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

2015 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 14 and August 21, 2015 by LWRMA Senior Limnologist, Scott Williams. Additional water clarity and temperature and dissolved oxygen data were provided by certified volunteer lake monitor, Ross Swain.

Critical indicators of lake water quality that have been monitored during the past twenty three 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, 2015, and the concentrations of algae and the nutrient phosphorus, and dissolved oxygen in the deepest area of the pond in July and August, Roxbury/Ellis Pond water quality was slightly better than average, relative to historical conditions 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.

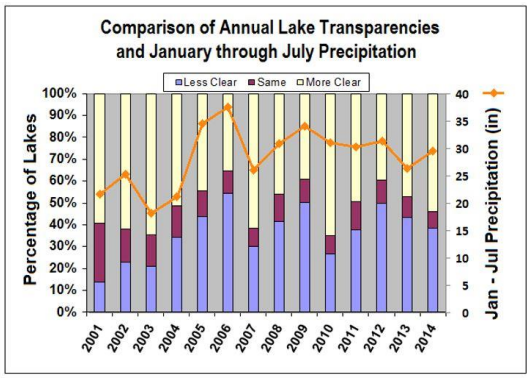
*2015 Weather Influences:

Weather conditions prior to, and during the annual lake monitoring period can strongly influence the indicators used to assess lake water quality, and often account for a significant percentage of the "annual variability" that occurs in lakes. 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.

Temperature, wind, sunlight, and precipitation also influence the biology, chemistry and physical aspects of lakes throughout the year. Understanding how weather-related variability affects lakes from year to year can be daunting. Factors include: 1) duration of ice cover, 2) long and short-term precipitation amounts, 3) storm event intensity, 4) fluctuations of lake water levels, 5) timing of the onset, and duration of thermal stratification, and others.

Lake water clarity (and corresponding Secchi transparency readings) seem to have a significant correlation to precipitation.

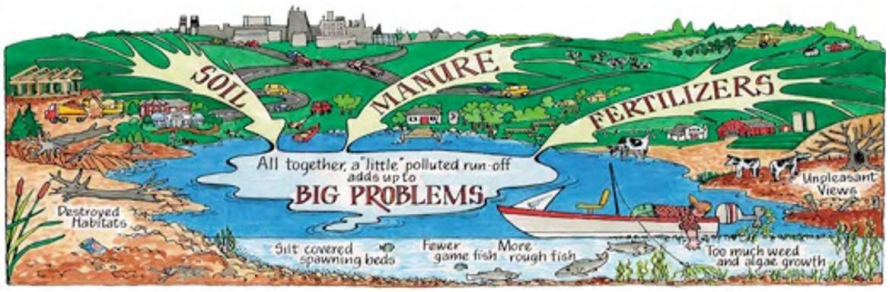
Figure 1 (right) illustrates the relationship between annual precipitation (January through July, Portland, Maine) and the annual average Secchi transparency for monitored Maine lakes over a period of fourteen years. There is an apparent inverse correlation between the two variables; in other words, as annual precipitation increases, Secchi transparency decreases in most, but not all, years. Preliminary statistics indicate that one-third of the variation we see in lake transparency is due to precipitation.



The correlation is significant, but not perfect by any means, due, no doubt to the interaction of many variables that make each lake somewhat unique, including the fact that the precipitation data from the National Weather Service is from one region of the State of Maine (Portland), whereas the Secchi average includes lakes throughout the state. Maine is a large state, and weather can vary considerably from north to south, east to west, and in between. However, a substantial percentage of the lakes represented in the VLMP database are situated in the south/southwesterly area of Maine, relatively close to Portland. A stronger correlation might exist if the graph were to only represent lakes situated within a short distance of where the precipitation was measured.

Given the correlation discussed above—imperfect or no—it is reasonable to assume that, on average, a majority of Maine lakes will be less clear during high-precipitation years, especially if precipitation occurs the winter before and/or during the lake monitoring season. That is because lakes are the natural repository of much of the stormwater runoff that results from precipitation events. As stormwater (including

snowmelt) moves across the landscape, it picks up pollutants that can negatively impact water clarity, such as phosphorus—which stimulates algal growth— and eroded soil particles. (See **Figure 2** below.)



A significant percentage of the annual phosphorus transported to Maine lakes typically occurs during the "spring runoff period", when the winter snowpack is melting, spring showers are taking place, and soils are often either frozen or saturated with water (resulting in greater runoff).

As suggested above, the correlation between precipitation and water clarity is not entirely straight forward. Qualitative factors, such as the timing and intensity of storm events can have a strong bearing on the extent to which precipitation runs off, as opposed to filtering slowly into the ground. Frequent low-intensity rain events cause less soil erosion and phosphorus export to lakes than high intensity storms, in which rain comes too fast to filter through the soil, often resulting in significant erosion and stormwater runoff to lakes. Also, for a relatively small group of lakes that experience internal phosphorus recycling, frequent rain events—by regularly flushing phosphorus-laden water from the lake—may actually have the opposite effect, causing an improvement in Secchi transparency.

