Integrated Monitoring Report
2017 Season

Mazinaw and Fall River Subwatersheds

Mississippi Valley Conservation Authority
50 YEARS OF CONSERVATION • 1968/2018

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Executive Summary

The purpose of this integrated monitoring report is to present a snapshot of the monitoring that MVCA undertook during the 2017 season. It is an alternative to the individualized lake reports previously created for the Watershed Watch (WW) program. As such, the emphasis of the report is on lake monitoring but also includes water levels and flow, snow pack, and fish data. Each subwatershed within the Mississippi Valley will be on a five year rotation for this more in depth analysis, with the Mazinaw and Fall River watersheds being in focus for 2017. This strategy will provide readers with a more holistic understanding of the watershed. In addition to the focus on Mazinaw and Fall River, two lakes along the main stem of the Mississippi River and one other auxiliary lake were also sampled.

The most significant factor affecting the lakes and streams in the summer of 2017 was, in contrast to 2016, extremely wet conditions. Water levels and flows were at severe highs for much of the beginning of the summer, from a number of flood events in the spring. This affected the lakes particularly during the July sample, with overall higher than average total phosphorus (TP) results at this time. In fact, three exceedances of the Provincial Water Quality Objective of 20 µg/L for TP occurred on our lakes during the July sample. This effect is not uncommon during flood years, as higher water levels and more rain events bring in excess nutrients from the surrounding landscape.

Aside from the atypical values in July, the lakes in the Mazinaw and Fall River subwatersheds overall maintained their previous trophic statuses, as well as historic trends in secchi depth, pH, and dissolved oxygen. Kishkebus, Shabomeka, and Mazinaw Lake all maintained summer thermal stratification and sufficient temperature and dissolved oxygen levels to support native cold water fish species.

Through our stream monitoring, 22 baseline sites and 5 supporting sites were surveyed in 2017 for fish and benthic communities. Seven of these sites were found to support cold water species. Two of these sites were previously unknown to MVCA to support such species (Mosquito and Donnelly Creek)! These two sites will continue to be monitored to determine if they maintain a stable population of these species. One site (Easton’s Creek), where the cold water species *Burbot* was found in 2016, did not present any Burbot when sampled in 2017. This may simply be due to catch variation but the site will continue to be monitored to determine if a change in community composition is occurring.

Bennett Lake

This report emphasizes the value of the monitoring conducted through MVCA’s Water Management, Watershed Watch, and Stream Monitoring programs. It also highlights some gaps in these programs. While we have tried to address a few of these deficiencies with revisions to monitoring protocols, lack of baseline stream data still remains an issue. Focusing on filling these sampling gaps will allow the MVCA to provide a better understanding of ecological trends to stakeholders, which will assist in future decision-making.

Introduction

The Watershed Watch (WW) program was initiated at the Mississippi Valley Conservation Authority (MVCA) in 1998 in partnership with the Mississippi Valley Lake Stewardship Network, with the goal to accumulate reliable environmental data on the plentiful and diverse lakes within the watershed. Despite various adjustments to the protocol throughout the years, the program has remained a fundamental part of MVCA's monitoring schedule and continues to provide valuable baseline data while promoting stewardship of these important features.

Accompanying the lake monitoring, MVCA's stream monitoring program collects valuable information on the temperature and fish and benthic communities of the watershed's many tributaries. It follows Ontario Stream Assessment Protocol (OSAP) methods to conduct stream Site Identifications, Electrofishing, and Benthic Surveys at various sites throughout the year. While these sites have historically been chosen on a year by year basis, in 2016 MVCA began collecting data at representative baseline sites within each subwatershed. Moving forward, two sites in each of the 11 subwatersheds will be visited *every* year along with a few extras in the targeted subwatershed systems for that year. This will allow for quicker accumulation of comparable baseline data that can be used to track trends in water quality. In 2017, this equated to 22 baseline sites and 5 accompanying sites in the Mazinaw and Fall River subwatersheds, for a total of 27 sites monitored.

The goal of MVCA's fish data collection is largely to determine the presence or absence of cold or cool water species. These species can be great indicators of the thermal regime of a stream as they require very specific conditions and changes in their abundance may indicate habitat trends. Benthic data collection is used as a means to determine water quality. Different classes of benthos vary widely in their tolerance of environmental stressors (eg. dissolved oxygen levels), so an analysis of community composition can be very telling of the health of a particular stream. Benthic samples are collected in the fall and processed throughout the winter and spring. As such, results for 2017 will not be ready for this report.

As previously mentioned, the main goal of the Watershed Watch program is to collect reliable environmental data and monitor trends on the lakes of the Mississippi Valley watershed. However, it is worth noting that while we would ideally have the resources to conduct extensive research on every lake each year, the reality is that this program is designed solely to collect *baseline* data and to monitor *general* trends. We are collecting relatively simple data on parameters that are easy to repeat and that give a broad idea of changes in water quality. While the data can be used in conjunction with other data, it is insufficient on its own for any environmental impact studies that may need to be conducted on a lake due to development projects etc. If lake stewards are interested in more detailed yearly assessments of their lake, they could consider the Lake Partner Program (LPP) through the Dorset Environmental Science Centre. With willing volunteers this program provides an excellent framework, as well as equipment, for reliable and detailed yearly data collection. It is also an excellent means to promote awareness and ownership of lake health.

Seasonal Conditions – *Water Quantity*

Three types of water quantity monitoring occurred in the Mazinaw and Fall River subwatersheds in 2017; snow pack, water levels, and water flow. Figure 1 and 2 portray the locations of the gauges used to collect level and flow data, the snow courses where snow pack is measured, and the locations of the Watershed Watch sites in both the Mazinaw and Fall River subwatersheds.

