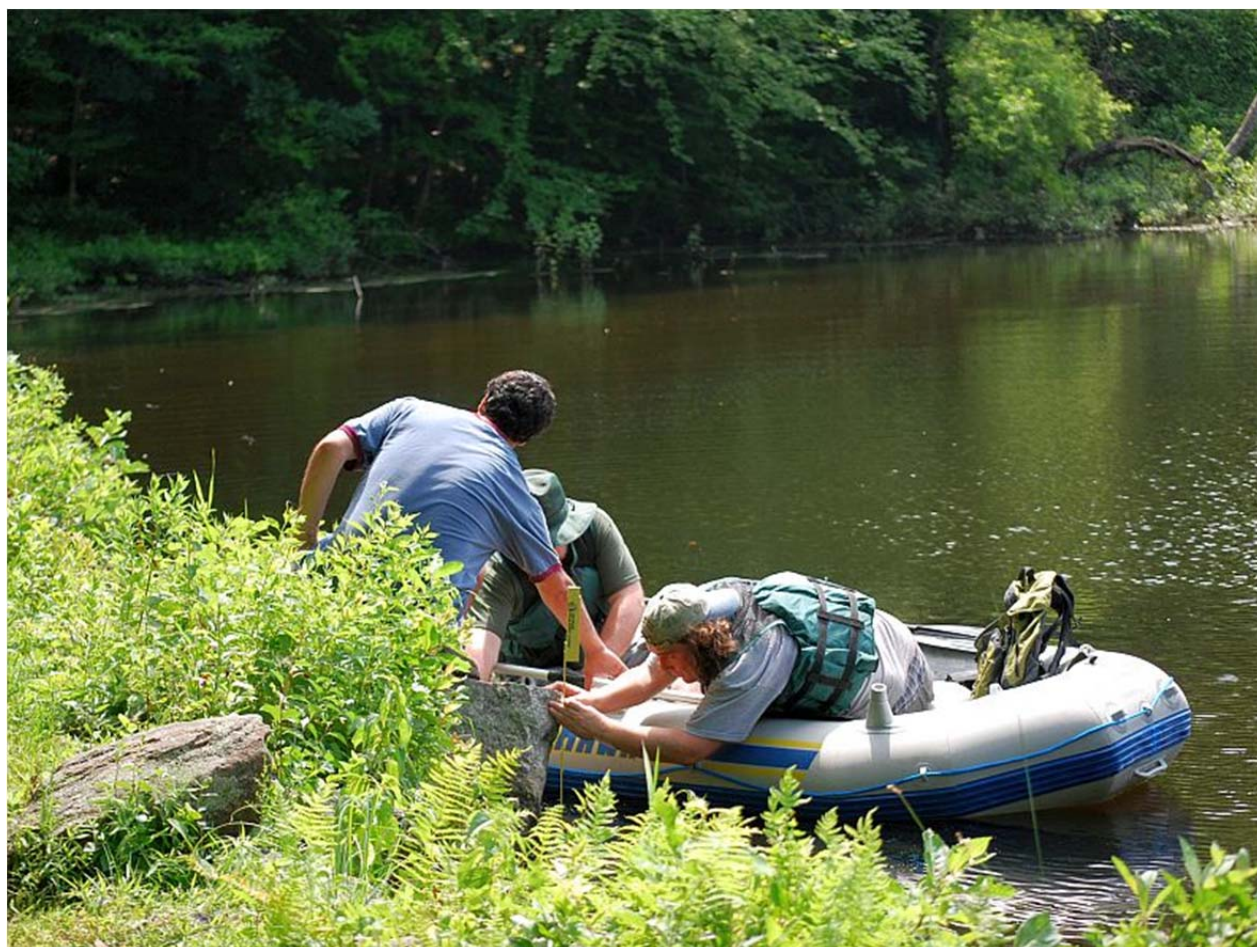




Water Quality Monitoring at Weir Farm NHS

Northeast Temperate Network 2011 Summary Report

Natural Resource Data Series NPS/NETN/NRDS—2012/347



ON THE COVER

Measuring pond stage (water level) at Weir Pond, July 2011

Photograph by: Beth Arsenaault

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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 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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Contents

	Page
Figures.....	v
Tables.....	vii
Introduction.....	1
Sampling Site.....	2
Methods.....	2
Water Quality Standards.....	2
Results.....	3
Water Quality.....	4
Specific Conductance.....	4
pH Level.....	5
Temperature.....	6
Dissolved Oxygen.....	7
Acid Neutralizing Capacity.....	8
Apparent Color.....	9
Nutrient Enrichment.....	10
Transparency.....	10
Phosphorus.....	11
Nitrogen.....	12
Water Quantity.....	13
Pond and Stream Stage.....	13
Invasive Aquatic Plants.....	13
Summary.....	15
Literature Cited.....	17

Contents (continued)

	Page
Appendix A. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2006-2011.	19

Figures

	Page
Figure 1. NETN water monitoring site at Weir Farm NHS.	1
Figure 2. Explanation of box plot graph	3
Figure 3. Specific conductance from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.....	4
Figure 4. pH from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.....	5
Figure 5. Water temperature (surface) from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.	6
Figure 6. Dissolved oxygen (surface) from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.	7
Figure 7. Acid neutralizing capacity from 2011 spring and summer water samples overlaid on a box plot of measurements taken from 2006-2011.	8
Figure 8. Apparent color from 2011 spring and summer water samples overlaid on a box plot of measurements taken from 2006-2011.	9
Figure 9. Secchi disk, measuring tape, and viewing scope (left) and view of submerged Secchi disk through viewing scope (right).	10
Figure 10. Total phosphorus (TP), total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) from spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2011. There is no numeric New Hampshire state water quality TP standard.....	11
Figure 11. Total nitrogen (TN), total dissolved nitrogen (TDN), nitrite + nitrate ($\text{NO}_2 + \text{NO}_3$), nitrite (NO_2), and ammonia (NH_3) from 2011 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2011.....	12
Figure 12. Pond and stream stage obtained in 2011 by measuring from a permanent datum point down to the water surface. <i>Note: Larger tapedown distances indicate LOWER water levels.</i>	13

Tables

	Page
Table 1. Water quality monitoring sites at Weir Farm NHS, Connecticut	2
Table 2. Connecticut lake and pond water quality standards.....	2
Table 3. EPA Ecoregion 14 nutrient criteria for lakes and ponds.....	3
Table 4. Maine Center for Invasive Aquatic Plants species of concern.....	14
Table 5. U.S. Geological Survey Nonindigenous Aquatic Species of concern.	14

Introduction

This report on the water quality of Weir Farm National Historic Site (WEFA) generated by the Northeast Temperate Network (NETN) Water Quality Monitoring Program includes data gathered in the 2011 monitoring season and displays these results in graphic form, accompanied by a brief interpretation. Appendix A contains data collected from 2006 through 2011.

The vital signs for freshwater bodies included in the 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 one pond (Figure 1) at WEFA to be sampled monthly from May through October. A cooperator from the University of Vermont or a NETN hydrologic technician 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.