2015 Weather Synopsis:

None of us need to be reminded that the winter of 2015 was long, cold and very snowy! However, precipitation in February and March was below normal in Portland, even though snowfall and the standing snowpack was above normal during that period. Very little melting occurred in February, and March was also colder than normal, the net effect of this being that in late winter/early spring, there was still a great deal of snow on the ground throughout much of the state. All of this set the stage for potential flooding and heavy runoff in the spring– not the best scenario for lakes.

Fortunately, April was only slightly warmer than normal, and precipitation—the first rain since December—was less than an inch above normal. As a result, the snowpack continued to melt slowly, with little flooding, and minimal runoff to lakes from their watersheds, as the snow and rain slowly infiltrated into the gradually warming soils.

Although May was unusually warm, precipitation was below normal, and with the exception of one storm that produced just under an inch of rain, much of what fell from the sky in May was likely to have infiltrated into the soil.

June was unusually cool, and although rainfall for the month was above normal, year-to-date precipitation was only .02 inches above normal.

Temperatures moderated in July, but precipitation was substantially below normal, being one of the driest Julys in 145 years! During such conditions, very little, if any, stormwater runoff made it to Maine lakes.

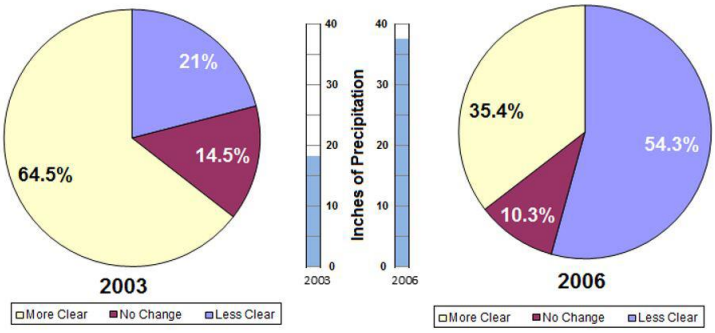
August was warmer than normal, but precipitation for the month remained below average, and conditions on the ground were becoming very dry. Once again, very little stormwater runoff occurred in the area. During the month of August, a number of volunteer lake monitors reported "better than average" Secchi readings for the month.

Warmer-than-average conditions persisted into September, and precipitation for the month was above normal, making it a notably wet month. However, much of the precipitation occurred in a 6 inch rain event on the 29th and 30th of September; too late to have any bearing on summer Secchi readings.

In summary, weather conditions in the Portland, Maine area during the first several months of 2015 would likely have had a favorable influence on lakes in the region, as a result of 1) relatively slow warm-up and snowpack melt in the spring, followed by 2) average, to below average rainfall during the mid and late summer period, likely resulting in relatively little runoff and soil erosion from lake watersheds during the period.

Note: The complete NWS narrative weather summary on which this information is based can be viewed at: http://www.mainevlmp.org/wp-content/uploads/2015/11/NWS-2015-Narrative-Summaries.pdf.

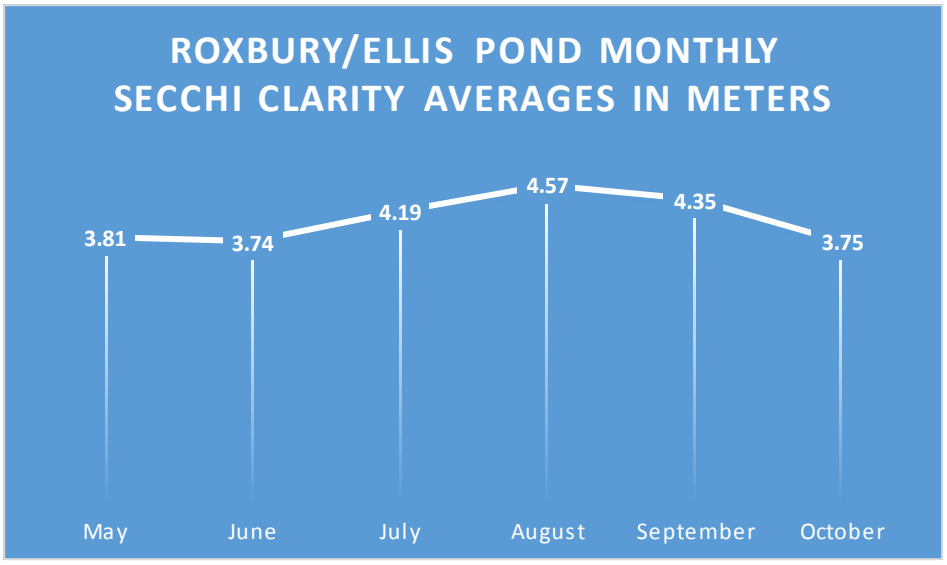
Now for some disclaimers: While the conditions noted above could have an overall beneficial effect for many lakes, weather is just one of a myriad of factors that determine how individual lakes will "behave" during the lake monitoring period. Moreover, Secchi transparency is only one indicator of lake water quality – albeit a pretty good one for gaging the overall health of a lake. For every year when a relatively high percentage of Maine lakes are clearer than they have been historically, many are also less clear, as the two pie charts in **Figure 3** below illustrate (note the differences in precipitation for the two years).



