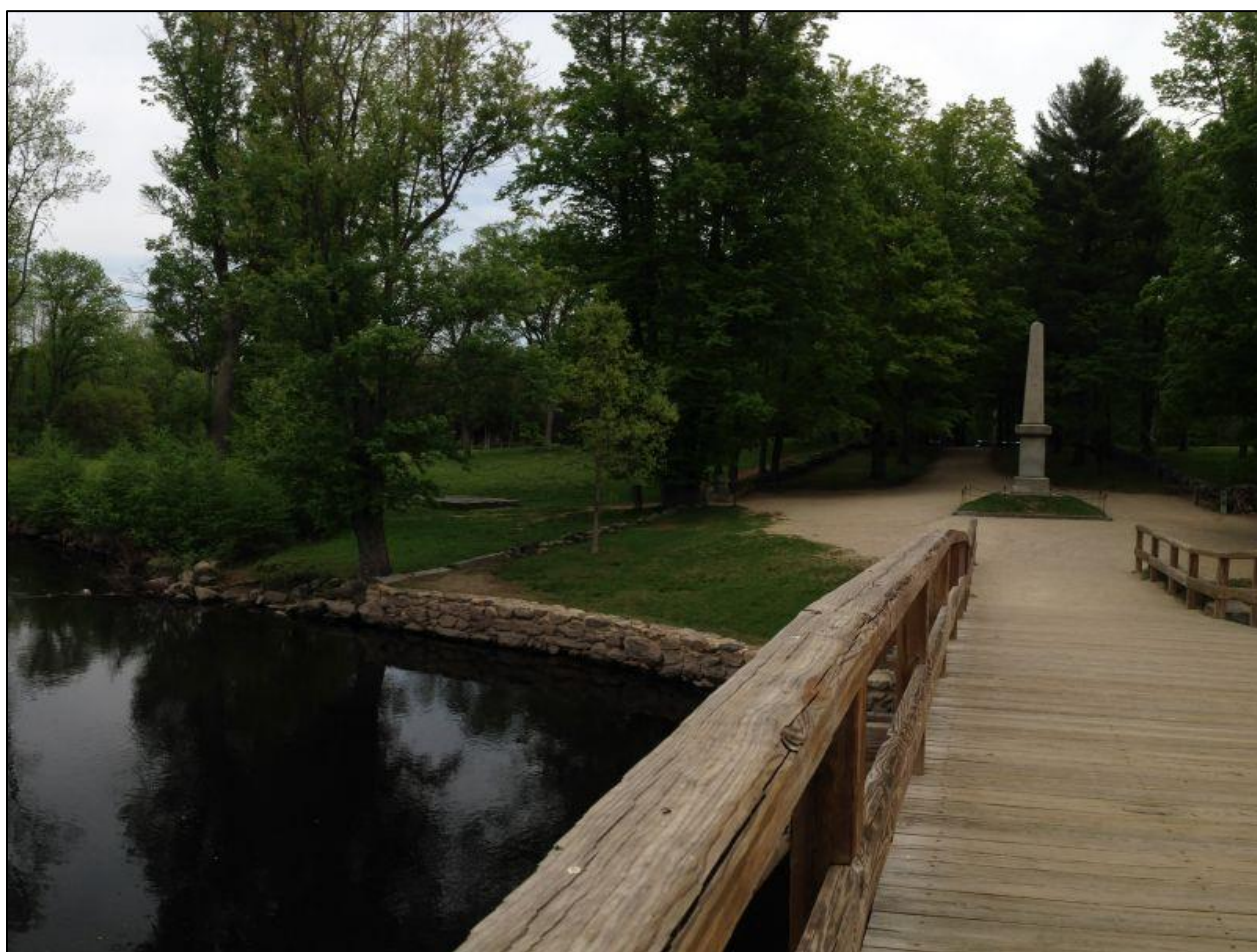




# Water Quality Monitoring at Minute Man National Historical Park

## *Northeast Temperate Network 2014 Summary Report*

Natural Resource Data Series NPS/NETN/NRDS—2016/1023



**ON THE COVER**

Concord River, May 2014

Photograph by: Hali Roy

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# **Water Quality Monitoring at Minute Man National Historical Park**

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Natural Resource Data Series NPS/NETN/NRDS—2016/1023

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

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## Executive Summary

This report on the water quality of Minute Man National Historical Park (MIMA) includes data gathered by the Northeast Temperate Network (NETN) in the 2014 monitoring season and displays these results in graphic form, accompanied by a brief interpretation. The data address the NETN objective to detect change in the status of physical, chemical, or biological attributes of park freshwater bodies.

The NETN Freshwater Monitoring Protocol calls for a total of three park streams to be sampled monthly from May through October at MIMA. Staff measured physical and in-situ water chemistry parameters each month and periodically collected water samples for analysis at the University of Maine's Sawyer Environmental Chemistry Research Laboratory.

Monthly sampling parameters included in-situ water quality measures (pH, specific conductance, temperature, dissolved oxygen, and turbidity), weather, stream flow (discharge), and stream stage. In May and August, water samples were obtained and analyzed for acid neutralizing capacity (ANC), color, nutrients, dissolved organic carbon (DOC), chloride, and sulfate.

Most water quality parameters for the monitored streams were within state standards, and were generally within the ranges of the historic NETN monitoring data from MIMA. Exceptions were the high temperatures in July at Mill Brook and Elm Brook, and the low DO readings from Mill Brook (June and July) and the Concord River (July). Additionally, although there is no state standard for chloride, the values were very high and likely reflect runoff of road de-icing chemicals.

ANC measurements showed that all streams had sufficient buffering to avoid severely depressed pH values from spring snowmelt and runoff that can contribute acidity and sediment to the stream water. Test results for TN and NO<sub>3</sub> were moderately high in most 2014 samples. Results for NO<sub>2</sub> were low at all sites. All ammonia (NH<sub>3</sub>) test results were below the method reporting limit of 0.08 mg/L. All total phosphorus results for 2014 were high and significantly above the EPA Region 14 criterion of 31.25µg/L. These results indicate that some nutrient enrichment is occurring in MIMA streams.



## Introduction

This report on the water quality of Minute Man National Historical Park (MIMA) generated by the Northeast Temperate Network (NETN) Water Quality Monitoring Program includes data gathered in the 2014 monitoring season and displays these results in graphic form, accompanied by a brief interpretation. Appendix A contains tabular data collected in 2014.

The vital signs for freshwater bodies included in the original NETN Freshwater Monitoring Protocol (Lombard et al. 2006) are water chemistry, nutrient enrichment, water quantity, and the detection of invasive plant species. These metrics were chosen to address the NPS Inventory and Monitoring Program objective to detect change in the status of physical, chemical, or biological attributes of the ecosystem.

The NETN Freshwater Monitoring Protocol calls for a total of three park streams to be sampled monthly from May through October at MIMA. Two NETN Student Conservation Association (SCA) interns measured physical and in-situ water chemistry parameters each month and periodically collected water samples for analysis at the University of Maine's Sawyer Environmental Chemistry Research Laboratory. All monitoring data are incorporated into a series of comprehensive databases that ultimately feed the U.S. Environmental Protection Agency's "STORET" data system, the repository for all NPS water quality and quantity data.

## Sampling Sites

Two streams, Mill Brook and Elm Brook, and one river, the Concord River, cut through MIMA (Figure 1). One water quality monitoring site was selected on each of these water bodies for the NETN monitoring program (Table 1). The monitoring site on Mill Brook (MIMASA) is located upstream of Lowell Road. The Mill Brook monitoring site is not located within park boundaries because the brook is intermittent where it flows through the Wayside Unit, and it becomes a wetland where it flows through the North Bridge Unit (Lombard et al 2006).

The site on Elm Brook (MIMASB) is within park boundaries at State Route 2A, 4.3 miles upstream from the confluence of Elm Brook with the Shawsheen River. The sampling results represent water quality conditions in Elm Brook within the park's Battle Road Unit (Lombard et al 2006).

The Concord River site (MIMASC) is at the Old North Bridge, 0.49 miles downstream from the confluence of the Sudbury and Assabet Rivers. The site is within the Minute Man NHP boundary and sampling results are intended to represent water quality conditions in the Concord River within the park's North Bridge Unit. Discharge measurements cannot be made by wading because of the size of the river, and this site also requires specialized techniques to obtain water quality sonde samples.

Mill Brook and Elm Brook are classified as capable of supporting cold water fisheries (National Park Service 1993), loosely defined as waters that can support, on a year-round basis, wild and stocked brook trout (*Salvelinus fontinalis*) or other species requiring similar conditions. The Concord River is considered capable of supporting warm water fish (bass, pickerel, sunfish).

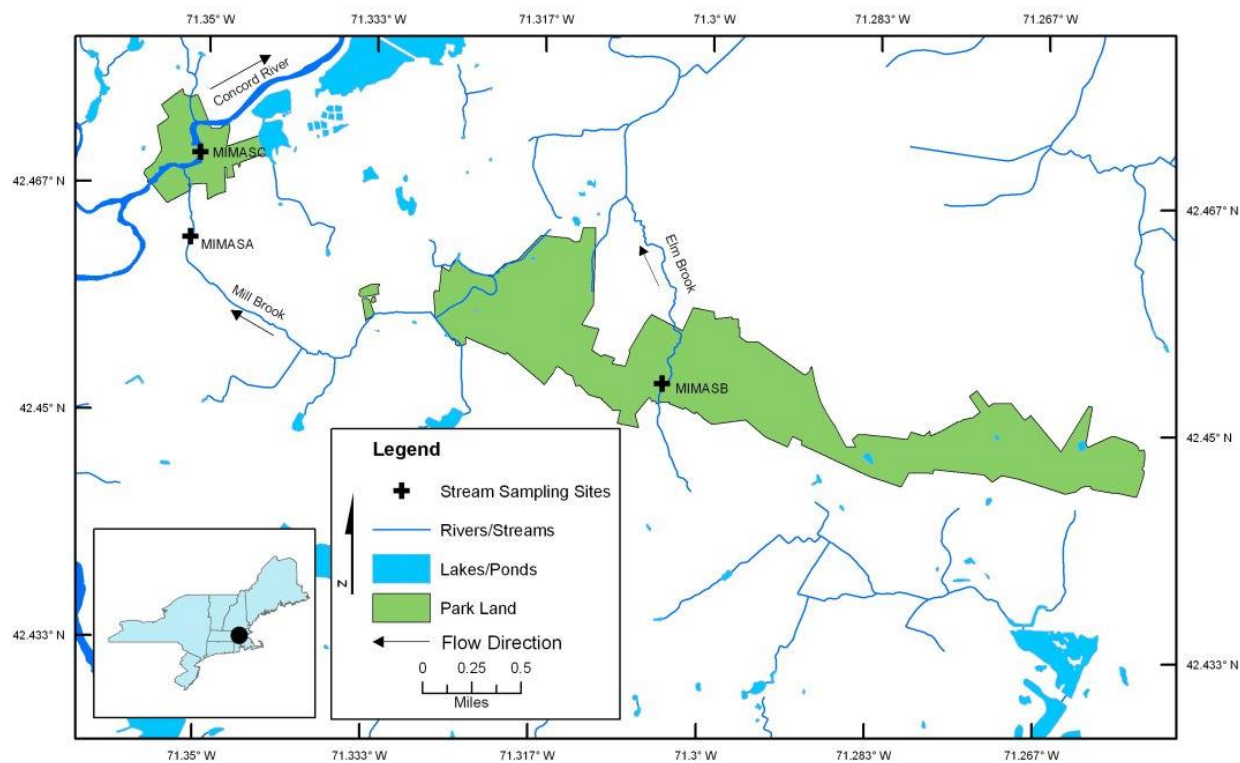


**Figure 1.** Map of water monitoring sites at Minute Man NHP.

**Table 1.** Water quality monitoring sites at Minute Man NHP.

| Waterbody                | NETN Site Code | Latitude   | Longitude   | Site Remarks         |
|--------------------------|----------------|------------|-------------|----------------------|
| Mill Brook (Stream A)    | MIMASA         | 42.4628000 | -71.3514167 | Cold water fisheries |
| Elm Brook (Stream B)     | MIMASB         | 42.4529333 | -71.3042167 | Cold water fisheries |
| Concord River (Stream C) | MIMASC         | 42.4690166 | -71.3506333 | Warm water fisheries |

