



Northeast Temperate Network Water Quality Report, 2006-2009

Marsh-Billings-Rockefeller NHP

Natural Resource Data Series NPS/NETN/NRDS—2011/160



ON THE COVER

The Pogue, October 2006. Photograph by: NETN

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Natural Resource Data Series NPS/NETN/NRDS—2011/160

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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.

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Introduction

This is the first report on the water quality of Marsh-Billings-Rockefeller National Historical Park (MABI) generated by the Northeast Temperate Network (NETN) Water Quality Monitoring Program. This report includes data gathered in the first 4 years of the monitoring program (2006-2009) and displays these results in graphic form, accompanied by a brief interpretation.

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

The NETN freshwater monitoring protocol calls for one pond and one stream site in MABI to be sampled monthly from May through October. A cooperator from the University of Vermont measured physical and in-situ water chemistry parameters each month, and gathered an early- and late-summer water sample at each site for analysis at a contract water quality lab. In 2006 and for most analyses in 2007, the U.S. Geological Survey (USGS) National Water Quality Laboratory (NWQL) analyzed the samples; otherwise the University of Maine's Sawyer Environmental Chemistry Research Laboratory conducted the analyses. All monitoring data were incorporated into a series of comprehensive databases that ultimately feed the U.S. Environmental Protection Agency's (EPA) "STORET" data system, the repository for all NPS water quality and quantity data.

Sampling Sites

One stream sampling site was selected to represent Pogue Stream. This is the only stream within the park, and there are no long-term historic stream water quality stations. This station was selected as the most downstream site within the park boundary with easy access and the ability to obtain an accurate discharge measurement over a range of flows. Additionally, a pond monitoring site was established at "The Pogue", a 4.5 hectare pond situated at the headwaters of Pogue Stream. Both sites are mapped in Figure 1.

Methods

Detailed descriptions of all monitoring methods are found in the protocol (Lombard et al. 2006). Monthly sampling parameters included in-situ water quality measures (pH, specific conductance, temperature, and dissolved oxygen) determined with a YSI 600XL sonde, transparency (pond site only), weather, stream flow (discharge), and stream and pond stage. In May (stream only), June (pond only) and August (both sites), water samples were obtained and analyzed for acid neutralizing capacity (ANC), color, and nutrients. The pond sampling procedure entailed collecting all in-situ measurements and water samples from the deepest point of the pond (approximately 3 meters). Nutrient chemistry parameters were analyzed from a half-meter grab sample.

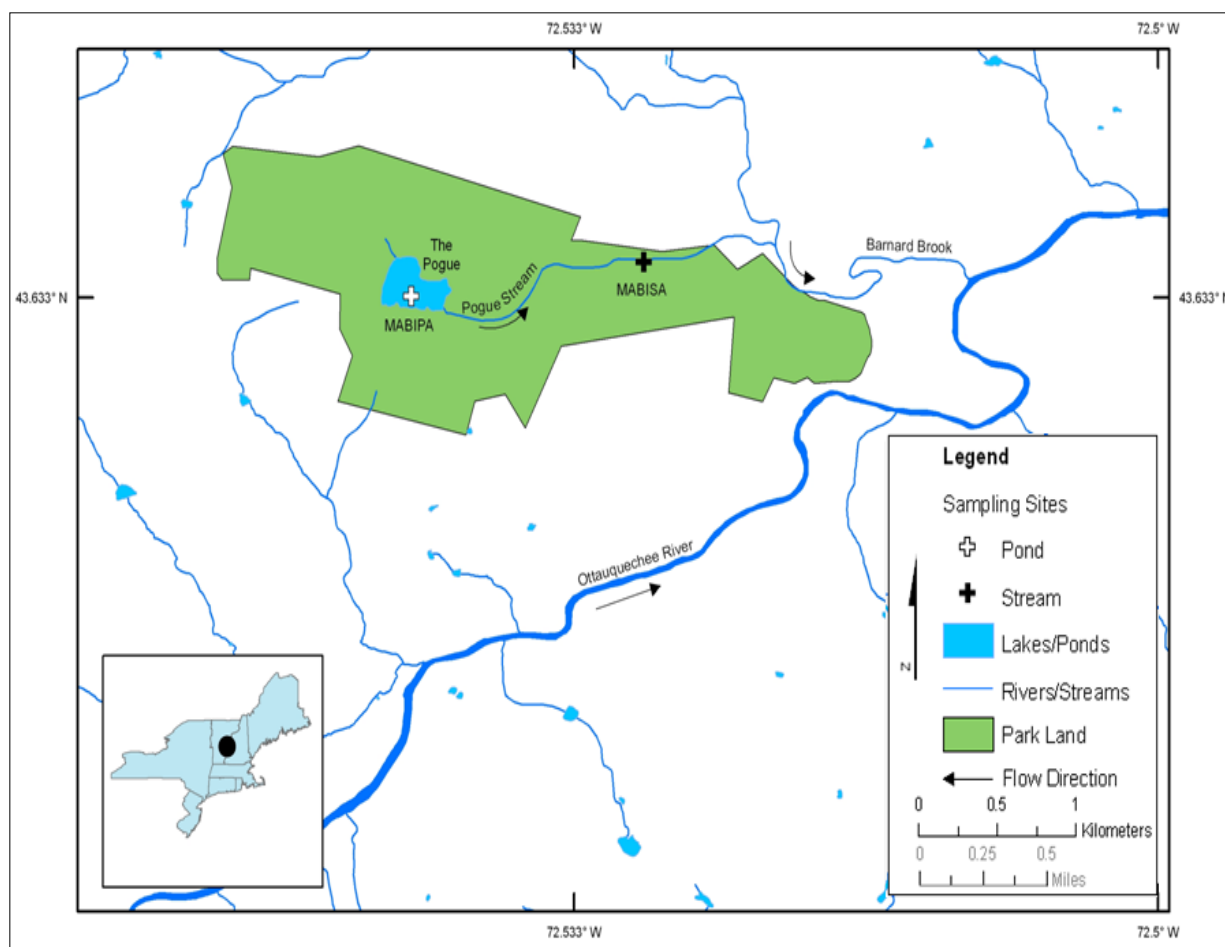


Figure 1. Water monitoring sites at Marsh-Billings-Rockefeller National Historical Park.

Stream discharge was measured using U.S. Geological Survey protocols, employing a measuring tape, wading rod, and Price pygmy or SonTek FlowTracker current meter to measure a particular cross-sectional area of the stream and the velocity of the water at that cross section.

In-situ stream water chemical and physical measurements and water samples were collected close to 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. Grab samples were obtained by submerging the sample bottle directly in the stream with a gloved hand. A peristaltic pump and Tygon tubing were used to collect samples if water levels were too low to completely submerge a bottle.

Water Quality Standards

According to the Vermont Water Quality standards, “all total phosphorus and nitrate concentrations shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.... In class B waters [such as Pogue Stream], nitrates are not to exceed 2.0 mg/L as $\text{NO}_3\text{-N}$ at flows exceeding low median monthly flows.... In lakes, ponds, and reservoirs,

nitrate concentrations are not to exceed 5.0 mg/L as NO₃-N regardless of classification” (State of Vermont Water Resources Board 2008).

The state standards set the following criteria for water chemistry: “pH values shall be maintained within the range of 6.5 and 8.5. Both the change and the rate of change in pH values shall be controlled to ensure the full support of the aquatic biota, wildlife, and aquatic habitat uses.”

Dissolved oxygen (DO) concentrations in cold water fish habitat is “not less than 7 mg/L and 75 percent saturation at all times, nor less than 95 percent saturation during late egg maturation and larval development of salmonids in areas that are salmonid spawning or nursery areas important to the establishment or maintenance of the fishery resource. Not less than 6 mg/L and 70 percent saturation at all times in all other waters designated as a cold water fish habitat.” In warm water fish habitat DO concentrations are “not less than 5 mg/L and 60 percent saturation at all times” (State of Vermont Water Resources Board 2008).

EPA Ecoregion 8 water quality criteria (U.S. Environmental Protection Agency 2002) are also used as a benchmark in this report (Table 1). 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.

Table 1. U.S. Environmental Protection Agency Ecoregion 8 nutrient criteria.

Nutrient Criteria	Streams	Lakes
Total Phosphorus (µg/L)	10	8
Total Nitrogen (mg/L)	0.38	0.24
Chlorophyll <i>a</i> (µg/L)	0.63	2.43
Secchi disk depth (m)	N/A	4.93

These criteria were developed specifically for Ecoregion 8 (which includes the entire states of Maine, New Hampshire, and Vermont) 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.

