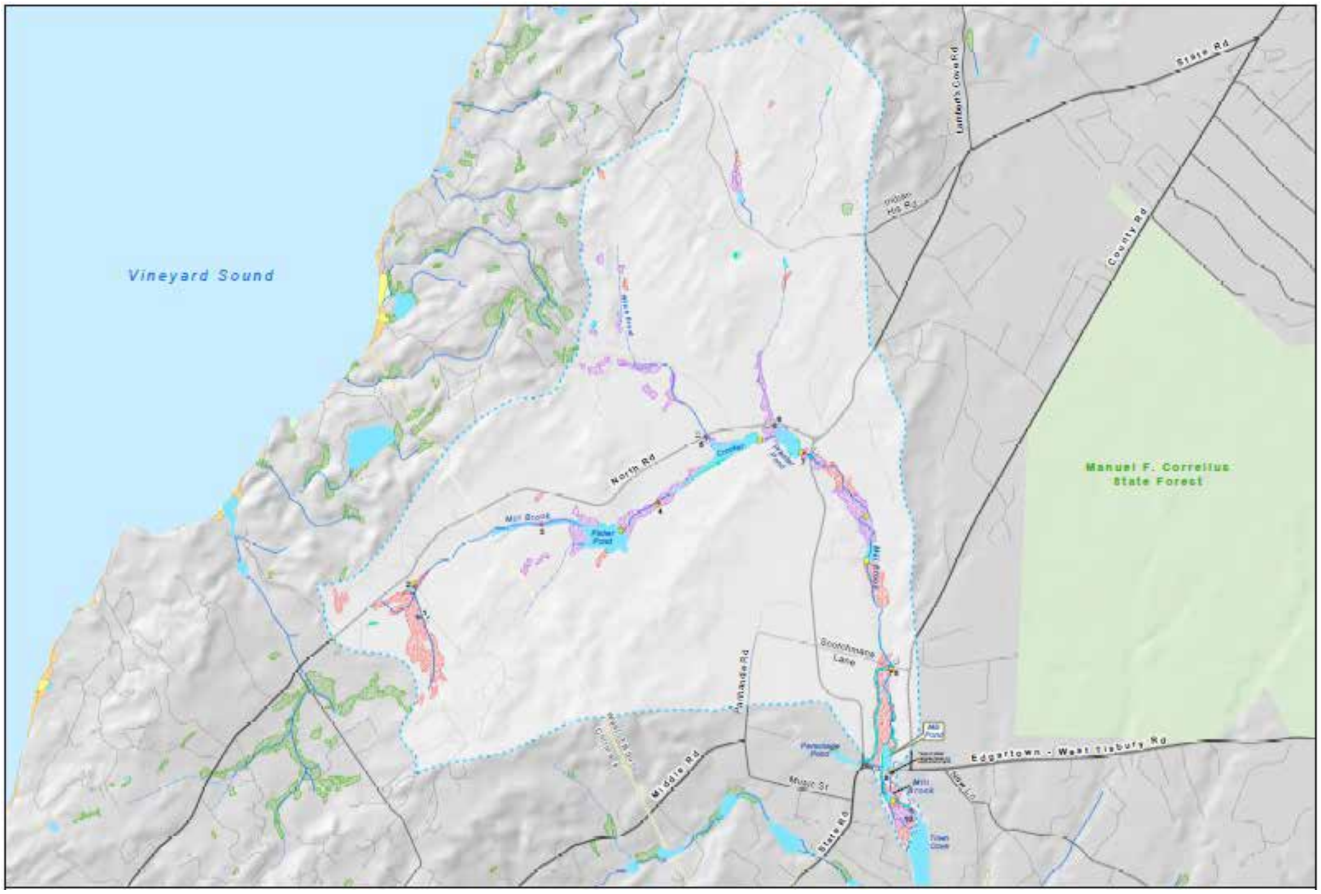
Mill Brook Watershed Study Report

and Recommendations



Town of West Tisbury

Mill Brook Watershed Management Planning Committee

2014-2018

Available at: http://www.westtisbury-ma.gov/Boards/mill-brook.html

Contents

1. **List of reference Documents Available on the Committee's Town Website Page**

http://www.westtisbury-ma.gov/Boards/mill-brook.html

Order in App	Year	Author	Abbreviated Document Name
1	2006	Aquatic Control Technology	Survey report Mill Pond baseline
2	1921	Belding, D. L.	A report upon the alewife fisheries of Massachusetts
3	2010	Chase, B. C.	Quality Assurance Program Plan for Water Quality Measurements Conducted for Diadromous Fish Monitoring
4	2012	Div. of Ecological Restoration, Dept. of Fish and Game	Aquatic Habitat Connectivity Survey, Mill Brook
5	2012	Division of Marine Fisheries; Chase, Brad	Memorandum on diadromous Fish Restoration in TGP
6	2013	Div. of Fisheries & Wildlife: Hurley, Steve	Sampling Report Mill Brook and Tributaries
7	2012	ESS Group	Final Engineering and Environmental Studies for the Mill Pond
8	2006	Healy, Kent	Mill Pond Dam Phase I Inspection
9	2009	Healy, Kent	Crocker Pond Dam Phase I Inspection
10	2009	Healy, Kent	Fisher Pond Dam Phase I Inspection
11	2010	Healy, Kent	Mill Brook (Flow and Elevation Map)
12	2013	Healy, Kent	Hydrology of Tisbury Great Pond
13	1988	Hilsenhoff, William L.	Field Assessment of Organic Pollution with a Family –Level Biotic Index
14	2006	Natural Heritage and Endangered Species Program	Priority Habitats-Rare Species and Estimated Habitats-Rare Wildlife

15	circa 2005	Nature Conservancy	ARC-GIS Vegetation Classification Maps
16	2011	Polly Hill Arboretum	Botanical Survey of Mill Pond and upstream ponds of Mill Brook Watershed
17	1972	Reback, K. E. and J. S. DiCarlo	Completion report on the anadromous fish project
18	2005	Reback et al	Survey of anadromous fish passage in coastal Massachusetts
19	2011	Stantec Consulting Services	Site reconnaissance, evaluation of probable cost for dam removal old Mill Pond dam
20	1990	Saunders Associates	Road runoff sampling Tisbury Great Pond tributaries
21	1989	Saunders Associates	Tisbury Great Pond watershed study
22	2013	Sea Run Brook Trout Coalition	Water temperature data, 2013 to date
23	2015	Sea Run Brook Trout Coalition	Mill Brook Water Temperature Study, 2013 & 2014
24	2012	Seidel, C. I. MV Commission	TGP Watershed Boundaries, Mass Estuaries Project
25	2014	Seidel, C. I. MV Commission	Mill Brook Watershed Map
26	2014	Seidel, C. I. MV Commission	Mill Brook Watershed Study Sampling Stations
27	2013	U Mass Dartmouth and Mass DEP	Mass Estuaries Project Critical Nitrogen loading for TGP and Black Pt. Pond
28	2008	Wilcox, William	Mill Brook Storm Water Runoff Assessment Draft
29	2010	Wilcox, William	Mill Brook Water Quality Assessment
30	1996	Wilcox, William	Tisbury Great Pond Watershed Study

Organizations Contributing to this Study:

BiodiversityWorks
wildlife research, monitoring & mentoring

The Nature Conservancy
Protecting nature. Preserving life.™

ESS group

MARTHA'S VINEYARD COMMISSION

SEA RUN BROOK TROUT COALITION

MARTHA'S VINEYARD LAND BANK COMMISSION ★ EST. 1986 ★

SHERIFF'S MEADOW FOUNDATION
A VINEYARD LAND TRUST

trustees

THE POLLY HILL ARBORETUM

Vineyard Conservation Society
Protecting Our Island Environment

Massachusetts Department of Fish and Game
Division of Ecological Restoration
Invested in Nature and Community

2. Background

The Board of Selectmen appointed the Mill Brook Watershed Management Planning Committee in June 2014 to execute town meeting voter directives dating back to 2010. The Committee's charge from the Selectmen was to design and field a comprehensive study of the Mill Brook Watershed, analyze the study's data plus relevant existing data and draft a report with recommendations for the Selectmen's consideration and eventual town meeting adoption. To accomplish this, the Committee met over 70 times since June 2014.

3. Mill Brook Watershed Study Purpose Statement

The Mill Brook Watershed Study will collect the necessary data to establish a baseline reading for determining the water quality and general health of the Mill Brook, the Mill Brook Watershed including all streams and ponds, the watershed ecosystem, and their impacts on the Tisbury Great Pond. The data will become the basis for drafting a Mill Brook Watershed, management plan. The study will help establish the criteria and standards for an on-going, Town-sponsored watershed monitoring and evaluation program that measures progress against established watershed management plan goals.

Intended study data measurements:

Specific data collection locations will be strategically established throughout the watershed to:

- Monitor a consistent set of nutrient and chemical content analyses for each water sample taken over the course of a year.
- Monitor water flow data – volume and velocity over the course of a year.
- Monitor the impacts of the ponds on the Mill Brook's water quality, flow, temperature and ecosystem—including bathymetric data.
- Monitor water source inputs into the brook.
- Monitor and identify diversions and withdrawals from the brook.
- Monitor and identify the summer in-season impacts, off-season impacts and post weather event impacts on the watershed.
- Monitor existing and potential sources and impacts that threaten the health of the watershed.
- Monitor rainfall measurement and nutrient/chemical content analysis.
- Conduct morphonetric and macroinvertebrate investigation of Mill Brook.

4. Watershed Study Approach

The Mill Brook stream system and land use in the watershed were both studied as a means to understand overall watershed health. Aquatic health in Mill Brook is a direct result of activities and land use/development throughout the larger Mill Brook Watershed. The Mill Brook Watershed is also within the Tisbury Great Pond Watershed. The same relationships exist for Tisbury Great Pond which are indicators of activity impacts throughout the larger Tisbury Great Pond Watershed.

The Committee issued a Request for Proposals (RFP) and invited firms that specialize in this type of data collection to submit proposals. One response came from the ESS Group, Inc. for $45,750 which exceeded our voter-approved $30,030 budget. The Committee reached out to all available on-island and off-island agencies and resources seeking supplemental, hands-on assistance or additional financial support to execute the highly technical phases of the study. The budget was increased through a $5,000 grant contribution from the

Martha's Vineyard Commission and an additional town meeting appropriation in April 2015 of $6,600 which brought the final available budget to $41,630.

After several weeks of negotiations,the study was divided into sections with the ESS Group being awarded $33,235 for overall responsibilities of data collection, quality control and lab analysis. BiodiversityWorks, an island wildlife research organization, was awarded the morphometric investigation and macroinvertebrate sampling portion of the study for $6,600. A third consultant, aquatic biologist Greg Whitmore, was hired for $1,475 to identify the macroinvertebrates collected by BiodiversityWorks and to interpret what these findings mean for the health of Mill Brook.

The Committee could not have completed its work without the generous assistance from the Polly Hill Arboretum, Kent Healy, Bill Wilcox, the Martha's Vineyard Commission, the West Tisbury Conservation Commission, the Sea Run Brook Trout Coalition and the Massachusetts Division of Ecological Restoration. Special thanks also goes to the 27 West Tisbury residents and student interns for contributing over 350 hours of volunteer service under the direct supervision of biologist Richard Johnson for BiodiversityWorks. They are: John Auerbacher, Howard Attebery, Cynthia Riggs-Attebery, Sharon Britton, Margaret Curtin, Wendy Culbert, Alysa Emden, Douglas Green, Cristina LaRue, Jess Lerner, Laura Murphy, Ken Neagle, Ann Nelson, Greg Palermo, John Patrick, Sharon Pearson, Ellen Rogers, Bill Roman, Selena Roman, Wendy Shields, Val Watson and Nancy Weaver, Katie Carlson and Hanna Snyder-Samuelson (interns, The Nature Conservancy), Emily Goetz and Daniel Kaeka (interns, BiodiversityWorks).

Fig. 1 Volunteers identifying specimens – BiodiversityWorks Report

5. The Island's Water Supply

All of our water comes from precipitation. Forty to sixty percent evaporates or transpires through vegetation and the remaining percentage infiltrates through the soil to our ground water.

The hydrology of precipitation in the Mill Brook Watershed: The Mill Brook Watershed is the area that contributes runoff and groundwater to the brook as a result of the soils and topography. It originates in the hills of the western moraine which directs precipitation to the stream and eventual outlet. The brook flows out of the western moraine and into the outwash plain as it turns southward to flow into Tisbury Great Pond.

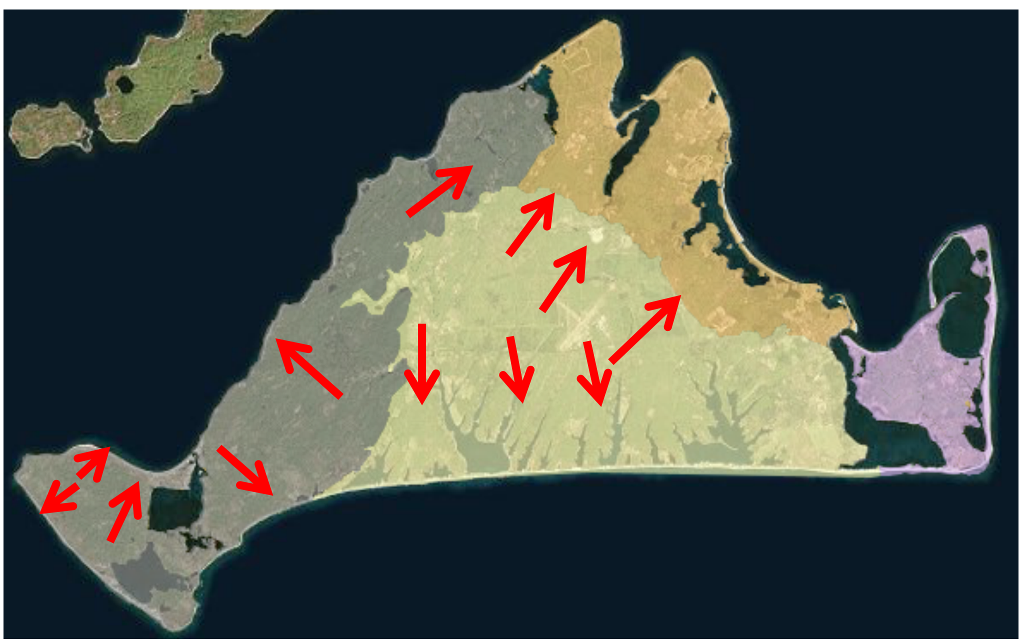


Fig. 2 Water flow direction of the Island's 4 watersheds.
Map Source: Clifford Kaye & Robert O'Dale, USGS

Tisbury Great Pond Watershed: The 10,000-acre Tisbury Great Pond Watershed (TGPW) is one of the largest watersheds on the Vineyard.

