Mayo Creek Restoration Committee

Final Report and Recommendations

10 June 2019

Summary

The Mayo Creek Restoration Committee was appointed in 2014 to study alternatives for habitat restoration in the diked Mayo Creek estuary. The ecosystem suffers from over 100 years of habitat loss and water-quality degradation. The Committee researched Health Department records and information from abutters and property owners, conducted field observations of tide and groundwater levels, contracted elevation surveys and contracted and directed hydrodynamic modeling to find a way to maximize salt-marsh restoration upstream of the Commercial Street causeway without harming upstream properties.

Replacement of the Commercial Street culvert with an enlarged culvert (e.g. 6 X 7 ft) with active water-level control (adjustable gates), along with excavation of the upstream creek channel, can yield 20 acres of estuarine habitat restoration and over five feet of tidal range (as opposed to the existing 1.7 ft). The Committee believes that this can be accomplished without harm to adjacent development including the lowest structures, wastewater systems and supply wells. This alternative should also expedite the drainage of flood water during low tides, for example after heavy rain and in the event of an overwash of the Mayo barrier beach. A very preliminary cost range for the large and adjustable culvert is $2-4 million.

The Committee believes that it has accomplished its charge. We recommend that the Town proceed to initiate detailed restoration planning, with a goal of obtaining permitting approvals and eventual restoration implementation.