## Methods

Detailed descriptions of all monitoring methods are found in the original protocol (Lombard et al. 2006) and the most recent protocol update (Gawley et al. 2014). Monthly sampling parameters included in-situ water quality measures (pH, specific conductance, temperature, and dissolved oxygen) determined with a YSI 600XL sonde, turbidity measured with a LaMotte 2020e meter, weather, stream flow (discharge), and stream stage (water level). In May and August, water samples were obtained and analyzed for acid neutralizing capacity (ANC), color, and nutrients. Beginning in 2012, fractions of these water samples were also analyzed for dissolved organic carbon (DOC), chloride, sulfate, and chlorophyll *a*. Nutrient chemistry parameters were analyzed from a grab sample obtained by submerging the sample bottle directly in the stream with a gloved hand. Concord River samples were collected from the bridge using a VanDorn-type water sampler suspended on a line.

Stream discharge was measured using U.S. Geological Survey protocols (Rantz et al 1982), employing a measuring tape, wading rod, and a SonTek FlowTracker current meter (a Price Pygmy current meter may be used when conditions are not suitable for a FlowTracker) to measure a particular cross-sectional area of the stream and the velocity of the water at that cross section. Discharge measurements of the Concord River could potentially be made off of the Old North Bridge, although bridge measurements are too expensive for NETN to cover at this time. Concord River stage was obtained by lowering a measuring tape from a specified point on the bridge to the surface of the water. Stream stage at the two smaller streams was measured by using a measuring tape or folding ruler to “tape down” or “tape up” from a fixed datum point to the surface of the water, or by reading the water level off of a staff gauge. Bolts were installed to permanently mark the Elm Brook and Mill Brook datum points in July 2012.

In-situ stream water chemical and physical measurements and water samples were collected within 5 meters from the location of the discharge measurement. Sonde measurements were taken in the main stream flow with care taken that the sonde was not resting directly on the stream bottom. In the Concord River, sonde measurements were taken from the bridge at each monitoring visit to better characterize river conditions. This was a deviation from the protocol, which calls for two sonde measurements (from pylons 2 and 4) at each visit. The protocol also calls for a seven-point set of cross-sectional measurements taken (at varied depths) once each year to confirm that the two-point measurement strategy is still representative.

## Water Quality Standards

Massachusetts surface water quality standards designate Class A waters as “excellent habitat for fish, other aquatic life and wildlife, and suitable for primary and secondary contact recreation” (Massachusetts Department of Environmental Protection 2013). ORW is used to denote those waters, other than Public Water Supplies, designated for protection as outstanding resources. The DO concentrations of Class A waters “shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions.” Temperature “Shall not exceed 68° F (20° C) based on

the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring... Temperature shall not exceed 83°F (28.3°C) in warm water fisheries... pH shall be in the range of 6.5 through 8.3 standard units but not more than 0.5 units outside of the natural background range... These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.” (Massachusetts Department of Environmental Protection 2013).

**Table 2.** Massachusetts stream water quality standards.

| Water quality class code | MaxTemp (°C)               | Min Dissolved Oxygen (mg/L) | pH Range (standard units) | Maximum Total Nitrogen (µg/L) | Maximum Total Phosphorus (µg/L) | Color (color units, platinum-cobalt method) | Turbidity (NTU)                           |
|--------------------------|----------------------------|-----------------------------|---------------------------|-------------------------------|---------------------------------|---------------------------------------------|-------------------------------------------|
| A                        | 20.0 (cold)<br>28.3 (warm) | 6.0 (cold)<br>5.0 (warm)    | 6.5-8.3                   | As naturally occurs           | As naturally occurs             | Not objectionable and does not impair use   | Not objectionable and does not impair use |

EPA Ecoregion 14 water quality criteria (Table 3; U.S. Environmental Protection Agency 2000) are also used as a benchmark in this report. EPA water quality criteria for nutrients help translate narrative criteria within State or Tribal water quality standards by establishing values for causal variables (e.g., total nitrogen and total phosphorus) and response variables (e.g., turbidity and chlorophyll *a*). Causal variables are necessary to provide sufficient protection of designated uses before impairment occurs and to maintain downstream uses. Early response variables are necessary to provide warning signs of possible impairment and to integrate the effects of variable and potentially unmeasured nutrient loads (U.S. Environmental Protection Agency 2002).

**Table 3.** EPA Ecoregion 14 nutrient criteria for streams.

| Nutrient Criteria | Value      |
|-------------------|------------|
| Total Phosphorus  | 31.25 µg/L |
| Total Nitrogen    | 0.71 mg/L  |

These criteria were developed specifically for Ecoregion 14 (which includes Minute Man NHP, Saugus Iron Works NHS, and Weir Farm NHS) and are designed to represent conditions of surface waters that are minimally impacted by human activities and thus protect against the adverse effects of nutrient over-enrichment from cultural eutrophication. The values are EPA’s scientific recommendations regarding ambient concentrations of nutrients that protect aquatic resource quality. They do not have any regulatory impact or meaning.

The criteria were established based on the lower 25<sup>th</sup> percentile of streams for which the EPA found data. This percentile of all streams is expected to approximately correspond to the 75<sup>th</sup> percentile of reference (undisturbed) streams. In other words, 75% of streams in the ecoregion do not meet the criteria, nor do roughly 25% of reference streams. (U.S. Environmental Protection Agency 2000).

## Results

Monitoring results for 2014 are displayed in scatter-plot graphs showing all data for each site for a given parameter. The scatter plots of 2014 data are overlaid on box plots representing the overall range and distribution of data values collected from 2006 through 2014 for the specified parameter and site (Appendix A contains all data in tabular form). A box plot (Figure 2) is a summary plot that graphs data as a box representing statistical values. The boundary of the box closest to zero indicates the 25<sup>th</sup> percentile, a line within the box marks the median, and the boundary of the box farthest from zero indicates the 75<sup>th</sup> percentile. Whiskers (error bars) above and below the box indicate the 90<sup>th</sup> and 10<sup>th</sup> percentiles respectively. Outliers are displayed as black filled circles. At least nine data points are required to compute the 5<sup>th</sup>, 10<sup>th</sup>, 90<sup>th</sup> and 95<sup>th</sup> percentiles. If a percentile point cannot be computed, that set of points is not drawn. If EPA or other water quality criteria exist for a particular parameter they are displayed on the graphs as specification lines.

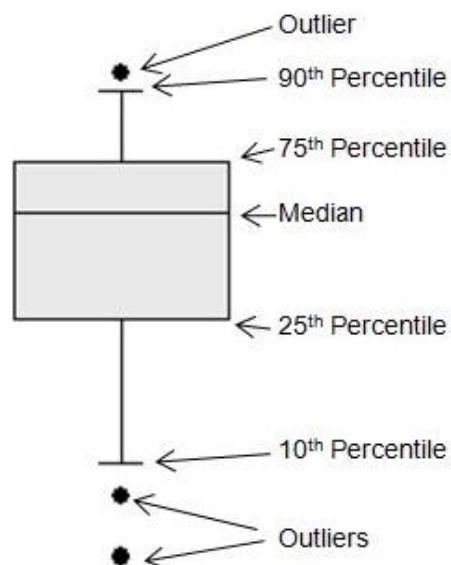


**Figure 2.** Explanation of box plot graph

### Water Quality

Measures of water quality include specific conductance, pH, water temperature, dissolved oxygen (DO), acid neutralizing capacity (ANC), and apparent color. Assessment of water quality data aids in the interpretation of the biotic condition and ecological processes of surface water resources.

#### ***Specific Conductance***

Specific conductance (Figure 3) is a measure of the ability of water to carry an electrical current, and is directly related to the level of dissolved ions in the water. An increase in specific conductance can be an indicator of pollutants in the water. Naturally occurring values range from less than 20 to more than 1,000 microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ). Specific conductance values from 2014 were within the appropriate range for high ionic strength waters. Mill Brook yielded high values in June,

August, and September (highest recorded at this site), with a low value in July. Specific conductance levels were also high at Elm Brook in May, June, and August. The highest specific conductance value for the Concord River since NETN began monitoring there was recorded in October.

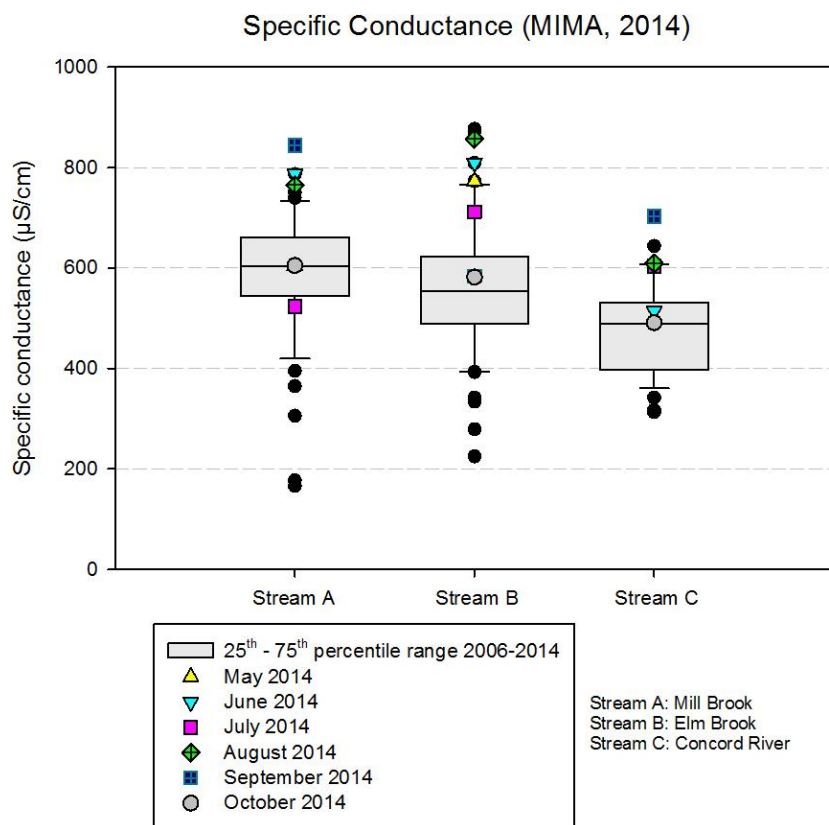


**Figure 3.** Specific conductance from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

### pH

The pH of a water body reflects how acidic or basic the water is, measured on a scale of 1 to 14, with 7 being neutral. Acid waters are below 7, and alkaline waters are above 7. A one unit change in pH represents a 10-fold change in acidity or alkalinity. Massachusetts standards, similar to those of most northeast states, indicate that a pH between 6.5 and 8.3 is within the acceptable range. pH values from the 2014 monitoring season (Figure 4) were circumneutral or slightly acidic and all but the July Mill Brook measurement were between the upper and lower Massachusetts water quality standards.