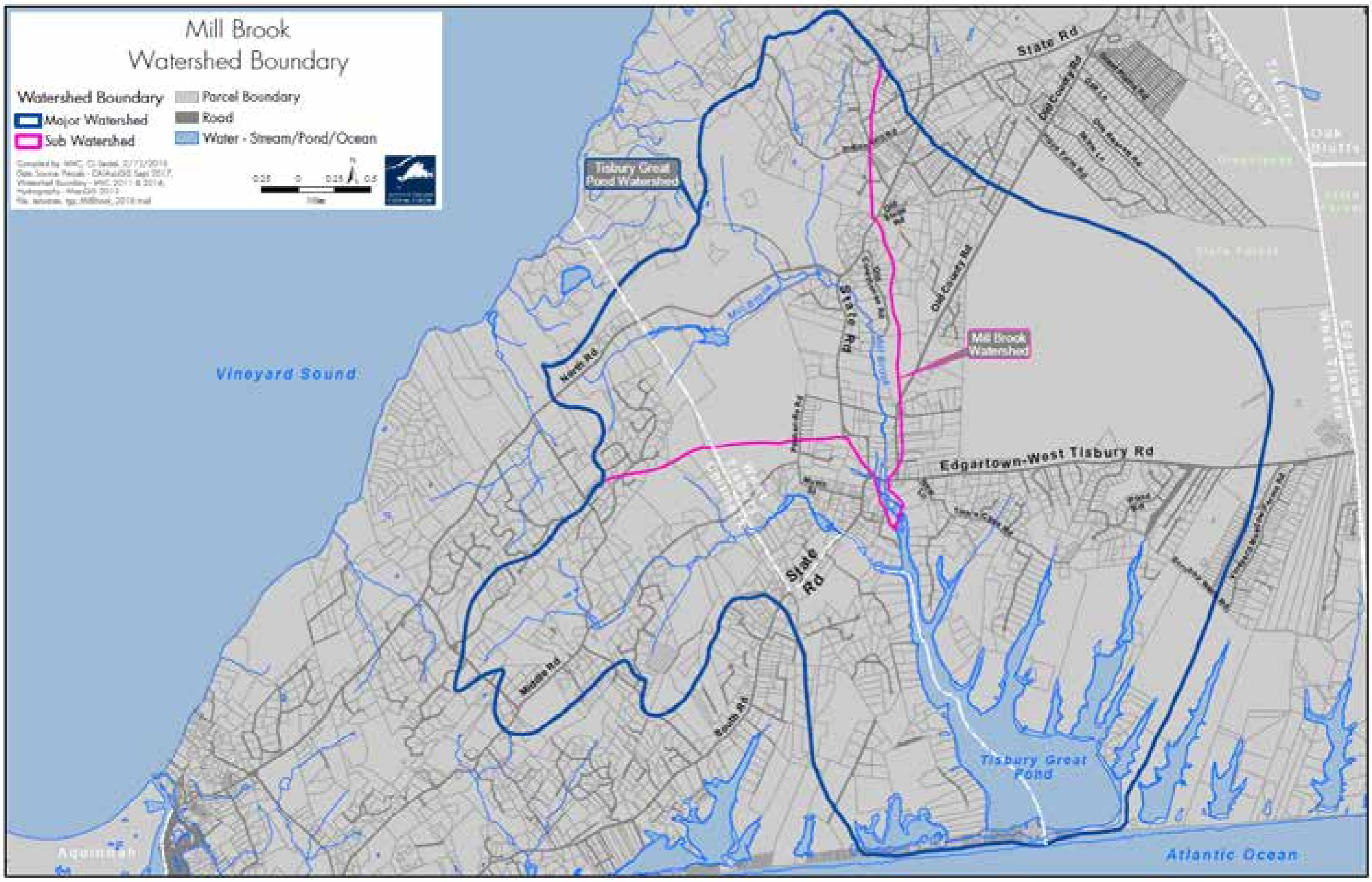


Fig. 3 Tisbury Great Pond Watershed outlined in blue, Mill Brook Watershed outlined in pink
Map by MVC-Chris Seidel

Mill Brook Watershed Characteristics

- A total of 2,928-acres;
- 2,460-acres are in West Tisbury:
    - 1,556-acres are permanently conserved.
    - 904-acres are developed or open land available for development of which:
        - 395-acres are developed residential.
        - 199-acres are available for development.
        - 262-acres are potentially available for development.
        - 48-acres are wetlands not on permanently conserved land.

Within this acreage:

- 27-acres are 7 man-made impoundments: Roth Woodlands Pond (.4 acre), Fisher's Pond (10.4 acres), Crocker Pond (7.8 acres), Priester's Pond (4 acres), Berresford's Pond (.10), Albert's Pond (1.8 acres), and Mill Pond (2 acres). Source MVC.

Fig. 4 View from Waskosim's Rock Reservation north over upper Mill Brook valley red leaf color of maple and beetlebung indicate location of the brook

- The brook is approximately 4 miles long.
- The "headwaters" originate just west of the Roth Woodland Sanctuary off Old Farm Road in Chilmark.
- The un-named tributary above Priester Pond, locally known as Indian Hill Brook, and Witch Brook are two tributaries that join Mill Brook on North Road along its course to Town Cove and into the Tisbury Great Pond.
- Width: Varies from 3 to 6 feet wide near the headwater to 30 to 40 feet wide at the outlet to Town Cove of Tisbury Great Pond. Along its length, average width ranges from ten to 20 feet.
- Depths: Varies from 8 inches deep near the headwater to 3 to 4 feet deep at the outlet to Town Cove, depending on whether TGP is open to the ocean. Along its length, depths vary from 1 to 2 feet.
- Culverts channel the brook under roadways. Culverts are located:

  - Under Old Farm Road in Chilmark,
  - Under North Road at Witch Brook,
  - Under North Road at Indian Hill Brook,

- Under State Road in North Tisbury,
- Under Scotchman's Bridge Lane,
- Under Edgartown Road at southwest corner of Mill Pond to Factory Brook.
- Under Edgartown Road at southeast corner of Mill Pond to Mill Brook.
- Some are perched above the stream bed at the culvert outlets effectively creating a dam depending on the water level. These are a barrier to fish and wildlife passage, as well as preventing any flow of water downstream during low flow periods.

- Dams impound the brook or divert it for other purposes.

  - See previous page for list of impoundments created by dams.
  - In addition, there are water withdrawals and diversions of the Mill Brook stream flow. These are discussed on pages 20 - 23 of this report.

6. <u>Why study the Mill Brook Watershed?</u>

Mill Brook flows into Tisbury Great Pond at Town Cove. The historic, recreational, economic (fisheries -- both shellfish and finfish) and ecological values of Tisbury Great Pond are directly influenced by the contribution of the Mill Brook Watershed to the larger Tisbury Great Pond Watershed - both in terms of fresh water and nutrient input. Understanding the health and conditions of the Mill Brook Watershed is paramount to the preservation and health of Tisbury Great Pond. This understanding will help us to better manage the brook and the course of land use change in the watershed.

Within the Mill Brook Watershed, the Mill Brook and two small tributaries (Witch Brook that flows into Mill Brook above Crocker Pond and Indian Hill Brook that flows into Mill Brook above Priester Pond) form the Mill Brook system. This stream system is designated as a Coldwater Fish Resource (CFR) by the Massachusetts Division of Fisheries & Wildlife. For example, CFRs provide habitat for species such as Eastern Brook Trout and American Brook Lamprey to fulfill one or more of their life stage requirements.

Fig. 5 Eastern Brook Trout, upper Mill Brook, MA Div. of Fisheries & Wildlife Fish Survey 2012

The Mill Brook Watershed has many recreational, ecological, agricultural, and educational values for West Tisbury residents. Protected open space in the watershed is owned or managed by Sheriff's Meadow Foundation, Martha's Vineyard Land Bank, The Nature Conservancy, Vineyard Conservation Society, The Trustees, Martha's Vineyard Agricultural Society and Polly Hill Arboretum. Also acknowledged are the West Tisbury residents who worked diligently for many years to conserve land within the watershed through the sale or donation of land and/or conservation restrictions now managed and owned by these organizations.

There are many public trail easements for walking, biking, horseback riding and permitted uses for hunting and fishing. There are various agricultural uses that occur within the watershed ranging from animal pasture to crops. Polly Hill Arboretum and the Martha's Vineyard Agricultural Society offer extensive educational opportunities on forestry, plant ecology, land use, agricultural and historical perspectives. Continued advocacy, education and vigilance are critical to the future preservation and protection of this resource.

Studying the Mill Brook stream system and its watershed provides a factual assessment of the impacts of various activities within the watershed.

Fig. 6 Hayfield – East side of North Road in the Mill Brook valley

Fig. 7 Hickie Field, State Road, West Tisbury – harvested sweet corn field with Mill Brook at far end of field. This field is irrigated with a pump via surface water flow from Mill Brook

Fig. 8 Livestock field adjacent to Indian Hill Brook, a tributary of Mill Brook on North Road

7. Determining Data for Collection and Analysis

There are several specific attributes that are good indicators of stream health. They include water quality, water temperature, plant life and the macroinvertebrate species composition. Thus, these are the data sets we collected within the Mill Brook Watershed.

The results of the year-long study should be viewed as a baseline. ***Further data needs to be collected for comparison before any trends can be identified.*** The following data was collected for this study:

<u>Data Logger Measurements</u>

1) Continuous base water flow – water flow in cubic feet per second (ft3/sec). The volume of water as measured in cubic feet flowing down the brook.
2) Continuous water temperature:
   a) Collected at the six locations by ESS Group
   b) Collected at six additional locations by Sea Run Brook Trout Coalition

Data logger for continuous measurement of water temperature and water level

A data logger is an instrument that is submerged at specific sites within the stream to continuously record data. Data was collected at each of six different sample sites every 15 minutes between March 2015 and August 2016.

<u>Field Measurements</u>

1) Water quality:
   a) pH
   b) total alkalinity
   c) nitrate-nitrite
   d) total nitrogen
   e) ammonium
   f) orthophosphate
   g) total phosphorous
   h) base flow total solids including total suspended solids

2) In-field measurements of specific electrical conductivity and dissolved oxygen.

3) Storm water flow and quality – of one storm event during May – August.
   a) Collected from four sample sites to document potential road runoff.
   b) First flush sample taken.
   c) A second sample taken after a suitable time period (approximately 30 minutes depending upon storm intensity and duration) following the first flush sample.

d) All samples analyzed as outlined for water quality.

4) Rainfall sampling (measured at Polly Hill Arboretum):
   a) Rainfall (inches) at PHA and samples of rain from events of more than ½" were tested for pH and NO3 (Nitrate).

5) Sediment sampling:
   a) One sediment sample was collected at 6 sites.

6) Morphometric and macroinvertebrate survey at 11 sites by BiodiversityWorks. The macroinvertebrate species were identified by Greg Whitmore:
   a) Collected macroinvertebrate species in Mill Brook and developed a Diversity Measure based upon the number and abundance of different aquatic organisms and their respective levels of pollutant tolerance.
   b) Created a Water Quality Index based upon temperatures, extreme pH and low dissolved oxygen.
   c) Evaluated vegetation and conditions of the riparian areas along the stream banks.

7) Review previous reports and studies performed on the Mill Brook system and Tisbury Great Pond—see appendix.

8. <u>Watershed Study Methodology</u>

The following outlines the methodology used for conducting the ESS component of the watershed study.

- Six stream water quality, temperature and base flow sampling stations:
  - Site #1 - Waskosim's Rock Reservation.
  - Site #2 - Outlet from Crocker Pond.
  - Site #3 - Outlet of Indian Hill Brook south of North Road.
  - Site #4 - State Road bridge crossing in North Tisbury.
  - Site #5 - Scotchman's Bridge Lane, below Whiting diversion dam.
  - Site #6 - Mill Pond outlet.
  - A blind duplicate sample was collected by the consultant to assess the accuracy of the lab analyses.

- Six rounds of water quality sampling and lab analysis
- March 25, 2015
- May 7, 2015
- July 30, 2015
- August 19, 2015
- October 26, 2015
- February 2, 2016

- Supplemental sampling August 26, 2016
- One storm water event sample – September 10, 2015
- Ten rainfall measurements at Polly Hill Arboretum between March 27 – December 2, 2015

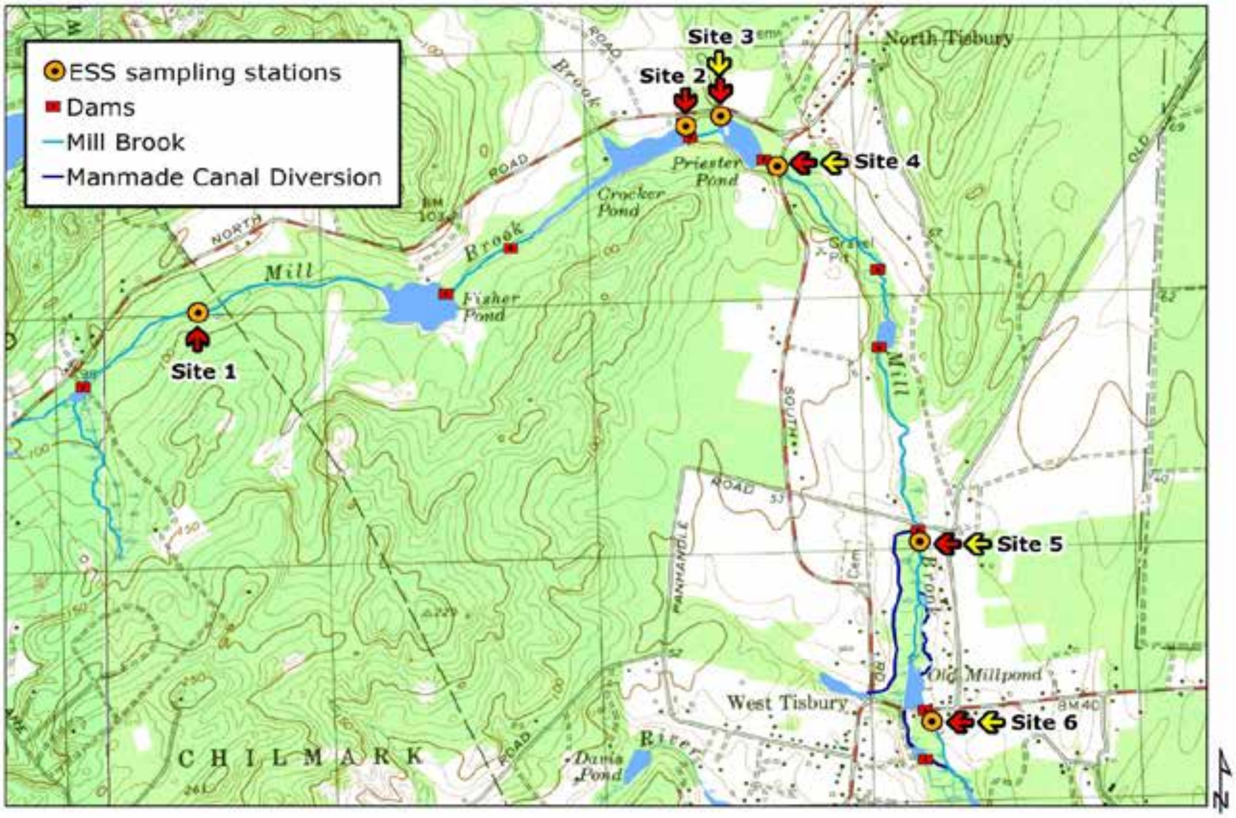


Fig. 9 Red arrows mark the six ESS Group base flow water quality sampling sites and continuous data logger locations, yellow arrows mark the four stormflow water quality sampling sites

<u>ESS six data logger site descriptions:</u>

<u>Site 1</u> is located just 10' east of the first stone bridge at Waskosim's Rock Reservation. This site is about 2/3 mile downstream from the headwater of Mill Brook. The water depth is about 6" and the stream is heavily shaded by deciduous tree/shrub canopy. This location is isolated from the uppermost headwaters of Mill Brook by a pair of culverts under a dirt road about 1700 feet above this location that block or severely limit water flow from the upper reaches to this site. The flow that resumes below these culverts is a result of groundwater and precipitation.

Site 2 is located about 150' east/downstream of the Crocker Pond outlet. The stream channel here is part of the former mill race for the Crocker Pond mill and is bordered on both sides by stone retaining walls, creating a defined channel about 10" deep.

Site 3 is located about 35' south of the Indian Hill Brook culvert outlet on the south side of North Road. The stream here is heavily shaded by deciduous tree/shrub canopy.

Site 4 is located about 25’ west of the State Road bridge crossing at North Tisbury. Both banks of the Mill Brook at this site are stone retaining walls, creating a defined channel about 16" deep. This site is marginally shaded by deciduous shrub canopy.

Site 5 is located about 15' south/downstream of the Whiting diversion dam which in turn is located about 120' south of Scotchman's Bridge Lane. The stream here is about 8" deep and very shaded by deciduous tree/shrub canopy.

Site 6 is located about 40' south/downstream of the Mill Pond outlet. The stream here is about 8" deep and shaded by deciduous shrub canopy.

The intent of the placement of these loggers was to continuously measure water temperature and water levels.

9. Watershed Study Results – ESS Group

a. Water Quality Test Results Summary:

In the aquatic environment, the growth of microscopic and larger photosynthetic plants (collectively referred to herein as algae) requires comparatively large amounts of the elements carbon, hydrogen, oxygen, nitrogen, phosphorus and, depending on species, silicon. These elements are required in somewhat fixed ratios and when one is deficient, growth of algae can only proceed so far before it locks up the least available of the major nutrients and new growth slows or halts. This element is known as the limiting nutrient.