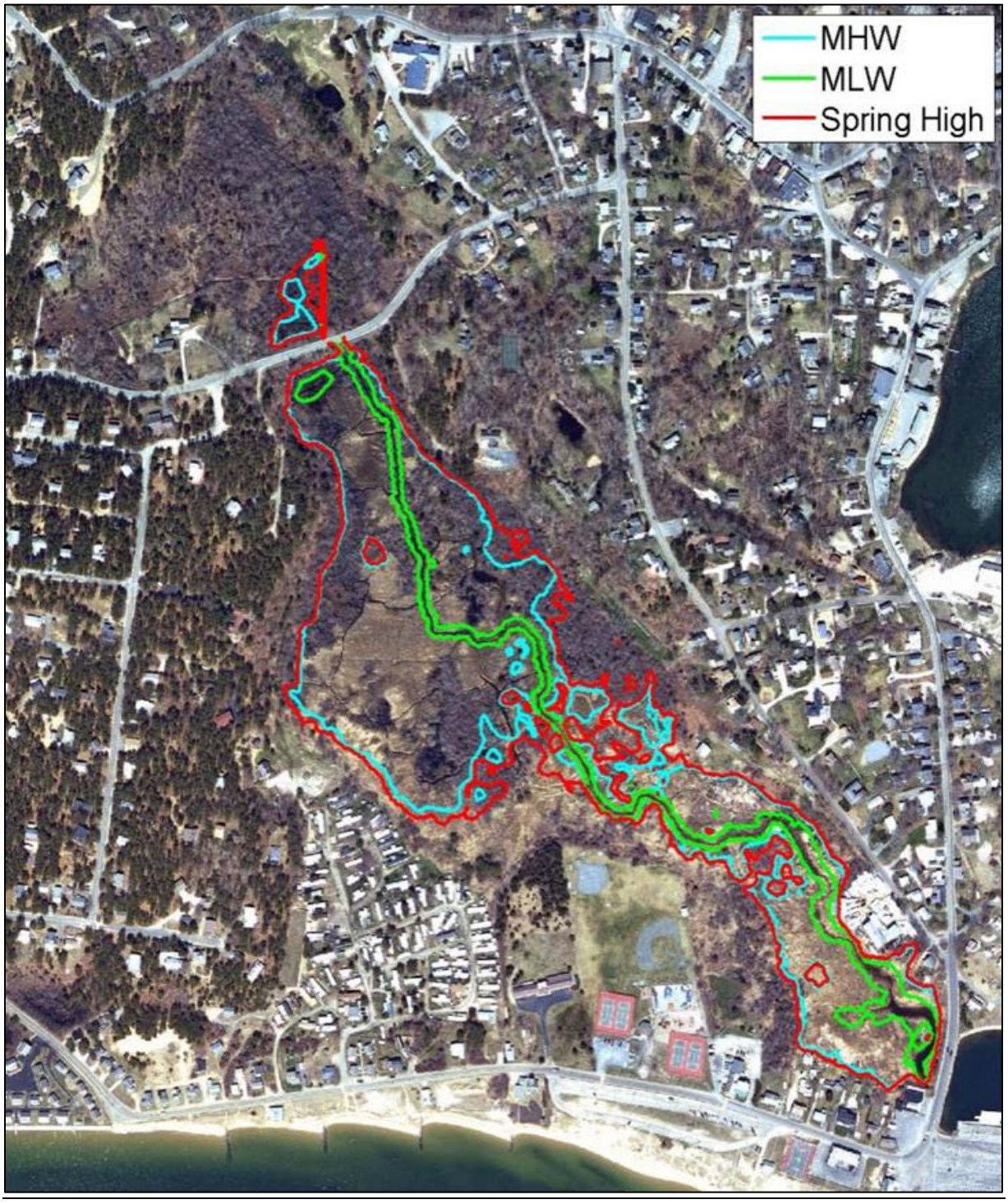


Figure 6. Aerial view of Mayo Creek showing the extent of mean high water (MHW), mean low water (MLW) and spring high tide under a scenario that maximizes salt-marsh restoration without flooding existing infrastructure (Woods Hole Group 2016).

Some History

The Mayo Creek Restoration Committee has studied the diked Mayo Creek (West Branch of Duck Creek, **Figure 1**) estuary since 2014, conducted office and field research, directed hydrodynamic modeling and held meetings with abutters, property owners and the general public. An interested audience has also been attending our open Committee meetings. The Committee herewith presents its findings and recommendations to the Selectboard regarding the advisability and next steps in habitat restoration.

The Mayo Creek estuary formed thousands of years ago behind the Mayo Beach barrier spit, and is bordered on three sides by hills: Summit Hill, Taylor Farm and the ridge along Holbrook Avenue. The original tidelands covered about 60 acres. Well drilling logs in and near the flood plain (Wellfleet Health Department; F. Cappello, personal communication) show several thick layers of clay, probably sediments deposited in glacial lakes during the last glacial retreat.

Tides and seawater were blocked from this back-barrier salt marsh in 1909 when, with the intention of filling the tidelands and probably to save money, the Town replaced a bridge across the original 100-foot-wide inlet with a solid-fill dike (Commonwealth of Massachusetts 1909, **Figure 2**). This dike currently serves as a causeway connecting Commercial Street with the Wellfleet Marina and Kendrick Avenue. The only opening for water passage through the dike is a two-foot-diameter culvert intended to allow freshwater drainage to the harbor; a one-way valve at the seaward end of this culvert prevents nearly all saltwater inflow to the Mayo Creek estuary. About 15 acres of the original tidelands were filled with harbor dredged material in the early to mid-20th century; this fill enabled the development of Bakers Field (1909 Annual Town Report), portions of the Harborside Village trailer park, and other low properties.

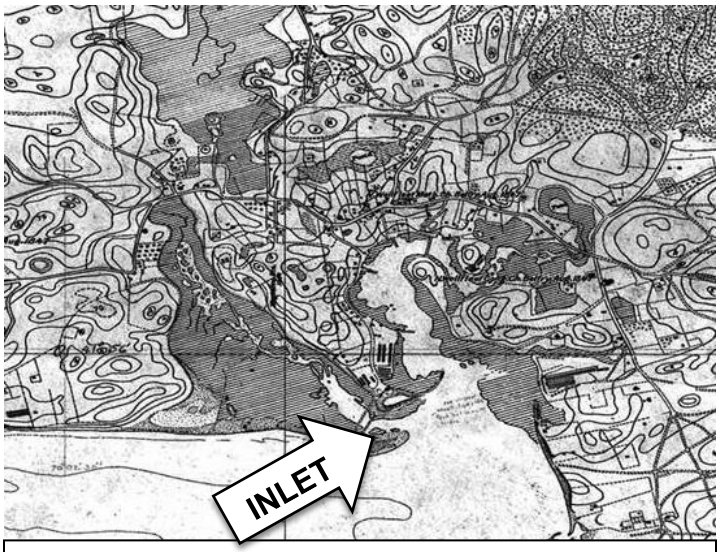


Figure 2. 1848 map of Wellfleet Harbor showing bridge over the natural Mayo Creek inlet, about 260 feet wide.

As a result of these man-made changes, the original back-barrier salt marsh is a highly degraded freshwater wetland. Original highly productive salt marsh grasses have been replaced by *Phragmites australis* (Common Reed), of much lower value to fish and wildlife, with freshwater wetland and upland shrubs and trees at higher elevations. As a result of negligible tidal flushing, the creek is chronically low in dissolved oxygen (APCC 2011), explaining the dearth of aquatic fauna, and high in nitrogen compounds and fecal coliform bacteria. Nitrogen

loading to Wellfleet Harbor may be contributing to excessive algae blooms and oxygen depletion in the summer months. Fecal coliform is the microbial group used by public health officials to classify shellfish waters; as little as 14 CFU (colony-forming units) per 100 ml cause the closure of shellfish beds. Shellfish bed closures due to fecal coliform are common in the inner harbor and Duck Creek.

