2025 Report on the Health of the Norway Lakes

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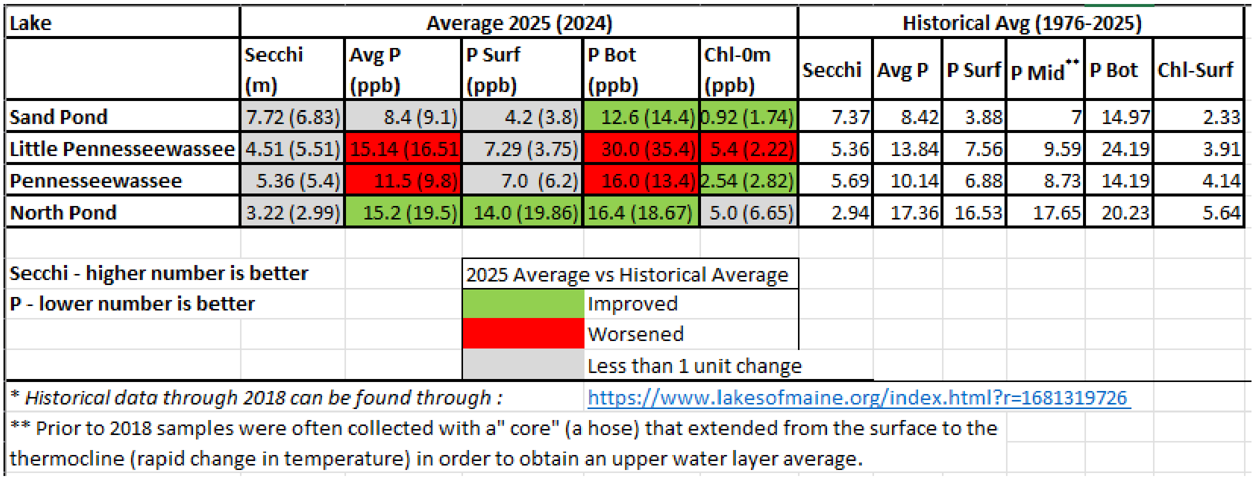
Overview

Table 1 Secchi depth, Total Phosphorus and Chlorophyll concentrations for 2025 compared to 2024 and the historical average for the four lakes. Data are presented for the seasonal average of the past two years and the long-term average.



Lake	**Average 2025 (2024)**					**Historical Avg (1976-2025)**					
	Secchi (m)	**Avg P (ppb)**	**P Surf (ppb)**	**P Bot (ppb)**	**Chl-0m (ppb)**	**Secchi**	**Avg P**	**P Surf**	**P Mid****	**P Bot**	**Chl-Surf**
Sand Pond	7.72 (6.83)	8.4 (9.1)	4.2 (3.8)	12.6 (14.4)	0.92 (1.74)	7.37	8.42	3.88	7	14.97	2.33
Little Pennesseewassee	4.51 (5.51)	15.14 (16.51	7.29 (3.75)	30.0 (35.4)	5.4 (2.22)	5.36	13.84	7.56	9.59	24.19	3.91
Pennesseewassee	5.36 (5.4)	11.5 (9.8)	7.0 (6.2)	16.0 (13.4)	2.54 (2.82)	5.69	10.14	6.88	8.73	14.19	4.14
North Pond	3.22 (2.99)	15.2 (19.5)	14.0 (19.86)	16.4 (18.67)	5.0 (6.65)	2.94	17.36	16.53	17.65	20.23	5.64

Secchi - higher number is better
P - lower number is better

2025 Average vs Historical Average	
🟩	Improved
🟥	Worsened
⬜	Less than 1 unit change

** Historical data through 2018 can be found through :* https://www.lakesofmaine.org/index.html?r=1681319726

** Prior to 2018 samples were often collected with a" core" (a hose) that extended from the surface to the thermocline (rapid change in temperature) in order to obtain an upper water layer average.

Hobbs Pond continued to be plagued by cyanobacterial blooms in 2025. The average surface phosphorus concentrations compared to last year were higher in Hobbs Pond, roughly the same in Sand Pond and Pennesseewassee, but lower in North Pond. In comparison to historical averages, surface P concentrations were about the same for Sand, Hobbs and Pennesseewassee, and lower in North Pond. Bottom concentrations had improved over 2024 in Sand, Hobbs, and North Pond. In comparison to historical averages, bottom concentrations improved for Sand and North Ponds but were worse for Hobbs and Pennesseewassee.

Secchi disk transparency remained at historical levels for all the lakes. Chlorophyll improved over historical levels in Sand Pond and Pennesseewassee, remained about the same for North Pond, but worsened in Hobbs Pond due to the bloom.

This year's report contains an extensive section on Hobbs Pond due to the ongoing problem with cyanobacterial blooms. It consists of a Summary and a more technical section for those who want to dive in deeper.

Explanation of Measurements

Source:
https://www.lakesofmaine.org/data/Explanation%20of%20Individual%20Lake%20Water%20Quality%20Report.pdf

SECCHI DISK TRANSPARENCY AND GRAPHS: Secchi Disk Transparency (SDT) is a measure of the water clarity, or transparency, of the lake. All Secchi disk readings are in meters [1 meter (m) = 3.28 feet]. Factors which reduce clarity are algae, zooplankton, water color and silt. Since algae are generally the most abundant, measuring transparency indirectly measures algal productivity. SDT readings can be used to track changes in water quality over time. Transparency values in Maine vary from 0.2 m (8 inches) to 21.27 m (70 ft), with the overall average being 4.83 m (15.8 ft). Unless a lake is highly colored (see explanation of color below) or some other factor interferes, a transparency of less than 2 m (6.6 ft) indicates a water quality problem that has resulted in an algal bloom. In Maine, the mean (average) SDT readings are related to algal productivity using the following guidelines: Productive or Eutrophic – 4 m (13 ft) or less; Moderately productive or Mesotrophic - 4.1-7.9 m (13-26.5 ft); Unproductive or Oligotrophic – 8 m (26.5 ft) or greater.

COLOR: The amount of "color" in a lake refers to the concentration of natural dissolved organic acids such as tannins and lignin's, which give the water a tea color. Color may also be due to the presence of metals such as iron, manganese and copper; or the presence of highly colored industrial wastes, the most common of which are pulp and paper and textile wastes. These latter causes are not likely for our lakes. Color is measured by comparing a sample of the lake water to Standard Platinum Units (SPU). Colored lakes (>30 SPU) can have reduced transparency readings and increased phosphorus values. This does not mean the lakes are more productive, the color simply interferes with the test so better results cannot be achieved. Chlorophyll a (Chla) is the best indicator of productivity in colored lakes and should be used if possible. Color varies from 1 to 500 (see Fig 45.), with the average in Maine being 28 SPU.

pH: The pH of a lake reflects how acidic or basic the water is and helps determine which plant and animal species are present. The measure of the acidity of water is based on a scale of 1-14, with 7 being neutral. Acid waters are below 7; alkaline waters are above 7. Epilimnetic (surface layer) pH varies, from 4.23 to 9.70, the average being 6.81. A one unit change in pH represents a 10 fold change in acidity or alkalinity.

ALKALINITY: Alkalinity is a measure of the capacity of water to neutralize acids and is also known as the buffering capacity. It is due primarily to the presence of naturally available bicarbonate, carbonate, and hydroxide ions, with bicarbonate being the major form. Epilimnetic(surface layer) alkalinity in Maine varies from -1.5 milligram per liter (mg/l) to 190.0 mg/l, with the average being 12.0 mg/l.

CONDUCTIVITY (µS/cm): Conductivity is a measure of the ability of water to carry an electrical current and is directly related to the dissolved ions (charged particles) present in water. Conductivity differs between water bodies, but typically lakes and streams have a conductivity range between 0-200 µS/cm, while major rivers can have a conductance value up to 1000 µS/cm. Water that has a conductivity range of 1000-10,000 µS/cm indicates that it is saline (https://atlas-scientific.com/blog/water-conductivity-range/). Most U. S. drinking water ranges from 50 to 1500 µS/cm (https://ecologiclife.com/what-does-conductivity-mean-for-water-quality.html). Conductivity will increase if pollutants increase. This is especially true of road salt in our area.

TOTAL PHOSPHORUS (ppb): Total Phosphorus (TP) is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits the plant growth in lakes. It is measured in parts per billion (ppb). As phosphorus increases, the abundance of algae also increases. Epilimnetic TP varies from 1 ppb to 426 ppb with the average being 12 ppb. EC = Epilimnetic core sample (mixed sample from epilimnion – upper layer) was taken; SG = Surface grab sample taken, BG = Bottom grab sample taken (1 m above bottom of lake), PG = Profile grab samples taken at intermediate depths.

CHLOROPHYLL A (ppb): CHLOROPHYLL A (Chla) is a measurement of the green pigment found in all plants including microscopic plants such as algae. It is used as an estimate of algal biomass, the higher the Chla number the higher the abundance of algae in the lake. Epilimnetic (above the thermocline) Chla, varies from 0.10 ppb to 238 ppb, with the average 5.3 ppb.

TROPHIC STATE INDICES: The Trophic State Index (TSI) is a scale which ranks lakes from 0 to 100+ with 0 supporting very little algae and 100+ being very productive. TSI can be calculated from the Secchi disk, Chla or Total Phosphorus results. TSI for a year is only calculated when there are at least five months of data. Lakes with TSI values greater than 60 may support blooms (less than 2m SDT). Lakes with TSI values over 100 indicate extreme productivity and annual algal blooms. TSI values can be used to compare lakes and track water quality trends within a lake. Lakes with color over 30 SPU will only have a valid TSI if the value is calculated from Chla. The range of TSI is from 5-136 with an average of 45. EPI PHOS = Epilimnetic Phosphorus samples taken to determine the TSI; C = core G = grab samples taken; SEC = TSI value calculated using the mean Secchi disk (water color < 30 SPU to ensure valid TSI); CHL = TSI calculated using the mean Chla. For an in depth explanation of these indices see https://www.nalms.org/secchidipin/monitoring-methods/trophic-state-equations/ . A table of Trophic State and possible changes which may occur in a lake is shown in Appendix 1.

Caveat: The TSI is often misinterpreted and/or misused from its original purpose, which is simply to describe the level of biological productivity. It is not meant to rate a lake's water quality. For example, higher TSI values represent lakes that support an abundance of algae, plants and wildlife. If you love to fish, this type of lake would not be considered to have "poor" water quality. However, if you are a swimmer or water skier, you might prefer a lake with lower TSI values.

LATE SUMMER TEMPERATURE / DISSOLVED OXYGEN (ppm) PROFILES: Dissolved Oxygen (D.O.) is the measure of the amount of oxygen dissolved in the water. All living organisms, except for certain types of bacteria, need oxygen to survive. Organisms living in the water can use the oxygen dissolved in the water to breathe. Too little oxygen severely reduces the diversity and population of aquatic communities. Therefore, the amount of D.O. in the water is very important to aquatic life. 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); less than 5 ppm of oxygen is generally considered so stressful that most cold-water fish will avoid these areas. Anoxic conditions can also promote TP release from sediments.

Temperature is the measure of heat in the water and can affect the water's chemistry and biology. For example, the amount of oxygen water can hold is directly related to the temperature of the water. The higher the temperature the less oxygen the water can hold. Oxygen will naturally decline during the summer months as water temperatures rise. Lakes deeper than 25-30 feet can also stratify (become layered), with warm water riding over cooler deep water, restricting circulation in the lake. This can contribute to oxygen loss in the lower waters. 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 disappear during the warmer temperatures of summer. For instance, salmonids generally prefer temperatures below 18°C (65°F) but can tolerate slightly higher temperatures for short periods of time. However, constant exposure to temperatures greater than 18°C (65°F) may result in some fish being more susceptible to disease or not being able to reproduce as well. Conversely, other more tolerant species will predominate during the more stressful summer months. The late summer temperature and dissolved oxygen profiles in data report represent the lake's most stressed open water period.

RELATIVE THERMAL RESISTANCE TO MIXING (RTRM): The density of freshwater is determined primarily by temperature, unlike salt water where both salt and temperature play major roles. We can use temperature to determine density and use density differences to determine how easily water is mixed. The larger the density difference the harder it is for two layers to be mixed. This is called thermal stratification. During stratification oxygen may become depleted near the bottom and nutrients may accumulate there due to the sinking and decomposition of organisms. The maximum density of freshwater occurs at 4 ° C; both colder and warmer water will rise above that layer. This fact means that in the Fall water temperatures can drop to 4 °C, and the surface water will sink to the bottom allowing the entire water column to mix due to increasing winds and decreased buoyancy differences. Lake scientists refer to this as "Fall Overturn". This process allows oxygen to reach the bottom and nutrients to disperse up to the surface.

