Lake & Watershed Resource Management Associates
P.O. Box 65; Turner, ME 04282; 207-576-7839

2017 Report on the Water Quality of Ellis (Roxbury) Pond
Prepared for, and Supported by the Silver Lake Campowners Association, and the Town of Roxbury

This monitoring and assessment summary report for Roxbury Pond is based on baseline sampling that took place on July 19 and August 16, 2017 by LWRMA Senior Limnologist, Scott Williams. Additional water clarity, surface total phosphorus, and temperature and dissolved oxygen data were provided by certified volunteer lake monitors, Ross and Christine Swain.

Critical indicators of lake water quality that have been monitored during past years were measured, sampled and assessed using methods and protocol for lake assessment established by the Maine Department of Environmental Protection and the Maine Volunteer Lake Monitoring Program.

Overview:
Based on the clarity of the water from May through October, 2017, as well as the concentrations of algae and the nutrient phosphorus, and dissolved oxygen in the deepest area of the pond in the late summer, Roxbury/Ellis Pond water quality was *close to the historical average* for the pond, based on data gathered from 1982 to the present.

Each lake and pond responds in a unique way to the influences of weather, changes in land use in the watershed, and other forces upon the ecosystem. The wide range of physical, chemical and biological characteristics of each lake basin and its watershed combine with weather, the influence of watershed land use and other factors to help explain the moderate natural annual variability that occurs within lakes over time.

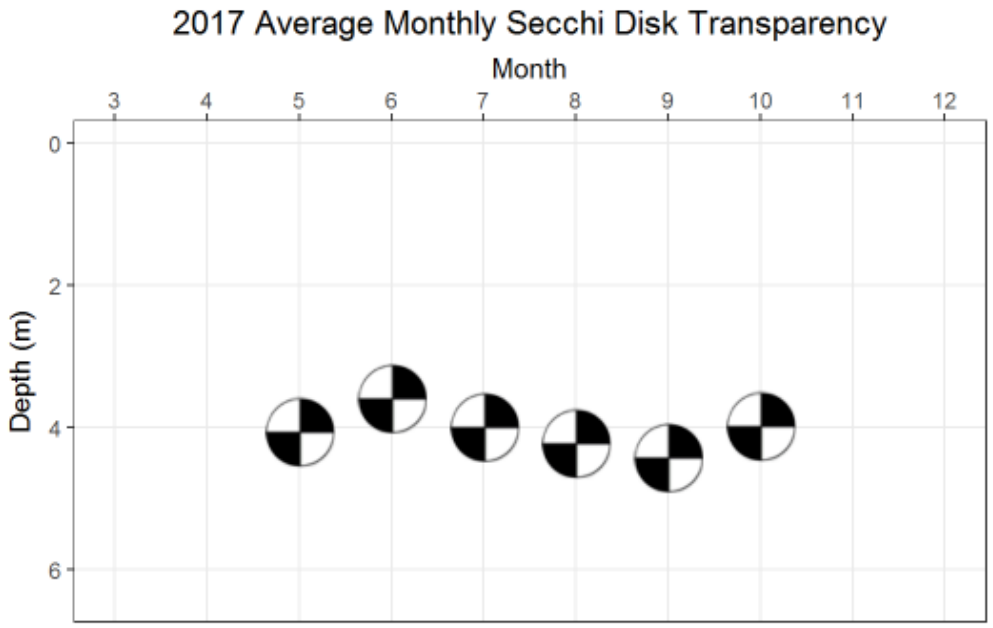
Stormwater runoff is the primary means by which the nutrient phosphorus is transported to lakes from their watersheds. Most of the annual phosphorus “loading” to lakes typically takes place from the period of spring snowmelt through early summer, when watershed soils are generally

frozen or saturated with water, resulting in a higher percentage of runoff from rain events during the period.

Moderate snowfall during the winter of 2017, followed by frequent spring rain events, brought an end to the severe drought of 2016. However, mid to late summer conditions throughout much of Maine were very dry in 2017.

