency for NEPA compliance, with the participation of the following cooperating agencies (agency consultation letters are included in appendix A):

- U.S. Fish and Wildlife Service (USFWS)
- Natural Resources Conservation Service (NRCS)
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Environmental Protection Agency (USEPA)
- U.S. Army Corps of Engineers (USACE)

This chapter explains what the restoration project intends to accomplish and why the NPS and the project partners are taking action at this time. The final EIS/EIR presents several alternatives for tidal restoration in the Herring River estuary and assesses the impacts that could result from continuing current practices (the no action alternative) or implementing the action alternatives. The NEPA and MEPA processes will be used to select an alternative to implement as the approved restoration plan for the Herring River. The selected alternative, with its various restoration components, will guide the Herring River tidal restoration project and will provide a strategy for long-term, systematic monitoring, management, and restoration of the Herring River estuary. Information in this chapter is largely taken from the *Herring River Tidal Restoration Project Conceptual Restoration Plan* (CRP) (Herring River Technical Committee (HRTC) 2007); where appropriate, references cited in the CRP are included to indicate the original supporting documentation.

1.2 PURPOSE OF THE PROJECT

The purpose of this project is to restore self-sustaining coastal habitats on a large portion of the 1,100-acre Herring River estuary in Wellfleet and Truro, Massachusetts. While the ecological goal is to restore the full natural tidal range in as much of the Herring River flood plain as practicable, tidal flooding in certain areas must be controlled to protect existing land uses and to facilitate habitat restoration. Where these considerations are relevant, the goal is to balance tidal restoration objectives with flood control by allowing the highest tide range practicable while also ensuring flood proofing and protection of vulnerable properties.

1.3 NEED FOR ACTION

The Herring River's wetland resources and natural ecosystem functions have been severely damaged by 100 years of tidal restriction and salt marsh drainage. Adverse impacts include the following:

Tidal Restriction (Lack of Tidal Inflow and Outflow)—The Chequessett Neck Road Dike restricts the tidal range (mean low water to mean high water) in the Herring River from more than 10.3 feet on the downstream, harbor side, to approximately 2.4 feet just upstream of the dike (figure 1-2). The dike dampens the upstream water surface elevation of the mean high spring tide and coastal storm driven tidal events by approximately 5.8 and 8.4 feet, respectively. All elevations referenced in this document are in North American Vertical Datum (NAVD) 1988.

Since 1980 when the Seashore began to consider restoring the Herring River, many studies have documented the negative impacts of tide restriction, ditching, and drainage, and have assessed the beneficial impacts that tidal restoration could have on natural resources and infrastructure. The following section summarizes the HRTC's information as presented in the Herring River Tidal Restoration Project CRP.

Plant Community Changes (Including Loss of Salt Marsh Vegetation and Increase in Non-native, Invasive Species)—The reduction of tidal influence on the river flood plain and intensified marsh drainage efforts (ditch-draining) has had a gradual but dramatic impact on the species' composition of the naturally occurring tidal marsh plant communities. Reduced salinities denied salt marsh plants their competitive edge over herbaceous freshwater wetland species. Cattail-dominated plant communities gradually replaced characteristic salt marsh vegetation. By the 1960s, intensified drainage for mosquito control further dewatered the soils and allowed upland grasses, forbs, and even trees to replace cattails. For example, black cherry and pitch pine are now dominant in areas that were once naturally occurring salt marsh habitats. Drainage made it possible for upland plants to invade the flood plain and shade out wetland species adapted to the previously saturated soils. By the 1970s, much of the original Herring River wetlands had been converted from tidal marsh to forest and shrublands dominated by opportunistic upland species. Concurrently, 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.

Loss of Estuarine Habitat and Degradation of Water Quality—Elimination of salt water input to the estuary and marsh dewatering has dramatically degraded estuarine water quality, with severe ecological consequences. Salt marsh diking and drainage allows air to enter the normally anaerobic subsurface environment of the salt marsh, converting it to an aerobic environment where both organic material and iron–sulfur minerals can be readily oxidized. In salt marsh peat, a product of iron-sulfur mineral oxidation is sulfuric acid, which lowers pH when reaching surface waters. Low pH can cause fish kills and, in 1980, a large pulse of acidic water released into the Herring River main channel following a period of heavy rainfall killed thousands of adult American eel. Mainstem Herring River pH was determined to be highly acidic (pH 4), whereas ditches were 10 times more acidic. These ditches contained water so acidic that predatory fish that normally preyed upon floodwater mosquito larvae were chemically blocked from major mosquito breeding sites. Low pH causes leaching of toxic metals, particularly aluminum and ferrous iron, further degrading water quality.

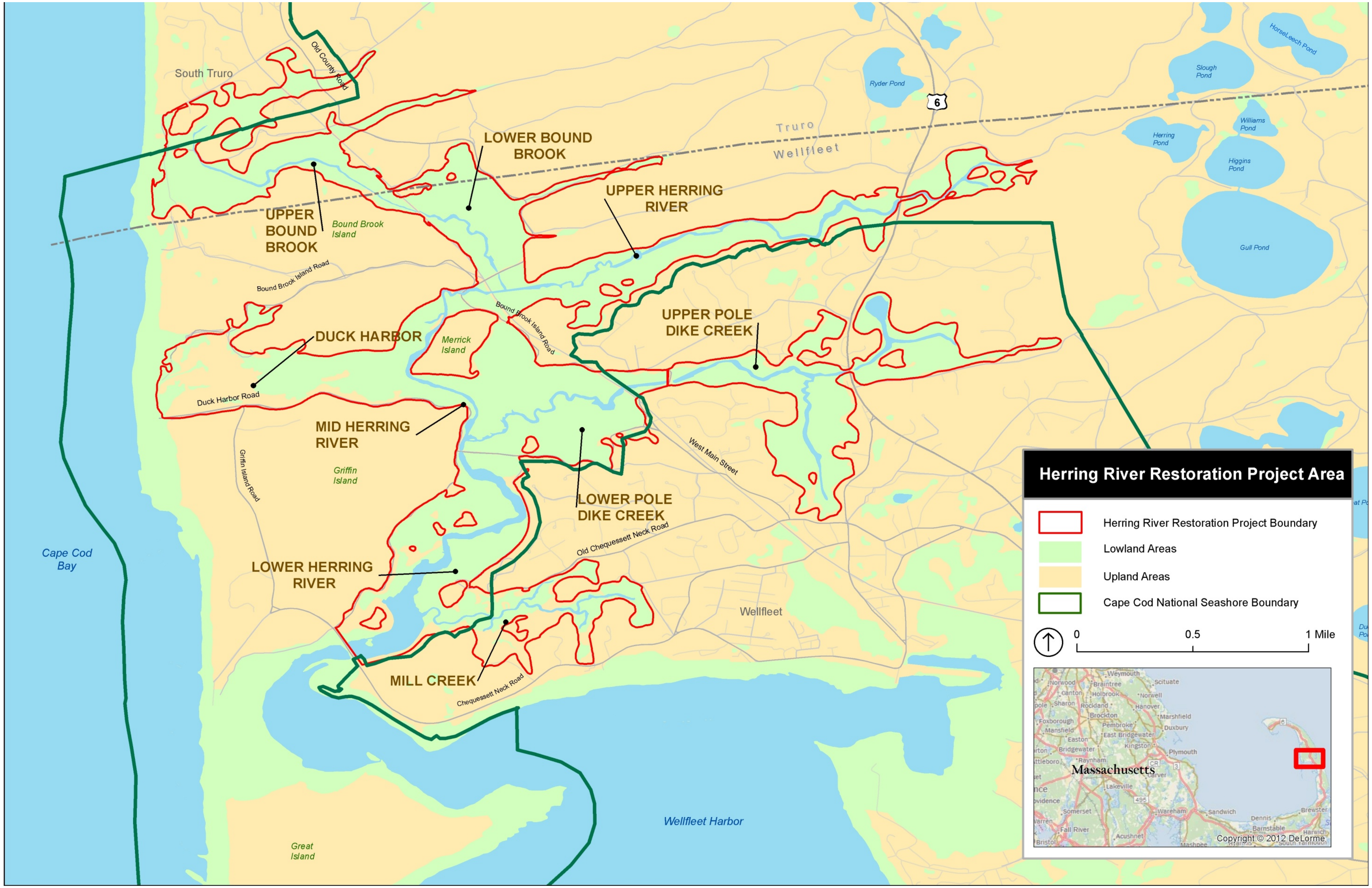


FIGURE 1-1: HERRING RIVER RESTORATION PROJECT AREA

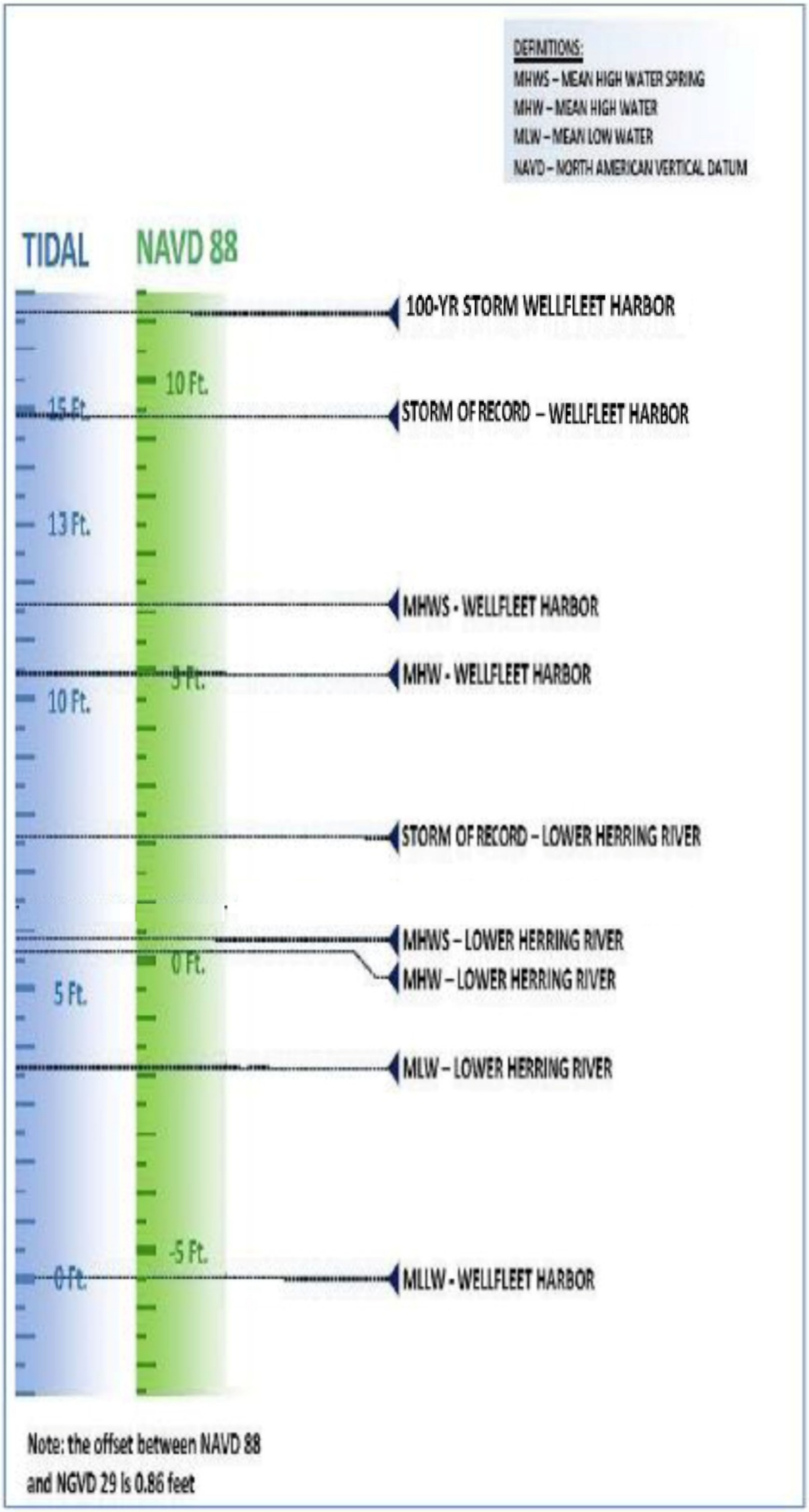


FIGURE 1-2: RELATIONSHIP BETWEEN NORTH AMERICAN VERTICAL DATUM OF 1988 AND TIDAL DATUM IN WELLFLEET HARBOR AND HERRING RIVER UNDER EXISTING CONDITIONS

Elimination of tidal flushing in the Herring River wetland system, which still contained abundant organic matter, caused regular summertime dissolved oxygen depletions and fish kills in the river's mainstem. Conditions, which were worst in mid-summer when oxygen demand was highest, compelled the NPS, at times, to control the emigration of juvenile herring to avert complete mortality and loss of the anadromous fish migration.

Alteration of Natural Sediment Processes and Increased Salt Marsh Surface Subsidence—Measurements indicate that, relative to sea level, much of the diked Herring River flood plain is up to 3 feet below its pre-dike elevation, and likewise below the current elevation of salt marsh seaward of the dike. Tidal restrictions radically affect the important process of sedimentation on the salt marsh. Coastal marshes must increase in elevation at a pace 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 inorganic sediment into an estuary and its deposition onto the marsh surface during flood tides. This sediment transport must occur to promote the growth of salt marsh vegetation and gradually increase the elevation of the marsh surface. However, the 1909 diking has dramatically reduced inorganic sediment from reaching the salt marshes in the Herring River basin. Additionally, marsh drainage has increased the rate of organic peat decomposition by aerating the sediment and caused sediment pore spaces to collapse. All of these processes have contributed to severe historic and continuing subsidence in the Herring River diked wetlands.

Nuisance Mosquito Production—Despite decades of work and large public expenditures to eliminate them, the Herring River remains a major breeding area for nuisance mosquitoes. Dense vegetation, lack of tidal flushing and substantial freshwater flows, marsh surface subsidence, and prior disturbances to the flood plain create extensive stagnant water breeding areas. In sampling conducted by the Seashore and the Cape Cod Mosquito Control Program (CCMCP), the dominant mosquito species caught in the Wellfleet area, *Ochlerotatus cantator*, breeds in fresh to brackish water. Its larvae can tolerate the acidified waters that keep its predators—fish species that eat mosquito larvae—at bay.

Impediments to River Herring Migration—In its unrestricted state, the Herring River provided a crucial connection between Cape Cod Bay and hundreds of acres of herring spawning and American eel habitat at Herring, Higgins, and Gull Ponds. In addition, the unrestricted estuary featured a gradual transition in salinity from seawater to freshwater, providing anadromous herring and catadromous eels a salinity gradient in which to adapt physiologically. The Chequessett Neck Road Dike physically impedes migratory fish passage and creates an artificially abrupt transition from seawater to fresh river water. As described previously, the tidal restriction also upsets wetland biogeochemical cycling which, in turn, severely degrades the water quality of aquatic habitat (e.g., depletion of dissolved oxygen). This has led to periodic fish kills during the summer when juvenile herring must swim from their natal kettle ponds down the Herring River's mainstem to Cape Cod Bay.

Carbon Storage and Methane Emissions—Blue carbon refers to the carbon naturally stored in coastal wetlands and seagrass beds that would otherwise contribute to atmospheric carbon dioxide loading and global climate change. Historically, the Herring River salt marshes absorbed large volumes of carbon in peat soils, which accumulated year after year as sea level slowly increased. However, decades of tidal restriction have led to massive release of carbon by altering sediment deposition and tidal circulation patterns. Blockage of tidal flow, and accompanying carbon-laden sediment, has allowed carbon to remain suspended in the water column where portions of it are released to the atmosphere as carbon dioxide. In addition, conversion of hundreds of acres of salt marsh to freshwater marsh has likely increased methane emissions, adding further to greenhouse gas emissions associated with the degraded Herring River flood plain.

1.4 OBJECTIVES IN TAKING ACTION

Objectives are "what must be achieved to a large degree for the action to be considered a success" (NPS 2011b). All alternatives selected for detailed analysis must meet project objectives to a large degree and resolve the purpose of and need for action. Objectives must be grounded in the enabling legislation, purpose, and mission goals of the Seashore, and must be compatible with the Seashore's General Management Plan direction and guidance, water resources plan, NPS *Management Policies* 2006, and/or other NPS management guidance. The NPS and HRRC identified the following objectives for developing this final EIS/EIR.

1.4.1 NATURAL RESOURCES

- To the extent practicable, given adjacent infrastructure and other social constraints, re-establish the natural tidal range, salinity distribution, and sedimentation patterns of the 1,100-acre estuary.
- Improve estuarine water quality for resident estuarine and migratory animals including fish, shellfish, and waterbirds.
- Protect and enhance harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Bay.
- Restore the connection between the estuary and the larger marine environment to recover the estuary's functions as (1) a nursery for marine animals and (2) a source of organic matter for export to near-shore waters.
- Remove physical impediments to migratory fish passage to restore once-abundant river herring and eel runs.
- Re-establish the estuarine gradient of native salt, brackish, and freshwater marsh habitats in place of the invasive non-native and upland plants that have colonized most parts of the degraded flood plain.
- Restore normal sediment accumulation on the wetland surface to counter subsidence and to allow the Herring River marshes to accrete in the face of sea-level rise.
- Re-establish natural carbon flows, including restoration of lost carbon storage volume and elimination of methane emissions from altered salt marsh habitats.
- Re-establish the natural control of nuisance mosquitoes by restoring tidal range and flushing, water quality, and predatory fish access.

1.4.2 CULTURAL RESOURCES

- Restore the expansive marshes and tidal waters that were once a principal maritime focus of both Native Americans and European settlers of outer Cape Cod in a manner that preserves the area's important cultural resources.
- Minimize adverse impacts to cultural resources during project construction and adaptive management phases.

1.4.3 SOCIAL AND ECONOMIC RESOURCES

- Minimize adverse impacts to surrounding land uses, such as domestic residences, low-lying roads, wells, septic systems, commercial properties, and private property, including the Chequessett Yacht and Country Club (CYCC).
- Educate visitors and the general public by demonstrating the connection between productive estuaries and salt marshes and a natural tidal regime.
- Improve finfishing and shellfishing opportunities.
- Enhance opportunities for canoeing, kayaking, and wildlife viewing over a diversity of restored wetland and open-water habitats.

1.5 DECISIONS TO BE MADE

In determining whether to implement the HRRP several federal agencies and two local communities will be using the environmental analysis in this EIS/EIR to inform their decision-making. These agencies and towns are currently working together to develop this document as lead and cooperating agencies under NEPA and MEPA, respectively. Each agency and town will consider the information in the EIS/EIR, public comments, and its own expertise related to the HRRP in making a decision whether to fund, authorize, implement, permit, or support the HRRP, or components of the HRRP.

MEPA requires that the environmental impacts of a proposed action be considered before a permit is issued by a Massachusetts state agency or commission if required by a local municipality. The two local municipalities for this HRRP are the towns of Wellfleet and Truro.

NEPA requires that the environmental impacts of a federal action be considered prior to a federal agency implementing the action to ensure its decision is informed. NEPA requires a lead agency for the development of the EIS and allows for the inclusion of cooperating agencies that either possess jurisdiction by law or have special expertise related to the HRRP. Federal NEPA decisions are captured in a Record of Decision (ROD). The following federal agencies intend to use this EIS/EIR to inform their decision, whether it is to fund, authorize, implement, or permit the HRRP in full or in part:

- National Park Service (NPS)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS)
- National Oceanic and Atmospheric Administration (NOAA)
- U.S. Environmental Protection Agency (USEPA)
- U.S. Army Corps of Engineers (USACE)

1.6 BACKGROUND

1.6.1 PURPOSE AND SIGNIFICANCE OF THE SEASHORE

Cape Cod is a slender spit of land curving some 60 miles into the Atlantic Ocean (figure 1-1); it has long been recognized as an extraordinary and diverse resource. Congress recognized that the Outer Beach of the Cape Cod peninsula was nationally significant for ecological, historical, and cultural reasons. On August 7, 1961, President John F. Kennedy signed legislation that established the Cape Cod National Seashore (Public Law 87-126). The purposes of the Seashore, as interpreted in the most recent General Management Plan (NPS 1998), are as follows:

1. Preserve the nationally significant and special cultural and natural features, distinctive patterns of human activity, and ambience that characterize the outer Cape, along with the associated scenic, cultural, historic, scientific, and recreational values.
2. Provide opportunities for current and future generations to experience, enjoy, and understand these features and values.

1.6.2 Project Study Area

The geographic study area for this final EIS/EIR is the Herring River estuary in Wellfleet and Truro on Cape Cod, Massachusetts. The Herring River (along with its flood plain, tributary streams, and associated estuarine habitats within Wellfleet Harbor) was the largest tidal river and estuary complex on the Outer Cape. Most of the river's flood plain (approximately 80 percent) is within the boundary of the Seashore. The river itself extends from Wellfleet Harbor northeast for nearly 4 miles to Herring Pond in north Wellfleet. Bound Brook, a major tributary, stretches northwest to Ryder Beach in South Truro. The river system, approximately defined by the landward limit of the flood plain of the river and its tributaries, encompasses about 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 including Duck Harbor, Mill Creek, Lower and Upper Bound Brook, and Lower and Upper Pole Dike Creek (figure 1-3). Each basin is distinct physically, and thus 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. In addition, each basin has a different land management history and habitat impacts, such as habitat fragmentation from road construction and residential development. The following section describes each sub-basin within the project area.

Herring River Basin—The Herring River basin is separated from Wellfleet Harbor by the Chequessett Neck Road Dike. The dike has 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 outgoing (ebbing) tides (WHG 2009).

The mainstem Herring River basin encompasses 396 acres and is divided into three separate hydrologic units: Lower Herring River, Middle Herring River, and Upper Herring River. The lower basin is the southern-most portion, immediately upstream of the Chequessett Neck Road Dike and extending northerly to the High Toss Road crossing. This basin covers roughly 166 acres and includes sub-tidal, riverine, vegetated wetland, and fringing upland flood plain habitats. The only remaining salt marsh in the Herring River system (approximately 13 acres) is located here, along with about 40 acres of non-native common reed (*Phragmites australis*) dominated marsh. The Middle Herring River covers 74 acres and extends north to Bound Brook Island Road. The Upper Herring River encompasses approximately 156 acres and extends northeast from Bound Brook Island Road and east of Route 6 to Herring Pond.

Mill Creek—Mill Creek sub-basin extends easterly from its confluence with the Herring River confluence, which is approximately 1,600 feet east of the Chequessett Neck Road Dike. The former tidal marsh portion of the Mill Creek basin comprises about 80 acres. *Phragmites* marsh and disturbed wooded wetland habitat covers much of the flood plain, although some salt marsh vegetation is found on the creek banks at the mouth of Mill Creek itself. In the 100 years since the Herring River Dike was constructed, CYCC, and several private residences and wells have been developed in the Mill Creek flood plain.

Pole Dike Creek Basin—This basin encompasses approximately 288 acres and forms the east central portion of the project area. The basin consists of two hydrologic units: Lower Pole Dike Creek and Upper Pole Dike Creek. Covering about 114 acres, Lower Pole Dike Creek sub-basin extends northeast from High Toss Road to Pole Dike Road. Upper Pole Dike Creek extends east of Pole Dike Road and includes the wetland and flood plain north of Wellfleet Center and east of Route 6. This basin is composed of about 174 acres of 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 Basin—This basin extends west from the mainstem of the river to the Duck Harbor barrier beach and comprises about 131 acres of flood plain north of Griffin Island and south of Bound Brook Island. Dry deciduous woodland 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. The shift of the Herring River from salt marsh to predominantly fresh/brackish and upland habitat was not solely caused by the 1909 Chequessett Neck Road Dike, but the natural closures of Bound Brook and then Duck Harbor also contributed to the changes. Today, Duck Harbor is separated from Cape Cod Bay by a line of vegetated dunes. However, historic maps show a tidal channel connecting it to the bay as recently as 1848 (Tyler 1922).

Bound Brook Basin—The Bound Brook basin extends to the north and west of Herring River above Old County Road. This basin consists of two hydrologic units: Lower Bound Brook (86 acres) and Upper Bound Brook (148 acres) that form a 234-acre wetland extending into the Ryder Hollow area of Truro. Today, Bound Brook basin is separated from Cape Cod Bay by a line of vegetated dunes, but this may be a relatively recent geological development, as the Bound Brook basin was connected to Cape Cod Bay until the mid-1700s (Roman 1987). In the past, Bound Brook basin was likely an estuary with tidal connection to Cape Cod Bay.

1.6.3 HISTORIC ALTERATIONS TO THE HERRING RIVER SYSTEM

Historically, the Herring River estuary included about 1,100 acres of salt marsh, intertidal flats, and open-water habitats (HRTC 2007) (figure 1-4). In 1909, the Town of Wellfleet diked the Herring River at its mouth, primarily to drain the breeding area for salt marsh mosquitoes. While salt hay production and fisheries productivity decreased, the mosquitoes did not. As a further attempt to control mosquitoes, the town dug drainage ditches in the marsh upstream of the dike structure. By the mid-1930s, the Herring River mainstem, now flowing with freshwater, was channelized and straightened, which cut off many creek meanders between High Toss Road and the present Route 6, substantially reducing the length of the river. Between 1929 and 1933, private developers of the CYCC constructed a nine-hole golf course in the Mill Creek flood plain. Several homes also have been built at low elevations in the flood plain. Freshwater vegetation and upland shrubs and trees now dominate the former tidal wetland (NPS 1999).

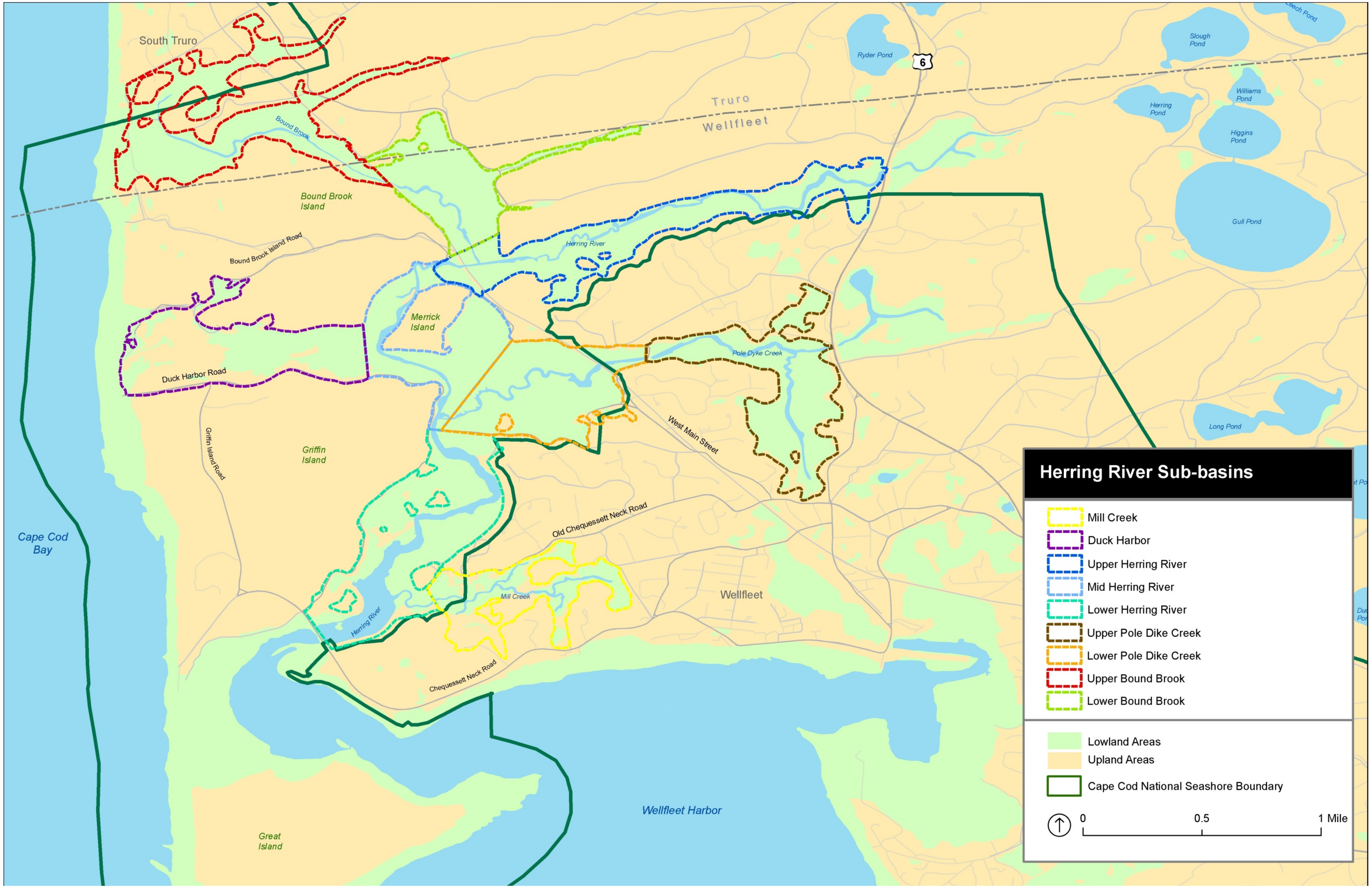


FIGURE 1-3: HERRING RIVER SUB-BASINS

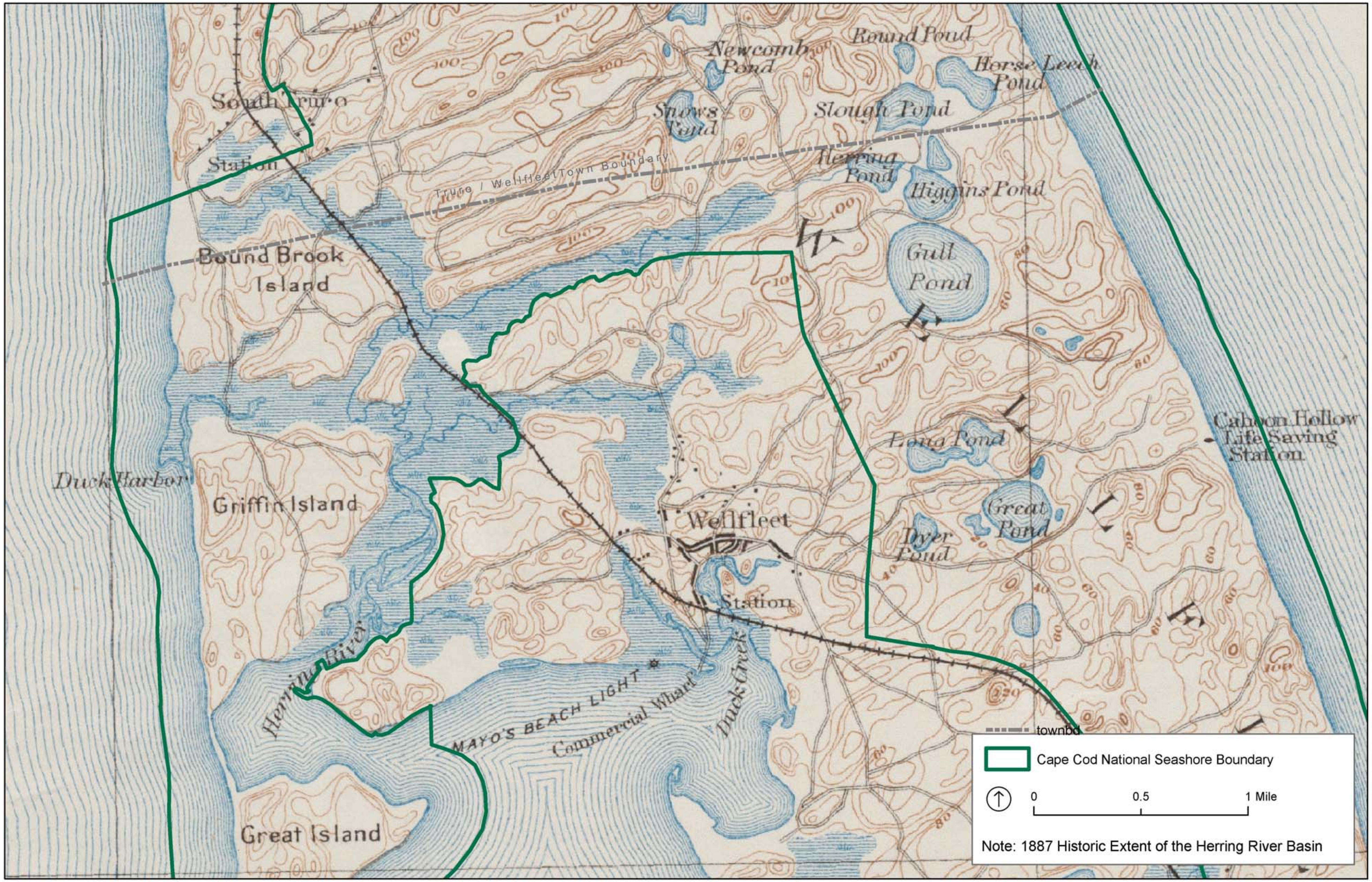


FIGURE 1-4: HERRING RIVER BASIN HISTORIC EXTENT (CIRCA 1887)

By the 1960s, structural deterioration caused the tide gates in the Chequessett Neck Road Dike to rust in an open position. As a result, tidal range and salinity in the Herring River increased, and shellfish recolonized in the river bottom and tidal flats upstream of the dike. However, increased tidal range in the river also caused periodic flooding of the CYCC golf course and other private properties. Although many local residents, scientists, and environmental advocates recognized and spoke publicly about the benefits of increased tidal flow in the river, in 1971 the Town of Wellfleet voted to allocate $37,500 toward repair of the damaged dike. In 1973, the Wellfleet Conservation Commission issued an Order of Conditions requiring that the repaired structure allow water levels matching those caused by the damaged tide gates. They further required that the new dike accommodate anadromous fish passage. Amid controversy, the state Department of Public Works rebuilt the dike in 1974 (HRTC 2007).

Following dike reconstruction, tide height monitoring conducted by the Association to Preserve Cape Cod showed that the new tide gate opening was too small to achieve the tide heights prescribed in the Order of Conditions. Local fishermen complained that siltation had increased and shellfish had again declined upstream of the Chequessett Neck Road Dike. The Association to Preserve Cape Cod sought to have the tide gate opened to the height mandated in the Order of Conditions. In 1977, the State Attorney General ordered that control of the dike be transferred to the Department of Environmental Quality Engineering (now the Department of Environmental Protection, or 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 focused attention on the poor water quality conditions in the Herring River. Massachusetts Division of Marine Fisheries and NPS scientists identified the cause of the fish kill to be high acidity and aluminum toxicity caused by diking and marsh drainage (Soukup and Portnoy 1986). Within a year of the eel kill, the NPS determined that the tide gate opening still did not provide the tide heights mandated in the 1973 Order of Conditions. Under continuing pressure from the Department of Environmental Quality Engineering and the Seashore, the town increased the tide gate opening to 20 inches in 1983. That same year, the Seashore scientists documented summertime dissolved oxygen depletions and river herring (*Alosa* spp.) kills for the first time (Portnoy 1991) and subsequently took steps to protect river herring and avert kills by blocking their emigration from upstream ponds to prevent the fish from entering low oxygen waters (HRTC 2007).

Despite these poor habitat conditions, concerns about tidal flooding of private properties and increased mosquito production prevented the town from opening the tide gate further. NPS mosquito breeding research conducted from 1981 to 1984 documented that although the principal mosquito species (*Ochlerotatus cantator* and *O. Canadensis*) were breeding abundantly in Herring River creeks and ditches, estuarine fish, which are important mosquito larvae predators, could not access mosquito breeding areas because of low tidal range, low salinity, and high acidity (Portnoy 1984a). In 1984, the town increased the sluice gate opening to 24 inches, where it has since remained (HRTC 2007).

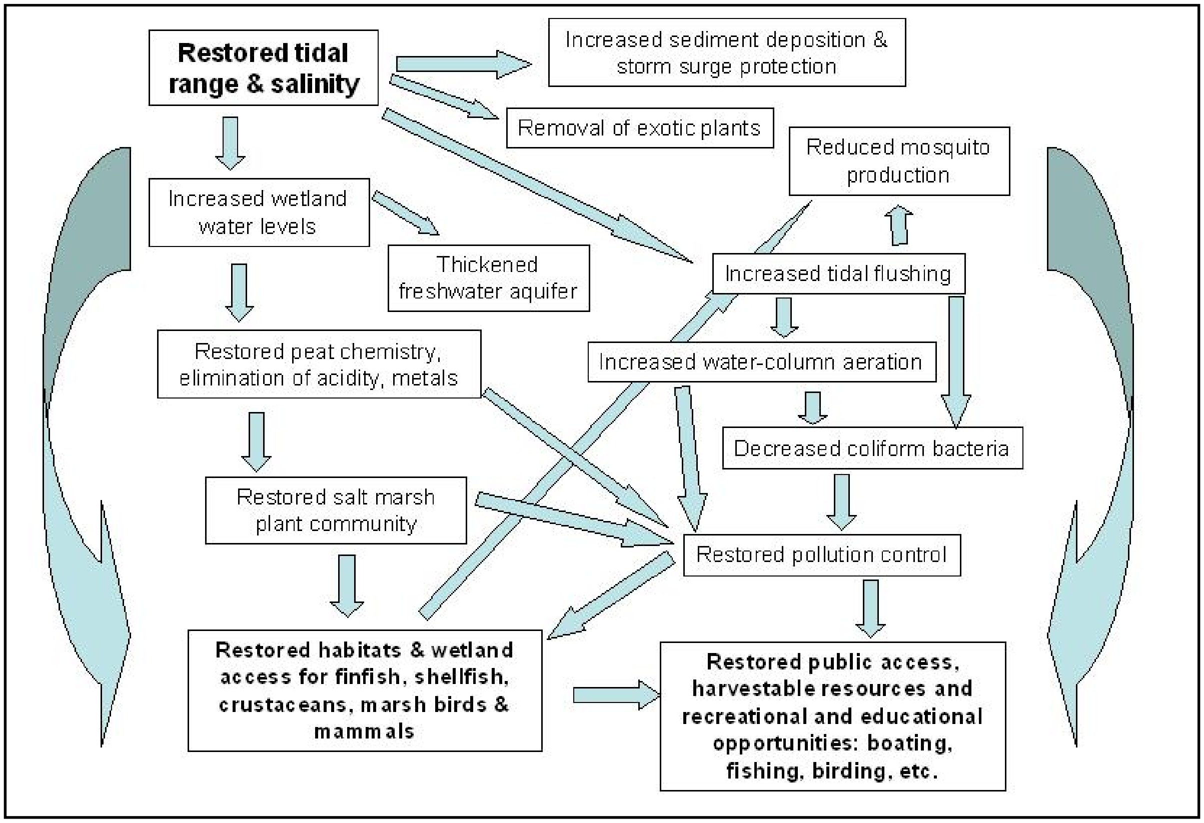
In 1985, the Massachusetts Division of Marine Fisheries, in a program of intensified bacteriological sampling of shellfish waters, classified shellfish beds in the river mouth as “prohibited” due to fecal coliform contamination. In 2003, water quality problems caused the MassDEP to list Herring River as “impaired” under the federal Clean Water Act (CWA) 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).

1.6.4 EXPECTED CHANGES FROM TIDAL RESTORATION

A restored tidal regime would provide diverse and interdependent changes in the Herring River estuary including the following:

- Higher average water levels in the estuary's wetlands (Spaulding and Grilli 2001), including the resaturation of hydric soils that have been drained by diking and ditches since 1909
- Lower low tides (Spaulding and Grilli 2001), which would improve basin drainage
- Reduced mosquito production by enhancing habitat quality for major predatory fish species, including mummichogs (*Fundulus heteroclitus*) and sticklebacks (*Gasterosteus* spp.) (Portnoy 1984b)
- Reversal of the chemical processes that have caused high acidity, mobilized toxic metals, and triggered fish kills (Portnoy and Giblin 1997b)
- Increased sediment transport and deposition onto the wetland surface, as flood tides would again overtop the river and creek banks and inundate the marsh surface, contributing to raising the surface elevation of the former tidal wetlands
- Dilution of high fecal coliform counts that have closed shellfish beds at the mouth of the Herring River (Portnoy and Allen 2006)
- Increased dissolved oxygen concentrations in the estuary by flooding the wetland twice each day with oxygen-rich Cape Cod Bay water
- Displacement and eventual elimination of upland and woody vegetation that has invaded the flood plain and re-colonization of native tidal marsh plants and re-establishment of a gradient of community types including tidal, brackish, and freshwater marsh
- Enhanced canoe/kayak access throughout the estuary on higher tides through salt marsh habitat instead of through the presently drained shrub thicket
- Increase in extensive, abundant, and diverse marine and estuarine resources for observation, education, and harvest both within the estuary and in nearby coastal waters.

Figure 1-5 provides a graphic representation of the interacting components of an HRRP.



(Source: Portnoy 2012).

FIGURE 1-5: RESTORATION PROCESSES CONCEPT DIAGRAM

1.7 USE OF HYDRODYNAMIC MODELING TO DESCRIBE CURRENT CONDITIONS AND EXPECTED CHANGES

The Woods Hole Group was contracted by the Town of Wellfleet to develop a hydrodynamic model sufficiently flexible to integrate with the adaptive management approach, capable of simulating the complexities of the Herring River system. The model is central to developing a restoration plan, as it allows for the evaluation of specific questions about potential change to surface water elevations, flow velocities, salinity changes, and sediment processes in the estuary. Spatially variable, time-dependent predictions from the model have allowed for an assessment of flood and ebb patterns and have been used to identify potential areas of ponding or stagnation.

Specifically, the numerical modeling has been used to evaluate the goals for the restoration effort. 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 water flow velocities and sedimentation patterns in the project area
- Assessment of impacts to low-lying properties and infrastructure.

Information on and results of the modeling process are included in "Chapter 2: Alternatives," "Appendix B: Hydrodynamic Modeling Report," and are discussed throughout the impacts analysis in "Chapter 4: Environmental Consequences."

1.8 USE OF ADAPTIVE MANAGEMENT TO ACHIEVE DESIRED CONDITIONS

Adaptive management is an important tool for resource management. It is based on the assumption that current scientific knowledge is limited and a level of uncertainty exists. In 2007, the Department of the Interior released its *Adaptive Management Technical Guide*, defining the term and providing a clear process for building adaptive management processes into natural resource management (Williams, Szaro, and Shapiro 2007). In 2008, the Department of the Interior codified the definition in regulations stating that adaptive management is "a system of management practices based on clearly identified outcomes and monitoring to determine whether management actions are meeting desired outcomes; and, if not, facilitating management changes that will best ensure that outcomes are met or re-evaluated" (43 CFR 46.30). The Department regulations also direct its agencies to use adaptive management (43 CFR 46.145).

Since the early planning stages of the HRRP, reintroduction of tidal influence has been understood as a long-term, phased process that would occur over several years. Gradual opening of adjustable sluice gates would incrementally increase the tidal range in the river. The primary reasons to implement the project in this manner are to avoid unexpected or sudden irreversible changes to the river and Wellfleet Harbor and to allow monitoring of the system so that unexpected and/or undesirable responses could be detected and appropriate remedial actions taken. In addition to the uncertainty, size, and complexity of the proposed project, other aspects of the project also dictate use of an adaptive management approach. Among these are a large and divergent group of stakeholders, tension between restoration goals and flood protection goals, and the need for phased and recurrent decisions. More information on the adaptive management approach to restoration of the Herring River estuary can be found in "Chapter 2: Alternatives" and "Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project."

1.9 SCOPING PROCESS AND PUBLIC PARTICIPATION

NEPA and MEPA regulations require an early and open process for determining the scope of issues to be addressed in the EIS/EIR. Scoping is used to define the purpose and need of the project; identify issues to be analyzed and eliminate issues that are not relevant; allocate assignments among interdisciplinary team members and participating agencies; identify relationships to other planning efforts or documents; identify additional permits, surveys, or consultations required by other agencies; and define a time schedule for document preparation and decision-making. Scoping is conducted both internally, with appropriate subject matter experts and with agency managers having legal jurisdiction or special expertise, and externally with interested and affected organizations and the public.

1.9.1 HERRING RIVER TECHNICAL COMMITTEE

Over the past several years, local, state, and federal partners and non-governmental organizations have expressed growing support for restoring the Herring River estuary. The process has not only encompassed many years of scientific and engineering investigations but also has included a public review process to ensure that all concerns and interests are recognized and considered.

Because the Town of Wellfleet owns the Chequessett Neck Road Dike and the Seashore manages roughly 80 percent of the Herring River flood plain, these two parties have been at the forefront of restoration planning. In August 2005, the two parties formally agreed to work together to restore the Herring River by signing a Memorandum of Understanding (MOU) that established a "process and framework that will determine whether a restoration of the Herring River is feasible and subsequently to develop a conceptual plan of the restoration goals and objectives to meet stakeholder needs should restoration be deemed appropriate." Prior to signing the MOU, in January 2005, the Town of Wellfleet Board of Selectmen agreed "…in principle to the fact that restoring the Herring River salt marsh will be beneficial to the public interests and the environment and is a project worth proceeding with, with the caveat that a MOU is signed between the NPS and the Town of Wellfleet and the development of a comprehensive restoration plan and filing for permits to [*sic*] proceed" (HRTC 2007).

The MOU called for a technical committee and a stakeholder group and provided criteria for the composition of both groups and their intended functions. The Board of Selectmen designated the HRTC to include representatives from the Seashore and the Massachusetts Coastal Zone Management's Wetland Restoration Program, plus representatives from the following local commissions and boards/agencies: Wellfleet Conservation and Health Agent, Wellfleet Open Space Committee, Wellfleet Shellfish Advisory Committee, Wellfleet Shellfish Constable, Wellfleet Herring Warden, Wellfleet Natural Resource Advisory Committee, CYCC, Town of Truro Selectmen, USFWS, NRCS, Cape Cod Cooperative Extension Service, NOAA Restoration Center, Barnstable County Health Department, and the Herring River Stakeholders Group Chair.

The Board of Selectmen further directed the HRTC to review and summarize the scientific and technical information on the Herring River system, consider community concerns, submit recommendations to the Board of Selectmen about the feasibility of restoring the system, and develop a CRP if appropriate. The HRTC formed subcommittees to address specific concerns about the restoration process, and each subcommittee produced reports summarizing the issues. Public involvement throughout the process included (1) attendance at HRTC meetings; (2) public presentations by HRTC members; and, (3) participation in the Herring River Stakeholder Group. The stakeholder group was composed of representatives from the towns and the Seashore, potentially affected landowners, the shellfish/fishing community, Cape Cod Mosquito Control Project, Massachusetts Division of Marine Fisheries, the NOAA, and the NRCS. The Board charged the group with communicating the public's interests and concerns to the HRTC.

In January 2006, the HRTC produced a "Full Report of the Herring River Technical Committee" which summarized their findings and recommended,

> …tidal restoration of the Herring River Salt marsh [*sic*] is feasible and will provide numerous and substantial public benefits. As outlined in the Technical Committee's Synopsis, significant improvements in water quality would provide subsequent public health, recreational, environmental, and economic benefits. Our recommendation includes a new structure capable of full tidal restoration. The new structure should incorporate controlled gates to provide incremental increases in tidal exchange. This would allow for well thought-out management, supervision, monitoring, and evaluation.

As the MOU directed, the HRTC's findings led to a CRP (HRTC 2007) which described several possible ways to restore the Herring River. On November 13, 2007, the Seashore and Wellfleet and Truro signed a second MOU accepting the CRP and agreeing to move forward with a detailed restoration plan, which is the subject of this final EIS/EIR. Having completed its work, the Board dissolved the HRTC in 2007. The second MOU established a new committee, the HRRC. In addition to Wellfleet, Truro, and Cape Cod National Seashore, the HRRC is composed of representatives from the USFWS, Massachusetts Division of Ecological Restoration (formerly Coastal Zone Management's Wetland Restoration Program), NOAA Restoration Center, and the NRCS. The HRRC also has the authority to solicit input from additional technical experts as it develops a detailed restoration plan.

As part of the restoration effort, the HRTC obtained funding from a NOAA-Gulf of Maine Council restoration partnership grant to develop 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 (WHG 2009). The Woods Hole Group was contracted by the Town of Wellfleet to identify and develop the hydrodynamic model for the Herring River system (see "Section 1.7: Use of Hydrodynamic Modeling to Describe Current Conditions and Expected Changes").

1.9.2 PUBLIC SCOPING

Two public scoping meetings held in Wellfleet in August and September 2008, gave the public the opportunity to learn about the planning process and provide input. Both meetings were open-house style sessions with short presentations that allowed the public to ask Seashore staff and HRRC members questions and provide input in an informal atmosphere. NPS representatives at the meeting recorded public comments. Following the meeting, a 60-day comment period gave the public the opportunity to submit additional comments through the mail or on-line through the NPS Planning, Environment, and Public Comment (PEPC) website.

Forty-three pieces of correspondence containing 288 separate comments were received during the public comment period. Topics raised by the public and agencies ranged widely – from concerns about impacts to private lands to compliance with state and local permitting requirements. A summary of the issues identified during public scoping is provided later in this chapter. A more detailed description of the issues is presented in "Chapter 5: Consultation, Coordination, and Regulatory Compliance."

The draft EIS/EIR was released on October 12, 2012. Following its release, a 60-day public comment period was open between October 12, 2012, and December 12, 2012. The draft EIS/EIR was made available for review through several outlets, including the NPS PEPC website, several local libraries, CD or hardcopy requests from the Seashore, and specific distribution to several government agencies, stakeholder groups, and regulators.

During the public comment period, the NPS, with the assistance of HRRC, and the CCC, held a public hearing for the HRRP draft EIS/EIR to continue the public involvement process and to obtain community feedback on draft EIS/EIR for tidal restoration of the Herring River. This hearing met the dual purposes of fulfilling the NPS's NEPA public involvement requirement and the formal public hearing for the CCC, as required by Section 5 of the Cape Cod Commission Act and MEPA regulations. The public hearing was held on November 8, 2012, beginning at 6:30 p.m. at the Wellfleet Senior Center/Council on Aging, in Wellfleet, Massachusetts. After having an opportunity to review the draft EIS/EIR, the public was encouraged to submit comments through the PEPC website, through oral statements, and written comments recorded during the public hearing. Substantive public comments received during the draft EIS/EIR public review process are summarized in the Concern Response Report that accompanies this final EIS/EIR (appendix M). During the comment period, 43 pieces of correspondence were received. Topics raised by the public and agencies were similar to those expressed in the comments received during the initial project scoping discussed above; no new issues were raised.

1.10 IMPACT TOPICS

Seashore staff, Wellfleet and Truro, members of the HRRC, and the public identified impact topics associated with tidal restoration in the Herring River. Impact topics are the specific resources and other aspects of the human environment that would be affected by implementing the alternatives described in this final EIS/EIR. The impact topics are derived from the issues described above and provide the organizational structure for the description of the affected environment in chapter 3 and the analysis of environmental consequences in chapter 4 of this final EIS/EIR.

1.10.1 SALINITY OF SURFACE WATERS

Salinity—Changes in the Herring River system would be driven primarily by increased tidal exchange and increased salinity levels. Species occurrence and distribution would depend on the salinity concentrations throughout the flood plain. Vegetation in areas subject to frequent tidal inundation would be expected to die out, allowing colonization of tidal marsh species. In addition, support for estuarine fauna would also depend on salinity concentrations and water depths.

1.10.2 WATER AND SEDIMENT QUALITY

Surface Water Quality in the Estuary—One of the more important hydrologic functions of tidal flushing and wetlands is water quality improvement. Degraded water quality conditions led the MassDEP to list the Herring River as "impaired" under the federal CWA Section 303(d) for low pH and high metal concentrations. Poor water quality in the river has also led to fish kills and closure of shellfish beds at the river's mouth. Water quality parameters to be addressed in this final EIS/EIR include the following:

- Dissolved oxygen—necessary to support fish and other aquatic animals
- pH—appropriate acidity range is needed to support the chemical processes required for nutrient cycling, waste processing, and to support aquatic animals
- Nutrients—balanced concentrations of nitrogen and phosphorus are important to support vegetation and the growth of algae
- Fecal coliform—increased tidal flushing would reduce these concentrations and improve water quality.

Surface Water Quality in Receiving Waters—The tidal flats of Wellfleet Harbor include the largest and some of the most productive shellfish aquaculture grants in the state. Protection of aquaculture interests is critical. Potential changes in water quality and sedimentation from increased tidal exchange between Wellfleet Harbor and the Herring River are a concern for restoration advocates, the Town of Wellfleet, and shellfish growers.

Acidification—Sudden reintroduction of salt water to diked salt marsh could potentially mobilize sulfides and nutrients into the system, inhibiting the recolonization of salt marsh vegetation. Gradual re-establishment of tidal range would resaturate wetland soils that were drained by diking, and over time reverse the chemical processes that have caused high acidity and triggered fish kills in receiving waters (Portnoy and Giblin 1997b). Restoration of the estuary would also improve flushing and eventually reduce or eliminate problematic acidity in the estuary.

Metal Mobilization—Tidal restoration would resaturate wetland soils with salt water and reverse the chemical processes that have mobilized toxic metals into the water column (Portnoy and Giblin 1997b).

1.10.3 SEDIMENT TRANSPORT AND SOILS

Sedimentation on Tidal Marshes—Much of the tidal marsh plain of the Herring River upstream of the dike has subsided up to 3 feet below its pre-dike elevation and below the surface of existing salt marsh seaward of the dike. If the elevation of the subsided wetland does not increase as tidal range is increased, the root zone would remain waterlogged throughout the tidal cycle, discouraging re-establishment of tidal marsh plants. Restored tidal range would lead to higher sediment transport and deposition onto the wetland surface, as sediment-carrying flood tides would again flood over creek banks and onto the marsh platform. Restored sediment transport processes would also allow for natural deposition and burial of carbon to become reestablished. This, in combination with eliminating methane emissions from existing freshwater wetlands (i.e., former salt marsh), would dramatically reduce the volume of greenhouse gas that is currently associated with the Herring River flood plain.

1.10.4 WETLAND HABITATS AND VEGETATION

Wetland Transition—Wetlands in the project area would change from degraded habitats influenced by freshwater to tidal marsh habitats influenced by varying degrees of salt water. Increased tidal range would restore an estuarine salinity gradient and allow for colonization of native tidal marsh plants.

Submerged Aquatic Vegetation—Reintroduction of tides into the Herring River flood plain may affect two important submerged aquatic vegetation species. The occurrence and distribution and widgeon grass (*Ruppia maritima*), which currently is found throughout the project area, would likely be affected by restored tidal flow and salinity, with a decrease in coverage and biomass in high salinity areas and a general migration toward brackish areas. Eelgrass (*Zostera marina*), which is currently not found in the Herring River, could become re-established in higher salinity areas if suitable water quality and soil substrate conditions develop. With increased salinity, *Zostera* may be introduced to the Lower Herring River basin and has the potential to co-exist with *Ruppia*.

1.10.5 AQUATIC SPECIES

Estuarine Fish—Degraded water quality conditions have limited fish habitat diversity and abundance in the Herring River estuary (Roman 1987; Roman, Garvine, and Portnoy 1995). As demonstrated during the 1960s and early 1970s when poorly functioning tide gates allowed modest tidal exchange into the river, the benefits to estuarine species, such as mummichog, striped killifish, and Atlantic silverside, would occur quickly and persist in the long term by restoring habitat and a connection with the marine environment. Improved water quality and increased salinity would also increase the extent and value of the Herring River as a nursery for estuarine fish species.

Anadromous and Catadromous Fish—The Herring River system provides migratory and spawning habitat for two species of river herring (*Alosa aestivalis* and *A. pseudoharengus*) and American eel. As demonstrated during the 1960s and early 1970s when poorly functioning tide gates allowed modest tidal exchange into the river, restoration of tidal conditions would both improve the estuarine habitat conditions necessary to support these species and improve access to spawning ponds at the headwaters of the system.

Shellfish and other Invertebrates—Shellfish were once widely distributed in the Herring River estuary. As a result of diking, which reduced salinity and pH, shellfish species are now found only a short distance upstream of the dike or are completely absent from this area. As demonstrated during the 1960s and early 1970s when poorly functioning tide gates allowed modest tidal exchange into the river, restoring tidal flows and improving water quality would increase habitat for shellfish and other invertebrates.

1.10.6 FEDERAL AND STATE-LISTED RARE, THREATENED, AND ENDANGERED SPECIES

Federally listed Threatened and Endangered Species—The Endangered Species Act of 1973 provides legal protection for federally listed endangered and threatened species, as well as those species proposed for listing under the Act. No federally listed threatened or endangered species have been documented within the Herring River project area. However, a search of the USFWS database identified the federally threatened subspecies of the red knot (*Calidris canutus rufa*) as potentially using tidal wetland habitats for foraging and the threatened northern long-eared bat (*Myotis septentrionalis*) as potentially using tidal wetlands for foraging and adjacent forested uplands as summer roosting habitat within the project area.

State-listed Rare, Threatened, and Endangered Species—Restoration of the Herring River estuary could impact several state-listed species and their habitats in the estuary, although not all impacts would be adverse. For marine or salt-tolerant species, such as diamondback terrapin (*Malaclemys terrapin*) and salt reedgrass (*Spartina cynosuroides*), tidal restoration would likely restore additional habitat. Changes in vegetation types could cause populations of eastern box turtle (*Terrapene c. carolina*) and water-willow stem borer (*Papaipema sulphurata*), species that rely on freshwater and upland habitats, to shift their range and move to adjacent habitat. Available nesting habitat for northern harrier (*Circus cyaneus*), primarily cat-tail dominated wetlands, could be affected by restored tidal exchange, but would likely remain unchanged. Foraging habitat for harriers would be improved with restored salt marsh. Four-toed salamander (*Hemidactylium scutatum*) and spotted turtle (*Clemmys guttata*), both found in the Herring River flood plain, were de-listed in 2008 and 2006 respectively. Several listed freshwater marsh bird species that may occur in the flood plain, including American bittern (*Botaurus lentiginosus*) and several rail species (*Rallus* spp.), could also be affected.

1.10.7 TERRESTRIAL WILDLIFE

Birds—Species common to shrub thickets and freshwater habitat likely increased in the Herring River flood plain as conditions changed due to the tidal restriction. These include red-winged blackbird, song sparrow, prairie warbler, common yellowthroat, eastern towhee, and grey catbird. Many of these species are abundant nesters elsewhere on Cape Cod and southeastern Massachusetts (Veit and Peterson 1993). Tidal restoration would eventually alter habitat conditions for some of these species and may cause them to shift to appropriate habitats upstream in the Herring River system.

Several high priority tidal creek and salt marsh-dependent species such as salt marsh sharp-tailed sparrow (*Ammodramus caudacutus*), willet (*Tringa semipalmata*), American black duck (*Anas rubripes*) (especially in winter), common and roseate tern (*Sterna hirundo* and *dougallii*), and several species of shorebirds and wading birds (USFWS 2006) are expected to benefit from restoration of nesting (*Spartina* dominated habitat) and/or foraging opportunities (primarily estuarine fish). Other species, such as osprey (*Pandion haliaetus*), belted kingfisher (*Megaceryle alcyon*), and marsh wren (*Cistothorus palustris*) likely, will benefit from the restoration of foraging habitat.

Mammals—Small mammals, such as mice, voles, and shrews are abundant in the Herring River estuary. Larger mammals, such as coyotes (*Canis latrans*), river otters (*Lontra canadensis*), raccoons (*Procyon lotor*), muskrat (*Ondatra zibethicus*) and white-tailed deer (*Odocoileus virginianus*) also use the flood plain. The most common group of mammals found in marsh habitats are rodents, such as the meadow vole (*Microtus pennsylvanicus*), which are an important prey-species for northern harriers and other raptors. Other common mammals include red fox (*Vulpes vulpes*), opossum (*Didelphis virginiana*), skunk (*Mephitis mephitis*), and chipmunk (*Tamias striatus*) (Smith 1997).

Most mammals in the area are generalists, highly adaptable, and likely to move to adjacent habitat that is unaffected by tidal restoration (Smith 1997). However, mammals inhabiting the areas around the project sites may experience disturbances from construction activities associated with the project. Because concerns about these potential impacts were raised during initial public scoping, mammals are analyzed in detail in "Chapter 4: Environmental Consequences."

Reptiles and Amphibians—In addition to the previously cited state-listed rare species, other common species of reptiles and amphibians – notably, spotted turtle (*Clemmys guttata*), snapping turtle (*Chelydra serpentine*), green frog (*Rana clamitans melanota*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousii fowleri*), spring peeper (*Pseudacris crucifer*), and spotted salamander (*Ambystoma maculatum*) – use the existing habitats in the Herring River flood plain, despite the likely impact on these populations from low pH and poor water quality. As with mammals, tidal restoration is expected to affect reptile and amphibian species as habitats transition and the populations migrate to suitable habitat. Because concerns about these potential impacts were raised during initial public scoping, reptiles and amphibians are analyzed in detail in "Chapter 4: Environmental Consequences."

1.10.8 CULTURAL RESOURCES

Archaeological/Historical Resources—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. According to an archaeological reconnaissance report completed for the Massachusetts Wetlands Restoration Program (LBG 2007) and a Phase IA Archeological Assessment (Herbster and Heitert 2011), there are numerous archeological sites around the project area. These sites are located in areas both above and below potential tidal inundation. Native American -pre-contact resources have the greatest potential to occur near shorelines, where natural resources would have been gathered and processed. Post-contact sites could include the remains of wharves, docks, mills, saltworks, and the Old Colony Railroad (Herbster and Heitert 2011). 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.

Programmatic Agreement—The NPS has developed a programmatic agreement (PA) with the Massachusetts Historical Commission (MHC) to guide the identification, evaluation, and protection processes for archaeological resources within the Herring River Estuary. This PA defines the measures that must be carried out as the project is implemented to comply with the requirements of the NEPA and National Historic Preservation Act of 1966 (NHPA) processes and Massachusetts state regulations. As the project design process continues, NPS will provide plans and other documentation and consult with MHC under the terms of the PA. The final PA is included as appendix I of this document.

1.10.9 SOCIOECONOMICS

Nuisance Mosquitoes—Conditions created over the past 100 years have increased mosquito breeding, despite the original intent to reduce nuisance mosquitoes by diking and draining the estuary. Tidal restoration is expected to improve drainage and reduce stagnant, freshwater breeding sites, but the potential that restoration could increase, rather than decrease, nuisance mosquitoes is nonetheless a concern of the surrounding communities. Nuisance mosquitoes are therefore retained for detailed analysis.

Shellfishing—Many people currently harvest shellfish commercially in Wellfleet Harbor, and oysters and softshell clams were once widely distributed in the Herring River estuary. As a result of diking, which reduced salinity and pH, oysters are now found only a short distance upstream of the dike. Due to poor tidal flushing and consequently high levels of fecal coliform bacteria in water exiting the river, the Division of Marine Fisheries has prohibited shellfishing and shellfish propagation in all areas upstream of the Chequessett Neck Road Dike, and at least 3,000 feet downstream of the dike depending on the season and rainfall. Research suggests that tidal flushing would substantially reduce fecal coliform concentrations in presently closed areas through dilution and increased salinity (Portnoy and Allen 2006).

Finfishing—The Herring River provides important spawning, nursery, and foraging habitat for many migratory and resident fish. Historically, the Herring River was heavily used by local residents for recreational and subsistence fishing. Sport fish found in the Herring River include estuarine and marine species such as striped bass (*Morone saxatilis*), white perch (*Morone americana*), Atlantic mackerel (*Scomber scombrus*), bluefish (*Pomatomus saltatrix*), and winter flounder (*Pseudopleuronectes americanus*), as well as freshwater species such as chain pickerel (*Esox niger*) and pumpkinseed (*Lepomis gibbosus*). Restored salinities would greatly increase fishing opportunities for estuarine species. Diking and drainage have degraded water quality and greatly reduced the extent and quality of fish habitat (Portnoy, Roman, and Soukup 1987). Improving water quality by restoring natural tidal flushing and increasing both upstream and downstream movement of fish would improve recreational finfishing opportunities.

Low-Lying Properties—Without additional flood controls, tidal restoration would impact some low-lying properties. Since the dike was constructed at Chequessett Neck, houses have been built in locations that might not have been permittable under current regulations. Potentially affected features include buildings, driveways, wells, septic systems, lawns, and gardens. The CYCC is the primary landowner in the Mill Creek sub-basin, occupying approximately 106 acres of upland and former tidal wetlands. The majority of this acreage is a nine-hole golf course built in 1929, a considerable portion of which was built directly on drained former salt marsh. Most restored high tides would inundate low portions of the course unless flood protection measures are implemented.

Low-Lying Roads—Several road segments, primarily at stream crossings, are vulnerable to restored tidal flooding, most notably along High Toss, Pole Dike, Bound Brook, and Old County Roads. Hydrodynamic modeling has confirmed the susceptibility of these roads to high tide heights as low as approximately 2.5 feet. In addition to the long-term disposition of low-lying roads, this final EIS/EIR also considers ways to maintain temporary vehicle access and emergency routes during the construction phases of the project.

Viewscapes—Changes to the Herring River and its flood plain would result in changes to the viewscape currently offered to residents and visitors. Increasing the availability to view dynamic water environments such as open water and tidal wetlands would likely have impacts on property value associated with views of the river and tidal marsh. Since there is a potential to impact viewscapes, it is retained for analysis.

Recreational Experience and Public Access— The Herring River flood plain provides numerous recreational opportunities to local residents and visitors such as recreational finfishing and shellfishing, boating, wildlife watching, and hunting. The action alternatives may impact some of these activities by altering points of access to the estuary or by affecting the quality of recreation experiences.

Regional Economic Conditions—The restoration of the Herring River estuary would have local and regional impacts to economics such as projected employment in construction and other services necessary for restoration activities. Given the direct and indirect correlation between restoration activities and employment and spending, this topic is retained for analysis.

1.11 IMPACT TOPICS CONSIDERED BUT DISMISSED FROM FURTHER CONSIDERATION

The following impact topics were dismissed from further analysis, as explained in the following sections.

1.11.1 AIR QUALITY

The Seashore is classified as a Class II area under the Clean Air Act of 1973. The Seashore is within a non-attainment area (that includes the entire Commonwealth of Massachusetts) for ozone. During construction activities, air pollutants associated with burning of fossil fuels (CO_2, NO_x, SO_x) and fugitive dust would be generated by construction equipment and activities. It is not anticipated that these emissions would result in measurable changes to air quality because equipment would be operated only during daylight hours, idling time would be limited under standard NPS resource protection measures, and the project area is subject to coastal winds, which tend to disperse pollutants quickly.

In addition, tidal restoration may result in increased limited amounts of hydrogen sulfide. Hydrogen sulfide (or H_2S) is a colorless gas with the characteristic odor of rotten eggs at concentrations up to 100 parts per million. It is the product of bacterial breakdown of organic matter in the absence of oxygen, such as in swamps and sewers; a process known as anaerobic digestion. It also occurs in natural gas, and some well waters. Hydrogen sulfide is detectable by humans at 0.47 parts per million and toxic at concentrations greater than 10 parts per million. Greenhouse gas benefits (i.e., "blue carbon") of the project associated with increased carbon sequestration and reduced methane emissions are discussed in sections 3.4.4 and 4.4.1.

According to Portnoy and Giblin (1997a, 1997b), reintroducing seawater to diked marshes will cause hydrogen sulfide concentrations to increase as freshwater vegetation dies and the chemistry of underlying peat soils change. In the Herring River system, gradual reintroduction of seawater, coupled with availability of iron (ferrous) ions and resource monitoring, are expected to limit production of hydrogen sulfide. However, there is the potential for adjacent landowners and visitors to notice a "rotten egg" odor during the adaptive management phase of the restoration effort. Because the project area is subject to coastal winds, it is not expected that the limited releases of hydrogen sulfide gas would result in concentrations high enough to result in a considerable nuisance.

In sum, impacts to air quality from implementing any of the alternatives are expected to be limited to small amounts of fugitive dust, emissions from construction vehicles, or production of hydrogen sulfide gas, any of which would only be present a short period of time due to rapid dispersal by coastal winds.

1.11.2 GROUNDWATER RESOURCES

The coastal aquifer system within the project area consists principally of a freshwater lens, known as the Chequessett Flow Lens. It consists of two principal lobes, each comprising a groundwater "mound," separated by the Herring River (Masterson and Portnoy 2005). The lens is recharged through precipitation, which percolates to the water table. The mound of the lens reaches a maximum elevation of approximately 9 feet and fluctuates seasonally. Of the total estimated discharge of 24.2 million gallons per day (gpd) from the Chequessett Flow Lens, approximately half discharges to the Herring River system. Studies (Fitterman and Dennehy 1991) characterized freshwater lens thickness at residential well locations of approximately 42 to 95 feet.

Groundwater withdrawals affecting the project area are comprised of pumping of private and public water supply and irrigation wells located throughout developed areas. Recent studies (Martin 2007; WHG 2009) focusing on identifying residential wells within low-lying portions of the project area have identified several within the historic Herring River flood plain. The public water supply in closest proximity to the project area is that of the CYCC (Massachusetts Public Water Supply No. 4318071), a non-community water system.

Because no new residential or commercial development is proposed under the actions proposed in this final EIS/EIR, there would be no changes to withdrawals from the Chequessett Flow Lens or disturbance to the natural precipitation recharge mechanism. Recent studies by the NPS (Martin 2007; Martin 2004) have shown that tidal restoration will deepen the layer in the groundwater that is influenced by saltwater, and therefore would not adversely affect the Chequessett Flow Lens or the majority of wells that rely on it. However, a few low-lying domestic wells located in or very near the Herring River flood plain could be affected. Impacts on these wells are described under the impact topic "Low-Lying Properties" in "Chapter 4: Environmental Consequences."

1.11.3 HEALTH AND HUMAN SAFETY

Currently, fishing is permitted from the Chequessett Neck Road Dike, with no visible posted warning or hazard signs. As part of any design implemented for restoration of the Herring River estuary, areas of high velocity flows and other potential hazards would be identified, marked with warning notices, or periodically or permanently closed to public entry (depending on the nature of the hazard). For example, the new tidal conveyance at Chequessett Neck Road Dike may have warning/avoidance signs posted, marked with buoys or other marine marks, or chained/roped off to prevent entry near the sluice gates. Low-lying roads that may be temporarily inundated would be signed to protect the safety of travelers and their vehicles. Ongoing coordination with agencies and local government officials will continue once culvert designs are advanced. Because safety issues would be addressed in an identical manner under all action alternatives, this topic is not carried forward for separate analysis.

1.11.4 OPERATIONS AND MANAGEMENT OF TIDE-CONTROL STRUCTURES

Following completion of the NEPA and MEPA processes for this project, the selected alternative will be moved forward for further design and implementation planning. The selected alternative identified through this process will establish future tidal inundation levels, and this EIS analyzes the environmental effects of the tidal restoration, dike construction, flood proofing low-lying roads and properties, and, programmatically, carrying out secondary management actions (e.g., future tree removal or channel dredging). However, the selected alternative will also undergo further design for constructed elements such as roads and dikes, and as the specific design and operational characteristics of the dike(s) become clear, a plan for operating and maintaining new dike structures will be developed.

The operations and maintenance plan will specify how structures and water levels will be managed throughout the multi-year restoration process, and will identify responsible management parties and oversight agencies. Because design details have not been determined, and proposed infrastructure would likely be owned and managed by a variety of entities (Wellfleet or the NPS), the range of responsibilities and responsible parties has not yet been identified. As the final approved project is implemented, the HRRC, Towns of Wellfleet and Truro, and NPS will work together to develop an operations and maintenance plan and any associated agreements. Because details are not currently available regarding the long-term operations and maintenance, this topic is not carried forward for full analysis.

A third MOU (MOU III) between the Towns of Wellfleet and Truro and Cape Cod National Seashore was developed to document the agreement between the entities for project implementation. The draft MOU III addresses partner relationships, roles and responsibilities, decision authority, financial obligations and governing structure for the design, permitting, construction and operation and management activities. The draft MOU III proposes establishment of an intergovernmental team to provide policy oversight, assume decision-making authority, and – through a contractual arrangement– direct the activities of an independent organization that would undertake specified activities during project permitting, construction and implementation, including the adaptive management process. A copy of the draft MOU III is included in appendix J of this document.

1.11.5 SOUNDSCAPE

In accordance with NPS *Management Policies 2006* and NPS Director's Order 47: Soundscape Preservation and Noise Management, an important part of the NPS mission is preservation of natural soundscapes associated with parks. Natural soundscapes exist in the absence of human-caused sound. The natural ambient soundscape is the aggregate of all the natural sounds that occur in park units, together with the physical capacity for transmitting natural sounds. The frequencies, magnitudes, and durations of human-caused sound considered acceptable varies, being generally greater in developed areas and less in undeveloped areas. Some increased recreational (i.e., canoeing/kayaking, fishing, shellfishing, and nature observing) and commercial (i.e., shellfishing) use of the Herring River estuary would be expected as a result of tidal restoration. These activities would result in some level of human-generated noise, but these levels are generally unobtrusive with little anticipated impact on wildlife and visitor enjoyment. Hauling material, operating equipment, and other activities associated with reconstruction/construction of dike structures could result in dissonant, human-caused sounds. However, any noise caused by construction activities would be temporary and limited in area; thus long-term or more than minor adverse impacts are not expected, and soundscapes is dismissed as an impact topic.

1.11.6 PRIME AND UNIQUE FARMLANDS

Prime farmlands have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. Unique farmlands are defined as land other than prime farmland used for production of specific, high-value food and fiber crops. Both categories require the land be available for farming uses (CEQ 1980). Lands within the project area do not include designated prime farmland, nor are they available for farming. Therefore, they do not meet these definitions. This impact topic was dismissed from further consideration.

1.11.7 CULTURAL LANDSCAPES

According to the NPS Director's Order 28: Cultural Resource Management, a cultural landscape is a reflection of human adaptation and use of natural resources. It is often expressed in the way land is organized and divided, settlement patterns, land use, circulation systems, and the types of structures built. Themes and context define eligibility for the National Register of Historic Places (National Register), but cultural landscapes define physical settings where cultural and natural resources are managed together. There are several cultural landscapes within the Seashore boundary. Of the known historic districts, only the Atwood-Higgins Historic District is located in proximity to the proposed tidal restoration project area. None of the significant resources within the district are within or immediately adjacent to the estuary. Therefore, cultural landscapes are dismissed as an impact topic.

1.11.8 ETHNOGRAPHIC RESOURCES

Ethnographic resources are defined as "cultural and natural features . . . that are of traditional significance to traditionally associated peoples" (NPS 2006). At present, no discrete traditional cultural properties or ethnographic groups have been identified at Cape Cod National Seashore. Consultation with the Wampanoag Tribes of Gay Head-Aquinnah and Mashpee is being conducted by the NPS to identify ethnographic resources within the Herring River estuary. In addition, the HRRC initiated consultation with the Massachusetts Historic Commission, with the submission of a Project Notification Form, and tribal interests. A representative of the Mashpee Wampanoag Tribe was invited to and attended a public meeting regarding the project in April 2011. The primary area of concern for the Mashpee Wampanoag within the project area is the uplands of the CYCC, which have been identified as archeologically sensitive for pre-contact sites.

1.11.9 MUSEUM COLLECTIONS

NPS *Management Policies 2006*, NPS Director's Order 28: Cultural Resource Management Guidelines, and NPS Director's Order 77-2: Floodplain Management require irreplaceable museum items, archival materials, photographs, natural and cultural specimens, artifacts, and other collections within the park be protected from threats by natural physical processes. Although the proposed action may result in the excavation and recovery of artifact collections from park land, the volume of these collections is expected to be minimal and should have no impact on the park museum collection; therefore, this topic was dismissed from further evaluation.

1.11.10 INDIAN TRUST RESOURCES AND SACRED SITES

The federal Indian trust responsibility is a legally enforceable fiduciary obligation on the part of the United States to protect tribal lands, assets, resources, and treaty rights. No formerly established or recognized Indian trust resources or sacred sites have been identified at in or near the project area, and this impact topic was dismissed from further consideration.

1.11.11 MINORITY AND LOW INCOME POPULATIONS, INCLUDING ENVIRONMENTAL JUSTICE

Executive Order: 12898 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires all federal agencies to incorporate environmental justice into their missions by identifying and addressing disproportionately high or adverse human health or environmental impacts of their programs and policies on minorities and low-income populations and communities. Guidelines for implementing this executive order under NEPA are provided by the Council on Environmental Quality (CEQ) (CEQ 1997). According to the USEPA, environmental justice is defined as

> The fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. The goal of this "fair treatment" is not to shift risks among populations, but to identify potentially disproportionately high and adverse effects and identify alternatives that may mitigate these impacts (USEPA 1998).

There are minority and low-income populations in the general vicinity of the Seashore. However, environmental justice was dismissed as an impact topic for the following reasons:

- NPS and HRRC staff actively solicited public participation as part of the planning process and gave equal consideration to input from all persons, regardless of age, race, income status, or other socioeconomic or demographic factors;
- Impacts associated with the construction and operation of the proposed project would not disproportionately affect any U.S. minority and/or low-income populations or communities;
- Implementation of the proposed project would not result in adverse impacts specific to minority and/or low-income populations or communities; and
- NPS and HRRC staff do not anticipate adverse impacts on public health and safety or the human environment that would affect more severely, or result in disproportionately high and adverse impacts, to minority and/or low-income populations or communities in the area.
- No minority populations within the Census Tracts, or residing within 10 miles of the Town of Wellfleet, would be directly impacted by this project (see table 1-1) (U.S. Census 2010).

TABLE 1-1: MINORITY AND LOW INCOME POPULATIONS IN THE VICINITY OF THE HERRING RIVER RESTORATION PROJECT AREA (2010)

Census Tracts within Barnstable County, Massachusetts	Census Tract 101	Census Tract 102.06	Census Tract 102.08	Census Tract 103.04	Census Tract 103.06	Census Tract 105
Total Population	3,039	2,946	1,831	2,522	2,538	2,900
Hispanic or Latino (of any race)	1%	0%	0%	1%	5%	0%
Non-Hispanic, White alone	97%	98%	99%	95%	94%	98%
Non-Hispanic, Black or African American alone	1%	0%	0%	0%	0%	0%
Non-Hispanic, American Indian and Alaska Native alone	0%	0%	1%	0%	0%	0%
Non-Hispanic, Asian alone	0%	0%	0%	4%	1%	2%
Non-Hispanic, Native Hawaiian and Other Pacific Islander alone	0%	0%	0%	0%	0%	0%
Non-Hispanic, Some other race alone	0%	0%	0%	0%	0%	0%
Non-Hispanic, Two or more races	2%	2%	0%	0%	0%	0%
Percentage of Total Population Living at or Below the Poverty Level	8.8%	4.2%	8.4%	5.0%	6.5%	3.0%

Source: U.S. Census Bureau 2010

1.11.12 ENERGY RESOURCES

Construction and long-term management of the tide control structures proposed for the restoration of the Herring River flood plain would require the use of non-renewable energy resources. Construction equipment would use diesel and gasoline during installation of the dike(s), to accomplish roadwork, and to implement changes at the CYCC and other flood proofing activities. Under alternative C, a pump may be needed to convey freshwater flows through a new Mill Creek Dike. Although there would be consumption of energy resources, design specifics, implementation timeframe, and nature of any pump which might be needed at Mill Creek are not yet known. In the absence of more project-specific details, it is not possible to reasonably estimate energy usage or the impacts of the project on the local availability of energy resources.

1.11.13 URBAN QUALITY AND GATEWAY COMMUNITIES

As part of planning, NPS considers the possible impacts on future planning efforts or land use and development patterns on adjacent or nearby lands. Residences and communities located adjacent to the Seashore and the Herring River estuary may be affected by the proposed alternatives, and any potential impacts to these communities are addressed under the Socioeconomics impact topic.

1.11.14 WASTEWATER

MEPA requires analysis of wastewater impacts for construction of wastewater treatment facilities and other actions that may discharge waste into waters of the state. The proposed tidal restoration project does not meet MEPA review thresholds because it does not involve the use or discharge of wastewater and would not, therefore, be expected to impact resources in the Seashore or the surrounding area.

1.11.15 Solid and Hazardous Waste

MEPA requires analysis of solid and hazardous waste for new capacity of expansion in capacity for storage, treatment, processing, combustion or disposal of solid waste. The proposed tidal restoration project does not meet MEPA review thresholds because it does not involve the use or storage of solid and hazardous waste.

1.12 FEDERAL AND STATE LAWS, POLICIES, REGULATIONS, AND REQUIREMENTS

A variety of federal, state, and NPS policies, regulations and guidelines apply to preparation of this final EIS/EIR, and to the management of the resources potentially affected by the HRRP. Details on the variety of applicable laws, policies, and regulations are listed in "Appendix D: Applicable Laws, Policies, and Regulations." Federal laws requiring special consultation or compliance processes are also discussed in "Chapter 5: Consultation, Coordination, and Regulatory Compliance."

The principal federal and NPS mandates applicable to the HRRP include

- NPS Organic Act of 1916
- NEPA of 1969
- NPS Management Policies 2006
- NPS Director's Order 12: Conservation Planning, Environmental Impact Analysis, and Decision-Making (NPS 2011b) and accompanying Director's Order 12 Handbook (NPS 2015)
- Federal Water Pollution Control Act of 1972 (the CWA)
- Coastal Zone Management Act Consistency Review
- NHPA and Amendments
- Fish and Wildlife Coordination Act of 1934 and Amendments
- Essential Fish Habitat (EFH) requirements of the Magnuson-Stevens Fisheries Conservation and Management Act of 1976 and Amendments.

The principal Commonwealth of Massachusetts, county, and local mandates applicable to the HRRP include the following:

- MEPA
- Massachusetts Waterways Licensing Program (M.G.L. c. 91)
- Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A)
- CCC–Regional Policy Plan
- Massachusetts Water Quality Certification

- Massachusetts Wetland Protection Act
- Wellfleet Environmental Protection Bylaw
- Truro Environmental Protection Bylaw.

1.13 COMPLIANCE WITH THE MASSACHUSETTS ENVIRONMENTAL POLICY ACT

MEPA jurisdiction is broad in scope and extends to all aspects of the project that may cause damage to the environment as defined in the MEPA regulations. These include water quality, wetlands, coastal/marine resources, rare species habitat, and cultural resources. A Special Review Procedure has been established for the project by MEPA, in part due to the multiple project components to be implemented over many years. A number of the components that may become part of the selected alternative are anticipated to meet or exceed several MEPA review thresholds; for example, the HRRP will alter more than one acre of salt marsh or bordering vegetated wetland (BVW), triggering a mandatory EIR. In addition, the project area is known to contain Estimated and Priority Habitat for state-listed threatened and endangered species, and species of special concern, 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 state funding.

The Secretary's Certificate on the Environmental Notification Form (ENF) (November 7, 2008) identified the critical general issues to be addressed in the EIR, as well as specific requirements for the scope of the EIR. Table 1-2 indicates the MEPA impact topics addressed in this final EIS/EIR and the document sections where they can be found. Thresholds presented are those found in MEPA Regulations 301 CMR 11.00.

TABLE 1-2: FINAL EIR REQUIREMENTS OF THE SECRETARY'S CERTIFICATE

EIR Scoping Topics		Requirements	Section and Page References
Project Description	Include a thorough description of the project and all project elements and construction phases.	General requirement	"Chapter 2: Alternatives," sections 2.3.1, 2.5 through 2.9; and "Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project"
	Include existing conditions illustrating resources, including the existing flood plain, structures and abutting land uses for the entire project area and a proposed conditions plan (or plans) illustrating proposed flood plain elevations, structures and access roads.		Chapter 2, section 2.3; and "Chapter 3: Affected Environment," section 3.10
	Include sufficient baseline data to allow a full characterization of existing conditions and natural resources and support a meaningful analysis of feasible alternatives.		Chapter 3, sections 3.2 through 3.10

EIR Scoping Topics		Requirements	Section and Page References
	Identify all project related activities including structural modifications, dredging, fill and removal of vegetation.		Chapter 2, sections 2.5, 2.6.3, and 2.6.4; and appendix C
	Identify where and how public access will be improved or introduced.		Chapter 2: section 2.6.7; chapter 3, section 3.10.7; and "Chapter 4: Environmental Consequences," section 4.10.8
Project Permitting and Consistency	Describe state permits required for the project and how the project will meet applicable performance standards.	General requirement	"Chapter 5: Consultation, Coordination, and Regulatory Compliance;" "Appendix D: Applicable Laws, Policies, and Regulations;" and "Appendix G: Statement of Findings for Wetlands and Flood Plains"
	Discuss the consistency of the project with any applicable local or regional land use plans.		Chapter 4, sections 4.1.2 and 4.12; chapter 5; and appendix D
	Address the requirements of Executive Order 385 (Planning for Growth).		N/A
Adaptive Management/ Environmental Monitoring	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-construction phases that will provide sufficient information to adequate assess progress towards projects, identify impacts and inform the development of adaptive management strategies.	General requirement	Chapter 2, section 2.6.1 and appendix C
	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.		Chapter 2, sections 2.6.1 and 2.6.2; and appendix C
Alternatives Analysis	Identify benefits, impacts, and mitigation associated with each alternative and provide information, data, and analysis necessary for state resource agencies to evaluate the alternatives.	General requirement	Chapter 2, sections 2.3 through 2.6, and 2.13; chapter 4, sections 4.2 through 4.11; and appendix C
	Provide adequate information to support the selection of the preferred alternative and discuss mitigation approaches.		Chapter 2, sections 2.6, 2.10 through 2.13; chapter 4, sections 4.2 through 4.11; and appendix C

EIR Scoping Topics		Requirements	Section and Page References
	Evaluate impacts of the alternatives.		Chapter 2, section 2.13, table 2-5; and chapter 4
	Investigate all feasible methods of restoring salt marsh while avoiding, reducing or minimizing negative impacts, in particular impacts to private properties.		Chapter 2, section 2.13, table 2-5; chapter 4; and appendix C
	Identify alternatives for avoiding impacts to private properties within each sub-basin.		Chapter 2, sections 2.9 and 2.10; chapter 4, sections 4.10 through 4.12; and appendix C
	The results of the modeling should be included in the EIR including the tidal ranges, expansion of the flood plain, salinities and velocities at road crossings.		Chapter 2, section 2.2; chapter 3; chapter 4; and "Appendix B: Hydrodynamic Modeling Report"
	Identify criteria that will be used to select a preferred alternative and explain any trade-offs in the alternatives analysis.		Chapter 2, sections 2.2, 2.5, and 2.10 through 2.13
	Consider and balance the private property concerns of the CYCC with potential impacts to wetlands, historic resources and rare species habitat.		Chapter 4, sections 4.5, 4.7, 4.9, and 4.10
Land Alteration	Quantify the amount of land alteration associated with the project.	Direct alteration of 50 acres of land or more	Chapter 2, sections 2.5 and 2.13; chapter 4, sections 4.4, 4.5, 4.10.5, 4.10.6, and 4.10.7; and appendix C
	Clearly identify how land should be altered, where vegetation will require removal and identify objectives and measures that will be included in the vegetation management program to maximize the effectiveness of the project.		Chapter 2, sections 2.5, 2.6, and 2.13; chapter 4: sections 4.5, 4.10; and appendix C
Wetlands	Characterize wetland resources throughout the site, identify and quantify wetland alterations associated with each alternative and identify how negative impacts will be minimized.	Alteration of one or more acres of salt marsh or BVWs	Chapter 2, sections 2.5, 2.6.3, and 2.13; chapter 3: section 3.5; chapter 4: section 4.5; and appendix G
	Include plans at an appropriate scale that illustrate impacts to resource areas.		Chapter 4, section 4.5; chapter 5; and appendix G
	Illustrate where new resource areas will be created and identify associated buffer zones.		Chapter 4, section 4.5; chapter 5; and appendix G
	Consult with MassDEP to determine if an amendment or modification is required to the Town of Wellfleet Wetlands Restriction Order.		Chapter 4, section 4.10.5; chapter 5: sections 5.3.5 and 5.3.6; appendix D; and appendix G

EIR Scoping Topics		Requirements	Section and Page References
	If MassDEP determines that the project requires a variance, provide information required for variance request.		Chapter 4, section 4.10.5; chapter 5, sections 5.3.5 and 5.3.6; appendix D; and appendix G
Waterways	Identify project elements associated with each alternative that would require Chapter 91 licensing.	Construction of a new dam Alteration of 1,000 square feet or more of salt marsh or outstanding resource waters Alteration of one half or more acres of any other wetlands Construction, reconstruction or expansion of an existing solid fill structure of 1,000 square feet or more base area or of a pile-supported or bottom-anchored structure of 2,000 square feet or more base area, except a seasonal, pile-held or bottom-anchored float, provided the structure occupies flowed tidelands or other	Chapter 5, section 5.3.5 and appendix C
	Include an analysis of the project's compliance with the Waterways Regulations.		Chapter 5, section 5.3.5
	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 and adverse impact on these rights.		Chapter 4, sections 4.5, 4.6, and 4.10; and chapter 5, section 5.3.5
Dredging	Identify any dredging associated with project alternatives, estimate the amount of material to be dredged and describe the soils to be dredged.	Dredging of 10,000 cubic yards of material or more	Chapter 2, sections 2.6.4 and 2.13; chapter 4: sections 4.1.2, 4.3, 4.4, 4.6, 4.7, and 4.11; and appendix C
	Identify measures that can be employed to avoid release of sediments into the river environment and to protect downstream shellfish beds.		Chapter 2, sections 2.6.4 and 2.13; chapter 4: sections 4.1.2, 4.3, 4.4, 4.6, 4.7, and 4.11; and appendix C
Rare Species/ Wildlife Habitat	Include detailed hydrologic/hydraulic models and impact analyses for all proposed alternatives.	Alteration of designated significant habitat Greater than 2 acres of disturbance of designated priority habitat as defined in 321 CMR 10.02	appendix B
	Address impacts to state-listed species for both the proposed restoration efforts, as well as for any associated upland projects.		Chapter 2, sections 2.9 and 2.13; table 2-5; chapter 4, section 4.7; chapter 5, section 5.3.5; and appendix C

EIR Scoping Topics		Requirements	Section and Page References
	Address how each alternative could be designed to avoid, minimize, and mitigate impacts to state-listed species.		Chapter 2, sections 2.9 and 2.13; chapter 4, section 4.7; chapter 5, section 5.3.5; and appendix C
	Identify how overall habitat within the flood plain will be monitored and evaluated consistent with adaptive management goals.		appendix C
Fisheries	Summarize the benefits of the project to fisheries and shellfish and provide projections regarding growth.		Chapter 2, sections 2.9 and 2.11; and chapter 4, sections 4.6 and 4.10
	Identify temporary impacts to fish and shellfish during construction and identify measures to avoid, minimize and mitigate these impacts.		Chapter 4, sections 4.6 and 4.11; appendix C; and "Appendix F: Essential Fish Habitat Assessment for the Herring River Restoration Project"
	Identify how restoration of tidal flow to the Herring River at Chequessett Neck Road will be designed to optimize fish passage.		Chapter 2, section 2.9; chapter 4, section 4.6; and appendix C
Water Quality	Identify baseline water quality data that measures salinity, pH and metals, dissolved oxygen and fecal coliform.		Chapter 3, sections 3.2 and 3.3; and appendix B
	Identify how project alternatives will affect water quality and identify how water quality will be monitored.		Chapter 2, sections 2.9 and 2.13; and chapter 4, sections 4.2 and 4.3
	Identify impacts on public and private water supplies and septic systems associated with each alternative.		Chapter 4, sections 4.10.5, 4.10, and 4.11
	Identify how the project will be conducted consistent with water quality standards associated with the 401 Water Quality Certification.		Chapter 4, sections 4.3 and 4.4; chapter 5, section 5.3.5; and appendix C
	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.		Chapter 4, section 4.4; appendix B; and appendix C

EIR Scoping Topics		Requirements	Section and Page References
Historic/ Archaeological Impacts	Identify historic properties and archaeological sites within the project area and its vicinity and identify impacts to these sites.	Demolition of all or any exterior part of any Historic Structure Destruction of all or any part of any Archaeological Site listed in the State Register of Historic Places or the Inventory of Historic and Archaeological Assets of the Commonwealth	Chapter 2, section 2.13; chapter 3, section 3.9; and chapter 4, section 4.9 (no demolition of historic properties or destruction of archaeological sites is proposed); appendix I
Greenhouse Gas Emissions	Identify how the impacts of climate change, including sea level rise are being incorporated into the analysis of the project.		Greenhouse gas benefits (i.e., "blue carbon") of the project associated with increased carbon sequestration and reduced methane emissions are discussed in sections 3.4.4 and 4.4.1
Construction Period Impacts	Include a discussion of construction phasing, evaluate potential impacts associated with construction activities and propose feasible measures to avoid or eliminate these impacts.		Chapter 2, section 2.3.1; chapter 4, section 4.11; and appendix C
	Implement measures to alleviate dust, noise, and odor nuisance conditions, which may occur during construction activities.		Chapter 2, section 2.3.1; chapter 4, section 4.11; and appendix C
Mitigation	Include a section in appendix C on mitigation measures. This section should form the basis of the proposed Section 61 Findings that will be proposed in the final EIR, including: 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 construction phasing of the project.		Chapter 4 and appendix C
Comments	Include a response to comments section.		Final EIS/EIR; contains a summary of public and agency comments with NPS/HRRC responses in appendix M
	Circulate EIR in compliance with section 11.16 of the MEPA regulations.		EIS/EIR and chapter 5, List of Recipients

EIR Scoping Topics		Requirements	Section and Page References
Circulation	Copies should be sent to the list of “comments received” and to local officials in Wellfleet and Truro.	Construction of a New roadway one-quarter or more miles in length	EIS/EIR and chapter 5, “List of Recipients”
	A copy of the EIR should be made available for public review at the Wellfleet and Truro public libraries.	Cut five or more living public shade trees of 14 inches or more in diameter at breast height	EIS/EIR and chapter 5, “List of Recipients”
	Proponent should provide a hard copy of the EIR to each state agency and town department from which the proponent will seek permits or approvals.		EIS/EIR and chapter 5, “List of Recipients”

Chapter 2:
Alternatives

CHAPTER 2: ALTERNATIVES

2.1 INTRODUCTION

The National Environmental Policy Act (NEPA) requires federal agencies to consider and fully evaluate a range of reasonable alternatives that address the purpose of and need for the action. Reasonable action alternatives must be economically and technically feasible and demonstrate common sense. The Council on Environmental Quality (CEQ) regulations (40 CFR 1502.14) also require that federal agencies analyze a "no action" alternative; this alternative evaluates future conditions under existing management plans or practices and allows the public to evaluate what would happen if no project were implemented.

The Massachusetts Environmental Policy Act (MEPA) (301 CMR 11.06 and 11.07) requires that the action proponent present a reasonably complete and stand-alone description and analysis of the project and its alternatives. Alternatives include (1) all feasible alternatives; (2) the alternative of not undertaking the project (no action) for the purpose of establishing a baseline in relation to which the alternatives can be described, analyzed, and potential environmental impacts and mitigation measures can be assessed; (3) an analysis of the feasible alternatives in light of the project objectives and the mission of participating agencies; (4) an analysis of the principal differences among the feasible alternatives under consideration, particularly regarding potential environmental impacts; and (5) a brief discussion of any alternatives no longer under consideration including the reasons for no longer considering these alternatives.

Alternatives may originate from the proponent agency, local government officials, or members of the public. Alternatives may also be developed in response to comments from coordinating or cooperating agencies. With the exception of the no action alternative, alternatives must meet, to a large degree, the stated purpose and objectives for taking action and should not conflict with federal, state, or local laws, regulations, and policies or constraints identified during scoping.

This chapter provides a description of the alternatives being considered for the restoration of the Herring River estuary, including the no action alternative. The project alternatives include adaptive management strategies for varying degrees of tidal exchange, as well as infrastructure and flood mitigation elements. The design and construction elements of each of these alternatives are described in this chapter, and are analyzed in "Chapter 4: Environmental Consequences."

2.2 ALTERNATIVES DEVELOPMENT PROCESS

The Herring River Restoration Committee (HRRC) applied a systematic approach, as required by NEPA and MEPA, to the development of alternatives and mitigation strategies. This section provides a summary of the alternatives development process and the draft alternatives, which evolved through public input and multiple meetings with the HRRC.

Hydrodynamic modeling has been central to developing a range of potential restoration alternatives. Modeling has allowed for evaluation of specific questions about potential changes to surface water elevations, salinity levels, flow velocities, sediment transport, and potential impacts to low-lying properties within the Herring River estuary under a range of restoration scenarios. The hydrodynamic model (provided in appendix B) also applied guidance provided by the U.S. Army Corps of Engineers (USACE) (USACE 2009, 2011) for projecting additional impacts resulting from various degrees of sea level rise over the next 50 years. A more detailed discussion of sea level rise is provided in section 4.10.5.

A range of preliminary alternatives, described in sections 2.2.1 and 2.2.2, were initially considered and screened for their ability to meet the project purpose and objectives for technical, logistical, and financial feasibility, and for their ability to avoid significant adverse impacts. This screening eventually resulted in three action alternatives, which were found to meet the purpose and objectives, to be feasible, and would result in clear differences in environmental outcomes. Thus, these alternatives constitute a reasonable range of alternatives for NEPA evaluation. These action alternatives are summarized in table 2-5 at the end of this chapter, and discussed in detail in sections 2.5 and 2.6.

Other alternatives or infrastructure options were dismissed from further consideration because they would not meet the purpose and need for action, are not feasible, or do not provide a substantial difference in environmental outcomes. These alternatives and the rationale for dismissal are described in detail in section 2.7.

2.2.1 Preliminary Alternatives – Conceptual Restoration Plan

The project team identified several preliminary project alternatives in early models and other studies (Roman 1987; Spaulding and Grilli 2001). Additional alternatives were formulated by the Herring River Technical Committee (HRTC) and studied in subsequent modeling efforts (Spaulding and Grilli 2005). The following range of preliminary alternatives was examined in the Conceptual Restoration Plan (CRP) (HRTC 2007):

- No Action: Retain existing tide gates and manage tides under existing conditions.
- Open existing culverts to their maximum (18-feet wide) extent.
- Build a replacement structure with an opening width of 100–130 feet, fitted with sluice gates to manage tides. Sub-options included:
  - Cast-in-place culverts.
  - Pre-cast arch spans.
  - A two-span bridge structure.
  - A trestle bridge structure.
- Build a bridge with no tide control at Chequessett Neck, and establish tide control structures at strategic upstream locations.

2.2.2 NEPA/MEPA ALTERNATIVES DEVELOPMENT

Several additional project alternatives were introduced during public scoping in July 2008 (Federal Register notice August 21, 2008; MEPA #14272), which formally started the NEPA/MEPA processes. With feedback from state and federal agencies, including a draft EIR scope from MEPA (certificate dated November 7, 2008; notice in Environmental Monitor, November 22, 2008) and detailed comments from the Cape Cod Commission (CCC), the HRRC refined the project alternatives and impact topics. The MEPA certificate called for the *Herring River Restoration Environmental Impact Statement / Environmental Impact Report* (EIS/EIR) to evaluate the following:

- **No Action**—Existing tide gates would remain in place and tide levels would be managed under existing conditions.
- **Modified Tide Gate Control at Chequessett 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 tide control and management.
- **Open Bridge with Upstream Tide Gate Controls**—An open bridge span would be constructed at the site of the Chequessett Neck Road Dike. The bridge would not have any tide control. Tide control would be established at upstream locations with several smaller structures to regulate the limit of tidal flooding.
- **Hybrid of Modified Tide Gate Control at Chequessett Neck Road with Upstream Tide Gate Controls**—A combination of controlling tides near the mouth of the river and at upstream locations.

The HRRC then conducted a two-day alternatives development workshop in September 2009. At this workshop, the HRRC reviewed the results of the hydrodynamic modeling, reviewed and refined the Statement of Purpose and Need for Taking Action, and reviewed NEPA and the National Park Service (NPS) NEPA guidance (or Director's Order 12 Handbook guidance) for alternatives development. The HRRC examined possible locations within the estuary where actions might be needed to achieve tidal restoration.

Based on the hydrologic modeling available at that time, the HRRC evaluated how different openings at Chequessett Neck Road would affect water surface elevations and salinity levels upstream of the dike. The HRRC developed a draft matrix to evaluate the many combinations of actions that could be used to achieve the project objectives.

After the two-day workshop, the HRRC continued alternatives development at subsequent meetings through 2009 and 2010. The alternatives matrix was revised by the HRRC to include only the options that are feasible for implementation and that address the purpose and objectives of the restoration effort. The draft alternatives and tidal flow diagrams were then presented to the Technical Working Group (TWG) (an advisory group made up of representatives of key federal, state, and regional regulatory agencies) for review and comment in 2010.

In the summer of 2010, the HRRC conducted informal public outreach to present the draft alternatives to the public. The Friends of Herring River sponsored a public meeting to present three proposed action alternatives:

- A single point of tide control at Chequessett Neck Road

- Full tide flow at Chequessett Neck Road with upstream tide controls at Mill Creek and Pole Dike Creek
- Multiple points of tide control within the estuary

These distilled the action alternatives into two broad options for tidal restoration through most of the Herring River flood plain, with specific options for Mill Creek. This has resulted in the three alternative restoration scenarios described in section 2.3.

2.2.3 ALTERNATIVES REFINEMENT FOR THE EIS/EIR

After refinement of the 2010 draft alternatives, additional hydrodynamic modeling was conducted to develop an understanding of the range of tidal influences, salinities, and sediment transport that could be expected under the range of proposed options. Initial modeling results were used to establish the range of tidal influences that could be expected and a lower and upper point of restoration potential. These benchmarks identified the range of desired high tide conditions as lying between 4.8 feet (the lowest mean high spring tide elevation in the Lower Herring River which would fulfill the minimum project objectives) and 7.5 feet (the highest coastal storm driven tide in the Lower Herring River possible with a 165-foot-wide culvert at Chequessett Neck). These modeled tidal elevations were used to develop the three action alternatives described in this chapter.

In June 2011, the HRRC conducted a three-day Value Analysis/Choosing by Advantages workshop to compare and rank the benefits, impacts, and costs of the action alternatives (Kirk Associates 2011). Factors such as water quality improvements, acres of salt marsh and fish habitat restored, and private property impacts were used to compare the alternatives for the Herring River Restoration Project (HRRP).

The Value Analysis/Choosing by Advantages process revealed that the greatest level of tidal restoration combined with the greatest level of low-lying property protection would be the most advantageous alternative for achieving the project objectives. The combination of these components is represented by alternative D (section 2.5.3), and is identified as the preferred alternative in this final EIS/EIR.

2.2.4 ADDITIONAL ALTERNATIVES REFINEMENT FOR THE FINAL EIS/EIR

Since publication and release of the draft EIS/EIR in 2012, the HRRC has continued design and planning work on several key project components, including design of the proposed new Chequessett Neck Road Dike and development of design options for the Mill Creek Dike. In response to agency and public comment several other aspects of the project have been clarified and incorporated into the descriptions of the alternatives. These address options for preventing tidal flow impacts to High Toss Road and building a tide control structure at the Pole Dike Creek Road culvert. They are each discussed in the remainder of this chapter.

2.3 OVERVIEW OF THE ALTERNATIVES

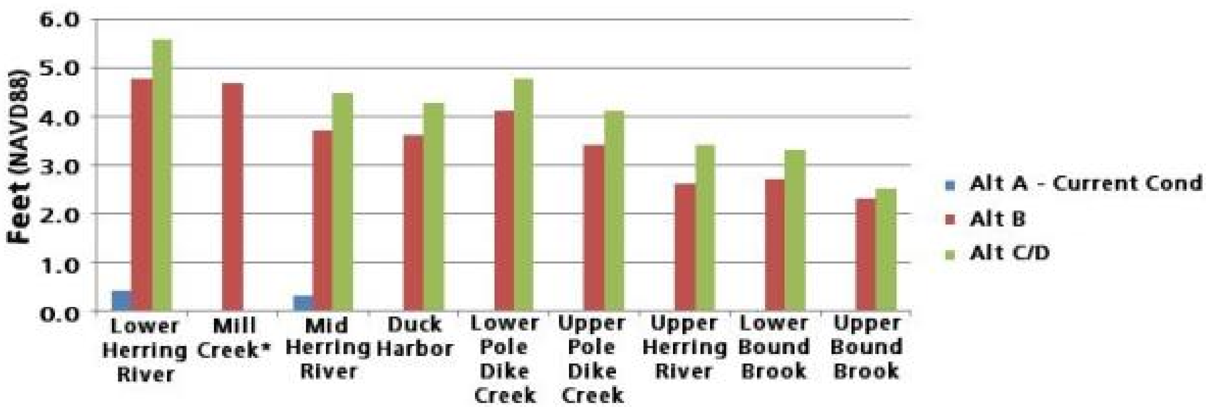
Three action alternatives have been developed for the restoration of the Herring River:

- **Alternative B:** New tide control structure at Chequessett Neck – No dike at Mill Creek.
- **Alternative C:** New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that excludes tidal flow

- **Alternative D:** New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that partially restores tidal flow

These three alternatives are intended to represent a range of desirable end points to be achieved through incremental restoration of tidal exchange and adaptive management. The alternatives are distinguished primarily by the long-term configuration of a new dike and tide control structure at Chequessett Neck Road and the resulting degree of tidal exchange. These alternatives represent the "bookends" of the minimum and maximum tidal exchange restoration necessary to meet project objectives, where alternative B achieves the minimally acceptable tidal restoration with the least impacts, and alternative D achieves the maximum practicable tidal restoration possible with more impacts, given the limitations of present day land use in the Herring River flood plain.

Figure 2-1 provides a representative comparison of the anticipated tidal exchange levels for the different alternatives. Predicted water surface elevations during mean high spring tide are shown for the no action alternative (current conditions) and for each of the action alternatives, as predicted by the hydrodynamic model. Implementation of any of the action alternatives does not necessarily imply that these exact water surface elevations would be achieved. Instead, they describe possible end points of incremental tidal restoration, while recognizing that, based on the results of adaptive management, the final degree of tidal exchange may lie somewhere between the "bookend" conditions identified in the action alternatives.



*Note: High tide in Mill Creek equivalent under alternatives B and D; no tidal exchange in Mill Creek under alternative C.

FIGURE 2-1: MODELED MEAN HIGH SPRING TIDE ELEVATIONS OF THE HERRING RIVER RESTORATION ALTERNATIVES

2.3.1 DESCRIPTION OF MAJOR PROJECT COMPONENTS

The Herring River flood plain is a large and complex area that has been impacted by more than 150 years of human manipulation, the most substantial being the construction of the Chequessett Neck Road Dike at the mouth of the river in 1909. Just as the current degraded state of the river is the combined effect of many alterations occurring over many years, restoration of the river will also require multiple, combined actions to return it to a more fully functioning natural system. Existing alterations and obstructions in the flood plain include more than 5 miles of roadway, an abandoned railroad embankment, several tidally restrictive culverts and berms, channelized stream reaches, and acres of invasive, non-native vegetation. There are multiple options for addressing each of these issues. The major components and focus areas of the Herring River project fall into three categories: (1) actions to construct or retrofit tide control structures in order to incrementally restore and control tidal exchange; (2) modifications to existing roads and low-lying structures to prevent adverse impacts resulting from restored tidal flow; and (3) other measures implemented within the project area to maximize the effects of restored tidal flow and enhance estuarine habitats. The project elements in the first category are discussed below. Other project elements are addressed in "Section 2.6 Elements Common to All Action Alternatives."

Chequessett Neck Road Dike

Reconstruction of the dike to allow greater tidal exchange is the primary element of the restoration project. In the draft EIS/EIR this structure was described generically as a new dike, retrofitted with a set of culverts increased from 18 feet to 165 feet wide and a height of 10 feet with adjustable tide gates. In 2013 HRRC and Friends of Herring River completed a study to evaluate possible structural alternatives to replace the existing culvert structure. Three culvert replacement concepts were evaluated to determine the option best suited to restore upstream water surface elevations and salinity concentrations:

- Three-sided pre-cast concrete box culvert
- Four-sided pre-cast concrete box culvert
- Pre-stressed box beam bridge

To evaluate these options, criteria were developed based on environmental, aesthetic, constructability, and cost factors. After initial review by the HRRC, the design concepts and rating criteria were reviewed by additional town of Wellfleet officials, including representatives from the Board of Selectmen, public safety departments, public works, natural resource boards, and the town manager.

Based on this study, the box beam bridge/dike structure equipped with adjustable and removable tide gates was selected as the most advantageous design concept. A concurrent hydraulic study evaluated alternative gate types/configurations and operating scenarios to determine the optimal number/type of gates to be constructed with the proposed structure. Wave generation and scour analyses were also completed to evaluate potential wave conditions at the structure and anticipated velocities under extreme storm/tidal conditions and gate operation configurations.

A structural evaluation was completed to address applicable items required for review by the Massachusetts Department of Transportation (MassDOT) under the Load and Resistance Factor Design (LRFD) Bridge Manual, including a type study to review existing data, assess alternative replacement structure configurations and identify the most appropriate structure type for the site conditions and required operations. Evaluations completed to date in support of the 25 percent complete design drawings were submitted to MassDOT in July 2014 and are included in appendix K

The proposed new Chequessett Neck Road Dike, which will function both as a pedestrian and automobile bridge and as a tide control structure, or dike, will have a final crest height similar to the existing dike (approximately 12 feet NAVD88, compared to the present 11.3 feet). Thus, the new dike is not proposed to serve as a designated flood control structure, as certified and recognized by Federal Emergency Management Agency (FEMA). This is because, according to new Flood Insurance Rate Maps released by FEMA and approved by both Truro and Wellfleet in July 2014, storm tides resulting from the coastal storm surge would enter the Herring River flood plain at multiple locations, in addition to over-topping the dike. Elevating the dike above the storm surge elevation would therefore not prevent flooding in the estuary during a storm surge. See section 4.1.2

for a more detailed discussion of how new FEMA Flood Insurance Rate Maps affect the Herring River Project.

The new dike will also include enhanced parking, pedestrian access, and viewing platforms, improved stormwater management, and improved aesthetics from burial of overhead utilities. Most importantly, the new structure also contains a total opening width of 165 feet spanned by a series of adjustable and removable tide gates. As will be described in the project's adaptive management plan (summarized in appendix C), these gates will be managed during implementation to achieve the ecological and socioeconomic objectives of the project, with a target of reaching the tidal range and extent of tidally-influenced area described in the preferred alternative (alternative D).

Details of the new dike design, including development and evaluation of design options, new geotechnical analyses, and scour/wave analyses can be found in appendix K, "25% Engineering Design Report Herring River Tidal Restoration Project." Structural components and the construction process for the new dike are identical under all of the action alternatives presented in the EIS/EIR.

To support and inform additional design work and permitting for the Chequessett Neck Road Dike, a Phase 1B Cultural Resources Assessment was conducted in the spring of 2015. Based on this and additional natural resource information and input from the NPS and other stakeholders, future design plans will identify the most appropriate construction staging and laydown areas and may include a new canoe/kayak portage and access point on the Griffin Island side of the new structure. Potential locations for these areas' access points are shown on Plan Sheet CS-101 (sheet 3 of 19 in the included plan set) in appendix K.

Impacts relating to construction of the new Chequessett Neck Road Dike, including additional information on construction staging, access, and traffic control, are summarized in section 4.11 and in draft Section 61 findings in appendix N. Details concerning construction sequencing, traffic management, dewatering, erosion/sediment control, dust and noise management, and other topics will be developed as engineering design progresses through 2015 and presented in federal, state, and local permitting plans, expected for submittal in 2016.

Mill Creek Dike

Mill Creek is the sub-basin most affected by increased tidal influence, and has a number of privately owned structures that could be more vulnerable to flooding without protective measures. The approach to flood protection in the Mill Creek sub-basin is a primary distinction between the action alternatives. As further described in section 2.5, alternatives C and D (the preferred alternative) require construction of a secondary dike to prevent or limit tidal exchange in Mill Creek, while alternative B does not.

Preliminary concept design plans for the Mill Creek Dike were included in the draft EIS/EIR. These plans depict the general layout, dimension, and volume of an earthen berm dike and tide gate structure capable of allowing controlled, bi-directional tidal exchange between the Herring River and Mill Creek (LBG 2010).

In 2013 the HRRC and Friends of Herring River undertook a study to determine and evaluate several design options for the Mill Creek Dike. In addition to an earthen berm, the new study included conceptual design and analysis of several other types of structures, including a cast-in-place concrete wall, a concrete I-wall, and a single sheet pile wall. Each of these options was evaluated based on environmental, constructability, aesthetic, sustainability, and cost factors and reviewed by the

HRRC, town of Wellfleet officials, and representatives of the Chequessett Yacht Country Club (CYCC).

After evaluation, only the earthen berm and single sheet pile wall designs were retained for further consideration. All other options provided no additional advantages over these two types and were more expensive to construct. This conceptual design and evaluation process, including a geotechnical assessment, is described in detail in appendix L: "Technical Memorandum, Mill Creek Dike Structural Alternatives Analysis."

Either of the Mill Creek Dike concepts would be constructed with a crest height of 9.5 feet. This is based on a maximum, storm-of-record high tide on the downstream side of 7.5 feet, thereby providing two feet of freeboard against an extreme storm event. Both designs also provide means for increasing crest height, if warranted by future conditions. Both dike designs contain five culverts or openings, each five feet wide, for a 25 foot wide opening in total, and with adjustable combination flap-slide gates. Under alternative D, these gates would be gradually and incrementally opened in a similar manner to the Chequessett Neck Road tide gates. Under alternative C, the gates would remain closed during incoming (i.e., flooding) tides, but would open automatically during ebbing tides to allow freshwater drainage. No tidal restoration would occur in the Mill Creek sub-basin under this scenario.

Selection of a final design option for the Mill Creek Dike is currently under review by the HRRC. The selection of either an earthen berm or single sheet pile wall dike option will be based on further structural and engineering evaluation, aesthetics, cost, and input from affected landowners. In either case, both short-term and long-term environmental and wetland impacts are predicted to be equal to or less than the impacts predicted in the draft EIS/EIR, based on the preliminary concept plan available at that time. These impacts are reviewed in detail in section 4.11.

In addition to the type of dike, several options are also being considered for the layout of either dike design concept. The most logical and convenient layout for the dike would utilize portions of the historic Mill Creek Dike embankment and locate a small portion of it on property currently owned by the CYCC. If Cape Cod National Seashore funds and constructs the new Mill Creek Dike, implementation of this option may require a reconfiguration of the NPS boundary and acquisition of land rights for it to be constructed in this location. An access easement would also be necessary for a construction and maintenance access route involving current CYCC or other privately-owned property.

Because landowner issues have not yet been worked out, an alternate design option is being evaluated that would confine the entire dike and construction/maintenance access route on lands within current NPS ownership. This would entail a slight modification to the layout of the dike and additional grading along the wetland-upland border; however, the size of the overall footprint and area of wetland impact would not be increased (see sheets CS-101 and CS-102 in appendix L).

Information concerning construction impacts, staging, and access route options are compared in section 4.11. Additional details and design plans for the Mill Creek Dike will be presented in local, state, and federal permit applications, expected for submittal in 2016.

Tide Control at Pole Dike Creek Road

The draft EIS/EIR indicated that a new tide control structure may be necessary at the Pole Dike Creek Road crossing in order to prevent impacts to privately owned structures in the Upper Pole Dike Creek sub-basin. After consultation with potentially affected property owners since the release of the draft EIS/EIR, the HRRC decided to propose this third tide control structure as part of the preferred alternative. This structure would be comprised of one or more adjustable tide gates, similar to those used at the Chequessett Neck Road Dike and Mill Creek Dike, installed on a new, and likely larger, culvert under Pole Dike Creek Road. Pole Dike Creek Road itself would be elevated to avoid tidal flow impacts to both the roadway and areas upstream. The tide gate(s) would be managed in a manner similar to those at Mill Creek, where tidal flow will be monitored carefully and high tide elevations limited by the lowest elevation of sensitive structures which cannot be relocated, elevated, or otherwise protected from harm. As implementation planning proceeds, the project proponents will consult with potentially affected property owners to identify ways to avoid or mitigate adverse effects while restoring as much tidal influence to the Upper Pole Dike Creek sub-basin as possible.