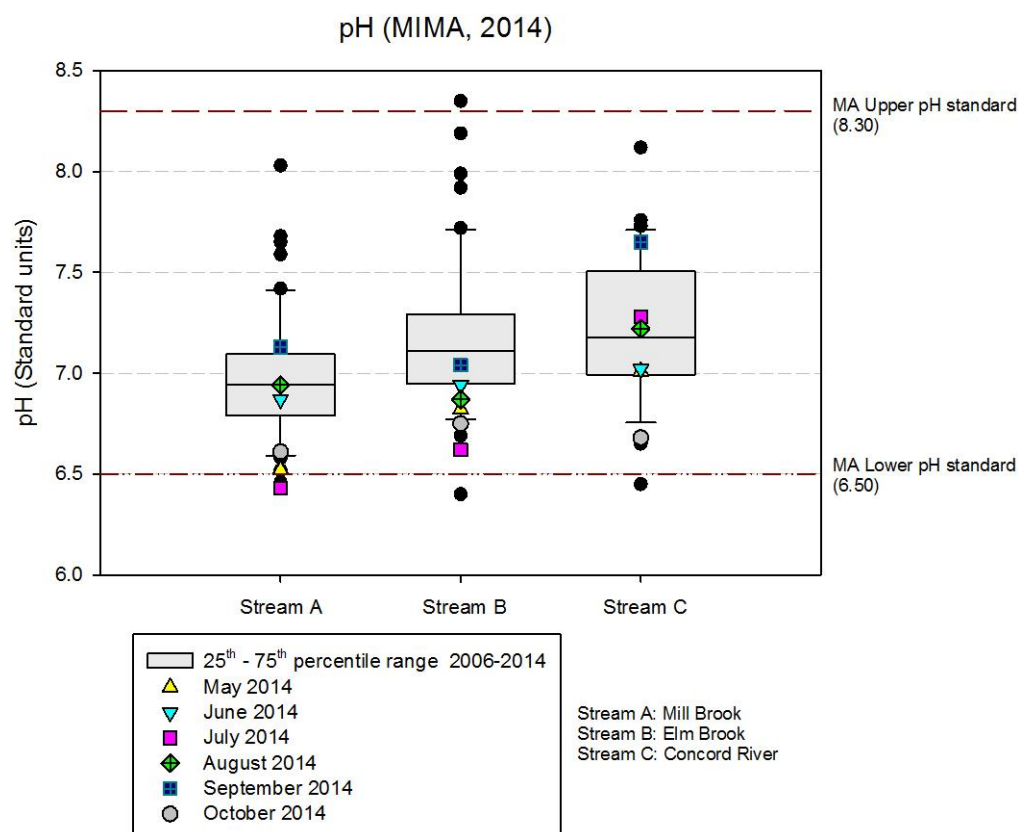


**Figure 4.** pH from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

### Temperature

Temperature can affect water chemistry and biology. For example, the amount of oxygen that water can hold is directly related to the temperature of the water. The higher the temperature, the less oxygen water can hold, which can be observed in both diel (day and night) and seasonal shifts. Oxygen will naturally decline during the summer months as water temperatures rise. Temperature can also determine the kinds of plants and animals found in the lake or pond. Certain species of fish, insects, and algae will predominate during the cooler temperatures of the spring and fall, yet be less apparent during the warmer temperatures of summer. Surface water temperatures in 2014 (Figure 5) were generally within the state water quality standards for the appropriate stream types, except in July and August at Mill Brook and July at Elm Brook (both streams classified as being able to support cold-water fisheries). The Concord River had the highest temperatures recorded in June, July, and August but still met the warm-water fisheries standard. The generally high July and August temperatures likely reflected the contributions of low flow and high air temperature.

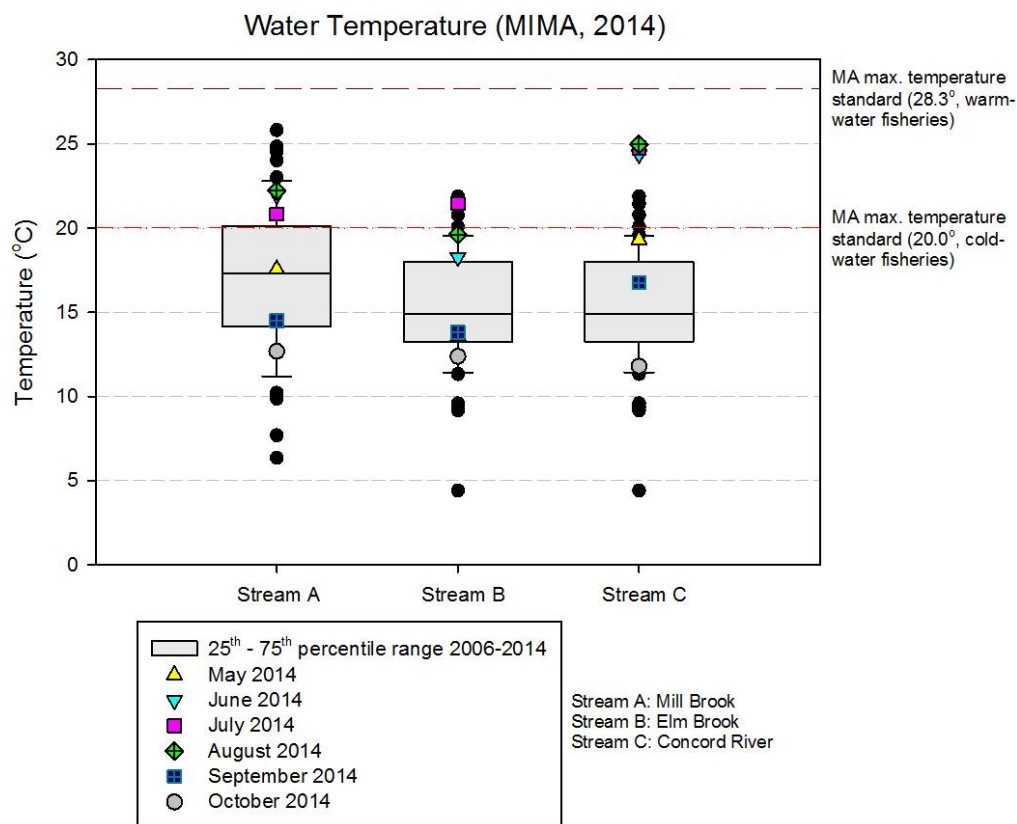


**Figure 5.** Water temperature (surface) from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

### ***Dissolved Oxygen***

Dissolved oxygen (DO) is a critical indicator of water quality because aquatic life generally needs DO concentrations at or above 5 mg/L to thrive. Low oxygen can directly kill or stress organisms such that they will not be able to successfully reproduce or grow. Water with less than 1 part per million (ppm) of oxygen is considered anoxic (no oxygen present). Elm Brook (Stream B) was well oxygenated throughout 2014 (Figure 6), and most measurements from the two other sites were above the (6 mg/L) state DO standard. The May and July measurements from Mill Brook (Stream A) were slightly below the state DO standard.

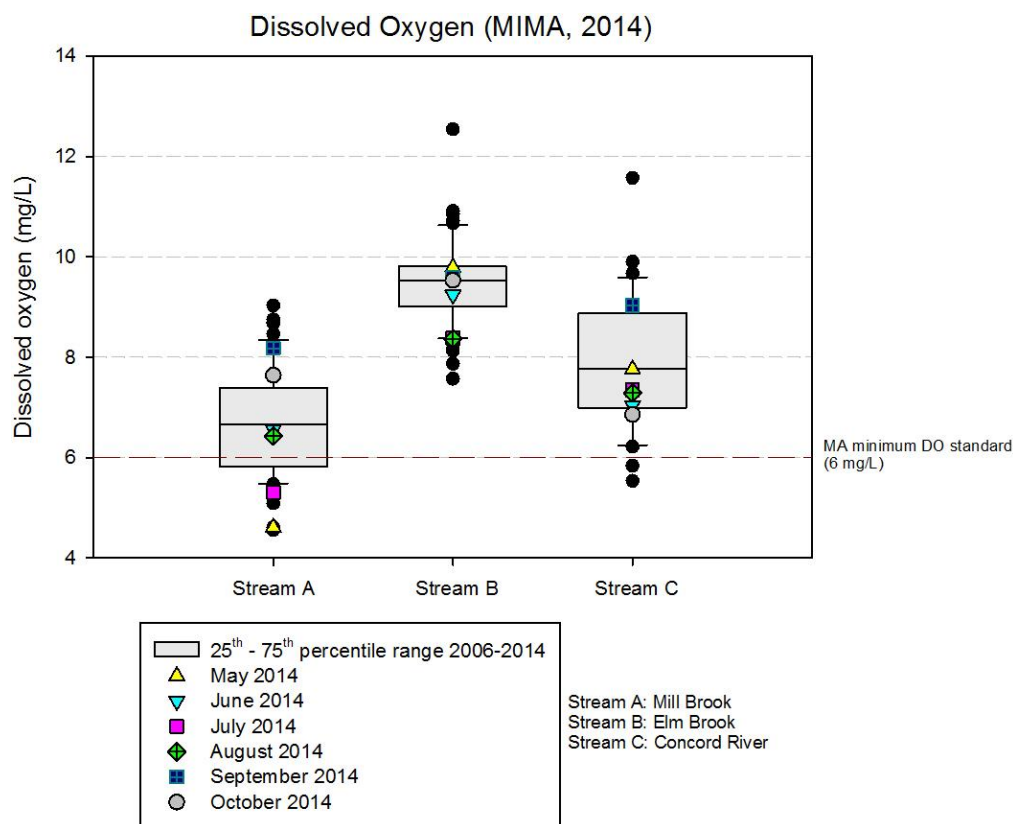


**Figure 6.** Dissolved oxygen (surface) from 2014 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2014.

### ***Acid Neutralizing Capacity***

Acid neutralizing capacity (ANC) is also known as alkalinity, or buffering capacity. It is due primarily to the presence of naturally available bicarbonate, carbonate, and hydroxide ions, with bicarbonate being the major form. Most states do not have numerical criteria for ANC in their water-quality standards. ANC values greater than 100  $\mu\text{eq/L}$  are considered well-buffered, while values less than zero typify acidic waters (Stoddard et al. 2003). Acid neutralizing capacity measured in the 2014 samples (Figure 7) illustrates that MIMA streams were well-buffered, likely due to the underlying geology. May (spring) 2014 ANC measurements follow the typical seasonal pattern of being lower than August (summer) values. This effect is likely due to the contribution of episodic acidification from spring snowmelt and runoff (and also illustrates the ability of the robust ANC to counteract the acidification pulses).