Figure 1 shows a season cycle of temperature and RTRM. Note that when temperature is relatively uniform as in spring and fall, the resistance to mixing is also small, and water can easily be circulated by winds from surface to bottom. As summer progresses the sun warms up the surface of the lake and stratification increases. As this happens RTRM increases around the thermocline, that is, the region where the temperature difference is greatest between the surface and bottom. It is this resistance to mixing that prevents materials from the bottom layer from getting into the top layer and *vice versa*. This density difference is important because it prevents dissolved oxygen from reaching deeper depths and prevents deep nutrients from reaching the surface. We calculate RTRM using the formula, the result has no units:

$$RTRM = \frac{Water\ Density\ Upper\ Layer - Water\ Density\ Lower\ Layer}{Water\ Density\ at\ 4\,°C - Water\ Density\ at\ 5\,°C}$$

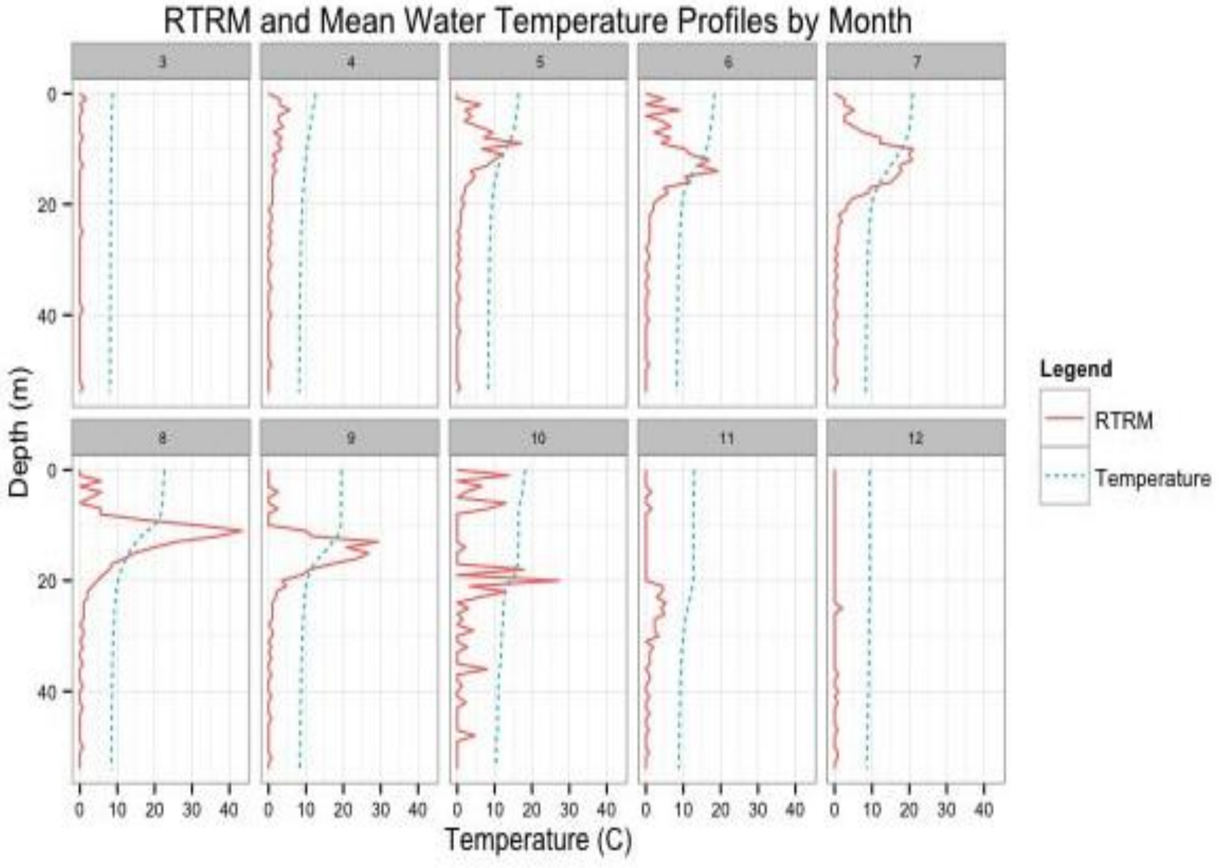


Figure 1 Temperature and RTRM profiles in a lake. (Source: http://www.ekwityn.com/blog/relative-thermal-resistance-to-mixing-rtrm)

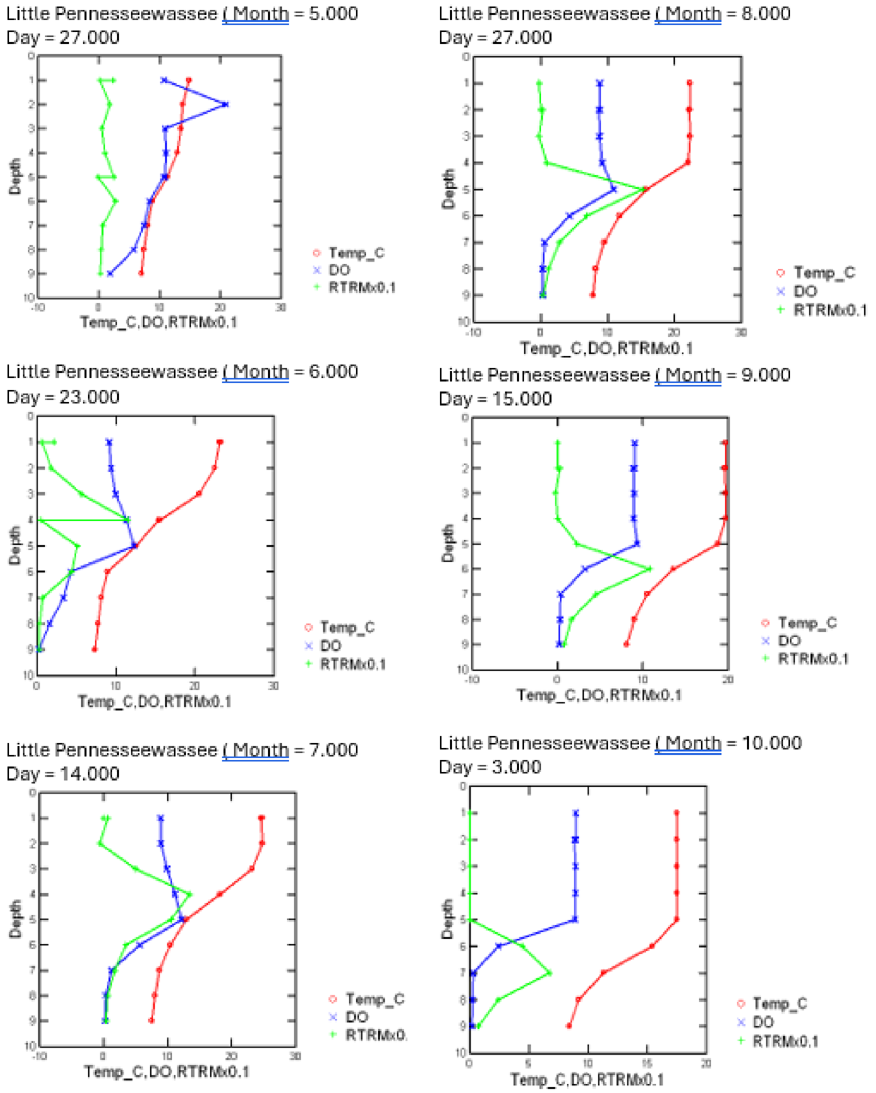
Hobbs Pond

Summary

Hobbs Pond was again plagued by a cyanobacterial bloom (aka blue-green algae) in 2025. The bloom was caused by a different species than in previous years for unknown reasons. The new species caused the water to become cloudier than in the past and reduced transparency from 7 meters down to just about 2 meters (Fig. 10). This goes against the trend of increasing transparency experienced over the years of monitoring (Fig. 11). The immediate cause of the cyanobacterial blooms remains uncertain, but the culprit almost certainly is increased nutrient availability. Phosphorus has been monitored since 1976. In 2025 the levels of phosphorus were somewhat lower than in the past few years. The long-term record shows that phosphorus has been declining since observations started at the surface (Fig. 12). The levels in the bottom water, on the other hand, have increased over time (Fig. 13). This raises the possibility that mixing phosphorus from deeper layers into the upper layers could stimulate phytoplankton growth. Alternatively, cyanobacteria are known to be able to move up and down through the water column by regulating their buoyancy, thus enabling them to scavenge nutrients in the deeper water and migrate to the surface for light availability. The blooms were surprising because Chlorophyll (a measure of phytoplankton numbers) had been declining through time (Fig. 9). However, in 2025 Chlorophyll levels increased throughout the summer as the bloom progressed (Fig. 8) to 11 mg/L, an amount three times what was seen in the last 5 years.

Other water quality parameters measured include pH, Conductivity, Alkalinity and Color of water. The pH levels increased to a level of 9.41 (Fig. 21), which is attributed to the heavy growth of cyanobacteria. This is not good since most biological activity in lakes is normally constrained to a pH between 6 and 9. The alkalinity (acid neutralizing capacity) values are somewhat lower than in normal surface waters but are not extreme (Fig. 21). Conductivity is related to pollutants such as road salt. We found values up to around 90 µS (Fig. 21 ad 22), which is in the good range as most waters are lower than 100 µS. The color of the water in the lake is related to decomposing vegetation which releases organic material such as tannins and other humic substances. Our values are below 30 (Fig. 21), which is normal. The Tropic State Indices determined using Chlorophyll, Secchi Depth and Total Phosphorus are in the high 30s and 40s indicating moderate biological productivity.

Technical Discussion.


Little Pennesseewassee (Month = 5.000 Day = 27.000

Little Pennesseewassee (Month = 8.000 Day = 27.000

Little Pennesseewassee (Month = 6.000 Day = 23.000

Little Pennesseewassee (Month = 9.000 Day = 15.000

Little Pennesseewassee (Month = 7.000 Day = 14.000

Little Pennesseewassee (Month = 10.000 Day = 3.000

Figure 2 Temperature, DO and RTRMx0.1 for 2025 in Hobbs Pond

Hobbs Pond Dissolved Oxygen, temperature and Relative Thermal Resistance are shown in Figure 2. RTRM has been divided by 10 for better illustration. As expected, the DO is high at the beginning of the year, and the RTRM is relatively low and uniform throughout the water column. As summer sets in, the thermocline strengthens and deepens due to solar warming. Due to the summer strengthening of the thermocline, oxygen successively gets lower in the deep water. As in the past, we see higher levels of DO in the region of the thermocline because phytoplankton there can take advantage of higher nutrients while still receiving adequate sunlight. As Fall begins, the thermocline deepens due to wind mixing but also weakens due to reduced sunlight.

The Total Phosphorus concentrations in Hobbs Pond for 2025 are shown in Figure 3. For description of the sample notation (SG, EC, PG, BG) see methods on sampling. While the surface levels remain relatively low, the bottom values increase. The intermediate depth samples were taken at 3 and 6 meters so there are two values plotted for each date. The PG samples are higher than the surface and reflect the sinking of organic matter to the bottom water layer. While in 2025 bottom phosphorus reached a maximum of around 45 µg/L, it has in the past few years exceeded 50 µg/L (Fig. 4). The surface and intermediate concentrations previously remained lower (below 20 µg/L) but did exceed 30 µg/L on two occasions (Fig. 4). To identify sources of phosphorus, inlet waters were tested. Figure 5 shows locations of stream sampling. The resulting data showed that several inlets carried high phosphorus loads (Fig 6).

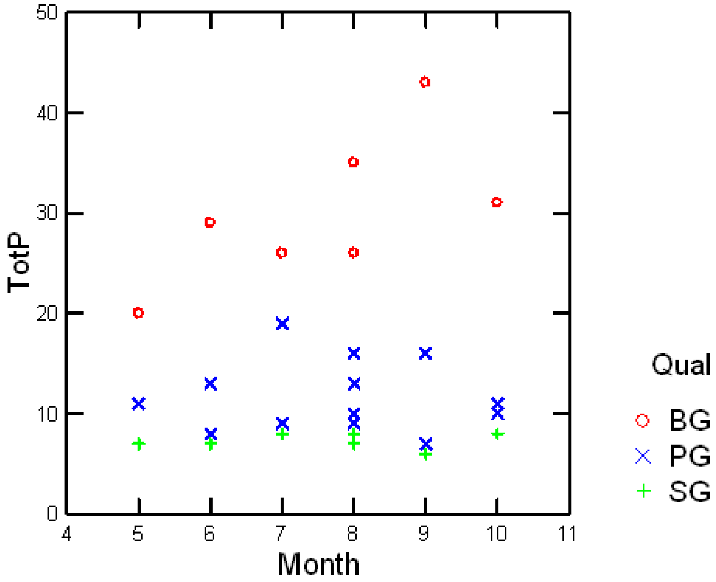


Figure 3 Total Phosphorus (µg/L) in Hobbs Pond. BG=bottom, SG=surface, PG=intermediate depths.