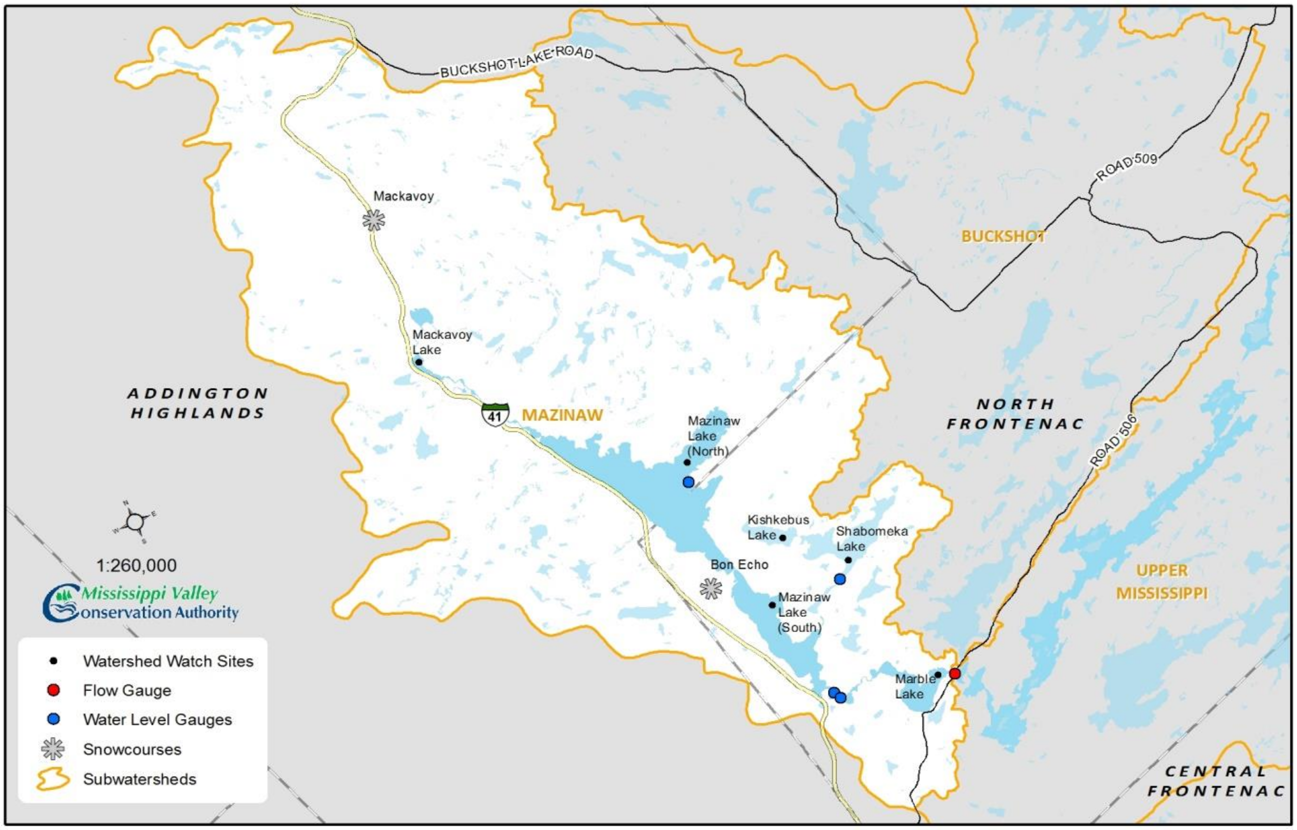


Figure 1. Various water quantity measuring sites in the Mazinaw subwatershed, plus Watershed Watch sites.