Because elevation and regrading of Pole Dike Creek Road is required whether a tide gate is installed on this culvert or not, the increased impacts of installing the tide gate are expected to be minimal compared to the impacts of road reconstruction (see sections 2.6 and 4.10.6 for more details on proposed road work). Detailed information about all impacts resulting from a new culvert and tide gate at Pole Dike Creek Road will be discussed in local, state, and federal permitting applications, expected to be submitted in 2016.

2.4 ALTERNATIVE A: NO ACTION – RETAIN EXISTING TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK

NEPA and MEPA regulations require measuring all alternatives against a future condition without the project. In this case, 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 2-2), and no tidal restoration would occur. Although no changes to infrastructure would occur, it is important to emphasize that "no action" is not a steady state from an environmental perspective.

2.5 ACTION ALTERNATIVES

The three action alternatives are differentiated primarily by the extent of restored tidal range throughout the estuary. The following section contains a narrative description of the project elements unique to each action alternative.

2.5.1 ALTERNATIVE B: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – NO DIKE AT MILL CREEK

Chequessett Neck Road Dike

Following the "bookend" concept described in section 2.3, alternative B provides the lowest high tide water surface elevations needed to achieve the project objectives. Under this alternative, 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 at the location of the Chequessett Neck Road Dike to allow passage of Wellfleet Harbor tides (an element common to all alternatives—see previous section 2.3). The tide gates would be opened gradually according to guidelines set forth in the Adaptive Management Plan with an objective to ultimately reach a mean high spring tide of 4.8 feet and a maximum coastal storm driven tide of 6.0 feet in the Lower Herring River (figure 2-3). These elevations reflect the maximum restoration possible without the need to install a secondary tide control structure at Mill Creek to protect private properties 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 3 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.

This alternative would provide a uniform degree of restoration in all sub-basins and would not require the construction or cost of a dike at Mill Creek. Flood proofing actions undertaken throughout the estuary would be designed to accommodate coastal storm driven tidal flooding up to 5.9 feet within the Mill Creek sub-basin and up to 5.3 feet in the Upper Pole Dike Creek sub-basin (table 2-1). The exact final maximum high tide elevations would be determined through the adaptive management process, but would not exceed these elevations.

TABLE 2-1: ACRES OF RESTORED HABITAT, ALTERNATIVE B

Sub-basin	Tidal Creeks	Intertidal Accretion Zone	Intertidal Marsh	Transitional Zone	Total Acres Restored
Lower Herring River	33.0	0.0	117.3	2.4	152.7
Mill Creek* (option 1)	5.5	0.0	59.0	2.5	67.0
Mill Creek* (option 2)	5.5	5.5	42.8	2.6	56.4
Middle Herring River	10.5	1.7	72.9	1.4	86.5
Duck Harbor	6.0	32.8	41.8	24.7	105.3
Lower Pole Dike Creek	7.8	26.8	69.6	0.9	105.1
Upper Pole Dike Creek	17.8	16.4	77.5	17.1	128.8
Upper Herring River	17.2	39.6	40.1	22.4	119.3
Lower Bound Brook	4.3	10.8	51.1	6.3	72.5
Upper Bound Brook	4.8	0.0	35.7	21.0	61.5
Total (Option 1)	**106.9**	**128.1**	**565.0**	**98.7**	**898.7**
Total (Option 2)	**106.9**	**133.6**	**548.8**	**98.8**	**881.1**

Tidal Creeks: Sub-tidal habitat below modeled extent of Mean Low Water

Intertidal Accretion Zone: Subsided former marsh below modeled extent of Mean Low Water, expect to transition into Intertidal Marsh

Intertidal Marsh: Areas between modeled high extent of Mean Low and Mean High Spring Tides, includes Mud Flats, Low Salt Marsh, High Salt Marsh, and Brackish Marsh

Transition Zone: Areas above modeled highest extent of Mean High Spring tides, includes Brackish, Freshwater Marsh, and Wetland-Upland Border

*Mill Creek: Option 1 (relocation) and Option 2 (elevation) for affected portions of CYCC

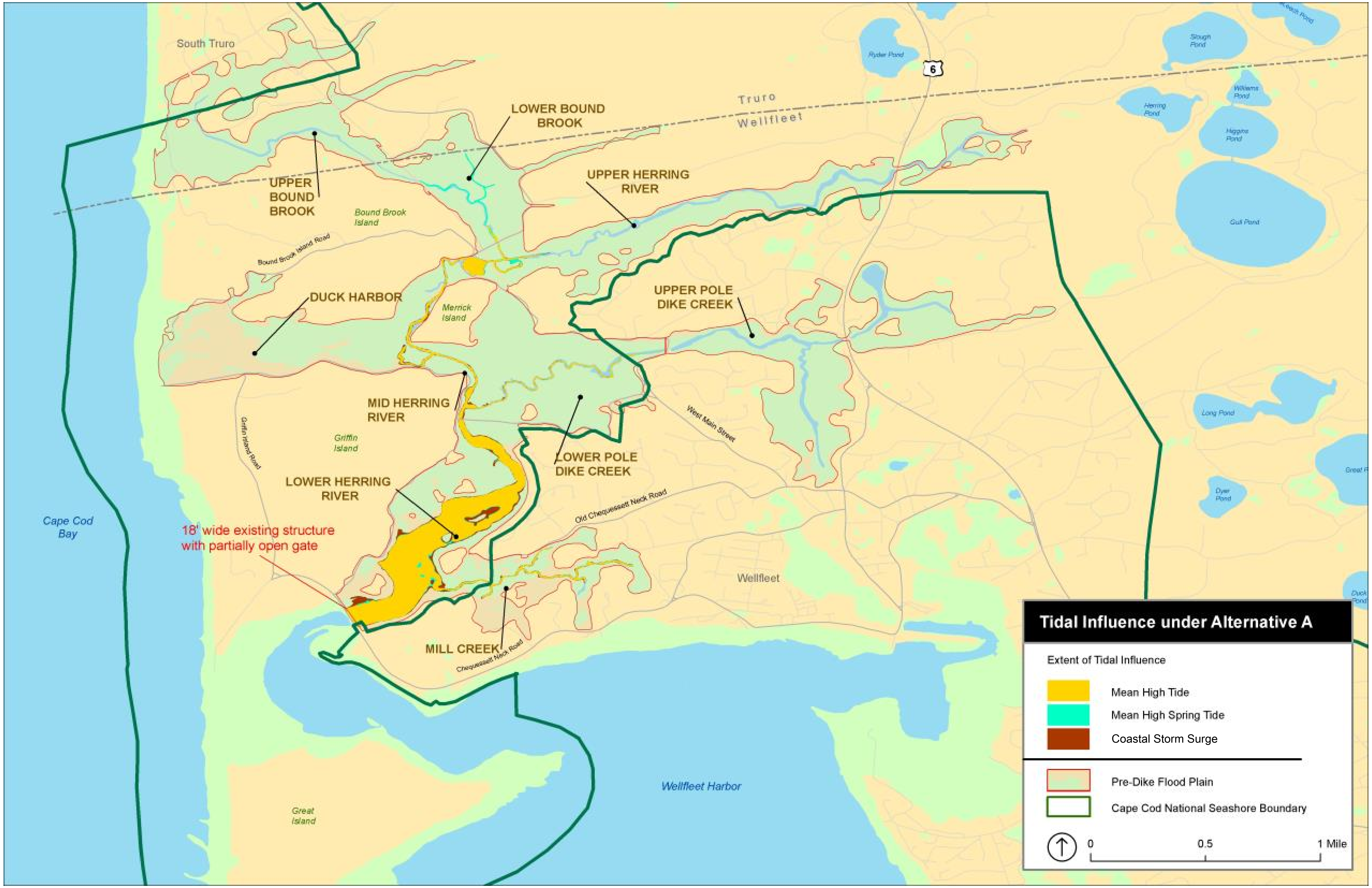


FIGURE 2-2: ALTERNATIVE A: NO ACTION – RETAIN EXISTING TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK

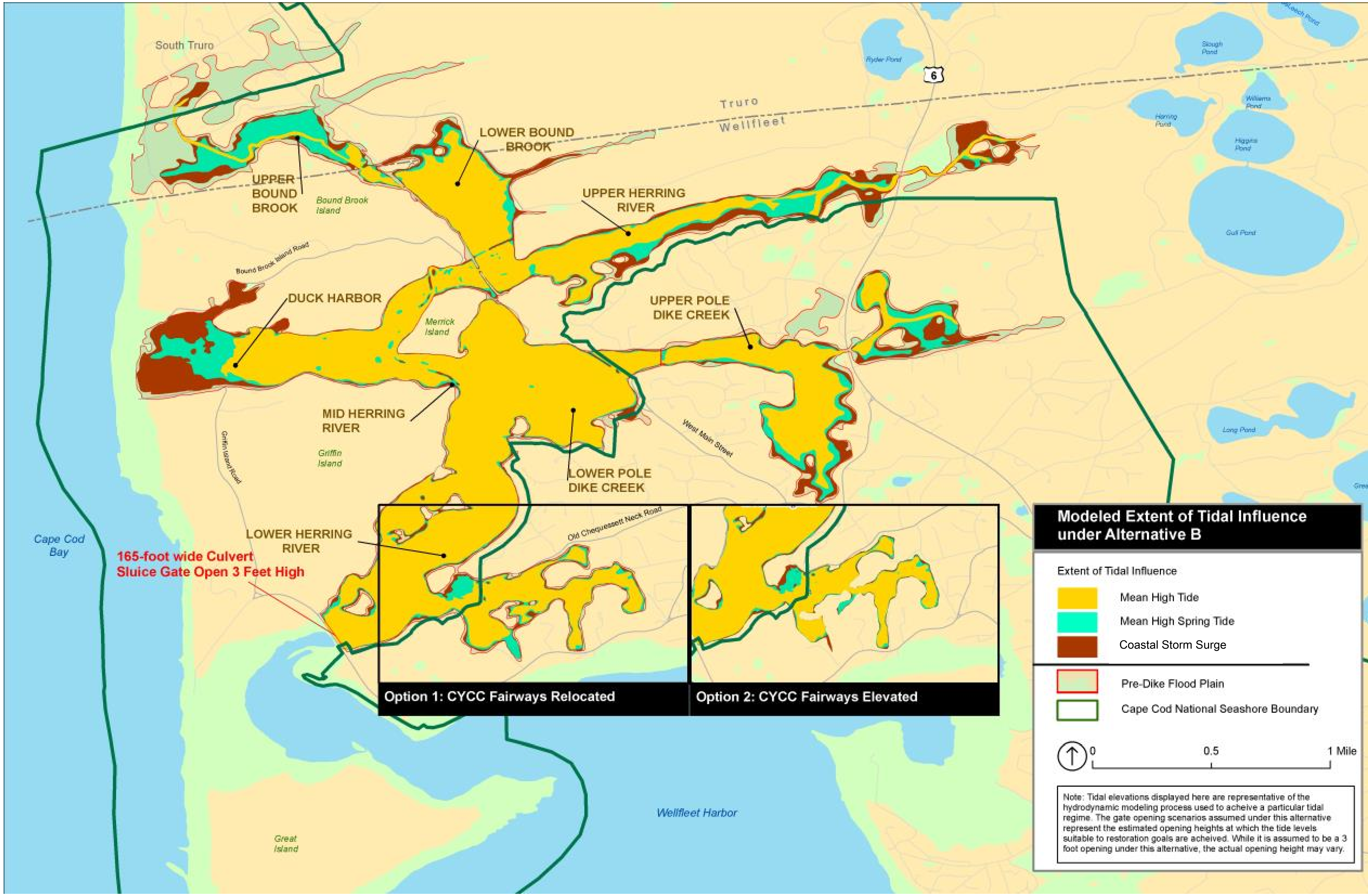


FIGURE 2-3: ALTERNATIVE B: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – NO DIKE AT MILL CREEK

Alternative B would require flood proofing measures for the Chequessett Yacht and Country Club (CYCC) golf course and other low-lying properties throughout the Herring River flood plain. Also, alternative B would forego the ability to pursue higher inundation levels in the estuary as part of an adaptive management process. This alternative would limit the total area of tidal wetland habitat that could be realized with tidal restoration.

Mill Creek Sub-basin

Under alternative B, the Mill Creek sub-basin would be left open to the Herring River, thereby subjecting the sub-basin to a limited tide regime controlled at Chequessett Neck Road Dike. However, the tide gates at Chequessett Neck Road Dike would remain partly closed to limit mean high water spring tides to a maximum of 4.8 feet and coastal storm events to a maximum of 6.0 feet in the Lower Herring River. This would equate to a maximum mean high water spring tide elevation of 4.7 feet and a maximum coastal storm event elevation of 5.9 feet in Mill Creek. As a result, this alternative would not require the construction or cost of a dike at Mill Creek if flood protection measures are in place.

Chequessett Yacht and Country Club

Hydrodynamic modeling has shown that several areas of the CYCC golf course would be affected by inundation levels proposed under alternative B. There are two options for addressing the impacts to the CYCC:

- 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. Approximately 30 acres of long-term upland disturbance would be generated under this option. One fairway would not be able to be relocated because of its proximity to the clubhouse and would require filling and regrading.
- Elevate the affected portions of the facility by providing necessary quantities of fill, regrading, and replanting the areas. Initial design concept plans for this effort include approximately 150,000 cubic yards of fill and 32 acres of disturbance for grading and site preparation. Portions of five low-lying golf holes would be reconstructed to a minimum elevation of 6.7 feet, which is 2 feet above the mean spring tide in Mill Creek (table 2-1).

2.5.2 ALTERNATIVE C: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT EXCLUDES TIDAL FLOW

Chequessett Neck Road Dike

Like the other action alternatives, tide gates at a rebuilt Chequessett Neck Road Dike would be opened gradually and according to guidelines set forth in the Adaptive Management Plan. The objective for alternative C would be to fully open the gates (maximum opening is 10 feet) 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 (figure 2-4). Following the “bookend” concept described in section 2.3, alternative C provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain; however, a tidal exclusion dike would be constructed at the mouth of Mill Creek in order to avoid flood impacts to low-lying private properties within this sub-basin. Tides in the upstream sub-basins would be lower because of natural tide attenuation. Flood prevention actions undertaken throughout the remainder of the Herring River estuary would be designed to accommodate flooding up to these maximum tidal elevations. Restored acreages from new tidal inundation are shown in table 2-2.

TABLE 2-2: ACRES OF RESTORED HABITAT, ALTERNATIVE C

Sub-basin	Tidal Creeks	Intertidal Accretion Zone	Intertidal Marsh	Transitional Zone	Total Acres Restored
Lower Herring River	33.0	0	130.0	2.4	165.4
Mill Creek	5.5	0	5.2	0.1	10.8
Middle Herring River	10.5	9.6	67.0	0.9	88.0
Duck Harbor	6.0	35.1	66.6	13.5	121.2
Lower Pole Dike Creek	7.8	42.7	55.2	0.9	106.6
Upper Pole Dike Creek	17.8	41.9	67.5	12.6	139.8
Upper Herring River	17.2	56.8	40.0	19.7	133.7
Lower Bound Brook	4.3	55.8	11.6	4.8	76.5
Upper Bound Brook	4.8	7.3	44.5	14.3	70.9
Total	**106.9**	**249.2**	**487.6**	**69.0**	**912.7**

Tidal Creeks: Sub-tidal habitat below modeled extent of Mean Low Water

Intertidal Accretion Zone: Subsided former marsh below modeled extent of Mean Low Water, expect to transition into Intertidal Marsh

Intertidal Marsh: Areas between modeled high extent of Mean Low and Mean High Spring Tides, includes Mud Flats, Low Salt Marsh, High Salt Marsh, and Brackish Marsh

Transition Zone: Areas above modeled highest extent of Mean High Spring tides, includes Brackish, Freshwater Marsh, and Wetland-Upland Border

Mill Creek Sub-basin

In contrast to alternative B, under alternative C, a new dike at the mouth of Mill Creek would need to be constructed to *eliminate* tidal influence to the sub-basin. Based on the results of hydrodynamic modeling the minimum recommended crest height of this dike is 2 feet above the projected coastal storm surge elevation, or 9.5 feet (based on the modeled prediction of the coastal storm elevation of 7.5 feet in the Lower Herring River). Construction of this structure could require up to approximately 2,900 cubic yards of fill and could permanently impact up to 12,500 square feet of wetland In addition, a construction work area encompassing up to approximately 105,000 square feet (2.4 acres) of vegetated wetlands would likely be required for dewatering and other associated work and would be impacted temporarily. The exact quantification of impacts resulting from the Mill Creek Dike will be presented in detail in local, state, and federal permitting applications and will depend on whether an earthen berm or single sheet pile water design is selected and whether the dike layout and access route in solely on NPS land or involves multiple landowners (see section 2.3 and appendix L).

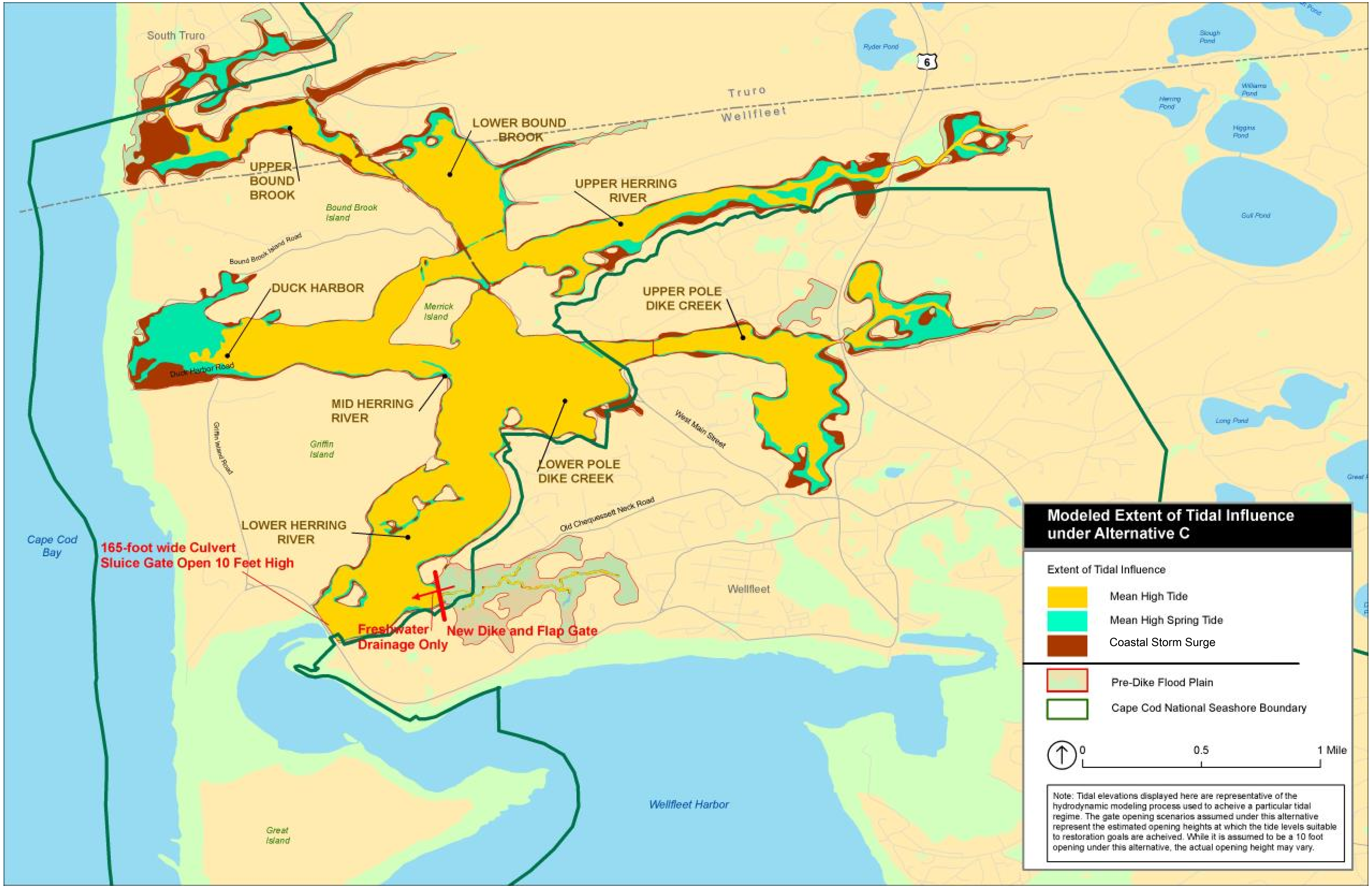


FIGURE 2-4: ALTERNATIVE C: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT EXCLUDES TIDAL FLOW

A one-way, flapper-style tide gate would need to be installed within the dike to allow freshwater to drain from the basin toward the Herring River while blocking seawater from passing upstream of the dike. Given the generally flat land surface of the flood plain and naturally occurring high water table, mechanical pumping may be necessary at times to facilitate freshwater drainage.

Chequessett Yacht and Country Club

Because a dike would eliminate tidal influence from the Mill Creek sub-basin, no additional flood protection measures would be required for CYCC or other Mill Creek properties.

2.5.3 Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow

Chequessett Neck Road Dike

Like the other action alternatives, tide gates at a rebuilt Chequessett Neck Road Dike would be opened gradually according to guidelines set forth in the Adaptive Management Plan. The objective for alternative D is to fully open the gates (maximum opening is 10 feet) 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 (figure 2-5). Following the “bookend” concept described in section 2.3, alternative D provides the highest practicable high tide water surface elevations possible, given the constraints of current land use in the flood plain (table 2-3). Tides in the upstream sub-basins would be lower because of natural tide attenuation. In most of the project area, measures to prevent tidally forced flooding of low-lying roads and the very few privately owned structures located outside of the Mill Creek and Upper Pole Dike sub-basin, will be based on these maximum water surface elevations. In Mill Creek and Upper Pole Dike creek, where most privately owned low lying structures are located, maximum water levels will be regulated by secondary water control structures and will be lower compared to the other areas.

Mill Creek Sub-basin

Similar to alternative C, a new dike at the mouth of Mill Creek would need to be constructed under alternative D. However, under alternative D, the one-way flapper style tide gate would be replaced with five two-way slide/flap combination tide gates, each 5 feet wide, which would be managed to partially restore tidal flow to the sub-basin. Mean high spring tides would be limited to 4.7 feet and coastal storm driven events to a maximum of 5.9 feet in Mill Creek. In contrast to alternative C, alternative D would require the same flood prevention measures and related costs for Mill Creek as specified under alternative B (e.g., golf course and private property impact prevention). In addition, alternative D will include the cost of Mill Creek Dike construction.

Chequessett Yacht and Country Club

As described for alternative B, two options for protecting the CYCC golf course would be possible under alternative D: (Option 1) relocating portions of multiple low-lying golf holes to upland areas currently owned by the CYCC or (Option 2) elevating the affected areas in place by filling and regrading.

TABLE 2-3: ACRES OF RESTORED HABITAT, ALTERNATIVE D

Sub-basin	Tidal Creeks	Intertidal Accretion Zone	Intertidal Marsh	Transitional Zone	Total Acres Restored
Lower Herring River	33.0	0	130.0	2.4	165.4
Mill Creek* (option 1)	5.5	5.2	52.1	3.2	66.0
Mill Creek* (option 2)	5.5	5.6	44.2	2.4	57.7
Middle Herring River	10.5	9.6	67.0	0.9	88
Duck Harbor	6.0	35.1	66.6	13.5	121.2
Lower Pole Dike Creek	7.8	42.7	55.2	0.9	106.6
Upper Pole Dike Creek	17.8	41.9	67.5	12.6	139.8
Upper Herring River	17.2	53.0	40.0	19.7	129.9
Lower Bound Brook	4.3	55.8	11.6	4.8	76.5
Upper Bound Brook	4.8	7.3	44.5	14.3	70.9
Total (Option 1)	**106.9**	**250.6**	**534.5**	**72.3**	**964.3**
Total (Option 2)	**106.9**	**251.0**	**526.6**	**71.5**	**956.0**

Tidal Creeks: Sub-tidal habitat below modeled extent of Mean Low Water

Intertidal Accretion Zone: Subsided former marsh below modeled extent of Mean Low Water, expect to transition into Intertidal Marsh

Intertidal Marsh: Areas between modeled high extent of Mean Low and Mean High Spring Tides, includes Mud Flats, Low Salt Marsh, High Salt Marsh, and Brackish Marsh

Transition Zone: Areas above modeled highest extent of Mean High Spring tides, includes Brackish, Freshwater Marsh, and Wetland-Upland Border

*Mill Creek: Option 1 (relocation) and Option 2 (elevation) for affected portions of CYCC

2.6 ELEMENTS COMMON TO ALL ACTION ALTERNATIVES

2.6.1 INCREMENTAL TIDAL RESTORATION AND ADAPTIVE MANAGEMENT

Since the early planning stages of the HRRP, reintroduction of tidal influence has been understood as a long-term, phased process that would occur over several years. The key to restoration, and an element common to all action alternatives, is the construction of a new dike at Chequessett Neck Road with adjustable tide gates. Gradual opening of adjustable tide gates would incrementally increase the tidal range in the river. The primary reason to implement the project in this manner is to allow monitoring of the system so that unexpected and/or undesirable responses could be detected and appropriate response actions taken. In addition, the complexity of the proposed project also dictates use of an adaptive management approach. Among these are a large and divergent group of stakeholders, multiple and overlapping objectives, and the need for phased and recurrent decisions through an extended period of time.

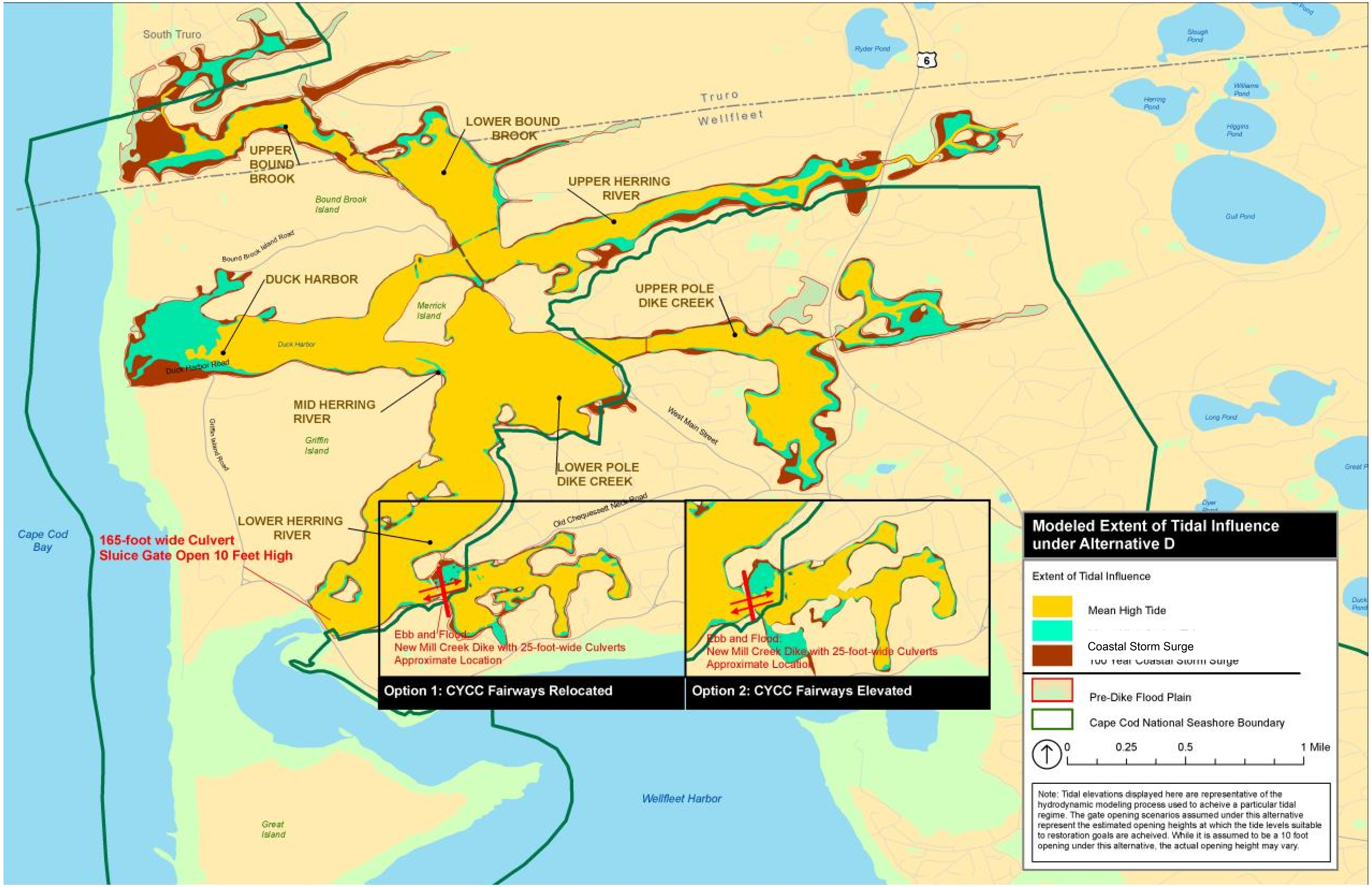
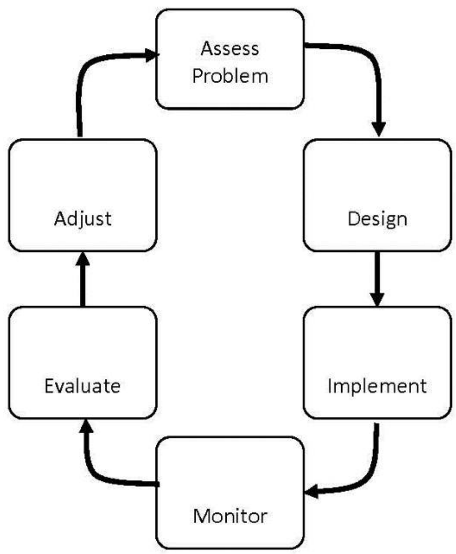


FIGURE 2-5: ALTERNATIVE D: NEW TIDE CONTROL STRUCTURE AT CHEQUESSETT NECK – DIKE AT MILL CREEK THAT PARTIALLY RESTORES TIDAL FLOW

Adaptive management is a formal, iterative process where (1) a problem is assessed, (2) potential management actions are designed and implemented, (3) actions and resource responses are monitored over time, (4) data are evaluated, and (5) actions are adjusted as necessary to better achieve desired management outcomes (DOI 2009) (figure 2-6). Details of this process and its application to the Herring River project are described in “Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project.”



Source: Williams et al. 2007

FIGURE 2-6: GENERAL ADAPTIVE MANAGEMENT PROCESS DIAGRAM

2.6.2 MONITORING

Field monitoring is frequently used in ecological restoration to measure the success of restorative activities. When part of an adaptive management process, field monitoring needs to be carefully designed to measure progress toward objectives and assumptions built into conceptual models. In contrast to standard ecological monitoring and other data gathering efforts, monitoring for adaptive management is not carried out primarily for scientific interest. Instead, adaptive management monitoring studies are designed and carried out to specifically support management decision-making and assessment. Adaptive management monitoring could be a subset of a broader monitoring program, but adaptive management monitoring activities must be specifically tied to project objectives and be cost/time-efficient and sustainable for the duration of the adaptive management plan.

2.6.3 VEGETATION MANAGEMENT

The increased tidal exchange between the Herring River estuary and Cape Cod Bay would be achieved in incremental steps over a number of years and would change many characteristics of the flood plain. One of the most important, 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 range, frequency and duration of tidal flooding, soil saturation, and, most notably, salinity. Predominantly shrubland and woodland plant communities exist on areas of the river flood plain that were once vegetated with salt-marsh plants including salt meadow grass (*Spartina patens*), smooth cordgrass (*S. alterniflora*), black grass (*Juncus gerardii*), and spike grass (*Distichlis spicata*). Most woody plants will not tolerate flooding with salt water, however gradually these impacts occur, and flooding will likely result in many acres of standing dead trees and shrubs covering a large portion of the flood plain.

Vegetation Management Objectives

Management of flood plain vegetation, specifically the removal of shrubs and trees before salt water reaches them, would have the following objectives:

- Encourage re-establishment of tidal marsh.
- Remove woody debris that might impede fish passage.
- Remove large trees that will eventually die, topple and leave holes on the wetland surface where mosquitoes might breed.

Vegetation Management Options

Potential techniques for dealing with woody vegetation include cutting, chipping, burning, and targeted herbicide application. A combination of these techniques will be part of a flexible approach to vegetation management.

The vegetation management activities would consist of primary and secondary management techniques. Primary management is cutting of the vegetation. This 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.

Secondary management is the processing and removal of the biomass that has been cut. This would be accomplished by a number of techniques including the use of cut hardwood (i.e., as firewood), removal of wood chips, and burning brush and branches. Woody vegetation with diameters of three or more inches could be used for biofuel, either as chips or logs, or chipped and left on the marsh surface. Natural decomposition of dead woody material as a management technique would be considered in some areas of the restored Herring River flood plain. Appropriate options for smaller diameter cut woody vegetation would be developed. Access, substrate type, and other factors would need to be considered to determine the most appropriate vegetation management techniques for specific areas and conditions.

Vegetation management actions would be of the same type and would be implemented in an identical manner under each of the action alternatives; however the spatial extent and timing of when actions would be taken might vary (see "Appendix C: Overview of the Adaptive Management Process for the Herring River Restoration Project" for a more complete discussion).

2.6.4 RESTORATION OF TIDAL CHANNEL AND MARSH SURFACE ELEVATION

Although reintroduction of tidal exchange and salinity is the primary component and main driver for restoration of the Herring River flood plain, several other actions would likely be necessary to reverse other previous direct and indirect alterations of the system's topography, bathymetry, and drainage capacity. Diking and drainage have caused subsidence of the former salt marsh by up to 3 feet in some locations, 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). After tidal restoration is initiated, these factors could limit or delay progress toward meeting the project objectives by inhibiting circulation of salt water, preventing recolonization of tidal 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 the project's adaptive management plan. In summary, these potential actions 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 and 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.
- Through the adaptive management process, the project could potentially involve the beneficial re-use of dredged material to enhance the sediment supply and promote marsh accretion within the flood plain.

2.6.5 LOW-LYING ROAD CROSSINGS AND CULVERTS

High Toss Road

High Toss Road Culvert

The Herring River passes under High Toss Road, the second road that crosses the river, approximately one mile upstream from Chequessett Neck Road. The road is an earthen berm that was built across the salt marsh in the 19th century. The road is unpaved and infrequently traveled by vehicles, but can accommodate emergency vehicle access to Griffin Island. The river passes under the road at the western end through a 5-foot-diameter concrete culvert. Hydrodynamic modeling has shown that the culvert would cause a major restriction if tidal flow were increased at Chequessett Neck Road. The road would be overtopped daily by seawater under any restoration scenario and ebb tide drainage would be impeded by the causeway.

Complete removal of the tidal restriction at High Toss Road is a major component of the project under all action alternatives. Increased tidal exchange from a rebuilt Chequessett Neck Road Dike could be accommodated at High Toss Road by replacing the existing 5-foot-diameter concrete culvert with either a properly designed box culvert or an open channel. An open channel could include a small bridge spanning the river if pedestrian and/or vehicle access were continued. In either case, preliminary analysis suggests that a tidal channel approximately 30 feet wide would be needed for adequate tidal water conveyance.

Further hydrodynamic modeling and analysis would be conducted to more precisely size this culvert or open channel. Direct and indirect impacts would be the same under each action alternative.

High Toss Road Flooding

Under all of the action alternatives, High Toss Road would be flooded at high tides greater than approximately 3 feet. Although replacement of the culvert, as described previously, is the only action necessary to allow unrestricted tidal exchange through the causeway, additional measures would be needed to ensure adequate drainage and to address impacts to the road and causeway from increased tidal flow. Options considered to protect the road from tidal flow have ranged from elevating it above the level of predicted high tides to removing it entirely. Since release of the draft EIS/EIR, officials from NPS and the town of Wellfleet have determined that elevating and reinforcing the embankment to withstand daily tidal flow so that vehicle use could continue is not practical given the environmental impact, cost, and infrequent vehicle use. However, maintaining some form of pedestrian access is a public concern and options for providing this will be developed and reviewed in a public process and presented in local, state, and federal permit applications expected to be submitted in 2016.

High Toss Road as Temporary Bypass

Earlier engineering analysis suggested that complete closure of Chequessett Neck Road would substantially reduce construction time and costs for rebuilding the dike. However, more recent engineering work completed as part of a 25 percent level design package (see appendix K) included a plan to avoid this by creating a traffic bypass at the Chequessett Neck Road Dike construction site. This bypass would have no additional impact beyond the footprint of the actual Chequessett Neck Road Dike construction zone and would obviate the need for road work along miles of overgrown road with several wetland crossings.

Pole Dike, Bound Brook, and Old County Roads

Several segments of Pole Dike, Bound Brook Island, and Old County Roads, where they cross the main Herring River and tributary streams, are below 4 feet, making the roads vulnerable to high tide flooding under all action alternatives. To prevent this, the road surfaces would need to be elevated or relocated. Preliminary engineering analysis shows that approximately 4,175 linear feet of these roads could be affected by the highest tide of any given year. An additional 2,000 feet would be impacted by coastal storm surge. To prevent this and maintain safe travel along these roads they should be elevated to a minimum grade of 5.5 feet, 1 to 3 feet above the current grade, to prevent overtopping from storm driven tides in the Herring River (see appendix H, CLE 2011). Elevating these roads would also require widening the road bases, which would impact over 6,000 square feet of adjacent wetlands. 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 might be feasible with potentially less wetland impacts and lower costs. Additional engineering studies and traffic analyses are needed to fully evaluate both of these options (CLE 2011).

These low-lying road segments also include three culverts on the mainstem of the Herring River, Pole Dike Creek, and Bound Brook. Replacement, and potential enlargement, of culverts would also be considered during additional design phases for road surface elevation and regrading, as described previously. In the case of Pole Dike Road, adjustable tide gates would also be installed as part of the preferred alternative.

2.6.6 LOW LYING PROPERTIES

Minimizing and mitigating impacts to low-lying properties is an important objective of the HRRP. Generally, these measures could include limiting water levels across entire sub-basins, elevating or relocating driveways and landscaping, moving wells, building small berms or flood walls, and moving or elevating structures.

Within the boundary of Cape Cod National Seashore in the Lower Herring River basin, there are two private properties with buildings that would be flooded by restoring tidal flow to the main river basin. These properties are at very low elevations and would be affected early on in the restoration process. Unlike potentially affected structures in other basins, there are no tide control structures between them and the Chequessett Neck Road Dike that can minimize high tide levels. In cases where no flood mitigation measures are feasible and in the absence of a willing seller or negotiated exchanges, NPS would consider an eminent domain taking. At present, a voluntary exchange is being negotiated for one of these two properties.

2.6.7 PUBLIC ACCESS AND RECREATION OPPORTUNITIES

As described in "Chapter 1: Purpose and Need," the Herring River estuary is included in the Seashore's natural zone, and is managed to protect natural processes with limited infrastructure. Given the Seashore's planning objective, it is anticipated that any development of public access points or visitor facilities would occur at the discretion of adjacent landowners or stakeholders, such as the Towns of Wellfleet and Truro, Wellfleet Conservation Trust, or the Friends of Herring River.

For example, the new Chequessett Neck Road Dike would be designed to include safe fishing access points, launch sites on the upstream and downstream sides of the new dike, and a safe portage route between those launch sites (see "Section 4.11, Potential Long-Term Use of Chequessett Neck Road Dike Staging Area and Adjacent Wetlands for Canoe/Kayak Access," for more detail). Launches for canoes or kayaks could also be provided at other points in the estuary. Walking trails could include access to the variety of habitats established by the restoration process. Over the long term, access to recreational shellfishing areas could also be considered once the shellfish resource is sustainable and capable of supporting harvest. The NPS would work with adjacent land managers by providing guidance on resource protection and interpretation.

2.7 ALTERNATIVES OR ALTERNATIVE ELEMENTS CONSIDERED BUT DISMISSED FROM CONSIDERATION

2.7.1 REPLACE DIKE WITH BRIDGE AND FULLY RESTORE THE ENTIRE ESTUARY (NO CONTROL STRUCTURES)

Comments received through public scoping meetings held over the summer of 2008 reflected interest in replacing the Chequessett Neck Road Dike with a bridge to facilitate canoe and kayak passage, improve access for anadromous fish, and aesthetics. The hydrodynamic model was used to simulate the effect of completely removing the road crossing at Chequessett Neck. A fully open connection between the Herring River and Wellfleet Harbor would be as close to the original, pre-dike condition as could be achieved today, allowing maximal tidal circulation and sediment flux. However, because of the need for tide control at least through the foreseeable adaptive management timeframe, and possibly much longer, construction of a bridge at Chequessett Neck Road was not considered practicable and was dismissed from further consideration. However, accommodations for fish passage, recreational boating, and aesthetics will be considered in design plans for the new dike.

2.7.2 FULLY OPEN THE EXISTING TIDE GATES

Earlier modeling studies (Roman 1987; Spaulding and Grilli 2001) evaluated the option of completely opening the existing three culverts in the Chequessett Neck Road Dike. The modeling showed that although this would result in a substantial increase in high tide heights and area of inundation upstream of the dike, the ebb tide drainage capacity of the dike would not increase, thereby increasing low tide heights. Opening the existing structure would actually decrease both the tidal range and flushing, while increasing the likelihood of harmful flooding. Because this outcome does not meet the project purpose and objectives, it has been dismissed from further consideration.

2.7.3 REBUILD THE DIKE WITH A TIDAL OPENING LESS THAN 165 FEET

Consideration has been given to the idea of deliberately undersizing a new Chequessett Neck Road Dike to diminish the range of Wellfleet Harbor tides allowed to pass into the Herring River. The underlying concept for this is that a passive tide control system could be designed that would allow normal monthly spring tides to propagate upstream but would also filter out higher tides caused by periodic astronomical events, coastal storm surges, and the impacts of sea level rise.

While this approach is technically feasible and has been successfully used at other tidal restoration projects, applying it at the Herring River could impose unnecessary constraints on the ability to manage tidal flows and sediment processes in keeping with the project's long-term goals and objectives. Changes to tidal hydrology resulting from sea level rise and other factors are uncertain and it is impossible to predict changes in land use within the Herring River estuary.

Additional modeling studies prepared for this project (Spaulding and Grilli 2005; WHG 2012) simulated new tidal inlets within the dike ranging from 30 to 300 feet wide. Results show that inlet widths less than 100 feet could improve the overall tidal range with higher high tides and lower lows, but the extent of salt water inundation of the flood plain remains muted. Although this could reduce the need for mitigation of adverse impacts in some locations, it precludes the minimally acceptable tidal exchange necessary to meet the project's restoration objectives. Therefore, this option was dismissed from further consideration.

2.7.4 TIDAL POWER GENERATION AT THE NEW CHEQUESSETT NECK ROAD DIKE

During public scoping meetings in August and September 2008 several commenters advocated for inclusion of tidal power generation within a newly reconstructed Chequessett Neck Road Dike. These comments were also included in the MEPA certificate issued by the Massachusetts Executive Office of Energy and the Environment on November 7, 2008. This element would present a hazard to the key diadromous fish species targeted to benefit from the project and therefore is in direct conflict with the project objectives.

In addition, application of a basic equation for calculating potential kinetic energy from open flow channels (WHG 2009) to the Herring River shows that the relatively low flow volume and head differential at a new Chequessett Neck dike would be far too small to produce electricity at a scale that would justify the costs, complications, and increased environmental impact of a tidal power turbine. Therefore, this option was dismissed from further consideration.

2.7.5 UNRESTRICTED TIDE FLOW AT CHEQUESSETT NECK

The HRRC has considered a long-term outcome that would remove tide control from the Chequessett Neck Road Dike and allow full, unrestricted tidal exchange between the river and

Wellfleet Harbor. This alternative provides many ecological benefits, such as increased sediment deposition on the restored upstream tidal marsh during storm events, and has long-term operational advantages because after a period of incremental adjustments tide gates would no longer be needed and could be removed. Removal of tide gates would also ensure that the Herring River continues to flow freely into the foreseeable future since the mechanism for restricting tides would be eliminated. However, given the uncertainty about the impacts of tidal restoration and sea level rise and the relatively long period during which the incremental restoration and adaptive management process would occur, it was determined that a decision to allow removal of any tide control structures could be considered in the future, but was beyond the planning horizon of this EIS/EIR.

2.8 CONSTRUCTION METHODS, TIMEFRAME, AND RESOURCE PROTECTION MEASURES

Standard construction methods and equipment would be used to construct the infrastructure needed to implement the action alternatives. Earth-moving equipment, graders, cranes, dump trucks, cement trucks, and other equipment would be operated and staged in the project area. 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. For dike construction, the sites would be de-watered using coffer dams and pumps, or other common methods for dike construction. Information concerning construction impacts, staging, and access route options are provided in section 4.11.

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, the new dike (under alternatives C and D) 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.

2.9 HOW ALTERNATIVES MEET OBJECTIVES

As stated in the “Chapter 1: Purpose and Need,” all action alternatives selected for analysis must meet all objectives to a large degree. The action alternatives must also address the stated purpose of taking action and resolve the need for action; therefore, the alternatives were individually assessed in light of how well they would meet the objectives for this plan and EIS/EIR (refer to “Chapter 1: Purpose and Need”). Alternatives that did not meet the objectives were not analyzed further (see section 2.7).

Table 2-4 compares how each of the alternatives described in this chapter would meet project objectives.

TABLE 2-4: COMPARISON OF HOW THE ALTERNATIVES MEET PROJECT OBJECTIVES

Objective	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Action Alternatives: B, C, and D
To the extent practicable, given adjacent infrastructure and other social constraints, re-establish the pre-dike tidal range, salinity distribution, and sedimentation patterns of the 1,100-acre estuary.	Alternative A would not meet this objective because restoration would not be undertaken. The Chequessett Neck Road Dike would continue to limit tidal influence in the estuary. Seawater would not reach areas upstream of High Toss Road. The Herring River flood plain would remain largely a freshwater system isolated from marine waters and lack of sediment availability would allow land subsidence to continue. The lowest reaches of the Lower Herring River would continue to receive some influence from tidally driven seawater.	The action alternatives would largely meet this objective by re-establishing the hydrologic connection between Wellfleet Harbor and the Herring River. Construction of a new Chequessett Neck Road Dike would allow long-term management of mean high spring tidal inundation levels to between 4.8 and 5.6 feet in the Lower Herring River. Tidal marsh restoration would occur over approximately 800 to 900 acres. A range of salinity concentrations – seawater to brackish to freshwater – would occur throughout the restoration area. Of the action alternatives, alternative D would best meet this objective by reintroducing tidal exchange and restoration processes to the greatest area.
Improve estuarine water quality for resident and migratory animals including fish, shellfish, and waterbirds.	Alternative A would only minimally meet this objective because limited tidal flushing and long residence times would contribute to poor water quality in the project area. The Herring River is currently listed on the Massachusetts 303(d) list for impaired water quality. Oxygen depletion, fish kills, high metals concentration, and fecal coliform contamination have all been issues in the Herring River flood plain, and this condition would continue. However, existing shellfishing activities would continue.	Under all action alternatives, water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to between 800 and 900 acres, and residence times would be reduced by a factor of 25. Regular tidal flushing would reduce nutrient concentration and bacteria counts, while changes in soil chemistry - from freshwater to saline – would eliminate metals contamination. Of the action alternatives, alternative D would best meet this objective by providing the greatest quantity of tidal exchange and water quality improvements.
Protect and enhance harvestable shellfish resources both within the estuary and in receiving waters of Wellfleet Bay.	Alternative A would not meet this objective because the Herring River estuary would remain degraded with diminished abundance and diversity of shellfish species. Fecal coliform contamination would persist, as would the 90-acre shellfish harvest closure.	Under all action alternatives, increased salinity and improved water quality would provide substantially more habitat for locally important shellfish species within the Herring River estuary. As populations increase, juveniles may spread to and establish in Wellfleet Harbor. Of the action alternatives, alternative D would be expected to best meet this objective by providing the greatest quantity of tidal exchange and potential for increased populations and migration of shellfish.

Objective	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Action Alternatives: B, C, and D
Restore the connection with the marine environment to recover the estuary's functions as 1) a nursery for marine animals and 2) a source of organic matter for export to near-shore waters.	Alternative A would not meet this objective because Herring River estuarine system would remain degraded with restricted access for and low abundance of locally important fish and shellfish species. The Chequessett Neck Road Dike would remain a hindrance to migratory fish passage, suitable habitat for juvenile fishes would be limited, and sediment and nutrients would remain trapped behind the dike.	Under all action alternatives, restored estuarine waters and formation of new tidal channels would provide substantially more habitat and access to upstream spawning and nursery habitats for both resident and transient fish species and shellfish, increasing their abundance. Although the new Chequessett Neck Road Dike would still present an impediment to sediment transport, nutrients and fine particles would move with the tides, both upstream into the sub-basins and downstream into Wellfleet Harbor. Of the action alternatives, alternative D would best meet this objective by providing the greatest quantity habitat and quantity of tidal exchange.
Remove physical impediments to migratory fish passage to restore once-abundant river herring and eel runs.	Alternative A would not meet this objective because Herring River estuarine system would remain degraded with restricted access for and low abundance of locally important anadromous and catadromous species. The Chequessett Neck Road Dike would remain a hindrance to migratory fish passage.	Under all action alternatives, restored estuarine waters and formation of new tidal channels would provide substantially more habitat and access to upstream spawning and nursery habitats for locally important anadromous and catadromous species, increasing their abundance. All action alternatives would include a new Chequessett Neck Road Dike that would provide adequate passage for herring and eels.
Re-establish native estuarine vegetative cover in place of the invasive non-native plants, freshwater wetland plants, and upland plants that have colonized most parts of the degraded flood plain.	Alternative A would not meet this objective because degraded freshwater wetland conditions would persist in over 1,000 acres of former salt marsh habitats due to tidal restriction. *Phragmites* and other non-native vegetation would persist and have the opportunity to spread in the project area.	Under all action alternatives, over the long term, extensive restoration of salt marsh vegetative communities would occur. Approximately 800 to 900 acres would be regularly inundated at a frequency to support growth of native, salt-tolerant wetland plants. However, conditions in upstream reaches of sub-basins would likely support transitional habitats and a border of persistent freshwater species. Of the action alternatives, alternative D would best meet this objective by providing the greatest acreage of vegetation change.
Restore normal sediment accumulation on the wetland surface to counter subsidence and to allow the Herring River marshes to accrete in the face of sea level rise.	Alternative A would not meet this objective because tidal flows would continue to be restricted, limiting upstream sediment transport. Channel width, depth, and capacity would remain restricted. Insufficient delivery of sediment to marsh surfaces, pore space collapse, and decomposition of organic matter would cause continued subsidence of the marsh surface. Normal tides would continue to mobilize sediment over approximately 56 acres.	Under all action alternatives, the larger tide gate opening would support accretion of sediment on the marsh over decades. The degree and rate of sediment mobilization would be determined by the amount of tidal influence and rate of incremental opening of the tide gates. Normal tides would mobilize sediment on between 144 and 156 acres, most of which would be deposited in upstream reaches. Of the action alternatives, C and D would best meet this objective by providing the greatest area of sediment mobilization.

Objective	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Action Alternatives: B, C, and D
Re-establish the natural control of nuisance mosquitoes by restoring tidal range and flushing, water quality, and predatory fish access.	Alternative A would not meet this objective because the absence of tidal flushing and predatory fish would persist. The Herring River would remain a productive mosquito habitat, particularly between High Toss Road and Route 6. The dominant mosquito species is *Ochlerotatus cantator.*	Under all action alternatives, a shift in species is expected as salinity is increased, with a long-term decline of freshwater and generalist species such as *O. cantator* and *O. canadensis*, with replacement by salt marsh mosquito species such as *O. solicitans* in the lower marsh. Because of the greater success in controlling this species, a decrease in the mosquito nuisance is expected. Of the action alternatives, alternative D would best meet this objective because 890 acres would be subject to saltwater influence.
Restore the expansive marshes and tidal waters that were once a principal maritime focus of both Native Americans and European settlers of outer Cape Cod in a manner that preserves the area's important cultural resources.	Alternative A would only minimally meet this objective because the 100-year old Chequessett Neck Road Dike would remain in place, with further degradation of the historic tidal marsh, absence of historically important aquatic species, and limited access for fishing and other recreational activities. Existing salt marsh areas in Lower Herring River would remain. However, there would be no impacts to cultural resources or archeological resources because existing conditions would be maintained.	Under all action alternatives, this objective would be partially met because tidal salt marsh would be restored, fish and shellfish populations would increase, and the open habitat type of the salt marsh would support greater access for fishing and recreation. However, there would be a potential for adverse effects to archeological resources in the area of potential effect (APE) from construction or other ground-disturbance. Higher tides would not affect archeological resources because inundation would be gradual. Erosion from increased tidal flows could affect transportation corridors across river channels, but these impacts would be mitigated by culvert replacement and other measures. Upland alteration to protect the CYCC golf course from flooding could result in disturbance of 5 to 30 acres of potentially sensitive cultural resources.
Minimize adverse impacts to surrounding land uses, such as domestic residences, low-lying roads, wells, septic systems, and private property, including the CYCC.	Alternative A would best meet this objective because tidal inundation levels and flood risk to adjacent landowners would not change. Properties in the project area would rely on the continued operation of the Chequessett Neck Road Dike for protection from tidal impacts.	The action alternatives would meet this objective because of improved water management and control at the Chequessett Neck Road Dike and because affected properties would receive site-specific flood proofing measures. Under alternatives B and D, flood protection and drainage on the CYCC golf course would be improved by filling and elevating 8.3 acres of wetland or relocating vulnerable portions of the course. Between 7,400 and 9,400 feet of low-lying paved roadways would be improved and elevated above the flood plain. Of the action alternatives, alternative C would result in fewer impacts and flood mitigation requirements to surrounding land uses.

Objective	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Action Alternatives: B, C, and D
Provide a highly visible example of the values of estuarine habitat restoration and a rich and long-term opportunity to educate the public about the dependency of productive salt marshes on unaltered tidal exchange.	Alternative A would not meet this objective because restoration of the Herring River would not be undertaken.	The action alternatives would meet this objective by restoring tidal exchange over most of the historic marsh plain.
Restore the aesthetic appeal and accessibility of the open herbaceous marsh in place of existing scrub/shrub invasive species.	Alternative A would only minimally meet this objective because the current vegetative cover of forest and shrubs would persist over much of the Herring River flood plain. However, the aesthetic qualities of the existing marshes and woodlands would remain.	Over the long term, the action alternatives would result in improved aesthetic appeal by eliminating woody species, and opening the vista of the marsh plain. Intertidal habitats would vary by basin, but would be mostly open water, broad meadows, and salt water marshes. Wooded areas within the flood plain would decrease, reducing obstructions to viewscapes. Of the action alternatives, alternative D would best meet this objective because up to 890 acres would be returned to native habitat.
Improve finfishing and shellfishing opportunities.	Alternative A would only minimally meet this objective because recreational and commercial shellfish harvest would remain permanently closed over 90-acres immediately downstream of the Chequessett Neck Road Dike due to fecal coliform contamination. The finfish population in the Herring River would remain depauperate. However, current shellfishing and finfishing opportunities would continue.	The action alternatives would meet this objective because shellfish and finfish populations are expected to increase as habitat and water quality improve. Decreased fecal coliform levels would allow the closed area downstream of the Chequessett Neck Road Dike to be reopened to shellfish harvest; other areas of Wellfleet Harbor that are only conditionally opened could be opened year-round. Of the action alternatives, alternative D would best meet this objective by restoring the largest area and providing the greatest tidal exchange.
Enhance opportunities for canoeing, kayaking, and wildlife viewing over a diversity of restored wetland and open-water habitats.	Alternative A would only minimally meet this objective because public access points would remain unaffected and the physical character of the estuary would be unchanged. However, current recreational canoeing, kayaking, and wildlife viewing opportunities would continue.	The action alternatives would meet this objective because after restoration, there would be improvements to recreational shellfishing, finfishing, wildlife viewing, boating, and visual aesthetics. There would be no net loss in public access. The more open character of the estuary would support improved access and abilities to view native wildlife. Of the action alternatives, alternative D would best meet this objective by restoring the largest area of open-water habitats.

2.10 CONSISTENCY WITH THE PURPOSES OF NEPA

As required under the CEQ regulations (40 CFR 1502.2(d)), an EIS must include a section stating how each alternative analyzed in detail would or would not achieve the requirements of sections 101(b) and 102(1) of NEPA and other environmental laws and policies. In the NPS, this requirement is met by (1) disclosing how each alternative, one of which is identified as the environmentally preferable, meets the criteria set forth in section 101(b) of NEPA; and (2) any inconsistencies between the alternatives analyzed in detail and other environmental laws and policies.

1. *Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.*

   Alternative A would not restore environmental conditions in the estuary, which is degraded due to diking, draining, and tidal restriction. This degraded environmental condition is expressed in the form of reduced salinity penetration, degraded water and sediment quality, closed shellfish beds, reduced distribution of salt marsh vegetation, obstructed fish migration, and lost habitat for diverse estuarine species. While current environmental laws provide some protection from additional environmental harm, without restoration future generations would inherit a substantially degraded estuarine environment. Alternative A, therefore, does not achieve criterion 1 to any great degree. Under each action alternative, environmental conditions would be substantially improved once the adaptive management process is complete. The majority of the Herring River flood plain would become tidally influenced, which would reverse the impacts of diking and draining. Penetration of saline water into the estuary would approximate pre-dike conditions. Increased flushing would improve water and sediment quality, allowing for the reopening of some shellfish beds in Wellfleet Harbor. The distribution of salt marsh vegetation would resemble pre-dike conditions, and substantial habitat for estuarine species would be restored. Future generations would inherit a substantially restored estuarine environment. Each of the action alternatives, therefore, achieve criterion 1 to a large degree, with alternative D achieving the most because the extent of tidal restoration is greatest.

2. *Ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.*

   Alternative A would retain the estuary's current scenic condition, which is shaped by upland and freshwater marsh vegetation, and which does provide a small measure of esthetic and cultural value. However, in most regards alternative A does not achieve criterion 2 due to poor water and sediment quality, degraded habitats, and closure of some shellfish beds. For all action alternatives, improved water quality, sediment quality, and salinity penetration would make the estuary more productive in terms of salt marsh vegetation; these improved habitat conditions would increase productivity for estuarine fish and shellfish species. Esthetic conditions would be improved for many residents and visitors as wooded areas give way to open views of the estuary. Potentially reduced mosquito hatches could also improve the estuary in an esthetic sense. The reopening of shellfish beds and increased shellfish productivity would enhance the role of the estuary for that culturally important aspect of the local economy. Each of the action alternatives, therefore, achieves criterion 2 to a large degree, with alternative D achieving criterion 2 the most because it would provide the greatest extent of restoration.

3. *Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.*

   While alternative A provides for a range of beneficial uses of the Herring River estuary, it does so by perpetuating degraded conditions that are themselves the unintended consequences of past diking, draining, and tidal restriction in the estuary and thus, does not achieve the goal of criterion 3. Each of the action alternatives would improve the condition and function of the estuary such that a wide range of sustainable, beneficial uses could be enjoyed over the long term without environmental degradation. These beneficial uses include recreational and commercial shellfishing, recreational finfishing, boating, and wildlife viewing. While the action alternatives would also result in increased flood risk for some private properties and low-lying road segments, beneficial use by residents is not precluded. The action alternatives would, therefore, achieve criterion 3 to a large degree. Of the action alternatives, alternative D would achieve criterion 3 the most because it would have the largest area of restoration over the long term and therefore provide the greatest benefit in terms of potential sustainable uses.

4. *Preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice.*

   Alternative A achieves criterion 4 to a small degree because it would not disturb cultural or historic resources; however, degraded environmental conditions would be perpetuated. Each of the action alternatives would restore tidal exchange and estuarine processes while mitigating impacts to cultural and historic resources that could result from higher tide levels, and therefore, achieve the goals of criterion 4 to a much larger degree, with alternative D achieving the most because it would provide the largest area of restoration over the long term.

5. *Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.*

   Alternative A does not achieve criterion 5 to any great degree because the current degraded condition of the Herring River estuary provides fewer amenities and contributes less to the standard of living of local residents than the estuary provided prior to diking, and less than it would provide after restoration. Each of the action alternatives would improve water quality and wetland function, increase aquatic life, reduce nuisance mosquitos, improve commercial and recreational shellfishing, improve landscape esthetics, and enhance recreation opportunities. The potential for tidal or storm surge waters to reach abutting properties would increase, but the NPS and HRRC are working with potentially affected property owners to develop site-specific flood mitigation measures for their property and structures. The action alternatives, therefore, achieve criterion 5 to a large degree because they would provide a broad range of amenities for the residents and visitors, and permit high standard of living for the resident population.

6. *Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.*

   Alternative A partially achieves the goal of criterion 6 because it would not involve construction and, thus, would not use depletable resources; however, the existing degraded environmental conditions do not enhance the quality and quantity of locally important renewable resources such as shellfish and finfish. Each of the action alternatives would improve water quality and habitats for renewable shellfish and finfish resources. Construction of a new Chequessett Neck Road Dike (under all action alternatives), a new dike at Mill Creek (under alternatives C and D), changes to low-lying roads, and site specific flood mitigation measures would all consume depletable resources as part of the construction processes, but mitigation measures, including recycling, would reduce this depletable resource use to the maximum extent practicable. The action alternatives, therefore, achieve criterion 6 to a large degree.

2.11 ENVIRONMENTALLY PREFERABLE ALTERNATIVE

In accordance with Director's Order 12, the NPS identifies the environmentally preferable alternative in its NEPA documents for public review and comment (section 4.5 E(9)). The environmentally preferable alternative is the alternative that causes the least damage to the biological and physical environment and best protects, preserves, and enhances historical, cultural, and natural resources. The environmentally preferable alternative is identified upon consideration and weighing by the Responsible Official of long-term environmental impacts against short-term impacts in evaluating what is the best protection of these resources. In some situations, such as when different alternatives impact different resources to different degrees, there may be more than one environmentally preferable alternative (43 CFR 46.30).

Alternative D was identified as the environmentally preferable alternative because tidal restoration would be maximized. Construction could result in temporary adverse impacts, but in the long-term alternative D would substantially improve the biological and physical environment. Compared with the other action alternatives, a larger portion of the flood plain would be subjected to tidal influence, increasing salinity penetration, improving water and sediment quality, increasing the distribution of salt marsh vegetation, eliminating obstacles to fish migration, and providing habitat for diverse estuarine species. Although there could be some low-lying areas impacted by periodic flooding, these impacts can be effectively mitigated on a site-specific basis. Therefore, alternative D is considered to best protect, preserve, and enhance historic, cultural, and natural resources.

2.12 NPS AND HRRC PREFERRED ALTERNATIVE

To identify the preferred alternative, each alternative was evaluated based on its ability to meet the plan objectives (see table 2-4) and their potential impacts on the environment (see "Chapter 4: Environmental Consequences" of this document). An initial screening of the alternatives was accomplished by the project team through the Value Analysis/Choosing by Advantages process held June 1–3, 2011 (Kirk Associates 2011). The Value Analysis/Choosing by Advantages process considered the advantages of the three proposed action alternatives, including the Mill Creek options for alternatives B and D. Each of the three alternatives was evaluated against three factors:

- Restore natural and cultural resources.
- Improve operational efficiency, reliability, and sustainability.
- Enhance and maintain socioeconomic benefits.

The HRRC evaluated the benefit or "importance of advantage" for each of the alternatives. Not considering the cost, alternative D, with Mill Creek Option 2 which includes installation of new tidal control structure at Chequessett Neck and a dike at Mill Creek that partially restores tidal flow, and elevates the fairways and practice area at the CYCC, would provide the greatest importance of advantage based on benefit points. Relative initial cost estimates for the alternatives were developed and the relative benefits and costs of the alternatives were graphed. This cost-benefit ratio also showed that alternative D with Mill Creek Option 2, elevation of the CYCC golf course, would offer the best value, with the highest benefit to cost ratio. Thus, in the Value Analysis/Choosing by Advantages process, alternative D with elevation of the CYCC golf course was identified as the preferred alternative.

2.13 SUMMARY AND IMPACTS OF THE ALTERNATIVES

The full range of impacts anticipated to result from implementation of the proposed alternatives is detailed in "Chapter 4: Environmental Consequences" of the EIS/EIR. A brief summary of these impacts is included in table 2-5.

TABLE 2-5: SUMMARY OF THE IMPACTS OF THE ALTERNATIVES

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Salinity of Surface Waters	The existing Chequessett Neck Road Dike would continue to limit tidal influence in the estuary. Seawater would not reach areas upstream of High Toss Road. The lowest reaches of the Lower Herring River would continue to receive some influence from tidally driven seawater.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 4.8 feet and a maximum coastal storm driven tide of 6.0 feet in the Lower Herring River. Salinity penetration would increase in most sub-basins.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 5.6 feet and a maximum coastal storm driven tide of 7.5 feet in the Lower Herring River. A new dike managed to exclude tides would be constructed at the mouth of Mill Creek. Salinity penetration would increase in all sub-basins beyond that achieved in alternative B, but no change would occur in Mill Creek.	The new Chequessett Neck Road Dike would be managed in the long term to allow mean high spring tide of 5.6 feet and a maximum coastal storm driven tide of 7.5 feet in the Lower Herring River. A new dike managed to control tides would be constructed at the mouth of Mill Creek. Salinity penetration would increase in all sub-basins to the same extent as alternative C, but salinity penetration in Mill Creek would be comparable to that of alternative B.
	Salinity ranges of specific sub-basins would be as follows: (0 parts per thousand (ppt) = freshwater, ~35 ppt = seawater): • Lower Herring River: 0-26 ppt • Middle Herring River: 0 ppt • Upper Herring River: 0 ppt • Duck Harbor: 0 ppt • Lower Pole Dike Creek: 0 ppt • Upper Pole Dike Creek: 0 ppt • Lower Bound Brook: 0 ppt • Upper Bound Brook: 0 ppt • Mill Creek: 0 ppt	Salinity ranges of specific sub-basins would be as follows: (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 22-29 ppt • Middle Herring River: 7-29 ppt • Upper Herring River: 0-1 ppt • Duck Harbor: 0-25 ppt • Lower Pole Dike Creek: 15-30 ppt • Upper Pole Dike Creek: 0-14 ppt • Lower Bound Brook: 2-24 ppt • Upper Bound Brook: 0-3 ppt • Mill Creek: 0-30 ppt	Salinity ranges of specific sub-basins would be as follows: (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 25-30 ppt • Middle Herring River: 12-29 ppt • Upper Herring River: 0-17 ppt • Duck Harbor: 3-24 ppt • Lower Pole Dike Creek: 17-30 ppt • Upper Pole Dike Creek: 0-20 ppt • Lower Bound Brook: 7-27 ppt • Upper Bound Brook: 0-15 ppt • Mill Creek: 0 ppt	Salinity ranges of specific sub-basins would be as follows: (0 ppt = freshwater, ~35 ppt = seawater): • Lower Herring River: 25-30 ppt • Middle Herring River: 12-29 ppt • Upper Herring River: 0-17 ppt • Duck Harbor: 3-24 ppt • Lower Pole Dike Creek: 17-30 ppt • Upper Pole Dike Creek: 0-20 ppt • Lower Bound Brook: 7-27 ppt • Upper Bound Brook: 0-15 ppt • Mill Creek: 0-30 ppt

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Water and Sediment Quality	Lack of tidal flushing would continue to impact water and sediment quality by lowering the pH of porewater and surface water, leaching iron and aluminum, reducing summer dissolved oxygen concentrations to levels dangerous to fish and invertebrates, and concentrating fecal coliform.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to approximately 800 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to approximately 830 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates. No water quality improvements would occur to Mill Creek.	Water quality in the Herring River would be greatly improved from present conditions. Tidal exchange would be restored to 889 acres. Porewater and surface water pH would improve, leaching of iron and aluminum, and fecal coliform concentration would be reduced. Summer dissolved oxygen concentrations would improve to levels safe for fish and invertebrates.
	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence Time under current conditions is approximately 200 days.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence time would be reduced to 8 days.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence time would be reduced to 6 days, but Mill Creek sub-basin would be excluded.	Residence time is an indicator of tidal flushing efficiency. A short residence time indicates good flushing. A long residence time indicates stagnant water and is associated with poor water quality. Residence Time would be reduced to 6 days.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Sediment Transport	Tidal flows would continue to be restricted by the existing Chequessett Neck Road Dike, limiting upstream sediment transport. Channel width, depth, and capacity would remain restricted. Insufficient delivery of sediment to marsh surfaces, pore space collapse, and decomposition of organic matter would cause continued subsidence of the marsh surface.	Enlarging the dike opening would result in accretion of sediment on the marsh. The degree and rate of sediment mobilization would be determined by the amount of tidal influence and rate of incremental opening of the tide gates. Restoration of marsh surface elevations may proceed for decades.	Same as alternative B.	Same as alternative B.
	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under current conditions: • Normal Tides: 56 acres • Storm Tides: 154 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative B: • Normal Tides: 144 acres • Storm Tides: 349 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative C: • Normal Tides: 156 acres • Storm Tides: 447 acres	The quantity of mobilized sediment is in part a function of the potential area of sediment mobilization (upstream and downstream of Chequessett Neck Road Dike). Normal tides and storm tides would be associated with the following acreages under alternative D: • Normal Tides: 156 acres • Storm Tides: 447 acres
Soils	The soils would continue to evolve as they have since the dike was built, as there would be no predicted changes in soil chemistry, structure, or organic content. Soil conditions would continue to reflect past adverse impacts of tidal exclusion.	Tidal restoration would result in estuary-wide, beneficial changes to hydric soils by increasing pore space, soil pH, and organic content as these soils are subjected to tidal inundation. Various local changes in soil texture are also expected as soils are subjected to different erosional and/or depositional forces that alter the sand, silt, or clay content.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Wetland Habitats and Vegetation	Degraded freshwater conditions would persist in over 1000 acres of former salt marsh habitats due to tidal restriction. The following habitat conditions are currently present for each cover type: • 75 acres wet deciduous forest • 7 acres dry deciduous forest • 26 acres pine woodland • 231 acres dry deciduous woodland • 288 acres wet shrubland • 1 acre dry shrubland • 18 acres old field herbaceous mix • 172 acres freshwater marsh (non-tidal) • 36 acres brackish marsh (tidal) • 13 acres salt marsh (tidal) • 20 acres heathland • 1 acre dune grassland • 94 acres water • 24 acres developed	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following cover type habitat conditions would undergo habitat change: • 44 acres wet deciduous forest • 2 acres dry deciduous forest • 22 acres pine woodland • 10 acres dry deciduous woodland • 122 acres wet shrubland • 2 acres old field herbaceous mix • 127 acres freshwater marsh (tidal) • 183 acres brackish marsh (tidal) • 358 acres salt marsh (tidal) • 11 acres heathland • 1 acres dune grassland • 86 acres water • 12 acres developed • 26 acres misc. non-tidal**	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following cover type habitat conditions would undergo habitat change: • 2 acres pine woodland • 67 acres wet shrubland • 99 acres freshwater marsh (tidal) • 98 acres brackish marsh (tidal) • 551 acres salt marsh (tidal) • 80 acres water • 24 acres developed • 57 acres misc. non-tidal**	Over the long term, extensive restoration of salt marsh vegetative communities would occur. The following cover type habitat conditions would undergo habitat change: • 2 acres pine woodland • 67 acres wet shrubland • 99 acres freshwater marsh (tidal) • 98 acres brackish marsh (tidal) • 585 acres salt marsh (tidal) • 86 acres water • 12 acres developed • 57 acres misc. non-tidal**
	** Misc. Non-tidal habitats include varied wetland and upland areas expected to persist along the periphery of the project and other isolated areas.			

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Aquatic Species	The Herring River estuarine system would remain degraded with diminished abundance of resident estuarine fish, marine migrant species, and macroinvertebrate species in the estuary, and limited use of fresh water spawning grounds by anadromous/catadromous species.	Restored estuarine waters and salt marsh would provide substantially more spawning and nursery habitat for both resident and transient fish species and for estuarine macroinvertebrates, increasing their abundance. Improved water quality and access to the head waters of the river would enlarge the river herring run.	Same as alternative B.	Same as alternative B.
	Total estuarine habitat would be limited to 70 acres within Lower Herring river.	Total estuarine habitat would increase to 790-800 acres.	Total estuarine habitat would increase to 822 acres.	Total estuarine habitat would increase to 878-885 acres.
State-listed Rare, Threatened, and Endangered Species	<u>Northern Harrier</u> • 96 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 251 acres of Foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 659 acres unsuitable habitat	<u>Northern Harrier</u> • 60 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 668 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 278 acres unsuitable habitat	<u>Northern Harrier</u> Impacts associated with alternative C are not addressed for this resource here because, compared to the preferred alternative, it only excludes the Mill Creek sub-basin from the project. Therefore, alternative C impacts are the same as, or only slightly less than, the preferred alternative.	<u>Northern Harrier</u> • 49 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 782 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 175 acres unsuitable habitat
	<u>American Bittern and Least Bittern</u> • 208 acres potential nesting habitat (83% fresh marsh; 17% brackish marsh) • 13 acres potential Foraging, roosting, and migratory habitat (salt marsh) • 785 acres unsuitable habitat	<u>American Bittern and Least Bittern</u> • 310 acres potential nesting habitat (40% fresh; 60% brackish) • 327 acres potential foraging, roosting, and migratory habitat (salt marsh) • 369 acres unsuitable habitat	<u>American Bittern and Least Bittern</u> Impacts are the same as, or only slightly less than, alternative D.	<u>American Bittern and Least Bittern</u> • 197 acres potential nesting habitat (50% fresh; 50% brackish) • 585 acres potential Foraging, roosting, and migratory habitat (salt marsh) • 224 acres unsuitable habitat

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	Diamondback Terrapin • 84 acres habitat with limited availability (tidal barrier; salt and brackish marsh, water) • 922 acres unsuitable habitat	Diamondback Terrapin • 627 acres available habitat (salt and brackish marsh, water) • 379 acres unsuitable habitat	Diamondback Terrapin Impacts are the same as, or only slightly less than, alternative D.	Diamondback Terrapin • 769 acres available habitat (salt and brackish marsh, water) • 237 acres unsuitable habitat
	Eastern Box Turtle • 88 acres principal habitat (dry and wet deciduous forest, dry shrubland, dry dunes); • 611 acres occasional habitat (dry deciduous woodland, heathland grass, old field, pine woodland, wet shrubland) • 307 acres unsuitable habitat • 3,870 acres immediately adjacent to project area within Cape Cod National Seashore	Eastern Box Turtle • 47 acres principal habitat • 145 acres occasional (misc. non-tidal*, pine woodland, wet shrubland) • 814 acres unsuitable habitat • 3,870 acres immediately adjacent to project area within Cape Cod National Seashore • * Misc. non-tidal habitats include varied wetland and upland areas expected to persist along the periphery of the project and other isolated areas.	Eastern Box Turtle Impacts are the same as, or only slightly less than, alternative D.	Eastern Box Turtle • 0 acres principal habitat • 123 acres occasional (misc. non-tidal*, pine woodland, wet shrubland) • 883 acres unsuitable habitat • 3,870 acres immediately adjacent to project area within Cape Cod National Seashore
	Water-Willow Stem Borer • 386 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 620 acres unsuitable habitat • 265 acres adjacent to project area	Water-Willow Stem Borer • 171 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 835 acres unsuitable habitat • 265 acres adjacent to project area	Water-Willow Stem Borer Impacts are the same as, or only slightly less than, alternative D.	Water-Willow Stem Borer • 131 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 875 acres unsuitable habitat • 265 acres adjacent to project area

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Federally listed Threatened and Endangered Species	Rufa Red Knot • 13 acres of potential red knot habitat (salt marsh [tidal]). • 993 acres of unsuitable habitat	Rufa Red Knot • 358 acres of potential red knot habitat (salt marsh [tidal]). • 648 acres of unsuitable habitat	Rufa Red Knot Impacts are the same as, or only slightly less than, alternative D.	Rufa Red Knot • 585 acres of potential red knot habitat (salt marsh [tidal]). • 421 acres of unsuitable habitat
	Northern Long-eared Bat • 339 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 667 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.	Northern Long-eared Bat • 78 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 978 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.	Northern Long-eared Bat Impacts are the same as, or only slightly less than, alternative D.	Northern Long-eared Bat • 2 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 1,004 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.
Terrestrial Wildlife	Birds Salt marsh species would remain limited to 13 acres in Lower Herring River. For other wetland species, 264 acres of freshwater/brackish habitat would remain available. For upland and other bird species, 723 acres of woodland, shrubland, and heathland habitat would remain in the project area.	Birds For salt marsh species, 393 acres of habitat would be restored in Lower Herring River, Mill Creek, Middle Herring River, and Lower Pole Dike Creek. For other wetland species, 407 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats.	Birds For salt marsh species, 346 acres of habitat would be restored in Lower Herring River, Middle Herring River, and Lower Pole Dike Creek. For other wetland species, 484 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats. No change would occur in Mill Creek.	Birds For salt marsh species, 399 acres of habitat would be restored in Lower Herring River, Mill Creek, Middle Herring River, Duck Harbor, and Lower Pole Dike Creek. For other wetland species, 491 acres of freshwater/brackish habitat would be restored or enhanced in the upper sub-basins. For upland and other bird species, woodland, shrubland, and heathland habitat would be limited to the estuary periphery and the uppermost sub-basin, but these species would utilize adjacent upland habitats.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
	Mammals Mammals would remain widespread throughout the 1000+ acre project area.	Mammals Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	Mammals Most species would relocate to the estuary periphery and to the upper extents of the 830-acre area affected by mean high spring tide. No change would occur in Mill Creek.	Mammals Most species would relocate to the estuary periphery and to the upper extents of the 890-acre area affected by mean high spring tide.
	Reptiles and Amphibians Reptiles and amphibians would remain widespread throughout the 1000+ acre project area.	Reptiles and Amphibians Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.	Reptiles and Amphibians Most species would relocate to the estuary periphery and to the upper extents of the 830-acre area affected by mean high spring tide. No change would occur in Mill Creek.	Reptiles and Amphibians Most species would relocate to the estuary periphery and to the upper extents of the 800-acre area affected by mean high spring tide.
Cultural Resources	No impacts to cultural resources or archeological resources would occur as a result of the no-action alternative, as existing conditions would be maintained.	There is a potential for adverse effects to archeological resources in the APE from construction or other ground-disturbance. Additional archeological assessment would occur prior to construction. Higher tides would not impact archeological resources because any inundation would be gradual. Erosion from increased tidal flows could impact transportation corridors across river channels, but these impacts would be mitigated by culvert replacement and other erosion control measures. Depending on the golf course flood proofing option implemented, either 5 or 30 acres (approximately) of sensitive uplands could be disturbed.	Same as alternative B, but with approximately 30 additional acres under tidal exchange; no tidal influence or disturbance in Mill Creek.	Same as alternative B, but with approximately 90 additional acres of tidal exchange, including in Mill Creek. Depending on the golf course flood proofing option implemented, either 5 or 30 acres (approximately) of sensitive uplands could be disturbed.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Socioeconomics Nuisance Mosquitoes	The Herring River would remain a productive mosquito habitat, particularly between High Toss Road and Route 6. The dominant mosquito species is *Ochlerotatus cantator.*	A shift in species is expected as salinity is increased, with a long-term decline of freshwater and generalist species such as *O. cantator* and *O. canadensis*, with replacement by salt marsh mosquito species such as *O. solicitans* in the lower marsh. Because of the greater success in controlling this species, a decrease in the mosquito nuisance is expected. These impacts are expected in 801 restored acres.	The same species shift is expected as in alternative B. These impacts are expected in 830 restored acres. No changes would occur in Mill Creek.	The same species shift is expected as in alternative B. These impacts are expected in 890 restored acres.
Shellfishing	Recreational and commercial shellfish harvest would remain permanently closed immediately downstream of the Chequessett Neck Road Dike, due to fecal coliform contamination.	Shellfish populations and shellfish harvest are expected to increase. Decreased fecal coliform levels would allow the closed area downstream of the Chequessett Neck Road Dike to be reopened; other areas of Wellfleet Harbor that are only conditionally opened could be opened year-round.	Same as alternative B.	Same as alternative B.
Finfishing	No improvement to recreational or commercial finfishing would occur. Ongoing estuary degradation and obstructed access would contribute to continued regional population declines of estuary-dependent fisheries.	Improvements to habitat and water quality in the estuary and Wellfleet Harbor would benefit populations of finfish and commercial finfishing industries. Restoring connectivity with Wellfleet Harbor for the full range of fish species formerly found in the estuary would provide a corresponding improvement to the recreational fishery.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Low-lying Properties	Properties in the project area would rely on the continued operation of the Chequessett Neck Road Dike for protection from tidal impacts. Certain properties may need to obtain flood insurance if the Chequessett Neck Road Dike is not upgraded to comply with FEMA design guidelines.	Increased tidal exchange would result in beneficial and adverse impacts to low-lying properties. Beneficial impacts would include transition to open marsh and water vistas, potentially increasing property values. Adverse impacts could include flooding of low-lying structures and cultivated vegetation. Flood proofing measures would mitigate flood impacts. Compared to the other action alternatives, this alternative has the least impact in terms of the number of properties affected and the degree of impact.	The types of impacts are the same as alternative B. This alternative would have more impact in terms of the number of properties affected and the degree of impact than alternative B, but less than alternative D, because there would be no change in Mill Creek.	The types of impacts are the same as alternative B. This alternative would have more impact in terms of the number of properties affected and the degree of impact than alternatives B and C.
Low-lying Roads	Present road conditions would persist under the no action alternative. None of the roads have serious flooding issues.	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 7,394 feet Sand/fire roads: 10,332 feet	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 8,694 feet Sand/fire roads: 10,332 feet	A number of paved and unpaved road segments would be subject to periodic flooding. These road segments could be raised or realigned to be protected from flooding, or could be closed during periodic inundation. The maximum length of affected roads would be Paved: 9,397 feet Sand/fire roads: 10,727 feet

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Viewscapes	The current natural features and landscape character, and therefore viewscapes, would not change.	Long-term viewscape benefits would result from expanding intertidal habitat and open vistas. Intertidal habitats would vary by basin, but would be mostly open water, broad salt meadows, and salt water marshes. More native wildlife may also be observed. Wooded areas within the flood plain would decrease, reducing obstructions to viewscapes. In the short term, some dead or dying vegetation could reduce the quality of the viewscape until the transition is complete.	Same as alternative B, except that slightly more wooded area in the upper sub-basins would be removed, and Mill Creek sub-basin would be unaffected.	Same as alternative B, except that slightly more wooded area in the upper sub-basins would be removed.
Recreational Experience and Public Access	Public access points would remain unaffected and the physical character of the estuary would be unchanged.	Some low-lying access points could be impacted in the short term, but in the long term these could be replaced with better access points. After restoration, there would be improvements to recreational shellfishing, finfishing, wildlife viewing, boating, and visual aesthetics. There would be no net loss in public access.	Same as alternative B, except that no change would occur in Mill Creek.	Same as alternative B.
Regional Economic Conditions	There would be no project expenditures. Current regional economic conditions and trends are expected to continue.	Regional economic conditions would benefit from engineering, construction, and related spending that would support jobs and increase economic activity.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Construction Impacts Chequessett Neck Road Dike	No construction would occur.	The Chequessett Neck Road Dike would be reconstructed, temporarily impacting approximately 103,200 square feet (2.4 acres) comprised of the current dike footprint and adjacent inter- and sub-tidal wetland areas.	Same as alternative B.	Same as alternative B.
Mill Creek Dike	No construction would occur.	No construction would occur.	This structure would require approximately 2,900 cubic yards of fill and would permanently impact 12,500 square feet of wetland. In addition, a work area of approximately 105,000 square feet (2.4 acres) of wetlands would be impacted temporarily for dewatering and other associated work.	Same as alternative C.
High Toss Road		If the road is reconstructed above high tide line, there would be a permanent loss of approximately 13,000 square feet of vegetated wetland. Alternatively, if High Toss Road were removed, approximately 12,000 square feet of additional wetland area would be restored.	Same as alternative B.	Same as alternative B.
Pole Dike/ Bound Brook Island Roads		Elevating the roads above the maximum coastal storm driven tidal elevation would fill approximately 4,000 square feet of adjacent wetlands. Elevating the roads above annual high water (AHW) would fill approximately 2,300 square feet.	Same as alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
CYCC Golf Course Flood Proofing		Two options exist for flood proofing low-lying golf holes: Option 1 (relocation) and Option 2 (elevation). Under the relocation option, most of the low-lying golf holes would be relocated to an approximately 30-acre adjacent upland area. One hole would be elevated in its current location, resulting in a wetland loss of about 89,000 square feet. For the elevation option, approximately 360,000 square feet (8.3 acres) of wetland would be filled and elevated above the high tide line. Most of this wetland is now a developed part of the golf course. Fill may be generated from an approximately 5-acre borrow area on adjacent uplands for both options. The upland area is highly sensitive for pre-contact archeological resources.	No flood proofing measures are required.	Same as alternative B.
Residential Flood Proofing		Several low-lying residential properties could be impacted by restored tides, requiring actions such as constructing a small berm or wall to protect a residential parcel, adding fill to a low driveway or lawn, or relocating a well. Some of these actions may have limited wetland impacts.	No flood proofing measures are required in Mill Creek. In other areas, impacts would be similar to alternative B.	Same as alternative B.

Resource	Alternative A: No Action – Retain Existing Tide Control Structure at Chequessett Neck	Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek	Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow	Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow
Secondary Restoration Actions / Minor Road Improvements		These actions may include direct vegetation management, sediment management, channel improvements, and planting of vegetation. Impacts are expected to include work within wetland areas to remove trees and shrubs, dredge and/or deposit of sediment, excavation or fill of channels, and other actions to improve tidal circulation. Some actions may include access for heavy equipment.	Same as alternative B, except that no restoration would occur in Mill Creek.	Same as alternative B.

Chapter 3:
Affected Environment

CHAPTER 3: AFFECTED ENVIRONMENT

This chapter describes the existing resource conditions in the project area, and includes background on historic conditions, as appropriate. Resources affected by current and proposed management of the Herring River flood plain have been included, based on issues identified in chapter 1. The conditions described in this Affected Environment chapter serve as the baseline against which to measure changes anticipated from the proposed alternatives.

3.1 INTRODUCTION

The Herring River estuary is characteristic of Atlantic coastal estuarine environments found along the eastern United States, where freshwater from rivers, streams, and groundwater meet and mix with salt water from the ocean. These estuaries are among the most productive ecosystems on earth, creating more organic matter each year than comparably sized areas of forest, grassland, or agricultural land (USEPA 2008). The tidal, sheltered waters of estuaries also support unique communities of plants and animals, specially adapted for life at the land/sea margin. Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, swamps, sandy beaches, mud and sand flats, rocky shores, oyster reefs, and sea grass meadows. In addition to supporting a variety of wildlife habitat, salt marsh grasses, and other wetland plants found in estuaries help to prevent erosion through streambank stabilization, provide storm surge protection, and provide vital pollution control for water draining from upland areas. During the last 200 years, 50 percent of United States coastal wetlands have been lost and even more have been substantially altered (Stedman and Dahl 2008). Along the Atlantic Coast, long-term diking and drainage efforts to control mosquito populations and for agricultural and land development have affected many coastal marshes, including the Herring River estuary (Roman and Burdick 2012). These alterations have dramatically changed the hydrologic patterns of tidal wetlands. During the last 100 years, natural estuarine functions within the Herring River estuary have been severely affected by reductions in tidal inundation and flushing. For additional information on the history of modifications to the Herring River estuary, see “Section 1.6: Background” in chapter 1.

3.2 SALINITY OF SURFACE WATERS

In Wellfleet Harbor, salinity typically ranges between 30 and 32 parts per thousand (ppt) (National Park Service (NPS) data, as presented in WHG 2009). Based on the analysis of plant remains (Orson, in Roman 1987), prior to construction of the dike in 1909, salinity penetration was extensive enough to support salt marsh cord-grass (*Spartina alterniflora*) throughout the historic flood plain. Construction of the dike has limited the upstream mean tide range to only 2.2 feet compared to 10.3 feet downstream of the dike (WHG 2012). Because of this altered hydrology, saline waters during high tide currently extend approximately 1.2 miles upstream of the dike (figure 3-1).

Note: psu = practical salinity unit; whereas ppt is parts per thousand. For the purposes of this analysis these units are used interchangeably.

FIGURE 3-1: MODELED MAXIMUM SALINITIES FOR MEAN HIGH SPRING TIDE UNDER EXISTING CONDITIONS

Salinity levels, along with other water and sediment quality parameters, are routinely monitored by Seashore staff. Monitoring was conducted monthly from March to October 2006 and 2010 during low tide conditions at 11 locations (figure 3-2). Monitoring took place independent of weather conditions during or prior to the sampling events. The monitored stations can be clustered into four general groups based on their site conditions:

Station 1: Unrestricted river mouth—This station was located on the harbor side of the dike and was representative of the conditions in the upper portion of Wellfleet Harbor and the unrestricted lower basin of the Herring River.

Stations 2, 3, 4, 8, 9: Tide-restricted, mid-river channels—These stations had flowing water at varying flow rates. The stations were within the zone of acid sulfate soils.

Stations 3A, 6, 10: Tide-restricted mosquito ditches—These ditches carried water only intermittently, and thus may have had standing water (which was sampled and analyzed) or could have been dry. All three stations were in ditches that drained acid sulfate soils.

Stations 5, 11: Tide-restricted, headwater channels—These stations in the headwater of the estuary had flowing water and did not receive discharge from drained acid sulfate soils.

The 2006 to 2010 Seashore monitoring data confirm that the waters within the upper estuary are consistently fresh (figure 3-3). Although these measurements were made during low tide, other observations (NPS 2007b; Portnoy and Allen 2006) document that saline water never reaches High Toss Road during normal tides. Downstream of the dike (station 1), waters at low tide were brackish to marine with monthly mean salinities of 15 to 27 ppt.

FIGURE 3-2: CAPE COD NATIONAL SEASHORE HERRING RIVER WATER QUALITY MONITORING STATIONS

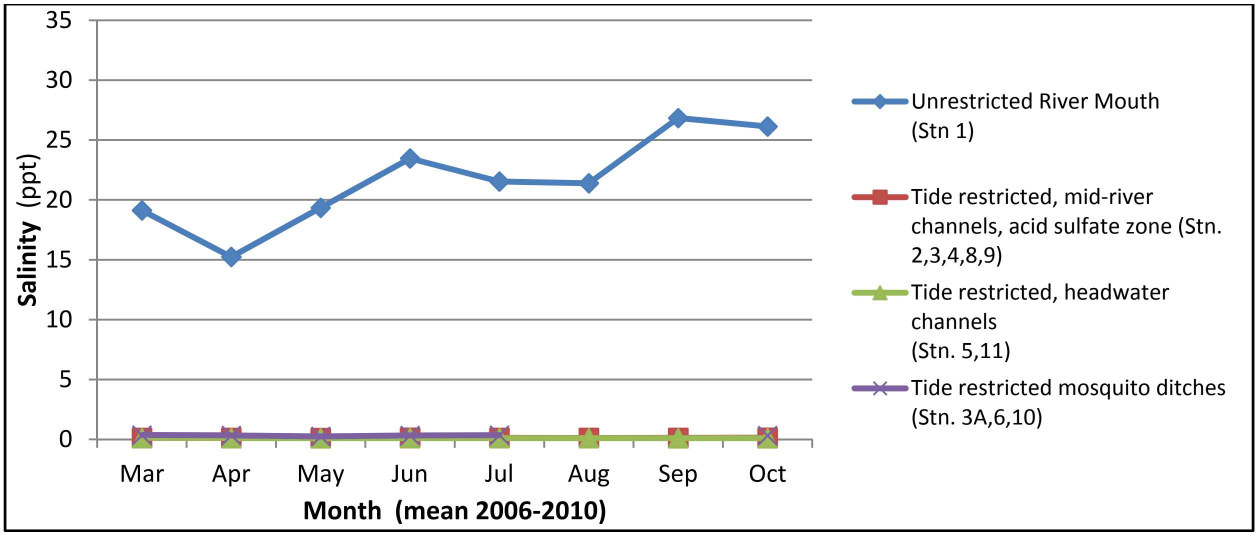


FIGURE 3-3: MONTHLY MEAN SALINITIES FOR THE HERRING RIVER AND ESTUARY AT LOW TIDE AS MONITORED BY THE CAPE COD NATIONAL SEASHORE (2006 TO 2010)

3.3 WATER AND SEDIMENT QUALITY

The Massachusetts Surface Water Quality Standards (314 CMR 4.00) have designated the Herring River as Class SA waters, the highest coastal and marine class. Class SA waters are required to have excellent habitat for fish, other aquatic life and wildlife, and primary and secondary recreation. The Herring River is also designated to be suitable for shellfish harvesting. In addition, the Herring River, and most of the Seashore, is designated by the Commonwealth as Outstanding Resource Waters [314 CMR 4.06(3)]. Outstanding Resource Waters include waters designated for protection based on their high socioeconomic, recreational, ecological, and aesthetic values. However, the Herring River estuary currently does not meet its targeted designations under the Massachusetts' regulations due to its degraded water quality conditions.

Water quality concerns have also resulted in the listing of Herring River on the 303(d) list of impaired waters under the federal Clean Water Act (CWA) (MassDEP 2011a). States are required to identify waters that do not meet requirements of their designated use. Specifically, Herring River segment MA96-07 (Herring Pond to south of High Toss Road) is impaired for metals and pH. Herring River segment MA96-33 (from south of High Toss Road to Wellfleet Harbor) is impaired for pathogens. Wellfleet Harbor (segment MA96-34) is also on the list as impaired for pathogens.

The following discussion of water and sediment quality describes the current environment as a result of historic disturbances to the Herring River estuary.

Over the last 100 years the surface water quality in the Herring River estuary has declined because of the severely restricted tidal flushing of the estuary as well as the drainage of marsh soils and sediments. Water quality and sediment quality are interrelated because chemical processes within the sediments affect the quality of the ground and surface water and vice versa. Relevant parameters discussed in more detail are dissolved oxygen, fecal coliform, pH, sulfate, metals, nutrients, and pesticides. The descriptions of current conditions are based on data from the ongoing monitoring program for the 5-year period between 2006 and 2010 (as described in section 3.2), as well as findings from other published technical studies.

3.3.1 Dissolved Oxygen

Decomposition of inorganic reduced compounds and organic matter in marsh peat contributes to high biological oxygen demand in sections of the Herring River estuary, particularly in summer. Low dissolved oxygen results from the combination of high oxygen demand (especially during periods of high water temperature) and greatly reduced tidal flushing, which would normally import copious volumes of oxygen-saturated seawater. Anoxic and near-anoxic conditions exist regularly along the mainstem of the river, particularly after heavy rains increase runoff of organic matter from the wetland (Portnoy 1991). Mean dissolved oxygen concentrations measured from 2006 to 2010 were below the regulatory limit of 6 mg/l for Class SA waters at all stations in the summer months (figure 3-4). During individual sampling events over the 5-year period, the minimum concentrations in some cases approached anoxic conditions (table 3-1). These low minimum concentrations were measured throughout the estuary upstream of the dike, with the lowest concentrations found within the mosquito ditches. Generally, dissolved oxygen concentrations in the mid-river channels as well as in the headwater channels were similar to concentrations near the dike.

Low dissolved oxygen concentrations have stressed anadromous fish species and resident aquatic fauna, and have resulted in fish kills (Portnoy 1991). In the past, low oxygen conditions in the summer compelled the NPS to control the emigration of juvenile herring to prevent complete mortality and loss of diadromous fish migration (Portnoy, Phipps, and Samora 1987), although this activity is no longer practiced. Conditions have improved since the discontinuation of annual dredging of the river for mosquito control in 1984 (HRTC 2007).

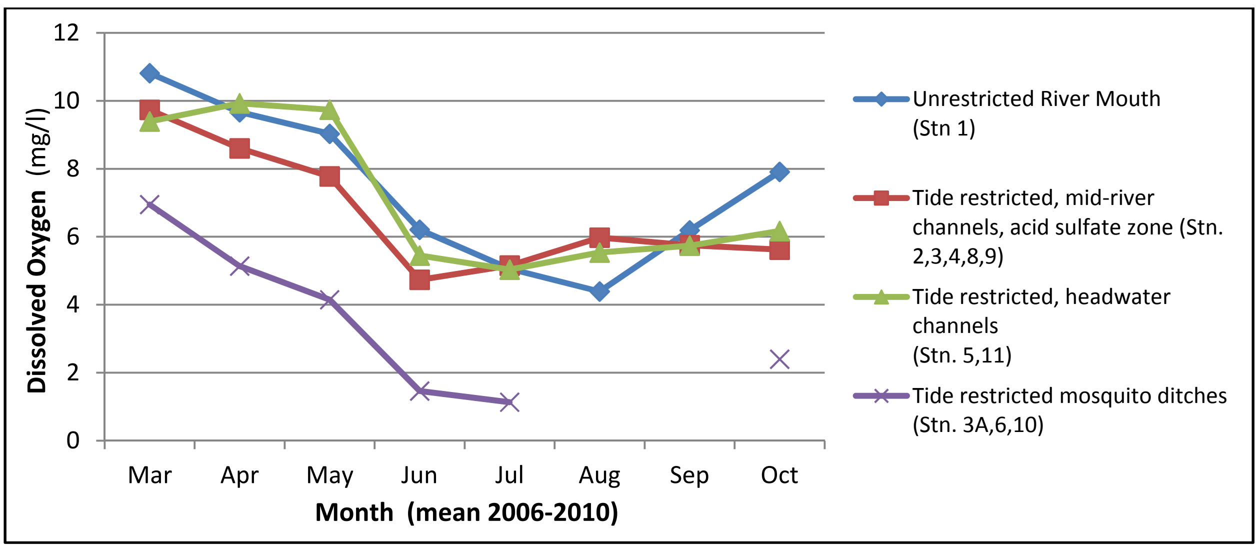


Figure 3-4: Monthly Mean Dissolved Oxygen Concentrations in the Herring River at Low Tide (2006 to 2010 Cape Cod National Seashore Monitoring Data)

TABLE 3-1: MEAN, MINIMUM, AND MAXIMUM MONTHLY DISSOLVED OXYGEN CONCENTRATIONS IN THE SURFACE WATER OF HERRING RIVER BETWEEN 2006 AND 2010 (CAPE COD NATIONAL SEASHORE MONITORING DATA)

Station	Dissolved Oxygen (monthly Mean, 2006–2010) (mg/l)*								Combined March to October Dissolved Oxygen (mg/l)				No. of ALL Samples
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean	std dev	Max	Min	
River Mouth: Unrestricted													
1	10.8	9.7	9.0	6.2	5.1	4.4	6.2	7.9	7.4	2.3	11.8	2.8	31
Mid-river Channels: Tide restricted, acid sulfate zone													
2	9.8	8.9	8.4	5.6	5.7	6.5	6.3	6.7	7.2	1.6	10.9	3.0	31
3	10.1	8.9	8.0	5.4	5.1	6.0	6.3	6.2	7.0	1.8	11.2	3.0	31
4	10.1	8.8	7.7	4.5	5.1	6.6	6.6	6.4	7.0	1.9	11.4	2.6	31
8	9.8	9.1	8.9	5.6	5.6	6.3	5.5	5.9	7.1	1.8	12.6	1.1	31
9	8.9	7.4	5.9	2.6	4.3	4.6	4.1	3.0	5.1	2.2	10.6	0.6	31
Headwater Channels: Tide restricted													
5	8.4	9.4	8.5	3.7	3.1	4.8	5.7	5.8	6.2	2.4	12.0	1.9	30
11	10.4	10.4	11.0	7.2	7.0	6.3	5.8	6.5	8.1	2.1	15.1	2.7	31
Mosquito Ditches: Tide restricted													
3A	5.5	4.9	3.6	2.4	1.3	dry	dry	3.7	3.6	1.6	7.1	1.1	18
6	9.2	5.7	4.2	1.2	1.0	dry	dry	0.8	3.7	3.4	10.4	0.8	18
10	6.2	4.8	4.6	0.7	dry	dry	dry	2.7	3.8	2.1	9.3	0.4	18

* Samples were collected at low tidal conditions.

3.3.2 PH AND SULFATE

Salt marsh soils in the Herring River estuary are naturally rich in sulfur. This is because salt marsh microbes commonly use sulfate, abundant in seawater, as an oxidizing agent to decompose organic matter in anoxic marsh sediments. The process produces dissolved sulfide, a large fraction of which is sequestered as iron sulfides, particularly pyrite; this mineral is very stable under water-saturated and anaerobic conditions. However, diking and drainage of the salt marsh has allowed air to enter the normally anaerobic subsurface environment converting it to an aerobic environment in which organic matter and iron-sulfide minerals are readily oxidized. As a result, the sulfide has reacted with oxygen to form sulfuric acid which has acidified the soil to pH levels less than three. The pH of surface waters can also be lowered to pH levels of three to five when sulfuric acid contained in the soil infiltrates surface water. Acidic water can result in a loss of aquatic vegetation, as well as the killing of fish and other organisms. For example, in 1980 acidic water released into the Herring River main channel following mosquito-control ditching, accompanying sediment disturbance and aeration, and heavy rainfall resulted in a die-off of thousands of American eel (*Anguilla rostrata*) and other fish species. During this event, pH levels of less than four were recorded in the mainstem of the Herring River (Soukup and Portnoy 1986).

The regulatory standard for pH for Class SA waters is 6.5 to 8.5. Currently, the pH levels in the channels of the estuary are often lower than the regulatory standard. Portnoy and Giblin (1997a) reported that acidic sulfate soils with pH levels of less than four can be found throughout much of the Duck Harbor, Lower Pole Dike Creek, Lower Herring River, and Mill Creek sub-basins. Soukup and Portnoy (1986) reported pH levels ranging from 6.0 to 4.2 in the water of the mainstem and 3.9 to 3.3 in drainage ditches.

The 2006 to 2010 monitoring data also show that low pH levels persist in the estuary, although the absence of mosquito control ditch maintenance since 1984 has allowed some improvement. Specifically, the March to October mean pH levels in the surface water of the mid-river channels ranged from approximately 5.5 to 6.0 (figure 3-5), reaching minimum pH levels as low as 3.6 during individual sampling events (table 3-2). In the drainage ditches, the mean pH was even lower ranging from approximately 4.5 to 5.5, with minimum pH levels reaching 3.0 during individual sampling events. The mean pH levels in the headwater channels were around 6, ranging from 4.4 to 7.0 during individual sampling events. These stations are affected more by groundwater seepage from the upland and outflows from the kettle ponds. Groundwater throughout Cape Cod has pH levels of between 6 and 6.5; Frimpter and Gay (1979) measured a median pH of 6.1 in 202 wells. Due to the permeability of the sandy soils on Cape Cod, pond waters have similar pH levels as the groundwater. The average surface pH of 193 ponds sampled on Cape Cod was 6.2 with a range of 4.4 to 8.9 (Eichner et al. 2003). Ponds that are least affected by development have pH levels closer to average pH level of rain of 5.7 (Eichner 2009). These data indicate that the pH of the headwater stations reflect average conditions on Cape Cod, whereas pH levels in the mid-river section, particularly in the drainage ditches, are lowered by chemical oxidation processes.

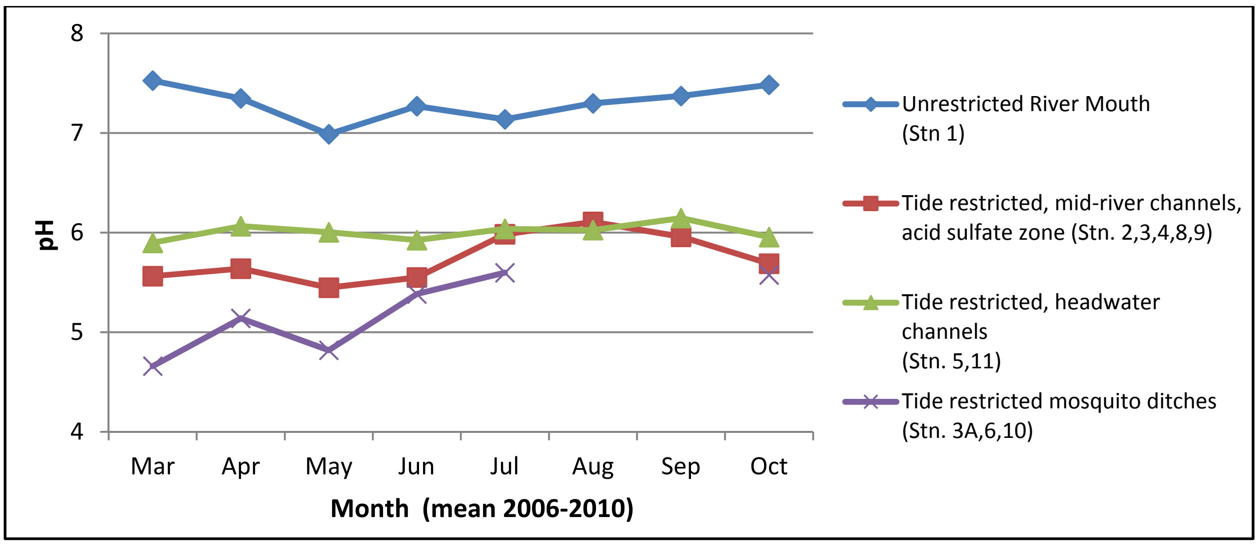


FIGURE 3-5: MONTHLY MEAN PH LEVELS IN THE HERRING RIVER AT LOW TIDE (2006 TO 2010 CAPE COD NATIONAL SEASHORE MONITORING DATA)

TABLE 3-2: MEAN, MINIMUM, AND MAXIMUM MONTHLY pH LEVELS IN THE SURFACE WATER OF HERRING RIVER (2006 TO 2010 CAPE COD NATIONAL SEASHORE MONITORING DATA)

Station	pH (monthly Mean, 2006–2010)*								Combined March to October pH Levels				No. of ALL Samples
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Mean	std dev	Max	Min	
River Mouth: Unrestricted													
1	7.5	7.3	7.0	7.3	7.1	7.3	7.4	7.5	7.3	0.2	8.2	6.6	39
Mid-river Channels: Tide restricted, acid sulfate zone													
2	5.5	5.7	5.5	5.4	6.3	6.2	5.9	6.0	5.8	0.3	6.9	4.2	39
3	5.5	5.7	5.4	5.6	6.3	6.4	6.2	5.9	5.9	0.4	7.5	4.1	39
4	5.9	5.9	5.8	5.8	5.9	6.1	6.2	5.9	5.9	0.2	7.2	4.4	39
8	5.9	5.8	5.6	5.8	5.9	6.2	5.9	5.9	5.9	0.2	6.9	4.9	39
9	5.1	5.2	4.9	5.2	5.5	5.5	5.6	4.8	5.2	0.3	6.8	3.6	39
Headwater Channels: Tide restricted													
5	5.9	6.0	5.8	5.6	5.9	6.0	6.0	6.0	5.9	0.2	6.7	4.4	38
11	5.9	6.1	6.2	6.3	6.2	6.1	6.3	5.9	6.1	0.1	7.0	5.2	39
Mosquito Ditches: Tide restricted													
3A	3.5	3.8	3.8	4.5	4.5	dry	3.9	4.8	4.1	0.5	5.8	3.0	21
6	6.3	6.1	5.5	5.8	6.7	dry	dry	6.0	6.1	0.4	8.7	5.0	21
10	4.2	5.5	5.1	5.9	dry	dry	dry	6.0	5.3	0.7	6.7	3.3	21

* Samples were collected at low tidal conditions.

Downstream of the dike, the March to October mean pH level was 7.4 (with a range of 6.6 to 8.2), meeting the regulatory standard. These pH levels indicate that the volume of acidic water in the upper part of the estuary is small enough to be neutralized quickly once the water reaches the well-buffered tidal water of the lower estuary. For reference, the pH in Wellfleet Harbor is approximately eight (Cape Cod Extension 2011). Sulfate generated in the acid sulfate zone of the Herring River estuary does not affect receiving marine waters because this anion is naturally abundant in seawater and is neutralized by seawater cations, especially sodium and magnesium. The mean annual sulfate concentrations at the stations in the upper estuary were 0.009 mg/l at the headwater stations, 0.014 mg/l at the mid-river stations, and 0.066 mg/l in the mosquito ditches. The mean March to October sulfate concentration at the unrestricted station 1 was substantially higher at 1.3 mg/l (figure 3-6).

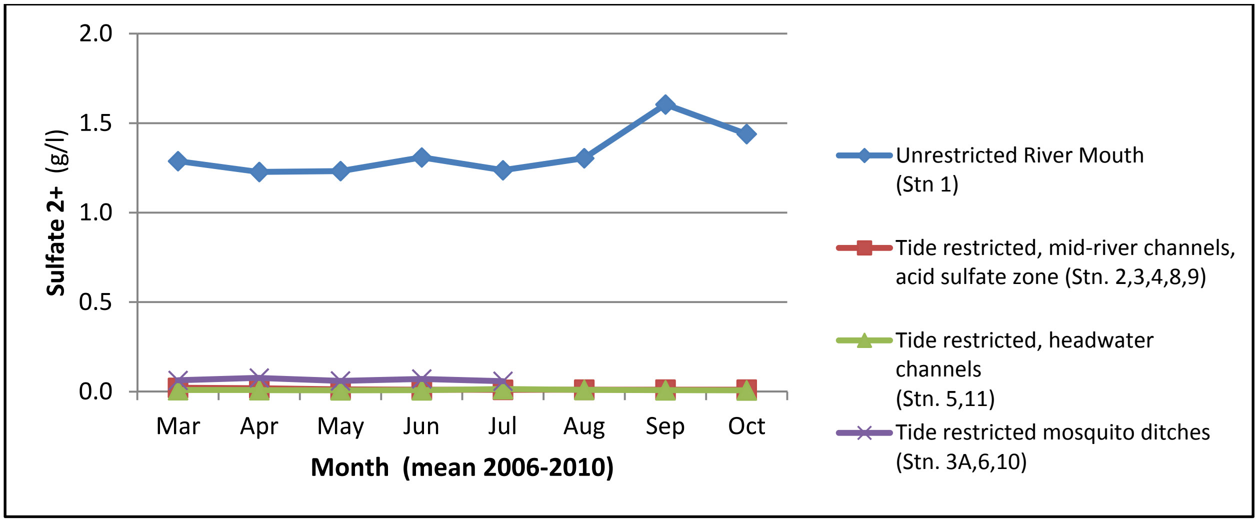


FIGURE 3-6: MONTHLY MEAN SULFATE CONCENTRATIONS IN THE HERRING RIVER AT LOW TIDE FROM 2006 TO 2010 (CAPE COD NATIONAL SEASHORE MONITORING DATA)

3.3.3 METALS

Metals in Surface Water

Low pH levels can cause leaching of metals from marsh soil, degrading water quality if they reach toxic concentrations. As stated previously, salt marsh soils naturally contain iron sulfides (particularly pyrite) that form under water-saturated and anaerobic conditions. Oxidation of the soil in dewatered marshes, such as the Herring River, releases iron, which may be present as ferrous iron (Fe^{2+}) and as ferric iron (Fe^{3+}). Total dissolved iron concentrations in surface water measured by the Seashore from 2006 to 2010 were highest at locations with the lowest flushing. Specifically in mosquito ditches, the mean March to October total iron concentration ranged from 9 mg/l to 18 mg/l (figure 3-7), with individual measurements over this 5-year period reaching 76 mg/l. Mean total iron concentrations at the mid-river channel stations were lower, ranging from 1 mg/l to 3 mg/l, but still highly variable which may have been a function of varying flow rates. At the headwater stations, the mean March to October total iron concentrations were 0.5 mg/l with much lower variability among sampling events. The mean March to October total iron concentration at the dike was 0.27 mg/l. The U.S. Environmental Protection Agency (USEPA) recommends a criterion of 1 mg/l for freshwater chronic conditions (see table 3-3 for definition). This criterion was often exceeded at the stations in the mosquito ditches and in the acid sulfate zone, but rarely at the headwater stations. There are no recommended criteria for iron in salt water (which would apply to the station downstream of the dike).

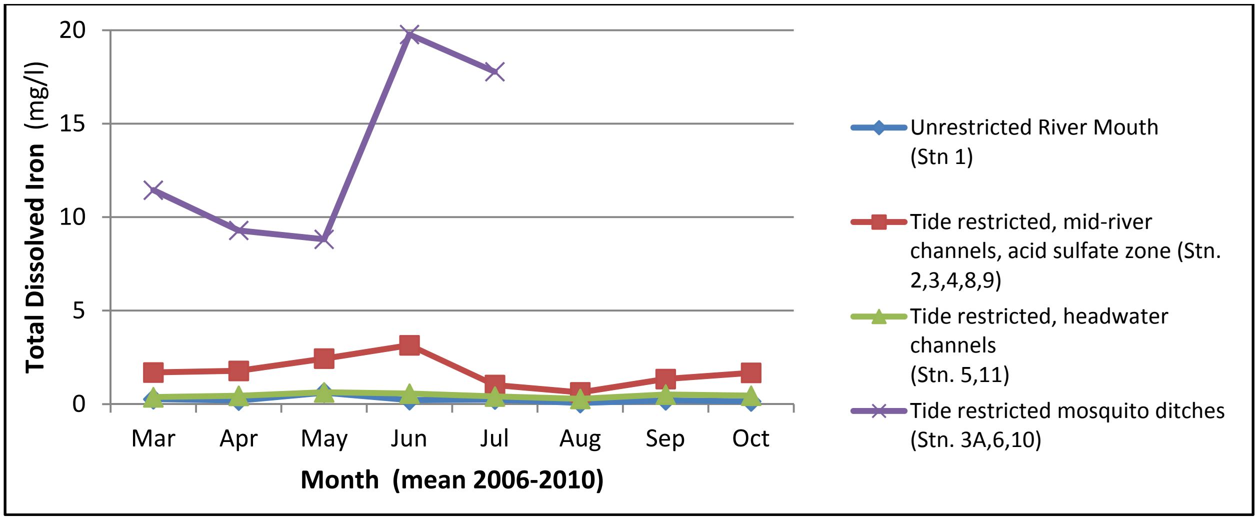


FIGURE 3-7: MONTHLY MEAN TOTAL IRON CONCENTRATIONS IN THE HERRING RIVER AT LOW TIDE FROM 2006 TO 2010 (CAPE COD NATIONAL SEASHORE MONITORING DATA)

TABLE 3-3: NATIONAL RECOMMENDED WATER QUALITY CRITERIA FOR SELECTED METALS

	Freshwater		Salt Water	
Metal	Criteria Maximum Concentration (or Acute) [a]	Criteria Continuous Concentration (or Chronic) [b]	Criteria Maximum Concentration (or Acute) [a]	Criteria Continuous Concentration (or Chronic) [b]
Aluminum (mg/l) (pH 6.5 – 9.0)	0.750 [c]	0.087 [c, d]	--	--
Arsenic (mg/l)	0.340 [e]	0.150 [e]	0.069 [e]	0.036 [e]
Iron (mg/l)	--	1.000	--	--

Source: USEPA 2009.

a “Acute criteria” corresponds to the USEPA definition of “Criteria Maximum Concentration” which was defined in 40 CFR 131.36 as the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time (1-hour average) without deleterious impacts.

b “Chronic criteria” corresponds to the USEPA definition of “Criteria Continuous Concentration” which is defined in 40 CFR 131.36 as the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious impacts.

c This value for aluminum is expressed in terms of total recoverable metal in the water column.

d The value of 0.087 mg/l is based on a toxicity test with the striped bass in water with pH = 6.5–6.5 and hardness <10 mg/L. Data in “Aluminum Water-Effect Ratio for the 3M Plant Effluent Discharge, Middleway, West Virginia” (May 1994) indicate that aluminum is substantially less toxic at higher pH and hardness, but the impacts of pH and hardness are not well quantified at this time.

