SNEP Watershed Grants
Final Report
February 28, 2022

Project Name: Upper Bass River Restoration Project
Contract Number: #SNEPWG-20-8-FOBR

Grant Period (for entire Project): October 1, 2020 – December 31, 2022

Grantee Organization: Friends of Bass River
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North Dennis Road currently

Photo Rendering of 60-foot span alternative

EXECUTIVE SUMMARY

In August of 2020, Friends of Bass River (FOBR) was awarded a grant of $253,779 by the Southeast New England Watershed Grant Program (SNEP) for Upper Bass River Watershed Restoration Project. FOBR contributed matching funds in the amount of $102,599.

The Bass River winds seven miles through Yarmouth and Dennis, from Nantucket Sound into Mill Pond. The area west of Mill Pond is called Hamblin's Brook. It extends from the levee in Mill Pond west to the first fish ladder at Miss Thacher's Pond. Bass River is an important waterway for recreation, fish, aquatic organisms, and community resiliency to storms and storm surges.

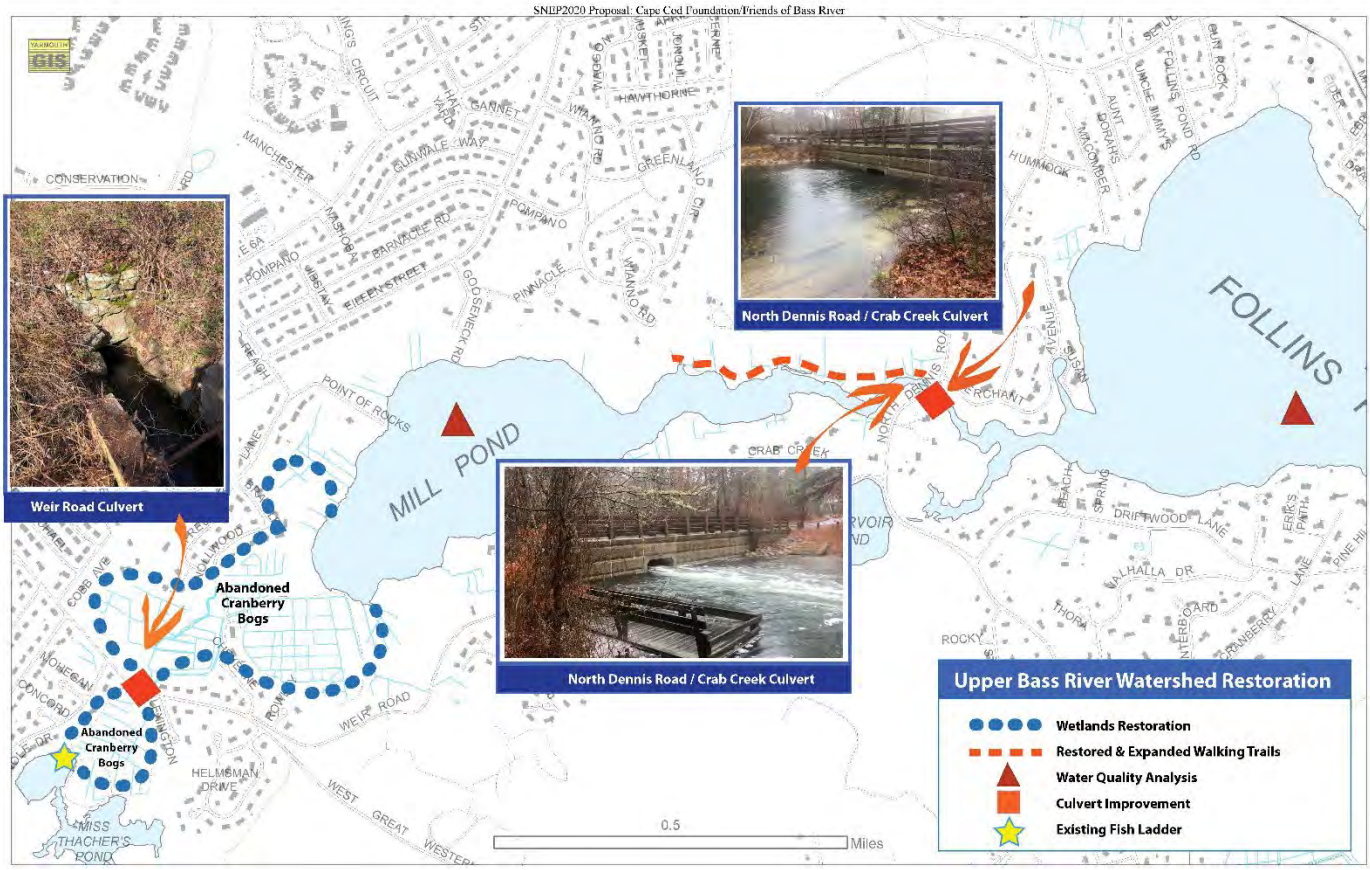
Water quality sampling by Massachusetts Estuaries Project (MEP) confirmed the declining state of Bass River. In November 2016, it recommended the Total Maximum Daily Load (TMDL) of Nitrogen for Bass River be reduced by 47%. This report resulted in the Cape Cod Commission creating a 208 plan for Bass River.

With the Town of Yarmouth, FOBR has initiated restoration efforts to reduce nutrient and nitrogen loads, improve fish passage, improve aquatic habitat, and improve wetland function.

The Upper Bass River Watershed Restoration Project has conducted data gathering and modeling, and developed engineering plans to document and demonstrate the necessary steps to achieve improved water quality through removal of barriers, increased water exchange, and the reintroduction of 57 acres of wetlands (abandoned cranberry bogs) to the riparian ecosystem.

This project focused on two impaired culverts—North Dennis Road/Crab Creek Culvert and Weir Road Culvert—in the Upper Bass River System and an area of abandoned cranberry bogs that includes the historic Hamblin's Brook and fish ladder, which once claimed the 2nd highest herring harvest in the state. The project area is all within and owned by our project partner the Town of Yarmouth in Massachusetts.

The project components include:
Friends of Bass River Water Quality Testing
Field Data and Modeling at Nort Dennis Road and Weir Road Culverts
Restoration Design at 60%
Recommendations for Next Steps, including Projected Costs



Water Testing

Friends of Bass River Water Quality Testing Program

2020 – 2021 Results

Monitoring nitrogen levels is vital to our work and our goals for restoring Bass River. To conduct water monitoring, FOBR launched the Bass River Water Testing Team in July 2020.

The Water Testing Team is a volunteer-based water monitoring program that monitors nitrogen levels weekly, May through October. We will be operating in our third year in 2022.

Our committed volunteers conducted comprehensive measurement and assessment of water quality, which serves as the baseline data for confirming current conditions in Bass River. We also compared this new data to the 2010 study of this same location. Testing has led to direct comparisons to the 2010 study conducted by Woods Hole Group, as well as the earlier study completed by the Massachusetts Department of Environmental Protection in 2002.

The Bass River Estuarine System was designated as impaired by the Massachusetts Estuaries Project (MEP) in the early to mid-2000s with areas of significant and moderate habitat impairment comprising more than 90% of the estuarine area of the system (Howes *et al.* 2011). One of the outcomes of the MEP study was the identification of a sentinel station and the determination of a threshold total nitrogen (TN) concentration that should be met to restore water and habitat quality throughout the system.

The Center for Coastal Studies started monitoring water quality at the sentinel station identified by MEP in 2014 and in 2020-2021 the Friends of Bass River began sampling six additional stations. **These data indicate that the system has not shown any improvement since it was designated as impaired over a decade ago.** TN levels consistently exceed the targeted threshold of 0.42 mg/L at the sentinel station, and the stations in the upper reaches of the Bass River System (e.g. Mill Pond, Follins Pond) remain severely impaired due to high nutrient levels, high chlorophyll levels, and low water clarity.

N. Dennis Road Culvert

Field Data Collection

We developed and implemented a field data collection program to inform the modeling efforts in the Upper Bass River study. The data acquisition involved two (2) components: 1) the measurement of water levels and salinities in key locations to assess tidal dampening and water exchange, and 2) a hydrographic survey to inform the development of a numerical model to simulate existing conditions and assess system response to potential remediation alternatives.

A comparison of the eight (8) restoration alternatives indicated that there are ecological benefitsto replacing the existing N. Dennis Road Culvert, the "status quo" alternative, with any of the potential restoration alternatives. As the connection between Mill Pond and Follins Pond gets larger, the increased tidal exchange, most noticeably in the lower residence times, will have positive impactson Mill Pond by increasing the amount of tidal exchange and enhanced flushing of the pond.

Of all the alternatives examined, the clear span bridge is the option that provides the greatest benefit based on the three (3) criteria established for this study: 1) increase in tide range, 2) reduction in residence time at Mill Pond, and 3) an increase in average salinity for potential shellfish habitat. The data acquisition coincided with a period of extended drought on Cape Cod, therefore no direct connection between precipitation and performance of the Upper Bass River system was established, with surficial runoff likely to have an effect on salinity, and to a lesser degree water levels in Mill Pond.

Evaluation of alternatives for replacement of the North Dennis Road Culvert and causeway over Bass River in Yarmouth, Massachusetts

Replacement of the North Dennis Road culvert is intended to be part of a larger project to restore Bass River, which includes improving nutrient flushing of Mill Pond, restoring

wetlandsalong Hamblins Brook between Miss Thatchers Pond and Mill Pond, and upsizing the Weir Road Culvert over Hamblins Brook to better accommodate terrestrial runoff and tidal flows. Improvements to the North Dennis Road Culvert are necessary to accommodate increased flows, improve upstream water quality, and prevent further erosion at the site. It is expectedthat the replacement structure will lead to improved resiliency and adaptability to climate change, through its ability to better handle increased flows and flood conditions.

The Alternatives Analysis Report outlines existing conditions that need tobe considered for a replacement structure, identify general replacement structure alternatives, and provide conceptual costs for each alternative.

Topographic survey data was collected in October 2020 and thedata in the vicinity of the culvert was used for the purposes of this study. Survey data in the vicinity of the culvert includes the road, culvert, guardrails, wetland boundaries, existing contours, and existing utilities. An existing conditions site plan is included in Appendix B.

A hydrographic survey was performed in October 2020 in support of a tidal flushing analysis of Mill Pond. This bathymetry data was combined with topographic data to provide comprehensive surface data.

We conducted a visual field review of the site in November 2020 to document existing conditions and verify general site conditions identified in the survey and the 2006 record drawings.

Tidal Flushing Analysis was performed with the goal of improving nutrient levels andwater quality of Mill Pond.

We determined that providing a clear span bridge would provide the greatest benefit basedon the following three criteria established for their study:

1. Increase in tide range
2. Reduction in residence time at Mill Pond
3. Increase in average salinity for potential shellfish habitat

Based on tidal flushing, the open span bridge configuration with an approximate span of 60-feet is preferred to optimize water quality of the river based on tidal range, residence time, and salinity.

Hydrologic and Hydraulic Analysis was performed for the existing and proposed North Dennis Road Culvert.

The analysis considered a wide range of hydraulic conditions which considered riverine flows, tides, mixed coastal-riverine storm events, and future sea-level-rise (SLR) based on MassDOT guidance for hydraulic analysis of replacement structures. SLR was projected using Northeast Climate Science Centers (NECSC).

Four different span configurations were evaluated for the H&H analysis. These include the existing 6'-6" box culvert, two 8'-0" span box culverts, four 8'-0" span box culverts, and a 60'-0" span bridge.

The hydraulic analysis revealed that increasing the hydraulic opening would provide greater freeboard during storm events and reduce stream velocity. The analysis indicated a 60-foot span bridge as the preferred alternative hydraulically since it will provide adequate hydrauliccapacity for the hydraulic design storm, the effect of sea level rise, and mixed coastal-riverinestorms.

Permitting

Proposed work for replacing the structure will require authorization under local, state, and federal environmental regulations. The design and permitting process will also require consideration of the Massachusetts Stream Crossing Standards, as replacement stream crossings and tidal crossings are required to comply with the standards to the maximum extent practicable.

Alternatives for the proposed culvert replacement are described and evaluated.

Alternatives that were evaluated include:

- Alternative 1: Replacement with a single span bridge to clear the banks of the river – estimated cost is $3,260,000
- Alternative 2: Replacement with multiple culvert spans – estimated cost $3,400,000

Considering biologic performance of the River, a 60-foot span bridge is preferred over a multi-span structure to satisfy the desired nutrient flushing of the upstream Mill Pond. Additionally,MARSCS would be satisfied with this alternative.

The 60-foot span bridge will also provide adequate hydraulic capacity for the hydraulic design storm (25-year storm), theeffect of sea level rise, and mixed coastal-riverine storms.

Restoration Design to 60%

The Restoration Design outlines the approach taken to develop the restoration designs for theheadwaters of the Bass River. We have collected and analyzed data using multiple recommended methods, analyzed the data collected, and drafted the necessary design elements with accompanying drawings. A recommended construction sequencing including:

- Install traffic control measures
- Install sediment and erosion control features
- Install stabilized construction entrances
- Remove dam and fish ladder
- Excavate pond and channel
- Complete bank treatment and large wood installation
- Microtopography
- Remove water control
- Invasive species treatment
- Remove earthen berm

- Construct boardwalk
- Construct footbridge across channel at earthen berm

Dam Removal
The dam and fishway at Miss Thatcher's Pond will be removed. The concrete fishway will be completely removed, and the contractor will dispose of the concrete in an approved off-site location. The earthen berm portion of the dam will be partially removed. We propose leaving approximately one vertical foot of the earthen berm above the adjacent floodplain elevation to provide a drier and more stable walking path for continued pedestrian access. The earthen berm will be removed laterally to the edge of the valley to the north and to the adjacent earthen berm to the south with walking slopes no steeper than 5:1.

Weir Road Culvert Replacement
The Weir Road culvert will be replaced with a larger opening to allow for greater hydraulic capacity for passing flood flows. The stream channel design in the vicinity of and through the culvert will be refined following design of the culvert by Tighe & Bond.

Channel Form and Habitat
Upstream of Weir Road, the current channel is straight with uniform widths and depths and channel bed and banks primarily made of sand. The proposed channel will be a meandering channel with sinuosity calculations based on channel size, watershed size, slope, and regional reference reaches.

Vegetation
We propose to replant disturbed areas with native seed and native potted trees and shrubs. In the next phase of design, we will provide a more detailed species list with proposed quantities and locations. Different areas of the site will develop into different vegetative ecosystems.

Recreation
Current recreation within the project site includes walking and wildlife viewing. Many of the trails are overgrown with some of the stream crossings broken, failing, or not present. Through this restoration project, the project partners would like to improve the walking trails and reconstruct the stream crossings. The existing trails will be cleared of encroaching vegetation and new trails will be developed to encourage more walking and wildlife viewing. While not part of Inter-Fluve's design engineering, the project partners plan to install benches and viewing areas where appropriate.

We collected topographic and bathymetric survey data on October 13, 14, and 15, 2020 and November 5, 2020 using Real Time Kinematic and Total Station surveying equipment. We captured the hydraulic control features and critical channel elevations starting at Miss Thatcher's Pond and ending at Mill Pond.

Sediment Analysis
This restoration project will require the receipt of a valid Water Quality Certification (WQC) from the Massachusetts Department of Environmental Protection (MassDEP). MassDEP requires contamination analytical results for the areas of ground disturbance within wetland areas. While allexcavated soils will be reused on site and not brought to a landfill or other disposal location, contamination concentrations of the excavated soils are still required by MassDEP. This section describes the sediment sampling and results completed to date.

The sediment samples analyzed generally had contamination concentrations under the human health and ecological thresholds, with the following exceptions:
BR2P – arsenic exceeded the MCP S1 human health threshold and the PEC ecological threshold; BR2S – dieldrin and DDE exceeded the PEC ecological thresholds; and BR4 – DDD exceeded the PEC ecological threshold. For a detailed table of all results.

Hydrologic Analysis
The Bass River Headwaters Restoration Project includes restoring several cranberry bogs and replacing the Weir Road crossing. Both of these project elements are affected by normal daily streamflow and peak flood flows in Hamblin's Brook.

Because Cape Cod is underlain by highly pervious sand and gravel, infiltration rates are high, and groundwater is a primary driver of streamflow in this region. For this study, we evaluated the hydrologic characteristics of Hamblin's Brook and the contributing watershed. of the report describes the approach for selecting design flows for the replacement culvert at Weir Road and the simulated natural geomorphic channel for the restored Hamblin's Brook. We also evaluated tidal datums because of the anticipated increased tidal influence within the Project Site following the replacementof the North Dennis Road culvert and as a result of sea level rise.

REPORT NARRATIVE

The Bass River estuarine system is the longest river on Cape Cod, extending The hydrologic evaluation included field data collection and desktop analyses. This section approximately seven miles. Forming the town line between Dennis and Yarmouth, the river is an important waterway forboating, fishing, and swimming. Anthropogenic impacts have degraded the river's water quality and ecological functioning. Although cranberry bogs in the headwaters were retired over 40 years ago, the headwaters stream remains hydrologically and hydraulicly altered. The Friends of the Bass River and the Town of Yarmouth are looking to return the bogs to ecologically functioning wetlandsand restore passage for aquatic organisms.

Project Goals

Specific goals of the Bass Headwaters Restoration Project (the Project) are to:

- Improve fish passage, with a focus on herring;
- Improve water quality through nutrient attenuation and tidal exchange;
- Enhance habitat for aquatic organisms; and
- Enhance public recreational opportunities.

After award from the SNEP 2020 grant program, FOBR chose to move forward with three contractors: Woods Hole Group, Tighe & Bond, and Inter-Fluve.