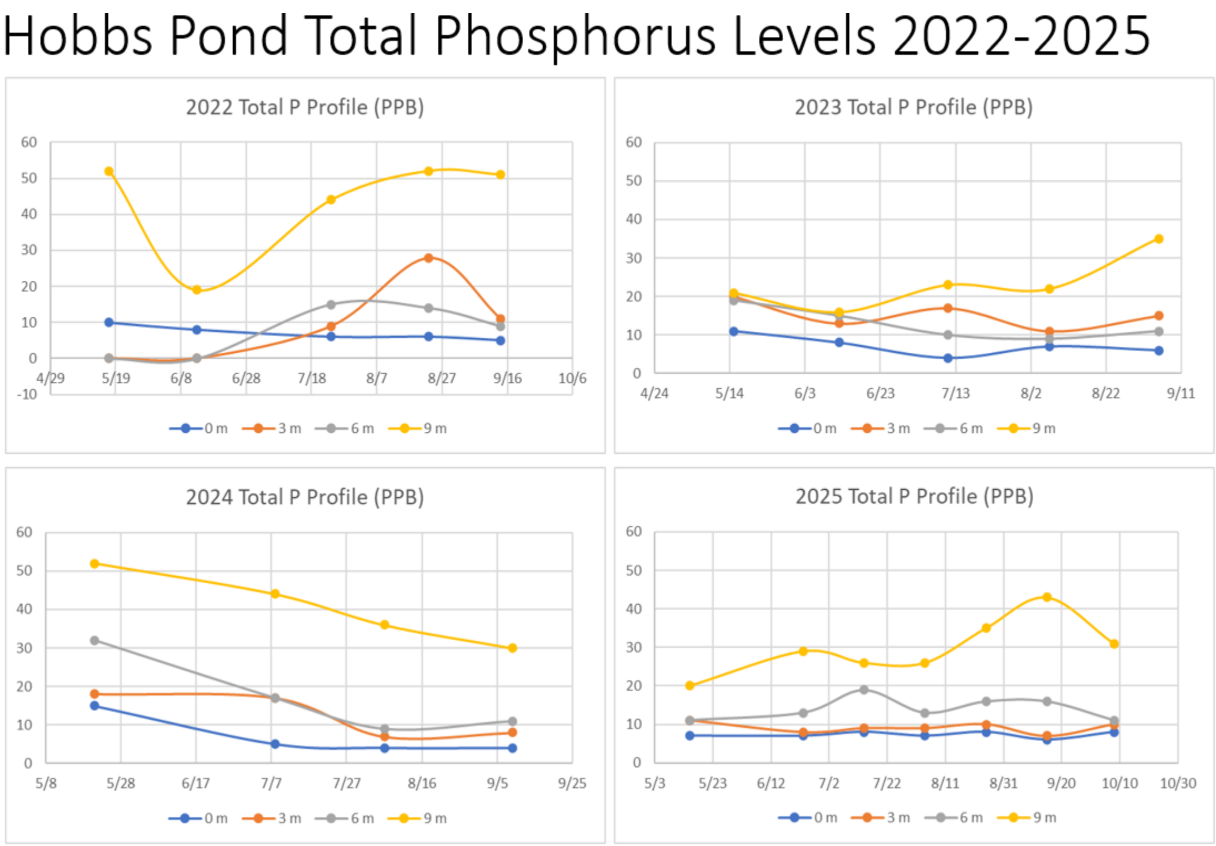
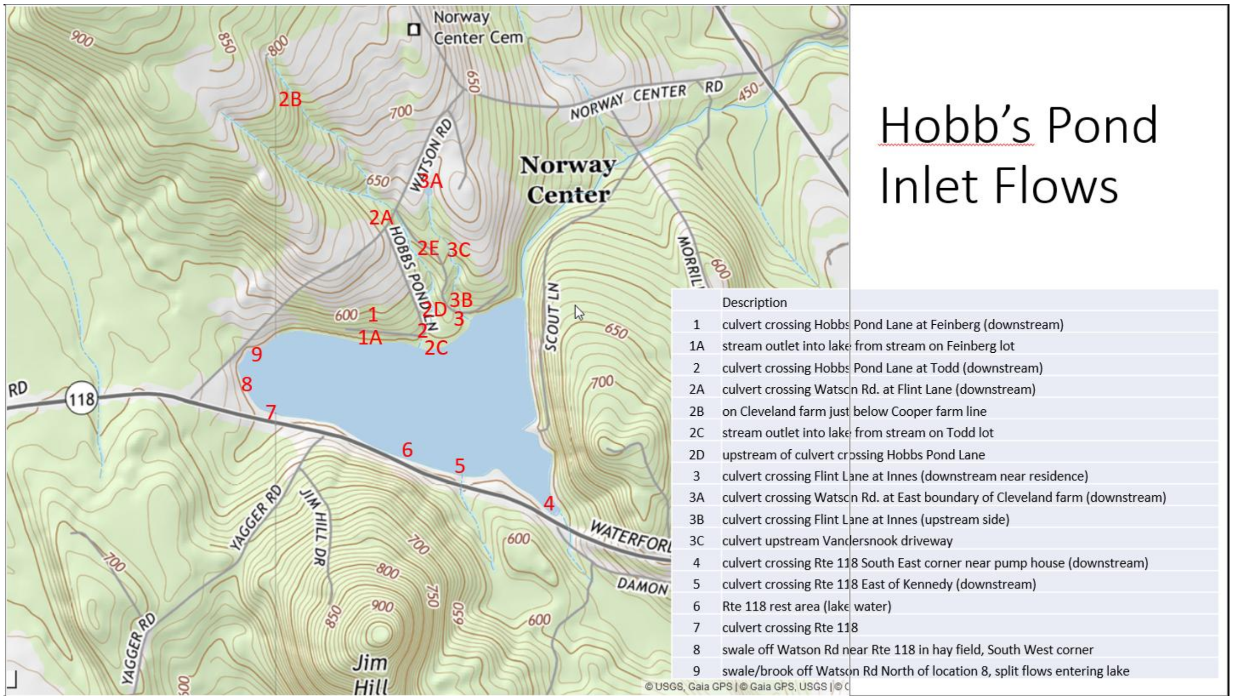


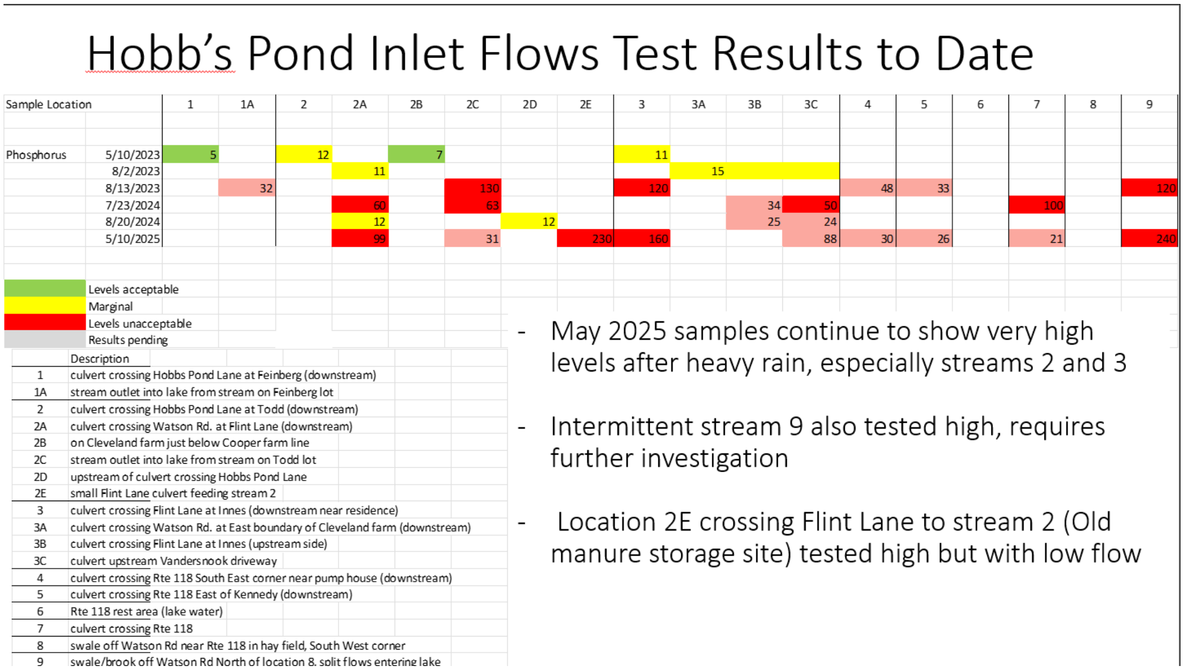
Figure 4. Total phosphorus levels over the past 4 years in Hobbs Pond.



Hobb's Pond Inlet Flows

	Description
1	culvert crossing Hobbs Pond Lane at Feinberg (downstream)
1A	stream outlet into lake from stream on Feinberg lot
2	culvert crossing Hobbs Pond Lane at Todd (downstream)
2A	culvert crossing Watson Rd. at Flint Lane (downstream)
2B	on Cleveland farm just below Cooper farm line
2C	stream outlet into lake from stream on Todd lot
2D	upstream of culvert crossing Hobbs Pond Lane
3	culvert crossing Flint Lane at Innes (downstream near residence)
3A	culvert crossing Watson Rd. at East boundary of Cleveland farm (downstream)
3B	culvert crossing Flint Lane at Innes (upstream side)
3C	culvert upstream Vandersnook driveway
4	culvert crossing Rte 118 South East corner near pump house (downstream)
5	culvert crossing Rte 118 East of Kennedy (downstream)
6	Rte 118 rest area (lake water)
7	culvert crossing Rte 118
8	swale off Watson Rd near Rte 118 in hay field, South West corner
9	swale/brook off Watson Rd North of location 8, split flows entering lake

Figure 5 Inlet sites to Hobbs Pond sampled for total phosphorus.



Hobb's Pond Inlet Flows Test Results to Date

Sample Location		1	1A	2	2A	2B	2C	2D	2E	3	3A	3B	3C	4	5	6	7	8	9
Phosphorus	5/10/2023	5		12		7				11									
	8/2/2023				11						15								
	8/13/2023		32				130			120				48	33				120
	7/23/2024				60		63					34	50				100		
	8/20/2024				12			12				25	24						
	5/10/2025				99		31		230	160			88	30	26		21		240

🟩 Levels acceptable
🟨 Marginal
🟥 Levels unacceptable
⬜ Results pending

	Description
1	culvert crossing Hobbs Pond Lane at Feinberg (downstream)
1A	stream outlet into lake from stream on Feinberg lot
2	culvert crossing Hobbs Pond Lane at Todd (downstream)
2A	culvert crossing Watson Rd. at Flint Lane (downstream)
2B	on Cleveland farm just below Cooper farm line
2C	stream outlet into lake from stream on Todd lot
2D	upstream of culvert crossing Hobbs Pond Lane
2E	small Flint Lane culvert feeding stream 2
3	culvert crossing Flint Lane at Innes (downstream near residence)
3A	culvert crossing Watson Rd. at East boundary of Cleveland farm (downstream)
3B	culvert crossing Flint Lane at Innes (upstream side)
3C	culvert upstream Vandersnook driveway
4	culvert crossing Rte 118 South East corner near pump house (downstream)
5	culvert crossing Rte 118 East of Kennedy (downstream)
6	Rte 118 rest area (lake water)
7	culvert crossing Rte 118
8	swale off Watson Rd near Rte 118 in hay field, South West corner
9	swale/brook off Watson Rd North of location 8, split flows entering lake

- May 2025 samples continue to show very high levels after heavy rain, especially streams 2 and 3
- Intermittent stream 9 also tested high, requires further investigation
- Location 2E crossing Flint Lane to stream 2 (Old manure storage site) tested high but with low flow

Figure 6 Inlet stream Total Phosphorus content.

The data show that surface runoff can be a significant contributor to lake phosphorus levels. To explore the total load in the lake we constructed a model using the volume of lake water at 1-meter depth intervals and P values at each depth to get a mass of P (kg) for each depth. These were then summed for each date. The graphs in Figure 7 show the result. We see that at the beginning of 2022 there is a very high total mass of phosphorus in the lake of around 60 kg. This drops during the summer to around 25 kg.

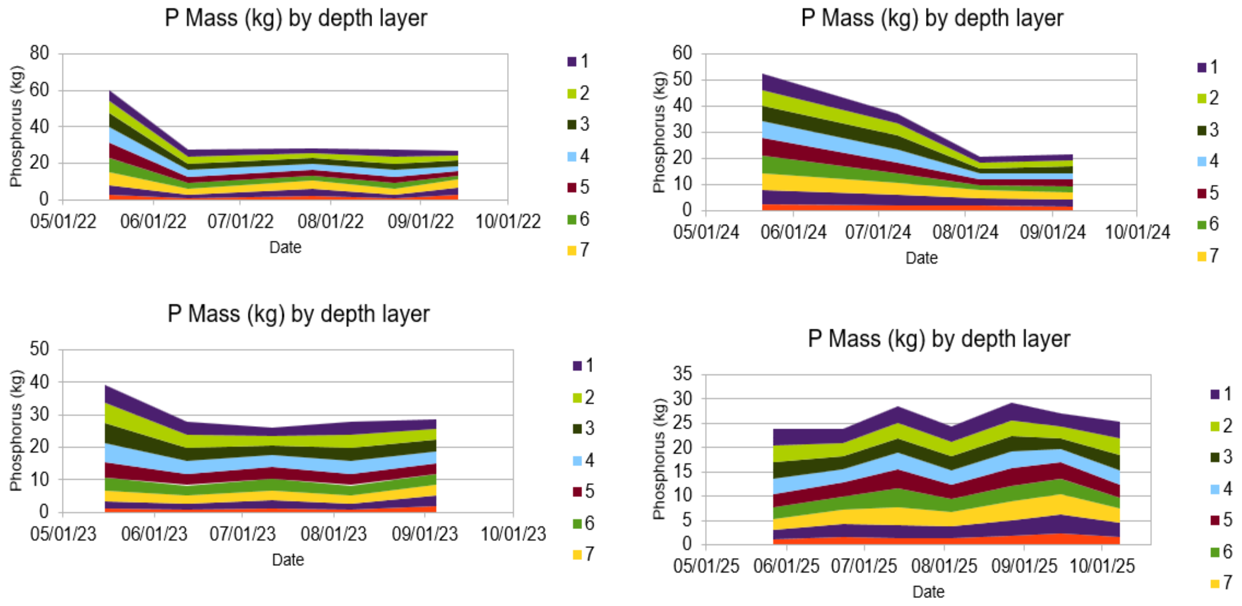


Figure 7 Volumetric P-content at meter intervals of lake water.