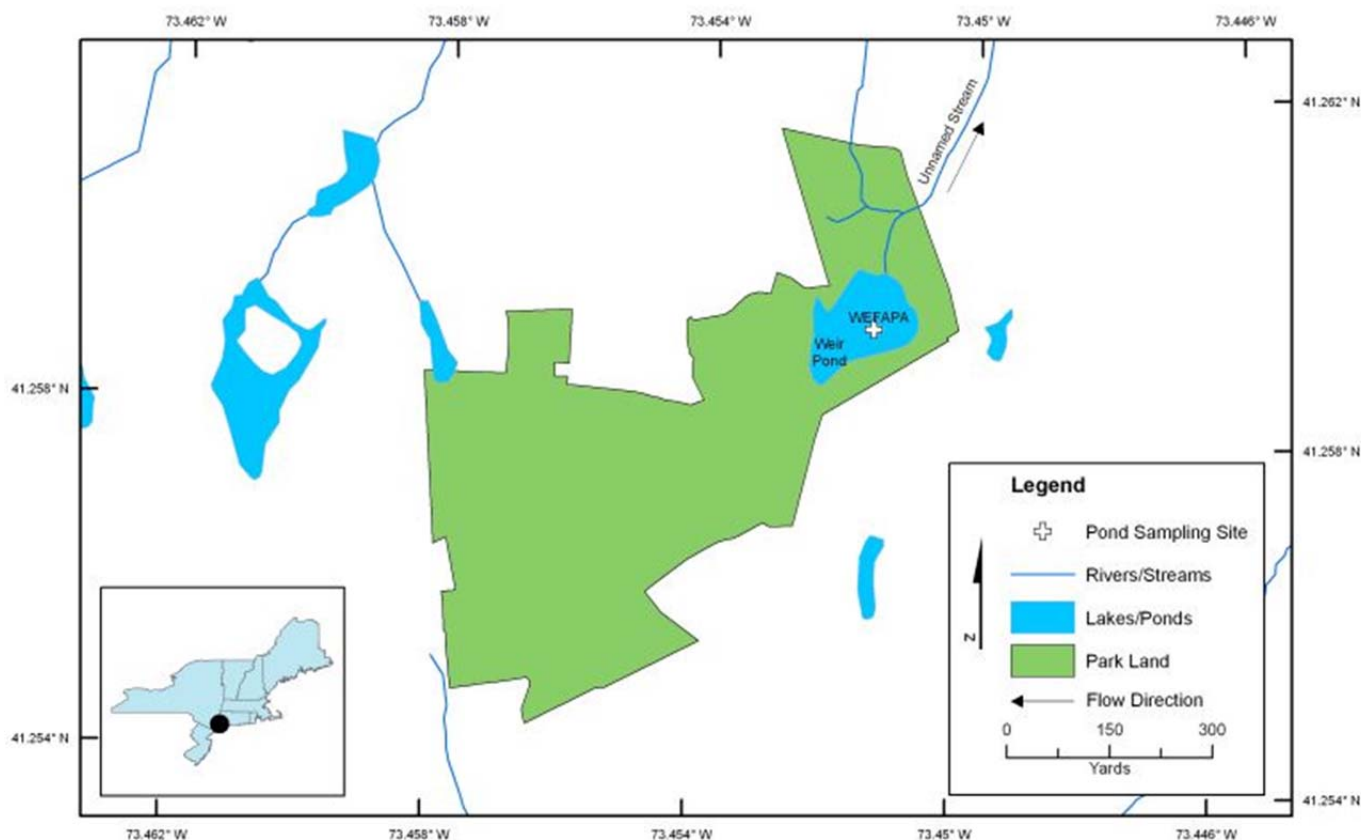


Figure 1. NETN water monitoring site at Weir Farm NHS.

Sampling Site

There is a minimal amount of water quality data available that have been collected at WEFA, so a long-term monitoring site was set up in Weir Pond, the largest fresh water body in the park (Table 1). The deepest point of the pond (approximately 1.5 meters) is monitored monthly from May-October for high priority vital signs including temperature, pH, specific conductance, dissolved oxygen (DO), and water clarity. A tape down point was established to monitor water levels in the pond.

Table 1. Water quality monitoring sites at Weir Farm NHS, Connecticut.

Water Body	NETN Site Code	Latitude	Longitude	Site Remarks
Weir Pond	WEFAPA	41.25952	-73.4515	Site at deepest point in pond

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, weather, and pond stage. In June and August, 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 1.5 meters). Nutrient chemistry parameters were analyzed from a half-meter grab sample, obtained by submerging the sample bottle directly in the pond with a gloved hand.

Pond stage was measured by using a folding wooden ruler (engineering scale) to “tape down” from a fixed datum point on a large boulder to the surface of the water. A bolt was installed to permanently mark the datum point in July 2011.

Water Quality Standards

Connecticut water quality standards for lakes and ponds vary according to the trophic status of the water body. Because Weir Pond (the only NETN pond in Connecticut) ranges between mesotrophic and eutrophic conditions, both criteria are included in this report. “Total nitrogen (N) concentrations shall range from 200 to 600 µg/L nitrite (NO₃) in mesotrophic lakes and from 600 to 1,000 µg/L NO₃ in eutrophic lakes. Total phosphorus concentrations shall range from 10 to 30 µg/L NO₃ in mesotrophic lakes and from 30 to 50 µg/L NO₃ in eutrophic lakes. Secchi disk depth (SD) shall range from 2 to 6 m in mesotrophic lakes and from 1 to 2 m in eutrophic lakes” (State of Connecticut Department of Environmental Protection 2002).

Table 2. Connecticut lake and pond water quality standards.

Pond Trophic Type	Maximum temperature (°F)	Minimum dissolved oxygen (mg/L)	pH range (standard units)	Maximum chlorophyll a (µg/L)	Minimum Secchi disk depth (m)	Maximum total nitrogen (µg/L)	Maximum total phosphorus (µg/L)
Mesotrophic				2-15	2-6	200-600	10-30
Eutrophic	--	--	--	15-30	1-2	600-1,000	30-50

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 lakes and ponds.

Nutrient Criteria	Value
Total Phosphorus	8 µg/L
Total Nitrogen	0.32 mg/L
Chlorophyll <i>a</i> - fluorometric	2.9 µg/L
Secchi disk depth	4.5 m

These criteria were developed specifically for Ecoregion 14 (which includes Minute Man NHP, Saugus Ironworks 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 25th percentile of lakes and ponds for which the EPA found data. 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. (U.S. Environmental Protection Agency 2000).

Results

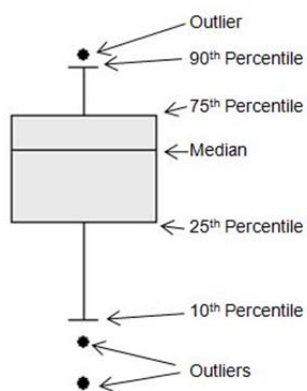


Figure 2. Explanation of box plot graph.

Monitoring results for 2011 are displayed in scatter-plot graphs showing all data for each site for a given parameter. The scatter plots of 2011 data are overlaid on box plots representing the overall range and distribution of data values collected from 2006 through 2011 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 25th percentile, a line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers (error bars) above and below the box indicate the 90th and 10th percentiles respectively. Outliers are displayed as black filled circles. If EPA or other water quality criteria exist for a particular parameter they are displayed on the graphs as specification lines.

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 2011 were within the appropriate range for moderate ionic strength waters, and were generally within the range of values shown on the box plot.