**Note: The weather synopsis above is excerpted from an article authored by Scott Williams in the 2015 edition of The Water Column, the newsletter of the Maine Volunteer Lake Monitoring Program.*

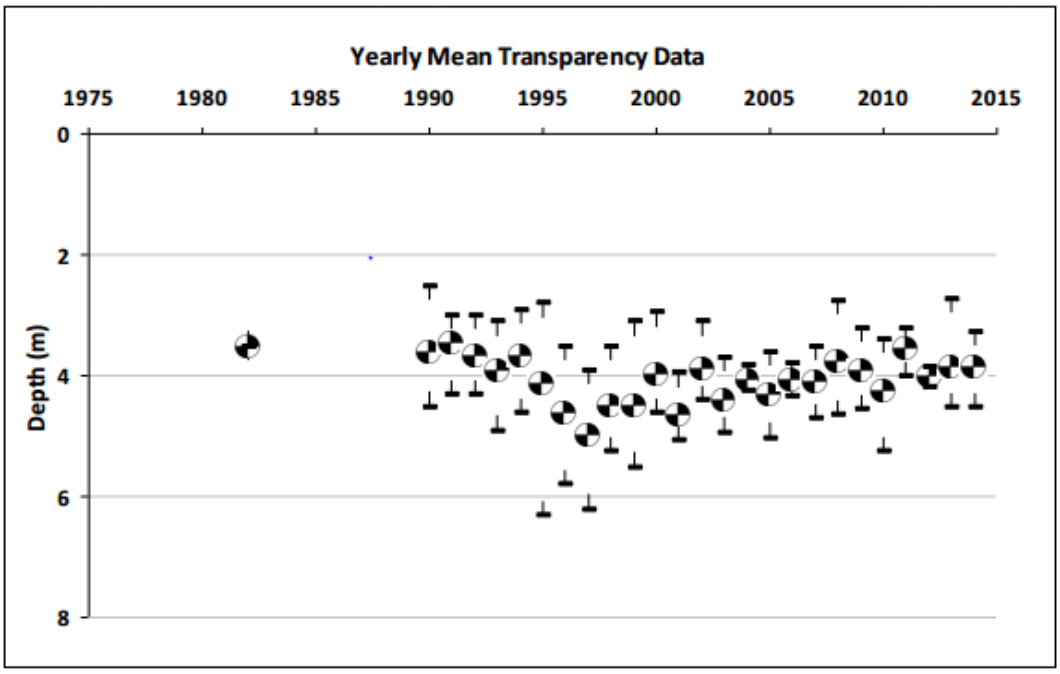
Summary of Findings:

The average of the May through October **water clarity** readings (the distance one can see down into the water) taken in Roxbury Pond in 2015 was 4.0 meters, very close to the historical average for the pond of 4.1 meters (~13 feet)**.** The clearest reading during the 2015 monitoring season was 4.74 meters, taken on August 21, and the least clear reading of 3.52 meters was taken on May 15. The following graphic illustrates the monthly average Secchi transparency (water clarity) for the lake in 2015.



The graph below illustrates the variation of water clarity in the lake from 1982 through 2014. The hatched disk represents the average for the year. Bars 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 (a single reading in 1982. Some of the annual variability is influenced by the relatively small number of readings for individual years. (Source: Maine DEP/VLMP)

Secchi Symbols: Mean Secchi disk transparency values; Tick Marks: maximum and minimum readings for each year.



This graphic illustrates the substantial changes that have occurred in the lake during the past15 years. An apparent improvement in lake clarity from 1990 through about 1997, (during which time a number of unusually high (clear) readings were recorded) reversed and appears to have stabilized at about the historical average for the lake (4.0 meters). It would not be accurate to characterize the decline in transparency since the mid 1990's as a trend, given the limited historical data prior to that time.

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. Total phosphorus samples taken at the sample station located in the deepest point in the lake measured 8 parts per billion (ppb) in July, and 9 ppb in August, averaging 9 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 12 ppb for this lake is considered moderate.

A phosphorus sample taken near the bottom of the deepest point in the lake on August 25 showed a moderate increase in concentration, compared to the surface sample (15 ppb at 11.5 meters depth compared to 8 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.