For lakes (waterbodies greater than 10 acres and with mean water residence time of 14 or more days; U.S. Environmental Protection Agency 2000a), the criteria in Table 1 were established based on the lower 25th percentile of lakes that EPA found data for. This percentile of all lakes is expected to approximately correspond to the 75th percentile of reference (undisturbed) lakes. In other words, 75% of lakes in the ecoregion do not meet the criteria, nor do roughly 25% of reference lakes. For streams and rivers, a parallel approach was used to establish the nutrient criteria (U.S. Environmental Protection Agency 2000b).

Climate

Both seasonal and annual shifts in precipitation and temperatures can have distinctive short-term and cumulative effects on stream flow, lake levels, physical lake properties, and water chemistry. Mean monitoring season (May – October) precipitation measured at the National Weather Service Cooperative Station Network site (#439984) near Marsh-Billings-Rockefeller NHP for the period 1940-2009 was 547.2 millimeters. Precipitation during the monitoring seasons from 2006 through 2009 was generally above average, and the 2006 May through October precipitation total was the highest in the period of historic record (Table 2, Figure 2).

Table 2. Annual monitoring season climate conditions.

Year	Average May-Oct Air Temp (C)	Average May-Oct Monthly Precipitation (mm)	Total May-Oct Precipitation (mm)	Total Annual Precipitation (mm)
2006	15.9	150.4	903.0	1,375.2
2007	16.4	87.4	524.3	1,073.4
2008	15.6	103.6	614.9	1,367.8
2009	15.1	125.2	725.9	1,190.8

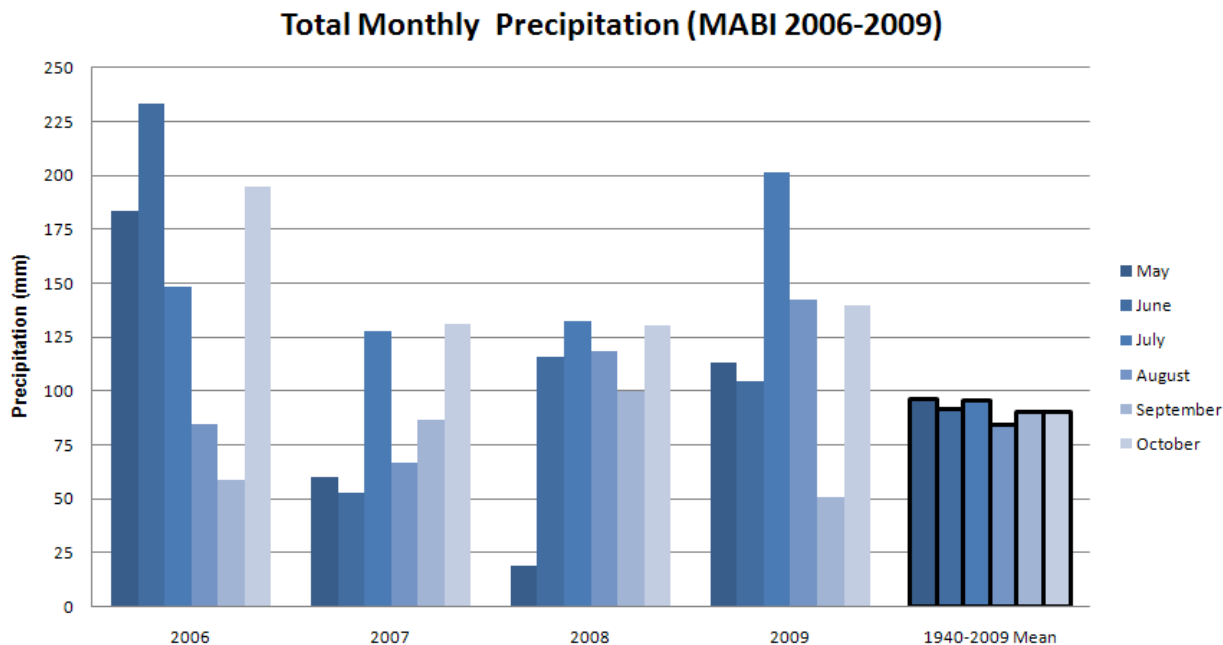


Figure 2. Monthly precipitation during the water monitoring season.

Average monthly air temperatures during the 2006-2009 monitoring seasons were typical of conditions recorded over the past decade, and very close to the 1940-2009 monthly averages (Figure 3).

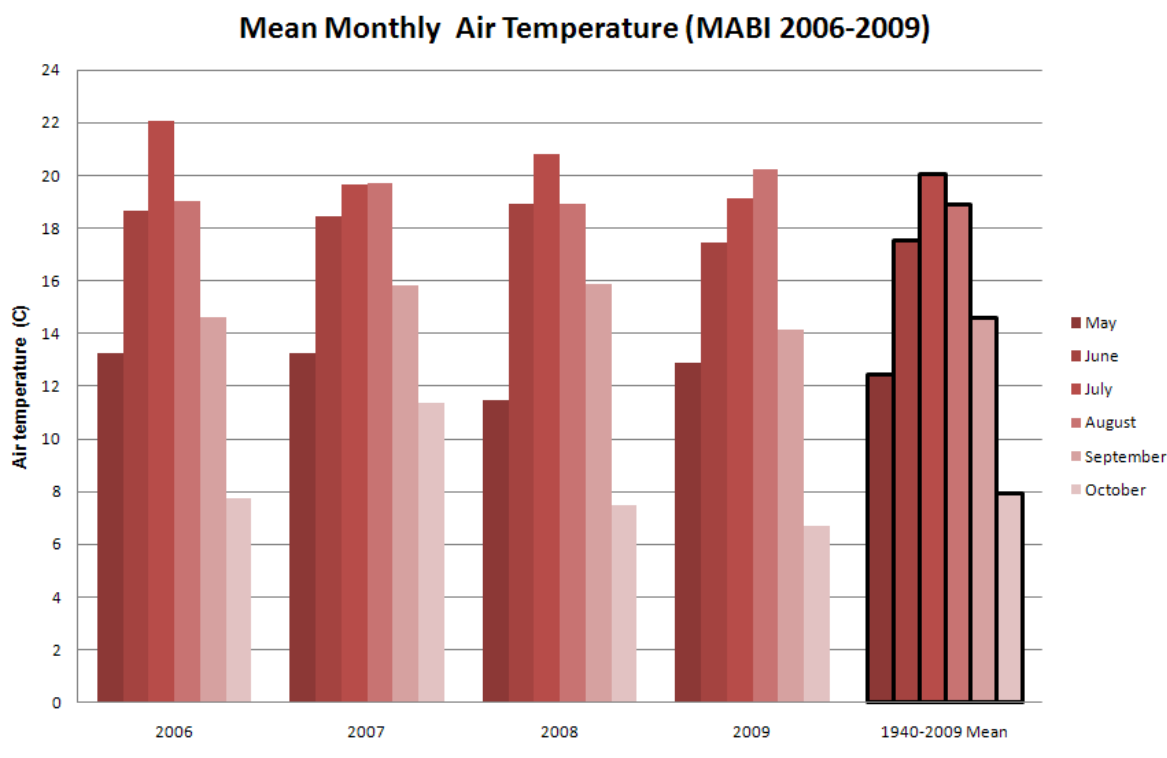


Figure 3. Monthly air temperature during the water monitoring season.

Annual mean air temperatures and precipitation totals appear to be highly variable in the period since 1940, and there is a significant climate data gap from 1988 to 1997 (Figure 4). Continuing the collection of water quality and climate data in future years will facilitate the understanding of the relationship between water quality and weather conditions.