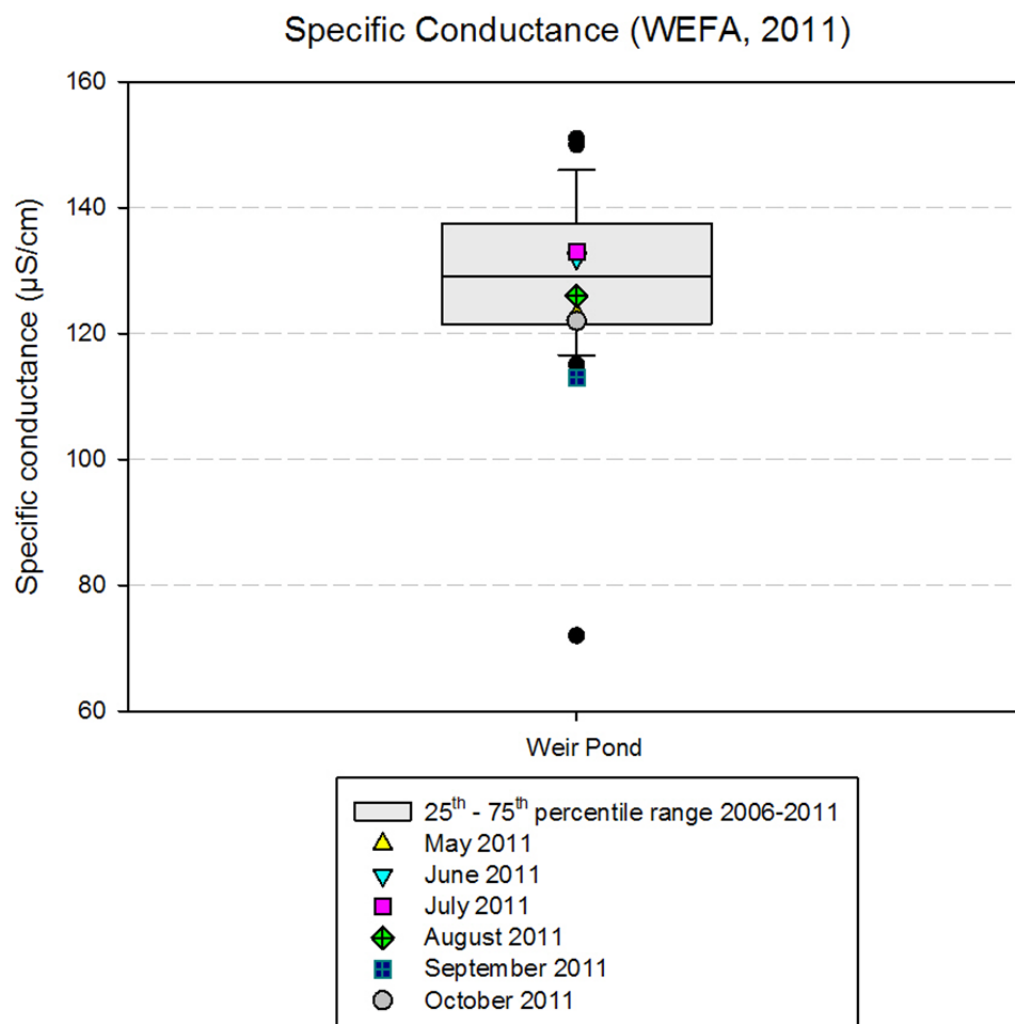


Figure 3. Specific conductance from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.

pH Level

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. Although Connecticut has no numeric pond water quality standards for pH, the stream water quality standards, similar to those of most northeast states, indicate that a pH between 6.5 and 8.0 is within the acceptable range. Most of the pH values from the 2011 monitoring season (Figure 4) were slightly acidic, in the lower range of variability of the historic NETN monitoring data from WEFA.

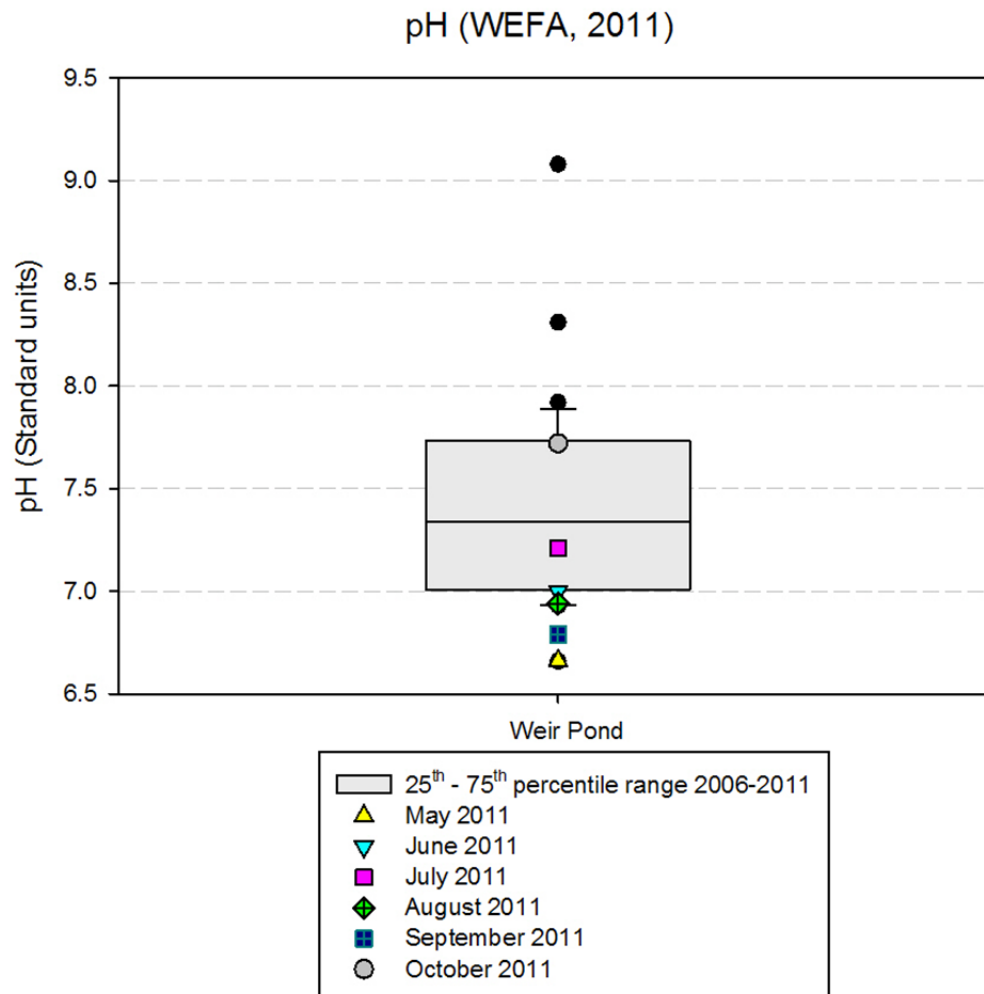


Figure 4. pH from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.

Water 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 (Figure 5) appeared to be within the normal range of variability in 2011, though the July values reflected the contributions of high air temperature and solar radiation.

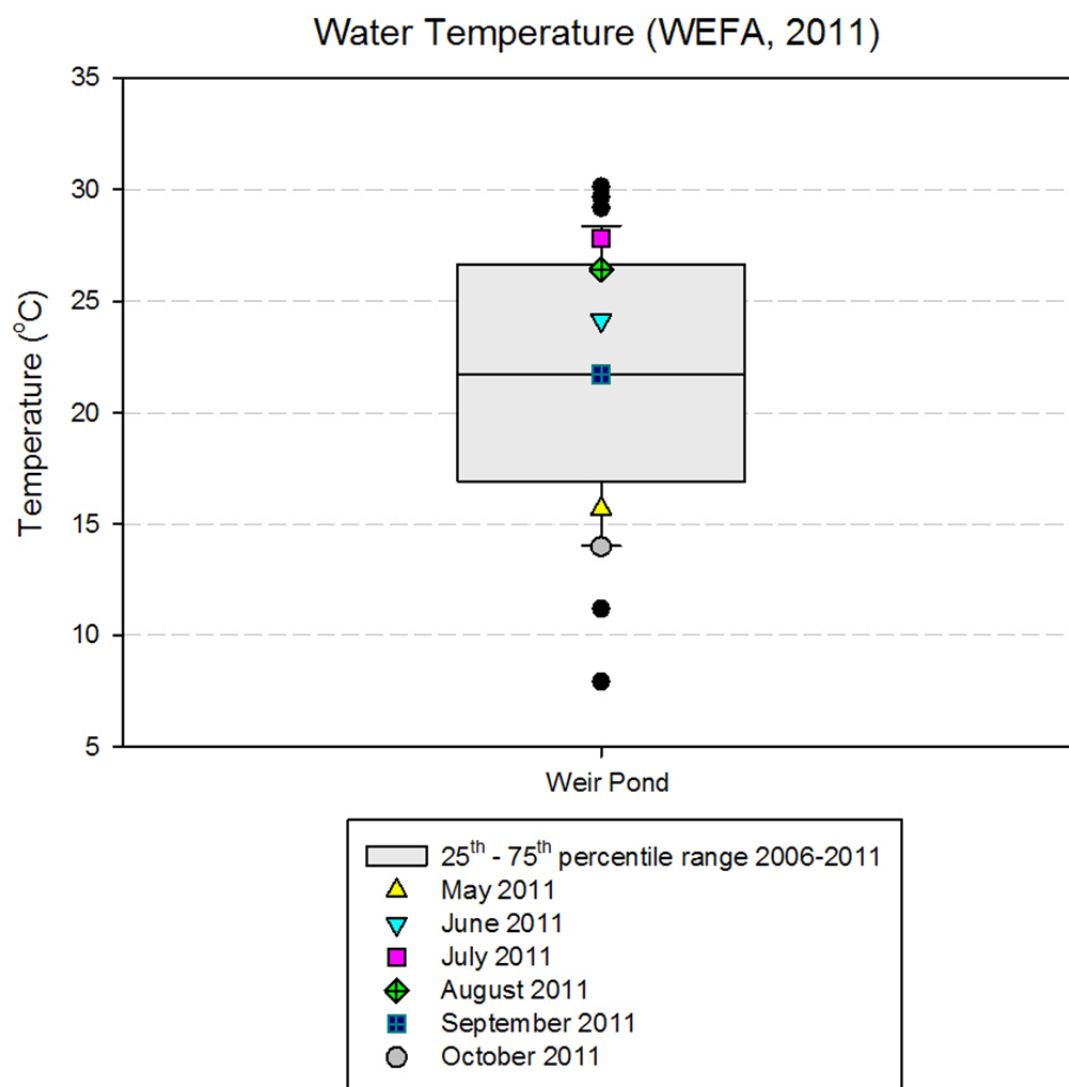


Figure 5. Water temperature (surface) from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.