- Woods Hole Group – contracted to the FOBR to conduct tidal analyses;
- Tighe & Bond – contracted to the FOBR to complete culvert and bridge designs at the NorthDennis Road and Weir Road crossings; and
- Inter-Fluve – contracted with FOBR to complete feasibility and design concepts to 60%

FOBR Water Testing

As the largest waterway on Cape Cod, the seven-mile Bass River is under increased danger from elevated nitrogen levels. FOBR was founded in 2017 to take action to protect and safeguard the Bass River Estuarine System and coastal life as we now know it. We are dedicated to protecting and preserving the ponds, coves, and sub-basins of the Bass River Estuarine System through public education, raising awareness, and increasing community involvement.

Monitoring nitrogen levels is vital to our work and our goals for restoring the Bass River. Through monitoring, vigilance and direct management, we can help preserve and protect Bass River's delicate ecosystem. Our water testing program provides ongoing critical feedback from the river, in the form of scientific data, thus helping FOBR plan and execute our goals for watershed restoration.

Comprehensive water testing includes: tide, weather, water temperature, precipitation, water turbidity, depth at each station, nitrogen, dissolved oxygen, phosphorus, and salinity. We use this

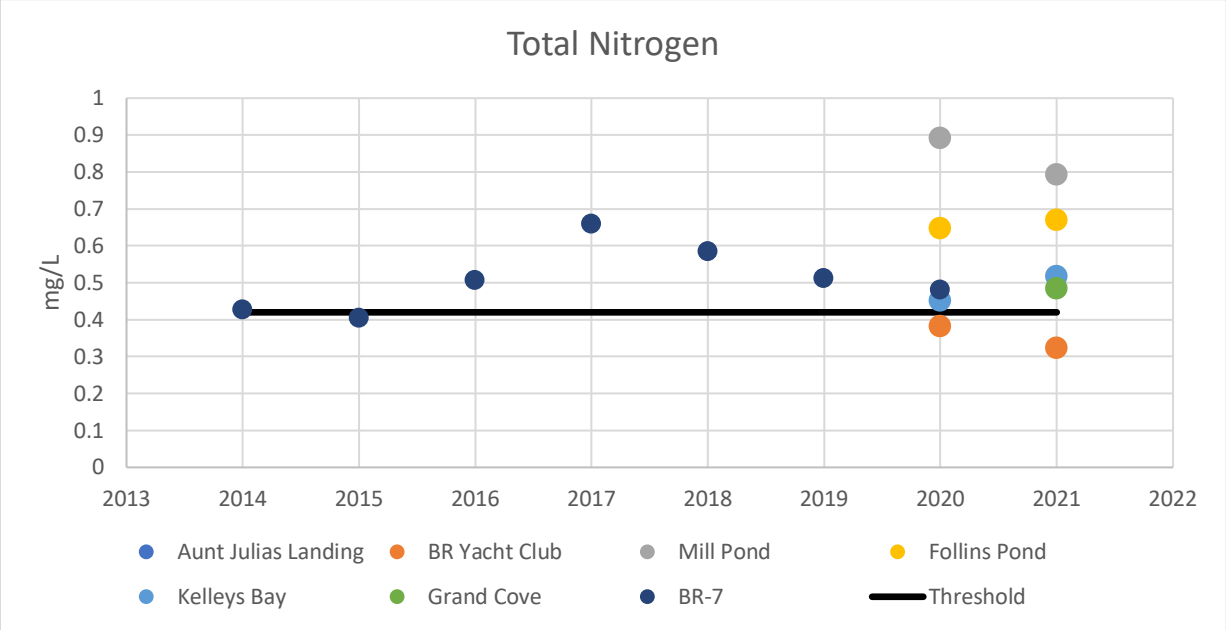
data to compare to previously collected data to see conditions over time which are crucial for our efforts in ongoing restoration.

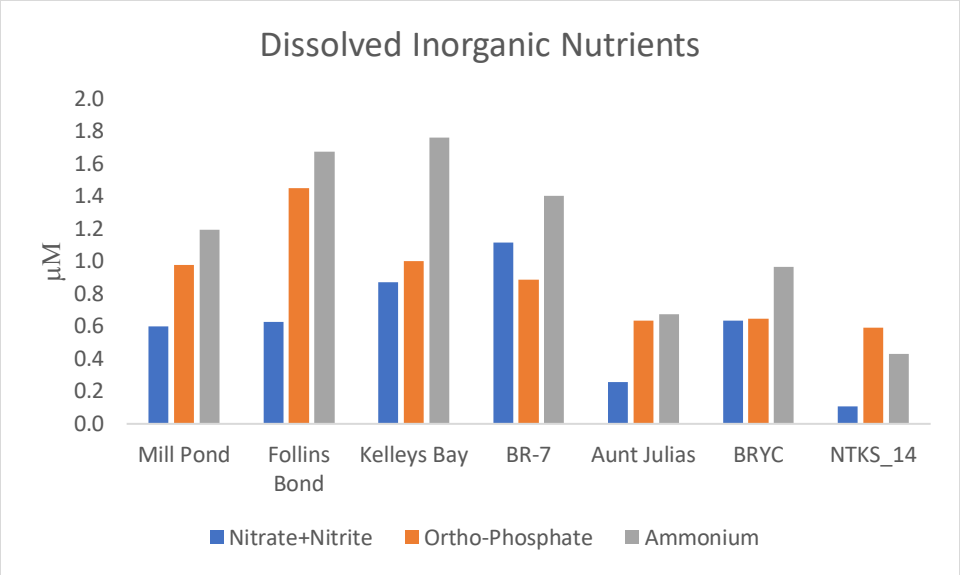
Having completed its second year, we have expanded our volunteer water testing team from 12 to 14 members, trained by experts with the Center for Coastal Studies. We have grown from five test sites to six. New in 2021, Dr. Dan Rogers from Stonehill College led a secondary testing program with four Stonehill college students in July and August. His students analyzed all our 2020 testing data a comparison with the 2021 findings.

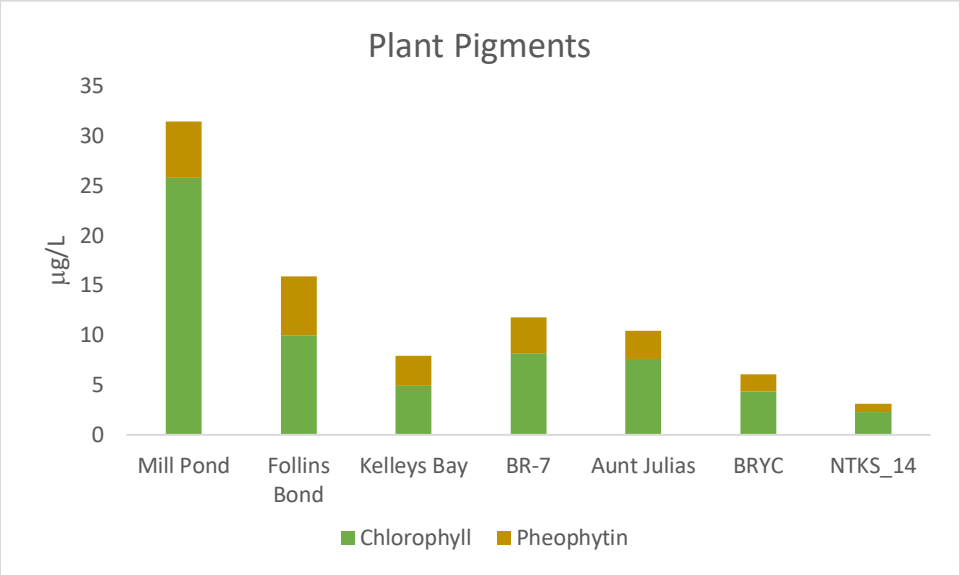
The Center for Coastal Studies started monitoring water quality at the sentinel station identified by MEP in 2014 and in 2020-2021 the Friends of Bass River began sampling six additional stations.

Mill Pond, Follins Pond, Kelley's Bay, Aunt Julia's Landing, Grand Cove, and Uncle Freeman's Landing.

These data indicate that the system has not shown any improvement since it was designated as impaired over a decade ago. TN levels consistently exceed the targeted threshold of 0.42 mg/L at the sentinel station, and the stations in the upper reaches of the Bass River System (e.g. Mill Pond, Follins Pond) remain severely impaired due to high nutrient levels, high chlorophyll levels, and low water clarity.







North Dennis Road/Crab Creek Culvert

Historically, reduced tidal exchange and limited flushing in the upper reaches of the estuarine system between Mill Pond and Follins Pond have resulted nitrogen building up in the system. This increase in nitrogen has resulted in algal blooms. The algal blooms, in addition to being unsightly, deplete the oxygen within the system, harming other aquatic species and cause unpleasant odors.

Previous studies conducted by Woods Hole Group indicated that the rail crossing downstream of Route 6 was a major source of tidal dampening in upper reaches and changes in the Crab Creek crossing would provide minimal changes in tidal exchange in Mill Pond.In 2016, the stream crossing at the railroad bridge downstream of Route

6 was widened to approximately 100 feet to encourage greater connectivity and enhanced tidal exchange betweenthe upper and lower reaches of Bass River.

Field Data Collection

We developed and implemented a field data collection program to inform the modeling efforts. The data acquisition involved two (2) components:

1) the measurement of water levels and salinities in key locations to assess tidal dampening and water exchange, and

2) a hydrographic survey to inform the development of a numerical model to simulate existing conditions and assess system response to potential remediation alternatives.

Time series of water conditions were collected at the four (4) sites shown in Figure 4 at Kelleys Bay (BR1), in Crab Creek both downstream (BR2) and upstream (BR3)of North Dennis Road, and in Mill Pond (BR4). The instruments were deployed from September 17, 2020 through November 02, 2020 (46 days) to measure a full range of tides including the dailytides and the monthly spring and neap tides, while the hydrographic survey was designed to accurately reflect the bathymetry in the UBR system by collecting data in the ponds in a grid withincreased resolution in the connecting streams and in areas of rapid change in elevation such aspits and channels.

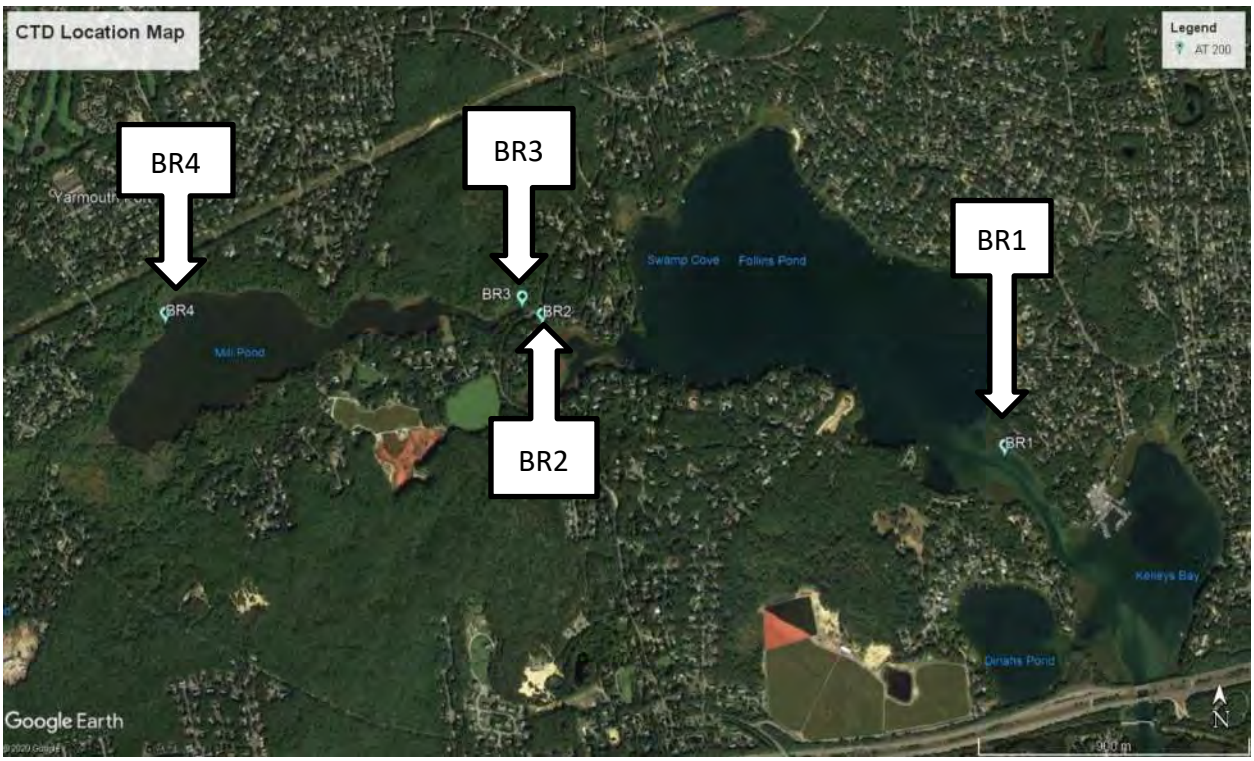


Figure 4. Locations of the four (4) AT200 CTD instruments during the deployment periodfrom 09/17/2020 through 10/21/2020.

The four (4) AT200 data loggers were deployed as shown in Figure 4 with the locations and deployment elevations listed in Table 1. All instruments were deployed on September 17, 2020 and recovered for processing on October 21, 2020. During the deployment period, three of the four stations (BR1, BR2, and BR4) collected conductivity, pressure, and temperature data at six (6) minute intervals for the 46-day deployment period. Station BR3, located in Crab Creek on the upstream side of N. Dennis Road was removed from its deployment location on September 25, 2020 by persons unknown and placed on the stream bank limiting the record length in that section of Crab Creek to approximately eight (8) days. In addition to the four (4) AT200 loggers, a HOBO data logger was deployed on a fence post at 17 Points of Rocks Road to measure local atmospheric pressure.

Table 1. Deployment locations of AT200 data loggers in Massachusetts State Plane(Mainland) coordinate system

Station Name	Northing	Easting	Elevation (ft-NAVD88)
BR1	2718801.121	1017967.098	-3.3505
BR2	2720160.643	1012873.066	-1.637
BR3	2720347.481	1012648.469	-0.905
BR4	2720108.296	1008726.193	-0.4595

The AquaTrolls built-in sensors directly measured total pressure, water temperature, and water conductivity. The AT200 used the measured conductivity and temperature to calculate the density of the water at the sensor. Internally, the AT200 calculated the salinity measurement using the observed conductivity. The atmospheric pressure from the adjacent HOBO sensor was removed from the total pressure measured at each AquaTroll to determine the pressure resulting from the water column at the AT200. The height of the water column above the sensor was then calculated by dividing the pressure measured at the sensor by the density of the water at the sensor. Finally, the water surface elevation at each sensor was calculated by adding the height of the water column to the surveyed elevation at each location. Time series of water levels at each of the stations are shown in Figure 5 and time series of salinity at each station are shown in Figure 7.

The time series of water levels for stations BR1, BR2, and BR3 were processed using the online NOAA Tidal Datum Calculator located at:
https://access.coops.nos.noaa.gov/datumcalc/index.jsp
using the NOAA tide gauge station 8447930 at Woods Hole, MA as the control station. Because the tidal datum calculator requires a minimum of fourteen (14) days of measured data points measured at constant intervals to calculate each datum, station BR3 with approximately eight (8) days of measurements did not have sufficient record length to be processed. Tidal datums for

each of the other three station are listed in Table 2 in feet referenced to the North American Vertical Datum of 1988 (NAVD88). The tide range, in

feet, for each station is also shown in the table and was calculated as the difference between Mean High Water (MHW) and Mean Low Water. At station BR1, located closest to Nantucket Sound, and station BR2, located in the downstream section of Crab Creek, Mean Higher High Water (MHHW) and MHW are essentially the same. At ebb tides, Mean Low Water (MLW) and Mean Lower Low Water (MLLW) are lower at BR1 than at BR2 which is reflected in a larger tidal range at BR1 (1.98 ft) compared with 1.9 ft of tide range at BR2. Moving upstream of the N. Dennis Road crossing to station BR4, both MHHW and MHW are lower than those of the downstream station, while MLW and MLLW are higher in Mill Pond than in Follins Pond. The other two (2) datums, Mean Tide Level (MTL) which is the arithmetic mean between MLW and MHW, and Diurnal Tide Level (DTL) which is the arithmetic mean between MHHW and MLLW, indicate that the average water levels decrease with distance downstream in the UBR system.

Table 2. Tidal datums at each of the AT200 deployment locations as determined by theNOAA Tidal Analysis Datum Calculator. All values in ft-NAVD88 except tide range

	BR1	BR2	BR3	BR4
MHHW	1.372	1.37	N/A	0.534
MHW	1.103	1.103	N/A	0.422
MTL	0.111	0.153	N/A	0.222
DTL	0.207	0.235	N/A	0.29
MLW	-0.88	-0.797	N/A	0.021
MLLW	-0.958	-0.9	N/A	0.047
Range (ft)	1.983	1.9	N/A	0.401

Table 3 lists the mean salinity and range of salinity in Practical Salinity Units (PSU) over the deployment period at each station, while time series of measured salinity at each of the monitoring stations are shown in Figure 7. Over the 34-day deployment the salinity was consistently higher downstream at station BR1 than the salinity at the uppermost station in Mill Pond with observed salinities at stations BR2 and BR3 increasing during flood tides and decreasing during ebb. The largest variability occurred at Station BR4 with a range of 10.52 PSU as compared to the other stations with a noticeable dip in salinity starting on the afternoon of October 6, 2020 through the evening of the same day with a measured low value of 14.37 PSU. This marked decrease in salinity was not observed at any of the other stations in the estuarine system, and the salinity was above 20 PSU for the rest of the record in Mill Pond.