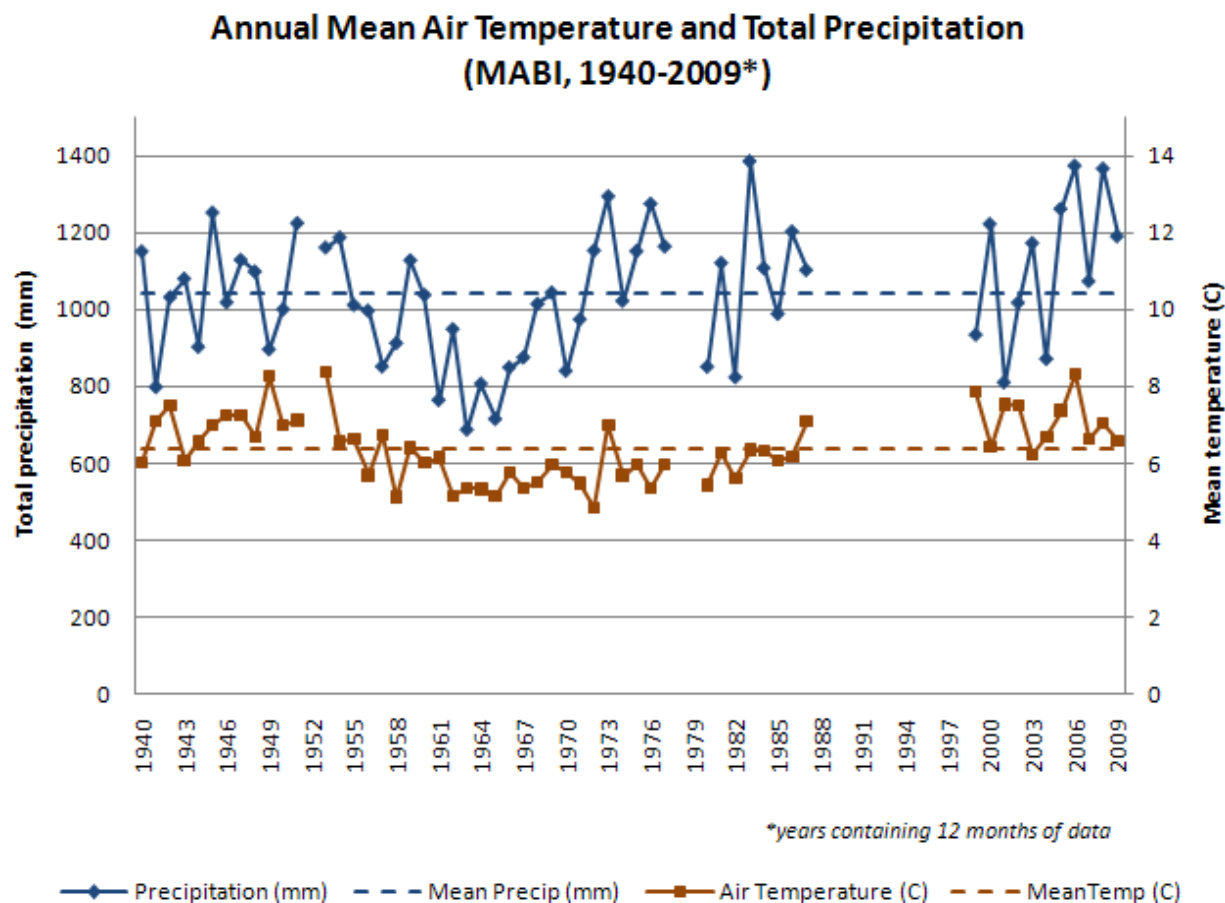


Figure 4. Annual air temperature and precipitation 1940-2009.

Results and analysis

Monitoring results are displayed in time series graphs showing all data for each site for a given parameter. Most data gaps are by design, for example the planned pauses between sampling series (no samples collected during winter months). As data richness increases, trends may emerge from these time series graphs.

If EPA or other water quality criteria exist for a particular parameter they are displayed on the graphs. In addition, error bars are included whenever possible, representing ± 1 standard deviation.

Water Quality

Measures of water quality include specific conductance, pH, acid neutralizing capacity (ANC), water temperature, and dissolved oxygen (DO). Assessment of water quality data aids in the interpretation of the biotic condition and ecological processes of surface water resources. There are few historic data records from these specific sites with which to compare the water quality data collected in the first 4 years of the NETN monitoring program. The NPS Baseline Water Quality Data Inventory and Analysis (National Park Service 1997) contains analytical results

from samples taken from The Pogue in October 1984 and November 1994 and Pogue Stream in November 1994.

Specific conductance (Figure 5) 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 can range from less than 20 to more than 1,000 microsiemens per centimeter ($\mu\text{S}/\text{cm}$). Specific conductance values from 2006 through 2009 are within the appropriate range for moderate to high ionic strength waters, and are similar to the 149 $\mu\text{S}/\text{cm}$ value in the baseline water quality report.

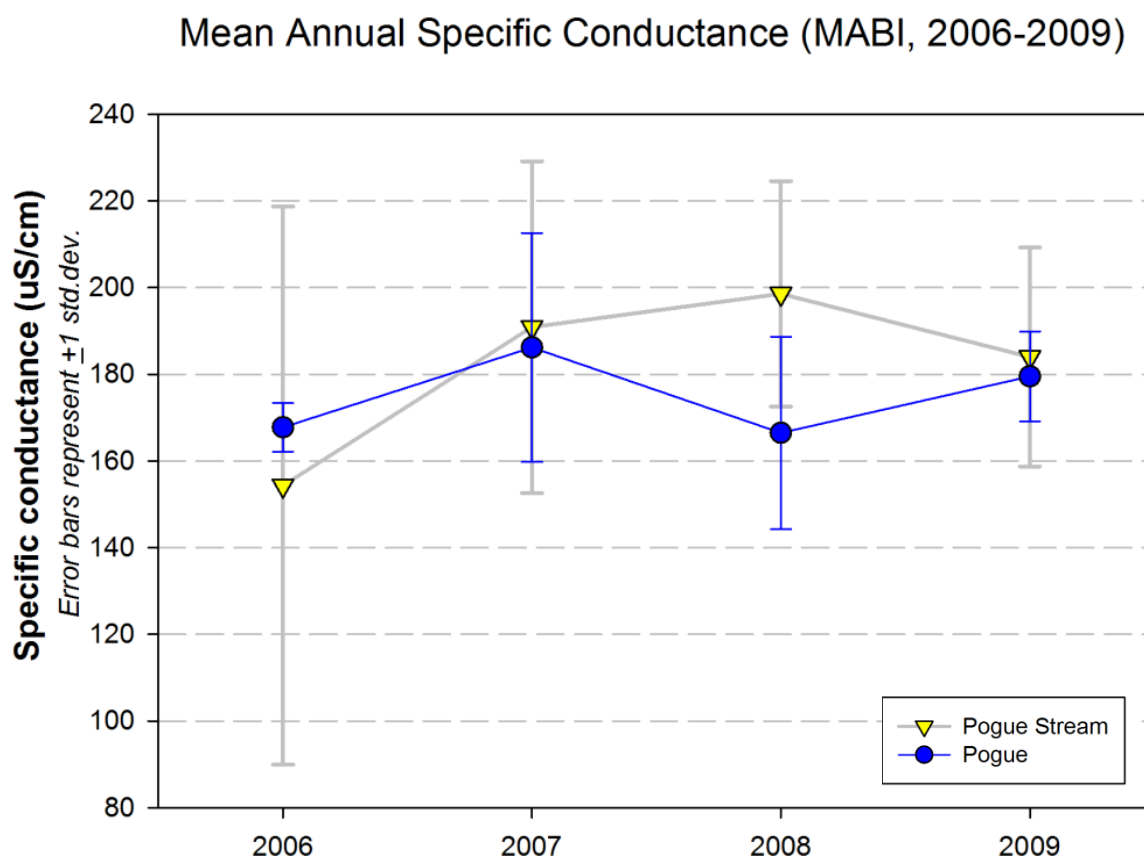


Figure 5. Pond and stream specific conductance.

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. Vermont standards, like those of most New England states, indicate that a pH between 6.5 and 8.5 is within the acceptable range. pH values from the 2006 through 2009 monitoring seasons (Figure 6) are all slightly basic, and within the upper and lower Vermont water quality standards. The Pogue had a pH of 8.0 in October 1984.