Mackavoy Lake

Mazinaw Lake

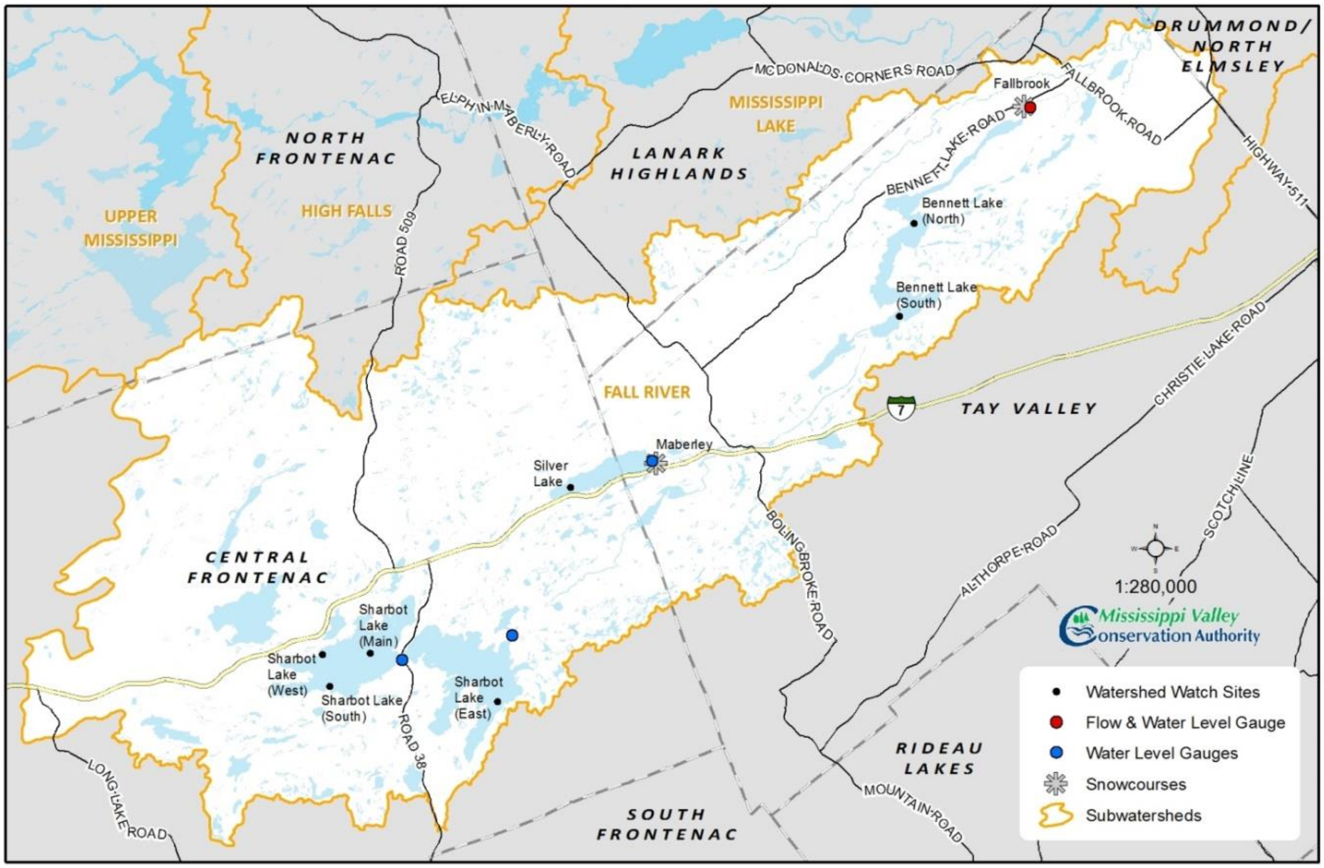
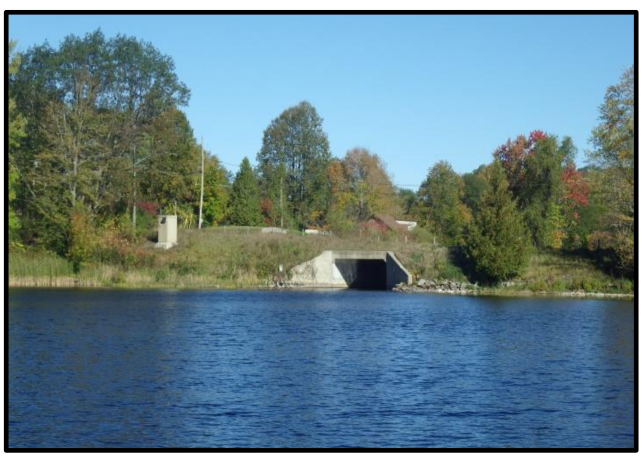


Figure 2. Various water quantity measuring sites in the Fall River subwatershed, plus Watershed Watch sites.



Sharbot Lake

Dragonfly near Silver Lake

Snow Pack

Snow pack is measured at various spots within the watershed and provides information on the expected spring runoff for that year. This helps inform MVCA on potential runoff that assists in dam operations and flood forecasting for the entire watershed. Water management is critical in order to minimize flood damage, maintain flows and levels for fish and wildlife, and meet the target levels for summer recreational activities. Two snow courses are maintained in the Mazinaw subwatershed to determine spring runoff; Mackavoy and Bon Echo, and two in the Fall River subwatershed; Maberley and Fallbrook. The results for 2017 can be seen in Figure 3 and 4.