Table 3. Mean salinity and salinity range at each station in Upper Bass River in PracticalSalinity Units (PSU)

	BR1	BR2	BR3	BR4
Mean (PSU)	27.94	25.21	25.39	22.24
Range (PSU)	6.12	8.33	7.15	10.52

We conducted a primary hydrographic survey of Follins Pond, Mill Pond, and Crab Creek on October 1, 2020. Data was collected using an EU-24 echosounder coupled with anRTK GPS unit. The EU-D24 was mounted to a small vessel which was motored slowly around thearea of study in the pattern shown in Figure 8.

The echosounder sends an acoustic beam that bounces off the river bottom to calculate the distance between the sensor and the channel bottom. The distance between the sensor and the riverbed was converted in elevations in ft- NAVD88 using the RTK GPS and correcting for the distance between the GPS and the EU D24 transducer. Additional bathymetric data in the section of Crab Creek downstream of the culvertwas collected on October 21, 2020, using a pole mounted RTK GPS unit to get elevations in the shallower sections of Crab Creek and immediately upstream of the culvert as heavy fish shoals interfered with the echosounder.

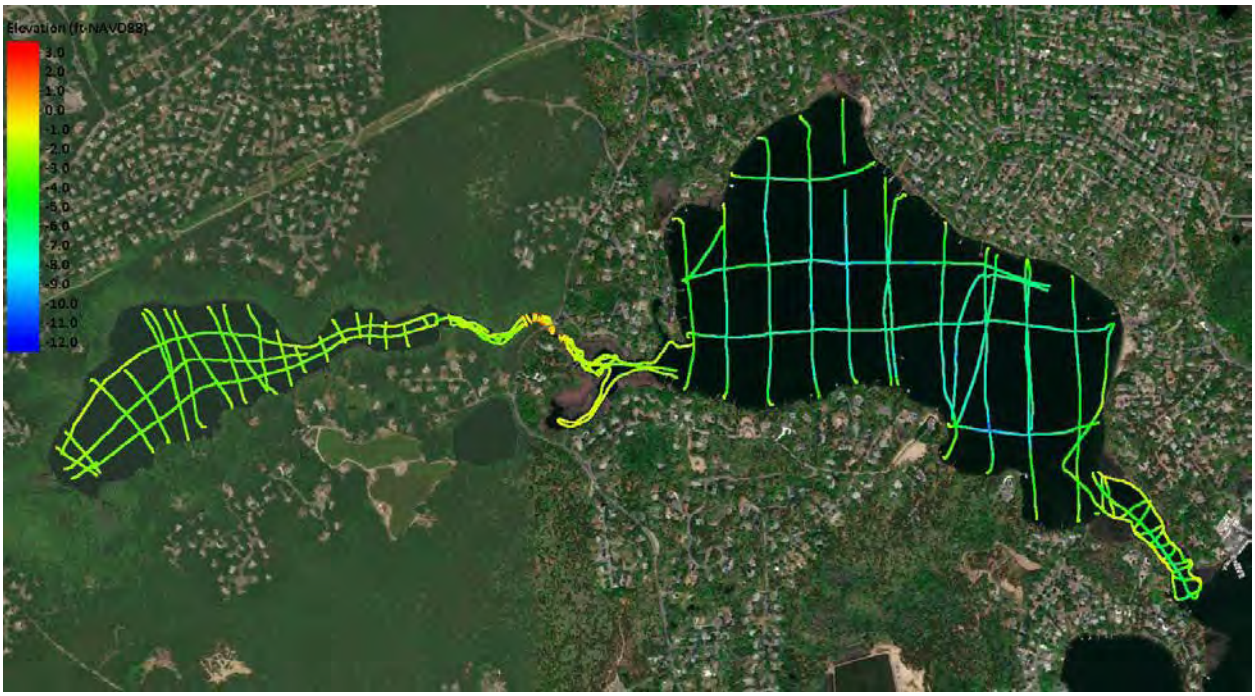


Figure 8. Hydrographic survey conducted on October 1, 2020.

A comparison of the eight (8) restoration alternatives indicated that there are ecological benefits to replacing the existing culvert, the "status quo" alternative, with any of the potential restoration alternatives. As the connection between Mill Pond and Follins Pond gets larger, the increased

tidal exchange, most noticeably in the lower residence times, will have positive impactson Mill Pond by increasing the amount of tidal exchange and enhanced flushing of the pond. Ofall the alternatives examined, the clear span bridge is the option that provides the greatest benefit based on the three (3) criteria established for this study: 1) increase in tide range, 2) reduction in residence time at Mill Pond, and 3) an increase in average salinity for potential shellfish habitat. The data acquisition coincided with a period of extended drought on Cape Cod,therefore no direct connection between precipitation and performance of the Upper Bass River system was established, with surficial runoff likely to have an effect on salinity, and to a lesser degree water levels in Mill Pond.

- Under existing conditions, the tide range using MHW and MLW calculated with the NOAATidal Datum calculator was 0.66 feet, with a residence time of 80.3 hours and an averagesalinity of21.4 PSU.

- Replacing the existing culvert with a single 8x6 concrete box culvert increased the tide range from 066 feet to 0.78 feet, reduces the residence time in Mill Pond to 70.9 hours, but had a slight decrease over the two-week simulation in average salinity to 21.2 PSU.

- Adding an additional 8x6 culvert, for a total of two (2) culverts, increased the tide range from 0.66 feet under existing conditions to 1.0 feet, reduces residence time 50.9 hours, and increases the average salinity by 1 PSU to 22.2 PSU.

- The additional of a third 8x6 culvert increased the tide range in Mill Pond to from 0.66 feet to 1.0 feet, reduced residence time from 80.3 hours to 43.7 hours, and increased the average salinity in Mill Pond to by 1.3 PSU.

- Increasing the number of 8x6 culverts to four (4) increased the tide range in Mill Pond from 0.66 feet to 1.20 feet, with a reduction in residence time from 80.3 hours to 40.4 hours, and increased the average salinity in Mill Pond from 21.4 PSU to 23.0 PSU.

- Adding a fifth and sixth 8x6 culvert increased both the tide range and average salinity in Mill Pond while reducing the residence time, but the improvements were incremental compared to the improvements obtained in the previous scenarios.

- The open span bridge provided the most restoration benefits with a 105% increase in tide range to 1.4 feet, a 51% reduction in residence time to 39.0 hours, and a 1.8 PSU increase in average salinity in Mill Pond to 23.2 PSU.

- The 1% Annual Exceedance Probability (AEP) storm event, also referred to as the 100-yearreturn storm, the bridge option did not change the flood risk to properties adjacent to Mill Pond as the current stream crossing at N. Dennis Road is expected to be overtoppedwith weir flow over the roadway.

- Contours of peak water levels are shown Figure 32. The highest potential 1 % AEP water level as specified by FEMA at 9.1 ft-NAVD88 are shown in red, the modeled 1% AEP for both existing and bridge alternatives at 8.1 ft-NAVD88 are shown in yellow, and the 7.5 ft-NAVD88 water surface elevation from the Massachusetts Coastal Flood Risk Model (MCFRM) are shown in green.

Figure 32. Contours of the 1% Annual Exceedance Probability (AEP) storm event. Red shows the FEMA flood elevation, yellow shows the modeled peak elevation with seiching, and the green line is the elevation from the MassachusettsCoastal Flood Risk Model (MCFRM).

The purpose of this Alternatives Analysis Report is to outline existing conditions that need to be considered for a replacement structure, identify general replacement structure alternatives, and provide conceptual costs for each alternative.

Topographic survey data was collected and the data in the vicinity of the culvert was used by for the purposes of this study. Survey data in the vicinity of the culvert includes the road, culvert, guardrails, wetland boundaries, existing contours, and existing utilities.

A hydrographic survey was performed October 2020 in support of a tidal flushing analysis of Mill Pond. This bathymetry data was combined with topographic data to provide comprehensive surface data.

We conducted a visual field review of the site in November 2020 to document existing conditions and verify general site conditions identified in the survey and the 2006 record drawing

The culvert is in good condition overall structurally and the structural configuration generally matches the original 2006 design drawings. Shop drawings and structural calculations are not available for the box culvert or wingwalls. Some provisions of the design criteria from the 2006 design are no longer applicable today, considering current codes or site conditions. Note that replacement is not warranted to meet current codes, but replacement or substantial modifications to the existing structure would require conformance to current codes.

Table 1 summarizes design criteria and some updated provisions.

Table 1 – Summary of revised design criteria

2006 Design Criteria	**2021 Design Criteria**
AASHTO Standard Specifications for Highways & Bridges – 17th Edition (2002)	LRFD Bridge Design Specifications – 9thEdition (2020)
HS25 Live Loading	HL-93 Live Loading
60’ span downstream bridge controllinghydraulic configuration	Downstream bridge replaced in 2018 and nolonger controls hydraulics
N/A	2020 MassDOT LRFD Bridge Manual
N/A	2011 Massachusetts River and Stream Crossing Standards

Since 2006, stream erosion has been observed. One foot of the natural streambed material originally placed in the box culvert has been eroded to bare concrete. Scour pockets up to 4- feet deep have been detected upstream and downstream of the crossing. The streambanks have been widened with evidence of exposed tree roots, undermined vegetation, and eroded material at the access stairs from the road to the river. An adjacent recreational boardwalk north of the culvert has been undermined and subsequently removed.

Continued future erosion is a concern and the exposed bury depth of the culvert and wingwalls should be monitored. 4-feet of embedment was provided in 2006, but has been reduced to

Tidal Flushing Analysis

Tidal Flushing Analysis was performed with the goal of improving nutrient levels andwater quality of Mill Pond. This analysis was performed using various proposed span configurations of the North Dennis Roadcrossing.

We have determined that providing a clear span bridge would provide the greatest benefit based on the following three criteria established for the study:

1. Increase in tide range
2. Reduction in residence time at Mill Pond
3. Increase in average salinity for potential shellfish habitat

Table 2 - Summary of WHG Tidal Flushing Analysis for various proposed configurations

Configuration	**Tide Range**	**Residence Time**	**Average Salinity**
6’ x 6.5’ box culvert (existing)	0.66 feet	80.3 hours	21.4 PSU
Single 8x6 culvert	0.78 feet	70.9 hours	21.2 PSU
Two 8x6 culverts	1.00 feet	50.9 hours	22.2 PSU
Three 8x6 culverts	1.00 feet	43.7 hours	22.5 PSU
Open Span Bridge	1.40 feet	39.0 hours	23.2 PSU

Based on tidal flushing, the open span bridge configuration with an approximate span of 60-feet is preferred to optimize water quality of the river based on tidal range, residence time, and salinity.

Hydrologic and Hydraulic (H&H) Analysis

Hydrologic and Hydraulic Analysis was performed for the existing and proposed North Dennis Road Culvert.

The analysis considered a wide range of hydraulic conditions which considered riverine flows, tides, mixed coastal-riverine storm events, and future sea-level-rise (SLR) based on MassDOT guidance for hydraulic analysis of replacement structures. SLR was projected using Northeast Climate Science Centers (NECSC). A target of 2-feet of freeboard is preferred between flood elevations and the low chord of the structure. Additional freeboard can be obtained by raisingthe roadway. Four different span configurations were evaluated for the H&H analysis. These include the existing 6’-6” box culvert, two 8’-0” span box culverts, four 8’-0” span box culverts, and a 60’-0” span bridge.

The hydraulic analysis revealed that increasing the hydraulic opening would provide greater freeboard during storm events and reduce stream velocity. The analysis indicated a 60-foot span bridge as the preferred alternative hydraulically since it will provide adequate hydraulic capacity for the hydraulic design storm, the effect of sea level rise, and mixed coastal-riverine storms.

Permitting

Proposed work for replacing the structure will require authorization under local, state, and federal environmental regulations. The design and permitting process will also require consideration of the Massachusetts Stream Crossing Standards, as replacement stream crossings and tidal crossings are required to comply with the standards to the maximum extent practicable.

Wetland resource area boundaries have been delineated by a wetland scientist on October 20, 2021, and the wetland boundaries have been surveyed and incorporated onto existing conditions drawings. The following types of wetlands are present at the site:

- Salt Marsh
- Coastal Bank
- Bordering Vegetated Wetlands (BVW)
- Land Under Waterbodies and Waterways
- Riverfront Area
- Land Subject to Coastal Storm Flowage

Environmental Permitting

Proposed work will occur within areas subject to protection and jurisdiction under local, state, and federal regulatory programs. Based on the assumed wetland resources relative to the proposed structure location, the Table 5 summarizes probable permit requirements.

TABLE 5

Summary of Anticipated Permits

Agency	Permit, Review, or Approval
Local	
Yarmouth Conservation Commission	Order of Conditions under the Massachusetts Wetlands Protection Act (MAWPA) and the Yarmouth WetlandsRegulation

Summary of Anticipated Permits

Agency	Permit, Review, or Approval
State	
Executive Office of EnvironmentalAffairs	Massachusetts Environmental Policy Act (MEPA) Environmental Notification Form (ENF) (wetlands thresholds are presumed to be exceeded triggering an ENF submission)

Massachusetts Department of Environmental Protection (MassDEP)	Superseding Order of Conditions (only required uponappeal of local Order)
	401 Water Quality Certification (if any impact temporaryor permanent to salt marsh; greater than 5,000 sf of work, cumulatively, in Land Under Water, BVW and/or IVW; or 100 cubic yards of dredging or more)
	Chapter 91 Waterways License
Massachusetts Historical Commission (MHC) & Massachusetts Board of Underwater Archaeological Resources (MABUAR)	Determination of No Adverse Effect (if filing Pre-Construction Notification with the Corps)

Federal	
U.S. Army Corps of Engineers (Corps)	Section 404 Pre-Construction Notification (for work in tidal waters)

Alternatives Analysis and Recommendations
In this section, general alternatives for the proposed culvert replacement are described and evaluated. Alternatives that were evaluated include:

- Alternative 1: Replacement with a single span bridge to clear the banks of the river
- Alternative 2: Replacement with multiple culvert spans

Both alternatives considered structural requirements, geometric recommendations outlined previously, cost, and durability. It was assumed that the existing horizontal and vertical alignments would be maintained. All bridge components would be designed to support HL-93live loading in accordance with AASHTO Load and Resistance Factor (LRFD) design criteria.

Alternatives that were not considered for further evaluation include:

- Replacement bridge or culverts on a new alignment (i.e. to the east or west of theexisting crossing)
- Two span bridge with one-pier in the river

For this conceptual analysis, alternatives have been limited as described below. As a part of design development in the next phase of the project, sub-alternatives can be considered and refined.

Alternative 1: 60-foot Span Bridge
A 60-foot span bridge was considered as a replacement to clear the banks of the river. Prestressed concrete NEXT D beams were assumed for the bridge type for the purposes of this study. A more detailed bridge-type selection worksheet is recommended as part of the next design phase. For this study, prestressed NEXT D beams are assumed to be viable basedon the span, ability to accommodate utilities, and durability in a salt-water environment. NEXT D beams would support an Accelerated Bridge Construction if desired in subsequent design phases.

Providing a 60-foot span would be considered an NBI structure (i.e. a span length greater than 20-feet) subject to MassDOT Chapter 85 review. Chapter 85 approval would be requiredprior to construction as well as subsequent future rehabilitation or replacement projects. Notethat the replacement bridge would have a design life of 75-years and subsequent review would not be anticipated until a major rehabilitation or replacement is needed. While additional design coordination is required for Ch 85 approval, MassDOT performs this reviewservice at no cost to the Town and serves as an additional quality control measure to ensureadherence to design and construction standards.

As an NBI bridge structure, MassDOT would be required to perform a detailed inspection of the bridge and the inspection report would be provided to the Town. If deficiencies are identified,

they would be reported to the Town and MassDOT could serve as a resource for repair. Additionally, while improvements are not anticipated in the near timeframe, NBI structures are eligible for federal and state financial bridge aid which could benefit the Townat the end of the proposed structure's service life.

Deep foundations would be required due to the poor soil conditions and the history of scour erosion at the site. For the 60-foot span alternative, an advantage is that the piles and pile caps would be placed outside the footprint of the river. This would result in substantially less dewatering than constructing foundations in the stream, and would likely simplify the permitting process. While a detour is assumed for the purposes of this study, piles could be driven using lane shifts and buried below the roadway to maintain traffic through the site prior to replacement. Accelerated Bridge Construction could be implemented depending on traffic needs using precast prestressed NEXT beams and closure pours.