In tests with the brook trout at low pH and hardness, impacts increased with increasing concentrations of total aluminum even though the concentration of dissolved aluminum was constant, indicating that total recoverable is a more appropriate measurement than dissolved, at least when particulate aluminum is primarily aluminum hydroxide particles. In surface waters, however, the total recoverable procedure might measure aluminum associated with clay particles, which might be less toxic than aluminum associated with aluminum hydroxide.

The USEPA is aware of field data indicating that many high quality waters in the United States contain more than 0.087 mg/l of aluminum, when either total recoverable or dissolved is measured.

e Dissolved arsenic.

Acidic soils can also mobilize naturally occurring aluminum and heavy metals (such as arsenic) from the clays within the marsh soil. There are no regulatory water quality standards or USEPA guideline values for aluminum in salt water (USEPA 2009). For freshwater, the National Recommended Water Quality Criteria for total recoverable aluminum are 0.75 mg/l (acute conditions) and 0.087 mg/l (chronic conditions) (table 3-3). The USEPA noted that the value of 0.087 mg/l is based on a toxicity test in water with pH of 6.5 to 6.6 and a hardness of less than 10 mg/l; the toxicity of aluminum appears to vary with different pH and hardness conditions. Other research examined the impact of elevated aluminum concentrations on the aquatic ecosystem. For example, Driscoll et al. (1980) considered aluminum concentrations of 0.3 mg/l toxic to many fish. Baker and Schofield (1982) found that aluminum concentrations of greater than 0.1 mg/l (for white suckers) and 0.2 mg/l (for brook trout) reduced the survival and growth of larvae and postlarvae at the investigated pH levels of 4.2 to 5.6. Sparling, Lowe, and Campbell (1997) suggested that aluminum concentrations of greater than 0.1 mg/l can be harmful for many fish in mildly acidic water.

Dissolved aluminum concentrations measured by the Seashore in the Herring River estuary during 6 months in 2007 showed that only one third of the stations had dissolved aluminum concentrations above the analytical laboratory reporting limit of 0.05 mg/l (table 3-4)[1]. Of those stations that had reportable dissolved aluminum concentrations, the mean concentration was 0.25 mg/l and the highest reading was 1.2 mg/l. At station 1 near the dike, the dissolved aluminum concentration was below the laboratory reporting limit at all times. In summary, dissolved aluminum concentrations occasionally exceeded concentrations of concern at some stations.

Arsenic can cause behavioral impairments, growth reduction, appetite loss, and metabolic failure in aquatic organisms (USEPA 2011). The National Recommended Water Quality Criteria for total recoverable arsenic in freshwater are 0.34 mg/l (acute conditions) and 0.15 mg/l (chronic conditions) (table 3-4). For salt water, recommended criteria are 0.069 mg/l (acute conditions) and 0.036 mg/l (chronic conditions). In the Herring River estuary, arsenic concentrations measured in the surface waters by the Seashore in 2007 did not exceed any of these recommended criteria (table 3-4).

Other heavy metals in the surface water analyzed by the Seashore in 2007 consisted of dissolved copper, zinc, and lead. Copper and zinc concentrations were below the laboratory reporting limit at all stations during all sampling events[2]. Lead was reported at low concentrations (all well below any level of ecological concern) in 8 of the 61 samples. Most of these samples were collected downstream of the dike (station 1), indicating that there is no substantial leaching of lead from the soil in the estuary.

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[1] Laboratory reporting limits are the lowest concentrations that can be reliably quantified under routine laboratory analyses.

[2] The reporting limit for copper was 0.025 mg/l. The reporting limit for zinc was 0.2 mg/l.

Table 3-4: Dissolved Aluminum and Arsenic Concentrations in the Surface Waters of Herring River in 2007 (Cape Cod National Seashore Monitoring Data)

Station	Aluminum, Dissolved (2007) (mg/l)						Arsenic, Dissolved (2007) (mg/l)					
	Mar 26	Apr 25	May 21	Jul 18	Aug 20	Sep 17	Mar 26	Apr 25	May 21	Jul 18	Aug 20	Sep 17
River Mouth: Unrestricted												
1	--	--	--	--	--	--	0.02	0.10	0.02	0.02	0.02	--
Mid-river Channels: Tide restricted, acid sulfate zone												
2	1.2	--	--	--	--	0.18	--	--	--	--	--	--
3	--	--	--	0.12	0.2	--	--	0.01	--	--	--	--
4	--	--	--	--	--	0.15	--	--	--	--	0.01	--
8	0.06	--	--	--	0.13	--	--	--	--	--	--	--
9	0.36	--	--	0.12	--	--	0.01	--	--	--	--	--
Headwater Channels: Tide restricted												
5	0.65	--	--	--	--	--	--	--	--	--	0.01	--
11	--	0.18	--	--	--	--	--	--	--	--	--	--
Mosquito Ditches: Tide restricted												
3A	--	0.55	0.66	--	n/s	0.53	--	--	--	--	n/s	--
6	0.63	0.15	0.1	--	n/s	n/s	--	--	--	--	n/s	n/s
10	0.66	0.29	0.18	--	n/s	n/s	--	--	--	--	n/s	n/s

n/s = Not sampled due to lack of water in the channel.
Entries marked with "--" reflect measurements below the laboratory reporting limit.

Metals in Sediment

During Seashore monitoring in August 2007 concentrations of zinc, copper, lead, and aluminum in the Herring River estuarine soil were low (table 3-5). Copper and zinc concentrations were below the reporting limit at all stations. One of the eight samples reported lead at concentrations well below National Oceanic and Atmospheric Administration (NOAA) sediment guideline concentrations. Aluminum occurs naturally in high concentrations in all soils. There are no NOAA sediment guideline values for aluminum.

Arsenic concentrations in seven out of the eight analyzed soil samples ranged from 1.7 to 17 mg/kg (table 3-5). The mean concentration of 7.7 mg/kg was below the effects range low (ERL) guideline value of 8.2 mg/kg for arsenic in marine sediments and well below the more critical effects range median (ERM) guideline value of 70 mg/kg. All values were also below the S-2 Soil Standard for Massachusetts for residential and non-residential properties of 20 mg/kg (MassDEP 2011b).

Arsenic in the Herring River marsh soils likely originates from natural sources (common in New England soils) but may also be related to the wide use of lead arsenate-based pesticides for control of mosquito and gypsy moth larvae before the advent of dichlorodiphenyltrichloroethane (DDT). Arsenic is a relatively abundant element in the earth's crust; the average concentration in Massachusetts soils is 4.7 mg/kg (MassDEP 2002).

TABLE 3-5: CONCENTRATIONS OF METALS IN SOIL SAMPLES FROM THE HERRING RIVER ESTUARY ON AUGUST 20, 2007 (CAPE COD NATIONAL SEASHORE DATA)

Station	Concentrations (mg/kg)				
	Aluminum	Arsenic	Copper	Lead	Zinc
River Mouth: Unrestricted					
1	2,800	3.4	--	--	--
Mid-river Channels: Tide restricted, acid sulfate zone					
2	1,000	1.7	--	--	--
3	8,000	17.0	--	31	--
4	1,800	--	--	--	--
8	4,000	7.1	--	--	--
9	6,800	7.4	--	--	--
Headwater Channels: Tide restricted					
5	2,100	4.5	--	--	--
11	1,800	13.0	--	--	--
Mean (all stations)	**3,538**	**7.2**	--	--	--
NOAA Guideline Values (mg/kg) (Buchman 2008)					
Freshwater Sediment					
TEL	n/a	5.9	35.7	35.0	123
PEL	n/a	17.0	197.0	91.3	315
Salt Water Sediment					
ERL	--	8.2	34.0	46.7	150
ERM	--	70.0	270.0	218.0	410

Entries marked with "--" reflect measurements below the laboratory reporting limit.

TEL: Threshold Effects Level; concentration below which adverse effects are expected to occur only rarely.

PEL: Probable Effects Level; concentration above which adverse effects are frequently expected.

ERL: Effects Range Low; concentration at which toxicity is found about 10% of the time.

ERM: Effects Range Median; concentration at which toxicity is found about 50% of the time.

Additional sediment analysis was conducted by the Seashore in 2014 to update information on metals and pesticide concentrations (tables 3-6 and 3-7). Six sediment samples were collected from the Herring River, including five samples between the Chequessett Neck Road Dike and High Toss Road, and one sample from just downstream of the dike (see figure 3-8). Multiple samples were collected at each location to develop a single composite sample for lab analysis of aluminum, arsenic, copper, lead, and zinc. Sample depths were 20–40 cm (consistent with an upper area of biological activity).

Data results from this testing are generally consistent with the 2007 data, although three stations returned levels of arsenic between ERL and ERM guidelines. Two of these were also above the S-2 Soil Standard for Massachusetts for residential and non-residential properties; however the overall mean value is below this threshold.

TABLE 3-6: CONCENTRATIONS OF METALS IN SEDIMENT SAMPLES FROM THE HERRING RIVER ESTUARY 2014 (CAPE COD NATIONAL SEASHORE DATA)

Station	Concentrations (mg/kg)				
	Aluminum	Arsenic	Copper	Lead	Zinc
Below the Chequessett Neck Road Dike					
HR1	996	1.92	3.30	2.45	9.16
Between Chequessett Neck Road Dike and High Toss Road					
HR2	3060	6.16	5.14	8.46	17.80
HR3	11300	48.1	10.6	21.1	37.5
HR4	8400	19.2	10.4	16.5	34.6
HR5	1550	2.95	2.17	4.15	9.29
HR6	5510	34.2	16.4	13.2	41.9
Mean (all stations)	**5136**	**18.8**	**8.0**	**11.0**	**25.0**
Freshwater Sediment					
TEL	--	5.9	35.7	35.0	123
PEL	--	17	197	91.3	315
Salt Water Sediment					
ERL	--	8.2	34.0	46.7	150
ERM	--	70.0	270.0	218.0	410

NOAA Guideline Values (mg/kg) (Buchman 2008)

Entries marked with "--" reflect measurements below the laboratory reporting limit.

TEL: Threshold Effects Level; concentration below which adverse effects are expected to occur only rarely.

PEL: Probable Effects Level; concentration above which adverse effects are frequently expected.

ERL: Effects Range Low; concentration at which toxicity is found about 10% of the time.

ERM: Effects Range Median; concentration at which toxicity is found about 50% of the time.

TABLE 3-7: CONCENTRATIONS OF PESTICIDES IN SEDIMENT SAMPLES FROM THE HERRING RIVER ESTUARY 2014 (CAPE COD NATIONAL SEASHORE DATA)

Sample [a]	Sediment Concentrations in Herring River - Stations													Marine Water Criteria [b]			
	HR1		HR2		HR3		HR4		HR5		HR6		Mean	TEL	ERL	PEL	ERM
Pesticides (ug/kg)																	
4,4'-DDD	0.3		49.5		11.1		5.1		0.3		24.7		15.2	1.22	2	7.81	20
4,4'-DDE	0.3		27.7		8.1		11.1		1.6	P	24.4		12.2	2.07	2.2	374	27
4,4'-DDT	0.3		0.7		1.0		0.6		0.3		4.4		1.2	1.19	1	4.77	7
Σ (4,4'-DDT+DDE+DDD)	0.3		77.9		19.2		16.2		1.9		53.5		28.2	3.89	1.58	51.7	46.1
2,4'-DDD	0.3		9.7		3.4		2.3		0.3		5.5						
2,4'-DDE	0.3		1.9	P	1.0		1.3	P	0.3		1.0						
2,4'-DDT	0.3		0.3		1.0		0.6		0.3		1.0						
Aldrin	0.3		0.3		1.0		0.6		0.3								
alpha-BHC	0.3		0.3		1.0		0.6		0.3								
alpha-Chlordane	0.3		0.3		1.0		0.6		0.3								
beta-BHC	0.3		0.3		1.0		0.6		0.3								
delta-BHC	0.3		0.3		1.0		0.6		0.3								
Chlordane	13.2		14.5		51.8		32.0		13.7		49.1			2.26	0.5	4.79	6
cis-nonachlor	0.3		0.3		1.0		0.6		0.3								
Dieldrin	0.3		0.3		1.0		0.6		0.3		1.3			0.715	0.02	4.3	8
Endosulfan I	0.3		0.3		1.0		0.6		0.3								
Endosulfan II	0.3		0.3		1.0		0.6		0.3								
Endosulfan sulfate	0.3		0.3		1.0		0.6		0.3		2.9						
Endrin	0.3		1.0	P	1.0		0.6		0.3								
Endrin aldehyde	0.8		0.9		3.1		1.9		0.8								
Endrin ketone	0.3		0.3		1.0		0.6		0.3								
gamma-BHC (Lindane)	0.3		0.3		1.0		0.6		0.3					0.32		0.99	

Sample [a]	Sediment Concentrations in Herring River - Stations													Marine Water Criteria [b]			
	HR1		HR2		HR3		HR4		HR5		HR6		Mean	TEL	ERL	PEL	ERM
gamma-Chlordane	0.3		0.3		1.0		0.6		0.3								
Heptachlor	0.3		0.3		1.0		0.6		0.3								
Heptachlor epoxide (B)	0.5		0.6		2.1		1.3		0.5		2.0						
Hexachlorobenzene	0.5		0.6		2.1		1.3		0.5		2.0						
Methoxychlor	2.6		2.9		10.3		6.4		2.7		9.8						
Mirex	0.3		0.3		1.0		0.6		0.3								
Oxychlordane	0.5		0.6		2.1		1.3		0.5		2.0						
Toxaphene	13.2		14.5		51.8		32.0		13.7		49.1						
trans-Nonachlor	0.3		0.3		1.0		0.6		0.3								

Exceedance of Saltwater guideline values:	33	A detected concentration exceeded the marine water ERL
	33	A detected concentration exceeded the marine water ERM.
		Not Detected; value listed is the Reporting Limit (RL) for the analysis.
	49.1	Reporting limit (RL) above the ERM for Chlordane

[a] Analyses from all samples presented on this table were conducted based on composite samples.

[b] Buchman, 1999.

P = Greater than 40% RPD between the two columns, the higher value is reported according to the method.

TEL: Threshold Effects Level; concentration below which adverse effects are expected to occur only rarely.

PEL: Probable Effects Level; concentration above which adverse effects are frequently expected.

ERL: Effects Range Low; concentration at which toxicity is found about 10% of the time.

ERM: Effects Range Median; concentration at which toxicity is found about 50% of the time.

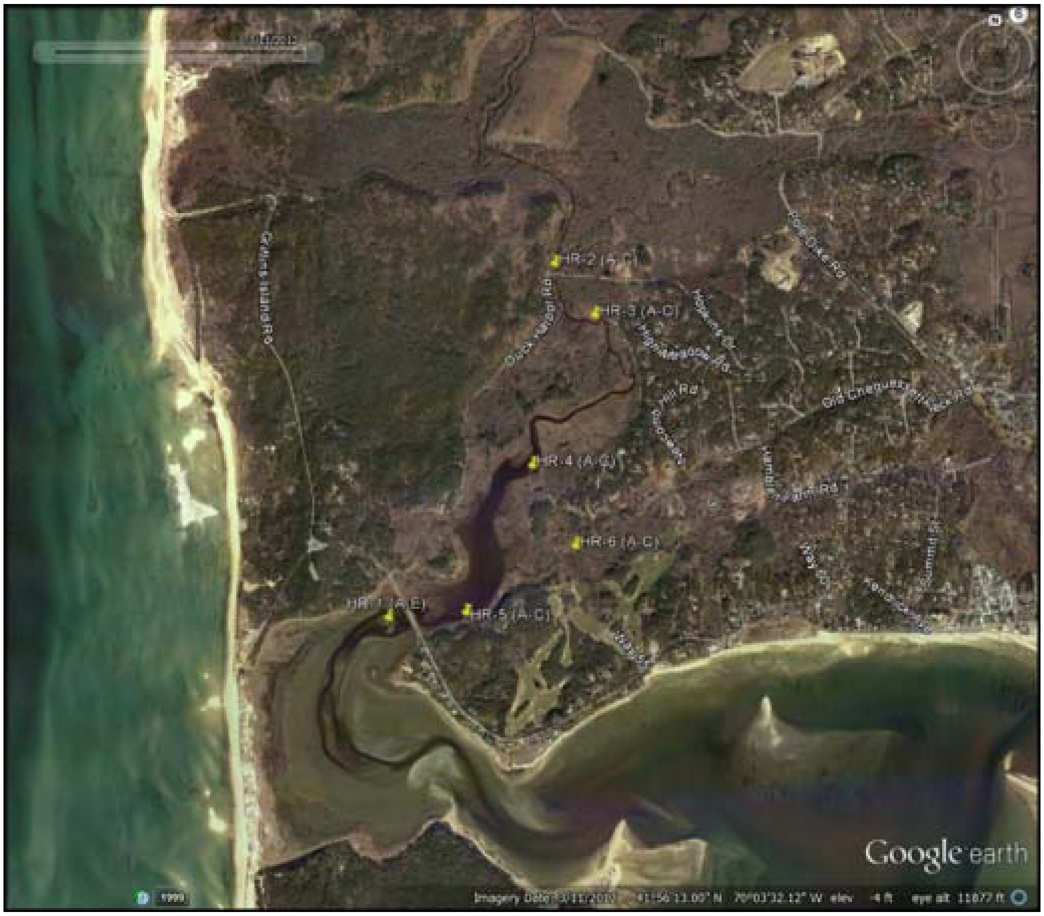


FIGURE 3-8: CAPE COD NATIONAL SEASHORE HERRING RIVER 2014 SEDIMENT SAMPLE LOCATIONS

3.3.4 NUTRIENTS

Compared to estuaries in more developed areas, point and nonpoint-source runoff into the Herring River is small. Although there is no documentation of specific anthropogenic or natural inputs, potential sources of excessive nutrients within the Herring River watershed include animal waste and atmospheric deposition. Irrespective of the exact sources of nutrient inputs, 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.

High organic matter production in salt marshes results in marsh soils that contain high concentrations of carbon and nutrients. Portnoy and Giblin (1997a) observed that the marsh soils of the Herring River estuary have retained high nitrogen and phosphorus concentrations, despite having been diked and drained for about a century. Here most inorganic nitrogen, the form used by plants and algae and most likely to cause eutrophication, is in the form of ammonium adsorbed to silt and clay particles. Experiments have shown that reflooding of these sediments with seawater will cause this ammonium-nitrogen to be released into receiving waters, at least over the short term (months) (Portnoy and Giblin 1997b). For this reason ammonium-nitrogen is of special concern in the Herring River and is a focus of ongoing nutrient monitoring. The highest ammonium concentrations were observed in the most acidic surface water samples (i.e., within the mosquito ditches) by the 2006 to 2010 Seashore monitoring program (figure 3-9).

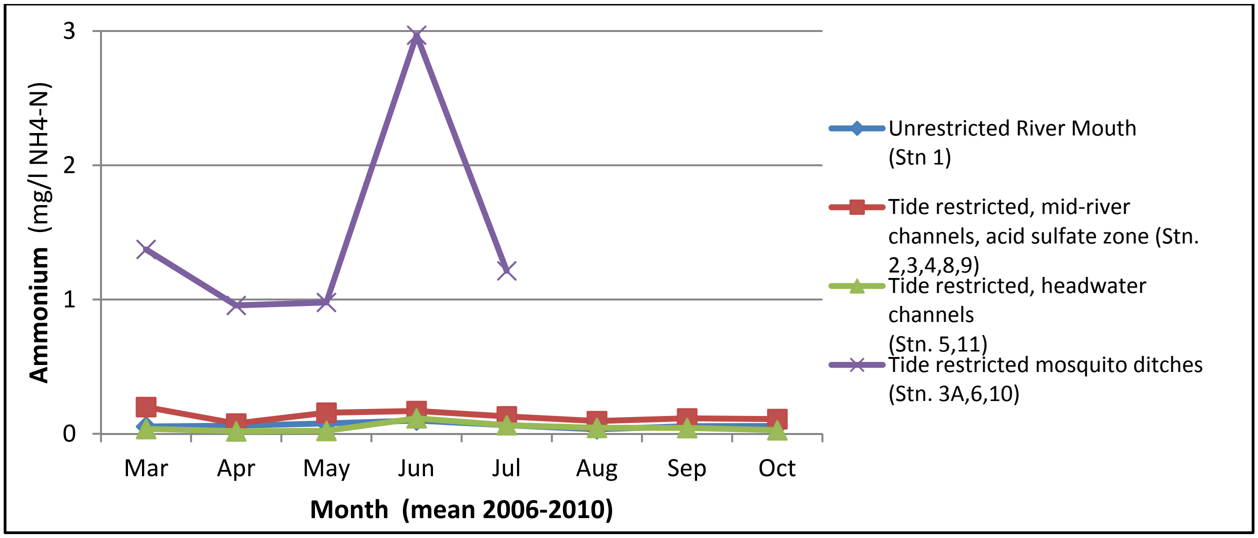


FIGURE 3-9: MONTHLY MEAN AMMONIUM CONCENTRATIONS IN THE HERRING RIVER AT LOW TIDE (2006 TO 2010 CAPE COD NATIONAL SEASHORE MONITORING DATA)

Phosphate levels are probably associated with the abundant iron and aluminum oxides remaining in the drained and aerobic marsh soils (figure 3-10). Tidal restoration is expected to cause a modest release of this chemically bound phosphorus through the dissolution of these minerals once the presently drained marsh peat again becomes waterlogged and anaerobic (Portnoy and Giblin 1997b). Phosphorus concentrations in the tide-restricted mid-river section and in the ditches are elevated reaching hypertrophic levels of greater than 0.1 mg/l. These concentrations are likely in part related to limited flows at these locations.

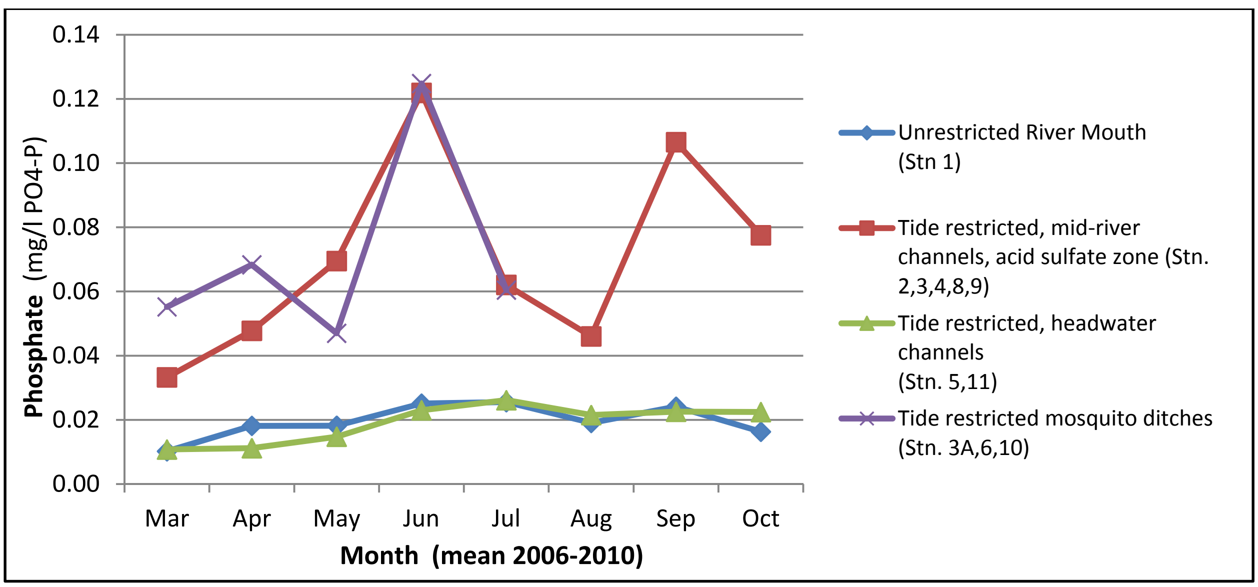


FIGURE 3-10: MONTHLY MEAN PHOSPHATE CONCENTRATIONS IN THE HERRING RIVER AT LOW TIDE (2006 TO 2010 CAPE COD NATIONAL SEASHORE MONITORING DATA)

3.3.5 Pesticides and Other Organic Compounds

Pesticides were used for mosquito control in the marsh in the past (Soukup and Portnoy 1986). Another potential source for pesticides could have been the Chequessett Yacht and Country Club (CYCC) golf course. The use of the pesticide DDT for agricultural purposes started in the United States in the 1940s and was banned in 1972; dieldrin (a common insecticide used from the 1950s to 1970s) was banned in 1985 (USEPA 2012). Pesticide concentrations (DDT, dieldrin) measured in the Herring River sediments downstream of the dike in 1969 (Curley et al. 1972) were found to be elevated for both compounds, exceeding NOAA ERM guideline values (Buchman 2008). However, samples analyzed for organics (including pesticides) from 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 the NOAA ERL guideline values, whereas PCBs and DDT were found to be above the ERL value but below the ERM value.

In 2007, the Seashore analyzed eight surface water samples for pesticides throughout the estuary (see figure 3-2, stations 1, 2, 3, 4, 5, 8, 9, 11). All samples tested below the analytical reporting limit (Cape Cod National Seashore, unpublished data).

To update information on sediment pesticide concentrations six sediment samples were collected from the Herring River in 2014, including five samples between Chequessett Neck Road Dike and High Toss Road, and one sample from just downstream of the dike (table 3-7 and figure 3-8). Multiple samples were collected at each location to develop a single composite sample for lab analysis. Sample depths were 20-40 cm (consistent with an upper area of biological activity).

Breakdown metabolites of DDT (**DDD** and DDE) were detected at all locations above the laboratory detection limit. The average concentration of total DDTs (a sum of all component parts) for the 2014 Herring River sampling was 33.6 parts per billion (ppb). Mean total DDT concentration from the 17 marshes throughout the Seashore included in the Quinn et al. (2001) study was 22 ppb. For comparison, the most conservative Method 1 Cleanup Standard (S1/GW1) for soil in the Cape Cod Mosquito Control Project (CCMCP) for DDT, DDD, and DDE combined is 10,000 ppb. The contemporary data, therefore, are very similar to previously identified background concentrations throughout the Cape Cod National Seashore and are well below published cleanup standards to address human health in Massachusetts.

3.3.6 Fecal Coliform

The Herring River is listed as impaired for fecal coliform in a 0.39 square mile area between Griffin Island and Wellfleet Harbor (MassDEP et al. 2009). In 2005, fecal coliform concentrations in Herring River at nine stations between High Toss Road and Egg Island were found to be elevated, reaching up to 1,000 colonies per 100 ml during the outgoing tide (figure 3-11; Portnoy and Allen 2006). For reference, shellfish harvesting is prohibited if the coliform concentrations exceed 14 colonies per 100 ml. During incoming tide on September 20, the concentrations at the most seaward stations 8, 9, and 10 were below this regulatory level reflecting the inflow of water from Wellfleet Harbor; higher fecal coliform concentrations existed further upstream (stations 5, 6, and 7), reflecting the lower tidal flushing rates. At stations 1 to 4, fecal coliform concentrations were similar during high and low tides. High fecal coliform concentrations have kept the Herring River downstream of the dike permanently closed for shellfishing in some parts and only conditionally approved in other parts (see section 3.10, figure 3-26).

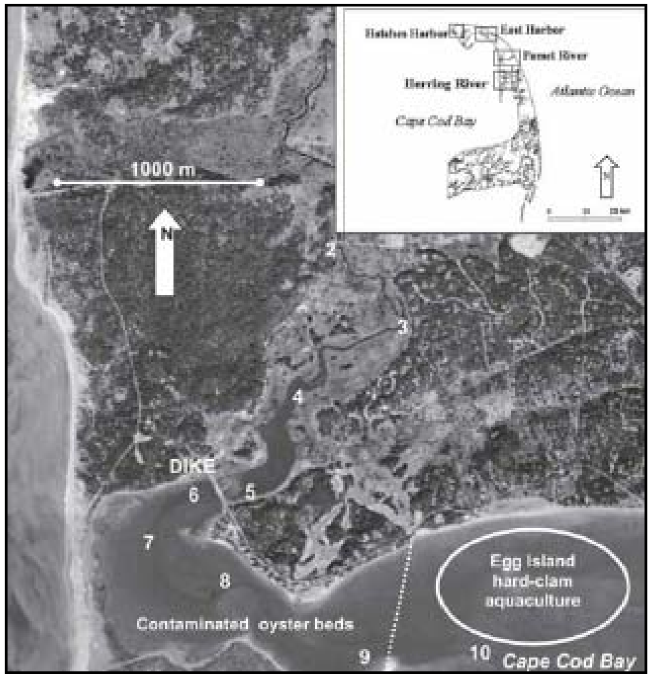


FIGURE 3-11: SAMPLING STATIONS FOR FECAL COLIFORM ANALYSES IN THE SURFACE WATERS OF THE HERRING RIVER IN 2005

Fecal coliform bacteria are found only in the fecal waste of warm-blooded organisms. Given the small number of houses (all of which have septic systems) within the watershed, the likelihood of fecal coliform bacteria from human sources is low. Therefore, fecal coliform bacteria probably originate from wildlife in the estuary and watershed (although confirmatory data do not exist). Over seven dry-weather sampling events, fecal coliform concentrations measured by Portnoy and Allen (2006) were highest in the tidal waters just upstream and seaward of the Chequessett Neck Road Dike (figure 3-12). However, peak fecal concentrations were measured after Tropical Storm Ophelia throughout the entire Herring River estuary, including the upper estuary. In fact, concentrations were higher by a factor of 2 to 4 over mean concentrations measured during the dry weather events, suggesting that runoff from the 3.5-inch rainstorm may have washed bacteria from wildlife sources in the marsh and surrounding watershed into the estuarine waters. Concentrations measured after the storm at stations near the dike were approximately 800 colonies per 100 ml.

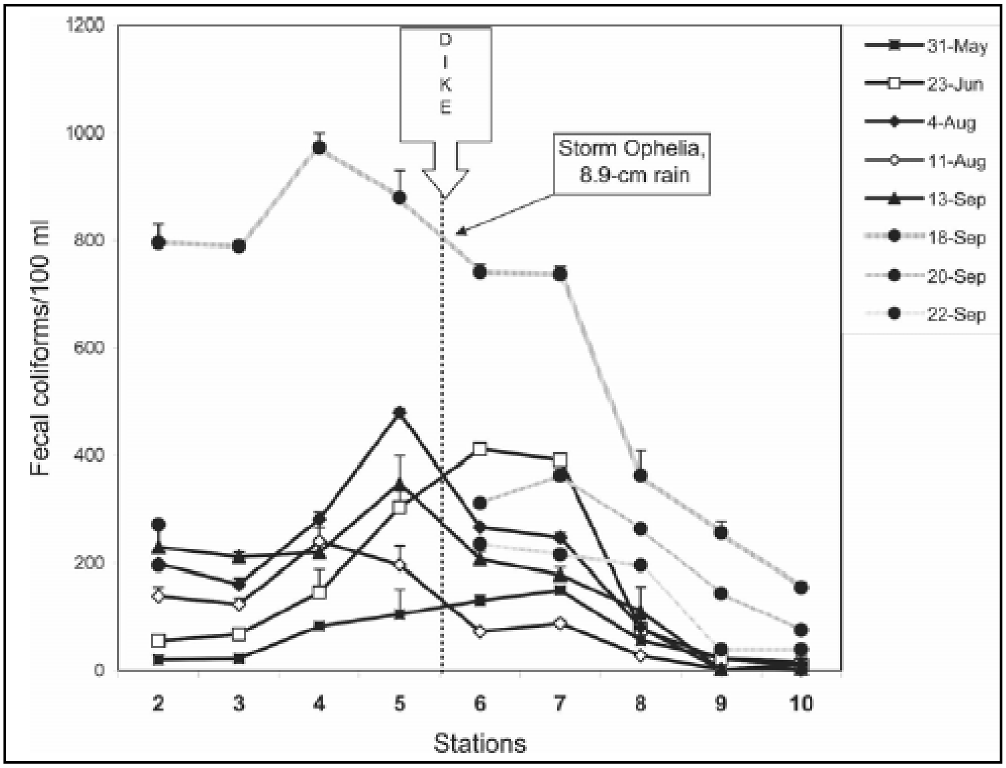


FIGURE 3-12: FECAL COLIFORM CONCENTRATIONS IN THE HERRING RIVER ESTUARY AT LOW TIDE

3.4 SEDIMENT TRANSPORT AND SOILS

The basic geomorphology surrounding the Herring River has been primarily determined by relatively recent glacial processes, which ended about 15,000 years before present. Landforms are generally comprised of post-glacial outwash plain deposits (fine to coarse gravelly sand, variably sized pebbles, stones, and boulders). Fluctuating sea levels associated with glacial retreat caused deposition of marine sands, silts, and clays (Oldale 1969). As sea level change slowed about 4,000 years ago, organic accumulation began to form peat, which provided the base for salt marshes to develop. Material derived from decaying salt marsh plants, diurnal tidal exchange, and coastal storm surges was crucial for maintaining salt marsh elevations as the sea level increased; the material eventually accumulated to a thickness of about ten feet (Roman 1987, Appendix 1). When the Herring River was diked more than 100 years ago, these processes were interrupted and both the salt marsh and the underlying peat began to subside.

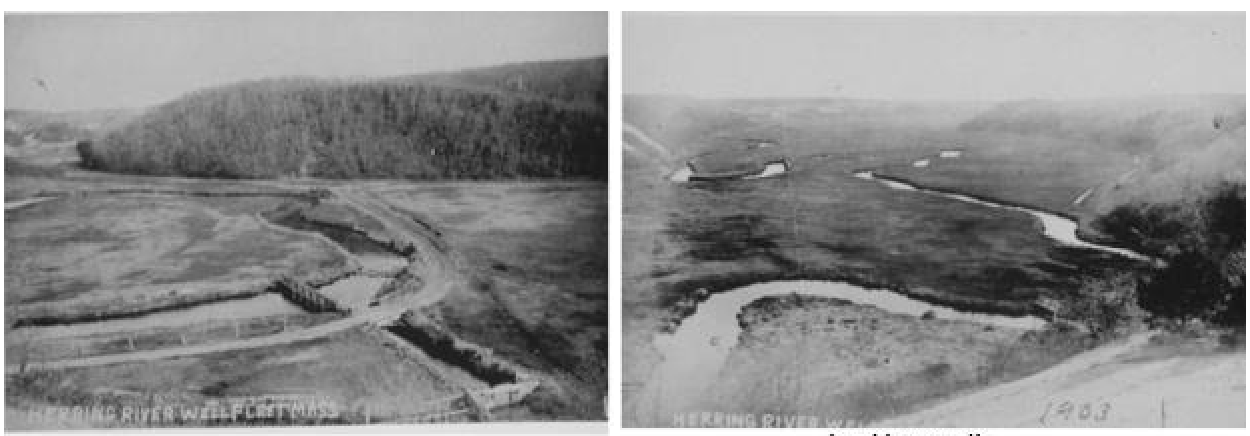
The ecological functions of the Herring River estuary are dependent on and linked to the river's proximity and connections to Cape Cod Bay and Wellfleet Harbor. Historically, a direct hydrologic connection to the bay existed at Duck Harbor in addition to the existing connection to the harbor at Chequessett Neck (now diked). The Duck Harbor inlet augmented tidal exchange into the upper reaches of Bound Brook and the Herring River, but mapping by the U.S. Coastal Survey (later, the U.S. Geological Survey) beginning in the 1840s shows the Duck Harbor channel naturally migrating southward and closing. Although the exact year of closure is unclear, by the time the Chequessett Neck Road Dike was constructed, the Duck Harbor channel was completely filled in.

Southward longshore drift along Cape Cod Bay also created Ryder Beach, Duck Harbor Beach, and Jeremy Point and the dunes which eventually connected Bound Brook Island, Griffin Island, and Great Island. The stretch of sand connecting Griffin and Great Islands, called a “tombolo” in geologic terms, is locally known as “the Gut.” The Gut formed long before the Herring River was diked and was not affected after the dike was constructed. The Gut is kept stabilized by the abundant sand supplied from erosion of the beach and dunes. For this reason, the Herring River flows into Wellfleet Harbor rather than directly into Cape Cod Bay through the Gut barrier beach (Dougherty 2004).

There are two sediment-related issues relevant for this restoration project. First, opening the dike would mobilize sediment that has accumulated within the existing channels as a natural tidal channel system begins to re-establish itself. Second, changes in the tidal water surface elevation in the estuary along with subsidence of the marsh surface during the last 100 years need to be considered to assure successful transition back to a salt marsh with healthy vegetation. Potential sediment impacts to commercial shellfish resources downstream of the dike in Wellfleet Harbor are discussed in “Section 4-10: Impacts on Socioeconomics.”

3.4.1 TIDAL CHANNELS

Tidal wetlands generally have channel systems with dimensions that are proportional to the volume of water passing through them with each tidal cycle (Friedrichs and Perry 2001). Because the volume of water flowing through the estuary was greatly reduced by the construction of the Chequessett Neck Road Dike, the tidal channel system in the Herring River estuary that existed prior to the construction of the dike (figure 3-13) has completely or partially filled with sediment. In addition, the river was straightened in some areas in an effort to improve drainage of the marsh, cutting off meanders from High Toss Road to the present Route 6. Organic and inorganic sediment from estuarine and upland sources has filled these channels to varying degrees.



Looking north. Looking south.

As seen from Old County Road, looking north and south; the photographs provide an understanding of the channel dimensions that existed prior to the construction of the dike. (Source: Friends of the Herring River 2012.)

FIGURE 3-13: PHOTOGRAPHS OF HERRING RIVER ESTUARY FROM YEAR 1903

Other existing depositional features that likely will be affected by a change in hydrology from the restoration alternatives include the flood-tidal shoal that has formed just upstream and the smaller ebb-tidal shoal has formed just downstream of the Chequessett Neck Road Dike. Sediments in the shoals consist predominantly of sand (Harvey 2010). The net sediment transport under existing conditions is upriver as reflected in the larger flood-tidal shoal, but the extent of transport of sediment further upstream is limited because of low flow velocities and the attenuation of tidal flow, even during storm surges (Spaulding and Grilli 2001; WHG 2010 and 2011a). The flow is sufficient to move the predominantly coarse sediment only in the vicinity of the dike.

Sediment transport analyses of the existing system (see appendix B) found that normal tidal flow velocities are sufficient to initiate sediment movement, but only in the vicinity of the dike. The study confirmed that the system is flood-dominant; meaning that net transport of sediment is into the Herring River. This flood-dominant process is the result of the greater flow velocities created by the existing culverts and tide gates at the Herring River Dike, which confines the cross-section to one 6-foot wide culvert during flood tides as compared to the lower velocities created by the three 6-foot wide culverts during ebb tides. The dike has also caused a substantial reduction in flow velocity during flood tides in the area immediately downstream of the dike (as compared to pre-dike conditions), which likely has resulted in settling and deposition of suspended sediment during the slack flood tide in this area.

3.4.2 MARSH SURFACE ELEVATIONS

Tidal restrictions adversely affect the process of sediment deposition on salt marshes. Coastal marsh elevations must increase at a pace equal to or greater than the rate of sea level rise to persist and to promote the growth of salt marsh grasses. An increase in marsh elevation depends on several processes, including net transport of sediment into an estuary and its deposition onto the marsh, the growth and accumulation of organic matter on the marsh surface, and accumulation of belowground peat.

In the Herring River estuary, the 1909 dike construction greatly reduced the upstream transport of inorganic sediment from reaching the salt marshes within the basin. Additionally, marsh drainage has increased the rate of organic peat decomposition by aerating and drying the sediment and has caused soil pore spaces to collapse and marsh elevations to subside. Much of the marsh surface upstream of the dike is currently at elevations between 1 to 3 feet (figure 3-14). These elevations are up to 3 feet (90 cm) lower than the marsh surface downstream of the dike relative to modern mean sea level. Approximately 2.3 feet (70 cm) of this difference is directly due to subsidence from pore-space collapse and peat decomposition; the remaining 20 cm are a result of an increase in marsh elevation downstream of the dike due to accretion in Wellfleet Harbor caused by sea level rise. Therefore, much of the former salt marsh surface is approximately 1 to 3 feet lower than the mean high water elevation of 4.8 feet in Wellfleet Harbor (Portnoy and Giblin 1997a) (figure 1-2 and figure 3-15).

Ultimately, to restore a healthy salt marsh, surface elevations need to increase in response to the restored tide levels and to sea-level rise. With restoration of tidal flows, the drained peat would be resaturated and may expand slightly, peat accumulation will increase with growth of marsh vegetation, subsidence would be reduced, and sediment delivery to the marsh would be enhanced, all contributing to an increase in marsh elevation that is necessary to sustain a restored marsh ecosystem.

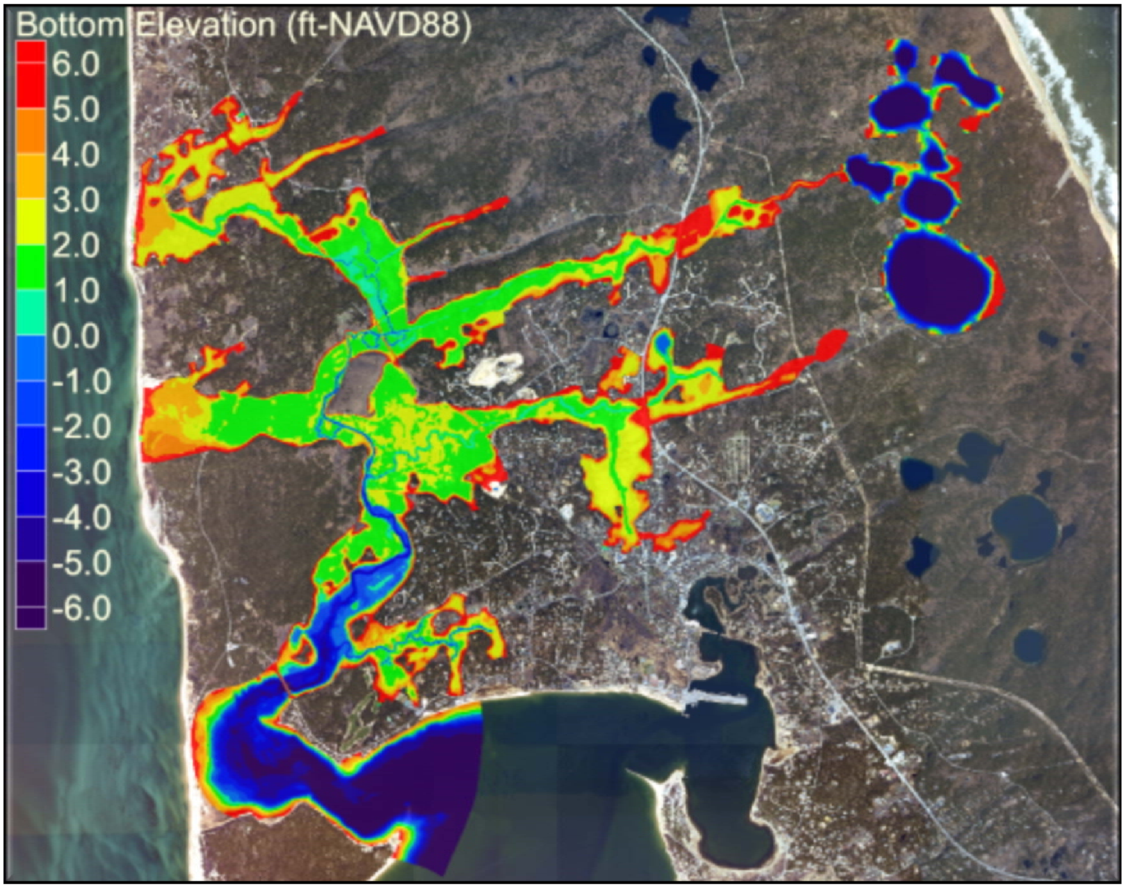
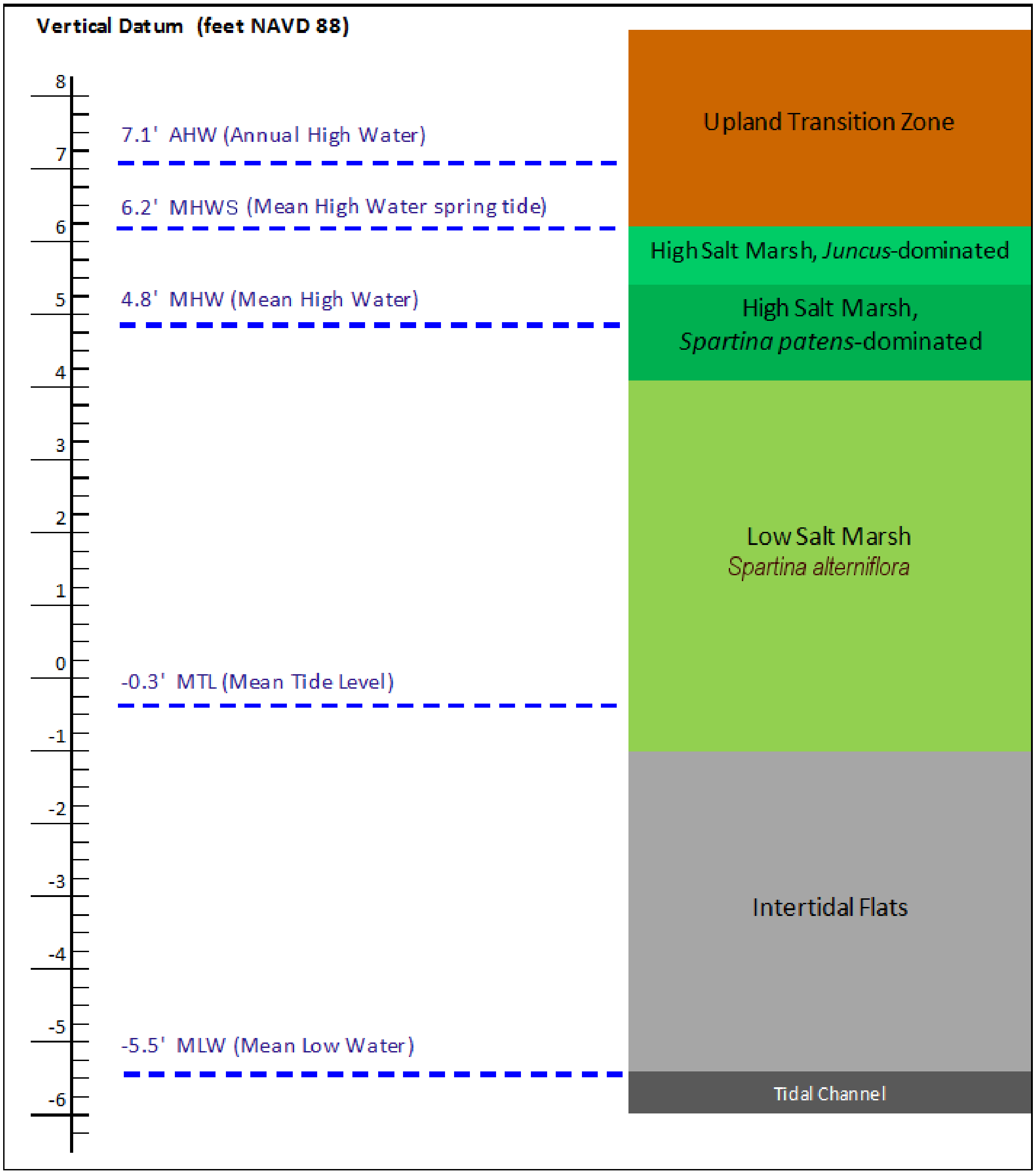


FIGURE 3-14: TOPOGRAPHY OF THE HERRING RIVER ESTUARY, BASED ON PHOTOGRAMMETRIC DATA



Note: All elevations presented in this EIS/EIR are based on the North American Vertical Datum of 1988 (NAVD88). NAVD88 replaced National Geodetic Vertical Datum of 1929 (NGVD 29) as a result of greater accuracy and the ability to account for differences in gravitational forces in different areas based on satellite systems. NAVD88 is 0.86 feet lower in elevation than NGVD 29.

FIGURE 3-15: IDEALIZED RELATIONSHIP BETWEEN SALT MARSH PLANT ZONATION AND MODEL DERIVED TIDAL ELEVATIONS FOR WELLFLEET HARBOR

3.4.3 SOILS

Approximately 80 percent of the Herring River flood plain is comprised of hydric soils, as determined by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) (figure 3-16). Typically, hydric soils include those developed under sufficiently wet conditions to support wetland vegetation. The following map unit descriptions are excerpted from the *Soil Survey of Barnstable County, Massachusetts* (Fletcher 1993). Soil types within the Lower Herring River sub-basin are generally equally distributed among subaqueous open water (22 percent), Freetown and Swansea mucks (22 percent), Maybid Variant silty clay loam (29 percent), and Carver coarse sand (23 percent). Freetown and Swansea mucks are very deep, level, very poorly drained soils found on outwash plains and moraines and in areas of glacial lake deposits. They are in depressions and in areas adjacent to streams, ponds, and lakes. Maybid Variant silty clay loam is a very deep, level, poorly drained soil found in low areas along the Herring River. This soil is formed in tidal marsh deposits that are no longer subject to tidal flooding and have been drained of salt water. Carver coarse sand is a very deep, gently sloping, excessively drained upland soil found in broad areas and on the tops of knobs on outwash plains.

Soils within the Mill Creek sub-basin are primarily comprised of Maybid silt loam (70 percent) with lesser amounts of Carver coarse sand (30 percent). Maybid silt loam is a very deep, nearly level, very poorly drained soil found in depressions, at the base of swales, and in low areas bordering ponds, streams, and swamps. The soil is formed in areas of glacial lake deposits. Soils within the Middle Herring River sub-basin are primarily comprised of Maybid Variant silty clay loam (79 percent) with lesser amounts of Freetown and Swansea mucks (11 percent) and Carver coarse sand (10 percent). Soils within the Pole Dike Creek sub-basin are primarily comprised of Freetown and Swansea mucks (83 percent) and Carver coarse sand (7 percent). Soils within the Duck Harbor sub-basin are generally equally distributed among Maybid Variant silty clay loam (43 percent), Pipestone loamy coarse sand (36 percent) and Carver coarse sand (20 percent). Pipestone loamy coarse sand is a very deep, nearly level, poorly drained soil found in depressions, at the base of swales, and in low areas bordering streams, ponds, and swamps. It is on outwash plains and in areas of glacial lake deposits. Soils within the Bound Brook sub-basin are primarily comprised of Freetown and Swansea mucks (73 percent) and with lesser amounts of Carver coarse sand (19 percent). Soils within the Upper Herring River sub-basin are primarily comprised of Freetown and Swansea mucks (72 percent) and with lesser amounts of Carver coarse sand (18 percent).

Three of the soil types are relevant for the Herring River project:

1. Carver coarse sand is an upland soil that surrounds most of the flood plain at higher elevations, such as Merrick Island. Its presence helps locate the upland/hydric soil boundary.
2. Maybid Variant silty clay loam is a hydric soil that it is formed in tidal marsh deposits that are no longer subject to tidal flooding and have been drained of salt water. Its presence illustrates that soils of the flood plain have been changed by the tidal restriction caused by the Chequessett Neck Dike, the Duck Harbor, and Bound Brook natural closures and marsh drainage. Since those hydrologic modifications have also changed the vegetation over time, upland plant types can be found in some parts of the flood plain growing on hydric soils.
3. Ipswich, Pawcatuck, and Matunuck peats occupy an area of salt marsh just south of the main dike at the mouth of the river. It is the typical soil complex found in unrestricted salt marshes.

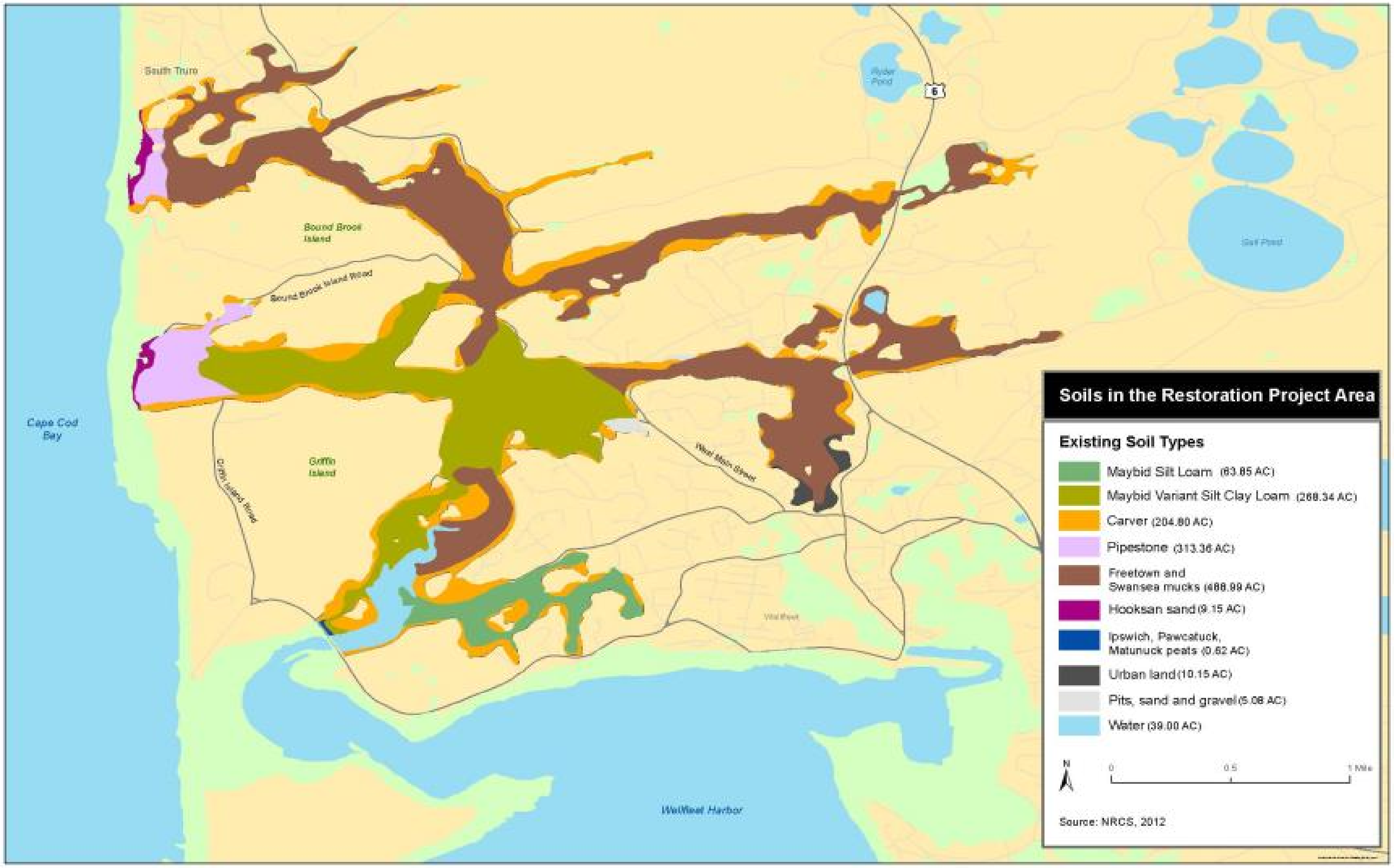
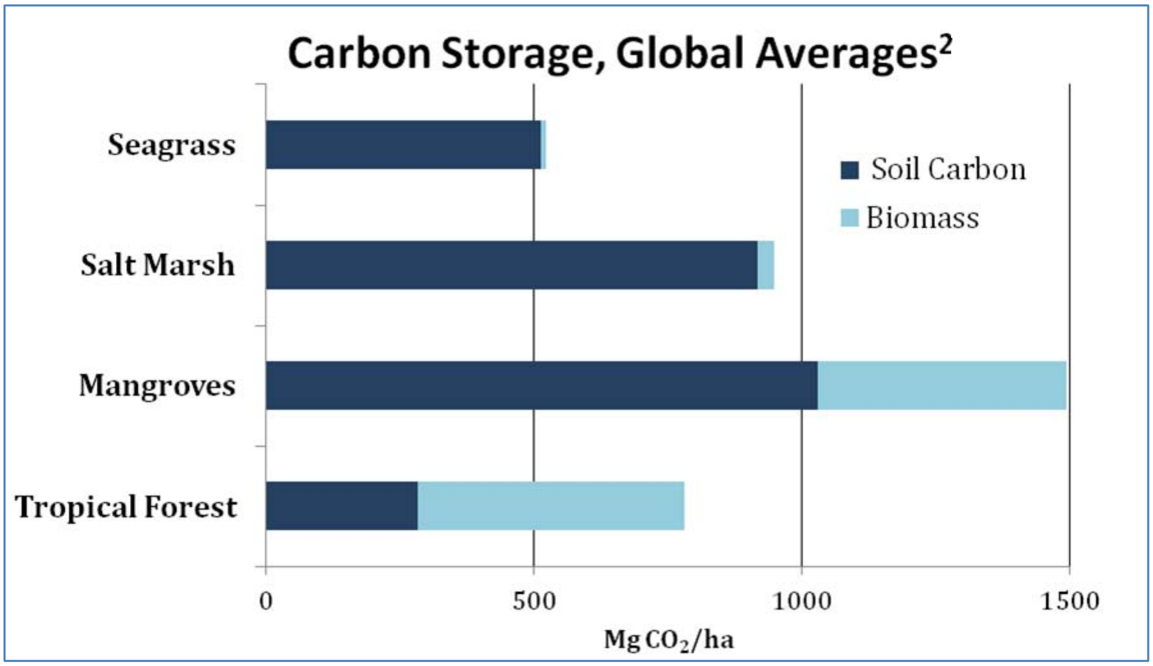


FIGURE 3-16: EXISTING SOILS IN THE HERRING RIVER FLOOD PLAIN

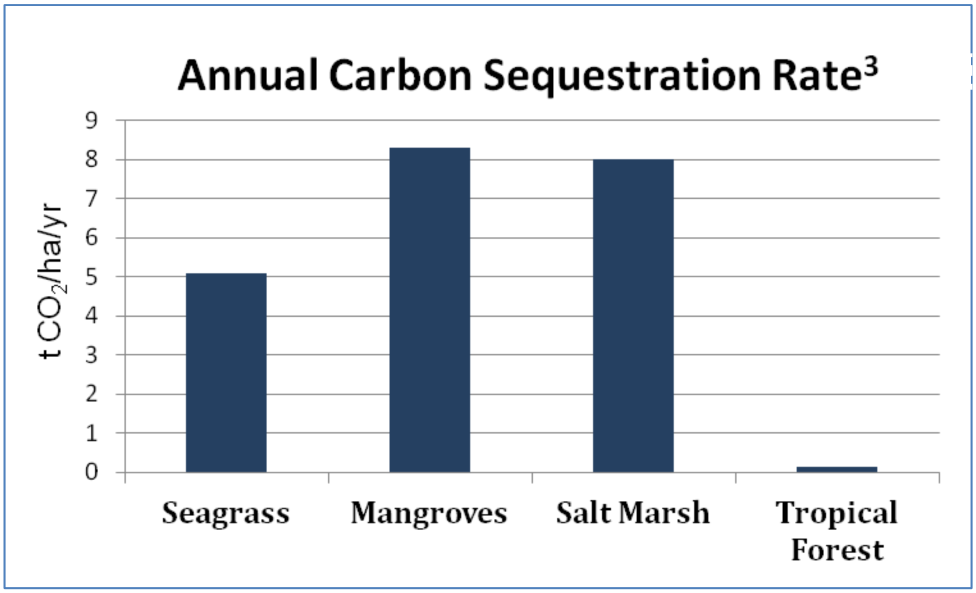
3.4.4 SEDIMENT TRANSPORT AND SOILS: BLUE CARBON

Blue carbon refers to the carbon naturally stored in coastal wetlands and seagrass beds. These habitats absorb and store massive amounts of carbon that would otherwise contribute to carbon dioxide loading in the atmosphere and global climate change. Wetlands store large quantities of carbon (Pendleton et al. 2012), and do it at a rate many times faster than even tropical forests. Moreover, because this storage is in waterlogged oxygen-poor peat, decomposition is very slow and turnover time of stored carbon is thus very long (McLeod et al. 2011). Salt marshes store carbon faster than nearly any other habitat on earth, except for mangroves, and about 80 times faster than tropical forests (figure 3.17). Salt marshes are exceeded only by mangrove forests, and far exceed tropical forests, in the amount of carbon that they store per unit area. Importantly, most of this carbon is stored in oxygen-poor peat, so that decomposition and the return of carbon to the atmosphere is very slow (figure 3.18). In addition to fish and wildlife habitat preservation, pollution control, and storm-surge buffering, carbon storage is now recognized as yet another reason for coastal wetland protection and restoration (Pendleton et al. 2013).



Source: McLeod et al. 2011.
Units are metric tonnes of carbon dioxide per hectare per year

FIGURE 3-17: CARBON STORAGE, GLOBAL AVERAGES



Source: Pendleton et al. 2012.
Units are megagrams per hectare; 1 megagram = 1 metric tonne = ~2200 pounds

FIGURE 3-18: ANNUAL CARBON SEQUESTRATION RATE

Several studies are currently underway to assess vertical and lateral movements of carbon between air, water, and soil in the Herring River flood plain, but the results are not yet available. Previous studies in New England have reported considerable variation of carbon storage rates in coastal wetlands. At salt marshes in Connecticut, average carbon storage rates were 165 $g/m^{-2}/yr$ in undisturbed salt marshes and 72 $g/m^{-2}/yr$ in tidally restricted marshes (Anisfield, Tobin, and Bernoit 1999, cited in Roman and Burdick 2012). On Cape Cod, work at the Waquoit Bay National Estuarine Research Reserve detected a range from 75 to 250 $g/m^{-2}/yr$ (Gonneea et al. n.d.).

Based on these studies, it is logical to conclude that hundreds of tons of carbon that would normally be buried in the Herring River flood plain each year remain suspended in the water column. In addition, huge volumes of previously stored carbon, deposited over millennia when the Herring River was open to full tidal exchange, has been mobilized and flushed out of the system. Quantifying the fate of lost carbon and carbon that is not deposited within the marsh is difficult, but most of it would eventually be oxidized and converted to carbon dioxide and emitted to the atmosphere, thereby contributing to the accumulation of greenhouse gas.

In addition to the functional loss of carbon storage, the tidally restricted Herring River is also likely contributing large volumes of methane to the atmosphere. Unlike the salt marshes that formerly dominated the Herring River, where sulfates prevented the production of methane from the soil, the freshwater wetlands that persist today undergo a form of anaerobic decomposition (i.e., methanogenesis), which produces methane (Poffenberger, Needelman, and Megonigal 2011). In a recent preliminary analysis, it was estimated that currently the Herring River is emitting 184 metric tons of methane per year (Walker 2015). This is particularly important because methane is estimated to be at least 20 times more potent as a greenhouse gas compared to carbon dioxide (Solomon et al. 2007).

3.5 WETLAND HABITATS AND VEGETATION

Wetland habitats and vegetation coverage within the Herring River flood plain have changed as Wellfleet Harbor developed into its current geological configuration and European settlers began to change the habitat conditions in the region. Over time longshore sediment transport created barrier beaches connecting Bound Brook Island and Griffin Island (Chamberlain 1964 in Snow 1975). Analysis of peat cores shows that salt marsh vegetation within the Herring River flood plain once extended east of present day Route 6 during the early formation of the marsh complex. However, much of the estuary shifted toward less salt tolerant vegetation with the natural closure of the Bound Brook and Duck Harbor tidal channels and reduction in tidal exchange (Orson and Roman 1987 in Roman 1987). Anthropogenic reductions in tidal exchange resulted from the construction of early roads across the flood plain and construction of the railroad to Provincetown in 1869. Following its construction, a large portion of the marsh upstream of the railroad embankment was separated from tidal impacts (Snow 1975). Further dramatic changes in vegetation resulted from the construction of the Chequessett Neck Road Dike in 1909, drastically reducing tidal flow at the mouth of the Herring River. Subsequent widespread ditching and straightening of the meandering creeks effectively drained most of remaining salt marshes. Based on an examination of historic aerial photography, Portnoy, Roman, and Soukup (1987) found brackish to fresh herbaceous marsh still persisted into the 1930s, but was largely replaced with woody species by 1977.

A summary of current wetland habitats and vegetation within the Herring River flood plain is based on vegetation mapping completed by the Seashore (figure 3-19). Color-infrared aerial photographs from 2000 were interpreted and assigned vegetation types from a broad classification system of New England plant communities (Sneddon 2004). Based in part on field observations in 2007, the classification was modified by the Seashore to include several unexpected assemblages of opportunistic upland species within drained portions of the flood plain where wetland communities would have been expected to appear (HRTC 2007). The Seashore mapping included 11 vegetation cover classes within the Herring River flood plain, as well as open water and developed lands. To further simplify the existing vegetation descriptions for this final *Herring River Restoration Environmental Impact Statement / Environmental Impact Report* (EIS/EIR), the various shrub and forested vegetation communities were consolidated into shrublands and woodlands. In addition, dune grassland and heathland grassland were consolidated into dune/heathlands and freshwater marsh and old field herbaceous were consolidated into freshwater marsh/meadow. The consolidation of the original 14 vegetation cover types into 8 classes is summarized in table 3-8. The aerial coverage of various consolidated cover types within the project area by sub-basin is provided in table 3-9.

Based on comments submitted after the release of the draft EIS/EIR and subsequent follow-up meetings with the National Heritage and Endangered Species Program (NHESP) and the Massachusetts Department of Environmental Protection (MassDEP), it was determined that additional analysis was necessary to adequately address agency comments and characterize potential changes to flood plain vegetation and associated habitats resulting from full implementation of the preferred alternative. This refined analysis is discussed in detail in chapter 4, section 4.5.7 “Refined Vegetation and Habitat Change Analysis of the Preferred Alternative for Final EIS/EIR.”

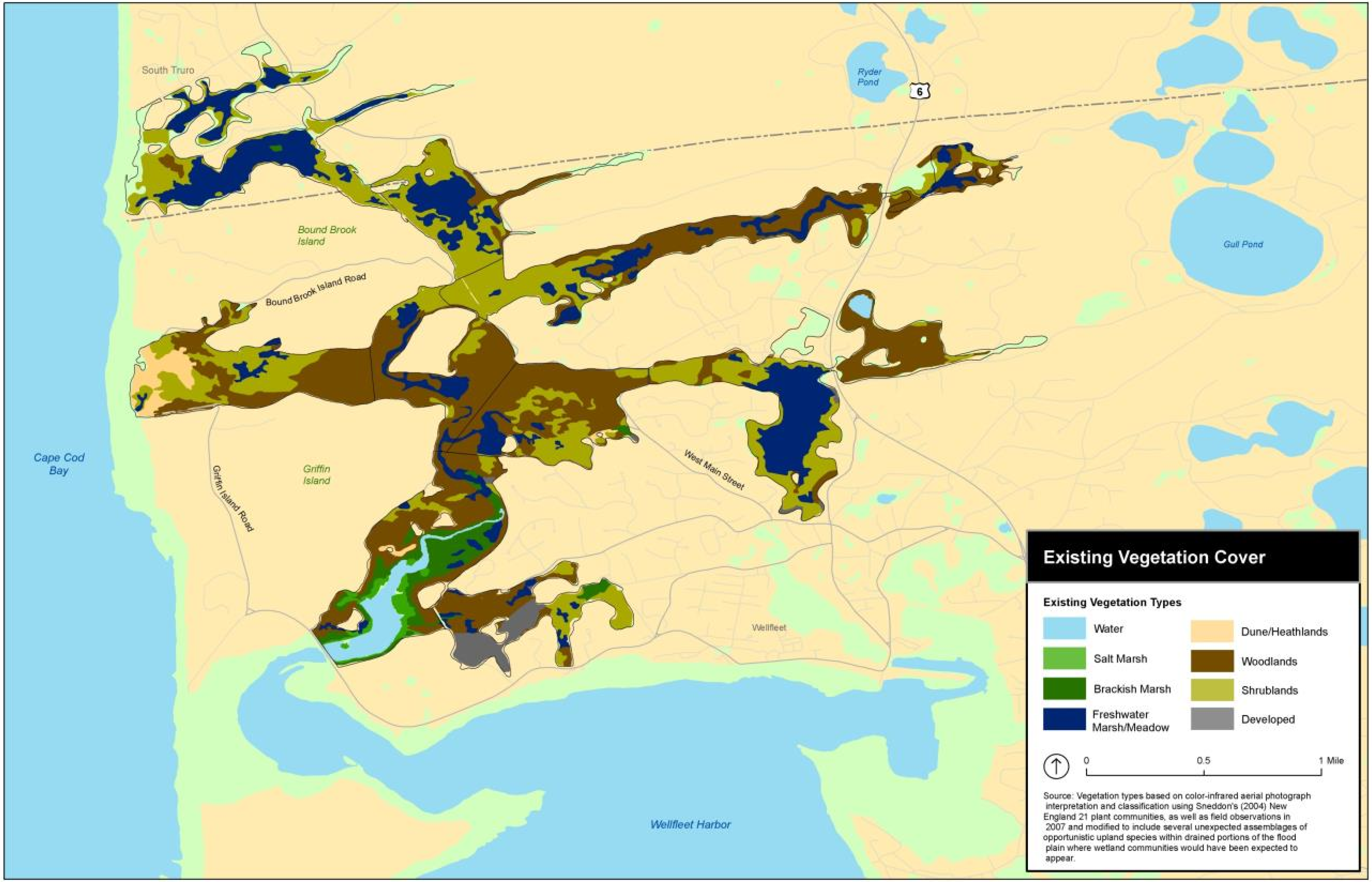


FIGURE 3-19: EXISTING VEGETATION COVER IN THE HERRING RIVER FLOOD PLAIN

TABLE 3-8: VEGETATION COVER TYPE CATEGORIES

Consolidated Cover Types	Original Seashore Mapping Cover Types
Water	Water
Salt Marsh	Salt Marsh
Brackish Marsh	Brackish Marsh
Freshwater Marsh/Meadow	Freshwater Marsh Old Field Herbaceous
Shrublands	Dry Shrubland Wet Shrub
Woodlands	Dry Deciduous Forest Dry Deciduous Woodland Pine Woodland Wet Deciduous Forest
Dune/Heathlands	Dune Grasslands Heathland Grasslands
Developed	Developed

To simplify the existing vegetation descriptions several vegetation cover types were consolidated into 8 cover types. However, for the final EIS/EIR refined vegetation and habitat change analysis, the original 14 cover type classes depicted on the 2007 Cape Cod National Seashore vegetation cover map were restored; this new analysis does not alter the original alternatives analysis or selection of a preferred alternative as discussed in chapter 4.

TABLE 3-9: EXISTING VEGETATION COVER TYPES IN ACRES WITHIN HERRING RIVER FLOOD PLAIN

Herring River Sub-basin	Water	Salt Marsh	Brackish Marsh	Freshwater Marsh/ Meadow	Shrub lands	Wood lands	Dune/ Heathlands	Developed	Total Area
Bound Brook			1	94	89	12			196
Duck Harbor				6	47	57	18		128
Lower Herring River	29	13	37	11	7	62	2	1	162
Middle Herring River				16	12	61		0	89
Mill Creek			3	6	17	25		20	71
Pole Dike Creek	3		1	60	78	116	1	3	262
Upper Herring River				29	49	69			147
Total Area	**32**	**13**	**42**	**222**	**299**	**402**	**21**	**24**	**1,055**

Source: HRTC 2007, Cape Cod Vegetation Map.

To simplify the existing vegetation descriptions several vegetation cover types were consolidated into 8 cover types (see table 3-8).

Typical vegetation is described in the following narrative. Where available, species occurrence is augmented by unpublished Seashore vegetation data collected in 2008 along 15 permanent transects established within the Herring River flood plain (8 within the Lower Herring River sub-basin, 4 within the Middle Herring River sub-basin and 3 within the Pole Dike Creek sub-basin, table 3-10). Table 3-10 lists representative species documented within each cover class and includes several species occurrences which are atypical for the listed vegetation type. These anomalies are attributed to the highly disturbed nature of the Herring River flood plain and the broad scale of cover type mapping which likely included transitional areas between various cover types.

3.5.1 SUB-TIDAL HABITAT

The Seashore vegetation map identifies 29 acres of open water within the Lower Herring River sub-basin which represents the impounded brackish condition immediately upstream of the Chequessett Neck Road Dike (table 3-9). This area of open water currently supports an extensive bed of submerged aquatic vegetation comprised of widgeon grass (Portnoy, Phipps, and Samora 1987; Snow 1975). An additional 3 acres of open water occur within the Upper Pole Dike Creek sub-basin east of Route 6. Watercress (*Rorippa nasturtium-aquaticum*) is a non-native, common freshwater submerged aquatic plant and is found within non-tidal portions of the Herring River (see “Section 3.5.9: Invasive Plants”).

3.5.2 SALT MARSH

As a result of natural and human-induced events, the previously extensive areas of salt marsh within the approximately 1,000-acre flood plain have nearly all developed into freshwater herbaceous and wooded habitats. Currently only 13 acres of salt marsh persist upstream of the dike within the Lower Herring River sub-basin (table 3-9). This area of salt marsh occupies a relatively narrow band between open water and brackish marsh dominated by common reed (*Phragmites australis*). In New England, salt marshes support salt-tolerant vegetation such as smooth cordgrass (*Spartina alterniflora*), salt marsh hay (*Spartina patens*), glasswort (*Salacornia virginica*), spikegrass (*Distichlis spicata*), black grass (*Juncus gerardii*), marsh elder (*Iva frutescens*), and groundsel bush (*Baccharis halimifolia*) (Niering and Warren 1980; Tiner 1987). Species occurrence in plots within salt marsh zones along permanent transects is found in table 3-10.

Within Herring River, Snow (1975) reported increases in smooth cordgrass and salt marsh hay fringing the river in response to the gradual deterioration of the original 1909 tide gates prior to their replacement in 1975. In subsequent surveys (Gaskell 1978; Valiela et al. 1983), a trend toward increased coverage of smooth cordgrass was reported, although no area estimates were provided. Portnoy, Roman, and Soukup (1987) reported an increase from zero to 7.4 acres of *Spartina*-dominated marsh between 1960 and 1977, reflecting the response of the vegetation community to increased salinity during the period when the tide gates were in disrepair.

3.5.3 BRACKISH MARSH

Forty-two acres of brackish marsh occurs within the project area, mostly within the Lower Herring River sub-basin (table 3-9). The remaining smaller areas lie within the Mill Creek, Bound Brook, and Pole Dike Creek sub-basins. In the Herring River, brackish marsh consists of nearly monotypic dense stands of common reed (*Phragmites australis*) with common three-square (*Schoenoplectus pungens*) a common associate. Common reed, a non-native invasive plant, is frequently found within tidally restricted marshes and tends to displace valuable native salt marsh and brackish plant communities. Species occurrence in plots within brackish marsh zones along permanent transects is found in table 3-9.

TABLE 3-10: SPECIES OCCURRENCE ALONG PERMANENT VEGETATION TRANSECTS WITHIN HERRING RIVER FLOOD PLAIN BY COVER TYPE

Salt Marsh	Brackish Marsh	Freshwater Marsh/Meadow	Shrublands	Woodlands
Ascophyllum nodosum (rockweed)	*Aster novi-belgii* (New York Aster)	*Agrostis alba* (creeping bentgrass)	*Calamagrostis canadensis* (bluejoint)	*Agrostis sp.* (bentgrass)
Convolvulus sepium (false bindweed)	*Calamagrostis canadensis* (bluejoint)	*Bidens connata* (purplestem beggertick)	*Decodon verticillatus* (swamp loosestrife)	*Convolvulus sepium* (false bindweed)
Fucus vesiculosus var. spiralis (bladderwrack)	*Cladophora sp.*(clado)	*Decodon verticillatus* (swamp loosestrife)	*Euthamia tenuifolia* (slender goldentop)	*Euthamia tenuifolia* (slender goldentop)
Phragmites australis (common reed)	*Convolvulus sepium* (false bindweed)	*Holcus lanatus* (common velvetgrass)	*Galium trifidum* (threepetal bedstraw)	*Holcus lanatus* (common velvetgrass)
Populus grandidentata (bigtooth aspen)	*Morella pensylvanica* (northern bayberry)	*Lysimachia terrestris* (loosestrife)	*Holcus lanatus* (common velvetgrass)	*Onoclea sensibilis* (sensitive fern)
Rubus hispidus (swamp dewberry)	*Phragmites australis* (common reed)	*Phalaris arundinacea* (reed canary grass)	*Ilex sp.* (holly)	*Phragmites australis* (common reed)
Spartina alterniflora (smooth cordgrass)	*Rosa palustris* (swamp rose)	*Phragmites australis* (common reed)	*Juncus effusus* (common rush)	*Populus tremuloides* (quaking aspen)
Toxicodendron radicans (poison ivy)	*Rubus hispidus* (swamp dewberry)	*Polygonum hydropiper* (marshpepper knotweed)	*Lysimachia terrestris* (loosestrife)	*Prunus serotina* (black cherry)
Viburnum recognitum (arrowwood)	*Salicornia maritima* (grasswort)	*Rosa palustris* (swamp rose)	*Morella pensylvanica* (northern bayberry)	*Quercus velutina* (black oak)
	Spartina alterniflora (smooth cordgrass)	*Rubus hispidus* (swamp dewberry)	*Phalaris arundinacea* (reed canarygrass)	*Rosa palustris* (swamp rose)
	Spiraea tomentosa (steeplebush)	*Smilax rotundifolia* (greenbriar)	*Rosa palustris* (swamp rose)	*Rubus hispidus* (swamp dewberry)
	Thelypteris palustris (eastern marsh fern)	*Solidago rugosa* (wrinkleleaf goldenrod)	*Rubus hispidus* (swamp dewberry)	*Rubus occidentalis* (black raspberry)
	Toxicodendron radicans (poison ivy)	*Spirea alba* (white meadowsweet)	*Rubus occidentalis* (black raspberry)	*Solanum dulcarama* (bittersweet)
	Viburnum recognitum (arrowwood)	*Spirea tomentosa* (steeplebush)	*Rumex acetosella* (common sheep sorell)	*Solidago rugosa* (wrinkleleaf goldenrod)
		Toxicodendron radicans (poison ivy)	*Solidago rugosa* (wrinkleleaf goldenrod)	*Sphagnum sp.* (sphagnum moss)
		Typha angustifolia (narrowleaf cattail)	*Sparganium eurycarpum* (broadfruit burreed)	*Spirea alba* (white meadowsweet)
			Spirea alba (white meadowsweet)	*Thelypteris palustris* (eastern marsh fern)
			Spiraea tomentosa (steeplebush)	*Toxicodendron radicans* (poison ivy)
			Toxicodendron radicans (poison ivy)	*Viburnum recognitum* (arrowwood)
			Typha angustifolia (narrowleaf cattail)	

Source: Cape Cod National Seashore 2008 unpublished data.

Valiela et al. (1983) reported that a majority of the marsh downstream of High Toss Road, formerly occupied by cattail (*Typha* spp.) had been colonized in 1974 by common reed in response to the deteriorated tide gates. This trend has likely continued to the present as common reed is more salt-tolerant than cattail and other freshwater wetland plants.

3.5.4 FRESHWATER MARSH/MEADOW

There are 222 acres of freshwater marsh/meadow occurring within the project area, representing the third most common cover type (table 3-9). This composite cover type is typically limited to banks of the river within the Lower, Middle, and Upper Herring River sub-basins. More extensive areas of freshwater marsh/meadow occupy the Bound Brook sub-basin (94 acres) and Pole Dike Creek sub-basins (60 acres). Freshwater marsh habitats within the project area are typically dominated by narrowleaf cattail (*Typha angustifolia*) with the following common associates: wool grass (*Scirpus cyperinus*), bluejoint (*Calamagrostis canadensis*), rushes (*Juncus* spp.), and American bur-reed (*Sparganium americana*). Narrowleaf cattail is somewhat tolerant of saline environments (Grace and Wetzel 1982) and is considered an early to mid-seral species and is known to replace cordgrasses (*Spartina* spp.) in diked or tidally restricted coastal wetlands (Barrett and Niering 1993).

Common species within the old field herbaceous cover type include little bluestem (*Schizchyrium scoparium*), wavy hairgrass (*Descahmpsia flexuosa*), common velvetgrass (*Holcus lanatus*) and red fescue (*Festuca rubra*). Of the 222 acres of freshwater marsh/meadow, 20 acres are identified as old field herbaceous. Because much of the vegetation data collected by the Seashore from plots within old field herbaceous zones along permanent transects is typical of wet meadow species (table 3-10), the two wetland freshwater herbaceous cover types were combined for this analysis.

Water-willow or swamp loosestrife (*Decodon verticillatus*) (a larval host plant for a state-listed moth, water-willow stem borer [*Papaipema sulphurata*]), is a common component of the flora along the banks of Herring River, Bound Brook, and Pole Dike Creek (Mello 2006). The majority of these occurrences were within freshwater marsh with the remaining areas found within shrublands.

3.5.5 SHRUBLANDS

There are 299 acres of shrubland habitat in the project area, representing the second most common cover type (table 3-9). Shrublands comprise large portions of the Bound Brook, Duck Harbor, Mill Creek, Pole Dike Creek and Upper Herring River sub-basins. Extensive areas of wet shrublands have encroached into former brackish and freshwater herbaceous marsh as a result of the effective drainage of the flood plain (Portnoy, Roman, and Soukup 1987). Nearly all the composite shrubland habitat is comprised of wet shrubland with just 2 percent mapped as dry shrubland. Common woody species within this cover type include highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), swamp azalea (*Rhododendron viscosum*), water-willow, buttonbush (*Cephalanthus occidentalis*), alder (*Alnus* spp.), and leatherleaf (*Chamaedaphne calyculata*). Common woody species within the dry shrubland habitat include northern bayberry (*Morella pensylvanica*), black oak saplings (*Quercus velutina*), and shadbush (*Amelanchier* spp.). Species occurrence in plots within shrubland zones along permanent transects is presented in table 3-10.

3.5.6 WOODLANDS

Woodland habitat within the Herring River flood plain represents a consolidation of several forested cover types (including dry deciduous woodland, wet deciduous forest, dry deciduous forest, and pine woodland) A total of 402 acres of woodland habitat currently occurs in the project area and represents the most common cover type for the entire project area as well as within each of the sub-basins except Bound Brook (table 3-9). The dry deciduous woodland cover type comprises the majority (242 acres) of the total woodland habitat. This common cover type was included to account for unexpected vegetation assemblages of species due to the effective drainage within areas where wetland communities would be expected to occur. The overstory of this cover type is dominated by black cherry (*Prunus serotina*) with shadbush and northern arrowwood (*Viburnum recognitum*) found as common shrubs in the understory. This vegetation cover type is common within the Lower Herring River, Middle Herring River / Lower Pole Dike Creek, and Duck Harbor sub-basins where black cherry can be found along with an understory of old field species, including goldenrod (*Solidago* sp.), Canadian lettuce (*Lactuca canadensis*), common velvetgrass (*Holcus lanatus*), and Alleghany blackberry (*Rubus allegheniensis*) (HRTC 2007). Species occurrence in plots within woodland zones along permanent transects is presented in table 3-10.

The wet deciduous forest cover type comprises 124 acres of the 402 acres of woodland habitat. The overstory of the wet deciduous forest is dominated by red maple (*Acer rubrum*) with sweet pepperbush and swamp azalea found as common shrubs in the understory. The pine woodland cover type comprises 29 acres of the total woodland habitat. Common species within the pine woodland include pitch pine (*Pinus rigida*), black huckleberry (*Gaylussacia baccatta*), lowbush blueberry (*Vaccinium angustifolium*), and wavy hairgrass (*Deschampsia flexuosa*). The dry deciduous woodland cover type comprises only 7 acres of the total woodland habitat with an overstory comprised of black oak, white oak (*Quercus alba*) American beech (*Fagus grandifolia*), and black locust (*Robinia pseudoacacia*).

3.5.7 Dune/Heathlands

Within the limits of the project area, coastal dune/heathland habitats are confined to the western extent of the Duck Harbor and Bound Brook sub-basins where they join the interior of the barrier beach system along Cape Cod Bay (figure 3-19). The combined area of dune and heathland grasslands is 21 acres (table 3-9). Common species within the dune grassland type include American beachgrass (*Ammophila breviligulata*) and wavy hairgrass. Common species within the heathland grassland type include bearberry (*Arctostaphylos uva-ursi*), northern bayberry (*Morella pensylvanica*), lowbush blueberry (*Vaccinium angustifolium*), goldenheather (*Hudsonia ericoides*), woolly beachheather (*H. tomentosa*), and broom crowberry (*Corema conradii*).

3.5.8 Developed

Twenty-four acres of land area within the project area is identified as developed (table 3-9). Due to the broad nature of the cover type mapping, developed lands include areas of managed landscapes associated with recreational, residential, and commercial development. Existing roadways within the project limits were too narrow to effectively map as developed lands at this broad scale. The majority of the total developed area (20 acres) is the low-lying portions of the CYCC golf course. The remainder consists of smaller developed lands within the Pole Dike Creek and Lower Herring River sub-basins.

3.5.9 Invasive Plants

Invasive plants are generally considered non-native species which cause economic or environmental harm by developing self-sustaining populations and become dominant and/or disruptive to those systems (Massachusetts Invasive Plant Advisory Group 2005). The Invasive Plant Atlas of New England (Mehrhoff et al. 2003) and the Massachusetts Invasive Plant Advisory Group maintain listings of non-native or exotic plants considered invasive. Exotic plants can cause a variety of problems including loss of habitat for native plant and wildlife species, reductions in biodiversity, and changes to natural ecological processes such as plant community succession, nutrient cycling, and the hydrologic regime (Martin and Hanley 2001). Martin and Hanley (2001) conducted a Seashore wide survey to establish a baseline of abundance and distribution of exotic plant species in preparation for the development of exotic vegetation management plans and implementation of control treatments. The flora of the Seashore is composed of about 830 species of plants, of which approximately 25 percent (211 species) are non-native to the outer Cape (Martin and Hanley 2001). During this study, the following exotic species were identified within the Herring River flood plain: Japanese barberry (*Berberis thunbergii*), spotted knapweed (*Centaurea biebersteinii*), Oriental bittersweet (*Celastrus orbiculata*), common velvet grass (*Holcus lanatus*), Japanese honeysuckle (*Lonicera japonica*), Morrow's honeysuckle (*Lonicera morrowii*), common reed, white poplar (*Populus alba*), multiflora rose (*Rosa multiflora*), water-cress, and black locust (*Robinia pseudo-acacia*). Watercress is a common freshwater aquatic plant found within non-tidal portions of the Herring River that is growing so densely in the waterway that it has become an obstacle to migrating riving herring (Hughes, pers. comm. 2011). All of the non-native species listed above except common velvet grass and white poplar are considered to be invasive (Massachusetts Invasive Plant Advisory Group 2005).

Additional invasive plant species documented along permanently established vegetation monitoring transects within the Herring River flood plain include Russian olive (*Elaeagus angustifolia*) and reed canary grass (*Phalaris arundinacaea*) (Smith 2007). These invasive species and others found in the area, including cheatgrass (*Bromus tectorum*), and curly dock (*Rumex crispus*), could be eliminated or greatly reduced through tidal restoration and the introduction of saline waters (Smith 2005). Narrow-leaf cat-tail (*Typha angustifolia*), the dominant plant within freshwater marshes in the Herring River flood plain, has become naturalized throughout most of eastern North America, but is probably not native to New England (Shih and Finkelstein 2008).

Wetland restoration projects often are designed to control common reed, as the expansive monotypic stands tend to displace valuable native coastal wetland plant communities, primarily salt marsh. Saltonstall (2002) documented the presence of numerous genetic strains of common reed throughout the world, including native and non-native types inhabiting New England. The native type is now classified as the sub-species *Phragmites australis* ssp. *americanus* (Saltonstall et al. 2004). This sub-species was historically a common, non-invasive component of New England wetland plant communities. But once the invasive type was introduced from Europe, it spread rapidly and generally replaced the native type, which is now rare compared to the massive stands of non-native common reed found in many locations. Within the Herring River flood plain, no known native populations are thought to exist (Smith 2011). As previously discussed, common reed is found primarily within the Lower Herring River sub-basin where it has formed an expansive monotypic stand and displaced valuable native coastal wetland plant communities. The control of existing stands and the future spread of this invasive species is an important component of the Herring River project. Another common invasive plant in freshwater wetland habitats is purple loosestrife (*Lythrum salicaria*). This species has not been recorded within the limits of the restoration project, but it has been identified on the shore of Higgins Pond further upstream in the watershed (Martin and Hanley 2001).

3.6 AQUATIC SPECIES

The mixing of fresh and salt water in estuaries creates a brackish transition zone where salinity can range from 0.5 ppt to 30 ppt. Estuarine salinity levels are generally highest near the mouth of the river where the ocean water enters, and lowest upstream where fresh water flows in. However, salinity levels throughout an estuary can change daily depending on tides, weather, or other factors (NOAA 2008). To survive in these conditions, species living in estuaries must respond quickly to the drastic changes in salinity.

Stenohaline species can tolerate a narrow range of salinity, and are typically freshwater specific or salt water specific. Euryhaline species can tolerate a wide range of salinities, such as those encountered in the brackish, shifting waters of an estuary. Because of the special features (physical and behavioral) and energy required to adapt to the constantly changing salinities in an estuary, there are far fewer euryhaline species than stenohaline species (NOAA 2008). Despite this, estuaries rank along with tropical rainforests and coral reefs as the most productive ecosystems in the world, more productive than the rivers and ocean influencing them (NOAA 2008).

The following sections summarize inventories and wildlife observations describing the aquatic fauna existing within the Herring River estuary, and where appropriate, the receiving waters of Wellfleet Harbor. In general, the estuary downstream of the Chequessett Neck Road Dike is characterized by estuarine species that are dependent on marine conditions, while the abrupt change in salinity and tidal flushing in the Lower Herring River basin between the dike and High Toss Road results in a dramatic change in species richness and abundance, with species more tolerant of lower salinities becoming most dominant. Upstream of High Toss Road only freshwater or anadromous/catadromous species are found.

3.6.1 ESTUARINE FISH

Estuaries provide spawning, nursery, and feeding grounds for many young and adult fish and shellfish species (see “Section 3.6.4: Shellfish” for a more detailed discussion). Some fish species (generally smaller fish) spend their entire lives in estuaries, while other larger species migrate short or long distances into or out of estuaries. Prior to construction of the Chequessett Neck Road Dike, the expansive Herring River provided important habitat for a number fish and macroinvertebrate species.

Within Herring River, upstream and downstream of the Chequessett Neck Road Dike, several surveys of fish species have been conducted by Gwilliam (2005 unpublished data), Raposa (1998 to 1999 unpublished data), and Marteinsdottir (as cited in Roman 1987). Curly et al. (1972) also conducted a survey downstream of the dike in 1968 to 1969 as part of a study of the marine resources in Wellfleet Harbor. The Gwilliam, Raposa, and Marteinsdottir studies surveyed areas both downstream and upstream of the dike. Gwilliam surveyed the entire length of the mainstem of Herring River upstream of the dike; while the upstream portions of the Raposa and Marteinsdottir surveys were confined to the area between the dike and High Toss Road. The 2005 (Gwilliam) and 1998–1999 (Raposa) surveys were conducted using a 1-m^2 throw trap, while the earlier surveys were conducted using seines. In addition to using a seine to sample the Herring River downstream of the dike and two other intertidal locations in Wellfleet Harbor, Curly et al. (1972) surveyed the deeper portions of the harbor with an otter trawl. Table 3-11 presents a summary of the finfish species caught during these surveys and their relative abundance. Differences in abundance between the two older surveys (Curley et al. and Marteinsdottir) and the more recent surveys (Raposa and Gwilliam) are due in large part to the sampling gear used and specific locations sampled. Table 3-12 provides estimates of species density (number of individuals per m^2) that were derived from the 2005 and 1998 surveys that used the 1-m^2 throw traps (Roman and James-Pirri 2011).

TABLE 3-11: FINFISH SPECIES AND SURVEY ABUNDANCE IN HERRING RIVER AND WELLFLEET HARBOR

Common Name	Scientific Name	1968–1969 [a,e]			1984 [b,e]			1998–1999 [c,f]			2005 [d,f]		
		Up stream Dike [g]	Down stream Dike	Wellfleet Harbor	Up stream Dike	Down stream Dike	Wellfleet Harbor [g]	Up stream Dike	Down stream Dike	Wellfleet Harbor [g]	Up stream Dike	Down stream Dike	Wellfleet Harbor [g]
Alewife	*Alosa pseudoharengus*	-	common	rare	occasional	common	-	rare	rare	-	absent	absent	-
American eel	*Anguilla rostrata*	-	absent	absent	rare	rare	-	occasional	rare	-	occasional	rare	-
Atlantic herring	*Clupea harengus*	-	absent	absent	absent	absent	-	absent	rare	-	absent	absent	-
Atlantic mackerel	*Scomber scombrus*	-	absent	absent	absent	rare	-	absent	absent	-	absent	absent	-
Atlantic menhaden	*Brevoortia tyrannus*	-	occasional	occasional	common	abundant	-	absent	occasional	-	abundant	occasional	-
Atlantic silverside	*Menidia menidia*	-	abundant	abundant	occasional	abundant	-	occasional	occasional	-	rare	rare	-
Atlantic tomcod	*Mircrogadus tomcod*	-	absent	rare	absent	absent	-	absent	absent	-	absent	absent	-
Blueback herring	*Alosa aestivalis*	-	rare	absent	rare	abundant	-	absent	absent	-	absent	absent	-
Blue fish	*Pomatomus saltatrix*	-	absent	rare	-	occasional	-	absent	absent	-	absent	absent	-
Chain pickerel	*Esox niger*	-	absent	absent	rare	absent	-	absent	absent	-	absent	absent	-
Cunner	*Tautogolabrus adspersus*	-	absent	rare	common	absent	-	absent	absent	-	absent	absent	-
Eastern shiner species	*Notropis* species	-	absent	absent	absent	absent	-	rare	absent	-	absent	absent	-
Four-spine stickleback	*Apeltis quadracus*	-	rare	absent	absent	occasional	-	common	absent	-	common	absent	-
Golden shiner	*Notemigonus chrysoleucas*	-	absent	absent	rare	absent	-	absent	absent	-	absent	absent	-
Goosefish	*Lophius americanus*	-	absent	rare	absent	absent	-	absent	absent	-	absent	absent	-
absent Grubby	*Myoxocephalus aenaeus*	-	-	rare	absent	absent	-	absent	absent	-	absent	absent	-
Hickory shad	*Notemigonus chrysoleucas*	-	absent	absent	absent	occasional	-	absent	absent	-	absent	absent	-
Hogchoker	*Trinectes maculates*	-	absent	absent	absent	absent	-	rare	absent	-	rare	absent	-
Inland silverside	*Menidia beryllina*	-	absent	absent	absent	absent	-	occasional	absent	-	absent	absent	-
Little skate	*Raja erinacea*	-	absent	rare	absent	absent	-	absent	absent	-	absent	absent	-
Lumpfish	*Cycolpterus lumpus*	-	absent	rare	absent	absent	-	absent	absent	-	absent	absent	-
Mummichog	*Fundulus heteroclitus*	-	common	common	common	abundant	-	common	abundant	-	common	abundant	-

Common Name	Scientific Name	1968–1969 [a,e]			1984 [b,e]			1998–1999 [c,f]			2005 [d,f]		
		Up stream Dike [g]	Down stream Dike	Wellfleet Harbor	Up stream Dike	Down stream Dike	Wellfleet Harbor [g]	Up stream Dike	Down stream Dike	Wellfleet Harbor [g]	Up stream Dike	Down stream Dike	Wellfleet Harbor [g]
Northern kingfish	*Menticirrhus saxatilus*	-	occasional	rare	absent	absent	-	absent	absent	-	absent	absent	-
Northern pipefish	*Syngnathus fuscus*	-	rare	rare	rare	rare	-	rare	rare	-	rare	rare	-
absent Northern puffer	*Maculates*	-	-	rare	absent	absent	-	absent	absent	-	absent	absent	-
Northern searobin	*Prionotus carolinus*	-	-	rare	absent	absent	-	absent	absent	-	absent	absent	-
Sheepshead minnow	*Cyprinodon variegates*	-	absent	absent	absent	absent	-	absent	absent	-	rare	absent	-
absent Smooth dogfish	*Mustelus canis*	-	-	rare	absent	absent	-	absent	absent	-	absent	absent	-
Striped killifish	*Fundulus majalis*	-	abundant	abundant	occasional	abundant	-	rare	rare	-	common	occasional	-
absent Striped searobin	*Prionotusevolans*	-	-	rare	absent	absent	-	absent	absent	-	absent	absent	-
Sunfish species	*Lepomis* species	-	absent	absent	rare	absent	-	rare	absent	-	absent	absent	-
Tautog	*Tautoga onitis*	-	rare	rare	absent	absent	-	absent	absent	-	absent	absent	-
Three-spine stickleback	*Gasterosteus aculeatus*	-	rare	rare	absent	absent	-	absent	absent	-	absent	absent	-
Tidewater silverside	*Menidia berilyna*	-	occasional	absent	rare	absent	-	absent	absent	-	absent	absent	-
White perch	*Morone Americana*	-	absent	absent	rare	rare	-	absent	absent	-	absent	absent	-
Windowpane flounder	*Scophthalmus aquosus*	-	absent	rare	absent	absent	-	absent	absent	-	absent	absent	-
Winter flounder	*Pseudopleuronectus americanus*	-	occasional	occasional	rare	rare	-	absent	absent	-	absent	rare	-

a Curley et al. 1972

b Roman 1987

c Raposa 1998-1999 unpublished data

d Gwilliam 2005 unpublished data

e absent = not observed; rare = density (number per m2) < 0.1; occasional = density between 0.1 and 1.0; common = density between 1.0 and 5.0; abundant = density > 5.0

f absent = not observed; rare = number of individuals per seine haul < 1.0; occasional = number of individuals per seine haul between 1.0 and 10.0; common = number of individuals per seine haul between 10.0 and 50.0; abundant = number of individuals per seine haul > 50

g Area not surveyed

TABLE 3-12: ESTIMATES OF FINFISH DENSITY IN HERRING RIVER DERIVED FROM RAPOSA (1998) AND GWILLIAM (2005) SURVEYS

Common Name	Scientific Name	1998 [a,b] Density (number/m²) [d] Upstream of Dike	Downstream of Dike	2005 [c] Density (number/m²) [d] Upstream of Dike	Downstream of Dike
Alewife	*Alosa pseudoharengus*	0.05	0.03	-	-
American eel	*Anguilla rostrata*	0.59	0.03	0.29	0.03
Atlantic menhaden	*Brevoortia tyrannus*	-	0.15	5.50	0.25
Atlantic silverside	*Menidia menidia*	0.10	0.15	0.09	0.20
Eastern shiner species	*Notropis* species	0.01	-	-	-
Four-spine stickleback	*Apeltis quadracus*	2.18	-	1.65	-
Hogchoker	*Trinectes maculates*	0.03	-	0.03	-
Inland silverside	*Menidia beryllina*	0.14	-	-	-
Mummichog	*Fundulus heteroclitus*	3.24	7.33	1.12	8.43
Northern pipefish	*Syngnathus fuscus*	0.01	0.03	0.06	0.03
Sheepshead minnow	*Cyprinodon variegates*	-	-	0.09	-
Striped killifish	*Fundulus majalis*	0.04	1.00	0.06	0.95
Sunfish species	*Lepomis* species	0.01	-	-	-
Winter flounder	*Pseudopleuronectus americanus*	-	-	-	0.03
	Total Fish Density	**6.39**	**8.73**	**8.79**	**9.90**

a Raposa 1999 unpublished data as reported in Roman and James-Pirri 2011.

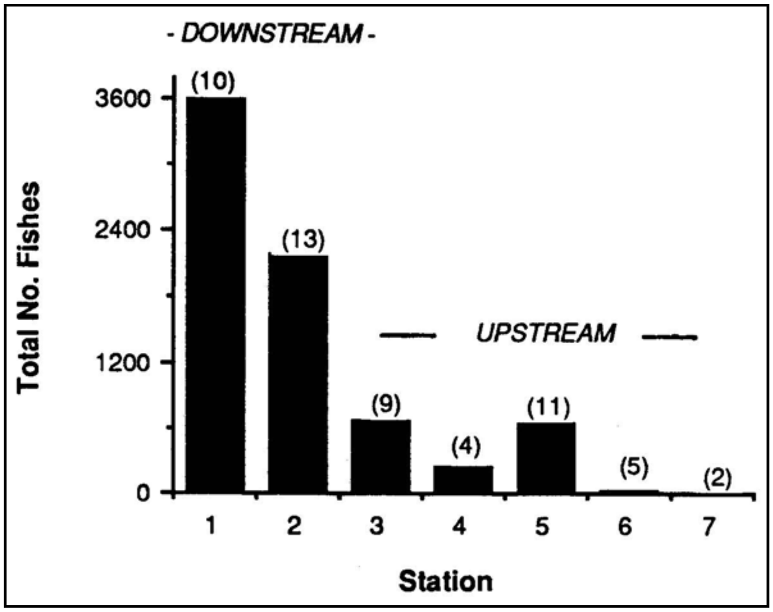
b Only includes August through October data to be comparable to Gwilliam data.

c Gwilliam 2005 unpublished data as reported in Roman and James-Pirri 2011.

d Densities derived from catch per unit effort (i.e., number of individuals caught in each 1 m2 throw trap sample).

In the more recent unpublished Raposa and Gwilliam surveys, a total of 14 species of fish were identified. Of the non-migratory estuarine species, mummichog (or common killifish) and four-spine stickleback were the dominant species upstream of the dike, while mummichog was the dominant species downstream of the dike (tables 3-11 and 3-12). In the 1998–1999 Raposa survey, the catadromous American eel was also an abundant species upstream of the dike. This species was most numerous during the May sampling (Raposa unpublished data), presumably during its spring migration upstream. The Atlantic menhaden was also found to be abundant upstream of the dike in 2005.

The Raposa and Gwilliam surveys also show that the relative abundance of non-migratory estuarine species such as mummichogs, striped killifish, and Atlantic silversides is greater downstream of the dike than upstream of the dike. This was consistent with the 1984 survey (Roman 1987) that showed that while the fish assemblage in the brackish waters immediately upstream of the dike was similar to that of downstream of the dike, the abundance of individuals was greatly reduced (table 3-11 and figure 3-20).



Source: Roman 1987.
Note: Number in parentheses is the number of species caught.

FIGURE 3-20: TOTAL NUMBER OF INDIVIDUALS AND SPECIES COLLECTED AT EACH SAMPLING STATION, 1984 SURVEY

Mummichogs use the high intertidal marsh as a nursery area, depending on it for spawning and survival of juveniles (Kneib 1984). Kneib (1993) also found that when high and low marshes had equal hydroperiods, growth rates and survival of mummichog larvae were greater in the high marsh, presumably due to the greater availability of preferred invertebrate prey. Striped killifish and Atlantic silversides prefer higher salinities, and, as indicated in tables 3-11 and 3-12, are more abundant downstream of the Chequessett Neck Road Dike when compared to upstream of the dike. Mummichogs, striped killifish, and Atlantic silversides are important in salt marsh food chains because of their distribution and abundance, and they are major prey for wading birds (e.g., herons and egrets), aerial searching birds (e.g., least and common terns) and many predatory fishes such as striped bass and blue fish (Abraham 1985). As such, they are also an important link in the transfer of organic material/energy within and out of salt marsh ecosystems (Abraham 1985; Kneib and Stiven 1978).

In the more recent surveys, fish with an affinity for fresh water and lower salinity waters (eastern shiner species, sunfish species, inland silverside and hogchoker) were found exclusively upstream of the dike. In 1984, the freshwater portion of the river exhibited the poorest habitat conditions in terms of number of species as well as abundance, as only three freshwater species, chain pickerel (*Esox niger*), pumpkinseed (*Lepomis gibbosus*), and golden shiner (*Notemigonus chrysoleucas*), represented by seven individuals were caught. In general, the freshwater fish fauna at Cape Cod is recognized as being depauperate (Roman 1987).

Wellfleet Harbor is an open embayment entering Cape Cod Bay and is the receiving waters for Herring River, which provides the only appreciable amount of freshwater into the harbor (Curley et al. 1972). The harbor serves as a nursery area for juveniles of many sport and commercial finfish, with Atlantic menhaden being by far the most abundant, numbering in the tens of thousands in the summer months (Curley et al. 1972; Town of Wellfleet 1995). Juveniles of other species found using the area as a nursery include winter flounder, windowpane flounder, northern kingfish, tautog, bluefish, and mackerel. Locally abundant forage species include Atlantic silverside, four-spine stickleback, common killifish, striped killifish, tidewater silverside, alewife, blueback herring, and white perch (Curley et al. 1972). These fish form the forage base for larger transitory fish visiting the area such as striped bass, bluefish, and Atlantic mackerel. For a more detailed discussion on migratory fish visiting the area see "Section 3.6.3: Anadromous and Catadromous Fish."

3.6.2 MACROINVERTEBRATES

In 2005 macroinvertebrates were sampled downstream and upstream of the Chequessett Neck Road Dike (Johnson 2005 unpublished data). Eleven species were collected from the Herring River downstream of the dike with the gastropod, Eastern mud snail (*Ilyanassa obsolete*) being the most dominant (Johnson 2005 unpublished data). Though uncommon, other gastropods identified included, the spiny slipper snail (*Crepidula aculeata*), Atlantic oyster drill (*Urosalpinx cinerea*), common periwinkle (*Littorina littorea*), greedy dovesnail (*Anachis avara*). The bivalves that were commonly found downstream of the dike included the quahog (*Mercenaria mercenaria*), eastern oyster (*Crassostrea virginica*), with lesser numbers of soft shell clam (*Mya arenaria*), razor clam (*Ensis americanus*), Baltic clam (*Macoma balthica*), and blood ark (*Anadara ovalis*). In the sub-tidal areas of the Herring River between the Chequessett Neck Road Dike and High Toss Road only two species were found, eastern mud snail and quahog, although the quahog was rare with only three specimens collected (Johnson 2005 unpublished data).

In 2004, Lassiter (2004 unpublished data) sampled macroinvertebrates at three locations, (1) immediately upstream of the Chequessett Neck Road Dike, (2) just downstream of High Toss Road and, (3) immediately downstream of Bound Brook Island Road. Species collected included nudibranchs, polychaete worms, oligochaetes, insects, amphipods, gastropods, isopods, green crab (*Carcinus maenas*), and quahog immediately upstream of the dike. Both the number of species and number of individuals were greatest immediately upstream of the dike and lowest in the upper portions of the system just downstream of Bound Brook Island Road (table 3-13).

TABLE 3-13: SPECIES RICHNESS AND RELATIVE ABUNDANCE OF MACROINVERTEBRATES IN THE HERRING RIVER UPSTREAM OF THE DIKE IN 2004

Location	Number of Species	Number of Individuals
Upstream of dike	23	391
High Toss Road	7	36
Bound Brook Island Road	4	14

Source: Lassiter 2004 unpublished data.

Raposa and Gwilliam also captured macroinvertebrates during their surveys in 1998 and 2005. Grass shrimp (*Palaemonetes* sp.) strongly dominated both sample years upstream and downstream of the dike, although in 2005 there was also a moderately high density of the longwrist hermit crab (*Pagurus longicarpus*) downstream of the dike (Raposa 1998 unpublished data and Gwilliam 2005 unpublished data as reported in Roman and James-Pirri 2011) (table 3-14).

TABLE 3-14: ESTIMATES OF CRUSTACEAN DENSITY IN HERRING RIVER DERIVED FROM RAPOSA (1998) AND GWILLIAM (2005) SURVEYS

Common Name	Scientific Name	1998 [a,b] Density (number/m²) [d]		2005 [c] Density (number/m²) [d]	
		Upstream Dike	Downstream Dike	Upstream Dike	Downstream Dike
American horseshoe crab	*Limulus polyphemus*	0.01	-	0.06	-
Atlantic mud crab	*Panopeus herbstii*	-	-	0.03	0.55
Atlantic sand fiddler	*Uca pugilator*	-	0.03	-	-
Crab (unidentified)	Unknown crab	-	-	-	0.05
Crayfish (unidentified)	Unknown crayfish	-	0.03	-	-
Grass shrimp species	*Palaemonetes* sp.	42.31	39.58	154.12	39.98
Grassflat crab species	*Neopanope* sp.	0.01	-	-	-
Green crab	*Carcinus maenas*	0.58	1.35	0.03	0.08
Lady crab	*Ovalipes ocellatus*	-	-	-	0.03
Longwrist hermit crab	*Pagurus longicarpus*	0.06	1.73	-	15.43
Say mud crab	*Dyspanopeus sayi*	-	-	0.41	0.85
Sevenspine bay shrimp	*Crangon septemspinosa*	0.80	2.03	1.09	1.60
	Total Density	**43.787**	**155.76**	**44.70**	**58.55**

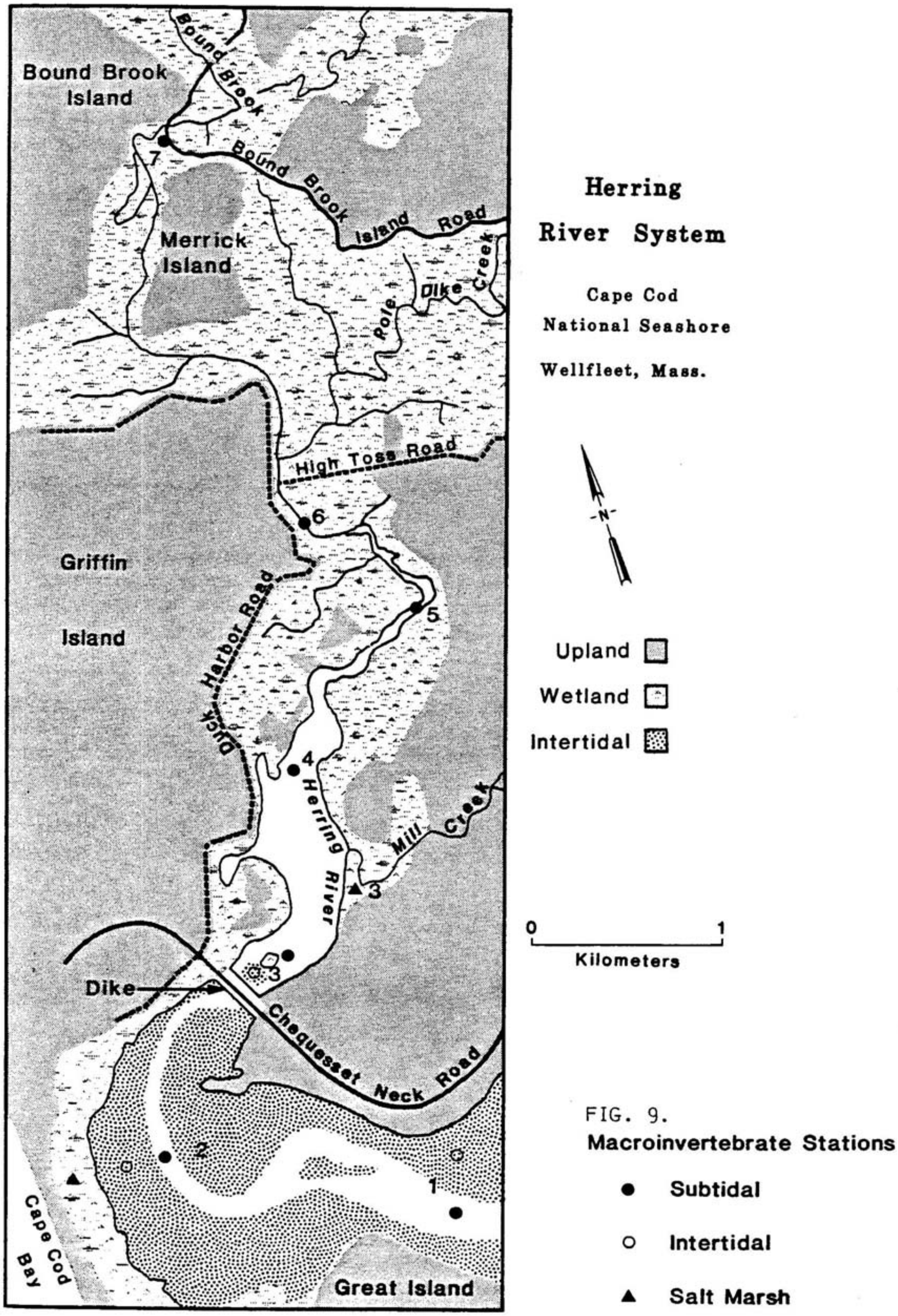
a Raposa 1998 unpublished data as reported in Roman and James-Pirri 2011.

b Only includes August through October data to be comparable to Gwilliam data.

c Gwilliam 2005 unpublished data as reported in Roman and James-Pirri 2011.

d Densities derived from catch per unit effort (i.e., number of individuals caught in each 1 m² throw trap sample).

In 1984 macroinvertebrates were sampled (Roman 1987) at seven locations in the sub-tidal, intertidal, and freshwater marsh habitats of the Herring River estuary (figure 3-21). Sixty-five species were collected from the estuarine portion of the river and the adjacent tidal marsh (stations 1–5), whereas 22 species were found in the freshwater portion of the system (stations 6–8). Species collected included bivalves (e.g., quahogs, razor clams (*Ensis directus*) and eastern oyster), decapod crustaceans (e.g., green crab), hermit crab (*Pagurus longicarpus*), and grass shrimp (*Palaemonetes* spp.), gastropods (e.g., Eastern mud snail and common periwinkle), amphipods, marine worms, leeches and others. For a complete list of the species, see Roman 1987. Species richness of intertidal and sub-tidal macroinvertebrates was moderate in the freshwater portion of the river, low in less saline areas, and high near the mouth of the river. Table 3-15 summarizes the relative abundance of the major estuarine macroinvertebrate species upstream of the Chequessett Neck Road Dike based on the sampling conducted in 1984 (Roman 1987). For a more detailed discussion of shellfish resources see "Section 3.6.4: Shellfish."



Source: Roman 1987.

FIGURE 3-21: MACROINVERTEBRATE SAMPLING STATIONS, 1984 SURVEY

TABLE 3-15: RELATIVE ABUNDANCE OF MAJOR ESTUARINE MACROINVERTEBRATES IN HERRING RIVER UPSTREAM OF THE DIKE AS REPORTED IN ROMAN (1987)

Organism	Occurrence in Herring River Upstream of the Dike
Oyster (*Crassostrea virginica*)	Rare
Hard clam (*Mercenaria mercenaria*)	Absent
Freshwater species • Isopod (Asellus sp.) • Freshwater shrimp (*Gammarus fasciatus*)	Common far upstream
Estuarine endemic species • Spionid worm (*Scolecolepides viridis*)	Abundant
Euryhaline species • Isopod (*Edotea triloba*) • Polychaete (*Eteone heteropoda*) • Capitellid worm (*Heteromastus filiformis*) • Spionid worm (*Streblospio benedicti*)	Common
Stenohaline species • Blood worm (*Glycera dibranchiate*) • Polychaete (*Spiochaetopterus oculatus*)	Absent
Grass Shrimp (*Palaemonetes pugio*)	Common
Grass Shrimp (*Palaemonetes vulgaris*)	Absent
Green crab (*Carcinus maenas*)	Absent
Lady crab (*Ovalipes ocellatus*)	Absent

Source: Roman 1987.

3.6.3 ANADROMOUS AND CATADROMOUS FISH

Five anadromous species (alewife, blueback herring, hickory shad, white perch, and striped bass), along with one catadromous species (American eel) are found in the Herring River.