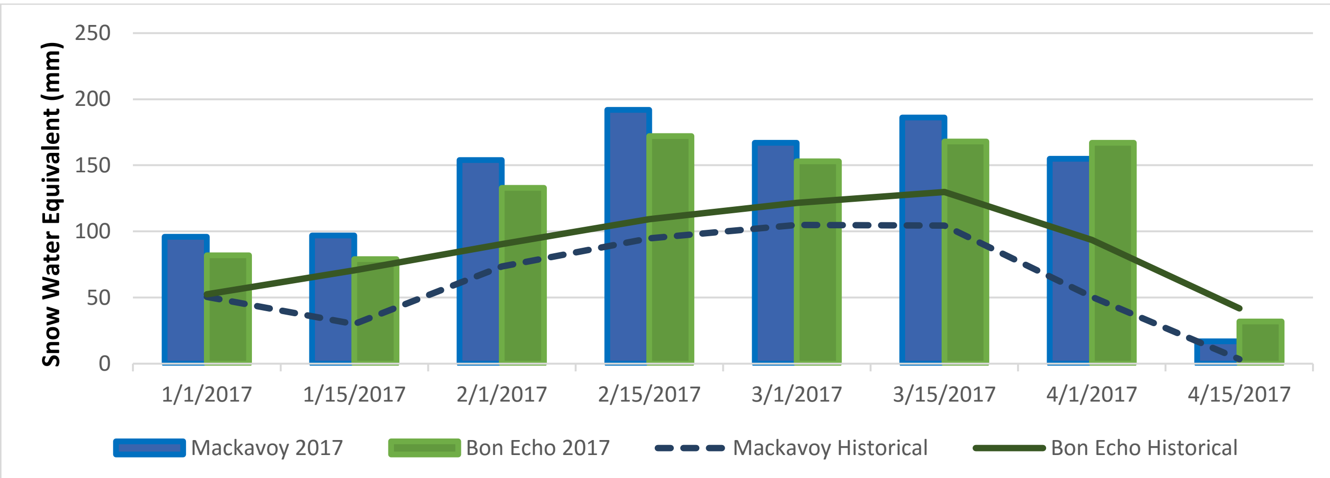


Figure 3: 2017 Mazinaw subwatershed snow pack levels vs. historical averages

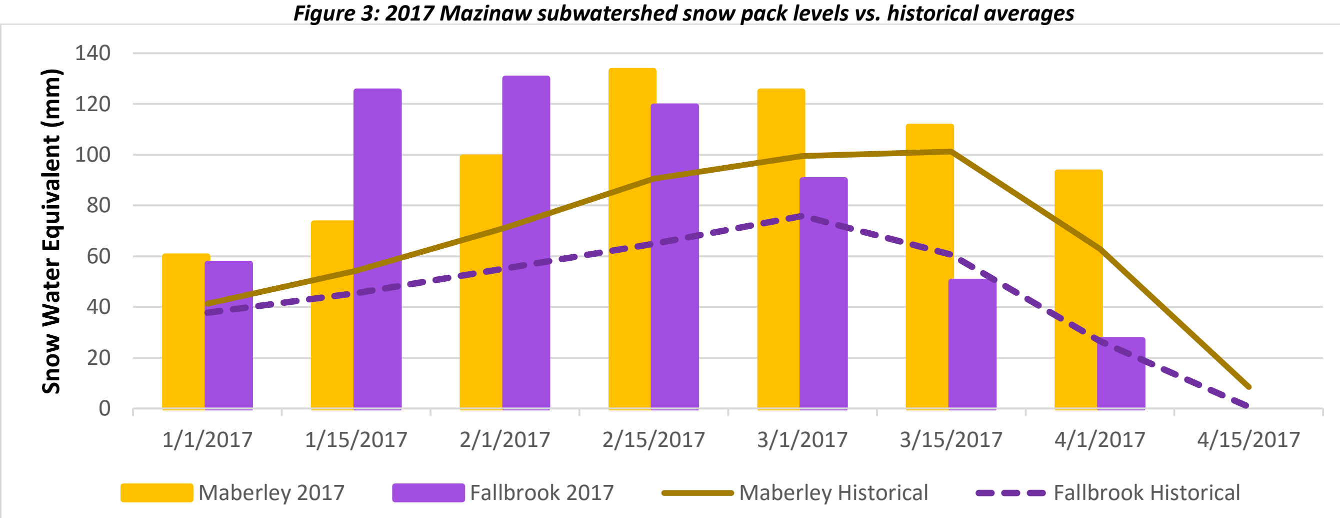


Figure 4. Fall River subwatershed snow pack levels vs. historical averages.

It is evident that from January through to the beginning of March, the watershed was above average in snow water content. Warm weather and precipitation received at the end of February and the first week of March resulted in a significant amount of runoff due to melting snow pack. This caused flows and levels to increase throughout the watershed, causing some minor flooding. Although the March thaw did deplete a portion of the water content in the snow, it was still above average going into the spring freshet in early April.

Water Levels and Precipitation

Water levels are most often measured at gauges at the MVCA owned and/or operated dams around the watershed. Precipitation gauges are normally located with streamflow sites on tributaries and the main stem of the Mississippi River. In the Mazinaw subwatershed, two water level gauges are located at the outlet of Shabomeka Lake and Mazinaw Lake. In the Fall River, they are located at the outlet of Sharbot Lake and Bennett Lake.

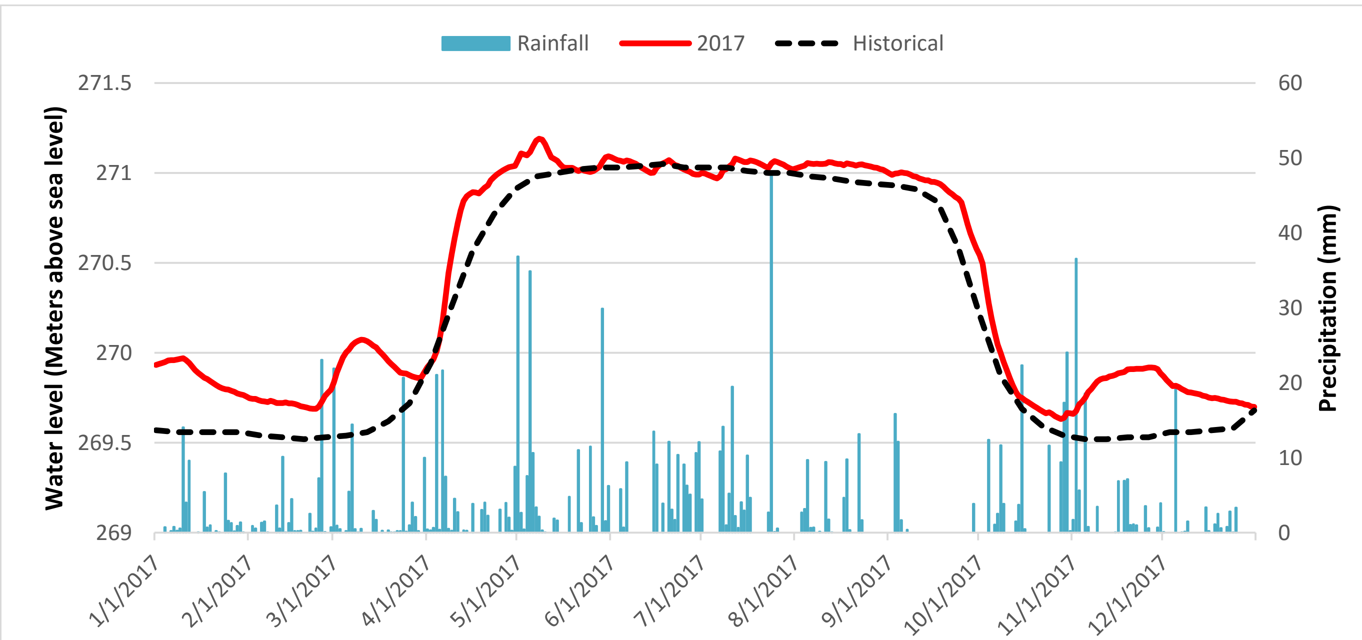


Figure 5. Water levels (2017 and historical) and precipitation at Shabomeka Lake.