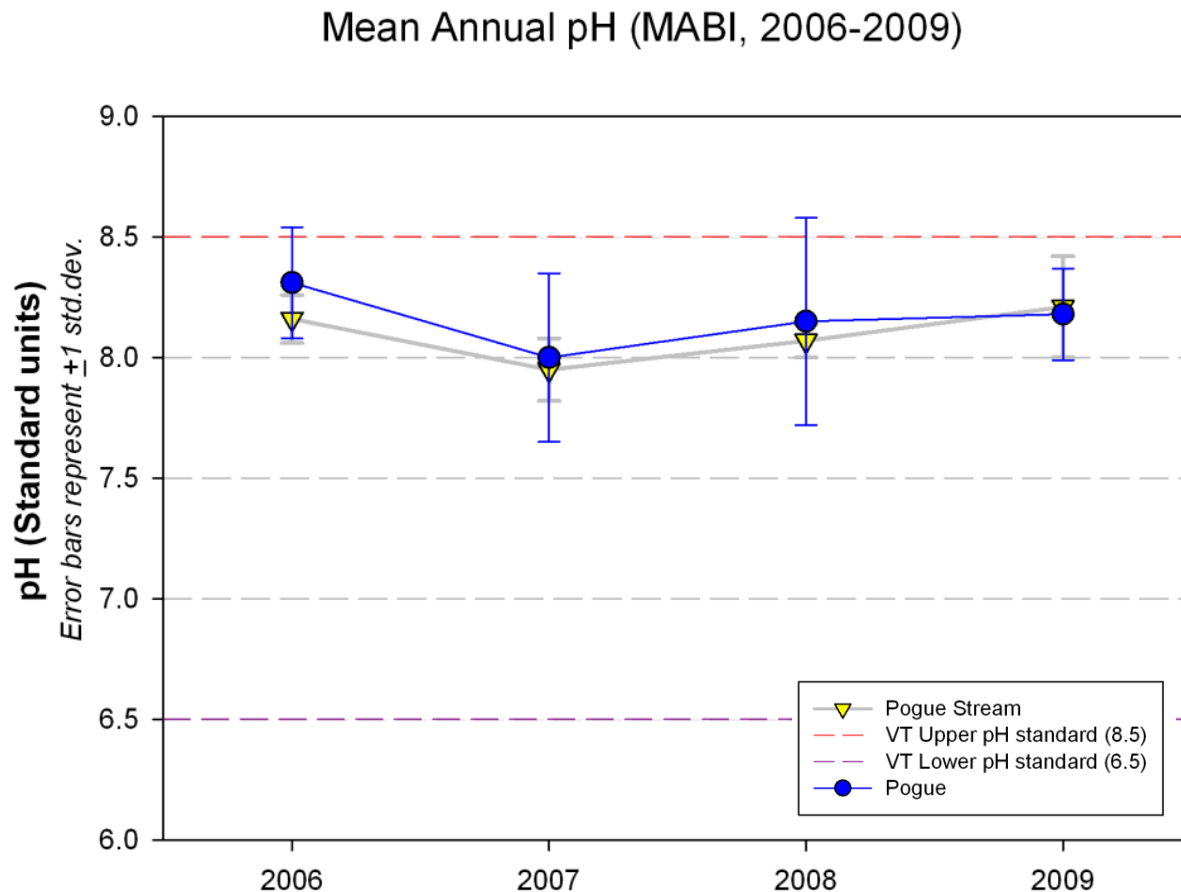


Figure 6. Pond and stream pH.

Acid neutralizing capacity 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 NETN samples (Figure 7) are all higher than the 1,370.3 $\mu\text{eq/L}$ value from the October 1984 Pogue sample. ANC is lower in the early summer samples from Pogue Brook, reflecting the acidic influence of spring snowmelt and runoff. ANC in the Pogue is more stable, showing less of a seasonal trend.

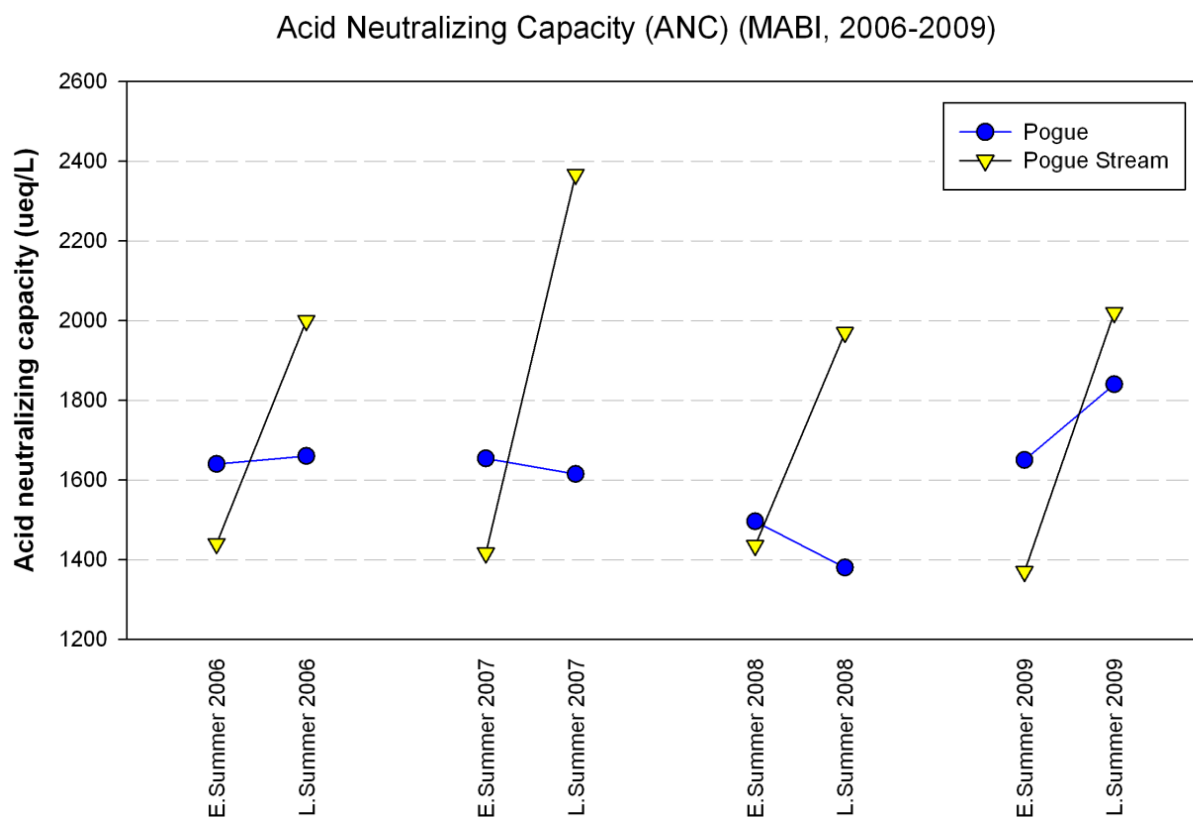


Figure 7. Pond and stream acid neutralizing capacity.

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 the 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. Annual mean water temperatures (Figure 8) appear to be fairly consistent throughout the reporting period, with variation likely due to changing air temperature and solar radiation levels.

Dissolved oxygen 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). Both sites are well oxygenated in all years (Figure 9), and are above the more stringent (7 mg/L) state DO standard. The 2007 mean for the Pogue is lowest because it contains data points from depths just above the bottom sediments, a normally hypoxic region, which were not monitored in other years.

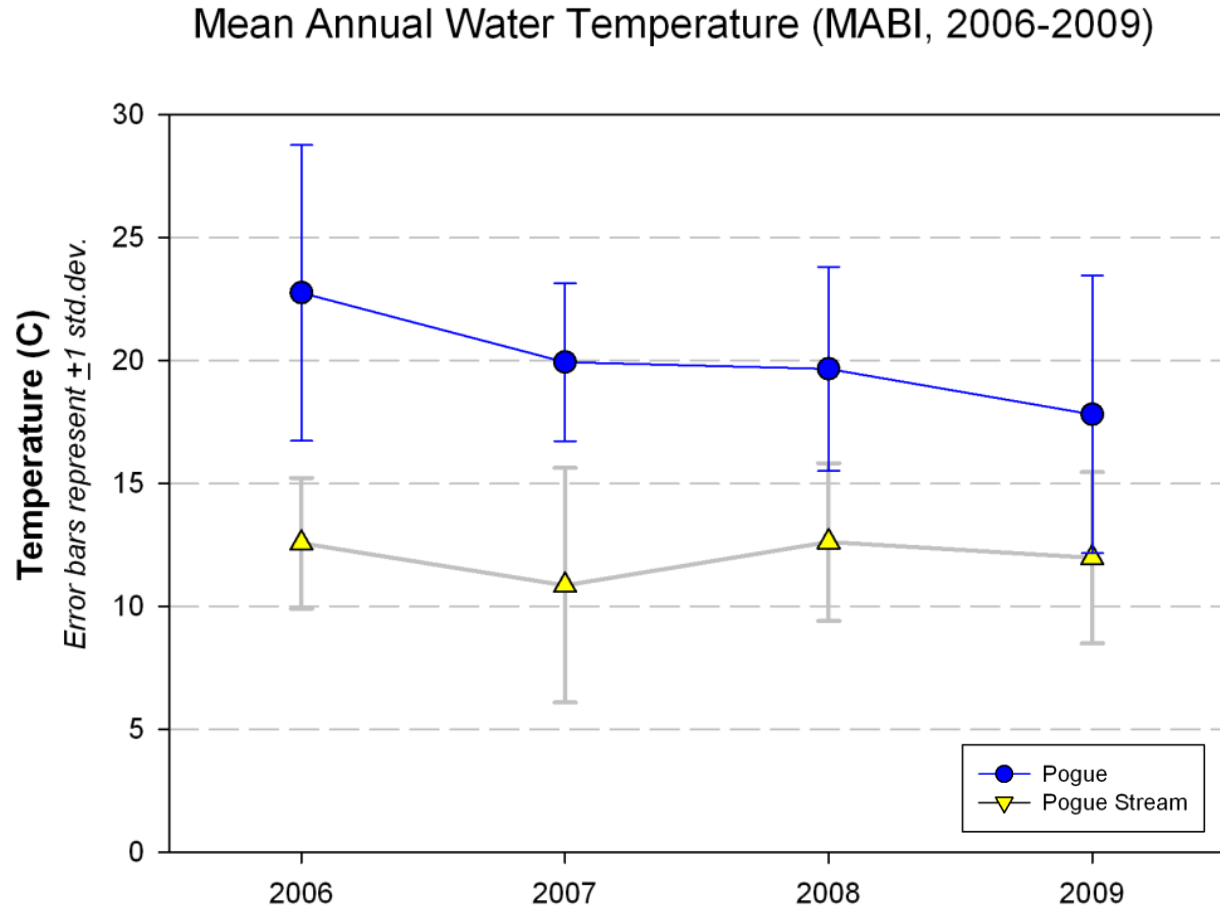


Figure 8. Pond and stream water temperature.