Alewives and blueback herring (collectively referred to as river herring) migrate into freshwater from the ocean in early spring to spawn. Alewives typically spawn in coastal ponds and blueback herring typically spawn in rivers and streams. Adults of both species migrate rapidly downstream after spawning, with a total spawning time of approximately five days for a single migrating group (Fay, Neves, and Pardue 1983). Although supporting data are sparse, river herring are highly tolerant of salinity changes, either gradual or abrupt (Fay, Neves, and Pardue 1983).

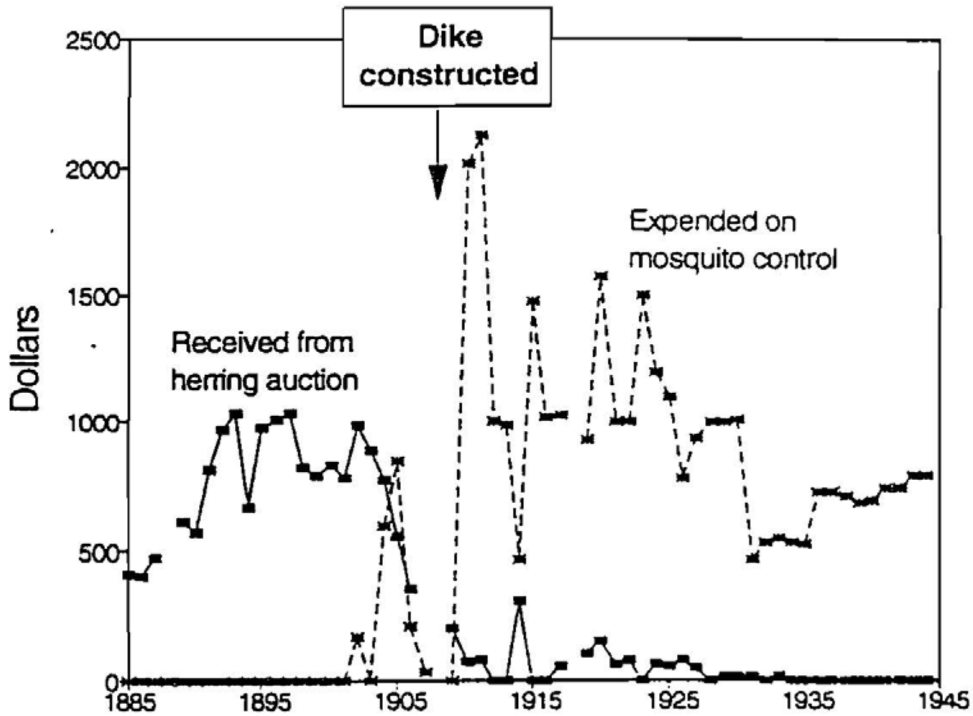
Juvenile river herring remain in freshwater systems for three to seven months prior to migrating to the ocean between June and November, often exhibiting pulses of early and late migrations (Iafrate and Oliveira 2008). The emigrations of juveniles appear to be affected by abiotic (precipitation, water temperature, lunar phase) and biotic (size, age, hatch date, food availability) factors (Fay, Neves, and Pardue 1983; Iafrate and Oliveira 2008). In the Herring River estuary the three headwater ponds (Herring, Higgins, and Gull Ponds) provide approximately 156 acres of alewife spawning habitat (figure 3-22).

Historically, the sources of the Herring River were Herring Pond (18.5 acres) and Higgins Pond (33.5 acres), but in 1893 a channel was cut between Higgins Pond and Gull Pond, increasing the spawning area by 104 acres (Curley et al. 1972). In the 1880s, alewives (and presumably blueback herring) were abundant in Wellfleet Harbor and supported a profitable fishery in the Herring River prior to the construction of the Chequessett Neck Road Dike (Curley et al. 1972, figure 3-23 from; Portnoy and Reynolds 1997). Historic Board of Selectman records indicate the annual river herring harvest to be about 200,000 to 240,000 fish (Town of Wellfleet 1889 and 1890). Because these were numbers of fish caught, the actual size of river herring run was much larger. As shown in figure 3-23 and described by Belding (1920), there was a large decline in river herring population in the early 1900s and the value of the fishery plummeted. The decline in the fishery was attributed to exploitation resulting from annual leases (Belding 1920) and construction of the Chequessett Neck Road Dike limiting the number of adults reaching their spawning grounds (Curley et al. 1972). In 1920, Belding (1920) indicated that partial obstruction affecting the migration of river herring included the abundant growth of wild rice (*Zizania aquatic*), the passageway under Old King’s Highway, and the dike.

In more recent years, low summertime dissolved oxygen levels in the upper river system, likely exacerbated by the restriction of seawater flow and flushing rate caused by the dike, resulted in large fish kills of emigrating juvenile river herring. Beginning in 1983, the NPS documented total stream anoxia lasting 10 to 17 days accompanied by massive die-offs of emigrating juvenile river herring. The number of fish killed in 1985 was estimated at 19,000 individuals, likely representing a major depression in the ultimate future annual recruitment from this year class (Portnoy, Roman, and Soukup 1987). Because of the massive die-offs, the NPS constructed a fish gate at the outlet of Herring Pond to permit the blockage of out-migrating juvenile river herring during periods of low dissolved oxygen (Portnoy, Roman, and Soukup 1987). This practice no longer occurs. In addition to low dissolved oxygen, non-native watercress (*Rorippa nasturtium-aquaticum*) and other submerged and emergent plant species just downstream of the Herring Pond outlet have grown dense enough in the waterway to become an obstacle to migrating riving herring. To help alleviate this problem, the Town of Wellfleet’s Herring Warden spends approximately 100 to 150 hours annually clearing a path through the vegetation for the herring to pass (Hughes, pers. comm. 2011).

In 2009 the Association to Preserve Cape Cod began a volunteer monitoring program to estimate the size of the herring run in Herring River from April 1 through June 1. Based on daytime counts from 7 a.m. to 7 p.m. the estimated river herring run (using the Massachusetts Division of Marine Fisheries’ Visual Counts Software) was 17,035 in 2009, 12,523 in 2010, and 7,740 in 2011 (APCC 2011). River herring mature and begin to return to spawn after three years (Fay, Neves, and Pardue 1983); with only three years of data, it is difficult to interpret the decrease from 2009 to 2011 as an ongoing trend because of inter-annual variations that could be occurring. Many outside factors such as increases in predators (e.g., striped bass) or offshore fishing can impact populations. However, regionally throughout the Atlantic coast, river herring populations have experienced substantial declines to the point where in 2006 NOAA listed the alewife and the blueback herring as species of concern (NOAA 2006), and currently NOAA is considering listing them as threatened under the Endangered Species Act (NOAA 2011).

FIGURE 3-22: HERRING RIVER ANADROMOUS FISH RUN



Source: Portnoy and Reynolds 1997.

FIGURE 3-23: VALUE OF THE HERRING RIVER HERRING FISHERY, 1885–1945

White perch, hickory shad, and striped bass are other anadromous fish that have been collected or observed at the mouth of the Herring River; however, because they are capable of avoiding the various sampling gears used, they are likely more common than surveys indicate (Curley et al. 1972; Roman 1987).

White perch, a commercially important and popular game fish, inhabit estuaries and freshwater systems from South Carolina north to the Canadian Maritimes. Marine populations migrate into estuaries and spawn in waters with salinities generally less than 4.2 ppt from May through July (Stanley and Danie 1983). Juveniles generally use the estuarine waters as a nursery site, staying in these areas for up to one year (Stanley and Danie 1983). Within Herring River, white perch can be found in abundance and use the upper main river stem and ponds as spawning sites (HRTC 2007).

Historically, hickory shad have been an important commercial fish; however, over the past 50 years their abundance has declined. Similar to river herring, hickory shad spend the majority of their adult life at sea, only entering freshwater in the spring to spawn. They spawn in rivers and tributaries along the Atlantic coast from the Bay of Fundy, Canada to Florida (ASMFC n.d.). Adults return to the sea after spawning, but most juveniles migrate from their nursery areas to the sea in early to late summer (ASMFC n.d.). Though, no adult or juvenile fish were caught during the 1984 sampling surveys, schools of hickory shad were observed at the dike on the downstream side in September (Roman 1987).

Striped bass, an important commercial and recreational fish, is another anadromous species not captured during either the 1984 or 1972 sampling surveys. However, they are common in Wellfleet Harbor and in Herring River immediately downstream of the Chequessett Neck Road Dike, where they are sought after and caught by sport fisherman (Curley et al. 1972; Roman 1987). In

Massachusetts, stripers are most common in spring and fall as transients. Spawning takes place from the spring to early summer, with the greatest activity when the water warms to about 65°F (MA DMF n.d.). Striped bass feed on a variety of macroinvertebrates and forage fish, many of which are common in Wellfleet Harbor and Herring River.

In addition to anadromous fish, the American eel, a catadromous species, is found in the Herring River. Eels spend most of their lives in rivers and freshwater ponds and migrate to sea to spawn. Young eels ("elvers") enter the river on their way to the ponds in April and May, and the adults migrate to the sea in June. Though counts of migrating eels do not take place in Herring River, in 2009 107 elvers were observed migrating into Herring Pond as part of the Association to Preserve Cape Cod and Friends of Herring River volunteer river herring counts (APCC 2011). Additionally, in the fall of 1980, several thousand eels of all sizes were killed as a result of low pH, high sulfate, and high aluminum concentrations in the surface waters in the upper reaches of the river (Portnoy, Roman, and Soukup 1987).

Brook trout (*Salvelinus fontinalis*) are the only trout native to much of the eastern United States, and although not currently found in Herring River, the "salter" variety of brook trout likely occurred historically in the Herring River (Hurley, pers. comm. 2011). Brook trout require cold (below 75°F), clean, and well oxygenated waters to survive (Smith 1985; EBTJV 2006). Salter brook trout are anadromous, spawning in the fall and moving downstream to salt water in November where they overwinter. Salters begin to move upstream in early spring and found in brackish or fresh water by mid-May.

Salter brook trout were historically an important native game fish of southeastern Massachusetts and during the 1800s Cape Cod was a favorite fishing destination (Hurley, pers. comm. 2007). Unfortunately, during the past couple hundred years, salter brook trout populations in Massachusetts have been in decline, largely due to pressures from urbanization and habitat fragmentation from the building of dams.

Although little population data exists for salter brook trout from Boston south to Cape Cod (EBTJV 2006; Hurley, pers. comm. 2007), restoration efforts in southeastern Massachusetts, such as Red Brook in Wareham, Massachusetts and Childs River in Mashpee, Massachusetts on Cape Cod have been successful. Other restoration efforts include the Coonamessett River in Falmouth, the Quashnet River, and potentially Marston Mills River on Cape Cod as well. Additionally, the Seashore is working with Trout Unlimited, Massachusetts Division of Fish and Game, and the U.S. Fish and Wildlife Service (USFWS) to potentially restore brook trout to Fresh Brook and other habitats in Wellfleet, and would likely extend this effort to Herring River as part of the restoration project (Hurley, pers. comm. 2011).

3.6.4 SHELLFISH

Oysters, quahogs, and softshell clams (*Mya arenaria*) constitute the most common shellfish in Wellfleet Harbor and Herring River, at least downstream of the dike, with oyster and quahog being the two most abundant and economically important species (see "Section 3.10: Socioeconomics" for detailed information on the commercial and recreational aspect of shellfishing in the Town of Wellfleet).

Oysters are filter feeders and prefer habitats in shallow estuarine waters including flats, offshore bars, and oyster reefs, and require hard substrate for their larvae to settle on (Sellers and Stanley 1984). They are usually restricted to waters with salinities between 5 ppt and 30 ppt, with an optimum salinity range of 10 ppt to 28 ppt (Sellers and Stanley 1984). Salinities above 7.5 ppt are required for spawning (Sellers and Stanley 1984). They are generally not found north of Cape Cod due to cool water temperatures (Curley et al. 1972; Sellers and Stanley 1984). Oysters spawn at water temperatures above 70°F, generally from early July through August in Wellfleet Harbor (Town of Wellfleet 1995). Sperm and eggs are synchronously released into the water column where fertilization takes place. The fertilized egg rapidly develops into a microscopic swimming larva and after 24 to 48 hours develops into a feeding form known as a veliger. After feeding on algae for 12 to 20 days, it develops a foot, becomes a pediveliger and settles to the bottom where it crawls along until it finds a location where it will cement itself to a suitable substrate by means of a limey secretion. It then becomes a tiny oyster known as spat. Spat grow rapidly to become juvenile oysters. Growth to harvestable size depends on water temperature, oxygen concentration, and quantity of food.

In 1969, Curley et al. (1972) sampled four areas downstream of the dike for oysters and found densities ranging from 0.1 to 7.8 per square yard for "legals" and 7.3 to 74 per square yard for "sub-legals." The current legal size for oysters in Massachusetts is 3 inches (7.5 cm, MA DMF 2011). They also reported that the Herring River (downstream of the dike) was one of the best spawning and setting areas for oysters in the Wellfleet Harbor area. In 1978, seed-size oysters averaging 2 inches long were found attached to rocks on the upstream face of the dike and scattered throughout the river to a point approximately 100 yards upstream of the dike (Gaskell 1978). During the 1984 survey (Roman 1987) oysters were found in densities of approximately 25 per square yard in the intertidal areas of the river downstream of the dike, but few were found upstream. Various factors limit the propagation and survival of oysters in Wellfleet Harbor, one of which is the lack of clean, hard bottom or substrate for oyster larvae to settle on. However, to provide suitable substrate, the town has been laying down cultch (empty oyster, clam, and scallop shells used as substrate) for larval settlement (Town of Wellfleet 1995; Koch, pers. comm. 2011a). Cultch is typically laid down beginning the second week of June and completed by July 1 to coincide with when the larvae settle out as spat, typically in mid-July. If cultch is laid out too soon, they can develop a coating of slimy algae which can hamper the ability of spat to attach to the cultch (Town of Wellfleet 2007). Cultch is typically placed at the mouth of Herring River; in Duck Creek, Chipman's Cove, and Blackfish Creek; south of Great Island; and along Indian Neck (Koch, pers. comm. 2011b).

The quahog (i.e., hard clam) can be found in intertidal and sub-tidal areas and is most abundant from Massachusetts to Virginia, though it ranges from the Gulf of St. Lawrence to Texas (Stanley and DeWitt 1983). Though they are found in substrates ranging from pure mud to coarse sand, optimum quahog production is generally reported from sandy mud to muddy sand sediments in areas with a 15 ppt to 35 ppt salinity range (Roman 1987; Stanley and DeWitt 1983). Spawning takes place at temperatures above 70°F; growth requires temperatures above 46°F. With suitable sediment, salinity, favorable temperatures for both growth (April through October) and spawning (July and August), and 10-foot tides moving large volumes of water through the area providing sufficient food, oxygen and waste removal, Wellfleet Harbor exhibits some of the highest quahog growth rates in the state of Massachusetts (Town of Wellfleet 1995). In 1969, Curley et al. (1972) reported average densities of less than 1 per square yard, but several areas throughout Wellfleet Harbor, including Herring River downstream of the Chequessett Neck Road Dike had densities of up to 8 per square yard. In 1984 (Roman 1987), the one station where a quantitative estimate was made downstream of the dike had quahog densities of 1 per square yard. Roman (1987) did not find quahogs upstream of the dike, possibly because existing salinities were too low to allow them to establish a population.

Within its range, the softshell clam is most abundant in the intertidal regions of the New England coast and sub-tidally in Chesapeake Bay. Optimum salinities are 10 ppt to 33 ppt and fine sediments are preferred over coarse sediments, although softshell clams can be found in soft muds, sands, compact clays, coarse gravel, and between stones (Newell and Hidu 1986). Curley et al. (1972) found in softshell clams in various areas of Wellfleet Harbor and seed clams (average size of 1 inch) have been found just upstream of the Chequessett Neck Road Dike in 1978 at densities of 4 per square foot in a narrow band on the east shore of the small tidal island in the middle of the river (Gaskell 1978). However, no softshell clams were found in Herring River upstream of the dike during the 1984 survey (Roman 1987). Softshell clams are currently harvested in Wellfleet Harbor at various locations. Other shellfish species found in the Herring River estuary include razor clams, blue mussels (*Mytilus edulis*), surf clams (*Spisula solidissima*), and bay scallops (*Argopecten irradians*) all of which are found downstream of the Chequessett Neck Road Dike (Town of Wellfleet 1995). Bay scallops are occasionally important commercially, but occur erratically in Wellfleet Harbor. According to Curley et al. (1972) their numbers are limited by the harbor's 10-foot tide range, which exposes large areas of flats in the winter, which can adversely affect survival (Curley et al. 1972).

3.7 FEDERAL AND STATE-LISTED RARE, THREATENED, AND ENDANGERED SPECIES

Federally listed Threatened and Endangered Species—The purpose of the Endangered Species Act is to protect and recover imperiled species and the ecosystems upon which they depend. Effective December 11, 2014, the rufa red knot (*Calidris canutus rufa*) was federally listed as a threatened subspecies of the red knot under the ESA (79 FR 73706). Effective May, 4, 2015, the northern long-eared bat was federally listed as a threatened species under the Endangered Species Act (80 FR 17974). The red knot has been identified as potentially utilizing Herring River tidal wetlands as foraging habitat during migration. The northern long-eared bat (*Myotis septentrionalis*) has been identified as potentially utilizing wetlands for foraging, and adjacent forested uplands as summer roosting habitat within the Herring River project area. As part of the permitting process, the project will complete Section 7 Consultations with the USFWS for both species pursuant to the Endangered Species Act of 1973, as Amended (16 USC 1531 et seq.). Informal consultation is underway.

State-listed Rare, Threatened, and Endangered Species—NPS policies (e.g., NPS *Management Policies 2006* and Director's Order 12) and the Massachusetts Endangered Species Act (MESA) (M.G.L c.131A and regulations 321 CMR 10.00) require examination of impacts on federal and state-listed threatened and endangered species and species of special concern. Massachusetts Division of Fish and Wildlife, NHESP oversees listing of state species and administering MESA. Species listed as endangered or threatened by the state are defined in the same way as federally endangered and threatened species. Currently, six state listed wildlife species occur within the Herring River project area: three birds, American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), and northern harrier (*Circus cyaneus*); two reptiles, diamondback terrapin (*Malaclemys terrapin*) and eastern box turtle (*Terrapene c. carolina*); and one invertebrate, water-willow stem borer (*Papaipema sulphurata*). The following sections describe these protected species and their current status within the Herring River.

3.7.1 RUFA RED KNOT (*CALIDRIS CANUTUS RUFA*) – FEDERALLY THREATENED

The rufa red knot is a medium-sized shorebird that completes a long distance migration between its breeding grounds in the Canadian Arctic and several wintering grounds that include the Southeastern United States, Northeast Gulf of New Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America. The red knot has been recorded as a spring migrant on Cape Cod, but it is more commonly present as a mid-summer-early fall migrant (Harrington et al. 2010a; Harrington et al. 2010b). During their southward migration to wintering areas, red knots typically feed on small clams and mussels found along coastal beaches and exposed intertidal flats.

3.7.2 NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*) – FEDERALLY THREATENED

The northern long-eared bat is a widespread species found in the United States from Maine to North Carolina on the Atlantic Coast, westward to eastern Oklahoma and north through the Dakotas, even reaching into eastern Montana and Wyoming. The northern long-eared bat is one of the species of bats most impacted by the disease white-nose syndrome, and these impacts are the main impetus behind the listing of the species in 2015.

During the summer, northern long-eared bats roost singly or in colonies in forested habitat underneath bark, in cavities or in crevices of both live trees and snags (dead trees). Northern long-eared bats seem to be flexible in selecting roosts, choosing roost trees based on suitability to retain bark or provide cavities or crevices. During the evening, northern long-eared bats can be found foraging in a variety of forested and non-forested habitats, including wetlands. During winter, northern long-eared bats hibernate in caves and mines (hibernacula) with constant temperatures, high humidity, and no air currents. Factors affecting the species include modifications to bat hibernacula, disturbance of hibernating bats, and loss of forest habitat including forest fragmentation.

3.7.3 AMERICAN BITTERN (*BOTAURUS LENTIGINOSUS*) – STATE ENDANGERED

The American bittern is a medium-sized bird that spends the majority of its time hidden among marshland vegetation. It prefers wetlands dominated by tall, emergent vegetation such as cattails, bulrushes, sedges, and grasses, but may also occur in brackish wetlands (NHESP n.d.). Within these habitats the American bittern frequents vegetation fringes and shorelines (Gibbs et al. 2009a). The American bittern forages in marshes, meadows, and along edges of shallow ponds. Preferred foods include frogs, small snakes and eels, crayfish, fish, salamanders, and occasionally mice and grasshoppers caught in open fields (NHESP n.d.).

Bitterns typically nest in marshes, but may also nest in grassy upland fields adjacent to wetlands. Nests are about a foot (30 centimeters) in diameter, made up of dead reeds, cattails, grasses, and sedges; nests located on the ground in dense vegetation or on a platform about a foot above the water. One clutch of three to five eggs is laid per year (NHESP n.d.). The breeding range of the American bittern extends from Newfoundland west to Manitoba and British Columbia; south to Maryland; and west through Oklahoma and Kansas to southern California. American bitterns return from their wintering habitat to Massachusetts marshes in April (Gibbs et al. 2009a).

The entire life cycle of the bittern is dependent on wetlands, so availability of suitable wetland breeding habitat within its range likely determines gross abundance of this species (Gibbs et al. 2009a). Population trends in Massachusetts are not known although the global population is thought to be declining (NHESP n.d.). Loss of wetland habitat is the major cause of decline, starting as early as the 1890s in some states, including Massachusetts. Over half the original wetlands in the United States have already been destroyed; inland, freshwater wetlands, the nesting and wintering areas of American bitterns are among the most threatened habitats. Other causes of population declines are human disturbance and pesticides/contaminants (Gibbs et al. 2009a).

Although call-playback survey results indicate the presence of American bitterns (Erwin, Conway, and Hadden 2002), there is no documentation of nesting activity of this species within the Herring River project area. Surveys conducted in parts of the Herring River flood plain in 2012 and 2013 (Broker n.d.) did not result in observations of American bittern. However, based on NPS vegetation mapping for the Herring River flood plain and discussions with NHESP, it is estimated that under existing conditions, potential nesting habitat for the American bittern is available. These habitats are primarily freshwater marsh located in the Lower Herring River, Upper Pole Dike Creek, and Bound Brook sub-basins with an additional 13 acres of salt marsh in the Lower Herring River as foraging, roosting, and migratory habitat.

3.7.4 LEAST BITTERN (*IXOBRYCHUS EXILIS*) – STATE ENDANGERED

The least bittern is the smallest member of the heron family, weighing on average 2.8 ounces (80 grams), and among the most inconspicuous of North American marsh birds. Suitable habitats include fresh and brackish water marshes with tall, dense emergent vegetation and clumps of woody plants over deep water (Gibbs et al. 2009b). Massachusetts NHESP occurrence records describe habitat as primarily cattails and open water (NHESP n.d.). Least bitterns forage by stalking along the openwater side of emergent vegetation, grasping clumps of plants with their long toes and curved claws. They are also known to build small foraging platforms at feeding sites, catching fast-moving prey (mainly small fish and insects) (Gibbs et al. 2009b).

The least bittern nest is an elevated platform with an overhead canopy, built of emergent aquatic vegetation and sticks. A clutch of four to five eggs is laid over a six-day period every year. A second attempt at breeding may occur if the first attempt fails. Least bitterns breed from southeastern Canada through the eastern and central United States to Mexico and Costa Rica. They typically arrive at nesting areas in Massachusetts by mid- to late-May; eggs and fledglings have been observed in the state throughout June (NHESP n.d.).

When encountered, least bitterns typically burrow through dense vegetation, fly away weakly over marsh vegetation, or stand still with their bill pointed upward, feathers compressed, and eyes directed forward (Gibbs et al. 2009b).

Although call-playback survey results indicate the presence of least bitterns (Erwin, Conway, and Hadden 2002), there is no documentation of nesting activity of this species within the Herring River project area. The least bittern was documented in parts of the Herring River flood plain during surveys conducted in 2012 and 2013 (Broker n.d.). These sightings have included spring-time observations of behaviors which suggest that least bitterns are nesting within the flood plain during some years (Broker n.d.; unpublished data). Based on the locations of these observations, NPS vegetation mapping for the Herring River flood plain, and discussions with NHESP, it is estimated that under existing conditions, potential nesting habitat for the least bittern is available. These habitats are primarily freshwater marsh located in the Lower Herring River, Upper Pole Dike Creek, and Bound Brook sub-basins with an additional 13 acres of salt marsh in the Lower Herring River as foraging, roosting, and migratory habitat.

3.7.5 NORTHERN HARRIER (*CIRCUS CYANEUS*) – STATE THREATENED

The northern harrier, sometimes referred to as the marsh hawk, is a slim, long-legged, long-tailed accipiter. Harriers establish nesting and feeding territories in wet meadows, grasslands, and coastal and inland marshes. Harriers construct their nests from grasses, weeds, and other emergent aquatic and upland vegetative material. Nests are typically on the ground among bushes and other low vegetation. Sometimes the nests are built over shallow water on raised mounds of sticks. Egg incubation occurs in the spring (April). Harriers prey on a variety of small animals, including rodents, rabbits, and other small mammals, small birds, insects, amphibians, reptiles, and carrion. In Massachusetts, meadow voles (*Microtus pennsylvanicus*) constitute an important component of the harrier's diet; there is a direct correlation between the breeding success of northern harriers and the number of voles found in their territory (NHESP n.d.).

Harriers are uncommon summer residents or migrants in Massachusetts, although they once were much more abundant in the state. The harrier was once a common breeder throughout Massachusetts from the mid-1800s to the early 1900s. Today, almost all of the breeding harriers in the state are confined to the offshore islands, Cape Cod, and Plum Island in the northeast corner of the state. Most harriers in the state that do not migrate south spend the winter in coastal marshes on Cape Cod and the offshore islands. Some northern harriers that breed in areas north of Massachusetts may also spend the winter on the offshore islands and along the coast (NHESP n.d.).

Results from field surveys conducted from 2004 through 2006 indicate the harrier breeding population at the Seashore in 2004 consisted of 10 nesting pairs, which was likely the largest breeding population anywhere on the Massachusetts mainland and, therefore, of statewide conservation significance. The 2005 population was smaller, comprising five nesting pairs plus four other pairs that mated and established a breeding territory early in the season but did not progress to nesting (Bowen 2006). The 2006 population was slightly larger and consisted of seven nesting pairs (Byrne 2007). Two of the seven nests were successful and produced five fledglings. Two nesting sites documented within the vicinity of the Herring River project at the Ryder Hollow and Bound Brook areas in all three survey years may be affected by the proposed project. Both sites were in freshwater marshes dominated by cattail. Although no formal, systematic nesting survey has been conducted since 2006, anecdotal observations of adult harriers have been made since then during the nesting season near documented nesting sites. Thus there is no reason to assume that northern harriers have not continued to nest in the Bound Brook sub-basin (Cook, pers. comm. 2011).

Cattail marshes are considered the single most important harrier nesting habitat at the Seashore, accounting for 50 percent of all nest sites. Other nests on Cape Cod have been found in outwash scrub oak barrens (Bowen 2006). The most substantial factor in the northern harrier decline has been destruction of suitable habitat by reforestation of agricultural land and destruction of coastal and freshwater wetlands. In coastal areas, human disturbance may cause some harriers to abandon their nests. Other factors such as prey abundance, prolonged periods of rain (which may destroy nests and eggs), and predation on eggs and nestlings can also affect their success (NHESP n.d.).

3.7.6 DIAMONDBACK TERRAPIN (*MALACLEMYS TERRAPIN*) – STATE THREATENED

The diamondback terrapin, a marine turtle, uses brackish marsh habitats for foraging and sandy shoreline habitats for nesting. The brackish marshes along the periphery of Wellfleet Harbor support the northernmost population on the East Coast, although individuals have been found in Provincetown.

Terrapins are strong, fast swimmers and feed primarily on snails, mussels, and crabs. They live most of their lives in the marsh and are the only emydid turtle capable of surviving in a high salinity environment without accessing a freshwater source. Terrapins hibernate in the mud of tidal creeks and mate in the calm waters of the salt marsh in mid-spring. Females nest on land, usually among the dunes and open habitats adjacent to the marsh, often within the Seashore (Cook 2008a).

Terrapin populations were decimated in the 19th century by overharvesting for food. They recovered by the mid-20th century, but now face renewed pressures from loss or degradation of nesting habitats to development, increased nest predation by raccoons and skunks, and increased adult mortality from road kills (Cook 2008b).

3.7.7 EASTERN BOX TURTLE (*TERRAPENE C. CAROLINA*) – STATE SPECIES OF SPECIAL CONCERN

Although listed as a Species of Special Concern under MESA, eastern box turtles are relatively common terrestrial reptiles on Cape Cod that use dry and moist woodland and freshwater marsh habitats (R. Cook pers. comm. 2011). The box turtle shifts habitats seasonally to avoid excessive heat or cold. They frequent the edges of wetlands, especially during dry summer periods when they move into fresh surface water for hydration.

Pine barrens and oak thickets present in areas adjacent to the Herring River estuary are optimal habitat types for this species. Upland habitats that support communities of bearberry (*Arctostaphylos uva-ursi*), lowbush blueberry (*Vaccinium angustifolium*), and bracken fern (*Pteridium aquilinum*), common upland plant species adjacent to the estuary, are also preferred habitat (Erb 2011). The turtles feed on a broad range of foods including insects, worms, slugs, fruit, mushrooms, vegetation, and carrion provided by the upland habitats.

Box turtles are in decline throughout much of their range in the eastern United States. They are extremely long lived, slow to mature, and have relatively few offspring per year. These characteristics, along with habitat degradation, road kill frequency, and pet collection, make the box turtle a species particularly susceptible to human-induced pressures. The Seashore, however, with its fairly intact, unfragmented landscape, likely provides some of the best remaining box turtle habitat in New England and they are frequently encountered in and adjacent to the Herring River project area (R. Cook pers. comm. 2011).

3.7.8 WATER-WILLOW STEM BORER (*PAPAIPEMA SULPHURATA*) – STATE THREATENED

The water-willow stem borer is a globally rare, noctuid moth found only on the coastal plain of southeastern Massachusetts and Cape Cod. Water-willow stem borer larvae feed almost exclusively on water-willow (*Decodon verticillatus*), a freshwater wetland plant widely distributed throughout New England.

Typically, water-willow grows in the shallowest portions of vernal ponds, in seasonally flooded freshwater swamps, and along upland edges of streams, ponds, and other permanent bodies of water. On outer Cape Cod, water-willow has become established in formerly tidal river systems where diking has created and maintained freshwater conditions.

Numerous stands of water-willow support the stem borer along the margins of the Herring River and its tributaries. During a survey performed in 2006, 89 larval host plant patches were located within the Herring River flood plain and 80 records of stem borer use were recorded. *D. verticillatus* patches were mapped as 172 discrete stands occurring along approximately 41,000 linear feet of streambank habitat. An additional 29 stem borer records were found within 17 host plant patches at Salt Meadow within the East Harbor system in Truro (Mello 2006). Casual observations by Seashore scientists made since the 2006 survey indicate that *D. verticillatus* also occurs along the edges of a majority of vernal pools and ponds throughout the Seashore (R. Cook, unpublished NPS data, 2012).

3.8 TERRESTRIAL WILDLIFE

Over 450 species of amphibians, reptiles, fish, birds, and mammals depend on the diversity of upland, wetland, and coastal ecosystems found in the Seashore and nearby environs. Depending on the species, the Seashore may provide habitat year round, or only during nesting season, migration, or winter. Seashore wildlife includes marine mammals and turtles; the familiar gulls, terns, and waterbirds of beaches and salt marshes; and a great variety of animals that inhabit Seashore woodlands, heathlands, grasslands, swamps, marshes, and vernal ponds (NPS 2011e).

3.8.1 BIRDS

The Seashore provides a wide diversity of freshwater, marine, and upland habitats for the roughly 370 species of birds. About 80 of these nest here during the spring and summer months, with the remainder using the Seashore for migratory stopovers or to overwinter. The Seashore contains prime habitat for a multitude of species including many that migrate along the Atlantic Flyway. A list of species observed within the project area is presented in appendix E.

Freshwater Marsh Birds and Upland Birds

The birds of the Wellfleet area were surveyed in 2000, as part of a survey of grassland birds (Kearney and Cook 2001). Species recorded at Wellfleet during the breeding season (June) and presumed to breed there or nearby and forage there include the following: northern flicker (*Colaptes auratus*), mourning dove (*Zenaida macroura*), eastern phoebe (*Sayornis phoebe*), eastern kingbird (*Tyrannus tyrannus*), brown thrasher (*Toxostoma rufum*), northern mockingbird (*Mimus polyglottos*), black-capped chickadee (*Poecile atricapillus*), prairie warbler (*Dendroica discolor*), red-winged blackbird (*Agelaius phoeniceus*), brown-headed cowbird (*Molothrus ater*), rufous-sided towhee (*Pipilo* spp.), American goldfinch (*Carduelis tristis*), song sparrow (*Meospiza melodia*), chipping sparrow (*Spizella passerina*), field sparrow (*Spizella pusilla*), and vesper sparrow (*Pooecetes gramineus*). Many of these species are generalists and live near freshwater habitats, but may also forage and rest near brackish water.

Species common to shrub thickets and freshwater habitat likely have increased in the Herring River flood plain as conditions changed due to the tidal restriction. These include red-winged blackbirds (*Agelaius phoeniceus*), song sparrows (*Melospiza melodia*), prairie warblers (*Dendroica discolor*), common yellowthroats (*Geothlypis trichas*), eastern towhees (*Pipilo erythrophthalmus*), and grey catbirds (*Dumetella carolinensis*). Many of these species are abundant nesters elsewhere on Cape Cod and southeastern Massachusetts (Veit and Peterson 1993).

Marsh birds were inventoried at the Seashore during a 1999 and 2000 auditory and visual detection survey. Seven species were identified; sora (*Porzana carolina*), pied-billed grebe (*Podilymbus podiceps*), Virginia rail (*Rallus limicola*), American coot (*Fulica Americana*), king rail (*Rallus elegans*), American bittern, and least bittern. As described in "Section 3.7: Federal and State-listed Rare, Threatened, and Endangered Species," the American bittern and least bittern are listed as endangered under Massachusetts Environmental Policy Act (MEPA). Within the entire survey area, the most commonly detected freshwater marsh birds were sora, pied-billed grebe, and Virginia rail. Sora and Virginia rail were the only species detected within the Herring River flood plain. Both were only detected auditorially, outside of the breeding season (Erwin, Conway, and Hadden 2002).

Salt Marsh Birds

Many birds use salt marsh habitats for breeding, foraging, and roosting, including several species of waterfowl, raptors, wading birds, shorebirds, and songbirds. Seasonal use of intertidal and salt marsh habitat also varies, with some species using the salt marsh for breeding and others during migration or the wintering period. Because freshwater habitats now dominate the once salt water marsh, many species of birds found in the Herring River likely are different today when compared to what existed prior to the construction of the Chequessett Neck Road Dike.

Much of the change in bird occurrence and use likely has been the result in the change of a system dominated by intertidal flats and cordgrass (*Spartina* spp.) to one currently dominated by freshwater (cattail and common reed) and mixed upland vegetation. Concurrent with these changes has been the resulting poor water quality conditions in the Herring River (e.g., acidification and oxygen depletions) and the limited tidal range that has adversely affected forage fish populations important seasonal food resources for many birds (HRTC 2007).

Several high-priority tidal creek and saltmarsh-dependent species such as saltmarsh sharp-tailed sparrows (*Ammodramus caudacutus*), willets (*Catoptrophorus semipalmatus*), American black ducks (*Anas rubripes*), common and roseate terns (*Sterna hirundo* and *S. dougallii*), and several species of shorebirds and wading birds (USFWS 2006) commonly use nesting (*Spartina* dominated habitat) and/or foraging opportunities (primarily estuarine fish) in salt marshes adjacent to the Herring River. Other species, including but not limited to, osprey (*Pandion haliaetus*), and belted kingfisher (*Ceryle alcyon*) also forage in nearby salt marshes.

3.8.2 MAMMALS

Small mammals, such as mice, voles, and shrews are very abundant in marsh grasses around Herring River. Small mammals are an important component of Seashore fauna. In addition to their direct contribution to species richness, they play a major role in trophic dynamics, consuming plant material and invertebrates, and in turn serving as prey items for snakes, raptorial birds, and small to mid-sized carnivorous mammals.

The most common group of mammals found in coastal marsh habitats in the New England region are rodents, such as the meadow vole, which are an important prey species for northern harriers and other raptors (see "Section 3.7.5: Northern Harrier (*Circus cyaneus*) – Threatened"). Other common mammals of coastal marshes include red fox (*Vulpes vulpes*), opossum (*Didelphis virginiana*), chipmunk (*Tamias* spp.), and muskrat (*Ondatra zibethicus*) (Smith 1997).

In 2000 and 2001, small mammals were inventoried at the Seashore to determine their occurrence, abundance, and preferred habitats (Cook, Boland, and Dolbeare 2006). Sites in heathland, freshwater marsh, grassland, oak forest, and pine forest were sampled using live traps. A total of 1,829 individuals representing 11 species were captured. Two species of rodents, the white-footed mouse (*Peromyscus leucopus*) and the meadow vole, accounted for 59 percent of all individuals caught. Collectively, rodents made up 83.5 percent of the total. Small mammals were most abundant in woodland and wetland habitats, with decreasing numbers in grasslands, pine forests, and heathlands (Cook, Boland, and Dolbeare 2006).

The three most common species documented in sites near the Herring River were white-footed mouse, meadow vole, and the meadow jumping mouse (*Zapus hudsoniu*). Although species composition of small mammal communities at the Seashore are essentially the same as those found elsewhere on Cape Cod, relative abundance of species differs (Adler 1988). Compared to other sites studied in the Cape Cod region, masked shrew and meadow jumping mouse were more abundant, and short-tailed shrew and red-backed vole were less abundant at the Seashore. Regardless of whether they are considered a generalist or a specialist with regard to habitat structure, the occurrence and abundance of prevalent species appears related to site moisture (Smith 1997).

Larger mammals, such as coyotes (*Canis latrans*), river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), and white-tailed deer (*Odocoileus virginianus borealis*) also use the freshwater habitats within Herring River flood plain. Within the Seashore, red fox and other carnivores prey upon nests of colonial waterbirds and shorebirds. Because small mammals serve as a food source for these predators, variation in their abundance may affect predation pressure on these birds (Cook, Boland, and Dolbeare 2006).

3.8.3 REPTILES AND AMPHIBIANS

The Seashore is an important area for reptiles and amphibians. In addition to its importance to the five species of migratory marine turtles foraging the offshore waters of Cape Cod, there are 23 species of reptiles and amphibians living their entire life at the Seashore within the Herring River project vicinity (table 3-16). Many of these species are important in the functioning of park ecosystems, consuming large quantities of small prey items, such as insects, and serving as prey for larger species of wildlife (Cook 2008a).

Turtles comprise a familiar group of vertebrates occupying a broad range of habitats and ecological functions. The Seashore supports populations of six species of nonmarine turtles, occupying terrestrial, freshwater, and estuarine habitats. In addition to the diamondback terrapin and eastern box turtle (discussed in “Section 3.7: Federal and State-listed Rare, Threatened, and Endangered Species”), these include presently common and/or widespread species such as the freshwater painted turtle (*Chrysemys picta*); snapping turtle (*Chelydra serpentina*); the less common musk turtle (*Sternotherus odoratus*); and spotted turtle (*Clemmys guttata*) (Cook 2008a).

Other species of reptiles and amphibians including the green frog (*Rana clamitans melanota*), Fowler’s toad (*Bufo woodhousii fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), eastern garter snake (*Thamnophis s. sirtalis*), and northern water snake (*Nerodia s. sipedon*) use coastal marsh habitats similar to those found at the Herring River and Wellfleet Harbor estuary. The four-toed salamander (*Hemidactylium scutatum*) has also been documented in or adjacent to wetlands associated with the Herring River (Cook, Portnoy, Murphy et al. 2006).

A long-term monitoring effort of pond breeding amphibians was initiated in 2003 as a component of freshwater wetland monitoring in the Seashore (Cook, Schult, Goodstine et al. 2006). Occurrence and abundance of vernal pond breeding species spotted salamander (*Ambystoma maculatum*) and wood frog (*Rana sylvatica*) are currently monitored through egg mass counts. Occurrence and relative abundance of the breeding anuran community park wide is also monitored. Five monitoring sites are within the Herring River project area, near Bound Brook Island Road, and Pamet Point Road. Of those sites, spotted salamander egg masses were present during the 2003 to 2005 surveys, but wood frogs were not present at any site location during the surveys. Additional monitoring of these species is necessary to better characterize the important role amphibians play in wetland habitats, and how global, regional, and local factors alter the abundance, distribution, and structure of their communities.

TABLE 3-16: REPTILES AND AMPHIBIANS OF CAPE COD NATIONAL SEASHORE AND ADJACENT TOWNS, BASED ON RECENT RECORDS (1980 THROUGH SEPTEMBER 2008)

Species	Eastham	Wellfleet	Truro	Provincetown
Spotted salamander	X*	X*	X*	
Red-spotted newt	X*			
Redback salamander	X*	X*	X*	X*
Four-toed salamander	X*	X*	X*	
Eastern spadefoot toad (MA T)	X*	X*	X*	X*
Fowler's toad	X*	X*	X*	X*
Spring peeper	X*	X*	X*	X*
Grey treefrog	X*			X*
Bullfrog	X*	X*	X*	X*
Green frog	X*	X*	X*	X*
Wood frog	X*	X*		
Pickerel frog	X	X*	X*	
Leatherback turtle (marine)	X	X	X	X
Green turtle (marine)	X	X	X	X
Loggerhead (marine)	X	X	X	X
Hawksbill turtle (marine)	X	X	X	X
Kemp's ridley turtle (marine)	X	X	X	X
Snapping turtle	X*	X*	X*	X*
Musk turtle	X*	X*	X*	
Painted turtle	X*	X*	X*	X*
Spotted turtle	X*	X*	X*	X*
Diamondback terrapin (MA T)	X	X*	X	X*
Eastern box turtle (MA SC)	X*	X*	X*	X*
Eastern garter snake	X*	X*	X*	X*
Eastern ribbon snake	X*	X*	X*	X*
Northern water snake		X*	X*	
Northern ringneck snake	X*	X*	X*	X*
Black racer	X*	X*	X*	X*
Eastern hognose snake	X	X*	X*	X
Eastern milk snake		X*	X*	X*

Source: Cook 2008a.
MA SC and MA T denote Massachusetts special concern and threatened species, respectively.
*Species with documented presence inside Cape Cod National Seashore.

3.9 CULTURAL RESOURCES

The NPS has a unique stewardship role for cultural resources, reflected in regulation and policy. NPS categorizes cultural resources as archeological resources, cultural landscapes, historic districts and structures, museum objects, and ethnographic resources. For this final EIS/EIR, the categories of archeological resources and historic structures were retained for analysis.

3.9.1 GUIDING REGULATIONS AND POLICIES

Federal actions that have the potential to affect cultural resources are subject to a variety of laws. The National Historic Preservation Act (NHPA) (1966, as amended) is the principal legislative authority for managing cultural resources associated with NPS projects. Generally, Section 106 of the act requires all federal agencies to consider the effects of their actions on cultural resources listed on or determined eligible for listing in the National Register of Historic Places (National Register). Such resources are termed historic properties. Agreement on how to mitigate effects to historic properties is reached through consultation with the State Historic Preservation Officer (SHPO); the Tribal Historic Preservation Officer (THPO), if applicable; and the Advisory Council on Historic Preservation, as necessary. In addition, federal agencies must minimize harm to historic properties that would be adversely affected by a federal undertaking. Section 110 of the act requires federal agencies to establish preservation programs for the identification, evaluation, and nomination of historic properties to the National Register.

The NHPA established the National Register, the official list of the nation's historic places worthy of preservation. Administered by the NPS, the National Register is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect America's historic and archeological resources. The criteria applied to evaluate properties are contained in 36 CFR 60.4. The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and/or association, and that are associated with events that have made a significant contribution to the broad patterns of our history; or

- that are associated with the lives of persons significant in our past; or
- 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
- that have yielded or may be likely to yield, information important in prehistory or history.

Cultural resources that meet the eligibility criteria for listing in the National Register are considered "significant" resources and must be taken into consideration during the planning of federal projects.

Other important laws or Executive Orders designed to protect cultural resources include, but are not limited to:

- NPS Organic Act—to conserve the natural and historic objects within parks unimpaired for the enjoyment of future generations;
- American Indian Religious Freedom Act—to protect and preserve for American Indians access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites;
- Archeological Resources Protection Act—to secure, for the present and future benefit of the American people, the protection of archeological resources and sites that are on public lands and Indian Lands;
- National Environmental Policy Act (NEPA)—to preserve important historic, cultural, and natural aspects of our national heritage

- Executive Order 11593 (Protection and Enhancement of the Cultural Environment)—to provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the Nation; and
- Executive Order 13007 (Indian Sacred Sites)—to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and avoid adversely affecting the physical integrity of such sacred sites.

Through legislation and the Executive Orders listed above, the NPS is charged with the protection and management of cultural resources in its custody. This is further implemented through Director's Order 28: Cultural Resource Management, NPS *Management Policies 2006* (NPS 2006), and the 2008 "Programmatic Agreement among the National Park Service (U.S. Department of the Interior), the Advisory Council on Historic Preservation, and the National Conference of SHPOs for Compliance with Section 106 of the National Historic Preservation Act" (NPS 2008). These documents charge NPS managers with avoiding, or minimizing to the greatest degree practicable, adverse impacts on park resources and values. Although the NPS has the discretion to allow certain impacts in parks, that discretion is limited by the statutory requirement that park resources and values remain unimpaired, unless a specific law directly provides otherwise.

Council on Environmental Quality (CEQ) regulations and NPS Director's Order 12 also call for a discussion of the appropriateness of mitigation, as well as an analysis of how effective the mitigation would be in reducing the intensity of a potential impact (e.g., reducing the intensity of an impact from major to moderate or minor). Any resultant reduction in the intensity of an impact due to mitigation, however, is an estimate of the effectiveness of mitigation under NEPA only. Cultural resources are non-renewable resources, and adverse effects generally consume, diminish, or destroy the original historic materials or form, resulting in a loss in the integrity of the resource that can never be recovered.

3.9.2 ARCHEOLOGICAL RESOURCES

Archeological resources consist of "any material or physical evidence of past human life or activities which are of archeological interest, including the record of the effects of human activities on the environment" (NPS 2006). Archeological resources in the project area have been assessed with combination of archival research, site file research, and walkover surveys. These were used to document known archeological resources within the Herring River restoration area and to identify areas where unknown archeological resources may exist. This information, in combination with predictive models developed for archeological resources elsewhere in the region, was then used to plot areas of archeological sensitivity within the area of potential effect (APE), which is the geographic area in which an undertaking may cause changes in the character or use of historic properties, as defined under Section 106 of the NHPA (36 CFR 800, as amended). For this project, the APE is defined as areas in the estuary below the 10-foot contour elevation, and certain upland areas where project impacts may occur, such as areas around CYCC, the Chequessett Neck Road Dike, and several low-lying roads including High Toss Road, Bound Brook Island Road, and Pole Dike Road. This APE was investigated by the Public Archaeology Laboratory in 2011 to identify areas where significant historic resources might be found (figure 3-24)(Herbster and Heitert 2011). However, significant archaeological resources have yet to be identified pending final project design. Steps to identify, evaluate, and mitigate any adverse effects to significant properties are defined in the final Programmatic Agreement (PA) developed among the consulting parties. The final PA is included as appendix I of this document.

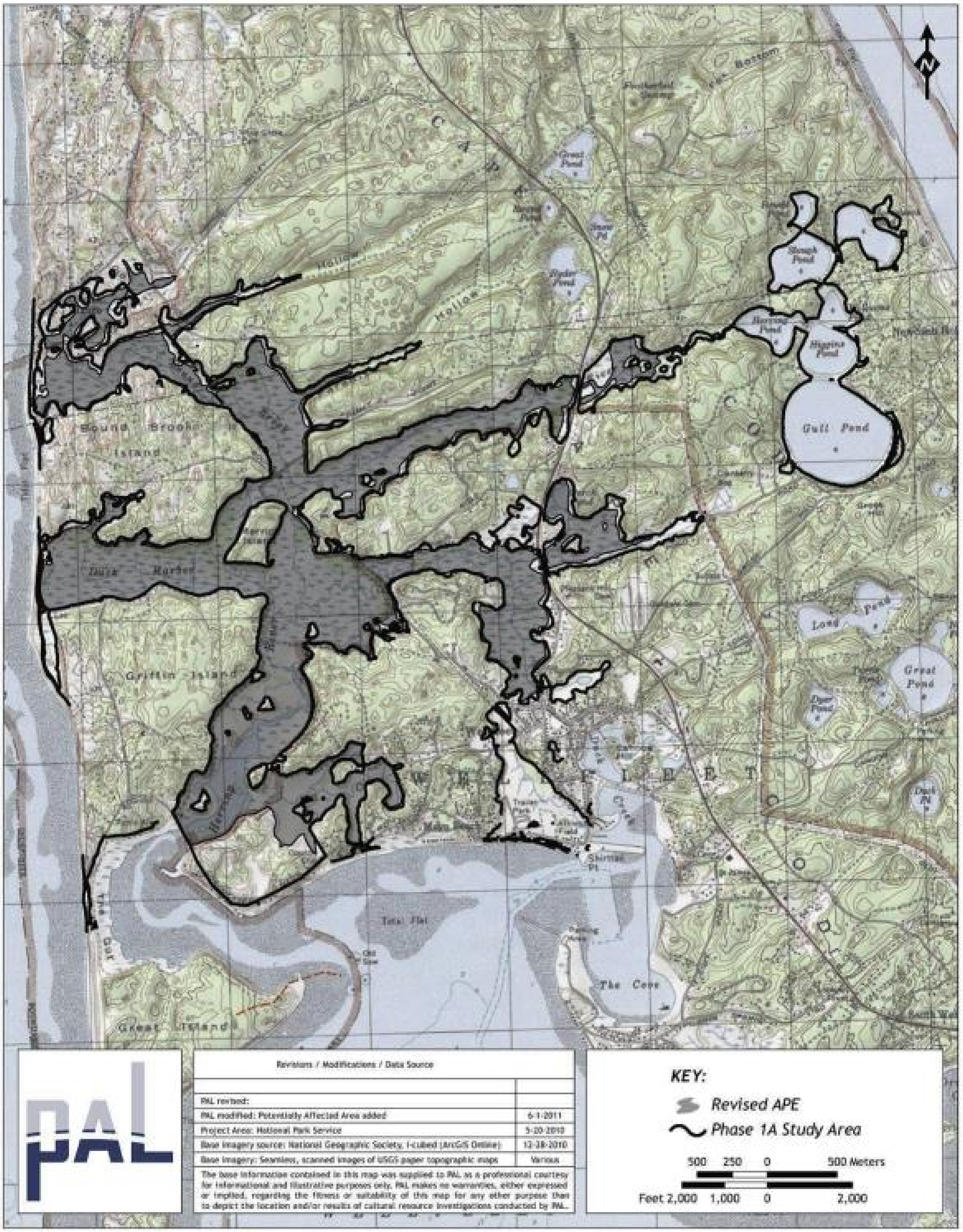


FIGURE 3-24: MAP OF THE HERRING RIVER RESTORATION PROJECT SHOWING PHASE IA STUDY AREA AND REVISED AREA OF POTENTIAL EFFECT

Archeologists have documented 12,000 years of pre-contact Native American occupation of the New England region, and oral tradition of some contemporary tribes recount a 50,000-year cultural legacy

(Herbster and Heitert 2011). The earliest archeologically documented peoples to inhabit the area are called Paleoindians by archeologists and are generally thought to have occupied Cape Cod between 10,000 and 12,000 years ago. Sites containing evidence from a number of time periods (i.e., multicomponent sites) have been identified in the Herring River basin in Harwich, and possible evidence of Paleoindian occupation has been recovered from some of these sites (Herbster and Heitert 2011:30). To date, no evidence of Paleoindian occupation has been found in the APE.

The subsequent Archaic period dates to between 3,000 and 10,000 years ago and is characterized by the frequent movement of small bands of people across the landscape to exploit a wide diversity of seasonal plant and animal resources. The toolkit of Archaic peoples was more diversified than in the prior Paleoindian period, and included a wide variety of stemmed and notched projectile points as well as groundstone tools such as axes, gouges, and grooved adzes. Beginning in the Middle Archaic period (circa 7,500 years ago), there is evidence that anadromous fish became a dietary staple, and brackish estuary heads are the locations of many sites dating to this period. By the end of the Archaic Period (circa 3,000 years ago), archeological sites are found in all types of environmental settings. Several sites in and around the APE contain evidence of Archaic occupation, in addition to a number of small lithic scatters of which many are likely Archaic in age.

The Woodland Period, dating between 3,000 and 500 years ago is signaled by the introduction of ceramic technology. There is an increase in the exploitation of shellfish, and evidence of Woodland period occupation is best represented by large accumulations of shell (middens). Archeological sites containing shell and pottery have been found along the Herring River in the vicinity of the APE. There are 25 known pre-contact sites within or adjacent to the APE. These sites include 15 sites documented by NPS staff during systematic surveys, and 10 sites indentified by amateurs (table 3-17). Pre-contact sites are generally small resource procurement and processing areas, especially shellfish gathering and middens (shell piles). Sites at higher elevations are generally lithic (chipped stone tools and debris) concentrations. Some include fire-cracked rock suggesting hearths (Herbster and Heitert 2011).

It is assumed that other unsurveyed sub-basins in the project area may contain pre-contact period archeological sites. Based on proximity to fresh or salt water, well-drained soils, level topography, known site locations, and degree of disturbance, an archeological sensitivity map has been developed for pre-contact archeological resources (Herbster and Heitert 2011:59-60). High and moderate sensitivity areas where pre-contact resources may be expected to occur have been identified within the APE, and consist primarily of flood plain margins along the edges of the APE. In addition, upland areas that could potentially be affected by the project have also been identified as sensitive for pre-contact archeological resources.

Contact and post-contact period sites date to after AD 1500, the entry period of Euro-Americans to the northeast coast of the United States. Native American contact period sites are characterized by shell middens and family farmsteads along coastal estuarine areas (LBG 2007). The population center of the Mashpee Wampanoag people was centered near Truro (LBG 2007). Ethnohistoric accounts document a well-established system of Native American trails on the Cape. A trail may have passed close to the project area along West Road, Route 6, and Chequessett Neck Road in Wellfleet (Herbster and Heitert 2011).

TABLE 3-17: KNOWN PRE-CONTACT SITES WITHIN OR ADJACENT TO THE AREA OF POTENTIAL EFFECT

Study Area Location	No.	Site Name MHC Number	Cultural Materials	Site Size/Type	Method of Identification
Herring River-Upper Basin	1	19-BN-133	Unknown	Unknown	Amateur Find
	2	19-BN-307	Low density chipping debris; Fire-cracked rock	100 sq meters Lithic scatter	NPS Survey
	3	19-BN-360	Low density chipping debris; Fire-cracked rock	200 sq meters Lithic Scatter	NPS Survey
	4	19-BN-433	Single flake; whiteware	0.5 sq meters Find Spot	NPS Survey
	5	19-BN-434	Low density chipping debris; Quartz biface; Fire-cracked rock	700 sq meters Lithic Scatter	NPS Survey
	6	19-BN-135	Chipping debris	1,200 sq meters Lithic scatter	Amateur Find
	7	19-BN-471* same general area as 135	High density debris; Shell; Projectile points; Pottery; Charcoal; Fire-cracked rock	12,500 sq meters Large site	NPS Survey
	8	19-BN-830 same area as 471; T-line site	Chipping debris	Unknown	NPS Surface Find
Griffin Island	9	19-BN-112* same general area as 313/320	Shell	Unknown Shell middens	Amateur Find
	10	19-BN-313* same general area as 112	Shell; Hammerstone	2 finds, 100-m apart Lithic scatter	NPS Survey
	11	19-BN-320* same general area as 112	Chipping debris; Fire-cracked rock	400 sq meters	NPS Surface Find
	12	19-BN-277	Low density chipping debris; Biface; Fire-cracked rock	900 sq m Lithic scatter	NPS Survey
	13	19-BN-110 GI Fencing Project #3	Shell; Pottery; Chipping debris; Hammerstone; Possible feature	Unknown Shell midden	Amateur Find/NPS Survey
	14	19-BN-443* same general area as 110	Shell; Pottery; Chipping debris	Unknown	NPS Survey
	15	19-BN-449* same general area as 110	Single flake	Unknown Find spot	NPS Survey
	16	19-BN-456	Low density chipping debris	Unknown	NPS Survey
	17	19-BN-464	Low density chipping debris; Shell	125 sq meters	NPS Survey
	18	19-BN-925 Old Road Site	Hammerstone; Quartz core	Unknown	NPS Survey

Study Area Location	No.	Site Name MHC Number	Cultural Materials	Site Size/Type	Method of Identification
Bound Brook Island	19	19-BN-125	Unknown	Unknown	Amateur Find
	20	19-BN-819 BBI Findspot	Single flake	0.5 sq meters Find Spot	CRM Survey
Pole Dike Creek	21	19-BN-117	Unknown	Unknown Shell midden	Amateur Find
	22	19-BN-118 Freeman Paine Red A	250 projectile points; 8 gouges; 20 plummets; 2 pestles; 30 choppers or hoes; Hammerstones; Red paint-indicative of possible burials	Unknown Habitation site	Amateur Find
	23	19-BN-119 Freeman Paine Red B	Unknown	Unknown	Amateur Find
Mill Creek	24	19-BN-107	Unknown	Unknown Shell midden	Amateur Find
	25	19-BN-113	Unknown	Unknown	Amateur Find

The year 1644 marks the beginning of permanent European settlement of the Lower Cape, when a tract of land that stretched from Pleasant Bay to Truro was purchased from the Nauset Indians by the Plymouth Colony. Within two decades, the southern portion of the patent, called Eastham, was no longer arable due to erosion from deforestation and agriculture, and settlers began moving north into what is now the Town of Wellfleet. The first meeting house was established at Chequessett Neck in 1712, and in 1723, the community was renamed the North Precinct or Billingsgate Parish. The parish was linked to the south by the King's Highway, constructed in 1720, and the first wharf was built on Griffin Island around this time (Herbster and Heitert 2011:35-36).

The North Precinct was incorporated as Wellfleet in 1763, and the primary industries of whaling, oystering, and fishing were the focus of commercial development in the area, including a whale-oil rendering try works located near Bound Brook Island Road. Limited agriculture was an aspect of the eighteenth-century economy of the town, as was the ship building industry in Duck Harbor. To support the booming mackerel and alewife fisheries, nearly 40 saltworks were built along the Herring River and its tributaries by 1837. These saltworks consisted of buildings and associated windmills, which were used to bring seawater up into evaporation vats. Diseased oyster beds were reseeded with oysters from the Chesapeake Bay, rejuvenating the industry, but agriculture continued to diminish in importance throughout the nineteenth century. One agricultural practice which continued throughout the nineteenth century was salt marsh haying, with over 300 tons of hay produced annually (Herbster and Heitert 2011:36-43).

The fishing industry, which served as the cornerstone of the economy through the eighteenth and early nineteenth centuries, began to decline after 1850. Siltation had begun to restrict the harbors, especially Duck Harbor, and the construction of the Cape Cod railroad causeway across the harbor in 1870 left it closed off from the sea. The construction of dikes and causeways for the railroad impounded marshes and restricted fish migrations, and by the end of the nineteenth century, communities on Bound Brook and Griffin islands once supported by the fishing industry had all but disappeared (Herbster and Heitert 2011:43).

However, construction of the Cape Cod Railroad led to a rise in tourism, and the local economy rebounded with the construction of resorts, hotels, and restaurants; local fishing and farming also rebounded to provide seafood and produce to growing numbers of summer visitors. Weir fishing became established in the 1870s, and by the end of the century, the herring runs throughout the Herring River estuary were some of the most productive in the state. One weir and an associated fish house may be located within or adjacent to the APE near the Atwood-Higgins property. Oyster shellfishing also flourished at this time, in part due to the proximity of reliable rail transportation to get the oysters to markets (Herbster and Heitert 2011:43-46).

By the beginning of the twentieth century, concerns that mosquitoes were affecting the tourism industry led to widespread ditching and diking of the low-lying flood plains and salt marshes. Unlike earlier dikes, these new structures prevented tidal exchange throughout much of the estuary; this tidal flushing was needed to maintain salt marsh hay crops and allow seasonal fish runs. Diking and ditching did allow for the construction of homes and resorts along the flood plain, including the CYCC, and the primacy of a tourism-based economy was firmly established. Throughout the twentieth century, roads were built or improved to handle the ever-increasing amount of automotive traffic bringing seasonal residents and visitors to the area (Herbster and Heitert 2011:47-48).

Eight post-contact period Euro-American sites have been recorded in the project area (table 3-18). All of the recorded sites relate to residential settlement. They include cemeteries, eighteenth and nineteenth century cellar holes with associated artifact scatters, and eighteenth - and nineteenth-century trash middens (Herbster and Heitert 2011).

TABLE 3-18: POST-CONTACT PERIOD EURO-AMERICAN SITES

Study Area Location	No.	Site Name MHC Number	Cultural Materials	Site Size/Type	Method of Identification
Herring River-Upper Basin	1	WLF-HA-14	Cellar hole; Shell; Ceramics; Charcoal; Glass; Brick; Mortar	925 sq meters Residential	NPS Survey
	2	WLF-HA-24	Metal; Nails	100 sq meters Historic scatter	NPS Survey
	3	WLF-HA-25	Ceramics; Shell; Building materials	5,000 sq meters refuse Dump	NPS Survey
Griffin Island	4	WLF-HA-33 GI Fencing Project #3	Ceramics; Brick; Glass	500 sq meters Historic Trash Deposit	NPS Survey
Bound Brook Island	5	WLF-HA-4 Lombard Family Graveyard	2 standing gravestones w/ 3 names	Mortuary	Amateur Find/CRM Survey
	6	WLF-HA-6 RM 11 Wellfleet	Unknown	Residential	Amateur Find
	7	WLF-HA-9	Cellar hole; Shell; Metal; Glass; Ceramics; Leather; Coal	700 sq meters Residential/Agrarian	NPS Survey
	8	WLF-HA-17	Cellar hole; Glass; Ceramics; Building Materials	2,500 sq meters Residential/Agrarian	NPS Survey

Based on historical references and limited above-ground evidence in walkover surveys, other likely types of post-contact Euro-American archeological resources that may potentially be found in the APE include wharves and docks; tidal mills and windmills; saltworks and try works; fishing stations and weirs; and foot paths, cart paths, and portions of the Cape Cod/Old Colony Railroad. Several historical sources refer to wharves or docks on Griffin and Bound Brook Island, but the on-the-ground locations have not been identified. With the arrival of the Cape Cod Railroad in 1870, water transportation diminished and there was little need to build or maintain these features. Mills and windmills appear on several historic maps, but none have been identified through archival research within the APE. If present, these features would likely be associated with a saltworks. Nineteenth century saltworks appear in the APE on Griffin and Bound Brook islands. The Bound Brook Island works also reportedly supported a try works (where whale oil was rendered from whale carcasses). The walkover survey of these saltworks did not identify above-ground features, with the possible exception of an earthen berm on Bound Brook Island. Archeological remains associated with saltworks could include wood from evaporation vats, barrel staves, or pipes; nails and screws; iron tool parts, such as shovels, rakes, poles, and barrel hoops; relict posts used to support vats; collapsed decking; and stone foundation elements associated with storage sheds. Try works could include iron tool parts such as kettles, hooks, and knives; burned bricks; heavily oxidized ground surfaces; stone foundations of storage sheds; and possibly whale remains. Areas of high and moderate sensitivity for post-contact archeological resources were identified during the Phase IA archeological survey and are present in the APE (Herbster and Heitert 2011:61-62). Site identification and evaluation of eligibility for the National Register was not determined.

3.9.3 Historic Structures

The NPS defines historic structures as “a constructed work, usually immovable by nature or design, consciously created to serve some human activity.” Examples are buildings, monuments, dams, roads, railroad tracks, canals, millraces, bridges, tunnels, locomotives, nautical vessels, stockades, forts, earthworks, ruins, fences, and outdoor sculpture (NPS 2006). Although there are no historic structures listed in the National Register in the Herring River estuary, a dike apparently spanned Mill Creek near the confluence with the Herring River. This dike was part of a historical tidal gristmill operation (Herbster and Heitert 2011). The Colonial period Atwood-Higgins House, listed on the National Register in 1976, and other buildings associated with the house lie within 100 meters (328 feet) of the APE of the restoration project near the confluence of Bound Brook and the Herring River on the eastern tip of Bound Brook Island (NPS pers. comm. 2011a; Herbster and Heitert 2011). Recent work has defined an Atwood-Higgins Historic District, which has been nominated for the National Register. The district as it is currently defined extends into or adjacent to the APE, although no significant resources in the district are within or immediately adjacent to the APE (Burke pers. comm. 2011a). Other historic structures may be identified and evaluated as the extent of project effects are finalized; steps necessary to identify and evaluate historic structures in the APE are defined in the final PA.

The Old Colony Railroad easement was constructed in 1870 and was incorporated into the Cape Cod Railroad in 1872. The railroad easement crosses the estuary from the west side of Bound Brook Island to the Town of Wellfleet. Along the railroad easement can be found the raised rail bed, tracks/ties, bridge abutments, and stone culverts (Herbster and Heitert 2011). A trestle also crosses Herring River northeast of the Bound Brook Island Bridge. Although these features can be classified as historic structures, the portions of the Cape Cod/Old Colony Railroad within the APE are considered archeological resources for the purposes of identification and evaluation.

The NPS maintains a List of Classified Structures (LCS). These structures are either listed in or eligible for the National Register or are to be treated as cultural resources even though they do not meet all National Register requirements. The LCS for the Seashore includes 72 structures such as stone walls, outhouses, shacks, and life-saving stations (NPS 2011d). None of the LCS structures are in the immediate project area.

3.10 SOCIOECONOMICS

The restoration of the Herring River estuary has several implications for local communities, homeowners, industries, and the local economy. First, changes to Herring River water quality and sediment transport could affect the Wellfleet Harbor shellfishery, most likely by allowing currently closed areas to open and by mobilizing sediment in areas immediately upstream and downstream of the Chequessett Neck Road Dike. Second, the estuary contains a number of low-lying roads and private properties that would be affected by higher tide levels if measures are not taken to protect them. Third, changes to the physical appearance and environmental conditions of the estuary would affect viewscapes and recreational opportunities in the estuary, possibly changing property values. Finally, construction activities associated with the project are expected to have a positive economic impact, although only general estimates about increased job opportunities can be made at this time.

3.10.1 NUISANCE MOSQUITOES

The human concern about biting mosquitoes has been a long-standing issue in the Herring River. Even the hardy Henry David Thoreau complained about the mosquitoes he encountered on the outer Cape during his famous walk in 1849 (Thoreau 1865, as cited in Cumbler, in press). By the beginning of the 20th century, as Wellfleet was evolving into a seasonal enclave for summer visitors, town leaders expressed concerns about mosquitoes and their potential for driving tourists away. One prominent citizen, Lorenzo Dow Baker, a wealthy former ship captain and the so-called "Banana King," owned the Chequessett Inn, a hotel built on a pier over Wellfleet Harbor. After several very wet years with high populations of mosquitoes, Baker led a group of town officials who petitioned the Massachusetts legislature for authorization to fund and construct a dike at the mouth of the Herring River (Cumbler, in press). According to an engineering study commissioned by the Town, "…the first and main object sought is to exterminate the mosquito pest…to transform the unsightly swamps…into clean and healthy areas, which will add to, instead of detract from, the beautiful landscape with which nature has richly endowed this locality" (Whitman and Howard 1906).

Although the Chequessett Neck Road Dike was built for this expressed purpose several years later in 1909, its effectiveness for mosquito control was marginal and the town was forced to continue and expand other mosquito control practices for several decades. This included oiling the marshes, channelizing the river, and creating grid ditches to drain freshwater. Much of this labor-intensive work was completed during the 1930s as the Works Progress Administration put thousands of men to work draining salt marshes all over the East Coast.

Although the practice of deliberately draining salt marshes for mosquito control diminished by the 1960s, on Cape Cod, the CCMCP continues to maintain salt marsh channels and ditches in an effort to drain freshwater and eliminate standing pools of water, which are prime mosquito breeding areas. In 1980, one of several massive die-offs of American eels (*Anguilla rostrata*) and other fish species occurred. After NPS researchers documented that fish kills in the Herring River were linked to low dissolved oxygen and re-suspension of highly acidic sediment caused by mosquito ditch maintenance in the tidally restricted system (see section 3.3.2 and refer to Soukup and Portnoy 1986), CCMCP discontinued mosquito ditch maintenance in the Herring River flood plain. However, ditches are still maintained outside the Seashore boundary in the Mill Creek, Upper Pole Dike Creek, and Upper Bound Brook sub-basins.

Despite decades of work and large public expenditures to eliminate them, the Herring River remains a major breeding area for nuisance mosquitoes. Dense vegetation, lack of tidal flushing and substantial freshwater flows, subsided marsh surfaces, and prior disturbances to the flood plain create extensive stagnant water breeding areas. In sampling conducted by the Seashore and CCMCP, the dominant mosquito species caught in the Wellfleet area, *Ochlerotatus cantator,* breeds in fresh to brackish water. Its larvae can tolerate the acidified waters that keep its predators—fish species that eat mosquito larvae—at bay. Species that are generally linked to human diseases, such as *Culex pipiens*—the primary vector for West Nile Virus in Massachusetts—are not abundant in the Herring River flood plain. In addition, *Culiseta melanura*, the primary vector of Eastern Equine Encephalitis among birds, which are the normal enzootic host, is uncommon on Cape Cod, where little of its breeding habitat (red maple and white cedar swamps) occurs. Although *C. melanura* does not bite humans, where it is common (e.g., southeastern Massachusetts, where large freshwater wetlands occur) it increases the frequency of the virus in the local bird population, thus increasing the potential for transmission from birds to humans by mammal biters like *O. cantator* or *O. sollicitans*.

3.10.2 SHELLFISHING

Tourism has surpassed commercial fishing as the main driver of the modern Wellfleet economy (Cataldo 2007). However, shellfishing remains a vitally important industry to Wellfleet's community identity and contributes considerable jobs and income to the local economy. Modern shellfishing also connects residents and visitors to an important aspect of Wellfleet's history, and confers status and name recognition to the community as the source for highly regarded Wellfleet oysters.

Historically, shellfishing harvests have fluctuated in Wellfleet. Shellfish in Wellfleet Harbor were consumed by Native Americans prior to the Pilgrims' arrival in the area in the 1600s (Cataldo 2007). Upon arriving to the area, the Pilgrims began harvesting shellfish in Wellfleet Harbor. The first major recorded decline of shellfish harvests in Wellfleet Harbor occurred during the 1770s (Cataldo 2007). However, the shellfish population rebounded, but declined again in the 1870s (Cataldo 2007). The first available record of the number of shellfish harvested amounts was in 1907 with approximately 145 shellfishermen harvesting 30,000 bushels of quahogs (Cataldo 2007). From 1915 to the mid-1920s, the number of commercial permits ranged from 10 to 60 permits per year. This number gradually increased over time and rose to 250 permits in the 1970s. Since the late 1990s, the number of permits has remained around 300 (Cataldo 2007).

Four commercially important species are harvested in Wellfleet: the hard clam, also known as the northern quahog (*Mercenaria mercenaria*); the eastern oyster (*Crassostrea virginica*); the bay scallop (*Argopecten irradians*); and the softshell clam or steamer (*Mya arenaria*). Although four shellfish species are harvested in Wellfleet Harbor, the town is best known for its eastern oysters and quahogs (Cataldo 2007). The quality of the shellfish products from Wellfleet is attributed to the high tide range and cold, nutrient rich waters of Wellfleet Harbor. Wellfleet oysters in particular are highly regarded by seafood enthusiasts and each October the town hosts the Wellfleet OysterFest to celebrate the oysters and the town's historical association with shellfishing (Wellfleet OysterFest 2011). The successful, long-standing shellfishery therefore has a more prominent local role than harvest values and job numbers alone would indicate. The connection with shellfishing distinguishes Wellfleet from other Cape Cod communities and contributes to a community identity that has both social and economic value.

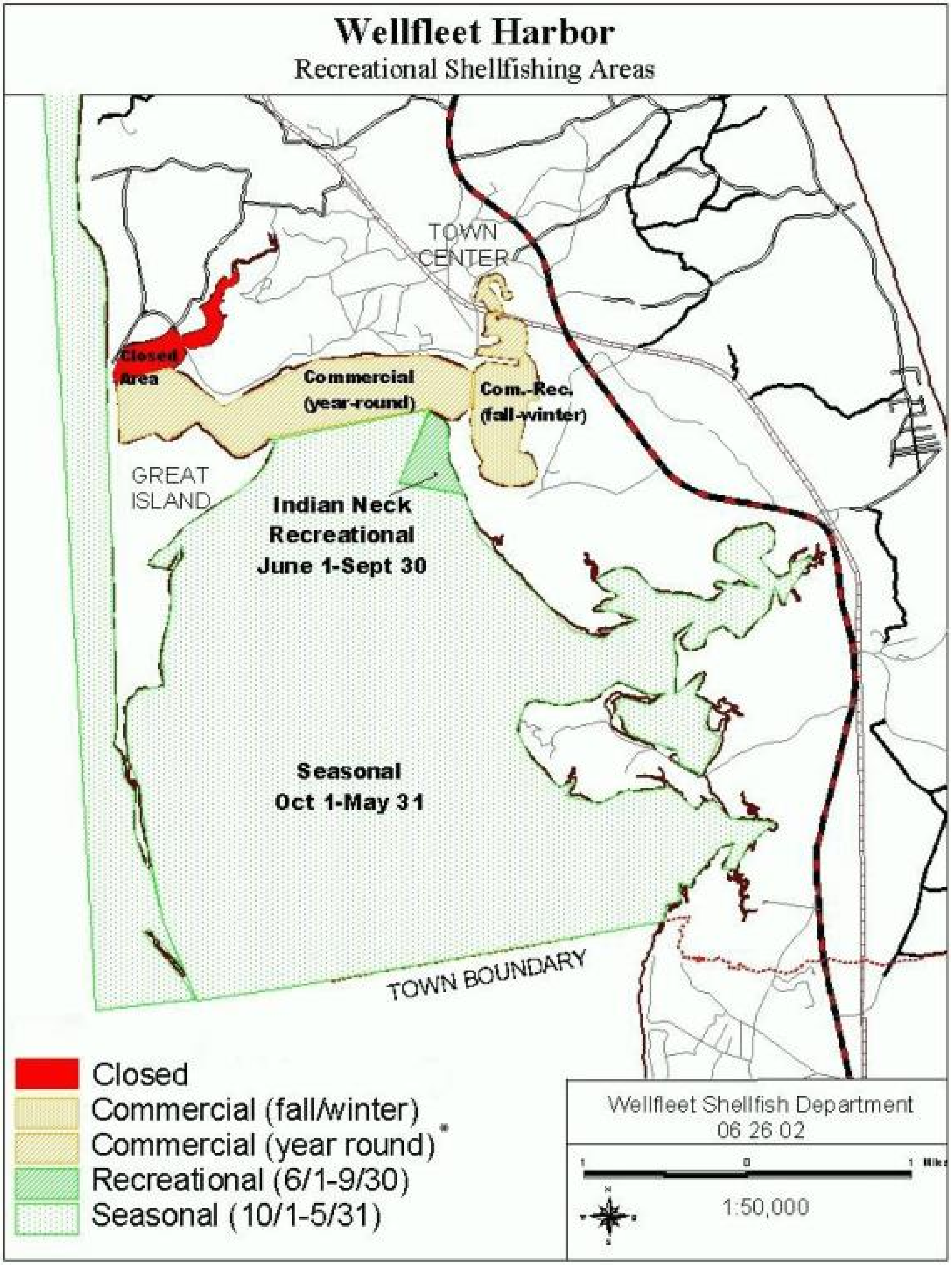
The shellfishing industry does not create a large number of jobs in a regional context, but employment in this industry represents a higher percentage of total employment in Wellfleet than it does in Cape Cod as a whole. In 2005, an estimated 200 people worked on aquaculture sites in Wellfleet Harbor (Cataldo 2007), while average annual employment in Wellfleet was 1,557 (BLS 2011a). A 1994 survey found that 14 percent of Wellfleet residents had worked in shellfishing or fishing in the past or were currently employed in the industry (Cataldo 2007). By comparison, less than 1 percent of total employment in Barnstable County in 2008 was in the commercial fishing and aquaculture industries (BEA 2011c).

The Town of Wellfleet has designated areas in Wellfleet Harbor for commercial harvesting of wild shellfish, aquaculture leasing operations, and recreational harvest of shellfish (figure 3-25). There are approximately 2,500 acres open for wild commercial and recreational shellfishing and approximately 262 acres leased for aquaculture in Wellfleet Harbor (Cataldo 2007; Moles, pers. comm. 2011a). Currently, shellfishing is prohibited in a 90-acre area immediately downstream of the Chequessett Neck Road Dike and within the Herring River due to poor water quality caused by fecal coliform bacteria (Cook, pers. comm. 2011). Additionally, an area of the Herring River downstream of the dike that is between Wellfleet Harbor and the closed shellfishing zone is now open only seasonally (from September through March) due to high levels of fecal coliform (Town of Wellfleet 2007). Shellfishing is not allowed in any part of Wellfleet Harbor when temperatures are at or below 28°F, which typically occurs in December, January and February.

Historically, commercial wild shellfish harvests in Wellfleet have fluctuated with no clear trends, whereas aquaculture harvests have increased since 1989. Although the Town of Wellfleet has supported aquaculture since the 1850s, harvest data has only been available since 1989 (Town of Wellfleet 2006). The largest reported harvest of wild shellfish, which includes quahogs, oysters, and clams combined, between 1955 and 2007 was approximately 91,000 bushels, which occurred in 1971. However, in most years, the total harvested amount of wild shellfish has been less than 20,000 bushels. Between 1989 and 2000, aquaculture harvests have remained relatively constant between 5,000 and 10,000 bushels harvested per year. Between 2000 and 2010, aquaculture harvests have increased and fluctuated between 17,000 and 40,000 bushels annually (Moles, pers. comm. 2011c; Churchill, pers. comm. 2011).

Tables 3-19 and 3-20 present wild and aquaculture shellfish harvest and value data. On average between 2006 and 2010, the wild shellfish catch (excluding lobster and crabs) in Wellfleet Harbor represented approximately 30 percent of the total harvest of all shellfish. In 2010, the wild shellfish harvest represented approximately 37 percent of the total volume and value of all shellfish harvested (McAfee, pers. comm. 2011). On average, between 2007 and 2010 approximately 2 percent of all wild shellfish commercially harvested in Wellfleet Harbor came from an area of the Herring River downstream of the Chequessett Neck Road Dike. The area of the Herring River immediately downstream of the dike is permanently closed to shellfishing. However, a seasonally open shellfishing area is located just southeast of this area, between the permanently closed area and greater Wellfleet Harbor area, which starts at the northeasternmost point of the Great Island (Town of Wellfleet 2007). In 2009, shellfish harvested from the seasonally open area downstream of the dike represented 4 percent of the total wild shellfish harvest (McAfee, pers. comm. 2011).

Since 1989, aquaculture harvests of quahogs and oysters have fluctuated but have generally increased over time (Moles, pers. comm. 2011c). In 2009, the eastern oyster represented approximately 40 percent of the total aquaculture harvest value and quahogs represented nearly 60 percent of the total aquaculture harvest value (Moles, pers. comm. 2011b). In 2009, quantities of harvested quahogs were almost half those of the harvested quantities that occurred in 2007 and 2008.



Source: Town of Wellfleet 2011. Edited by The Louis Berger Group in 2012.

* Not all of this area is open year round. Portions of the area of the Herring River downstream of the dike between Wellfleet Harbor and the closed shellfishing zone are open only seasonally, from September through March annually (Town of Wellfleet 2007).

FIGURE 3-25: REGULATED SHELLFISHING AREAS OF WELLFLEET HARBOR

TABLE 3-19: VALUE AND LANDED LIVE WEIGHT OF WILD-HARVESTED SHELLFISH (2006–2010)

Year	Wellfleet Harbor		Seasonally Open Area of the Herring River Downstream of the Dike	
	Live lbs.	Value	Live lbs.	Value
2006	929,370	$1,168,648	*	*
2007	718,011	$891,857	2,105	$5,058
2008	577,791	$793,308	7,612	$16,497
2009	716,961	$944,806	25,602	$36,493
2010	973,572	$1,550,012	12,729	$34,145

Source: McAfee, pers. comm. 2011.

* Herring River values and land live weight data are included in Wellfleet Harbor data. Data for the Herring River for 2006 are confidential; therefore data is not displayed. Values are the value paid by the primary buyer of shellfish at the initial point of sale after the fish are harvested. Values may therefore be considered wholesale values.

TABLE 3-20: VALUE AND VOLUME OF AQUACULTURE HARVEST (2007–2009)

Year	Species	Bushel Amounts	Bushel Value ($)	2009 Value ($)
2007	Quahogs, Little Necks	22,869	68.00	1,555,092
	Quahogs, Cherrystones	81	32.50	2,632
	Quahogs, Chowder	86	22.50	1,935
	Eastern Oyster	4,629	100.00	462,900
	Soft-Shelled Clam	1	80.00	80
	TOTALS	**27,666**		**2,022,639**
2008	Quahogs, Little Necks	22,915	60.00	1,374,900
	Quahogs, Cherrystones	81	28.00	2,268
	Quahogs, Chowder	86	15.00	1,290
	Eastern Oyster	4,723	110.00	519,530
	Soft-Shelled Clam	1.0	75.00	75
	TOTALS	**27,806**		**1,898,063**
2009	Quahogs, Little Necks	12,710	60.00	762,630
	Quahogs, Cherrystones	20	28.00	560
	Quahogs, Chowder	8	15.00	120
	Eastern Oyster	4,770	110.00	524,700
	Soft-Shelled Clam	4	75.00	300
	TOTALS	**17,512**		**1,288,310**

Source: Moles, pers. comm. 2011b.

Note: Little Necks range in size from 25.4 to 36.4 mm. Cherrystones range in size from 36.5 to 41.3 mm. Any Quahog larger than 41.3 mm is considered a Chowder (Cataldo 2007). Figures reported for 2008 and 2009 might include wild shellfish production.

Various methods are used to increase wild shellfish stock and harvests. For instance, cultch (old clam and oyster shell) is currently spread in various portions of Wellfleet Harbor, including the area of the Herring River downstream of the dike (see figure 3-26), to provide suitable substrate to which spat can bond. Spat is a larval oyster that is beginning to develop a shell. The spreading of cultch benefits wild oyster harvesting operations by providing more substrate habitat than what would be available naturally. Cultch, like naturally occurring oyster beds, is susceptible to being covered by sediment (Koch, pers. comm. 2011c).

Shellfish aquaculturists also use various methods to protect and increase the productivity and growth of shellfish stock. In designated areas of Wellfleet Harbor (see figure 3-26), shellfish aquaculturists raise oysters in cages that are elevated above the harbor bottom to protect the oysters from being covered by sediment. Aquacultural operations also use ‘Chinese hats’ to grow and mature spat. These Chinese hats allow aquaculturists to collect and nurture their own seed, rather than having to buy seed from a commercial hatchery. Chinese hats are shallow plastic cones that can be stacked upon one another, bonded by a cement mixture, resulting in 3 to 4 feet tall stacks that are set into the water before the reproductive season. When spat are of appropriate age, they are removed from the Chinese hats and planted in the raised aquaculture oyster beds for later harvesting (Koch, pers. comm. 2011c). Generally, Chinese hats are tall and sit above the sediment on the bottom of the harbor.

In the designated aquaculture areas, aquaculturists also use nets to protect quahogs from predators while they mature. These nets are kept over the quahogs year round and are only removed while the clams are being harvested or to remove sediment from portions of the nets (Koch, pers. comm. 2011c).

According to the Cape Cod 1998 General Management Plan, the NPS is an upland owner of the shellfish beds residing within Cape Cod National Seashore; however, the Commonwealth of Massachusetts has preeminence in the area of shellfishing, and state statute devolves responsibility for managing shellfishing and aquaculture to local communities. The General Management Plan states that, therefore, the NPS will cooperate with state agencies and local towns on shellfish aquaculture activities within seashore boundaries as long as customary low technology and a dispersed character of small shellfishing grants for individuals and families are maintained and if cultural patterns of use and enjoyment are sustained, as long as marine biodiversity is safeguarded. Furthermore, when national seashore managers are approached to evaluate aquaculture activities, they consider the aquaculture species proposed, the potential impacts of increased aquaculture development on marine systems and other environmental, recreational, and aesthetic impacts, and the density of aquaculture use in balance with other values of the tidal flats and coastal area (NPS 1998).

3.10.3 FINFISHING

Finfishing, like shellfishing, is an important industry and recreational activity in Wellfleet and connects residents and visitors to an important aspect of Wellfleet’s history. Bluefish, striped bass, and winter flounder are predominant salt water sport fish within Wellfleet Harbor.

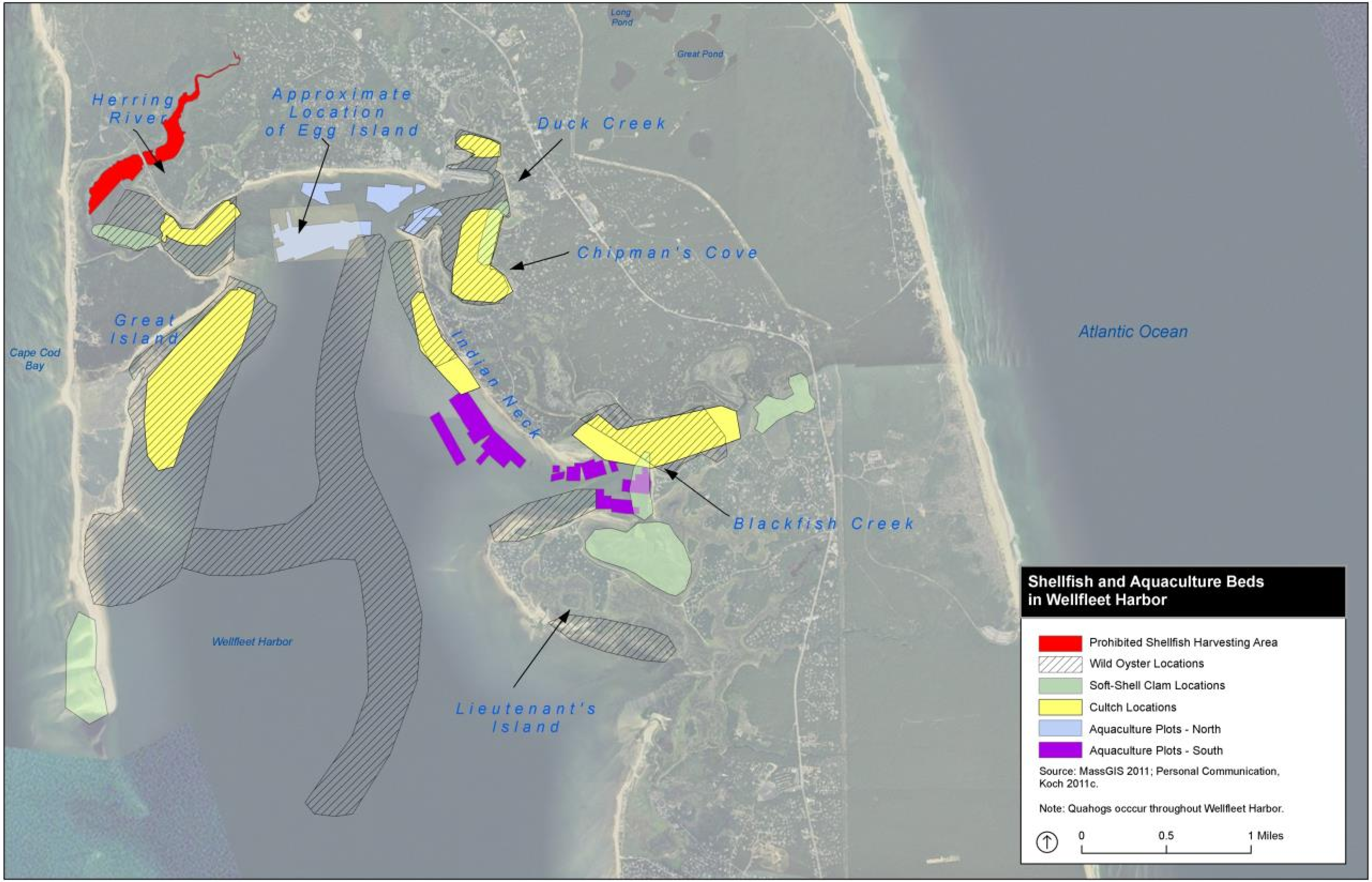


FIGURE 3-26: SHELLFISH AND AQUACULTURE BEDS IN WELLFLEET HARBOR (LOCATIONS APPROXIMATE)

Bluefish (*Pomatomus saltatrix*) and striped bass (*Morone saxatilis*) are the two predominantly fished species today in Wellfleet Harbor and the greater Cape Cod waters and are dependent on an estuarine environment at some point in their lifecycle. Striped bass represent an important commercial commodity throughout both Massachusetts and Cape Cod. The value of the striped bass fishing industry in Massachusetts in 2010 was approximately $3.6 million (NOAA 2012), with Cape Cod accounting for one-half to two-thirds of this amount (Town of Wellfleet 2006). The commercial finfishing industry has declined in Wellfleet in recent years; as a result, the industry has shifted toward recreational finfishing (Town of Wellfleet 2006). Recreational finfishing is addressed further in "Section 3.10.7: Recreational Experience and Public Access."

Estuaries provide habitats for finfish, such as the winter flounder (*Pseudopleuronectus americanus*), to spawn and grow; typically, salt marshes are important spawning habitats, provide protection from predators, and offer food for both juvenile and adult finfish (NPS 2011e). Throughout the nation, estuaries play a crucial role in supporting the fishing industry. Approximately 75 percent of the 10 billion pounds of the total United States. commercial fish landings annually, worth over $3.8 billion, are species that are dependent on estuarine conditions for at least some stage of their lifecycle (Pendleton 2008). Additionally, increased tidal exchange and salinity in an estuary can lead to greater species diversity and finfish abundance (Portnoy et al. 2005).

Table 3-21 summarizes the total commercial finfish harvests (i.e., catch) and values for Wellfleet between 2006 and 2010. The amount of landed commercial finfish has fluctuated over the period from 2006 through 2010. These values are relatively small compared to the shellfish harvest values. In 2009, the value of landed commercial finfish in Wellfleet Harbor represented less than 1 percent of the aquaculture and wild commercial shellfish harvest values. In 2009, the amount of commercial finfish landed in Wellfleet, at 9,606 pounds, made up a small portion of the total amount of commercial finfish landed in the state of Massachusetts, which had a total landed weight of approximately 356,000,000 pounds (McAfee, pers. comm. 2011; NPS, pers. comm. 2011c).

TABLE 3-21: TOTAL COMMERCIAL FINFISH HARVEST IN WELLFLEET, MA (2006–2010)

	Finfish [a,b]	
Year	Live lbs.	Value
2006	7,390	$8,085
2007	9,130	$13,148
2008	7,684	$9,806
2009	9,606	$16,439
2010	3,009	$5,174

Source: McAfee, pers. comm. 2011.

a Finfish include species such as bluefish, cod, winter flounder, and striped bass. Shellfish include species such as the northern quahog, blue mussel, eastern oyster, crabs, and lobster.

b The finfish identified were landed in Wellfleet and were not explicitly caught in Wellfleet Harbor. These finfish could have come from anywhere, including Cape Cod Bay, and were landed in Wellfleet.

According to the Cape Cod 1998 General Management Plan, a consistent policy toward stocking programs for fishing would be developed in cooperation with the Massachusetts Division of Fish and Wildlife and the use of native species will be encouraged in such programs. Additionally, this General Management Plan stated that fishing within the national seashore (focusing on native species) is allowed at levels compatible with the purposes of the seashore and with sustainable populations and ecosystems. Efforts are made to minimize conflicts with other visitor uses and private property. Finally, finfish aquaculture is permitted within the seashore, subject to several conditions outlined in the General Management Plan, and Finfish habitat cannot be altered merely to support game animals (NPS 1998).

3.10.4 LOW-LYING PROPERTIES

Approximately 390 non-federally owned properties lie partially or fully within the Herring River flood plain as it existed prior to construction of the Chequessett Neck Road Dike. These properties include residential land, parcels owned by non-profit organizations, non-federal conservation land, commercial parcels, municipal lands, and undeveloped land (Town of Wellfleet 2011). In total, these parcels cover approximately 354 acres of land within the Herring River flood plain[3]. Table 3-22 summarizes the types of properties. Figure 3-27 identifies all privately owned land within the flood plain.

TABLE 3-22: LOW-LYING PROPERTIES IN THE HISTORIC FLOOD PLAIN

Property Type	Percentage of Parcels (of 390 total parcels)
Residential	82%
Commercial	3%
Undeveloped	7%
Municipality	5%
Conservation, Non-Profit	3%

Residential Property

Residential land comprises approximately 17 percent of the total land within the historic flood plain. Approximately 82 percent of non-federal lands are private residential properties having a portion of their land within the pre-dike flood plain. These properties are primarily in the Upper Pole Dike Creek, Mill Creek, and Bound Brook sub-basins.

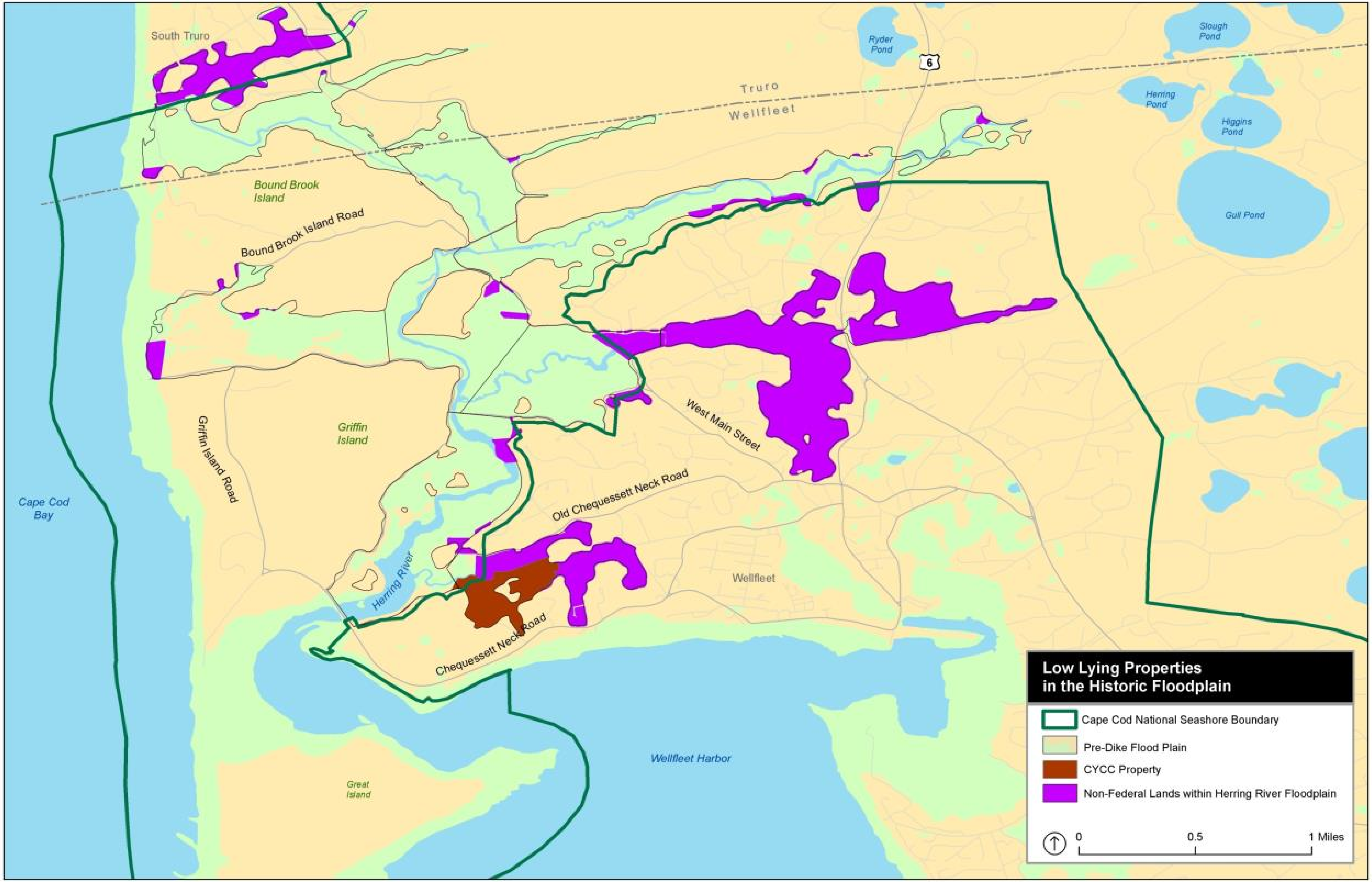
Commercial Properties

In addition to the golf course, there are 10 other commercial properties in the pre-dike flood plain. Three are in Upper Pole Dike Creek along Route 6 in Wellfleet. Eight other commercial properties are on the south end of Upper Pole Dike Creek. Commercial properties are used for restaurants and small business offices.

Undeveloped, Municipal, and Non-Profit Properties

Three other classifications of properties exist in the pre-dike Herring River flood plain. These properties include undeveloped land, municipal lands owned by the Towns of Wellfleet or Truro, and non-profit lands. Most of the properties classified as non-profit are owned by the Wellfleet Conservation Trust. Other properties are owned by religious organizations.

[3] The CYCC is excluded from this analysis and is analyzed separately, below.



Source: Town of Wellfleet 2011.

FIGURE 3-27: CURRENT NON-FEDERAL LAND OWNERSHIP IN THE HISTORIC (PRE-DIKED) HERRING RIVER FLOOD PLAIN

Chequessett Yacht and Country Club

The CYCC, established in 1929, is a semi-private country club southeast of the Chequessett Neck Road Dike in the Mill Creek sub-basin. The CYCC nine-hole golf course covers approximately 106 acres, with approximately 37 acres of this land located within the Mill Creek sub-basin in the historic flood plain (HRTC 2007). Portions of the golf course were built on former salt marsh. The low elevation, subsidence caused by diking and tidal restriction, and poorly drained soils have created present day flooding problems on the golf course. Property elevations on the CYCC property range from below Wellfleet Harbor mean sea level to about 60 feet above mean sea level (NPS pers. comm. 2011a; USGS 2008; MassGIS 2011).

3.10.5 LOW-LYING ROADS

Several segments of low-lying roads occur within the historic Herring River flood plain and may be susceptible to flooding after tidal exchange is restored. These are public roads that cross the river and various tributary streams and link upland areas that surround the estuary. They range from infrequently traveled fire roads to moderately busy paved roads. The major low-lying roads identified as potentially affected by the project are portions of High Toss Road, Old County Road, Pole Dike Road, Snake Creek Lane, Old Chequessett Neck Road, Duck Harbor Road, Ryder Beach Road, and Bound Brook Island Road. These roads are summarized in table 3-23 (ENSR 2007b) and depicted in figure 3-28. Several other short road segments and minor roads are also included in the table and figure.

High Toss Road—High Toss Road begins at an intersection with Pole Dike Road and extends to a dead end on Griffin Island. It crosses the Herring River approximately one mile upstream of the Chequessett Neck Road Dike. The road is unpaved and provides access to several residential areas and to Rainbow Lane. From Rainbow Lane to its end, High Toss Road is a causeway, crossing the Herring River flood plain and is only slightly higher than adjacent wetlands. At the western end of the road, a tidally restrictive, 60-inch-diameter, 24-foot-long concrete culvert conveys the Herring River beneath the road. Portions of this road, including the entirety of the causeway crossing the flood plain, are between 3 and 5 feet in elevation (ENSR 2007b).

Pole Dike, Bound Brook Island, and Old County Roads—Despite the separate names, these three road segments form a single, continuous route traversing the eastern edge of the Herring River and Bound Brook flood plains. From High Toss Road, Pole Dike Road extends north, crosses Pole Dike Creek, and turns into Bound Brook Island Road. Bound Brook Island Road crosses both the Herring River and Bound Brook, and turns into Old County Road in Truro, which extends to Ryder Beach Road and beyond. The route is heavily traveled, particularly for access to the Wellfleet transfer station. It also provides a key alternate to Route 6, linking the centers of Wellfleet and Truro. Together these roads comprise about 2 miles, with more than 7,000 feet occurring at elevations below the historic flood plain. Several sections, mostly near stream crossings, are below 3 feet and just slightly higher than adjacent wetlands.

Rainbow Lane—Rainbow Lane runs north/south along the eastern part of the Lower Herring River flood plain and provides access from High Toss Road to several residential properties. Rainbow Lane, as it extends to Old Chequessett Road, is overgrown and impassable to vehicles beyond the developed properties and used mostly by walkers. Rainbow Lane is also known locally as Snake Creek Road.

TABLE 3-23: SUMMARY OF LOW-LYING ROADWAYS IN THE HERRING RIVER FLOOD PLAIN

Road Name	Approximate Lowest Elevation (ft. NAVD88)	Approximate Length (ft.) in Flood Plain (below 6 ft. NAVD88)
Paved Roads		
Bound Brook Island Road/Old County Road	2.3	3700
Pole Dike Creek Road	2.7	3,105 (two segments)
Duck Harbor Road/Griffin Island Road	5.5	1,284 (two segments)
Old Chequessett Neck Road (Snake Creek Rd)	5.4	703
Old County Road (Paradise Hollow), Wellfleet	3.2	289
Old County Road (Lombard Hollow), Truro	3.5	197
Old County Road (Prince Valley), Truro	4.0	119
Approximate Length of Low Paved Roads		9,397
Sand and Fire Roads		
Duck Harbor Road, Fire Road West of Herring River	4.0	4,574
High Toss Road, From Pole Dike Rd to Rainbow Lane	4.0	3,299
High Toss Road, Causeway Across Flood Plain	3.1	1,017
Rainbow Lane (Snake Creek Road)	4.0	992
Mill Creek Lane	5.5	395
Ryder Beach Road, Truro	4.0	349 (three segments)
DPW Yard Driveway	5.0	101
Approximate Length of Low Sand and Fire Roads		10,727
Approximate Length of All Low Roads		**20,124**

Old Chequessett Neck Road—Old Chequessett Neck Road is a paved public road extending from West Main Street in Wellfleet to its end at Chequessett Knolls Road. This road runs along the eastern edge of the Lower Herring River sub-basin and the northern edge of the Mill Creek Sub-basin. It is also known locally as Snake Creek Road.

Duck Harbor Road—Most of Duck Harbor Road is an unimproved, dirt road that runs north to south from Chequessett Neck Road to north of High Toss Road and along the northern edge of Griffin Island. Several sections are overgrown and vehicles are rare. The road is used primarily for walking. There is also a busier paved section of Duck Harbor Road at the northwest edge of Griffin Island connecting Griffin Island Road to a public landing at Duck Harbor.

Ryder Beach Road—Ryder Beach Road is a paved and unpaved public road in Truro that runs west from Old County Road to Ryder Beach for approximately 0.6 mile and beyond to several residential properties.

FIGURE 3-28: LOW-LYING ROAD SEGMENTS IN THE HERRING RIVER HISTORIC FLOOD PLAIN

3.10.6 VIEWSCAPES

Currently, there are approximately 700 acres of woodlands and shrublands in the flood plain, while open water and salt and brackish marsh account for 88 acres primarily located in the Lower Herring River sub-basin. Freshwater marsh and meadows account for approximately 222 acres within the flood plain.

The existing landscape character differs markedly between the upper and lower portions of the historic flood plain, with vegetation changing dramatically from north to south. This change is primarily a function of the existence of ponded freshwater and drained salt marshes in the upper flood plain, whereas brackish conditions exist toward the more open waters near the mouth of the river at the Chequessett Neck Road Dike. The upper Herring River flood plain is a wet forest environment characterized by abundant dense vegetation. Examples of these viewscapes are portrayed in figures 3-29 and 3-30.

Compared to the woodland in the northern portions of the historic flood plain, the landscape of the lower Herring River is more open, with expansive views in many directions. Grasses and other low-growing vegetation dominate in this area, with some trees present at the periphery (figure 3-31). Larger structures including the dike and several houses are also apparent at the mouth of the flood plain. In Mill Creek, the CYCC golf course is the prominent visual component. Access roads, ranging from narrow dirt roads to two-lane paved roads, weave through portions of the flood plain, offering glimpses of the estuary. Broader views are generally obscured by trees and dense shrub thickets.

FIGURE 3-29: AERIAL VIEW OF WOODED WETLANDS AROUND MERRICK ISLAND IN THE HERRING RIVER FLOOD PLAIN

FIGURE 3-30: CURRENT CONDITIONS IN UPPER HERRING RIVER SUB-BASIN FRESH WATER MARSH AND WOODED WETLAND

FIGURE 3-31: CURRENT CONDITIONS IN LOWER HERRING RIVER FROM CHEQUESSETT NECK ROAD DIKE

The presence of coastal wetlands and water features can affect the value of lands and properties. Bodies of water have historically been population magnets and property values along the coasts are indicative of this value. Environmental psychologists have explained this appeal to water as the desire to return to the natural state of existence (Pitt 1989). Others have suggested that water and water views hold attention and interest more effectively than urban scenes (Ulrich 1981). The added value of waterfront properties has implications for homeowners' wealth, but can also benefit local governments by generating higher property taxes.

Provencher, Sarakinos, and Meyer (2006), in their study of property valuations following the removal of control structures under river restoration efforts, suggest that residential property values near a free-flowing stream are higher than identical properties in the vicinity of a small impoundment. Johnston et al. (2002) examined the value of salt marshes to residents of Rhode Island. Although the authors did not directly analyze property values, they found that residents placed greatest value on mosquito control and protection of shellfish habitat, followed by protection of fish and bird habitat.

The Wellfleet Assessor's Office identifies properties in three neighborhood types based on their proximity to the Seashore or a body of water; (1) woodlot[4], (2) water-influenced, and (3) National Seashore (Vail, pers. comm. 2011). The Wellfleet Assessor's Office values properties that are located in the Seashore neighborhood (inholdings located within the Seashore boundary), in general three times higher than comparable woodlot neighborhood properties. Properties that are located in the water-influenced neighborhood, (lots that are located next to a body of water such as the ocean or harbor), are on average valued 2.2 times higher than comparable woodlot neighborhood properties (Vail, pers. comm. 2011). There a number of water-influenced properties in the Mill Creek sub-basin, as well as Seashore inholdings across the Herring River sub-basins; however, the majority of properties in the Herring River flood plain are identified as non-water-influenced or woodlot properties.[5]

3.10.7 RECREATIONAL EXPERIENCE AND PUBLIC ACCESS

The Herring River flood plain provides numerous recreational opportunities to local residents and visitors. The restoration project may have impacts on some of these activities. Under the General Management Plan for Cape Cod National Seashore, the Herring River is zoned as a natural area where development is limited and recreational activities are to remain passive and unobtrusive. A brief description is provided of the primary recreational opportunities that are available in the Herring River area.

Recreational Finfishing—Historically, the Herring River has been heavily used by local residents and visitors for recreational fishing. Today, the area still provides limited recreational fishing opportunities. Although several freshwater fish species inhabit the Herring River (these species are identified in section 3.6) and access points to the river occur in several locations, fishing upstream of the Chequessett Neck Road Dike is rare because of poor habitat and the generally depauperate condition of the freshwater fishery. In contrast, fishing off of the downstream side of the dike is extremely popular, especially during striped bass and bluefish seasons when the dike is almost

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[4] Woodlot neighborhood properties are properties that are not located within the boundaries of the Seashore or are not located within close proximity to, or have their property values influenced by, a body of water.

[5] There are properties within the Town of Truro boundaries that have not been assessed.

constantly occupied by fishermen. In addition to striped bass and bluefish, winter flounder are an important recreational finfish species in the Wellfleet Harbor area.

In addition to recreational fishing along the Herring River, a large trip boat for recreational fishing operates out of the Town of Wellfleet's marina, as do many smaller charters. Six sport fishing charter companies were listed on the Wellfleet Chamber of Commerce's website in November 2011. These Charter boats take paying customers out into Cape Cod Bay to fish (Wellfleet Chamber of Commerce 2011). Recreational fishermen also use private boats, which can be launched from multiple spots around Wellfleet including the town's marina (Town of Wellfleet 2006). Currently, 57 Bait and Tackle Shops are in business on Cape Cod and provide fishing equipment and bait to recreational fishermen (NPS, pers. comm. 2011c). The closest bait and tackle shop to Wellfleet is located in Eastham, approximately 8 miles south from the Wellfleet Town Pier.

Recreational Shellfishing—Wellfleet Harbor is a popular location for shellfishing. Shellfishing areas are regulated and include specific regions for aquaculture and recreational shellfishing. Recreational shellfishing is currently limited to two areas in Wellfleet Harbor, Indian Neck and an area open seasonally on the east side of Wellfleet Harbor (see figure 3-26). Although the portion of the Herring River just downstream of the Chequessett Neck Road Dike is designated as a shellfish harvest area, it is permanently closed because of fecal coliform pollution originating from the river (see sections 3.6 and 3.10.2).

Boating—There are no official canoe/kayak launches on the Herring River. However, the river can be accessed at several locations and canoes and kayaks are seen occasionally.

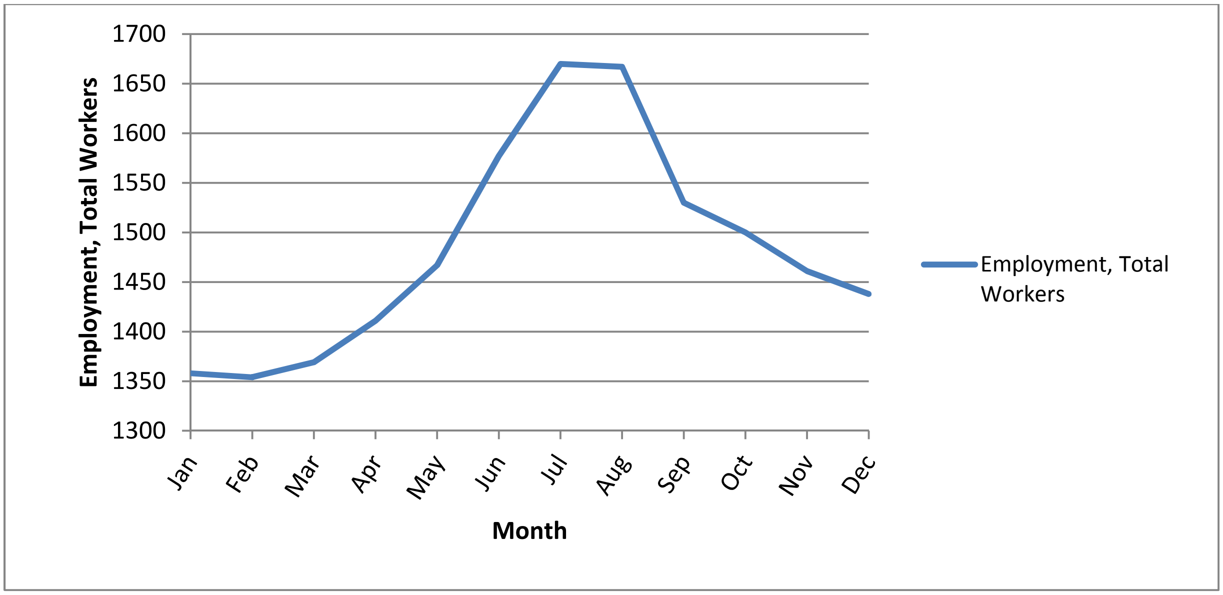
Trails and Camping—The 8-mile Great Island Trail is the only official hiking trail near the Herring River, but is across the harbor and not within the project area. Several fire roads, such as the remote portions of Duck Harbor and Bound Brook Island Roads on Griffin and Bound Brook Islands are popular for walking. There is no legal camping in the area around Herring River.

Wildlife Watching and Hunting—Hunting for upland game and migratory waterfowl is permitted at the Seashore. Specific game species include white-tailed deer (*Odocoileus virginianus*), eastern cottontail (*Sylvilagus floridanus*), wild turkey (*Meleagris gallopavo*), gray squirrel (*Sciurus carolinensis*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), and opossum (*Didelphis spp.*). Hunting is currently permitted from approximately Jeremy Point on Great Island, north to the Bound Brook basin, and in the Upper Herring River sub-basin to the west. Birding and wildlife viewing is a popular activity in the Herring River vicinity.

3.10.8 REGIONAL EMPLOYMENT CONDITIONS

Tourism is the primary driver of the Cape Cod economy (Cataldo 2007), although other factors also influence the seasonal nature the region's economy. Following a pattern observed in all Cape Cod towns, economic activity and employment levels in Wellfleet rise in the spring, are at their peaks during the summer months, decline in the fall, and are lowest during winter months. Figure 3-32 depicts this pattern in a typical year (Bureau of Labor Statistics 2011c).

Since the fall of 2008 when the economic recession began, national and regional economies have been affected by losses in jobs and income. Unemployment rates have also risen since 2007, reflective of the current economic downturn. Employment by industry was analyzed in 2007 and 2010 to assess the available workforce to support the construction of the project.



Source: Bureau of Labor Statistics 2011c.

FIGURE 3-32: EMPLOYMENT LEVELS IN WELLFLEET. JANUARY 2010 TO DECEMBER 2010

In 2010, 24 percent of the employment in Cape Cod, (Barnstable County), was associated with retail sales, accommodations, and food and beverage establishments, reflecting the important tourism economy in Wellfleet and across the Cape. Other important sectors in Barnstable County include health care and social assistance (13 percent), government (11 percent), and construction (8 percent). From 2007 through 2010, Barnstable County lost over 5,000 jobs, a 4 percent decrease during this period. Overall, unemployment rates have also increased since 2007, rising approximately 4 percent in Wellfleet and Barnstable County between 2007 and 2010. Employment by industry in Barnstable County is summarized in table 3-24 for 2007 and 2010; additionally the number of jobs lost or gained is also summarized along with the percentage change in employment during this period.

Restoration of Herring River involves construction of one or more dikes, the elevation of several low-lying roads, the relocation or elevation of a portion of the golf course, and variety of potential actions as tide exchange is reintroduced, such as vegetation removal and dredging. All of these actions will support jobs that are expected to benefit the regional economy, primarily in the construction sectors. In 2010, the construction industries accounted for over 11,500 jobs in Barnstable County, while in the nearby Boston metropolitan area, the construction industry accounted for over 136,000 jobs. The construction industry has been especially affected by the economic downturn. Between 2007 and 2010, the construction industry in Barnstable County lost over 2,300 jobs. With workforce available in both Barnstable County and in the Boston metropolitan area, there should be sufficient supply of construction workers to support the restoration project.