For about the past 10 years, the Town has investigated restoration of this estuary, initially through the Harbor Management Plan of 2006 and the Town Conservation Agent and, since 2014, through the Mayo Creek Restoration Committee. Over that period, the Committee has sought tidal-restoration alternatives that meet two criteria: 1) substantial salt-marsh restoration area within the Mayo Creek flood plain and 2) protection of surrounding infrastructure. This work has been guided by hydrodynamic modeling of physical alternatives by Woods Hole Group (WHG), under contract to the Town and funded by grants from the MassBays and Coastal America Programs. This report summarizes the Committee's current state of knowledge regarding: 1) justification for tidal restoration; 2) constraints on habitat restoration imposed by development; 3) an evaluation of management alternatives; and 4) recommendations for a physical restoration alternative (with preliminary cost estimate) and associated additional studies.

Justification for tidal restoration

Besides the water quality problems and salt-marsh vegetation loss mentioned above, the continued blockage of tides from Mayo Creek marshes also blocks sediment supply and limits the marsh's ability to grow upward as sea level rises (Turner 2004, Portnoy & Giblin 1997). In this way the storm-surge protection that this wetland would provide to shoreline properties is diminished - a condition that will become increasingly threatening with climate warming, accelerating sea-level rise and increased storm intensity. It is important to note that the principal storm-surge protections for low-lying properties around Mayo Creek are the Mayo barrier beach and marshlands, and not the Commercial Street causeway, which is too low to serve as a flood barrier.

The diked Mayo Creek flood plain is further threatened by prolonged flooding after major rain events, and an inevitable future overwash of Mayo Beach, by the undersized culvert under Commercial Street that provides the only outlet for water impounded in the diked wetland. This prolonged flooding was evident in computer simulations of heavy rain events (WHG 2011).

Mayo Creek wetlands are located strategically along the groundwater flow path between Town Center, with many on-site wastewater systems and high groundwater nitrogen, and nitrogen-sensitive Wellfleet Harbor. Coastal wetlands, and especially regularly flooded salt marshes, can remove nitrogen before its discharge to surface waters. Diked and drained wetlands lose much

of their nitrogen-removal capacity (Venterink et al. 2002). The importance of maintaining good water quality for the Harbor's shellfish industry and for public recreation is obvious (Massachusetts Estuaries Project 2017).

Restoration of the Mayo Creek estuary is part of the Town's Comprehensive Wastewater Management Plan ("208 plan"). MCRC has been communicating with the Wellfleet Comprehensive Wastewater Planning Committee (CWWPC) on the role of Mayo Creek restoration in this plan. The CWWPC has recently supplied MCRC with an estimate of 2000 kg/year nitrogen removal in a restored Mayo Creek. The Town's 208 plan requires the Town of Wellfleet to achieve a remediation goal of 10,000 kg/year.

Tidal salt marsh estuaries are of fundamental importance to the biological health and diversity of harbors. The diking and subsequent fill of Mayo Creek has eliminated about 60 acres of habitat for estuarine fish, shellfish, mammals, waterbirds, and the State-listed Diamondback Terrapin. Salt marshes serve as nurseries for both forage fish and for their larger predators like Bluefish, Striped Bass and Winter Flounder, all of commercial and recreational value.

Natural salt marshes store carbon faster and retain it longer than any other ecosystem on the planet; they are net sinks for atmospheric carbon dioxide. In contrast, diked and freshened marshes, like tide-restricted Mayo Creek, have been found to be net sources of greenhouse gases including highly heat-absorbing methane (Drake et al. 2015).

Despite purported mosquito control, historic salt marsh diking has been shown to increase mosquito breeding by degrading water quality and habitat for predatory fish and reducing tidal flushing (Easton & Marshall 2000, Portnoy 1984, Portnoy et al. 2016). For this reason, the Cape Cod Mosquito Control Project supports tidal restoration in Mayo Creek (letter of 20 August 2014, **appended**) and similarly altered coastal wetlands.

Constraints on habitat restoration imposed by infrastructure

The Committee determined the following through Health Department record searches, consultation with scientific and engineering experts, literature research, field surveys and extensive meetings and interviews with project abutters. Technical reports that formed the basis of our conclusions are available upon request, and will be submitted to the Town for inclusion on its website. **Note that elevations are all relative to NAVD88**. See Table 1 and **Figure 3** for a summary of critical tidal, land-surface and structural elevations.