Summary of Findings:

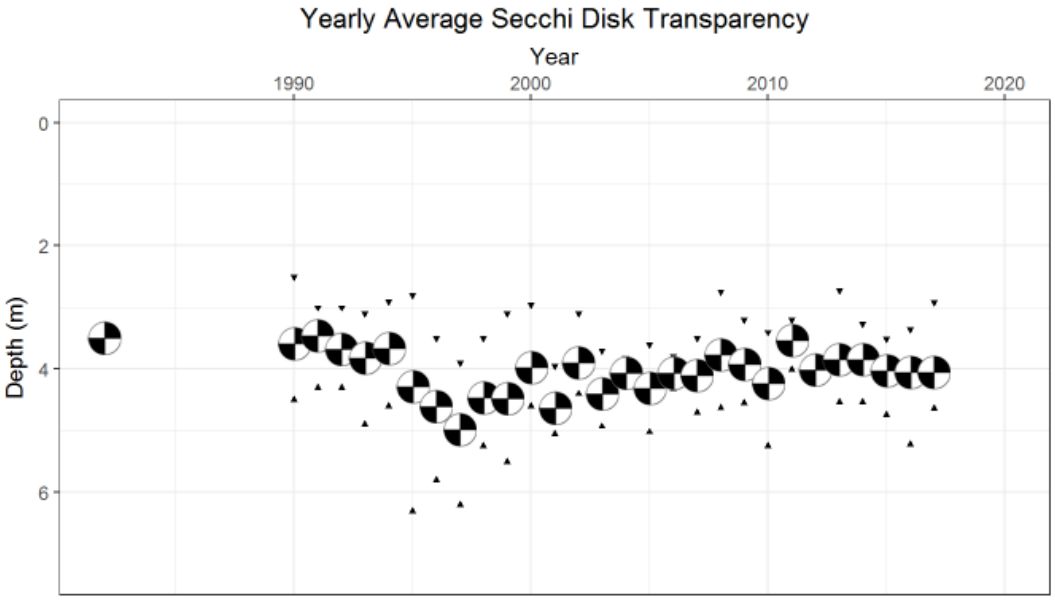
The average of the May through October **water clarity** readings (the distance one can see down into the water) taken in Ellis/Roxbury Pond in 2017 was 4.0 meters (~13 feet), which is also the current historical average for the lake. The clearest reading during the 2017 monitoring season was 4.64 meters, taken on September 25, and the least clear reading of 2.94 meters was taken on June 30. Both readings were taken by Ross Swain. The following graphic (source: Maine DEP & VLMP) illustrates the average Secchi transparency for each month during the May-October period.



The graph below illustrates the variation of water clarity in the lake from 1982 through 2017. The hatched disk represents the average for the year. Small markers above and below the disks represent the lowest and highest readings for each year represented. Note that for some years during the period, annual averages are based on only a few readings (for example, only one reading was taken in 1982, and only two readings were taken on several years). Some of the annual variability is likely influenced by the relatively small number of readings for individual years. For the past several years, certified volunteer lake monitors have submitted full seasons of Secchi transparency data.(Source: Maine DEP/VLMP).

It is interesting to note that while a highest (clearest) reading in 2016 is likely the result of drought conditions, the average for the year does not appear to be. The clearest reading is lower in 2017, and the least clear reading for the year is also lower than in 2016. While many Maine lakes were clearer than their historical average in both 2016 (especially so) and 2017, ostensibly due to the influence of drought conditions, other lakes, such as Ellis/Roxbury responded differently. The average Secchi transparency for this lake has been close to its historical average for the past 6 years.

Graph Legend: Secchi symbols = average Secchi Disk Transparency Values; tick marks = maximum and minimum values for each year.



User perception surveys that have been conducted in Maine, and throughout the U.S., have consistently shown that the characteristic of lakes that is most highly valued by the public is "clear water". Water clarity, also referred to as "Secchi transparency", is the distance that one can see down into a lake from the surface. It is one of several key indicators used to assess the quality of Maine lakes.

Phosphorus is the nutrient in lakes that most directly influences the growth of algae in the water, which in turn influences water clarity. Epilimnetic core total phosphorus samples taken at the sample station located in the deepest point in the lake measured 13 parts per billion (ppb) in July, and 10 ppb in August, averaging 11.5 ppb for the year. The historical average for the pond is 12 ppb. *Annual* average phosphorus concentrations for Ellis Pond have ranged from a high of 14 ppb in 1993, 2000 and 2009, to a low of 9 ppb in 1995, 2014 and 2015. Variation of one or two parts per billion from year to year is well within the range of seasonal and annual natural variability for Maine lakes. The average of 11.5 ppb for this lake is considered moderate.