The pattern repeats in 2023 but starts off at less than 40 kg. By the third year, 2024, the beginning values are back up to above 50. The pattern changes in 2025 with total phosphorus content remaining below 30 kg throughout the sampling period. At this stage, we are uncertain if the cycle has returned to normal. We suspect that winter has something to do with the observed patterns. Perhaps runoff from the surrounding area was increased due to weather conditions. Or perhaps bottom anoxia (low oxygen) lasted longer than normal, allowing more phosphorus to be leached from the sediments. The high initial concentrations may be what ultimately led to the cyanobacterial blooms experienced by Hobbs Pond and only time will tell if they reduce in intensity

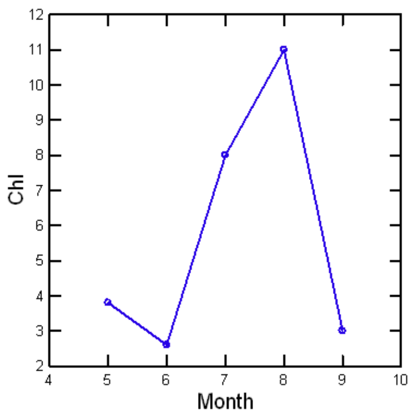


Figure 8. Chlorophyll values for 2025 by month

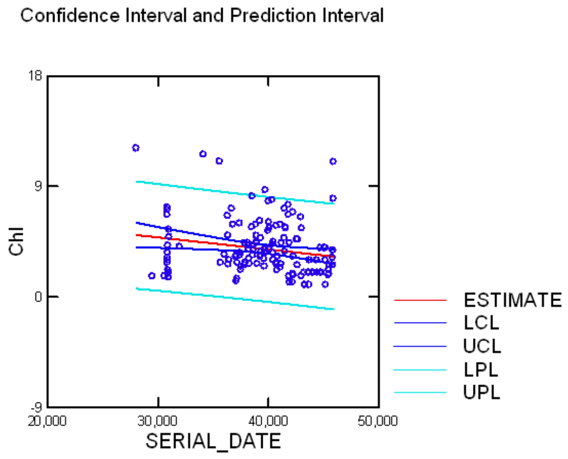


Figure 9. Chlorophyll values 1976-2025 with least square regression line and upper and lower confidence limits.

As we know, higher concentration of nutrients like phosphorus leads to increased algal populations, and increased phytoplankton algae leads to reduced water transparency. In 2025 we saw Chlorophyll (indicative of phytoplankton) increase during the summer like the increase of bottom phosphorus (Fig.8). We show the entire data set from 1976-2025 in Figure 9. There is an apparent downward trend in the data, and this is borne out by a trend analysis using the Mann-Kendall test. The probability of 0.003 indicates that the downward trend is significant.

Mann-Kendall Test for Chlorophyll trend Downward Trend is statistically significant
p-Value = 0.003, Kendall Tau Statistic ¦ -0.160.

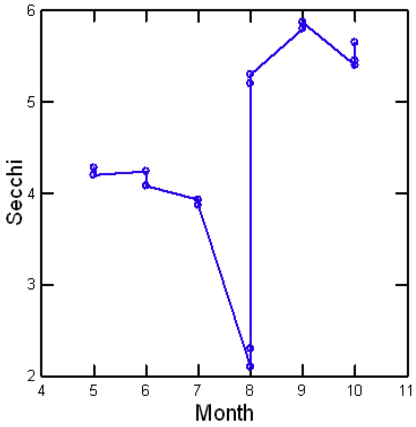


Figure 10. Secchi depths for 2025.

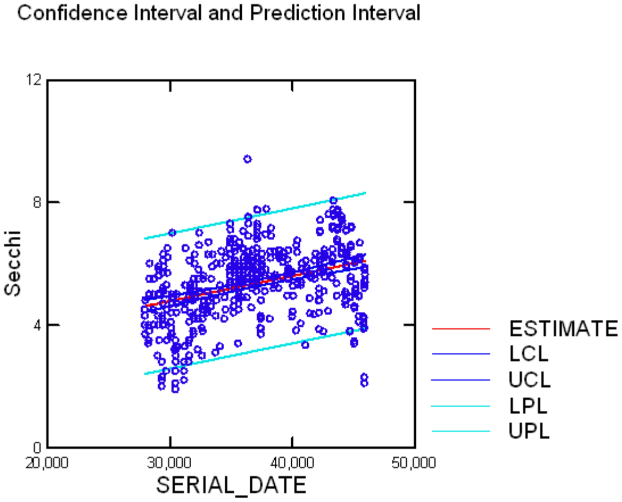


Figure 11. Historical Secchi data 1976-2025 with least squares regression line and confidence limits.

Figure 10 shows the Secchi disk data for 2025. Note that there is a precipitous drop in the Secchi depth in August which coincides with the peak chlorophyll concentrations (Fig. 8). This is followed by a rapid increase which also corresponds to a rapid decline in chlorophyll in September. The onset of the cyanobacterial bloom this year was extremely rapid, probably due to the species change to *Dolichospermum* (see below). The historical data (Fig. 11) show an upward trend which is significant according to the Mann-Kendall test (p-value < 0.05).

> Mann-Kendall Test for upward trend in historical Secchi data is statistically significant
> p-Value = 0.039, Kendall Tau Statistic ¦ 0.058

The four graphs above (Figs. 8-11) show the relationship between decreasing chlorophyll and increasing water transparency.

The declining Chlorophyll trend seems counterintuitive given the cyanobacterial blooms in recent years, however there is other evidence that bolsters the argument that conditions may be improving over the long run. There appear to be trends for Total Phosphorus in the EC and SG samples (Fig.

12), these however are artifacts. The Mann-Kendall test for EC , SG, and PG is not significant for a trend (p values > 0.05).

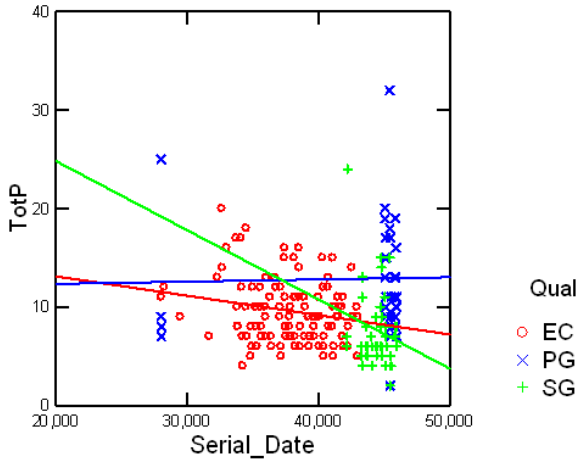


Figure 12. Total Phosphorus in the upper water layer for EC (epilimnetic core), SG (surface grab) and PG (profile grab), R (repeat measurement).

Mann-Kendall Test for EC - downward
p-Value = 0.052
Kendall Tau Statistic ¦ -0.101
Mann-Kendall Test for SG - downward
p-Value = 0.516
Kendall Tau Statistic ¦ 0.005
Mann-Kendall Test for PG - upward
p-Value = 0.676
Kendall Tau Statistic ¦ -0.085

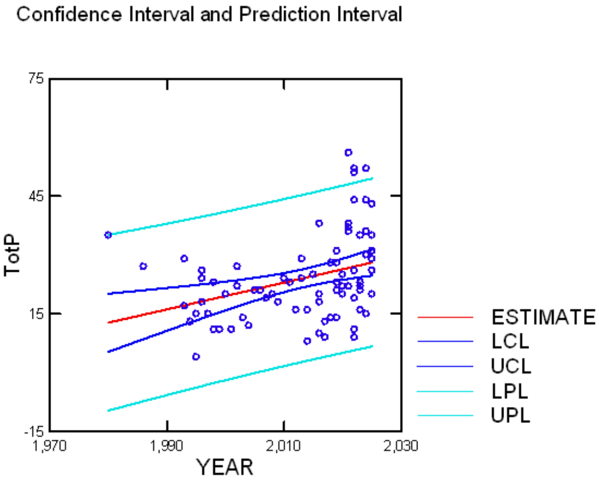


Figure 13. Total phosphorus in the lower water layer (BG) with linear regression line and confidence limits.

Mann-Kendall Test
H0: No Trend vs. H1: Upward Trend

Statistic	ASE	Z	p-Value
875	231.562	3.774	0.000

Kendall Tau Statistic ¦ 0.291

Unfortunately, the lower water column shows an upward trend (Fig. 13). So, while it is encouraging that the surface waters have stable phosphorus levels, the bottom waters could be a source that is fueling the growth of cyanobacteria, especially if strong mixing events occur.

The cyanobacterial bloom was much different in 2025 than prior years. The bloom had been dominated by a filamentous species called *Planktothrix* in the past, but this year the dominant species was *Dolichospermum*. The result was much soupier-looking green water. Figure 14 shows the timing of visual observations of the blooms. The longest bloom period was recorded in 2022 which lasted until mid-September. The blooms affected water clarity as populations grew during the summer, with the worst experienced during 2025 with the *Dolichospermum* bloom when Secchi transparency dropped to about 2 meters (Fig. 10) when it should have been about 7-8 meters. The decreased Secchi Disk measurements correspond to increased chlorophyll, as expected, during the *Dolichospermum* bloom (Fig. 8 and 15), but not necessarily during the *Planktothrix* blooms.

notes

2024 July 26th fairly strong after a period of heat then Westwind

2025 July 29th samples sent to LEA lab, very low Secchi 2.55 M, Dolichospermum "bloom"

Figure 14. Visual observations of cyanobacteria in Hobbs Pond.

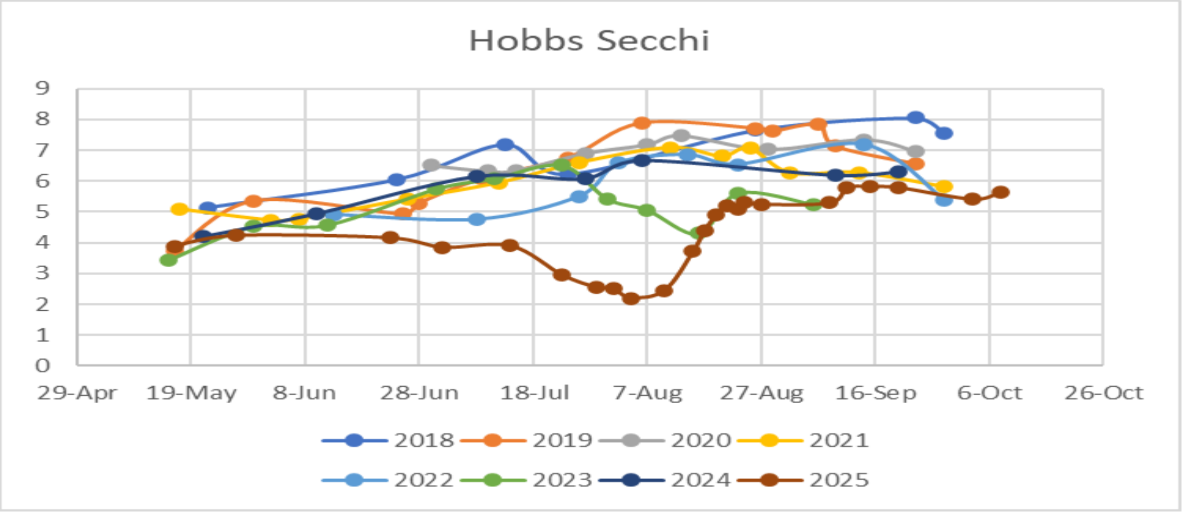
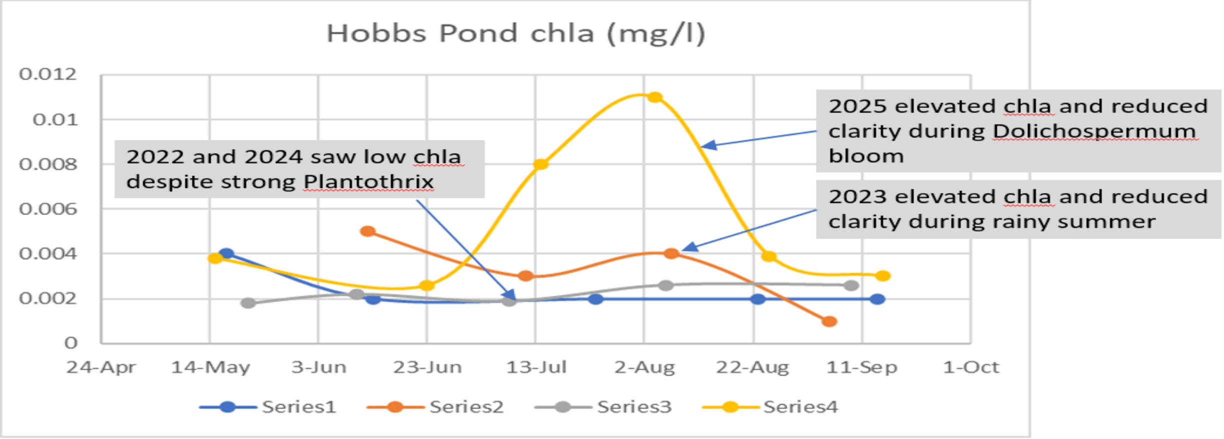


Figure 15. Secchi transparency during summers of 2018-2025.



2025 elevated chla and reduced clarity during Dolichospermum bloom

2022 and 2024 saw low chla despite strong Plantothrix

2023 elevated chla and reduced clarity during rainy summer

Figure 16. Chlorophyll concentrations during bloom periods.

The two species are somewhat different in their shape (Figs. 17 and 18) and "behavior". *Planktothrix* is found as solitary filaments and doesn't form colonies (they may clump together as they are dying and floating to the surface), while *Dolichospermum* can be solitary or form clusters, but do not form mats. Their shape and internal structure may have affects on light penetration and scattering, affecting the observed Secchi transparency (Figures 19 and 20).

Figure 17. Planktothrix filament. (https://www.microbia-environnement.com/publications-presse/mini-revue-sur-le-genre-planktothrix/)

Figure 18. Dolichospermum filaments. (https://www.cayuganaturecenter.org/habs/lakes-v2)

Figure 19. Appearance of Planktothrix on the surface. (Paul Shook)

Figure 20. Appearance of the lake during the Dolichospermum bloom. (Paul Shook)

The trends for pH, Alkalinity, Conductivity and color of water are shown in Figure 21. All are within expected ranges. The pH of the bottom water is slightly more acidic than the surface which is expected due to decomposition of organic matter in the bottom layer. The pH is important because pH values above 9 or below 6 are important regarding which organisms can survive. In 2025 the pH was abnormal in that there were some higher values than we normally see, up to a pH of 9.41. This was probably the result of the *Dolichospermum* bloom.