In fresh waters, the growth of microscopic and macroscopic algae is typically limited by the availability of phosphorus. As the limiting nutrient, when phosphorus is added to a pond or stream, the amount of algae can increase. The growth is acceptable up to a point as algae are the base of the food chain for many animals, both microscopic and larger. Negatively, excessive algae in the water column increases the turbidity of the water and reduces light penetration impacting rooted plants growing in deeper water. The increased plant material (biomass) in the water column reduces dissolved oxygen, particularly where there is a strong and stable temperature gradient (that is, colder water that is heavier at the bottom and warmer near the surface). This stable gradient minimizes mixing and the bottom water becomes isolated from the air and the oxygen that it contains. As decay proceeds, oxygen in the bottom water layer is consumed. The subsequent lack of oxygen reverses the chemistry that normally locks phosphorous into the sediment. This results in the release of phosphorous from the bottom mud into the water, leading to even more biomass production.

Key Finding: ***One of the important implications of studying the Mill Brook stream system and its watershed is that throughout its length the stream tests high for both dissolved inorganic phosphorus and for total phosphorus that includes the inorganic form as well as organic complexes that include phosphorus (P).***

This finding is supported by previous studies. In water samples collected during 2008 (Wilcox, 2009), total phosphorus was found to be around 0.06 to 0.08 parts per million which is similar to values found in this study and are well above guidance levels. Data collected in 2001 showed similar elevated levels of Total P, ranging from 0.05 to 0.06 mg/l (parts per million) during a single sample collection in October (Wilcox, personal communication). Samples collected from below Mill Pond in 1994 (Wilcox, 1996) also tested high for inorganic phosphorus (averaging 0.12 milligrams per liter). Each of these data sets was analyzed at a different lab that strongly supports the current results.

In the charts that follow, the values for the 6 sample sites are shown for each of the six sample rounds. ***The acceptable level is shown as a solid horizontal line.*** It is clear that the concentrations found exceed the acceptable guidance for phosphorus and are below the limit for nitrogen, with the exception of Site 3.

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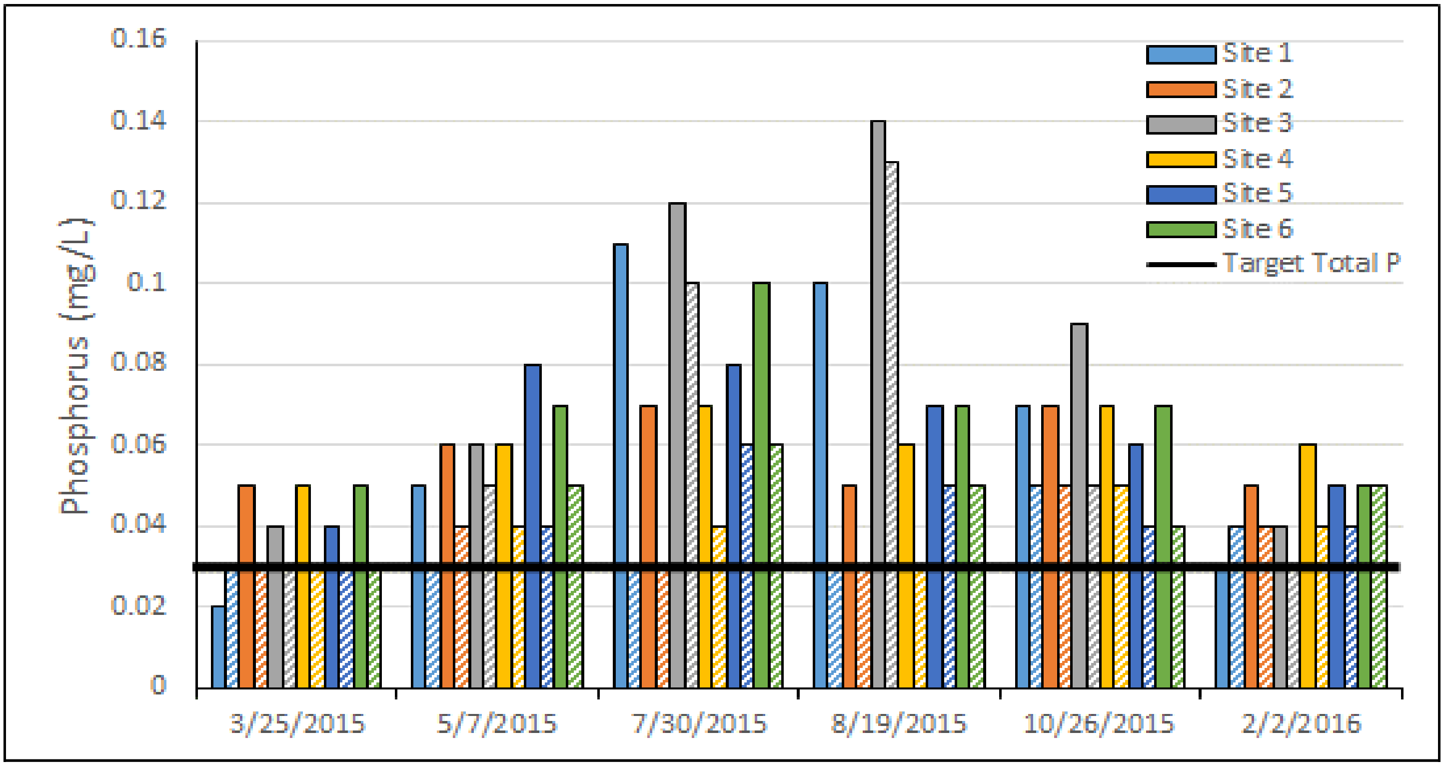
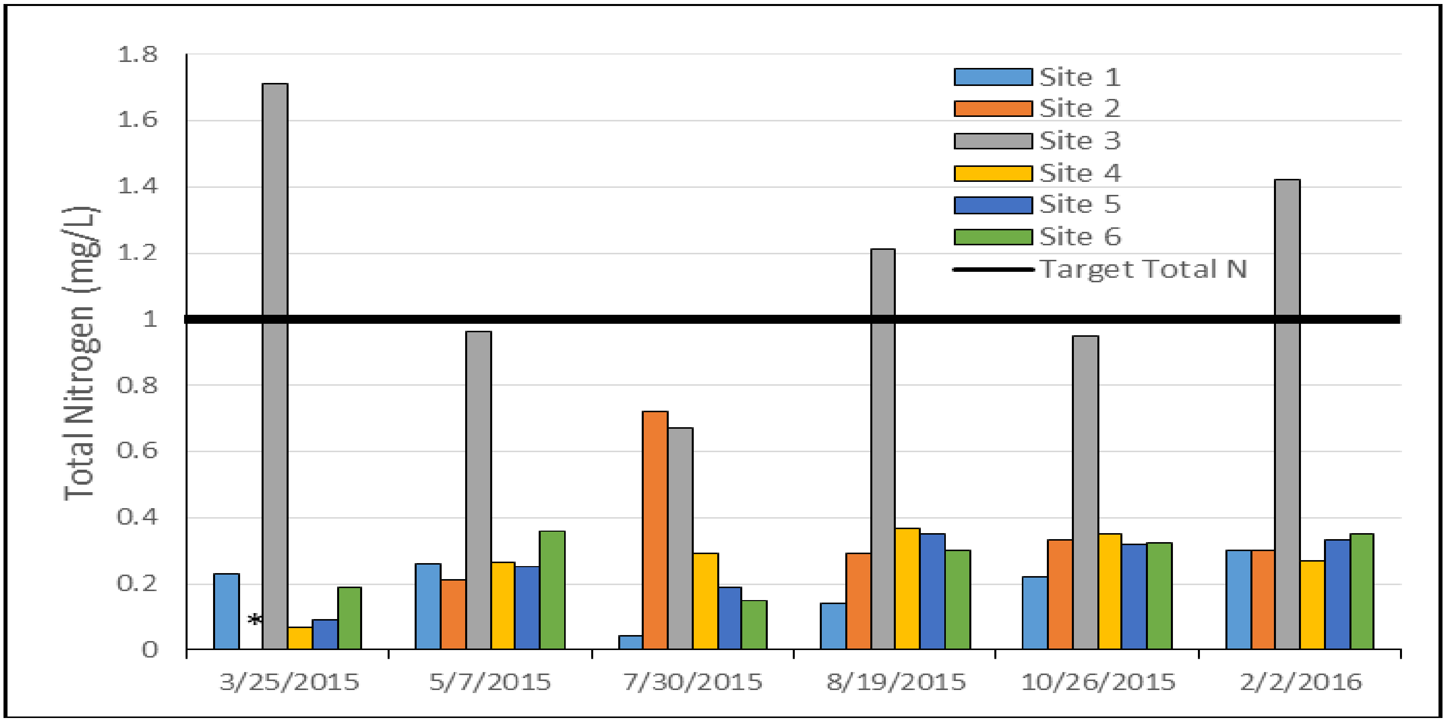
ESS Group



<u>Baseflow Phosphorous Concentrations.</u>

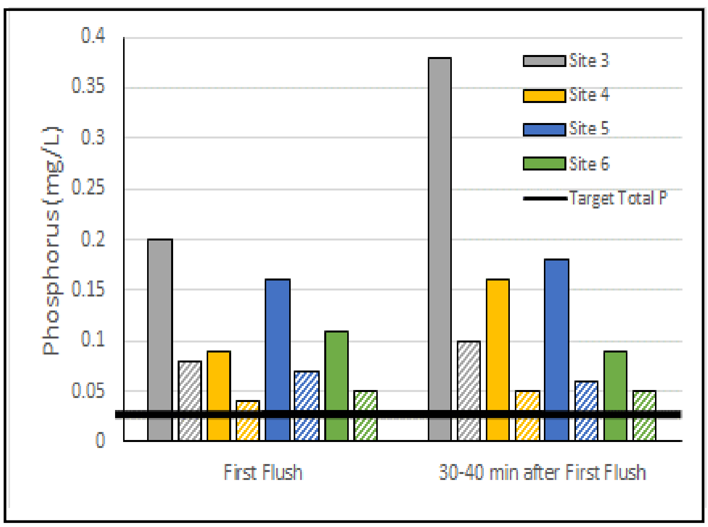
<u>Solid bars indicate total phosphorous. Hatched bars indicate dissolved phosphorous</u>

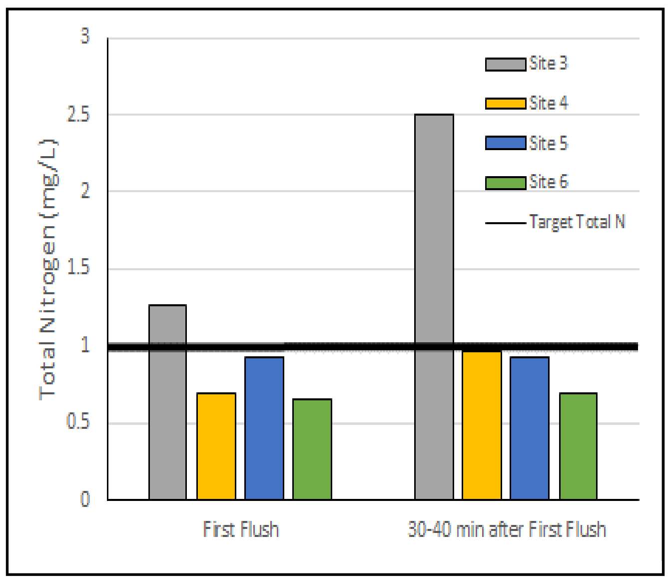
Samples from all stations are close to or significantly exceed the guidance level for total phosphorous from near the headwaters of the stream (site 1) to below Mill Pond (site 6) throughout the sampling period.



Baseflow Nitrogen Concentrations

** The sum of nitrate, nitrite and total Kjeldahl nitrogen (which combined represent Total Nitrogen) were found to be at levels below the laboratory detection limit.*





Stormflow Phosphorus and Nitrogen Concentrations

Solid bars indicate *total phosphorus*. Hatched bars indicate *dissolved phosphorous.*

Fig. 10 ESS Report Results: Baseflow and stormflow water quality results

Storm runoff is a clear source of both phosphorus and nitrogen. The overall impact of these runoff contaminants can only be determined by gathering more information on the area that contributes the runoff so that the volume of flow can be estimated. Figure 10 provides a comparison of stormflow nutrient load compared to base flow nutrient load.

Key Finding: ***The implication of the high concentration of phosphorus is that, as more nitrogen is added to the stream, there is a likelihood that there will be increased plant growth that could reach undesirable levels, impacting habitat quality.***

Site 3 Summary

This site is Indian Hill Brook, which flows into Priester Pond via a culvert under North Road. Over the last ten years this site has consistently tested high for phosphorus, nitrogen and total suspended solids (material carried by the stream that may include silt, algae and plant fragments that can be caught on a filter). Figure 10 shows that test results for this location are again at the highest for phosphorus and nitrogen under base flow conditions and clearly are well above the other stations during a storm event. In previous studies, the cause was suspected to be agricultural activity in the immediate vicinity of this small stream that flows into Priester Pond. At the time of this report, the West Tisbury Conservation Commission has worked with the property owner and the farmer lessee to restrict cattle access to the brook. There are additional farming activities in this sub-watershed that are further removed from the stream and therefore better buffered by intervening natural vegetation but may still have some effect on the water quality at this location.

Fig. 11 Livestock with access to the vegetated wetland adjacent to Indian Hill Brook

Fig. 12 Condition of the brook prior to restricting livestock access

Fig. 13 Condition of the brook today after restricting livestock access

Key Finding: ***Future monitoring should reflect improved conditions at this site or indicate a need for additional action.***

- **<u>Sediment Sampling</u>**

One sediment sample was collected from each of the six sites to test for pesticide residue.

Key Finding: ***No pesticide residue was detected at any of the six sites.***

- **<u>Specific Conductivity</u>**

Specific conductivity is a measure of the ability of water to pass an electrical current in micro-Siemens per centimeter (uS/cm). The levels measured are increased by the presence of dissolved inorganic nutrients such as nitrate and phosphate and metals such as sodium, calcium, iron, aluminum and magnesium. Sources of increased conductivity include the geology of the surrounding watershed, the input of groundwater containing nutrients from septic systems, agricultural runoff or stormwater runoff containing road salt. Low stream flow periods may lead to higher uS/cm. Conductivity may be lowered by the presence of hydrocarbons or other organic compounds in the water or a substantial input of rainwater.

An exact guidance level is not available. Most of the dissolved components that contribute to conductivity do have guidance levels and are the factors that better indicate water quality. Conductivity values above 300 micro-Siemens have been found to lead to the complete loss of some fish species in rivers or failure of fish hatchery spawning. A reasonable reference level for fresh streams would be 150 micro-Siemens to be protective of all aquatic species. The values found in Mill Brook are well below this threshold level, generally ranging from 80 to 120 micro-Siemens per centimeter.

b. **Water Flow Measurements Summary**:

ESS Group collected continuous water level measurements through the use of data loggers. Three discharge readings were performed as contracted by Request for Proposal.

Past studies demonstrate that there is a wide variability in flow from year to year. We have a lengthy record of water flow, recorded by Kent Healy which does not include the effects of water withdrawals and diversions. This shows a range in total annual flow from 69 million cubic feet/year in 2002 to 297 million cf/year in 2010 (1cf = 7.48 gal) (Healy 2013). ***The average annual flow over a period of 17 years was 188.2 million cubic feet (roughly 1.4 billion gallons per year).*** The total annual stream flow measured during this study was about 100 million cubic feet placing it toward the low end of the range. This data was collected over a period of light precipitation. The low flow may be the result of low water table levels as groundwater is a major input to stream flow.