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). WEFA surface water was generally well oxygenated in 2011 (Figure 6) although the May value of 4.91 mg/L is notable as the lowest surface DO measurement at WEFA to date.

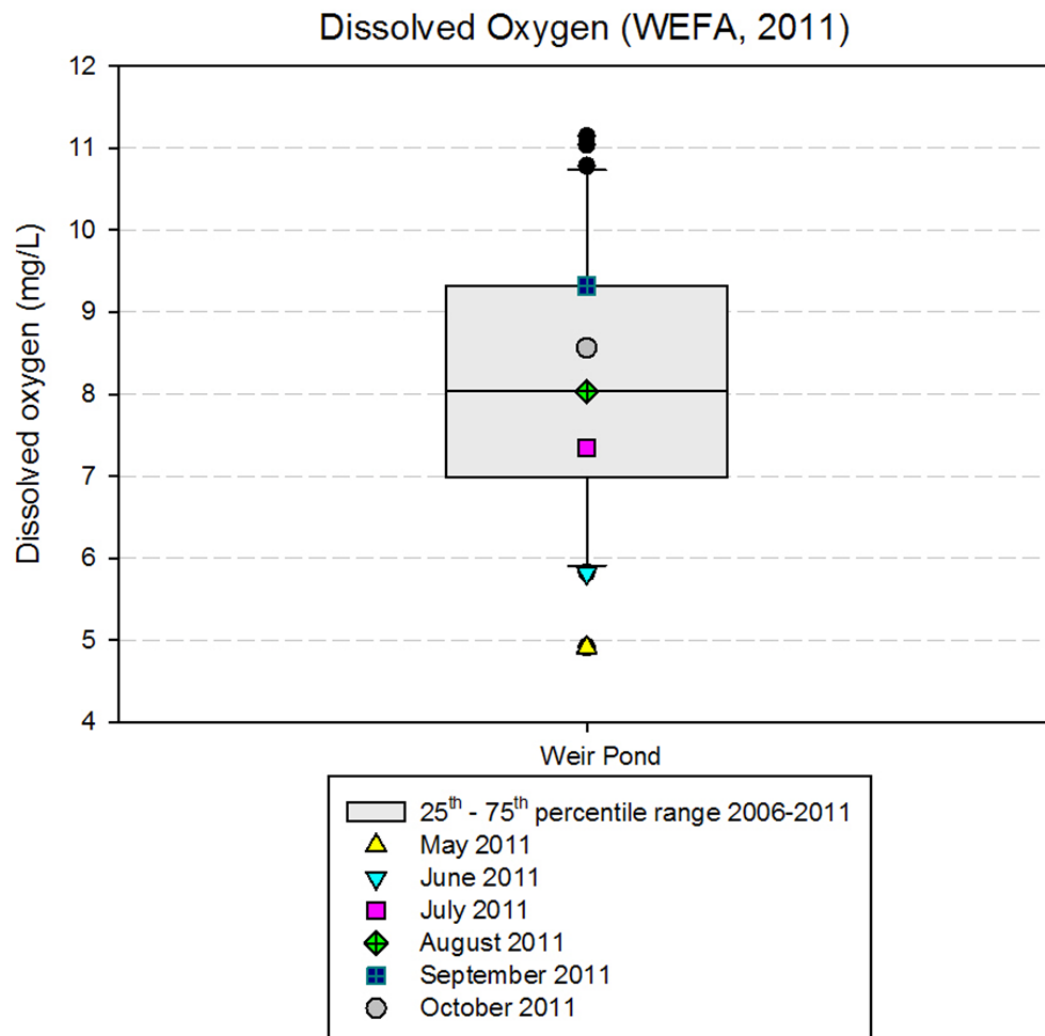


Figure 6. Dissolved oxygen (surface) from 2011 YSI sonde in-situ measurements overlaid on a box plot of measurements taken from 2006-2011.

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 2011 samples (Figure 7) illustrates that Weir Pond is well-buffered, likely due to the underlying geology. The 2011 ANC measurements from June (Spring) follow the typical seasonal pattern of being lower than August (Summer) values. This 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).

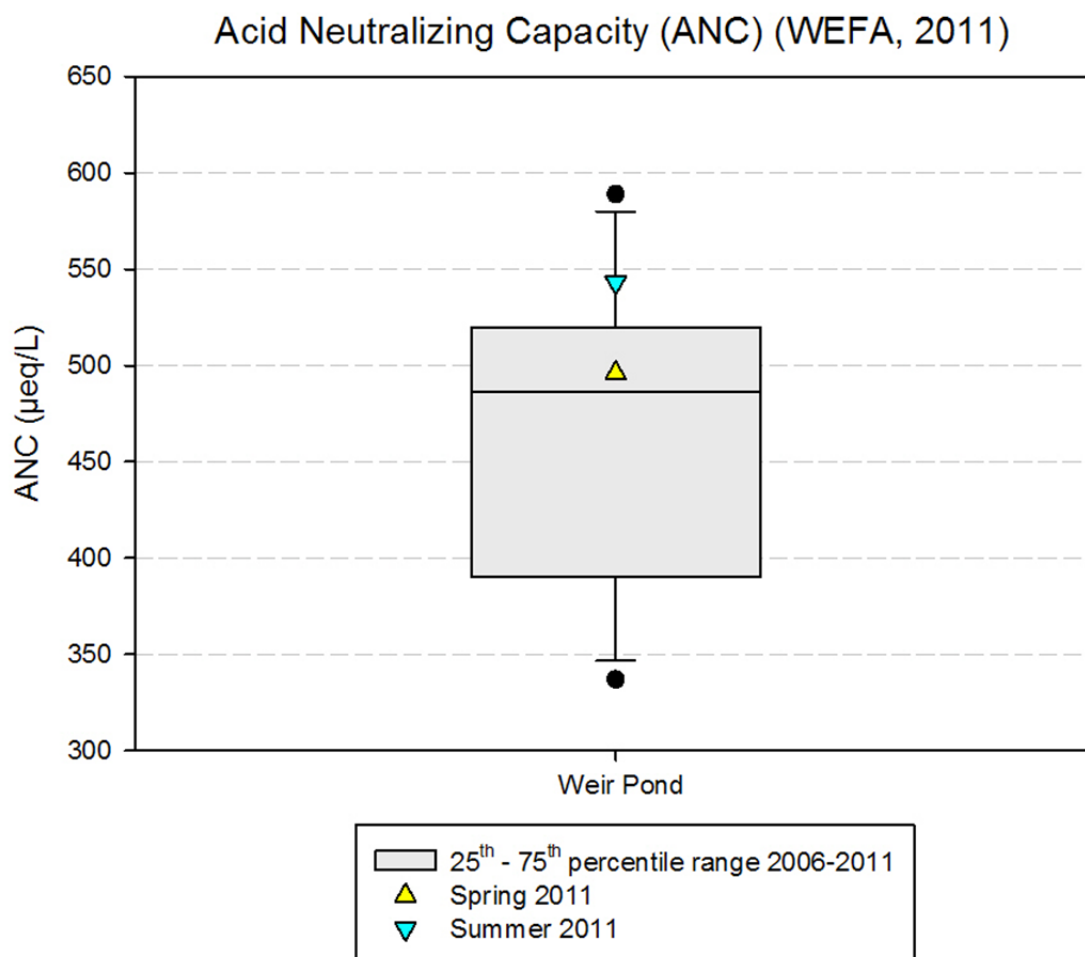


Figure 7. Acid neutralizing capacity from 2011 spring and summer water samples overlaid on a box plot of measurements taken from 2006-2011.