MVCA operates 19 dams throughout the watershed. Shabomeka Lake is the first in the system, as it feeds into Mazinaw Lake. Because of its headwater position, the maintenance of this dam is critical to maintaining levels throughout the watershed. Due to the extremely wet conditions in 2017, levels on the lake stayed at or well above the historical normal throughout the entire year.

Shabomeka Lake Dam

Shabomeka Lake Staff Gauge

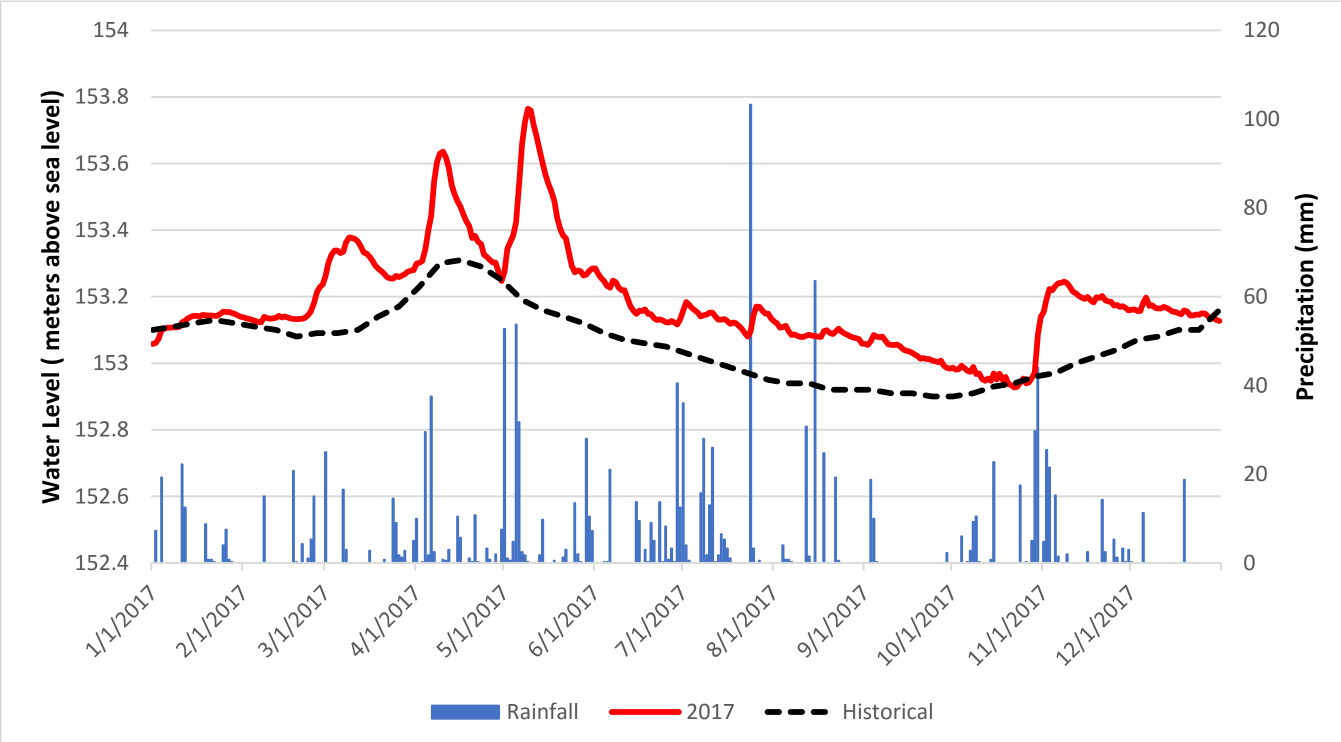


Figure 6. Water levels (2017 and historical) and precipitation at the Bennett Lake Dam.

Three peaks are visible in the Bennett Lake water level graph. The first is a March melt, the second is the spring freshet, and the third is a significant multi-day rain event in May. We can also see smaller peaks throughout the year that correspond with shorter rain events. Similar to Shabomeka, the above average rainfall continuing into the summer months caused levels on Bennett Lake to remain well above normal for the entire year.

Bennett Lake Dam

Bennett Dam Gauge

Flow

There is one stream flow gauge in the Mazinaw subwatershed at Myers Cave (just downstream of Marble Lake) and one in the Fall River subwatershed at the outlet of Bennett Lake. The data collected by these gauges is another piece of the puzzle used to assist with water management decisions. Flows for these two gauges can be seen below.