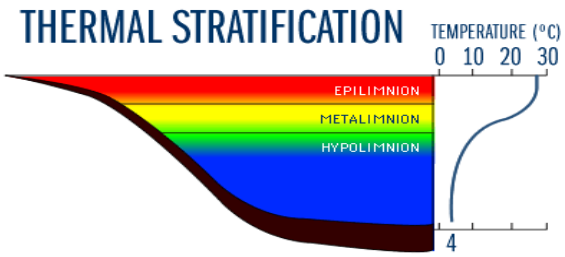
This could be a potential cause for future concern, because lake sediments generally contain a significant reservoir of phosphorus, capable of causing a negative change in water quality under certain circumstances. The recycling of phosphorus from the bottom sediments in Ellis Pond may not be significant 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. 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 5.9 and 6.0 ppb respectively, resulting in an average of 6.0 ppb for the summer. The historical average for Ellis is 4.2 ppb. The 2015 average is one of the highest on record for this lake. 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. The moderately high CHL average in 2015 is not inconsistent with the concentrations of phosphorus and the clarity of the water, but similar conditions in previous years have not been associated with the high concentrations of CHL measured in both July and August, 2015.

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 in Ellis/Roxbury Pond measured 20 SPU in July and 18 SPU August, 2015, compared to the average of 24 SPU for the lake. Color levels below 25 SPU generally have minimal effect on other indicators of water quality.

Temperature and dissolved oxygen profiles were taken in July and August by LWRMA staff, and throughout the May-October monitoring period by Ross Swain. The full season of temperature and dissolved oxygen data show the onset of anoxia in the deepest area of the lake in the mid-July readings. *Thermal stratification and anoxic conditions continued, and the dissolved oxygen loss worsened in all of the profiles through early September.* The October 7 profile indicated that the lake had de-stratified (mixed), restoring oxygen to the water from surface to bottom.

Temperature and dissolved oxygen (DO) profiles taken in July and August at the deepest location in the lake documented anoxic conditions (less than 1.0 ppm DO below 12 meters depth. By mid-August, the water below 8 meters depth to the bottom of the lake (~13 meters was at zero ppm DO. The full season of temperature and DO readings is helpful in analyzing the mixing dynamics of the lake, and it suggests that the oxygen loss was persistent from mid summer to early September.

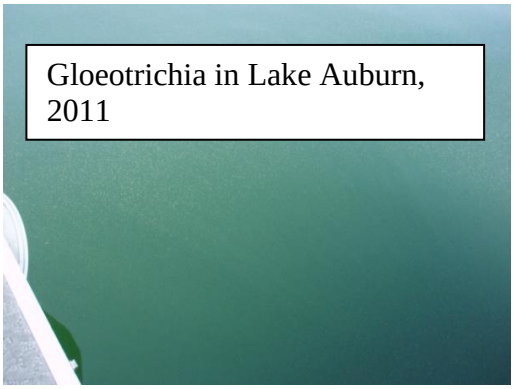


The timing of sampling can have a critical bearing on annual oxygen profile results in Ellis/Roxbury Pond, especially when comparing the results to those of previous years. The loss of oxygen in lakes and ponds during the summer months is a function of a phenomenon known as thermal stratification (see illustration above), in which temperature "layers" form in the water column, with the warmest layer at the surface, and the coldest layer in the deepest area. The coldest water near the bottom of the lake is physically isolated during the summer stratification period. The decomposition of algae and other organic matter in the water results in the loss of oxygen

in the bottom layer. Ellis/Roxbury Pond experiences moderate summer thermal stratification, but the overall bathymetry (shape, and resulting depth profiles) of the lake basin is such that strong winds can break down the stratification, resulting in full, or partial mixing of the water column, and a replenishment of oxygen as the water comes into contact with surface winds and atmospheric oxygen. While ephemeral mixing events may have occurred in the late summer of 2015, the temperature and DO profiles taken during the period suggest otherwise.

Oxygen loss in lake water during the summer has a number of implications, including compromised coldwater fishery habitat and the potential for a degradation of water quality over time. When dissolved oxygen levels in lake water fall below a critical point (approximately two parts per million) phosphorus that is stored in the lake sediments may be released into the overlying water, with the potential to dramatically stimulate the growth of algae.

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.



Gloeotrichia in Lake Auburn, 2011

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, 2015, and found none. We will continue to carefully screen the lake for this alga during future monitoring visits to the pond.

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 20 microsiemens per centimeter. The historical average for this indicator is also

20 ms/cm. based on samples ranging from 13-29 ms/cm collected during the past 23 years.

Additional water quality indicators monitored in 2015 (pH, total alkalinity) 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.

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 clearly taken a leadership role in this undertaking, as the primary advocate for the protection of the lake. 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