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 the 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.

Color results from the 2011 samples were highly colored and greater than most in the 2006 to 2011 historic data values (Figure 8). This could be the effect of runoff and sediment input to the systems, rather than dissolved constituents, since the samples were not filtered before analysis.

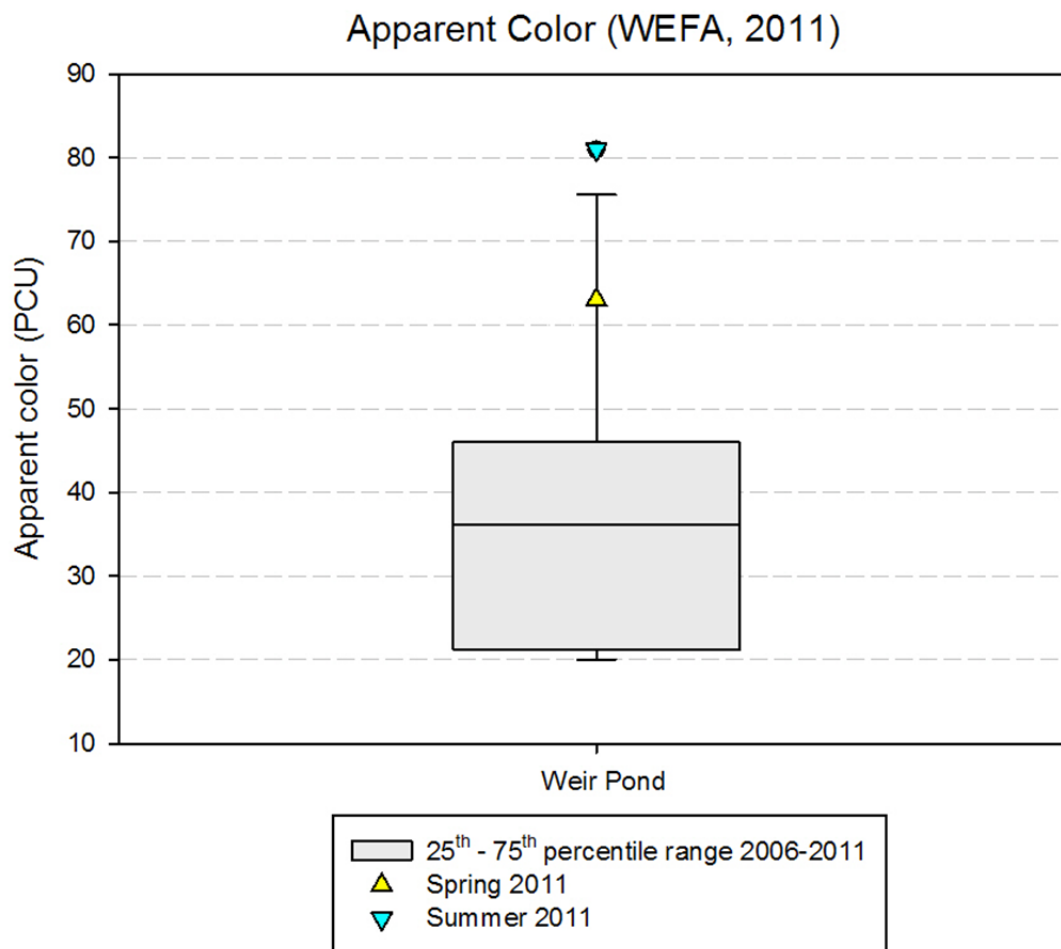


Figure 8. Apparent color from 2011 spring and summer water samples overlaid on a box plot of measurements taken from 2006-2011.

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 are measured to give managers information regarding the trophic status and productivity of freshwater systems.

Transparency

Transparency measurements can 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 a high rainfall year.

It is difficult to obtain transparency measurements with a Secchi disk (Figure 9) in Weir Pond. Due to the pond's shallow depth, the disk hit the pond bottom before disappearing from the observer's view in all NETN measurements. In measurements taken with the 120 cm turbidity tube, the small target disk on the bottom of the tube was always still visible through the 120 cm column of pond water. Transparency data from 2006 through 2011 is listed in Appendix A (Table A4). Beginning in 2012, the NETN will measure light attenuation in ponds using an underwater photocell to provide additional information on the water clarity and trophic characteristics of Weir Pond.



Figure 9. Secchi disk, measuring tape, and viewing scope (left) and view of submerged Secchi disk through viewing scope (right).

Phosphorus

Phosphorus (P) is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits the plant growth in streams and ponds. Several forms of phosphorus were tested individually. Total phosphorus (TP) is a measure of both inorganic and organic forms of phosphorus, and is the common water quality standard or criteria metric. Phosphorus can be present as dissolved or particulate matter, and filtered samples were analyzed for total dissolved phosphorus (TDP). Soluble reactive phosphorus (SRP, or “orthophosphate”) is a measure of the inorganic oxidized form of soluble phosphorus. This form of phosphorus is the most readily available for uptake during photosynthesis. High concentrations of SRP generally occur in conjunction with algal blooms.

In 2011, total phosphorus concentrations in Weir Pond (Figure 10) were relatively high, with the expected seasonal variation of lower spring values. The August (Summer) TP value exceeded the state standard for eutrophic (highly productive) ponds, indicating that nutrient enrichment is likely occurring at Weir Pond. All TP values were well above the EPA Ecoregion 14 criterion of 8 $\mu\text{g/L}$ for ponds. As described above (“Water Quality Standards”), the EPA criteria do not have any regulatory meaning. TDP and SRP levels were generally low.

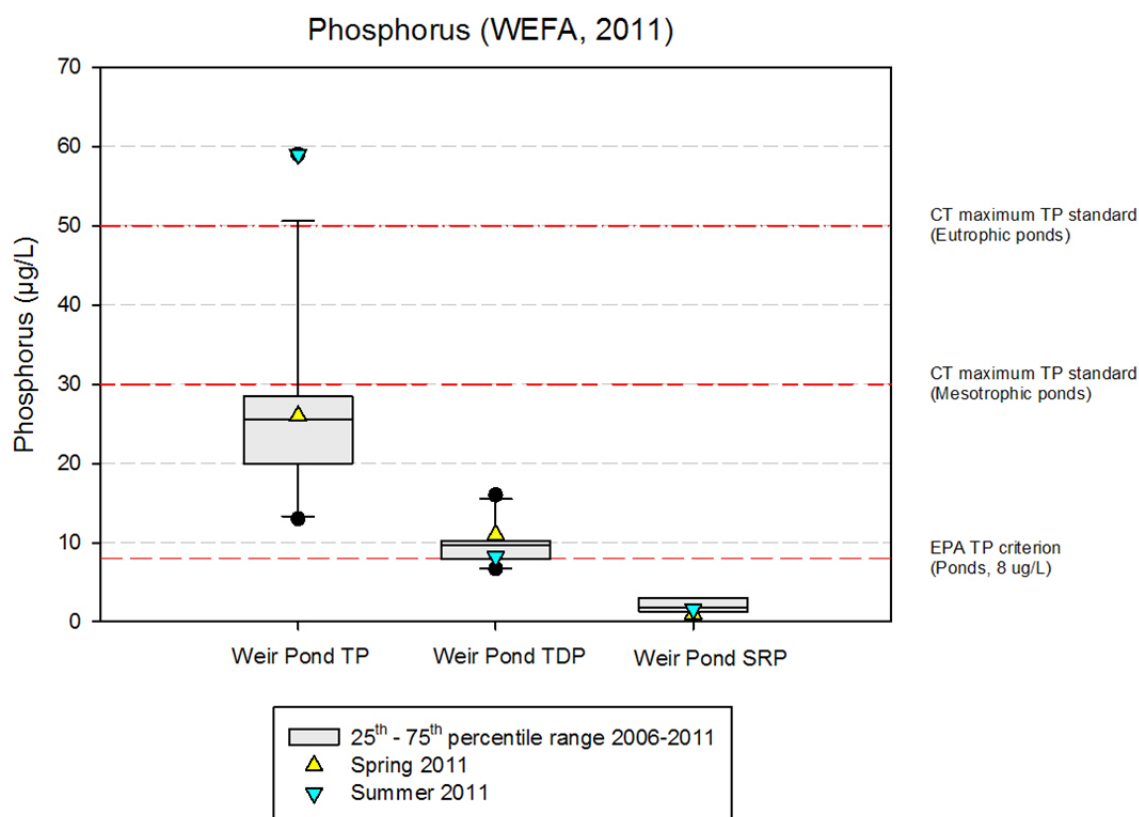


Figure 10. Total phosphorus (TP), total dissolved phosphorus (TDP), and soluble reactive phosphorus (SRP) from spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2011.