Table 3-24: 2007 and 2010 Employment by Industry for Barnstable County, MA

Industry	2007 Employment	2007 Percent of Total	2010 Employment	2010 Percent of Total	Loss or Gain of Jobs 2007-2010	Percent Change 2007-2010
Farm employment	459	0%	462	0%	3	1%
Forestry, fishing, and related activities	(D)	(D)	(D)	(D)	(D)	(D)
Mining	(D)	(D)	(D)	(D)	(D)	(D)
Utilities	412	0%	403	0%	-9	-2%
Construction	13,839	10%	11,448	8%	-2391	-17%
Manufacturing	2,214	2%	1,950	1%	-264	-12%
Wholesale trade	2,439	2%	2,271	2%	-168	-7%
Retail trade	20,735	15%	17,958	13%	-2777	-13%
Transportation and warehousing	2,572	2%	2,457	2%	-115	-4%
Information	2,202	2%	2,041	1%	-161	-7%
Finance and insurance	4,775	3%	5,923	4%	1148	24%
Real estate and rental and leasing	10,449	7%	9,641	7%	-808	-8%
Professional, scientific, and technical services	9,694	7%	9,575	7%	-119	-1%
Management of companies and enterprises	695	0%	513	0%	-182	-26%
Administrative and waste services	7,456	5%	7,407	5%	-49	-1%
Educational services	2,073	1%	2,299	2%	226	11%
Health care and social assistance	17,491	12%	18,187	13%	696	4%
Arts, entertainment, and recreation	5,235	4%	5,099	4%	-136	-3%
Accommodation and food services	15,161	11%	15467	11%	306	2%
Other services, except public administration	8,080	6%	7639	6%	-441	-5%
Government and government enterprises	15,597	11%	15696	11%	99	1%
Total employment	142,999	100%	137,809	100%	-5,142	-4%

Source: Bureau of Economic Analysis 2011c; The Louis Berger Group 2011.

Chapter 4:
Environmental Consequences

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

The Environmental Consequences chapter analyzes the impacts that would result from implementing any of the alternative elements described in chapter 2. It is organized by resource topic and provides a comparison among alternatives based on topics discussed in chapter 1 and further described in chapter 3. For a complete discussion of guiding authorities, refer to "Appendix D: Applicable Laws, Policies, and Regulations."

Massachusetts Environmental Policy Act (MEPA) requires a detailed description and assessment of the "negative and positive potential environmental impacts" of the project and its alternatives. Thus, this *Herring River Restoration Project, Final Environmental Impact Statement / Environmental Impact Report* (final EIS/EIR) assesses (in quantitative terms, to the maximum extent practicable) the direct and indirect potential environmental impacts from all aspects of the Herring River Restoration Project (HRRP). The assessment presented for each impact topic includes the anticipated long-term impacts of restoration efforts. As permitted in MEPA regulations, this final EIS/EIR combines a variety of impact topics to cover the spectrum of analyses required [301 CMR 11.07(6)(g) through (l)] (State of Massachusetts 2009). Construction impacts are included in "Section 4.11: Construction Impacts of the Action Alternatives."

4.1.1 GENERAL ANALYSIS METHOD

The analysis of impacts follows Council on Environmental Quality (CEQ) guidelines (40 CFR 1500–1508) and Director's Order 12 procedures (NPS 2011b) and is based on the goal of analyzing the environmental consequences of restoring the Herring River estuary to conditions that approximate those that existed prior to the construction of the Chequessett Neck Road Dike. The MEPA review process extends to all aspects of the project that may cause damage to the environment and includes an alternatives analysis, environmental impact assessment, analysis of consistency with applicable state regulations and policies, and implementation of appropriate mitigation measures. MEPA considers projects which may impact land, rare species, wetlands, water quality, coastal/marine resources, and historic and archeological resources. This analysis incorporates the best available scientific information applicable to the region and setting, the physical, biological, and social environment, and the actions being considered in the alternatives. The use of hydrodynamic modeling and the temporal and spatial limits of the analysis are discussed below. Also, the applicable analysis methods are discussed for each resource topic addressed in this chapter.

Hydrodynamic Modeling

As described in chapters 1 and 2, the anticipated outcome of the efforts to restore the Herring River estuary by re-introducing tidal flows have been estimated using two-dimensional hydrodynamic modeling. A successful model provides information needed to meet the goals of a project. The model needs to be dynamic, be capable of handling 2-way flows, include important processes, be capable of determining change in water surface elevation over time, and account for freshwater inflow (see appendix B).

By integrating hydrodynamic modeling and Geographic Information System (GIS) mapping, areas of inundation by tide level were estimated (see maps for the alternatives in chapter 2). However, over time, tidal flushing will scour channels in the existing flood plain, and relocate some of this sediment to the intertidal areas. These channels will effectively move water and sediment in and out of the estuary. The sediment transport process will include deposition (accretion) of sediment on the tidal plains, and salt-tolerant vegetation will colonize as the tidal plain elevation increases. These processes are described in detail in this chapter, and maps developed for each resource and each alternative represent the anticipated outcome of these processes. For this final EIS/EIR, updated output from the model was used for a refined estimate of acres transformed from freshwater or upland vegetation to salt-tolerant and flood-tolerant marsh vegetation in response to several comments from the Massachusetts Department of Environmental Protection (MassDEP) and Massachusetts Natural Heritage and Endangered Species Program (NHESP).

Analysis Period

This final EIS/EIR is intended to describe and compare foreseeable long term, permanent outcomes of restored tidal exchange resulting from specified tide control gate configurations that differ for each action alternative. No matter which alternative is ultimately chosen, tidal restoration would be implemented gradually over several years by making incremental openings to adjustable tide gates. That process, and the ecological monitoring and implementation of subsequent management decisions will be addressed in detail in the project's adaptive management plan (see appendix C).

The impact analysis completed in this chapter is based on the end-point conditions (i.e., final tide gate configuration) specified under each action alternative after the adaptive management process is completed and the project is fully implemented. Some impacts, such as improvements to water quality and sub-tidal habitat, are expected to begin relatively soon after tidal exchange is restored. Other changes, especially those involving vegetation/wetland habitat change and marsh surface accretion, are expected to continue for decades, until the system reaches a state of self-sustainable equilibrium and long after tidal range reaches the maximum extent prescribed by the preferred alternative. It is possible that the maximum tide gate openings described in the action alternatives (especially alternative D) would not be reached if ecological and social constraints are identified in the adaptive management process.

Geographic Area Evaluated for Impacts

The general geographic study area for this EIS/EIR is the Herring River flood plain and adjacent properties. However, the area of analysis may vary by impact topic beyond the boundaries of the existing flood plain, as applicable.

Assessing Significance of Impacts

The impacts of the alternatives are assessed using the CEQ definition of "significantly" (1508.27), which requires consideration of both context and intensity:

1. Context – This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole.
2. Intensity – This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:

a. Impacts that may be both beneficial and adverse. A significant effect may exist even if the federal agency believes that on balance the effect would be beneficial.

b. The degree to which the proposed action affects public health or safety.

c. Unique characteristics of the geographic area such as proximity to historic or cultural resources, parklands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

d. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

e. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

f. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

g. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

h. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places (National Register) or may cause loss or destruction of significant scientific, cultural, or historical resources.

i. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

j. Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment.

An assessment of significance of the impacts of the alternatives is provided in the "Conclusions" section following the analysis of impacts of the alternatives.

4.1.2 CUMULATIVE ANALYSIS METHOD

The CEQ regulations that implement National Environmental Policy Act (NEPA) require the assessment of three types of impacts in the decision-making process for federal projects: direct, indirect, and cumulative (40 CFR 1502.16). Direct impacts are those impacts that happen in the same place and at the same time as the federal action; whereas indirect impacts are those that happen later in time or farther removed from the area of the federal action. Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, or reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions" (40 CFR 1508.7). As stated in the CEQ handbook, "Considering Cumulative Effects under the National Environmental Policy Act" (CEQ 1997b), cumulative impacts need to be analyzed in terms of the specific resource, ecosystem, and human community being affected and should focus on impacts that are truly meaningful. Cumulative impacts are considered for all alternatives, including alternative A, the no action alternative.

In order to analyze cumulative impacts for the alternatives being considered, it was necessary to identify other ongoing or reasonably foreseeable future projects and plans in the Herring River watershed and, if applicable, the surrounding region. Reasonably foreseeable future projects are those expected to occur within the life of the project. The analysis of cumulative impacts was accomplished using four steps:

1. **Identify Resources Affected**—Fully identify resources affected by any of the alternatives. These include the resources addressed as impact topics in chapters 3 and 4 of this document.
2. **Set Boundaries**—Identify an appropriate spatial and temporal boundary for each resource. The temporal boundaries are described by the analysis period noted above and the spatial boundary for each resource topic is listed under each topic.
3. **Identify Cumulative Action Scenario**—Determine which past, present, and reasonably foreseeable future actions to include with each resource. Reasonably foreseeable future actions include those federal and non-federal activities not yet undertaken, but sufficiently likely to occur, that a reasonable official of ordinary prudence would take such activities into account in reaching a decision. These activities include, but are not limited to, activities for which there are existing decisions, funding, or proposals identified. Reasonably foreseeable future actions do not include those actions that are highly speculative or indefinite (43 CFR 46.30).
4. **Cumulative Impact Analysis**—Summarize impacts of these other actions (x) plus impacts of the proposed action (the alternative being evaluated) (y), to arrive at the total cumulative impact (z). This analysis is included for each resource in chapter 4.

Table 4-1 summarizes the actions that could affect the various resources of the Herring River flood plain.

Dismissal of New Federal Emergency Management Agency Flood Insurance Maps as a Cumulative Impact Topic

The draft EIS/EIR included revisions to the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) and Flood Insurance Rate Maps for Barnstable County as a cumulative impact topic. At that time, it was understood that the Herring River project would impact the FEMA mapped 100-year flood plain depicted on the maps currently in effect, released in 1990, and on the new proposed maps, which were not released at that point. No matter which set of maps is in effect when the project is implemented, the Towns of Wellfleet and Truro would likely have needed to submit Letters of Map Revision to FEMA for these changes.

If tidal restoration were to result in an alteration to the regulatory flood plain, flood insurance rates for some flood plain landowners would increase and some would be required to obtain flood insurance. In addition, the jurisdictional area of Wellfleet's environmental protection bylaw would change. Although no specific proposal was stated, the draft EIS/EIR also discussed the potential for rebuilding the new Chequessett Neck Road Dike high enough to meet FEMA and U.S. Army Corps of Engineers (USACE) design standards in order to lower the elevation of the 100-year flood plain and reduce some of these impacts.

TABLE 4-1: IMPACT TOPICS AFFECTED BY CUMULATIVE IMPACTS

Project	Brief Description	Connection to Herring River	Possible Impact Topics/Comments
Town of Wellfleet Comprehensive Wastewater Management Plan	This project would address nutrient loading in Wellfleet Harbor and propose possible mitigation measures. The plan could lead to "natural" solutions to nutrient attenuation that could avert the setting of total maximum daily loads by the Massachusetts Estuaries Project, and possibly avert a state mandate to build a public wastewater system.	The restoration of the Herring River estuary could contribute to the Comprehensive Wastewater Management Plan by opening the estuary for nitrogen attenuation and restoring a large amount of oyster habitat, which could reduce Wellfleet Harbor nutrient loads.	• Water and Sediment Quality • Aquatic Species
Mayo Creek Salt Marsh Restoration Project, Wellfleet	This is a tidal restoration project near the town pier which is still in the planning phase. No decision about implementation has been made. The project would restore a limited amount of habitat similar to that of the Herring River estuary.	Similar vegetation change and water quality improvements are expected from both restoration projects.	• Water and Sediment Quality • Wetland Habitats and Vegetation • Federal and State Listed Species: (Diamond-back terrapin, Eastern Box Turtle, Northern Long-eared Bat, and Red Knot) • Terrestrial Wildlife • Socioeconomics
Oyster spawning experiments in Wellfleet Harbor	The Town of Wellfleet Wastewater Committee Project is sponsoring a pilot demonstration project associated with the wastewater treatment plan. This would create a 1.3-acre artificial oyster reef in Duck Creek. The pilot is intended to sequester or attenuate nitrogen concentrations.	There is no direct connection to the Herring River restoration, but the pilot project could improve conditions for shellfish.	• Water and Sediment Quality • Aquatic Species (Shellfish)
Dredging of Wellfleet Harbor	The federal navigation channel between the town pier and harbor is regularly maintained by the U.S. Army Corps of Engineers (USACE) by dredging the L-Shape Pier, Boat Channel, and possibly Mooring Basin. Dredging has occurred four times since 1971, with the last dredging in 2007. Dredged materials are taken to the designated Cape Cod Bay disposal site 8 miles off shore. The schedule for dredging is unknown.	Through the adaptive management process for the Herring River restoration, the project could potentially involve the beneficial re-use of dredged material to enhance the sediment supply and promote marsh accretion within the flood plain.	• Water and Sediment Quality • Sediment Transport and Soils • State Listed Species (terrapins)

Since the draft EIS/EIR was released in October 2012, FEMA completed the revised Barnstable County FIS and released new provisional Flood Insurance Rate Maps. After a public review period and modifications to draft maps, both towns voted to approve and adopt the final maps at their April 2014 Town Meetings. This process is required for the towns and coastal property owners to be eligible for the National Flood Insurance Program. FEMA made the new Flood Insurance Rate Maps effective for Wellfleet and Truro in July 2014.

For the Herring River project area, the new FEMA FIS and maps indicate that changes to tidal hydrology stemming from enlarging flow structures will have no effect on the regulatory 100-year flood plain. The reason for this is that FEMA's hydrologic modeling and FIS predicts that 100-year coastal storm tides would reach levels where water would enter the system at several locations, including over-topping the Chequessett Neck Road Dike, breaching barrier dunes at Ryder Beach and Duck Harbor (Secret Beach), and overwashing a low segment of Chequessett Neck Road near Powers Landing. The coastal flood-driven water levels filling the Herring River basin are a result of flows at these locations and are not governed to any extent by water flowing through the new tide control structures built as elements of the restoration project. Although it would be theoretically feasible to reconstruct the new Chequessett Neck Road Dike to FEMA and USACE standards to the extent that it could be certified as a flood protection structure by FEMA, this would increase the costs of the project significantly. In addition, because water would still enter the Herring River flood plain at three other locations, building a larger dike would not affect 100-year flood elevations or the mapped extent of the 100-year flood plain. Modifying these areas to prevent storm surge breaches is technically impracticable and beyond the scope of the restoration project.

For these reasons, the Herring River project will have no bearing on the 100-year flood plain and the FEMA FIS revisions and remapping has been dismissed from the final EIS/EIR as a Cumulative Impact topic. The new Chequessett Neck Road Dike will be rebuilt to a similar crest height as the existing dike, approximately 12 feet, and will be not be proposed as a FEMA certified flood control structure. Note, however, that FEMA's new maps do indicate changes to the regulatory 100-year flood plain of the Herring River and its tributaries, both increasing and decreasing the flood plain area depending on location. New FEMA maps can be examined at each Town Hall and online at: http://cccommission.maps.arcgis.com/apps/Compare/storytelling_compare/index.html?appid=e16623f58d784cf585bb3e1946f42fae.

4.2 IMPACTS ON SALINITY OF SURFACE WATERS

Estuaries are dynamic interfaces between land-based freshwater systems and the marine environment where physical and chemical attributes show marked variation. Salinity is variable throughout estuaries such as the Herring River, mostly controlled by tidal action and freshwater inputs from river flow and groundwater. Salinity is a fundamental factor influencing the soil and water biogeochemical processes and the occurrence and distribution of flora and fauna. Therefore, the impacts of the HRRP are strongly influenced by the areal extent of tidal inundation with saline water, the variable salinities (or salt content) of that water, the frequency and depth of inundation (both during daily cycles and infrequent storm events), and the volume of tidal water (i.e., tidal prism) moving in and out of the estuary.

4.2.1 METHODS AND ASSUMPTIONS

The impact analysis is primarily based on a hydrodynamic model that was developed for the estuary (WHG 2011a), which includes simulation of water surface elevations, salinities, and flow velocities throughout the Herring River. Predicted water surface elevations and salinities were used to estimate the spatial extent of tidal exchange achieved under the various alternatives. The model itself relies upon water surface elevation and water column salinity data collected by the Cape Cod National Seashore (the Seashore) and other investigators between 2005 and 2010 (see appendix B for additional details of hydrodynamic modeling).

The hydrodynamic model predicts tidal conditions based on ground-surface elevations estimated from aerial photography and ground-based topographic/bathymetric surveys conducted in 2006. However, as the estuary adjusts to restored tidal flows under any of the action alternatives, topography and bathymetry are expected to change through both natural sediment transport processes and potential restoration actions undertaken to facilitate accretion of the subsided marsh surface. Thus, hydrologic parameters (e.g., hydroperiod) and salinity projections generated by the model are expected to change over the long term and will be subject to adaptive management actions.

Additionally, simulation of future salinities throughout the estuary was based on calibration of the model under existing salinity conditions. However, under these conditions (with the Chequessett Neck Road Dike inhibiting tidal exchange), saline water from Wellfleet Harbor does not penetrate very far upstream into the Herring River. Specifically, tidal water only reaches upstream to approximately High Toss Road, and therefore the model can only use salinity data that currently exists in the Lower Herring River. Because of the lack of a salinity gradient throughout the system under existing conditions, calibration and validation of the modeled salinities for the mixing, transport, and diffusion processes have a degree of uncertainty. Thus, whereas the hydrodynamic model is fully calibrated for water surface elevations throughout the entire system and accurately represents the water surfaces for both existing and proposed alternatives to the system, the salinity component of the model could only be calibrated in the Lower Herring River. This reduces the level of certainty of the salinity estimates for the upper portions of the system. In the upper sub-basins of the Herring River, the salinity model uses standard coefficients for the transport and diffusion of salt and presents a reasonable estimate of the expected salinity levels. In general, salinity values should track closely to the water surface elevation results in the lower portions of the system (Lower Herring River, Mill Creek, and Lower Pole Dike Creek) where the large inflow of high-salinity Cape Cod Bay water will clearly dominate; this relationship is less clear from the Middle Herring River and further upstream because of the diminishing contribution of saline water. As restoration progresses, increasing the size of opening at the Chequessett Neck Road Dike may also result in greater salt penetration than that predicted by the model because of erosion (deepening) of the tidal channels and improved low tide drainage, both effectively increasing the rate of tidal flushing. With each incremental dike opening and associated monitoring of water elevations and salinity, the model can be further validated and the level of uncertainty reduced for future incremental openings.

4.2.2 IMPACTS OF ALTERNATIVE A: NO ACTION

Under the no action alternative, the estuary would remain a freshwater system upstream of High Toss Road. Limited tidal flows, and marginally saline waters, would remain confined to the Lower Herring River sub-basin, except during major storm events when tidal surges cause saline water to extend slightly further upstream into the estuarine channels (see figure 3-1 in chapter 3). Under the no action alternative, approximately 70 acres of sub- and inter-tidal habitat would be subject to tidal exchange during mean spring tides (see table 4-2) and poor water quality is expected to persist throughout much of the Herring River estuary (see section 4.3). The existing tide gates and dike would continue to limit the mean tidal range in the Lower Herring River to approximately 2.4 feet, compared to 10.3 feet in Wellfleet Harbor. Over the long term and without management and maintenance of the existing tide gates, the tidal range upstream of the dike would be expected to increase slightly as sea level continues to rise.

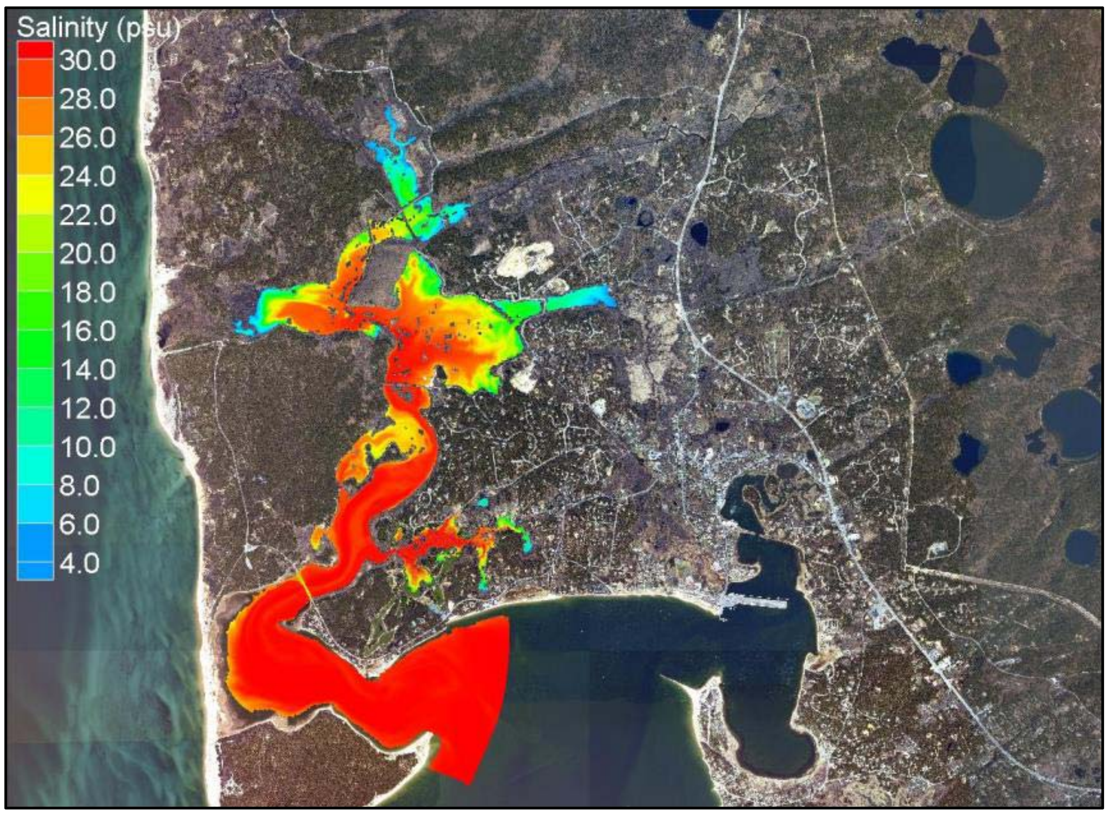
TABLE 4-2: AREA OF HERRING RIVER ESTUARY SUBJECT TO TIDAL EXCHANGE FOR EACH ALTERNATIVE

Alternative	Acres			
	Mean High Water	Mean High Water Spring	Annual High Water	Coastal Storm Surge
A	68	70	72	N/A
B Options 1/2	662/654	800/789	898/888	961/946
C	673	830	899	991
D Options 1/2	718/709	889/881	961/952	1,059/1,048

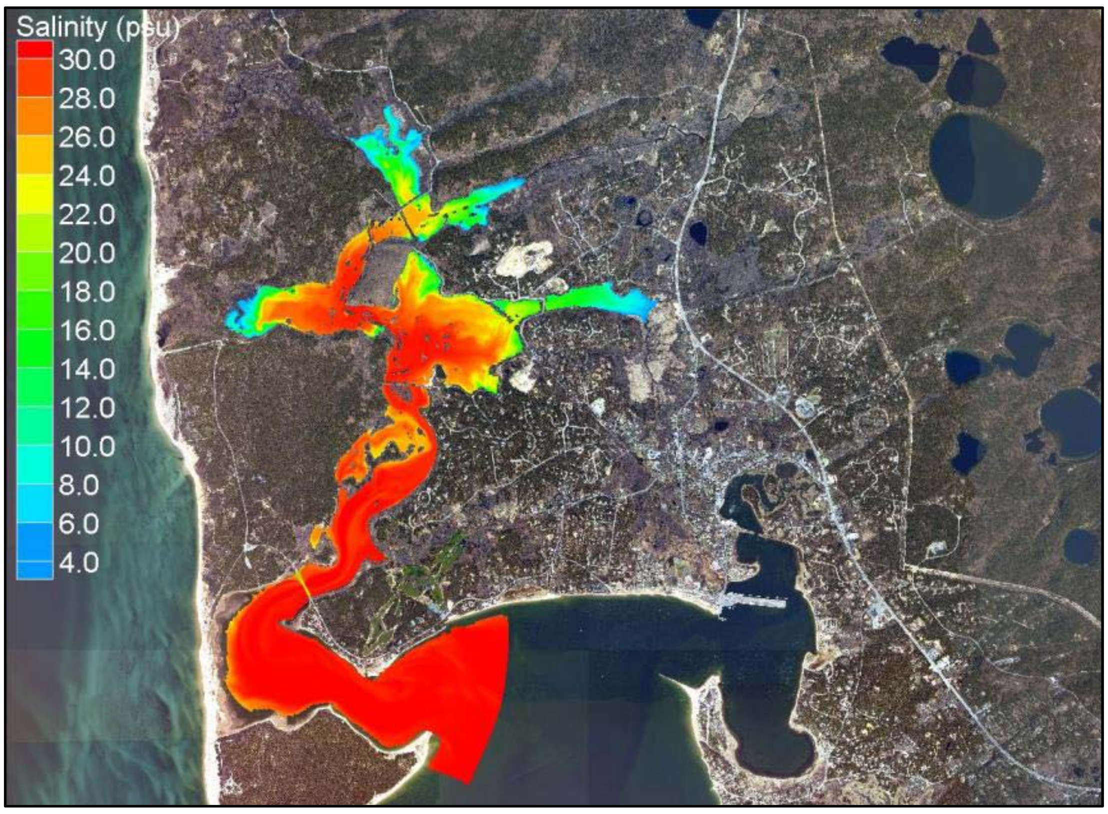
4.2.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

Under all action alternatives, the Herring River estuary upstream of High Toss Road would change from a freshwater system to a tidally influenced environment with saline water penetrating much farther upstream compared to current conditions. Table 4-2 and figure 4-1 compare the extent of tidal exchange and salinity distribution for each alternative on a system-wide basis.

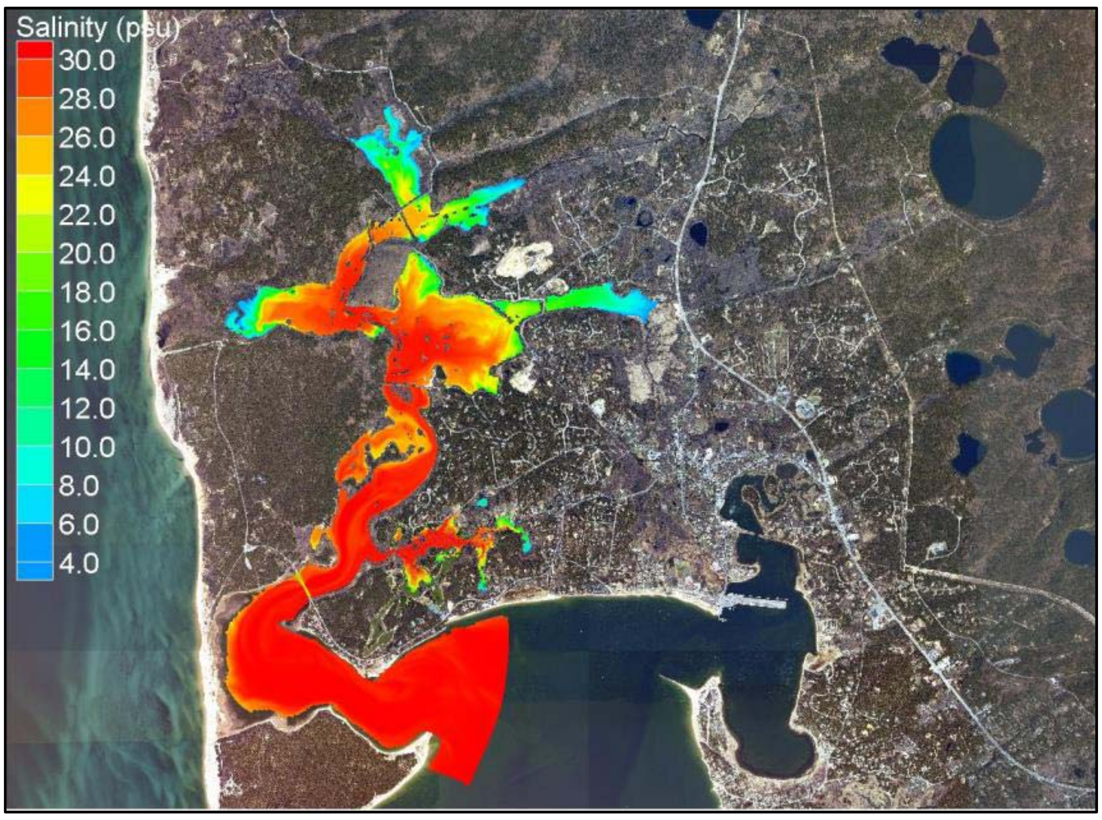
As summarized in table 4-2 and in chapter 2, alternatives B, C, and D would increase the areal extent of tidal influence by an order of magnitude compared to existing conditions. While alternatives C and D would provide only marginal increases to the area of restored intertidal habitat when compared to alternative B, hydrodynamic modeling revealed that the larger tide range achieved by alternatives C and D would result in much higher salinities in several sub-basins. These model results are summarized in table 4-3 and reported in detail in appendix B. Additionally, as described in detail in "Section 4.3: Impacts on Water and Sediment Quality" greater flushing with saline water, resulting in lower residence times, is expected to substantially improve water quality in all sub-basins under all three action alternatives. As previously described, there is some uncertainty in predicting future salinities, especially within middle and upper sub-basins, and actual salinities may be expected to trend somewhat higher as the restoration process proceeds (see section 4.2.4). Within a given sub-basin, the estimated salinity in the tidal channel is generally greater than that predicted for the marsh surface (see table 4-3). This is especially true in the upper sub-basins, which are subject to much less tidal influence and receive proportionately more fresh groundwater discharge. Specific uncertainties, hypotheses, monitoring strategies, and potential management actions aimed at assessing impacts associated with changes in salinity throughout the Herring River system will be addressed in the project's adaptive management plan (see appendix C).



Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek



Alternative C: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow



Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow

FIGURE 4-1: COMPARISON OF MODELED SALINITY PENETRATION INTO THE HERRING RIVER FLOOD PLAIN UNDER THE RESTORATION ALTERNATIVES

TABLE 4-3: MODELED MEAN AND MAXIMUM SALINITY (PSU, PPTS) FOR EACH SUB-BASIN AND ALTERNATIVES

Sub-basin	Alt. A		Alt. B		Alt. C		Alt. D	
	Mean	Max.	Mean	Max.	Mean	Max.	Mean	Max.
Lower Herring River								
Salinity in Channels	26	30	28	29	29	30	29	30
Salinity Range on Marsh Surface (N = 6)	0–25		22–27		25–30		25–30	
Mill Creek								
Salinity in Channels	0	0	28	30	0	0	29	30
Salinity Range on Marsh Surface (N = 5)	0		0–30		0–0		0–30	
Middle Herring River								
Salinity in Channels	0	0	25	29	27	29	27	29
Salinity Range on Marsh Surface (N = 3)	0		7–28		12–29		12–29	
Duck Harbor								
Salinity in Channels	0	0	7	25	18	24	18	24
Salinity Range on Marsh Surface (N = 2)	0		0–14		3–20		3–20	
Lower Bound Brook								
Salinity in Channels	0	0	11	24	25	27	25	27
Salinity Range on Marsh Surface (N = 1)	0		2–5		7–12		7–12	
Upper Bound Brook								
Salinity in Channels	0	0	1	3	10	15	10	15
Salinity Range on Marsh Surface (N = 3)	0		0–0		0–0		0–0	
Upper Herring River								
Salinity in Channels	0	0	0	0	10	17	10	17
Salinity Range on Marsh Surface (N = 3)	0		0–1		0–14		0–14	
Lower Pole Dike Creek								
Salinity in Channels	0	0	15	21	17	26	17	26
Salinity Range on Marsh Surface (N = 3)	0		20–30		24–30		24–30	
Upper Pole Dike Creek								
Salinity in Channels	0	0	0	20	0	26	0	26
Salinity Range on Marsh Surface (N = 4)	0		0–14		0–24		0–24	

PSU is the practical salinity unit; whereas ppt is parts per thousand. For the purposes of this analysis these units are used interchangeably.

N = number of marsh points

4.2.4 COMPARISON OF IMPACTS OF THE ACTION ALTERNATIVES

Impacts of Alternative B

Under alternative B, the modeled mean high spring tide water surface elevation of approximately of 4.8 feet in the Lower Herring River would restore tidal influence to about 800 acres of the former Herring River flood plain (see table 4-2 and chapter 2). Average channel salinities in the lower sub-basins, including Lower Herring River, Mill Creek, Middle Herring River, and Lower Pole Dike Creek, would consistently reach above 15 ppt and occasionally rise close to 30 ppt during spring and storm tides. Even with some attenuation of salinity on the marsh surface in the upper portions of the Middle Herring River and Lower Pole Dike Creek, salinity values in this range should largely suppress existing brackish and freshwater vegetation and sustain a steady transition to salt marsh vegetation throughout these sub-basins.

Model results suggest that the Duck Harbor and Lower Bound Brook sub-basins would be subjected to mean channel salinity levels between 7 and 11 ppt, occasionally rising above 20 ppt during spring and storm tides. Salt marsh vegetation would not be expected to dominate these areas, except perhaps in locations immediately adjacent to the tidal channels (see “Section 4.5: Impacts on Wetland Habitats and Vegetation”). The mid-range salinity values predicted for the Duck Harbor and Lower Bound Brook sub-basins may provide conditions that are suitable for non-native *Phragmites*, which could be afforded a competitive advantage over native wetland plants in salinity ranges of less than 5 to 20 ppt (Chambers et al. 2003; Smith et al. 2009). In nearby Hatches Harbor, it wasn’t until salinity reached 25 ppt that *Phragmites* was greatly diminished (Smith et al. 2009). *Phragmites* can persist at 25 ppt, although with reduced vigor (Burdick et al. 2001; Warren et al. 2001).

Upper sub-basins, including Upper Herring River, Upper Pole Dike Creek, and Upper Bound Brook would be subjected to small tidal fluctuations and salinities generally would remain very low (below 5 ppt). Except for the most sensitive salt-intolerant vegetation in these upstream sub-basins, substantial vegetation change would not be expected.

Impacts of Alternative C

Impacts with respect to salinity changes for alternative C are identical to those for alternative D (see the following section), except that the 78-acre Mill Creek sub-basin would not be influenced by tidal exchange and would remain a tidally restricted, freshwater system. The area of the Herring River flood plain restored by tidal exchange during mean spring tides would be 830 acres (see table 4-2).

Impacts of Alternative D

Under alternative D, the predicted mean high spring tide water surface elevation of approximately of 5.6 feet in the Lower Herring River would restore tidal influence to about 890 acres of the former Herring River flood plain (approximately 80 acres more than alternative B) (see table 4-2 and chapter 2). Similar to alternative B, average channel and marsh surface salinities in the Lower Herring River, Middle Herring River, Mill Creek, and Lower Pole Dike Creek sub-basins would generally reach into the mid-20s ppt and occasionally rise close to 30 ppt during spring and storm tides.

In direct comparison with alternative B, channel salinities predicted under alternative D should be much greater (averaging above 18 ppt) in the Duck Harbor, Lower Pole Dike Creek, and Lower Bound Brook sub-basins. Predicted salinities on the marsh surface (range 3–30 ppt) for these three sub-basins are also much greater than those predicted by alternative B. The generally high channel salinities predicted for these three basins should sustain a transition to salt marsh vegetation through most of this 317-acre area. However, the mid-range salinity values predicted for the marsh surface areas in most upstream portions of Lower Bound Brook and Duck Harbor may provide conditions that are suitable for non-native *Phragmites*, which could be afforded a competitive advantage over native wetland plants in salinity ranges of 5 to 18 ppt (Smith, pers. comm. 2011).

Under alternative D, model results predict that maximum channel salinities might not exceed the mid-range levels of approximately 12-17 ppt, in the Upper Herring River, Upper Pole Dike Creek and Upper Bound Brook sub-basins and that marsh surface salinities would remain very low (generally below 5 ppt) in the upper portions of these basins. All three of these upper sub-basins would be subjected to small tidal fluctuations, and salt marsh species would not be expected to dominate these areas, except perhaps in locations immediately proximal to the tidal channels (see “Section 4.5: Impacts on Wetland Habitats and Vegetation”). Except for the most sensitive salt-intolerant vegetation, in upstream sub-basins where salinities are expected to remain below 5 ppt, extensive vegetation change would not be expected.

4.2.5 Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on salinity.

4.2.6 Conclusion

Under alternatives B, C, and D, high salinity water should consistently reach the Lower Herring River, Middle Herring River, Lower Pole Dike Creek sub-basins and the eastern half of the Duck Harbor sub-basin, all of which should sustain a transition to salt marsh plant communities. However, salinity levels would remain low, generally below 5 ppt, in the upper portions of the Herring River, Bound Brook, and Upper Pole Dike Creek sub-basins, where only the most salt intolerant vegetation would be stressed or killed.

Mill Creek would also be subject to high salinity tidal flow under alternatives B and D, and salt marsh would become the dominant habitat within the sub-basin. Existing freshwater conditions would remain in Mill Creek under alternative C.

Therefore, under all action alternatives, permanent, estuary-wide changes in the penetration of high salinity water into lower and mid-flood plain sub-basins, which currently receive little or no tidal influence, would occur. This increase in salinity is a critical factor in achieving the desired transition from a degraded freshwater wetland to a functioning estuarine wetland, which is an ecologically critical component of the coastal ecosystem of Cape Cod. Based on the degree of salinity change, particularly in the lower sub-basins, the importance of salinity as an ecological factor, and the regional importance of tidal wetlands in terms of biodiversity, this would likely constitute a significant beneficial local and regional impact. Of the action alternatives, alternative D would be most successful in restoring salinity penetration to a pre-dike condition, but all of the action alternatives would represent a substantial change relative the no action alternative.

Under alternative B, mid-range salinity levels also may provide conditions suitable for non-native *Phragmites* in the Duck Harbor, Lower Pole Dike Creek, Lower Bound Brook sub-basins and perhaps portions of the Middle Herring River sub-basin; however, under alternatives C and D salinity should be high enough to sustain a transition to salt marsh habitats over most of these four sub-basins. In the Upper Bound Brook, Upper Pole Dike Creek, Upper Herring River, and the upstream portions of the Lower Bound Brook and Duck Harbor sub-basins salinities should remain low enough to sustain the existing freshwater plant communities under alternative B. Under alternatives C and D, freshwater conditions are expected to persist in the upper portions of these sub-basins, but mid-range salinity levels throughout the remainder of these sub-basins may provide conditions suitable for brackish water vegetation including non-native *Phragmites*. Specific uncertainties, hypotheses, monitoring strategies, and potential management actions aimed at addressing impacts associated with low water-column salinity will be addressed in the project's adaptive management plan (see appendix C), and would be expected to prevent widespread expansion of *Phragmites*, although, as the previous discussion indicates, there are expected changes in distribution. Therefore, despite the uncertainty associated with changes to *Phragmites* distribution, the impacts are not anticipated to be significant for any of the action alternatives.

Under the no action alternative, there would be no detectable change in salinity penetration compared to the current, degraded condition of the estuary. Therefore, despite the significance of past adverse environmental impacts caused by diking and draining the estuary, there would be no significant new adverse impacts from not taking action.

4.3 IMPACTS ON WATER AND SEDIMENT QUALITY

More than 100 years of restricted tidal influence and marsh drainage has severely degraded water and sediment quality of the Herring River, resulting in low pH, increased mobilization of aluminum and iron, periods of low dissolved oxygen, and high levels of fecal coliform bacteria. This degradation of the Herring River has resulted in periodic fish kills and the listing of segments of the river on U.S. Environmental Protection Agency (USEPA) 303(d) list of impaired waters. Tidal restoration would substantially improve water and sediment quality by allowing increased flows of seawater, creating higher high tides and increased low tide drainage. Tidal restoration would also substantially decrease system residence times which is a measure of the amount of time required to exchange water from a given area in the Herring River system with Wellfleet Harbor. Water and sediment quality improvements are major objectives for the project and are integral for restoring the natural habitat conditions required for the re-establishment of native fish, shellfish, and other estuarine animals.

4.3.1 METHODS AND ASSUMPTIONS

In addition to findings of published studies of the Herring River estuary and other natural and restored estuaries in the northeastern United States, this impact analysis used unpublished water quality and sediment quality data collected by the Seashore between 2006 and 2010 (the most relevant results are summarized in chapter 3). The analysis also integrated findings of the hydrodynamic modeling of the estuary (WHG 2012).

4.3.2 IMPACTS OF ALTERNATIVE A: NO ACTION

Lack of tidal flushing and continued drainage in the Herring River would sustain the unnaturally narrow tidal range and likely would continue the oxidation of marsh peat, primarily in the Mill Creek, Middle Herring River, Lower Pole Dike Creek sub-basins, and the eastern portion of Duck Harbor sub-basin. Oxidation of pyrite stored abundantly in salt-marsh soils would continue, releasing sulfuric acid and lowering the pH of porewater and surface water in nearby channel segments, especially those with low flows or standing water. Acidic water would also continue to cause leaching of iron and aluminum and concentrate these metals in drainage ditch water. Under current conditions in the Herring River, iron has been observed to exceed USEPA guideline values for freshwater chronic conditions and prolonged exposure (several days) can have deleterious impacts on aquatic life (see "Section 4.6 Impacts on Aquatic Species"). Aluminum in the Herring

River has been observed to exceed concentrations considered toxic by some researchers (see "Section 3.3: Water and Sediment Quality"). Under the no action alternative, the segments of the Herring River upstream of High Toss Road likely would remain on the 303(d) list for low pH and high aluminum (MassDEP 2011a).

Under the no action alternative, decomposition of marsh soils likely would continue to cause high biological oxygen demand and low summer dissolved oxygen concentrations, especially within subsided and water-logged parts of the estuary. Dissolved oxygen levels would periodically fall below the USEPA regulatory standard of 6 mg/l, which is the threshold for maintaining healthy aquatic life such as resident and migratory fish and invertebrates. Normal estuarine processes of nutrient and energy (organic matter) exchange between Wellfleet Harbor and the Herring River estuary would also remain restricted, thus providing only limited benefits to the coastal ecosystem.

Fecal coliform concentrations in the Lower Herring River and adjacent portions of Wellfleet Harbor would continue to be elevated at times, exceeding the Massachusetts regulatory standard for shellfish harvest. High fecal coliform concentrations would likely keep the Herring River estuary downstream of the dike permanently closed for shellfishing in some areas and only conditionally opened in other areas. Water with elevated fecal coliform levels would continue to flow into Wellfleet Harbor during outgoing tides. The Lower Herring River would likely remain on the 303(d) list as impaired for pathogens (MassDEP 2011a).

4.3.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

With system residence times upstream of High Toss Road reduced (table 4-4) by at least a factor of 25 (200 days vs. 8 days), 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 (see section 4.6).

TABLE 4-4: MODEL CALCULATED SYSTEM RESIDENCE TIMES OF THE HERRING RIVER ESTUARY

Basin / Sub-basin	Alternatives	Residence Time (days)	Improved Flushing over Existing Conditions	Extent of Tidal Exchange (acres)
Mill Creek with Wellfleet Harbor	A	523	—	70
	B	21	96%	800
	(C), D*	18	97%	(830), 889
Sub-basins above High Toss Road with Wellfleet Harbor	A	200	—	70
	B	8	96%	800
	(C), D *	6	97%	(830), 889

Source: Hydrodynamic Model (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, but alternative C does not include tidal flushing in Mill Creek which would not change from existing conditions.

Summertime dissolved oxygen levels could remain low in ponded areas and obstructed ditches that are not regularly flushed by tidal waters. This condition could persist until a more natural tidal channel system becomes established, i.e., in equilibrium with restored tides and wetland topography. As part of the adaptive management plan, the extent of standing water, dissolved oxygen, and other parameters would be monitored and ponding could be reduced by targeted excavation of silted-in channels to increase circulation and promote low-tide drainage.

Soil Chemistry

Restored tidal flushing from any of the action alternatives is expected to reduce acidification within the mid-portion of the Herring River estuary where saline water would again saturate drained peat. The rate of aerobic decomposition and acid production within the soil would decrease substantially, and the pH of porewater and surface water would increase (Portnoy and Giblin 1997a). With restored salinities, aluminum and iron would no longer be leached from the soil to receiving waters in concentrations that stress aquatic life. Decreased decomposition and increased saturation of soil pore spaces with water would also prevent further subsidence of the marsh surface.

The flooding of the lowest and most waterlogged and organic sediments with seawater could result in elevated porewater sulfide concentrations, especially in areas with poor low-tide drainage. Despite some tolerance, even salt marsh plants can be stressed by very high sulfide concentrations. Therefore, porewater sulfide levels and salt marsh plant colonization will be monitored in these low areas. As part of the adaptive management program, some tidal channel excavation may be required to improve low-tide drainage and, consequently, peat aeration.

Nutrients

Despite drainage and decomposition of peat in the middle portion of estuary over the last century, concentrations of nitrogen and phosphorus in the wetland sediments of Herring River have remained high. Portnoy and Giblin (1997a) demonstrated that renewed tidal flushing of acid sulfate soils would allow ammonium-nitrogen to be released into receiving waters, at least over the short term (months), (i.e., until the reserve of ammonium-nitrogen adsorbed onto soil particles is depleted). However, with the great improvement of tidal flushing (minimum 24 times faster), nutrients would be diluted and removed from the system with each tide cycle.

Overall, released nutrients would benefit growth of salt marsh vegetation in the restored marsh. However, if large volumes of sea water were introduced suddenly, abundant nutrient release and sulfide production could inhibit the growth of salt marsh grasses while promoting algal blooms both in the river and downstream into Wellfleet Harbor. The gradual reintroduction of tidal exchange should allow ammonium-nitrogen to be slowly released, thus avoiding nitrogen loading that could contribute to algal blooms in receiving waters. 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 thus well-flushed, limiting the potential impacts of any temporary increases in nutrient loading. Therefore, with small, incremental increases in tidal exchange, informed by appropriate water quality monitoring, the release of nutrients from the estuary would likely be small and would not result in persistent algae blooms in the harbor (Portnoy 1999).

Pesticides and Other Organic Compounds

As described in section 3.3.5, there likely has been historical use of pesticides throughout the Herring River watershed. Under all of the action alternatives, a tidal channel system likely would be reestablished. During restoration, sediment is expected to be mobilized within the estuary in response to the increased volume of tidal exchange (see section 4.4.1 for further discussion). Mobilized sediment is expected to mostly be transported upgradient onto the marsh surface, and partially downgradient toward Wellfleet Harbor.

Sediment sampling in 2014 by the Seashore detected pesticide concentrations that exceed the effects range median (ERM) value of 46.1 parts-per-billion (ppb) at two locations (HR-2 and HR-6; see table 3-7 and figure 3-8 in chapter 3). These concentrations appear to be consistent with previously detected background conditions in Cape Cod National Seashore, where total dichlorodiphenyltrichloroethanes (DDTs) in salt marsh sediments (n=17) ranged between 1 and 222 ppb (Quinn et al. 2001). The range of total DDTs found in the Herring River is 1.6 to 90 ppb. Despite finding slightly elevated concentrations at two locations (>ERM), the average and range of concentrations are still within what has reasonably been established as background concentrations throughout the Cape Cod National Seashore per the Quinn study. The greatly enhanced transport and mixing of sediment post-restoration will continue to result in similar concentrations throughout the Herring River and downstream in the estuary.

Local and regional sediment quality, therefore, is unlikely to be significantly affected post-restoration given the anticipated sediment transport and substantial mixing dynamics. Similar to other freshwater and marine restoration sites around Massachusetts, low concentrations of such contaminants are ubiquitous given past land use practices (i.e., aerial spraying). The new data do not suggest a contemporary ‘release’ as defined by the Massachusetts Contingency Plan (MCP; 310 CMR 40.0000) or a point-source discharge that would require pro-active intervention. Although additional testing may have limited utility given the similarity of prior findings, more data could help better define the range of organochlorine pesticides concentrations. The Herring River Restoration Committee (HRRC) will continue to discuss the need for additional sampling in the Herring River and Wellfleet Harbor with MassDEP as part of the section 401 Water Quality Certification process.

Fecal Coliform

Regular tidal flushing is expected to substantially decrease fecal coliform concentrations in the Herring River. The tidally influenced area within the estuary would increase significantly compared to existing conditions. Flushing rates would be increased (i.e., residence time would be decreased) at least 24 fold (see table 4-4). In addition, 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 removal of the river from the 303(d) list for impairment by pathogens, leading to the potential for additional areas of shellfish beds that could be reopened for harvest.

Even with tidal restoration, elevated bacteria concentrations could still occur within some upstream reaches of the Herring River system especially after rainstorms. However, increasing salt penetration and flushing will substantially reduce bacteria survival time and density prior to discharge into Wellfleet Harbor. Therefore, fecal coliform concentrations should be minimal in lower sections of the river and adjacent parts of the harbor. Nonetheless, fecal coliform will continue to be monitored during the restoration process, particularly after rainstorms.

4.3.4 COMPARISON OF IMPACTS OF ACTION ALTERNATIVES

While the differences between existing conditions and any of the action alternatives are substantial, differences among each of the alternatives are comparatively small. Two parameters which can be used to quantify these differences are residence time and size of area inundated. As shown in table 4-2, the size of the area regularly influenced by tidal waters under each of the action alternatives ranges from 800 to 889 acres. The area of expected water quality improvements correlate closely with the areas that experience restored tides, although the exact nature and extent of any water quality changes will also depend on actual surface water salinity and other local conditions (particularly elevation and sediment quality).

The substantially lower residence times (i.e., improved flushing with Wellfleet Harbor) estimated under all action alternatives will be a major component of improved water quality. However, water quality also is dependent upon nutrient loading, naturally occurring chemical breakdown processes, and the quality of water outside the embayment.

Residence times under all action alternatives would be significantly reduced (see table 4-4). For example, in areas upstream of High Toss Road, flushing would be more than 25 times greater under alternative B than under current conditions (i.e., 8 days system residence time as compared to the current 200 days). Residence times above High Toss road would decrease to 6 days under alternatives C and D. Reducing residence times to this extent is expected to substantially dilute any water quality constituent of concern (e.g., nutrients, bacteria, and other potential contaminants) that would be exported downstream of the dike.

4.3.5 CUMULATIVE IMPACTS

Other projects and plans in the area with the potential to beneficially affect local water and sediment quality include the Town of Wellfleet Comprehensive Wastewater Management Plan, the Mayo Creek salt marsh restoration project, and oyster spawning experiments in Wellfleet Harbor. The Wellfleet wastewater management plan would improve water quality in the project area by reducing the potential for nutrient loading and domestic sewage contamination of local surface waters. The Mayo Creek restoration project, although smaller in scale that the HRRP, would improve water quality in a nearby location. The oyster spawning experiments in Wellfleet Harbor could directly increase the local population of oysters which could improve the overall local water quality because oysters filter nitrogen out of the water, improving water quality. Recurrent, but infrequent, dredging of Wellfleet Harbor has the potential to adversely affect water quality through sedimentation and turbidity. 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. Although these impacts are temporary, they recur with each dredging event, thus resulting in long-term, intermittent impacts.

Overall, the combined impact of the Comprehensive Wastewater Management Plan, the Mayo Creek salt marsh restoration project, and oyster spawning experiments in Wellfleet Harbor would have a beneficial impact on water and sediment quality in the project area and in Wellfleet Harbor. In combination with the substantial beneficial impacts of the proposed project, the cumulative impacts would be considered beneficial and long term.

4.3.6 CONCLUSION

All action alternatives would result in a permanent increase in tidal flushing that would greatly improve water quality in the estuary and in Wellfleet Harbor. This improvement to water quality is an important factor in achieving the desired transition from degraded freshwater marsh to a functioning estuarine wetland, which is ecologically critical in the geographic area of Cape Cod. There is an unknown risk of adverse water quality impacts, but if they occurred they would be transient, localized, and mitigated by adaptive management actions. Based on the probable degree of long-term water quality improvements, the importance of water quality as an ecological factor and the regional importance of estuarine wetlands, this would likely constitute a significant beneficial impact.

4.4 IMPACTS ON SEDIMENT TRANSPORT AND SOILS

4.4.1 IMPACTS ON SEDIMENT TRANSPORT

Healthy salt marshes rely on the interchange of marine inorganic and organic sediments to remain at equilibrium with coastal processes. The construction of the Chequessett Neck Road Dike in 1909 interrupted sediment transport and likely caused extensive changes to the dimensions of the Herring River channel and a cessation of the deposition of sediment on the surface of the salt marsh. This interruption of coastal sediment transport processes likely was most pronounced during storm events when inorganic marine sediments (primarily sands) historically were moved into the Herring River estuary.

Restoration of sediment transport processes are an important aspect of the overall restoration project because they would enhance accretion of sediment on subsided marsh plains, restore the dimension and pattern of tidal channels, and could potentially influence ecological processes and resources in the river and Wellfleet Harbor. This section analyzes the potential impact of mobilized sediments to the former Herring River salt marsh and tidal channel system. Sediment deposition on the marsh plain and a concurrent increase in elevation to the subsided salt marsh surface is a critical element for the re-establishment and long-term sustainability of marsh habitat. The potential impacts of sediment movement on commercial shellfish resources in Wellfleet Harbor are addressed in “Section 4.10: Impacts on Socioeconomics.”

Methods and Assumptions

This impact analysis is primarily based on findings from a quantitative sediment transport study of the Herring River system using time-varying results from a two-dimensional hydrodynamic model and sediment data collected throughout the existing system (see appendix B). This study also provided a qualitative and quantitative comparison of sediment transport potential and its spatial movement during normal and coastal storm surge tides under existing and restored conditions. One important condition inherent to the hydrodynamic model is that the topography of the salt marsh and bathymetry of the tidal channel bathymetry are held constant, i.e., elevations do not change from either deposition or erosion, a situation that would not occur when tides are incrementally restored in the Herring River. The model output indicates potential areas of erosion and deposition but does not provide estimates of depth or volumes of erosion or deposition.

Impacts of Alternative A: No Action

Tidal flows would continue to be restricted by the existing tide gates at the Chequessett Neck Road Dike (6-foot wide opening for incoming tides and 18-foot wide opening for ebb tides). Even though the Herring River is a flood-dominated system, the tidal restriction at the dike would continue to limit upstream sediment transport under all tidal conditions. As described in section 3.4, there is essentially no tidal influence, and consequently little or no movement of sediments, in areas upstream of the Lower Herring River sub-basin even during a coastal storm surge event. Sand-sized particles, for example, would not be transported upstream beyond the immediate vicinity of the Chequessett Neck Road Dike due to inadequate flow velocities.

The restriction of the tides likely has resulted in extensive siltation within the Herring River channel (including the flood tide shoal immediately upstream of the Chequessett Neck Road Dike), leading to a decrease in width and depth and an overall decrease in channel capacity. Under the no action alternative, there would be no change in sediment transport between the river and Wellfleet Harbor. The area of the estuary immediately downstream of the Chequessett Neck Road Dike would continue to be subject to potential sediment movement during both normal and storm-driven tides (see table 4-5). Insufficient delivery of marine sediments to the former salt marsh surface throughout all of the Herring River sub-basins would continue, as would the potential for continued subsidence of the marsh due to pore space collapse and decomposition of organic matter.

Impacts Common to All Action Alternatives

Under all of the action alternatives, sediment transport throughout the Herring River estuary would be enhanced. Three classes of sediment transport would occur; the relative importance of each would be dependent on the size and configuration of the restored tidal opening at the Chequessett Neck Road Dike. Under the action alternatives sediment would be transported as follows:

- **Bedload**—sediment that moves along the bottom of the tidal channels
- **Suspended load**—sediment that is picked up by tidal currents and moves within the water column, but eventually settles out somewhere in the Herring River estuary
- **Suspended fines**—material that is transported by tidal currents that remains in suspension for greater than one tide cycle.

Two primary impacts of enhanced sediment transport are relevant for all of the action alternatives. First, in response to increased tidal flow, the fine sediments that have accumulated in the tidal channels upstream and downstream of the dike would be mobilized as suspended load and suspended fines. This process is expected to be temporary and would diminish considerably once the hydrologic system reaches equilibrium with restored tidal conditions. Over a longer period, bank and bed erosion is expected to increase the dimensions of the restored tidal channels. Much of this sediment movement would take place as bedload and suspended load, and the duration of this process would largely depend on the rate at which tides are incrementally restored, as well as the size and configuration of the final opening.

Second, the increased size of the tide gate opening would alter the long-term sediment transport patterns in the marsh. Because the system is flood-dominated, the restoration of sediment transport processes would provide a source of marine sediment to the marsh surface, and would be crucial to the establishment of a sustainable tidal marsh system.

Both types of sediment transport impacts are discussed in more detail below.

Changes to Tidal Channels

Over the last 100 years much of the tidal channel network throughout the estuary has accumulated sediment and has been partially modified by ditching for mosquito control. With an increase in the size opening at the Chequessett Neck Road Dike and associated increased tidal prism and flow velocities, channel sediment will be mobilized and channel geomorphology changed. Sediment mobilization in tidal channels is supported by preliminary model results (see appendix B). The model found that velocity increases would be significant enough under normal tidal conditions for all of the action alternatives to initiate movement of sediment, increasing sediment transport within the system. As tidal flows are increased incrementally, both the width and depth of the channels are expected to increase due to bank erosion and erosion of the channel bed. Over time, a much deeper, wider, and well-defined channel would be expected to form from just below the Chequessett Neck Road Dike upstream to the Middle Herring River and Lower Pole Dike Creek sub-basins.

Different pathways would exist for fine-grained sediment and coarse-grained sediment. Coarser-grained sediment (dominated by sands) would be transported primarily as bedload along the bottom of tidal channels. Model results indicate that 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 predominantly upstream to eventually 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 Cape Cod Bay.

Changes to Marsh Surface Elevation

Much of the suspended load component of the remobilized sediments that is transported under restored tidal conditions is expected to be deposited on the marsh surface. In addition, once the tidal channel reaches equilibrium, deposition of sediment on the marsh surface is expected to continue, especially during storm-driven tidal events (WHG 2012). During flood tide and storm events, suspended sediment will reach the marsh plain including the subsided areas of the former salt marsh where flow velocities will decrease and particles suspended in the water will settle out. As velocities decrease further, sediment will deposit in the marsh channels. Initially, deposition of sediment is expected to occur primarily in the subsided areas of the Lower Pole Dike Creek, Duck Harbor Lower Bound Brook, and Upper Herring River sub-basins. Over time, sediment accretion is expected to contribute to the long-term sustainability throughout the Herring River marsh. While enhanced accretion on the salt marsh from organic and inorganic sediments is expected to occur under all of the action alternatives, a program will be developed to monitor the long-term changes in the elevation of the marsh surface.

Three primary sources of sediment which could affect long-term salt marsh accretion are as follows:

Inorganic Matter from Wellfleet Harbor—An important long-term sediment source would be inorganic materials that would be transported into the restored Herring River estuary by tidal currents from nearshore waters (i.e., Wellfleet Harbor and Cape Cod Bay). Sediment mobilization would be particularly high during storm events associated with tidal surges (Roman et al. 1997; Christiansen 1998). Even though they are relatively rare, storm-driven tides have been shown to contribute a disproportionate amount of sediment to the salt marsh surface, underscoring the influence of storms in sediment transport.

Upland Sediment Sources—There is little runoff from upland sources to the Herring River estuary due to sandy soil and the rural nature of the watershed. Therefore, upland inputs of sediment are assumed to be comparatively minor.

Organic Matter—Organic matter from macrophyte production on the marsh surface is an important contributor to salt marsh accretion. Anisfeld, Tobin, and Benoit (1999) stated that even in situations where inorganic matter inputs dominate the mass accumulation of sediment, organic matter could have a crucial role in vertical accretion of the salt marsh because of its lower particle density and its ability to increase sediment pore space. In addition, several studies have documented the role of belowground root and rhizome production and associated expansion of peat substrate as an important mechanism contributing to marsh surface elevation increases (e.g., Bricker-Urso et al. 1989).

Organic matter on the marsh surface is also important as a sediment trapping mechanism. Studies have demonstrated that salt-marsh cordgrass (*Spartina alterniflora*) can have a significant dampening impact on the turbulence of tidal flows, promoting the settling of particles suspended in the water column (Stumpf 1983). More specifically, there will likely be a greater amount of sediment available for deposition on the marsh surface in the vicinity of the marsh channels and ditches. Areas remote from the channels and ditches may receive less suspended sediment for marsh accretion. Similar processes are expected to assist in sediment trapping in the restored Herring River system.

Currently, due to pore space collapse and decomposition of the organic matter, the marsh surface in the Herring River estuary upstream of the Chequessett Neck Road Dike has subsided as much as 90 cm compared to the marsh surface elevation downstream of the dike. The rate with which sediment would be deposited under restored tidal conditions would be dependent on several previously described factors. Accretion rates in established southern New England salt marshes typically range from 0.2 to 0.6 cm/year (Bricker-Urso et al. 1989; Roman et al. 1997; Donnelly and Bertness 2001). However, an accretion rate of 2.4 cm/year was measured subsequent to major storm events (Roman el al. 1997). Salt marshes exposed to restored tidal conditions have also undergone accretion rates of 0.7 to 1.0 cm/year over a period of three decades since restoration (Anisfeld, Tobin, and Benoit 1999).

Blue Carbon

Changes to sediment transport and associated accretion of marsh surface elevations will also affect carbon cycling dynamics within the Herring River. These will be primarily driven by increased tidal flow and reintroduction of sediment deposition and marsh accretion processes, but will also include related lateral and vertical fluxes between air, water, and soil.

Data do not currently exist to discern differences among the alternatives. However, under any of the alternatives, reestablishing tidal exchange will result in substantial increase to the volume of carbon stored within the Herring River marshes. Currently, the lack of tidal influence impedes the flow of carbon into the system from Wellfleet Harbor and deposition and long-term burial (sequestration) within salt marsh peat soils. With tidal flow restored, this process would be restored and the Herring River would resume its function as a carbon sink. This process would involve both the import and sequestration of carbon from outside the system (i.e., “allochthonous” carbon) and the uptake of carbon dioxide gas from the atmosphere through increased primary production within restored tidal habitats and eventual burial within salt marsh peat soil.

Using an averaged value of carbon storage rates reported in previous studies performed in New England (e.g., Anisfield et al. 1999; Gonneea n.d.; see section 3.4.4), an order of magnitude approximation of annual carbon storage volume can be estimated for the Herring River. This value, about 400 metric tons, represents the volume of carbon that would be buried within the flood plain soils *each year* with tide gates fully open. In relation to carbon dioxide, this amount is equivalent to the greenhouse gas emissions from about 300 passenger cars (http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results). This includes carbon imported into the flood plain by tidal exchange and carbon dioxide gas absorbed from the atmosphere and stored as it cycles through salt marsh vegetation and soil. The extent and rate of increase of these processes is expected to increase dramatically in response to restored tidal exchange and increasing primary productivity.

Tidal restoration of the Herring River will also result in a substantial reduction of methane emissions from the system. A recent preliminary analysis conducted as part of the “Bringing Wetlands to

Market" project at the Waquoit Bay National Estuarine Research Reserve (http://www.waquoitbayreserve.org/research-monitoring/salt-marsh-carbon-project/) estimates that approximately 180 metric tons of methane are released each year from the Herring River flood plain (Walker, in press). This is because the freshwater wetlands that currently dominate the flood plain promote methanogenesis, a process of anaerobic decomposition by soil microbes that releases methane gas to the atmosphere. The process would be reversed as salt marsh habitats become reestablished. Salt marshes naturally contain sulfates, derived from seawater, which impedes methanogenesis and prevents most methane emissions. Because methane is at least 20 times more potent as a greenhouse gas compared to carbon dioxide (Solomon et al. 2007), avoiding these emissions would be a substantial benefit, equivalent to preventing the annual greenhouse gas emissions from about 940 passenger cars.

Additional studies of carbon in the Herring River system are currently underway, including direct measurement of vertical (i.e., air to plants to soil) and lateral (i.e., water to soil) fluxes and development of a model to predict carbon states under future conditions. This work will also include a greenhouse gas marketing feasibility study. This will be a first of its kind study to evaluate whether potential monetary carbon credits derived from marketing the restored river's carbon-storage potential could provide long-term funding for all-important monitoring and adaptive management activities.

Comparison of Impacts of the Action Alternatives

The focus of the three action alternatives is to increase tidal influence and concurrently restore sediment transport processes to all of the Herring River sub-basins. Alternatives B, C, and D would result in different amounts of tidal exchange and different levels of potential sediment transport in the estuary. Generally, with the greater tidal flows under alternatives C and D, greater amounts of potential sediment mobilization would be expected when compared to alternative B. This would be especially true during storm events when greater tidal flows would result in greater transport potential in areas both upstream and downstream of the Chequessett Neck Road Dike (see table 4-5).

By inference, sediment accretion rates resulting from suspended sediment being deposited on the marsh surface would in part be a function of the different amount of tidal exchange under each of the alternatives. Actual depths of sediment deposition and rates of accretion under each of the action alternatives would be dependent on a variety of complex factors and cannot be quantified with certainty. As stated previously, a program will be developed to monitor the long-term changes in the elevation of the marsh surface.

TABLE 4-5: TOTAL MAXIMUM AREA OF POTENTIAL SEDIMENT MOBILIZATION (EROSIONAL AREA)

Tidal Conditions	Simulation Case	Alternatives	Chequessett Neck Road Dike (Acres)[a]		
			Upstream	Downstream	Sum
Normal Tides	Existing Conditions	A	0.1	56	56
	3-ft high tide gate opening	B	42	102	144
	10-ft high tide gate opening	(C), D [b]	58	98	156
Coastal Storm Surge Tide	Existing Conditions	A	0.1	153	153
	3-ft high tide gate opening	B	132	217	349

Tidal Conditions	Simulation Case	Alternatives	Chequessett Neck Road Dike (Acres)[a]		
			Upstream	Downstream	Sum
	10-ft high tide gate opening	(C), D [b]	217	230	447

a Area estimated from graphical outputs of the hydrodynamic model (see appendix B) (WHG 2012).

b Impacts for alternative C are identical to alternative D but exclude the Mill Creek sub-basin.

Impacts of Alternative B

In areas upstream of the Chequessett Neck Road Dike, the restoration of tides under alternative B would greatly increase the area of potential sediment mobilization during normal tidal conditions (42 acres) and coastal storm surge conditions (132 acres), both substantially greater than the 0.1 acre of potential sediment mobilization under existing conditions. The predicted areas showing increased erosion potential are confined mostly to the future location of a more defined Herring River channel, whereas areas of potential sediment deposition are predicted along the edges of the channel and the upper Herring River sub-basins.

For areas downstream of the dike, the area of potential sediment mobilization during normal tidal conditions would increase from 56 acres to 102 acres over existing conditions and from 153 acres to 217 acres during coastal storm surge events (see table 4-5).

Impacts of Alternative C

Areal estimates of potential sediment mobilization for alternative C are expected identical to those for alternative D (see next section) excluding the Mill Creek sub-basin. The dike at the mouth of Mill Creek is not expected to change sediment mobilization potential in the Mill Creek sub-basin, except perhaps for minor accumulations of sediment upstream of the new structure.

Impacts of Alternative D

In areas upstream of the Chequessett Neck Road Dike, the restoration of tides under alternative D would greatly increase the area of potential sediment mobilization during normal tidal conditions (58 acres) and coastal storm surge conditions (217 acres), both substantially greater than the 0.1 acre of potential sediment mobilization under existing conditions. When compared to alternative B, this would also represent increases in potential sediment mobilization of 38 percent (58 acres vs. 42 acres) and 64 percent (230 vs. 217 acres) for normal and coastal storm surge conditions respectively. The areas showing increased erosion potential upstream of the dike are confined mostly to the future location of a more defined Herring River channel and would likely extend farther upstream in the Herring River when compared to alternative B. Areas of potential deposition are predicted along the margins of the channel and the upper Herring River sub-basins.

For areas downstream of the dike, the area of potential sediment mobilization during normal tidal conditions would increase by 75 percent (98 vs. 56 acres) over existing conditions and by 50 percent (230 vs. 153 acres) during coastal storm surge events. Alternatives D and B are predicted to have similar areas of potential sediment mobilization downstream of the dike (102 vs. 98 acres for normal tides, and 230 vs. 217 acres for coastal storm surge events).

Cumulative Impacts

In terms of sediment transport, there are two potential cumulative interactions between the impacts of harbor dredging and the impacts of any of the action alternatives. First, increased tidal range can mobilize and transport a small volume of sediment to Wellfleet Harbor. Because of the small quantity of this mobilized sediment and the predicted hydrodynamics, increased deposition of fine-grained sediment in aquaculture areas is not expected. If this sediment is mobilized concurrently with Wellfleet Harbor dredging, the combined impact is difficult to predict. However, any cumulative impacts would be unlikely, because the sediment sources are separated by greater than one mile and it is not currently known if harbor dredging will occur during the Herring River project implementation period.

The second potential interaction between harbor dredging and estuary restoration is that harbor dredging could produce sediment that could be used for beneficial reuse in the Herring River flood plain if it is demonstrated that additional sediment is needed to enhance the pace of marsh surface accretion.

Additional study and assessment would be necessary to determine the suitability and impact of this action, and the availability of this sediment for beneficial reuse is speculative. Past and future harbor dredging are therefore unlikely to have cumulative impacts on sediment transport that differ from the overall beneficial impacts of each of the action alternatives.

Conclusion

Over the long term, all action alternatives would mobilize sediment that would permanently restore marsh surface elevation to conditions that approximate pre-dike natural conditions. The degree and rate of sediment mobilization would be largely determined by the amount of tidal influence and rate of incremental opening of the tide gates. The rate of incremental opening of the tide gates would determine to a large extent the time required to reach equilibrium conditions in the restored tidal channel. Tide gates would be used to manage water levels and flows in a manner that promotes deposition of sediment upstream of the dike. Adaptive management would be informed by appropriate monitoring, evaluating both upstream and downstream transport and deposition of sediment during the incremental dike opening process (see appendix C).

The accretion rate and marsh elevation response would depend on factors such as flow regime, inorganic sediment supply (sand, silt, clay) from downstream sources, organic matter supply from above and belowground vegetation production, and sediment that is mobilized during the natural re-configuration of the tidal channel. The highest sediment transport potential would occur during storm tides. Accretion rates on the Herring River marsh plain in the lower and Middle Herring River sub-basins are expected to be greater than the 0.2 to 0.4 cm/year observed in established marshes, but restoration of marsh surface elevations would proceed for many decades given the extent of marsh surface subsidence. The recovery of the marsh surface is an important factor in achieving the desired transition from a degraded freshwater marsh to a functioning estuarine wetland, which is an ecologically critical component of the coastal ecosystem of Cape Cod. Based on the degree of expected marsh surface recovery, the importance of marsh surface recovery as an ecological factor, and the regional importance of estuarine wetlands, this would likely constitute a significant beneficial impact that would be realized as a long-term goal of the restoration process.

Sediment mobilization would also pose potential adverse impacts in the form of sedimentation of shellfish beds downstream of the dike. These uncertain impacts would be mitigated by monitoring sediment deposition and taking management action to avoid adverse impacts; the potential for adverse impacts would therefore not be considered significant under any of the action alternatives.

Under the no action alternative, sediment interchange between the Herring River upstream Chequessett Neck Road Dike and Wellfleet Harbor would remain largely non-existent, while the area immediately downstream of the Chequessett Neck Road Dike would still be subject to potential sediment mobilization for both normal tides and coastal storm surge events. This potential for sediment transport is very limited relative to pre-dike conditions, and would remain unchanged under the no action alternative, leading to further subsidence of marsh surfaces due to pore space collapse and organic matter decomposition. Therefore, despite the significant reduction in sediment transport, there would be no significant new adverse impacts on sediment transport from taking no restoration action. However, continued subsidence of the marsh surface could constitute a significant new impact of failing to take restoration action.

4.4.2 IMPACTS ON SOILS

Potential impacts were assessed based on the extent of disturbance to soils, including natural undisturbed soils, the potential for soil erosion resulting from disturbance, and limitations associated with soils. The analysis is based on the Soil Survey of Barnstable County, MA, the soils map (figure 3-16 in chapter 3), on-site inspection of resources within the Herring River flood plain, review of existing maps and literature on soil and vegetation of the Herring River flood plain from National Park Service (NPS) and other agencies, and professional judgment of subject matter experts.

Impacts of Alternative A: No Action

Under the no action alternative, no tidal restoration would occur. Oversight and maintenance of the structures would continue along the same schedule used since the dike was reconstructed in 1974. Physical factors acting on the dike will continue and the tide gates will entail maintenance costs over the next several years. Ecological conditions with the Herring River would continue to be affected by tidal restrictions. The soils will continue to evolve as they have since the dike was built, as there will be no change in tide height or salinity within the system.

Impacts Common To All Action Alternatives

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

Since the Maybid Variant Silty Clay Loam soil type is likely the most affected by the tidal restriction, it is anticipated that it will be the soil type most affected by the reintroduction of the tidal flows.

Wherever saline tidal flow is restored and salt marsh plants re-establish, it is likely that it will change back, over a long period of time, to eventually resemble (at least in some way) what it was before the flow was limited and the flood plain drained. Since the soil was not examined before the dike was constructed as it was in the 1980s when the soil survey was conducted, it is not possible to describe exactly what this soil was like prior to diking.

All action alternatives would result in estuary-wide, similar beneficial changes to other hydric soil types within the flood plain by increasing pore space, soil pH, and organic content as these soils are subjected to tidal inundation. Various local changes in soil texture are also possible as soils are subjected to different erosional and/or depositional forces that alter the sand, silt, or clay content. These changes in structure, organic content, and chemistry play an important overall role in the expected transition from degraded freshwater wetland to functioning estuarine wetland. This local, permanent change in soil structure, organic content, and chemistry, in the context of the project objective of restoring an estuarine wetland ecosystem, would be considered a substantial beneficial impact. Upland (non-hydric) soil types currently mapped within the limits of predicted inundation, including Carver Coarse sand Hooksan sand upland soil type likely reflect mapping inaccuracies and would be unaffected since all hydrologic modifications would take place in the hydric soil flood plain.

Comparison of Impacts of the Action Alternatives

As depicted on the soils map (figure 3-16 in chapter 3), the Maybid Variant Silty Clay Loam soil is located in the following sub-basins: Lower River, Lower Pole Dike, Middle River and the eastern side of Duck Harbor. Under all of the action alternatives, tidal flow would return to those areas creating pre-dike conditions. Salinity conditions for alternative B are expected to be high enough to favor salt marsh plants in all those sub basins except Duck Harbor where conditions probably will be brackish. However, alternatives C and D will impact a larger area, pushing higher salinity conditions into the eastern portion of Duck Harbor, thus covering nearly all of the areas occupied by this soil type.

Widespread change to existing soils from freshwater nontidal soils to Estuarine sub-tidal and inter-tidal soil types would be expected to occur over the adaptive management period. The majority of the project-wide restoration of inter-tidal soil types would occur within Maybid Variant Silty Clay Loam, Freetown and Swansea mucks, Carver coarse sand, Pipestone loamy coarse sand and subaqueous open water.

Impacts of Alternative B

Alternative B would vary in its impacts to certain soils based on the two options being considered. Since option 2 would impact a lower percentage of the particular soil, it is listed first when a difference occurs. Under alternative B, approximately 94 to 96 percent of the existing 332 acres of Maybid Variant Silty Clay Loam, 69 percent of the existing 489 acres of Freetown and Swansea mucks, 42 to 44 percent of the existing 205 acres of Carver coarse sand, 4 percent of the existing 313 acres of Pipestone loamy coarse sand, and 99 percent of the existing 39 acres of subaqueous open water, would be encompassed by the predicted mean high water spring tide line. Lesser amounts of tidal habitat restoration would occur within other soils types including Hooksan sand and Ipswich, Pawcatuck, Matunuck peats.

Impacts of Alternative C

Under alternative C, approximately 83 percent of the existing 332 acres of Maybid Variant Silty Clay Loam, 77 percent of the existing 489 acres of Freetown and Swansea mucks, 46 percent of the existing 205 acres of Carver coarse sand, 11 percent of the existing 313 acres of Pipestone loamy coarse sand, and 100 percent of the existing 39 acres of subaqueous open water, would be encompassed by the predicted mean high water spring tide line. Lesser amounts of tidal habitat restoration would occur within other soils types including Hooksan sand and Ipswich, Pawcatuck, Matunuck peats.

Impacts of Alternative D

Under alternative D, approximately 97 percent of the existing 332 acres of Maybid Variant Silty Clay Loam, 77 percent of the existing 489 acres of Freetown and Swansea mucks, 53 percent of the existing 205 acres of Carver coarse sand, 11 percent of the existing 313 acres of Pipestone loamy coarse sand, and 100 percent of the existing 39 acres of subaqueous open water, would be encompassed by the predicted mean high water spring tide line. Lesser amounts of tidal habitat restoration would occur within other soils types including Hooksan sand and Ipswich, Pawcatuck, Matunuck peats.

Cumulative Impacts

Few actions would result in cumulative impacts to soils. There is the potential for beneficial impacts as a result of dredging, if dredge spoils are reused in the Herring River floodplain or estuary. Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on soils.

Conclusion

All action alternatives would result in estuary-wide, beneficial changes to hydric soils by increasing pore space, soil pH, and organic content as these soils are subjected to tidal inundation. Various local changes in soil texture are also possible as soils are subjected to different erosional and/or depositional forces that alter the sand, silt, or clay content. While impacts on particular soils may not be substantial (i.e., enough to require a change in classification), these changes in structure, organic content, and chemistry play an important overall role in the expected transition from degraded freshwater wetland to functioning estuarine wetland. The most substantial changes would occur to Maybid Variant Silty Clay Loam in Lower River, Lower Pole Dike, Middle River, and the eastern side of Duck Harbor. In these locations, soil changes would be substantial and may approximate pre-dike conditions. This local, permanent change in soil structure, organic content, and chemistry, in the context of the project objective of restoring an estuarine wetland ecosystem, would be considered a significant beneficial impact.

Under the no action alternative, there would be no predicted changes in soil chemistry, structure, or organic content. While soil conditions would continue to reflect past adverse impacts of tidal exclusion, there would be no significant new impacts on soils.

4.5 IMPACTS ON WETLAND HABITATS AND VEGETATION

Based on comments submitted after the release of the draft EIS/EIR and subsequent follow-up meetings with the Massachusetts NHESP and the MassDEP, it was determined that additional analysis is necessary to adequately address agency comments and characterize potential changes to flood plain vegetation and associated habitats resulting from full implementation of the preferred alternative. This new analysis is included at the end of section 4.5. Although there are some slight differences in the updated results presented here and those summarized in the draft EIS/EIR, this new analysis does not alter the original alternatives analysis or selection of a preferred alternative. The analysis immediately following is unchanged from the draft EIS/EIR.

Re-introduction of tidal flows within the Herring River flood plain under all of the action alternatives would result in the widespread restoration of degraded coastal wetlands to estuarine sub-tidal and inter-tidal habitats.

4.5.1 Methods and Assumptions

The following impact analysis is based on the results of hydrodynamic modeling (see appendix B) which shows that salinity within restored inter-tidal habitat (area inundated up to the mean high spring tide line) will range from near full strength seawater (approximately 30 ppt) in the lower portions of the system (i.e., those areas nearest to Wellfleet Harbor and the Chequessett Neck Road Dike) to freshwater (< 5 ppt) in the upper reaches. Varying mid-range salinities (5–18 ppt) would be dependent on which action alternative is implemented, and would occur predominantly in the middle portions of the flood plain. High salinity is expected to stress salt-sensitive plants that have become established on the former salt marsh flood plain and sustain re-colonization of native salt marsh plants. In areas with predicted lower salinities, brackish and freshwater plants would be expected to persist and in some areas little or no change to existing vegetation communities is expected to occur. In addition to the hydrodynamic model, the impact analysis used unpublished vegetation data and plant community mapping completed by the Seashore to project potential change to existing wetland habitats.

An idealized relationship between restored tidal water surface elevations and vegetation within the restored Herring River flood plain is presented in figure 4-2. Areas below predicted mean low water (sub-tidal) include the limits of tidal creeks, as well as subsided portions of the former marsh surface. Inter-tidal habitat would occur between mean low water and the annual high tide line. As stated previously, in areas with higher salinities, the inter-tidal habitats would eventually become salt or brackish marsh, while freshwater habitats would be expected to persist in peripheral areas and upper sub-basins of the Herring River.

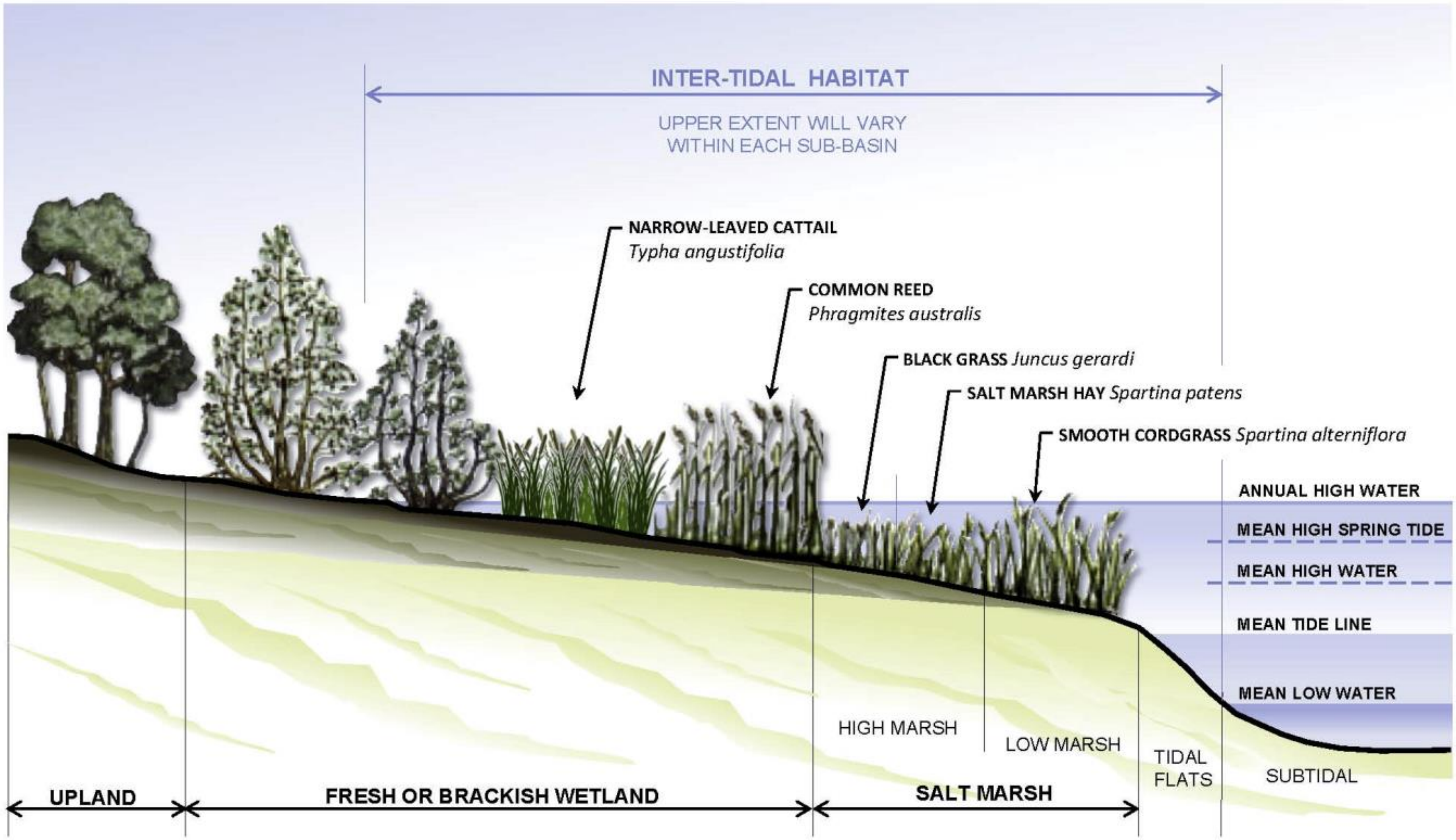


FIGURE 4-2: CONCEPTUAL ESTUARY SALT MARSH HABITATS AND VEGETATION OCCURRENCE RELATED TO TIDAL DATUM

4.5.2 IMPACTS OF ALTERNATIVE A: NO ACTION

Continued absence of tidal flushing in the Herring River would limit sub- and inter-tidal habitats to 80 acres, all confined to the Lower Herring River sub-basin. The no action alternative would cause freshwater conditions to persist in over 1,000 acres of former salt marsh habitats. These freshwater conditions are currently classified as degraded due to poor water quality and taking no action would result in the continued degradation of the system including continued encroachment and possible expansion of invasive plant species including the existing non-native common reed (*Phragmites australis*). The no action alternative likely will result in the continued subsidence of former salt marsh peat soils and will maintain limits in detrital, nutrient, and biota exchange between the estuarine flood plain and the nearshore coastal waters.

4.5.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

Vegetation Change within Restored Inter-Tidal Habitat

All of the action alternatives are expected to result in the widespread change of existing, degraded freshwater wetlands to estuarine sub-tidal and inter-tidal habitats. Restored inter-tidal habitat subjected to higher salinity waters, generally 18 ppt and higher, is expected to transition to salt marsh. However, lower salinities would likely occur on the landward periphery of the project area and in the upper reaches of many sub-basins where brackish and freshwater plant species are expected to persist. While the changes occurring in higher salinity areas are relatively clear and predictable, experience with other tidal restoration projects makes predictions of vegetation change in restored inter-tidal areas with lower salinity less certain and difficult to quantify.

Potential Sulfide Toxicity

With restored tidal flooding and biogeochemical conditions within the peat, it is possible that resulting sulfide toxicity may impact salt marsh plant colonization. In experimental microcosms of diked-waterlogged peat collected from the Herring River flood plain, Portnoy (1999) found that sudden introduction of seawater resulted in a decline in cordgrass production (likely due to sulfide toxicity) and further subsidence. As described in section 4.3.3, the small, incremental increases in tidal exchange, as well as the likely beneficial impacts of restored daily tidal flushing, including improved low tide drainage, are expected to limit sulfide production to acceptable levels.

Potential Changes in the Distribution of *Phragmites*

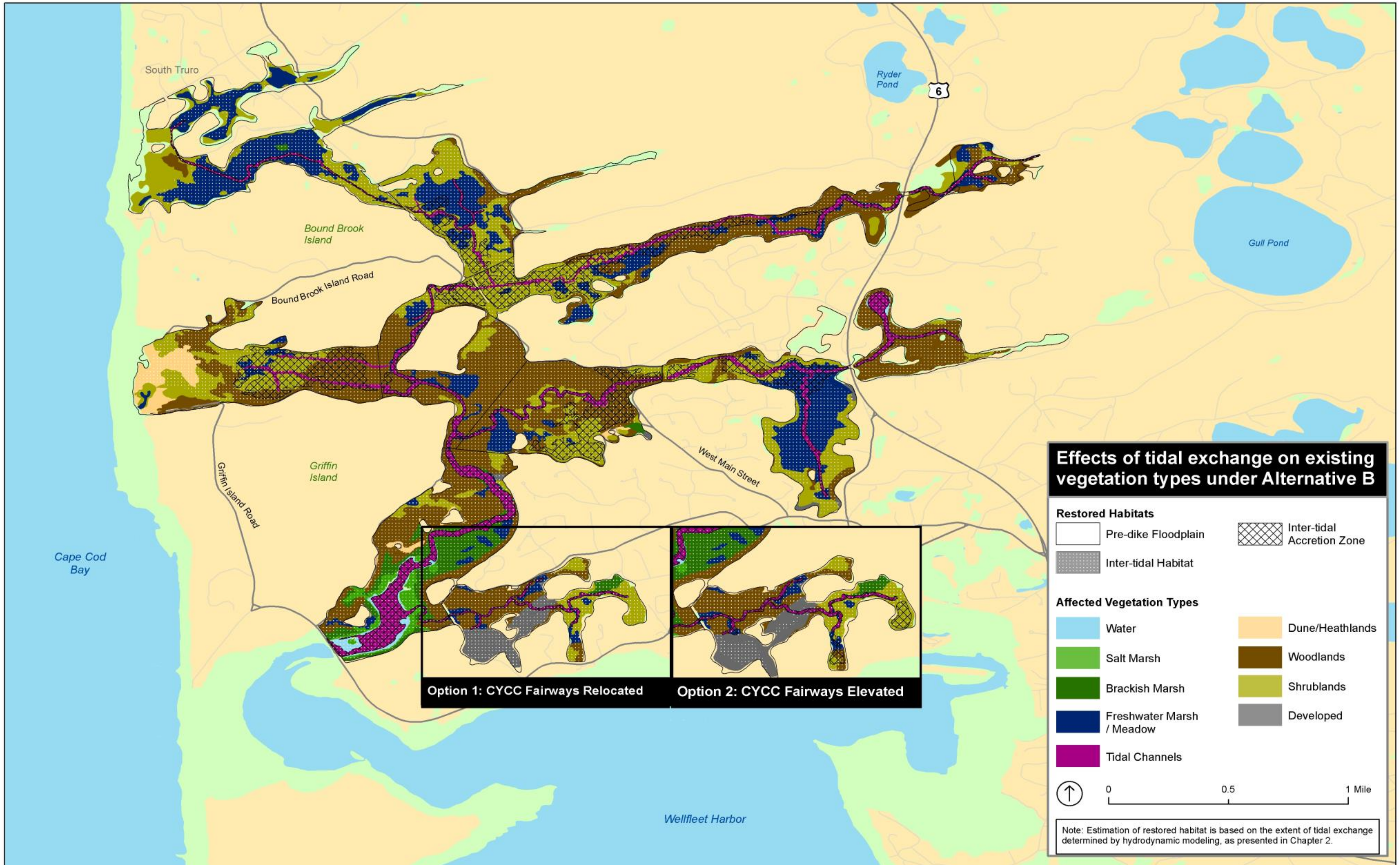
Reducing the overall coverage of this non-native invasive plant species and increasing coverage of native salt marsh halophytes are objectives of the HRRP. Hydrodynamic modeling indicates that restored salinity levels under all of the action alternatives will be above those conducive to *Phragmites* and likely will lead to the elimination of 42 acres that currently exist in the Lower Herring River and Mill Creek sub-basins. However modeling also indicates that mid-range salinity levels of approximately 5 to 18 ppt may persist in some upper reaches of the estuary, especially in the Bound Brook and the Upper Herring River sub-basins. Salinities within this range may not be high enough to allow native salt marsh plants to outcompete *Phragmites* without active management, and could lead to expansion of *Phragmites* into areas where it currently does not occur. This is similar to what occurred at the Hatches Harbor restoration project in Provincetown, Massachusetts where *Phragmites* has greatly diminished or disappeared where porewater salinities reach 22 ppt and higher, but in areas subjected to lower salinities has migrated landward a considerable distance and has not decreased in overall abundance (Smith 2007; Smith et al. 2009). To manage this in the Herring River, herbicide likely would have to be used to greatly reduce coverage of *Phragmites* from the system prior to tidal restoration and subsequently in a targeted fashion if new stands of *Phragmites* colonize elsewhere in the estuary. As tidal exchange is incrementally restored, monitoring will be conducted to track vegetation change and salinities throughout the system. If *Phragmites* is observed to be significantly expanding its range or colonizing new areas, supplemental management actions in addition to herbicide application, including mechanical control or hydrological (increased inundation and salinity) alterations could be implemented to limit or control its spread. Any herbicide application would be planned and implemented carefully as a component of the adaptive management plan. Techniques would be used that specifically target *Phragmites* while minimizing the chance for any collateral impacts on non-target resources.

Woody Vegetation on the Flood Plain

With the restoration of tidal inundation and its associated increase in soil saturation and salinity, mortality of approximately 700 acres of the existing upland shrubland and woodland vegetation that is growing on former salt marsh soils is anticipated. Large volumes of dead standing and fallen woody debris on the flood plain surface may be undesirable since it could result in obstructions within tidal channels and may impact the establishment of marsh grasses by decreasing natural seed dispersal and germination. Options for vegetation management include the removal of woody vegetation through cutting, chipping, and/or burning as well as the processing of biomass that has been cut (harvest for firewood or wood chips and burning brush and branches). Any future vegetation management program would necessitate the concurrence of landowners (both private and public) as well as regulatory agencies. Future management would likely specify the types of mechanized equipment that could be allowed in the project area in order to minimize rutting of the marsh surface and potential time-of-year restrictions to minimize unintentional adverse impacts to fish, wildlife, and natural seedling establishment.

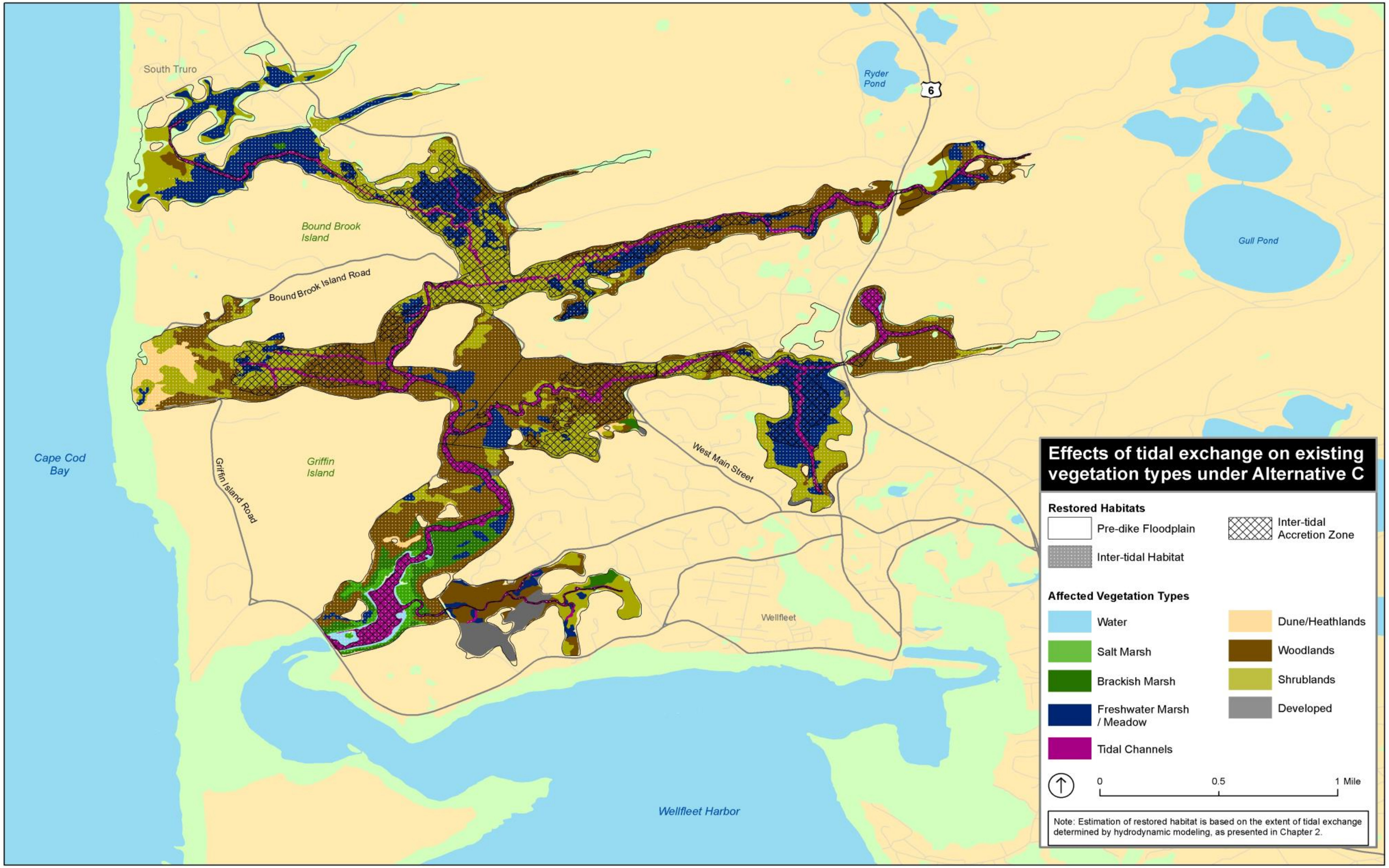
4.5.4 Comparison of Impacts of the Action Alternatives

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 (see figure 4-3). The area of existing vegetation cover types affected up to the mean high water spring tide line for each alternative are summarized in table 4-6. 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 annual high water (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.



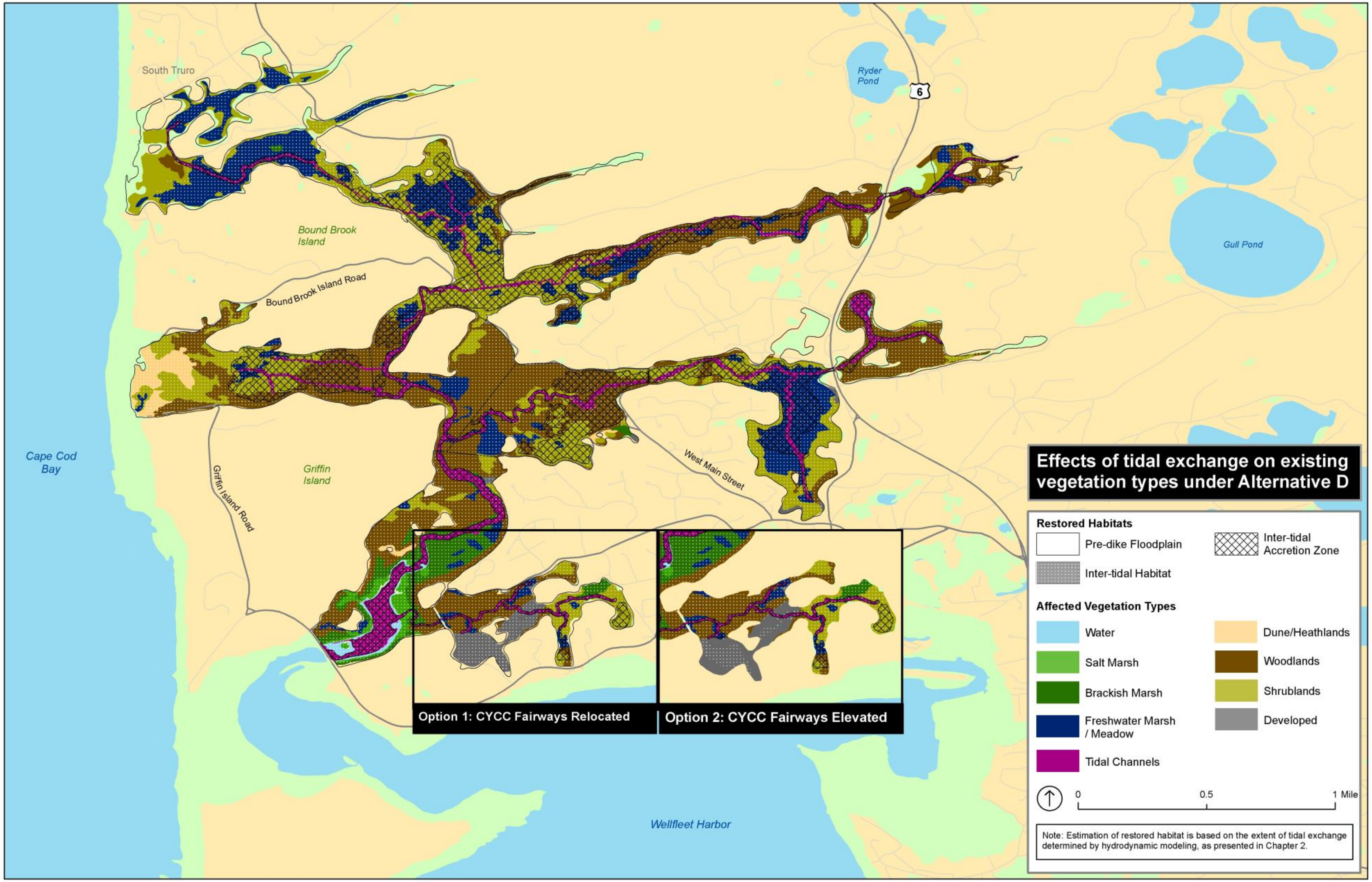
Wetland Habitats and Vegetation Change Anticipated under Alternative B: New Tide Control Structure at Chequessett Neck – No Dike at Mill Creek

FIGURE 4-3: CONCEPTUAL ESTUARY SALT MARSH HABITATS AND VEGETATION OCCURRENCE RELATED TO TIDAL DATUM (1 OF 3)



Wetland Habitats and Vegetation Change Anticipated under Alternative C: New Tide Control Structure at Chequessett Neck –Dike at Mill Creek Excluding Tidal Flow

FIGURE 4-3: CONCEPTUAL ESTUARY SALT MARSH HABITATS AND VEGETATION OCCURRENCE RELATED TO TIDAL DATUM (2 OF 3)



Wetland Habitats and Vegetation Change Anticipated under Alternative D: New Tide Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow with Relocation (option 1) and Elevation (option 2).

FIGURE 4-3: CONCEPTUAL ESTUARY SALT MARSH HABITATS AND VEGETATION OCCURRENCE RELATED TO TIDAL DATUM (3 OF 3)

TABLE 4-6: AREA OF EXISTING VEGETATION COVER TYPES AFFECTED BY MEAN HIGH WATER SPRING TIDE FOR EACH ACTION ALTERNATIVE

Existing Cover Type	Existing Acreage	Estimated Acreage				
		Alt B Option 1	Alt B Option 2	Alt C	Alt D Option 1	Alt D Option 2
Open Water	29	29	29	29	29	29
Salt Marsh	13	13	13	13	13	13
Brackish Marsh	40	39	39	37	40	40
Freshwater Marsh/ Meadow	222	176	178	189	194	196
Shrublands	299	203	204	217	231	232
Woodlands	403	314	314	321	342	342
Dune/ Heathland	20	6	6	14	14	14
Developed	21	17	7	0	17	7
Total Area	1047	797	790	820	880	873

Lower Herring River

Under all of the action alternatives there would be extensive vegetation change within the 162-acre Lower Herring River sub-basin. Over the long term, tidal waters with salinity levels consistently in the mid-20s and higher would affect the existing freshwater and brackish marsh (much of this area is currently dominated by *Phragmites*), woodland, and shrubland plant communities that has replaced the historic salt marsh habitats. This area would largely be restored to low and high salt marsh vegetative communities, but would also include sub-tidal and inter-tidal habitats. The small area of existing salt marsh in this sub-basin would be subjected to increased periods of salt water inundation as the existing marsh surface likely would be too low relative to increased tidal elevations. This could stress even the most salt and flood tolerant vegetation, such as *Spartina alterniflora*, ultimately leading to vegetation die-back and conversion of existing salt marsh to inter-tidal mud flats. This condition is expected to be temporary but could remain until the marsh surface accretes and the marsh surface elevation reaches equilibrium in relation to the restored tide regime. Impacts to existing vegetation cover types in the Lower Herring River are summarized in table 4-7.

TABLE 4-7: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN THE LOWER HERRING RIVER

	Existing Conditions	Alternative B	Alternatives C and D
Mean high water (MHW) Spring Tide (Feet, NAVD88)	0.4	4.8	5.6
Salinity (ppt)			
In Channels	0 - 30	28 - 30	29 - 30
On Marsh Surface	0 - 30	29 - 30	25 - 30
Cover Type	**Acres Affected**		
Water (Sub-tidal)	29	29	29
Salt Marsh	13	13	13
Brackish Marsh	37	36	37
Freshwater Marsh	11	10	11
Shrubland	7	7	7
Woodland	62	54	58
Dune/Heath	2	< 1	1
Developed	1	0	0
Total	**162**	**150**	**156**
Transition Zone (AHW)		1	2

In comparison with alternative B, the higher mean high spring tides of approximately 0.8 feet achieved under alternatives C and D would affect four additional acres of primarily woodland habitat. In addition, a small area of wetland-to-upland transitional habitat (1 acre under alternative B and 2 acres under alternatives C and D) along the periphery of the sub-basin 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.

Mill Creek

The impacts of tidal restoration on existing vegetation within the 72-acre Mill Creek sub-basin would be identical under alternatives B and D because in both cases high tide would be limited to a maximum elevation of approximately 4.8 feet during spring tide periods. Under both of these alternatives, salinity levels would consistently reach the mid-20s ppt and low and high salt marsh vegetation would be expected to eventually replace the existing brackish marsh, freshwater marsh, shrubland, and woodland that is growing in this former salt marsh area. In addition, 2-3 acres of wetland-to-upland transitional habitat along the periphery of the sub-basin would be affected by AHW (the highest tide within a given year). Some vegetation change would be expected in these transitional areas depending on the species present and the exact frequency and duration of tidal influence. Under alternative C there would be no tidal restoration in the Mill Creek sub-basin and therefore there would be no anticipated impacts to existing vegetation. Vegetation impacts in Mill Creek are summarized in table 4-8.

TABLE 4-8: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN MILL CREEK

	Existing Conditions	Alt B Option 1 Alt D Option 1	Alt B Option 2 Alt D Option 2
MHW Spring (Feet, NAVD88)		4.8	4.8
Salinity (ppt)			
In Channels	0	28 – 30	28 – 30
On Marsh Surface	0	0 – 30	0 – 30
Cover Type	**Acres Affected**		
Salt Marsh	0	--	--
Brackish Marsh	3	3	3
Freshwater Marsh	7	5	7
Shrubland	17	14	15
Woodland	25	21	21
Dune/Heath	0	--	--
Developed (CYCC golf course)	20	17	7
Total	**72**	**60**	**53**
Upland Vegetation (CYCC Flood Remediation)		30	5
Transition Zone (AHW)		2	3

Although the impacts of tidal restoration in the Mill Creek sub-basin do not differ between alternatives B and D, the extent of vegetation impacts vary depending on which option is selected for addressing flood impacts on the Chequessett Yacht and Country Club (CYCC) golf course. These impacts primarily involve the managed, i.e., mowed, portions of the golf course and are reflected in the "Developed" cover type category in table 4-8. Alternative B option 1 and alternative D option 1 involve reconfiguration of the golf course through the relocation of portions of the course to higher ground. Alternative B option 1 and alternative D option 1 would result in approximately 12 low-lying acres of the existing golf course being abandoned which then would be expected to revert to salt marsh. Under alternative B option 2 and alternative D option 2 the existing course configuration would largely be retained and approximately 10 acres of low-lying playing surfaces would be filled, elevated, and regraded, although 7 acres would remain and would revert to salt marsh.

In addition to impacts driven directly by restored tidal exchange, CYCC flood remediation would also incur indirect impacts to upland areas owned by the CYCC where existing vegetation is comprised primarily of scrub oak-pitch pine woodlands. Under alternative B option 1 and alternative D option 1, this area would become almost completely developed and subsequently managed as a golf course resulting in conversion of most of the 30 acres of existing woodland. Under alternative B option 2 and alternative D option 2, most of this 30-acre area would remain undisturbed. However, a borrow area which would disturb approximately 5 acres of existing woodland would have to be established within the area in order to generate the clean fill required to raise the elevation of the low-lying portions of the golf course (see grading plan figure 4-9 in section 4.10.5). CYCC representatives have expressed a desire to regrade this 5-acre area after excavation for future use as a golf practice area.

Middle Herring River

Within the 89-acre Middle Herring River sub-basin, vegetation changes would be substantial under all of the action alternatives. Most of the change would occur within existing 61 acres of woodlands that are growing on former salt marsh soils (see table 4-9). Salinity levels would reach the mid-20 ppt range in tidal channels and adjacent areas of marsh, where existing woodlands and, to a lesser degree, shrublands and freshwater marsh, would be restored to a mix of low and high salt marsh. Hydrodynamic modeling suggests that salinity would decrease with increasing distance from the channels with predicted salinities in some areas between 7-28 ppt for alternative B and 12-29 ppt for alternatives C and D. While some salt sensitive plant species would be adversely affected under alternative B, salt marsh vegetation would not be expected to dominate these transitional areas. However, under alternatives C and D, the higher salinities in the Middle Herring River likely would be able to sustain salt marsh habitat over much of the sub-basin. The ultimate vegetation that eventually results in marsh areas away from the channel is difficult to predict given the uncertainty with predicted salinity levels in comparison to the actual salinity levels experienced in the future from the tidal restoration.

The Middle Herring River sub-basin also contains areas of significant subsidence of the former salt marsh surface. The lowest of these areas (2 acres under alternative B and 10 acres under alternatives C or D) 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 (see section 4.4). In the long term, these areas should accrete to support salt marsh plant communities as the marsh surface reaches equilibrium with a restored tidal regime. As restoration in the subsided areas progresses, a transition in vegetation from the existing cover types (woodland, shrubland, and freshwater marsh) to sub-tidal habitat and unvegetated mud flats with a trajectory to low salt marsh communities is expected. These subsided areas will be monitored to track sediment deposition and revegetation, and decisions about applying additional restoration management actions, such as supplementing sediment supply, removing blockages to salt water circulation, and planting appropriate native species, will be a component of the adaptive management process.

TABLE 4-9: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN THE MIDDLE HERRING RIVER

	Existing Conditions	Alternative B	Alternatives C and D
MHW Spring (feet, NAVD88)		3.7 ft	4.5 ft
Acres below mean low water (MLW)	--	2	10
Salinity (ppt)			
In Channels	0	25 – 29	27 – 29
On Marsh Surface	0	7 – 28	12 – 29
Cover Type	**Acres Affected**		
Salt Marsh	0	--	--
Brackish Marsh	0	--	--
Freshwater Marsh	16	15	15
Shrubland	12	11	12
Woodland	61	59	60
Dune/Heath	0	--	--
Total	**89**	**85**	**87**
Transition Zone		1	< 1

Upper Herring River

Vegetation changes in the 147-acre Upper Herring River would be limited compared to the lower sub-basins. Although this sub-basin was historically dominated by salt marsh vegetation, the relatively low maximum tidal elevations achieved by alternative B would largely maintain the existing freshwater conditions as salinity levels within the channel and on the marsh surface would remain near zero (see table 4-10). Although no salt marsh or brackish species would colonize under these conditions, pulses of tidally forced freshwater would resaturate the marsh surface, favoring riparian and palustrine wetland species over upland species which have colonized the sub-basin since the river was diked and channelized. Representative upland species which are expected to be displaced by the restored hydrologic regime include quaking aspen (*Populus tremuloides*), black cherry (*Prunus serotina*), and black oak (*Quercus velutina*) and could be replaced by wetland dependent species.

TABLE 4-10: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN THE UPPER HERRING RIVER

	Existing Conditions	Alternative B	Alternatives C and D
MHW Spring (Feet, NAVD88)		2.6	3.4
Acres below MLW		39	56
Salinity (ppt)			
In Channels	0	0	10 – 17
On Marsh Surface	0	0 – 1	0 – 14
Cover Type	**Acres Affected**		
Salt Marsh	0	--	--
Brackish Marsh	0	--	--
Freshwater Marsh	29	24	26
Shrubland	49	41	44
Woodland	69	39	43
Dune/Heath	0	--	--
Developed	0	--	--
Total	**147**	**104**	**113**
Transition Zone (AHW)		22	20

In contrast to alternative B, hydrodynamic modeling shows that with the greater tidal exchange afforded by alternatives C and D, that salinity levels in tidal channels could reach as high as 17 ppt and 14 ppt on portions of the marsh surface. Generally, higher salinities would occur closer to the channels and diminish landward. Uncertainty about salinity modeling in the upper sub-basins and the wide range of predicted low to intermediate salinity levels make specific projections about vegetation change difficult. Generally, the salinity levels predicted by the model would not be high enough or occur consistently enough to support extensive salt marsh plant communities, although some salt marsh plants could grow adjacent to the channels. Species tolerant of low to moderate salinity levels, such as narrow-leaf cat-tail (*Typha angustifolia*), northern bayberry (*Morella pennsylvanica*), and northern arrowwood (*Viburnum recognitum*), would likely persist and perhaps expand as they displace less salt tolerant species. Intermediate salinity levels could also make the Upper Herring River sub-basin suitable for *Phragmites*. As stated in section 4.5.3, efforts will be made to control this non-native species throughout the project area prior to restoring tidal exchange.

During restoration vulnerable areas will be monitored for *Phragmites* occurrence, and measures implemented to control its spread in accordance with guidelines laid out in the adaptive management plan.

The Upper Herring River sub-basin also contains areas of significant subsidence of the former salt marsh. The lowest of these areas (39 acres under alternative B and 56 acres under alternatives C or D) would lie below mean low water if the current topography remains unchanged. However, sediment transport modeling indicates these severely subsided areas are expected to receive large volumes of sediment as higher tides are incrementally restored (see section 4.4). In the long term these areas should accrete to support brackish and tidal freshwater marsh plant communities as the marsh surface reaches equilibrium with a restored tidal regime. As restoration progresses in the subsided areas, a transition in vegetation from the existing cover types (woodland, shrubland, and freshwater marsh) to sub-tidal habitat and unvegetated mud flats with a trajectory toward brackish and tidal freshwater marsh communities is expected. These subsided areas will be monitored to track sediment deposition and revegetation, and decisions about applying additional restoration management actions, such as supplementing sediment supply, removing blockages to salt water circulation, and planting appropriate native species, will be a component of the adaptive management process.

Along the landward periphery of the Upper Herring River sub-basin, the action alternatives would result in a wetland-to-upland habitat transition zone (20 acres under alternative B and 22 acres under alternatives C and D). These areas would be tidally influenced during the annual high tides (the highest predicted tides in a given year). Impacts to existing freshwater marsh, woodland, or shrubland plant species are expected to be minimal in this zone.

Duck Harbor

Within the 129-acre Duck Harbor sub-basin, expected vegetation changes would be extensive under all of the action alternatives. Most of the change would occur within the 105 acres of existing shrublands and woodlands that have come to dominate the sub-basin since tides were restricted by the construction of the Chequessett Neck Road Dike (see table 4-11). Salinity levels are predicted to reach the mid 20-ppt range in tidal channels, and adjacent areas of marsh where existing vegetated habitats likely would be restored to a mix of low and high salt marsh. Hydrodynamic modeling suggests that salinity would decrease with increasing distance from the channels with predicted salinities ranging from 0-14 ppt for alternative B and 3-20 ppt for alternatives C and D. While some salt sensitive plant species would be adversely affected under these conditions, under alternative B salt marsh vegetation would not be expected to colonize the landward margins of the sub-basin, while larger portions of these areas likely would transition to salt marsh under alternatives C or D. Intermediate salinity levels, especially those expected under alternative B, could also make conditions in the Duck Harbor sub-basin suitable for *Phragmites*. As stated in section 4.5.3, efforts will be made to control this non-native species throughout the project area prior to restoring tidal exchange. During restoration, vulnerable areas will be monitored for *Phragmites* occurrence, and measures implemented to control its spread in accordance with guidelines laid out in the adaptive management plan. The vegetation that ultimately grows in marsh areas away from the channel is difficult to predict because of the uncertainty associated with the actual salinity levels achieved by tidal restoration.

TABLE 4-11: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN DUCK HARBOR

	Existing Conditions	Alternative B	Alternatives C and D
MHW, Spring (Feet, NAVD88)		3.6	4.3
Acres below MLW		33	35
Salinity (ppt)			
In Channels	0	7 – 25	18 – 24
On Marsh Surface	0	0 – 14	3 – 20
Cover Type	**Acres Affected**		
Salt Marsh	0	--	--
Brackish Marsh	0	--	--
Freshwater Marsh	6	4	4
Shrubland	47	30	41
Woodland	58	41	49
Dune/Heath	18	6	13
Developed	0	--	--
Total	**129**	**81**	**107**
Transition Zone (AHW)		25	13

The Duck Harbor sub-basin also contains areas of significant subsidence of the former salt marsh. The lowest of these areas (33 acres under alternative B and 35 acres under alternatives C or D) 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 (see section 4.4). In the long term these areas should accrete and support salt marsh and brackish marsh vegetation as the marsh surface reaches equilibrium with a restored tidal regime. As restoration progresses in the subsided areas, shifts in vegetation from the existing cover types (woodland, shrubland, and freshwater marsh) to sub-tidal habitat and unvegetated mud flats, with a trajectory to low salt marsh communities is expected. These subsided areas will be monitored to track sediment deposition and revegetation, and decisions about applying additional restoration management actions, such as supplementing sediment supply, removing blockages to salt water circulation, and planting appropriate native species, will be a component of the adaptive management process.

Along the upstream periphery of the Duck Harbor sub-basin, all of the alternatives would result in a wetland-to-upland habitat transition zone (25 acres under alternative B and 13 acres under alternatives C and D). These areas would be tidally influenced only during the annual high tides (the highest predicted tides in a given year). Impacts to existing freshwater marsh, woodland, or shrubland plant species are expected to be minimal in this zone because of the infrequency of flooding and likely low salinity levels.