Mayo Creek Today

1. After 109 years of tidal restriction, the Mayo Creek estuary suffers from dissolved oxygen stress, high nitrogen and fecal coliform pollution and the invasion of non-native

Phragmites australis and upland shrubs and trees, which have displaced native salt-marsh plants (APCC 2011).

2. Since diking, creek channels upstream of Commercial Street have filled with sediment.

3. Existing tidal range in diked Mayo Creek is only 1.7 ft, as opposed to the 10-ft range in Wellfleet Harbor; the former results in negligible marsh inundation (WHG 2011; Fig. 3: plot of relative elevations).

4. Existing mean tide level in Mayo Creek is -1.7 ft; it is -0.42 ft in Wellfleet Harbor (WHG 2011).

5. The land-surface elevation of developed fill is generally 2-4 ft (Outermost Land Survey), at least a foot below the height of average high tide (~5 ft) in the Harbor.

Low-lying Structures

6. Development within and around the diked flood plain since 1909 severely limits the Town's restoration options because of low-lying structures and other infrastructure, as indicated below.

7. The land surface at the lowest maintained yard within the diked flood plain is at an elevation of about 1.3 ft (Outermost Land Survey). It, and many other abutting parcels, are also fronted by embankments extending down to the marsh surface. Note that high tides in an unrestricted Wellfleet Harbor regularly reach about 5 ft. Respecting this constraint limits the maximum marsh restoration to about 20 acres and the maximum depth of high-tide flooding across a restored marsh to 1-2 feet.

Wastewater Systems

8. The elevation of the water table at the coast is equal to the mean tide height at the shoreline; thus, any increase in mean tide level will raise the water table to some extent along the shore. This could reduce the separation distance between the lowest wastewater leachfield and the water table; a five-foot separation is currently required by the State health code to reduce bacterial contamination.

   We have reviewed Wellfleet Board of Health data on wastewater systems abutting Mayo Creek. Most are either distant from the creek or are already protected as, for example, sealed systems. However, there are several sub-surface waste-water systems near Mayo Creek that may be at risk due to a rise in the water table, either due to actual interference with operations or health code violations. The lowest sub-surface wastewater disposal system in or near the flood plain (Wellfleet Marine Corp.) is at elevation 6.8 ft (Board of Health data). This barely meets the minimal separation distance to groundwater mandated by the health code, and any increase in mean tide level in Mayo Creek could reduce this separation further.

Therefore, unless this leachfield were elevated, the only alternative is to manage tides so that the mean tide level remains at or below existing conditions. Hydrodynamic modeling (WHG 016) has shown that dredging to deepen the creek is required to both maintain the existing mean tide height in Mayo Creek and achieve significant tidal range for about 20 acres of salt marsh restoration.

Restoring the natural depth of Mayo Creek has the added benefit of restoring a natural marsh connection to the harbor.

9. Groundwater monitoring has found that shallow groundwater in developed fill is well above and unaffected by water levels in Mayo Creek (**Figure 4**); therefore, any ponding on Baker's Field and other developments on fill over original Mayo Creek marshes is the result of direct precipitation, and not surface flooding from Mayo Creek. This shallow groundwater table is slightly above the mean tide height of, and fluctuates with the tides in, Wellfleet Harbor, indicating a strong hydraulic connection with the Harbor, and not Mayo Creek. (MCRC water table monitoring 2015).

Drinking Water Systems

10. The MCRC has reviewed drinking water installations for properties abutting Mayo Creek. Most of these are on higher ground on Summit Hill and along Holbrook Avenue. These are hydrologically up-gradient from the low-lying Mayo Creek marsh (Cape Cod Commission Water Table Map 2002).

    Most private-supply wells located in lowlands from the foot of Holbrook Avenue west along Kendrick are now on Town water. We believe that the others are also low risk (for reasons see below). However, if necessary, well relocation or agreements to supply Town water are possible.

11. Private water-supply wells around Mayo Creek should not be affected by tidal restoration because of their depth, the thickness of the freshwater lens and, in some cases, intervening layers of impermeable clay (Personal communications, Cape Cod Commission and Horsley Witten hydrologists 2018; see also Martin 2007 for additional background information). Hydrologic studies by USGS (J.A.Colman & J.P.Masterson 2007, Weiskel et al. 2016) and water-table mapping by the Cape Cod Commission (2002) strongly suggest a flow of groundwater from the hills surrounding the Mayo Creek marsh to the marsh basin. This flow of fresh groundwater typically extends under coastal marshes like Mayo Creek (Portnoy et al. 1998), and blocks the penetration of salty water into the freshwater aquifer, protecting water-supply wells.

    We have discussed this analysis with outside hydrology experts from the County, Federal government and private consultants. These all support this analysis.