A phosphorus sample taken near the bottom of the deepest point in the lake on August 16 showed a moderate increase in concentration, compared to the surface sample (17 ppb at 12 meters depth compared to 10 ppb at the surface layer). This sampling process helps determine whether or not the low dissolved oxygen levels in the lake (see below) are causing phosphorus to be released from the bottom sediments-and potentially stimulating the growth of algae. The higher concentrations of phosphorus in the bottom during late summer when dissolved oxygen has been depleted in the deepest area of the lake may indicate that under the right circumstances, this phenomenon does occur in Ellis/Roxbury Pond. This is consistent with historical samples from the lake, which have also suggested that phosphorus recycling from the bottom sediments may take place when oxygen levels are low.

This could be a potential cause for future concern, because lake sediments generally contain a significant reservoir of phosphorus, capable of causing a negative change in water quality under certain circumstances. The recycling of phosphorus from the bottom sediments in Ellis Pond may not be significant at this point in time, largely due to the total sediment area in the pond that is exposed to anoxic conditions during the late summer (a relatively small percentage of the lake bottom is exposed to low-oxygen conditions, due to the overall shallow depth of the lake). However, stress to the lake ecosystem caused by additional phosphorus inputs from development in the watershed has the potential to increase the risk factor for internal phosphorus release. The combined effect of both internal and external phosphorus loading could result in a decline in water quality.

Chlorophyll-a is a pigment that is found in plant cells. Measured in lake water, it is a direct indication of the amount of algae growing in the water. The July and August chlorophyll-a (CHL) samples measured 5.6 and 3.3 ppb respectively, resulting in an average of 4.4 ppb for the summer. The historical average for Ellis is 4.2 ppb. The historical range from 1981 to the present is from a low average of 3.0 in 2014 to a high of 6.3 in 1991. Because each of the readings and samples represent “instantaneous” conditions in the lake, the primary water quality indicators may not always appear to be in phase with each other. A full season of sampling might provide a better understanding of the water quality dynamics of the lake.

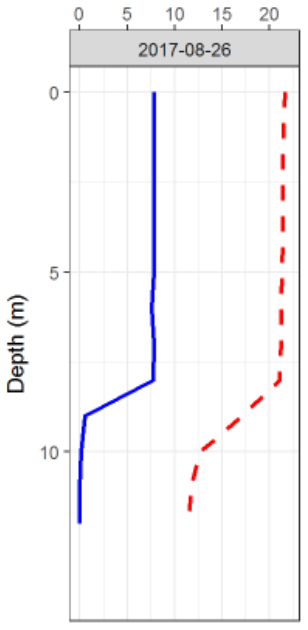
Temperature and dissolved oxygen profiles were taken in July and August by LWRMA staff, and throughout the May-September monitoring period by Ross Swain. As noted above, and documented through the full season of temperature and oxygen data gathered by Ross Swain, thermal stratification in this lake is "ephemeral", meaning that the relatively shallow depth profile for the lake is such that although thermal stratification does take place, it takes relatively little energy from the wind to mix and destratify the water column. This can be a significant risk factor for lakes that also experience the release of phosphorus associated with low DO during the open water period.

Oxygen loss in this lake during the summer months has the potential to overshadow otherwise somewhat stable water quality conditions, if the phenomenon worsens over time. The loss of oxygen is linked to algae growth, which at the present time is low to moderate, based on recent CHL levels. Algae growth is linked to phosphorus levels in the water, which in turn is related to watershed development. The use of watershed conservation practices to minimize soil erosion from private and public roads, and which encourage land owners to maintain vegetated "buffers" to reduce stormwater runoff to the pond from developed areas can be an effective long-term strategy for reducing algae growth and protecting the pond from a future water quality decline.