Nutrient Enrichment

Nutrient enrichment and the acceleration of eutrophication have been identified in most NETN parks as one of the stressors of greatest concern. Several forms of total and dissolved phosphorus and nitrogen, and transparency (water clarity, measured with a Secchi disk or turbidity tube), are measured to give managers information regarding the trophic status and productivity of freshwater systems.

Transparency measurements provide simple and affordable assessments of pond and lake productivity. Variation in precipitation is one of the major factors contributing to annual shifts in transparency. Often during drier conditions lakes and ponds will become clearer due to lower runoff of nutrient and soil inputs. In contrast, decreased transparency readings can often be attributed to the effects of high levels of spring and fall precipitation, as well as the cumulative effects of high rainfall years.

Mean Annual Dissolved Oxygen (MABI, 2006-2009)

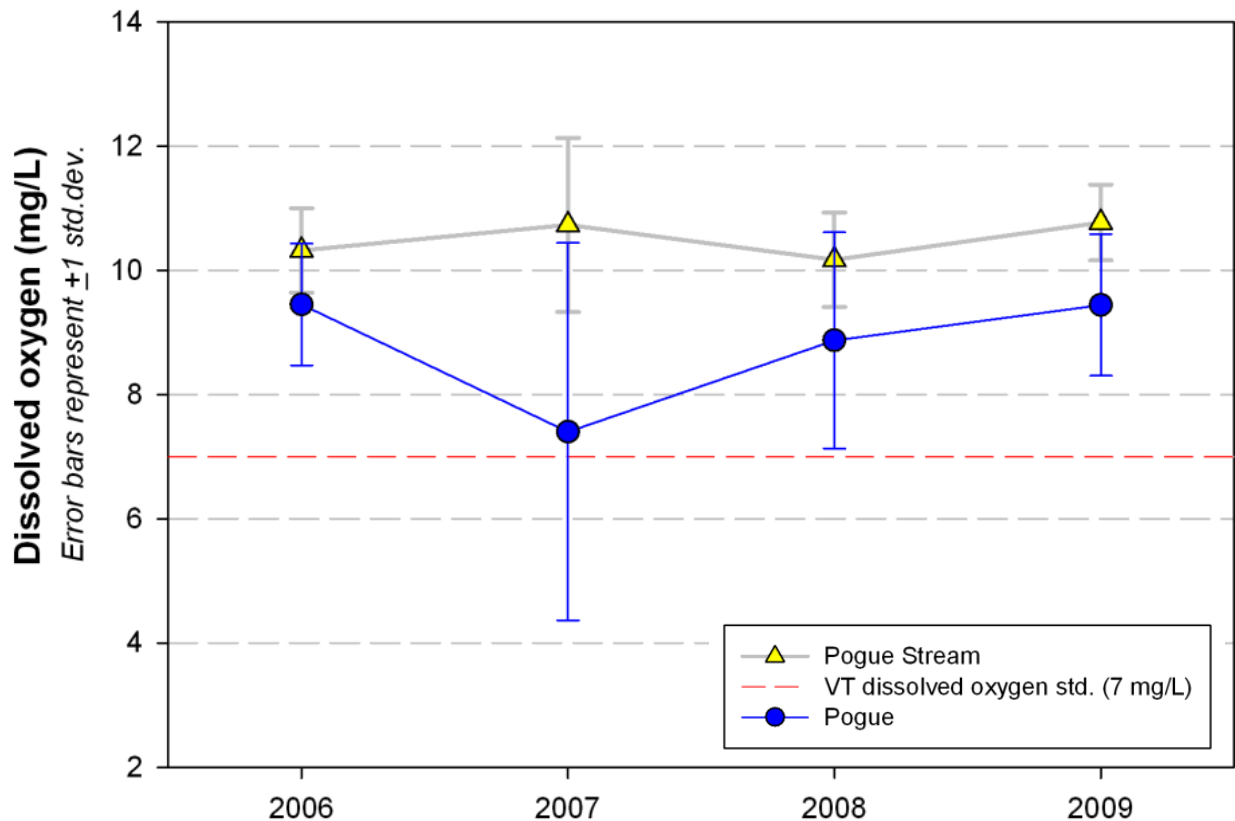


Figure 9. Pond and stream dissolved oxygen.

It is difficult to obtain transparency measurements with a Secchi disk in the Pogue. Due to the water clarity and shallow depth, the disk is likely to hit the pond bottom before disappearing from the observer's view. In measurements taken with the 120 cm turbidity tube, the small target disk on the bottom of the tube was always still visible through 120 cm of pond water. An alternate method, such as measuring light attenuation using a photocell, may provide additional information on water clarity and trophic characteristics of the Pogue. Phosphorus is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits the plant growth in lakes and ponds. As total phosphorus (TP) increases, the amount of algae also increases. In the Pogue, TP concentrations were fairly consistent from year to year, as was the seasonal (June/August) variation (Figure 10). Pogue Stream values were more variable, suggesting more effects of runoff from the surrounding watershed. Although several of the TP values exceed the EPA nutrient criteria, most are within the expected range for a shallow, relatively productive pond and its outlet stream. The Pogue TP value was 8.8 $\mu\text{g/L}$ in 1984.

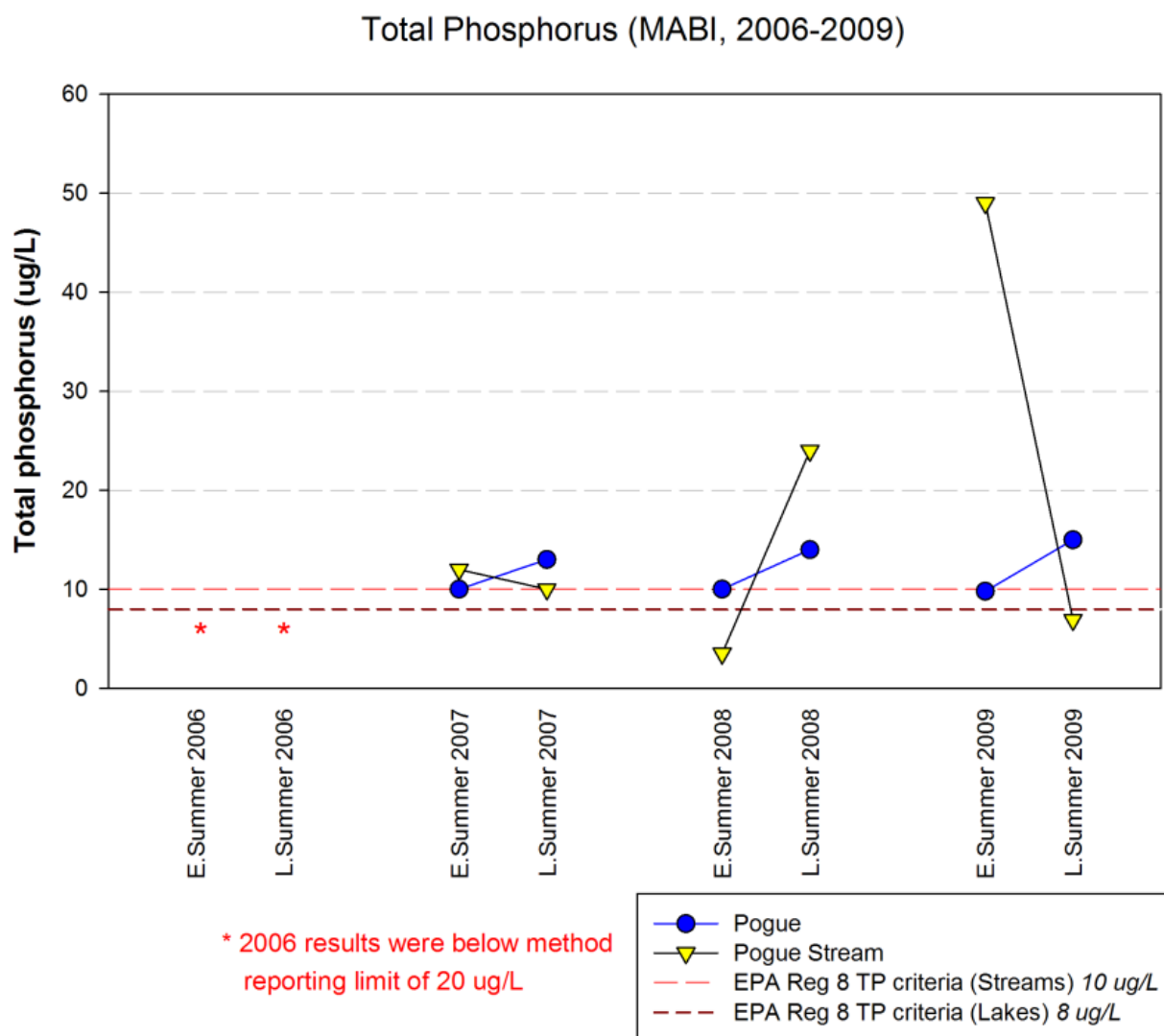


Figure 10. Pond and stream total phosphorus.