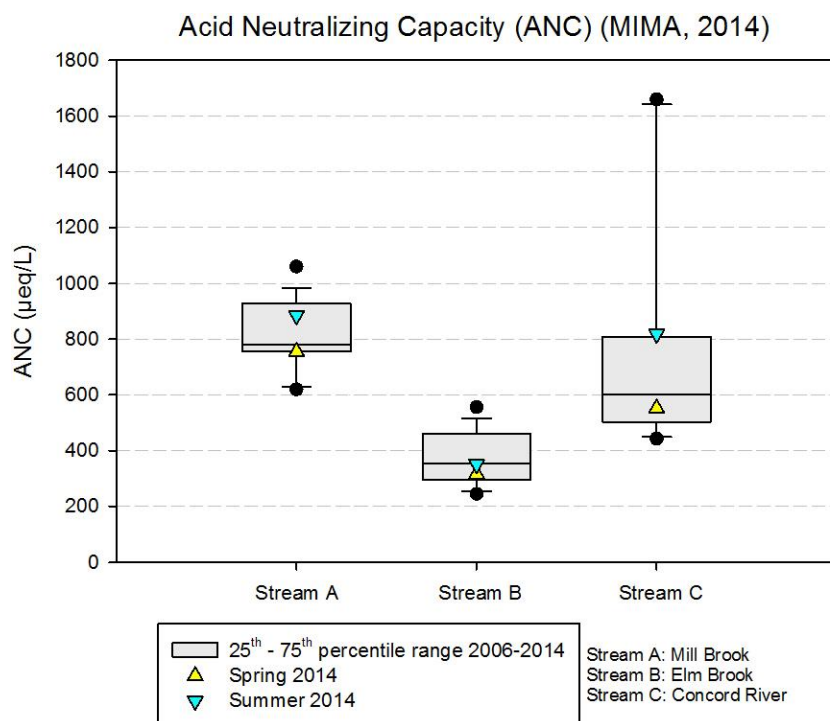


**Figure 7.** Acid neutralizing capacity from 2014 water samples overlaid on a box plot of measurements taken from 2006-2014.

### **Apparent Color**

Color in pond and stream water is caused by natural metallic ions, humus and peat materials, plankton, weeds, and industrial wastes. Color is reported in Pt-Co units (PCU). True color is the color measurement of water from which suspended particles have been removed by filtration. Apparent color (the measurement method utilized by NETN) is determined on original samples without filtration. Color can be a rough indicator for organic acidity.

Water bodies with apparent color values of greater than 25 PCU are considered to be highly colored, and often exhibit reduced water clarity and high phosphorus concentrations. Values of color are usually not included in water quality standards, except to note that they should be “as naturally occurs”.

Median color values from 2006 to 2014 monitoring (Figure 8) show that MIMA streams tend to be highly colored. At two of three sites (Mill Brook and Elm Brook), spring measurement values were higher than summer values. Because the samples were not filtered before analysis, the color can be due to runoff and sediment input to the streams (although corresponding turbidity measurements were near historic median values); or dissolved constituents.

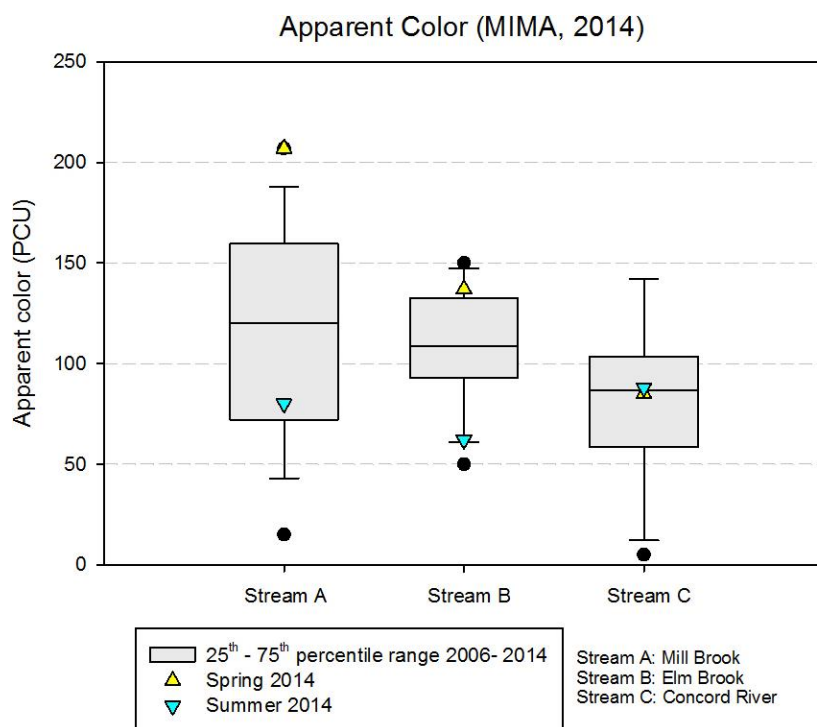


**Figure 8.** Apparent color from 2014 water samples overlaid on a box plot of measurements taken from 2006-2014.

### ***Dissolved Organic Carbon***

NETN began measuring dissolved organic carbon, a nutrient required for biological processes, in 2012. Sources of organic carbon in water include humic substances from plant and soil organic matter, wetland peat deposits, and atmospheric deposition. Certain forms of DOC can contribute to “tea” color in water, which can affect light attenuation. DOC is also an important part of the energy balance and acid-base chemistry in many freshwater systems. It also affects the transport (solubility and bioavailability) of metals, including mercury, in aquatic systems.

DOC concentrations in most streams in temperate zones range from 1 mg/L to 20 mg/L, with a worldwide mean of 5.75 mg/L (Meybeck 1982). MIMA DOC concentrations (Figure 9) were moderate but variable in 2014.

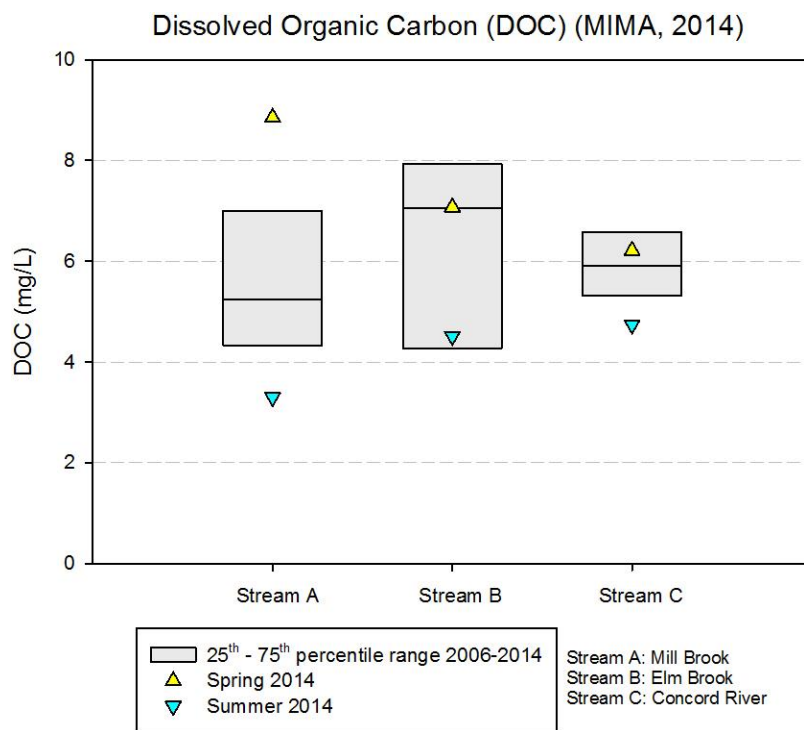


**Figure 9.** Dissolved organic carbon (DOC) from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014.

### ***Turbidity***

Turbidity is the measure of the relative clarity of a liquid. It is measured by passing light through a water sample to determine how much light is scattered, and the results are reported in nephelometric turbidity units (NTU). Turbidity is caused by suspended matter or impurities that interfere with the clarity of the water. These impurities may include clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, and plankton and other microscopic organisms. In natural waters, turbidity is often used as an indicator of water quality and productivity. Turbidity is measured in the field using an electronic meter.

Turbidity in the water can create aesthetic, ecological, and health issues. Turbid water may indicate runoff from construction, roads, agriculture or other types of pollution. Suspended sediment can carry nutrients and pesticides throughout the water system. Suspended particles near the surface absorb additional heat from sunlight, raising the water temperature. High turbidity levels can reduce the amount of light reaching lower depths of lakes and streams, which can inhibit growth of submerged aquatic plants, and reduce dissolved oxygen levels. Suspended materials can clog fish gills, affecting fitness, growth, and reproduction (U.S. Environmental Protection Agency 1997). Turbidity values measured in all MIMA streams during 2014 (Figure 10) were all in the low range of dry-weather turbidity of surface waters, which normally ranges from 0 to 10 NTU (U.S. Environmental Protection Agency 1999). Mill Brook had the highest (June) turbidity values while the Concord River had the lowest measured turbidity in October.

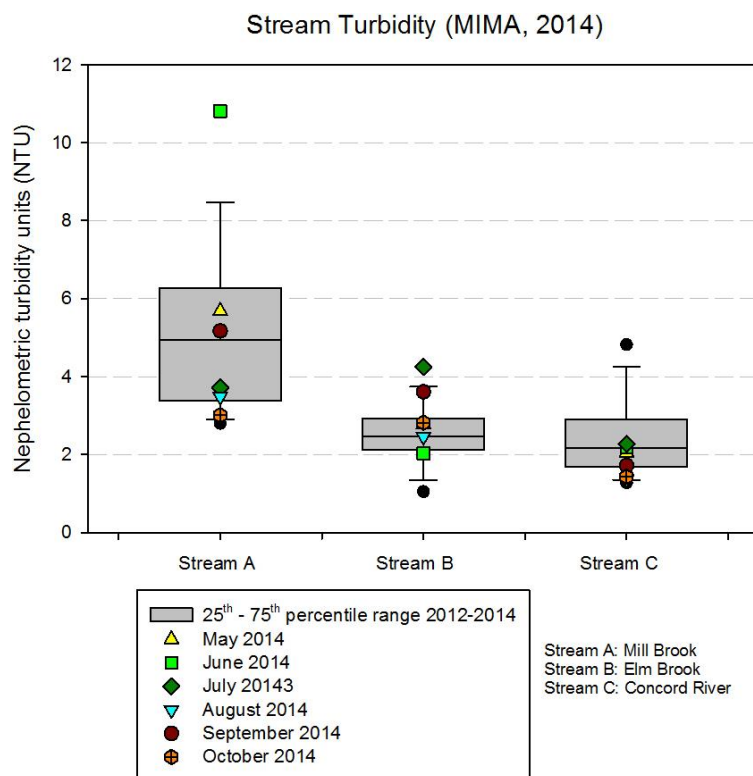


**Figure 10.** Stream turbidity from 2014 monthly measurements. The data are overlaid on a box plot of measurements taken from 2012-2014.