Lower Pole Dike Creek

Under alternatives B, C, or D, there would be extensive vegetation change within the 109-acre Lower Pole Dike Creek sub-basin. Over the long term, tidal waters with predicted salinity levels consistently in the mid-20s and higher would restore conditions suitable for low and high marsh that would replace the existing freshwater marsh, woodland, and shrubland communities, that have become established since tides were restricted. Impacts to existing vegetation cover types in the Lower Pole Dike Creek sub-basin are summarized in table 4-12.

TABLE 4-12: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN LOWER POLE DIKE CREEK

	Existing Conditions	Alternative B	Alternatives C and D
MHW Spring (Feet, NAVD88)		4.1	4.8
Acres below MLW		27	43
Salinity (ppt)			
In Channels	0	15 – 21	17 – 26
On Marsh Surface	0	20 – 30	24 – 30
Cover Type	**Acres Affected**		
Salt Marsh		--	--
Brackish Marsh		--	--
Freshwater Marsh	10	10	10
Shrubland	29	27	27
Woodland	70	67	68
Dune/Heath		--	--
Developed		--	---
Total	**109**	**104**	**105**
Transition Zone (AHW)		< 1	< 1

The Lower Pole Dike Creek sub-basin also contains areas of significant subsidence of the former salt marsh. The lowest of these areas (27 acres under alternative B and 43 acres under alternatives C or D) 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 (see section 4.4). In the long term these areas should accrete and support salt marsh vegetation as the marsh surface reaches equilibrium with a restored tidal regime. As restoration progresses in the subsided areas, shifts in vegetation from the existing cover types (woodland, shrubland, and freshwater marsh) to sub-tidal habitat and unvegetated mud flats, with a trajectory toward low salt marsh communities is expected. These subsided areas will be monitored to track sediment deposition and revegetation, and decisions about applying additional restoration management actions, such as supplementing sediment supply, removing blockages to salt water circulation, and planting appropriate native species, will be a component of the adaptive management process.

Upper Pole Dike Creek

Vegetation changes in the 146-acre Upper Pole Dike Creek sub-basin would be limited in comparison to the lower sub-basins. Although most of this sub-basin is thought to have been historically dominated by salt marsh vegetation, the relatively low maximum tidal elevation achieved by alternative B would not allow salt water to regularly propagate into this sub-basin and salinity levels within both the channel and on the marsh surface are predicted to remain low. Although no salt marsh or brackish species likely would colonize the marsh surface under these conditions, pulses of tidally forced freshwater would favor riparian and palustrine wetland species over the upland tree and shrub species that have colonized the sub-basin since the river was diked and channelized. Representative upland woodland species which are expected to be displaced by the restored hydrologic regime include quaking aspen (*Populus tremuloides*), black cherry (*Prunus serotina*), and black oak (*Quercus velutina*) and could be replaced by more freshwater wetland dependent species.

In contrast to alternative B, hydrodynamic modeling shows that with the greater tide exchange afforded by alternatives C and D, salinity levels in tidal channels could reach as high as 12 ppt, and 20 ppt on portions of the marsh surface. Uncertainty about salinity modeling in the upper sub-basins and the wide range of predicted low to intermediate salinity levels make specific projections about vegetation change difficult. Generally, the salinity levels predicted by the model would not be high enough or occur consistently enough to support extensive salt marsh plant communities, although some salt marsh plants could grow in areas adjacent to the channels. Species tolerant of low to moderate salinity levels, such as narrow-leaf cat-tail (*Typha angustifolia*), northern bayberry (*Morella pennsylvanica*), and northern arrowwood (*Viburnum recognitum*), likely would persist and perhaps expand as they displace less salt tolerant species. Intermediate salinity levels could also make conditions in the Upper Pole Dike Creek sub-basin suitable for *Phragmites*. As stated in section 4.5.3, efforts will be made to control this non-native species throughout the project area prior to restoring tidal exchange, vulnerable areas will be monitored for its occurrence, and measures implemented to control its spread in accordance with guidelines laid out in the adaptive management plan.

The Upper Pole Dike Creek sub-basin also contains areas of significant subsidence of the former salt marsh. The lowest of these areas (16 acres under alternative B and 42 acres under alternatives C or D) would lie below mean low water if the current topography remains unchanged. However, sediment transport modeling indicates these severely subsided areas are expected to receive large volumes of sediment as higher tides are incrementally restored (see section 4.4). In the long term, these areas should accrete to support brackish and freshwater marsh plant communities as the marsh surface reaches equilibrium with a restored tidal regime. As restoration in these subsided areas progresses, shifts in vegetation from the existing cover types (woodland, shrubland, and freshwater marsh) to sub-tidal habitat and unvegetated mud flats, with a trajectory toward vegetated marsh communities is expected. These subsided areas will be monitored to track sediment deposition and revegetation, and decisions about applying additional restoration management actions, such as supplementing sediment supply, removing blockages to salt water circulation, and planting appropriate native species, will be a component of the adaptive management process.

Along the landward margins of the Upper Pole Dike Creek sub-basin, all of the action alternatives would result in a wetland-to-upland habitat transition zone (17 acres under alternative B and 13 acres alternatives C and D) (see table 4-13). These areas would be tidally influenced only during the annual high tides (the highest predicted tides in a given year). Impacts to existing freshwater marsh, woodland, or shrubland plant species are expected to be minimal in this zone given the infrequency of flooding and low expected salinity levels.

TABLE 4-13: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN UPPER POLE DIKE CREEK

	Existing Conditions	Alternative B	Alternatives C and D
MHW Spring (Feet, NAVD88)		3.4	4.1
Acres below MLW		16	42
Salinity (ppt)			
In Channel	0	2 – 6	5 – 12
On Marsh Surface	0	0 – 14	0 – 20
Cover Type	**Acres Affected**		
Salt Marsh		--	--
Brackish Marsh		--	--
Freshwater Marsh	49	47	48
Shrubland	49	33	40
Woodland	48	28	37
Dune/Heath		--	--
Developed		--	--
Total	**146**	**108**	**125**
Transition Zone (AHW)		17	13

Lower Bound Brook

Within the 80-acre Lower Bound Brook sub-basin, vegetation changes would be extensive under all of the action alternatives. Most of the vegetational change would occur within existing shrublands (see table 4-14). This sub-basin was historically dominated by salt marsh vegetation prior to construction of the Chequessett Neck Road Dike. Restored salinity levels are expected to reach the mid 20-ppt range in tidal channels and adjacent marsh areas where existing shrublands and, to a lesser degree, woodlands and freshwater marsh, would be replaced with a mix of low and high salt marsh. Hydrodynamic modeling suggests that salinity would decrease with increasing distance from the channels with modeled salinities as low as 2 ppt for alternative B and 7 ppt for alternatives C and D in some areas. While some salt sensitive plant species could be adversely affected under these conditions, salt marsh vegetation would not be expected to colonize in marsh areas away from the channel. The vegetation that ultimately grows in areas distant from the channel is difficult to predict given the uncertainty associated with the actual salinity levels achieved by tidal restoration.

TABLE 4-14: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN LOWER BOUND BROOK

	Existing Conditions	Alternative B	Alternatives C and D
MHW Spring (Feet, NAVD88)		2.7	3.3
Acres below MLW		11	56
Salinity (ppt)			
In Channel	0	11 – 24	25 – 27
On Marsh Surface	0	2 – 5	7 – 12
Cover Type	**Acres Affected**		
Salt Marsh		--	--
Brackish Marsh		--	--
Freshwater Marsh	29	29	29
Shrubland	41	33	36
Woodland	10	5	6
Dune/Heath		--	--
Developed		--	--
Total	**80**	**67**	**71**
Transition Zone (AHW)		6	5

The Lower Bound Brook sub-basin also contains areas of significant subsidence of the former salt marsh. The lowest of these areas (11 acres under alternative B and 56 acres under alternatives C or D) 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 (see section 4.4). In the long term, these areas should accrete to support a mix of salt, brackish, and tidal freshwater marsh communities as the marsh surface reaches equilibrium with a restored tidal range. As restoration in the subsided areas progresses, shifts in vegetation from the existing cover types (woodland, shrubland, and freshwater marsh) to sub-tidal habitat and unvegetated mud flats, with a trajectory toward a mixed vegetated marsh community is expected. These subsided areas will be monitored to track sediment deposition and revegetation, and decisions about applying additional restoration management actions, such as supplementing sediment supply, removing blockages to salt water circulation, and planting appropriate native species, will be a component of the adaptive management process.

Along the landward margins of the Lower Bound Brook sub-basin, all of the action alternatives are predicted to result in a wetland-to-upland habitat transition zone (6 acres under alternative B and 5 acres alternatives C and D). These areas would be tidally influenced only during the annual high tides (the highest predicted tides in a given year). Impacts to existing freshwater marsh, woodland, or shrubland plant species are expected to be minimal in this zone given the infrequency of flooding and low expected salinity levels.

Upper Bound Brook

Vegetation changes in the 113-acre Upper Bound Brook sub-basin would be limited in comparison with the lower sub-basins. Even though much of this sub-basin was likely dominated by salt marsh vegetation prior to construction of the Chequessett Neck Road Dike, the relatively low maximum tidal range achieved by alternative B likely would not allow salt water to propagate this high into the system and existing freshwater conditions are expected to persist (see table 4-15). Although no salt marsh or brackish species would colonize under these conditions, pulses of tidally forced freshwater would resaturate the marsh surface, favoring riparian and palustrine wetland species over the upland tree and shrub species that have colonized the sub-basin since the river was diked and channelized. Representative upland species which are expected to be displaced by the restored hydrologic regime include quaking aspen (*Populus tremuloides*), black cherry (*Prunus serotina*), and black oak (*Quercus velutina*) and could be replaced with freshwater dependent species.

TABLE 4-15: SUMMARY OF AFFECTED VEGETATION COVER TYPES IN UPPER BOUND BROOK

	Existing Conditions	Alternative B	Alternatives C and D
MHW Spring (Feet, NAVD88)		2.3	2.5
Acres below MLW		0	0
Salinity (ppt)			
In Channels	0	1 – 3	10 – 15
On Marsh Surface	0	0	0
Cover Type	**Acres Affected**		
Salt Marsh		--	--
Brackish Marsh		--	--
Freshwater Marsh	65	32	46
Shrubland	48	7	10
Woodland		--	--
Dune/Heath		--	--
Developed		--	--
Total	**113**	**39**	**56**
Transition Zone (AHW)		21	14

In contrast to alternative B, hydrodynamic modeling shows that with the greater tidal exchange afforded by alternatives C and D, that salinity levels in tidal channels could reach as high as 15 ppt with predicted salinities remaining near zero in marsh areas away from the channel. Uncertainty about salinity modeling in the upper sub-basins makes specific projections about vegetation change difficult. Generally, the salinity levels predicted by the model would not be high enough or occur consistently enough to support extensive salt marsh plant communities, although some salt marsh plants could grow adjacent to the channels. Species tolerant of low to moderate salinity levels, such as narrow-leaf cat-tail (*Typha angustifolia*), northern bayberry (*Morella pennsylvanica*), and northern arrowwood (*Viburnum recognitum*), likely would persist and perhaps expand as they displace less salt tolerant species. The intermediate tidal channel salinity levels achieved under alternatives C or D could also make the Upper Bound Brook sub-basin suitable for *Phragmites*. As stated in section 4.5.3, efforts will be made to control this non-native species throughout the project area prior to restoring tidal exchange. During restoration, vulnerable areas will be monitored for *Phragmites* occurrence and measures implemented to control its spread in accordance with guidelines laid out in the adaptive management plan.

Along the landward margins of the Upper Bound Brook sub-basin, all alternatives would result in a wetland-to-upland habitat transition zone (21 acres under alternative B and 14 acres under alternatives C and D). These areas would be tidally influenced only during the annual high tides (the highest predicted tides in a given year). Impacts to existing freshwater marsh, woodland, or shrubland plant species are expected to be minimal in this zone given the infrequency of flooding and low expected salinity levels.

4.5.5 CUMULATIVE IMPACTS

The Mayo Creek salt marsh restoration project would restore a limited amount of tidal salt marsh habitat on Wellfleet Harbor. This project, like each of the action alternatives in the HRRP, would increase the total amount of native tidal salt marsh habitat available on Cape Cod, having a beneficial cumulative impact on the availability of wetland habitat and vegetation.

4.5.6 CONCLUSION

Over the long term, all action alternatives are expected to result in extensive restoration of salt marsh vegetative communities, primarily in the Lower Herring River, Middle Herring River, and Lower Pole Dike Creek sub-basins. Alternative B is expected to restore 339 acres and alternatives C and D 346 acres of vegetated inter-tidal habitat in these sub-basins. Approximately 53 acres of salt marsh would be restored in the Mill Creek sub-basin if alternative B option 2 and alternative D option 2 (elevating) were implemented for the CYCC golf course. An additional 7 acres of salt marsh would be restored if alternative B option 1 and alternative D option 1 (relocating) were implemented. No restoration or tidally driven vegetation change would occur within Mill Creek under alternative C.

Due to the low salinity levels expected in the upper reaches of the system, little if any salt marsh vegetation would colonize the Upper Herring River, Upper Bound Brook, and Upper Pole Dike Creek sub-basins under any of the action alternatives. However, wetter conditions driven by tidal forcing with periodic influxes of brackish water, especially under alternatives C and D, may cause some degree of vegetation change, favoring facultative and obligate wetland plant species over upland species. Up to 251 acres of habitat could be affected within these sub-basins under alternative B and up to 294 acres under alternatives C and D. In most of the Duck Harbor and Lower Bound Brook sub-basins, an area of approximately 200 acres, the amount of vegetation change would be highly dependent on the degree of tidal restoration. Under alternative B, changes would be minimal and would be similar to those occurring in the upper sub-basins under any of the action alternatives. With the larger tidal ranges and higher salinity levels afforded by alternatives C and D, vegetation changes would be more extensive, with salt marsh species colonizing marsh areas adjacent to tidal channels and in some areas extending landward across the marsh surface.

A wetland-to-upland transition zone (between the mean high water spring tide and AHW tide elevations) is expected to occur primarily along the landward periphery of most of the upstream sub-basins. Astronomic high and storm-driven tides may result in some vegetation change in this zone depending on the frequency, duration, and salinity of tidally forced inundation and the flood and salt tolerances of affected plant species. The approximate size of this zone is estimated to be 95 acres under alternative B and 70 acres under alternatives C and D. Extensive areas of subsided, former salt marsh occur in the Middle and Upper Herring River, Lower and Upper Pole Dike Creek, Duck Harbor, and Lower Bound Brook sub-basins. Sediment transport modeling indicates these severely subsided areas (128 acres under alternative B and 242 acres under alternatives C or D) are expected to receive large volumes of sediment as higher tides are incrementally restored (see section 4.4). In the long term these subsided areas should accrete to support a mix of salt marsh, brackish, and tidal freshwater marsh plant communities as the marsh surface reaches equilibrium with a restored tidal regime.

Therefore, all action alternatives would result in a permanent, estuary-wide transition from a degraded freshwater marsh to a functioning estuarine wetland. Also, all action alternatives would significantly increase the total regional acreage of functioning estuarine wetlands; these estuarine habitat types are ecologically critical in this geographic area of Cape Cod. Based on the degree of salt marsh recovery and the regional importance of estuarine wetlands in terms of biodiversity, this would likely constitute a locally and regionally significant beneficial impact, which would be most pronounced for alternative D, but would be significantly beneficial for all action alternatives relative to the no action alternative.

In some areas, intermediate salinity levels, between approximately 5 and 18 ppt, could create conditions suitable for common reed (*Phragmites australis*). As stated in section 4.5.3, efforts will be made to control this non-native species throughout the project area prior to restoring tidal exchange. During restoration, vulnerable areas will be monitored for *Phragmites*, and measures implemented to control its spread in accordance with guidelines laid out in the adaptive management plan. Because the spread of *Phragmites* would be actively controlled, it would not be likely to constitute a significant adverse impact, despite some uncertainty about its response intermediate salinity levels that would occur in some areas.

All action alternatives would result in temporary construction impacts during construction, as described in “Section 4.11: Construction Impacts of the Action Alternative.” Short-term disturbance of construction sites, including dewatering and staging, may occur on approximately 8 acres, and would be restored when construction is complete. A permanent loss of up to 9 acres of vegetation/wetland habitat would also occur to accommodate CYCC golf course elevation (8.26 acres of total), and the footprint of new dikes or raised/relocated roads. These wetland losses would effectively be mitigated by the restoration of hundreds of acres of sub and inter-tidal habitat. All construction impacts would be mitigated through use of construction best management practices (BMPs). Activities related to secondary restoration and residential flood proofing would be limited in scale. Overall, the adverse impacts of construction impacts would not be considered significant when viewed in the context of the estuary-wide restoration that necessitates these construction impacts.

Under the no action alternative, there would be no predicted changes to wetland function, which is currently degraded, or to the distribution of vegetation types in the estuary. Sub-tidal and inter-tidal habits, which are of unique importance ecologically, would continue to be confined to 80 acres in the lower Herring River sub-basin, while freshwater conditions would continue to prevail in over 1,000 acres of pre-dike salt marsh. Therefore, there would be no significant new adverse impacts from taking no restoration action, despite the significance of past adverse environmental impacts caused by diking and draining the estuary. There would also be no construction impacts.

4.5.7 Refined Vegetation and Habitat Change Analysis of the Preferred Alternative for Final EIS/EIR

Based on comments submitted after the release of the draft EIS/EIR and subsequent follow-up meetings with the Massachusetts NHESP and the MassDEP, it was determined that additional analysis is necessary to adequately address agency comments and characterize potential changes to flood plain vegetation and associated habitats resulting from full implementation of the preferred alternative. This refined analysis is needed to describe and, to the extent practicable, quantify:

1. Projected transitions from freshwater and upland habitat (currently located in former tidal wetlands that existed prior to construction of the Chequessett Neck Road Dike) to tidally dependent estuarine habitats;
2. Estimated changes to the coverage, and the potential expansion, of the non-native, invasive species common reed, Phragmites australis; and
3. Potential impacts to freshwater dependent state-listed rare species habitat.

METHODS AND ASSUMPTIONS

The refined vegetation and habitat change analysis is based on the same data sources used for the draft EIS:

- Vegetation mapping produced by the NPS in 2007; and
- Output from the hydrodynamic model (Woods Hole Group 2012).

In the draft EIS/EIR, data from both of these sources were generalized for a simplified analysis. The vegetation map classification system depicted in the draft EIS/EIR contained 8 cover type classes which were aggregated from 14 classes used for the original 2007 map (see draft EIS/EIR pages 112-115). After review, it was determined that this simplified cover type classification did not describe the extent and magnitude of impacts to specific habitat types in enough detail to estimate changes in vegetation cover types and state-listed rare species habitat. Thus, the original 14 cover type classes depicted on the 2007 Cape Cod National Seashore vegetation cover map are incorporated into this new analysis (see table 4-16 and figure 4-4). Note that the limitations and anomalies pertaining to vegetation mapping for the Herring River described in the draft EIS/EIR and on the 2007 vegetation map still apply to this refined analysis (see draft EIS/EIR pages 112-113).

TABLE 4-16: DIFFERENCES IN COVER CLASSES AND TYPICAL SPECIES FROM 2007 CAPE COD NATIONAL SEASHORE MAP AND 2012 DRAFT EIS/EIR

Draft EIS/EIR Cover Classes	2007 Map Cover Classes	Typical Dominant Species
Woodlands	Wet deciduous forest	• Red Maple (*Acer rubrum*) • Swamp Azalea (*Rhododendron viscosum*) • Sweet Pepperbush (*Clethra alnifolia*)
	Dry deciduous forest	• Black Oak (*Quercus velutina*) • White Oak (*Q. alba*) • American Beech (*Fagus grandifolia*) • Black Locust (*Robinia pseudoacacia*)
	Pine woodland	• Pitch Pine (*Pinus rigida*) • Huckleberry (*Gaylussacia baccatta*) • Hair-grass (*Deschampsia flexuosa*) • Low-bush Blueberry (*Vaccinium angustifloium*)
	Dry deciduous woodland	• Black Cherry (*Prunus serotina*) • Shadbush (*Amelanchier* spp.) • Viburnum (*Viburnum* spp.)
Shrublands	Wet shrubland	• High-bush Blueberry (*Vaccinium corymbosum*) • Sweet Pepperbush (*Clethra alnifolia)* • Swamp Azalea (*Rhododendron viscosum*)

Draft EIS/EIR Cover Classes	2007 Map Cover Classes	Typical Dominant Species
		• Water-willow (*Decodon verticillatus*) • Buttonbush (*Cephalanthus occidentalis*) • Alder (*Alnus* spp.) • Leatherleaf (*Chamaedaphne calyculata*)
	Dry shrubland	• Northern Bayberry (*Morella pensylvanica*) • Black Oak (*Quercus velutina*) • Shadbush (*Amelanchier* spp.)
Freshwater Marsh/Meadow	Old field herbaceous mix	• Little Blue-stem Grass (*Schizchyrium scoparium*) • Hair-grass (*Deschampsia flexuosa*) • Velvet Grass (*Holcus lanatus*) • Red Fescue (*Festuca rubra*) • Red-top Grass (*Agrostis gigantean*) • Goldenrod (*Solidago* spp.) • Spirea (*Spiraea* spp.) • Dewberry (*Rubus* spp.)
	Freshwater marsh	• Narrow-leaf Cat-tail (*Typha angustifolia*) • Wool-grass (*Scirpus cyperinus*) • Blue-joint Grass (*Calamagrostis americana*) • Bur-reed (*Sparganium Americana*)
Brackish Marsh	Brackish marsh	• Common Reed (*Phragmites australis*) • Common Three-square (*Schoenoplectus pungens*)
Salt Marsh	Salt marsh	• Salt-marsh Cord-grass (*Spartina alterniflora*) • Salt-marsh Hay (*S. patens*) • Glasswort (*Salicornia* spp.) • Seablite (*Suaeda* spp.)
Dune/Heathland	Heathland	• Bearberry (*Arctostaphyllos uva-ursi*) • Northern Bayberry (*Morella pensylvanica*) • Low-bush Blueberry (*Vaccinium angustifolium* • Golden Heather (*Hudsonia ericoides*) • Beach Heather (*H. tomentosa*) • Broom Crowberry (*Corema conradii*)
	Dune grassland	• Beach-grass (*Ammophila breviligulata*) • Hair-grass (*Descahmpsia flexuosa*)

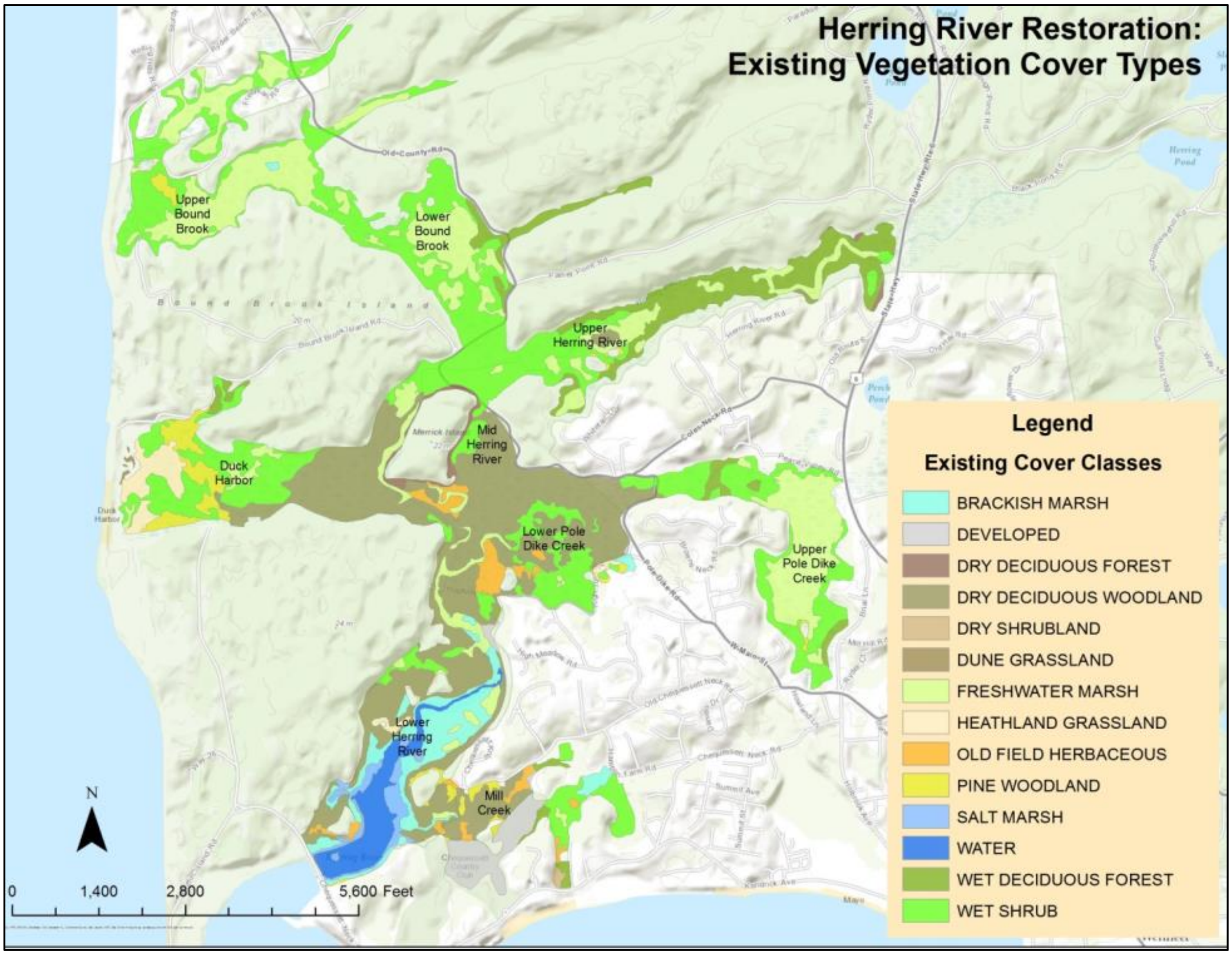


FIGURE 4-4: EXISTING VEGETATION COVER TYPES USING 2007 NPS VEGETATION MAPPING DATA

Because the extent of tidally forced salt and brackish water throughout the flood plain is presumed to be the primary driver for vegetation change, the draft EIS/EIR analysis was based on hydrodynamic model output data which predicted future water column salinity levels at discrete points throughout the flood plain. These points were intended to represent the general salinity levels within each sub-basin.

While preparing responses to draft EIS/EIR comments, modeling output was reviewed in greater detail. This revealed that the complex topography, bathymetry, and flow dynamics of the Herring River flood plain led to some inconsistency among the salinity model output. The discrete points used for the draft EIS/EIR analysis were not all representative of the future salinity range of the sub-basin in which they were located. For this new analysis, refined model output incorporating a larger number of data points that included predicted water column salinities within river channel and surface water salinities throughout the marsh were used to provide a more representative characterization of estimated future salinity levels for each sub-basin.

Although this new analysis presents a refined, more accurate, and higher resolved overview of the likely impacts to existing vegetation and projections of future habitat types under the preferred alternative, it is important to note that the limitations of the salinity model data output summarized in the draft EIS/EIR and the Final Hydrodynamic Modeling Report are still applicable. Unlike tidal water surface predictions from the model, the salinity model cannot be fully calibrated to existing data because the system currently has no salinity above High Toss Road. As such, there is less confidence and a greater degree of uncertainty about the salinity output and the projections presented here should be regarded as general estimates only. As restoration proceeds, new monitoring data will be incorporated into the hydrodynamic model, which will be refined to improve predictions of future salinities throughout the Herring River project area. Although there are some slight differences in the results presented here and those summarized in the draft EIS/EIR, this new analysis does not alter the original alternatives analysis or selection of a preferred alternative.

PROJECT-WIDE VEGETATION CHANGE

Existing Conditions and Alternative A (No Action) Impacts

Re-examining the Herring River vegetation mapping data and salinity output from the hydrodynamic model yielded a net reduction of 49 acres (4.7 percent) of mapped area broadly considered to be within the Herring River project area. Overall, the estimated area of potentially affected vegetation changed from 1,055 acres in the draft EIS/EIR to 1,006 acres in the new analysis (see table 4-17). The majority of this difference is attributed to removing 35 acres of high elevation land classified as dry deciduous forest on Merrick Island from the analysis. This area is well above any future tidal influence and would not be affected by the project. Areas east of Route 6 were also removed because of inconsistency in available mapping data and the minor degree of vegetation change expected to occur in these regions (figure 4-4). Additional small changes in several cover types result from changes in methods used for mapping open water, other minor improvements to data accuracy, and rounding errors.

TABLE 4-17: COMPARISON OF COVER CLASS ACRES FROM 2007 VEGETATION MAP AND 2012 DRAFT EIS/EIR

Consolidated Cover Classes for Draft EIS/EIR Analysis	Existing Acres	Cover Classes from 2007 Vegetation Map	Existing Acres	Change
Woodlands	402	Wet deciduous forest	75	-63
		Dry deciduous forest	7	
		Pine woodland	26	
		Dry deciduous woodland	231	
Shrublands	299	Wet shrubland	288	-10
		Dry shrubland	1	
Freshwater Marsh/Meadow	222	Old field herbaceous mix	18	-32
		Freshwater marsh	172	
Brackish Marsh	42	Brackish marsh	36	-6
Salt Marsh	13	Salt marsh	13	0
Dune/Heathland	21	Heathland	20	0
		Dune grassland	1	
Water	32	Water	94	+62
Developed	24	Developed	24	0
TOTAL ACRES, from Draft EIS	**1055**	**TOTAL ACRES, 2007 Map**	**1006**	**-49**

Under the No-action Alternative ("alternative A") changes to vegetation cover types for the 1,006 acres defined by the new analysis would be no different from those discussed for the 1,055 acres identified in the draft EIS/EIR (page 201). In general, existing cover types would persist, with likely slow increases to the amount of upland and freshwater plant species as the steady degradation of the diked and drained flood plain continues. Non-native invasive species, especially common reed (*Phragmites australis*), would also be expected to expand.

Impacts Associated with the Action Alternatives

Preferred Alternative (alternative D, with CYCC Option 2: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Partially Restores Tidal Flow, Elevate Affected Areas of CYCC Golf Course, draft EIS/EIR p. 55)

When the preferred alternative is fully implemented, of the total 1006 acres within the project area, approximately 868 acres will be restored as inter-tidal habitat (figure 4-4). Of this, approximately:

- 585 acres would be subjected to regular water column salinity levels of 18 parts per thousand (ppt) and higher;
- 99 acres would be affected by salinity between 6 and 18 ppt;
- 98 acres would be affected by freshwater tidal flow with salinity consistently below 6 ppt; and
- 86 acres would be tidally influenced sub-tidal, open water habitat with a salinity gradient ranging from approximately 30 ppt in the downstream reaches to 0 ppt in the upper reaches.

These effects dramatically increase the extent and quality of inter-tidal habitats, which under existing conditions, occupy only about 70 acres. Within the 585 acre area expected to experience higher salinity levels (18 ppt and above) and collectively referred to as "salt marsh," a range of saltwater dependent habitats are expected to develop. These include low and high salt marsh, inter-tidal mud flats, and open water salt pannes and pools (pools tend to retain water during the summer months between high tides, whereas pannes generally do not). These habitats will develop based on variation in marsh surface elevation, frequency of tidal inundation, and salinity levels. The lowest areas within the inter-tidal range would remain unvegetated and develop into mud flats. Areas that are slightly higher, up to approximately the extent of mean daily tides, will become low salt marsh, dominated by salt marsh cord-grass (*Spartina alterniflora*). High salt marsh, dominated by salt marsh hay (*S. patens*), black grass (*Juncus gerardii*), and spike grass (*Disticilis spicata*), are expected to colonize the highest inter-tidal zone, affected by twice monthly spring tides. Low depressions within the inter-tidal zone will likely retain salt water at low tide and provide salt panne and pool habitat. Although the conditions which contribute to the development and sustainability of these habitats are well established, the variable conditions within the restored Herring River make it difficult to predict precise acreage estimates and locations of specific intertidal habitats.

Within the 99-acre area expected to be primarily influenced by brackish tidal flow (6-18 ppt), vegetation community changes likely will vary depending on actual salinity levels and the extent and duration of tidal inundation. Generally, brackish zones will be limited to the upper reaches of the Herring River, Pole Dike Creek, Bound Brook, and Duck Harbor. In areas of lower elevation (and therefore more frequently inundated) and the higher end of the brackish salinity range, some of the salt marshes species referred to in the previous paragraph would likely occur. Species adapted to more brackish conditions, including common three-square (*Schoenoplectus pungens*), salt reedgrass (*Spartina cynosuroides*), narrow-leaf cattail (*Typha angustifolia*), and of emergent vegetation, and a limited expansion of moderately salt tolerant species in higher salinity zones (figure 4-5).salt marsh bulrush (*Scirpus robustus*), will occur slightly landward. Habitat zones influenced by tidal flow at the lower end of the brackish salinity range would be dominated by typical emergent freshwater marsh species, including narrow-leaf cattail, wool-grass (*Scirpus cyperinus*), blue-joint grass (*Calamagrostis canadensis*), and bur-reed (*Sparganium americana*). In general, vegetation habitat changes within areas subjected to brackish tidal flow will result in a substantial reduction in the extent of existing shrub, woodland, and forested habitats, an increase in the overall extent of emergent vegetation, and a limited expansion of moderately salt tolerant species in higher salinity zones (Figure 4-5).

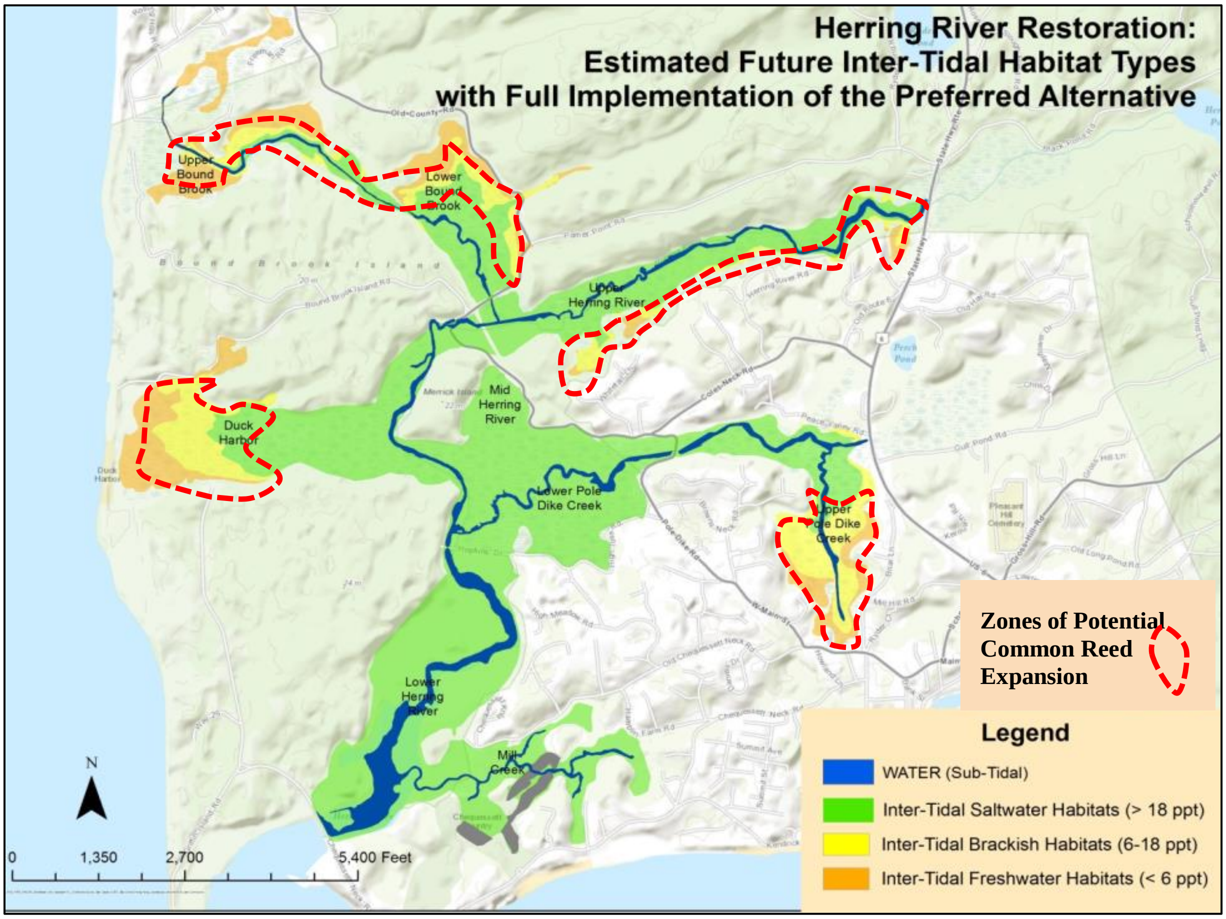


FIGURE 4-5: ESTIMATED INTER-TIDAL HABITATS UNDER THE PREFERRED ALTERNATIVE.

In the uppermost reaches of the future inter-tidal area, salinities will likely remain very low (below 6 ppt) although small daily and semi-monthly spring tide fluctuations in water surface elevations can be expected. Within this 98-acre freshwater tidal zone, vegetation community changes are difficult to predict given the subtle hydrologic change. Changes driven by higher water column salinity levels would be expected to be minor, although some moderately salt-tolerant species, such as those expected in brackish zone, could become established. In general, conditions within this zone are likely to be somewhat wetter, with respect to both the depth of water and the extent and frequency of saturated soil, contributing to an overall reduction in the cover of woody trees and shrubs and an increase in emergent freshwater marsh.

Complete implementation of the preferred alternative will also result in a slight net reduction of permanently inundated, sub-tidal open water habitat from approximately 94 to 86 acres. This includes both reduced sub-tidal area in the Lower Herring River as currently flooded zones rebuild elevation and develop into inter-tidal salt marsh and increased open water upstream as tidal channels and creeks become reestablished with increased tidal flow. Sub-tidal habitat conditions will vary with salinity, which will range from 30 ppt in the lower reaches to 0 ppt in freshwater tidal and non-tidal zones. Where sufficient channel depth occurs, primarily in lower and middle reaches, a vertical salinity gradient may also occur, with a high salinity salt wedge near the bottom of the water column and fresher water nearer the surface.

Restoration of 868 acres of sub- and inter-tidal estuarine habitat under the preferred alternative will result in the loss or substantial reduction of several existing upland and freshwater habitat types (table 4-18). It is expected that when the project is fully implemented and vegetation and habitat changes reach a point of equilibrium, virtually all of the existing forest, woodland, dry shrubland, and heathland/old field habitat will be replaced with inter-tidal marsh. Existing non-tidal freshwater marsh will be largely replaced by tidally influenced freshwater marsh, although the specific vegetation community changes between these habitat types are difficult to predict and quantify. Approximately 67 acres of existing wet shrubland and 57 acres of varied freshwater and wetland-upland transition habitats will persist on the periphery of the inter-tidal area above the reach of mean high spring tides. Exact vegetation changes within this zone will depend on the frequency and extent of storm driven and other extreme high tide events which are difficult to predict. With tidal flow along Mill Creek and grading changes to the CYCC golf course, about 12 acres of land currently classified as “developed” (i.e., used for the golf course) will be converted to intertidal-marsh.

TABLE 4-18: ESTIMATED COVERAGE OF VEGETATION COVER TYPES UNDER EACH ALTERNATIVE (ACRES)

Alt. A	Cover Class	Alt. B	Alt. C	Alt. D*
75	Wet deciduous forest	44		
7	Dry deciduous forest	2		
26	Pine woodland	22	2	2
231	Dry deciduous woodland	10		
288	Wet shrubland	122	67	67
1	Dry shrubland			
18	Old field herbaceous mix	2		
172	Freshwater marsh (non-tidal)			
N/A	Freshwater marsh (tidal)	127	99	99
36	Brackish marsh (tidal)	183	98	98
13	Salt marsh (tidal)	358	551	585
20	Heathland	11		
1	Dune grassland	1		
94	Water	86	80	86
24	Developed	12	24	12
N/A	Misc. Non-Tidal**	26	57	57
1006	***TOTAL***	***1006***	***978***	***1006***

* Alt. D = “Preferred alternative”

** Misc. Non-tidal Habitats include varied wetland and upland areas expected to persist along the periphery of the project and other isolated areas.

Changes to Coverage of Common Reed under the Preferred Alternative

Under existing conditions, non-native common reed covers approximately 48 acres of the Herring River flood plain. The majority of this occurs in the Lower Herring River and Mill Creek sub-basins, where this species dominates the wetland vegetation community. Large stands are also found in Lower and Upper Pole Dike Creek and Upper Bound Brook (figure 4-6). Smaller patches are scattered in wetter locations throughout the flood plain.

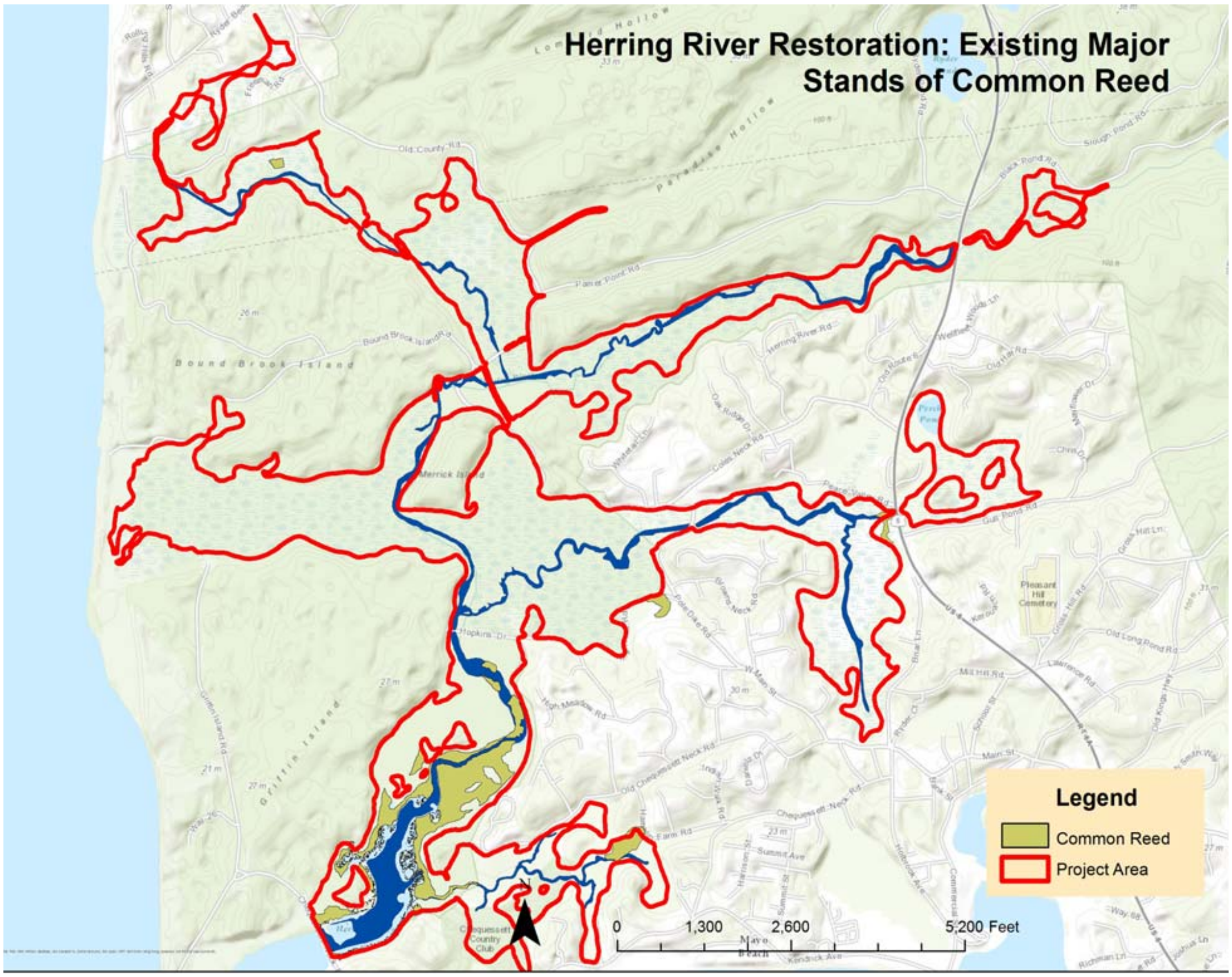


FIGURE 4-6: EXISTING CONDITIONS: MAJOR STANDS OF COMMON REED (*PHRAGMITES AUSTRALIS*) IN HERRING RIVER PROJECT AREA

Under the preferred alternative it is likely that restored tide range and high salinity waters (expected to be consistently 24 ppt and higher), will effectively eliminate common reed in the Lower and Mid Herring River, Mill Creek, and Lower Pole Dike Creek. Existing stands would be salt-killed fairly rapidly as tidal restoration is implemented and eventually replaced by native salt marsh plant communities, as previously described. As long as tidal flow is maintained and salinity levels remain high, common reed should not remain within these areas, accounting for approximately 450 acres.

It is possible that without active management, that common reed could colonize and increase in coverage in upstream areas. Within the upper extent of the 585 acre zone depicted as inter-tidal salt water marsh on figure 4-5, and in particular those areas projected to be brackish marsh, mid-range salinity levels between approximately 6 and 18 ppt could create favorable conditions for common reed. The species is highly adaptable and tolerant of a wide salinity range, from 0 to about 20 ppt. Other, less salt tolerant, species which currently exist would likely be stressed and eventually succumb to brackish water, affording common reed with a strong competitive advantage for increased colonization. It is less likely that common reed will expand in areas which will remain freshwater (see figure 4-5). These areas are largely free of the species and established freshwater vegetation is expected to persist and retain a competitive edge. Overall, there could be 150-250 acres of brackish habitat that may be susceptible to invasion by common reed.

A suite of management actions will be proposed to ensure that common reed does not expand or create new stands in areas made vulnerable to invasion by restoration of brackish habitat. Prior to implementation of tidal restoration, stands of common reed occurring upstream of High Toss Road (figure 4-6) are proposed to be treated with herbicide. These stands are not extensive and it is feasible that common reed could be largely eradicated from this portion of the flood plain. (Details regarding herbicide applications, including measures to avoid non-target effects and other impacts, will be included in the project's adaptive management plan and permitting applications). After the initial herbicide application, and as tidal restoration proceeds, the entire area of concern will be monitored explicitly to detect whether and to what extent common reed is colonizing. Follow-up herbicide applications, as well as other possible control treatments, will be considered to keep the species from establishing at new locations. Given the relatively limited occurrence of common reed throughout the Herring River flood plain and adjacent areas (with the exception of the Lower Basin and Mill Creek, as previously discussed), it is expected that high salinity levels in some areas and repeated herbicide applications in other areas, combined with focused monitoring, will be effective means for controlling common reed and increasing the likelihood that native estuarine plant communities will be restored.

Alternative B: New Tidal Control Structure at Chequessett Neck – No Dike at Mill Creek (draft EIS/EIR p. 47)

Under alternative B, reduced tide range and salinity penetration would result in an overall smaller area (668 acres vs 868 acres) of restored inter-tidal habitat. The area of higher salinity salt marsh would be only 358 acres (compared to 585 under the preferred alternative), whereas predicted inter-tidal fresh and brackish marsh would increase to 127 and 183 acres, respectively (table 4-18). Approximately 200 acres of wet shrubland and forest/woodland would also remain. This reduced area of high salinity inter-tidal marsh and increased area of fresh and brackish habitat would increase the area into which common reed could expand to more than 300 acres.

Alternative C: New Tidal Control Structure at Chequessett Neck – Dike at Mill Creek that Excludes Tidal Flow, (draft EIS/EIR p. 51)

Vegetation and habitat change within the Herring River flood plain under alternative C would be identical to those previously described for the preferred alternative (alternative D), with the exception that no impacts (similar to alternative A) would occur within the Mill Creek sub-basin, where tidal restoration would not occur. Removing Mill Creek from the project reduces the total project area to 978 acres and the area of restored inter-tidal wetlands to 748 acres (table 4-18). Concerns about expansion of common reed under alternative C would increase since existing patches within the Mill Creek sub-basin would remain, providing a population which could expand into the Herring River.

4.6 IMPACTS ON AQUATIC SPECIES

Estuary habitat is extremely important for a variety of aquatic species, providing spawning, nursery and feeding grounds for fish, macroinvertebrates, and shellfish. Some species migrate in and out of the system while others spend their entire life-cycle in the estuary.

4.6.1 METHODS AND ASSUMPTIONS

Potential impacts on estuarine fish and macroinvertebrates, anadromous and catadromous species, and shellfish, as well as their habitats were evaluated based on known life histories and habitat requirements, and their past and present occurrence in the Herring River estuary and Wellfleet Harbor. Information on habitat, occurrence within the Herring River estuary and Wellfleet Harbor, and potential impacts on species from salt marsh restoration efforts was acquired from park staff at the Seashore, Wellfleet town officials, and available literature. The analysis also integrated the findings of the hydrodynamic modeling of the estuary, using the predicted mean high spring tide as the best approximation of the extent of tidal influence and the areal extent of estuarine habitat that would occur under the different alternatives. In accordance with Magnuson-Stevens Fisheries Conservation and Management Act, an Essential Fish Habitat Assessment has been included in this EIS/EIR as appendix F.

4.6.2 IMPACTS OF ALTERNATIVE A: NO ACTION

Under alternative A, the tide gate openings at the Chequessett Neck Road Dike would remain in their current configurations. The sluice gate opening of 24 inches would continue to limit the amount of tidal exchange upstream of the dike, resulting in a depressed mean tidal range of approximately 2.4 feet upstream of the dike as compared to the mean tidal range of approximately 10.3 feet downstream of the dike. As indicated in "Section 4.3: Impacts on Water and Sediment Quality," the Herring River estuary under this configuration would remain a freshwater system upstream of High Toss Road and tidal flows, and thus saline waters, would remain confined to the Lower Herring River sub-basin (see figure 3-1 in chapter 3). Under these conditions, the total acreage of estuarine waters (based on the mean high spring tide) within the Herring River estuary would remain 70 acres (25 acres of sub-tidal and 45 acres of intertidal habitat) located in the Lower Herring River sub-basin. The Herring River estuary would remain a degraded system adversely impacting estuarine fish, macroinvertebrate communities, anadromous and catadromous fish, and shellfish that inhabit Wellfleet Harbor and the Herring River estuary.

Estuarine Fish and Macroinvertebrates

The degraded estuarine system under alternative A would continue to result in the existing estuarine fish assemblages described in section 3.6.1 being confined to the approximately 70 acres of estuarine waters below High Toss Road in the Lower Herring River sub-basin. Species composition of the resident fish assemblage would continue to be similar to that found below the dike, with the mummichog, striped killifish, and Atlantic silverside being dominant species; however, the overall abundance of these species upstream of the dike would continue to be greatly reduced. A contributing factor to this dissimilarity in abundance upstream and downstream of the dike is the dike itself, for Eberhardt, Burdick, and Dionne (2010) found that undersized culverts with accelerated currents that restrict tidal flow in estuarine systems can also restrict the upstream/downstream movement of resident fish, such as the mummichog. Raposa and Roman (2003) also found dissimilarities in the nekton communities upstream and downstream of tidal restrictions in several New England salt marshes.

With the depressed tidal range under alternative A, salinity levels upstream of the dike would continue to be limited as would the amount of intertidal habitat available for use by resident estuarine species for spawning and nursery areas, adversely affecting the abundance of these species in the Herring River upstream of the dike. With reduced abundances of these species which act as forage for birds and predatory fish, alternative A would also continue to adversely affect the function that these fish play in transferring energy within and out of the Herring River estuary.

The occurrence of non-resident marine fish migrants utilizing the system upstream of the dike would also remain limited. Fish such as the Atlantic menhaden and winter flounder use the estuary as a nursery and for forage. However, with the limited amount of estuarine sub-tidal and intertidal salt marsh habitat available upstream of the dike and with the relatively small sluice gate opening impeding fish passage, the abundance of these species upstream of the dike would continue to be low under alternative A.

As discussed in section 3.6.1, predatory fish such as striped bass and blue fish use estuaries as foraging grounds, feeding on small tidal marsh fish such as killifish and Atlantic silversides. However, because the population of prey species would continue to be limited upstream of the dike under alternative A, and because the dike itself likely impedes upstream migration of the larger predatory fish, their abundance and use of the Herring River estuary upstream of the dike under alternative A would also continue to remain low. Fish play an important role in exporting energy and nutrients out of salt marshes, and in tidally restricted systems the decreased connectivity of fish populations upstream and downstream of the restriction inhibits the transfer of marsh-derived production to the coastal ecosystem (Eberhardt, Burdick, and Dionne 2010). With limited abundance of resident fish species and few predatory fish being able to access the river upstream of the dike to forage, the amount of energy production transported out of the estuary to the surrounding coastal waters would continue to be limited.

With no change in the tide gate configuration at the Chequessett Neck Road Dike, the Herring River upstream of High Toss Road would continue to remain a freshwater system and both the abundance and number of freshwater fish species would remain low.

For macroinvertebrate species, the upstream/downstream distribution of the species currently shows a trend that is related to the presence of the Chequessett Neck Road Dike. This is due to the depressed mean tidal range limiting the amount of salinity penetrating upstream as well as the limited amount of sub-tidal and intertidal estuarine habitat. The density of individual macroinvertebrate species, except for grass shrimp, is greater downstream of the dike than upstream and this trend is likely to continue under alternative A. There is a moderate abundance of freshwater species in the Herring River system upstream of High Toss Road (Gwilliam unpublished data; Johnson unpublished data; Lassiter unpublished data, Raposa unpublished data; Roman 1987). This trend would continue under alternative A.

Anadromous and Catadromous Fish

The headwater ponds of the Herring River provide approximately 157 acres of spawning habitat for river herring and the only major obstruction on the river is Chequessett Neck Road Dike. While passable, the 24-inch sluice gate opening is undersized and limits fish passage. As noted in section 3.6.3, prior to the construction of the dike the Herring River supported a productive river herring fishery of about 200,000 to 240,000 fish, with the actual river herring run size likely much larger. While other factors, such as offshore fishing and abundance of predators, have likely contributed to some of the decrease in river herring runs in Herring River and other areas throughout the northeast United States, construction of the dike has been a major factor in the decrease in river herring within the Herring River system (Curley et al. 1972). Besides impeding upstream migration, the sluice gate and the two flapper gates that allow river discharge on the ebbing tide may also increase the mortality of post-spawning adults migrating back into the coastal waters. The natural mortality of post-spawning alewifes is known to be high (estimated to be 57.4 percent by Kissil 1974 as cited in Roman 1987), so hazards encountered during the outmigration may increase the already high mortality rate of post-spawning adults, which may affect the size of subsequent spawning runs. Current run sizes have averaged approximately 12,400 fish over the past three years (APCC 2011), and with continued limited fish passage at the dike under alternative A run sizes would likely continue to remain below what a restored system could accommodate.

In addition to the dike, the narrower upstream reaches of the Upper Herring River sub-basin can become so choked with primarily watercress (*Rorippa nasturtium-aquaticum*) that it impedes the emigration of juvenile herring moving out of the freshwater ponds into the downstream waters. Plant growth can be so thick that the fish cannot get through or around it, so they attempt to swim over it and often times die in their attempt as they get preyed upon by birds (Hughes 2011). As a result, the Wellfleet Herring Warden spends as much as 150 hours during late summer/early fall clearing the aquatic plants to enhance fish passage (Hughes 2011). Under alternative A, these conditions would not change and would continue to adversely impact juvenile river herring.

Poor water quality upstream of High Toss Road would continue to occur under alternative A and would continue to adversely affect river herring. Alewife and blueback herring juveniles have been shown to prefer areas with dissolved oxygen levels ranging from 2.4 to 10.0 parts per million (ppm) and pH levels from 5.2 to 6.8 (Roman 1987); however, levels below these have been recorded in the upper reaches of the Herring River (Portnoy 1991). Additionally, high concentrations of suspended solids within the upper Herring River system may also affect river herring. Suspended solid concentrations have been recorded as high as 300 ppm in the upper part of the Herring River system (Portnoy 1984b) and levels this high can lead to the direct mortality of adult migrating fish and can reduce the viability of embryos (Roman 1987).

Besides river herring, hickory shad also migrate from offshore waters to spawn in the Herring River and under alternative A the Chequessett Neck Road Dike would continue to pose an obstacle to their upstream migration. They would also likely be adversely affected by the continued poor water quality of the system upstream of High Toss Road.

Under alternative A, white perch would continue to inhabit the Herring River system and spawn in the upper main river stem where salinities are generally less than 4 ppt and in the freshwater ponds. American eel elvers would also continue to migrate upstream to the freshwater ponds, and adult eels would continue to emigrate out of the system on their spawning migration to the Sargasso Sea. However, as with all fish inhabiting or migrating through the river upstream of High Toss Road, poor water quality conditions such as low dissolved oxygen and pH would continue to create a stressful environment for these species to inhabit and migrate through.

Shellfish

Under alternative A, shellfish populations upstream of the Chequessett Neck Road Dike would continue to be limited, mainly due to the salinity range and availability of suitable substrate. While oysters are abundant downstream of the dike and in Wellfleet Harbor, the few that exist upstream of the dike are limited to the area of the Lower Herring River sub-basin immediately adjacent to the dike. Upstream of this area, salinity levels are frequently below 5 ppt, which is the lower limit for oyster survivability.

Oysters also require a stable substrate for attachment and growth. Suitable substrates are not common immediately upstream of the dike, because the tide velocities near the sluice gates leave mostly coarse, shifting sands. Further upstream the sediments are fine and organic, which is also a poor oyster substrate. These conditions would continue to limit oyster populations in the Lower Herring River under alternative A. Hard and soft shelled clams are extremely rare upstream of the dike because salinity levels are frequently below the species threshold for survivability. These conditions would also continue under alternative A. Wild and cultivated shellfish populations downstream of the dike and in Wellfleet Harbor are expected to continue at current population levels.

4.6.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

Estuarine Fish and Macroinvertebrates

Under any of the action alternatives, opening the tide gate structure to allow increases in the mean spring tide would change the Herring River estuary from a largely freshwater system to a largely tide-influenced system with saline waters extending much farther upstream than under alternative A.

Upstream of the dike, throughout the Lower Herring River and more upstream areas where salinity penetrates, the diversity of resident estuarine fish species would increase and reflect that of the Herring River downstream of the dike, while the abundance of individual species would also increase as documented in other New England salt marsh restoration projects (e.g., Burdick et al. 1997; Raposa and Roman 2003; Raposa and Talley 2012). The larger tide gate openings at the new dike would enhance fish passage allowing both resident species such as the mummichog, and migrants such as striped bass and others to readily move between downstream and upstream habitats. The additional intertidal habitat (tidal wetland and intertidal flats) upstream of the dike would also provide more spawning and nursery habitat for species such as mummichog, striped killifish, Atlantic silversides and other common tidal salt marsh species, greatly increasing their populations throughout the Herring River estuary. However, exactly how much of that habitat is actually available for use by various fish species is dependent upon its accessibility. The number and location of tidal creeks, marsh surface water depth, and hydroperiod (the length of time the marsh surface is inundated) all play key roles in determining how accessible the marsh surface is to various species and life stages (Kneib and Wagner 1994; Minello et al. 1994; Peterson and Turner 1994; Rozas et al. 1988). The larger volumes of water moving upstream through the system under the action alternatives onto the marsh surface may create new tidal creeks in addition to widening the mainstem tidal creeks, creating new habitat for both resident and transient species.

For migrant species such as striped bass and bluefish, the increased fish passage afforded by the new dike and the increased abundance of small resident forage species and macroinvertebrates would increase their accessibility and their numbers upstream of the dike; however, they would not likely use the entire restored estuary as habitat, because predatory fish such as striped bass often move up into estuaries on the late ebb or early flood tides (i.e., around low tide) when prey are more concentrated in the tidal creeks than on the marsh surface (Tupper and Able 2000).

For freshwater fish species such as chain pickerel, golden shiner and pumpkinseed, and freshwater macroinvertebrate species, such as isopods and freshwater shrimp, available habitat would be somewhat reduced in lower sub-basins where higher salinity levels would occur. However, in the upper sub-basins – Upper Pole Dike Creek, Upper Herring River, and Upper Bound Brook – these, and other, species would benefit from increased flow, water levels and water quality as compared to alternative A.

With increased salinity, especially throughout the lower sub-basins where salinity levels would be relatively high (i.e., 20-30 ppt), habitat for estuarine macroinvertebrate species such as grass shrimp, fiddler crab, clam worm, moon snail, and common periwinkle would greatly expand with individual species moving into areas within their individual salinity tolerance ranges.

Anadromous and Catadromous Fish

The design of the new dike under the action alternatives would benefit all species of anadromous and catadromous fish, including river herring (alewife and blueback herring), hickory shad, white perch and American eels through better fish passage. In addition to allowing more fish to move upstream, the new tide gates would also reduce the direct mortality of emigrating juveniles and post-spawning adult river herring by creating larger openings for passage and likely lower water velocities that need to be overcome. Improved water quality upstream of High Toss Road, as described in sections 4.2.3 and 4.3.3, would decrease the mortality of juvenile and post-spawning adult river herring, as well as American eels. Though total suspended solids from sediment mobilized during the initial increased flushing of the system could temporarily adversely impact adult and juvenile river herring, small, incremental openings of the tide gates will mitigate these temporary impacts. With the increased tidal range under the action alternatives, intertidal waters on spring high tides would expand into the upper reaches of Upper Herring River. With increased salinity levels the creek channels leading to the headwater ponds would likely become free of the emergent and submergent freshwater aquatic plants that often choke and block the waterway, benefiting juvenile river herring as they emigrate from the ponds and move downstream. With increased intertidal and sub-tidal habitat and access to small tidal creeks and ditches there would also be an increase in the amount of nursery habitat for juvenile fish. Though there are outside factors that also influence the population size of river herring, all of the above benefits that would occur under any of the action alternatives would increase the probability that the river herring run size would significantly increase in the years after restoration.

Increased fish passage and estuarine nursery habitat under the action alternatives would also increase the utilization of the Herring River estuary by white perch and hickory shad. In addition, the increased fish passage, improved water quality, and improved habitat within the Herring River estuary could lead to favorable conditions for restoration of a sea-run brook trout population to the Herring River.

Shellfish

The new tide gate openings at the Chequessett Neck Road Dike would allow increased tidal flow upstream of the dike bringing increased salinity levels. Oysters could potentially recolonize areas where salinity values fall within their preferred range of 10 to 30 ppt; however, oysters need stable, clean, hard substrate to settle on, for which there is little upstream of the dike. Even with restoration upstream of the dike it is unlikely that oysters would establish themselves naturally, unless the bottom substrate of the river hardens naturally with restoration.

Hard clams prefer a salinity range of 15 to 35 ppt and can be found in sediments ranging from pure mud to coarse sand. Given the range of sediments they can be found in, and the wild populations in Wellfleet Harbor that could provide spawn, hard clams would likely be able to colonize tidal creek habitat upstream of the dike within their preferred salinity range.

Softshell clams have a salinity range of 5 to 35 ppt and can be found in sediments ranging from mud to sand. Though softshell clams have not been found upstream of the dike in recent studies, during the 1973 period when the dike was in disrepair allowing some increased tidal flow to increase the salinity levels upstream of the dike, softshell clams occurred along approximately 0.5 acre of sub-tidal sandy shoreline in the Lower Herring River sub-basin (Gaskell 1978), indicating that with increased salinity under any alternative conditions could be suitable for softshell clams.

In addition to providing suitable habitat for shellfish, the action alternatives would also provide additional habitat for predators of shellfish, such as moon snail, green crab and mud crab, whose populations upstream of the dike would also likely increase. However, without knowing just how populous they would be come, it is not possible to assess what their potential impact would be on shellfish that become re-established upstream of the dike.

Increased tidal flows would erode sediments in the existing tidal creeks upstream and downstream of the dike, both deepening and widening them. Higher current velocities on the incoming tide than on the outgoing tide, would deposit a greater proportion of sediment upstream on to the marsh surface. However, peak velocities during the outgoing tides would also erode sediment that would be transported downstream into Wellfleet Harbor. It is not known how much deposition would occur or how much sediment would be mobilized in areas of new or existing erosion. Species such as hard clams and softshell clams can move up and down in the sediment column and would not likely be affected by sediment. Oysters, however, are sedentary and would be susceptible to burial by excessive sedimentation. However, because of the fine grain size of the mobilized sediment in the Herring River, these sediment accumulations would likely be temporary. The accumulated sediment would be redistributed by currents and waves in the harbor with the finest particles flushed into Cape Cod Bay, or transported into tidal estuaries surrounding the harbor.

4.6.4 Comparison of Impacts of the Action Alternatives

The drivers which distinguish between the action alternatives are 1) the volume of the restored tidal prism and 2) the amount of estuarine habitat (sub-tidal and intertidal habitat) that would be restored under each alternative. The differences in areal extent of impacts between the action alternatives are comparatively small as the areas influenced by mean high water spring tides are not substantially different, though additional estuarine habitat would become available for use by aquatic species in Mill Creek under alternatives B and D. However, the increased tidal range and variation of salinity levels afforded by alternatives C and D, could result in differences in habitat types in several sub-basins. Table 4-19 indicates the amount of sub- and intertidal estuarine habitat that would be restored and made available to aquatic species and provides general ranges of expected salinity for each alternative. For each action alternative table 4-20 indicates the amount of mainstem tidal creek habitat that would be available for use by species along the marine-to-freshwater gradient.

Impacts of Alternative B

The total estuarine habitat within the Herring River system available to estuarine fish and macroinvertebrate species would be approximately 11 times more than under alternative A (table 4-19). Additionally, the restored habitat would include approximately 11.5 miles of mainstem tidal creek for use by resident as well as migratory species, and anadromous species (table 4-20). Salt water habitat, with salinity levels of approximately 18 to 30 ppt would occur throughout the Lower and Middle Herring River, Mill Creek, and parts of the Lower Pole Dike Creek sub-basins, encompassing about 49 acres of sub-tidal and 394 acres of intertidal habitat. Freshwater conditions would persist in the Upper Herring River and Upper Bound Brook sub-basins, however increased flow, tidal exchange, and water quality would expand and improve habitat for aquatic species using these habitats. Varying levels of brackish habitats would develop in the transitional sub-basins between the lower and upper portions of the system.

TABLE 4-19: TOTAL ESTUARINE HABITAT BY SUB-BASIN FOR ACTION ALTERNATIVES

Sub-basin	Alternative A			Alternative B			Alternatives *C and D		
	Sub-tidal (acres)	Intertidal (acres)	Total Estuarine (acres)	Sub-tidal (acres)	Intertidal (acres)	Total Estuarine (acres)	Sub-tidal (acres)	Intertidal (acres)	Total Estuarine (acres)
Lower Herring River	45	25	70	33.0	117.3	150.3	33.0	123.2	156.2
Mill Creek* (option 1)	0	0	0	5.5	59.0	64.5	5.5	57.3	62.8
Mill Creek* (option 2)	0	0	0	5.5	48.3	53.8	5.5	49.8	55.3
Middle Herring River	0	0	0	10.5	74.6	75.1	10.5	76.6	87.1
Duck Harbor	0	0	0	6.0	74.6	80.6	6.0	101.7	107.7
Lower Pole Dike Creek	0	0	0	7.8	96.4	104.2	7.8	97.9	105.7
Upper Pole Dike Creek	0	0	0	17.8	93.9	111.7	17.8	109.4	127.2
Upper Herring River	0	0	0	17.2	79.7	96.9	17.2	96.8	110.2
Lower Bound Brook	0	0	0	4.3	61.9	66.2	4.3	67.4	71.7
Upper Bound Brook	0	0	0	4.8	35.7	40.5	4.8	51.8	56.6
Total Acres (Option 1)	**NA**	**NA**	**NA**	**107**	**693**	**800**	**107**	**778**	**885**
Total Acres (Option 2)	**NA**	**NA**	**NA**	**107**	**683**	**790**	**107**	**771**	**878**

Sub-tidal: habitat below modeled extent of Mean Low Water

Intertidal: areas between modeled high extent of Mean Low and Mean High Spring Tides

Salinity:

- = salt water (18-30 ppt)
- = brackish, mixed (5-18 ppt)
- = freshwater (<5 ppt)

* = No Restored Estuarine Habitat in Mill Creek under alternative C.

TABLE 4-20: MAINSTEM TIDAL CREEK ESTUARINE HABITAT

	Estuarine Tidal Creek Habitat (miles)			
Sub-basin	Alternative A	Alternative B	Alternative C	Alternative D
Lower Herring River	1.4	1.4	1.4	1.4
Mill Creek (option 1)	0	0.9	-	0.9
Mill Creek (option 2)	0	0.9	-	0.9
Middle Herring River	0	1.2	1.2	1.2
Duck Harbor	0	0.9	0.9	0.9
Lower Pole Dike Creek	0	0.9	0.9	0.9
Upper Pole Dike Creek	0	1.9	1.9	1.9
Upper Herring River	0	2.4	2.4	2.4
Lower Bound Brook	0	0.7	0.7	0.7
Upper Bound Brook	0	1.2	1.2	1.2
Total Acres (Option 1)	**NA**	**11.5**	**10.6**	**11.5**
Total Acres (Option 2)	**NA**	**11.5**	**-**	**11.5**

Impacts of Alternative C

The total restored estuarine habitat within the Herring River system would be approximately 12 times more than under alternative A and slightly more than alternative B; though the Mill Creek sub-basin would not be restored to estuarine habitat (table 4-19). Additionally, the restored habitat would include approximately 10.6 miles of mainstem tidal creek for use by resident as well as migratory species, and anadromous species (table 4-20). This amount is slightly less than alternative B due to Mill Creek sub-basin not being restored to estuarine habitat. Salt water habitat, with salinity levels of approximately 18 to 30 ppt would occur throughout the Lower and Middle Herring River, Mill Creek, Lower Pole Dike Creek, and parts of the Duck Harbor sub-basins, encompassing about 60 acres of sub-tidal and 402 acres of intertidal habitat. Freshwater conditions would persist in most of the Upper Bound Brook sub-basins, however increased flow, tidal exchange, and water quality would expand and improve habitat for aquatic species using these habitats. Varying levels of brackish habitats would develop in the transitional sub-basins between the lower and upper portions of the system.

Impacts of Alternative D

The total restored estuarine habitat within the Herring River system would be approximately 12-13 times more than under alternative A and slightly more than alternatives B and C (table 4-19). Additionally, the restored habitat would include approximately 11.5 miles of mainstem tidal creek for use by resident as well as migratory and anadromous species (table 4-20). Salinity levels would be identical to those achieved by alternative C, with the addition of about 5 acres of high salinity sub-tidal habitat and 50 to 57 acres of intertidal habitat in Mill Creek, depending which golf course option is implemented.

4.6.5 CUMULATIVE IMPACTS

The Town of Wellfleet Comprehensive Wastewater Management Plan, the Mayo Creek salt marsh restoration project, and oyster spawning experiments in Wellfleet Harbor have the potential to beneficially affect aquatic species. 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. The Mayo Creek 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 local water quality by filtering nitrogen out of the water; improving habitat conditions for all aquatic species.

Recurrent dredging of Wellfleet Harbor has the potential to adversely affect aquatic species through temporary disturbance, decreases in local water quality, sedimentation, and direct mortality. Mobile species, both fish and macroinvertebrates, would temporarily move out of the area during dredging, returning once the activities are over. Dredging delivers sediment to the water column and increases turbidity. Increased turbidity can adversely impact aquatic species, including shellfish, and sedimentation can adversely affect shellfish through burial. Dredging could also result in the direct mortality of some benthic species that are not mobile enough to move out of the area, impacting feeding resources for predatory species. However, once dredging activities cease, species would quickly recolonize the affected area. Although these adverse impacts are temporary, they may recur with each dredging event.

Overall, each of the action alternatives, when combined with the impacts of the actions in the cumulative impact scenario, would have long-term beneficial impacts on aquatic species and habitats; any adverse impacts would be temporary and localized.

4.6.6 CONCLUSION

Under all action alternatives, the amount of estuarine habitat in the Herring River estuary would be greatly increased relative to the no action alternative. The estuary would change from being a freshwater system upstream to a tide-influenced estuarine system. 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 compared to existing conditions, which would continue under the no action alternative. The new dike at Chequessett Neck Road would provide better fish passage for all fish including anadromous and catadromous species. This, combined with improved water quality and access to the head waters of the river, would likely enhance the river 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 be enhanced. The permanent increase in spawning and nursery habitat for fish species and estuarine macroinvertebrates, and their corresponding increase in abundance, would constitute a significant beneficial impact for those aquatic species. For shellfish and resident estuarine fish these beneficial impacts would be local, limited to the estuary. For diadromous fish the benefits would be regional.

Under all action alternatives, sedimentation and erosion downstream of the dike in Herring River and Wellfleet Harbor could pose some adverse impacts to shellfish. Different pathways would exist for fine-grained sediment and coarse-grained sediment. Coarser-grained sediment (dominated by sands) would be transported primarily as bedload along the bottom of tidal channels. Model results indicate that 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 predominantly upstream to eventually 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 Cape Cod Bay. However, if the dike is opened slowly so that all of the sediment is not mobilized at once or over a short period, adverse impacts would be avoided or minimized. Therefore, this uncertain impact is not likely to constitute a significant adverse impact.

Under the no action alternative, there would be no predicted changes for aquatic species, which receive limited habitat benefits from the estuary due to its degraded condition. Aquatic species in the estuary would remain lacking in number and/or variety due to the past environmental impacts of diking and draining the estuary, but there would be no significant new adverse impacts from taking no restoration action.

4.7 IMPACTS ON FEDERAL AND STATE-LISTED RARE, THREATENED, AND ENDANGERED SPECIES

As described in the draft EIS/EIR (sections 3.7 and 4.7), the degraded conditions of the Herring River flood plain support several species listed as rare, threatened, or endangered by the Massachusetts NHESP or the United States Fish and Wildlife Service (USFWS). The majority of these species are dependent on freshwater and upland habitats and probably did not occur on a regular basis in the Herring River before construction of the Chequessett Neck Road Dike restricted tidal influence in 1909. As described in chapter 3, the Herring River flood plain supports populations of several state-listed species, including northern harrier (*Circus cyaneus*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*)[1], diamondback terrapin (*Malaclemys terrapin*), eastern box turtle (*Terrapene c. carolina*), and water-willow stem borer (*Papaipema sulphurata*). The Herring River may also contain individuals or population of federally listed red knot (*Calidris canutus rufa*) and northern long-eared at (*Myotis Septentrionalis*). Both the Endangered Species Act (ESA; 16 USC § 1531 et seq.) and the Massachusetts Endangered Species Act (MESA) (M.G.L c.131A and regulations 321 CMR 10.00) protect rare species and their habitats by regulating the "taking" of any plant or animal species listed as endangered, threatened, or species of concern. Taking includes harassing, killing, trapping, collecting, as well as the disruption of nesting, breeding, feeding, or migratory activity, including habitat modification or destruction.

Federal and state-listed species were identified through informal consultation with the USFWS and NHESP and formally through comments submitted to MEPA by the NHESP in 2008 on the environmental notification form (ENF) (see chapter 5). This impact analysis is primarily based on the results of hydrodynamic modeling and the projected changes to vegetation and habitats resulting from increased tide range and salinity presented in section 4.6.

Vegetation changes resulting from restoration of tidal flow and estuarine salinity levels will alter some of the existing habitats that these species currently are using. Based on consultations with USFWS and NHESP and the refined vegetation change analysis discussed above, projected habitat changes resulting from the preferred alternative are described on a species-by-species basis in the

[1] For purposes of this analysis, American bittern and least bittern are treated together given the overlap and similarity of their habitats.

following sections. Habitat impacts resulting from the preferred alternative are compared to existing conditions and alternative B in table 4-21 for all species. Impacts associated with alternative C are not addressed here because, compared to the preferred alternative, it only excludes the Mill Creek sub-basin from the project. Therefore, alternative C impacts are the same as, or only slightly less than, the preferred alternative since the Mill Creek sub-basin provides minimal habitat for any of the listed species.

TABLE 4-21: SUMMARY OF IMPACTS ON FEDERAL AND STATE-LISTED RARE, THREATENED, AND ENDANGERED SPECIES

Species	Existing Conditions	Alternative B	Alternative D (Preferred Alternative)
American Bittern and Least Bittern	• 208 acres potential nesting habitat (83% fresh marsh; 17% brackish marsh) • 13 acres potential Foraging, roosting, and migratory habitat (salt marsh) • 785 acres unsuitable habitat	• 310 acres potential nesting habitat (40% fresh; 60% brackish) • 327 acres potential foraging, roosting, and migratory habitat (salt marsh) • 369 acres unsuitable habitat	• 197 acres potential nesting habitat (50% fresh; 50% brackish) • 585 acres potential Foraging, roosting, and migratory habitat (salt marsh) • 224 acres unsuitable habitat
Northern Harrier	• 96 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 251 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 659 acres unsuitable habitat	• 60 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 668 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 278 acres unsuitable habitat	• 49 acres nesting habitat in documented breeding area (freshwater marsh in Bound Brook sub-basin) • 782 acres of foraging, roosting, and migratory habitat throughout project area (fresh, brackish, and salt marsh) • 175 acres unsuitable habitat
Diamond-back Terrapin	• 84 acres habitat with limited availability (tidal barrier; salt and brackish marsh, water) • 922 acres unsuitable habitat	• 627 acres available habitat (salt and brackish marsh, water) • 379 acres unsuitable habitat	• 769 acres available habitat (salt and brackish marsh, water) • 237 acres unsuitable habitat
Eastern Box Turtle	• 88 acres principal habitat (dry and wet deciduous forest, dry shrubland, dry dunes); • 611 acres occasional habitat (dry deciduous woodland, heathland grass, old field, pine woodland, wet shrubland) • 307 acres unsuitable habitat • 3870 acres immediately adjacent to project area within Cape Cod National Seashore	• 47 acres principal habitat • 145 acres occasional (misc. non-tidal*, pine woodland, wet shrubland) • 814 acres unsuitable habitat • 3870 acres immediately adjacent to project area within Cape Cod National Seashore	• 0 acres principal habitat • 123 acres occasional (misc. non-tidal*, pine woodland, wet shrubland) • 883 acres unsuitable habitat • 3870 acres immediately adjacent to project area within Cape Cod National Seashore

Species	Existing Conditions	Alternative B	Alternative D (Preferred Alternative)
Water-Willow Stem Borer	• 386 acres of potential Decodon habitat (wet shrubland and wet deciduous forest) occurring within project area • 620 acres unsuitable habitat • 265 acres adjacent to project area	• 171 acres of potential Decodon habitat (wet shrubland and misc. non-tidal habitat) occurring within project area • 835 acres unsuitable habitat • 265 acres adjacent to project area	• 131 acres of potential Decodon habitat (wet shrubland and misc. non-tidal habitat) occurring within project area • 875 acres unsuitable habitat • 265 acres adjacent to project area
Rufa Red Knot	• 13 acres of potential red knot habitat (salt marsh [tidal]). • 993 acres of unsuitable habitat	• 358 acres of potential red knot habitat (salt marsh [tidal]). • 648 acres of unsuitable habitat	• 585 acres of potential red knot habitat (salt marsh [tidal]). • 421 acres of unsuitable habitat
Northern Long-Eared Bat	• 339 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 667 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.	• 78 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 978 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.	• 2 acres of potential NLEB habitat (wet deciduous forest, dry deciduous forest, pine woodland, dry deciduous woodland). • 1004 acres of unsuitable habitat • Potential habitat for NLEB is widespread in upland areas of Cape Cod.

Note: Impacts associated with alternative C are not addressed here because, compared to the preferred alternative, it only excludes the Mill Creek sub-basin from the project. Therefore, alternative C impacts are the same as, or only slightly less than, the preferred alternative.

* Misc. Non-Tidal Habitats include varied wetland and upland areas expected to persist along the periphery of the project and other isolated areas.

Proposed measures to monitor impacts to listed-species are also generally discussed here and will be presented in greater detail in a draft Habitat Management and Monitoring Plan to be submitted to NHESP as part of habitat management plan for review and approval under MESAs habitat management exemption provisions (321 CMR 10.14(15)). All monitoring work, including development of study plans, field and sampling procedures, and data analysis and reporting will be coordinated and planned in close consultation with USFWS and NHESP. Monitoring activities that will be conducted within the Seashore will also require consultation and formal research permits from the NPS. The HRRC began planning initial field studies for listed species during the winter of 2014/2015. Baseline data collection began in the spring of 2015.

4.7.1 Impacts of Alternative A: No Action

Under the no action alternative, the continued degradation of the former salt marsh habitats of the Herring River would result. There would be no expected changes to habitats for listed wildlife over the short term (years). However, even with the tidal opening at the Chequessett Neck Road Dike remaining in its current condition, the habitat within the tidally restricted flood plain is expected to change over the long term. The most obvious changes during the past few decades have been the establishment of forest and shrubland habitats and the occurrence of non-native *Phragmites* both of which have largely replaced the former salt marsh, brackish and tidal freshwater herbaceous plant communities on the marsh plain. This process was initiated by the construction of the Chequessett Neck Road Dike in 1909, which eliminated salt water and lowered wetland water levels (soil saturation). Forest and shrub growth and expansion of *Phragmites* has the potential to continue to expand under existing conditions which would adversely affect the herbaceous habitats required by northern harriers, water-willow stem borers, American bitterns, and least bitterns. Additional forestland and the expansion of *Phragmites* would continue to reduce harrier foraging habitat, could shade out water-willow (*Decodon verticillatus*), the critical host plant for water-willow stem borer, and degrade freshwater habitat used by bitterns. Therefore, under the no action alternative, the occurrence of the northern harrier, both species of bitterns, eastern box turtle, and water-willow stem borer may remain unaffected over the short term, but could decline locally in the longer term. Under no action, diamondback terrapins, a state-listed marine and brackish water species, would continue to be limited to the tidally influenced areas of the Lower Herring River sub-basin below and immediately above the Chequessett Neck Road Dike.

American Bittern/Least Bittern

Several species of marsh wading birds, including clapper rail, Virginia rail, and the state-listed least bittern have been documented in parts of the Herring River flood plain during surveys conducted in 2012 and 2013. These sightings have included spring-time observations of behaviors which suggest that least bitterns are nesting within the flood plain during some years (Broker, unpublished data). Based on the locations of these observations, NPS vegetation mapping for the Herring River flood plain, and discussions with NHESP, it is estimated that under existing conditions, approximately 208 acres of emergent freshwater and brackish marsh is thought to be available as nesting habitat for both species of bitterns. These habitats are primarily freshwater marsh (85 percent) located in the Lower Herring River, Upper Pole Dike Creek, and Bound Brook sub-basins. An additional 13 acres of salt marsh is also available in the Lower Herring River as foraging, roosting, and migratory habitat. Approximately 785 acres of the Herring River system currently provides unsuitable habitat for bitterns. Taking no action would allow both species of bitterns to continue to use freshwater marsh habitats throughout the project area as they do currently, although the potential expansion of woodlands and *Phragmites* across the original marsh plain may degrade foraging habitat.

Northern Harrier

Northern harriers were last surveyed in the project area between 2004 and 2006 during a Seashore wide survey on outer Cape Cod (Bowen 2006). This survey identified successful nesting sites (i.e., fledglings left the nest) by harriers in cat-tail marshes within the Bound Brook sub-basin in each survey year. Though no formal surveys have been conducted since 2006, anecdotal observations and the continued presence of suitable habitat suggest that harriers have continued to use this area.

Currently, the Bound Brook flood plain contains approximately 96 acres of freshwater emergent marsh, dominated by narrow leaf cat-tail (*Typha angustifolia*). Adjacent areas within the Herring River flood plain, Pole Dike Creek, and Duck Harbor, provide approximately 251 acres of foraging, roosting, and migration habitat comprised of other freshwater, brackish, and salt marshes. Approximately 659 acres throughout the project area are currently considered as unsuitable habitat for northern harriers.

Under the no action alternative, northern harrier nesting and foraging opportunities likely would remain unchanged during the short term, with low-lying herbaceous wetland habitats, e.g., cat-tail marshes within Bound Brook and Pole Dike Creek sub-basins continuing to persist. However, harrier hunting habitat would likely continue to deteriorate throughout the remainder of the Herring

River system as woodland habitat and *Phragmites* continues to spread across the original marsh plain. Nesting would likely continue on slightly elevated “islands” within the areas of the upper Herring River or possibly in adjacent upland thickets.

Diamondback Terrapin

The drastic loss of estuarine habitat likely has reduced the size of the diamondback terrapins population in the Herring River, although the species had likely been part of the aquatic faunal community for centuries. Under current conditions, the 1,006-acre Herring River project area provides only approximately 84 acres of habitat for this estuarine-dependent turtle species, which is confined to the inter- and sub-tidal areas immediately upstream of the Chequessett Neck Road Dike where tidal flow and salinity levels are relatively high. While terrapins are sighted somewhat frequently downstream of the dike, the terrapin’s access to this habitat is severely hampered by the dike and tide gates and anecdotal observations suggest that utilization of areas landward of the dike occurs infrequently. Under the no action alternative, the terrapin’s limited range and foraging opportunities in the Herring River estuary would remain unchanged. The Chequessett Neck Road Dike would continue to impede terrapin movements, allowing passage only during a short period of the tidal cycle. Diamondback terrapins would not be restored to their original distribution in the Herring River estuary, which probably included several hundred acres of salt-marsh habitats that provided critical wintering, foraging, and nursery areas upstream of the Chequessett Neck Road Dike.

Eastern Box Turtle

Eastern box turtles primarily use dry and wet deciduous forest, dry shrubland, and dry dunes for essential life history functions, such as nesting, rearing, and feeding. Eastern box turtles have been documented in wooded upland areas adjacent to the Herring River basin and may occur in the woodland habitats that have largely replaced the former estuarine wetland habitats. Under existing conditions these areas constitute approximately 88 acres of principal core habitat within the Herring River flood plain. Large areas of secondary habitat, (including dry deciduous woodland, heathland grassland, old fields, pine woodland, and wet shrubland) comprising approximately 611 acres, currently also occur and are defined as occasional habitat used for resting, thermal regulation, and dispersal. Existing salt, brackish, and freshwater marshes, along with open water, are not considered suitable habitat for box turtles for purposes of this analysis, although their periodic occurrence in estuarine areas has been documented (Culver 1915; Latham 1916; Nichols 1917; Nichols 1939b; Overton 1916; Tyler 1979).

In addition to principal and occasional habitats within the Herring River flood plain, more than 3,500 acres of existing dry and wet deciduous forest, dry shrubland, and dry dune habitat occurs immediately adjacent to the project area and is protected as part of Cape Cod National Seashore (figure 4-7). Additional, similar box turtle habitat also occurs outside of the Seashore boundary.

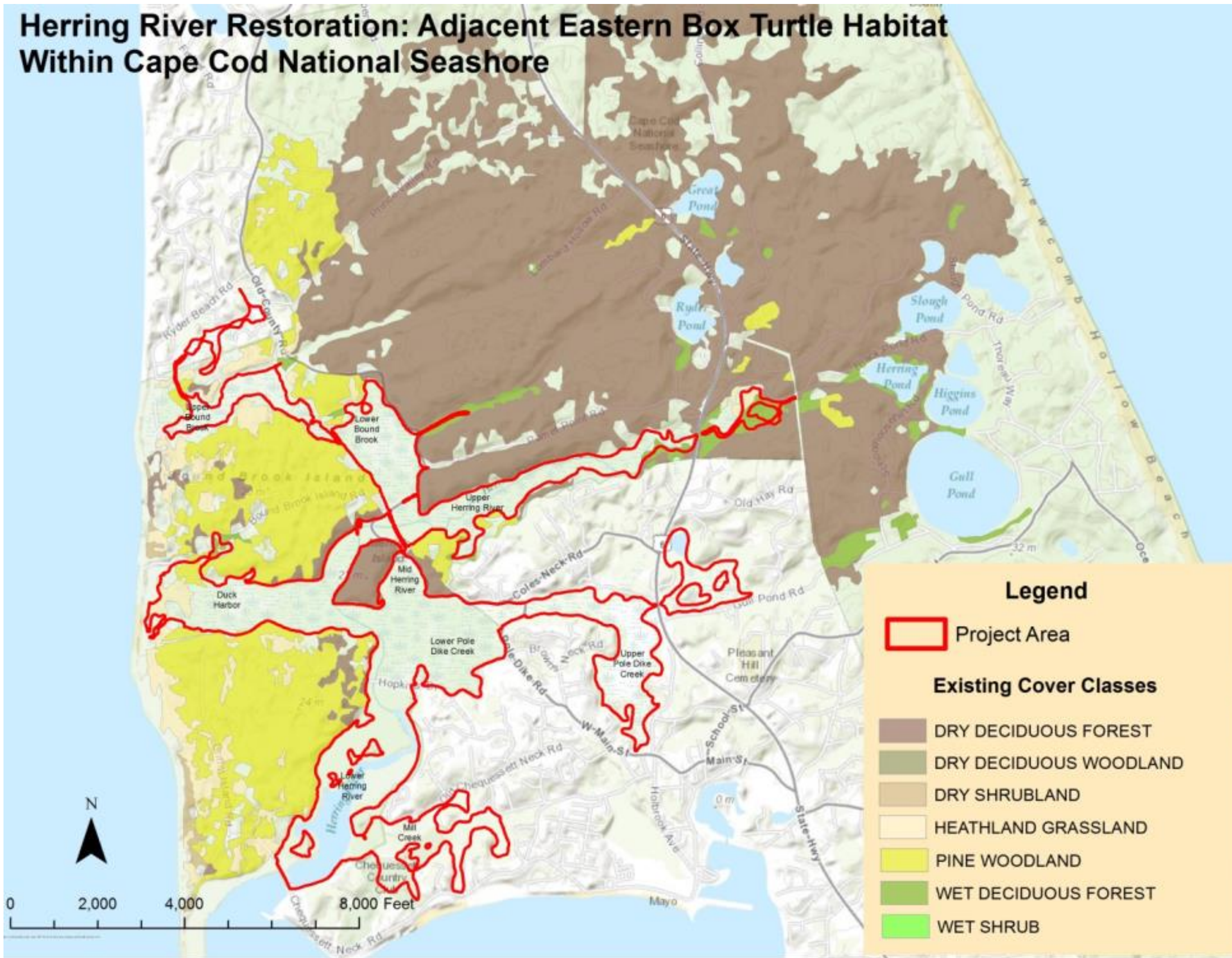


FIGURE 4-7: EXISTING EASTERN BOX TURTLE HABITAT ADJACENT TO THE HERRING RIVER FLOOD PLAIN

Water-Willow Stem Borer

The occurrence of water-willow and the stem borer moth within the Herring River project area was documented by Mello in 2006 as part of a larger study for outer Cape Cod. This study was not intended to be a systematic inventory of the entire Herring River project area and instead targeted areas where water-willow was expected to occur, such as riverbanks and pond shores, making it difficult to quantify the full extent of water-willow within the Herring River flood plain. Mello (2006) identified 89 host plant patches of varying sizes along the Herring River and its tributaries. Because some patches were inaccessible, 76 stands were examined for presence of the water-willow stem borer. Out of these, 41 patches (54 percent) showed signs of occupancy. Most stands of water-willow occurred along the banks of the river, primarily in zones mapped as wet shrubland and wet deciduous forest (figure 4-8).

Given the apparent correlation between the water-willow stands identified by Mello (2006) and the mapped wet shrubland and wet deciduous forest vegetation types, it's reasonable to assume that additional occurrences of water-willow likely occurred and continue to occur in these habitats. Thus a conservative estimate of existing and potential water-willow habitat can be made by combining the mapped areas of the two habitat types. Under existing conditions, this yields a total area of approximately 386 acres of suitable habitat within the Herring River flood plain. The remaining

620 acres within the Herring River project area are considered not to contain suitable habitat for water-willow or the stem borer moth. An additional 265 acres of wet shrub and wet deciduous forest habitat currently occurs immediately adjacent to the project area. This area contains water-willow stands identified by Mello (2006) and is considered potential habitat (figure 4-8).

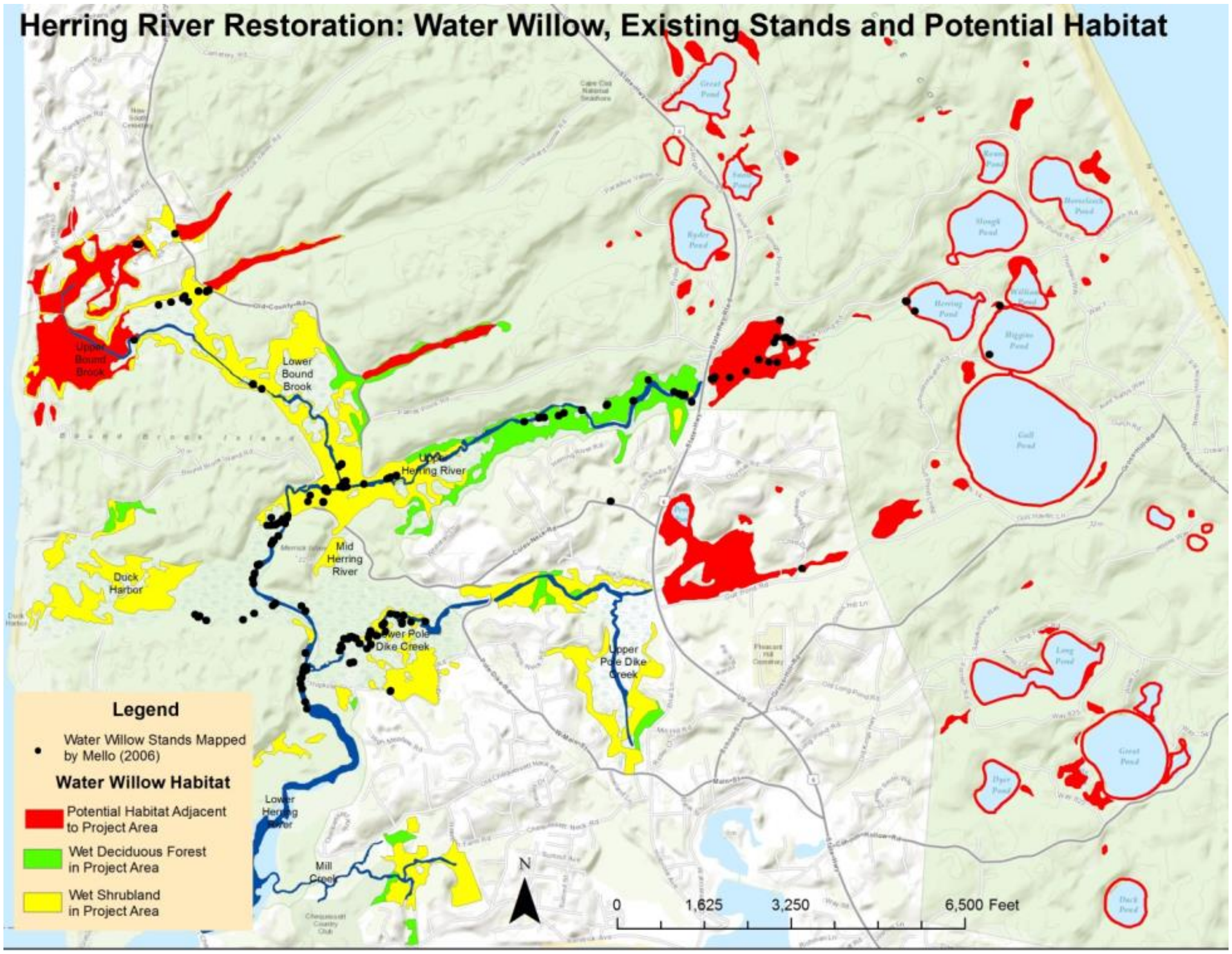


Figure 4-8: Existing and Potential Water-Willow Habitats within the Herring River Flood Plain

Under the no action alternative, populations of water-willow stem borer and water-willow would probably remain unchanged in the short term, (i.e., restricted to the shallow freshwater areas adjacent to the Herring River). Although tidal freshwater habitat, including patches of *Decodon,* likely existed in portions of the upper sub-basins of the Herring River prior to the construction of the Chequessett Neck Road Dike, the area suitable for *Decodon* growth likely has increased when compared to that which occurred prior construction of the dike (Mello 2006). Under this alternative, the dike would continue to impede salt water influence allowing freshwater plant communities to persist in the Herring River. Mello (2006) indicated that the water-willow stem borer population found in the tidally restricted Herring River is relatively new, likely the result of the expansion of *Decodon* into nutrient-rich wetlands. Although over the long term, the potential expansion of woodlands and *Phragmites* may degrade emergent freshwater habitats, the stem borer is expected to persist in these *Decodon* patches.

Red Knot

There are no records confirming red knot presence in the Herring River project area, but because they have been observed on Cape Cod, they are assumed to be present. Under the no-action alternative, no habitat change or other impacts to red knot would occur, and thus no impact to red knot would occur.

Northern Long-Eared Bat

No recent records confirm the presence of northern long-eared bats in the Herring River estuary, although monitoring elsewhere on Cape Cod did result in observations of northern long-eared bats. In the absence of field work conducted in the project area, northern long-eared bats are assumed to present. Under the no-action alternative, no habitat change or tree removal would occur, and thus no impact to northern long-eared bats would occur.

4.7.2 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

Restoration of the Herring River estuary under any of the action alternatives will likely affect state-listed species and their habitats, although not all impacts would be adverse. For the diamondback terrapin, a turtle dependent on marine and estuarine conditions, tidal restoration is expected to restore additional habitat which would provide critical wintering, foraging, and nursery areas. The restoration of tides is expected to change the mix of freshwater and brackish marsh vegetation which would influence how and where northern harriers and American and least bitterns utilize habitat. Tidal restoration is likely to adversely affect the eastern box turtle and water-willow stem borer which are more dependent on freshwater wetland or upland habitats.

American Bittern and Least Bittern

Although both American and least bitterns primarily use freshwater marsh habitats, both species also use brackish marsh habitats. Under each of the action alternatives, existing foraging, resting, or migratory habitat for American bitterns and least bitterns would be affected by restored tidal exchange. In the Lower Herring River, Mill Creek, Middle Herring River, Lower Pole Dike Creek sub-basins, where salinity levels would regularly reach above 18 ppt, existing cat-tail and other freshwater emergent plant species would be replaced by salt marsh plants. In the upper sub-basins, where salinity would remain below 5 ppt, existing freshwater marsh habitat should persist. Additionally, tidal freshwater and low salinity brackish marsh could expand as the existing shrubland and woodland habitats become wetter and are replaced by herbaceous emergent plants.

Northern Harrier

Northern harriers occur throughout the project area and several pairs have been recorded as nesting within the Bound Brook sub-basin (Bowen 2006). Any of the action alternatives could result in small habitat changes within Bound Brook sub-basin, but these are not expected to hinder future nesting activity. Other plant community changes throughout the Herring River project area likely will restore and enhance harrier foraging habitat as existing forest is replaced by herbaceous tidal fresh, brackish, and salt marsh.

Current northern harrier nesting sites in the Upper Bound Brook sub-basin are located in cat-tail-dominated plant communities which have replaced the original salt marsh vegetation. Tidal restoration in this area under any of the action alternatives is not expected to result in the complete restoration tidal fresh, brackish, and salt marsh habitats. Narrow-leaf cat-tail (*Typha angustifolia*), the existing dominant species in Bound Brook, is somewhat salt tolerant and likely would remain and could expand its distribution as woodland communities are displaced under the restored hydrology. Thus, areas suitable for harrier nesting should remain unchanged or potentially could increase. If nesting sites were to be impacted by brackish or salt water, harriers are expected to relocate to other suitable locations within the Bound Brook sub-basin or other nearby suitable locations.

Tidal restoration is expected to provide improved habitat for foraging by increasing the extent of tidal fresh, brackish, and salt marsh. Harriers hunt for small mammals, especially meadow voles (*Mircotus pensylvanicus*), throughout the year in marshes and elimination of *Phragmites* and woody vegetation would likely enhance the populations for some prey species while also enhancing foraging success for harriers.

Diamondback Terrapin

In the short term, a small amount of salt marsh habitat occurring upstream of the Chequessett Neck Road Dike, which has recently been used by nesting terrapins, (unpublished MA Audubon data) would likely be impacted as tidal range increases. Terrapins nest in sandy dunes and open habitat within upland areas adjacent to salt marshes, but not in salt marshes (Cook 2008a). In addition, terrapins would probably not be able to pass through the dike while it is being reconstructed and could be affected by construction noise, vibrations, and other activities. However, over the long term, tidal restoration is expected to restore hundreds of acres of nesting, nursery, wintering, and foraging habitat in the Lower Herring River, Mill Creek, Middle Herring River, Lower Pole Dike Creek sub-basins, and portions of Duck Harbor sub-basin, allowing diamondback terrapins to almost fully reoccupy their historic distribution within the Herring River flood plain. Terrapins would have improved access to restored habitats in the Herring River estuary and increased opportunities to use sandy shorelines along the river as nesting habitat. Under all the action alternatives, restoration would provide at least 30 times more habitat for the terrapin and other estuarine-dependent species within the Herring River system than under the no action alternative.

Eastern Box Turtle

Restoration of tidal conditions throughout the Herring River flood plain are expected to affect eastern box turtles by restoring more saline and/or wetter conditions in areas that have dried out in response to diking of the river and drainage of salt marsh soils. Restored tidal influence may also limit the ability of box turtles to access freshwater for thermoregulation and hydration. As conditions gradually change through the incremental restoration of tides, turtles would be expected to move to adjacent uplands. There is some potential for isolating individuals that are now able to move freely throughout the project area. During periods of high storm-driven tides, it is possible that groups of turtles that occur on Griffin, Bound Brook, and Merrick Islands may be restricted to those islands. However, during normal tidal conditions, eastern box turtles should be able to move among the islands and the mainland along the upper boundaries of the flood plain where areas are expected to remain as freshwater and periodically dry.

Water-Willow Stem Borer

Under any of the action alternatives, varying amounts of freshwater wetland habitat supporting *Decodon* would be changed with tidal restoration. *Decodon* is predicted to have low tolerance to frequent inundation by salt water; therefore, any long-term level of salt water influence is likely to adversely affect its distribution. However, increased water levels and subsequent change from forested to palustrine shrub- and emergent-dominated habitats could increase the occurrence of *Decodon* in the upstream areas of the Duck Harbor, Bound Brook, Upper Herring River, and Upper

Pole Dike Creek sub-basins, areas where salinity of tidally influenced water is expected to remain low. Specific impacts to *Decodon* associated with each alternative are summarized below. The assessment of impacts to stands of *Decodon* is intended to serve as a proxy for direct impacts to the state-listed water-willow stem borer. Although the coverage of *Decodon* was recently inventoried and mapped (Mello 2006), the occupancy of the stem borer in individual stands of *Decodon* at any given time is not known. Therefore, impacts to *Decodon* do not necessarily correlate to the exact impacts to water-willow stem borer, but do serve to illustrate a worst-case scenario if all affected stands are occupied and used by stem borers. In any case, *Decodon* is abundant along pond margins, vernal pools, and freshwater streams on outer Cape Cod, and the regional population would not be affected by tidal restoration at the Herring River.

Red Knot

There are no records confirming the presence of red knot in the Herring River project area, but because they have been observed on Cape Cod, they are assumed to be present. In general, the habitat changes associated with restoration would benefit red knot.

Northern Long-Eared Bat

No recent records confirm the presence of northern long-eared bats in the Herring River estuary, although monitoring elsewhere on Cape Cod did result in observations of northern long-eared bats. In the absence of field work conducted in the project area, northern long-eared bats are assumed to present and USFWS mitigation recommendations will be implemented. These measures include monitoring for bats during planned forest management activities, avoiding tree removal within 0.25 miles of known, occupied hibernacula, and avoiding tree removal of known, occupied roost trees during pup season (June 1 - July 31).

In general, habitat changes associated with restoration would reduce the acreage in the project area that is suitable for northern long-eared bats feeding and roosting. However, the wooded habitat types that would be restored to other estuarine habitats during restoration are currently degraded, they are common in other parts of Cape Cod, and habitat transition would occur very slowly, over a number of years. If northern long-eared bats are indeed present in the project area, it is unlikely that loss of a limited number of acres of degraded woodlands would have a detectable effect on individuals or population of bats.

4.7.3 COMPARISON OF IMPACTS OF THE ACTION ALTERNATIVES

Impacts of Alternative B

American Bittern and Least Bittern

Under alternative B, the lowered tide range and lesser degree of salinity penetration throughout the system would increase potential bittern nesting habitat in the Upper Bound Brook, the Upper Herring River, and the Upper Pole Dike Creek sub-basins to a total of 310 acres of emergent marsh, with approximately 40 percent being freshwater. Secondary habitat available for roosting, foraging, and migration would amount to approximately 327 acres. Wetter conditions in these areas could lead to die-off of woody-species dominated habitats and an expansion of suitable freshwater and low salinity brackish marsh habitat. Existing freshwater marshes in lower sub-basins – Duck Harbor, Middle Herring River, Lower Pole Dike Creek, Mill Creek, and the Lower Herring River would likely revert to brackish or salt marsh. Some habitat functions for bitterns and other wading marsh birds could be expected to continue in these areas depending on specific vegetation transitional changes.

Northern Harrier

Under alternative B, 60 acres of emergent freshwater wetland habitat are expected to remain in the Bound Brook flood plain, slightly more than the 49 acres of available harrier nesting habitat under the preferred alternative. This potentially would affect the general area used by northern harriers for nesting in recent years. However, hydrodynamic modeling indicates that salinities would generally remain less than 5 ppt under alternative B; therefore, Typha-dominated areas would not be expected to change significantly and harrier nesting areas should not be affected. Throughout the rest of the project area, hundreds of acres of degraded shrublands and Phragmites-dominated habitat would be restored to tidal fresh, brackish and salt marsh, which should increase the quality and extent of harrier foraging areas.

Diamondback Terrapin

Alternative B would result in the restoration of approximately 393 acres of salt marsh habitat suitable for terrapin foraging and nesting in the Lower Herring River, Mill Creek, Lower Pole Dike Creek, and Middle Herring River sub-basins.

Eastern Box Turtle

High tide elevations achieved by alternative B could potentially displace turtles from the 800-acre flood plain which would experience restored mean high spring tides. However, as tidal influence is restored incrementally over a period of years, turtles would move to adjacent upland areas and would still be able to traverse the flood plain along the periphery of most sub-basins where salinity levels will remain low and dry land would still occur.

Water-Willow Stem Borer

Under alternative B, the majority of *Decodon* occurrences would be affected by high salinity, tidally driven flow. Modeling indicates that as many as 103 of 174 *Decodon* stands mapped by Mello (Mello 2006) occurring along approximately 12,800 linear feet of streambank in the Lower and Middle Herring River, Duck Harbor, and Lower Pole Dike Creek sub-basins would eventually be impacted by salt and brackish water when alternative B is fully implemented. Stands occurring higher in the system in the Upper Herring River, Bound Brook, and Upper Pole Dike sub-basins would likely remain unaffected, depending the exact extent and frequency of salinity penetration. However, approximately 28,000 linear feet of suitable streambank habitat would remain and it is also likely that *Decodon* coverage would increase in these upper reaches of the system as tree-dominated woodland habitat becomes wetter and gradually develops into palustrine shrub- and emergent-dominated habitat. Thus, the overall long-term impact on *Decodon*, and the population of water-willow stem borer supported in the Herring River flood plain, should be minimal.

Red Knot

There are no records confirming the presence of red knot in the Herring River project area, but because they have been observed on Cape Cod, they are assumed to be present. In general, the habitat changes associated with restoration would benefit red knot. Under alternative B, a total of 345 acres of potential red knot habitat (salt marsh [tidal]) would be added to the project area.

Northern Long-Eared Bat

No recent records confirm the presence of northern long-eared bat in the Herring River estuary, although monitoring elsewhere on Cape Cod did result in observations of northern long-eared bats. In the absence of field work conducted in the project area, northern long-eared bats are assumed to present and USFWS mitigation recommendations will be implemented. These measures include monitoring for bats during planned forest management activities, avoiding tree removal within 0.25 miles of known, occupied hibernacula, and avoiding tree removal of known, occupied roost trees during pup season (June 1 - July 31).

Under the alternative B, given appropriate monitoring and mitigation, a total of 261 acres of forested potential habitat (including wet deciduous forest, dry deciduous forest, pine woodland, and dry deciduous woodland) would be restored to intertidal marsh. These are common habitat types on Cape Cod, and it is not anticipated that this limited reduction in wooded habitat types would have detectable effects on northern long-eared bats in terms of habitat availability. Also, as discussed in "Impacts Common to All Alternatives," incremental habitat restoration is not likely to result in direct effects on northern long-eared bats due to the slow pace of change and bat mobility.

Impacts of Alternative C

American Bittern and Least Bittern

The higher tidal range and greater extent of tidal influence achieved by alternative C would increase the likelihood that brackish and salt water flow would displace existing freshwater marsh and would impact habitats used by American and least bitterns in the middle sub-basins of the Herring River project area. However, tidal freshwater and low salinity brackish conditions are projected for upper areas of the Bound Brook, Herring River, and Pole Dike Creek sub-basins during normal tidal conditions. Although storm-influenced tidal events may drive higher salinity water into these sub-basins, the frequency of these events is not expected to result in significant vegetation change on the marsh surface. In addition, higher tidal ranges would also result in wetter conditions and potentially enhance and expand freshwater marsh habitat through approximately 294 acres. Any habitat currently used by both bittern species that exists within the Mill Creek sub-basin would remain unchanged.

Northern Harrier

Impacts to northern harrier under alternative C would potentially be greater than those of alternative B and depend on the actual extent of salt penetration and salt marsh restoration within the existing nesting areas of the Bound Brook basin. Hydrodynamic modeling projects that approximately 127-acres of the 193-acre sub-basin would be subjected to tidal influence in the Upper and Lower Bound Brook sub-basins, where the harrier nesting was last confirmed. As tide range is increased beyond that attained by alternative B, salinities would increase, at times reaching about 20 ppt in the tidal channels of the Lower Bound Brook Basin, which could support development of salt marsh vegetation adjacent to tidal channels. Salinities would be lower landward and in the upper reaches, but could still affect stands of *Typha* and potentially limit harrier nesting habitat.

Diamondback Terrapin

Alternative C would result in the restoration of approximately 346 acres of salt marsh habitat suitable as terrapin foraging, wintering, and nesting areas in the Lower Herring River, Lower Pole Dike

Creek, and Middle Herring River sub-basins. No terrapin habitat would be restored in the Mill Creek sub-basin.

Eastern Box Turtle

Impacts to eastern box turtle under alternative C are similar to those under alternative B, but would encompass an area of 830 acres. This accounts for a greater aerial extent of tidal influence during mean high spring tides and the exclusion of any tidal influence in the 70-acre Mill Creek sub-basin.

Water-Willow Stem Borer

Under alternative C, the majority of Decodon occurrences would be affected by high salinity, tidally driven flow. Modeling indicates that as many as 106 of 174 Decodon stands mapped by Mello (Mello 2006) occurring along approximately 13,800 linear feet of streambank in the Lower and Middle Herring River, Duck Harbor, Lower Pole Dike Creek, and Lower Bound Brook sub-basins would eventually be impacted by salt and brackish water when alternative C is fully implemented. Stands occurring higher in the system in the Upper Herring River, Upper Bound Brook, and Upper Pole Dike sub-basins would likely remain unaffected, depending the exact extent and frequency of salinity penetration. However, approximately 25,000 linear feet of suitable streambank habitat would remain and it is also likely that *Decodon* coverage would increase in these upper reaches of the system as tree-dominated woodland habitat becomes wetter and gradually develops into palustrine shrub- and emergent-dominated habitat. Thus, the overall long-term impact on *Decodon*, and the population of water-willow stem borer supported in the Herring River flood plain, should be minimal.

Red Knot

There are no records confirming the presence of red knot in the Herring River project area, but because they have been observed on Cape Cod, they are assumed to be present. In general, the habitat changes associated with restoration would benefit red knot. Under alternative C, a total of 538 acres of potential red knot habitat (salt marsh [tidal]) would be added to the project area.

Northern Long-Eared Bat

No recent records confirm the presence of northern long-eared bat in the Herring River estuary, although monitoring elsewhere on Cape Cod did result in observations of northern long-eared bats. In the absence of field work conducted in the project area, northern long-eared bats are assumed to present and USFWS mitigation recommendations will be implemented. These measures include monitoring for bats during planned forest management activities, avoiding tree removal within 0.25 miles of known, occupied hibernacula, and avoiding tree removal of known, occupied roost trees during pup season (June 1 - July 31).

Under the alternative C, given appropriate monitoring and mitigation, a total of 337 acres of forested potential habitat (including wet deciduous forest, dry deciduous forest, pine woodland, and dry deciduous woodland) would be restored to intertidal marsh. These are common habitat types on Cape Cod, and it is not anticipated that this limited reduction in wooded habitat types would have detectable effects on northern long-eared bats in terms of habitat availability. Also, as discussed in “Impacts Common to All Alternatives,” incremental habitat restoration is not likely to result in direct effects on northern long-eared bats due to the slow pace of change and bat mobility.

Impacts of Alternative D

American Bittern and Least Bittern

With full implementation of the preferred alternative, existing emergent freshwater and brackish marsh habitat needed by bitterns for nesting will be both slightly reduced and largely relocated from the lower to the upper portions of the project area (see figure 4-5 and table 4-22). Most existing emergent marsh habitat, especially in the Lower Herring River and other areas, that is subjected to salinity levels of approximately 18 ppt and higher would develop into salt marsh. In Upper Pole Dike Creek, Bound Brook, and the western parts of Duck Harbor sub-basins bittern nesting habitat will persist or increase as shrub and forested habitat transitions to emergent marsh. Under the preferred alternative, a total of 197 acres of habitat is expected to develop which will be approximately evenly split between freshwater (99 acres) and brackish (98 acres) marsh. Restoration of inter-tidal salt marsh habitat will also provide approximately 585 acres for roosting, foraging, and migratory habitat.

Overall, the preferred alternative is expected to have minimal effects on the quantity and quality of bittern nesting habitat and will substantially increase salt marsh habitat used for foraging, resting and other non-breeding behaviors. As the project is implemented, the development of suitable emergent marsh habitat will be monitored and data will be collected to document how and to what extent bitterns are using the Herring River system. The HRRC and any contracted personnel conducting this field work and data analysis will closely consult with NHESP, the Seashore, and other taxa experts as appropriate on all aspects of this monitoring.

Northern Harrier

Restoration of tidal flow under the preferred alternative is expected to have a less pronounced effect in the Upper Bound Brook sub-basin, compared to downstream areas where salinity levels will be higher. However, existing freshwater marsh is expected to be reduced from 90 to approximately 49 acres in the Upper Bound Brook sub-basin and higher elevation portions of the lower Bound Brook sub-basin. Given that only one or two harrier nests were documented during the 2004-2006 survey, and the extensive adjacent areas available for roosting, foraging, and other functions, it is expected that an adequate quantity of emergent cattail habitat will persist throughout the Bound Brook area and that harriers will continue to nest in similar numbers. Thus any impact to northern harriers is expected to be minimal and no effects on the regional population are anticipated as a result of the HRRP.

Similar to the other state-listed species, monitoring will track nesting habitat change for northern harriers within the Bound Brook sub-basin as the restoration project is implemented. Nesting and foraging within the entire project area by harriers will also be evaluated. The HRRC and any contracted personnel conducting this field work and data analysis will closely consult with NHESP, the Seashore, and other taxa experts as appropriate on all aspects of this monitoring.