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. Filtered samples were analyzed for total dissolved nitrogen (TDN). 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.

Test results for several forms of nitrogen are shown in Figure 11. Both TN measurements from Weir Pond exceeded the EPA Ecoregion 14 criterion of 0.32 mg/L (for ponds), although as with TP this criterion does not have regulatory meaning. The August (Summer) TN measurement of 1.1 mg/L was slightly above the maximum Connecticut state TN standard of 1.0 mg/L for eutrophic ponds. Nitrate (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 (NO_2) is an unstable form of nitrogen that is either rapidly oxidized to nitrate (nitrification) or reduced to nitrogen gas (denitrification). This form of nitrogen can also be used as a source of nutrients for plants. NETN water samples were analyzed using a combined test for nitrate and nitrite, and these test results (along with results from individual tests for nitrite) were very low, with all 2011 values below the method reporting limit of 0.005 mg/L. Ammonia (NH_3 , another inorganic, bioavailable form of concern) test results were also low, and August (Summer) NH_3 results were below the method reporting limit of 0.08 mg/L.

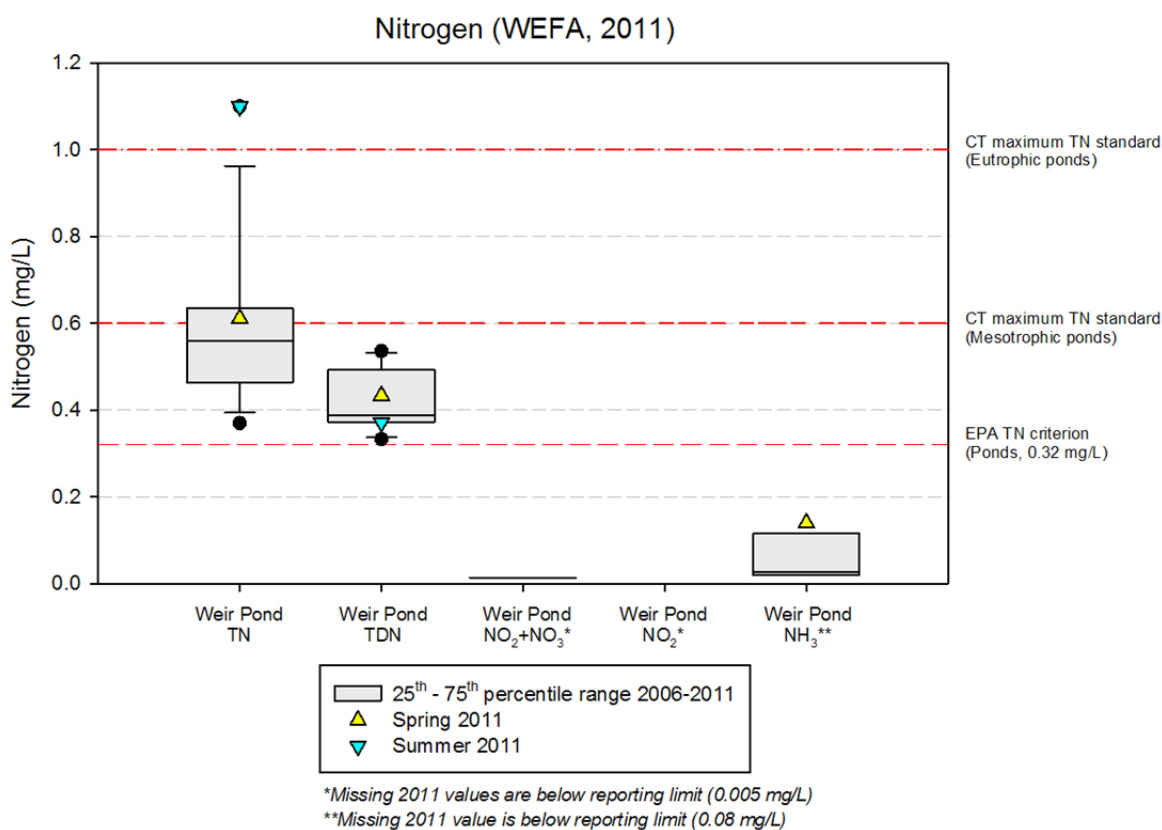


Figure 11. Total nitrogen (TN), total dissolved nitrogen (TDN), nitrite + nitrate ($\text{NO}_2 + \text{NO}_3$), nitrite (NO_2), and ammonia (NH_3) from 2011 spring and summer water samples. The data are overlaid on a box plot of measurements taken from 2006-2011.

Water Quantity

Pond and Stream Stage

Pond stage measurements were taken by measuring to the water surface from a fixed datum point. Stage measurements from 2011 are graphed in Figure 12. Stage measurements from 2006 to 2011 are listed in Table A3 in Appendix A. Water levels in 2011 followed the expected seasonal sequence of being high in May, and dropping to minimal levels in July and August, with gradual recovery in September and October.

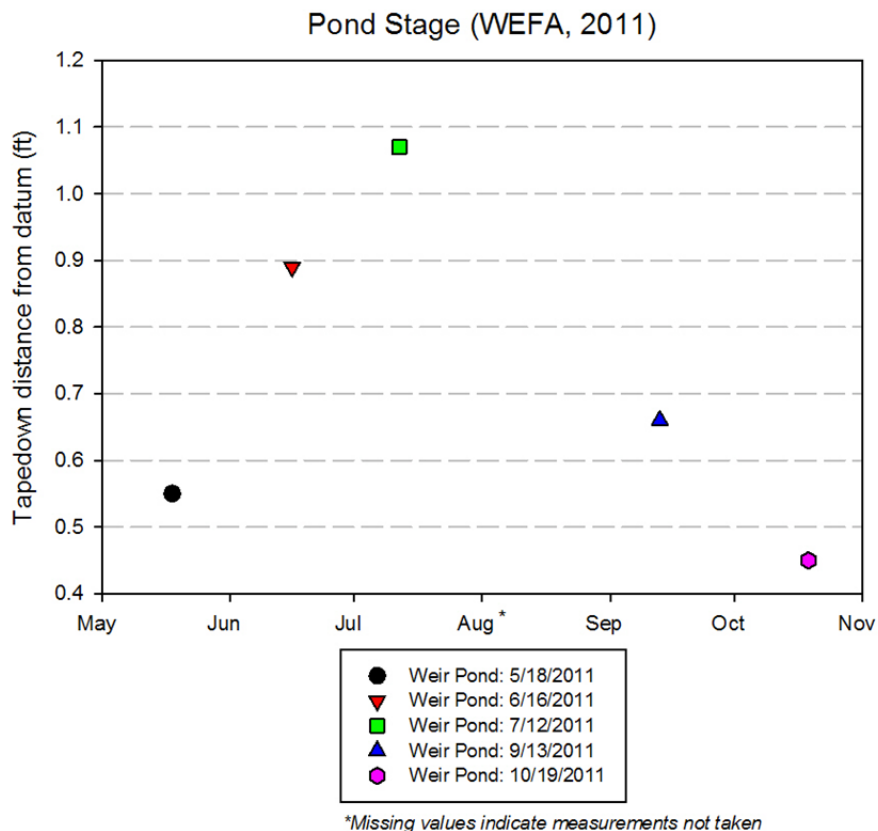


Figure 12. Pond and stream stage obtained in 2011 by measuring from a permanent datum point down to the water surface. *Note: Larger tapedown distances indicate LOWER water levels.*

Invasive Aquatic Plants

NETN's 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.