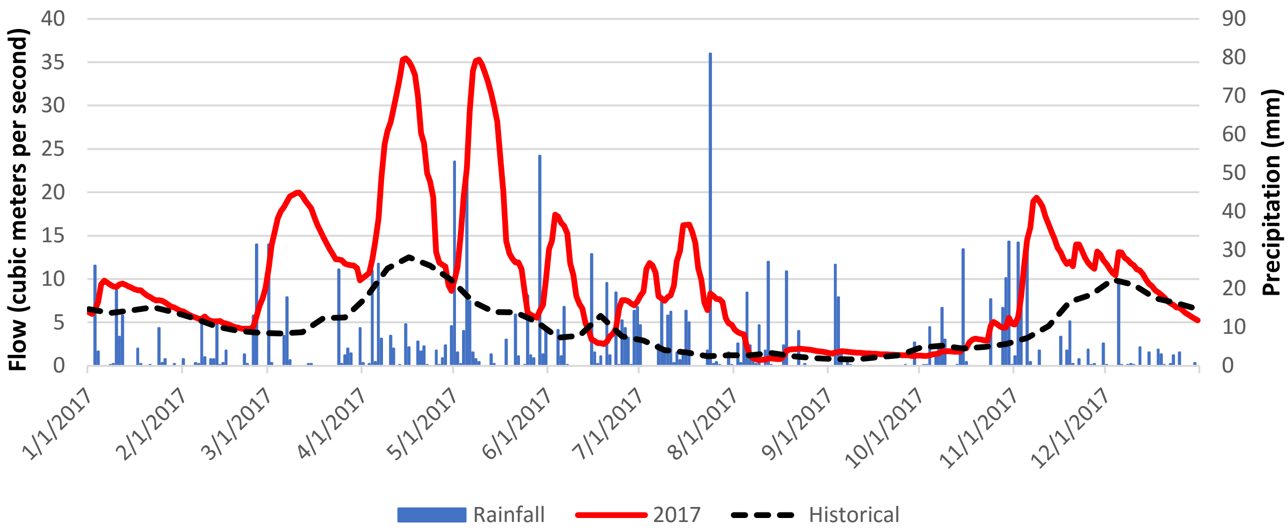


Figure 7. Water flows and precipitation at Myers Cave.

The large number of rain events is quite visible when looking at the above average flows at Myers Cave. Also to be noted is the significant response in flow following each precipitation event. This is in direct contrast to the drought conditions of 2016, where due to the extremely low soil moisture content, rain that did fall was largely absorbed by the soil rather than flowing into the streams. In 2017, soil moisture content was high so rain events quickly increased flow. Similar results can be seen in the Fall River subwatershed, in Figure 8 below.

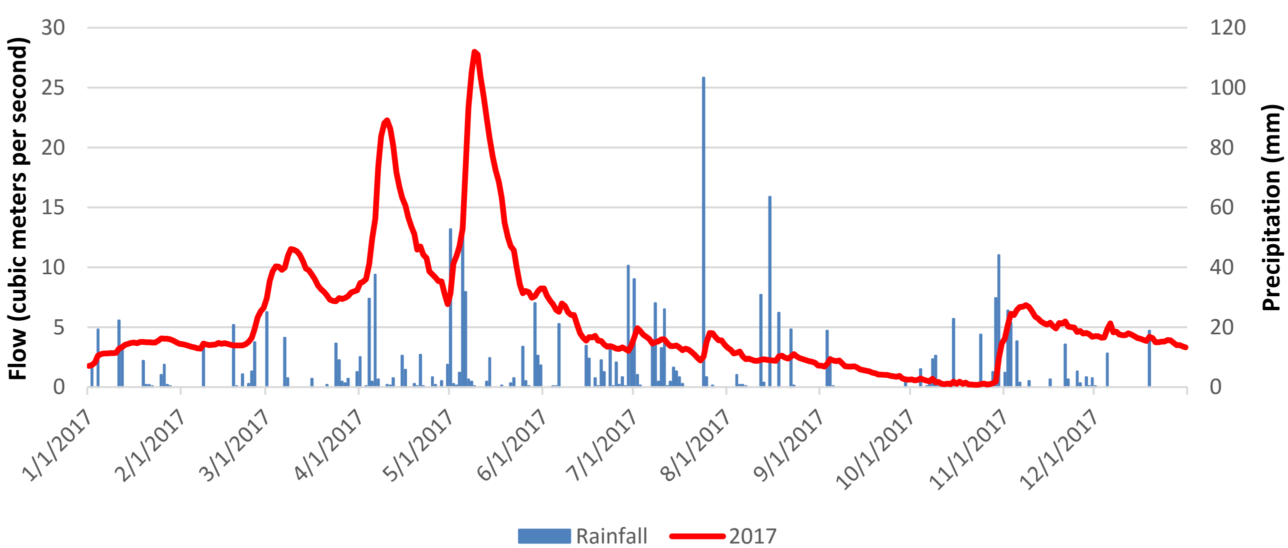


Figure 8. Water flows and precipitation at Bennett Lake Dam.

Indicators and Methodology

The Watershed Watch program tests for numerous water quality parameters. These parameters are selected for their relative simplicity of collection, reproducibility, and ability to contribute to trophic status determination.

Total Phosphorus (TP)

Phosphorus is an essential nutrient for all living organisms as it plays a role in numerous aspects of biological metabolism. It is also the limiting nutrient in biological activity and therefore when phosphorus levels get too high we tend to see adverse effects such as algae blooms. Phosphorus can be found naturally in the environment, as well as in many man-made products such as soaps, detergents, fertilizers and septic waste. Total phosphorus is measured in micrograms per litre (µg/L).

As part of the Watershed Watch program, two types of total phosphorus levels are measured at each sampling location: euphotic zone phosphorus and bottom phosphorus. The euphotic zone is defined as twice the Secchi depth and is the depth to which light can reach and influence plant growth.

Kemmerer Sampler

The bottom phosphorus sample is collected at approximately 1 meter off the bottom of the lake, at sites that have a depth greater than the euphotic zone, using a device called a Kemmerer Bottle. The bottle is sent down to the appropriate depth with both ends open, then a weight on the rope is dropped, causing both ends to close and sealing the sample water in the bottle; providing a discrete volume of water from the appropriate depth.