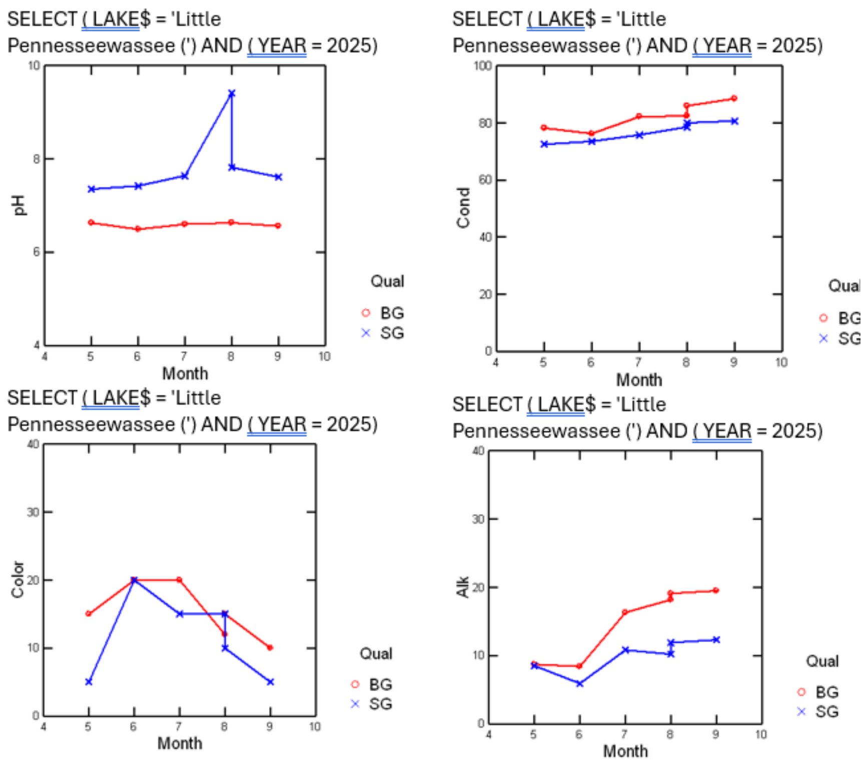


Figure 21. Hobbs Pond result in 2025 for pH, Color, Conductivity and Alkalinity

Alkalinity should more properly be called Acid Neutralizing Capacity and is mostly derived from minerals in the local geology. In our region the rocks are mostly weather-resistant granites which lead to low alkalinity. Changes in alkalinity are also associated with changes in pH, among other things. The values in Hobbs Pond are somewhat lower than the range of typical surface waters, 20-200 (mg/L CaCO3), indicating little buffering capacity against things such as acid precipitation.

Interestingly all our lakes show a historical increase in alkalinity, probably related to the implementation of the Clean Air Act and revisions of 1977 and 1990 which reduced acid rain in the region (https://www.epa.gov/acidrain/acid-rain-program-results).

The Color of Water measurements were at the lower end of values, never exceeding 25 PCU with 30 being a normal value seen in lakes. So, there is not much in terms of humic substance input from decaying vegetation.

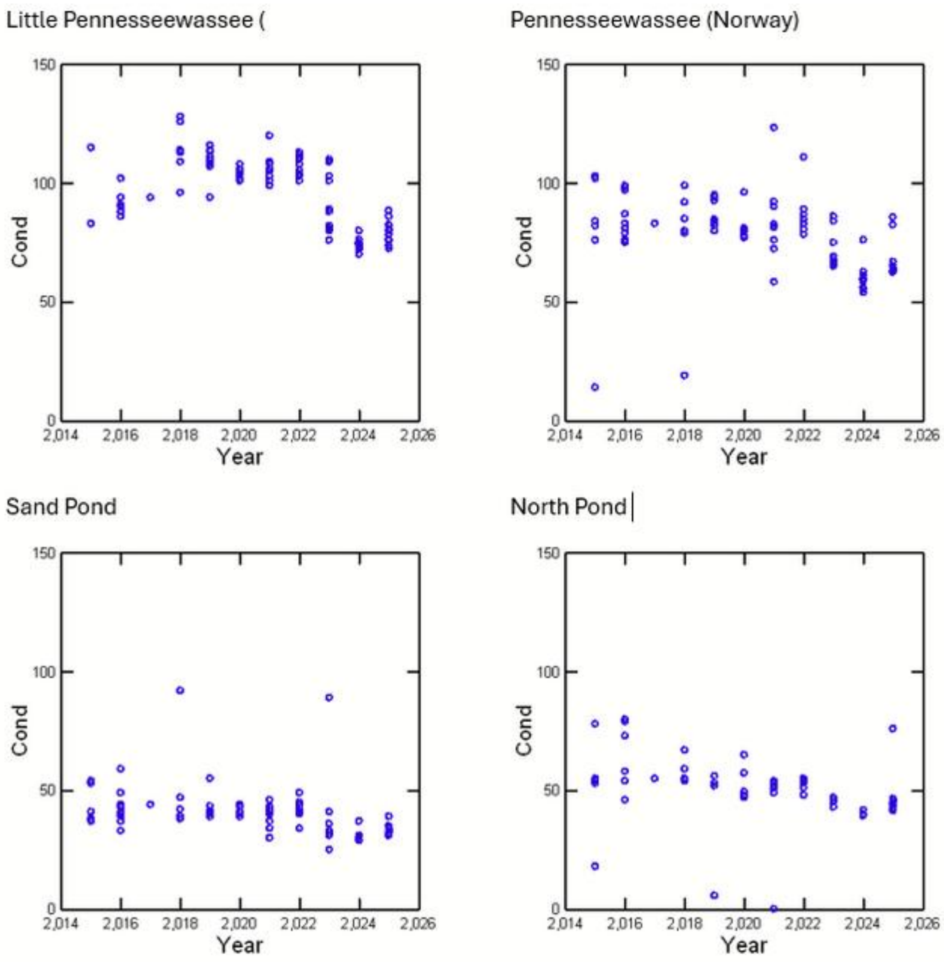


Figure 22. Conductivity over the past ten years in all four lakes.

Conductivity increased during the summer reaching close to 90 µS (Fig. 21). The values are in a good range as most surface waters are typically less than 100 and should not exceed 400 µS. In comparison melted snow ranges between 2 and 42 µS. Increases seen here during the summer may be due to higher concentration of dissolved solids from runoff, and/or higher temperatures which increase solubility and ionic mobility but also increases evaporation rates, all of which can increase the salt concentrations. It is interesting to note that over the past three years there has been a decline in conductivity in all our lakes, most noticeably in Hobbs Pond (Fig. 22). It is unclear why this drop happened, but Maine, and especially Oxford County, experienced a very wet year between October 2022 and September 2023 receiving 60.4 inches of precipitation, 16.6 inches above the 1901-2000 average (https://stacker.com/stories/maine/counties-maine-more-precipitation-over-past-year-average). This could have diluted ions present in the lake.

The Tropic State Index was calculated using Chlorophyll, Secchi Depth and Total Phosphorus. The results, TSI_{chl} =47.1, TSI_{SD} = 38.3, and TSI_{TP} = 43.3, indicate Hobbs Pond is mesotrophic, that is moderately productive in terms of biology (see Appendix 1).

Sand Pond

Sand Pond remains as the lake with the best water quality in the area. Not much has changed since last year and bottom P levels are better than historical values (Table 1). Average surface phosphorus concentrations were around 4 ppb while at the bottom it was close to 12.6 ppb (Table 1).

Phosphorus levels started out high, both in the surface and bottom layers, after which the surface levels declined (Fig. 23). For description of the sample (SG,EC,PG,BG) see methods on sampling. The bottom values decreased sharply in June but then climbed again to about 15 ppb by September. We interpret this as the surface P being taken up by phytoplankton growth and then sinking to the bottom after they die. The historical data are shown in Figure 24. The data are fairly consistent over time, indicating no changes in the phosphorus during this period.

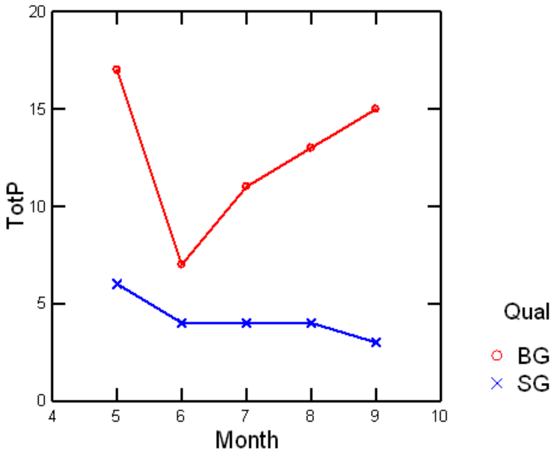


Figure 23 Total Phosphorus (ppb) in 2025 at surface (SG) and bottom (BG).

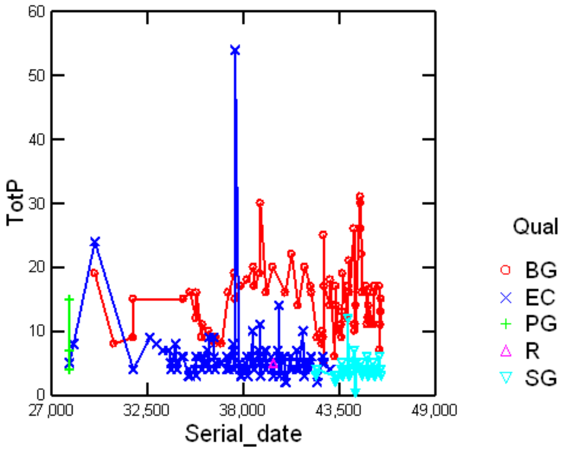


Figure 24. Total Phosphorus over the period of 1976-2025. SG = Surface Grab, EC = Epilimnetic Core, PG = Profile Grab, BG = Bottom Grab, R = Repeat Sample.

Sand Pond Dissolved Oxygen, temperature and Relative Thermal Resistance are shown in Figure 25. As expected, the DO is high at the beginning of the year, and the RTRM is relatively low and uniform throughout the water column. As summer sets in, the thermocline strengthens and deepens due to solar warming. The larger temperature differences between adjacent layers of water lead to increased RTRM. Due to the summer strengthening of the thermocline, oxygen successively gets lower in the deep water because the resistance to mixing has increased which causes exchange between the surface and lower layers to be reduced. As Fall begins, the thermocline deepens due to wind mixing but also weakens due to less sunlight leading to reduced RTRM.

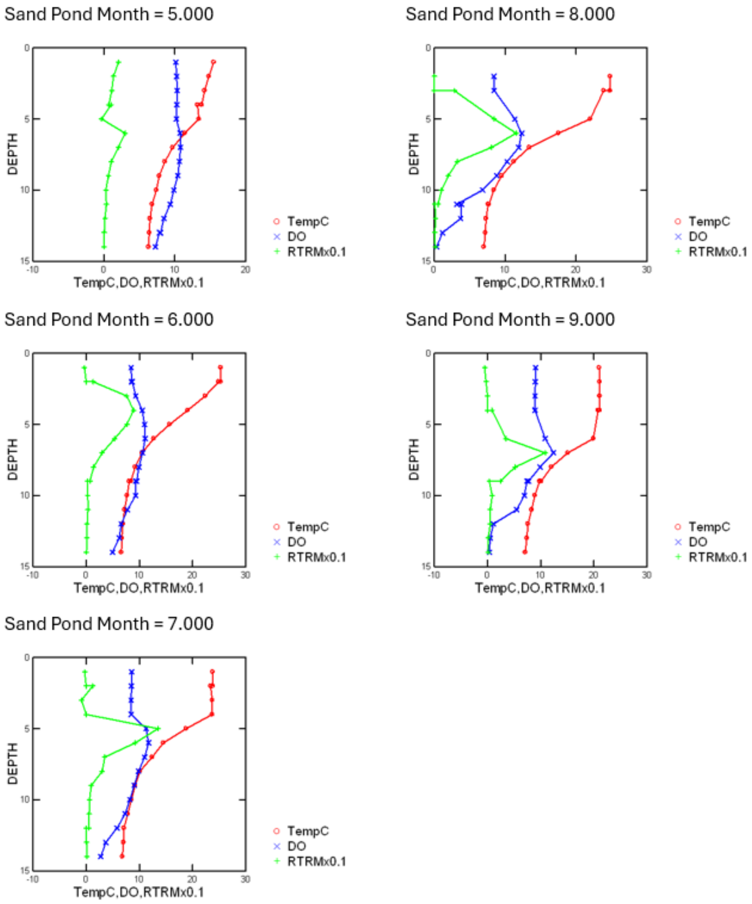


Figure 25. Temperature, DO and RTRM x 0.1 for Sand Pond in 2025.

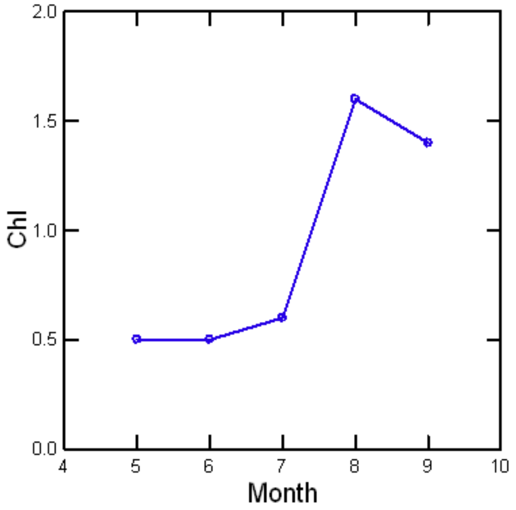


Figure 26. Chlorophyll concentrations (ppb) in 2025.