Diamondback Terrapin

Opening the Chequessett Neck Road Dike to increased tidal flow is expected to substantially improve habitat conditions for diamondback terrapins. The larger tidal opening with lowered flow velocities through the new structure will make it easier for terrapins to move from Wellfleet Harbor up into the river. With full implementation of the preferred alternative, the restored sub- and inter-tidal areas will provide approximately 769 acres of new terrapin habitat, thereby providing a large increase in area available to them within the greater Wellfleet Harbor system (see figure 4-5 and table 4-22). Subsequent to consultation with NHESP and the Seashore, monitoring of the terrapin response to tidal restoration and utilization of restored habitat within the Herring River is expected to be led by Dr. Barbara Bressennel, professor emeritus in biology from Wheaton College.

Eastern Box Turtle

Complete implementation of the preferred alternative would eventually impact nearly all of the existing 88 acres of principal box turtle habitat within the Herring River flood plain. Increased tide range and salinities within the Mid Herring River, Lower Pole Dike Creek, Duck Harbor, and Lower Bound Brook would largely eliminate any wet or dry wooded habitat although most if not all of this area likely was not principal habitat prior to the construction of the Chequessett Neck Road Dike in 1909. The transition to inter-tidal salt marsh is expected to occur over several years. In areas further upstream, where salinity is projected to remain close to 0 ppt, freshwater tidal fluctuations will create generally wetter conditions which would tend to favor freshwater emergent marsh and wet shrublands and lead to the decline of dry shrubland and forest habitat. These changes, however, are expected to occur over a much longer timeframe (i.e., decades) compared to the relatively rapid transitions (i.e., years) from fresh to salt water dependent habitats.

Despite the transition of approximately 88 acres of principal box turtle habitat within the area of regular tidal inundation, suitable occasional habitat will remain among approximately 123 acres of wet shrubland and varied non-tidal habitats (see note, table 4-22) located in the upper reaches of the project area. Additional areas will persist immediately adjacent to the project area above the reach of normal tides where more than 3500 acres of box turtle habitat will remain unaffected and protected by the NPS. Because tidal restoration will be implemented slowly, with expected annual increases in tide range of several inches, subsequent habitat change is expected to be gradual, especially in the upper reaches where salinity will be low. Box turtles within the affected area should be able to move landward and no impact on the overall population is anticipated.

As part of a proposed Habitat Management and Monitoring Plan the project will develop and implement a monitoring strategy to assess habitat use and movements by box turtles that results from tidal restoration. Prior to any reintroduction of tidal exchange, or any other restoration actions, baseline data will be collected to characterize the current population. Data will also be collected to document movements of turtles from the affected area to adjacent areas as the project is implemented. The HRRC and any contracted personnel conducting this field work and data analysis will closely consult with NHESP, the Seashore, and other taxa experts as appropriate on all aspects of this monitoring.

Water-Willow Stem Borer

With full implementation the of the preferred alternative, restored tidal range and estuarine salinity levels are expected to impact much of the area currently or potentially occupied by water-willow and presumably used, or potentially available to, the stem borer. Water-willow, and many of the other plant species that define the wet shrubland and wet deciduous forest habitats, have very low salinity tolerances and thus large portions of these areas are expected to develop into inter-tidal emergent salt and brackish marshes as estuarine tidal range and salinity levels are restored. This effect will be most pronounced in the Mid Herring River, Lower Pole Dike Creek, and Lower Bound Brook sub-basins, where salinities will consistently be 20 ppt and higher. Some existing stands of water-willow may persist in the Upper Pole Dike Creek, Upper Herring River, Upper Bound Brook sub-basins and the higher elevations of the 131-acre Duck Harbor sub-basin, where salinity levels are projected to remain close to 0 ppt and wet shrub and forested habitats are expected to persist to some degree. Under the preferred alternative, 265 acres of existing water-willow habitat adjacent to the project area will remain undisturbed and available for continued use and potential colonization by the stem borer.

As part of a proposed Habitat Management and Monitoring Plan to be submitted to NHESP, a monitoring strategy will be designed and implemented to track the response of water-willow and its occupancy by the stem borer to tidal restoration in the Herring River project area. Prior to the reintroduction of tidal exchange, or any implementation of other restoration actions, baseline data will be collected to update the Mello (2006) survey and define baseline conditions for the current extent of water-willow and occupancy by the water-willow stem borer throughout the project area and suitable locations in adjacent areas. As the project is implemented, data will continue to be collected to detect plant community changes, with special focus on the response of water-willow to increased tidal flow under a range of salinity levels. Areas adjacent to, but outside of, those directly affected by tidal flows will be studied to assess whether, and to what extent, stem borers may be colonizing new areas. The HRRC and any contracted personnel conducting this field work and data analysis will consult with NHESP, the Seashore, and other taxa experts as appropriate on all aspects of this monitoring.

Red Knot

There are no records confirming the presence of red knot in the Herring River project area, but because they have been observed on Cape Cod, they are assumed to be present. In general, the habitat changes associated with restoration would benefit red knot. Under alternative D, a total of 572 acres of potential red knot habitat (salt marsh [tidal]) would be added to the project area.

Northern Long-Eared Bat

No recent records confirm the presence of northern long-eared bat in the Herring River estuary, although monitoring elsewhere on Cape Cod did result in observations of northern long-eared bats. In the absence of field work conducted in the project area, northern long-eared bats are assumed to present and USFWS mitigation recommendations will be implemented. These measures include monitoring for bats during planned forest management activities, avoiding tree removal within 0.25 miles of known, occupied hibernacula, and avoiding tree removal of known, occupied roost trees during pup season (June 1 - July 31).

Under the alternative D, given appropriate monitoring and mitigation, a total of 337 acres of forested potential habitat (including wet deciduous forest, dry deciduous forest, pine woodland, and dry deciduous woodland) would be restored to intertidal marsh. These are common habitat types on Cape Cod, and it is not anticipated that this limited reduction in wooded habitat types would have detectable effects on northern long-eared bats in terms of habitat availability. Also, as discussed in "Impacts Common to All Alternatives," incremental habitat restoration is not likely to result in direct effects on northern long-eared bats due to the slow pace of change and bat mobility.

4.7.4 CUMULATIVE IMPACTS

The Mayo Creek salt marsh restoration project would restore a limited amount of tidal salt marsh habitat available to the diamondback terrapin in Wellfleet Harbor. Dredging of Wellfleet Harbor has the potential to adversely affect diamondback terrapin through temporary disturbance and temporary decreases in local water quality. Impacts would depend on the timing and duration of the dredging and on the type and placement of the dredge spoils. Overall, each of the action alternatives, when combined with the impacts of harbor dredging and the Mayo Creek salt marsh restoration, would have long-term beneficial impacts on diamondback terrapins; any adverse impacts associated with dredging would be temporary and localized. No cumulative impacts are anticipated for the other federal or state-listed rare species discussed above.

4.7.5 CONCLUSION

All action alternatives would have the potential to affect the habitat of eastern box turtles, water-willow stem borers, American and least bitterns, diamondback terrapins, northern harriers, red knot, and northern long-eared bat. In the case of eastern box turtles, water-willow stem borers, American and least bitterns, and northern long-eared bats, the action alternatives would cause a change to species distribution as the transition to estuarine wetland took place. These impacts would be local and limited in degree, because of the mobility of these species relative to the pace of restoration and availability of adjacent habitat, and therefore would not be considered significant. For box turtle, as tidal influence is restored individuals would move to adjacent upland areas and would still be able to traverse the flood plain along the periphery of most sub-basins where salinity levels will remain low and dry land would still occur. For northern harriers, some local nesting habitat may be affected by tidal exchange under alternatives C and D, but harrier nesting habitat and nesting opportunities should remain unaffected. Harriers and red knot would gain some tidal marsh foraging habitat under all action alternatives. Again, these impacts would be limited in degree, and given the species' mobility; they would not result in population level impacts and would therefore not be considered significant. For diamondback terrapin, the increase in tidal marsh habitat, particularly the increase in the species' preferred nesting habitat, would represent a significant beneficial impact in the context of the local terrapin population.

Under the no action alternative, long-term habitat change in the form of Phragmites expansion and forest and shrub growth could reduce the abundance and/or distribution of northern harrier, both species of bitterns, eastern box turtle, water-willow stem borer, red knot, and northern long-eared bat. Because these effects would be local, and because current habitat conditions are in a degraded state, adverse impacts on federal or state-listed species are not expected to be significant under alternative A.

4.8 IMPACTS ON TERRESTRIAL WILDLIFE

As described in chapter 3, even in its existing degraded state the Herring River flood plain contains diverse habitats for a wide array of insect, reptile, amphibian, bird, and mammal species. Tidal restoration for the river will initiate changes to many of these habitats and could potentially affect certain wildlife populations.

4.8.1 METHODOLOGY AND ASSUMPTIONS

Given the lack of detailed information regarding the local status of most wildlife species and their specific use of the Herring River flood plain, this analysis is necessarily a broad view of general wildlife habitat changes resulting from tidal restoration. It is based primarily on the analysis of vegetation and wetland habitat change presented in section 4.5, which coupled findings of hydrodynamic modeling of the estuary (WHG 2011a) and vegetation mapping completed by the Seashore (HRTC 2007) to predict how increased tidal range and varying salinity levels throughout the project area would drive vegetation and habitat changes.

4.8.2 IMPACTS OF ALTERNATIVE A: NO ACTION

Under the no action alternative, species present within the Herring River basin would continue to occur under current degraded conditions with limited expansion of woodland and shrubland habitat. The system would remain dominated by freshwater and mixed upland vegetation. Although tidal restriction would continue to contribute to poor water quality conditions in the Herring River, brackish and freshwater wetlands, woodlands, and shrublands would continue to provide habitat for birds, mammals, reptiles, and amphibians.

4.8.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

As discussed in section 4.5, under any of the action alternatives wildlife habitats within the project area would generally change from degraded brackish and freshwater wetland, shrubland, and woodland habitats to tidally influenced marsh habitats. In the lower sub-basins of the flood plain, increased salinity levels would displace salt-sensitive, non-native plants that have invaded the flood plain and allow for recolonization of native salt marsh plants. Lower salinities, however, would likely occur in the upper sub-basins where existing woodland and shrubland habitats dominated by upland species would, over the long term, gradually develop into brackish and freshwater marsh habitat. Existing freshwater marsh habitat would likely be enhanced by higher water levels and improved water quality.

During construction, wildlife species would likely temporarily avoid the areas because of construction noise and habitat disturbance. Because none of the potential construction sites provide unique or critical habitat most wildlife species are likely to use other habitats nearby. Mobile species would likely leave the area and return when construction is complete. Once construction is completed, wildlife species are expected to re-establish in the restored area.

Birds

Shifts in avian community structure following tidal restoration and increases in open-water habitat generally include an overall increase in avian abundance and an accompanying transition from a community dominated by generalists and passerines to one dominated by waterfowl, shorebirds, and wading birds (see e.g., Seigel et al. 2005). A similar response is anticipated for most of the Herring River avian community following restoration.

Several high priority salt marsh- and tidal creek-dependent species such as salt marsh sharp-tailed sparrows, willets, great and snowy egrets, osprey, and common and roseate terns, are expected to benefit directly through restoration of nesting (salt marsh habitat) and/or foraging opportunities (primarily estuarine fish) in the Herring River. Tidal restoration would also restore wetland and open-water habitats for resident and migratory waterfowl and shorebirds such as wintering black ducks, mergansers, bufflehead, willets, and yellowlegs. Existing shrublands and woodlands dominated by upland vegetation, habitats widely used by generalist resident and migrating passerine species, such as upland sparrows and wood warblers, would be reduced and replaced by tidally influenced brackish and freshwater marsh. This would likely increase the amount and quality of habitat for wetland dependent bird species such as bitterns (see preceding section), rails, marsh wrens, red-wing blackbirds, and common yellowthroats.

Generalist upland bird species could potentially be affected in the long term by a reduction in nesting and feeding opportunities as herbaceous marsh plants replace woodland and shrub habitat. However, these 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 after restoration. These areas would continue to provide nesting, foraging, and perching sites for sparrows, nuthatches, woodpeckers, catbirds, and other passerines along the upland border.

Mammals

It is expected that adequate habitat elements (e.g., suitable food, cover, and den sites) would remain for most mammalian species as a result of tidal restoration. Tidal restoration, provided it occurs gradually, would allow these animals to readjust to the restored salt marsh system and shift their local range within and adjacent to the river and its flood plain.

The most common group of mammals found in salt marsh habitats in the region are rodents, such as the meadow vole and white-footed mouse, which are an important prey-species for northern harriers and other raptors. Initial restoration would result in gradual flooding of habitat and landward migration of many species, but eventually habitats for voles, mice, and other rodents would be dramatically expanded. As tidal restoration progresses, many mammals would continue to forage on the invertebrates, fish, and marsh vegetation and would still use surrounding wooded uplands for den sites and refugia.

Other mammal species in the Herring River are generalists and opportunists that can occupy a variety of habitats. Although in the short term, medium and large mammal species such as raccoon, skunk, muskrat, river otter, and white-tailed deer may be displaced from currently occupied habitat, increased tidal range and salinity, restored salt, brackish, and freshwater marsh habitat may provide long-term benefits with improved water quality, more abundant and diverse prey species, and a more open, expansive habitat structure.

Reptiles and Amphibians

The Herring River flood plain provides habitat for a variety of reptiles and amphibians. Snapping and spotted turtles and northern water snake generally inhabit the freshwater areas upstream of High Toss Road, but can 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 due to the detrimental impacts of salt water on their biological functions. These species are more commonly found along the periphery and in the upper reaches of most sub-basins and in upland transitional habitats (see chapter 3 for a detailed list of species). Increases in tidal range associated with restoration may, in the short term, limit and disrupt reptile and amphibian breeding, foraging, and nesting in lower areas of the flood plain if salinities and water levels increase suddenly. 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, reptile and amphibian populations should shift and adjust their ranges, but no significant declines in species diversity or abundance is expected.

4.8.4 COMPARISON OF IMPACTS OF THE ACTION ALTERNATIVES

While the nature of impacts to terrestrial wildlife populations described in section 4.8.2 do not vary among the three action alternatives, the magnitude of impacts slightly differ depending on which alternative is implemented. The magnitude of impacts is based primarily on projected habitat changes driven by increased tidal range and salinity described in section 4.5.

4.8.5 CUMULATIVE IMPACTS

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on terrestrial wildlife.

4.8.6 CONCLUSION

All action alternatives would result in habitat changes that would affect the distribution of terrestrial wildlife. Mammals, reptiles, and amphibians would gradually relocate to suitable habitat as the estuary undergoes the expected transition from degraded freshwater wetland to functioning estuarine wetland. Because of the gradual pace of environmental change and the animals' mobility, no significant adverse impacts on regional populations are anticipated. For bird species, within the geographic context of the estuary, there would be a substantial change in the composition of species using the estuary. Species dependent on estuarine wetlands would become more abundant, while species dependent on woodland, shrubland or heathland would become less abundant. This estuary-wide, permanent change in species composition, in the context of restoring a now-rare and ecologically critical estuarine wetland ecosystem, would be considered a significant beneficial impact.

Under the no action alternative, there would be no predicted changes for terrestrial wildlife species, in terms of distribution or abundance. While the assemblage of species would remain dissimilar from the assemblage that existed under unmodified, pre-dike habitat conditions, there would be no significant new adverse impacts on terrestrial species, as shown in table 4-22.

TABLE 4-22: SUMMARY OF IMPACTS ON TERRESTRIAL WILDLIFE

Species Group	Alternative A	Alternative B	Alternative C	Alternative D
Birds	• Salt marsh species: limited to 13 acres in Lower Herring River. • Other wetland species: 264 acres of freshwater/brackish habitat available. • Upland and other species: 723 acres of woodland, shrubland, and heathland habitat.	• Salt marsh species: 393 acres of habitat restored in Lower Herring River, Mill Creek, Middle Herring River, and Lower Pole Dike Creek. • Other wetland species: 407 acres of freshwater/brackish habitat restored/enhanced in upper sub-basins. • Upland and other species: woodland, shrubland, and heathland habitat limited to periphery and uppermost sub-basin; species utilize adjacent upland habitats.	• Salt marsh species: 346 acres of habitat restored in Lower Herring River, Middle Herring River, and Lower Pole Dike Creek. • Other wetland species: 484 acres of freshwater/brackish habitat restored/enhanced in upper sub-basins. • Upland and other species: woodland, shrubland, and heathland habitat limited to periphery and uppermost sub-basin; species utilize adjacent upland habitats. • No change in Mill Creek.	• Salt marsh species: 399 acres of habitat restored in Lower Herring River, Mill Creek, Middle Herring River, Duck Harbor and Lower Pole Dike Creek. • Other wetland species: 491 acres of freshwater/brackish habitat restored/enhanced in upper sub-basins. • Upland and other species: woodland, shrubland, and heathland habitat limited to periphery and uppermost sub-basin; species utilize adjacent upland habitats.

Species Group	Alternative A	Alternative B	Alternative C	Alternative D
Mammals	Widespread throughout 1000+ acre project area.	Most species relocate to periphery and upper extents of 800-acre area affected by mean high spring tide.	Most species relocate to periphery and upper extents of 830-acre area affected by mean high spring tide; no change in Mill Creek.	Most species relocate to periphery and upper extents of 890-acre area affected by mean high spring tide.
Reptiles and Amphibians	Widespread throughout 1000+ acre project area.	Most species relocate to periphery and upper extents of 800-acre area affected by mean high spring tide.	Most species relocate to periphery and upper extents of 830-acre area affected by mean high spring tide; no change in Mill Creek.	Most species relocate to periphery and upper extents of 890-acre area affected by mean high spring tide.

4.9 IMPACTS ON CULTURAL RESOURCES

This section analyzes potential impacts to cultural resources based on the survey documented in the Public Archaeology Laboratory's (PAL) *Phase IA Archeological background Research and Sensitivity Assessment* report (Herbster and Heitert 2011) within the area of potential effect (APE) defined by each of the Herring River Tidal Restoration alternatives (see chapter 3, figure 3-24 for APE). No historic (above-ground) resources were identified within the APE for the study (Herbster and Heitert 2011). One historic district, the Atwood-Higgins Historic District extends to the Herring River on its southernmost edge, but no significant resources within the district are within the APE. No documented ethnographic resources are known to be located within the project APE, but consultation regarding the presence of ethnographic resources in the Herring River estuary is ongoing. As a result, this section considers potential impacts only to archaeologically sensitive areas and archaeological sites. For the purposes of this analysis, historic-era resources at, or primarily at, ground level are considered archeological sites or areas of sensitivity for historical archaeological resources. This includes historically documented resources that may be present in the APE.

4.9.1 METHODS AND ASSUMPTIONS

The archaeological resources reconnaissance survey (Phase IA) for the Herring River Tidal Restoration Project was undertaken in accordance with the Secretary of the Interior's *Standards and Guidelines for Identification* (48 FR 44720-23), the Massachusetts Historical Commission (MHC) standards and guidelines set forth in *Public Planning and Environmental Review: Archaeology and Historic Preservation* (MHC 1985), and the MHC historic resources survey standards. The survey complies with the standards of the MHC, state archaeologist's permit regulations (950 CMR 70), the Secretary of the Interior's *Standards and Guidelines for Identification* (48 FR 44720-23), The Standards of the Massachusetts State Register of Historic Places (State Register), and the NPS guidelines for assessing eligibility for listing in the National Register, specifically *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*.

The study area for cultural resources is limited to the areas within or immediately adjacent to the geographic project area as defined in figure 1-1 in chapter 1. For purposes of this study, the area of analysis is the APE as defined by the archeological resources reconnaissance survey, which has been generally defined as the 10-foot contour elevation of areas upstream of the existing Chequessett Neck Road Dike, although adjacent upland areas within the CYCC were included as well. This boundary was used for the Phase IA archeological survey conducted for the project (Herbster and

Heitert 2011). As the alternative analysis proceeded, this boundary was further refined, and the final APE, dependent on the selected alternative, may be smaller. Currently, estimates of the area to be inundated by the action alternatives range from 897 to 960 acres, and approximately 30 additional acres would be disturbed by relocation of the CYCC fairways. With the exception of the CYCC Property, no upland areas are considered in this analysis, as no impacts are expected to occur in upland areas outside the CYCC, and are therefore outside the APE.

The study area for the Phase IA archeological survey encompassed approximately 1100 acres, with the majority of this area located within the inundated tidal wetlands of the Herring River estuary. The archeological sensitivity assessment was focused on the existing shoreline at and below the 10-foot elevation contour, as well on designated upland areas where project impacts may occur. These upland areas include the majority of the CYCC, the Chequessett Neck Road Dike, and several low-lying roadways including High Toss Road, Bound Brook Island Road, Pole Dike Road, and the former Cape Cod Railroad bed. Other ancillary areas may also be impacted by borrow activities or construction staging.

4.9.2 IMPACTS OF ALTERNATIVE A: NO ACTION

Alternative A is the no action alternative, in which conditions in the project area would remain unchanged. Estuary management practices would continue under the present constraints.

Under the no action alternative, no impacts to archeological resources would occur, because no ongoing impacts to existing archeological resources or archeologically sensitive areas have been documented within the APE (Herbster and Heitert 2011).

4.9.3 IMPACTS COMMON TO ALL ACTION ALTERNATIVES

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 archeological sites and 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 will be resolved through implementation of the Programmatic Agreement under Section 106 of the National Historic Preservation Act of 1966 (NHPA).

Increased Tidal Elevations and Tidal Flow

Increased tidal elevations may adversely affect recorded archeological resources or areas identified as archeologically sensitive. Archeological sites or archeologically sensitive areas where flooding would occur as a result of increased tidal flows may require additional documentation prior to flooding. Additional actions may be required for some archeological resources to mitigate impacts that may occur as a result of flooding.

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

Chequessett Neck Road Dike

Although the dike and roadway are not considered historic resources, staging or stockpiling areas outside the construction footprint could potentially impact archeological sites or sensitive areas (Herbster and Heitert 2011).

Impacts of Adaptive Management Actions

The adaptive management actions that could potentially affect archaeological resources are those actions which would require ground disturbance. Impacts to archeological resources associated with adaptive management actions relate to the impacts that would occur to existing and former transportation corridors through the raising of roadways or easements or the replacement of culverts beneath these roadways or easements. The Phase IA archeological investigation conducted as a part of this project identified archeologically sensitive areas along these transportation corridors, including the former Cape Cod railroad easement (Herbster and Heitert 2011, figure 5-4).

Potential Adverse Impacts that will be Avoided, Minimized, or Mitigated

The NPS has developed a programmatic agreement (PA) with the MHC to guide the identification, evaluation, and protection processes for archaeological resources within the Herring River Estuary. This PA defines the measures that must be carried out as the project is implemented to comply with the requirements of the NEPA and NHPA processes and Massachusetts state regulations. As the project design process continues, NPS will provide plans and other documentation and consult with MHC under the terms of the PA in order to take into account the effects of the undertaking on the archeological resources of Herring River Basin. The final PA is included as appendix I of this document.

In order to minimize potential impacts associated with the action alternatives and adaptive management plan, any archeologically sensitive areas or sites should be avoided. If avoidance is not possible, specifically if an action alternative requires construction in a sensitive area, then additional archeological assessment and/or survey should be conducted where ground-disturbing activities are to be conducted to determine if these areas contain archeological sites that are eligible to be included in the National Register. This would include construction footprints and any ancillary areas associated with construction, if these areas correspond to archeological sites or sensitive areas. If significant archeological sites were identified, then specific actions to mitigate impacts would need to be developed for these specific resources.

4.9.4 Comparison of Action Alternatives

Impacts of Alternative B

Flood proofing measures in the Mill Creek Sub-basin (in which the CYCC fairways are raised by filling and grading) will not result in an impact to archeological resources as prior disturbance has likely impacted any archeological resources which may have been present (Herbster and Heitert 2011). However, if flood proofing measures within the Mill Creek sub-basin include the relocation of fairways to upland areas, or if these upland areas are used for borrow material to raise the fairways, then there is the potential for archaeological resources to be impacted. Additional archeological assessment and/or survey would be required in areas proposed for fairway development or borrow pits prior to implementation of this aspect of alternative B.

Impacts of Alternative C

Under alternative C, dike construction at Mill Creek could potentially affect areas archeologically sensitive for pre-contact resources located along the flood plain of the Mill Creek/Herring River confluence. No impacts to resources within the Mill Creek sub-basin would occur, as existing conditions would be maintained, and with no need to flood proof low-lying areas within CYCC or relocate fairways to upland areas, no archeological resources would be affected by this alternative in the Mill Creek Sub-basin.

Impacts of Alternative D

Under alternative D, impacts to archeological resources would be equivalent to the impacts discussed for alternatives B and C combined.

4.9.5 Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on archeological resources.

4.9.6 Conclusion

There is a potential for the project to adversely affect archeological resources within the APE. These effects would be primarily associated with the footprints of construction activities, as well as any other ground-disturbing activities, including borrow or construction staging areas. Prior to any construction, additional archeological assessment and/or survey should be conducted where ground-disturbing activities are planned to determine if these areas contain archeological resources that are eligible for inclusion in the National Register. Such activities would include dike construction, culvert replacement, and road reconstruction. Archeological sites or sensitive areas have been identified in proximity to all areas of potential construction, including existing or former transportation easements, but it has not yet been determined that impacts to these sites or sensitive areas would require mitigation.

Changes in tidal elevations may impact archeological resources, and additional documentation of these resources may be required prior to flooding. Site-specific mitigation measures would be implemented if adverse effects to these resources are identified as a result of inundation. Some transportation corridors that span the existing tide channels could be affected by erosion associated with increased tidal flows. Any impacts here would be identified in the adaptive management plan, and corrective actions are likely to be the same as those already discussed, such as culvert replacement.

Therefore, under all action alternatives, in an estuary-wide context, the gradually increasing tidal effects on some areas that may contain archeological resources would be subject to additional study as needed to ensure that there are no significant adverse effects on those resources. In the site-specific context associated with direct construction impacts, avoidance and mitigation would ensure that significant impacts do not occur. Under the no action alternative, there would be no new effects to archeological resources, and therefore no significant effects from taking no restoration action.

4.10 IMPACTS ON SOCIOECONOMICS

The human environment is defined by CEQ as the natural and physical environment, and the relationship of people with that environment (NPS 2011b). As described in chapter 3, the socioeconomic environment associated with the HRRP has been identified to include nuisance mosquitoes, shellfishing, finfishing, low-lying properties, low-lying roads, viewscapes, recreational use and experience, and regional economic conditions.

4.10.1 METHODOLOGY AND ASSUMPTIONS

While NEPA is triggered when there is a physical impact on the environment, the CEQ regulations require analysis of social and economic impacts in an EIS/EIR (NPS 2011b). Although the socioeconomic environment receives less emphasis than the physical or natural environment in the CEQ regulations, NPS considers it an integral part of the human environment (NPS 2015) and social and economic impacts should be analyzed in any NEPA document where they are affected (NPS 2015, sec 1.3).

In addition, the Certificate and EIR Scope issued by the Massachusetts Secretary of Energy and Environment in November 2008 directs the Herring River project proponents to address several socioeconomic topics in the final EIS/EIR. The requirement of MEPA for an EIR, also triggered review by the Cape Cod Commission (CCC) as a Development of Regional Impact (DRI) under the Barnstable County Regional Policy Plan. In comments on the ENF submitted to MEPA in 2008, CCC also requested information in the final EIS/EIR on these socioeconomic topics.

4.10.2 NUISANCE MOSQUITOES

Herring River tidal restoration would be undertaken incrementally, but would ultimately result in tidal waters inundating a large portion of the wetlands upstream of the Chequessett Neck Road crossing. Although lower low tides are also anticipated, resulting in much-improved drainage, anthropogenic changes to the marsh over the past 100 years could create stagnant-water breeding sites for floodwater mosquitoes. Marsh subsidence, old piles of dredged material and dense vegetation are all likely to impede low tide drainage. This concern, together with the knowledge that a primary impetus for the original diking in 1909 was a locally intense mosquito nuisance, urges careful planning to avoid worsening seasonal adult mosquito production.

Complicating the situation is the fact that 80 percent of the Herring River wetlands are under the management responsibility of the NPS, which protects native insect populations unless they threaten human health or safety by, for example, vectoring disease as determined by the U.S. Public Health Service. Unless a public health threat develops, which is unlikely on outer Cape Cod, nuisance mosquito control is against NPS policy; therefore, the NPS would not take any actions solely intended to control native mosquitoes. Nevertheless, NPS has in the past allowed hydrologic restorations (e.g., re-establishment of historic tidal channels) with the purpose of improving low-tide drainage to enhance wetland restoration success; coincidentally this management action may reduce floodwater mosquito breeding (Portnoy et al. 2003).

According to the Cape Cod National Seashore General Management Plan any program that is implemented to manage pests would use environmentally sensitive solutions that would protect important resources to the seashore. Furthermore, the plan states that pest-control methods would always to be the least toxic, use the minimal amount of control needed, and would be targeted at a specific pest without harming other plant or animal species. Finally, the General Management Plan states that the Park Service would work with the state's Cape Cod Mosquito Control District and the Cape Cod Cooperative Extension (through the University of Massachusetts) in developing appropriate responses and techniques to respond to nuisance insects affecting visitors and neighbors of the national seashore (NPS 1998).

Impacts of Alternative A: No Action

The Herring River currently supports productive mosquito breeding habitat, particularly between High Toss Road and Route 6. The dominant mosquito species caught in the Wellfleet area, *Ochlerotatus cantator*, breeds in fresh to brackish water, and its larvae can tolerate the acidified waters that keep its predators at bay. Under the no action alternative, this condition would persist.

Impacts Common to All Alternatives

Restored tidal exchange should decrease the overall production of floodwater mosquito species by (1) increasing flushing and low-tide drainage of presently stagnant pools and ditches within the wetland, and (2) greatly improving water quality (decreased acidity and increasing dissolved oxygen) for the predators of mosquito larvae and pupae, especially estuarine fish. As observed at the Hatches Harbor salt marsh restoration in Provincetown, Massachusetts, a shift in species could be expected as salinity is increased throughout the Herring River, with overall long-term decline of freshwater and generalist species such as *O. cantator* and *O. canadensis* (NPS 2003, unpublished data); however some increase in breeding activity of these species could be expected in subsided marsh areas. This would abate as subsided areas accrete sediment and develop into inter-tidal habitats. Eventually, salt marsh mosquito species such as *O. solicitans* may recolonize the salt marsh, however, with enhanced low tide drainage and increased populations estuarine fish feeding on mosquito larvae, it is expected that salt marsh mosquito populations would be naturally controlled. For these reasons, an increased opening in the dike is expected to decrease the mosquito nuisance within and surrounding the Herring River estuary.

The question of whether to maintain or fill historically dug drainage ditches is controversial. In the diked Herring River, where seawater has been completely excluded from hundreds of acres of original salt-marsh soils, ditch drainage lowers the water table and worsens the problem of acid sulfate soils and acidified surface waters. With tidal restoration, the ditches will have only a local impact within about 15 meters (Hemond and Fifield 1982) and concerns for biogeochemical disturbance diminish greatly. Decisions of ditch maintenance may therefore hinge more on the objectives of restoring water and sediment movement, than on controlling mosquito breeding. Regardless of what management action is taken with the ditches, mosquito experts agree that tidal restoration, and its anticipated improvement of river water quality and flushing, would reduce nuisance mosquito production as compared to existing conditions.

Comparison of Impacts of the Action Alternatives

Alternative B

Under alternative B, approximately 801 acres of the Herring River flood plain would be affected by mean high spring tides. The majority of this area would be well-flushed a minimum of several times per month, greatly reducing coverage of ponded, stagnant pools and ditches where most mosquito larvae are produced. Associated water quality improvements should also reduce the amount of available breeding habitat. Though some breeding would be expected to continue, especially along the periphery of some sub-basins and in the upper reaches of the system, predatory estuarine fish, such as mummichog (*Fundulus heteroclitus*), which eat mosquito larvae, would be more abundant and have easier access to potential breeding pools, further reducing successful emergence of adult mosquitoes. As part of the adaptive management approach, potential breeding sites will be identified and monitored and additional restoration actions will be taken to maximize tidal flushing and fish access. The Cape Cod Mosquito Control Project (CCMCP) will be consulted on any actions related to mosquito habitat management.

Alternative C

Under this alternative, impacts on mosquitoes within the project area are identical to those of alternative B, with the exception that 830 acres would be affected, encompassing a slightly larger area subjected to mean high spring tides. No changes would occur in the Mill Creek sub-basin.

Alternative D

Mosquito related impacts associated with alternative D would affect 890 acres, including the Mill Creek sub-basin and a slightly larger area subjected to mean high spring tides compared to alternative B.

Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on nuisance mosquitoes.

4.10.3 SHELLFISHING

As described in section 3.10.2, the four commercially important shellfish harvested in Wellfleet include the eastern oyster, hard clam (northern quahog), soft shell clam, and bay scallop. Oysters and quahogs dominate the Wellfleet shellfishery and are harvested from both wild stock and aquaculture operations. Soft shell clams and bay scallops are harvested from primarily from wild populations. Because of the valuable wild and aquaculture shellfish industry in Wellfleet Harbor there has been interest in the potential impacts on both the existing shellfishery and the potential for increased shellfishing that the restoration project could have in the Herring River. Increased tidal exchange to the Herring River likely will result in both short-term and long-term changes in water quality and patterns of sediment deposition and erosion which could affect existing opportunities for shellfish harvest. This section addresses these potential impacts and is primarily based on results of the Herring River hydrodynamic and sediment model (WHG 2012) and several studies and data sets pertaining to sediment particle size and sediment dynamics within the river and Wellfleet Harbor (Dougherty 2004; Harvey 2010; unpublished NPS data 2005, 2009).

Impacts of Alternative A: No Action

Currently, because of poor water quality due to high fecal coliform levels, all recreational and commercial shellfish harvest is permanently closed in areas immediately downstream of the Chequessett Neck Road Dike (see figures 3-25 and 3-26 in chapter 3). Water quality is not expected to improve under the no action alternative, so it is likely this area would continue to be subject to fecal coliform contamination and would remain closed to shellfish harvest. Shellfish harvests in Wellfleet Harbor under the no action alternative would continue based on current trends in shellfish abundance and environmental conditions. Shellfish re-colonization of historic shellfish habitat upstream of the Chequessett Neck Road Dike would not occur without restoration of tidal influence and improvements in water quality resulting from project implementation.

Impacts Common to All Action Alternatives

All action alternatives are expected to provide long-term benefits to shellfish populations and potentially provide increased opportunities for shellfish harvest. Because fecal coliform levels in the Herring River estuary are expected to decrease to levels below the regulatory limit, the closed area of the Herring River downstream of the Chequessett Neck Road Dike could be opened to harvesting and other areas of Wellfleet Harbor that are only conditionally available to harvesting could be opened year-round (Koch, pers. comm., 2011c). Subject to approval by the Town of Wellfleet and Massachusetts Division of Marine Fisheries, the improved environmental conditions downstream of the dike could provide enhanced opportunities for the harvest of oysters, quahogs and soft shell clams.

Under each of the action alternatives it is expected that restored salinities and daily tidal exchange will restore shellfish habitat upstream of the Chequessett Neck Road Dike. As described in section 3.6.4, oysters require salinities between 10-33 ppt, quahogs between 15-33 ppt, and soft shell clams between 10-33 ppt, which would be provided to varying degrees under each of the action alternatives. If tidal exchange also restores suitable substrates it is possible that oysters, quahogs, and soft shell clams would recolonize the lower Herring River. This would primarily occur in the wide portion of the 117-acre Lower Herring River sub-basin immediately upstream of the reconstructed Chequessett Neck Road Dike. This area falls within the Seashore's boundary where wild-picking is generally permitted; however, as described in chapter 3 and outlined in the Cape Cod General Management Plan, shellfishing activities in this area would need to be approved by the Town of Wellfleet and Massachusetts Division of Marine Fisheries. Regardless of any decision to change shellfish harvest areas, restored tidal conditions should increase populations of shellfish in the areas immediately above and below the Chequessett Neck Road Dike which will provide source populations of several species for the remainder of Wellfleet Harbor.

Shellfish harvests could also increase as improved tidal flows introduce more organic matter into the estuary. This would provide additional food for shellfish upstream and downstream of the dike and in Wellfleet Harbor (Koch, pers. comm., 2011c). As food availability increases, it is possible that the shellfish growth rates would increase, causing wild and aquaculture shellfish to mature to harvestable size more quickly than today, and therefore increasing the frequency of harvests and total yields (Koch, pers. comm., 2011c).

Valuable shellfish aquaculture exists in Wellfleet Harbor and there have been concerns that the restoration of tidal exchange to the Herring River may result in short-term sediment discharge to the harbor that may adversely affect these resources. However, recent data and historical documentation (unpublished NPS data 2004 and 2009; Dougherty 2004) show the flats and shoals of Egg Island and areas along Mayo Beach are currently, and were historically (prior to construction of the

Chequessett Neck Dike), comprised of relatively coarse-grained sediment. Additionally, sediment particle size analyses and modeling of sediment transport dynamics (Harvey 2010; WHG 2012), show that the particle size of mobilized sediment and predicted flow velocities are inadequate to deposit sediment within the aquaculture areas. Sediment transport processes are far more dependent on tidally driven forces in Cape Cod Bay at present than whatever forces might be exerted by a new, larger tidal opening for the Herring River.

During the early stages of tidal restoration, the incremental opening of the tide gates at the Chequessett Neck Road Dike could transport some fine-grain material downstream into Wellfleet Harbor. The amount of this mobilized sediment is expected to be small and the predicted ebb-tide velocities too great for deposition of fine-grain particles to occur and a measurable impact in the harbor is not expected. Most suspended fine-grain particles would move through the system over several tidal cycles and eventually be transported through the harbor and into Cape Cod Bay (WHG 2012).

Although deposition upstream of the Chequessett Neck Road Dike is expected to be the most prominent sediment-related process occurring within the project area (see section 4.4), monitoring for potential sediment transport and deposition downstream of the dike, including within the aquaculture areas, will be a component of the project's long-term adaptive management and monitoring program. Monitoring will be designed to detect changes in volume of suspended particles, particle size, and rate of deposition at key areas. As part of the adaptive approach to restoring tide range, alternate management actions will be considered in response to detections of change beyond pre-established threshold values (an expanded overview of the adaptive management approach proposed for the Herring River project is provided in appendix C). Detailed information about monitoring and management/mitigation responses with respect to shellfishing in Wellfleet Harbor will be developed in close collaboration with the Town of Wellfleet and the shellfishing community throughout the adaptive management and permitting processes.

Comparison of Impacts of the Action Alternatives

Improvements to shellfishing conditions are driven by water quality improvements, particularly reduced fecal coliform levels, which are linked to improved tidal flushing (see section 4.2.3, table 4-3). As discussed in "Section 4.3: Impacts on Water and Sediment Quality," all of the action alternatives would greatly improve water quality relative to the existing conditions, with alternatives C and D being slightly more effective in reducing residence time than alternative B. This slight difference in residence times, however, is not expected to translate into a detectable difference in shellfishing conditions.

Although not expected, any potential sediment impacts to shellfishing and aquaculture areas downstream of the Chequessett Neck Road Dike likely would occur only in the early stages of incremental tide gate openings, which would occur under any of the alternatives. Thus, alternatives B, C, and D are expected to have similar outcomes in terms of shellfishing opportunities.

Cumulative Impacts

Oyster spawning experiments in Wellfleet Harbor could beneficially affect socioeconomic resources in the local and regional area if the experiments in Wellfleet Harbor lead to an increase in oyster productivity. In combination with any of the proposed action alternatives, the cumulative impact would be beneficial and long term.

4.10.4 FINFISHING

Along with shellfishing, finfishing is an important recreational activity throughout Wellfleet and outer Cape Cod and an integral component of the region's natural and cultural history. Though the Chequessett Neck Road Dike has become a popular spot for anglers casting their lines on the harbor side, fishing rarely occurs in the river upstream of the dike. 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. In addition, improvements to estuarine habitat and connectivity with Wellfleet Harbor would also improve the near shore fishery in Cape Cod Bay.

Impacts of Alternative A: No Action

Tidal exchange would continue to be limited upstream of the Chequessett Neck Road Dike. No new habitat would be created for river herring or other recreationally or commercially important species, such as bluefish or striped bass, which are dependent on estuarine habitat at some point in their life cycle. The herring run within the Herring River would remain obstructed. This would continue to adversely affect river herring, which once was a commercially important fish in Wellfleet. It is therefore expected that no improvement to recreational or commercial finfishing would occur and ongoing estuary degradation and obstructed access will contribute to continued regional population declines of estuary-dependent fisheries.

Impacts Common to All Action Alternatives

Any of the action alternatives would directly and indirectly benefit commercial and recreational finfishing by increasing the quantity and quality of habitat and components of the food web (i.e., nutrients, zooplankton, bait fish, and prey fish) that rely on estuarine conditions to survive (NRCS 2006). All of the action alternatives would increase available habitat for spawning, cover, and food (NPS 2011e). Additionally, restoration actions are expected to improve the water quality in the estuary and Wellfleet Harbor. These increases in habitat and water quality are assumed to be beneficial for populations of finfish and commercial finfishing industries. Additionally, an increase in the local fish supply could bring anglers to the area and increase the associated revenue from fishing permit sales (NRCS 2006). The beneficial socioeconomic impacts associated with the action alternatives are not anticipated to be measurably different.

Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on finfishing.

4.10.5 LOW-LYING PROPERTIES

More than 100 years of diking and drainage of the Herring River flood plain has allowed land uses and development of the former salt marsh and adjacent areas. Several dozen of these properties will 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. This section describes both physical impacts to low-lying properties caused by increased tidal influence and potential changes to jurisdictional wetland resource areas that will result in changes to local and state regulatory jurisdictions. Note that impacts to low-lying roads are addressed separately in the following section.

Physical Impacts to the CYCC Golf Course

Under alternatives B and D, all of or portions of CYCC golf holes number 1, 6, 7, 8, and 9 and the practice area would be impacted by tidal waters and require modifications to avoid flooding (figure 4-9). Alternative B option 1 and alternative D option 1 would relocate the practice area and portions or all of holes 1, 6, 7, and 8 to upland areas west of the current golf course and would elevate part of fairway 9 in place as well as a portion of former fairway 1 for a new practice area. Most of the abandoned parts of the golf course would become subject to tidal exchange and would be part of the restored salt marsh in the Mill Creek sub-basin. Alternative B option 1 and alternative D option 1 would avoid wetland loss, but would still require filling 89,000 square feet (2 acres) on hole number 9, which cannot be relocated due to its proximity to the clubhouse. Permitting considerations for these wetland impacts are discussed in chapter 5.

Alternative B option 2 and alternative D option 2 would retain the current layout of the course, elevate the low-lying golf holes, and relocate the practice area to an upland site that would also serve as the borrow area for the fill needed to elevate the low fairways. The current practice area and the area between fairways 7 and 8 would be restored to tidal wetland. Alternative B option 2 and alternative D option 2 would result in approximately 360,000 square feet (8.3 acres) of direct wetland loss by filling the low areas.

During flood proofing for alternative B options 1 and 2, and alternative D options 1 and 2, the use of the golf course would be curtailed, resulting in lost golf course revenue to CYCC. After construction, the CYCC would have newer, improved golf holes, practice area, and appurtenances, which may increase use (and revenue) and improve golf quality. Under alternative C, no changes attributable to the project would be expected within the Mill Creek sub-basin. The addition of a dike at Mill Creek would block tides, and flood proofing of the golf course and other individual properties in the Mill Creek sub-basin would not be needed. Portions of the CYCC golf course would continue to experience periodic flooding and land subsidence issues due to its low elevation and underlying marsh peat.

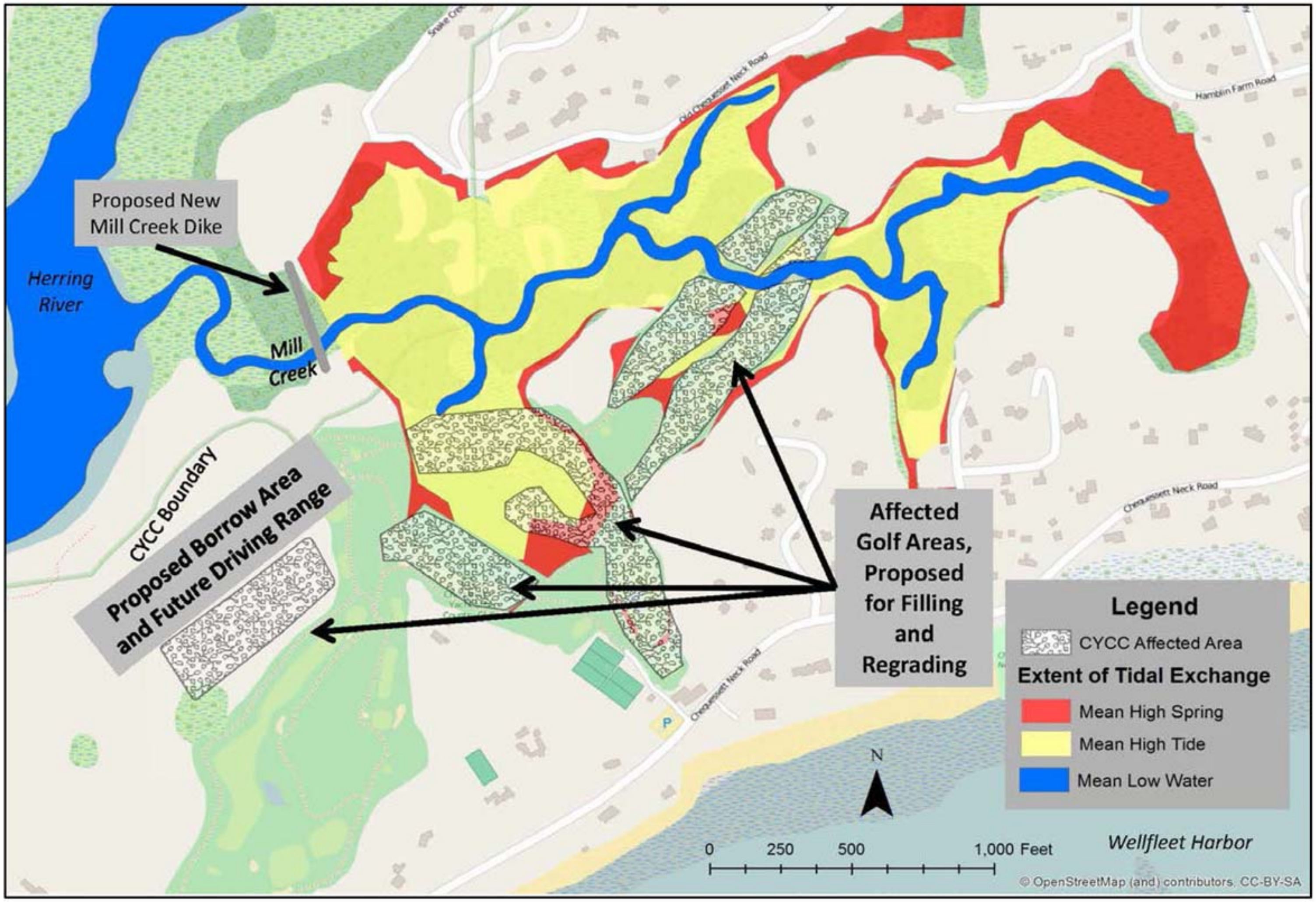


FIGURE 4-9: TIDAL IMPACTS AND FLOOD PREVENTION MEASURES FOR THE CYCC GOLF COURSE UNDER THE PREFERRED ALTERNATIVE

Physical Impacts to Low-lying Residential Properties

Hydrodynamic modeling results, aerial photography, topographic and ground survey data, and property records from the town assessor's databases were used to compile a preliminary list of privately owned properties within the project area which could potentially be affected by increased tidal exchange. Potential physical impacts include any level of predicted tidal flow on any portion of a property. Potential regulatory impacts were also estimated based on changing jurisdictional boundaries. Properties were categorized based on the frequency of tidal water reaching the property and the nature of the land or structures impacted, as follows:

No Physical Impact—No physical impact will occur as properties lie outside the extent of maximum tidal influence for all action alternatives and tidal events.

Infrequent Impacts to Natural Vegetation—Natural (i.e., non-cultivated, non-landscaped, "wild") vegetation affected by tidal flow, on average, one time per year or less frequently. The impacts would only occur during the highest predicted tide of the year or during coastal storm events. Depending on the type of vegetation and salinity of tidal water, some species could be temporarily stressed, but would likely recover and persist. Tidal influence would not be frequent enough to convert the vegetation type to salt or brackish marsh.

Frequent Impacts to Natural Vegetation—Natural (i.e., non-cultivated, non-landscaped, "wild") vegetation affected by tidal flow with a frequency ranging from daily high tides up to monthly high spring tides. Tidal influence would be frequent enough to stress and kill salt-intolerant species and convert the area to salt or brackish marsh, depending on the exact frequency and salinity of tidal waters.

Infrequent Impacts to Cultivated Vegetation—Cultivated, landscaped vegetation (lawns, gardens, planted trees, etc.) affected by tidal flow, on average, one time per year or less frequently. The potential for impacts would only occur during the highest predicted tide of the year or during coastal storm events. Depending on the type of vegetation and salinity of tidal water, some species could be temporarily stressed, but would likely recover and persist. Tidal influence would not be frequent enough to convert the vegetation type to salt or brackish marsh. Properties in this category may also include impacts to natural vegetation on some land parcels.

Frequent Impacts to Cultivated Vegetation—Cultivated, landscaped vegetation (lawns, gardens, planted trees, etc.) affected by tidal flow with a frequency ranging from daily high tides up to monthly high spring tides. Tidal influence would occur frequently enough to stress and kill salt-intolerant species and convert the area to salt or brackish marsh, depending on the exact frequency and salinity of tidal waters. Properties in this category may also include impacts to natural vegetation on some land parcels.

Infrequent Impacts to Structures—Buildings (including residences, sheds, garages, etc.), driveways, private lanes, wells, and septic systems affected by tidal flow, on average, one time per year or less frequently. The potential for impacts would only occur during the highest predicted tide of the year or during coastal storm events. Depending on the exact nature of the structure, the impact could render it temporarily unusable or inaccessible (i.e., a flooded driveway) or cause minor, short-term damage. Properties in this category may also include impacts to natural or cultivated vegetation on some land parcels.

Frequent Flooding to Structures—Buildings (including residences, sheds, garages, etc.), driveways, private lanes, wells, and septic systems affected by tidal flow with a frequency ranging from daily high tides up to monthly high spring tides. Depending on the exact nature of the structure, the impact could render it regularly unusable or inaccessible and could cause long-term or permanent damage. Properties in this category may also include impacts to natural or cultivated vegetation on some land parcels.

Potential Jurisdictional Changes to Low-lying Land Uses

In addition to the physical changes discussed previously, restoration of tidal exchange throughout the Herring River flood plain will also result in changes to the jurisdictional limits of several state statutes and local bylaws which regulate activity in wetlands, flood plains, and associated buffer zones. These laws include:

- **Town of Wellfleet Zoning Bylaw**—Defines "lot area" as the contiguous horizontal area of a lot exclusive of any area on a street or way open to public or private use and excluding that land which is swamp, pond, bog, dry bog, marsh, areas of exposed groundwater, or which is subject to flooding from storms and mean high tides. Tidal restoration could reduce the lot area on some properties.
- **Massachusetts Wetlands Protection Act (WPA) and 310 CMR 10.00 et seq. and local wetland bylaws**—Although the entire project area was tidally influenced wetland in its natural, pre-dike state and the majority of the area remains freshwater wetland, it is possible that small areas on some properties may no longer exhibit standard indicator criteria for defining jurisdictional wetlands (supporting hydric soils, hydrophytic vegetation, and wetland hydrology) and could currently be defined as upland. In some cases, tidal restoration could reverse this, restoring areas of wetlands that in their current state are not subject to regulation. Proposed activities within 100 feet of these restored wetlands would require filing a Notice of Intent (NOI) with the town conservation commission. As discussed in section 4.5, the vast majority of changes to wetlands involves conversion of one wetland type to another and not the conversion of upland to wetlands.
- **Massachusetts Rivers Protection Act and 310 CMR 10.58**—In coastal areas, the Rivers Protection Act regulates development and other activities within the "riverfront area" 200 feet of the mean high tide line. Given the severely tide-restricted nature of the Herring River in its present condition, only a relatively small number of private properties within the flood plain are currently affected by these regulations; however, all of the tidal restoration alternatives under consideration would move the riverfront area landward by a significant distance and subject many properties to these regulations. Proposed activities located within the riverfront area on these parcels would require filing a NOI with the town conservation commission and would have to comply with associated regulatory performance standards.

Impacts of Alternative A: No Action

By taking no action, it would be assumed that the properties in the project area would continue to be protected from inundation by the Chequessett Neck Road Dike. There are no buildings, structures, wells, or septic systems impacted by tidal flows under existing conditions. However, a recent inspection report of the Chequessett Neck Road Dike, prepared for the Town of Wellfleet, has highlighted existing issues which need attention to maintain the existing level of flood protection.

Impacts Common to All Action Alternatives

Increased tidal exchange under all action alternatives would result in a variety of both positive and adverse impacts to multiple low-lying properties. Positive impacts could include retreat of invasive vegetation and transition to open marsh and water vistas, resulting in potential increases in property values. Adverse physical impacts could include tidal flooding of low-lying structures and cultivated vegetation. Adverse impacts to structures would be avoided through various flood proofing measures as appropriate for specific impacts and properties. Any of the action alternatives would also cause changes to jurisdictional wetland resource areas on some properties within the project area.

Comparison of Impacts of the Action Alternatives

Physical Impacts

Physical impacts range from very small portions of a property impacted only during very infrequent coastal storm events to large areas affected by every high tide. The approximate number of properties in each physical impact category, as defined previously in this section, is summarized in table 4-23. These figures are approximations based primarily on preliminary desktop analysis. The number of structural impacts has been refined after consultation with individual property owners and development of more comprehensive, site-specific property data. More specific characterization of potential impacts to specific properties will be developed further as outreach to property owners continues and the project advances through design, permitting, and implementation phases.

Regulatory Impacts

Under alternative D, there are approximately 170 parcels that would not be physically impacted by water, but are close enough to the flood plain to be affected by a change in the Riverfront Area (i.e., located within 200 feet of the estimated new mean high tide line). This includes properties currently outside the Riverfront Area where the line would move onto the lot and properties where the Riverfront Area already exists and would expand landward. Of the approximately 190 properties physically impacted by water (see table 4-23), approximately 150 properties would be affected to varying extents by landward movement of the line. Approximate Riverfront Area changes are summarized in table 4-23.

Similar impacts to regulatory boundaries would occur under alternative C in comparison to alternative D, with the exception that all impacts within the Mill Creek sub-basin would be avoided, reducing the total number of affected properties by about 80 and averting any impact to the CYCC golf course. Alternative B would involve the Mill Creek properties, while the slightly lower elevations of the mean high tide line would reduce the number of overall regulatory impacts.

TABLE 4-23: IMPACTS OF THE ACTION ALTERNATIVES ON LOW-LYING PRIVATE PROPERTIES

Physical Impacts due to Restored Tidal Influence	Number of Affected Parcels[a]		
	Alternative B	Alternative C	Alternative D
Natural Vegetation Only Total	126	120	145
Frequent Only[b]	8	7	8
Infrequent Only[c]	46	50	54
Both Frequent and Infrequent[d]	72	63	83
Cultivated Vegetation Only Total	2	1	2
Frequent Only[b]	None	None	None
Infrequent Only[c]	2	1	1
Both Frequent and Infrequent[d]	None	None	1
Both Natural and Cultivated Vegetation Total	28	24	32
Frequent Only[b]	None	None	None
Infrequent Only[c]	None	None	None
Both Frequent and Infrequent[d]	28	24	32
Total Physically Affected Parcels	**156**	**145**	**179**
Parcels with Affected Structures[e,f]			
Frequent[b]	5	4	6
Infrequent[c]	2	2	4
Changes to Riverfront Area			
Parcels with both Riverfront Area Change and Physical Impacts	318	247	322
Parcels with Riverfront Area Change Only[g]	165	126	169

a these figures are approximations based primarily on preliminary desktop analysis and will continue to be refined upon further consultation with individual property owners and development of more comprehensive, site-specific property data

b entire parcel or structure affected by mean high and mean high spring tides

c affected portion of the parcel or structure impacted only by annual high and storm tides

d parcels contain areas both above and below mean high spring tide

e includes physically affected driveways, wells, and buildings; several parcels include multiple affected structures

f lots with affected structures may also include vegetation and Riverfront Area impacts

g no physical impacts expected

Mitigation of Low-lying Property Impacts

Minimizing and mitigating impacts to low-lying properties is an important objective of the HRRP. The analysis presented in this final EIS/EIR represents an on-going process to identify potentially affected properties, assess impacts, and work with substantially affected landowners on mutually acceptable solutions to mitigate impacts. Properties with estimated structural impacts will require additional site-specific analysis to confirm and refine those impacts and to develop cost-effective flood mitigation measures. Generally, these measures could include elevating or relocating driveways and landscaping, moving wells, building small berms or flood walls, moving or elevating structures, and compensation for lost value or voluntary sale of easements or other interests in land.

Within the boundary of Cape Cod National Seashore in the Lower Herring River basin, there are two private properties with buildings that would be flooded by restoring tidal flow to the main river basin. These properties are at very low elevations and would be affected early on in the restoration process. Unlike potentially affected structures in other basins, there are no tide control structures between them and the Chequessett Neck Road Dike that can minimize high tide levels. In these cases, where no other flood mitigation measures are feasible, in the absence of a willing seller, NPS could consider an eminent domain taking. At present, a voluntary exchange is being negotiated for one of these two properties.

Potentially affected landowners within the project area were contacted prior to the release of the draft EIS/EIR and have been offered opportunities to meet with members of the HRRC to learn more about how the project might affect their property. Since then, the HRRC has worked individually with affected landowners. The purpose of these interactions is to further explain and refine property-specific project effects and develop mitigation plans that address substantial adverse impacts. The most effective (and only practical) way to do this is to consult one-on-one with affected landowners to review information specific to their properties. Road access to private properties will be protected. Low-lying sections of public roads (such as Old County Road) will be raised to prevent flooding as part of the project (see section 4.10.6 of the final EIS/EIR).

Most of the structurally affected private properties are located within either the Mill Creek or the Upper Pole Dike Creek basins of the Herring River flood plain. Structures within these sub-basins will receive four levels of overlapping and redundant protection from the impacts of restored tidal flow:

- First, the tide control structure installed as part of the new Chequessett Neck Road Dike will be carefully opened to increase tide range and water levels throughout the project area monitored to ensure that the system is performing as expected and no adverse impacts occur.
- Second, additional tide control structures will be constructed specifically across Mill Creek and Upper Pole Dike Creek to provide an additional layer of control and a tide regime specifically limited for these sub-basins. These structures will be opened and monitored similarly to the Chequessett Neck tide gates.
- Third, site-specific measures will be employed for individual properties to prevent tidal flows from impacting structures; these may include, but are not limited to, berms, elevation of land or structures, relocation of structures, and other practices. These would be constructed with the explicit consent and cooperation of land owners under the terms of site-specific written landowner agreements.
- Fourth, in addition to monitoring of water surface elevations, the effectiveness of all individual impact mitigation practices will be specifically monitored to ensure they are working properly, maintained, and in good condition; the exact nature and duration of this monitoring will vary based on site-specific circumstances, but will be specified as a component of each landowner agreement.

Considerations of Long-Term Sea Level Rise for Low-Lying Property and Road Mitigation

As sea-level rises in the tide-restored Herring River, salt marsh and other tidal wetland habitats will migrate landward (Donnelly and Bertness 2001). Mitigation measures should seek opportunities within the tidal basin where roadways or other infrastructure could be re-located further upland or removed, thereby facilitating the natural landward migration of tidal wetlands in response to sea-level rise.

The restoration project partners are committed to addressing and mitigating any structural impacts resulting from the restoration of natural tidal flow. Some of the options available include raising or relocating affected buildings, driveways or wells, building berms to protect such structures, and/or limiting water levels across entire sub-basins. The cost of these impact mitigation measures will be borne by the project. Water surface elevations within any sub-basin will not be increased until the necessary impact mitigation is in place.

Any mitigation measure implemented as part of the Herring River project will be designed to prevent adverse impacts of restored tidal flow to low-lying structures and roads that have been constructed within the historic Herring River flood plain. This includes the CYCC golf course, several private residential properties, and approximately 4,000 linear feet of public and private roadways (see section 10.4.6). Potential impacted structures on residential parcels include buildings, wells, driveways, and other features.

The hydrodynamic model is being used for mitigation needs assessment, planning, and design. Estimates of maximum impacts are based on the high tide elevation resulting from the highest tide ever observed in Wellfleet Harbor, the so-called “storm of record,” a 9.7 foot tide observed during the blizzard of 1978 (USACE Atlas of Tidal Flood Profiles for the New England Coast, 1988). In the model, a coastal storm in Wellfleet Harbor of similar magnitude lasting for three days is simulated and forced through the rebuilt Chequessett Neck Road Dike with all tide gates completely open across the 165-foot wide span. For the Mill Creek sub-basin, a secondary interior dike has also been simulated in the model and will be installed to provide additional tidal control. (Note: While the effect of a tidal control structure for the Upper Pole Dike Creek sub-basin has not been explicitly modeled, a similar approach to limited tidal restoration and low property impact protection for this sub-basin is also a component of the preferred alternative.)

For example, in order to continue use of the golf course, HRRC and CYCC representatives worked together to develop a conceptual grading plan which would allow high tide elevations up to 5.9 feet to occur within the Mill Creek sub-basin. As predicted by the model, water surface elevations would reach this level only during a storm event, similar to the blizzard of 1978 in magnitude and duration (i.e., 9.7 foot high tide), with the rebuilt Chequessett Neck Road Dike limiting the storm-driven high tide in the Lower Herring River to 7.5 feet and the new Mill Creek Dike further reducing the level to 5.9 feet. Normal daily and monthly high tides would be much lower, approximately 4.0 and 5.0 feet, respectively. Low areas of the golf course would be filled and graded a minimum of two feet higher than the mean high spring tide elevation, resulting in playable golf surfaces at 6.7 feet and higher. Under the preferred alternative, the tide gates at the rebuilt Chequessett Neck Road Dike and the new Mill Creek Dike will be managed to ensure that high tide does not exceed this elevation within the sub-basin. The Mill Creek Dike will be built to a crest elevation of at least 9.5 feet, two feet above the maximum storm-driven high tide elevation in the Lower Herring River to allow for a higher tide through the majority of the system compared to the lower tide range within Mill Creek.

A similar approach is being used to prevent tidal flow impacts to other private properties and roads. Any constructed mitigation measure, such as berms or elevated structures, will be designed based on the maximum storm-driven high tide elevation (which varies throughout the system) and tide gates will be designed and managed to limit tides within this range. Similarly, relocated structures, such as wells, will also be sited at elevations above the maximum, storm-driven high tide for any specific location.

The practice of building tidal impact protection measures above the maximum storm-driven high tide elevation, also referred to as “free board” (http://www.fema.gov/floodplain-management/freeboard), is intended to provide a margin of safety against unexpected circumstances and extremely rare events that could result in high tide elevations higher than those predicted by the model. Although the maximum storm-driven high tides incorporated into the model represent a very low probability of actually occurring (approximately equivalent to the 100-year coastal storm surge, with a 1 percent chance of occurring in any given year, this extra level of protection is a standard civil engineering practice and compensates for the unknown factors that are inherent in projects of this nature. The amount of free board provided for flood protection measures associated with the Herring River project varies and will be determined based on specific site conditions.

In order to test this concept, Woods Hole Group modified the hydrodynamic model to increase the tidal forcing boundary condition (i.e., the elevation of water from Wellfleet Harbor being forced through the rebuilt Chequessett Neck Road Dike with all tide gates wide open) to simulate a severe storm event with tides peaking at 11.9 feet through three tide cycles. This elevation is just below the crest of the rebuilt Chequessett Neck Road Dike, which will be approximately 12 feet and represents the most severe storm that could occur before the dike would be overtopped. This event would have a return frequency of approximately 1500 years and less than a 0.07 percent chance of occurring in any given year. Under this very extreme and unprecedented condition, the maximum high tide in the Lower Herring River would be 8.8 feet, still 0.7 feet below the crest of the new Mill Creek Dike. This analysis ensures that impact mitigation measures would remain effective against tidal flow impacts resulting from even the most extreme storm events that could be expected into the foreseeable future.

The Woods Hole Group hydrodynamic model also applied guidance provided by the USACE (USACE 2009, 2011) for projecting additional impacts resulting from various degrees of sea level rise over the next 50 years. The most extreme scenario would increase mean high water in the Lower Herring River from 4.3 to 4.6 feet by 2060 with the restoration project fully implemented. Although these are stillwater elevations during normal daily tidal exchange and increased storm effects are not explicitly accounted for, this analysis, combined with the extreme coastal storm modeling described previously, indicate that the amount of freeboard incorporated into the design of tidal impact mitigation structures is sufficient to ensure continued protection against surface water impacts at least within the next 50 years under the most severe sea level rise scenario analyzed.

The longer term effects of climate change and sea level rise, beyond 50 years, are more uncertain, difficult, if not impossible, to analyze, and potentially much more severe. A recent study released by the Massachusetts Coastal Zone Management (CZM) Program makes a compelling argument that sea level along the Massachusetts coast could increase by 4 to 6 feet by 2100 (Massachusetts CZM, “Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning,” 2013). However, within the 50-100 year time frame when sea level rise impacts are projected by some to become severe, future managers and stakeholders for the Herring River will need to revisit the tide control infrastructure and mitigation measures constructed as part of the currently proposed restoration project. Dikes, tide gates, and other project elements will require maintenance and possibly replacement or modification. At that time, planners will need to assess the condition of the estuary, the tidal regime of Wellfleet Harbor and Cape Cod Bay, and other related factors and plan for a course of action that continues to support the ecological health and function of the Herring River while also protecting vulnerable private property and public infrastructure. This may include mitigating and/or adapting to severe sea level rise.

It is important to note that potential increases in sea level to the extent suggested by the Massachusetts CZM report and others will have effects that greatly alter the entire Cape Cod groundwater and surface water system independent of the physical status of dikes, bridges, and water control structures in the Herring River. These effects are outside the influence and scope of the restoration project and include a higher groundwater table, increased surficial freshwater discharge into the river, and the potential for overwash of storm surges at several points including the Chequessett Neck Road Dike, Duck Harbor, Bound Brook and Powers Landing.

Although sea level rise is a global issue of huge magnitude, the impact of it and its associated effects on Wellfleet Harbor and the Herring River would be diminished by the restoration project. If overwash or increased freshwater flooding were to occur, the duration of any impact would be greatly reduced with the rebuilt and much larger Chequessett Neck dike in place compared to the flow restricted and very limited drainage capacity that currently exists in the system. In addition, as previously described, modern, well-designed, and properly monitored tide control and mitigation infrastructure will be in place. As a result of tidal restoration, the return of native salt marsh vegetation and other components of the estuarine ecosystem will provide a resilient buffer to more frequent storms. This will allow most of the Herring River estuary to perform its vital function as a coastal flood plain, while current land use continues.

4.10.6 Low-lying Roads

Several roadways have been constructed within and adjacent to the Herring River flood plain (see figure 3-28 in chapter 3). Roads built prior to construction of the Chequessett Neck Road Dike were presumably built higher than the high tide line but are now below this elevation because of marsh subsidence and would be vulnerable to flooding by restored tidal exchange. The tidal range restriction imposed by construction of the dike in 1908 allowed other road segments to be constructed or improved for automobile use at low elevations. These low-lying road segments would need to be addressed prior to tidal restoration to avoid flooding, erosion, and other impacts.

Low-lying road segments within the project area were inventoried and surveyed in 2007 (ENSR 2007a). The inventory included both paved roads frequently used by vehicles and sand or fire roads which today serve primarily as walking paths or provide access to relatively remote areas. The roads included in this analysis are listed in table 4-24. Output from the hydrodynamic model was used to compare potential high tide elevations resulting from each of the action alternatives to determine the extent of possible flood impacts. This comparison was then used to develop conceptual plans for road surface elevation and realignment options for several high road segments (CLE 2011). In addition, conceptual plans for High Toss Road flood proofing options are also summarized (The Louis Berger Group, Inc. 2010), as are potential flooding impacts to other road segments throughout the flood plain.

TABLE 4-24: SUMMARY OF LOW ROAD IMPACTS

Road Name	Approximate Lowest Elevation (ft NAVD)	Maximum Length Affected (ft)	Impacts of Alternative B	Impacts of Alternative C	Impacts of Alternative D	Potential Flood Proof Solution(s)/Comments
Paved Roads						
Bound Brook Island Road/Old County Road	2.3	3,700	Flooded at MHW and above	Flooded at MHW and above	Flooded at MHW and above	Elevate, possibly relocate some sections; also replace two culverts
Pole Dike Creek Road	2.7	3,105 (two segments)	Flooded at MHW and above	Flooded at MHW and above	Flooded at MHW and above	Elevate, possibly relocate some sections; also replace culvert
Duck Harbor Road/Griffin Island Road	5.5	1,284 (two segments)	300 ft flooded by coastal storm driven tidal event	All flooded by coastal storm driven tidal event	All flooded by coastal storm driven tidal event	Elevate or accept minimal risk
Old Chequessett Neck Road (Snake Creek Rd)	5.4	703	Not affected	Not affected	Adjacent area flooded by coastal storm surge	Elevate or accept minimal risk
Old County Road (Paradise Hollow), Wellfleet	3.2	289	Flooded at AHW and above	Flooded at MHWS and above	Flooded at MHWS and above	Elevate and replace culvert
Old County Road (Lombard Hollow), Truro	3.5	197	Not affected	Flooded at AHW and above	Flooded at AHW and above	Elevate and replace culvert
Old County Road (Prince Valley), Truro	4.0	119	Not affected	Flooded by coastal storm driven tidal event only	Flooded by coastal storm driven tidal event only	Elevate and replace culvert
Maximum length of affected paved roads		9,397	7,394	8,694	9,397	

Road Name	Approximate Lowest Elevation (ft NAVD)	Maximum Length Affected (ft)	Impacts of Alternative B	Impacts of Alternative C	Impacts of Alternative D	Potential Flood Proof Solution(s)/Comments
Sand/Fire Roads						
Duck Harbor Road, Fire Road West of Herring River	4.0	4,574	• < 10% flooded at MHW • 10–25% flooded at MHWS • 25–50% flooded at AHW • 50–75% flooded at coastal storm driven tidal event	> 75% Flooded at MHWS and above	> 75% flooded at MHWS and above	• Elevate sections • Relocate to adjacent upland • Accept minimal risk
High Toss Road, from Pole Dike Rd to Snake Creek Rd.	4.0	3,299	• < 10% flooded at MHW • 10–25% flooded at MHWS • 25–50% flooded at AHW • 50–75% flooded at coastal storm driven tidal event	> 75% flooded at MHWS and above	> 75% flooded at MHWS and above	• Elevate sections • Relocate to adjacent upland • Accept minimal risk
High Toss Road, causeway across flood plain	3.1	1,017	Flooded at MHW and above	Flooded at MHW and above	Flooded at MHW and above	• Elevate • Remove • Culvert to be removed or enlarged
Snake Creek Road (Rainbow Lane)	4.0	992	• < 10% flooded at MHWS • 10–25% flooded at AHW • 25–50% flooded at coastal storm driven tidal event	> 75% flooded at MHWS and above	> 75% flooded at MHWS and above	• Elevate sections • Relocate to adjacent upland • Accept minimal risk

Road Name	Approximate Lowest Elevation (ft NAVD)	Maximum Length Affected (ft)	Impacts of Alternative B	Impacts of Alternative C	Impacts of Alternative D	Potential Flood Proof Solution(s)/Comments
Mill Creek Lane	5.5	395	100 ft flooded at coastal storm driven tidal event	Not affected	100 ft flooded at AHW; All flooded at coastal storm driven tidal event	• Elevate sections • Accept minimal risk
Ryder Beach Road, Truro	4.0	176	Not affected	Affected by coastal storm driven tidal event only	Affected by coastal storm driven tidal event only	• Elevate • Accept minimal risk
Ryder Beach Road, Truro	4.0	118	Not affected	Affected by coastal storm driven tidal event only	Affected by coastal storm driven tidal event only	• Elevate • Accept minimal risk
DPW Yard Driveway	5.0	101	Not affected	Affected by coastal storm driven tidal event only	Affected by coastal storm driven tidal event only	• Elevate • Accept minimal risk
Ryder Beach Road, Truro	4.0	55	MHW and above	MHW and above	MHW and above	• Replace culvert • Elevate
Maximum length of affected sand and fire roads		10,727	10,332	10,332	10,727	
Maximum Length of All Affected Roads		**20,124**	**17,726**	**19,026**	**20,124**	

Impacts of Alternative A: No Action

Present road conditions would persist under the no action alternative. None of the roads are currently known to have serious flooding issues.

Impacts Common to All Action Alternatives

Under the action alternatives, several segments of roadways occurring at very low elevations would be flooded to varying degrees during most tidal cycles unless actions are taken to protect them.

Bound Brook Island Road

Bound Brook Island Road is the most extensive stretch of paved road which would be vulnerable to flooding if it remains at its present elevation. The low-lying portion is approximately 3,700 feet long, extending from Pole Dike Creek Road and the intersection of Pamet Point and Old County Roads (see figure 3-28 in chapter 3). The lowest elevation of the road, which is near the Herring River crossing, is approximately 2.3 feet. The road also crosses Bound Brook. Culverts at both of these crossings may need to be enlarged to promote tidal exchange. Under any of the action alternatives, Bound Brook Island Road would begin to flood when high tide reaches approximately 2.5 feet in the Middle Herring River sub-basin and would be affected during most tide cycles at mean high water when tide gates reach their maximum opening size. To prevent flooding, the low segment of Bound Brook Island Road would have to be elevated above the maximum high tide. This would require widening the base of the road, depositing fill, and regrading the road surface to the required design elevation, which would differ by approximately one foot between alternatives B, C, and D. To minimize the length of road requiring fill and an increase in elevation, some portions of this road segment could alternatively be rerouted onto the abandoned railroad right-of-way nearby, although traffic and engineering studies and securing land rights to the right-of-way would be required to fully implement this option.

Pole Dike Creek Road

Pole Dike Creek Road is the second longest stretch of paved road which would be vulnerable to flooding if it remains at its present elevation. The low-lying portions total approximately 3,105 feet, in two segments extending from West Main Street to Bound Brook Island Road (figure 3-28 in chapter 3). The lowest elevation of the road is approximately 2.7 feet, occurring near the Herring River crossing. The culvert at this crossing may need to be enlarged to enhance tidal exchange. Under any of the action alternatives, Pole Dike Creek Road would begin to flood when high tide reaches approximately 3 feet in the Lower Pole Dike Creek sub-basin and would be affected during most tide cycles at mean high water when tide gates reach their maximum opening size. To prevent flooding, the low portions of the road would have to be elevated above the maximum high tide. This would require widening the base of the road, depositing fill, and regrading the road surface to the required design elevation, which would differ by approximately one foot between alternatives B, C, and D. To minimize the length of road requiring fill and an increase in elevation, some portions of Pole Dike Creek Road could alternatively be rerouted onto the abandoned railroad right-of-way nearby, although traffic and engineering studies and securing land rights to the right-of-way would be required to fully implement this option.

High Toss Road

Approximately 1,000 foot of High Toss Road crosses the Herring River flood plain from Snake Creek Road (a/k/a Rainbow Lane) to its dead end on Griffin Island. This section of High Toss Road is within the Seashore boundary, owned by the NPS with access rights granted to the public, and is an unpaved sand berm used primarily as a fire road and for recreational access to Griffin Island. The lowest elevation of the road segment is approximately 3.1 feet, occurring near the Herring River crossing. The 5-foot diameter culvert at this crossing must be removed or enlarged to restore tidal exchange. Under any of the action alternatives, this section of High Toss Road would begin to flood when high tide reaches approximately 3.5 feet in the Lower Herring River sub-basin and would be completely inundated during most tide cycles at mean high water when tide gates reach their maximum opening. To prevent flooding, given its relative lack of use and that it is a dead end, the road could be left at the same elevation and stabilized by armoring the side slopes and top so that it could withstand periodic flooding, or be decommissioned and completely or partially removed. Removal of the road would prohibit vehicular access, while allowing restoration of salt marsh within the road foot print. If High Toss Road is completely removed, pedestrian and bicycle access to Griffin Island could be maintained by constructing a boardwalk across the marsh; however, such a project is not currently proposed in this final EIS/EIR, although a study to identify and evaluate options was undertaken in January 2015. Impacts to the remaining section of High Toss Road, between Pole Dike Creek Road and Snake Creek Road (a/k/a Rainbow Lane) and other impacts to low roads are summarized in table 4-24. Impacts to wetlands and construction-related impacts associated with flood proofing these roads are addressed in section 4.11.

Comparison of Impacts

There are several other shorter segments of roadways throughout the project area which could also be affected by tidal restoration (see table 4-24). The majority of these roadways are built at higher elevations or occur along the periphery of the project area and thus would be impacted to varying degrees depending on which project alternative is implemented. Some of the roads are seasonal sand/fire roads which could be relocated, abandoned or allowed to be affected by the tides. These road impacts, and those previously described, are summarized in table 4-24.

Mitigation of Low-lying Road Impacts

As discussed above in section 4.10.5, the restoration project partners are committed to addressing and mitigating potential impacts low-lying structures and roads resulting from the restoration of natural tidal flow. Some of the options available for low lying roads include raising or relocating or elevating affected roads or driveways, enlargement of culverts, and/or limiting water levels across entire sub-basins. The cost of these impact mitigation measures will be borne by the project. Water surface elevations within any sub-basin will not be increased until the necessary impact mitigation is in place.

Any mitigation measure implemented as part of the Herring River project will be designed to prevent adverse impacts of restored tidal flow to low-lying structures and roads that have been constructed within the historic Herring River flood plain. This includes the CYCC golf course, several private residential properties, and approximately 4,000 linear feet of public and private roadways discussed above.

Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on low-lying roads.

4.10.7 VIEWSCAPES

As discussed in chapter 3, published literature and property tax assessment records show a clear positive correlation between higher property values and viewscapes of open water, tidal wetlands, and other dynamic water environments. Additionally, there is evidence that property values increase with proximity to wetlands and water features. The Town of Wellfleet Assessor's Office values water-influenced properties 2.2 times higher than comparable woodlot properties (Vail pers. comm., 2011). Although the magnitude and applicability of this correlation for specific properties depends on many site-specific variables, it is generally assumed that the values of properties in close proximity and within the viewshed of the Herring River flood plain may be increased by the open views, proximity to tidal habitats, and other aesthetic changes that will result from the restoration project.

For this analysis, the mean high spring tide level was used to approximate changes in vegetation across the alternatives. A map (see figure 4-10) was developed that estimates the maximum extent of non-wooded areas (white areas) after full tidal restoration is achieved, although the exact extent of conversion of wooded areas to more open viewscapes is not known due to a broad range of vegetation types within the transition and intertidal zones that could occur in the upper reaches of the sub-basins.

Impacts of Alternative A: No Action

The current natural features and landscape character, and therefore viewscapes, would not change under the no action alternative.

Impacts Common to All Action Alternatives

Under all action alternatives, there would be long-term viewscape benefits resulting from expanding intertidal habitat and open vistas. Inter-tidal habitats would vary by basin, but would be mostly open water, broad salt meadows, and salt water marshes, and may also include tidal brackish marsh, tidal fresh marsh, and wet shrublands. More native wildlife may also be observed under all action alternatives.

Long-term viewscape improvements would include the ability to observe broad expanses of salt marsh and meadows. Wooded areas within the flood plain would decrease, reducing obstructions to viewscapes across meadows, marshes, and open water. Fringing shrublands or woodlands in transitional or nontidal zones and stands of tall common reeds along the perimeter or upper reaches of the basins might continue to obscure views in some areas. Temporary adverse visual impacts may be caused by the presence of standing dead woody vegetation, including shrublands and woodlands. Reduction of dead vegetation from the landscape would be a function of both decomposition and adaptive management measures, such as physically removing it from the flood plain (see section 4.5).

Comparison of Impacts of the Action Alternatives

Figure 4-10 depicts the change in wooded areas after restoration. The green in the figure represents forest and shrubland land covers, which would be replaced by intertidal habitat dominated by salt marshes, meadows, and open water.

As previously mentioned, the Town of Wellfleet assesses water-influenced properties at higher values than comparable woodlot properties. It is possible that some frequently inundated woodlot properties and possibly infrequently inundated woodlot properties would be considered water-influenced after restoration, increasing their property values.

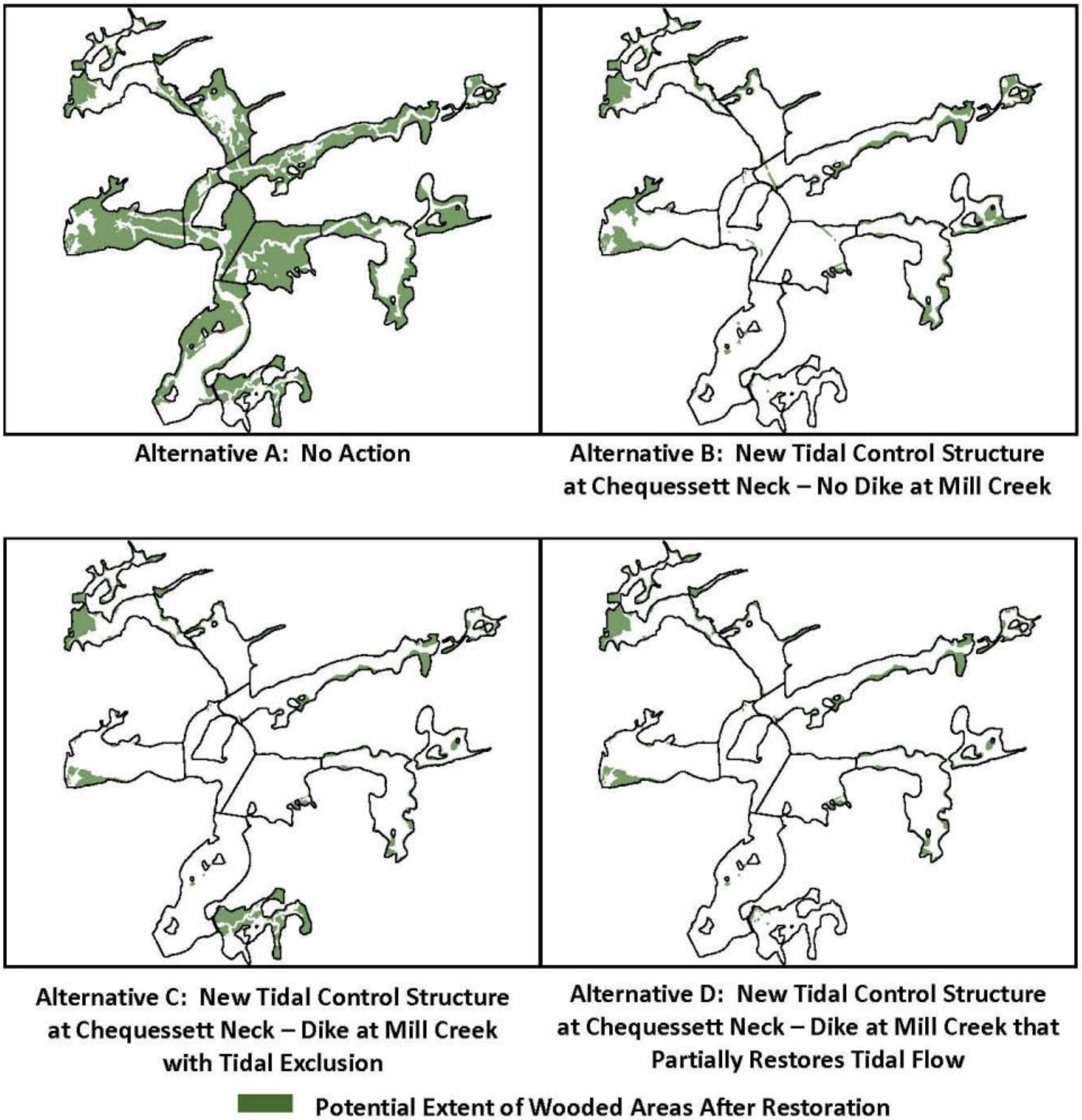


FIGURE 4-10: COMPARISON POTENTIAL EXTENT OF WOODED AREAS AFTER RESTORATION BY ALTERNATIVE

As figure 4-10 suggests, all action alternatives would likely improve a significant number of property viewsheds compared with the no action alternative. Of the action alternatives, alternative D would result in the greatest change to view-obstructing vegetation and therefore would result in the most improvement to viewsheds. Alternatives B and C are qualitatively different in that alternative C involves no improvement to Mill Creek sub-basin while alternative B has more limited improvement to all other sub-basins. The relationship to property values is assumed to be related to open viewsheds and water-influence on property. Therefore alternative D is assumed to have the greatest positive impact on property values; the difference between alternatives B and C is not readily assessed.

Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on viewscapes.

4.10.8 Recreational Experience and Public Access

Numerous opportunities for public recreational activities, such as canoeing/kayaking, fishing, and wildlife viewing currently exist in the Herring River flood plain. Some of these access points are located just at the water's edge and could be affected by high tides and coastal flooding events as tidal influence is restored to the estuary. The public access and recreational experience analysis relies in part on an inventory of existing recreational access sites conducted from October 2009 through December 2009 by Seashore and Town of Wellfleet staff. The inventory identified 41 public use areas currently used within the Herring River flood plain (see table 4-25). Identified public use areas include parking areas, canoe and kayak launches, hunting access areas, walking routes, and scenic landmarks along the river. Hydrodynamic modeling output was then used to determine if any of these sites would be affected by the action alternatives. Additionally, there are management zones within Cape Cod National Seashore. These zones are divided into four classes: natural, historic, developed, and special use. The following public use areas within table 4-25 fall within one of these four zones (NPS 1998).

Table 4-25: Public Use Areas within the Herring River Flood Plain

Location Description	Notes
High Toss Parking Area	4 parking spaces
High Toss Culvert	Used as canoe crossing
Social trail from High Toss parking area to Duck Harbor	An alternate route- trail used to avoid N. section of Duck Harbor Rd. that is now overgrown
Social trail off Duck Harbor Rd.	On the left at end of High Toss
Vehicle access trail off Duck Harbor Road	On right off Duck Harbor Rd.
Duck Harbor Rd./Chequessett Neck Rd. Parking Area	2 parking spaces
Public Landing off Chequessett Neck Rd.	Approximately 94 feet of parking area; access to Great Island hikes
Chequessett Neck Dike (west)	Fishing spot
Chequessett Neck Dike (east)	Fishing spot
Great Island Parking Lot	40 parking spaces; 2 portable toilets
Tomb of Unknown Indian Woman	At head of stairs from Great Island parking lot
Sunset Point (Adjacent on northside of Great Island Parking Extension)	22 parking spaces in extension parking
Duck Harbor Parking Lot	45 parking spaces
Fire Road off of Griffin's Island Road	
2nd Fire Rd. off of Bound Brook Island Road/Merrick Island	3–4 parking spaces; road leads to bridge over Herring River
Bridge over Herring River	
1st Fire Rd. off of Bound Brook Island Road	3–4 parking spaces

Location Description	Notes
3rd Parking Area at base of Bound Brook Island	2–3 parking spaces; next to Herring River
Bound Brook Island Beach	3–5 parking spaces
Bench up dune from Bound Brook Island Beach Parking Area	Possibly new bench
Railroad Bed off Bound Brook Island Road	
1st Trail on Bound Brook Island Road (Beyond Merrick Island)	1–2 parking spaces
Parking Area (Beyond Old County Sign, north of Pamet Pt. Rd.)	1–2 parking spaces; used for hunting access
Lombard Hollow	
Fire Road that connects Old Railroad Bed to Old County Rd. (Truro)	
Lombard Hollow Dead End	
River Crossing on Lombard Hollow	
End of Railroad Bed (Truro)*	
Access to Old Railroad Bed (S. Truro)	
Viewing Spot over Old Railroad Bed	Good view of flood plain and ocean
Fire Road on Pamet Point (next to Le Hac House)	On the north side of the road
Ryder Pond Parking on Elsies Road	3 parking spaces
Ryder Pond	Access for kayaks, canoes, swimmers
Old King's Highway and Herring River Crossing	South of Black Pond Road
Herring Pond Public Landing	Signs saying "private"; 6-8 parking spaces
Slough Pond Triangle	6–8 parking spaces
Herring River Crossing at Higgins Pond/Herring Pond	
Parking west of Higgins Pond/east of Herring Pond	2 parking spaces
Parking spot east of Herring Pond	1 parking space
Sluiceway Herring/Gull Pond	2 parking spaces; popular fishing spot
Gull Pond Landing	Access for kayaks, canoes, swimmers; large parking area

* Only the End of Railroad Bed is located outside of Cape Cod National Seashore. All other locations are located within the national seashore.

Impacts of Alternative A: No Action

Under alternative A, public access points would remain unaffected and visitors could continue to utilize the sites for recreation. The physical character of the estuary and its impacts on the experience of canoeing, kayaking, and other non-motorized boating would continue unchanged over time, with generally unabated passage along the main channel and difficult boat access at the periphery due to the presence of denser vegetation in tributaries and in the upper basins. Water quality in the Herring River estuary would remain impaired and in non-compliance with Massachusetts Surface Water Quality Standards. Under these conditions, the quality of recreational experience would remain compromised and recreational visitation would be anticipated to remain at current levels.

Impacts Common to All Action Alternatives

Under the action alternatives, some low-lying recreational access areas currently at the water's edge could be impacted by high tides and coastal storm events. While there would be short-term impacts on certain sites during the initial phases of restoration, over the long term these river access sites could be replaced by other more suitable access points in response to the changing dynamics of the estuary system.

Of the 41 sites documented, a majority of existing access points will remain unaffected by higher tide ranges in the estuary (eight of the sites are east of Route 6). The public use sites located closest to the river's edge (including the sites off High Toss Road and Duck Harbor Road as well as the old rail road bed and fire roads off Bound Brook Island Road and through Lombard Hollow) may require slight reconfiguration to accommodate their continued use and to ensure that there is no net loss in public access points. Many of these areas are important to the residents and visitors of Wellfleet who have come to rely upon these lands for hiking, biking, hunting, wildlife viewing, and small boat launching. Specific provisions for parking and other recreation infrastructure will be integrated into the design process for the various construction components of the project, such as the rebuilding of Chequessett Neck Dike, the removal of High Toss Road, and the elevation of other low-lying roads.

It is also apparent that restoration would require a reconfigured tide control structure over the Herring River on Chequessett Neck Road. Presently a number of people use the buttresses of the existing tide control structure for fishing. Maintaining this use in the future is important to the Town of Wellfleet and will be included in the design of any new structure.

Links have been established between improvements to environmental conditions in estuaries and the quality of recreational experience in the form of recreational fishing success, wildlife viewing, and visitor attendance (Pendleton 2008). Under the action alternatives, closed recreational shellfishing areas would likely be opened due to water quality improvements downstream and potentially upstream of the dike. Recreational finfishing would improve in terms of fishing success rates and the types of fish that are caught.

Opportunities for wildlife viewing would be enhanced over the long term as a result of the more expansive views in the upper basins after woodlands are removed. While some river access points would be relocated from their present positions, there would be no net loss in public access and opportunities for visitor experience during all phases of restoration. Recreational boating access would improve along the periphery, on tributaries, and in upper basins that are now too thickly vegetated to pass a canoe/kayak. In general a more natural, tidally influenced environment should improve recreation aesthetics for all types of visitors.

Comparison of Impacts of the Action Alternatives

All action alternatives would improve recreation access and quality as compared to the no action alternative. The primary distinction among the action alternative is that conditions for recreation would not be improved in Mill Creek under alternative C.

Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on recreational experience and public access.

4.10.9 REGIONAL ECONOMIC CONDITIONS

The regional economic impact assessment of the HRRP is based on projected employment associated with construction and restoration activities. This approach utilizes employment estimates associated with coastal habitat restoration as described in a report by Restore America's Estuaries, "Jobs and Dollars: Big Returns from Coastal Habitat Restoration" (RAE 2011). These jobs figures are supported by two reports, one by the Department of the Interior and one by National Oceanic and Atmospheric Administration (NOAA), which have estimated the economic impact associated with restoration projects and other American Recovery and Reinvestment Act of 2009 investments (NOAA in press; DOI 2009).

Direct jobs include those in construction and engineering. Indirect jobs are jobs in industries that support construction activities, such as lumber yards, concrete plants, and fuel suppliers, etc. Induced jobs are those that are supported by the direct and indirect workers spending their money in the economy. The abovementioned reports estimate that between 20 and 32 direct, indirect, and induced jobs (full-time employment equivalent) for every $1 million invested in coastal habitat restoration construction activities. Direct jobs would be experienced in those areas within close proximity to the Seashore. Indirect and induced growth would be experienced in the local area as well as the larger region.

Impacts of Alternative A: No Action

There would not be any project expenditures under this alternative. Current regional economic conditions and trends are expected to continue into the future under this alternative.

Impacts Common to All Action Alternatives

All action alternatives would benefit regional economic conditions through considerable engineering, construction, and construction-related spending that will support jobs and increase economic activity. Project spending elements under all of the action alternatives include

- Replacing culverts along High Toss, Pole Dike and Bound Brook Roads;
- Flood proofing High Toss, Pole Dike Bound Brook, and Old County Roads;
- Flood proofing certain low-lying properties;
- Rebuilding Chequessett Neck Road Dike;
- Vegetation management;
- Engineering, design, and permits; and
- Post-construction monitoring and assessment.

Comparison of Impacts of the Action Alternatives

In addition to the elements outlined above, alternatives B and D include costs to either move or flood proof the CYCC's low fairways and flood proof other low-lying properties within the Mill Creek sub-basin, while alternatives C and D also include the costs of constructing the Mill Creek Dike. Under alternative C, no flood proofing would occur at specific Mill Creek properties. Rough estimates of construction spending for the action alternatives range from $40 million (for alternative C) to $48 million (for alternative D option 1).

It is likely that these construction activities would be undertaken with both local and non-local workforces. Restoration construction spending has been shown to stay within the county (80 percent) and the state (90 percent) (Moseley and Nielsen-Pincus 2010). However, more technical aspects of the project, such as those related to engineering for dike reconstruction, may require companies and expertise from outside the region. This may include the temporary relocation of skilled workers (and equipment) during the project.

Cumulative Impacts

Based on the cumulative impact scenario, there are no other actions that are expected to have cumulative impacts on regional economic conditions.

Conclusion

While the primary changes associated with all action alternatives are physical environmental changes associated with the restoration of a functioning estuarine wetland, there are also diverse socioeconomic impacts related to the following topics: nuisance mosquitoes, shellfishing, finfishing, low-lying properties, low-lying roads, viewscapes, recreational use and experience, and regional economic conditions. Considered in the aggregate, nuisance mosquitoes, shellfishing, finfishing, viewscapes, recreational use and experience, and regional economic conditions should be affected beneficially, while low-lying properties and low-lying roads are expected to suffer adverse impacts.

Reducing mosquito breeding areas was the main objective of building the Chequessett Neck Road Dike in 1909. Instead, it led to a replacement of salt marsh mosquito species with generalist and freshwater species. All action alternatives would restore estuarine conditions that are expected to reverse this species shift. Some existing marsh surface damage from subsidence and ditching could create stagnant mosquito breeding pools. However, because drainage would be improved in most parts of the estuary, and due to better control methods for salt marsh species, nuisance mosquito production is expected to be beneficially reduced under all action alternatives. Shellfishing would also be benefitted under all action alternatives, which should lead to newly opened aquaculture areas and better shellfish yields. Concerns that newly mobilized sediment could smother some cultured shellfish beds are not supported by sediment transport models; long-term monitoring will detect sediment deposition in these areas and allow for mitigation. Finfishing would also improve under all action alternatives by increasing fish habitat, fish populations, and fish species diversity. Viewscapes are expected to improve as wooded areas give way to open views of water and restored estuarine wetland. Alternative D is expected to have the most substantial beneficial impact on views, and potentially on property values. Recreation access may change as some existing access points for boaters and fishermen are lost, but new access points are created. Overall, the quality of recreational activities is expected to improve. Finally, construction spending is expected to generate some temporary benefits to employment and consumer spending that would be experienced locally and to a lesser extent regionally.

In terms of potential adverse impacts, restored tidal exchange could expose several dozen low-lying properties to some form of inundation, ranging from occasional exposure of naturally vegetated lands to storm tides or annual high tides to frequent flooding of structures such as buildings, driveways, wells, and septic systems. In total, it is expected that not more than approximately 20 properties would contain a structure that might be occasionally affected. A variety of preventative mitigation measures could be undertaken, including elevating or relocating driveways and landscaping, moving wells, building small berms or flood walls, or moving or elevating structures. It is expected that most potential flood effects could be resolved with these preventative mitigation measures. Where flood effects cannot be prevented, there would be options for compensatory mitigation such as acquiring flood easements or fee ownership, or compensating for lost value. Alternatives B and D would also require that five golf holes on the CYCC golf course be elevated above high tides or be relocated to an adjacent upland area on the CYCC property. A number of low-lying roads would be affected in a like manner, requiring elevation or relocation to remain above flood waters. Alternately, some less important roads could be permitted to be occasionally flooded or could be permanently closed if elevation or relocation was not thought to be warranted. Under the action alternatives, the length of affected roads would range from 17,726 feet (alternative B) to 20,124 feet (alternative D).

In the broad view, the socioeconomic benefits of all the action alternatives would be experienced by a broad cross-section of residents and visitors to the local area in the form of improved social and economic conditions. While the individual impacts of each of the sub-topics discussed above are relatively minor, in the aggregate, considering the permanent nature of these benefits and the wide range of people that would be affected, these impacts could be considered significant at the local level. In a regional context these benefits would be less significant. The adverse socioeconomic impacts, in contrast, are highly site-specific, affecting particular properties and roads and the people who own or use them. In the absence of any effort to mitigate these impacts, they could constitute a significant adverse impact on a relatively small number of individuals, who could lose certain uses of a private property or lose road access to a private property or public use area. For this reason, mitigation measures will be undertaken to resolve the most significant potential adverse impacts on low-lying properties and roads.

4.11 CONSTRUCTION IMPACTS OF THE ACTION ALTERNATIVES

As described in chapter 2, each of the action alternatives includes construction of one or more dikes and adjustable tide gates to control tidal exchange in the Herring River flood plain, relocation or elevation of several road sections, installation of new culverts at road crossings, and relocating or filling in place portions of the CYCC golf course. Secondary management actions, such as clearing of woody vegetation and channel dredging, would also incur construction-related impacts. These are examined at the end of this section.

Along with the persistent, long-term, and mostly gradual impacts resulting from the incremental reintroduction of tidal exchange to the Herring River, the various restoration actions described as components of all action alternatives would incur short-term impacts during actual construction and, in some cases, would require direct, permanent adverse impacts to wetlands or other jurisdictional resource areas within or adjacent to construction areas. Impacts associated with each construction element are described below. Permitting considerations for these impacts are discussed in chapter 5.

Construction activities would result in soil disturbance and loss of vegetative cover in the construction area. This disturbance could lead to temporary adverse impacts to water quality during stormwater runoff events. However, 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.

Chequessett Neck Road Dike

Under any of the action alternatives, the Chequessett Neck Road Dike would be reconstructed to provide a 165-foot wide by 10-foot high opening with adjustable tide gates. This would be achieved by construction of pre-stressed box beam bridge/dike structure, as described in chapter 2.

Generally, reconstruction of the dike would incur temporary impacts to a construction foot print of approximately 103,200 square feet (2.4 acres) currently comprised of the dike itself and adjacent inter- and sub-tidal wetland areas. Dike reconstruction and associated dewatering, sub-grade preparation, slope protection, and other work is expected to be confined to this footprint. Impacts could include temporary loss of wetland habitat and short-term increased sedimentation of adjacent waters. However, impacts are expected to be minimal, as BMPs, including the use of erosion control measures and the maintenance of freshwater flow during dewatering will be required during construction activities. The site would recover quickly after construction is completed.

Construction Staging Areas

As part of the 25 percent engineering design process, several areas potentially suitable for staging, laydown, and storage during construction of the Chequessett Neck Road Dike were identified. These consist of several previously disturbed, currently paved roads and parking areas and an undisturbed area immediately adjacent to the Griffin Island side of the construction area (figure 4-11).

Using the adjacent undisturbed area could likely help the project avoid construction delays and cost overruns by providing contractors with a nearby and large area for equipment and material storage. Close proximity to the staging area would also reduce harm to the environment by limiting trucking and movement of supplies. Other areas, though previously disturbed and paved, are smaller and between approximately 0.3 and 1.3 miles from the construction site, making their use for primary staging unpractical and inefficient. Using the undisturbed location for staging would require clearing up to approximately two acres of upland vegetation and grading to create a flat area. The area is adjacent to the Herring River flood plain and associated wetland areas, however disturbance within any jurisdictional resource areas and buffer zones will be avoided and erosion and sedimentation controls will be used to prevent run-off.

The preferred staging area is also within a vicinity mapped by Massachusetts NHESP as eastern box turtle habitat as well as areas of potential cultural resource and archaeological sensitivity (Herbster and Heitert 2011). However, the exact location and boundaries of the staging area have not been finalized. It is expected that as designs are advanced and more information about turtle use and cultural resources is developed, the project will be able to work around any archaeologically or ecologically sensitive areas and avoid impacts to these resources. The project will continue to work with Massachusetts NHESP and the State Historic Preservation Officer (SHPO) and Tribal Historic Preservation Officers (THPOs) on this data collection and to ensure that any unavoidable impacts are minimized and mitigated where necessary. Studies for turtle use and cultural resources within proposed staging areas were conducted in the spring of 2015 and all pertinent information will be included in permit applications and other compliance documents expected for submittal in 2016.

The other identified parking areas and road segments may also be used for longer-term staging and storage of materials and supplies not needed on a day-to-day basis during construction. As these areas are previously disturbed and paved, no additional cultural or natural resource impacts are expected. These areas would only be actively used during the vacation off-season and contractors will not place equipment and supplies in locations which could impede normal traffic flow through the area. To the extent necessary, erosion and sedimentation controls will be in place to avoid run-off and impacts to surrounding upland and wetland habitats.

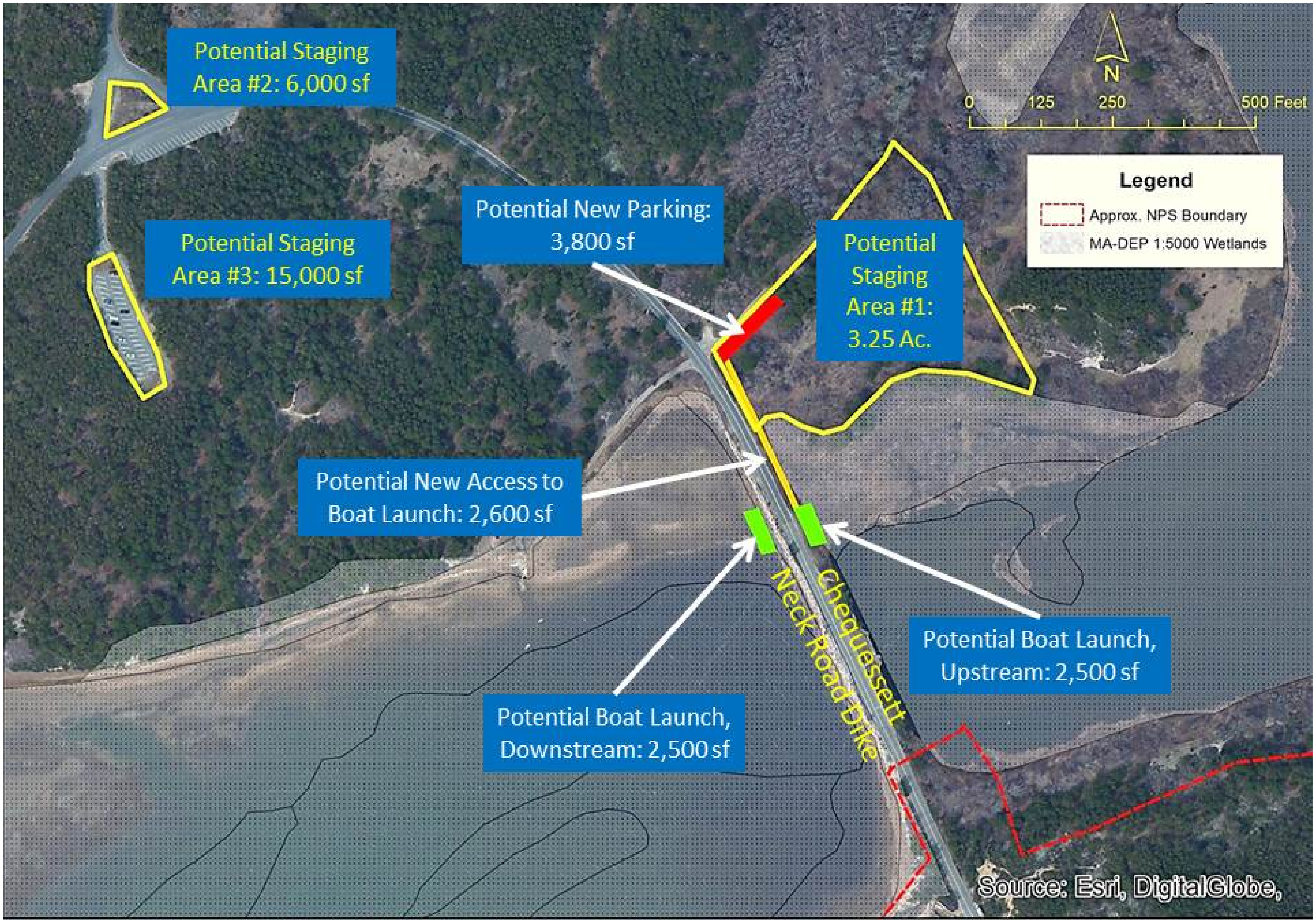


FIGURE 4-11: POTENTIAL CONSTRUCTION STAGING AND ACCESS POINTS FOR THE CHEQUESSETT NECK ROAD DIKE

Potential Long-Term Use of Chequessett Neck Road Dike Staging Area and Adjacent Wetlands for Canoe/Kayak Access

Improvements to recreation, especially with respect to the quality of experience and enhanced access for non-motorized boating (generally canoes and kayaks), is an important objective of the HRRP and a strong community interest. During the development and public review of 25 percent level design plans for the new Chequessett Neck Road Dike, it became evident that new features are likely necessary to facilitate safe and convenient passage of small boats between the downstream side of the dike and upstream areas. Currently, there is a small parking area and launch area on the downstream side of the dike, which provides good access to Wellfleet Harbor, but no access upstream of the dike. Despite this, canoeists and kayakers attempt to carry boats across the dike, requiring climbing over steep riprap embankments and crossing traffic lanes. Passage through any of the existing culverts is not possible due to the restrictive tide gates.

To alleviate this, and to advance the recreational boating objectives for the project, the HRRC is considering several options for a designated hand-carry portage to be incorporated into the design of the proposed new dike. No formal design work has been undertaken, but it is likely this would be located on the northern, Griffin Island, side of the dike near the location of the existing parking and launch area on the downstream side and the proposed staging area on the upstream side (see figure 4-11). On the downstream side, parking access would likely be continued at the current parking area. The existing launch would likely remain, however a portage beginning from this point would require walking and carrying more than 500 feet along a narrow road to reach the upstream side of the dike. A new launch area closer to the dike would reduce the length and increase the safety and convenience of the portage. The latter option would necessarily require some disturbance of wetlands in order to create a new landing. Ramps and stairways would be added along the embankments on both sides of the dike to allow transfer of boats and gear and access between upstream and downstream sections of the river.

On the upstream side, an existing, informal parking area at the end of Duck Harbor Road, currently able to accommodate two cars, is being considered for expansion for a modest increase in parking (no more than 8-10 cars) within a small sub-section of the location to be cleared as a staging area. Of the approximate two acres cleared for staging, only about 500 square feet would be used in the long term for parking, while the remaining area would be restored as closely as possible to the original vegetated condition. The expanded parking area will remain unpaved and informal, in keeping with the rural character of trails and access points in this portion of the Seashore. To provide access to the river, a trail would need to be cleared from the parking area, a length of about 400 feet, requiring disturbance to up to approximately 4,000 square feet of wetlands. The trail would lead to a new boat launch, similar what would be constructed on the downstream side. Each boat launch would require disturbance of up to approximately 10,000 square feet of wetlands.

In summary, the most suitable staging area for construction of the new Chequessett Neck Road Dike would involve up to approximately two acres of upland vegetation clearing and grading, most of which would be restored to close to its original condition. Up to about 500 square feet of this cleared area could be used for in the long-term for informal parking to accommodate car-top launching of canoes and kayaks. A designated small boat portage across the new dike could disturb a total of up to approximately 24,000 square feet of wetlands for new launching areas and trail access from the expanded parking area on the upstream side. Potentially sensitive cultural resources and state-listed rare species habitat occur within the uplands in this location, but project designs could work around these areas and likely avoid all impacts. Detailed information about sensitive resources, impacts, and any required mitigation plans will be included in permitting documents.

Traffic Control During Construction

In the draft EIS/EIR a bypass route along High Toss and Duck Harbor Roads was described to accommodate traffic to and from Griffin Island during construction of the new Chequessett Neck Road Dike. As engineering of the new dike advanced to the 25 percent design stage since release of the draft EIS/EIR in 2012 alternate methods for traffic control during construction were explored. This resulted in development of a construction sequencing strategy that would allow close to normal traffic across the dike throughout the construction period. This makes the bypass route unnecessary and avoids all impacts associated with clearing and grading High Toss and Duck Harbor Roads. Instead, a temporary bridge would be installed adjacent to the construction area on the upstream side of the dike. The bridge would be inside the dewatered area and would not incur any additional wetland or resource area impacts. One-way traffic would be maintained at all times and traffic flow would be regulated by an automated signal system. A cantilevered walkway will be mounted onto the temporary bridge to allow safe pedestrian and bicycle passage across the dike during the construction period. Details and drawings of the traffic bypass plan can be found in appendix K.

Mill Creek Dike

As described in chapter 2, alternatives C and D would require construction of a dike at Mill Creek to control tidal flow within the Mill Creek sub-basin; under alternative C, the Mill Creek Dike would be intended to completely prevent tidal flow into the sub-basin, while alternative D, the preferred alternative, would allow for controlled, two-way tidal flow and eventual restoration of approximately 53 acres within the 80 acre sub-basin. More detail regarding this action is provided in chapter 2, sections 2.3 and 2.5.2. No dike at Mill Creek is required for alternative B.

Based on the current concept design, the earthen berm would be approximately 615 feet long and 48 feet wide at the base. A 12-foot wide roadway would be built along the crest to provide access across the dike for maintenance. This structure would require approximately 29,500 square feet of permanent wetland loss due to placement of fill. Permanent wetland disturbance for the sheet pile wall would be far less, limited to the length of the dike and the several inch thickness of the sheet pile, an area of less than 300 square feet. For this option, however, an area of salt marsh approximately 300 feet long by 12 feet wide would require stabilization to provide occasional vehicle access from the adjacent upland area to the tide gates for maintenance. A cantilevered walkway would be used along the top of the wall to provide access to the tide gate controls. These design concepts are presented in detail in appendix L.

In addition, dewatering and other associated work would require a work area encompassing approximately 105,000 square feet (2.4 acres) of vegetated wetlands; this area would be temporarily impacted. Temporary impacts are expected to be minimal, as BMPs, including the use of erosion control measures and maintenance of freshwater flow, will be required during construction activities. The site would recover quickly after construction is completed and tidal flow is restored.

No matter which option is selected, construction of the Mill Creek Dike will also require impacts for staging areas and access points. Access route options for construction activities and long-term maintenance and operations of the Mill Creek Dike are also under consideration. These are depicted in figure 4-12 and include:

1. Access across currently developed areas within CYCC golf course—This route would traverse approximately 2,235 feet along dirt roads and cart paths of the CYCC golf course. Disturbance would be primarily limited to the active portions of the golf course and thus impacts to natural and cultural resources would be minimal. Approval, coordination, and an access easement with CYCC officials are required for this option.
2. Access from Old Chequessett Neck Road (a/k/a Snake Creek Lane)—Access from the end of Old Chequessett Neck could be gained by clearing an approximately 650 foot long path from the road to the north side construction area. Based on a preliminary desktop analysis and lacking site-specific wetland delineation, this route would require filling a wetland area approximately 12 feet wide by 300 feet long, a total area of about 3,600 square feet. Approval and an access easement would be needed from one or two private landowners to cross from the road to NPS property, on which most of the route would be located.
3. Access from Chequessett Neck Road—If no approvals from private landowners can be secured, access to the south side of Mill Creek Dike construction zone could be provided from Chequessett Neck Road exclusively on NPS land. This would require clearing a 12 foot path for approximately 1,887 feet in presently undisturbed upland habitat. Because the NPS boundary is legislatively mandated to be the 20-foot contour interval through this area, wetlands could likely be avoided while staying within the NPS boundary, however some grading and slope stabilization may be required along steep grades.

Construction staging areas would largely be determined by the final access option. Additional field studies, including cultural resource investigations, engineering design, and consultations with landowners are required to identify the most suitable access and staging locations. This process will continue as designs and plans for permitting of the Mill Creek Dike are advanced in 2015 and 2016.

High Toss Road

As described in chapter 2, several options exist for protecting High Toss Road from increased tidal range, including removal of the 1,000-foot long segment crossing the Herring River flood plain. The draft EIS/EIR included an option to retain vehicular access and elevate it above the reach of restored high tides and widening the base as necessary. After discussions between the town and the Seashore, this option is not favored given the road's relatively light vehicle use, amount of anticipated wetland impacts associated with stabilizing the road (approximately 13,000 square feet), and requirements for long-term maintenance. However, public input is still needed for this decision to be finalized.

Friends of Herring River is currently developing and evaluating options for improving tidal flow through the High Toss Road crossing of the floodplain while also maintaining public access. Alternatives to be considered for the road will include complete or partial removal of the causeway crossing of the floodplain, reusing excavated material to elevate other low portions of this, and possibly other, low roads in the Herring River flood plain, and construction of a boardwalk to facilitate non-vehicular public access. Public access may include pedestrian, bicycle, and equestrian and canoe/kayak access. Options considered for the river crossing will include new box culverts, a bridge, and the feasibility of a naturalized channel. Consideration of options outlined above will be facilitated by a review process to enable the stakeholders to select a preferred option. Upon selection of the preferred option, permit-level design plans will be prepared.