## Nutrient Enrichment

Nutrient enrichment and the acceleration of eutrophication have been identified in most NETN parks as one of the stressors of greatest concern. Total phosphorus and several forms of nitrogen are measured to give managers information regarding the trophic status and productivity of freshwater systems.

### Phosphorus

Phosphorus (P) is one of the major nutrients needed for plant growth. It is generally present in small amounts in natural systems and limits the plant growth in streams and ponds. Total phosphorus (TP) is a measure of both inorganic and organic forms of phosphorus, and is the common water quality standard or criteria metric. Although several forms of phosphorus were tested individually since 2006, tests for total dissolved phosphorus (TDP) and soluble reactive phosphorus (SRP) were discontinued in 2012.

During the spring of 2014, the phosphorus measurements at Mill Brook was above the 95<sup>th</sup> percentile (Figure 11), and field notes stated the stream was at bank-full stage and “smelled like sewage”. Elm Brook and the Concord River TP values were within the 25<sup>th</sup> to 75<sup>th</sup> percentile range during this same period. The summer 2014 reading for Mill Brook was within the long-term range for phosphorus, while Elm Brook and the Concord River were below the long-term range. All TP values were above the EPA Region 14 criterion of 31.25µg/L, with the summer measurement from the Concord River

being the lowest recorded. As described above (“Water Quality Standards”), the EPA criteria do not have any regulatory meaning. There are no numeric Massachusetts TP standards.

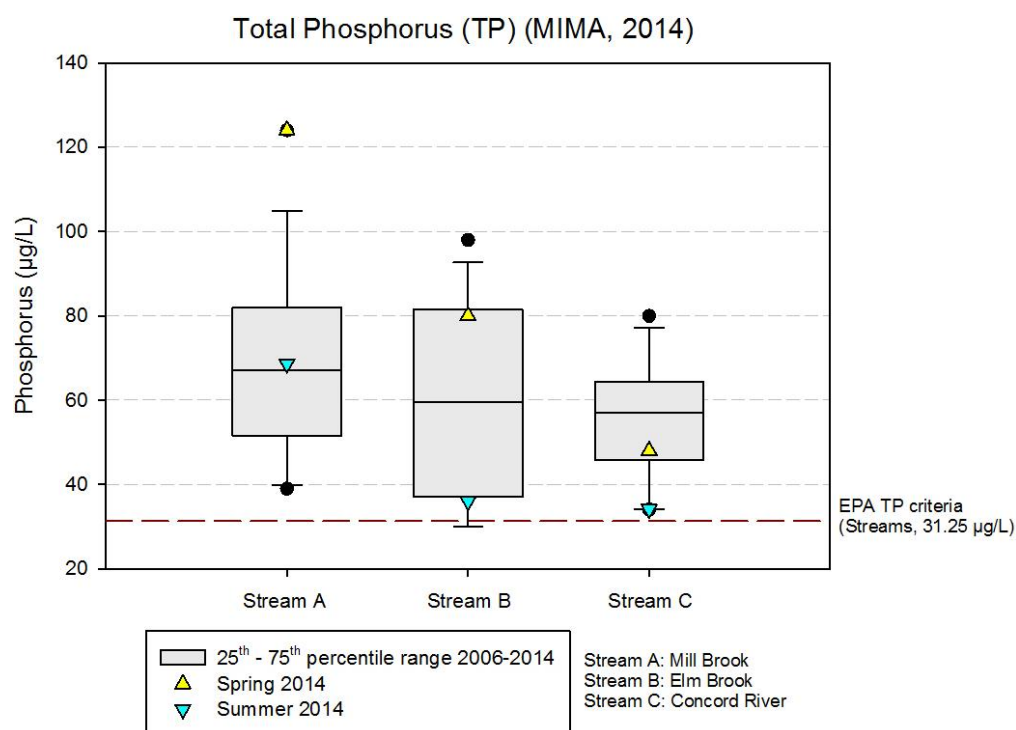


**Figure 11.** Total phosphorus (TP) from spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2014.

## Nitrogen

Total nitrogen (TN) is a measure of all forms of nitrogen (organic and inorganic). Nitrogen is an essential plant element and is often the limiting nutrient in marine waters, and it can also limit some freshwater systems. The importance of nitrogen in the aquatic environment varies according to the relative amounts of the forms of nitrogen present, including nitrate, nitrite, and ammonia. Nitrate ( $\text{NO}_3$ ) is the most oxidized and stable form of nitrogen in a water body, and is the primary form of nitrogen used by plants as a nutrient. Nitrite ( $\text{NO}_2$ ) is an unstable form of nitrogen that is either rapidly oxidized to nitrate (nitrification) or reduced to nitrogen gas (de-nitrification). This form of nitrogen can also be used as a source of nutrients for plants. Ammonia ( $\text{NH}_3$ ) is generated by bacteria as a decomposition product of nitrogenous organic compounds, and is also readily assimilated by plants. Results of  $\text{NO}_3$ ,  $\text{NO}_2$ , and  $\text{NH}_3$  tests are all reported as the concentrations of the N component of these compounds, expressed in mg/L.

Test results for several forms of nitrogen are shown in Figure 12. All but three of the 2014 TN values exceeded the EPA Region 14 criterion of 0.71 mg/L, although as with TP this criterion does not have regulatory meaning. All of the TN results were below 2.0 mg/L, the value used as a TN standard in several northeast states (Massachusetts has no numeric TN standard). Nitrate was the predominant form of TN levels at all sites. Nitrite test results in all streams were low, and all 2014 ammonia test results were below the method reporting limit of 0.08 mg/L.

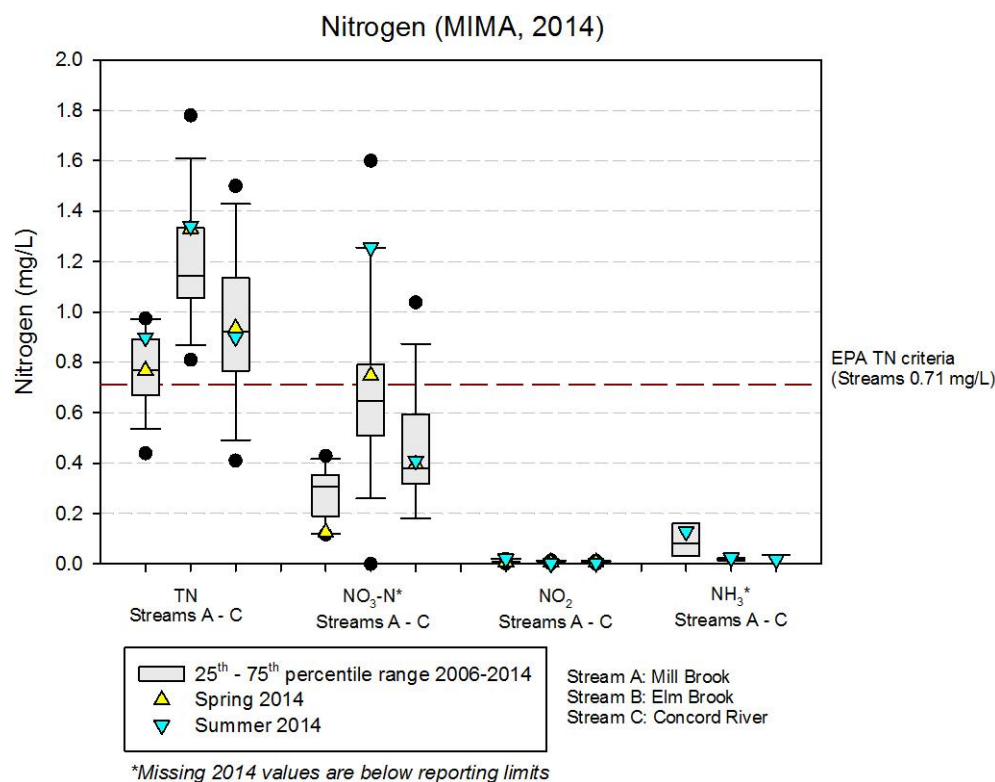


**Figure 12.** Total nitrogen (TN), nitrate (NO<sub>3</sub>-N), nitrite (NO<sub>2</sub>) and ammonia (NH<sub>3</sub>) from 2014 water samples. The data are overlaid on a box plot of measurements taken from 2006-2014.

## Other Analytes

### Chloride

Chloride is one of the major negatively-charged ions in fresh water systems. The chloride content of natural surface waters will depend to a great extent on the geology of the area. Concentrations are generally greater in lakes that are in proximity to marine regions. Another source of chloride is road run-off from de-icing materials. Chloride is important in terms of metabolic processes, as it influences osmotic salinity balance and ion exchange.

Average chloride concentration in natural fresh water is 234.1 µeq/L (Wetzel 1983). Chloride values in MIMA samples were extremely high in 2014 (Figure 13), especially at Mill Brook and Elm Brook, which are both in close proximity to major roads. Overall, measurements from 2014 exceeded the long-term median at all sites.

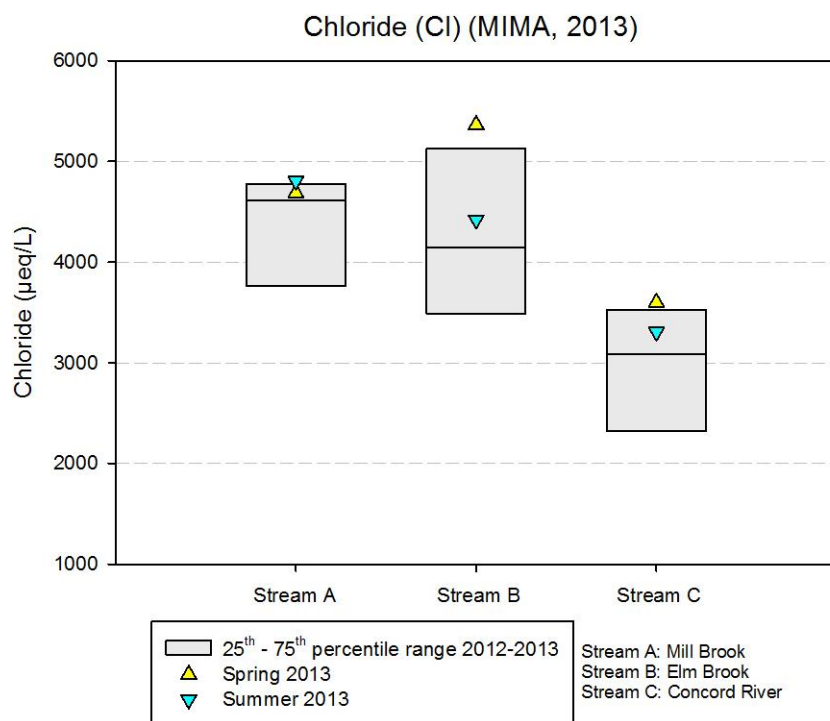


**Figure 13.** Chloride from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014

### Sulfate

Sulfate is found in most natural waters, originating from watershed geology and soils, and also from atmospheric transport and deposition (in precipitation) of by-products from the combustion of fossil fuels. Sulfate can play a major role in acidification of lakes and streams. Sulfate concentrations in atmospheric deposition have declined significantly since 1982, in part due to the 1995 implementation of Phase I controls of the Clean Air Act Amendments and in part to other long-term pollution reduction efforts (Kahl 1999).