Volume data:

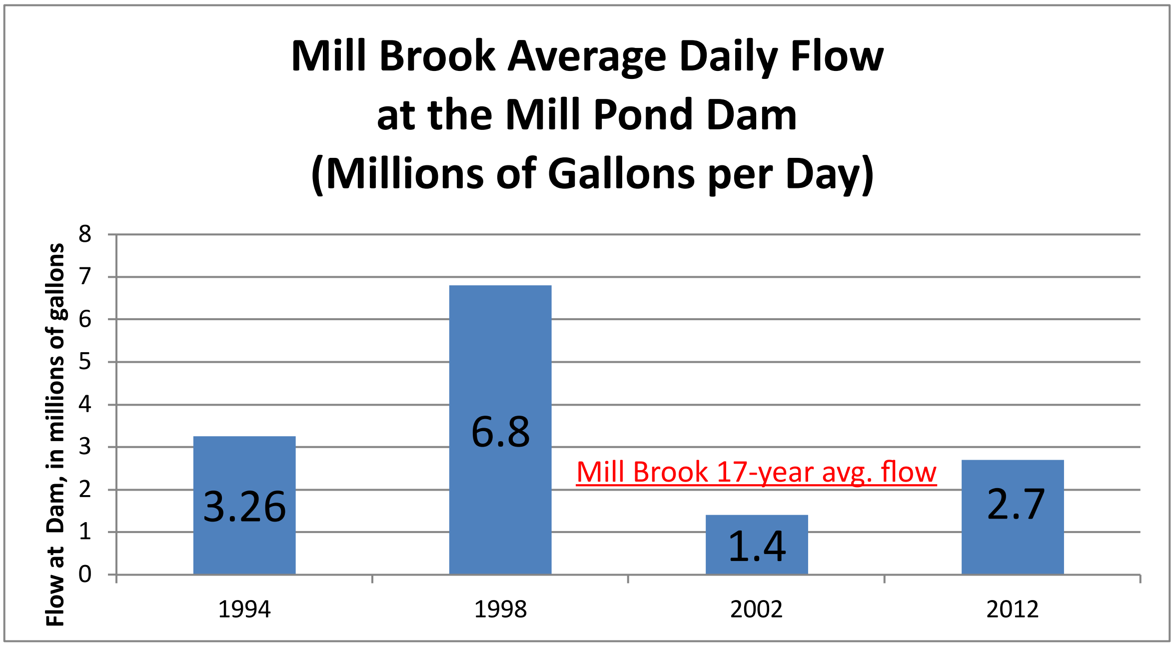


Fig. 14 Source: Kent Healy

The volume of water flowing in the brook along its length informs us as to whether it is receiving groundwater input or losing water to the groundwater by seepage through the stream bed.

Volume data also allows us to estimate the quantity of nitrogen and phosphorus the stream is carrying to Town Cove in Tisbury Great Pond. It is clear from the average daily flow data collected by Kent Healy at the Mill Pond discharge that the flow varies widely from year to year. For this study, data was collected at five stations from near the headwater at Roth Woodlands to the Mill Pond outlet.

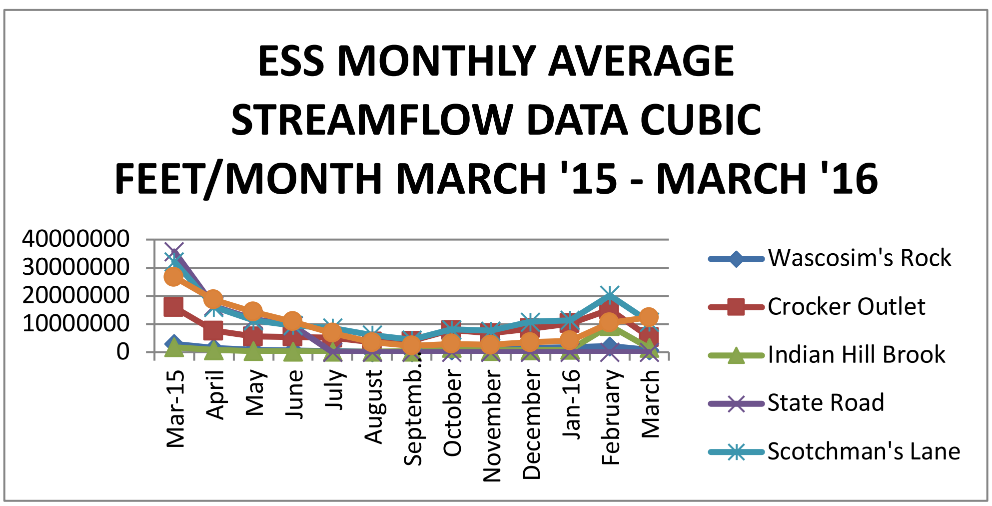


Fig. 15 ESS Monthly Avg. Streamflow March 2015 – March 2016

Key Finding: ***This study resulted in a limited amount of data. Improved calibration will be achieved through future additional discharge readings.***

Withdrawals and Diversions

The following describe known diversions and water withdrawals from the main flow of Mill Brook. See Fig. 16. Numbered site descriptions follow:

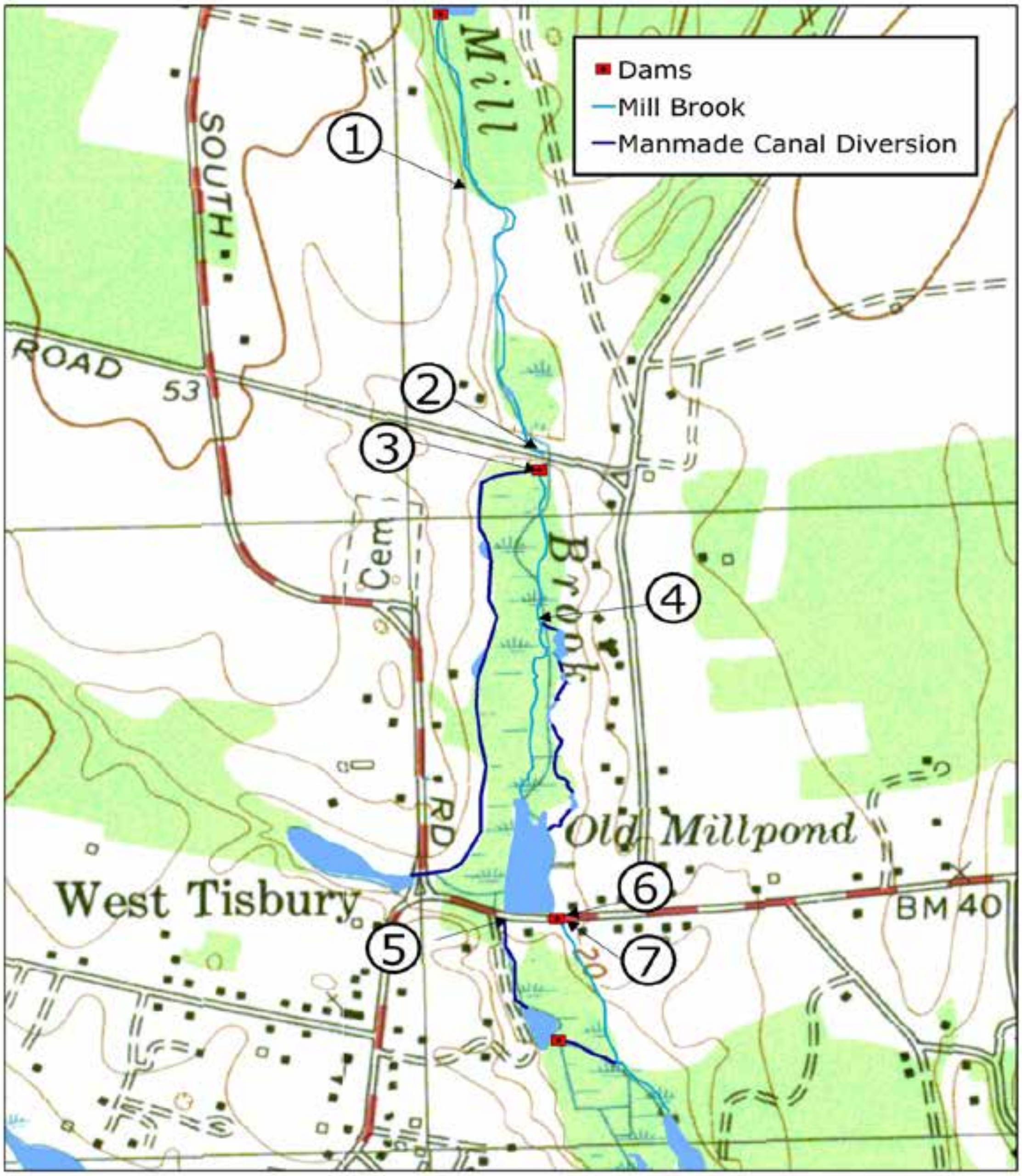


Fig. 16: Known surface water withdrawals and diversions from Mill Brook

1

Agriculture surface water withdrawals

The farmer/lessee at the Greene-Hickie fields north of Scotchman's Bridge Lane withdraws surface water to irrigate crops. This generally happens in late summer, the time of year when Mill Brook is at its lowest flow.

2

Scotchman's Bridge Lane, surface water withdrawals

This is where water is withdrawn at the Scotchman's Bridge Lane road crossing by landscapers (to fill hydroseeding + spray tanks); pool companies (to fill private pools); well drillers; and by town fire fighting apparatus.

3

Whiting diversion dam

Whiting diversion dam ~100' south of Scotchman's Bridge Lane directs as much as 20% of the flow away from the main channel of Mill Brook.

4

Diversions to east side of Mill Brook

Diversions like this one north of Mill Pond also direct flow from the main channel of Mill Brook.

5

Factory Brook diversion

At the southwest corner of Mill Pond, Factory Brook diverts water from Mill Brook via a culvert under Edgartown Road to Maley's Pond – a town designated fire pond.

6

Blocked fish Ladder

In order to maintain flow to Maley's Pond during low flow periods, Kent Healy (caretaker of Mill Pond Dam) has blocked flow through the fish ladder at the main spillway.

7

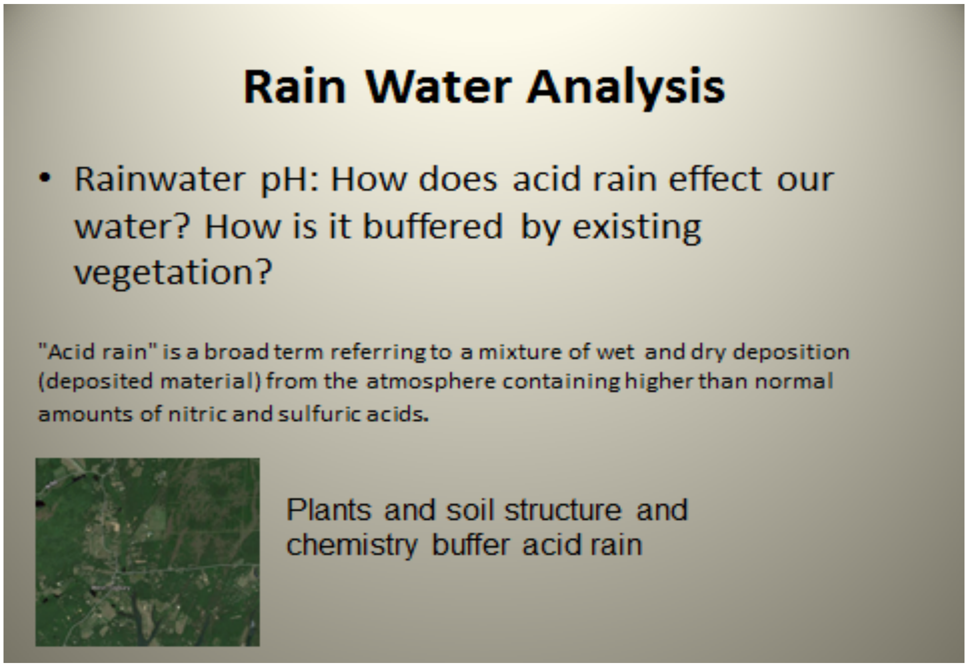
No flow over west weir boards at Mill Pond

Dry weir boards during low flow period in late summer at main spillway, Mill Pond.

Lastly, some water can be lost throughout the year to evaporation, evapotranspiration (water is transferred from the land to the atmosphere by evaporation, from the soil and other surfaces and by transpiration from plants), or loss to groundwater, and does not make it back into the main flow for Mill Brook.

Key Finding: ***As a result of these withdrawals and diversions along the Mill Brook, there is often insufficient water flow in late summer. This interrupts the flow over the west weir boards of the main spillway at Mill Pond, further disrupting flow to the downstream channel of Mill Brook. Due to variability in the annual water flow in Mill Brook, ongoing and continuous stream flow measurements will create a more comprehensive record of flow over time. This will result in a better understanding of nutrient inputs to Tisbury Great Pond via this surface water flow.***

c. **Rainfall Measurement and Analysis summary:**



Rainfall was recorded at the Polly Hill Arboretum using a Hach wide range pH kit. Samples were sent to Phoenix Lab for analyses for the nitrate content. The acidity as indicated by pH of the stream below the Roth Woodlands sample site are mostly between 6 and 7 (pH 7 is neutral). This is in the desirable range for good habitat. The pH measured in the precipitation was significantly lower (50 to 100 times more acid). ***The fact that the stream pH is in the desirable range despite the acidity of the rainfall indicates that the rainfall is buffered by the upland soil and vegetation that it percolates through on its way to the stream. Without this buffering, this acidity could have an impact on habitat quality.***

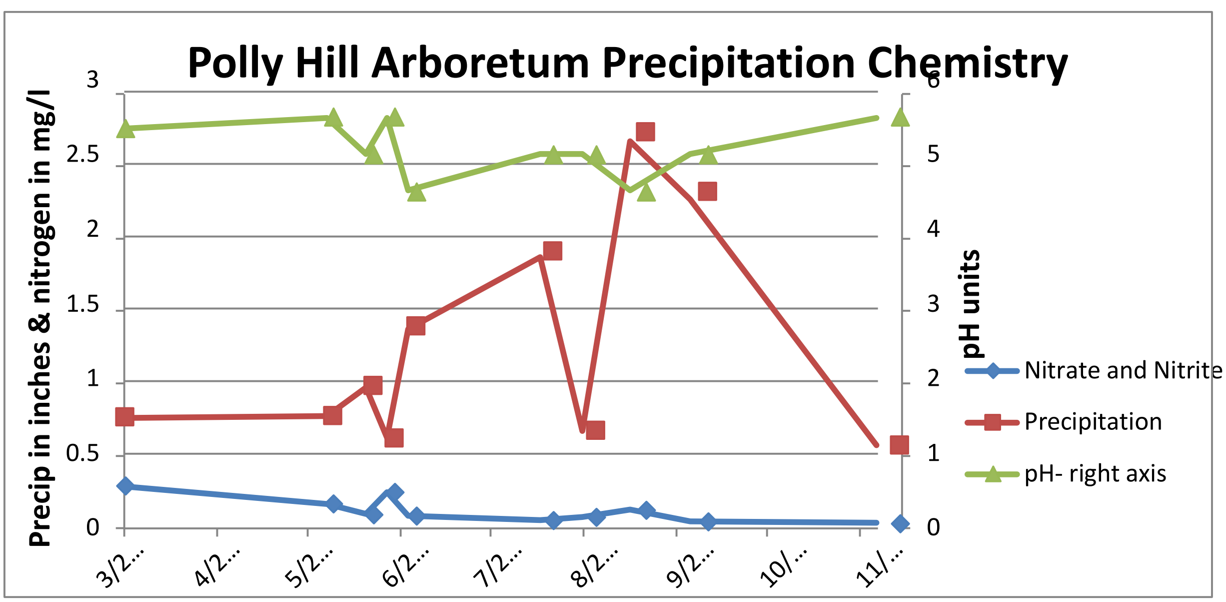


Fig. 17 Polly Hill Rainfall March – November, 2015

Key Finding: ***The nitrate content of the rainfall collected during this study was low compared to Massachusetts Estuaries Project (MEP) nitrogen load calculations for Tisbury Great Pond.***

The Massachusetts Estuaries Project (MEP) provides water quality, nutrient loading, and hydrodynamic information for each estuary to construct a cutting edge watershed/estuary model that will predict the water quality changes resulting from land use management decisions. This project is a collaborative effort by two state agencies: the Executive Office of Environmental Affairs (through the Department of Environmental Protection) and the University of Massachusetts's School of Marine Science and Technology and the Towns of Chilmark and West Tisbury. ***Results of the MEP study in 2007 indicate that Tisbury Great Pond is receiving excessive nitrogen from its watershed, mostly via groundwater. In order to restore water quality in the system, steps must be taken to reduce the impact. MEP Recommended steps include: increased tidal exchange, reduced nitrogen from the watershed and increased oyster populations.***

MEP used a concentration of total nitrogen of 1.09 mg/l in precipitation for nitrogen load calculation for Tisbury Great Pond. The readings at Polly Hill Arboretum are lower in part because they only measure nitrate and nitrite while the MEP figure includes all forms of nitrogen in the rainfall. This discrepancy suggests that we should collect more rainfall data.

d. **Water Temperature Summary – ESS Group and Sea Run Brook Trout Coalition**

- **ESS Group**

ESS Group deployed continuous water temperature and water level data loggers at six locations along Mill Brook (See ESS Sampling Site Map, Fig. 9; Page 11). These loggers were programmed to record data at 15 minute intervals. These six sites reflect conditions found above and below three of the seven impoundments on Mill Brook as well as a site at Waskosim's Rock Reservation near the headwater of the brook, and at Indian Hill Brook.