The unusually high total phosphorus concentration in the June (“E. Summer”) 2009 sample from Pogue Stream (49 $\mu\text{g/L}$) could possibly be a result of contamination during sample collection. However, this sample also had a very high apparent color value (Figure 11). Color is caused by natural dissolved organic acids such as tannins and lignins which leach from the vegetation into the lake or stream water, causing a tea color. Colored water samples (>30 PCU) can have increased total phosphorus values since the color can interfere with accuracy of the TP test (Williams 2010). Chlorophyll *a* (Chl*a*) is a better indicator of productivity in colored waters and should be used if possible. Total dissolved phosphorus and orthophosphate concentrations for the June 2009 Pogue Stream sample (Table 3) were substantially lower than TP, further suggesting problems with the TP test results.

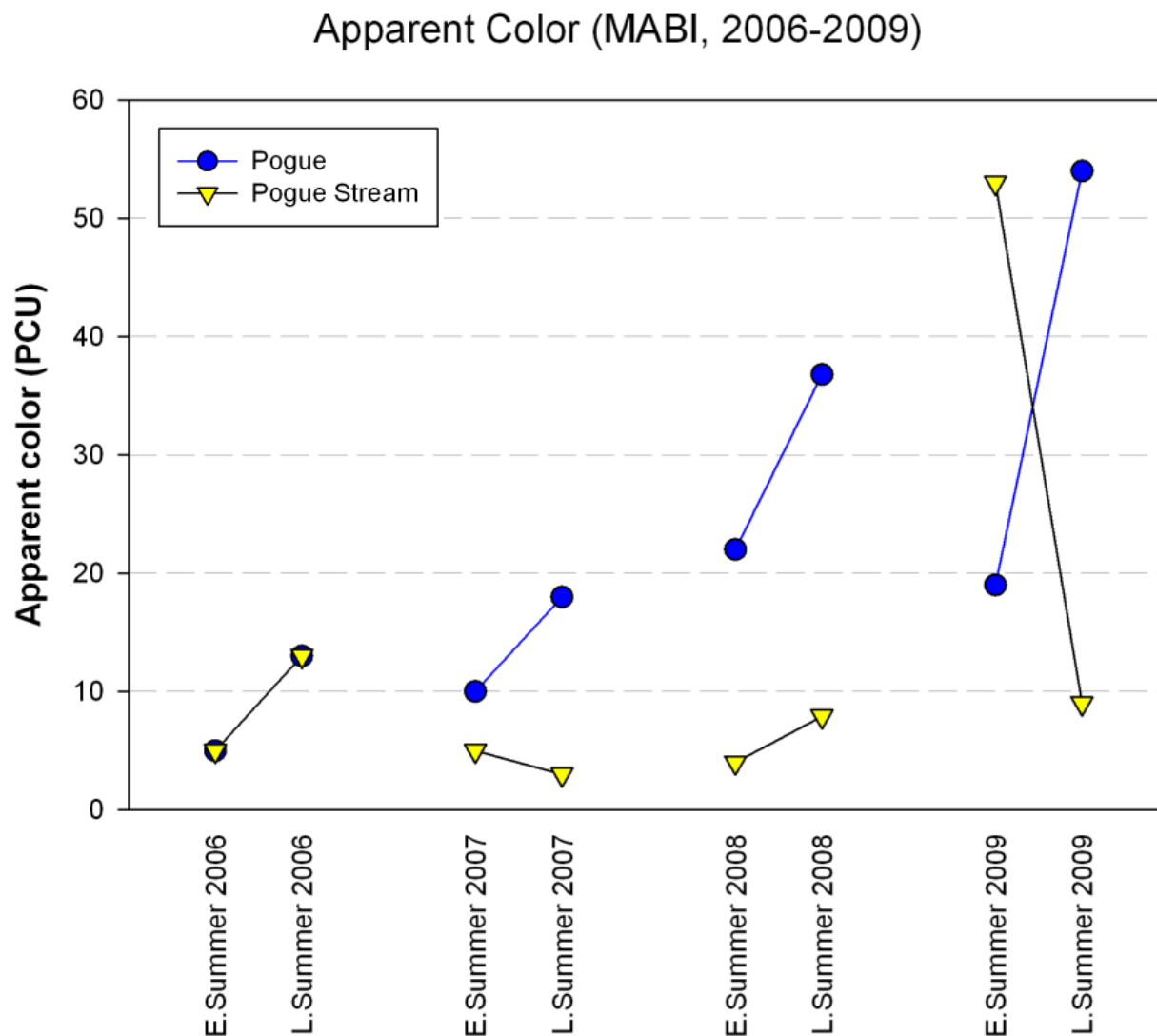


Figure 11: Pond and stream apparent color.

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, be it ammonia, nitrite, nitrate, or organic nitrogen.

Total nitrogen concentrations were low in the Pogue Stream, with all values remaining below the EPA nutrient criteria in all years during this reporting period. TN levels in the Pogue were higher than those in Pogue Stream, though only slightly above the EPA criterion (Figure 12). There are no numeric Vermont water quality standards for total nitrogen.

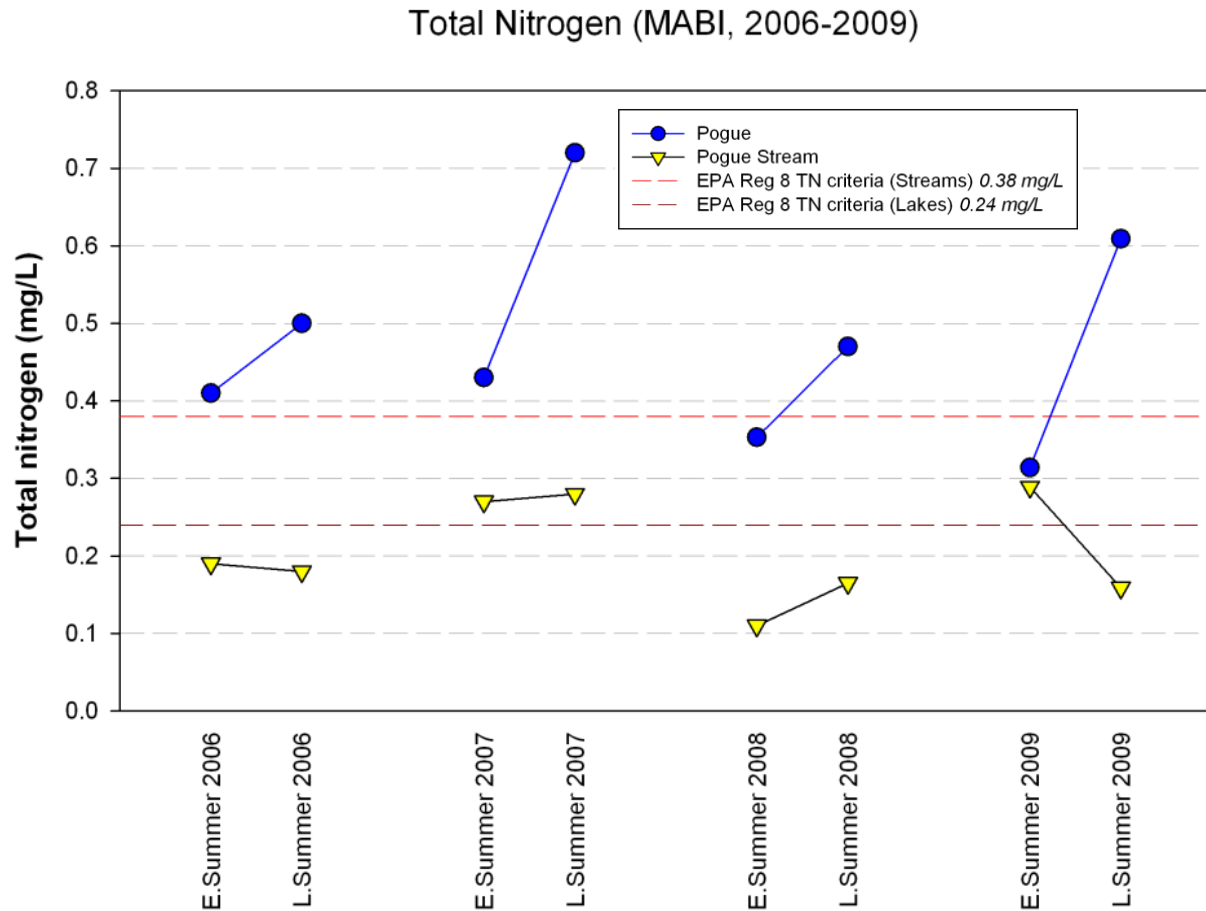


Figure 12. Pond and stream total nitrogen.