The usual range of sulfate concentration in natural water is 104 µeq/L to 695 µeq/L (Wetzel 1983). Sulfate concentrations at MIMA ranged widely in 2014 (Figure 14), especially at Mill Brook where the summer measurement was well above the long-term 75<sup>th</sup> percentile.

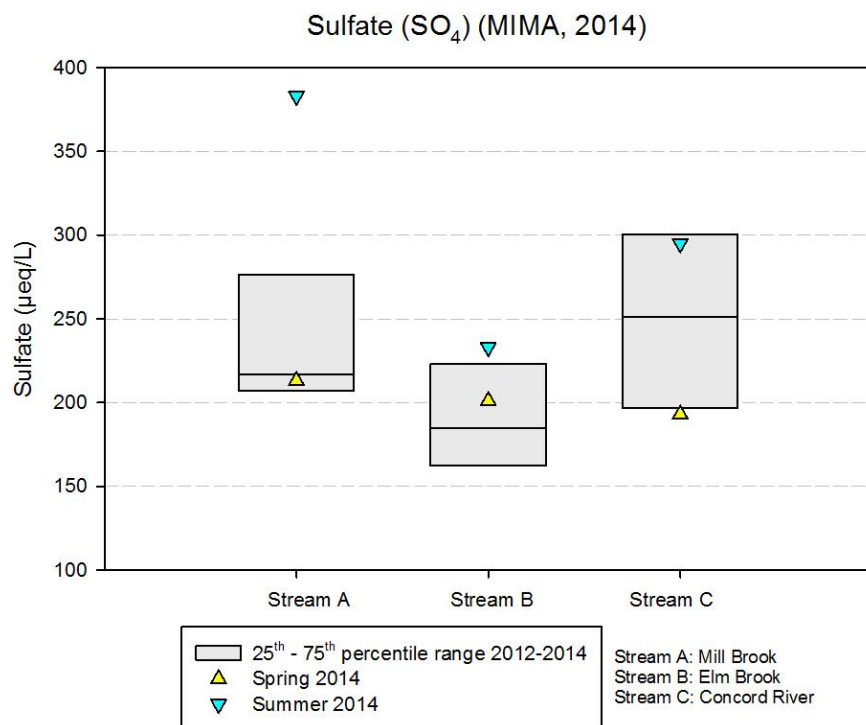


**Figure 14.** Sulfate from 2014 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2012-2014.

## Water Quantity

Monthly stream discharge measurements, taken with a current meter and wading rod, can be used to calculate loading of nutrient chemical constituents (flow x concentration), and also provide a record of variations in stream flow. Stream stage (height of water) measurements can be paired with discharge values and over time a stage to discharge relationship can be calculated. Once this relationship is established, investigators can interpolate the stream discharge from the stage measurement alone. Numerous discharge measurements at all ranges of streamflow are required to establish and maintain an accurate stage to discharge relationship. Stream stage measurements from 2014 are graphed in Figure 15.

NETN staff are continuing to review discharge and stage measurement methodology and quality assurance/quality control procedures in order to enhance the quality and utility of the water quantity data. A stage to discharge relationship graph will be produced once sufficient data are collected, although this may be difficult considering the limited ability to measure a wide range of flow conditions.

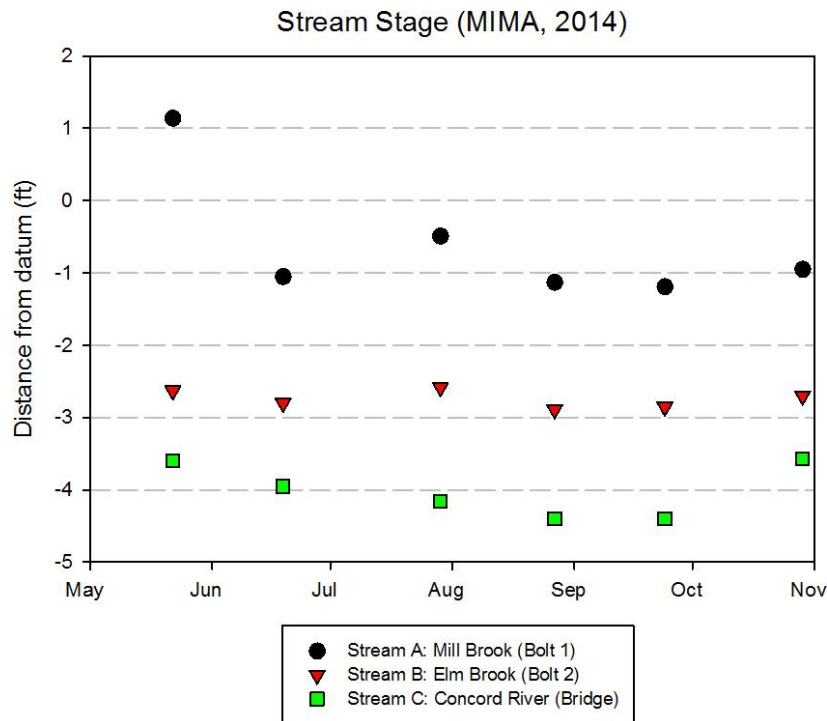


**Figure 15.** Stream stage obtained in 2014 by measuring from a permanent datum point to the water surface.

### Invasive Aquatic Plants

Invasive aquatic plant monitoring was not conducted at MIMA during the 2014 monitoring season, since the protocol specifies that targeted invasive aquatic plant monitoring is only conducted at pond and lake sites. However, during future visits to all NETN parks, monitoring crews will be increasingly attentive for the presence of Didymo (*Didymosphenia geminata*), also known as “rock snot,” a highly invasive algae species that has recently invaded the northern reaches of the Connecticut River in New Hampshire and the White River and Battenkill Rivers in Vermont. This species has a great potential to alter habitats and displace native species, and is of great concern to officials in regions where infestations have been established.

Didymo can easily be spread by waders and potentially by water monitoring equipment and other gear that touches the bottoms of streams in infested areas. Just one cell breaking off and drifting downstream can spread the algae. Enhanced equipment cleaning and decontamination procedures are included in the latest NETN monitoring protocol revision (Gawley et al. 2014).

Since non-native, invasive plants have recently been detected with increasing frequency in New England lakes and ponds, it has become crucial to closely monitor the status of park waters. The early detection of an infestation can make eradication or control more feasible, and it can lead to efforts that reduce the spread of the plant to neighboring water bodies. Designating the early detection of these plants as a NETN vital sign and the ongoing partnership with state and local monitoring and eradication efforts are highly effective prevention strategies.

## Quality Assurance and Quality Control (QA/QC)

QA/QC is important to the success of a long-term data collection and trend detection program. Quality assurance (QA) is achieved through the establishment and use of the NETN Freshwater Monitoring Protocol. Specific procedures are used to control critical components of a project such as sampling at the right place with the right equipment and using the right methods. Over the years, staff will change, equipment may be updated, and methods may evolve. Although these changes will be kept to a minimum, changes are inevitable and therefore following an established and well-documented protocol will ensure that the data remain valid.

QA requirements incorporated in the protocol include consistency and low turnover in project leaders and staff, consistency in staff training and oversight, consistency in equipment used and calibration methods, the selection of a well-established chemical laboratory with a proven track record, and a robust sample design that includes an adequate number of field and laboratory quality control (QC) samples.

QC includes the assessment of bias and variability through the use of additional samples such as blank and replicate samples. QC samples are an objective assessment of whether or not QA protocols are adequate. The protocol calls for the collection of two blank and two replicate samples (one each from lakes/ponds and streams, respectively) during both the spring and summer nutrient sampling months at Acadia NP, and the same number, distribution, and schedule at the combined eight “Lower NETN” parks. Sample collection sites are selected at random from both monitoring groups.

The latest (2014) protocol revision requires in situ measurements, including Secchi transparency, sonde water quality, and stream discharge, to be periodically replicated to ensure that field equipment and observers are performing within the required precision standards. Water quality sonde temperature, pH and specific conductance measurements are to be compared monthly in the laboratory with similar measurements made with a NIST-traceable thermometer and benchtop pH and conductivity meters. Sonde dissolved oxygen measurements will be compared in the field to measurements made using a LaMotte dissolved oxygen test kit (Winkler titration method). These additional procedures will begin network-wide in the 2015 monitoring season.

### Nutrient QC Sample Results

Analysis results of all 2014 blank samples collected from Lower NETN ponds and streams (Appendix B, Table B1) were near or below the method reporting limits, indicating little or no contamination was introduced during the sampling, handling and analysis processes. However, new instrumentation utilized at the analytical lab in June and August provided lower detection and reporting limits for several analytes (NO<sub>2</sub>, NH<sub>3</sub>, SO<sub>4</sub>), allowing quantification of some levels of possible contamination not detected in the past. Replicate sample analysis results (Appendix B, Table B2) showed that most Lower NETN samples were in the acceptable range of precision (relative percent difference or precision objective in units, depending on sample concentration).

## Summary

Most water quality parameters for the monitored streams were within state standards, and were generally within the ranges of the historic NETN monitoring data from MIMA. Exceptions were the high temperatures in July and August at Mill Brook and Elm Brook (July only), and the low DO readings from Mill Brook (May and July). Additionally, although there is no state standard for chloride, all values were very high and the spring sample values likely reflect the contribution of runoff of road de-icing chemicals.

ANC measurements showed that all streams had sufficient buffering to avoid severely depressed pH values from spring snowmelt and runoff that can contribute acidity and sediment to the stream water. Test results for TN and NO<sub>3</sub> were moderately high in most 2014 samples. Results for NO<sub>2</sub> were low at all sites. All ammonia (NH<sub>3</sub>) test results were below the method reporting limit of 0.08 mg/L. All total phosphorus results for 2014 were high, and significantly above the EPA Region 14 criterion of 31.25µg/L. These results indicate that some nutrient enrichment is occurring in MIMA streams.