Due to ESS Group instrument outage at Site #4, their temperature record for that logger has a six month gap for 2015, which should be kept in mind while viewing Figures 18, 19 and 20.

Temperatures are reported in Fahrenheit.

Mill Brook is designated a Coldwater Fish Resource (CFR) by Massachusetts Division of Fisheries and Wildlife (DFW). CFRs are particularly sensitive habitats. Changes in land and water use can reduce the ability of these waters to support brook trout (*Salvelinus fontinalis*), present in Mill Brook. American Brook Lamprey (*Lethenteron appendix*), listed as 'threatened' by Natural Heritage and Endangered Species Program (NHESP) is another cold water species found in Mill Brook. Brook lamprey are vulnerable to sedimentation, water temperature increases, pollutants and extreme water level change.

Figure 18 shows average water temperatures for the six sites from March, 2015 through August, 2016. This graph illustrates the seasonal changes in water temperature recorded at these six sites; warmer in the summer, cooler in the fall/winter.

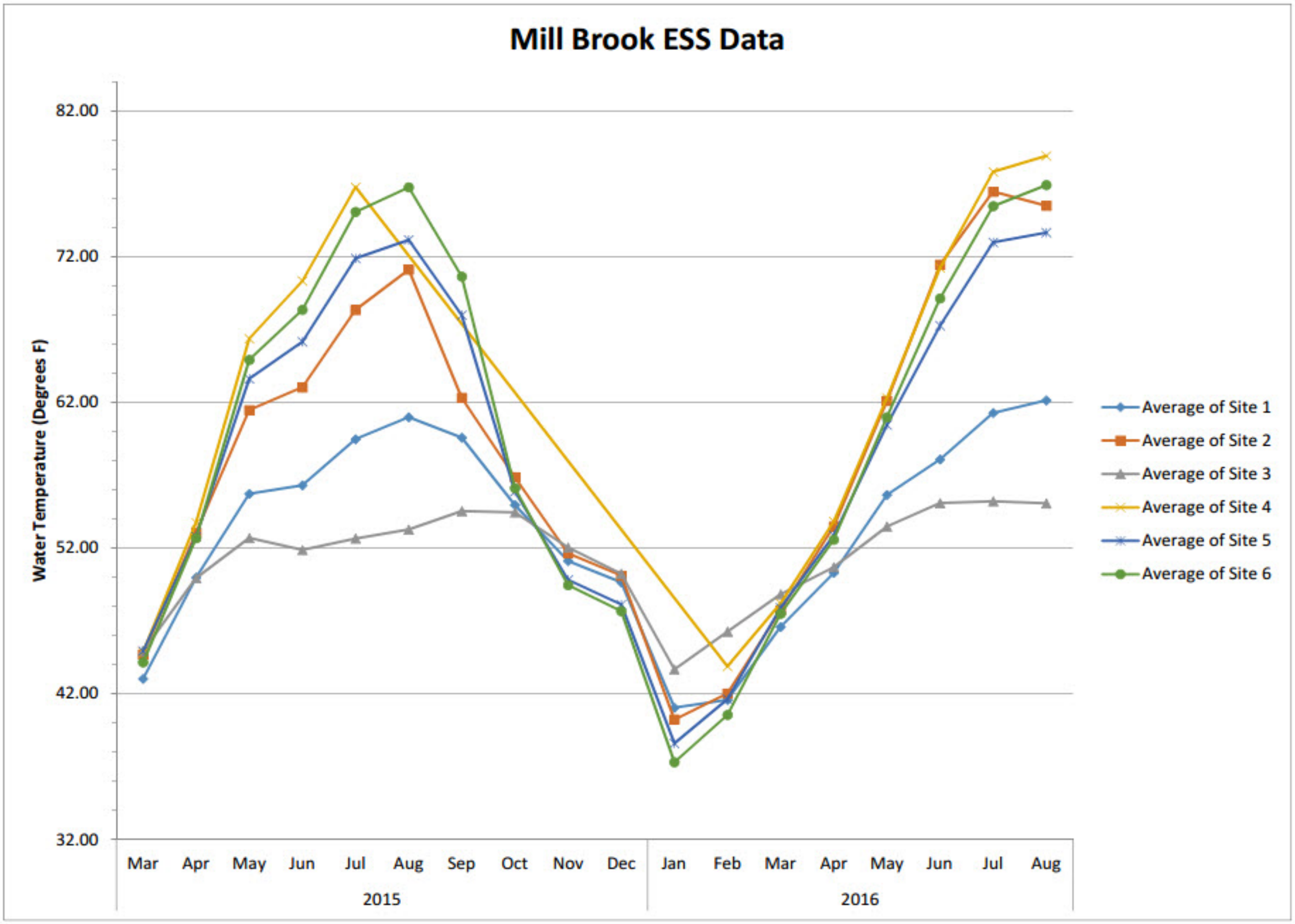


Fig. 18 Mill Brook ESS Data Average Water Temperature illustrates the seasonal fluctuations in average stream temperatures for this study period

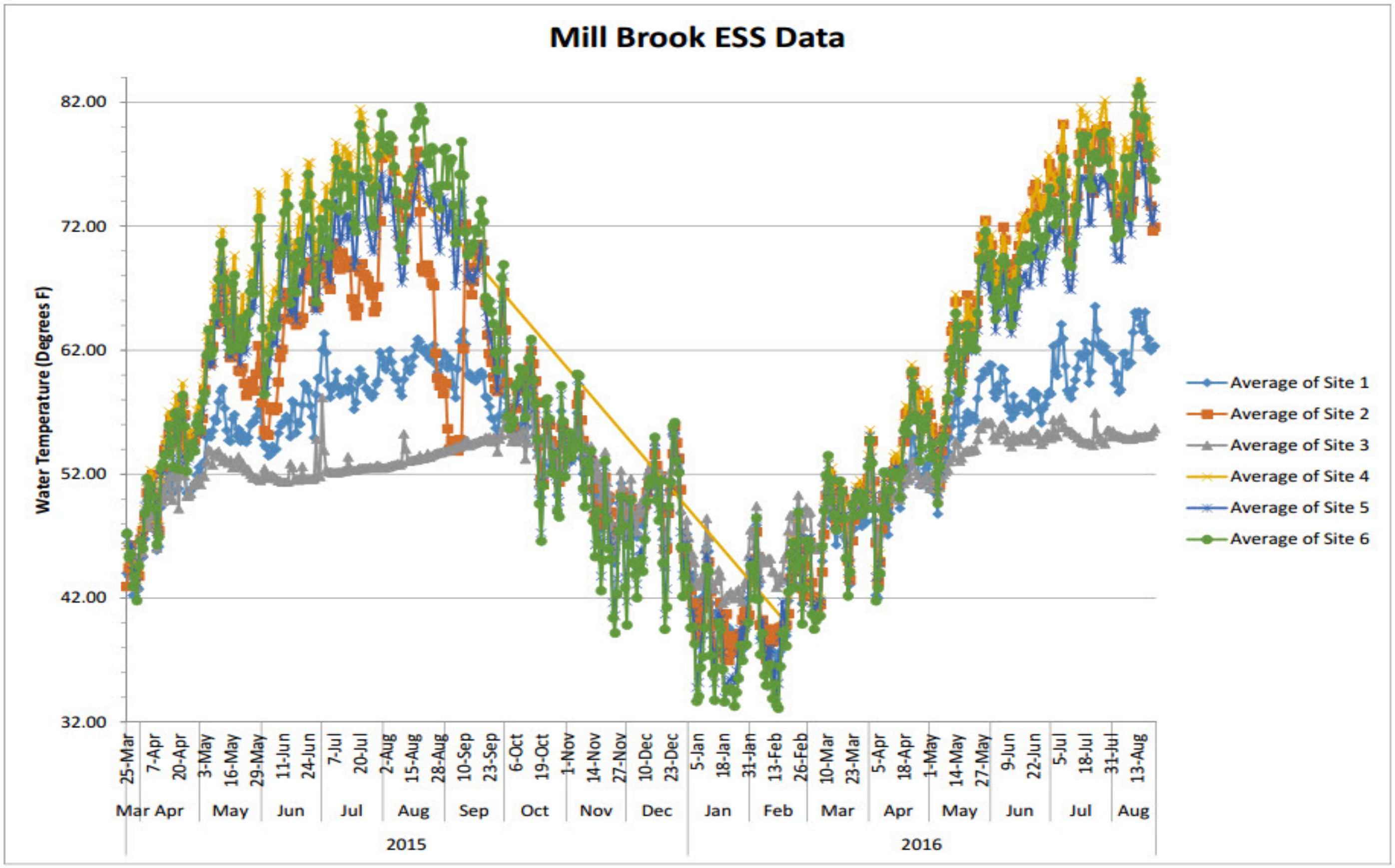


Fig. 19 Mill Brook ESS Data Daily Fluctuations

In addition to the seasonal cycle of water temperature, Mill Brook temperature rises during the day. When the stream flows from under the shaded canopy of the woods into an open impoundment, sunlight heats the larger surface expanse. This is known as solar impact. The water temperature can fall at night as the heat radiates back into the air. The water temperature can also be lowered by groundwater input which is at ~50 degrees throughout the year in our region, and by precipitation that is typically cooler than the surface water temperature.

Figure 20 represents maximum and average water temperatures recorded at these six sites in both 2015 and 2016. Maximum water temperatures of nearly 90 degrees were recorded below Priester and Mill Ponds.

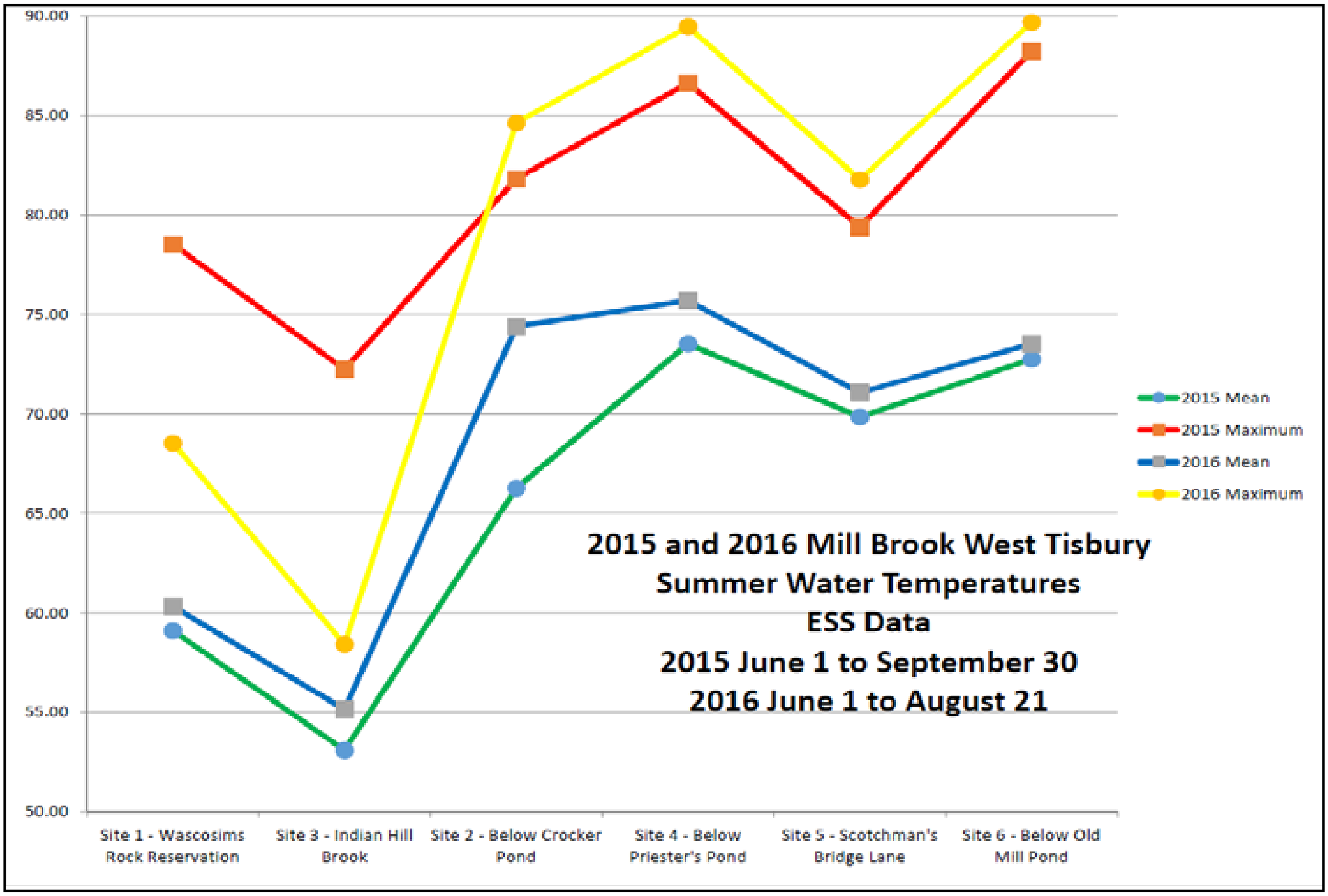


Fig. 20 ESS Group Maximum and Average Water Temperature March 2015 through August 2016 within the Mill Brook Stream System

Sites #1 and #3, both located above impoundments on Mill Brook, reflect the groundwater (~50 degrees in our region) inputs to this cold water stream before the addition of the solar impacts of the impoundments. Data from sites #2, 4, 5 and 6 clearly illustrate how the solar impact of the impoundments in this section of Mill Brook raises the water temperature.

Sea Run Brook Trout Coalition

In addition to the data gathered by ESS Group, the Sea Run Brook Trout Coalition (SRBTC), a non-profit organization dedicated to the preservation and restoration of native brook trout habitat, has (through a grant from the local Edey Foundation) installed and monitored continuous water temperature loggers at ten locations along the four mile length of Mill Brook These data loggers were installed in May, 2013, and are still in place and recording at intervals of 15 minutes, 24/7 (Fig. 21).