Nitrate and nitrite results are illustrated in Figure 13. Nitrate 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 is an unstable form 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. NETN water samples were analyzed with a combined test for nitrate and nitrite, and results were very low. Several test results were below the method reporting limit of 0.005 mg/L, and all were well below the state nitrate standard of 2.0 mg/L. Ammonia (NH_3 , another inorganic, bioavailable form of concern) levels were also very low (Table 3).

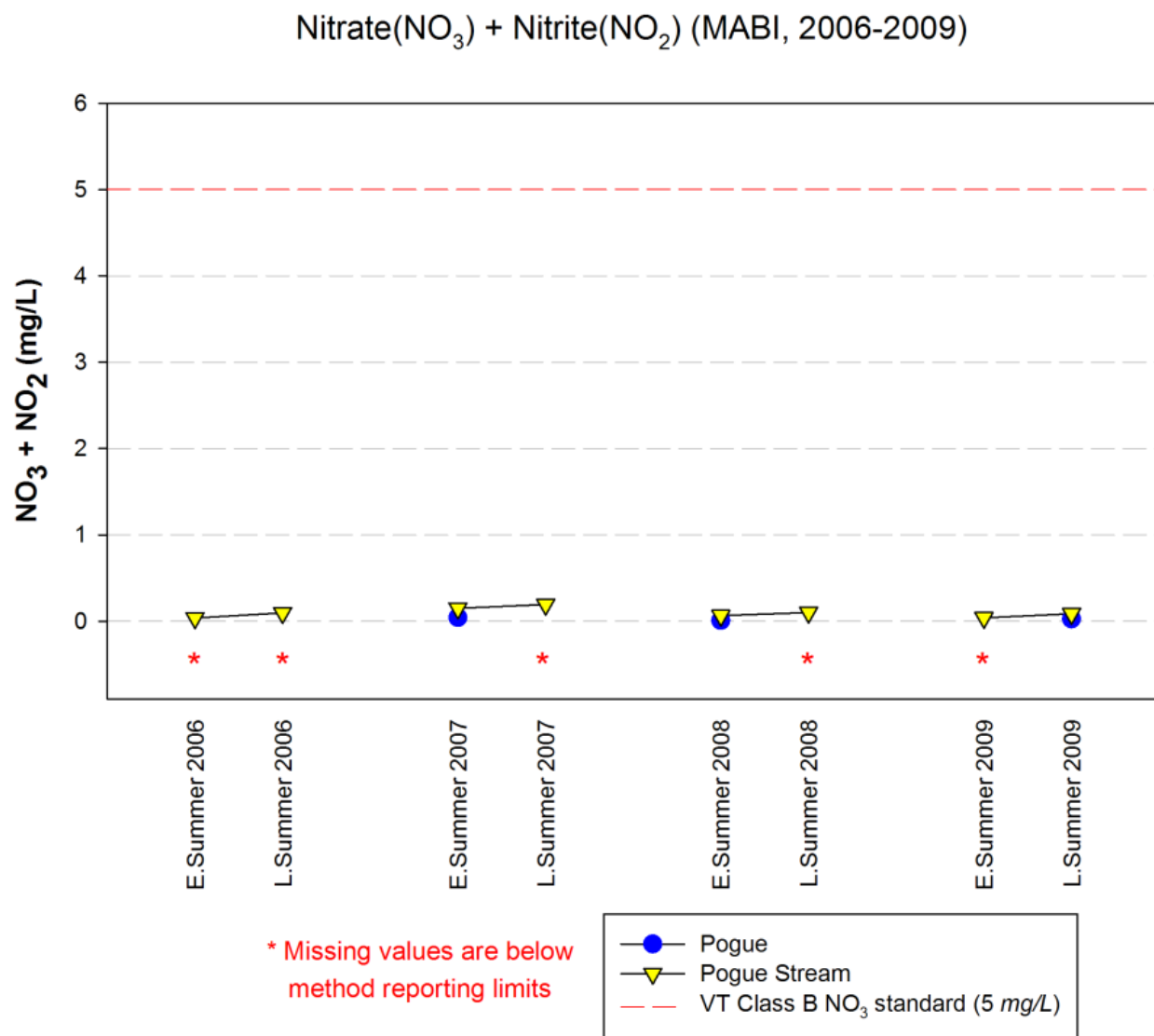


Figure 13. Pond and stream nitrate and nitrite.

Table 3. Pond and stream nutrient data..

Date	Site	ANC (µeq/L)	App. Color (PCU)	Total P (µg/L)	Total Diss. P (µg/L)	Ortho P (µg/L)	Total N (mg/L)	Total Diss. N (mg/L)	NO ₂ +NO ₃ (mg/L)	NO ₂ (mg/L)	NH ₃ (mg/L)	Stream Dis. (cfs)
6/13/2006	Pogue Stream	1,440.0	5	<MRL 20	N/A	3 (E, <MRL 6)	0.19	N/A	0.037 (E, <MRL 0.06)	<MRL 0.002	0.017	0.95
8/23/2006	Pogue Stream	2,000.0	13	<MRL 20	N/A	6 (E, <MRL 6)	0.18	N/A	0.096	<MRL 0.002	0.024	0.13
5/8/2007	Pogue Stream	1,416.2	5	12	3 (E, <MRL 6)	<MRL 6	0.27	0.2	0.15	0.002 (E, <MRL 0.002)	<MRL 0.02	0.56
8/14/2007	Pogue Stream	2,367.1	3	10	5 (E, <MRL 6)	6	0.28	0.27	0.193	<MRL 0.002	<MRL 0.02	0.02
5/20/2008	Pogue Stream	1,435.0	4	3.5	1.9	1.5	0.11	<MRL 0.1	0.065	<MRL 0.005	<MRL 0.08	0.31
8/22/2008	Pogue Stream	1,970.0	7.89	24	4	2	0.165	0.18	0.101	<MRL 0.005	<MRL 0.08	N/A
5/7/2009	Pogue Stream	1,370.0	53	49	4.1	1.6	0.289	0.149	0.039	<MRL 0.005	<MRL 0.08	1.73
8/27/2009	Pogue Stream	2,020.0	9	6.9	3.2	2.8	0.159	0.172	0.087	<MRL 0.005	<MRL 0.08	0.24
6/13/2006	The Pogue	1,640.0	5	<MRL 20	N/A	<MRL 6	0.41	N/A	<MRL 0.06	0.001 (E, <MRL 0.002)	0.006 (E, <MRL 0.010)	N/A
8/23/2006	The Pogue	1,660.0	13	<MRL 20	N/A	4 (E, <MRL 6)	0.5	N/A	<MRL 0.06	<MRL 0.002	0.068	N/A
6/7/2007	The Pogue	1,653.9	10	10	<MRL 6	3 (E, <MRL 6)	0.43	0.32	0.041	0.001 (E, <MRL 0.002)	0.053	N/A
8/14/2007	The Pogue	1,614.8	18	13	7	<MRL 6	0.72	0.58	<MRL 0.016	<MRL 0.002	0.099	N/A
6/17/2008	The Pogue	1,496.0	22	10	4.3	<MRL 1	0.353	0.257	0.0077	<MRL 0.005	<MRL 0.08	N/A
8/22/2008	The Pogue	1,380.0	36.8	14	4.3	<MRL 1	0.47	0.316	<MRL 0.005	<MRL 0.005	<MRL 0.08	N/A
6/18/2009	The Pogue	1,650.0	19	9.8	4	1.3	0.314	0.292	<MRL 0.005	<MRL 0.005	<MRL 0.08	N/A
8/27/2009	The Pogue	1,840.0	54	15	4.4	1.5	0.609	0.415	0.025	<MRL 0.005	<MRL 0.08	N/A

E= Estimated value MRL= Method Reporting Limit N/A = no analysis performed for this sample parameter

Water Quantity

Monthly stream discharge measurements (Figure 14), taken with a current meter and wading rod, can be used to calculate loading of nutrient chemical constituents (flow times 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. Pond stage measurements were taken by measuring to the water surface from a fixed datum point. NETN staff are currently reviewing stage measurement methodology and quality assurance/quality control procedures in order to enhance the quality and utility of the water quantity data.