Eight years of monitoring under the NETN protocol have provided critical baseline information on the chemical and physical status of the streams monitored in Minute Man National Historical Park. Several changes implemented in the 2012 monitoring season, including the addition of sulfate, chloride, and dissolved organic carbon (DOC) analyses to the spring and summer water chemistry testing, are helping to expand the scope and usefulness of the monitoring data. As more data are collected, the ability to detect changes outside this natural range of variability will increase, which in turn will more clearly indicate the status of the vital signs of water quality, nutrient enrichment, water quantity, and the detection of invasive plant species.

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## Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2014.

**Table A1.** YSI sonde in-situ stream water quality measurements collected at MIMA.

| Site                    | NETN Code | Date       | Depth (m) | Temp (C) | DO (mg/L) | pH   | Specific Conductance (µS/cm) |
|-------------------------|-----------|------------|-----------|----------|-----------|------|------------------------------|
| Mill Brook (Stream A)   | MIMASA    | 5/22/2014  | 0.08      | 17.55    | 4.61      | 6.52 | 604.00                       |
| Mill Brook (Stream A)   | MIMASA    | 6/19/2014  | 0.05      | 21.96    | 6.56      | 6.87 | 787.00                       |
| Mill Brook (Stream A)   | MIMASA    | 7/29/2014  | 0.12      | 20.82    | 5.31      | 6.43 | 523.00                       |
| Mill Brook (Stream A)   | MIMASA    | 8/27/2014  | 0.09      | 22.21    | 6.43      | 6.94 | 765.00                       |
| Mill Brook (Stream A)   | MIMASA    | 9/24/2014  | 0.05      | 14.50    | 8.18      | 7.13 | 844.00                       |
| Mill Brook (Stream A)   | MIMASA    | 10/29/2014 | 0.06      | 12.68    | 7.64      | 6.61 | 605.00                       |
| Elm Brook (Stream B)    | MIMASB    | 5/22/2014  | 0.11      | 13.57    | 9.79      | 6.82 | 773.00                       |
| Elm Brook (Stream B)    | MIMASB    | 6/19/2014  | 0.03      | 18.27    | 9.24      | 6.94 | 809.00                       |
| Elm Brook (Stream B)    | MIMASB    | 7/29/2014  | 0.15      | 21.45    | 8.38      | 6.62 | 712.00                       |
| Elm Brook (Stream B)    | MIMASB    | 8/27/2014  | 0.05      | 19.61    | 8.37      | 6.87 | 857.00                       |
| Elm Brook (Stream B)    | MIMASB    | 9/24/2014  | 0.06      | 13.81    | 9.59      | 7.04 | 584.00                       |
| Elm Brook (Stream B)    | MIMASB    | 10/29/2014 | 0.14      | 12.38    | 9.53      | 6.75 | 582.00                       |
| Concord River (Pylon 4) | MIMASC    | 5/22/2014  | 0.26      | 19.31    | 7.76      | 7.01 | 497.00                       |
| Concord River (Pylon 3) | MIMASC    | 5/22/2014  | 0.26      | 19.31    | 7.71      | 7.01 | 500.00                       |
| Concord River (Pylon 4) | MIMASC    | 6/19/2014  | 0.19      | 24.38    | 7.04      | 7.02 | 514.00                       |
| Concord River (Pylon 4) | MIMASC    | 6/19/2014  | 0.24      | 24.38    | 7.03      | 7.02 | 513.00                       |
| Concord River (Pylon 2) | MIMASC    | 7/29/2014  | 0.46      | 24.76    | 7.35      | 7.28 | 604.00                       |
| Concord River (Pylon 4) | MIMASC    | 7/29/2014  | 0.46      | 24.78    | 7.31      | 7.24 | 605.00                       |
| Concord River (Pylon 3) | MIMASC    | 8/27/2014  | 0.32      | 24.96    | 7.29      | 7.22 | 609.00                       |
| Concord River (Pylon 3) | MIMASC    | 9/24/2014  | 0.24      | 16.76    | 9.03      | 7.65 | 703.00                       |
| Concord River (Pylon 4) | MIMASC    | 9/24/2014  | 0.26      | 16.65    | 9.02      | 7.64 | 702.00                       |
| Concord River (Pylon 2) | MIMASC    | 10/29/2014 | 0.30      | 11.80    | 6.86      | 6.68 | 491.00                       |
| Concord River (Pylon 4) | MIMASC    | 10/29/2014 | 0.37      | 11.79    | 7.06      | 6.60 | 490.00                       |

## Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2014 (continued).

**Table A2.** Laboratory nutrient chemistry data for MIMA. “<MRL” indicates the result was below the method reporting limit (0.1 for TN, 0.005 for NO<sub>2</sub>, and 0.08 for NH<sub>3</sub>).

| Site                  | Date      | ANC<br>(µeq/L) | A Color<br>(PCU) | DOC<br>(mg/L) | TP<br>(µg/L) | TN<br>(mg/L) | NO <sub>3</sub><br>(µeq/L) | NO <sub>3</sub> -N<br>(mg/L<br>Calc) | NO <sub>2</sub><br>(mg/L) | NH <sub>3</sub><br>(mg/L) | Cl<br>(µeq/L) | SO <sub>4</sub><br>(µeq/L) |
|-----------------------|-----------|----------------|------------------|---------------|--------------|--------------|----------------------------|--------------------------------------|---------------------------|---------------------------|---------------|----------------------------|
| Concord River         | 5/22/2014 | 552.00         | 85               | 6.21          | 48           | 0.935        | 28                         | 0.395                                | 0.006                     | <MRL<br>0.08              | 3502          | 193                        |
| Concord River         | 8/27/2014 | 818.18         | 88               | 4.74          | 34.1         | 0.899        | 29                         | 0.409                                | 0.004                     | 0.017                     | 4291          | 295                        |
| Elm Brook (Stream B)  | 5/22/2014 | 316.00         | 137              | 7.07          | 80           | 1.330        | 53                         | 0.747                                | 0.0058                    | <MRL<br>0.08              | 5790          | 201                        |
| Elm Brook (Stream B)  | 8/27/2014 | 350.53         | 62               | 4.51          | 36           | 1.340        | 89                         | 1.255                                | 0.002                     | 0.024                     | 7640          | 233                        |
| Mill Brook (Stream A) | 5/22/2014 | 755.00         | 207              | 8.85          | 124          | 0.767        | 8.9                        | 0.125                                | 0.0072                    | <MRL<br>0.08              | 4330          | 213                        |
| Mill Brook (Stream A) | 8/27/2014 | 884.12         | 80               | 3.3           | 68.6         | 0.898        | <MRL 1                     | <MRL                                 | 0.02                      | 0.128                     | 7230          | 383                        |

## Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2014 (continued).

**Table A3.** Stream stage and discharge data for MIMA. *Missing values indicate data are unavailable.*

| Site                  | Date       | Datum name | Time  | Distance from datum (ft) | Total CS area (sqft) | Average velocity (f/s) | Discharge (cfs) |
|-----------------------|------------|------------|-------|--------------------------|----------------------|------------------------|-----------------|
| Mill Brook (Stream A) | 5/22/2014  | Bolt2      | 13:11 | -0.28                    | 19.78                | 0.85                   | 16.88           |
| Mill Brook (Stream A) | 5/22/2014  | Bolt2      | 13:57 | -0.36                    |                      |                        |                 |
| Mill Brook (Stream A) | 6/19/2014  | Bolt1      | 13:18 | -1.05                    | 3.58                 | 0.45                   | 1.62            |
| Mill Brook (Stream A) | 6/19/2014  | Bolt1      | 14:00 | -1.04                    |                      |                        |                 |
| Mill Brook (Stream A) | 6/19/2014  | Other      | 13:18 | -2.48                    |                      |                        |                 |
| Mill Brook (Stream A) | 6/19/2014  | Other      | 14:00 | -2.48                    |                      |                        |                 |
| Mill Brook (Stream A) | 7/29/2014  | Bolt1      | 11:16 | -0.49                    | 9.96                 | 0.64                   | 6.33            |
| Mill Brook (Stream A) | 7/29/2014  | Bolt1      | 12:01 | -0.49                    |                      |                        |                 |
| Mill Brook (Stream A) | 7/29/2014  | Bolt2      | 11:18 | -1.91                    |                      |                        |                 |
| Mill Brook (Stream A) | 7/29/2014  | Bolt2      | 12:02 | -1.92                    |                      |                        |                 |
| Mill Brook (Stream A) | 8/27/2014  | Bolt1      | 13:18 | -1.13                    | 1.73                 | 0.22                   | 0.45            |
| Mill Brook (Stream A) | 8/27/2014  | Bolt1      | 14:35 | -1.14                    |                      |                        |                 |
| Mill Brook (Stream A) | 8/27/2014  | Bolt2      | 13:19 | -2.55                    |                      |                        |                 |
| Mill Brook (Stream A) | 8/27/2014  | Bolt2      | 14:37 | -2.54                    |                      |                        |                 |
| Mill Brook (Stream A) | 9/24/2014  | Bolt1      | 14:19 | -1.19                    |                      |                        |                 |
| Mill Brook (Stream A) | 9/24/2014  | Bolt1      | 15:22 | -1.19                    |                      |                        |                 |
| Mill Brook (Stream A) | 9/24/2014  | Bolt2      | 14:20 | -2.65                    |                      |                        |                 |
| Mill Brook (Stream A) | 9/24/2014  | Bolt2      | 15:26 | -2.66                    |                      |                        |                 |
| Mill Brook (Stream A) | 10/29/2014 | Bolt1      | 14:10 | -0.95                    | 4.92                 | 0.54                   | 2.67            |

## Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2014 (continued).