Mill Brook

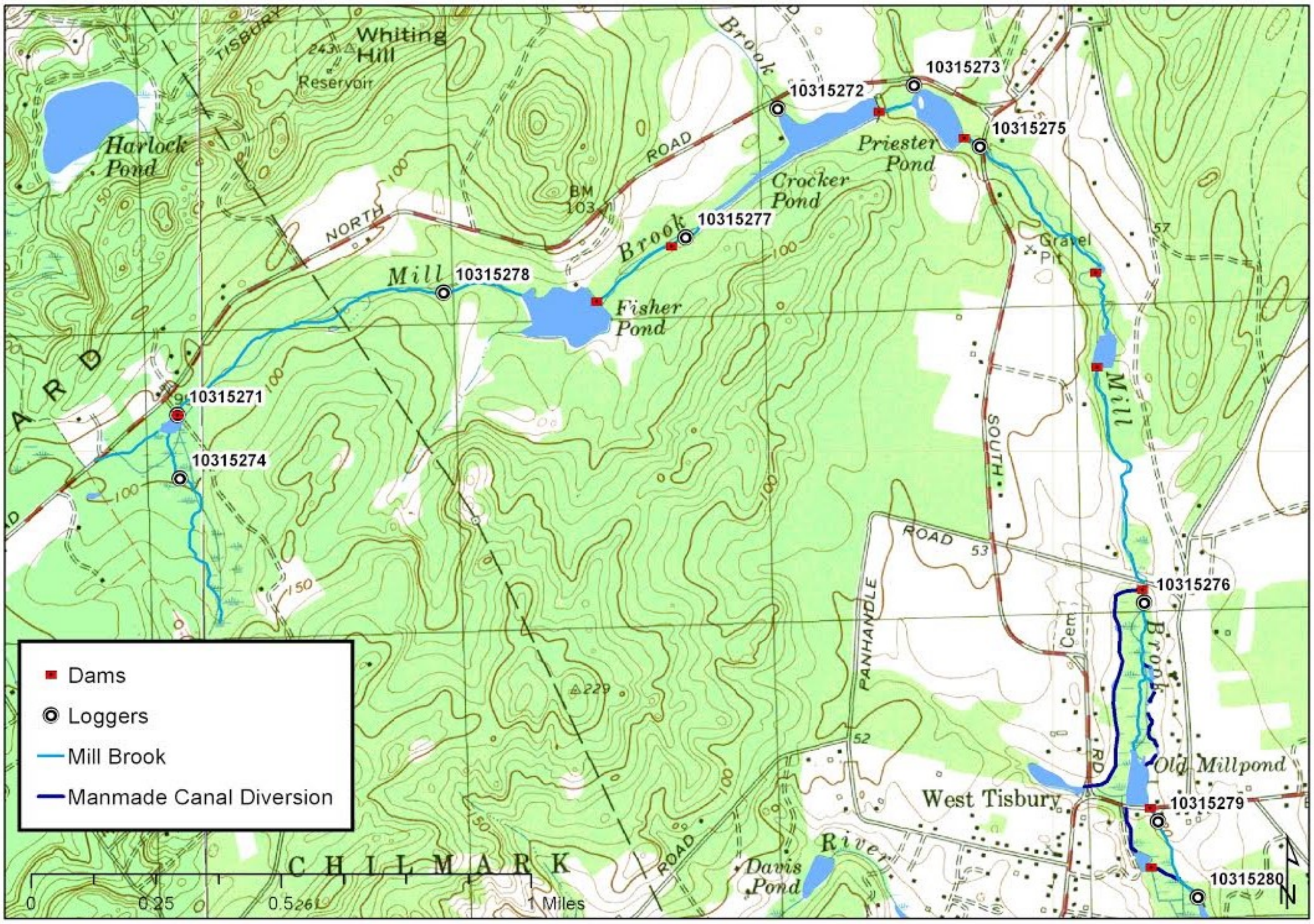


Fig. 21 Sea Run Brook Trout Coalition Data Logger Locations

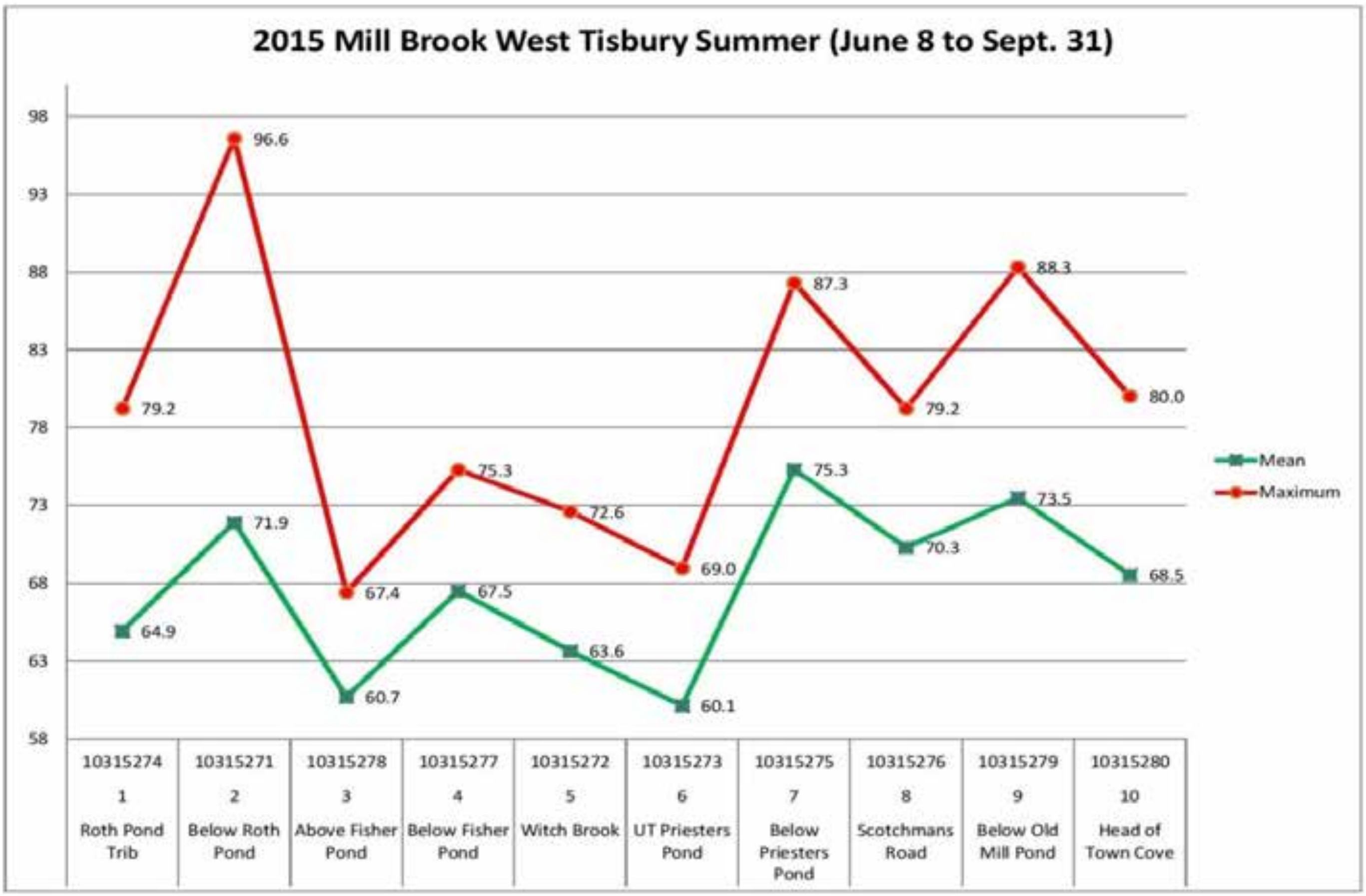


Fig. 22 Sea Run Brook Trout Coalition Maximum and Average Water Temperature June to September 2015 within the Mill Brook Stream System

Key Finding: ***Data from this study illustrates that the Mill Brook headwater and two tributaries remain consistently cool, and that the solar heating of these impoundments raises the water temperature to levels lethal to our native cold water species.***

Brook trout cannot long survive water temperatures above 70 degrees and water temperatures above 78.8 degrees impair river herring egg incubation and juvenile river herring habitat; River herring (*Alosa pseudoherengus*) are seasonally present and spawning in Mill Brook below the dam at Mill Pond, as are numbers of American eel (*Anguilla rostrata*). Warm water temperatures persist far downstream of the impoundments. Mill Brook water temperatures have been recorded as high as 82 degrees where it flows into Town Cove of Tisbury Great Pond (Fig. 22 ; # 10 "Head of Town Cove").

While there is a fish ladder at the Mill Pond dam, no river herring or other fish have been observed passing upstream at this location, nor have herring young of the year been observed upstream of the dam. Attempts to overcome the physical barrier posed by this dam cannot address or overcome the thermal barrier created by this impoundment, as indicated in any of these graphs.

The 2012 electrofishing survey of Mill Brook conducted by the Massachusetts Division of Fisheries and Wildlife (DFW) confirms that these warmer water temperatures impact where native cold water species (historically found in Mill Brook) can still survive in Mill Brook.   This survey also found reproducing wild brook trout surviving in the upper, colder reaches of Mill Brook. None were found below Scotchman's Bridge Lane. The multiple impoundments in the lower segment of the brook create a cumulative increase in water temperature.

In his report of the 2012 electrofishing survey of Mill Brook, Steve Hurley, District Fisheries Manager at MA. DFW, noted that: "The small stream cold water habitats of Mill Brook are a habitat at risk due to climate change".   These changes include warmer air and water temperatures in the future, changes in precipitation patterns, increasing storm frequency and intensity and sea level rise.   Dams fragment habitat, preventing fish from escaping the following: predation, the effects of environmental factors such as lethal water temperatures created by the impoundments, as well as flooding/storm events.   A focus on habitat connectivity and water quality is among the many options to increase resilience for fish and wildlife populations in the face of climate change (Steve Hurley, personal communication).

All of this water temperature data can be viewed in its entirety on our page of the town website.

Fig. 23 Electro Fishing Survey at Waskosim's Rock by MA Div. of Fisheries and Wildlife - 2012

Fig. 24 Sample Bucket - Electro Fishing Survey by MA Div. of Fisheries and Wildlife – 2012

- **<u>Water Temperature and Dissolved Oxygen:</u>**

The oxygen content of a water body is affected by water temperature, aquatic plant photosynthesis, riffles and rapids that aerate the stream, and organic matter content that is decaying. Water temperature and dissolved oxygen are inextricably linked. As water temperatures rise, dissolved oxygen, essential for aquatic life, drops – cold water holds more dissolved oxygen. Continuous water temperature measurements over the last five years show that warmest summer water temperatures have consistently been recorded around 5 p.m., and coolest temperatures recorded around 5 a.m. During 2015, dissolved oxygen was sampled on 15 occasions, mostly in the morning when cooler water temperatures were recorded (ESS Group recorded D.O. levels ranging from 2.83-15.86 mg/l, BiodiversityWorks recorded levels between 5.7-8.4 mg/l). Standards adopted by MA Division of Fisheries and Wildlife for listed Coldwater Fish Resources such as the Mill Brook stream system, set a minimum of 6 mg/l. At levels less than 2 mg/l, fish start dying directly from oxygen depletion; between 2-4 mg/l only a few fish species and aquatic insects can survive. While the data from 2015 is sparse, results from ESS Group sampling show lower dissolved oxygen levels in the July and August field measurements than those taken in February, March and May. Site 3, Indian Hill Brook, a Mill Brook tributary above Priester Pond, had the lowest dissolved oxygen levels sampled (4.3 mg/l on 7/30/15, 2.83 on 8/19/15 and 3.71 on 10/26/15).

Key Finding: ***Dissolved oxygen is a critical component used to assess water quality. This portion of the initial study forms a baseline as part of an overall water quality index that includes pH, temperature and conductivity. While this temperature data clearly illustrates water temperature fluctuations along the length of Mill Brook, additional data collection of dissolved oxygen levels, particularly afternoon measurements, at multiple locations along the brook is necessary for a complete assessment of aquatic health in this system.***

As Mill Brook is one of the main surface water inputs into Town Cove of Tisbury Great Pond, water quality and habitat conditions in Mill Brook directly affect water quality and habitat conditions in Tisbury Great Pond. This has direct bearing on the ability of both shellfish and finfish populations (especially those that are diadromous - use both fresh and salt water for different parts of their life cycles), to survive and thrive and the recreational and commercial opportunities they provide. This is especially important as our watershed and the species it supports face increasing habitat pressure due to development and climate change.

10. <u>Morphometric and Macroinvertebrate Survey, BiodiversityWorks and Greg Whitmore</u>

- **<u>BiodiversityWorks</u>**

Morphometric and macroinvertebrate surveys are used to assess the quality of the stream habitat. The study conducted by BiodiversityWorks and a cadre of dedicated volunteers is the first of its type on Martha's Vineyard. Like the ESS study, it represents a snapshot in time. ***This work should be part of a consistent longterm management plan that recognizes the value and importance of the health and welfare of Mill Brook Watershed.***

Survey Methodology

- 11 sampling sites (Fig. 25 next page):
    - Above and below four impoundments excluding the Mill Pond
    - Waskosim's Rock Reservation
    - Witch Brook after passing under North Road above Crocker Pond
    - Indian Hill Brook after passing under North Road above Priester Pond

- Field work was conducted in two parts: June 3 – 25, 2015; August 6 – 27, 2015

- Data collected at each site
    - Physical characteristics using the Stream Habitat Walk form from the EPA.
    - Basic water quality measures (pH, temperature, dissolved oxygen and conductivity) measured with a YSI 60 pH meter and a YSI 85 multimeter
    - Plant list
    - Sample of aquatic organisms

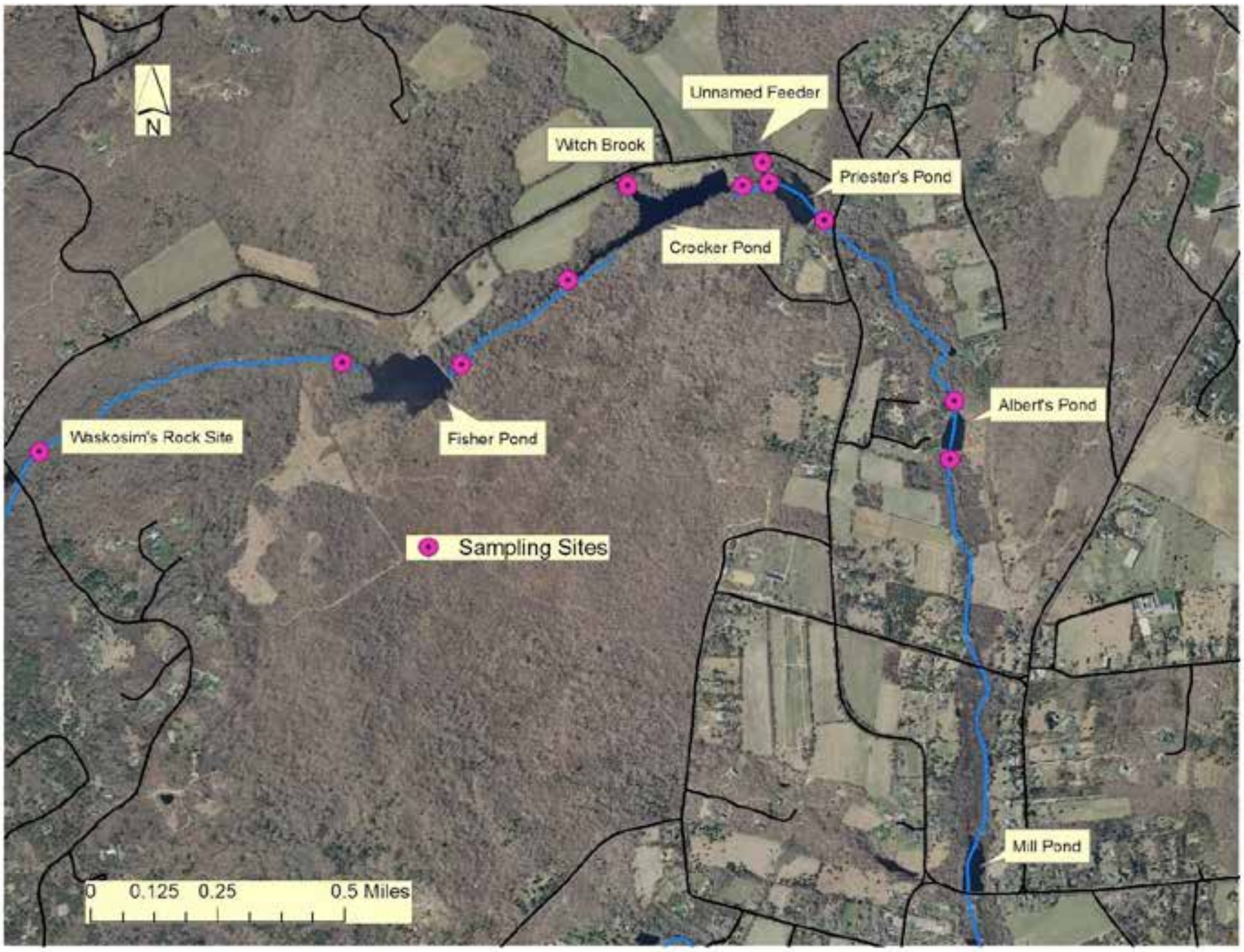


Fig. 25 BiodiversityWorks Sampling Sites

Fig. 26 Sampling above Albert's Pond – June 2015

Fig. 27 Elver (juvenile American eel) – Below Albert's Pond June 2015

The study looked at the most important factors that are used to study freshwater systems and determine their biological health; stream temperature, dissolved oxygen, acidity and conductivity. A secondary but corollary study was a biological inventory (macroinvertebrate study). The presence/absence of animals gives an indication of habitat quality and health. In addition, the study looked at the physical characteristics of the watershed; impoundments, stream size, shape, depth, natural vegetation and many other characteristics as part of a morphometric analysis. The study also included a measurement of the specific conductivity which is used to indicate if pollutants are present in the watershed. All of these components attempt to bring together data sets that provide a measurement of water quality, the central tenet of this study.