Photo Rendering of 60-foot span alternative

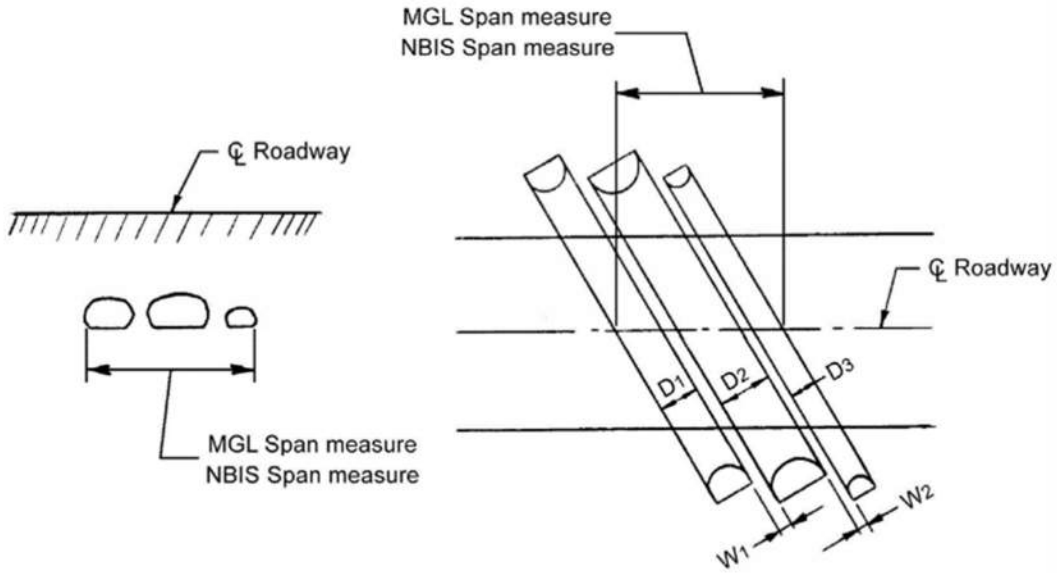
Considering biologic performance of the River, a 60-foot span bridge is preferred over a multi-span structure to satisfy the desired nutrient flushing of the upstream Mill Pond. Additionally, MARSCS would be satisfied with this alternative.

Hydraulically, a 60-foot span bridge is preferred to satisfy the various design criteria and provides the most freeboard. While additional freeboard may be required, the roadway couldbe raised to provide additional protection. Future sea level rise is anticipated and this alternative provides the most resilient approach to address this concern for the community. While the site does not have a history of flooding, it should be noted that the former railroadbridge downstream previously controlled hydraulics at North Dennis Road until 2018 when the hydraulic opening was increased by over 100-feet. The North Dennis Road culvert is the next crossing upstream of this new bridge.

Alternative 2: Multi-Span Box Culverts

A series of box culverts could be constructed to convey flow and improve the hydraulic capacity of the existing crossing. A series of four, 8-foot span four-sided box culverts spaced4-feet apart were assumed for the purposes of this study.

Culverts provided in this configuration would be spaced far enough apart such that their spans would not be added together when calculating span length of the crossing. Therefore, each structure would have an 8-foot independent span per MassDOT definition and be defined as culverts. As such, MassDOT would not have jurisdiction for design reviews and Chapter 85 approval would not be needed. Also, this configuration would not be eligible for future federalor state bridge funds currently or at the end of the structure's service life. Even though MassDOT would not have jurisdiction, MassDOT's LRFD Bridge Manual and AASHTO LRFD Loading would still apply as design standards. The Town would need to perform their own inspections as MassDOT would not be responsible for performing them.



NOTE: In order for the MGL Span measure to be taken as shown above, W1 must be less than 1/2 D1 and 1/2 D2 and W2 must be less than 1/2 D2 and 1/2 D3. If, for instance, W2 were greater than 1/2 D3, then the span measure would only include D1, W1, and D2. This method of measure also applies to multiple opening Clapper type structures, where a stone slab sits on thick piers.

Figure 3 - MassDOT Definition of Measuring Span for Multiple Culvert Structures

Concrete box culverts typically use the bottom of the structure as the foundation to distributeloads to the subgrade. The existing boring logs and geotechnical evaluations indicate low values of allowable bearing capacity with over excavation and soil improvements. Conceptualcalculations indicate 8-foot span box culverts would marginally satisfy the bearing requirements. Note that design standards have changes since the 2006 construction of the existing 6'-6" span box culvert including loads, design guides, and environmental stream crossing standards. Based on final borings, the implementation of box culverts could requiredeep foundations which would be a non-standard application of box culverts. For the purposesof developing costs, deep foundations were assumed. Alternatively, 3-sided frames or archescould be used with strip footings, but piles would be required. Further investigation for thesetypes of structures as part of a type-study report would be required.

Open-bottom structures are preferred over box culverts per MARSCS. If box culverts are provided, 2-feet of natural streambed material would be required within the box. The existingbox culvert was constructed with 1-foot of natural material, but the streambed has scoured and lowered since its construction. The new culvert would require cutoff walls at the inlet andoutlet below the scour zone, which would need to be calculated in final design. Providing 4- feet of frost protection would need to be considered as well.

Headwalls would be required between culvert openings perpendicular to the stream, and would also need to be designed for frost and scour depths. These walls would also need to satisfy bearing capacity requirements based on the soils.

A significant drawback for this alternative is the excavation and significant dewatering required within the stream to improve subgrade conditions and place box culvert segments and headwalls. Phasing temporary water diversion to maintain streamflow would also be required. Substantial and prolonged dewatering could conflict with time of year restrictions for in-water work, and could result in more temporary wetland impacts.

The traffic closure is expected to have a much longer duration compared to the single span bridge alternative for numerous reasons. The amount of in-stream excavation and dewatering would be significant, and the existing crossing would need to be taken out of service to perform this work. The contractor would need to be cautious with excavation around the existing water main. Dewatering would be required until the precast units are placed and backfilled. Traffic staging would not be feasible across the existing culvert, and would be challenging for the proposed culvert until the system is fully backfilled and compacted.

Considering biologic performance of the hydraulic network, a multi-span culvert does not provide the same level of nutrient flushing of the upstream Mill Pond compared to an open span bridge. Additionally, many MARSCS provisions would not be satisfied with this alternative which could complicate the permitting process. The use of multiple-span box culverts is explicitly stated in the MARSCS as a span configuration that should be avoided if possible.

Hydraulically, a multi-span box structure provides less freeboard and hydraulic capacity compared to a 60-foot span bridge. The roadway may need to be raised to achieve desired freeboard. As a consideration, additional fill will add load and increase bearing pressures on the subgrade, which

has limited bearing capacity. Therefore, deep foundations may be required. This alternative is less resilient from a coastal perspective especially if future sea level rise is considered.

Summary and Opinion of Probable Construction Cost

Conceptual opinions of probable construction cost are presented below in Table 6 and detailed breakdowns are included in Appendix E. The costs include a 40% Construction Contingency and a 20% Material and Bidding Contingency.

TABLE 6

Summary of Opinions of Probable Construction Cost

Alternative	Opinion of Probable Construction Cost
1 – Single span bridge	$3,260,000
2 – Multiple span culverts	$3,400,000

Restoration Study and Recommendations, Weir Road, Abandoned Cranberry Bogs

The Project Site is the area available for active construction and staging. The site is owned by the Town of Yarmouth and is located south of Route 6a, north of Route 6, east of Union Street and west of Mill Pond (Figure 1). The area includes approximately 57 acres of retired cranberry bogs and the headwaters of the Bass River historically known as Hamblin's Brook. Please refer to the accompanying drawings for the cell numbers assigned to each bog and referenced in this report.

Miss Thatcher's Pond

Miss Thatcher's Pond is the upstream extent of the Project Site, with a surface area of approximately 0.8 acre (Figure 2). According to historical records, farmers excavated the wetlands to create a pondthey could use as an irrigation source for their cranberry bogs. The pond has a maximum depth of 4feet and the average depth is approximately 2.5 feet.

Miss Thatcher's Pond is divided into two main components. The southern portion is larger and deeper and was the primary water source for farming. The northern portion was a cranberry bog before being converted to a pond between the 1930s and 1970s. Historical topographic maps from the U.S. Geological Survey show the pond having two outlets: one flows north very close to the location where Hamblin's Brook enters Miss Thatcher's Pond and one flows into the project area to the east (Figure 3). The outlet to the north has been abandoned, and we were unable to locate the ditch during the site assessment. Portions of the ditch have been filled in, and houses have been builton top of the fill along Seminole Drive and Starbuck Lane. North of Starbuck Lane, we were able to identify the ditch, but the culvert under the road was not present or likely filled in through road reconstruction and housing development. The fish ladder at the eastern outlet of the northern portion now controls water levels of the pond (Figure 4). The fish

ladder consists of a series of boards placed between two concrete slabs that extend 20 feet long. Each step is 3 feet wide. From thefish ladder, the river flows into the first area of cranberry bogs.

According to the Massachusetts Department of Environmental Protection (DEP) Drinking Water Program, Miss Thatcher's Pond is within a DEP Approved Wellhead Protection Area (Zone II). Miss Thatcher's Pond is the eastern-most boundary of the protection area, suggesting that Miss Thatcher'sPond is at a hydrogeologic boundary.

Figure 1. Project area location map

Many areas of Miss Thatcher's Pond have filled in with organic material and aquatic vegetation, resulting in low levels of dissolved oxygen and elevated water temperatures. Water warmed in MissThatcher's Pond flows downstream, degrading water quality through the rest of the Bass River watershed. While conducting our survey and site assessment, we observed ducks, geese, and swansin Miss Thatcher's Pond. One resident spoke about large snapping turtles that he observed in the pond. Though no records are available, we assume that warm-water fish species currently live within the pond.

Along the northern and eastern edges of Miss Thatcher's Pond, an earthen berm was created to maintain water levels and separate the pond from Cells 2 and 4. This earthen berm remains intact,though portions of the berm are showing signs of deterioration with erosion around disused flow control structures. Two flow control structures had historically carried water from the pond to thecranberry bogs to the north, but these culverts have filled in and no longer support flow. A formerpump house was located on the earthen berm with only a portion of its concrete walls now remaining.

Figure 2. Miss Thatcher's Pond

Figure 3. U.S. Geological Survey topo map of Miss Thatcher's Pond, 1940s.

Figure 4. Miss Thatcher's Pond outlet and fish ladder

Cranberry Bogs Between Miss Thatcher's Pond and Weir Road

Cells 1-4 (refer to the drawings) are defined by a levee that divides Cells 1 & 3 from Cells 2 & 4. The Project Site includes the levee, an adjacent ditch, and the bogs in Cells 1 & 3. The main channel through the bogs runs along the left toe of the levee (looking downstream) in Cell 3 (Figure 5). The main channel has a bottom width that ranges from 7 to 11 feet and a bank height of approximately

1.5 to 3 feet. At certain spots throughout Cell 3, the channel becomes less defined as water spreads throughout the relic side ditches on river left. The water level through Cell 3 is dictated by flow control structures downstream of Weir Road that currently elevate the water.

During the site assessment, we examined portions of the main channel with active flow for an indication of appropriate design channel sizing. Approximately 75 feet downstream of the fish ladder at Miss Thatcher's Pond, trees have grown close to the channel and roots obscure portions ofa nearby ditch leaving an active flow area of approximately 4 feet wide at the top of bank and 1 to 1.5 feet deep (Figure 6). Here, the water moves more swiftly than elsewhere, is close to the top of bank, and has created some scour around the roots. Further downstream where the water spreadsinto the adjacent vegetation, the active flow appears to be limited to an approximately 4-foot-widechannel between hummocks (Figure 6).

Much of the cranberry bog landscape is now a mix of hummocks of vegetation and deep pockets of water. The vegetation in Cells 1 & 3 is a mix of sphagnum moss, shrubs, and red maple saplings over20 feet in height. In Cells 2 & 4, higher water levels limit woody growth and vegetation is mainly herbaceous, primarily grasses, rushes, sedges, and sphagnum moss.

Figure 5. Looking downstream along the top of a levee separating Cells 1 & 3 from Cells 2 & 4. The main channel within the Project Site runs along the left toe of the levee in Cell 3.

Figure 6. Approximately 75 feet downstream of the fish ladder at Miss Thatcher's Pond, vegetation and roots have constrained the channel to be approximately 4 feet wide at the top of bank (left). Further downstream, the effective flow through the hummocky vegetation is approximately 4 feet wide at the top of bank (right).

Weir Road Culvert

The Weir Road culvert, a stone masonry box culvert, has partially collapsed. On the downstream side of the road, the existing opening is 3.2 feet wide and 2.5 feet tall. On the upstream side of the road, the existing opening is 1.8 feet wide and 2 feet tall. The weir road crest elevation is 10.7 feet. Inaddition to its poor physical condition, the culvert restricts flood flows and elevates water levels upstream. Weir Road is classed as an Urban Local Road/ Rural Minor Collector. It mostly serves theresidential areas that surround it.

Figure 7. Culvert at Weir Road

Cranberry Bogs Between Weir Road and Cheyenne Lane

The Project Site downstream of Weir Road consists of another area of retired cranberry bog (Cell 5). Approximately 75 feet downstream of Weir Road, the channel splits in two with flow control structures regulating water elevations in each channel. A straightened ditch conveys a portion of theflows to the northeast, while a more natural-looking sinuous channel conveys water to the northwest. These two channels generally flow north/northeast and under the earthen berm and walkway between Cheyenne Lane and Knollwood Drive. Ditches through Cell 5 currently hold water and historically would have conveyed water from the ditch to the bog platform as needed for farming. The more natural-looking channel ranges in width from 12 to 18 feet and becomes undefined in the middle of this former bog. The levee adjacent to the ditch has been converted into awalking path for public use.

The vegetation within Cell 5 has grown substantially since the bogs were abandoned. In the middle of the bog along the main channel, vegetation is primarily shrubs and grass hummocks where waterlevels are elevated as a result of the undersized and clogged culvert downstream (see below).

Elsewhere, mature red maple and pitch pine trees have grown to more 30 feet in height. The lateral and perimeter farm ditches remain visible, though many have partially filled in with sphagnum moss. Small patches of the invasive plant *Phragmites* were observed in the northeastern portion ofthis bog.

At the downstream end of Cell 5, the channel flows through an undersized, 18-inch corrugated metal culvert beneath the earthen berm and walkway between Cheyenne Lane and Knollwood Drive (Figure 8). The culvert is partially filled and restricts flows, increasing the water elevationsupstream of the crossing.

Figure 8. Looking upstream at the 18-inch corrugated metal pipe under the earthen berm and walkway between Cheyenne Lane and Knollwood Drive

Cranberry Bogs Between Cheyenne Land and Mill Pond

Downstream of the earthen berm between Cheyenne Lane and Knollwood Drive is another former cranberry bog (Cell 6) with a straightened ditch flowing along the southern edge and a more natural stream channel flowing east along the northern and middle portions of the bog. An earthen berm separates the ditch from the bog and is currently used as a walking path. In the southwest corner of the bog, we found remnants of the site's history as a cranberry farm: Abandoned farm equipment sits partially buried and obscured by vegetation, and mounds of disposed earth from digging out ditches dot the surface (Figure 9).

The western portion of the bog has mature trees and understory vegetation, and the eastern portion is made up primarily of woody shrubs and other marshland vegetation. Phragmites has spread through the eastern portion of the marsh. At the eastern end of the bog, an earthen berm separates the wetland from Mill Pond. The channel exits through a gap in this berm with abandoned farm equipment and flow control structures nearby. This portion of the wetland and Mill Pond experience tidal fluctuations.

To the south, is another abandoned cranberry bog with wetland vegetation growing throughout (Cell 7). Ditches have filled in with sphagnum moss and other vegetation. In the wetter areas, shrubs and herbaceous plants thrive while maple and pitch pine trees grow in the drier areas. Groundwater from the nearby hillslopes flows through the ditches of this abandoned bog and into Mill Pond under the earthen berm and path.

Figure 9. Abandoned farm equipment and mounds from excavating a farm ditch.

Data Collection and Review

Land Use/ Land Cover, Geology, and Soils

The headwaters of the Bass River watershed comprise primarily forested and single-family residential areas. The remaining area is forested and non-forested wetlands with some commercial land to the south of Route 6. Residential development throughout the watershed has led to increased nitrogen and nutrient loads to the groundwater and subsequent surface water in Mill Pond and further downstream. No significant sources of industrial or commercial impacts to the soils or water are known except for the chemical use on the former cranberry bogs. We describe the results of our bog soil sampling and testing in Section 5.

The headwaters of the Bass River are near the crest of Cape Cod with the northern part of the Cape draining to Cape Cod Bay, and the south draining to Nantucket Sound. The soils in the headwaters area are a glacially-derived mix of sand and gravel with a high infiltration rate (Group A) and a moderate infiltration rate with a high-water table (Group B/D).[1] The soils within the Project Site are made up of Freetown coarse sand spread by farmers over Freetown muck, the organic peat and wetland soils that historically supported peatlands prior to the construction of dams and cranberry farms.

FEMA Studies and Mapping

The entire study area is within the Coastal AE Flood Zone with a 1% annual chance of flooding due to coastal storm surge. The base flood elevation calculated for this 1% annual chance of inundation is 13 feet (NAVD88) at the mouth of the Bass River at Nantucket Sound and 9 feet in Follins Pond, Mill Pond, and the study area. The effective date of the flood insurance rate map is July 16, 2014 (FEMA, 2014).

Wetlands and Ecology

The wetlands within the study area that were previously active cranberry bogs are now classified as Shrub Swamp and Deciduous Wooded Swamp by MassDEP and Freshwater/Forested Shrub Wetland and Freshwater Emergent Wetland by the National Wetlands Inventory2. The proposed work area is not within estimated or priority habitats of rare species and wildlife according to the Natural History and Endangered Species Program (NHESP) 14th Edition Heritage Atlas. The proposed work area is also not within an Area of Critical Environmental Concern or Outstanding Resource Waters.

One of the goals of the project is to improve fish passage. Mill Pond and the headwaters of the Bass River were historically known to have large herring runs. By removing the flow control structures and undersized culverts within the study area, fish passage will be restored to headwater aquatic habitat for herring, American eel, and other species.

Utilities

Overhead electric lines were observed along Weir Road during the survey. We have requested additional utility data from the Town of Yarmouth to supplement our observations. From documents initially received, it appears that a water line is under Weir Road and another utility under the earthen berm between Cells 5 and 6. We are confirming these utility locations and whether additional utilities are located here or elsewhere within the project area.

Infrastructure

Within the Project Site, infrastructure features include stream crossings and abandoned flow control structures in between the former bogs. In addition, the abandoned concrete foundation of a pump house remains along the eastern edge of Miss Thatcher's Pond and a concrete fish ladder is present at the outlet of Miss Thatcher's Pond.