**Table A3 (continued).** Stream stage and discharge data for MIMA. *Missing values indicate data are unavailable.*

| Site                  | Date       | Datum name | Time  | Distance from datum (ft) | Total CS area (sqft) | Average velocity (f/s) | Discharge (cfs) |
|-----------------------|------------|------------|-------|--------------------------|----------------------|------------------------|-----------------|
| Mill Brook (Stream A) | 10/29/2014 | Bolt1      | 15:19 | -0.95                    |                      |                        |                 |
| Mill Brook (Stream A) | 10/29/2014 | Bolt2      | 14:11 | -2.35                    |                      |                        |                 |
| Mill Brook (Stream A) | 10/29/2014 | Bolt2      | 15:20 | -2.35                    |                      |                        |                 |
| Elm Brook (Stream B)  | 5/22/2014  | Bolt1      | 15:00 | -0.81                    | 2.06                 | 0.07                   | 0.14            |
| Elm Brook (Stream B)  | 5/22/2014  | Bolt1      | 15:22 | -0.81                    |                      |                        |                 |
| Elm Brook (Stream B)  | 5/22/2014  | Bolt2      | 15:02 | -2.63                    |                      |                        |                 |
| Elm Brook (Stream B)  | 5/22/2014  | Bolt2      | 15:22 | -2.63                    |                      |                        |                 |
| Elm Brook (Stream B)  | 6/19/2014  | Bolt1      | 14:42 | -1.00                    | 1.33                 | 0.24                   | 0.33            |
| Elm Brook (Stream B)  | 6/19/2014  | Bolt1      | 15:13 | -1.00                    |                      |                        |                 |
| Elm Brook (Stream B)  | 6/19/2014  | Bolt2      | 14:43 | -2.80                    |                      |                        |                 |
| Elm Brook (Stream B)  | 6/19/2014  | Bolt2      | 15:14 | -2.80                    |                      |                        |                 |
| Elm Brook (Stream B)  | 7/29/2014  | Bolt1      | 15:32 | -0.78                    | 2.74                 | 0.37                   | 1.01            |
| Elm Brook (Stream B)  | 7/29/2014  | Bolt1      | 16:29 | -0.79                    |                      |                        |                 |
| Elm Brook (Stream B)  | 7/29/2014  | Bolt2      | 15:32 | -2.59                    |                      |                        |                 |
| Elm Brook (Stream B)  | 7/29/2014  | Bolt2      | 16:29 | -2.60                    |                      |                        |                 |
| Elm Brook (Stream B)  | 8/27/2014  | Bolt1      | 15:18 | -1.10                    |                      |                        |                 |
| Elm Brook (Stream B)  | 8/27/2014  | Bolt1      | 15:47 | -1.10                    |                      |                        |                 |
| Elm Brook (Stream B)  | 8/27/2014  | Bolt2      | 15:19 | -2.89                    |                      |                        |                 |
| Elm Brook (Stream B)  | 8/27/2014  | Bolt2      | 15:48 | -2.89                    |                      |                        |                 |

## Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2014 (continued).

**Table A3 (continued).** Stream stage and discharge data for MIMA. *Missing values indicate data are unavailable.*

| Site                     | Date       | Datum name | Time  | Distance from datum (ft) | Total CS area (sqft) | Average velocity (f/s) | Discharge (cfs) |
|--------------------------|------------|------------|-------|--------------------------|----------------------|------------------------|-----------------|
| Elm Brook (Stream B)     | 9/24/2014  | Bolt1      | 16:48 | -1.06                    |                      |                        |                 |
| Elm Brook (Stream B)     | 9/24/2014  | Bolt1      | 17:29 | -1.06                    |                      |                        |                 |
| Elm Brook (Stream B)     | 9/24/2014  | Bolt2      | 16:50 | -2.86                    |                      |                        |                 |
| Elm Brook (Stream B)     | 9/24/2014  | Bolt2      | 17:29 | -2.85                    |                      |                        |                 |
| Elm Brook (Stream B)     | 10/29/2014 | Bolt1      | 11:50 | -0.92                    | 5.45                 | 0.03                   | 0.17            |
| Elm Brook (Stream B)     | 10/29/2014 | Bolt1      | 12:41 | -0.92                    |                      |                        |                 |
| Elm Brook (Stream B)     | 10/29/2014 | Bolt2      | 11:52 | -2.70                    |                      |                        |                 |
| Elm Brook (Stream B)     | 10/29/2014 | Bolt2      | 12:39 | -2.71                    |                      |                        |                 |
| Concord River (Stream C) | 5/22/2014  | Bridge     | 11:28 | -3.60                    |                      |                        |                 |
| Concord River (Stream C) | 5/22/2014  | Bridge     | 11:52 | -3.60                    |                      |                        |                 |
| Concord River (Stream C) | 6/19/2014  | Bridge     | 11:42 | -3.95                    |                      |                        |                 |
| Concord River (Stream C) | 6/19/2014  | Bridge     | 12:15 | -3.95                    |                      |                        |                 |
| Concord River (Stream C) | 7/29/2014  | Bridge     | 13:14 | -4.16                    |                      |                        |                 |
| Concord River (Stream C) | 7/29/2014  | Bridge     | 13:48 | -4.16                    |                      |                        |                 |
| Concord River (Stream C) | 8/27/2014  | Bridge     | 11:49 | -4.40                    |                      |                        |                 |
| Concord River (Stream C) | 8/27/2014  | Bridge     | 12:18 | -4.39                    |                      |                        |                 |
| Concord River (Stream C) | 9/24/2014  | Bridge     | 12:03 | -4.40                    |                      |                        |                 |
| Concord River (Stream C) | 9/24/2014  | Bridge     | 12:50 | -4.41                    |                      |                        |                 |
| Concord River (Stream C) | 10/29/2014 | Bridge     | 10:36 | -3.57                    |                      |                        |                 |
| Concord River (Stream C) | 10/29/2014 | Bridge     | 11:05 | -3.57                    |                      |                        |                 |

## Appendix B. Minute Man National Historical Park (MIMA) Blank and Replicate Water Samples, 2013.

**Table B1.** 2014 Blank sample analysis results (Lower NETN).

| Site | Date      | ANC<br>(µeq/L) | A<br>Color<br>(PCU) | DOC<br>(mg/L) | Chla<br>(µg/L) | Cl<br>(µeq/L) | SO <sub>4</sub><br>(µeq/L) | TP<br>(µg/L) | TN<br>(mg/L) | NO <sub>2</sub><br>(mg/L) | NO <sub>3</sub><br>(µeq/L) | NH <sub>3</sub><br>(mg/L) |
|------|-----------|----------------|---------------------|---------------|----------------|---------------|----------------------------|--------------|--------------|---------------------------|----------------------------|---------------------------|
| SARA | 5/20/2014 | -1.70          | 1                   | <MRL 0.5      |                | <MRL 2        | <MRL 2                     | <MRL 1       | <MRL 0.1     | <MRL 0.005                | <MRL 1                     | <MRL 0.08                 |
| WEFA | 6/11/2014 | -2.12          | 1                   | <MRL 0.5      | <MRL 1         | <MRL 2        | <MRL 2                     | <MRL 1       | 0.017        | <MRL 0.005                | <MRL 1                     | <MRL 0.08                 |
| MABI | 8/4/2014  | -2.95          | 1                   | <MRL 0.5      |                | <MRL 2        | <MRL 2                     | <MRL 1       | 0.018        | <MRL .001                 | <MRL 1                     | <MRL 0.003                |
| MABI | 8/4/2014  | -1.44          | 1                   | <MRL 0.5      | 0.2            | <MRL 2        | <MRL 2                     | <MRL 1       | <MRL 0.1     | <MRL .001                 | <MRL 1                     | 0.01                      |

**Table B2.** Replicate sample analysis results and measurement quality analysis (Lower NETN).

| Site   | Date      | Color<br>Reg | Color<br>Rep | Diff<br>(PCU) | % Diff | DOC<br>Reg | DOC<br>Rep | Diff<br>(mg/L) | % Diff | ANC<br>Reg | ANC<br>Rep | Diff<br>(µeq/L) | % Diff |
|--------|-----------|--------------|--------------|---------------|--------|------------|------------|----------------|--------|------------|------------|-----------------|--------|
| MIMASA | 5/22/2014 | 207          | 204          | 3.0           | 1.4%   | 8.85       | 8.62       | 0.23           | 2.60%  | 755.0      | 749.0      | 6.0             | 0.8%   |
| MABIPA | 6/3/2014  | 26           | 26           | 0.0           | 0.0%   | 2.3        | 2.39       | -0.09          | 3.91%  | 1632.6     | 1628.9     | 3.7             | 0.2%   |
| WEFAPA | 8/12/2014 | 30           | 32           | -2.0          | 6.7%   | 5          | 5          | 0.00           | 0.00%  | 379.8      | 378.4      | 1.3             | 0.4%   |
| MORRSB | 8/12/2014 | 19           | 22           | -3.0          | 15.8%  | 2          | 1.85       | 0.15           | 7.50%  | 789.7      | 791.6      | -1.9            | 0.2%   |

## Appendix A. Minute Man National Historical Park (MIMA) Water Monitoring Data, 2014 (continued).

| Site   | Date      | Chla<br>Reg | Chla<br>Rep | Diff<br>(µg/L) | % Diff | TP<br>Reg | TP<br>Rep | Diff<br>(µg/L) | % Diff | TN<br>Reg | TN<br>Rep | Diff<br>(mg/L) | % Diff |
|--------|-----------|-------------|-------------|----------------|--------|-----------|-----------|----------------|--------|-----------|-----------|----------------|--------|
| MIMASA | 5/22/2014 |             |             |                |        | 124       | 136       | -12.0          | 9.7%   | 0.77      | 0.87      | -0.11          | 9.7%   |
| MABIPA | 6/3/2014  | 6.1         |             |                |        | 10.3      | 10.3      | 0.0            | 0.0%   | 0.28      | 0.30      | -0.02          | 0.0%   |
| WEFAPA | 8/12/2014 | 3.4         |             |                |        | 15.3      | 15        | 0.3            | 2.0%   | 0.54      | 0.45      | 0.09           | 2.0%   |
| MORRSB | 8/12/2014 |             |             |                |        | 28.4      | 30.3      | -1.9           | 6.7%   | 0.49      | 0.48      | 0.01           | 6.7%   |

| Site   | Date      | NO <sub>3</sub><br>Reg | NO <sub>3</sub><br>Rep | Diff<br>(µeq/L) | % Diff | NO <sub>2</sub><br>Reg | NO <sub>2</sub><br>Rep | Diff<br>(mg/L) | % Diff | NH3<br>Reg | NH3<br>Rep | Diff<br>(mg/L) | % Diff |
|--------|-----------|------------------------|------------------------|-----------------|--------|------------------------|------------------------|----------------|--------|------------|------------|----------------|--------|
| MIMASA | 5/22/2014 | 8.9                    | 8.4                    | 0.50            | 5.6%   | 0.0072                 | 0.0073                 | 0.000          | 1.4%   | < MRL      | < MRL      |                |        |
| MABIPA | 6/3/2014  | < MRL                  | < MRL                  |                 |        | < MRL                  | < MRL                  |                |        | < MRL      | < MRL      |                |        |
| WEFAPA | 8/12/2014 | < MRL                  | < MRL                  |                 |        | < MRL                  | < MRL                  |                |        | 0.032      | 0.03       | 0.002          | 6.3%   |
| MORRSB | 8/12/2014 | 28                     | 28                     | 0.00            | 0.0%   | < MRL                  | < MRL                  |                |        | 0.024      | < MRL      |                |        |

| Site   | Date      | SO4<br>Reg | SO4<br>Rep | Diff<br>(µeq/L) | % Diff | Cl Reg | Cl Rep | Diff<br>(µeq/L) | % Diff |
|--------|-----------|------------|------------|-----------------|--------|--------|--------|-----------------|--------|
| MIMASA | 5/22/2014 | 213        | 199        | 14.0            | 6.6%   | 4330   | 3985   | 345.0           | 8.0%   |
| MABIPA | 6/3/2014  | 88         | 88         | 0.0             | 0.0%   | 17     | 17     | 0.0             | 0.0%   |
| WEFAPA | 8/12/2014 | 92         | 89         | 3.0             | 3.3%   | 932    | 932    | 0.0             | 0.0%   |
| MORRSB | 8/12/2014 | 291        | 300        | -9.0            | 3.1%   | 170    | 175    | -5.0            | 2.9%   |

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