Stream Discharge and Pond Level (MABI 2006-2009)

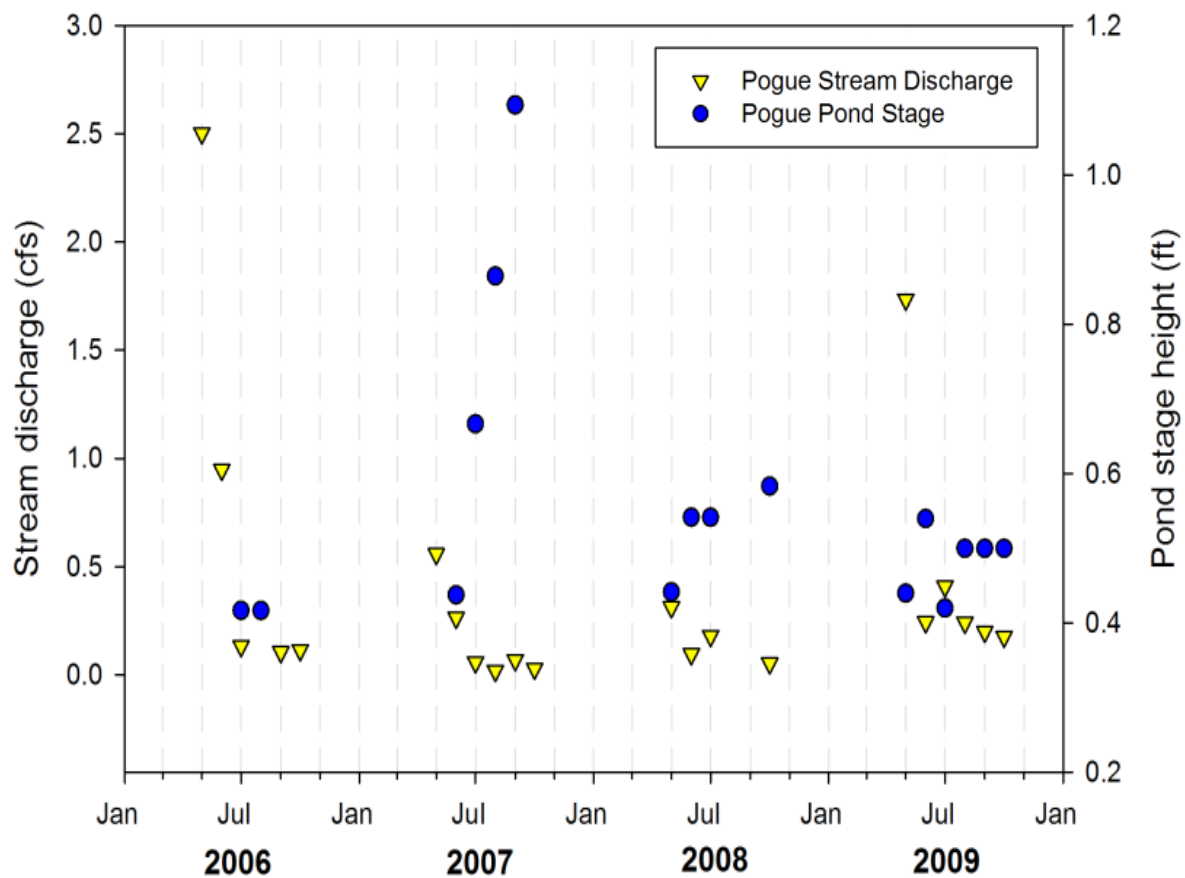


Figure 14. Pond and stream water quantity indicators.

Invasive Aquatic Plants

Methods for invasive aquatic plant monitoring were adapted from the Maine Center for Invasive Aquatic Plants (MCIAP), a division of the Maine Volunteer Lake Monitoring Program (VLMP). Investigators utilize a level 3 survey, which involves surveying the entire shoreline and transects covering the littoral zone. Detailed survey instructions can be found in the NETN protocol (Lombard et al. 2006).

The primary targets of the invasive plant surveys were the 11 plants currently listed by the MCIAP (Table 4). Surveyors also looked for species on a secondary list (Table 5), compiled from the USGS Nonindigenous Aquatic Species website (<http://nas3.er.usgs.gov/>). The database was queried to obtain species of concern for each of the states containing NETN park units. This list includes some species that have not been located in some states in which the NETN monitors (CT, NH, VT), but are of regional concern. For both tables, species in bold type were specifically targeted on the Vermont Water Quality Division aquatic invasive species website (http://www.anr.state.vt.us/dec/waterq/lakes/htm/ans/lp_ans-index.htm).

Table 4. Maine Center for Invasive Aquatic Plants species of concern.

Common name	Latin name
European Frogbit	<i>Hydrocharis morsus-ranae</i>
Water Chestnut	<i>Trapa natans</i>
Yellow Floating Heart	<i>Nymphoides peltata</i>
Eurasian Water Milfoil	<i>Myriophyllum spicatum</i>
Variable Water Milfoil	<i>Myriophyllum heterophyllum</i>
Parrot Feather	<i>Myriophyllum aquaticum</i>
Fanwort	<i>Cabomba caroliniana</i>
Hydrilla	<i>Hydrilla verticillata</i>
Brazilian Elodea	<i>Egeria densa</i>
European Naiad	<i>Najas minor</i>
Curly-Leaved Pondweed	<i>Potamogeton crispus</i>

Table 5. U.S. Geological Survey Nonindigenous Aquatic Species of concern.

Common name	Latin name	State(s) listed
Flowering Rush	<i>Butomus umbellatus</i>	NY, CT, VT
Pond water-starwort	<i>Callitriche stagnalis</i>	NY, CT, MA
Water Hyacinth	<i>Eichhornia crassipes</i>	NY
Yellow Iris	<i>Iris pseudacorus</i>	NY, NH, VT, MA, CT
Dotted Duckweed	<i>Landoltia salicaria</i>	MA
Water Primrose	<i>Ludwigia hexapetala</i>	NY
Purple Loosestrife	<i>Lythrum salicaria</i>	NY, MA, CT, NH, VT
European Water-clover	<i>Marsilea quadrifolia</i>	NY, CT
Water-cress	<i>Nasturtium officinale</i>	NY, CT, NH, VT, MA
Sacred Lotus	<i>Nelumba nucifera</i>	NY
Water Lettuce	<i>Pistia straitotes</i>	NY
Amphibious Yellow-cress	<i>Rorippa amphibia</i>	NY, CT, VT

Invasive aquatic plant monitoring was conducted at the Pogue during the 2007 – 2009 monitoring seasons. Results indicated that invasive aquatic plants do not currently exist at the Pogue.

During future visits to all NETN parks, monitors will be increasingly attentive for the presence of Didymo (*Didymosphenia geminata*), also known as “rock snot”, a highly invasive alga that has recently invaded the northern reaches of the Connecticut River in New Hampshire and in the White River and Battenkill River 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 is easily spread by even just one cell of the alga breaking off and drifting downstream in infested reaches. It is also very easily spread by waders, and potentially, water monitoring equipment and other gear that touches the bottoms of streams in infested areas. Enhanced equipment cleaning and decontamination procedures are being included in the latest protocol revision.

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 waterbodies. 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.

Summary

The introduction of NETN water monitoring protocols during the 2006 season provided the ability to detect changes in the quality and quantity of surface waters in Marsh-Billings-Rockefeller NHP. This report does not attempt to determine long-term trends for specific water quality parameters, since the sites do not have a sufficient data history to enable trend detection.

All water quality parameters for the Pogue and Pogue Stream are within state standards, and are generally within the range of EPA criteria, where applicable. The values are similar to the extremely limited historical observations from the NPS Baseline Water Quality Data Inventory and Analysis. Both water bodies were well buffered, with pH values between 8.0 and 8.5, and are unlikely to be affected by atmospheric deposition. Nutrient levels are low (nitrogen) to moderate (phosphorus) but could be susceptible to increased loading from runoff. Spikes in apparent color that accompany several of the higher TP and TN values suggest that the samples may have captured the effects of moderate runoff from precipitation events. More sensitive measures of water clarity and/or turbidity might help to verify this observation.

Four years of monitoring under the NETN protocol have provided critical baseline information on the chemical and physical status of the Pogue and Pogue Stream. Refinements of the monitoring protocol and enhanced quality assurance and quality control procedures have improved the data quality with each subsequent year, allowing a better understanding of the seasonal and temporal variability of individual constituents within each water body. 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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