Two stream crossings within the Project Site restrict flow and fish passage: Weir Road and the berm/path crossing farther downstream between Cheyenne Lane and Knollwood Drive. Both will be addressed as a part of the project scope.

Recreation

The Project Site is currently used by the public for walking and wildlife viewing; however, many of the trails are overgrown and difficult to navigate. The trails are located along the

earthen berms created during cranberry farming to separate the bog cells. One of the goals of the project is to enhance recreational opportunities by improving trails and installing other improvements.

Historical/ Cultural Resources

Prior to European colonization, the Pawkunnawkuts of the Wampanoag nation prospered along the Bass River. Decimated by the early colonizers through disease and fighting, the remaining Pawkunnawkuts sold their land to European farmers in the late 17th century. As villages were established, the river was used to support industry, fishing, and recreation. According to a local historian, there was a mill at the west end of Mill Pond in the 1750s.[3] In the 1880s, there was a major herring run that went through the channel at Weir Road. Fish populations in the Upper Bass River dropped after the construction of the railroad bridge downstream of the present Route 6 in 1857.

Another major ecological disruption starting in the 1800s was cranberry farming, which led to the sanding, damming, and ditching of the headwaters of the Bass River. Like many cranberry bogs throughout the Cape, the bogs at the Bass River headwaters are now retired.

No state-listed historical sites are known to exist within the study area[4]. However, the project will be reviewed by the Massachusetts Historical Commission who will determine the need for further assessment of historical and archaeological resources.

Climate Change

The project area is impacted by climate change through increased frequency of higher magnitude storm events, sea level rise, increased air temperatures, and periods of drought. Section 6 describes our hydrologic analyses, including consideration of climate change and sea level rise. Our restoration design approach at the site will aim to help build climate resiliency by incorporating an adaptable stream form that can adjust its size and location over time as the hydrology changes and variable wetland topography to encourage a range of vegetation species.

Topographic Survey

We collected topographic and bathymetric survey data on October 13, 14, and 15, 2020 and November 5, 2020 using Real Time Kinematic and Total Station surveying equipment. We captured the hydraulic control features and critical channel elevations starting at Miss Thatcher's Pond and ending at Mill Pond.

Geomorphic Assessment

Geomorphologists assessed the project site during the same period as the topographic survey, October 13-15, 2020. We reviewed the channel and wetland conditions, the system of

ditching, flowcontrol structures, and the vegetative growth within the aquatic and terrestrial ecosystems. Our observations are described in Section 3.1.

Site Constraints

The existing data review and site assessments and surveys provided valuable opportunities to evaluate the constraints that might challenge ecological restoration efforts. The primary challenge that we observed will be staging and access. We did not observe any large open areas for staging, sothe staging areas will need to be developed through clearing of vegetation and leveling of the ground surface in select areas. Access is also complicated with the multiple work areas. No access for construction vehicles exists off of Weir Road, so access roads will need to be developed along theexisting earthen berms and footpaths on either side of the road.

Sediment Analysis

This restoration project will require the receipt of a valid Water Quality Certification (WQC) from the Massachusetts Department of Environmental Protection (MassDEP). MassDEP requires contamination analytical results for the areas of ground disturbance within wetland areas. While all excavated soils will be reused on site and not brought to a landfill or other disposal location, contamination concentrations of the excavated soils are still required by MassDEP. This section describes the sediment sampling and results completed to date.

Due Diligence Review

Per the requirements of 314CMR9.07(2) we completed a due diligence review. We reviewed the following databases for possible sources of contamination within the contributing watershed of thestudy area:

Database	Finding
National Priorities List (Superfund)[5]	None
CERCLIS/NFRAP[6]	None
RCRA[7]	No large waste generators
MassDEP[8]	No Activity and Use Limitations; no underground storage tanks

Based on these findings, the sediment sampling plan must address the requirements of314CMR9.07(2)(B)(6) with the analysis of samples for the following parameters:

- Metals
  - Arsenic
  - Cadmium
  - Chromium
  - Copper
  - Lead
  - Mercury
  - Nickel
  - Zinc

- Polycyclic Aromatic Hydrocarbons (PAHs)
- Polychlorinated Biphenyls (PCBs) by NOAA Summation of Congeners
- Extractable Petroleum Hydrocarbons (EPHs)
- Volatile Organic Compounds (VOCs)
- Total Organic Carbon
- Percent Water
- Toxicity Characteristic Leaching Procedure
- Grain Size Distribution

Because of the history of agricultural use within the watershed and project site, we also analyzedsediment samples for organochlorine pesticides.

Sediment Sampling Plan

We collected six (6) sediment samples throughout the study area on October 13, 2020:

- Downstream work area near Mill Pond – 1 sample of the sand layer and 1 sample of the peatlayer;
- Upstream of Cheyenne Lane within the southern portion of the bog – 1 sample of the sandlayer and 1 sample of the peat layer;
- Downstream of Weir Road – 1 sample within the active stream channel; and
- Upstream of the earthen dam and concrete fish ladder at Miss Thatcher's Pond – 1 samplewithin the impoundment.

Samples were collected using a custom-made hand coring device. Sampling procedures followedInter-Fluve's internal guidelines based on Massachusetts, Wisconsin, and USEPA sampling recommendations[9]. Samples were submitted to Absolute Resource Associates, a Massachusetts certified laboratory, for analysis.

Laboratory Analysis

The sediment samples analyzed generally had contamination concentrations under the humanhealth and ecological thresholds, with the following exceptions:

- BR2P – arsenic exceeded the MCP S1 human health threshold and the PEC ecological threshold;
- BR2S – dieldrin and DDE exceeded the PEC ecological thresholds; and
- BR4 – DDD exceeded the PEC ecological threshold.

Sediment Management Approach

Multiple restoration projects involving retired cranberry bogs have been permitted by MassDEP andmunicipal conservation commissions. The sediment management plan for this project will follow those of the previously permitted and completed projects: All excavated soils will be reused on site to fill ditches and other areas previously excavated during cranberry cultivation. No soil or sedimentis proposed to be disposed of, or reused, at offsite locations.

Hydrologic Analysis

The Bass River Headwaters Restoration Project includes restoring several cranberry bogs and replacing the Weir Road crossing. Both of these project elements are affected by normal daily streamflow and peak flood flows in Hamblin's Brook.

Because Cape Cod is underlain by highly pervious sand and gravel, infiltration rates are high, and groundwater is a primary driver of streamflow in this region. For this study, we evaluated the hydrologic characteristics of Hamblin's Brook and the contributing watershed. The hydrologic evaluation included field data collection and desktop analyses. This section of the report describes the approach for selecting design flows for the replacement culvert at Weir Road and the simulated natural geomorphic channel for the restored Hamblin's Brook. We also evaluated tidal datums because of the anticipated increased tidal influence within the Project Site following the replacementof the North Dennis Road culvert and as a result of sea level rise.

HYDRAULIC DESIGN CRITERIA

The peak flood flows from the rainfall-runoff analysis will be used as inputs into the hydraulic modeling to inform the design of various project components. Prior to carrying out the modeling, we developed the following hydraulic design criteria to help focus our efforts and adhere to state guidance where appropriate.

Weir Road Culvert

Because Weir Road is classified as an Urban Local Road/ Rural Minor Collector, the following designevents will be evaluated according to the Massachusetts Department of Transportation (MassDOT) Requirements for New and Full Bridge replacement projects guidelines[11]: 10-year event for flood frequency, 25-year event for design scour frequency, and 50-year event to check scour frequency. It also states that the bridge must be scour stable after the Design Scour Event but does not necessarily need to be available for use. If the culvert span is over 20 feet, there needs to be 2 feet of freeboard.

Hydraulic Analysis

We developed a hydraulic model of the Bass River that extends from Mill Pond upstream to MissThatcher's Pond. The hydraulic model is designed to provide a basis of comparison between the existing condition of Bass River and the proposed design condition.

The hydraulic model of Bass River is designed to:

- Simulate hydraulic conditions at the Weir Road culvert,
- Simulate project impacts on flood profiles, velocities, and bed shear stresses during peakflood flows, and
- Simulate project impacts on water-surface profiles and depths for future projections ofMHHW and MLLW tidal datums.

Project Design

The project scope of work includes removing and/or replacing barriers to flow and aquatic organism passage throughout the former bogs within the Project Site. Other elements of work are realigning the stream to increase sinuosity and create habitat variability; filling existing ditches and creating microtopography to help restore historical hydrologic and vegetative conditions; creating a new pond feature; and improving pedestrian access.

Suggested Construction Sequence

In this section, we provide a recommended construction sequence of restoration activities. Once a contractor has been selected, they will submit a detailed work plan with their own recommendations for sequencing. This will be reviewed by Inter-Fluve, the Town, and the FOBR before approval to do any work. The channel and floodplain work upstream of Weir Road have to be done in conjunction with the replacement of Weir Road as access is obtained when the road is closed and the restoration in Cells 3 and 4 are only functional once the flow control structures at and downstream of Weir Road are removed.

- Mobilization
  - Install traffic control measures
  - Install sediment and erosion control features
  - Install stabilized construction entrances
  - Create staging areas
- While Weir Road is closed and the culvert is being replaced:
  - Establish access along berm between Cells 3 and 4
  - Improve access around Cell 2
- Cell 1
  - Establish water control in Cell 1
  - Remove dam and fish ladder
  - Excavate pond and channel
  - Complete bank treatment and large wood installation
  - Microtopography
  - Remove water control
- Cell 3
  - Establish water control
  - Complete grading and channel construction
  - Install large wood
  - Microtopography
  - Remove water control
  - Install stream crossing between Cells 3 and 4
- Cell 5
  - Establish water control
  - Complete channel construction
  - Install large wood
  - Remove water control
  - Invasive species treatment
  - Complete floodplain grading
  - Complete microtopography
- Cell 7
  - Establish construction access
  - Complete grading
  - Complete microtopography
- Cell 6
  - Establish water control
  - Remove earthen berm at downstream end

- Complete channel construction at the upstream end
- Complete floodplain grading
- Complete microtopography
- Remove earthen berm between Cells 6 and 7
- Construct boardwalk between Cells 6 and 7
- Construct footbridge across channel at earthen berm between Cells 5 and 6
- Remove water control

- Complete planting
- Remove traffic signs as appropriate
- Remove sediment and erosion controls once site has stabilized

Dam Removal

The dam and fishway at Miss Thatcher's Pond will be removed. The concrete fishway will be completely removed, and the contractor will dispose of the concrete in an approved off-site location. The earthen berm portion of the dam will be partially removed. We propose leaving approximately one vertical foot of the earthen berm above the adjacent floodplain elevation to provide a drier and more stable walking path for continued pedestrian access. The earthen berm will be removed laterally to the edge of the valley to the north and to the adjacent earthen berm to the south with walking slopes no steeper than 5:1.

Weir Road Culvert Replacement

The Weir Road culvert will be replaced with a larger opening to allow for greater hydraulic capacity for passing flood flows. The stream channel design in the vicinity of and through the culvert will be refined following design of the culvert by Tighe & Bond.

Channel Form And Habitat

Upstream of Weir Road, the current channel is straight with uniform widths and depths and channel bed and banks primarily made of sand. The proposed channel will be a meandering channel with sinuosity calculations based on channel size, watershed size, slope, and regional reference reaches.

Stream Channel Morphology

To design a new stream channel, it is an important exercise to locate relatively undisturbed streams or streams that have achieved an equilibrium with their watershed landuse and hydrology. When choosing an analog or reference stream, the analog must have similar watershed and morphological attributes to the proposed restored channel, including:

- Watershed size;
- Surficial geology;
- Bordering vegetation;
- Soils; and
- Land use.

There are few sites that check all the boxes since most streams and wetlands in New England have been manipulated for farming, deforestation, development or other means. We analyzed aerial photographs and maps of streams around Cape Cod and the South

Shore to find reference sites. Wealso looked to the designs of our past cranberry bog restoration projects. To develop planform geometry values for design, we examined belt width, meander length, and radius of curvature for reference stream segments and past project designs in the following watersheds:

- Upper Herring River;
- Herring Brook;
- Eel River; and
- West Beaver Dam Brook.

We then correlated planform values with the watershed area and used ranges of each parameter to guide the form of the new channel upstream of Weir Road. We designed the stream to have a slightly irregular meander pattern based on the reference and past project sites. The planform valuesthat guided our design are listed in Table 9.

Table 9. Planform values for the new channel above Weir Road

Belt Width	45-50 feet
Meander Length	45-65 feet
Radius of Curvature	10-30 feet

Stream Channel Dimensions

With the removal of flow control structures within the project area, future sea level rise predictions, and planned upgrades to downstream culverts, we expect to see greater tidal influence in our project area post restoration. We designed a channel that is sized for current hydrologic conditions with the ability to adapt to changing and uncertain factors such as rising sea level and intensifying precipitation events.

In the headwaters, we observed naturally formed channel segments with four to eight feet top widths. We determined that a cross sectional geometry with a channel top with of six feet and bank height of 1 foot will overtop during the 2-year return period flood. With little sediment supply, the proposed channel continues to have a 6-foot top width through most of the bog upstream of Weir Road. Approximately 200 feet before Weir Road, the channel transitions to a top width of 14 feet and bank height of 1.5 feet. The existing channel downstream of Weir Road has an average top width of 14 feet. While the channel is over-widened and channelized, we concluded the existing channel dimensions will allow for the additional flow that comes from the elimination of the main ditch and future sea level rise conditions.

The crossing at the footpath between Cheyenne Lane and Knollwood Drive will see the impact of rising tides sooner; therefore, the proposed channel is sized to a top width of 20 feet. We will create floodplain and riparian connectivity to allow for flood waters to spread over the surface of the floodplain, while maintaining pedestrian passage.

Channel and Bank Stabilization

The proposed channel slopes through much of the restored channel area are less than 0.2%. Therefore, we are not proposing riffle construction or the use of stone in the channel bed or banks. As described above, we propose using large wood to provide habitat along the channel banks in the proposed freshwater systems. This wood will also provide some bank stabilization. Elsewhere, however, the banks will be sloped back no steeper than a 2(H):1(V) slope with no additional stabilization measures.

The one location of steeper proposed channel slope is upstream of the proposed new pond in the headwaters of the restoration area. This channel section is close to a 2% slope and will be constructed with gravel and cobble with banks made up of a stone toe and fabric encapsulated soil lifts.

Vegetation

We propose to replant disturbed areas with native seed and native potted trees and shrubs. In the next phase of design, we will provide a more detailed species list with proposed quantities and locations. Different areas of the site will develop into different vegetative ecosystems:

- The wetlands east of the pedestrian bath between Cheyenne Lane and Knollwood Drive will be influenced more by tidal flows with the removal of downstream constrictions. Therefore, we propose a mix of salt marsh vegetation species and transitional species that do well in the mixing zone between salt marsh and freshwater wetlands.

- In the area of sand removal south of Mill Pond, we recommend planting potted Atlanticwhite cedar trees
- In the disturbed areas between the pedestrian path and Weir Road, we recommend a mix of Atlantic white cedar, American holly, and wetland shrubs for the wetland surface. Along theedges in the areas of ditch filling to the east and south of this work area, more upland speciessuch as pitch pine or white oak would be appropriate.
- South of Weir Road in the upstream portions of this restoration, we recommend focusing on developing a robust Atlantic white cedar stand with a mix of wetland shrub species.

Recreation

Current recreation within the project site includes walking and wildlife viewing. Many of the trails are overgrown with some of the stream crossings broken, failing, or not present. Through this restoration project, the project partners would like to improve the walking trails and reconstruct thestream crossings. The existing trails will be cleared of encroaching vegetation and new trails will bedeveloped to encourage more walking and wildlife viewing. We envision installing benches and viewing areas where appropriate.

Engineer's Opinion of Probable Costs

The engineer's opinion of probable costs (EOPC) described below are separated by areas of work: Cells 1 through 4, Cell 5, Cell 6, and Cell 7. These costs are commensurate with the level of design presented in this document and the design drawings. The costs include earthwork calculations, channel bed and bank treatments, large wood structures, microtopography, and plantings. They alsoinclude some of the critical footbridge crossings and the boardwalk. This cost estimate does not include:

- Trail construction,
- Overlooks,
- Parking areas,
- Other recreational features,
- Weir Road replacement, and
- Utility replacement or updates.

The infrastructure costs have been separated out from the restoration costs. At this level of design, we have assumed a 15% construction contingency. This will decrease in later rounds of design. It should be noted that these costs reflect our understanding of the current designs and are based onrecent construction bid prices received on similar projects in 2020 and 2021. Escalation of approximately 3% is typically added for each year after this estimate (for example, if construction occurs in 2023, add approximately 6% to these costs presented below).