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,NH,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 Weir Pond during the 2011 monitoring season. Results indicated that invasive aquatic plants do not currently exist at Weir Pond.

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 NETN monitoring 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 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.

Summary

Most 2011 water quality parameters for Weir Pond in Weir Farm National Historic Site are within state standards, and are slightly above the range of EPA criteria, where applicable. The majority of values are within the ranges of the historic NETN monitoring data from WEFA. Apparent color, TP, and TN measurements from the August (summer) samples were fairly high, with TP and TN exceeding state standards. The data indicate that there is some nutrient enrichment occurring at WEFA. Residential areas within the pond watershed may contribute to this nutrient input.

ANC measurements showed that Weir Pond was sufficiently buffered to avoid severely depressed pH values from episodic acid deposition. Test results for NO_3 and NO_2 were very low in 2011 samples with all results below the method reporting limit of 0.005 mg/L. August (summer) ammonia (NH_3) test results were below the method reporting limit of 0.08 mg/L.

Monitoring under the NETN protocol builds on the historic water quality monitoring by park staff and other agencies to provide critical baseline information on the chemical and physical status of the water resources at Weir Farm National Historic Site. Several changes will be implemented in the 2012 monitoring season, including the addition of sulfate, chloride, chlorophyll *a*, and dissolved organic carbon (DOC) analyses to the spring and summer water chemistry testing. These changes will 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. Weir Farm National Historic Site (WEFA) Water Monitoring Data, 2006-2011.

Table A1. YSI sonde in-situ water quality measurements collected at WEFA.

Site	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	Specific Conductance (µS/cm)
Weir Pond	5/22/2006	0.0	17.84	8.46	7.03	122
Weir Pond	5/22/2006	1.0	14.60	8.20	6.90	123
Weir Pond	5/22/2006	2.0	13.95	3.61	6.40	159
Weir Pond	6/19/2006	0.0	28.10	8.69	7.88	127
Weir Pond	6/19/2006	1.0	24.26	10.58	8.00	125
Weir Pond	7/24/2006	0.0	28.15	5.42	7.32	125
Weir Pond	7/24/2006	1.0	25.26	5.15	7.12	124
Weir Pond	8/14/2006	0.0	26.66	7.51	7.79	132
Weir Pond	8/14/2006	1.0	23.96	8.79	7.67	130
Weir Pond	9/18/2006	0.0	23.39	9.06	8.31	120
Weir Pond	9/18/2006	1.0	20.72	10.32	8.19	118
Weir Pond	10/16/2006	0.0	14.05	10.78	9.08	120
Weir Pond	10/16/2006	0.0	14.07	9.84	8.20	117
Weir Pond	10/16/2006	1.0	11.62	11.67	8.48	117
Weir Pond	10/16/2006	1.0	11.57	10.56	8.10	117
Weir Pond	5/21/2007	0.0	21.12	6.78	7.47	115
Weir Pond	5/21/2007	1.0	17.21	7.41	7.39	113
Weir Pond	5/21/2007	1.1	17.15	6.11	7.19	115
Weir Pond	6/11/2007	0.0	23.58	6.21	7.53	118
Weir Pond	6/11/2007	1.0	21.26	4.71	7.22	124
Weir Pond	6/11/2007	1.2	20.88	2.20	6.70	137
Weir Pond	7/9/2007	0.0	30.13	7.79	7.92	124
Weir Pond	7/9/2007	1.0	25.32	7.09	7.67	124
Weir Pond	7/9/2007	1.1	25.05	5.43	7.15	127
Weir Pond	8/6/2007	0.0	26.65	4.92	7.64	130
Weir Pond	8/6/2007	1.0	26.57	4.45	7.48	130
Weir Pond	8/6/2007	1.2	26.47	2.64	7.10	132
Weir Pond	9/4/2007	0.0	25.00	8.56	7.78	121
Weir Pond	9/4/2007	1.0	23.22	8.49	7.68	121
Weir Pond	9/4/2007	1.5	23.12	7.07	7.30	120
Weir Pond	10/1/2007	0.0	19.23	8.88	7.86	117
Weir Pond	10/1/2007	1.0	18.86	8.59	7.78	117
Weir Pond	10/1/2007	1.4	18.81	8.25	7.43	116
Weir Pond	5/12/2008	0.0	15.38	8.01	6.96	131
Weir Pond	5/12/2008	1.0	15.42	7.80	6.90	130
Weir Pond	5/12/2008	1.2	15.38	7.52	6.86	132
Weir Pond	6/12/2008	0.0	27.02	7.20	7.02	137
Weir Pond	6/12/2008	1.0	26.22	5.87	6.90	138

Appendix A. Weir Farm National Historical Park (WEFA) Water Monitoring Data, 2006-2011 (continued).

Table A1. YSI sonde in-situ water quality measurements collected at WEFA (continued).

Site	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	Specific Conductance (µS/cm)
Weir Pond	6/12/2008	1.3	23.71	0.70	6.33	160
Weir Pond	7/17/2008	0.0	29.66	6.21	7.01	138
Weir Pond	7/17/2008	1.0	26.76	7.53	7.00	138
Weir Pond	7/17/2008	1.3	25.78	2.49	6.41	158
Weir Pond	8/26/2008	0.0	22.55	5.99	7.19	138
Weir Pond	8/26/2008	1.0	22.26	6.15	7.03	138
Weir Pond	8/26/2008	1.2	22.28	5.91	7.01	138
Weir Pond	9/18/2008	0.0	19.76	8.72	7.27	118
Weir Pond	9/18/2008	1.0	19.64	8.59	7.27	118
Weir Pond	9/18/2008	1.1	19.63	8.64	7.29	118
Weir Pond	10/9/2008	0.0	15.20	10.69	7.81	125
Weir Pond	10/9/2008	1.0	13.84	12.14	7.94	126
Weir Pond	10/9/2008	1.3	13.70	10.91	7.41	126
Weir Pond	5/11/2009	0.0	18.19	11.14	7.77	151
Weir Pond	5/11/2009	1.0	16.88	13.01	8.93	151
Weir Pond	5/11/2009	1.3	16.61	11.68	7.42	151
Weir Pond	6/17/2009	0.0	19.62	10.17	7.22	139
Weir Pond	6/17/2009	0.3	19.41	8.79	6.91	145
Weir Pond	7/29/2009	0.0	25.97	9.34	7.55	145
Weir Pond	7/29/2009	1.0	23.90	1.13	6.80	175
Weir Pond	7/29/2009	1.2	22.63	0.79	6.53	211
Weir Pond	8/19/2009	0.0	28.17	7.61	6.93	150
Weir Pond	8/19/2009	1.0	26.32	4.15	6.67	156
Weir Pond	8/19/2009	1.1	25.81	1.29	6.47	169
Weir Pond	9/22/2009	0.0	19.33	9.23	6.97	139
Weir Pond	9/22/2009	1.0	18.59	9.26	6.91	139
Weir Pond	9/22/2009	1.3	18.53	5.00	6.17	168
Weir Pond	10/15/2009	0.0	11.18	9.61	7.69	135
Weir Pond	10/15/2009	1.0	11.19	9.75	7.71	136
Weir Pond	10/15/2009	1.2	11.19	9.35	7.73	136
Weir Pond	5/12/2010	0.0	14.14	9.56	7.18	129
Weir Pond	5/12/2010	1.0	14.10	9.48	7.14	129
Weir Pond	5/12/2010	1.3	14.15	4.95	6.79	136
Weir Pond	6/9/2010	0.0	21.85	7.03	7.08	135
Weir Pond	6/9/2010	1.0	21.65	6.27	7.00	135
Weir Pond	6/9/2010	1.2	21.57	4.29	6.82	135
Weir Pond	6/9/2010	1.3	21.58	3.67	6.74	137
Weir Pond	7/21/2010	0.0	29.18	7.89	7.39	150
Weir Pond	7/21/2010	1.0	27.49	5.09	6.96	152
Weir Pond	7/21/2010	1.2	27.15	0.92	6.64	171
Weir Pond	8/25/2010	0.0	21.59	6.83	7.29	137

Appendix A. Weir Farm National Historical Park (WEFA) Water Monitoring Data, 2006-2011 (continued).