Total phosphorus levels provide an accepted standard to characterize a lake's trophic status following the general guidelines seen in Table 1 below. It should be noted that while these numbers provide an idea of a lake's trophic status, lakes naturally progress over time from oligotrophic to eutrophic, so an 'ideal' trophic status does not exist. Furthermore, natural variation can cause a great deal of change from year to year and within years, so it is important to look at larger trends rather than one or two exceptional years.

Table 1: Interpreting Total Phosphorus Results

Total Phosphorus Level	Lake Trophic Status
0 – 10 µg/L	Oligotrophic – unenriched, few nutrients
10 – 20 µg/L	Mesotrophic – moderately enriched, some nutrients
>20 µg/L	Eutrophic – enriched, higher levels of nutrients

The Provincial Water Quality Objective (PWQO) for phosphorus in lakes is 20 µg/L (*Water Management, Policies and Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy. MOE. 1994*). The goal is to maintain phosphorus below this level to help ensure aquatic health and maintain the recreational value of our lakes.

Secchi Depth

Secchi depth is a measure of water clarity and is collected using a Secchi disc. The Secchi disc is a black and white disc that is lowered into the water on the shady side of the boat. The greater your Secchi depth, the clearer your lake is. As previously mentioned, the Secchi depth also helps determine the euphotic zone (the depth of water through which light is able to penetrate). Secchi depth can be influenced by the concentration of algae in the water. Usually, a decrease in Secchi depth occurs in unison with an increase in phosphorus. The following guideline shown in Table 2 is used to determine your lake's nutrient status according to Secchi depth.

A Secchi disc

Table 2: Interpreting Secchi Disc Results

Secchi Depth	Lake Nutrient Status
> 5 meters	Oligotrophic – unenriched, few nutrients
3.0 – 4.9 meters	Mesotrophic – moderately enriched, some nutrients
< 3.0 meters	Eutrophic – enriched, higher levels of nutrients

pH

The pH scale is a logarithmic measure of the concentration of hydrogen ions in solution. It is a measure of the acidity of a solution and ranges from 0 to 14. A pH of 7 is considered neutral, while values above 7 are basic, and values below 7 are acidic. The logarithmic scale means that a change from pH 7 to pH 8 is a ten-fold decrease in the concentration of hydrogen ions in solution.

The acidity of a water body affects all chemical reactions within the water. Even small changes in pH can have a large influence on the solubility of some nutrients, including phosphorus, which in turn can influence plant growth. The PWQO for pH in lakes is 6.5 – 8.5, which ensures optimal conditions for most aquatic species.

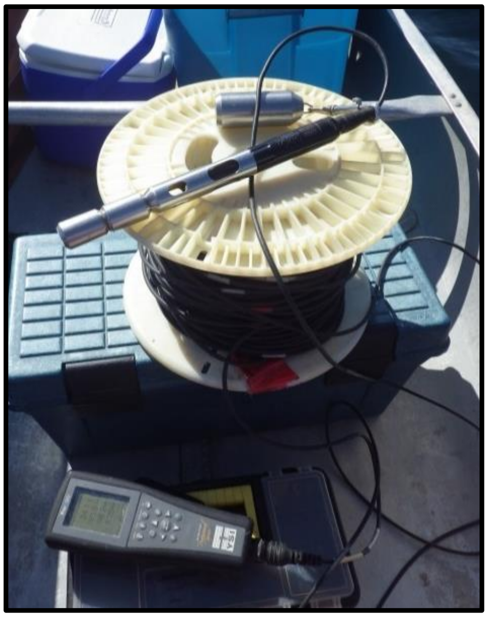
Calcium

Calcium in lakes is a measure of the levels of Ca^{2+}, Mg^{2+} and HCO_3^- ions in the water. Higher levels of these ions classify the water as 'hard' water, and lower levels 'soft' water. This can be measured various ways but is usually done either as the concentration of free calcium ions (Ca^{2+}) (mg/L) or, because most hard water ions stem from calcium carbonate, as calcium hardness as $CaCO_3$ (mg/L). For this program, we measure Calcium Hardness (in mg/L as $CaCO_3$) in the field then the result is multiplied by 0.4 to determine the concentration of Ca^{2+} freely available in the water. Ca^{2+} in freshwater usually falls within the range of 4 to 100 mg/L.

Calcium enters a lake largely through the mineral weathering of rocks (especially marbles and limestones). It is then either used by aquatic organisms for bones or shells or as a component in the cell walls of aquatic plants, and eventually deposits into the sediment of the lake. Because of its importance in shell/body coverings, calcium has been shown to influence zooplankton (small planktonic invertebrates) communities, which are an important food source for many baitfish species. Higher calcium levels also allow Zebra Mussels to thrive.

Dissolved Oxygen (D.O.)

Adequate dissolved oxygen levels are critical for good water quality and are essential to all aquatic life, including fish, invertebrates and bacteria. Many factors can influence dissolved oxygen concentrations in a lake but two key factors are lake stratification (water temperature) and the amount of phytoplankton (microscopic algae) biomass produced in the lake.



Pro ODO (Optical Dissolved Oxygen Probe).

Lake stratification is the separation of the lake into three layers: the epilimnion (top layer), metalimnion (middle layer) and the hypolimnion (bottom layer). Stratification is caused by changes in water temperature with depth, and occurs from late spring to early fall.

D.O. is at its lowest during the late summer and early fall as water in the hypolimnion cannot recharge its oxygen concentrations since it is isolated from the atmosphere by the epilimnion and thermocline. Also during the fall the phytoplankton that are active during the summer months begin to die and settle to the bottom of the lake. The bacteria that then decompose this phytoplankton consume large amounts of oxygen, further depleting stores in the hypolimnion. The low levels of D.O. in the bottoms depth of a lake decrease the amount of critical habitat for cool water fish species to thrive.