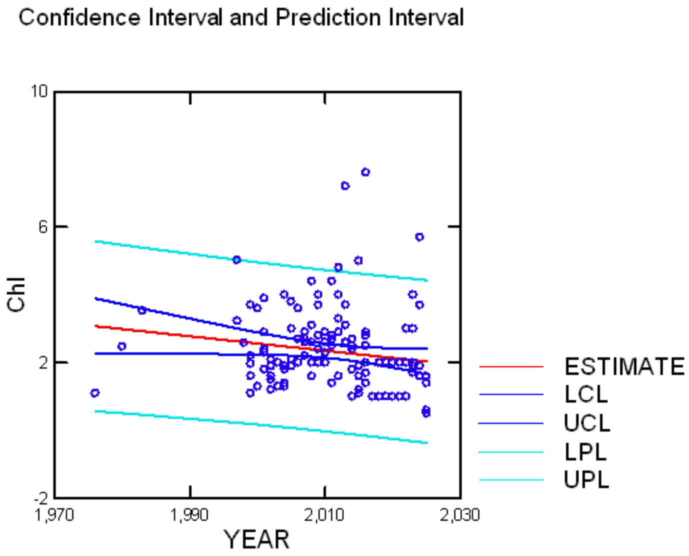


Figure 27. Historical Chl concentrations with regression and confidence limits.

Chlorophyll is indicative of the quantity of phytoplankton algae present in a lake. The numbers for Sand Pond are shown in Figure 26 for Summer 2025. By lake standards these are relatively low values and are apparently declining over time as seen in Figure 27. The downward trend is verified by Mann-Kendall test (Tau = -0.137, p=0.013). This result should indicate improving water clarity since phytoplankton numbers are decreasing. The 2025 data for Secchi depths are shown in Figure 28, and with one exception exceeds 7 meters, which is very good for our lakes. The long-term Secchi trend is shown in Figure 29, apparently showing an increase (improvement) over time. This trend is verified by the Mann-Kendall test (Tau = 0.143, p=0.000) indicating an upward slope.

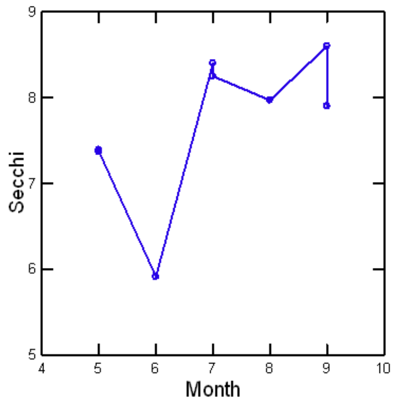


Figure 28. Secchi depth for Sand Pond in 2025.

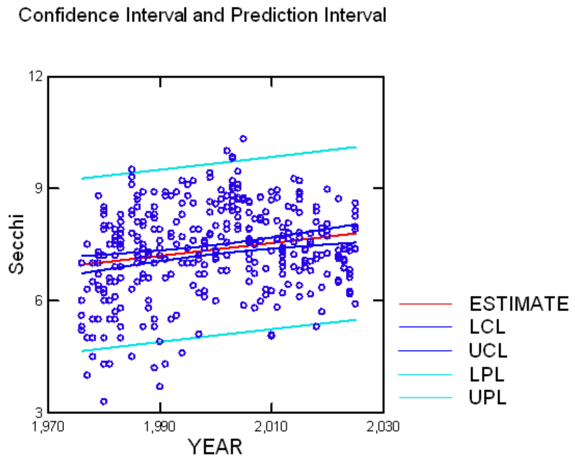


Figure 29. Historical trend of Sechi depth for Sand Pond with upper and lower confidence limits for line.

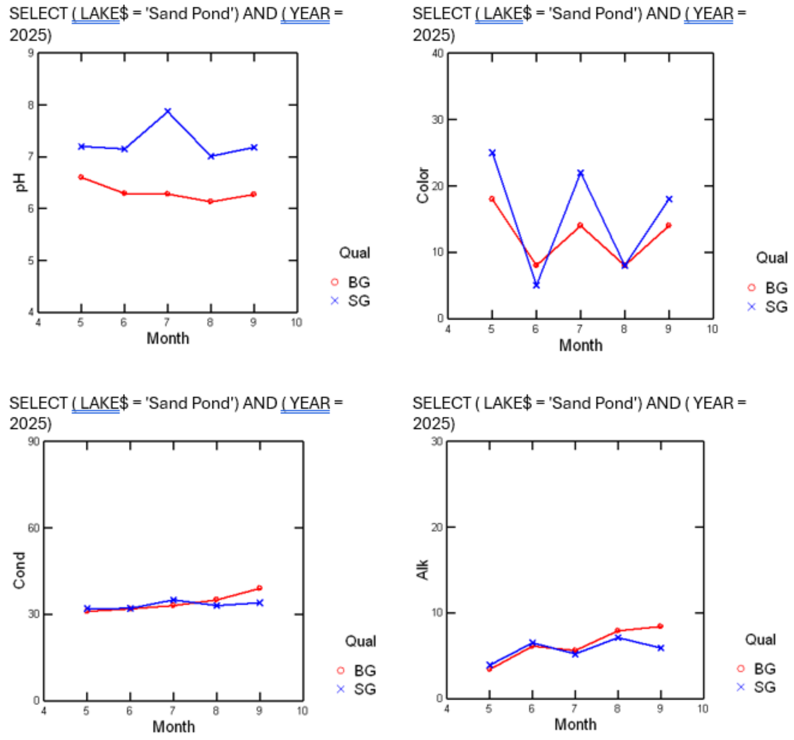


Figure 30. The 2025 values of pH, Color, Conductivity and Alkalinity (SG= Surface Grab, BG=Bottom Grab).

The 2025 values of pH, Color, Conductivity and Alkalinity are shown in Figure 30. The pH values were typical for most lakes, ranging from 6.1 to 7.9. This is good for organisms living in the lake. Color was also in the normal range, remaining below 30. That means there are no excessive products of plant decomposition. Conductivity values were low, between 30 and 40, indicating low influence of road salt or pollutants. If there is a potential problem, it might be Alkalinity, or rather Acid Neutralizing Capacity. These values were relatively low, 3-4-8.4, which means there is very little to buffer any acid input, for example, from acid precipitation. Interestingly all our lakes show a historical increase in alkalinity, probably related to the implementation of the Clean Air Act and revisions of 1977 and 1990 which reduced acid rain in the region (https://www.epa.gov/acidrain/acid-rain-program-results).

The Trophic State Indices are all in the oligotrophic range (TSI-Chl = 29.8, TSI-Secchi = 30.5, and TSI-TotP = 34.8) or low productivity, which is good (see Appendix 1).

Pennesseewassee

Lake Pennesseewassee is the largest lake we monitor and has been observed since 1976. The long-term data trend shows that the water quality has been relatively stable over this time. Figure 31 shows Dissolved Oxygen, Temperature and RTRM (Relative Thermal Resistance) in 2025. The water column again showed declines in bottom dissolved oxygen as the season progressed (Fig. 31). The bottom DO depletion coincides with the increase in bottom Total Phosphorus (Fig. 32).

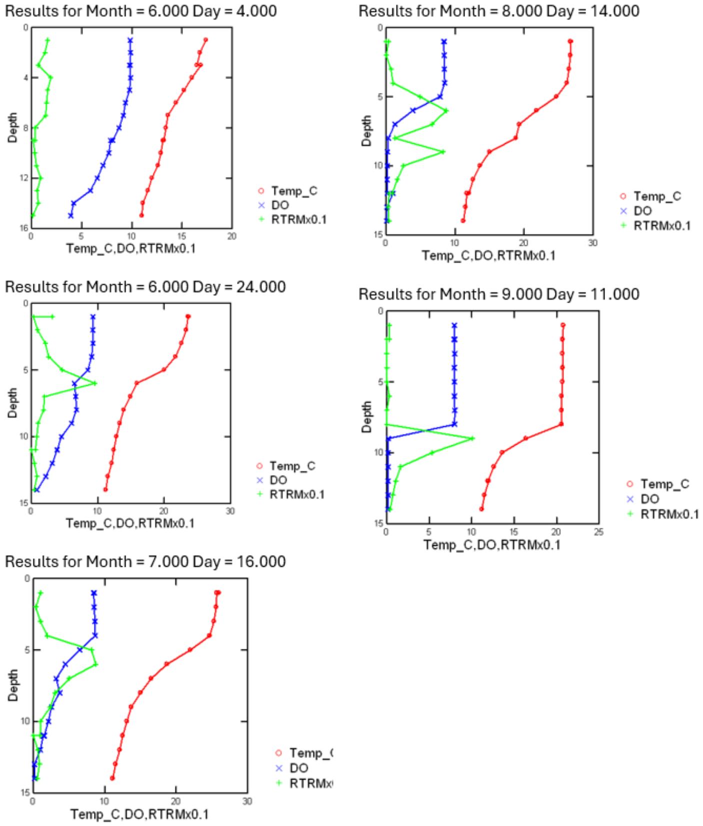


Figure 31. Temperature, DO and RTRMx0.1 for 2025 in Pennesseewassee.

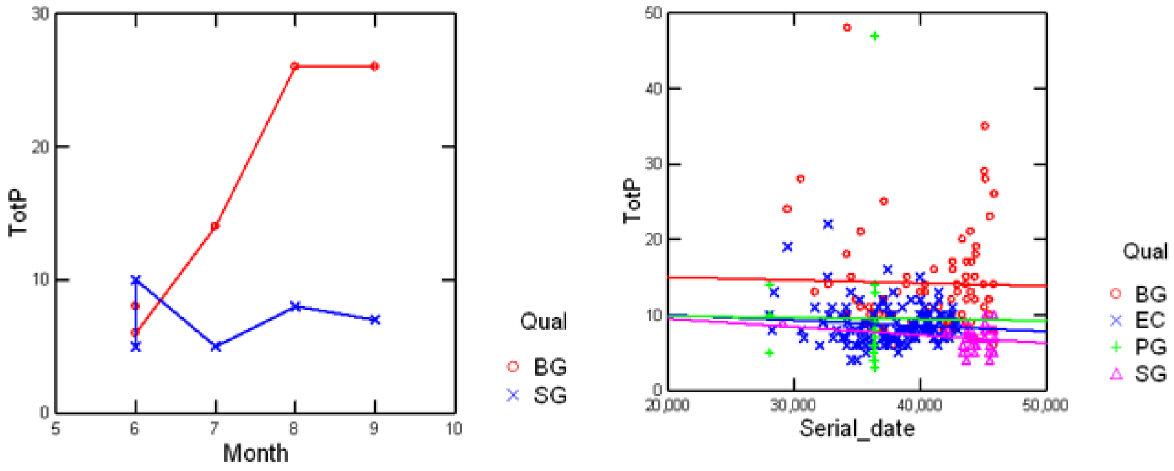


Figure 32. Total Phosphorus in 2025 (left panel) and over the period of 1976-2025 (right panel) in Pennesseewassee. SG=Surface Grab, EC=Epilimnetic Core, PG=Profile Grab, BG=Bottom Grab.

For descriptions of the sample (SG,EC,PG,BG) see methods on sampling. The increase is directly related to DO, because as DO approaches zero, the bottom sediments change chemically and begin to release phosphorus that had been deposited there over time. The long-term data set is shown in the right panel of Figure 32. The trends are shown by the regression lines, which indicate little change, although there seem to be more higher values in the bottom water recently. These trends were all non-significant according to Mann-Kendall tests.

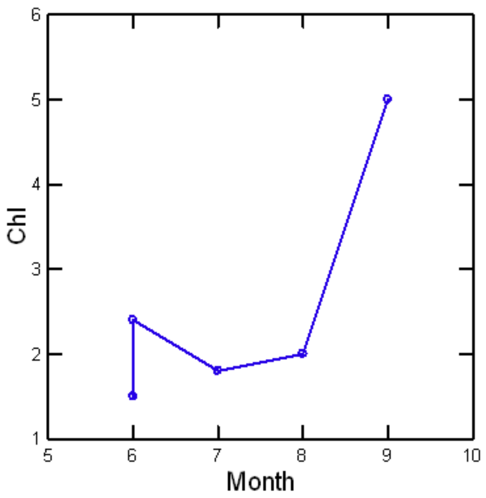


Figure 33. Chlorophyll concentrations (mg/L) for 2025.

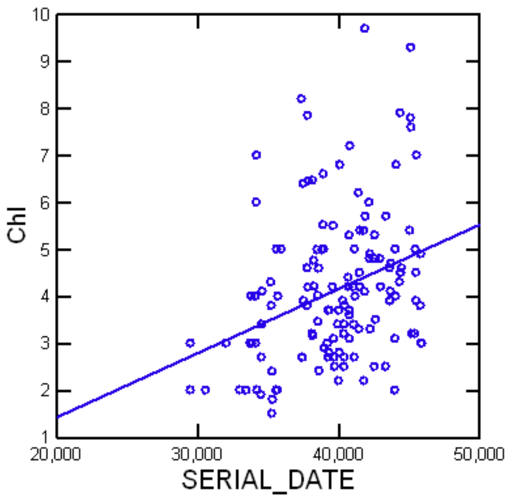


Figure 34. Chlorophyll concentrations (mg/L) for 1976-2025.

Chlorophyll concentrations started low in 2025 but rapidly increased in September (Fig .33). This is in response to nutrients being brought to the surface from deeper water during Fall Overturn (complete mixing of the water column), the mixing of the water column due to decreasing temperatures causing density changes, and wind mixing. This is seen in Figure 31 by the deepening of the RTRM, which is where the temperature difference is the strongest. This deepening of RTRM means the deep water is mixing with the surface water, thus introducing nutrients from below.

Chlorophyll concentrations have apparently been increasing over time (Fig. 34). And this is borne out by trend analysis (Mann-Kendall test upward trend p=0.000) since the probability is zero.