12. Moreover, the proposed restoration design would maintain the current mean tide level in the restored Mayo Creek. The consequence is that the average shape, level and flow direction of the fresh water lens that supplies private-well drinking water would be unaffected by the restoration. This is consistent with published research carried out as closely as the mouth of Herring River in Wellfleet (Portnoy & Martin, 2007).

12a. The drinking water service at Harborside Village Cooperative Cooperation (HVCC) has deserved special attention. It is a public water supply, serving 85 families. The well head is located about 275 feet from a maximum projected high tide and 750 feet from low tide, in the creek bed. Groundwater flow would tend to carry any marsh salinity away from the well head.

Given the importance of a public water supply, we took the added initiative to meet privately with the HVCC technical representative and two external hydrology consultants (Cape Cod Commission and Horsley Witten Group) to discuss specific concerns at HVCC. One outcome of this meeting was a suggestion for a "pump test" if required to further clarify the risks. An outline of the test protocol has been completed. A key requirement for any future work is to define the analysis of pump-test results to minimize ambiguity, perhaps including some modeling (see Masterson, 2004 as a modelling example) . These principles could apply, of course, to any abutting well where there might be concerns.

Sediments

13. Sediment flow as part of any restoration is a concern, especially to shellfishermen and especially if the net flow is seaward onto downstream shellfish beds. However, hydrodynamic modeling of the system under tide-restored conditions has shown that flooding tides will run faster than ebbing tides. As a result, the net transport of sediment will be upstream, not downstream. The question of whether restored tidal ebb velocities would disturb the existing "black mayonnaise" in the north channel of the marina needs to be further evaluated. If Mayo Creek tidal restoration were to follow dredging of the north channel, any risk would be greatly reduced.

Note that sediments currently in the Mayo Creek channel above Commercial Street will be dredged as part of the tide-restoration project, primarily to limit the mean tide height and protect subsurface septic components. Another environmental benefit derived from the upstream transport of sediment is that this added material will over the long term help the wetland recover after 100 years of drainage and subsidence.

Storms

14. There is abutter concern about storm surge protection, both to avoid flooding and to drain the marsh as rapidly as possible after a storm. Therefore, any implementation plan should include Town responsibilities for tidal gate management during storms.

Wildlife in the Mayo Creek Basin

15. Tidal restoration of Mayo Creek is supported by the Cape Cod Mosquito Control Project because of expected improvements in tidal flushing and reductions in breeding habitat (letter of 20 August 2014**).**

16. The Massachusetts Division of Fisheries and Wildlife has determined that there are no endangered species that would be affected by restoration in Mayo Creek (letter of June 2 2008). It is likely that tidal restoration here would in fact increase habitat for the State-threatened Diamondback Terrapin, as well as a multitude of more common native fish and wildlife.

Table 1. Critical elevations for tidal restoration at Mayo Creek, Wellfleet MA.

Tides and groundwater

- Commercial St. culvert downstream invert elevation is -4.73 ft.
- Commercial St. upstream invert (inner pipe) is -3.59 ft.

- Under existing conditions, tides range from **-2.56 (MLW) to -0.84 (MHW)** with Mean Tide Level of **-1.70 ft** and **range of 1.72 ft.**
- With duckbill removed, tides range from **-0.30 (MLW) to 0.98 (MHW)** with a MTL of **0.34 ft** and range of 1.28 ft (WHG 2011).
- Thus, duckbill removal increases mean tide level by **2.04 ft**.
- With a 6X7-ft combination sluice/flap gate and creek excavation tides range **-4.58 to 1.21 ft**, with a mean tide level of **-1.68**.
- During 29 May to 10 June HOBO deployment:
    - Creek tides ranged from **-3.6 to -1.8 ft**.
    - Groundwater behind Baker's Field ranged from **0.4 to 0.94 ft**.
    - Thus, creek water levels were always at least 2.2 ft below groundwater level.
    - Thus, water table at Baker's Field affected by Harbor and not Mayo Creek.