The onset of thermal stratification was documented by Ross Swain in late May, and early indications of significant dissolved oxygen loss associated with stratification were evident by the end of June. Oxygen loss in the deepest area of the lake continued steadily through July to mid August. Two sets of temperature and oxygen profiles taken on August 16 and 19 illustrated the effect that weather can have on conditions in the lake. In 8/16, the onset of the thermocline (temperature transition area between the surface layer and lower layer) was measured between 7 and 8 meters depth. The dissolved oxygen concentration at 7 meters measured 7.4 ppm, and 1.0 ppm at 8 meters. Only three days later, the temperature dropped sharply between 9 and 10 meters depth. Dissolved oxygen, which had been at 1.0 ppm at 8 meters depth three days earlier, had increased to 7.3 ppm. During the three day period, heavy wind was documented on the 16th and 17th of August. The mixing energy of the wind caused a deepening of the lake surface layer (epilimnion) and a lowering of the thermocline.

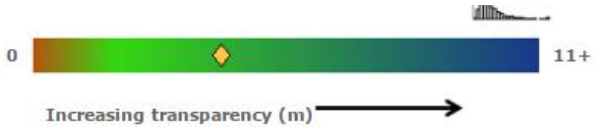
Full, or partial mixing of the water column may result in short, and sometimes extended periods of reduced lake clarity, in part due to the turbulence of the event, and the suspension of material in the water from the bottom sediments. However, it is also possible, in this case, that phosphorus that had been released from the bottom sediments (due to low oxygen in the water) was swept to the surface during mixing. In turn, this could stimulate the growth of algae, resulting in the reduced water clarity. This event is a good example of the potential vulnerability of this lake to a late summer increase in algae growth, due to the recycling of phosphorus from the bottom sediments.

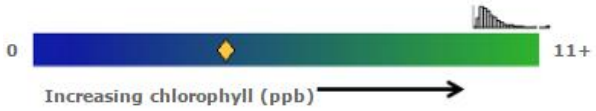
The adjacent graphic illustrates the temperature (red line) and dissolved oxygen (blue line) profiles from the surface of the lake to the bottom at the deep station on August 26,

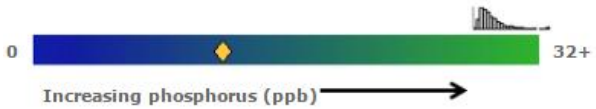


2017. A sharp drop in oxygen occurs at 9 meters depth (virtually zero oxygen), and continues to the bottom of the lake. The change occurs at the onset of the thermocline, which isolates the surface temperature layer from the colder, denser water below.

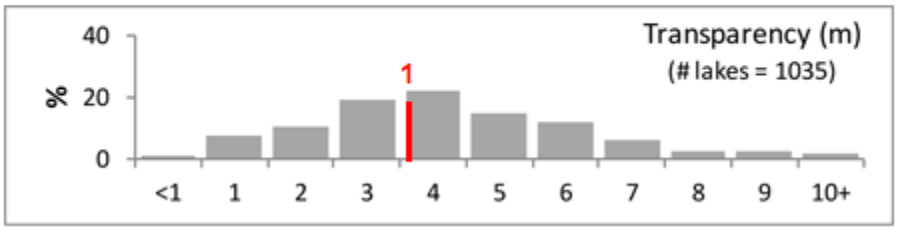
The following graphics, taken from the Maine Volunteer Lake Monitoring Program's www.lakesofmaine.org website, illustrate the position of Roxbury/Ellis Pond for the primary indicators of lake productivity, aka "trophic state". Each bar below represents a range of values for each indicator, with increasing values from left to right. Please note that while an increase in water clarity (transparency) is generally equated with good water quality, an increase in phosphorus and chlorophyll are more likely to be associated with declining water quality. The yellow diamond represents the historical average for Roxbury/Ellis for each indicator.





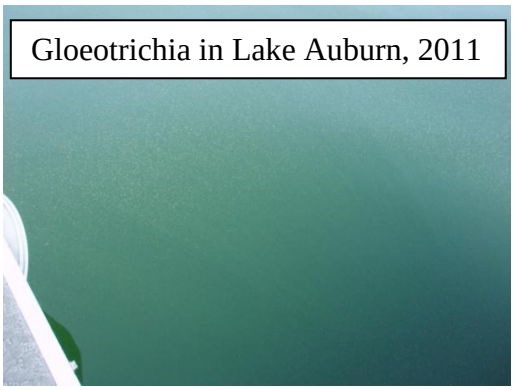


A histogram is a graphic that illustrates the frequency distribution for, in this case, a given indicator of water quality. For example, the histogram below for Ellis Pond shows the position of this lake on the continuum of water clarity/transparency for Maine lakes(1035 lakes). The average transparency for the lake falls within the low end (4.2 meters) of the 4-5 meter range, as shown by the red bar.