Summary of restoration construction costs across the site

Location	Restoration	Infrastructure	Total
Cells 1-4	$363,430	$40,150	$403,580
Cell 5	$154,940	$0	$154,940
Cell 6	$231,960	$326,150	$558,110
Cell 7	$94,310	$0	$94,310
Construction Subtotal	$844,640	$366,300	$1,210,940
15% Contingency	$126,690	$54,940	$181,630
Construction Total	**$971,330**	**$421,240**	**$1,392,570**

Cells 1 through 4

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal
1	Mobilization & Demobilization	LS	$36,690	1	$36,690
2	Clearing & Grubbing	AC	$20,000	1	$20,000
3	Erosion, Pollution & Water Control	LS	$30,000	1	$30,000
4	Earthwork (channel/wetland)	CY	$20	3,625	$72,500
5	Earthwork (Ditches/Uplands/Berms/Dams)	CY	$16	410	$6,560
6	Microtopography	DAY	$1,200	2	$2,400
7	Riffle Aggregate	TON	$110	160	$17,600
8	Large Wood Logs & Snags (Furnish & Install)	EA	$250	200	$50,000
9	Large Wood rootwads (Furnish and Install)	EA	$300	200	$60,000
10	FES lifts	FF	$28	1,000	$28,000
11	Slash	DAY	$5,220	2	$10,440
12	Riparian Seed Mix	AC	$9,000	2	$18,000
13	1-Gallon Potted Plants	EA	$30	333	$9,990
14	3-Gallon Potted Plants	EA	$45	109	$4,905
15	Crossing	EA	$36,500	1	$36,500
			Restoration Subtotal		$363,430
			Infrastructure Subtotal		$40,150
Design and Construction Contingency					
	15% Restoration Contingency				$54,510
	15% Infrastructure Contingency				$6,020
			Construction Total		$464,110

Cell 5

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal
1	Mobilization & Demobilization	LS	$14,090	1	$14,090
2	Clearing & Grubbing	AC	$20,000	1.0	$20,000
3	Invasives Removal	AC	$7,500	0.5	$3,750
4	Erosion, Pollution & Water Control	LS	$10,000	1	$10,000
5	Earthwork (Channel/Wetland)	CY	$20	1,450	$29,000
7	Microtopography	DAY	$1,200	4.5	$5,400
8	Riffle Aggregate	TON	$110	110	$12,100
9	Large Wood Logs & Snags (Furnish & Install)	EA	$250	16	$4,000
10	Large Wood rootwads (Furnish & Install)	EA	$300	16	$4,800
11	FES	FF	$28	200	$5,600
12	Upland transition Seed Mix	AC	$9,000	1	$9,000
13	1-Gallon Potted Plants	EA	$30	832.0	$24,960
14	3-Gallon Potted Plants	EA	$45	272	$12,240
			Restoration Subtotal		$154,940
			Infrastructure Subtotal		$0
Design and Construction Contingency					
	15% Restoration Contingency				$23,240
	15% Infrastructure Continency				$0
			Construction Total		$178,180

Cell 6

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal
1	Mobilization & Demobilization	LS	$50,737	1	$50,740
2	Clearing & Grubbing	AC	$20,000	1	$20,000
3	Invasives Removal and Treatment	AC	$7,500	2	$15,000
4	Erosion, Pollution & Water Control	LS	$15,000	1	$15,000
5	Earthwork (Channel/Wetland)	CY	$20	575	$11,500
6	Earthwork (Ditches/Uplands/Berms/Dams)	CY	$16	2,000	$32,000
7	Microtopography	DAY	$1,200	1.8	$2,160
8	Riffle Aggregate	TON	$109	140	$15,260
9	1-Gallon Potted Plants	EA	$30	354	$10,620
10	3-Gallon Potted Plants	EA	$45	266	$11,970
11	Plugs	EA	$4	19,340	$77,360
12	Boardwalk	FT	$650	400	$260,000
13	Crossing	EA	$36,500	1	$36,500
			Restoration Subtotal		$231,960
			Infrastructure Subtotal		$326,150
Design and Construction Contingency					
	15% Restoration Contingency				$34,790
	15% Infrastructure Contingency				$48,920
			Construction Total		$641,820

Cell 7

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal
1	Mobilization & Demobilization	LS	$8,570	1	$8,570
2	Clearing & Grubbing	AC	$10,000	2.5	$25,000
3	Earthwork (wetland)	CY	$20	1,600	$32,000
4	Microtopography	DAY	$1,200	3.0	$3,600
6	1-Gallon Potted Plants	EA	$30	562	$16,860
7	3-Gallon Potted Plants	EA	$45	184	$8,280
			Restoration Subtotal		$94,310
			Infrastructure Subtotal		$0
Design and Construction Contingency					
	15% Restoration Contingency				$14,150
	15% Infrastructure Contingency				
			Construction Total		$108,460

QAPP: Completed and approved on October 28, 202

Major Project Partners

Friends of Bass River:
Rick Bishop, Executive Director and Project Leader
Erinn McCarty, FOBR Board Member and Project PR & Budget Manager

Town of Yarmouth:
Kelly Grant, Conservation Administrator
Jeff Colby, DPW Director
Karl von Hone, Natural Resources Director
Amanda Lima, Town Engineer

Contractors:
Woods Hole Group, Arden Herrin (Coastal Engineer)

Tighe & Bond, Eric O'Hanian (Project Manager)
Adam Yanulis
Dan Murphy
Troy Berry
Amanda Houle

Inter-Fluve, Nick Nelson (Geo-morphologist)
Sarah Widing

Outreach & Communications

Funding for the project was covered in the Cape Cod Times and posted on our website. We also covered the project with background and educational information in two of our most recent newsletters.

Article: A River Runs Through Cape Cod, attached

Aritcle: Abandoned cranberry bogs in Yarmouthslated for wetland restoration by state – announcing Massachusetts Department of Ecological Restoration bestowing Priority Project Status

We have 1,500 community supporters who follow our work and we keep them updated through our quarterly newsletter, of which the latest we have included with this proposal package.

We led multiple tours to groups, list attached.

Project Budget Report

Summary Budget Table 1: Expenditures by Federal Cost Category

Budget Category	Total Budgeted Funds	Total Budgeted Match	Grant Funds Expended Cumulative	Match Funds Expended Cumulative	Match Source (note cash or in-kind)
Personnel	$0	$67,745	$0	$67,745	In-Kind, Cash
Fringe	$0	$4,990	$0	$4,990	In-Kind
Travel	$0	$362	$0	$362	In-Kind
Equipment	$0	$3,981	$0	$3,981	In-Kind,Cash
Supplies	$0	$500	$0	$500	In-Kind, Cash
Contractual	$253,779	$25,021	$253,779	$25,021	Cash
Other					
Total Direct	$253,779	$102,599	$253,779	$102,599	
Indirect					
Total	$253,779	$102,599	$253,779	$102,599	

Summary Budget Table 2: Expenditures by Project Task (Grant Funds Only)

Budget Category	Budgeted Grant Funds	Expended Progress Period 1	Actual Expended to Date
Contractor A T&B			
Wetland Resource Delineation at N. Dennis Road Survey at N. Dennis Road Borings at Weir Road Geotech Evaluation and Reports at both sites Hydrologic & Hydraulic Modelling at N. Dennis Road	$95,500	$62,075	$95,500

Meetings, PM Duties, etc. Coordination with Inter-Fluve and Woods Hole Group Stitching together of gathered surveys Outlining Alternative Analysis Reports			
Contractor B WHG			
Numerical Model (EFDC) Development for Upper Bass River	$14,000	$14,000	$14,000
Culvert Optimization Simulations	$6,300	$4,725	$6,300
Reporting	$7,500	$1,875	$7,500
Project Management & Administrative	$1,700	$850	$1,700
Contractor C, Inter-Fluve			
Field Work	$28,300	$28,273.81	$28,300
Feasibility Study	$26,900	$12,938.68	$26,900
Field Work for Preliminary Designs	$26,079	$11,279.61	$26,079
Hydrology and Hydraulics	$9,700	$6,321	$9,700
Preliminary Designs	$34,800	$280	$34,800
QAPP	$3,000	$0	$3,000
Total	$253,779	$142,618	$253,779

Certification

Include this language: *The undersigned verifies that the descriptions of activities and expenditures in this final report are accurate to the best of my knowledge; and that the activities were conducted in agreement with the grant contract. I certify that the matching fund levels established in the grant contract and reported here have been met.*

Grantee Signature: 
Name: Rick Bishop
Title: Executive Director
Organization: Friends of Bass River
Date: 2/28/2022

CAPE COD TIMES

NEWS

Abandoned cranberry bogs in Yarmouth slated for wetland restoration by state

Jeannette Hinkle Cape Cod Times

Published 4:00 a.m. ET Dec. 23, 2021 | **Updated 7:58 a.m. ET Dec. 23, 2021**

When Cape Cod's cranberry farmers abandon a working bog, when they quit adding the nutrients, pesticides and layers of sand that keep the iconic expanses of crimson berries coming back year after year, the landscape changes.

After about 30 years without maintenance, the Bayview Bogs in West Yarmouth are badly overgrown. Cape Cod Conservation District Chairman and Yarmouth Board of Selectmen Chairman Mark Forest described them as blighted. In 2016, police said they discovered a homeless encampment they discovered a homeless encampment where people were cooking meth.

"Clearly the impairments to the flow of water in the system are really creating all sorts of problems to the ecology of the site and the site itself," Forest said.

But over the next few years, thanks to a new commitment by the Department of Fish and Game's Division of Ecological Restoration, the Bayview Bogs will be transformed into a thriving wetland ecosystem, enhancing the area's wildlife habitat, water quality and resilience to coastal flooding.

Bayview Bogs, a 90-acre parcel owned by neighboring Cape Cod Hospital, was recently accepted into DER's priority projects program, according to a Dec. 17 press release from the Baker-Polito administration.

The new designation means that the project, along with three others on Cape, is now eligible to receive technical and program management support from ecological restoration division staff, technical services from contractors and direct funding not yet announced.

Cape Cod Restaurants: Finding a Christmas meal is still possible

Several new DER priority projects involve retired cranberry bogs, a focus of wetland restoration efforts in Massachusetts.

There are more than 13,000 acres of cranberry farmland in Massachusetts, but falling prices and other factors have led some farmers to consider other uses for their land, according to the state.

“For some,” the state’s Cranberry Bog Program website says, “a ‘green exit strategy’ involving land conservation and habitat restoration makes sense.”

That’s the plan for another newly accepted priority project involving abandoned cranberry farmland in Yarmouth, near the Upper Bass River headwaters.

There, the Friends of Bass River plan to work with DER to restore about 57 acres of abandoned cranberry farmland to healthy wetlands, a project intended to improve water quality, increase public access to town-owned land, promote recreational use with walking trails and improve fish passage, in part through the replacement of an undersized culvert at North Dennis Road.

Friends of Bass River Executive Director Rick Bishop said the DER commitment will allow his organization to pursue a restoration design plan they already procured from the engineering firm Tighe & Bond with the help of two other sizable grants.

'Relentless investigation': Yarmouth police ask for public's help in deadly hit and run

“Tighe & Bond is recommending replacing the culvert with a 60-foot-wide bridge to get water up into the Mill Pond area, which is a very upper portion of Bass River,” said Bishop, who serves on Yarmouth’s conservation commission.

Nitrogen mitigation part of the plan

That part of Bass River is suffering particularly severe nitrogen pollution, according to a state report released in 2011.

“The state determined that the Mill Pond area required a 76% reduction in nitrogen to get back to a healthy state,” Bishop said. “If we're able to take the retired cranberry bogs and restore them as wetlands, they become, naturally, a very effective carbon sink and nitrogen sink. We're able to naturally begin the water cleansing there.”

Yarmouth is in the early stages of a gradual transition from septic to sewer, a massive infrastructure project intended to reduce nitrogen pollution in the town's degrading waterways.

While the wastewater overhaul is a historic effort to improve water quality in town, Bishop said it will take years to finish. In the meantime, projects like the one at Bass River will move the ball forward, he said.

"The Yarmouth plan is fantastic, I'm so proud of what was accomplished at the last town meeting, but the reality is the pipes won't get up to that part of town for possibly 40 years," Bishop said. "So it's even more important that we're able to kickstart this natural process of beginning to reduce the nitrogen getting into the water."

Pollution solutions: UMass Dartmouth gets funding to build new Biodegradable Plastics Lab

The project would also help to restore the habitat that fish, including herring, need to survive.

"In 1873, that area was the second largest herring catch in all of Massachusetts," Bishop said. "Now it is zero because the fish can't get there, because when they built the cranberry bogs, they blocked off all the access."

Following a restoration blueprint

The Bass River and Bayview Bogs projects are following a cranberry bog restoration blueprint already hammered out in Falmouth.

There, a retired bog at the Childs River is in the midst of wetland restoration, and a few minutes away, a retired bog at the Coonamessett River has been fully restored to a natural wetland habitat.

"The Coonamessett River now, after I think 18 months, has wildflowers," Bishop said. "It's just gorgeous. And when they replaced their undersized culvert, within seven days they had herring going back upriver."

While cranberry bog restoration can be jarring — it often involves tearing out invasive plants and shrubs, removing layers of sand, and tilling soil to expose long-dormant native seeds — Association to Preserve Cape Cod Executive Director Andrew Gottlieb said residents who see the finished product usually appreciate the work.

“The Childs River is about two years behind the Coonamessett, so it doesn’t look great, but if you go back in the spring, it’ll start to look like what the Coonamessett looks like now,” Gottlieb said.

But the benefits of turning dormant cranberry bogs into wetlands goes beyond aesthetics or wildlife preservation, Gottlieb said. One of the main benefits of wetland restoration is the protection of human infrastructure from flooding, which is projected to worsen as climate change produces more intense storms.

“From a human perspective, one of the primary ecological values of properly functional wetlands is to absorb floodwaters and provide opportunities for floodwaters to get processed through the plant matter and make their way down to the groundwater without carrying all these pollutants through them, as opposed to all that floodwater having no place to go and ending up in someone's backyard and flooding public infrastructure,” Gottlieb said.

Cape Cod Bay: Seafood, aquaculture trades oppose possible discharge of radioactive water

In addition to the cranberry bog restoration projects, the Division of Ecological Restoration also committed to assisting with two other Cape projects, both in Chatham.

One project, headed by the Chatham Conservation Foundation, would restore natural tidal exchange and stream flow in the Frost Fish Creek estuary.

The other, headed by the Massachusetts Department of Transportation, would restore salt marsh, increase tidal flow and restore estuarine habitat with the goal of supporting herring, American shad, striped bass and rainbow smelt populations in Ryder’s Cove.

Contact Jeannette Hinkle at jhinkle@capecodonline.com.

A River Runs Through Cape Cod

Bass River, beset by pollution and collapsed infrastructure, finally finds a friend in a new nonprofit organization dedicated to bringing the river back to health.

JAMES KINSELLA/CAPE COD REVIEW

By RICH HOLMES of the CAPE COD REVIEW

Dipnet in hand, a woman stood in shallow water on the south side of the North Dennis Road bridge over Crab Creek in Yarmouth Port, eyeing the water flowing out of the bridge's square concrete culvert for blue crabs.

"Any luck?" I yelled down to her from a gravel patch by the east end of the bridge.

"Just small ones," she replied.

"You'll get bigger ones later in the season," said Rick Bishop, standing beside me. She nodded her reply.

Bishop is executive director of the Friends of Bass River, a non-profit organization working toward environment improvement of Cape Cod's biggest tidal stream. The section of the river near North Dennis Road goes by the name "Crab Creek."

The scene before us seemed a slice of bucolic beauty, as sunlight illuminated the creek running through the forested conservation area.

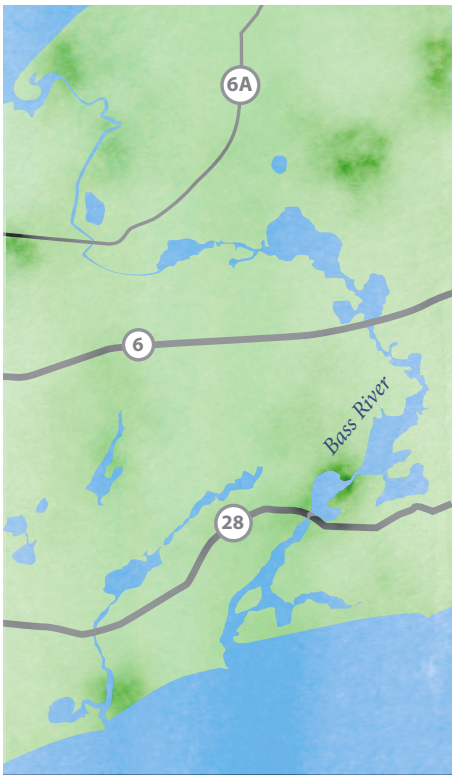
But to Bishop, the same scene displayed damage done to the upper part of Bass River.

He pointed to the creek's wide banks. Erosion, he said, had washed away soil and toppled trees so the once 18-foot-wide streambed is now 58 feet across.

In 2018, the railroad bridge built in the 1800s, which crossed Bass River a short distance south of the four-lane Mid-Cape Highway, Route 6, was replaced with a bike and pedestrian bridge. That allowed stronger tidal surges to come up the river.

At North Dennis Road, these watery forces met the precast 6-foot-square culvert, a pinch point, causing erosion on both sides of the bridge.

Installed in 2010, the culvert is one of several physical barriers the Friends of Bass River hope to rectify in its attempt to restore the upper reaches of the river to a more natural state.



JAMES KINSELLA/CAPE COD REVIEW

A young Yarmouth family crabs for fun, not food, at Crab Creek just downstream from the North Dennis Road bridge.

The battle is personal for Bishop, a Cape native who grew up swimming at Windmill Beach in the Bass River section of Yarmouth, and used to harvest scallops as far up the river as Follins Pond, northwest of where Route 6 passes by Kelleys Bay.

Those scallops disappeared along with the eelgrass that grew on the river's bottom, he said, killed off by rising levels of nitrogen, primarily from septic systems around the river. Eelgrass is vital to the scallops, which find their first home on the slender blades of grass and can hide amongst them as they begin to grow to maturity.

Too much nitrogen in coastal waters causes algae blooms and oxygen-starved dead zones, along with fish kills and smelly, slimy areas.

"It was loaded (with scallops) when I was a kid – loaded," he said.

By the mid-1980s, scallops could still be had between the Bass River bridge (Route 28) and High Bank Road bridge, Bishop said, but no longer.