- **Water Quality:**

a. **Temperature:**

The temperature of the water determines the amount of dissolved oxygen that the water can hold. This is a critical factor for the health of those aquatic organisms that obtain their oxygen from the water itself. It has been clear for some time that the temperature in the stream increases from the headwaters to below Mill Pond (Wilcox, 2009, SRBTC 2013-present). This reflects the heating of the water as the stream passes through the ponds but is also a reflection of the influence of cooler groundwater which remains at temperatures between ~50 degrees year round.

Key Finding: ***The stream temperature patterns in this study strongly complement earlier studies (SRBTC, 2013-present) which show the impacts of impoundments on cold water streams with wide temperature variations over the physical course of the watershed.***

b. **Water Acidity or pH**

The pH or acidity of the water can impact the desirable species that have low tolerance for acid water: trout and many of their prey species (e.g. mayfly, stonefly and caddis fly larvae) prefer pH of 6.5 to 7.5.

In June, the lowest pH found was at Waskosim's Rock (6.2) and above Fisher Pond (6.1). Below Fisher Pond the pH was 6.5 and it remained between 6.4 and 6.6 as it passed through the next three ponds and was 6.5 below Alberts Pond.

Key Finding: ***Measurements indicate that while the pH in the Mill Brook was on the acidic side (below 7.0), it was within the survival range for most organisms over the entire length of the brook and for most of the sites tested it was within or very close to the lower range of pH preferred by most organisms. The rainwater analysis during the course of this study indicates that acidic precipitation with a pH range of (4.5-5.5) is positively buffered by vegetation and soil as it enters the watershed.***

c. **Biological Assessment: (BiodiversityWorks, Whitmore)**

BiodiversityWorks collected macroinvertebrates from the same 11 sampling sites they used for water quality measurements. Aquatic macroinvertebrates are good indicators of water quality and stream health since they spend up to a year in the stream, have limited mobility and are the primary food source for many fish. They are also relatively abundant, big enough to see with the naked eye, and easy to collect. The identification of macroinvertebrates to the species level is essential to be able to determine stream health.

Greg Whitmore, an aquatic biologist from Deerfield, New Hampshire was hired to do a detailed taxonomic review of the specimens collected by BiodiversityWorks. Whitmore conducted the first comprehensive invertebrate assessment of cold water streams on the island resulting in a paper for the American Entomological Society in 2008, entitled "Macroinvertebrate Stream Fauna of Martha's Vineyard, with records from Southeastern Mainland Massachusetts." Greg's report and spreadsheet analysis of the specimens collected by BiodiversityWorks is found on this committee's page of the town website.

Sixty-two identifiable species of macroinvertebrates were collected during this study. Numerous specimens of snails, fingernail clams and some fly larvae could not be identified as these require either live specimens or special preparation for identification. Twenty of the species collected are new records for the island, though most of these new species are associated with slow-flowing streams and impoundments and are not good indicators of a high quality cold water stream system.

Macroinvertebrate sampling for this study occurred in June and August. In studies that focus on diversity, samples should be taken from the largest possible date range. Many species are present in larval form only from late fall–early spring and are not collected if sampling only occurs in the summer months. Species found in the summer months tend to be more tolerant of lower oxygen levels, higher temperatures and organic pollutants. This means that sampling only in the summer can give an incomplete view of the overall quality of the watershed. A more comprehensive representation of the macroinvertebrates living within the Mill Brook stream system would require sampling throughout the calendar year.

d. **Tolerance Values**

For the purposes of biomonitoring, species are assigned a tolerance value. ***A tolerance value is the point at which species are no longer able to survive due to increasing levels of organic pollution and other determinants.*** Tolerance values and species occurrence records can be used to generate a Hilsenhoff biotic index. This index was developed by freshwater stream ecologists using the presence or absence of specific taxa (species) which directly correlates to the water quality that supports their reproduction and survival. Whitmore calculated a biotic index number for each site (see his report for detailed explanation) on a scale of 0-10, with lowest numbers (0-3.75) indicating excellent water quality and higher numbers (5.76-10) indicating fairly poor to very poor with substantial to severe organic pollution likely. ***While overall, the biotic index for all sampling sites combined is 4.75 ('good' water quality), there are several factors which may have negatively affected this index.*** One is the time of year of sampling as summer species tend to be more tolerant of higher temperature and lower amounts of dissolved oxygen. Another factor is the locations that were sampled. Both Witch Brook and Indian Hill Brook were sampled south of North Road where stream characteristics are markedly different than the upstream course of these streams; the water slows dramatically as it approaches the impoundment and the stream bottom is covered with accumulated organic muck. Fauna attracted to these sampling sites have a higher tolerance for lower levels of dissolved oxygen. Sampling upstream at these two locations could yield more cold water species with lower tolerance values.

Species diversity tends to increase along the course of a stream as the stream increases in size. This is due to an ever increasing amount of organic material being present in the stream as it progresses. This natural progression is not seen in Mill Brook, as the sites above Fisher Pond and Priester Pond have the highest diversity. The dams and impoundments have influenced the suite of species found in Mill Brook, which could be a cold water, moderate-flowing stream throughout its entire course. The dams and resulting impoundments increase water temperature, decrease dissolved oxygen, decrease the overall riffle habitat and create impenetrable barriers for the migratory movement of fish and the continuous downstream drift of macroinvertebrates.

Key Findings: ***There are data gaps due to collection methodology – when, where and how sampling occurred.***

Fifty species collected by Whitmore in 2007 at some of the same sites were not found during this 2015 study. This is likely due to the time of year of sampling, as 25 of the species collected by Whitmore in 2007 were from a date range outside of the June and August dates used in this study.

Twenty species collected by BiodiversityWorks are species not previously recorded. Most of these new species are associated with slow-flowing streams and lakes/ponds and are not good indicators of a cold water stream system.

Certain species collected can reproduce and survive only under high quality stream conditions. Thirty-nine of the macroinvertebrates specimens collected (comprised of three species) are rated as having zero tolerance to organic pollutants. Thirty of these were collected at Waskosim's Rock Reservation. The Waskosim's Rock site is a free flowing stream site near the headwaters of the Mill Brook and not as affected by the conditions (high water temperatures, low dissolved oxygen and siltation of the stream bed) found further downstream. Siltation of the stream bed upstream of the impoundments is caused by the stream flow spreading out and slowing as it approaches the impoundment and dropping its load of organic debris on the stream bed.

Future macroinvertebrate sampling should occur on a scheduled basis in order to address the data gaps and to measure changes over time.

11. Mill Pond Description, Bathymetry

Bathymetry is defined as: *"The elevation of the earth's surface beneath a body of water typically determined by measurements of depth from the water surface." -USGS.GOV*

The Mill Pond accounts for 2 acres of the 2,460 acres in the West Tisbury section of the Mill Brook watershed and is a wide and shallow portion of Mill Brook.

Once each year from 2014 - 2017, the depth of water in the Mill Pond was measured to determine if the pond was filling in with sediment.

Bathymetry Methodology

On April 2, 2017, Kent Healy (civil engineer) and Bill Austin (registered land surveyor) laid out a grid using 12" lengths of ½" reinforcing bar to mark each end of each section line on each side of the pond. Stretching a 300 foot tape across the pond between the reinforcing bars enabled them to take soundings at the same location each year. This system gives 43 sounding locations. The first year they pushed a rod down through the soft sediment to hard bottom to get the elevation of the hard bottom. That year and each year thereafter they measured down to the top of the soft sediment (organic muck) using a 14" diameter disc on the end of a rod that barely sank. Letting this disc rest gently on top of the soft sediment gives a consistent way to determine the elevation of the top of the soft sediment. These measurements were taken to the 0.01 foot from the top of the organic muck to the surface of the pond. The elevation of the pond surface was determined each sampling day from the FEMA benchmark chiseled in the west end of the concrete spillway abutment. These measurements were then translated into elevations of the top of the soft sediment and are presented in Figure 28.

Due to small errors in taking measurements (small waves, tipping rod, the boat blowing around) the overall accuracy of the elevations shown should be considered to be 1.25 inches.

These elevations show that there has been no significant (1.25 inches) change in the elevation of the top of the soft sediment in the three years sampled.

Key Finding: ***As illustrated in Figure 28 bathymetry data gathered by Kent Healy and Bill Austin annually from April 2014 until May 2017 indicates no measurable change in water depths at Mill Pond.***

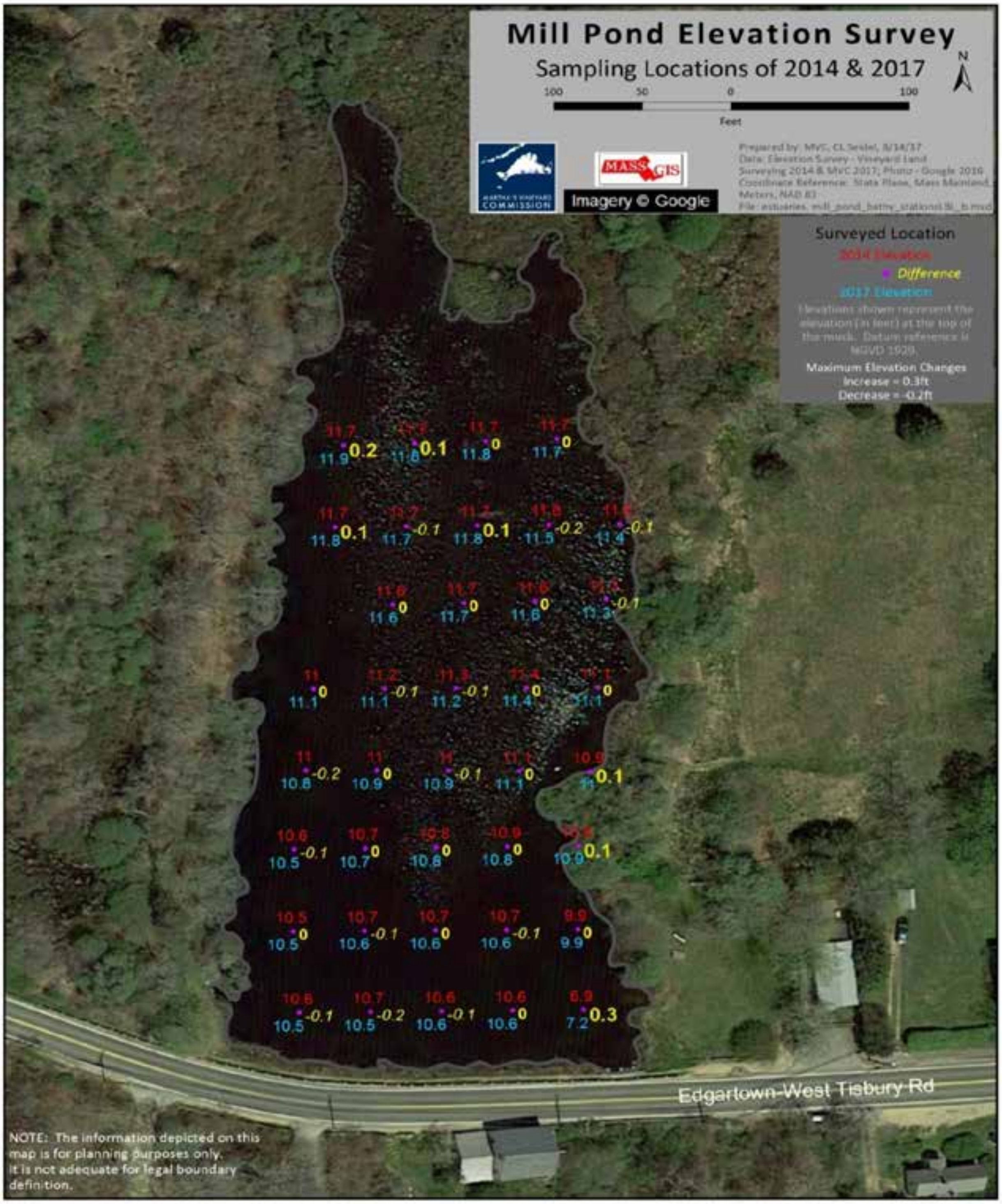


Fig. 28 Mill Pond Elevation Survey – Data source Kent Healy, Prepared by Seidel MVC

12. Land Use and Development within the Mill Brook Watershed

The ***three charts*** (fig. 29, 30, 31) demonstrate the development density within the watershed in 1985, 2005 and the projected impact if all buildable land in the watershed were developed.