Table A1. YSI sonde in-situ water quality measurements collected at WEFA (continued).

Site	Date	Depth (m)	Temp (C)	DO (mg/L)	pH	Specific Conductance (µS/cm)
Weir Pond	8/25/2010	1.0	20.73	7.00	7.23	136
Weir Pond	8/25/2010	1.3	20.74	6.72	7.21	136
Weir Pond	9/15/2010	0.0	19.69	8.05	7.68	145
Weir Pond	9/15/2010	1.0	19.02	8.70	7.80	144
Weir Pond	10/12/2010	0.0	16.00	9.04	7.00	128
Weir Pond	10/12/2010	1.0	15.25	8.83	7.00	123
Weir Pond	10/12/2010	1.2	15.23	8.75	7.00	128
Weir Pond	5/18/2011	0.0	15.70	4.91	6.66	123
Weir Pond	5/18/2011	1.0	15.07	2.71	6.51	135
Weir Pond	5/18/2011	1.4	14.79	3.86	6.52	147
Weir Pond	6/16/2011	0.0	24.14	5.82	7.00	132
Weir Pond	6/16/2011	1.0	20.93	4.79	6.81	130
Weir Pond	6/16/2011	1.3	20.60	0.76	6.59	140
Weir Pond	7/12/2011	0.0	27.81	7.34	7.21	133
Weir Pond	7/12/2011	1.0	27.01	6.23	7.08	134
Weir Pond	7/12/2011	1.3	26.29	1.51	6.58	145
Weir Pond	8/10/2011	0.0	26.41	8.03	6.94	126
Weir Pond	8/10/2011	1.0	24.88	5.55	6.89	127
Weir Pond	8/10/2011	1.3	24.80	2.06	6.70	130
Weir Pond	9/13/2011	0.0	21.72	9.32	6.79	113
Weir Pond	9/13/2011	1.0	21.00	7.88	6.74	116
Weir Pond	9/13/2011	1.3	20.99	6.38	6.61	120
Weir Pond	10/19/2011	0.0	13.98	8.56	7.72	122
Weir Pond	10/19/2011	1.0	13.76	8.51	7.62	127
Weir Pond	10/19/2011	1.4	13.76	6.45	7.51	128

Appendix A. Weir Farm National Historical Park (WEFA) Water Monitoring Data, 2006-2011 (continued).

Table A2. Laboratory nutrient chemistry data for WEFA. “<MRL” indicates the result was below the method reporting limit (provided after the abbreviation). *Missing values indicate data are unavailable.*

Site	Date	ANC (µeq/L)	Apparent Color (PCU)	TP (µg/L)	TDP (µg/L)	SRP (µg/L)	TN (mg/L)	TDN (mg/L)	NO2+NO3 (mg/L)	NO2 (mg/L)	NH3 (mg/L)
Weir Pond	8/14/2006	520.00	20	20		3.0	0.550		<MRL 0.060	<MRL 0.002	0.028
Weir Pond	6/19/2006	420.00	20	20		<MRL 6	0.370		<MRL 0.060	<MRL 0.002	<MRL 0.01
Weir Pond	8/6/2007	486.00	20	27	10.0	<MRL 6	0.630	0.500	<MRL 0.016	<MRL 0.002	0.015
Weir Pond	6/11/2007		25	14	10.0	3.0	0.450	0.380	<MRL 0.016	<MRL 0.002	0.023
Weir Pond	6/12/2008	390.00	47	31	16.0	<MRL 1	0.545	0.395	<MRL 0.005	<MRL 0.005	
Weir Pond	8/26/2008	438.00	36	25	10.0	1.8	0.643	0.536	<MRL 0.005	<MRL 0.005	<MRL 0.08
Weir Pond	6/17/2009	337.00	33	20	7.0	2.0	0.450	0.333	<MRL 0.005	<MRL 0.005	<MRL 0.08
Weir Pond	8/19/2009	512.00	38	13	6.7	<MRL 1	0.507	0.372	<MRL 0.005	<MRL 0.005	<MRL 0.08
Weir Pond	8/25/2010	589.00	36	26	9.3	1.3	0.637	0.492	0.014	<MRL 0.005	0.090
Weir Pond	6/9/2010	385.00	43	29	8.9	<MRL 1	0.569	0.375	<MRL 0.005	<MRL 0.005	<MRL 0.08
Weir Pond	8/10/2011	543.00	81	59	8.2	1.6	1.100	0.371	<MRL 0.005	<MRL 0.005	<MRL 0.08
Weir Pond	6/16/2011	496.00	63	26	11.0	1.0	0.612	0.434	<MRL 0.005	<MRL 0.005	0.140

Appendix A. Weir Farm National Historical Park (WEFA) Water Monitoring Data, 2006-2011 (continued).

Table A3. Pond stage data for WEFA. *Missing values indicate data are unavailable.*

Site	Date	Tapedown from datum (ft)
Weir Pond	5/22/2006	
Weir Pond	6/19/2006	
Weir Pond	7/24/2006	0.95
Weir Pond	8/14/2006	1.27
Weir Pond	9/18/2006	
Weir Pond	10/16/2006	1.01
Weir Pond	4/16/2007	0.50
Weir Pond	5/21/2007	0.85
Weir Pond	6/11/2007	0.97
Weir Pond	7/9/2007	1.23
Weir Pond	8/6/2007	1.49
Weir Pond	9/4/2007	1.49
Weir Pond	10/1/2007	1.81
Weir Pond	5/12/2008	0.75
Weir Pond	6/12/2008	0.86
Weir Pond	7/17/2008	1.02
Weir Pond	8/26/2008	
Weir Pond	9/18/2008	
Weir Pond	10/9/2008	0.83
Weir Pond	5/11/2009	0.67
Weir Pond	6/17/2009	0.71
Weir Pond	7/29/2009	0.92
Weir Pond	8/19/2009	1.04
Weir Pond	9/22/2009	1.06
Weir Pond	10/15/2009	0.92
Weir Pond	5/12/2010	0.75
Weir Pond	6/9/2010	1.00
Weir Pond	7/21/2010	1.20
Weir Pond	8/25/2010	1.20
Weir Pond	9/15/2010	1.54
Weir Pond	10/12/2010	1.00
Weir Pond	5/18/2011	0.55
Weir Pond	6/16/2011	0.89
Weir Pond	7/12/2011	1.07
Weir Pond	8/10/2011	
Weir Pond	9/13/2011	0.66
Weir Pond	10/19/2011	0.45

Appendix A. Saratoga National Historical Park (SARA) Water Monitoring Data, 2006-2011 (continued).

Table A3. Stream stage and discharge data for SARA (continued).

Table A4. Pond water transparency data for WEFA. “B” after transparency value indicates disk pattern still visible at pond bottom or through fully filled turbidity tube.

Site	Date	Secchi Depth (m)	Turbidity Tube (cm)
Weir Pond	5/12/2008		120 B
Weir Pond	6/12/2008		120 B
Weir Pond	7/17/2008		120 B
Weir Pond	8/26/2008		120 B
Weir Pond	10/9/2008		120 B
Weir Pond	5/11/2009		120 B
Weir Pond	6/17/2009		120 B
Weir Pond	7/29/2009	1.408	B
Weir Pond	8/19/2009		120 B
Weir Pond	9/22/2009		120 B
Weir Pond	10/15/2009		120 B
Weir Pond	5/12/2010		120 B
Weir Pond	6/9/2010		120 B
Weir Pond	7/21/2010		120 B
Weir Pond	8/25/2010		120 B
Weir Pond	9/15/2010		120 B
Weir Pond	10/12/2010		120 B
Weir Pond	5/18/2011		120 B
Weir Pond	6/16/2011		120 B
Weir Pond	7/12/2011		120 B
Weir Pond	9/13/2011		120 B

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