"I'm so passionate about the river – it's part of my life," he said.

Taking on the problem

In 2017, a handful of residents concerned about the river's degradation formed the Friends of Bass River.

In 2020, they hired Bishop, a member and former chair of the Yarmouth Conservation Commission, as executive director.

"I immediately started a testing program in six locations," he said.

Water samples taken weekly during the summer by a team of 12 volunteers go to the Center for Coastal Studies in Provincetown for nitrogen analysis.

Ten years ago, the Massachusetts Estuaries Project estimated the total amount of nitrogen in Bass River estuarine system at 338 kilograms a day.

Five years ago, the state Department of Environmental Protection recommended levels be lowered to 206 kilograms a day.

With all the development that's occurred in the past decade, imagine what the total nitrogen load is now, Bishop said. Because of the impaired water flow, the upper reaches of the system are more subject to the harmful effects of nitrogen loading.

The sampling now being done by the Friends will provide the first new data on nitrogen levels in a decade or more. Bishop said results should be known in a few weeks.

The Friends of Bass River want to Increase tidal flushing and recreate historic wetlands to lower nitrogen levels in the river and improve the habitat for fish, shellfish and other native wildlife.

Revising the culverts at Crab Creek and Weir Road would help accomplish this.

The upper estuary, west of Follins Pond

The North Dennis Road bridge traverses Crab Creek upstream from Follins Pond. Going further up, the creek flows west to become Mill Pond. Continuing on from Mill Pond, Hamblins Brook heads toward Weir Road.

There, another crossing forms another bottleneck, caused by a collapsed culvert. It hampers passage of fish and limits water flow in and out of the surrounding 57 acres of wetlands and old cranberry bogs, which are crisscrossed with drainage ditches, berms and water controls.

Bishop's organization wants to replace the Crab Creek culvert with a single-span bridge or add more precast culverts to increase flow while lowering the pressure that's scouring the banks.

It also seeks to remove the collapsed Weir Road culvert and create a meandering stream through the old bogs, now owed by the Town of Yarmouth, and connect to Miss Thatcher's Pond, which he identified as the historical spawning grounds for herring, and the true spring-fed headwaters of Bass River.

The pond and surrounding wetlands lie between Weir Road and Union Street in Yarmouth Port.

The Crab Creek culvert might even be reused if replaced, as it's "nearly a perfect fit" to replace the fallen Weir Road culvert, according to the Friends' website.

Hamblins Brook, as a natural stream, "no longer exists," Bishop said, but "in the 1870s, it was the second-largest herring run in all of Massachusetts."

The Friends of Bass River are starting by focusing on the upper part of the estuarine system because changes there could be done relatively quickly with great effectiveness, Bishop said.

Attempts to reduce nitrogen entering the watershed by installing sewers in the residential areas around the upper part of the river is "decades away," he said. "This could be done in five years."

A $253,779 grant from the U.S. Environmental Protection Agency's Southeast New England Program, awarded last year to the organization, has helped the Friends of Bass River sample, study and plan the restoration effort.

Bishop said the organization recently applied for the another SNEP grant to complete the second phase of the project.

The group paid for all the engineering work, he said.

Once the project design and plans are complete, the group will raise funds to do the restoration.

"We like holistic projects—projects that have a broad impact," said Tom Ardito, administrator of the Southeast New England Program's watershed grant program.

He said the Bass River project received a grant because it seeks to improve conditions for both habitat and wildlife, and ameliorate the effects of flooding. Plus, it's backed by the Town of Yarmouth.

Yarmouth voters placed about $95,000 in community preservation funds toward the project, Bishop said, and the town's conservation commission been involved "since the beginning."

Yarmouth conservation administrator Kelly Grant said town staff from conservation, natural resources and public works departments regularly attend meetings on the project's progress.

The grant program looks for commitment from all involved parties, Ardito said.

"You had very strong support from the municipality," he said.

Ardito said the grant requires a 33 percent match in non-federal funds. The grant funds are being administered for the Friends by Cape Cod Foundation, a larger organization better suited to handle the accounting responsibilities, Ardito said.

Despite the pandemic, the Friends managed to keep to its project schedule, Bishop said. Ardito praised the group as "one of more timely grantees" in accomplishing the work set forth its grant application.

He said he couldn't speak about the merits of the Friends' second grant request, but its fate will be decided in mid-August and this year's grants will be announced in September.

Other local organizations that have received SNEP grants include the Association for the Preservation of Cape Cod, Buzzards Bay Coalition, Pleasant Bay Alliance and the Falmouth Rod and Gun Club, which is restoring old cranberry bogs on the Childs River to natural wetlands, and improving the waterway to allow fish to travel upstream.

A shared problem for Dennis and Yarmouth

While the initial project lies within Yarmouth, the Friends' interests extend to the entire river. The eastern half of the waterway from the middle of Follins Pond to the river's mouth on Nantucket Sound falls within the town of Dennis.

JAMES KINSELLA/CAPE COD REVIEW

This view of the North Dennis Road bridge over Crab Creek may look bucolic, but the reconstruction of a bridge just south of the Mid-Cape Highway to carry a westward extension of the Cape Cod Rail Trail inadvertently changed the tidal flow of the river, damaging its Crab Creek branch.

Erinn McCarty, the group's vice chair, said she would like to see a similar project in the area of Weir Creek in West Dennis where she lives.

Lower County Road and Loring Avenue both cross the creek, which widens near the West Dennis Yacht Club to pass by "The Fingers," a neighborhood of homes on short canals, and then empties into the river just north of its mouth.

The Weir Creek area suffers from the same issues as the upper river, she said.

Improvement of the river's nitrogen levels isn't just a nice thing to do for the environment. All Cape towns are under legal pressure to reduce nitrogen pollution of their coastal waters to become compliant with the federal Clean Water Act, as laid out under the county's 208 Plan.

An effort to create a regional plant in Dennis that would treat wastewater from Yarmouth, Dennis and Harwich foundered last month when Harwich officials decided to pull out. McCarty said Dennis residents should know that the town still has to clean up its nitrogen problem, whether or not a regional plant is built.

"Dennis has to have a comprehensive wastewater plan," she said.

The 208 plan places the responsibility for nitrogen reduction on towns, but looks at the problem by watershed. Of the 53 watersheds identified in the plan, 32 lie within two or more towns, so cooperation would seem to be the name of the game. Dennis officials are aware of the Friends' project, McCarty said, adding she has discussed it with members of the select board.

She said the Friends of Bass River has quickly grown to about 1,300 members, with many from Dennis. The group plans a "state of the river" meeting in October at which it will try to get representation from all levels of government.

George Macdonald, chairman of the Dennis Conservation Commission, said that he has not been involved with the Friends' project, but supports the goals of restoring wetlands, clearing waterways and lowering nitrogen water levels.

"In a general way, I certainly would be in favor of all of them," he said, noting he had worked on a similar project on Sesuit Creek back when he was the town natural resources officer.

Both Bishop and McCarty stressed the need for more public education on threats to the river and what local residents, summer visitors and businesses can do to help out.

The Friends' website encourages maintenance of septic systems, organic lawn care, use of boat pumpout facilities, and proper disposal of hazardous wastes. The group's newsletters have discussed Styrofoam pollution from boating, and how low tidal flushing encourages the growth of invasive plants into salt marshes.

ROBERT SCOTT BUTTON

An aerial view of Bass River, the largest estuary on the Cape and, like the rest of the Cape's estuaries, suffering from pollution.

Why restoring Bass River matters

Bass River may be the Cape's largest tidal stream, but it's far from the only one, and those other estuaries shares its flow and pollution problems.

Work has begun on some of those waterways, including the Herring River in Wellfleet and the Coonamessett River in Falmouth.

"Cape Cod's small estuaries, like the Bass River, are incredibly important for residents and visitors—for swimming, boating, fishing, birding and aesthetic enjoyment," Ardito said.

"By restoring cleaner water to the Bass River," the program director said, "this project will ensure that present and future generations can continue to enjoy the unique beauty of Cape Cod's coastal environment."

Alternative septic systems may help address the pollution

All of 15 of Barnstable County's towns have been on notice to reduce nitrogen pollution of coastal waters since 2011, when the Conservation Law Foundation sued the Environmental Protection Agency over the matter. In response, the Cape Cod Commission created the 208 Area Wide Water Quality Management Plan.

Horsley worked as a water resources consultant on that plan and is now working with the Friends of Bass River and other like-minded groups, including the Barnstable Clean Water Coalition, as well as the Town of Wellfleet.

Horsley said while it's taken years, Cape towns and local organizations are making steps to cut nitrogen pollution.

"There's been way too many plans developed and not enough action," he said. But now, "it's happening," he continued, citing sewer projects moving forward in Mashpee and Barnstable.

Big sewer projects typically serve downtowns and other densely developed areas, such as along Route 28 on the Cape's south side. Alternatives to traditional septic systems could provide relief for less densely settled areas, like those around the upper section of the Bass River system, Horsley said. The technology is simple, less expensive than sewers and natural.

After leaving the first tank in a traditional septic system, where solids settle out, the effluent would then be aerated and sent into a tank of wood chips, where bacteria (using carbon from the wood chips) remove nitrogen before the treated wastewater is dispersed through a leaching field. The technology has improved to the point where it gets rid or 80-90 percent of the nitrogen, he said, and it can be scaled up to serve several buildings.

The technology may become part of the state's Title V septic regulations. Horsley said he sits on an advisory committee to the Department of Environmental Protection that's considering adopting the technology as part of an update of the existing rules. It's already being tried on Cape Cod in projects in Wellfleet and Barnstable, he said.

FOBR

friendsofbassriver.org

Please consider supporting the Friends of the Bass River and the Cape Cod Foundation.

Friends of Bass River Receives Grant from EPA's "Restoring America's Estuaries" Program and SNEP

Friends of Bass River is more than pleased to announce that today we were awarded a grant of $253,779 by the **Southeast New England Watershed Grant Program (SNEP)**. Funding will be provided by the EPA via **Restore America's Estuaries**. FOBR will use these funds towards the engineering and feasibility studies needed as our first step towards breaking down man-made barriers in the upper Bass River Watershed area.

We will be sending out a detailed River News in the next few days but we wanted to

shout this good news from the rooftops! Please stay tuned for more information on the scope of this grant and how FOBR intends to use these funds. Special thanks to our Executive Director, Rick Bishop; our grant-writer; our Board of Directors; and the Town of Yarmouth for their assistance and cooperation throughout this process and into the future.

Our goal at FOBR is to make a lasting positive impact on the health of Bass River for generations to come. We could not have reached this point without our Friends, Volunteers, and Donors. Thank You!

For more Information about the Restore America's Estuaries program and the other recipients of this year's SNEP Watershed Grants please see below.

Southeast New England Program

SNEP Watershed Grants
2020 Summary of Awards

RELEASE DATE 26 AUGUST, 2020

For more information, contact:
Restore America's Estuaries
Thomas Ardito, Director, SNEP Watershed Grants
tardito@estuaries.org **401-575-6109**

Background: In 2012, Congress charged the US Environmental Protection Agency (EPA) with conserving and restoring southeast New England's coastal environment, and in 2014 began providing funding to develop a Southeast New England Program (SNEP). As EPA's pass-through organization, Restore America's Estuaries (RAE) is now working with EPA to manage the SNEP Watershed Grants program, funding local organizations that are restoring clean water and healthy coastal ecosystems while strengthening local communities.

Recent Awards: In 2018 and 2019, SNEP Watershed Grants awarded $6.6 million to high-impact projects throughout the SNEP region. The grants funded municipalities, non-profit organizations, academic institutions and others working on a variety of innovative projects, including cranberry bog and salt marsh restorations, urban and suburban storm-water programs, and environmental monitoring and research. The diverse partnerships funded by SNEP Watershed Grants increase local capacity to restore coastal ecosystems, while SNEP provides a framework for communicating that experience—enhancing our region's ability to tackle shared environmental challenges.

2020 Grants: In 2020, SNEP Watershed Grants is will support 11 important initiatives, including dam and culvert removal, shellfish restoration, and urban community resilience planning. The awards—$1.8 million in Rhode Island and Massachusetts—were selected through a rigorous competitive process, with the advice of an independent, interdisciplinary committee of coastal scientists and managers. RAE received more than 40 grant applications totaling more than $10 million in requests from which the 2020 grants were selected. With non-federal match, these SNEP grants will result in more than $2.3 million in new project funding for Southeast New England's coastal ecosystems and communities in 2020.

This document provides a brief summary of the 11 awards planned for 2020 SNEP Watershed Grants. While we do not expect any significant changes, awards are not final until grant contracts have been fully executed. Dollar figures below are award amounts; grantees provide at least 33% in additional non-federal funding toward each project. Awards will be announced at a virtual event on **Wednesday, August 26th at 10:00 a.m.**

Click here to register!

For more about EPA's Southeast New England Program, see www.epa.gov/snecwrp.

Summary of Awards

Town of Warren: *Market to Metacom: Adaptation and Economic Development* $91,875
The Town of Warren, RI, will work with local property owners to create a sustainable redevelopment plan for a highly vulnerable, flood-prone and economically distressed area. The project will foster climate resilience, economic development, and environmental equity.

City of Providence: *Woonasquatucket River Greenway* $250,000
This funding will support ongoing work by the City of Providence, RI Dept. of Transportation, and non-profit organizations to develop greenspace and improve water quality along an urban river. The work will promote environmental justice, economic development and climate resilience in an underserved neighborhood.

RI Division of Marine Fisheries: *Oyster Habitat Conservation and Restoration Planning* $150,000
This grant will support a partnership between RI Div. of Marine Fisheries, Northeastern University and The Nature Conservancy to undertake research necessary toward developing a statewide oyster restoration plan. The team will study natural and restored oyster reefs in Narragansett Bay and Rhode Island's coastal ponds; the information will ultimately be used to identify sites for oyster restoration and to assess the success of oyster restoration efforts.

Town of South Kingstown: *Green Hill Pond Stormwater Plan* $100,000
With this funding, the Town of South Kingstown, RI, will undertake a watershed-scale assessment and stormwater management plan for a valuable coastal pond, working closely with local stakeholders. Once implemented, the plan will benefit clean water, shellfish resources and estuarine fish such as migratory river herring.

University of Rhode Island: *Mt. Hope Bay Water Quality Monitoring* $301,289
This grant will fund equipment, data analysis and management for real-time water quality monitoring in Mt. Hope Bay, Narragansett Bay's largest sub-estuary. The project fills a critical gap in Narragansett Bay monitoring and dovetails with a 2018 SNEP Watershed Grant that funded similar equipment elsewhere in the Bay.

Pleasant Bay Alliance: *Nitrogen Management in Pleasant Bay* $132,178
Pleasant Bay is the largest estuary on Cape Cod. Its waters are an exceptional public resource for fishing, shellfishing and recreation, but are threatened by pollution from septic systems and other sources of nitrogen. This grant will support a partnership among the Towns of Chatham, Orleans, Harwich and Brewster to implement innovative solutions to reduce pollution and ensure clean water for residents and visitors to Cape Cod.

Buzzards Bay Coalition: *Multi-Community Collaboration to Reduce Nitrogen in Upper Buzzards Bay* $118,275
This grant continues funding to the Buzzards Bay Coalition to lead a large-scale partnership among the Towns of Wareham, Bourne, Plymouth, and Marion, MA, and the Mass. Maritime Academy, to complete engineering and other studies aimed at expanding the capacity and

service area of the Wareham wastewater treatment plant. When implemented, this project will have an enormous positive impact on clean water for Buzzards Bay.

Friends of Bass River: ***Upper Bass River Watershed Restoration*** **$253,779**
With this award, a local watershed organization will complete engineering and permitting to reconnect historic cranberry bog wetlands with the riparian system of Cape Cod's largest river by replacing failed road crossings in Yarmouth, MA. The project will improve both freshwater and estuarine habitat through improved water quality and fish passage restoration.

Mt. Holyoke College: ***Bioreactors for Nitrogen Removal in Coastal Cranberry Farms*** **$232,352**
This project will implement and study the effectiveness of an innovative, low-tech method for reducing nitrogen pollution to coastal waters from cranberry farming operations with installations in Barnstable, MA, and could provide a model for restoring water quality in other degraded areas.

Center for Coastal Studies: ***Ecosystem Research Conference for Pleasant Bay*** **$8,984**
This grant will support a conference to inform stakeholders about the state of the science on Pleasant Bay, Cape Cod's largest estuary. This grant dovetails with SNEP Watershed Grants' support of the Pleasant Bay Alliance, described above.

Mass. Audubon Society: ***Protecting Salt Marshes*** **$150,000**
This grant will fund a variety of science and restoration activities at coastal sanctuaries on Buzzards Bay in Wareham and Dartmouth, MA. The project will improve our understanding of the impacts of sea level rise on salt marshes; implement innovative restoration techniques to address such impacts; and monitor the results of the work.

Attachment: Summary Table

HELP TURN THE RED DIAMONDS BLUE!
Only through your financial support and volunteer involvement can we achieve our goal of a healthier River.
Please consider a donation to fund our new river testing program.

https://capecodfoundation.fcsuite.com/erp/donate/create?funit_id=1254

Click on the map to Donate now!

Our mailing address is:
Friends of Bass River
P.O. Box 303
West Dennis, MA 02670

friends of BASS RIVER

September 2020

RIVER NEWS / SPECIAL EDITION / THE HEALTH OF THE RIVER / VOL 5 A FUND OF THE CAPE COD FOUNDATION

NOTES from our Executive Director, Rick Bishop

Most mornings, just after 7am, I can be found crossing Bass River biking on the rail trail bridge. It is a wonderful way to start the day with a north-south view of Kelley's Bay and the Blue Rock narrows. This past Friday I found myself thinking, as I often do, about the unique moment that we are in together. New ways of connecting, shuffled schedules, and an affirmation that a healthy natural environment is a critical part of our future, have all found their way into our lives while we navigate these turbulent times.