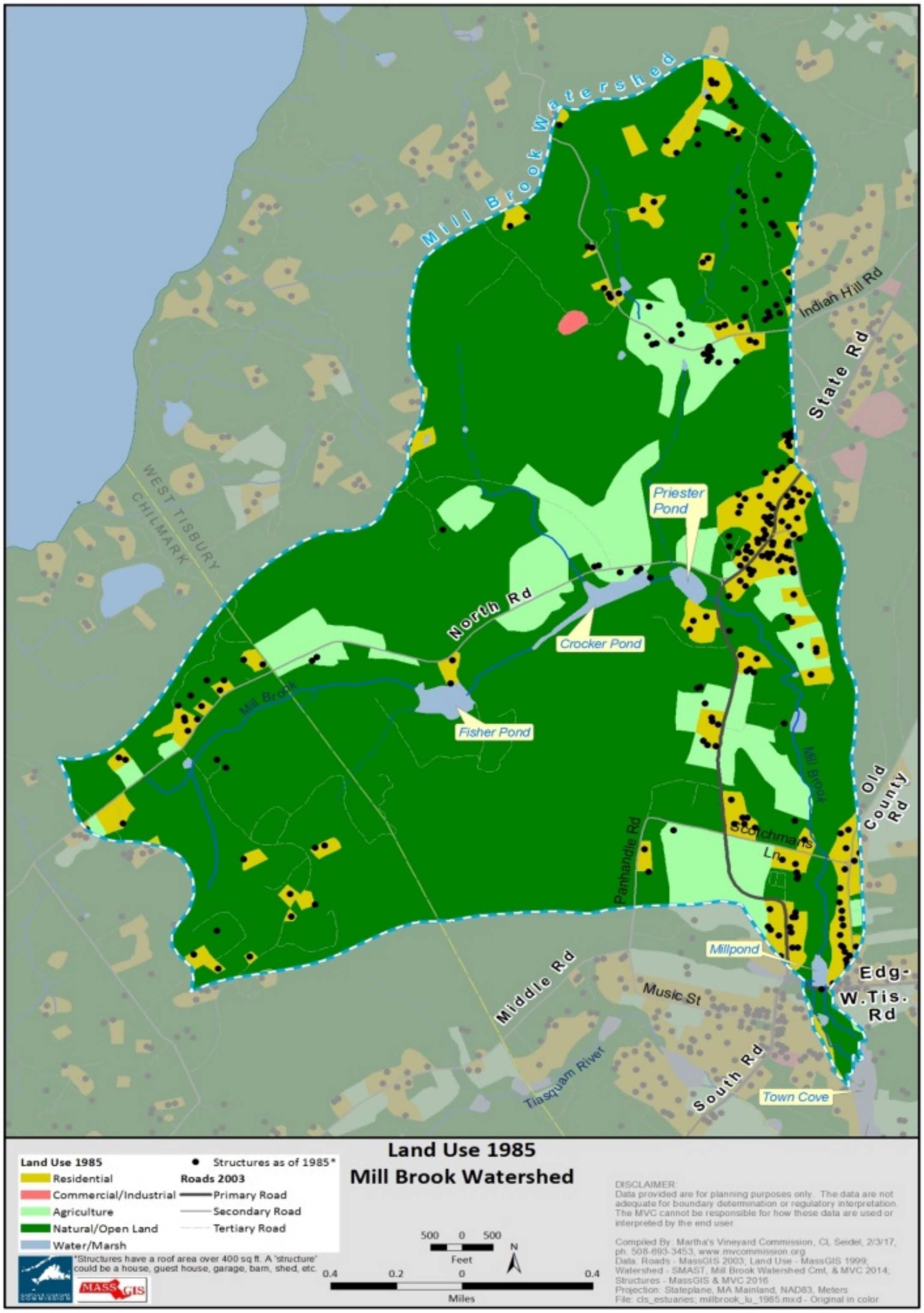


Fig. 29 Mill Brook Watershed Land Use 1985 - MVC

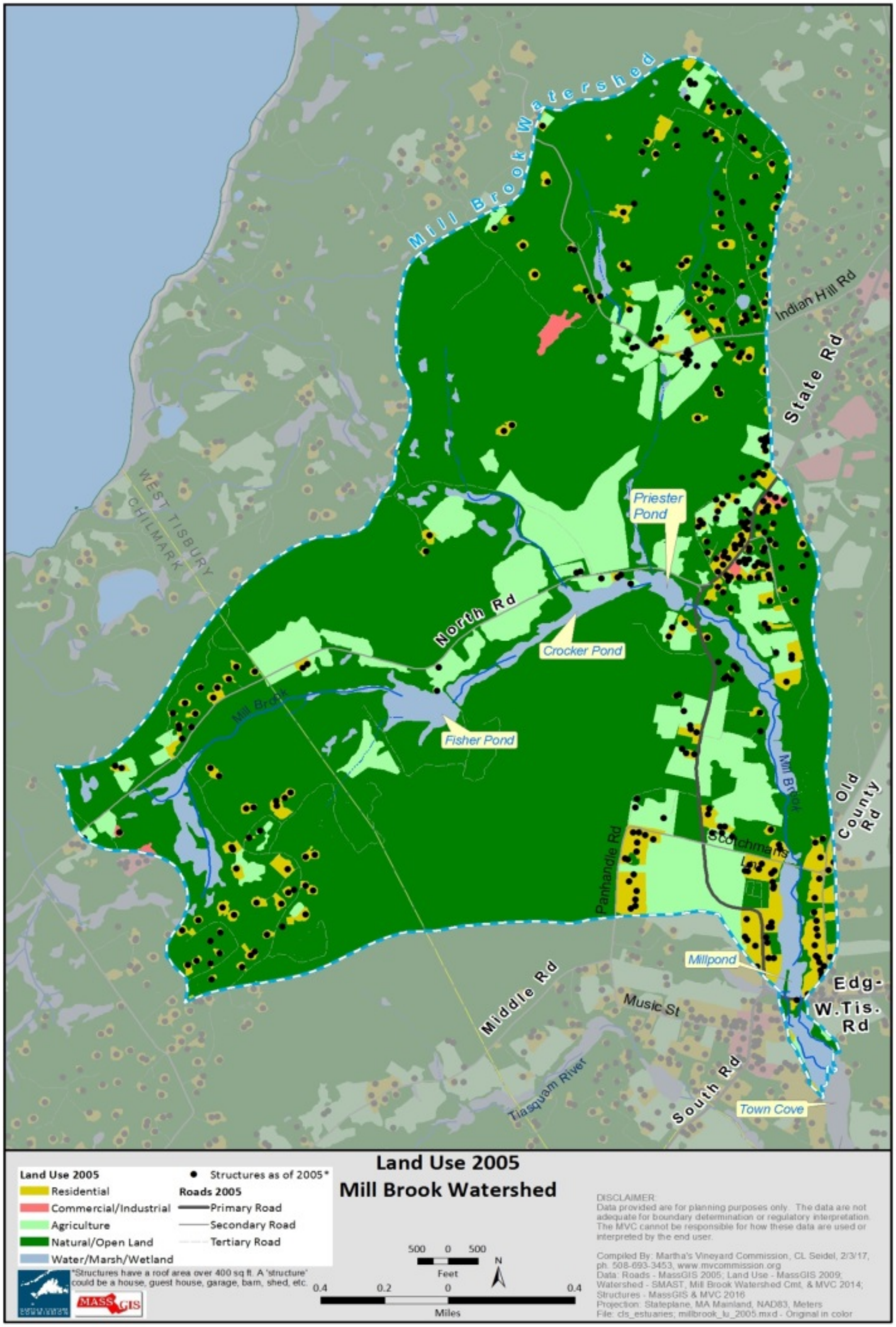


Fig. 30 Mill Brook Watershed Land Use 2005 - MVC

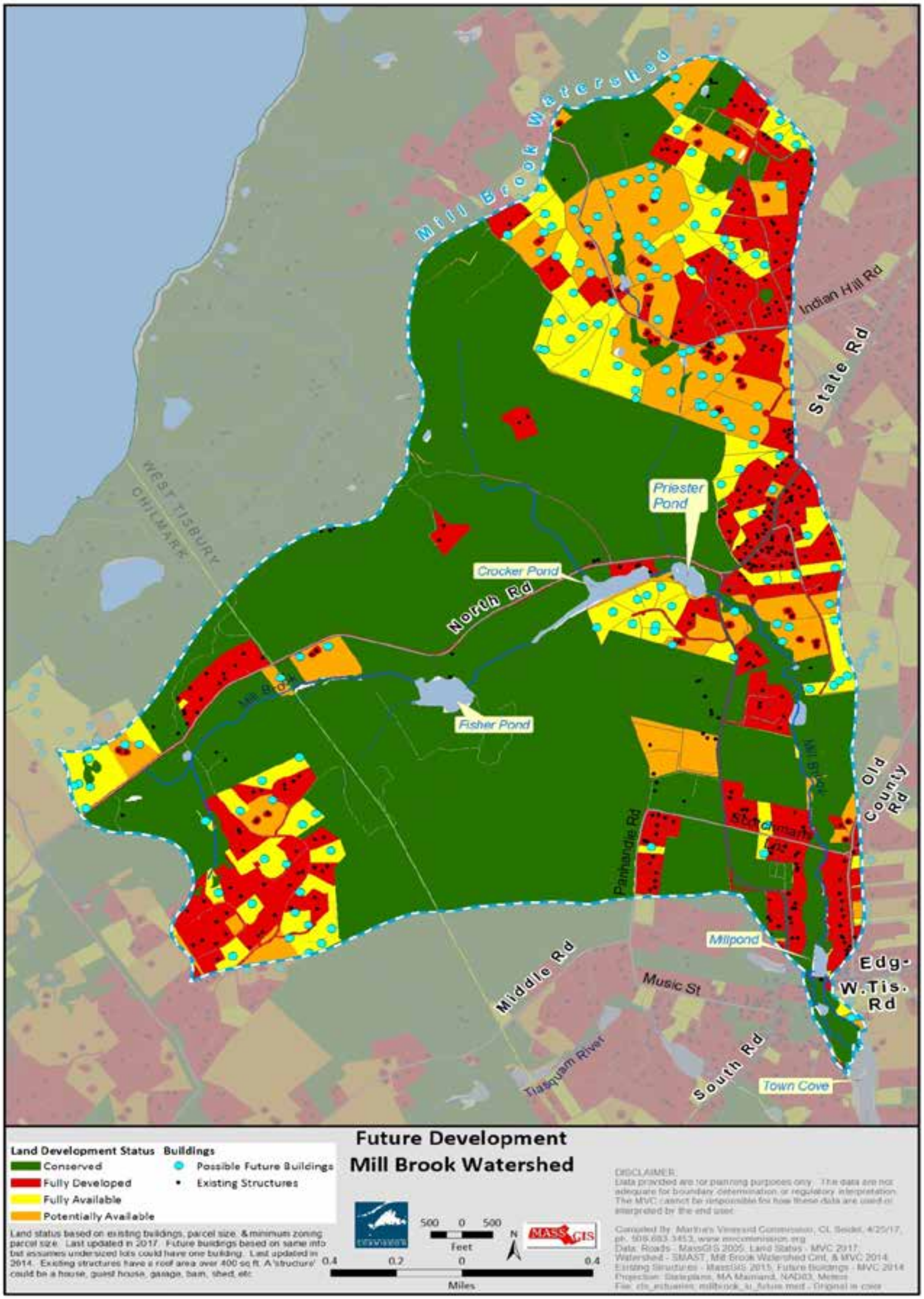


Fig. 31 Projected Mill Brook Watershed Development of all Buildable Land – MVC

Key Finding: ***Within the Mill Brook watershed, in 1985 there were 255 houses; in 2005, 360; and future build-out based on existing zoning predicts 507 houses. Combined with the existing levels of phosphorus, increased nitrogen from development and other sources could lead to the production of algae and other aquatic plants, including invasive. To help mitigate the impacts of development, agricultural use and the management of these nitrogen and phosphorus sources, the Town should be more proactive in its land protection practices. For example, the town could develop a plan to strategically acquire certain highly sensitive, undeveloped parcels of land within the watershed to be preserved as open space, while allowing for creative affordable housing solutions. Community Preservation Act funds are available for these purposes.***

13. Conclusions and Recommendations moving forward:

WATER QUALITY KEY FINDING:

The implication of the high concentration of phosphorous as more nitrogen is added to the stream, is that there is likelihood that there will be increased plant growth that could reach undesirable levels, impacting habitat quality.

Conclusions and Recommendations:

1. Add a water sampling station above Site 1 (Waskosim's Rock) to investigate the cause of high phosphorous at Site 1.

2. Develop policies for low impact road management including snow, ice and storm water runoff.

3. Develop a water monitoring program to fill data gaps to form a complete baseline and to assess changes to water quality going forward. Sampling to occur every 5 years.

4. The Town should implement all of the stormwater management practices not yet implemented as set forth in the 1989 Don Liptack report written for the Tisbury Great Pond Think Tank.

5. Implement ground water and voluntary private well sampling program to form a baseline and to assess changes to water quality going forward.

WATER FLOW MEASUREMENTS KEY FINDING:

This study resulted in a limited amount of data. Improved calibration will be achieved through future additional discharge readings.

Conclusions and Recommendations:

1. Collaborate with Massachusetts Division of Ecological Restoration's (MA DER) River Instream Flow Stewards Program (RIFLS) to collect additional stream flow data (with many discharge readings) for improved calibration.

2. Replace undersized and/or perched culverts to meet new stream crossing standards. Town of West Tisbury could help facilitate this with the help of MA DER.

3. Pursue the Municipal Vulnerability Preparedness (MVP) program which provides support for townsto begin the process for planning for climate change resiliency. This program could offer funding to address undersized culverts, storm water runoff, and other impacts of climate change on the watershed.

WITHDRAWALS AND DIVERSIONS KEY FINDING:

As a result of these withdrawals and diversions along the Mill Brook, there is often insufficient water flow in late summer. This interrupts the flow over the west weir boards of the main spillway at Mill Pond, further disrupting flow to the downstream channel of Mill Brook. Due to variability in the annual water flow in Mill Brook, ongoing and continuous stream flow measurements would create a more comprehensive record of flow over time. This will result in a better understanding of nutrient inputs to Tisbury Great Pond via this surface water flow.

Conclusions and Recommendations:

1. The West Tisbury Board of Selectmen, Conservation Commission and Fire Department could work with adjacent landowners to find alternatives to withdrawals and diversions for fire suppression purposes, agricultural irrigation, commercial pumping and other uses.

2. Determine water rights and explore alternatives to existing diversions. Conservation organizations holding Conservation Restrictions on relevant parcels might help facilitate discussions about potential alternatives with interested landowners.

RAINFALL MEASUREMENTS AND ANALYSIS SUMMARY KEY FINDING:

The nitrate content of the rainfall collected during this study was low compared to the Massachusetts Estuaries Project (MEP) nitrogen load calculations for Tisbury Great Pond.

Conclusions and Recommendations:

1. Collect more rainfall data to address discrepancy between this study and the MEP nitrate content data in order to evaluate the variability of nitrate content and the rainfall quantity across the watershed.

WATER TEMPERATURE SUMMARY KEY FINDING:

Data from this study illustrates that the Mill Brook headwater and two tributaries remain consistently cool, and that solar heating of the impoundments monitored along the Mill Brook raises the water temperature to levels lethal to cold water species.

Conclusions and Recommendations:

1. Within the 2 ½ acres of existing Mill Pond, investigate the concept of a pond separate from, but co-located with, a free flowing Mill Brook. This would require qualified engineering and environmental assessment. This concept could maintain recreational and aesthetic purposes at Mill Pond dam, while reducing solar heating and restoring the ecology of the stream in this location. This third alternative deserves the same consideration as previously explored concepts of dam removal and dredging.

2. Facilitate and work with willing landowners to remove dams located on public and private property.

3. Educate landowners on the importance of stream buffers of canopy and understory vegetation along the stream and impoundment edges.

WATER TEMPERATURE AND DISSOLVED OXYGEN KEY FINDING:

Dissolved oxygen is a critical component used to assess water quality. This portion of the initial study forms a baseline as part of an overall water quality index which includes pH, temperature and conductivity. While the temperature data illustrates temperature fluctuations along the Mill Brook, additional data collection of dissolved oxygen levels, particularly afternoon measurements, at multiple locations along the brook is necessary for a complete assessment of aquatic health in this system.

Conclusions and Recommendations:

1. Collect continuous data of dissolved oxygen levels in summer season at multiple locations (above and below the impoundments) along the brook. This will capture conditions found in the higher afternoon water temperatures and fill the data gap.

BIOLOGICAL ASSESSMENTS KEY FINDING:

There are data gaps due to collection methodology - when, where, and how sampling occurred.

Conclusions and Recommendations:

1. Macroinvertebrate sampling should occur on a scheduled basis over time. These studies should include sampling throughout the year, varied sampling sites, kick net and drop net sampling techniques, long term storage of specimens in glass vials containing 70% ethanol.

<u>BATHYMETERY KEY FINDING</u>:

As illustrated in Figure 28, bathymetry data gathered by Kent Healy and Bill Austin annually from April of 2014 to May of 2017 indicates no measurable change in water depths at Mill Pond.

<u>Conclusions and Recommendations</u>:

1. Continue to collect Mill Pond bathymetry data on an annual basis.

2. Bathymetry data shows that the Mill Pond is not filling in with sediment. It appears to be growing in with vegetation. The Town could work with NHESP (Natural Heritage Endangered Species Program) to develop a vegetation management plan to address the *Decadon verticillata* (water willow) population as well as invasive species such as *Salix cinerea* (gray willow).

<u>LAND USE AND DEVELOPMENT WITHIN THE MILL BROOK WATERSHED KEY FINDING</u>:

Within the Mill Brook watershed, in 1985 there were 255 houses; in 2005, 360; and future build-out based on existing zoning predicts 507 houses. Combined with the existing levels of phosphorus, increased nitrogen from development and other sources could lead to the production of algae and other aquatic plants, including invasives. To help mitigate the impacts of development, agricultural use and the management of these nitrogen and phosphorus sources, the town should be more proactive in its land protection practices. For example, the town could develop a plan to strategically acquire highly sensitive, undeveloped parcels of land within the watershed to be preserved as conservation land while also allowing for creative affordable housing solutions. Community Preservation Act funds are available for these purposes.

<u>Conclusions and Recommendations</u>:

1. The Town of West Tisbury should maintain and monitor a prioritized land acquisition list and collaborate with conservation groups to strategically acquire highly sensitive undeveloped parcels of land within the watershed.

2. Educate farmers and other landowners on best management practices for agricultural land use within the watershed. Farmers could work with Natural Resource Conservation Service (NRCS) and MV Ag Society (MVAS) to develop plans and receive funding support for these practices.

3. Educate landowners on the benefits of native meadows and reduced-sized lawns that require less fertilizer and water while supporting native species.

4. Educate interested landowners on the potential benefits of dam removal to improve natural sediment transport, to allow the free movement of organisms and their food sources within the stream, and to restore cold water stream characteristics.

14. Committee Members

This work could not have been completed without the commitment and dedication of the following people:

Chuck Hodgkinson and Cynthia Mitchell, Co-Chairs
Tim Boland
Prudy Burt
Kristen Fauteux
Selena Roman
Rez Williams
Early participation from Nancy Huntington, Sue Hruby and John Christensen

Kent Healy and Bill Wilcox, Consultants

15. Appendix

- ESS Report.
- BiodiversityWorks Report.
- Greg Whitmore Macroinvertebrate Data Analysis.
- Prior reports referenced and on file at the Town website as outlined on pages 3, 4. http://www.westtisbury-ma.gov/Boards/mill-brook.html