Water Color is a natural phenomenon that is caused by dissolved humic acids in the water that leach from wetland and terrestrial vegetation in the lake and watershed. High concentrations of water color impart the appearance of weak tea or coffee to lake water. The organic compounds that influence lake water color can reduce water clarity, increase phosphorus levels, and influence dissolved oxygen as color levels increase. Color (apparent) in Ellis/Roxbury Pond averaged 25 SPU in 2017, compared to the historical average of approximately 30 SPU for the lake. The higher color level in 2017, compared to 2016 was likely the result of greater precipitation.

Gloeotrichia echinulata is a bluegreen algae (aka: cyanobacteria) that has occurred historically in many Maine lakes during late summer, in relatively low densities. However, during the past several years Gloeotrichia (pronounced: glee-o-tricky-ah) concentrations have increased dramatically in some lakes in the state, and based on recent research, it is thought that under certain circumstances, Gloeo has the potential to be a causative factor in the decline of lake water quality in some lakes. We looked for Gloeo colonies in Ellis Pond in both July and August, 2017, and found none. We will continue to carefully screen the lake for this alga during future monitoring visits to the pond.


Gloeotrichia in Lake Auburn, 2011

A sample to measure the **Specific Conductance** (SC) of the water in Ellis/Roxbury Pond was taken in August. SC is a measure of the ability of water to pass an electrical current. In turn, this reflects the concentration of specific ions in the water. As lake watersheds develop over time, many lakes experience an increase in SC. The August sample measured 34 microsiemens per centimeter. The historical average for this indicator is 23 ms/cm. based on samples ranging from 13-29 ms/cm collected during the past 23 years.

Additional water quality indicators monitored in 2017 (pH: 6.87 in August, total alkalinity: 3.5 mg/l in August) were within the average historical range of values for the lake, and generally supported the primary indicators of water quality discussed above.

Metaphyton is a term that is used to collectively refer to a number of species of algae, consisting of long, stringy filaments that form green to yellow "clouds" or "pillows", having the appearance of "green cotton candy". This form of algae is observed primarily in shallow areas of lakes, where the filaments become entangled in the stalks of rooted aquatic plants, sticks, and other debris in the water (see photos). During peak growth periods, gasses that form as a byproduct may cause mats to form on the lake surface. Eventually, the mats decompose and sink, forming brown sludge to form along the bottom of the lake in shallow areas.

In recent years, some residents of Roxbury/Ellis Pond believe they have observed an increase in metaphyton in shallow, protected coves. While not new to Maine lakes, and not an invasive species, many people from lakes throughout Maine have speculated that metaphyton density has been increasing during the past decade. However, because no quantitative studies have been conducted, virtually all of the information on this alga are based on observational reports.

The ecology and life cycle of metaphyton is not entirely understood. There does not appear to be a relationship between the concentration of phosphorus and planktonic algae in lakes and resulting metaphyton abundance. The shortening of the period of ice cover in lakes, which results in early warming of shallow areas, may provide metaphyton with a competitive advantage over the planktonic algae that are abundant throughout the open water areas of lakes.


Metaphyton aka: Filamentous algae

Please note that the Maine Volunteer Lake Monitoring Program has developed a simple methodology that can be used by volunteers from Maine lake communities to document metaphyton growth in their lakes. Information pertaining to this method can be found at : www.mainevlmp.org

The Ellis/Roxbury Pond community, which consists of shoreline property owners, watershed residents and community officials who make decisions regarding development in the watershed must share the responsibility of long term stewardship for this exceptional resource. The Silver Lake Camp Owners Association has taken a leadership role in this undertaking. The results of a watershed survey that was organized and conducted by SLCOA and members of the community in 2013, have been used to successfully leverage grant funding for a watershed mitigation project, the effect of which will be to further reduce external pressures on the health of the lake.

Prepared by Scott Williams
LWRMA Limnologist