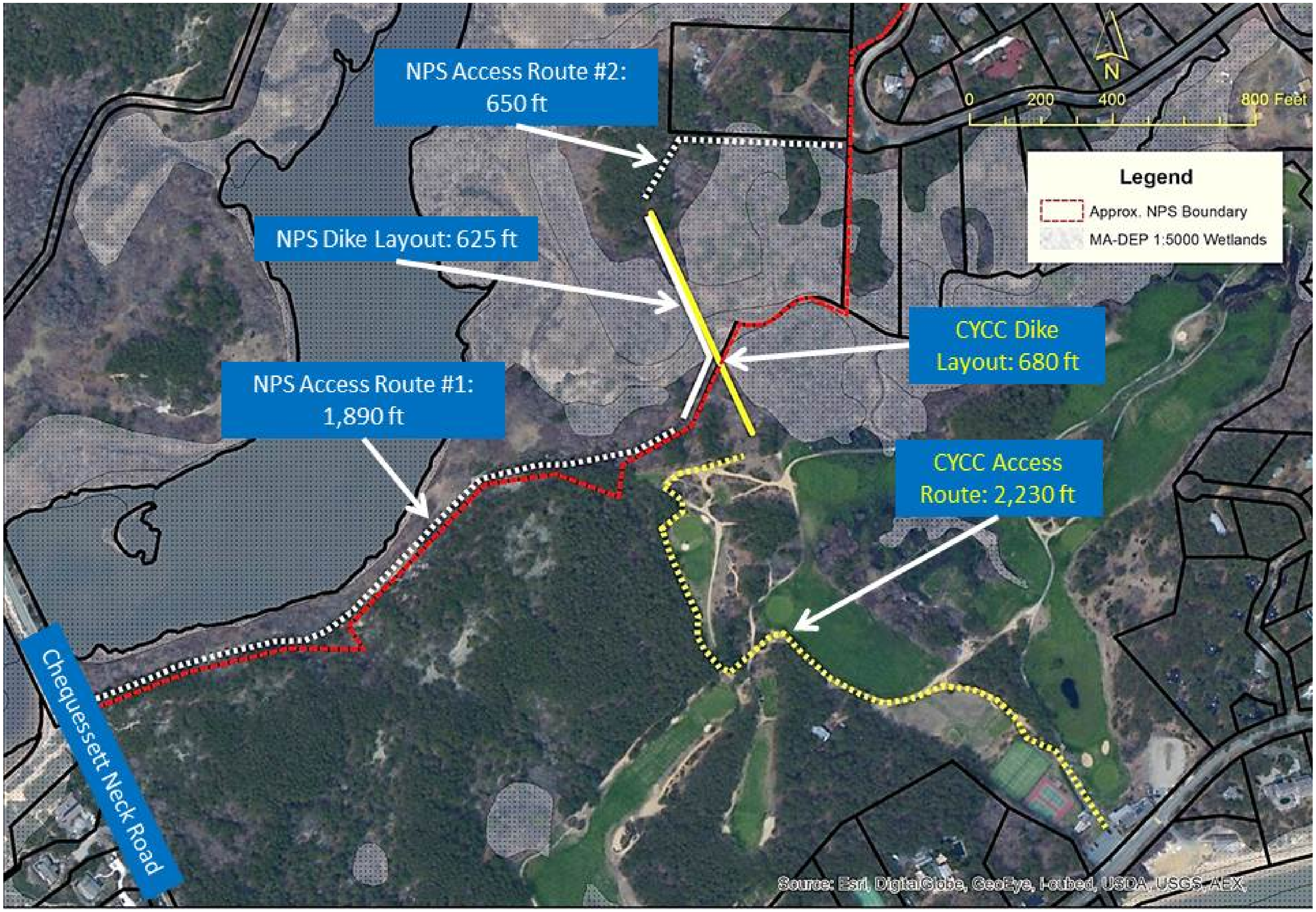


FIGURE 4-12: POTENTIAL CONSTRUCTION STAGING AND ACCESS POINTS FOR THE MILL CREEK DIKE

If High Toss Road were completely or partially removed, up to approximately 12,000 square feet of additional wetland area would be restored. Indirect, temporary impacts associated with the removal or elevation of High Toss Road are expected to be minimal and would be mitigated by employing BMPs such as erosion and sediment control. In addition to replacing the culvert and widening the Herring River channel at High Toss Road, any impacts associated with High Toss Road are independent of which action alternative is implemented.

Pole Dike/Bound Brook Island Roads

Under any of the action alternatives, approximately 4,175 linear feet of roadway segments along these roads could be affected by the highest tide of any given year. An additional 2,000 feet would be impacted by a coastal storm surge. To prevent this and maintain safe travel along these roads they must be elevated above these high tide elevations. In order to properly elevate these road sections, the road base would need to be widened, resulting in direct and permanent loss of vegetated wetlands. Elevating the roads above the coastal storm surge elevation would require filling approximately 4,000 square feet of adjacent wetlands, while protecting against AHW would minimize wetland loss to 2,300 square feet. These impacts were addressed in engineering studies in 2011 and 2015 (see appendix H). Design and preparation of permit-level design plans for roadway elevation is currently underway.

Temporary impacts are expected to be minimal, as BMPs, including the use of erosion control measures and maintenance of freshwater flow will be required during construction activities. The site would recover quickly after construction is completed. Stockpiling, lay-down areas, storage, and field operations will be based in an appropriate upland location nearby.

CYCC Golf Course Flood Proofing

Although under alternatives B and D tidal exchange would be limited within the Mill Creek sub-basin, measures would still be needed to protect the CYCC golf course, and other residential properties, from flooding. As described in section 4.10, two basic options have been discussed to achieve this (relocation vs. elevation of low golf holes). Both of these would incur impacts to wetlands and other regulated areas.

Direct impacts to wetlands would be reduced by implementing the golf course relocation option (Option 1). Under the relocation option, most of the low-lying golf holes would be relocated onto approximately 30 acres of adjacent upland already owned by the CYCC. However, because of its proximity to the club house, the final hole must remain in its current location in a low spot on the CYCC property. In order to maintain playability as tidal range in increased, this hole would need to be filled and elevated, resulting in a loss of about 89,000 square feet (2.04 acres) of wetland. All of this area is currently managed by the CYCC of part of the current course. The relocation option would require extensive archeological investigation over a larger sensitive upland area before land disturbing activities could be undertaken compared to the elevation option. Relocation of low portions of the golf course to higher ground would also result in the conversion of approximately 30 acres of undisturbed pitch pine-scrub oak woodland to managed golf course uses.

For the elevation option (Option 2), approximately 360,000 square feet (8.3 acres) of wetlands would be filled (with 150,000 cubic yards of clean fill) and elevated above the high tide line and regraded as golf holes. The existing layout of the golf course would remain essentially unchanged. The majority of the wetlands to be filled are currently maintained by the CYCC as part of the golf course; however a small portion, approximately 4,800 square feet, is naturally vegetated.

If allowed by CYCC officials, fill would be generated from an approximately 5-acre borrow area on adjacent uplands under their ownership. Preliminary cultural resource assessment reports have identified the preferred area for a borrow pit as highly sensitive for potential pre-contact archeological resources (see figure 4-9). Unless an alternative borrow area or source of fill were identified, some degree of site-specific archeological inventory would be required before this site could be disturbed.

Residential Flood Proofing

As described in section 4.10.3, several low-lying residential properties would be impacted by restored tidal exchange unless measures are taken to protect them. Although no specific measures are identified or proposed in this draft EIS/EIR, and therefore cannot be quantified, it is likely that some of these actions could impact wetlands or other regulated resource areas. Examples of these include, but are not limited to, constructing a small berm or wall to protect a specific residential parcel, adding fill to a low driveway or lawn, and relocating a well. Implementation of any of these measures would occur with close consultation with landowners and would be subject to the regulatory review strategy described in chapter 5 and the adaptive management plan (appendix C).

Impacts Resulting From Secondary Restoration Actions and Minor Road Improvements

Secondary restoration actions are those needed to maximize the positive effects of restoring tidal exchange beyond simply rebuilding the Chequessett Neck Road Dike and other tide control structures and increasing tidal range. They include, but are not limited to, vegetation management, sediment management, and channel improvements. These activities, and their associated impacts, 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. To the extent possible given the uncertainty about implementation of any of these activities, impacts resulting from secondary management actions are described in this section. More specific information and guidelines governing this work will be included in the project's adaptive management plan (see also appendix C). A review of the proposed permitting process for oversight of these activities in the Herring River is described in chapter 5.

Vegetation Management

As described previously in section 2.6.3, active management of vegetation within the Herring River flood plain is considered necessary in order to maximize and hasten the benefits of tidal restoration. Managing vegetation primarily involves cutting and removal of upland tree and shrub species that have colonized the former tidal marsh, selective treatment, including the application of herbicides of non-native, invasive species, most notably common reed (*Phragmites australis*) (see sections 4.5.3 and 4.5.7 for additional *Phragmites* discussion), and planting and/or introduction of native seedlings and seed stock. Over the long-term, vegetation management activities are expected to result in dramatic improvements to the overall ecological health and function of the Herring River system. As described in section 4.5, under any of the action alternatives habitats currently dominated by upland, freshwater, and non-native plant species would be replaced by native salt and brackish marshes and, in the upper reaches of the system, freshwater tidal marsh.

Based on mapping completed by NPS in 2007 and the analysis presented in section 4.5 it is estimated that woody plant removal could occur over an area encompassing a maximum of 339 acres, areas classified as wet and dry deciduous forest, pine woodland, and dry deciduous woodland (see figure 4.13). Cutting and removal of trees and shrubs would result in localized, short-term impacts within and immediately adjacent to areas undergoing treatment. Although details are still to be determined, this could involve accessing treatment areas with heavy equipment for cutting, grinding, chipping, and burning woody plant material and/or removing logs, brush, chips, or leaving wood chips on site, etc. from the flood plain. All of this area is considered jurisdictional wetland and thus the work would be subject to permitting under the U.S. Clean Water Act (CWA), Massachusetts WPA, and Wellfleet Environmental Bylaw. Short-term impacts resulting from this activity could include rutting of soil by equipment and inadvertent deposition of sediment into adjacent waters. Removal of trees and shrubs would also temporarily alter existing habitats for other plants and wildlife until the marsh recovers and native estuarine plant species become established. Despite these localized, short-term effects, the long-term active management of woody vegetation would result in no reduction in wetland acreage and, in concert with tidal restoration, also result in dramatic improvements in ecological function of these estuarine habitats.

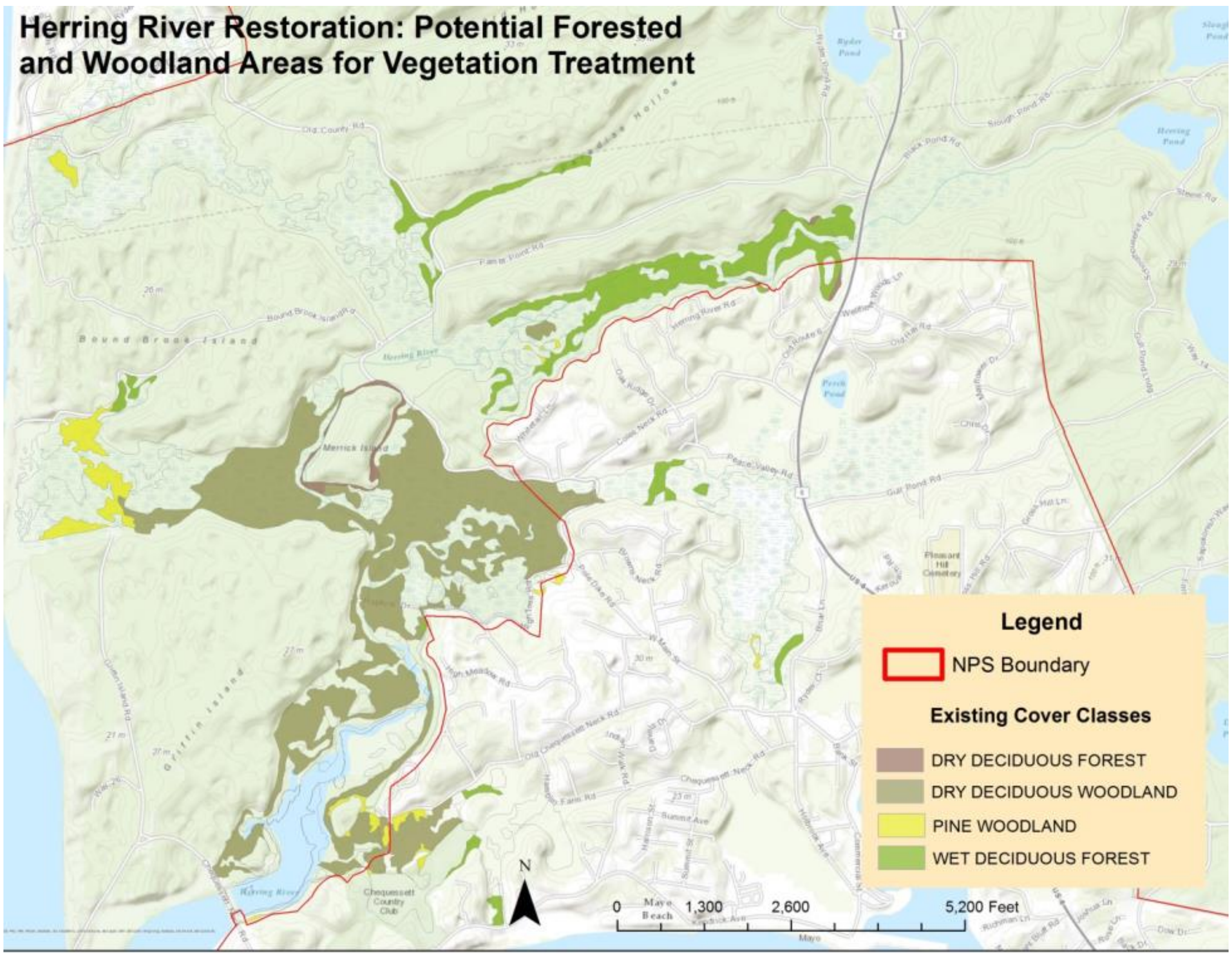


FIGURE 4-13: POTENTIAL FORESTED AND WOODLAND AREAS FOR VEGETATION TREATMENT

Although the area requiring treatment is large, encompassing about one-third of the Herring River flood plain, vegetation removal would occur in stages over a period of several years. In order to reduce impacts, work is expected to occur before tidal flow is restored in each sub-basin. This will allow the work to be performed in relatively dry conditions and avoid large pulses of sediment entering the water column and being transported downstream. To further limit soil erosion and potential sedimentation, efforts will also be made to conduct as much vegetation management work in the winter when the ground surface is at least partly frozen. Additional erosion control will include doing as much work as possible by hand, use of low ground pressure heavy equipment and marsh mats, siltation fencing, and haybales. In areas particularly prone to erosion, such as streambanks adjacent to high velocity tidal flows, vegetation will be planted to stabilize exposed soils.

The majority of vegetation management activities will occur on land under control of the NPS. Any work proposed on privately-owned land will be conducted with the consent and cooperation of individual property owners.

Sediment Management and Channel Improvements

As described in sections 4.3 through 4.5, more than 100 years of tidal restriction has caused subsidence of large portions of the Herring River floodplain and the sedimentation of numerous tidal channels and streams. In addition, work undertaken to eliminate mosquitoes after it became apparent that the construction of the Chequessett Neck Road Dike was not achieving this intended purpose included cutting ditches and channelizing (i.e., straightening) reaches of the river to drain the marshes. In order to alleviate the varied ecological perturbations caused by tidal restriction, marsh plain subsidence, and channelization (see chapter 3), secondary actions in coordination with tidal restoration are necessary to restore ecological function to the floodplain and maximize project benefits. Because of the inter-related nature of this work, the impacts involved with implementing these activities are discussed together in this section.

Actions to Promote Marsh Accretion

Approximately 250 acres of the Herring River floodplain have subsided to elevations below the projected mean low water line if the Chequessett Neck dike were removed. This means that without accretion of the marsh surface, these areas would hold water at low tide and remain inundated, a condition that is not compatible with the objectives of the project. Although the restoration of normal tidal flow will result in large volumes of sediment entering the system and begin the natural process of marsh accretion, it is possible that without other pro-active intervention the time for marsh recovery would likely be unacceptably long and achievement of the project's objectives would be delayed for decades. Poor drainage and near-permanent inundation of the marsh surface could also cause adverse effects, such as increasing mosquito breeding habitat that could be worse than existing conditions.

Tide gate management techniques could be used to reintroduce large volumes of marine sediment into the Herring River system through normal tide exchange and during coastal storm events (see also appendix C: Overview of the Adaptive Management Process for the HRRP). Most sediment is expected to settle out and be deposited on the floodplain, as occurred naturally during the approximate 3,000 year development of the estuary, before tidal flow was restricted in 1909. This process of natural sediment deposition is a critical component of the system's recovery and the accretion of subsided marsh surfaces.

In coordination with incremental restoration of tide range and salinity, several methods will be considered to increase the rate and extent of marsh accretion. As described in appendix C, the decision-making process for implementation, monitoring, and oversight of these activities will be guided by the project's adaptive management plan. They include:

- Redistribution of Sediment Trapped within the Floodplain—As described further below, many natural and man-made channels and ditches throughout the Herring River floodplain have filled in with sediment or have been lost due to the lack of tidal exchange. As part of a program to restore the floodplain stream and channel system to some semblance of its natural condition, the project would seek to selectively remove much of the trapped sediment to reopen channels while also gaining access to material to spread on subsided marsh surfaces in order to accelerate marsh accretion processes. This work would involve accessing the marsh surface with heavy equipment to excavate sediment from channels and ditches and transporting it to subsided areas. It is likely that the channels providing the sediment would be located within, or adjacent to, the subsided areas requiring enhanced accretion. Some impacts could also occur further afield from equipment traversing other marshes to access treatment areas. Impacts would generally involve rutting of soil by equipment and possible sedimentation into the water column from spillage and erosion. Although the area where sediment would be deposited is large, redistribution of sediment is expected to occur in stages over a period of several years. In order to reduce impacts, to the extent possible work will occur before tidal flow is restored in each sub-basin. This will allow the work to be performed in relatively dry conditions and avoid large pulses of sediment entering the water column and being transported downstream. To further limit soil erosion and potential sedimentation, efforts will also be made to conduct as much work in the winter when the ground surface is at least partly frozen. Additional erosion control will include use of small, low ground pressure heavy equipment working on marsh mats, siltation fencing, and hay bales. In areas particularly prone to erosion, such as streambanks adjacent to high velocity tidal flows, vegetation will be planted to stabilize exposed soils. All areas where this work would be undertaken are jurisdictional wetlands under the CWA, Massachusetts Wetlands Protection Act, and Wellfleet Environmental Bylaw, however sediment redistribution may be necessary to improve the ecological function of these wetlands and would not entail any other adverse impacts, besides the short-term impacts described here. Therefore, no other mitigation for wetland impacts is deemed necessary or is proposed. The majority of channel clearing and sediment redistribution activities will occur on land under control of the NPS. Any work proposed on privately-owned land will be conducted with the consent and cooperation of individual property owners.

- Augmentation of Sediment Supply—In addition to redistribution of sediment trapped within the Herring River floodplain, it is possible that sediment may also need to be introduced into the system from sources outside of the floodplain in order to promote accretion of subsided marsh surfaces. Only sediment that is free of contaminants and of suitable particle size will be considered for sediment augmentation. These actions would be triggered when or if it is determined that natural sediment delivery from restored tidal flow and redistribution of trapped sediment do not provide sufficient volumes of material to allow marsh surfaces to accrete to targeted inter-tidal elevations capable of supporting native salt marsh vegetation over a reasonable timeframe. This work would involve identifying sources of suitable sediment, transporting it to the Herring River floodplain, and spreading and grading it to the appropriate elevation. One potential source could be the beneficial reuse of dredged material from periodic maintenance dredging in Wellfleet Harbor. Normally, this material is deposited at a designated disposal site in Cape Cod Bay, approximately eight miles offshore. Studies will be needed to determine the suitability of this material for use in the Herring River or whether it may also be suitable for other purposes, such as beach nourishment. Other regional dredging and/or excavation projects may also be potential sources of sediment for the Herring River project. No matter the source, the majority of impacts associated with depositing sediment on subsided marsh surfaces would likely result from accessing areas with heavy equipment and machinery, potentially resulting in soil compaction, rutting, erosion, and inadvertent deposition of sediment into adjacent waters. Although the area where sediment could be potentially deposited is large, up to approximately 250 acres, any work would be implemented on a sub-basin by sub-basin basis, in coordination with incremental tidal restoration so that any impacts would be localized to the areas where work is actually occurring. To further minimize any potential impacts, work will be conducted in winter to the greatest extent possible, when the ground is at least partly frozen and more stable. Appropriate sediment and erosion controls, such as siltation fences, haybales, and sediment traps will also be employed. All areas where this work would be undertaken are jurisdictional wetlands under the CWA, Massachusetts WPA, and Wellfleet Environmental Bylaw; however sediment augmentation may be necessary to improve the ecological function of these wetlands and would not entail any other adverse impacts, besides the short-term impacts described here. Therefore, no other mitigation for wetland impacts is deemed necessary or is proposed.

Actions to Maximize Tidal Exchange and Circulation of Water

Historic manipulations taken within the Herring River system to restrict tidal flow and drain coastal marshes have resulted in hundreds of acres of degraded estuarine habitat. Among the numerous factors that contribute to this are former tidal streams and channels that are filled with sediment, construction of man-made ditches and channelized segments of the river and tributary streams, and anthropogenic spoil piles (i.e., dredged material) left on the marsh surface. Although restoration of normal tidal flow will naturally alleviate some of these conditions (e.g., natural scouring of filled in channels by increased flow), the extent and magnitude of these alterations will likely require more active management in order to fully achieve overall project objectives. A number of inter-related actions will be considered in coordination with incremental tidal restoration and other activities. The overall intent of these actions is to restore, to the greatest extent practicable, the natural, historic channel system and to promote maximum penetration of saltwater and drainage of freshwater throughout the system. This would be achieved through a program of selective opening/cleaning of natural channels, plugging of ditches, and removal of anthropogenic fill on the floodplain (including spoil piles, portions of old dikes and channel diversions, and portions of the former Old Colony railroad embankment). This work will implemented in coordination with the channel clearing and sediment redistribution activities previously described and the associated impacts and mitigation methods are similar.

Minor Culvert Replacements

In addition to the previously described impacts associated with major road flood prevention and culvert improvements along Pole Dike Creek, Bound Brook Island, and Old County Roads (see discussion above), short-term construction impacts will also occur while upgrading several short segments of other low-lying roads, improving roads for temporary bypass routes, and replacing small culverts. These occur at small stream crossings along Old County Road at Paradise Hollow, Lombard Hollow, several sand roads in the Ryder Beach area, and other small roads and are summarized in table 4-26. These culverts will be replaced in coordination with other work to increase the elevation of road segments above the projected maximum flood elevations in order to improve tidal flow and drainage to upstream areas. Additional short-term impacts associated with construction, beyond those associated with the necessary roadwork, are expected to be minimal and will be presented in detail in permitting documents. Impacts from permanent infrastructure footprints are summarized in table 4-26.

TABLE 4-26: TEMPORARY AND PERMANENT VEGETATION/WETLAND DISTURBANCE RESULTING FROM THE HERRING RIVER RESTORATION PROJECT ALTERNATIVES

Location	Temporary Impacts	Permanent Impacts	Note
Chequessett Neck Dike	Up to 2.4 acre construction foot print (coffer dam, dewatering)	Up to 800 linear feet permanent inter- and sub-tidal wetland loss, if dike crest elevated (unknown width of fill)	Final design of dike would determine width at the dike base and the total acreage occupied by the structure.
Mill Creek Dike	Up to 2.4 acre construction footprint (coffer dam, dewatering)	Up to 12,500 (approximately 0.3 acres) square feet of dike footprint and vegetation/wetland loss	Applies to alternatives C and D only. Final design of dike would determine the total acreage occupied by the structure.
High Toss Road	Approximately 20 feet width of disturbance along 1,000 length of causeway (0.5 acre)	Up to 13,000 square feet (approximately 0.3 acres) vegetated wetland loss if elevated; up to 12,000 (approximately 0.28 acres) gain of restored wetland if removed	Independent of alternatives
Pole Dike/Bound Brook Island Roads	Construction corridor of approximately 20 feet along 6,200 linear feet adjacent to vegetated wetlands (2.85 acres)	Up to 4,000 square feet (0.1 acre) vegetation/wetland loss to elevate above coastal storm driven tidal surge, 2,300 square feet (just over 0.05 acre) lost to elevate to AHW	Independent of alternatives
CYCC Golf Course		Relocation (option 1): 89,000 square feet (just over 2 acres) wetland loss (most is existing maintained golf course; 4,800 square feet natural vegetation), ~30 acres potentially sensitive archeological resource disturbance Elevation (option 2): 360,000 square feet (8.26 acres) wetland loss (most is existing maintained golf course; 4,800 square feet natural vegetation), ~5 acres potentially sensitive archeological resource disturbance	Applies to alternatives B and D
Residential Flood Proofing	To be determined with input from landowners but could include wetland fill for elevation, berms, or walls		

Location	Temporary Impacts	Permanent Impacts	Note
Secondary Restoration Actions/Minor Road Improvements	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 benefits; would likely include access by heavy equipment for some restoration actions	Clearing of 339 acres upland tree and shrub species that have colonized the former tidal marsh, selective treatment, including the application of herbicides of non-native, invasive species. Channel dredging and sediment augmentation - the majority of channel clearing and sediment redistribution activities will occur on land under control of the NPS.	
Total Impacts	Minimum of 8.15 acres of temporary vegetation/wetland disturbance plus that needed to implement vegetation management during adaptive management phase	Up to approximately 9 acres of long-term vegetation/wetland disturbance for dike(s), road elevation or realignment, and culvert installation	

Construction Related Impacts to Fish and Shellfish

During construction of the new dike and any other infrastructure improvements such as upstream culverts or road relocations there could be local, temporary adverse impacts on both fish and macroinvertebrate species in the vicinity of the construction. Estuarine fish species could be temporarily displaced from habitat in the area of the construction due to noise and vibration impacts. There could also be some mortality of sedentary and less mobile species and life stages through burial and other in-water activities; however, many species are highly mobile and would just avoid the areas. The use of BMPs will minimize siltation and impacts on water column turbidity near the construction activities. Once construction was completed, both estuarine fish and macroinvertebrate species would be expected to readily recolonize and use the affected areas.

To protect marine resources in Massachusetts from in-water construction work during times when there is a higher risk of known or anticipated significant lethal, sub-lethal or behavioral impacts, the Massachusetts Division of Marine Fisheries recommends certain in-water time-of-year restrictions. For estuarine fish species that occur in the project area, there are recommended time-of-year restrictions for winter flounder; Atlantic silversides, mummichogs, and other *shore-zone fishes* (finfish that occupy and use nearshore waters (intertidal to 16 feet)); and juvenile life stages of commercially important species that also use the shore-zone such as winter flounder and tautog among others (Evans et al. 2011). These recommended time-of-year restrictions are shown in table 4-27. Whether or not time-of-year restrictions pertain to a specific project depends on the type of work proposed, the location of the project relative to the resource area, and the timing and duration of the activity. Therefore, the HRRC would consult with Massachusetts Division of Marine Fisheries as well as NOAA Fisheries to further reduce potential adverse impacts to estuarine fish in the project area. Also, provisions would be made in concert with the Division of Marine Fisheries and NOAA Fisheries to ensure that during construction of the dike existing levels of fish passage would be maintained.

TABLE 4-27: MASSACHUSETTS DIVISION OF MARINE FISHERIES RECOMMENDED TIME-OF-YEAR RESTRICTIONS FOR IN-WATER CONSTRUCTION FOR ESTUARINE FISH SPECIES IN THE HERRING RIVER

Species	Time-of-Year Restriction	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter flounder	Feb 1–Jun 30												
Shore-zone fishes	May 1–Nov 1												
Juvenile fishes	May 1–Nov 1												

Source: Evans et al. 2011

During construction activities there could be temporary adverse impacts to anadromous and catadromous fish species similar to those described above for other estuarine fish species, though provisions would be made to ensure the existing level of fish passage would occur during construction of the dike as currently exists. However, to protect anadromous and catadromous fish species during their inward and outward migrations within estuaries, in their comments on the MEPA ENF filing the Massachusetts Division of Marine Fisheries has proposed time-of-year restrictions for in-water construction activities (table 4-28) (MA DMF 2008). These in-water restrictions would limit the time for possible dike and other construction to the months of late November through early February, which would not provide enough time to complete construction activities, nor is winter the ideal time for construction.

TABLE 4-28: MASSACHUSETTS DIVISION OF MARINE FISHERIES PROPOSED TIME-OF-YEAR RESTRICTIONS FOR IN-WATER CONSTRUCTION FOR ANADROMOUS/CATADROMOUS FISH SPECIES IN THE HERRING RIVER

Species	Time-of-Year Restriction	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
In-Migration													
Alewife	Mid Apr-May												
Blueback	Mid Apr-Jun												
White Perch	Mid Feb-May												
American eel	Mar-Jun												
Out-Migration													
Alewife	Mid Jul-Sep												
Blueback	Sep-early Nov												

Source: MA DMF 2008.

Therefore, the HRRC would consult with Massachusetts Division of Marine Fisheries and NOAA Fisheries to develop appropriate measures to allow construction to occur during months for which there are time-of-year restrictions to mitigate any adverse impacts to anadromous and/or catadromous species using the Herring River estuary.

Shellfish would be also adversely impacted by construction activities under the action alternatives, though most impacts would occur below the dike as currently few species occur. 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. Employing BMPs would minimize the amount of sediment resuspended during construction activities. Massachusetts Division of Marine Fisheries also recommends in-water time-of-year restrictions to protect the vulnerable spawning, larval and settlement periods of shellfish during certain in-water construction projects (Evans et al. 2011) (table 4-29).

TABLE 4-29: MASSACHUSETTS DIVISION OF MARINE FISHERIES RECOMMENDED TIME-OF-YEAR RESTRICTIONS FOR IN-WATER CONSTRUCTION FOR SHELLFISH SPECIES IN THE HERRING RIVER

Species	Time-of-Year Restriction	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
American oyster	Jun 15–Sep 15												
Northern quahog	Jun 15–Sep 15												
Soft-shell clam	May 1–Sep 30												
Blue mussel	May 15–Aug 31												
Bay scallop	Jun 1–Sep 30												
Surf clam	Jun 15–Oct 15												

Source: Evans et al. 2011

Whether or not time-of-year restrictions pertain to a specific project depends on the type of work proposed, the location of the project relative to the resource area, and the timing and duration of the activity. Therefore, the HRRC would consult with Massachusetts Division of Marine Fisheries as well as NOAA Fisheries to develop appropriate in-water construction measures to mitigate any potential adverse impacts to shellfish in the project area.

4.12 SUSTAINABILITY AND LONG-TERM MANAGEMENT

4.12.1 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Under the proposed action alternatives, dike construction, site-specific flood mitigation of roads and other infrastructure, and adaptive management actions would create local, short-term impacts to soils, water quality, vegetation, aquatic species, and terrestrial wildlife. These impacts would be limited to less than 2 percent of the total restored wetland acreage. Once in place, the tide control structures would require long-term management and operations to achieve the targeted restoration goals and protect adjacent landowners during storm surge events.

Over the long term, the controlled, regular influx of saline marine waters provided at the dike(s) would improve water quality and habitat for aquatic species, establish tidal channels for anadromous and catadromous fish passage, support re-establishment of native salt-tolerant wetland vegetation, and mobilize sediment to form a marsh plain. Terrestrial wildlife that now inhabit the restoration area would gradually be displaced over the several year adaptive management period to similar nearby environments. Should the NPS and HRRC choose to implement the preferred alternative, the largest practicable area would be restored to tidal marsh wetlands, with long-term tide gate operations and management.

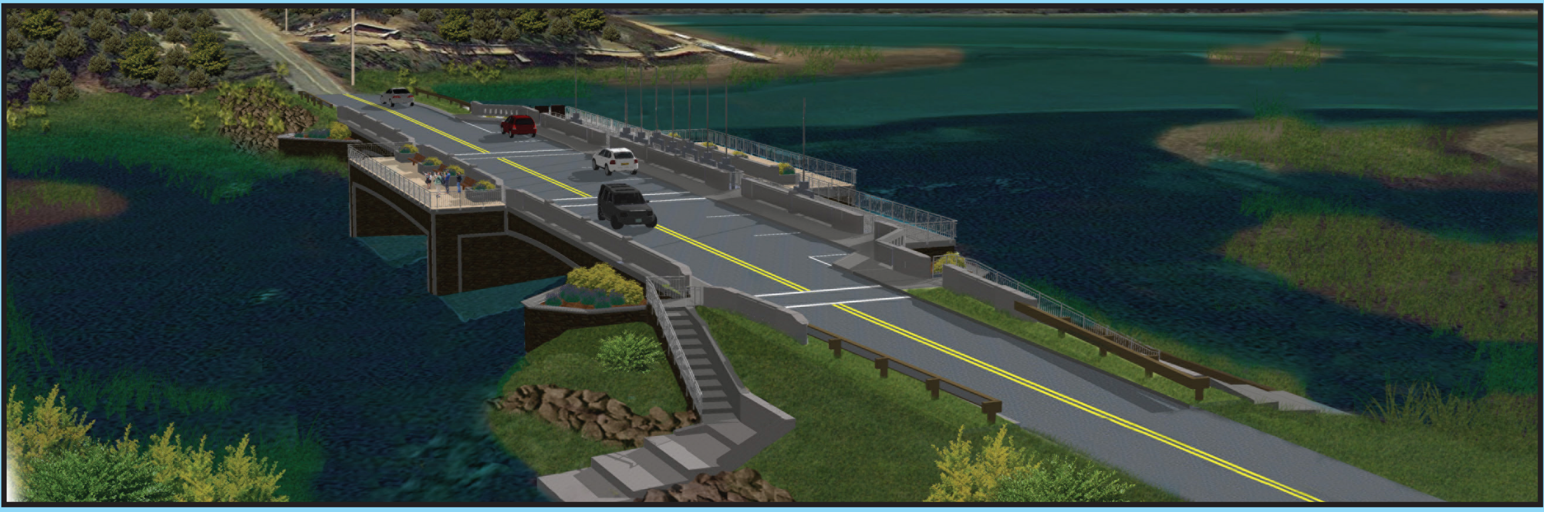
4.12.2 Irreversible and Irretrievable Commitments of Resources

Under alternative A, the environmental conditions in the Herring River flood plain would continue – including the potential for episodes of poor water quality, spread of invasive plant species, land subsidence, and limited habitat for locally important fish and shellfish species. Impacts to these and other tidal salt marsh resources since construction of the Chequessett Neck Road Dike, over 100 years ago, are irretrievable and would continue into the future under current management. However, restoration is based on the premise that current conditions are not irreversible. By returning tidal influence to the flood plain, the processes that support a tidal salt marsh would gradually return, and transform the project area to conditions similar to that of the pre-dike estuary.

4.12.3 Unavoidable Adverse Impacts

Under any of the proposed restoration alternatives, construction activities and adaptive management actions would be accompanied by limited unavoidable adverse impacts. In addition to short-term disturbance of soils, vegetation, and wildlife; intermittent adverse impacts to water quality could result as the wetland soil chemistry changes from freshwater and upland to salt water; die-off of freshwater vegetation (including large trees) would occur and require management; and formation of tidal channels may need to be achieved by limited dredging and filling. Although these actions would support the long-term conversion of the project area to the desired salt marsh condition, they are accompanied by soil and vegetation disturbance, sediment impacts to nearby water quality, and noise. These impacts would be managed by BMPs and other appropriate resource protection measures.

Chapter 5:
Consultation, Coordination, and Regulatory Compliance



CHAPTER 5: CONSULTATION, COORDINATION, AND REGULATORY COMPLIANCE

5.1 INTRODUCTION

This chapter describes the interagency consultation and stakeholder involvement that occurred during development of the *Herring River Restoration Environmental Impact Statement / Environmental Impact Report* (EIS/EIR). One focus of interagency consultation in this planning effort is to identify the regulatory and permitting requirements that must be met before restoration activities can be undertaken. This chapter also includes a description of the public involvement process and a list of the recipients of the final EIS/EIR. Details regarding other applicable laws, policies, and regulations that do not involve special consultation or compliance processes are listed in "Appendix D: Applicable Laws, Policies, and Regulations."

5.2 THE SCOPING PROCESS

The project proponents used internal and public scoping to identify issues related to restoration of the Herring River. Internal scoping involved discussions among the Herring River Restoration Committee (HRRC) regarding the purpose of and need for management actions, issues, potential management alternatives, mitigation measures, the analysis boundary, appropriate level of documentation, available references and guidance, and other related topics. The HRRC also sought agency input from a variety of federal, state, and local entities in developing the restoration plan.

Public scoping is the early involvement of the interested and affected public in the planning and environmental analysis process. The public scoping process helps ensure that people are given an opportunity to comment and contribute early in the decision-making process. For this EIS/EIR, project information was distributed to individuals, agencies, and organizations early in the scoping process, and people were given a variety of opportunities to express concerns or views and identify important issues or other alternatives or elements that should be considered.

Taken together, internal and public scoping are essential elements of the National Environmental Policy Act (NEPA) and Massachusetts Environmental Policy Act (MEPA) planning process. The following sections describe the various ways internal and public scoping was conducted for this project.

5.2.1 INTERNAL SCOPING: STAKEHOLDER GROUPS

Town of Wellfleet/Town of Truro Memorandum of Understanding I

In 2005, a Memorandum of Understanding (MOU I) between the National Park Service (NPS) and the Town of Wellfleet was signed to evaluate the proposed (HRRP). The purpose of the MOU was to establish a process and framework to determine whether a restoration of the Herring River was technically feasible and subsequently to develop a conceptual plan of the restoration goals and objectives to meet stakeholder needs should restoration be deemed appropriate. The MOU created the Herring River Technical Committee (HRTC) to review the scientific literature and determine the feasibility of restoration.

Herring River Technical Committee

The HRTC included representatives from the following local commissions and boards/agencies:

- Cape Cod National Seashore (the Seashore)
- Wellfleet Conservation and Health Agent
- Wellfleet Open Space Committee
- Wellfleet Shellfish Advisory Committee
- Wellfleet Shellfish Constable
- Wellfleet Herring Warden
- Wellfleet Natural Resource Advisory Committee
- Chequessett Yacht and Country Club (CYCC)
- Town of Truro Selectmen
- Massachusetts Wetland Restoration Program
- U.S. Fish and Wildlife Service (USFWS)
- Natural Resources Conservation Service (NRCS)
- Cape Cod Cooperative Extension Service
- National Oceanic and Atmospheric Administration's (NOAA's) Restoration Center

In 2007, the HRTC developed the *Herring River Conceptual Restoration Plan* (CRP) based on a review of the scientific and technical information on the Herring River system, as well as community input. The CRP concluded that tidal restoration for the Herring River was feasible and in the public interest and recommended moving forward with development of a more detailed plan and environmental review documents.

Memorandum of Understanding II

Upon approval of the CRP by the Seashore and Wellfleet Board of Selectmen, a second MOU (MOU II) between the Towns of Wellfleet and Truro and Cape Cod National Seashore (the Seashore) was signed in 2007, thus disbanding the HRTC and creating the HRRC. MOU II charged the HRRC with development of a detailed restoration plan and oversight of the environmental review process under NEPA and MEPA. Under MOU II, the towns serve as co-applicants for the MEPA process and the Seashore serves as lead agency for the NEPA process.

Herring River Restoration Committee

The HRRC is a multi-agency group comprised of representatives from Wellfleet, Truro, the Seashore, the USFWS, Massachusetts Division of Ecological Restoration (formerly Coastal Zone Management's Wetland Restoration Program), the NOAA's Restoration Center, and the NRCS. The HRRC also has the authority to conduct additional planning, seek funding, and complete environmental compliance for a detailed restoration plan. When complete the plan would be ratified by the parties under a final MOU (MOU III) for project implementation.

Technical Working Group

The Herring River Technical Working Group (TWG) was established as part of an approved Special Review Procedure under a 2008 MEPA Certificate to identify and address environmental management and permitting issues associated with the Herring River restoration. The TWG met quarterly throughout the preparation of the EIS/EIR to assist in developing appropriate study methodologies and protocols and to ensure that it adequately addresses the analyses and data requirements of required permits and approvals.

Memorandum of Understanding III

A third MOU (MOU III) between the Towns of Wellfleet and Truro and Cape Code National Seashore documents the agreement between the entities for project implementation. MOU III addresses partner relationships, roles and responsibilities, decision authority, financial obligations and governing structure for the design, permitting, construction and operation and management activities. In January 2013, a MOU Working Group was formed to oversee the development of MOU III. The Working Group includes representatives of the HRRC, the Towns of Wellfleet and Truro, the Massachusetts Division of Ecological Restoration, and the Friends of Herring River. The Working Group met monthly during 2013 and 2014 to review and evaluate management options for the Restoration Project. The Working Group engaged an outside consultant to help research organizational models for a third-party restoration management entity and produced a draft MOU III.

The draft MOU III proposes establishment of an intergovernmental team to provide policy oversight, assume decision-making authority, and –through a contractual arrangement– direct the activities of an independent organization that would undertake specified activities during project permitting, construction and implementation, including the adaptive management process. The structure of the intergovernmental team would generally include the following elements:

- A Herring River Executive Council comprised of:
  - Two members of Town of Wellfleet Board of Selectmen and the Town Administrator
  - Two members of Town of Truro Board of Selectmen and the Town Administrator
  - The Superintendent of Cape Code National Seashore or his/her designee.
- A continued interdisciplinary management team (HRRC), which shall serve as an advisory group to the Herring River Executive Council with representation from:
  - Town of Wellfleet
  - Town of Truro
  - Cape Code National Seashore
  - Commonwealth of Massachusetts Division of Ecological Restoration
  - USFWS
  - NRCS
  - NOAA

The Herring River Executive Council and the HRRC will work with a proposed regulatory oversight group to facilitate compliance with federal, state, regional and local permitting requirements. The Herring River Executive Council may also establish working committees, as needed, such as a stakeholder committee and/or science committee.

Through contracts for services and/or Cooperative Agreements, the Towns and/or Cape Code National Seashore may engage the services of an independent organization to undertake some or all of the responsibilities and functions outlined below in coordination with the HRRC:

- Provide and manage professional level technical and administrative staff necessary for the completion of all project elements;
- Compete for, receive, and administer project funding from state, federal, and private sector sources;
- Prepare and submit permit applications, ensure compliance with all permit conditions, noticing requirements, and other environmental compliance obligations;
- 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;
- Facilitate agreements with affected landowners;
- Conduct operations and maintenance of infrastructure in cooperation with the towns and Cape Code National Seashore as stipulated by any contract agreement(s);
- Implement the adaptive management plan under the technical direction of HRRC;
- Perform public outreach and education activities.

A copy of the 2016 draft MOU III is included in appendix J of the final EIS/EIR.

Friends of Herring River

The Friends of Herring River is a non-profit organization formed in 2008 to "promote education, research and public awareness of the Herring River estuary as one of critical environmental concern, to preserve the native environmental integrity of the river and estuary, to ensure habitat protection and retention of the native biological diversity and productivity of the river and estuary, to retain and enhance public access to the river and estuary, to preserve natural and historic sites, and to promote public awareness." Friends of Herring River is independent of the HRRC but works closely with the HRRC to promote the restoration of the Herring River Estuary. Since 2013, Friends of Herring River has submitted several successful grant proposals to state and federal agencies. These resources have been used to undertake much of the technical studies, engineering and design work, and project coordination necessary for completion of the final EIS/EIR and advancement of various project components.

5.2.2 Public Scoping

Two public scoping meetings held in August and September 2008 in the Town of Wellfleet gave the public the opportunity to learn about the planning process and provide input. Both meetings were open-house style sessions with short presentations that allowed the public to ask HRRC members questions and provide input in an informal atmosphere. NPS representatives at the meeting recorded public comments. Following the meeting, a 60-day comment period gave the public the opportunity to submit additional comments through the mail or on-line through the NPS Planning, Environment, and Public Comment (PEPC) website.

Forty-two items of correspondence containing 288 comments were received during the public comment period. Topics raised by the public and agencies ranged widely – from concerns about impacts to private lands to compliance with commonwealth and local permitting requirements. However, several topics received more than 20 comments each (NPS 2008):

- **Potential Impacts to Adjacent Properties and Landowners** (30 comments)—Commenters expressed concerns about wells, septic systems, vegetation on private property, and impacts to the CYCC. Mitigation and compensation were commonly cited in these comments.
- **Consultation and Coordination** (29 comments)—Commenters included agencies and other stakeholder groups, with requests that the NEPA/MEPA compliance document address all appropriate requirements.
- **CYCC Golf Course** (30 comments)—The CYCC made several comments specific to this topic that capture concerns and requests for further information regarding options for the golf course.
- **Purpose and Need for the Plan** (25 comments)—Commenters raised various issues to be analyzed in this EIS/EIR. Commenters specifically mentioned the following resource and impact topics: wetlands, fisheries, water quality, wildlife/aquatic habitats, sea level rise, public rights, public health and safety, soils, species of special concern, and adjacent lands. Other commenters noted that the final EIS/EIR should include a thorough listing of mitigation measures.
- **Coastal Resources** (21 comments)—The Cape Cod Commission (CCC) submitted several comments specific to wildlife and plant habitat and the Regional Policy Plan, including minimum performance standards, comments to focus the analysis, and information requested.

The draft EIS/EIR was released on October 12, 2012. Following its release, a 60-day public comment period was open between October 12, 2012 and December 12, 2012. The draft EIS/EIR was made available for review through several outlets, including the NPS PEPC website, several local libraries, CD or hardcopy requests from the Seashore, and specific distribution to several government agencies, stakeholder groups, and regulators.

The NPS, with the assistance of HRRC, and the CCC, held a public hearing for the HRRP draft EIS/EIR. The hearing was held during the public comment period on November 8, 2012, beginning at 6:30 p.m. at the Wellfleet Senior Center/Council on Aging, in Wellfleet, MA. This hearing met the dual purposes of fulfilling the NPS's NEPA public involvement requirement and the formal public hearing for the CCC, as required by Section 5 of the Cape Cod Commission Act and MEPA regulations. The public hearing was held to continue the public involvement process and to obtain community feedback on draft EIS/EIR for tidal restoration of the Herring River.

After reviewing the draft EIS/EIR, the public was encouraged to submit comments through electronic comment, oral statements, and written comments recorded during the public meeting on the draft EIS/EIR. During the public review comment process period, 43 pieces of correspondence were received. Substantive public comments received are summarized in a Concern Response Report (appendix M). Topics raised by the public and agencies were similar to those filed for the initial project scoping discussed above.

5.3 COMPLIANCE WITH FEDERAL, STATE, AND LOCAL REGULATORY AGENCIES

5.3.1 PROPOSED STRATEGY FOR REGULATORY PERMITTING

This section explains the proposed strategy for regulatory permitting over the duration of project implementation. This strategy was developed in consultation with the Herring River TWG that was established in accordance with the November 7, 2008 MEPA Special Review Procedure and EIR scope and includes representatives from federal, state, regional, and local regulatory authorities that have jurisdiction over proposed project activities. The Special Review Procedure and TWG acknowledge that the unique and complex nature of this project warrants development of a coordinated and comprehensive permitting strategy that facilitates efficient review, accommodates a long-term and dynamic implementation program, and ensures proper environmental protection and public input throughout the process. Potential implications for permitting based on recent updates to the Massachusetts Wetland Protection Act Regulations (310 CMR 10.00) and U.S. Army Corps of Engineers General Permit for Clean Water Act (CWA) compliance are also addressed. Most notable is a new provision for approval of Ecological Restoration Limited Project, which would allow the Herring River to proceed without a variance, as had been described in the draft EIS/EIR.

The project would require multiple permits and approvals from several federal, state, county, and municipal regulatory agencies. These approvals would need to encompass the project's multi-year implementation period and allow for flexibility to accommodate inherent uncertainties regarding certain project elements and timeframes. Restoration activities would proceed in an incremental and phased approach that would be guided by, and adjusted in response to, the adaptive management plan. To accommodate the unique characteristics of this project, a tailored regulatory permitting strategy is proposed with the following core components.

Section 5.3.5 provides an overview of how the HRRC envisions permitting could occur under the Massachusetts Wetlands Protection Act (WPA). This is intended to serve as an example for regulatory review and approval under other jurisdictions, such as Ch. 91, S. 401, and S. 404, which would be approached in a similar fashion as the WPA process. To the extent that these regulations apply to specific activities, original permits/approvals would be sought for project elements as they are proposed for implementation. Throughout project implementation, a recommend regulatory oversight group, as described below, would be regularly briefed on adaptive management and monitoring progress, and would advise the project proponents on regulatory review requirements as additional project elements are proposed for implementation.

5.3.2 COMPREHENSIVE LONG-TERM PERMITS

Following publication of the NPS Record of Decision (ROD) and a Final EIR Certificate from MEPA, but prior to initiation of restoration activities, project proponents would apply for a comprehensive set of permits and approvals from all federal, state, regional, and local regulatory authorities. Permit applications would address all possible project elements grouped into two classes associated with project implementation phases.

Class 1 covers all elements that are required to implement the initial phase of the project, including but not limited to:

- reconstruction of the Chequessett Neck Road Dike,
- construction of the dike at Mill Creek,

- installation of a new tide gate at Pole Dike Creek Road, and
- hydraulic improvements and public access modifications at High Toss Road.

Class 1 elements also cover the following measures located in areas that lie below targeted water elevations of the project's initial implementation phase, including:

- mitigation measures designed to prevent flooding impacts to private structures,
- elevation of low-lying portions of public roads,
- channel and marsh surface modifications, and
- vegetation management.

Tide gates and water levels would be managed to prevent structural impacts in the Mill Creek and Upper Pole Dike Creek sub-basins and other potentially affected locations until associated Class 1 impact mitigation measures have been implemented.

Class 2 covers elements that would be implemented in subsequent phases of the project. Prior to approval and implementation of Class 1 elements and adaptive management analysis, Class 2 elements have unavoidable and varying degrees of uncertainty about whether, where, when, and/or how they would be implemented. These elements include, but are not limited to:

- additional private property impact mitigation measures,
- additional channel and marsh surface modifications,
- modifications to minor roads and replacement of small culverts in upstream areas, and
- vegetation management activities beyond the Lower Herring River.

Class 2 impact mitigation measures for structures and other infrastructure would be determined by future agreements with landowners, monitoring, and adaptive management decisions based on system response to incremental increases in tidal exchange.

Distinctions between how Class 1 and Class 2 elements would be reviewed and permitted / approved by regulatory authorities is covered below in sections 5.3.3 and 5.3.5.

This approach provides for efficient and comprehensive regulatory review of a complex and atypical public-benefit project. It effectively accommodates inherent project uncertainties while avoiding project segmentation and maintaining full regulatory review authority and public / abutter / landowner rights and opportunities for input.

5.3.3 Standing Regulatory Oversight Group

As a successor to the TWG established by MEPA, it is recommended that MEPA continue the Special Review Procedure specifying that local, state, federal and regional agencies establish a standing regulatory oversight group with participation from representatives of regulatory authorities having jurisdiction over project activities. After Class 1 infrastructure construction is commenced and the project begins the adaptive management phase, group representatives would review the incremental tidal restoration process and advise project proponents, as necessary, on approval requirements for any major proposed design changes to Class 1 elements. The group would also review and advise on approval requirements for more detailed design plans, methodologies, and specific restoration management actions associated with Class 2 elements when they are proposed for implementation. Committee deliberations would be informed and guided by the adaptive management plan.

Meetings between the Restoration Committee and the regulatory oversight group are recommended at least annually to review monitoring results in relation to predicted project outcomes and consider proposed changes and/or refinements to project designs and management activities. Each agency representative would determine for their respective jurisdictional authority whether implementation of proposed Class 1 changes and/or Class 2 refinements may proceed under the original permit authorization or require an amendment of said permit. If an amendment is deemed necessary, the project proponents would submit an application in compliance with the applicable regulations and procedures.

Oversight group meetings would be open to the public and would be noticed in advance via the Massachusetts Environmental Monitor and the Towns of Wellfleet and Truro websites. Copies of materials to be reviewed would also be made available to the public in advance of each meeting. The public would have opportunity to submit written comments for consideration by group members. Group deliberations and decisions regarding proposed changes would be documented in official meeting minutes and published in the Massachusetts Environmental Monitor and the Towns of Wellfleet and Truro websites.

5.3.4 Federal Agency Regulation and Consultation

Endangered Species Act Section 7 Consultation

The USFWS has jurisdiction over terrestrial special-status species while USFWS and National Marine Fisheries Service (NMFS), a branch of NOAA, share jurisdiction over marine threatened and endangered species. Effective December 11, 2014, the rufa red knot was federally listed as a threatened species under the Endangered Species Act (79 FR 73706). Effective May, 4, 2015, the northern long-eared bat was federally listed as a threatened species under the Endangered Species Act (80 FR 17974). As part of the permitting process, the project will complete Section 7 Consultations with the USFWS for both species pursuant to the Endangered Species Act of 1973, as Amended (16 USC 1531 et seq.). On November 1, 2011, NMFS determined that an August 5, 2011 petition to list alewife and blueback herring (together referred to as river herring) under the Endangered Species Act presented enough scientific and commercial information to warrant further review. As a result, the agency conducted a formal review of river herring population status and trends. NMFS considered information contained in the petition, published literature, and other information about the historic and current range of river herring, their physical and biological habitat requirements, population status and trends, and threats. On August 12, 2013 NMFS determined that listing these species is not appropriate, therefore this process is closed.

Magnuson-Stevens Fishery Conservation and Management Act Consultation

The Magnuson-Stevens Fishery Conservation and Management Act is the primary law governing marine fisheries management in United States waters (NOAA 2009; 16 USC 1801, et seq.; 50 CFR 601, et seq.). Under the Magnuson-Stevens Act, essential fish habitat (EFH) areas are designated by regional fisheries councils and managed under regional fisheries management plans. The act authorizes NMFS to evaluate programs and projects that are proposed, permitted, or licensed by federal agencies that may adversely affect marine, estuarine, or anadromous species (e.g., herring), or the habitats of these species. Adverse impacts may be direct (e.g., physical disruption of habitat) or indirect (e.g., loss of prey species). NMFS may make recommendations regarding how to avoid, minimize, or compensate those adverse impacts. Federal agencies are required to consult and cooperate with NMFS.

Compliance with the Magnuson-Stevens Fishery Conservation and Management Act

Because restoration of the Herring River estuary would result in short- and long-term changes in water quality, sediment distribution, and estuarine habitats, this final EIS/EIR includes an analysis of impact to EFH. In accordance with NMFS requirements and guidelines, the physical components of EFH in the project area (physical, chemical, and biological characteristics; sediments; hard substrates; and related biological communities [NOAA 2004]) necessary to fish for spawning, breeding, feeding, or growing to maturity) are described in chapter 3 and appendix F and impacts to these resources associated with the proposed alternatives are described in chapter 4, section 4.6 and appendix F.

This final EIS/EIR, and EFH finding contained herein, was reviewed by NMFS representatives and their comments and recommendations are included in the final EIS/EIR. See appendix M, Concern Response Report, for a summary of EFH related responses.

Clean Water Act

The CWA (33 USC 1344 et seq.), as amended, is the primary federal law governing water integrity. The goal of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the nation's water." Waters of the United States generally include tidal waters, lakes, ponds, rivers, streams (including intermittent streams), and wetlands.

Section 404 of the Clean Water Act and Section 10 of Rivers and Harbors Act

Section 404 of the CWA authorizes the U.S. Army Corps of Engineers (USACE) to issue permits to project applicants for the "discharge of dredged and/or fill material in waters of the U.S." and is the primary federal authority for the protection of wetlands. USACE jurisdiction for waters of the United States is based on the definitions and limits contained in 33 CFR 328, which encompasses all navigable waters, their tributaries, and adjacent wetlands, and includes ocean waters within three nautical miles of the coastline. Projects involving the discharge of dredged and/or fill material into waters of the United States require authorization from the USACE. The USACE may only permit discharges of dredged or fill material into waters of the United States that represent the least environmentally damaging practicable alternative, if the alternative does not have other significant adverse environmental consequences. Practical alternatives must be presented and evaluated during the permit process so the USACE can determine which alternative would have a less adverse impact on aquatic ecosystems. The USACE also administers Section 10 of the Rivers and Harbors Act of 1899, which is required for all work including structures seaward of the annual high water (AHW) line in navigable waters of the United States. Compliance with CWA Section 404 would be pursued jointly with Section 10 of the Rivers and Harbors Act, as described below. 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 CWA, and lastly issues a permit if deemed appropriate.

Compliance with Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act

Several components of the HRRP would include unavoidable impacts to wetlands under federal jurisdiction, primarily through the discharge of fill into waters of the United States. Actions that would result in such impacts include but are not limited to the reconstruction of the Chequessett Neck Road Dike, potential construction of a dike at Mill Creek (under alternatives C or D only), work to elevate or otherwise flood proof low-lying roadways, and potential fill placed in low-lying areas of the CYCC golf course. These impacts are described in more detail in section 5.3.5. Because the cumulative extent of these impacts would impact more than 0.5 acre of tidal wetlands and more than one acre of non-tidal wetlands under USACE jurisdiction, it is anticipated that compliance under Section 404 and Section 10 would require the filing of an Individual Permit versus being eligible for review under the 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 Protection Agency (USEPA) Section 404(b) (1) guidelines. The Section 404 (b) (1) 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 impacts to the aquatic environment.

All the project alternatives seek to comply with the requirements of Section 404 of the CWA and the Section 404(b) (1) guidelines.

Practicable Alternatives—This final EIS/EIR includes several practicable project alternatives which to varying degrees meet the purpose of and need for the restoration project. The process of evaluating these alternatives considers impacts to the built and natural environment.

Water Quality/Threatened and Endangered Species—All of the action alternatives would include adequate stormwater management measures to mitigate for potential impacts to water quality by removing pollutants from the stormwater runoff discharging from reconstructed roadways to surface water resources. The proposed project would be designed to comply with the Massachusetts Stormwater Standards for redevelopment activities and revised Section 401 Water Quality Certification regulations recently promulgated by Massachusetts Department of Environmental Protection (MassDEP). The proposed project may affect recently listed federally threatened species rufa red knot and northern long-eared bat. As part of the permitting process, the project will complete Section 7 Consultations with the USFWS for both species pursuant to the Endangered Species Act of 1973, as Amended (16 USC 1531 et seq.)

No Significant Degradation—The proposed construction and associated restoration actions would not significantly degrade any water or wetlands. In fact, over the long-term, the planned restoration would improve flushing and is expected to reduce or eliminate the current “impaired” listing under Section 303(d) of the CWA (see section 4.3). Measures to protect and avoid adverse impacts to wetlands and water resources would be incorporated into the design and construction process for the preferred alternative. Construction best management and resource protection practices would be implemented in accordance with state and federal guidelines to avoid unnecessary impacts to wetland and water resources.

Reasonable Steps to Minimize Adverse Impacts—To the extent practicable, adverse impacts to wetland resources would be avoided, minimized, and mitigated. Because major infrastructure construction and impact mitigation measures would occur within wetlands and are fundamental actions necessary to restore tidal range and salinity to the Herring River, avoidance of all direct wetland impacts is not possible for any of the action alternatives. Specific measures incorporated into the design process to avoid and minimize adverse impacts to wetlands, such as roadway realignments and steepened embankment slopes, are critical considerations as designs for each component of the preferred alternative are developed. These will be presented in detail in Section 404 and state/local permitting documents.

Mitigation—Typically, infrastructure improvement projects with impacts to wetlands would provide wetland mitigation in the form of enhancement, restoration, creation, or preservation to offset lost wetland area as well as lost functions and values. However, as this project would restore hundreds of acres of native tidal wetland habitat to large portions of the Herring River flood plain by re-establishing tidal exchange, and because the substantial benefits of the project to tidal wetlands and waterways far outweigh the adverse impacts, no additional wetland impact mitigation is proposed.

Section 401 of the Clean Water Act

Section 401 of the 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 is addressed below in the section titled "Massachusetts 401 Water Quality Certification."

Section 402 of the Clean Water Act

Under Section 402 of the CWA, stormwater discharges from construction activities that disturb one or more acres, are regulated by the National Pollutant Discharge Elimination System stormwater program. Prior to discharging stormwater, construction operators must obtain coverage under a National Pollutant Discharge Elimination System permit, which in Massachusetts is administered by the USEPA. It is anticipated that the construction-related stormwater discharges would be permitted under the Construction General Permit. The Construction General Permit requires compliance with effluent limits and other permit requirements, such as the development of a Stormwater Pollution Prevention Plan. Typically, the contractor is responsible for filing a Notice of Intent (NOI) along with the Stormwater Pollution Prevention Plan certifying that the work has met the permit's eligibility conditions and that they would comply with the permit's effluent limits. Preliminary design plans for Chequessett Neck Road Dike include enhanced stormwater treatment for the new structure (discussed in appendix K), which has been reviewed by Massachusetts Department of Transportation (MassDOT) and will be presented for permitting to MassDEP under the WPA and Massachusetts stormwater regulations. Because portions of the project in Wellfleet and Truro are not within the National Pollutant Discharge Elimination System Stormwater Program Designated MS4 Areas, it is likely that no other project elements would be subject to National Pollutant Discharge Elimination System /MS4. The project will be in full compliance with stormwater regulations during construction; however, since discussions with the Towns and agencies are ongoing, it is not clear at this point in the design if improvements to proposed stormwater treatment would be required.

Protection of Wetlands and Floodplain Management

Executive Order 11990: Protection of Wetlands and Executive Order 11988: Floodplain Management describes the executive branch policy on impacts to wetlands and floodplains as a result of taking a federal action. Executive Order 11990 requires agencies "…to avoid to the extent possible the long and short term adverse impacts associate with destruction or modification of wetlands…" among other tenets. The NPS policies related to wetland protection are outlined in NPS Director's Order 77-1 and Procedural Manual 77-1. Executive Order 11988 has similar requirements when it comes to actions proposed in the floodplain. Appendix G provides a Statement of Findings related to the potential impacts to wetlands and floodplains in the project area.

National Historic Preservation Act and Massachusetts Historical Commission

Section 106 of the National Historic Preservation Act of 1966 (NHPA) requires federal agencies to take into account the effects of their undertakings on historic properties, and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment. Historic properties are properties that are included in the National Register of Historic Places (National Register) or that meet the criteria for the National Register. If so, it must identify the appropriate State Historic Preservation Officer (SHPO) or Tribal Historic Preservation Officer (THPO) to consult with during the process. The lead federal agency, in consultation with the appropriate preservation officer, assesses adverse effects on the identified historic properties based on criteria found in Advisory Council on Historic Preservation's regulations. If they agree there would be no adverse effect, the lead federal agency proceeds with the undertaking and any agreed-upon conditions.

Compliance with National Historic Preservation Act Section 106 Requirements

For the HRRP, the NPS has taken the lead in consulting with the Massachusetts Historical Commission (MHC), which must review any projects that require funding, licenses, or permits from any commonwealth agency in compliance with Massachusetts General Law (MGL) Chapter 9, Sections 26–27C. In July 2008, MHC responded to the environmental notification form (ENF) for the HRRP requesting consultation with the NPS under Section 106, development of an environmental assessment or EIS for the project (this document), and a site investigation conducted under a State Archeologist's permit. A Phase IA Archeological Sensitivity Assessment (Herbster and Heitert 2011) has been conducted within the area of potential effect (APE) and consultation between the NPS, MHC, and THPO regarding the scope of additional archeological investigations is ongoing. To facilitate the long-term implementation of the project and the adaptive management approach, NPS and MHC have executed a Programmatic Agreement (PA) to address Section 106 compliance. The PA, including maps of the agreed upon APE, is included in appendix I. Under the PA, and the appropriate MHC and NPS archeology permits, Phase 1B intensive/locational investigations are underway for proposed work areas near the Chequessett Neck Road Dike, CYCC golf course, and Mill Creek.

National Historic Preservation Act and Tribal Consultation

The NHPA, amended in 1992, is the basis for the tribal consultation provisions in Advisory Council on Historic Preservation regulations. The two amended sections of NHPA that have a direct bearing on the Section 106 review process are Section 101(d)(6)(A), which clarifies that historic properties of religious and cultural significance to Indian tribes may be eligible for listing in the National Register, and Section 101(d)(6)(B), which requires Federal agencies, in carrying out their Section 106 responsibilities, to consult with any Indian tribe that attaches religious and cultural significance to historic properties that may be affected by an undertaking. Advisory Council on Historic

Preservation regulations incorporate these provisions and reflect other directives about tribal consultation from executive orders, presidential memoranda, and other authorities.

Compliance with the National Historic Preservation Act Consultation Requirements

In 2008, the NPS contacted the Mashpee Wampanoag Tribe and the Wampanoag Tribe of Gay Head-Aquinnah to share information about the proposed HRRP and request input from the tribes. Areas of concern were identified as a result of consultation with these tribal groups including onsite meetings with the Mashpee Wampanoag Tribe in April 2011 and the Wampanoag Tribe of Gay Head-Aquinnah in January 2012. These concerns were primarily focused on (but not limited to) potential impacts to the uplands within the CYCC property (per Option 1: Relocation). Consultation with these tribal groups and the MHC is ongoing, and as specific impacts become defined as the ground-disturbing activities related to the project are finalized, potential impacts to cultural resources will be identified and resolved through the implementation of the PA between the project proponents and the consulting parties.

5.3.5 COMMONWEALTH OF MASSACHUSETTS REGULATION AND CONSULTATION

In addition to meeting the requirements of NEPA and MEPA, this final EIS/EIR addresses a variety of other state regulatory and compliance needs of the project. Brief summaries of these requirements, and descriptions of how they will be met during the permitting process, are presented below. Copies of relevant correspondence are included in appendix A.

Massachusetts Wetlands Protection Act

The Massachusetts WPA and its recently revised implementing regulations (310 CMR 10.00 et seq.) provide protection for both inland and coastal wetland resource areas as well as 100-foot buffer zones. The Massachusetts Rivers Protection Act likewise regulates activity within 200 feet of perennial rivers (Riverfront Area). Any proposed alteration to a wetland resource area (defined as a change in vegetation, hydrology, or water quality) is reviewed for compliance with performance standards established for each resource area. The WPA also requires compliance with the MassDEP Stormwater Management Standards. City- or Town-appointed Conservation Commissions have delegated statutory authority to administer the WPA and to issue Orders of Conditions for most alterations to wetland resource areas. New regulations, promulgated by MassDEP in October 2014, will result in important changes to how the HRRP may be permitted, compared to information presented in the draft EIS/EIR. Most notable among these changes is the provision for Ecological Restoration Limited Projects, which would allow the Herring River project to proceed without a variance to the WPA or S. 401 WQC regulations, as had been noted in the draft EIS/EIR. For this reason, text describing how the project would or would not meet certain performance standards of the WPA has been removed from this final EIS/EIR.

Proposed Approach to Massachusetts Wetlands Protection Act Permitting

Given the magnitude of certain unavoidable impacts and alterations to wetland resource areas, the draft EIS/EIR stated that a variance would likely be needed from certain provisions of the WPA. However, since the release of the draft EIS/EIR, MassDEP has promulgated new regulations which, among other changes, include provisions for Combined Applications and Limited Project status for eligible ecological restoration projects. Sections 10.24(8) and 10.53(4) (coastal and inland, respectively) of the new regulations allow approval of an Ecological Restoration Limited Project that "may result in the temporary or permanent loss of Resource Areas and/or the conversion of one Resource Area to another when such loss is necessary to the achievement of the project's ecological restoration goals." There are no thresholds for the amount of alteration/loss allowed if the issuing authority determines that the project complies with the other applicable Ecological Restoration Limited Project provisions. This regulatory change eliminates the need for a WPA variance to permit the project.

The Herring River project may be permitted by the Wellfleet and Truro Conservation Commissions as an Ecological Restoration Limited Project based on the following factors, as set forth in the WPA regulatory provisions governing review and approval of ecological restoration projects:

- The project meets the definition of an Ecological Restoration Project, as stated at 10.04 because "its primary purpose is to restore or otherwise improve the natural capacity of a Resource Area(s) to protect and sustain the interests identified in MGL c. 131 S. 40, when such interests have been degraded or destroyed by anthropogenic influences";

- The project will be carried out in accordance with a habitat management plan which will be submitted to the Massachusetts Natural Heritage and Endangered Species Program (NHESP) for approval;

- The project will be carried out in accordance with any time of year restrictions or other conditions recommended by Massachusetts Division of Marine Fisheries;

- The project will not involve any work on or adjacent to a Coastal Dune or Barrier Beach;

- This final EIS/EIR and subsequent NOIs will clearly demonstrate the well-documented extent and severity of impairments to the Herring River Estuary, the substantial magnitude and significance of the project benefits to protect and sustain the interests of the WPA, and that any unavoidable adverse impacts to existing Resource Areas will be minimized while allowing achievement of the project's ecological restoration goals;

- Best management practices (BMPs) will be used to avoid and minimize impacts occurring during construction of the required project elements; and

- As a tidal restoration project, the project will not increase flooding or storm damage impacts to the built environment (e.g., buildings, wells, driveways, roads) because any potential impacts will be avoided by implementing site-specific flood prevention measures in accordance with recognized design standards and formal agreements with affected landowners. Details of flood impact mitigation measures and landowner agreements will be included in forthcoming permitting applications and supporting documentation.

In addition, although the project will involve dredging more than 100 cubic yards in an area of critical environmental concern (ACEC) and Outstanding Resource Water, this may be permitted with a S. 401 Water Quality Certification, per 310 CMR 10.12(1)(l) (see below).

As previously described, primary construction elements and other activities that fall into Class 1 would be addressed with detailed plans and narratives in the initial NOI. In sum, the approach is to submit one "umbrella" NOI that proposes implementation of the Class 1 project elements that will be required to implement the initial phase of the project. Other project elements that fall into Class 2 would be covered more broadly with lesser detail in the initial NOI, but would be further refined in detailed applications for permit amendments when they are proposed for implementation based on adaptive management analysis as tidal restoration progresses over time. Any flood prevention or other physical work activities, such as vegetation management, proposed on private property as part of the initial phase Class 1 elements would require the signature(s) of respective landowners on the NOIs. To ensure that approved Class 1 elements do not cause flooding or storm damage impacts to the built environment, proponents anticipate that the orders of conditions would include a requirement that tide gates and water levels be managed to prevent adverse impacts to the built environment. These conditions would remain in effect until additional Class 2 flood prevention and other project elements are fully designed, permitted, and implemented.

Class 2 elements proposed for implementation based on analysis of monitoring data and other factors, such as executing final work agreements with respective landowners, would be generally described in the NOIs and cited as “potential work” in the orders of conditions. These elements include activities such as additional vegetation management, channel dredging, and other flood impact mitigation actions. When any of these elements are subsequently proposed for definitive implementation, they will be submitted to the conservation commissions under requests to amend the Orders of Conditions, and would be accompanied by detailed plans, narratives, and other information as necessary to demonstrate compliance with the WPA.

Any flood prevention or other work, such as vegetation management, proposed on private property under an amended order of conditions would require the signature(s) of respective landowners on the amendment applications. To ensure that flood impacts to the built environment are prevented, amended orders of conditions could allow increased tidal elevations only after appropriate flood prevention and mitigation measures are in place and documented.

Affected Resource Areas

This section contains information about Resource Areas within the Herring River project area and how they would be directly impacted by the project alternatives. This information will be provided in greater detail for the preferred alternative in the forthcoming Notice(s) of Intent and other permitting documents. Indirect impacts to wetlands, those occurring as a result of returning tidal flow to the degraded Herring River flood plain, are discussed and quantified in chapter 4.

Under existing conditions, wetland resource areas upstream of the Chequessett Neck Road Dike and within the extent of tidal influence above the dike (Lower Herring River sub-basin) are considered coastal wetlands. The western extent of the Duck Harbor basin is an area of overwash from the barrier beach system and is considered a coastal dune. The remaining portions of the Herring River flood plain are considered inland wetlands.

The extent of the 100-year flood plain encompasses the entire project area (“AH” zone on the Flood Insurance Rate Maps prepared by the National Flood Insurance Program) and is thus considered Land Subject to Coastal Storm Flowage. This is the appropriate designation because the 100-year flood plain for the Herring River is determined by a coastal storm surge event and not a 100-year rain event.

Impacts to Coastal Wetland Resource Areas

Land Under the Ocean

The reconstruction of the Chequessett Neck Road Dike would include short- and long-term impacts up to an approximately 3.2-acre area comprised primarily of land under the ocean (lands below mean low water). This area also contains small inclusions of inter-tidal coastal beach (tidal flat), coastal bank, and salt marsh.

Coastal Beaches (Tidal Flats)

The reconstruction of the Chequessett Neck Road Dike would include short- and long-term impacts to a 3.2-acre area comprised primarily of Land Under the Ocean (lands below mean low water). This area also contains small inclusions of inter-tidal Coastal Beach (Tidal Flat), Coastal Bank, and Salt Marsh. These impacts would be temporary in nature, associated with the construction of cofferdams.

Coastal Bank

Activity Impacting this Resource Area—Reconstruction of the Chequessett Neck Road Dike is the only proposed activity anticipated to impact Coastal Bank along the dike itself and where it ties into the natural land forms at either end. This activity could alter up to 750 linear feet of Coastal Bank on the seaward side of the dike. While the Lower Herring Basin is subject to tidal action, the fringing coastal wetlands are bounded by freshwater wetlands, and there is no Coastal Bank behind it (Coastal Zone Management Office 1978 A Guide to Coastal Wetland Regulations).

Coastal Dune

The western extent of the Duck Harbor basin is a less than 2-acre area of overwash from the barrier beach system and is considered a Coastal Dune. Reintroduction of tidal flow into this sub-basin would result in areas of salt marsh landward of these Coastal Dunes. This is discussed in chapter 4.

Salt Marshes

In the Herring River, most of the area of salt marsh which is jurisdictional under the WPA occupies a relatively narrow band between open water and brackish marsh dominated by *Phragmites*. This 50-acre area includes 13 acres of salt marsh comprised of typical native salt marsh vegetation (discussed in chapters 3 and 4). According to the WPA, the extent of spring tides is the landward extent of a jurisdictional Salt Marsh [310 CMR 10.32(2)]. The definition further states “dominant plants within a salt marsh are salt meadow cord grass (*Spartina patens*) and/or salt marsh cord grass (*Spartina alternaflora*).” However, much of the vegetated marsh below the extent of spring tides within the Herring River is dominated by *Phragmites*. In a 2010 appeals decision (Van Loan Docket No. WET-2009-067), MassDEP found that the distinction between coastal and freshwater wetlands does not rely exclusively on vegetation and wetlands located below the extent of spring tides which are dominated by *Phragmites* are to be considered salt marsh. Therefore, the aerial estimate of jurisdictional salt marsh in the Herring River system also includes *Phragmites*-dominated brackish marsh and is larger than the vegetation cover type estimate based solely on existence of typical salt marsh plant species.

The reconstruction of the Chequessett Neck Road Dike would include short- and long-term impacts to a 3.2-acre area comprised primarily of Land Under the Ocean. This area also contains small inclusions of inter-tidal Coastal Beach (Tidal Flat), Coastal Bank, and Salt Marsh. A total of less than 0.5 acres of salt marsh occurring adjacent to the Chequessett Neck Road Dike could be impacted during reconstruction by coffer dams or other dewatering operations. The majority of the approximately 50 acres of *Phragmites*-dominated salt marsh upstream of the dike would be permanently altered by restoration of tidal flow. In addition, very small patches of *Phragmites*-dominated Salt Marsh totaling less than 0.25 acres occurring within the Mill Creek sub-basin could be permanently lost by construction of a new Mill Creek Dike (alternatives C and D only). This is discussed in more detail in chapter 4.

Land Containing Shellfish

While the Herring River within the vicinity of the Chequessett Neck Road Dike is currently closed to shellfishing due to elevated fecal coliform levels, the reconstruction of the Chequessett Neck Road Dike would result in impacts to the approximate 90 acre area of Land Containing Shellfish occurring downstream of the dike. This is discussed in more detail in chapter 4.

Monitoring for potential sediment transport and deposition downstream of the dike, including within shellfish habitat, will be a component of the project's long-term adaptive management and monitoring program. Monitoring will be designed to detect changes in volume of suspended particles, particle size, and rate of deposition at key areas. As part of the adaptive approach to restoring tide range, alternate management actions will be considered in response to detections of change beyond pre-established threshold values (an expanded overview of the adaptive management approach proposed for the Herring River project is provided in appendix C). Detailed information about monitoring and management/mitigation responses with respect to shellfishing in Wellfleet Harbor will be developed in close collaboration with the Town of Wellfleet and the shellfishing community throughout the adaptive management and permitting processes.

Fish Runs

Reconstruction of the Chequessett Neck Road Dike and culvert replacements at High Toss Road, Pole Dike Creek Road, and Bound Brook Road could result in temporary impacts to approximately 15 miles of habitat for migrating river herring and American eels. This is discussed in more detail in chapter 4.

Impacts to Inland Wetland Resource Areas

Bordering Vegetated Wetlands

Although formerly tidally-influenced coastal marsh prior to construction of the Chequessett Neck Road Dike, the majority of the Herring River project area is considered Bordering Vegetated Wetland (BVW) for the purposes of Massachusetts WPA jurisdiction. This includes all existing vegetated wetlands upstream of High Toss Road and wetlands in the Lower Herring River and Mill Creek sub-basins above the reach of mean high spring tide.

Any of the proposed alternatives would result in the loss of well over 5,000 square feet of BVW and would include loss of BVW within state-designated estimated and priority habitat for rare, endangered, and threatened species and within the Wellfleet Harbor ACEC. Direct BVW losses could include the following:

Fill for Mill Creek Dike (alternatives C and D only)	Up to 12,500 square feet (also includes small areas of salt marsh, see above)
Flood proofing CYCC Golf Course (alternatives B and D only)	Up to 360,000 square feet (most of BVW currently maintained as golf course)

Elevation of Pole Dike/Bound Brook/Old County Roads	Up to 90,000 square feet
Other restoration and flood proofing activities	TBD upon further project design, adaptive management plan implementation, and land owner consultation

In addition to these direct wetland losses, virtually all of the approximately 840 acres of BVW within the Herring River project area will be altered to some degree by restoring tidal exchange. As discussed in chapter 4, vegetation change throughout large areas of the flood plain will be extensive as native salt marsh plant species replace *Phragmites* and other brackish and freshwater species. In some locations, primarily along the periphery of the project area and in upper sub-basins, higher levels of tidally-influenced freshwater would promote a die-off of upland trees and shrubs which have invaded the drained flood plain and promote the establishment of freshwater emergents and palustrine shrub species. Temporary indirect impacts to BVW would also occur throughout the project to facilitate construction and on-marsh adaptive management activities such as clearing vegetation and removing spoil berms. Additional impacts to wetlands as they relate to low-lying roadways are discussed further in “Appendix K: 25% Engineering Design Report Herring River Tidal Restoration Project.”

Bank

Within the Herring River flood plain natural banks occur along the mainstem of the river and its tributaries. In addition, the edges of roads crossing the flood plain are considered jurisdictional Banks for purposes of the WPA. These occur primarily along High Toss, Pole Dike Creek, Bound Brook, and Old County Roads. Impacts to this resource area will be estimated upon further project design. Alteration of bank along these roads would be unavoidable to elevate them above restored high tides or, in the case of High Toss Road, potentially removing the road to facilitate tidal circulation. Naturally occurring banks could be impacted by overtopping resulting from restored tide flow. In some areas, artificial spoil berms deposited along banks during mosquito ditch maintenance would be proposed for breeching and/or removal to further promote tidal circulation within interior marshes.

Land Under Waterbodies

Small areas of Land Under Waterbodies and Waterways within the Herring River project area would be impacted by construction of the Mill Creek Dike (under alternatives C and D only) and culvert replacements at High Toss, Pole Dike Creek, Bound Brook, and Old County Roads. At each of these locations, the magnitude of the impact would be limited to the footprint of the new structure within the stream channel, which ranges from less than 100 square feet at the smaller crossings to approximately 900 square feet at High Toss. In total, these impacts would amount to approximately 1,500 square feet.

Riverfront Area

The Riverfront Area in the Herring River system includes the zone within 200 feet of all perennial streams and thus encompasses large portions of the watershed, including the tributary streams of

Mill Creek, Snake Creek, Pole Dike Creek, and Bound Brook. Construction activities would impact Riverfront Area, however virtually all work and impacts would also occur within the other jurisdictional resource area types previously described. The sole exception would be for several potentially affected wells which may require relocation from within the flood plain to an upland location presumably within the Riverfront Area. This is expected to involve no more than 10 wells, with a maximum cumulative short- and long-term impact of 1,000 square feet to Riverfront Areas.

Massachusetts 401 Water Quality Certification

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 Commonwealth of Massachusetts that require federal licenses or permits and that are subject to Massachusetts water quality certification under Section 401 of the federal CWA. For work in USACE jurisdiction involving a discharge to waters of the United States, MassDEP must provide or waive certification before work can proceed. 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 WPA, and otherwise avoids or minimizes individual and cumulative impacts to Massachusetts waters and wetlands. The Massachusetts Water Quality Certification regulations at 314 CMR 9.00 were revised in coordination with WPA regulation updates in October 2014.

Compliance with Massachusetts Water Quality Certification

MassDEP is required to issue water quality certificates for projects that result in discharge or fill, pursuant to the Massachusetts Clean Waters Act (MGL c. 21 §§ 26-53) and Section 404 of the Federal CWA.

There are seven criteria for the evaluation of applications for discharge of dredge or fill material (314 CMR 9.06):

- No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem
- No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken which would minimize potential adverse impacts to the Bordering or Isolated Vegetated Wetlands or Land Under Waterbodies and Waterways
- No discharge of dredged or fill material shall be permitted to state-designated Outstanding Resource Waters, except for the activities specified in 314 CMR 9.06(3)(a) through (k), which may be permitted without requiring a variance in accordance with 314 CMR 9.08
- The discharge of dredged of fill material into wetlands or water of the Commonwealth with 400 feet of the high water mark of a Class A surface water requires a variance
- No discharge of dredged or fill material is permitted for the impoundment or detention of stormwater for the purposes of controlling sedimentation or other pollutant attenuation
- Stormwater discharges shall be provided with BMPs to attenuate pollutants and provide a set back from receiving water or wetland
- No discharge of dredged or fill material shall be permitted in the rare circumstances where the activity meet the criteria for evaluation but would result in substantial adverse impacts to the physical, chemical, or biological integrity of surface waters of the Commonwealth.

Similar criteria and performance standards for evaluating applications for dredging and dredged material management are found at 314 CMR 9.07.

In a manner similar to the justifications cited previously which would allow the Herring River project to be permitted under the Massachusetts WPA as an Ecological Restoration Limited Project, approval under the S. 401 Water Quality Certification standards is expected because:

- The project meets the definition of an Ecological Restoration Project, as stated at 310 CMR 10.04 because "its primary purpose is to restore or otherwise improve the natural capacity of a Resource Area(s) to protect and sustain the interests identified in MGL c. 131 S. 40, when such interests have been degraded or destroyed by anthropogenic influences";
- The project will demonstrate that it will be carried out in accordance with any time of year restrictions or other conditions recommended by Massachusetts Division of Marine Fisheries;
- There are no Class A Surface Waters within the proposed project area;
- This final EIS/EIR, and any ensuing permitting documents and supporting materials, will clearly demonstrate the extent and severity of impairments to the Herring River, the magnitude and benefits of tidal restoration, and that any adverse impacts to existing wetlands and waters of the Commonwealth are unavoidable to fully achieve these benefits;
- Removing tidal restrictions at tidal stream crossings by replacing undersized culverts is the major objective of the Herring River project and all such crossings will be guided by an operations and maintenance plan;
- Any stormwater discharge shall be provided with BMPs and no new stormwater conveyance will discharge directly into or cause erosion in wetlands or waters of the Commonwealth.

Because it is likely that the project will result in impacts to greater than 5,000 square feet of BVWs and will dredge more than 100 cubic yards of sediment in an Outstanding Resource Water, an Individual Water Quality Certification is expected to be required. This application will include:

- details regarding removal, handling, and placement of sediment entrained in former tidal channels and other measures required to improve tidal circulation and accretion of marsh surface elevations;
- additional information about sediment chemistry, including plans for additional sampling and characterization of metals and organochloride pesticides potentially mobilized during the project;
- stormwater management considerations, and;
- details regarding BMPs for construction, time of year restrictions, erosion and sediment control, and construction sequencing.

In addition to the above, it is also expected that the project will seek a Combined Permit, as allowed by 314 CMR 9.0.9(4), to cover both S. 401 Water Quality Certification and Chapter 91 Waterways licensing.

Massachusetts Public Waterfront Act, Chapter 91 (Massachusetts Waterways Licensing Program)

Chapter 91 is a collection of early ordinances and subsequent statutes designed to preserve and protect the public's rights in tidelands by ensuring that such lands are only used for water-dependent uses or otherwise serve a proper public purpose. Compliance with Chapter 91 is administered by MassDEP through the Waterways Regulations at 310 CMR 9.00. These regulations establish procedures for the issuance of licenses for activities and structures located within jurisdictional areas. Maintenance, repair and minor modifications to existing structures within jurisdictional area may be permitted without a new license or license amendment under the procedures at 310 CMR 9.22.

Within the Herring River project area, Chapter 91 jurisdiction potentially extends to the placement of fill and the new construction, substantial alteration, or expansion of existing structures below the historic (pre-Chequessett Neck Dike) mean high water line. No structures or fill in the Herring River flood plain (with the exception of the Bound Brook Road culvert) currently have Chapter 91 licenses, thus new license applications would need to be submitted for all fill and structures below historic mean high water. These will include:

- the new Chequessett Neck Road Dike;
- a new dike and tide control structure at Mill Creek;
- fill placed to elevate portions of the CYCC golf course;
- a new culvert and access improvements along High Toss Road;
- several new culverts and fill placed along reaches of Pole Dike Creek, Bound Brook Island, and Old County Roads; and
- other small culverts and related fill along roads in upstream reaches of the project area.

It is expected that the project will seek a Combined Permit, as allowed by 314 CMR 9.0.9(4), to cover both S. 401 Water Quality Certification and Chapter 91 Waterways licensing.

Massachusetts Stormwater Management Standards

The proposed project requires work within Wetland Resource Areas and buffer zones as defined and regulated under the WPA and the Wetlands Protection Regulations (310 CMR 10.00). Projects that fall under the jurisdiction of the WPA must comply with the Massachusetts Stormwater Management Standards (310 CMR 10.05(6)). The Stormwater Management Standards define the requirements for proper stormwater management for new or redeveloped sites in Massachusetts. The reconstruction of the Chequessett Neck Road Dike and elevating of local roadways within their current alignments would be treated as redevelopment where certain standards only need to be met to the maximum extent practicable. A new dike at Mill Creek would likely not qualify as redevelopment and would need to meet all the stormwater management standards. The stormwater management designs for all components of the preferred alternative would be refined and analyzed in future design and permitting phases to demonstrate compliance with the Massachusetts Stormwater Management Standards. The project will be in full compliance with state and federal storm water regulations (Section 402 of the CWA) during construction; however, it is not clear at this point in the design if improvements to stormwater treatment would be required. Providing enhanced treatment would require an increase in ROW width, which may result in additional impacts to wetlands.

Massachusetts Endangered Species Act

The Massachusetts Endangered Species Act (MESA) (MGL c.131A and regulations 321 CMR 10.00) protects rare species and their habitats by prohibiting the "taking" of any plant or animal species listed as endangered, threatened, or species of special 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 NHESP 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.

Compliance with Massachusetts Endangered Species Act

In October 2008, the Massachusetts Division of Fisheries and Wildlife responded to the ENF for the Herring River project by providing a full list of state-listed species with the potential to occur in the project area. Of these species, four have been recorded within the Herring River project area:

- northern harrier (*Circus cyaneus*): threatened
- diamondback terrapin (*Malaclemys terrapin*): threatened
- eastern box turtle (*Terrapene c. carolina*): species of special concern
- water-willow stem borer (*Papaipema sulphurata*): threatened

In addition, in subsequent consultations, Massachusetts NHESP has also asked for information about the status of and potential impacts to American bittern (*Botaurus lentiginosus*) and least bittern (*Ixobrychus exilis*), which are both listed as endangered.

Chapter 3 (section 3.7) describes the species and their potential occurrence in the project area and chapter 4 (sections 4.7.2 through 4.7.4) describes the anticipated impacts to these species that would result from implementation of the proposed alternatives. Vegetation changes resulting from restoration of tidal flow and estuarine salinity levels will alter some of the existing habitats that these species currently are using. Based on consultations with NHESP and the refined vegetation change analysis, projected habitat changes resulting from the preferred alternative are described on a species-by-species basis in the final EIS/EIR.

Proposed measures to monitor impacts to listed-species will be presented in a Habitat Management and Monitoring Plan to be submitted to NHESP as part of habitat management plan for review and approval under the habitat management exemption provisions at 321 CMR 10.14(15) of the MESA. All monitoring work, including development of study plans, field and sampling procedures, and data analysis and reporting will be coordinated and planned in close consultation with NHESP. Monitoring activities that will be conducted within Cape Cod National Seashore will also require consultation and formal research permits from the NPS. The HRRC began planning initial field studies for listed-species in the Fall-Winter of 2014/2015. Baseline data collection began during the 2015 Spring field season. The Habitat Management and Monitoring Plan will be developed as these baseline studies are completed and assessed.

Areas of Critical Environmental Concern

The ACEC Program is administered by the Department of Conservation and Recreation. The ACEC Regulations (301 CMR 12.00) describe the procedures for the nomination, review, and designation of ACECs. The project area is included within the Wellfleet Harbor ACEC, which was designated in 1989 because of the area's extraordinary natural resources. The ACEC regulations also direct the agencies of the Executive Office of Energy and Environmental Affairs to take actions, administer programs, and revise regulations in order to preserve, restore, or enhance the natural and cultural resources of ACECs through a variety of state agency programs and regulations. Regulations administered by the MassDEP, MEPA, and the Massachusetts Office of Coastal Zone Management contain specific provisions regarding ACECs. Compliance with these provisions is addressed under the relevant regulations in this chapter.

Coastal Zone Management Act Consistency and Massachusetts Coastal Zone Management

In response to the federal Coastal Zone Management Act, enacted in 1972, the Commonwealth of Massachusetts developed its coastal zone management (CZM) program to help "preserve, protect, develop, and where possible, restore and enhance the resources of the nation's coastal zone." The Coastal Zone Management Act provides states with the ability to review federal activities and ensure that such activities are consistent, to the maximum extent practicable, with their CZM plans. The review process is used to make a "consistency determination." If a proposed action is inconsistent with the requirements of the state's approved program, the applicant and federal agency are prohibited from conducting the activity unless certain significant additional procedures are followed.

The Massachusetts program was approved by NOAA in 1978 and is implemented and monitored by CZM. The Massachusetts Office of Coastal Zone Management Policy Guide (October 2011) is 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 CZM 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. Specific policies applicable to the HRRP are outlined below.

Compliance with Massachusetts Coastal Zone Management Policies

Coastal Hazards – Policy 1—*Preserve, protect, restore, and enhance the beneficial functions of storm damage prevention and flood control provided by natural coastal landforms, such as dunes, beaches, barrier beaches, coastal banks, land subject to coastal storm flowage, salt marshes, and land under the ocean.*

CZM recognizes that natural landforms in coastal zone provide important protection from coastal storms, flooding, and erosion relative sea level rise. The ability of the former Herring River flood plain to serve in this capacity was severely limited by the construction of the Chequessett Neck Road Dike. The HRRP would gradually restore the beneficial functions of storm damage prevention and flood control provided by natural landforms above the dike. The goal of the restoration project is to balance tidal restoration objectives with flood control by allowing the highest tide range practicable while also ensuring flood proofing and protection of vulnerable properties including domestic residences, low lying roads, wells, and private property such as the CYCC. Effective protection would be achieved by the reconstruction and attentive oversight of the Chequessett Neck Road Dike and other tide control structures. The habitat restoration would also improve the ability of the subsided marsh plain to keep pace with sea level rise.

Coastal Hazards – Policy 2—*Ensure that construction in water bodies and contiguous land areas will minimize interference with water circulation and sediment transport. Flood or erosion control projects must demonstrate no significant adverse impacts on the project site or adjacent or downcoast areas.*

The HRRP seeks to restore natural physical coastal processes including water circulation and sediment transport to the extent possible. One of the more important hydrologic functions of tidal flushing and wetlands is water quality improvement. Degraded water quality conditions led the MassDEP to list the Herring River as “impaired” under the federal CWA Section 303(d) for low pH and high metal concentrations. Poor water quality in the river has also led to fish kills and closure of shellfish beds at the river’s mouth. The planned restoration would improve tidal flushing and is expected to eliminate problematic acidity in the estuary as well as resaturate wetland soils with salt water and reverse the chemical processes that have mobilized toxic metals into the water column. Restored tidal flows would lead to higher sediment transport and deposition onto the wetland surface, as sediment-carrying flood tides would again flood over creek banks and onto the subsided marsh platform. However, the proposed gradual opening of adjustable tide gates would incrementally increase the tidal range avoiding unexpected or sudden irreversible changes to the river and Wellfleet Harbor and allow monitoring of the system so that unexpected and/or undesirable responses could be detected and appropriate remedial actions taken.

Coastal Hazards – Policy 3—*Ensure that state and federally funded public works projects proposed for location within the coastal zone will:*

- Not exacerbate existing hazards or damage natural buffers or other natural resources
- Be reasonably safe from flood and erosion-related damage
- Not promote growth and development in hazard-prone or buffer areas, especially in velocity zones and ACECs
- Not be used on Coastal Barrier Resource Units for new or substantial reconstruction of structures in a manner inconsistent with the Coastal Barrier Resource/Improvement Acts.

This policy is primarily aimed at ensuring the soundness of public investment for public works projects in hazardous coastal areas. The proposed structural improvements needed to restore the Herring River flood plain would be designed to promote habitat restoration and functioning of natural processes to the extent possible. Newly constructed infrastructure would replace existing infrastructure that is over 40 years old, thereby minimizing future costly storm-related repair and maintenance. The majority of the project is within the boundary of the Seashore and therefore not anticipated to encourage new development in high risk areas, stimulate new or expanded development, or induce pressure for additional federal or commonwealth subsidies in hazardous coastal areas. Protecting existing properties is a critical part of all action alternatives. Flood protection would be realized either by controlling tides in specific sub-basins or by flood proofing individual properties.

Habitat - Policy 1—*Protect coastal, estuarine, and marine habitats—including salt marshes, shellfish beds, submerged aquatic vegetation, dunes, beaches, barrier beaches, banks, salt ponds, eelgrass beds, tidal flats, rocky shores, bays, sounds, and other ocean habitats—and coastal freshwater streams, ponds, and wetlands to preserve critical wildlife habitat and other important functions and services including nutrient and sediment attenuation, wave and storm damage protection, and landform movement and processes.*

Cape Cod has long been recognized as an extraordinary and diverse resource. Congress recognized that the Outer Beach of the Cape Cod peninsula was nationally significant for ecological, historical, and cultural reasons with the establishment of the Seashore with the intent to preserve the nationally significant and special cultural and natural features, distinctive patterns of human activity, and ambience that characterize the outer Cape. Most of the river's flood plain (approximately 80 percent) is within the boundary of the Seashore. Integral to the restoration plan is the restoration and long-term preservation of critical wildlife habitat and other important functions and services including nutrient and sediment attenuation, wave and storm damage protection, and landform movement and processes. The restoration of tidal flow would increase salinity and inundation, resulting in changes to vegetation and ultimately wildlife species and their habitats. Wetlands in the project area would be restored from degraded habitats influenced by freshwater to tidal marsh habitats influenced by salt water. Increased salinity would eliminate freshwater and upland plants and allow for colonization of native salt marsh plants.

Habitat - Policy 2—*Advance the restoration of degraded or former habitats in coastal and marine areas.*

The Herring River (along with its flood plain, tributary streams, and associated estuarine habitats within Wellfleet Harbor) was the largest tidal river and estuary complex on the Outer Cape. The HRRC proposes to restore native tidal wetland habitat to large portions of the Herring River flood plain in and adjacent to the Seashore by re-establishing tidal exchange in the river basin and its connected sub-basins. Tidal exchange would be increased incrementally, over time, using an adaptive management approach, to achieve desired conditions for native salt marsh habitats.

Protected Areas - Policy 1—*Preserve, restore, and enhance coastal ACECs, which are complexes of natural and cultural resources of regional or statewide significance.*

The restoration project is consistent with CZM's intent to preserve, restore, and enhance recognized complexes of marine resources by restoring degraded intertidal wetlands while ensuring the components of the restoration plan avoid or minimize adverse impacts. The project area is included within the Wellfleet Harbor ACEC. The Wellfleet Harbor ACEC was designated in 1989 because of the area's extraordinary natural resources. Portions of the area have been designated by the Department of Conservation and Recreation as containing visual landscapes and cultural resources that place it in the top 5 percent of all landscapes in Massachusetts (1982 Massachusetts Scenic Landscape Inventory). Important habitats within the ACEC boundary include largely unaltered barrier beaches, islands, marsh systems, salt and fresh water ponds, rivers, bays, and tidal flats. These areas provide flood control, storm damage prevention, improved water quality, wildlife habitat, and recreation opportunities to surrounding communities.

Protected Areas - Policy 3—*Ensure that proposed developments in or near designated or registered historic places respect the preservation intent of the designation and that potential adverse impacts are minimized.*

An objective of the project is to restore the expansive marshes and tidal waters that were once a principal maritime focus of both Native Americans and European settlers of outer Cape Cod in a manner that preserves the area's important cultural resources. Cultural resources consist of archeological resources and archeologically sensitive areas (below-ground resources), historic structures, properties, or objects (above-ground resources) and ethnographic resources. No historic (above-ground) resources were identified within the APE for the study (Herbster and Heitert 2011). No documented ethnographic resources are known to be located within the project APE, but consultation regarding the presence of ethnographic resources in the Herring River estuary is ongoing. No impacts to archeological resources or archeologically sensitive areas are expected to occur due to the gradual increase in tidal elevations. There is a potential for construction activities to adversely affect archeological resources within the APE. Prior to any construction, additional archeological assessment and/or survey should be conducted where ground-disturbing activities are to be conducted to determine if these areas contain archeological sites that are eligible for inclusion in the National Register.

Water Quality - Policy 2—*Ensure the implementation of nonpoint source pollution controls to promote the attainment of water quality standards and protect designated uses and other interests.*

Several road segments, primarily at stream crossings, are vulnerable to restored tidal flooding, most notably along High Toss, Pole Dike, Bound Brook, and Old County Roads. As a result, low-lying portions of these roadways may be elevated in place, removed, or relocated. The reconstruction of roadways and associated stormwater management systems would meet Department of Environmental Protection redevelopment stormwater management standards as applicable. All construction areas would maintain stormwater BMPs to comply with commonwealth and federal non-point source pollution requirements to the maximum extent practicable while still achieving the project purpose of estuary restoration.

Massachusetts Division of Marine Fisheries

Massachusetts Marine Fisheries has broad legal authority within the Commonwealth of Massachusetts to provide suitable passage for anadromous fish coming into fresh water to spawn. This includes the authority to examine dams and other obstructions to passage in brooks, rivers, and streams, which flow into coastal waters to decide if fishways are needed and determining whether existing fishways are suitable and sufficient for the passage of fish. The emphasis of their work is on fishway maintenance, reconstruction and replacement of fishway passage facilities with more advanced designs.

Compliance with the Massachusetts Division of Marine Fisheries

It is anticipated that the final design of the Chequessett Neck Road and Mill Creek Dikes would be reviewed by the Massachusetts Division of Marine Fisheries to ensure that adequate fish passage is made available for migration of herring, and other anadromous and catadromous species, prior to project implementation. The project team would also rely on the Massachusetts Division of Marine Fisheries to specify construction constraints to avoid impacts to these important species.

Massachusetts Department of Transportation

Under Chapter 85, Section 35 of the Massachusetts General Laws, any structure (culvert, bridge or other) measured 10 feet or over along the roadway centerline (or 8 feet measured square to the abutments) is considered a “bridge” for the purpose of review by the MassDOT. By this law, MassDOT has been charged the task of reviewing all bridges along a public way (state maintained or otherwise). Under this review, MassDOT’s Bridge Section ensures new or replacement bridges would be designed to American Association of State Highway and Transportation Officials specifications and that the structure would be safe for the anticipated design loading. Also upon review of these structures, MassDOT would assign all structures with spans 10 feet or greater a BIN (bridge identification number) to help maintain a statewide inventory of such structures.

Compliance with Chapter 85, Section 35 is being achieved in the design of the proposed new Chequessett Neck Road Dike. This is the sole component of the preferred alternative expected to involve a road / stream crossing structure spanning 10 feet or greater and thereby requiring review by MassDOT’s Bridge, Geotechnical and Hydraulic Sections. Initial consultations are underway and formal approval by MassDOT’s Bridge Section will be required when the final plan set and specifications documents are prepared.

5.3.6 LOCAL AND REGIONAL AND CONSULTATION

Cape Cod Commission – Development of Regional Impact

The CCC was created in 1990 by an Act of the Massachusetts General Court (the state legislature), and it was confirmed by a majority of Barnstable County voters. The CCC 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 development of multiple residential or commercial properties, transportation facilities, changes to historic structures, bridge, ramp, or road construction providing access to several types of water bodies and wetlands, and site alterations generating disturbance greater than 2 acres. In addition, any proposed development for which an EIR is required under MEPA is deemed to be a DRI.

Compliance with Cape Cod Regional Policy Plan Standards

The HRRP meets the threshold for a DRI review because it requires an EIR under MEPA. The CCC responded to the 2008 ENF for the project with a letter and matrix of regional planning issues to be addressed in the draft EIS/EIR. Following the release of the draft EIS/EIR in October of 2012, a joint CCC/MEPA public hearing was held and the Commission received public and agency comments on the draft document. During the hearing, the HRRC members, including representatives of the Towns of Truro and Wellfleet made a presentation on the proposed project and draft EIS/EIR. Commission staff provided an analysis of the draft EIS/EIR in a staff report, which analyzed the Project’s compliance with the Regional Policy Plan standards. After consideration of this information, the CCC Subcommittee met and voted to adopt the Commission staff report as their comments to MEPA. The Commission’s letter was included by reference in the scope of the December 21, 2012 Certificate of the Secretary of Energy and Environmental Affairs.

Following issuance of a final Certificate by the Massachusetts Secretary of Energy and Environmental Affairs, the HRRP will submit a DRI application to the CCC. The Project will be proposed as a Project of Community Benefit under the CCC Enabling Regulations, Section 9, Hardship Exemptions. Under this section, the Commission may waive or modify application of one or more of the Minimum Performance Standards of the Regional Policy Plan where full compliance with the Minimum Performance Standards would constitute a hardship by diminishing the community benefit conferred by the Project.

Wellfleet Environmental Protection Bylaw

The Wellfleet Conservation Commission protects the natural resources and wetlands existing in the Town of Wellfleet by controlling activities deemed to have a significant or cumulative adverse impact upon environmental values. The local bylaw incorporates and expands upon the Massachusetts WPA and regulations with several notable additions including:

- Stricter controls over work within the 100-foot buffer zone and a 50-foot filter strip
- Impacts to freshwater wetlands are prohibited whether they are bordering or not
- More detailed filing requirements for coastal engineering structures
- Performance standards for the Land Subject to Coastal Storm Flowage within the Wellfleet Harbor ACEC.

The Wellfleet Environmental Protection Bylaw considers the AH zone on the Flood Insurance Rate Maps to be significant for storm damage prevention. This ponding generally occurs as a result of overwash from coastal floodplains. The placement of fill within these areas may increase flood levels on adjacent properties. Any activity proposed on Land Subject to Coastal Storm Flowage or within the Wellfleet Harbor ACEC shall not:

- Reduce the ability of the resource to absorb and contain flood waters
- Reduce the ability of the resource to buffer more inland areas from flooding and wave damage
- Displace or divert flood waters to other areas
- Cause or create the likelihood of damage by debris to other structures on land within the flood plain
- Cause ground, surface or saltate pollution triggered by coastal storm flow
- Reduce the ability of the resource to serve as a wildlife habitat and migration corridor.

Compliance with the Wellfleet Environmental Protection Bylaw

The proposed elements of the restoration project cannot meet the performance standards established within the Wellfleet Environmental Protection Bylaw and would require a variance from the Wellfleet Conservation Commission. Under the bylaw, the Commission may grant a variance upon clear and convincing proof that the proposed work, or its impacts, would not adversely affect the public interests and environmental values protected by the bylaw. Criteria for a variance are similar to those under the Massachusetts WPA.

Truro Conservation Bylaw

The Truro Conservation Bylaw is administered by the Truro Conservation Commission and mirrors the Massachusetts WPA and regulations. If the Commission, after a public hearing, determines that the activities are likely to have a significant individual or cumulative impact upon the resource area values protected by this bylaw, the Commission shall issue an Order of Conditions, permitting the activities requested or denying the application. The bylaw does not establish thresholds on the extent of work that can be authorized under an Order of Conditions issued by the Commission. Applicants aggrieved by a Commission's order may appeal to MassDEP and to an appropriate court. It is anticipated that the proposed minor culvert replacements and flood mitigation work for several short sections of road and change in water levels in Bound Brook would trigger the need to file a NOI under this bylaw. The HRRC intends to submit a NOI concurrently to both towns for rebuilding the Chequessett Neck Road Dike. If any subsequent direct work is done in the Town of Truro, a separate NOI would be submitted to the Truro Conservation Commission.

5.4 LIST OF RECIPIENTS

The following list includes government, stakeholder groups, and regulators who received this final EIS/EIR for review or were directly notified of its availability for review and comment.

Congressional Delegates

- Senator Elizabeth Warren
- Senator Edward Markey
- Rep. William Keating, Massachusetts Congressional District 9

National Park Service

Environmental Protection Agency

U.S. Army Corps of Engineers

U.S. Fish and Wildlife Service

National Atmospheric and Oceanic Administration

Natural Resources Conservation Service

Federal Emergency Management Agency

Advisory Council on Historic Preservation

Commonwealth of Massachusetts

Commonwealth of Massachusetts Legislators

- Sarah K. Peake, 4th District Barnstable (House)
- Daniel A. Wolf, Cape and Islands District (Senate)

Massachusetts Environmental Policy Act Office, MEPA Unit

Massachusetts Department of Environmental Protection, Southeast Regional Office

Massachusetts Department of Environmental Protection, Boston Headquarters

Massachusetts Department of Conservation and Recreation, Areas of Critical Environmental Concern Program

Massachusetts Office of Coastal Zone Management

Massachusetts Division of Marine Fisheries

Massachusetts Natural Heritage & Endangered Species Program

Massachusetts Department of Transportation

Massachusetts Emergency Management Agency

Massachusetts Historical Commission

Barnstable County

- Cape Cod Commission
- Cape Cod Conservation District
- Barnstable County Department of Health and the Environment

Town of Wellfleet

- Board of Selectman
- Board of Health
- Conservation Commission
- Department of Public Works
- Shellfish Advisory Board
- Town Planner
- Open Space Committee
- Natural Resources Advisory Board

Town of Truro

- Board of Selectman
- Board of Health
- Conservation Commission
- Department of Public Works
- Shellfish Advisory Committee
- Town Planning Board

Open Space Committee

Natural Resources Advisory Board

Federally Recognized Indian Tribes

Mashpee Wampanoag Tribe

Wampanoag Tribe of Gay Head Aquinnah

Libraries

Other Organizations and Businesses

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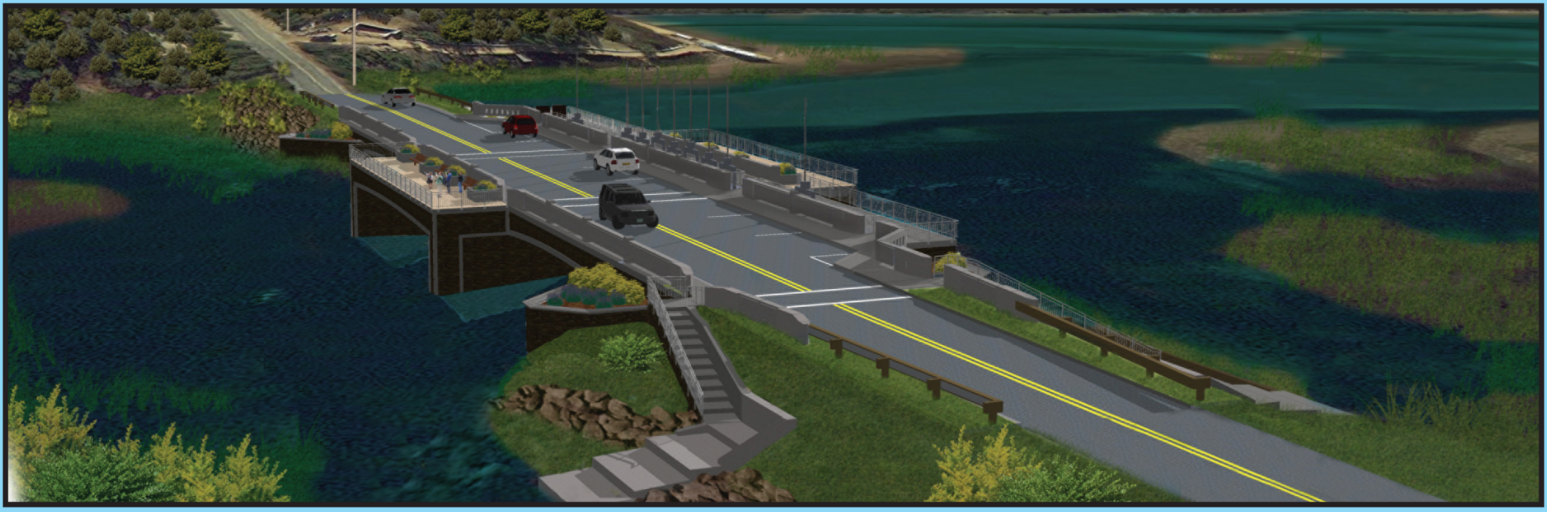

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GLOSSARY

accretion—The act of adding material, such as from the deposition and accumulation of waterborne particles.

Action Alternative—An alternative that proposes a different management action or actions to address the purpose, need, and objectives of the plan; one that proposes changes to the current management. Alternatives B and C are the action alternatives in this planning process. See also: "No-Action Alternative."

Adaptive Management—A systematic management paradigm that assumes natural resource management policies and actions are not static but are adjusted based on the combination of new scientific and socio-economic information in order to improve management by learning from the ecosystems being affected. A collaborative adaptive management approach incorporates and links knowledge and credible science with the experience and values of stakeholders and managers for more effective management decision-making.

Affected Environment—A description of the existing environment that may be affected by the proposed action (40 CFR 1502.15).

algae—Simple rootless plants that grow in bodies of water (e.g., estuaries) at rates dependent on sunlight, temperature and the amounts of plant nutrients (e.g., nitrogen and phosphorus) available in water.

alluvial—Relating to the deposits made by flowing water; washed away from one place and deposited in another; as, alluvial soil, mud, accumulations, deposits.

amphibian—A cold-blooded, smooth-skinned vertebrate animal of the class Amphibia, such as a frog or salamander, that typically hatches as an aquatic larva with gills. The larva then transforms into an adult having air-breathing lungs.

amphipods—A small freshwater or marine crustacean with a thin body and without a carapace.

anadromous—Fish species that spend their lives in the ocean, but return to freshwater streams, rivers, and ponds to spawn.

anaerobic—Not containing oxygen or not requiring oxygen.

anoxic—Without oxygen; water that contains no dissolved oxygen.

anthropogenic—Involving the impact of humans on nature; induced, caused, or altered by the presence and activities of humans, as in water and air pollution.

aquifer—Underground rock or soil layer yielding groundwater for wells and springs, etc.

astronomic tides— The periodic rise and fall of a body of water resulting from gravitational interactions between the Sun, Moon and Earth.

attenuation—Reduction.

base flood—A flood having a one percent chance of being equaled or exceeded in any given year.

bathymetry—Of or relating to measurements of the depths of water bodies, such as oceans, estuaries or lakes.

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

biota—The combined flora and fauna of a region.

biotic—Pertaining to life or living things, or caused by living organisms.

bog—A wetland that has poorly-drained, acidic peat soil dominated by sedges and sphagnum moss.

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

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

buffer zone—A barrier between sensitive wildlife habitat and land uses such as agriculture or urban development. A transitional zone intended to provide for compatibility of nearby dissimilar uses.

candidate species (federal definition)—A species for which the U.S. Fish and Wildlife Service has on file sufficient information to support a proposal to list the species as endangered or threatened, but for which proposed rules have not yet been issued.

catadromous—Fish species that spend their lives in freshwater streams, rivers, and ponds, but return to the ocean to spawn.

Council on Environmental Quality (CEQ)—Established by Congress within the Executive Office of the President with passage of the National Environmental Policy Act of 1969. CEQ coordinates federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives.

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

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

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

ecotone—A transition zone between two ecosystems.

endangered (federal definition)—Any species which is in danger of extinction throughout all or a significant portion of its range.

EIS/EIR—Environmental Impact Statement/Environmental Impact Report.

essential fish habitat (EFH)—Waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

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

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

eutrophication—Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.

exotic species—Any introduced plant or animal species that is not native to the area and that may be considered a nuisance. See also invasive species.

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

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

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

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

habitat—The range of environmental factors at a particular location supporting specific plant and animal communities.

halophyte—Salt-tolerant vegetation.

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

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

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

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

inundation—Covered by a flood.

invasive species—A species that is 1) non-native (exotic) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

invertebrate—A animal without a backbone.

jurisdictional wetlands—Wetlands which meet the criteria of "waters of the United States" and are thereby under the jurisdiction of the Corps and the USEPA. The definition developed by the Corps considers as wetlands those areas which "…are inundated or saturated by surface or ground water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Under this definition, all three of the following conditions must be present: a) a dominance of wetland plants; b) hydric soils (soils with low oxygen concentrations in the upper layers during the growing season); and c) wetlands hydrology.

mammal—Any of various warm-blooded vertebrate animals of the class Mammalia, including humans, characterized by a covering of hair on the skin and, in the female, milk-producing mammary glands for nourishing the young.

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

Massachusetts Environmental Policy Act (MEPA)—The Act articulates the state law that requires that state agencies study the environmental consequences of their actions, including permitting and financial assistance. It also requires them to take all feasible measures to avoid, minimize, and mitigate damage to the environment. MEPA jurisdiction is broad in scope and extends to all aspects of the project that may cause damage to the environment as defined in the MEPA regulations. These include water quality, wetlands, coastal/marine resources, rare species habitat, and cultural resources.

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

mean high water (MHW)—The average height of all the high tides.

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

mean low water (MLW)—The average height of all low water heights.

migratory—Moving regularly or occasionally from one region or climate to another; as, migratory birds.

National Environmental Policy Act (NEPA)—The Act as amended articulates the federal law that mandates protecting the quality of the human environment. It requires federal agencies to systematically assess the environmental impacts of their proposed activities, programs, and projects including the "no-action" alternative of not pursuing the proposed action. NEPA requires agencies to consider alternative ways of accomplishing their missions in ways which are less damaging to the environment.

National Historic Preservation Act of 1966 (NHPA) (16 USC 470 et seq.)—An Act to establish a program for the preservation of historic properties throughout the nation, and for other purposes, approved October 15, 1966 [Public Law 89-665; 80 STAT. 915; 16 USC. 470 as amended by Public Law 91-243, Public Law 93-54, Public Law 94-422, Public Law 94-458, Public Law 96-199, Public

Law 96-244, Public Law 96-515, Public Law 98-483, Public Law 99-514, Public Law 100-127, and Public Law 102-575].

native species—Species which have lived in a particular region or area for an extended period of time.

navigation channel—The buoyed, dredged, and policed waterway through which ships proceed, especially in general shallow areas.

nonpoint source—A diffuse source of pollution that cannot be attributed to a clearly identifiable, specific physical location or a defined discharge channel. This includes the nutrients that run off the ground from any land use (e.g., croplands, feedlots, lawns, parking lots, streets, forests, etc.) and enter waterways. It also includes nutrients that enter through air pollution, through the groundwater, or from septic systems.

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

permeability—The degree to which something (e.g., an earthen structure) can be penetrated by a liquid.

pH—Measure of the acidity or alkalinity (basicity) of water (pH 7 is neutral, increasing values indicate alkalinity and decreasing value indicate acidity).

restoration—The return of an ecosystem to a close approximation of its condition prior to disturbance.

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

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

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

sedimentation—The deposition or accumulation of sediment.

spawn—The act of reproduction of fishes and certain marine invertebrates.

special status species—Collective term for endangered species, threatened species, species of concern and species of special concern.

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

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

submerged—Below water.

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

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

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

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

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

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

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

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

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

toxic—The property of being poisonous, of causing death or severe temporary or permanent damage to an organism.

toxicity—The degree to which a substance is *toxic*.

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

upland—Ground elevated above the lowlands along rivers or shorelines.

vector—An insect or other organism that transmits a pathogenic fungus, virus, bacterium, etc.

watershed—An area of land where all of the ground water and surface water drains to the same water body (typically a river or creek).

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

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