Land surface elevations

- Land surface of developed fill is at elevation **2-4 ft**.
- However, the yard at observation well behind house at Map parcel 20:1 is at **1.32 ft**. (Outermost Land Survey survey of Nov 2015). This is the lowest point of structure along the old marsh.
- Driveway at Map 20:138 ; (Outermost Land Survey survey) 4.2-4.7 ft
- Yard at Map 21:105; (Outermost Land Survey survey) 2.1-2.5 ft

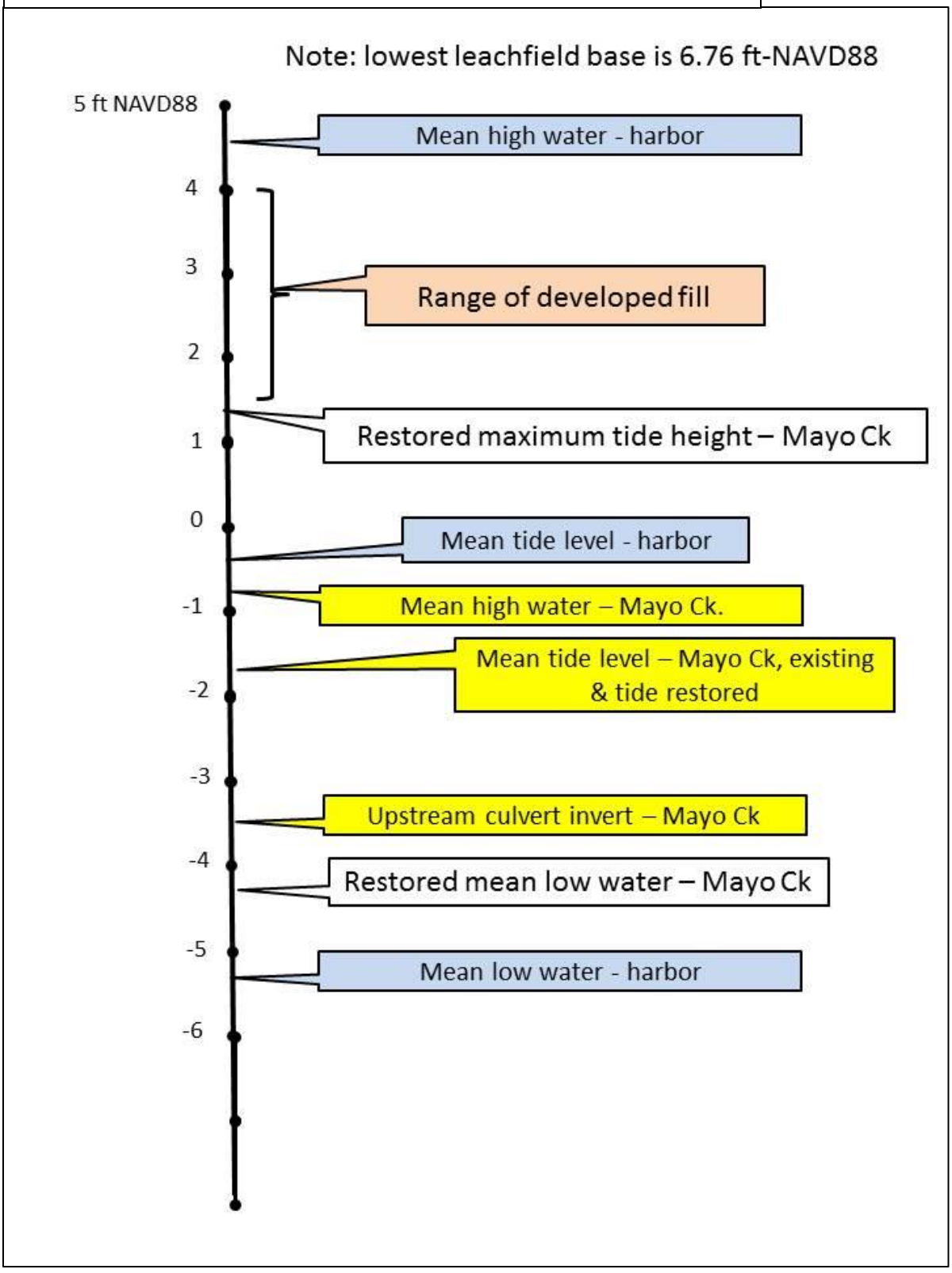
Hydrogeology and wells

- All private well heads are above 3 ft.
- All private wells are screened in a confined aquifer below layers of clay.
- MCRC Observation well MC6 at HVCC casing elevation = 4.95 ft-NAVD88

Wastewater disposal systems

- The HVCC wastewater system is ~420 ft from Mayo Creek wetland border with bottom of leachfield 7 ft above the maximum water table (HVCC supplied data).
- Wellfleet Marine leach chamber bottom is at **6.76 ft**-NAVD88. (Board of Health data).
- High water table at Wellfleet Marine is at **2.8 ft**-NAVD88 (Board of Health data.
- During May-June 2015, water table at Map 21:105 was **1.5 ft**-NAVD88 (MCRC report).

Figure 3. Comparison of water levels in and adjacent to Mayo Creek.