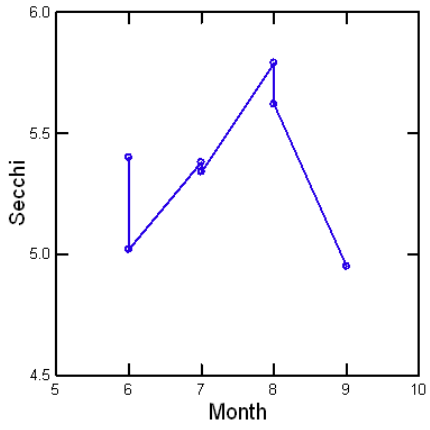


Figure 35. Secchi depths (m) for 2025.

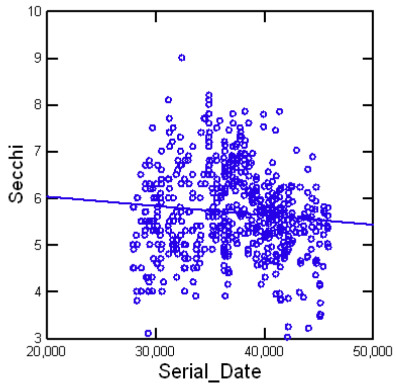


Figure 36. Secchi depth (m) over the period of 1976-2025.

The water clarity as shown by Secchi depths is seen in Figure 35. The sharp decline in September is due to the high chlorophyll concentrations seen in Figure 33. The low value in June is most likely due to pollen in the water, which would not be reflected by chlorophyll. The apparent downward trend in Secchi depth over time (Fig. 36) is not real as seen by trend analysis (Mann-Kendall test downward trend p=0.959) since the probability value is above 0.05.

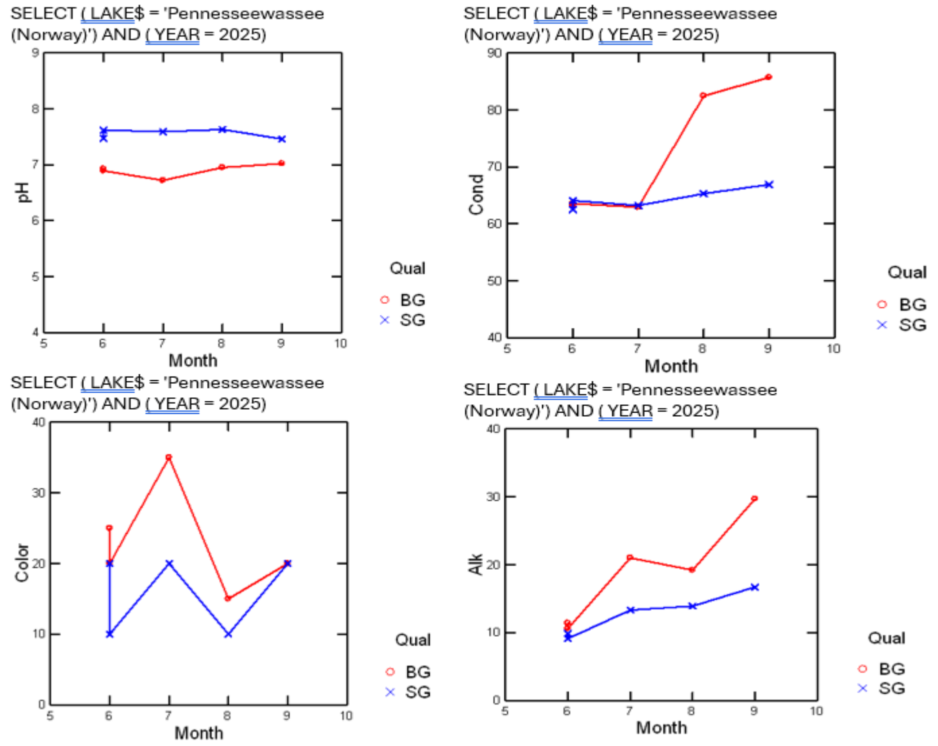


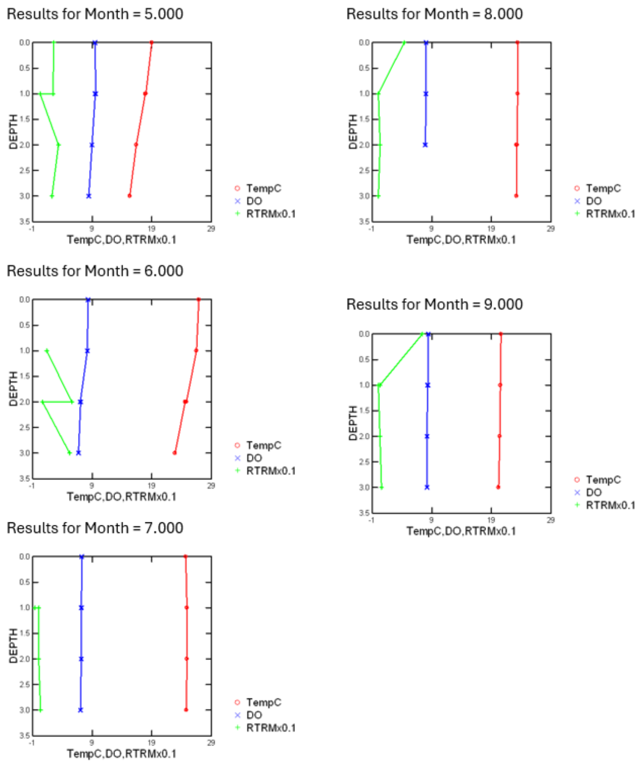
Figure 37. pH, Conductivity, Color and Alkalinity results for 2025 for Surface Grabs (SG) and Bottom Grabs (BG)

The pH values were in the typical range between 6 and 8, indicating no problems (Fig 37, upper left). Color too was in the normal range with only one value above 30 (Fig. 37, lower left) indicating no abnormal inputs of humic material from plant decomposition. Conductivity, while normal, showed an increase toward the end of summer (Fig. 37, upper right). Alkalinity (Acid Neutralizing Capacity) also showed an increase as summer progressed (Fig. 37, lower right). The increase in Alkalinity could have been due to the accumulation of particulate matter from the decomposition algae dying (their lifespan is measured in days). Interestingly all our lakes show a historical increase in alkalinity, probably related to the implementation of the Clean Air Act and revisions of 1977 and 1990 which reduced acid rain in the region (https://www.epa.gov/acidrain/acid-rain-program-results).

The Trophic State Indices are all in the upper end of the oligotrophic range, (TSI-Chl = 39.7, TSI-Secchi = 35.8, and TSI-TotP = 39.4) or low productivity (see Appendix 1). This means that the lake currently has low productivity, generally a good sign, but it is relatively close to the mesotrophic range which starts at a TSI of 40. The lake could become mesotrophic if only a small increase in nutrients were to enter the lake.

North Pond

North Pond is a shallow (3 m deep) pond, which makes it unique to our lakes. The shallow depth means that any wind can mix it from top to bottom, so it rarely stratifies (becomes layered). This can be seen in Figure 38, which shows Temperature, Dissolved Oxygen and the Resistance to Thermal Mixing (RTRM). It is clear that the distributions are more or less uniform throughout the


Results for Month = 5.000

Results for Month = 8.000

Results for Month = 6.000

Results for Month = 9.000

Results for Month = 7.000

Figure 38. Temperature, Dissolved Oxygen and RTRM observed monthly in 2025.

water column. The uniform temperature means that any dissolved substances or properties such as conductivity would be distributed evenly. This lack of stratification lasts throughout the summer, unlike our other lakes which become stratified during the warmer months.

The Total Phosphorus concentrations for 2025 are shown in Figure 39 and illustrate that bottom and surface waters have nearly the same concentrations. The concentrations are mostly in the 10-20 ppb range which is moderately high. This is within the historical range as seen in Figure 39 (right panel). The trend lines shown in Figure 39 are not significant as shown by the Mann-Kendall tests since all the probability values are greater than 0.05 (upward trend SG p = 0.601, EC p = 0.554, downward trend BG p = 0.366). For a description of how the samples (SG,EC,PG,BG) were collected, see methods on sampling. The lack of statistical significance in the trend lines means that phosphorus has been relatively stable over time.

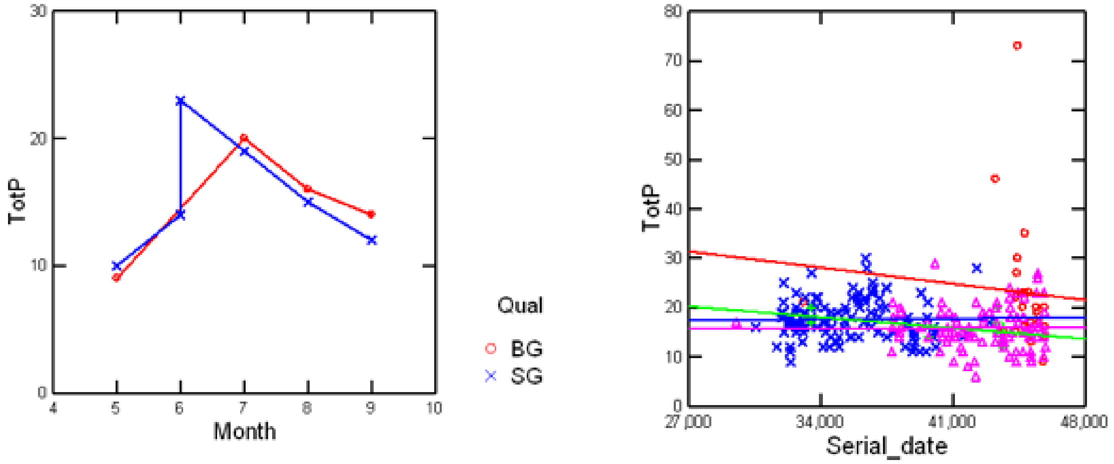


Figure 39. Total Phosphorus (ppb) in Surface Grabs (SG) ad Bottom Grabs (BG) for 2025, left panel. Total Phosphorus for the period of 1976-2025 for SG, BG, and Epilimnetic Core (EC) samples.

Phosphorus is a key element for phytoplankton growth, and we measure the abundance of phytoplankton by analyzing for chlorophyll, the molecule that allows them to use photosynthesis to make food. Chlorophyll concentrations are shown in Figure 40. The 2025 observations show that

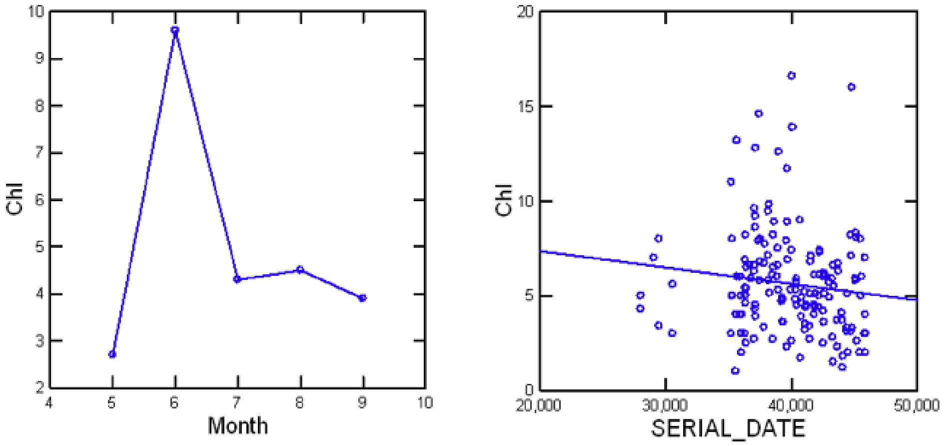


Figure 40. Chlorophyll concentrations in 2025 (left panel) and chlorophyll through the period of 1976-2025 (right panel).

Chlorophyll levels were normal for North Pond. Even the high value was not as high as some of the historical values were (Fig. 40, right panel). The historical data indicate that there is a declining trend, which is a good sign. The trend was verified with a Mann-Kendall test which showed that the downward trend was significant, with a probability value of < 0.05 (p = 0.014). This is a promising result given the work LAON has done with the watershed survey and subsequent efforts to mitigate runoff into the lake, including the efforts of property owners to prevent erosion.

Water clarity as determined by Secchi depth is normally correlated with the amount of chlorophyll present. However, since North Pond is so shallow, the Secchi disk normally reaches the bottom and is still visible, making this measure not meaningful. We can see in Figure 41 (left panel) that the Secchi depth is right around 3 meters in 2025. In earlier years, right panel of Figure 41, we see some departures from this. Water levels may have changed over time, or there may have been plankton blooms or sediment in the water. However, most of the data still falls right around 3 meters.