An aerial view of the Bass RIver at Crab Creek by Alex Belisle
Masthead: An evening paddle at Mill Pond by Mary-Ann Agresti

The Friends of Bass River board members and myself care deeply about our river. Each day, we are collaborating with local government, promoting water quality improvements, restoring habitats and inspiring the next generation to care for our river. We are committed to moving at full speed, project to project, safely, and respectfully, during this challenging time. To that end, we have extraordinary news to share! We hope you enjoy this issue of River News!

Kindest Regards, Rick

Rick Bishop

*FOBR has been awarded an EPA funded SNEP *** grant for $257,000!*

Our dedicated grant application team worked for nearly two months to insure we produced the most complete application possible. Specifically targeting the upper Bass River watershed, our plans will result in major water quality improvements. This grant is a "game changer" in our plan to improve the upper Bass River.
*****What's SNEP? See more details on page 3.**

Since July, we have been working with 12 dedicated volunteers that comprise "The Friends of Bass River Water Testing Team". Thanks to Jenn Burkhardt from Center for Coastal Studies in Provincetown, our volunteer team is trained using state of the art processes, proven methods of estuarine testing. Weekly they gather samples of Bass River water at five locations: Mill Pond, Follins Pond, Kelley's Bay, Aunt Julia's Landing and to the south at Uncle Freeman's landing. I am so grateful for their time and enthusiasm. With the data collected and the collaboration of the Center, we will have a clear understanding of the water's makeup. This is data that is essential for future projects that protect our River.

(continued on next page / NOTES from Rick)

Our water sampling team!
Front row: Mary Jo Jollett, Judy Jollett, Ann Cave, Marie Ward, Pat Mulhearn, Mary-Ann Agresti, Jack
Back Row: Kate Grinberg, Ainslee Caton, Rick Bishop, Clint Cave
Missing from photo: Erik Hunter, Carl Depuy, Erinn McCarty, Alex Lilly, Frankie Lilly and Abby Bishop

(continued from previous page / NOTES *from Rick)*

We continue to work with the Woods Hole Group, engineers from Tighe and Bond and internationally recognized Inter-Fluve, planning upper Bass River watershed improvements. Later in September I will be sharing what we have in store.

As we continue to adapt during the Covid-19 period, we are always looking for more effective ways to communicate with you. I have heard from our supporters that they would prefer a "hard copy" of our River News. In the age of e-mail and Instagram we are preparing a return to the days of printed newsletters. Please let us know what you think.

In February, while touring the upper ponds, I noticed a number of derelict dock floats silted into a marsh grass shore. (Details, photos and a great result appear later in River News.) Lemco Marine and the Town of Yarmouth donated time and services to remove them, allowing the river's edge to recover.

Some projects seem simple but add up to a larger whole that makes a big difference. Each project and each gift, large or small, has an immediate and direct impact on the health of our river.

For easy online donations please visit our web site:

www.friendsofbassriver.org

or use the enclosed envelop.

Every gift makes a difference.

Thank you!

Do you know where this is?
Look for the answer in the next River News!

friends of BASS RIVER

OUR WATER TESTING PROGRAM BEGINS!

We are so pleased to share with all of our "Friends" news of our very successful water testing program now underway on the River. Thanks to 12 committed and energetic volunteers, an invaluable relationship with Carl Depuy from Dennis Yarmouth Highschool and Jenn Burkhardt from the Center for Coastal Studies, we are collecting weekly water samples to analyze current conditions. The Friends of Bass River "Water Testing Team" can be found at five locations steadfastly completing their work through the end of September.
We look forward to sharing results later this season.

Top: Ainslee Caton & Mary-Ann Agresti sampling at Kelley's Bay.
Inset: Judy and Mary Jo Jollett performing titrations in Mill Pond.
Background: DYHS Student Ainslee Caton testing on the float at Driftwood Ln

EXCITING FUNDING NEWS!

FOBR has been awarded a Southern New England Estuaries Projects (SNEP) grant for $257,000 from the Environmental Protection Agency (EPA).

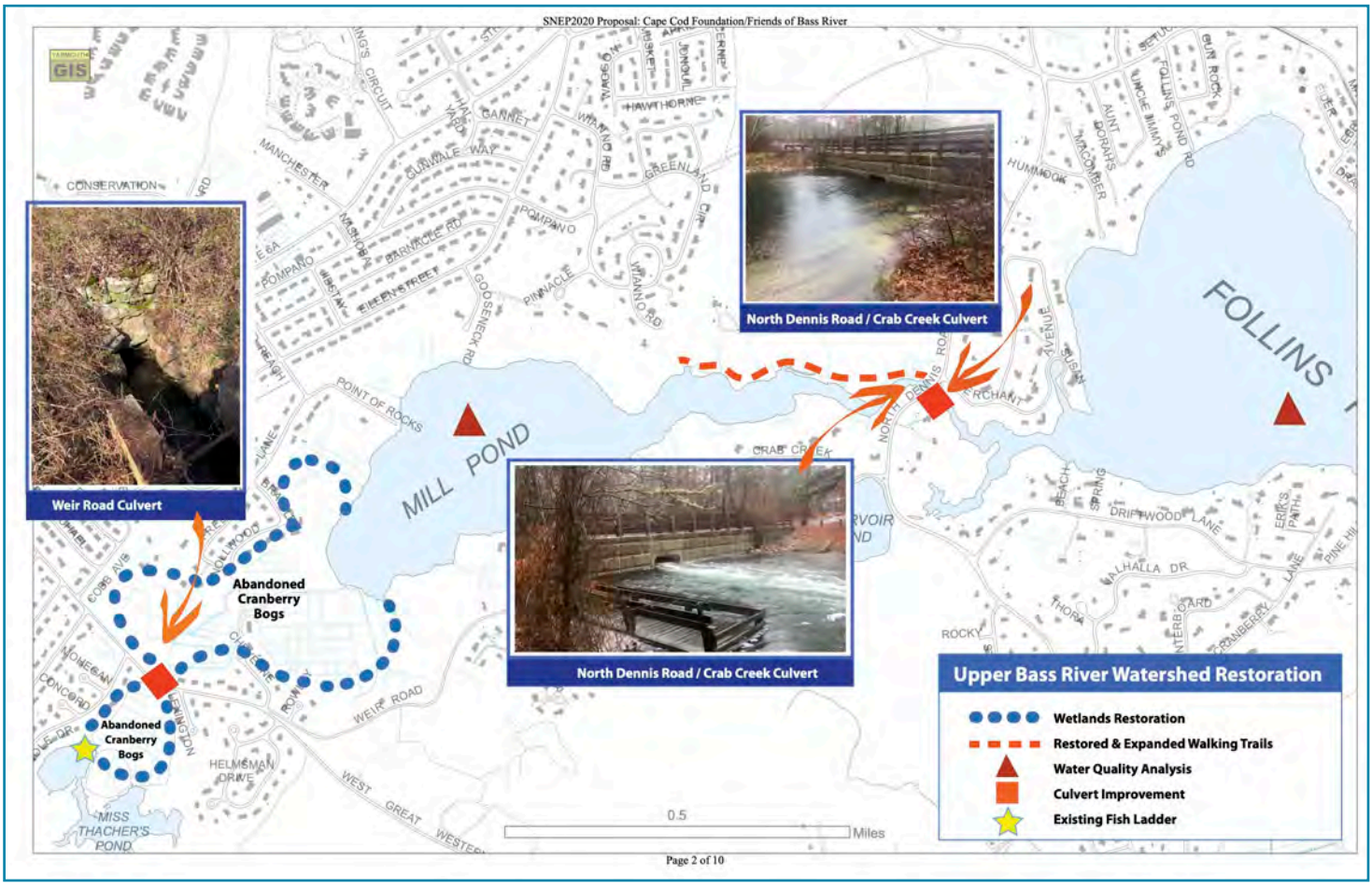
Our Upper Bass River Watershed Restoration Project was recognized among strong competition with this full request reward! We are beyond excited to hit the ground running. The project will address two recommendations of the Massachusetts Estuaries Project Report (DEP 2008): **improved tidal flushing** via culvert improvements and **attenuation** via wetlands restoration. We will be working with two consulting firms who will conduct data gathering and modeling, and develop engineered plans to redesign and replace the culverts at North Dennis Road (Crab Creek) and at Weir Road. In addition, a third firm will be doing surveys in the abandoned cranberry bogs that stretch from Miss Thatcher's pond eastward to Mill Pond and a plan will be mapped out for restoration.

We are grateful to our partners – **the Town of Yarmouth** for their cooperation and assistance in putting this proposal together and their support going forward. Thank you also to all of the other non-profits and members of environmental agencies Cape-wide who are our allies in environmental stewardship.

We are already off & running with our consulting partners: Tighe & Bond, The Woods Hole Group, and Interfluve. We had our first kick off meeting earlier this week & we expect to see initial surveys conducted around the Crab Creek area starting September 20th.

Take some time to enjoy the beautiful autumn by taking a tour around the area from Crab Creek and westward. There are some great Yarmouth Conservation trails to wander & enjoy the fall foliage, or take out your canoe or kayak in Mill Pond & discover this quietly important key to the river's health.

The map below shows the critical aspects of our proposal for the SNEP grant.



FOBR & THE CENTER FOR COASTAL STUDIES

In addition to being an active and amazing whale research & rescue organization, the Center for Coastal Studies has a comprehensive water quality management program and provide education, data integration & analytical services to many organizations across the Cape.FOBR is pleased to partner with the Center in volunteer training, data management and nutrient testing.

NUTRIENT TESTING IN THE LAB

In addition to on-site testing for Salinity, Turbidity, Temperature and Dissolved Oxygen our volunteer water testers are collecting samples for in-the-lab tests. Samples taken by our volunteers for nutrient testing are frozen immediately. We are very thankful for Center For Coastal Studies Researcher, Jennifer Burkhardt who lives in Dennis and transports our samples to Provincetown for analysis.

WHAT IS THE CENTER FOR COASTAL STUDIES TESTING FOR?

1. DISSOLVED NUTRIENTS

We know from the MEP report that most of the river (over 90%) is showing signs of "nitrogen-related habitat impairment" – especially in the area from Mill Pond to Grand Cover which are "significantly impaired". The MEP report set target nitrogen level values to ensure a healthy ecosystem and as we have said many times it is the mission of FOBR to work towards these prescribed goals. Nutrient testing is being conducted on the River to measure current levels and (hopefully) positive change as improvements are made as prescribed in the report.

2. DISSOLVED INORGANIC NUTRIENTS NITRATES, NITRITES, ORTHO-PHOSPHATES, SILICA & AMMONIA.

The earth's atmosphere is about 78% Nitrogen. Both nitrogen & phosphorus are essential to plant and animal growth. They are also a key ingredient in household & agricultural fertilizers. These nutrients, and another form of nitrogen - ammonia (NH3) are also found in septic systems as a by-product of the breakdown of urine & feces. These inorganic nutrients are very soluble & easily washed into estuaries, ponds & other bodies of water. Currently run-off from septic systems is the #1 source of nitrogen in Bass River.

One of our FOBR water testing kits.

3. DISSOLVED ORGANIC NUTRIENTS NITROGEN & PHOSPHORUS

Organic Nitrogen & Phosphorus is also present in the river - mainly in the form of living or dead organisms. The MEP report states that the Upper Ponds in particular have significantly high organic nutrient levels, while the lower reaches of the river, which experiences more flushing, are some of the healthiest in all of the Cape. We would expect the concentration of these nutrients (both organic & inorganic) to be highest on Bass River during the summer months when the water temperature is high, its hot out (increased evaporation), and there is generally more fertilizer entering our waterways from lawns & sprinkler run-offs. In addition we have more toilets flushing in July & August when our population swells from around 200,000 to over 500,000.

4. CHLOROPHYLL A

We all know what chlorophyll is - it's the stuff that makes plants green...but we know it's a little more complicated than that. Chlorophyll a specifically is used to capture light energy (in this case violet-blue and orange-red light) which is then used to convert water, oxygen and minerals into organic compounds (food). We know this as photosynthesis.

The amount of chlorophyll in the water indicates how much organic matter is in the river. The MEP report states that the River's Upper Ponds are dominated by algae blooms & high chlorophyll levels.

Imagine in the photo below that each of these rocks represents nutrient levels, chlorophyll, oxygen levels, salinity, temperature, etc. If the size of each rock were to grow or shrink, or move slightly the whole balance would be disrupted. The same is true for the health of the river.

Samples taken by our volunteers for nutrient testing are stored in the FOBR freezer awaiting delivery to The Center for Coastal Studies!

The health of the river requires a fine balance.

The Bass River from Follins Pond looking West

photo Scott Button

IT TAKES A COMMUNITY | THANK YOU LEMCO MARINE AND TOWN OF YARMOUTH

This August, Friends of Bass River identified and coordinated removal of four large derelict dock floats from the shore of Follins Pond. These floats have been suffocating a very important marsh grass habitat, and shedding pieces of non-biodegradable blue flotation foam for over seven years.

Thanks to help and cooperation from **Kelly Grant, Yarmouth Conservation Administrator, Roby Whitehouse, Public Works Waste Management Superintendent for the Town of Yarmouth, and Paul Butler & Lee Colton from LEMCO Marine**, we were able to successfully remove and dispose of these floats.

In total 1.77 tons of debris was removed from the River!

Thank you LEMCO!

The floats suffocating the grass habitat.

To the transfer station!

After removal, the marsh grass habitat will be revitalized.

PO Box 303
W. Dennis MA
02670

Through your financial support and volunteer involvement we can achieve our goal of a healthy Bass River. Please consider a donation to fund our water testing programs and educational initiatives.

THANK YOU!

www.friendsofbassriver.org

friends of BASS RIVER

Our River Restoration Project Begins

DEPLOYMENT OF THE AQUA-TROLL A200

This morning the Woods Hole Group arrived bright & early to the shores of Kelley's Bay. They are here to set up monitoring stations from Kelley's Bay westward into Mill Pond.

The Aqua-Troll A-200 is a remote data logger that measures and records water level and

pressure, conductivity and temperature. 5 such monitoring stations will be established to collect data on current conditions in the River.

WHG will be on site for the next few weeks making detailed surveys. This data will help the WHG with their summary of current conditions & to make recommendations for improvements to the Culvert at Crab Creek & Weir Road.

Zach is over 6 feet tall. Here he is working just west of the North Dennis Road overpass. The scouring from increased flow through the narrow culvert has created a over 6' deep!

HELP TURN THE RED DIAMONDS BLUE!
Only through your financial support and volunteer involvement can we achieve our goal of a healthier River.
Please consider a donation to fund our new river testing program.

https://capecodfoundation.fcsuite.com/erp/donate/create?funit_id=1254

Click on the map to Donate now!

Our mailing address is:
Friends of Bass River
P.O. Box 303
West Dennis, MA 02670

SNEP Project Area Tours Through 12/31/2020

All tours average between 1.5 and 2.0 hours in length/15-20 hours for all tours

1. Yarmouth Water Resources Advisory Council
2. Yarmouth Community Preservation Commission
3. Yarmouth Conservation Commission
4. Cape Cod Ducks Unlimited
5. Town of Yarmouth Select board members.
6. Yarmouth DPW director and staff
7. Massachusetts DER staff
8. Men’s alliance group
9. Bass River Rod and Gun Club
10. Dennis Yarmouth Regional HS instructors

Figure 1 Conservation Committee

Figure 2 Control Point Inter-Fluve

Figure 3 Culvert Survey Tighe & Bond

Figure 4 Debris in Bass River

Figure 5 GPS Survey Site

Figure 6 H&H Woods Hole Group

Figure 7 Soil Boring Tighe & Bond

Figure 8 Soil Testing

Figure 9 Water Testing

Figure 10 Water Resource Advisory Group

Figure 11 Water Testing Team Pic 1

Figure 12 Water Testing Team Pic 2

Figure 13 Woods Hole Group

FOBR Upper River Restoration Project Meeting 11 Dec 2020

Arden - Woods Hole Group

Completed model & working on simulations. Will be good for presentation to stakeholders.

5 simulations. Single culvert replacement up to 4 culvert replacement.

Comparison of 2002 water levels to today. Graphs are on FTP.

Graph in tidal datums axis is labeled in meters - should be feet. Will be corrected.

Herrin showed simulations showing current saltwater tidal influx into Mill Pond over a 4 days period & simulations based on various culvert scenarios.

Eric would like to arrange meeting with Arden's group

Three culverts max - then bridge (no 4-culvert model) - based on the modeling.

Jeff would like to remind everyone to think about utilities.

Eric - Tighe & Bond

Started modeling at North Dennis Road Culvert. Draft ready in one week.

Will arrange meeting with Arden's group.

Drafting geotek evaluation & preparing reports. One week to internal draft. 3 weeks to public.

CAD Files are being prepped.

Eric's group needs to meet with YDPW to discuss how the utilities cross at North Dennis Road.

Does YDPW need to make any changes to existing utilities while the project is ongoing.

Nick - Interfluve

Working on H&H - no data yet.

Artistic renderings will be ready by Christmas. Two plan-view sheets & two cross sections.

One big sheet (poster size) of whole site with additional cross sections as call-outs (bubbles)

Rick reviewed the prelim plan with Jeff & Conservation

Upstream of weir road its wet along the northern edge (where the trail was proposed) - area may need to be built up. Nick need to look at where the conservation edge is.

Proposed parking area across from Seminole proposed by Jeff Colby.