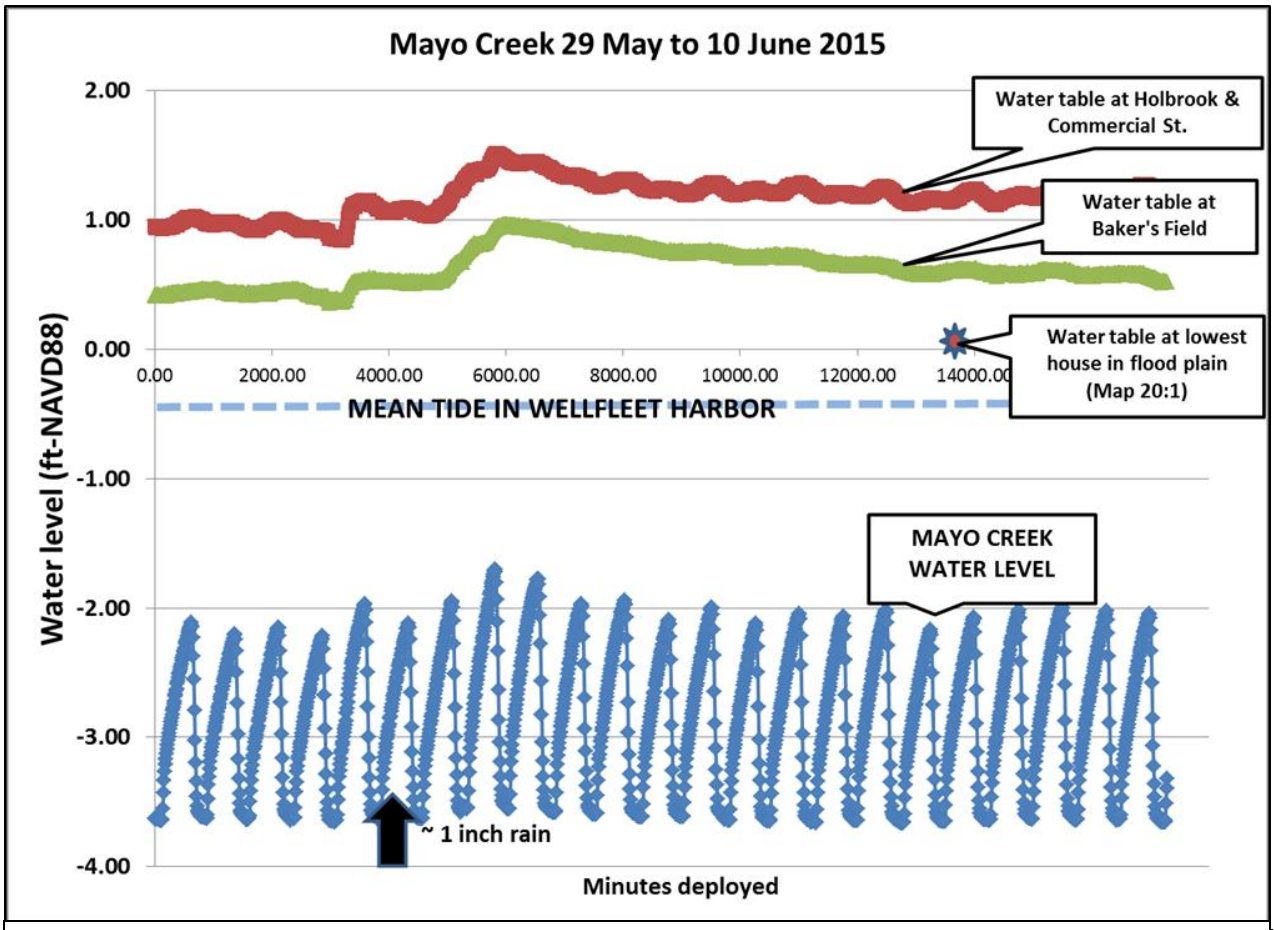


Figure 4. Water level monitoring in 2015 showed that the water table in developed fill at Mayo Creek is controlled by the mean tide level in Wellfleet Harbor, and not by water levels in Mayo Creek. This condition will continue after proposed tidal restoration because the latter will not increase the mean water level in the creek.

An evaluation of tidal-restoration alternatives

For all of the reasons described above, the Committee concludes that no action, i.e. continued diking of Mayo Creek, is contrary to shared public interests and will allow adverse effects, including poor water quality, shoaled channels, lost fish, shellfish and wildlife habitat, reduced storm-surge protection, to worsen over time. Therefore, alternatives for tidal restoration, given environmental objectives and social constraints, were investigated.