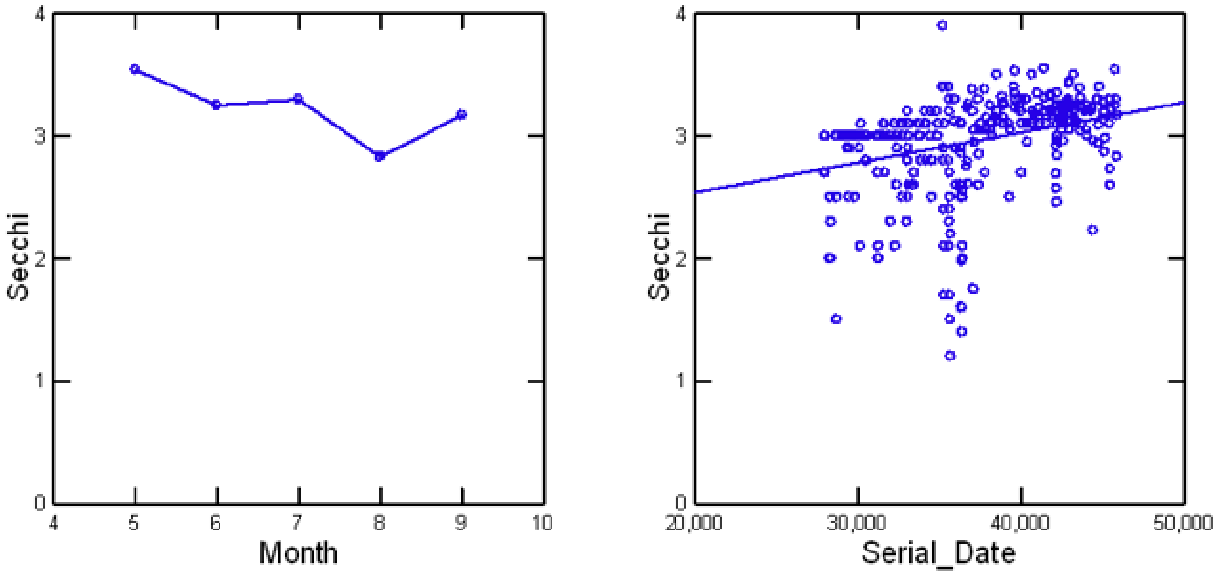


Figure 41. Secchi depth in 2025 (left panel) and data from 1976-2025 (right panel).

Despite this, there is trend line that can be put through the data and according to the Mann-Kendall test, the upward trend is highly significant (p = 0.000). For the reasons stated above, we do not feel this is the case, and Secchi should be around 3 meters except under unusual circumstances. The low values may be due to phytoplankton blooms, runoff of soil, or possibly pollen.

The pH data for both surface and bottom were very close (Fig. 42, upper left panel) again indicating that the shallow depth of North Pond prevented stratification from occurring. The values were between 7-7.5, which is normal for lakes and does not indicate any problems.

Conductivity (Fig. 42, upper right panel) shows one surface value near 80 µS/cm, but it is very different from the bottom sample, unlike the other samples which are very close. This leads us to suspect this value as being invalid and possibly contaminated.

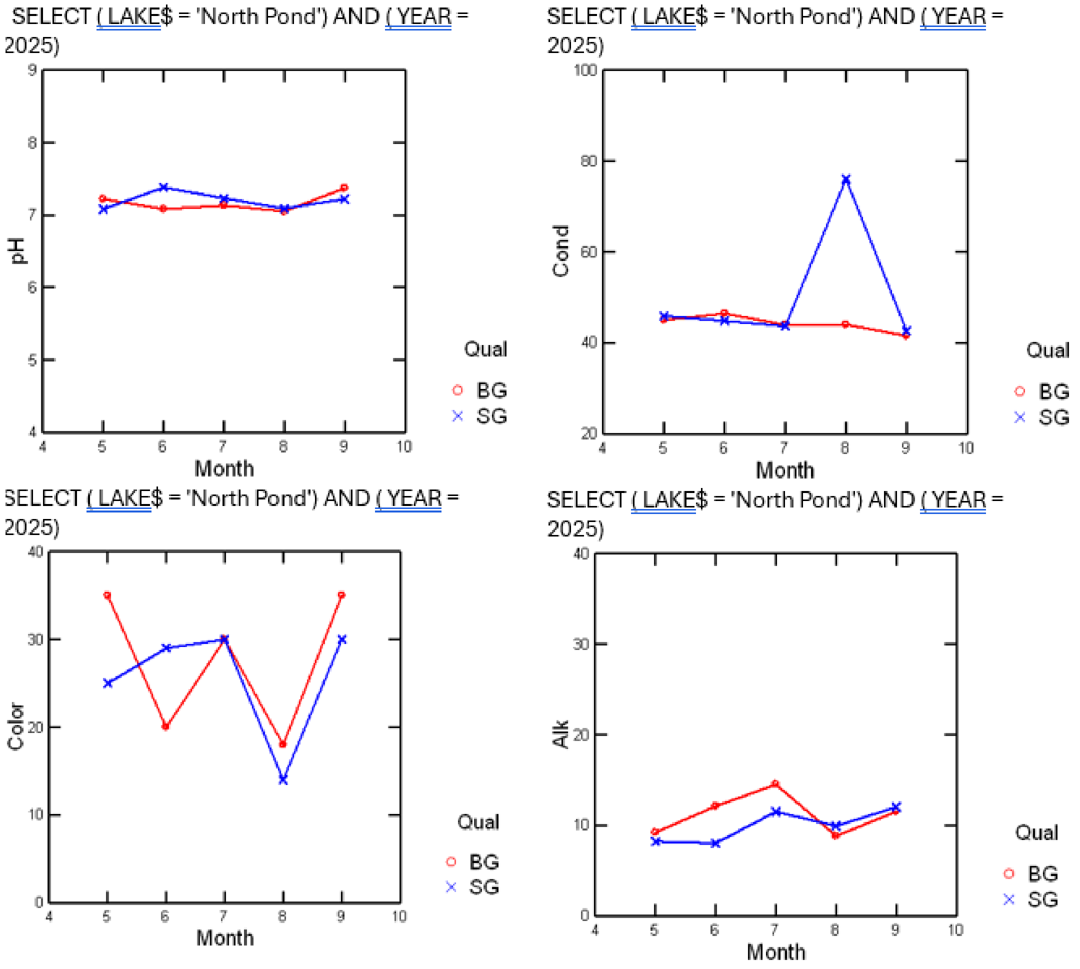


Figure 42. pH, Conductivity, Color, and Alkalinity graphs for 2025 (SG=Surface Grab, BG=Bottom Grab).

The Color of Water data for North Pond (Fig. 42, lower left panel) is also within the expected range, between 15 and 35. There is no real pattern for the fluctuations, and we can't discern any trend here.

The Alkalinity, or Acid Neutralizing Capacity, is between 8 and 15 mg/L as $CaCO_3$ (Fig. 42, lower right panel). While not bad, it is on the lower end of the scale. This could put it risk if there should be an increase of acid precipitation or other pollutant events. Interestingly all our lakes show a historical increase in alkalinity, probably related to the implementation of the Clean Air Act and revisions of 1977 and 1990 which reduced acid rain in the region (https://www.epa.gov/acidrain/acid-rain-program-results).

The Trophic State Indices for North Pond are in the upper end of the mesotrophic range (TSI-Chl = and TSI-TotP = 43.4) or moderate productivity (see Appendix 1). The TSI for Secchi Disk is not included because the shallow depth means that the Secchi Disk always reached the bottom before it can disappear. The lake is considered moderately productive, but we don't find any evidence of algal blooms.

Methods

The methods described here are the ones currently employed. In the historical records discussed in this Report, other methods may have been used (see Sample Designation below).

Water Clarity:

Water transparency was measured with a standard Secchi disk, 20 cm in diameter, with black and white quadrants. It was lowered on a measuring tape marked in meters. A measurement was made to the nearest centimeter, while looking through an Aquascope II©, at the point where the disk disappeared.

Sample Designation

Samples were collected by different methods in the past. EC = Epilimnetic core sample (mixed sample from epilimnion) was taken by lowering a flexible tube to the thermocline and collecting that sample in the tube as a mixture representing the surface layer; SG = Surface grab sample taken directly from the surface water; BG = Bottom grab sample taken (approx. 1 m above bottom of lake) using a sampling device like a van Dorn bottle, PG = Profile grab samples taken at intermediate depths with a sampling device like a van Dorn bottle.

Water Samples:

Water samples were collected in 2-liter polycarbonate bottles. The first was immersed, inverted at the surface and filled by turning it right-side up. A second 2-liter polycarbonate bottle was filled from a van Dorn sampler. The van Dorn bottle can be lowered to a specific depth with a marked line, and then closed at depth by sending a weight, called a messenger, down the line. The weight triggers the closing of the ends of the sampler. The 2-liter bottles were covered to seal out light with aluminum foil and duct tape. They were kept in a cooler on ice until they were returned to shore for sample processing.

One exception to this was the collection of total phosphorus samples. For surface samples, a conical tube was inverted and passed through the surface in an arc so that the tube emerged right-side up. The deep samples for total phosphorus were collected in a conical tube directly from the van Dorn sampler prior to any other sample being taken.

Total Phosphorus:

Total phosphorus samples were collected as described in Water Samples. Both samples were collected in 50 ml tubes to measure out the volume and then transferred into Erlenmeyer flasks and sealed with a screw top. These samples were kept refrigerated and sent to the Maine State Health and Environmental Testing Laboratory (HETL) in Augusta to be analyzed.

Chlorophyll:

Chlorophyll was sampled from the 2-liter bottles collected at the surface and at depth as described in Water Samples above. The water was then vacuum filtered with an electric pump at < 8 in Hg vacuum, through a 0.45 micrometer pore-size filter. The filtered volume was recorded and typically was between 300-600 mL. After filtration was complete, the filters were frozen and sent to the

Maine State Health and Environmental Testing Laboratory (HETL) in Augusta to be analyzed spectrophotometrically.

Dissolved Oxygen:

DO was measured at 1-meter intervals from surface to the bottom with a YSI ProSolo meter. The meter was calibrated daily with air-saturated water. This was done by filling a container with tap water and bubbling air through it with the use of an aquarium pump and air stone. Barometric pressure was obtained for the calibration from the National Weather Service, using the Lewiston-Auburn station. The meter has a stated accuracy ± 0.1 mg/L for DO and ± 0.2°C for temperature.

Temperature:

Temperature was measured at 1-meter intervals from surface to the bottom with a YSI ProSolo meter. The meter has a stated accuracy of ± 0.2°C for temperature.

Conductivity:

Conductivity was sampled from the 2-liter bottles collected at the surface and at depth as described in Water Samples above. The conductivity was then measured on a subsample of about 100 ml, with an Orion VersaStar meter and an Orion 013005MD conductivity cell. The probe was calibrated with a 84 microSiemens per cm (µS/cm) standard solution. The stated accuracy of the instrument is ± 0.5% of reading, ±1 digit.

pH:

The pH was sampled from the 2-liter bottles collected at the surface and at depth as described in Water Samples above. The pH was then measured with an Orion VersaStar meter and an Orion 8302BNUMD Ross Ultra pH/ATC triode. The probe was calibrated each sampling day with a pH 10.0, 7.0 and 4.0 buffer solutions. The meter has a stated accuracy of ± 0.002 pH units.

Alkalinity

Water samples were obtained from the 2-literbottles collected at the surface and bottom as described in Water Samples above. Alkalinity was measured with a Hach Model AL-DT digital titrator. It measures both phenolphthalein and total alkalinity as mg-$CaCO_3$ in the range of 10-4,000 mg/L.

Color:

Water samples were obtained from the 2-liter bottles collected at the surface and bottom as described in Water Samples above. The color of water was measured with a Hach CO-1 test kit. It uses a comparator disc (Fig. 43) that allows the user to compare a water sample to standard colors on the disc. We filtered the sample water through a 0.22 µm filter to obtain the true color of water. The results were read in the 0–100 range APHA (Amer. Public Health Assoc.) platinum cobalt color units (Fig. 44). Accuracy for color disc kits is typically +/- 10% or +/- the smallest increment (10 Pt-Co units), subject to individual color perception.

Figure 43. Hach CO-1 comparator disc calibrated in Platinum-Cobalt units

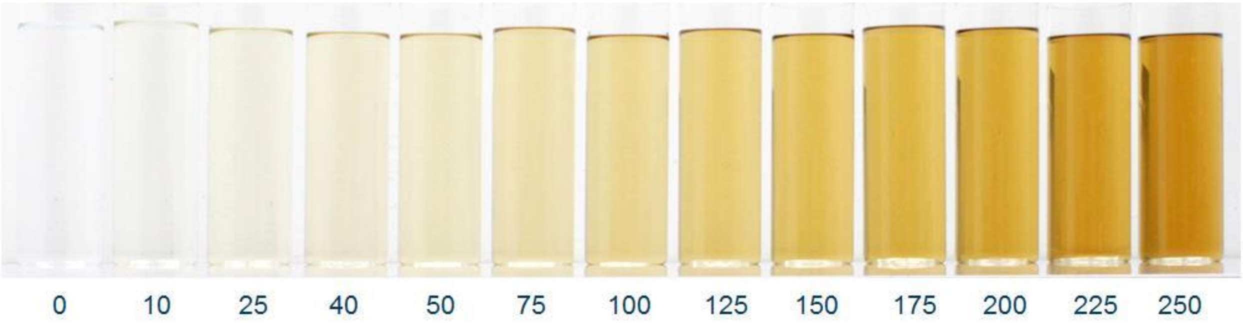


Figure 44. Examples of colors for the Platinum- Cobalt scale.

Appendix 1.

A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient.

TSI	**Chl**(µg/L)	**SD**(m)	**TP** (µg/L)	**Attributes**	**Water Supply**	**Fisheries & Recreation**
< 30	< 0.95	> 8	< 6	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion.	Water may be suitable for an unfiltered water supply.	Salmonid fisheries dominate.
30 – 40	0.95 – 2.6	8 – 4	6 – 12	Hypolimnia of shallower lakes may become anoxic.		Salmonid fisheries in deep lakes only.
40 – 50	2.6 – 7.3	4 – 2	12 – 24	**Mesotrophy:** Water moderately clear; increasing probability of hypolimnetic anoxia during summer.	Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
50 – 60	7.3 – 20	2 – 1	24 – 48	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible.		Warm-water fisheries only. Bass may dominate.
60 – 70	20 – 56	0.5 – 1	48 – 96	Blue-green algae dominate, algal scums and macrophyte problems.	Episodes of severe taste and odor possible.	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
70 – 80	56 – 155	0.25 – 0.5	96 – 192	**Hypereutrophy:** (light limited productivity). Dense algae and macrophytes.		
> 80	> 155	< 0.25	192 – 384	Algal scums, few macrophytes		Rough fish dominate; summer fish kills possible.