The Committee determined the following through hydrodynamic modeling by Woods Hole Group (2011, 2016). Importantly, scenarios were run for both standard and storm tides.

1. Simple removal of the existing one-way duckbill valve is not recommended. Modeling showed that if the valve were removed, allowing unrestricted flow through the existing 2-ft-diameter culvert, high tide levels would increase, but so would low tide levels, because the small culvert greatly impedes drainage during ebb tides. This alternative would fail to attain salt-marsh restoration goals, because it would limit tidal range, promote waterlogging, and reduce flushing.

   Importantly, simple duckbill removal would also have raised the mean tide level, in turn raising the shoreline groundwater table and possibly degrading nearby septic system function. (WHG 2011).

2. Despite the severe limits that past development has placed on the Town's options for tidal restoration:

   Replacement of the Commercial Street culvert with an enlarged culvert (e.g. 6 X 7 ft) with active control (adjustable gates, **Figure 5**), along with excavation of the upstream creek channel, can yield 20 acres of estuarine habitat restoration and over five feet of tidal range (as opposed to the existing 1.7 ft). Importantly, increased tidal range is achieved by two-foot higher high tides along with two-foot lower low tides (WHG 2016). These tidal ranges keep the important mean tide level in the creek, and the shoreline water table, unchanged.

The principles of "adaptive management" should be used throughout the process. Tidal restoration should be incremental, using an adjustable culvert gate (WHG 2016), and ecosystem response carefully monitored with emphasis on tide heights and groundwater and surface water quality.

In order to control the extent of restored tidal reach during the restoration, appropriate detailed surveying and engineering design of the tidal gates will be needed to ensure adequate control during all phases of the restoration. This conservative approach will mean that the final restored

marsh acreage may be less than the 20-acre theoretical maximum. (It will also likely result in a belt of *Phragmites* remaining along the marsh-upland edge, providing continued privacy to abutters.)

The Committee believes that 20 acres of estuarine restoration can be accomplished without harm to adjacent development including the lowest-lying structures and yards, wastewater systems and supply wells. This alternative should also improve freshwater drainage during low tides, especially after heavy rain and in the event of an overwash of the Mayo barrier beach (WHG 2011, 2016).

A very preliminary cost range for the large and adjustable culvert is $2-4 million (N.Wiberg, Fuss & O'Neil, personal communication).

Figure 5. Example of an adjustable tide gate (Golden Harvest GH-50) that would meet Mayo Creek tidal-restoration and infrastructure-protection objectives, based on hydrodynamic modeling (Woods Hole Group 2016). Such a design would allow the Town complete control of the opening to ensure that water levels meet social and environmental

Committee recommendations for future actions

Some 20 acres of salt-marsh restoration in Mayo Creek is feasible without harming adjacent development and furthers public interests associated with estuarine habitat and water quality.

Should the Selectboard accept these conclusions, we further recommend that the Town identify resources to oversee restoration planning, analogous in goals to the Herring River Restoration Committee. Restoration of Mayo Creek would need to work closely with Town wastewater projects, such as currently being developed by the CWWPC.

We note that many of the issues raised in considering Mayo Creek restoration are shared with the much larger Herring River restoration project. That project is now much advanced. Learnings as that project is implemented will be of great use to the Mayo Creek project.

Mayo Creek Restoration Committee

The charter of the Mayo Creek Restoration Committee is:

An ad hoc Mayo Creek Restoration Committee is established for the following purposes:

- To identify the benefits and drawbacks to the Town resulting from the restoration of the Mayo Creek salt marshes;
- To plan, permit and execute necessary tests and verifications in support of restoration planning;
- To engage with the public and abutters to address benefits and concerns;
- To prepare and submit a restoration plan for Board of Selectmen approval ; and
- To fund the restoration planning without use of Town fun

The MCRC membership believes we have achieved the goals of our charter and recommend that the Selectboard formally retire the committee.

Respectfully submitted:

Walter Baron, Marina Advisory Committee

John Portnoy, Conservation Committee

Jake Puffer, Shellfish Advisory Board

John Riehl (Chairperson) , Natural Resources Advisory Board

Pat Winslow, Comprehensive Wastewater Planning Committee

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***NOTE**: A complete file of documents and reports underlying this report will be made available on-line through the Town Clerk's office.*

<u>Acknowledgements</u>.

We thank Coastal America and the MassBays program for financial support. Assistance and support from Town staff, committees and the Association to Preserve Cape Cod (APCC) has also been invaluable.

The work of the MCRC has received support from the Marina Advisory Committee and the Shellfish Advisory Board. We have also profited greatly from the work of the Comprehensive Wastewater Planning Committee.