Dissolved Oxygen is measured using an Optical Dissolved Oxygen Probe. This instrument, pictured above, is lowered through the water at one meter increments, where it takes both temperature and D.O. readings. This creates a dissolved oxygen profile where we can see the changes in temperature and D.O. as the depth increases. Table 3 shows the optimal temperature/D.O. combinations for cold, cool, and warm water fish habitat.

Table 3: Optimal Conditions for Different Fish Habitat			
	Dissolved Oxygen		Temperature
Cold Optimal	>6 mg/L	AND	<10 °C
Cool Optimal	>4 mg/L	AND	<15.5 °C
Warm Optimal	>4 mg/L	AND	<25 °C

Source: Coker, G.A., Portt, C.B., & Minns, C.K.(2001). Morphological and Ecological Characteristics of Canadian Freshwater Fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2554.

2017 Sampling – *Water Quality*

In 2017, sampling focus was on the Mazinaw subwatershed, at the far northwest end of the watershed, and the Fall River subwatershed in the south. Figure 9 below marks the lake and stream sites where sampling occurred.

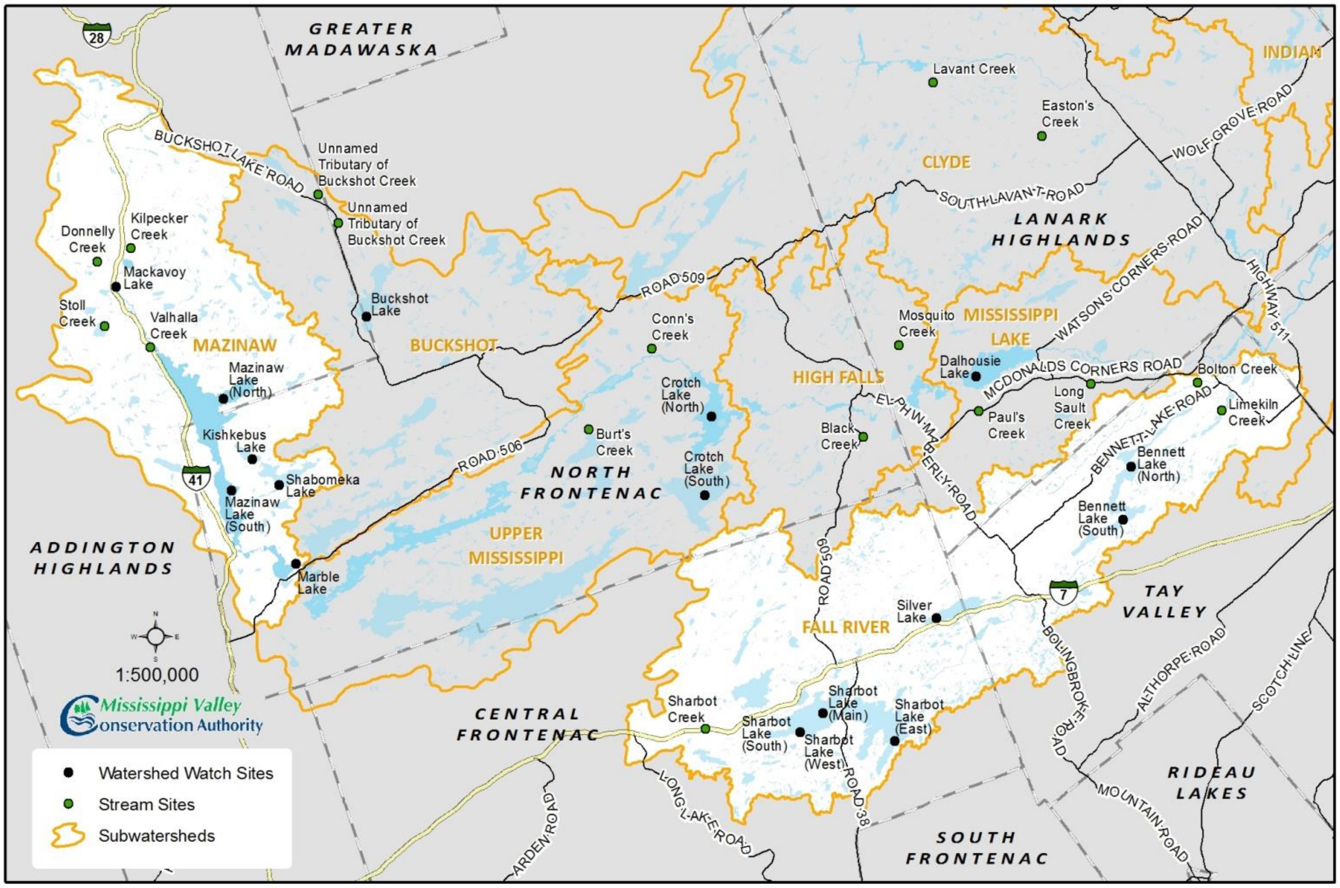


Figure 9. Watershed Watch and Stream Site locations for the 2017 sampling.

In total, two lakes were sampled along the main Mississippi line, five were sampled in the Mazinaw subwatershed, three in the Fall River system, and one auxiliary lake for a total of eleven lakes sampled in 2017. Table 4 lists the lakes sampled along with their subwatershed. The main Mississippi River lakes were Crotch Lake, an important reservoir lake; and Dalhousie Lake, a lake about halfway along the River.

Table 4: Lakes Sampled in 2017			
Mississippi Main Stem	**Mazinaw Subwatershed**	**Fall River Subwatershed**	**Auxiliary Lakes**
Dalhousie Lake (*High Falls*)	Mazinaw Lake	Silver Lake	Buckshot Lake (*Buckshot*)
Crotch Lake (*Upper Mississippi*)	Mackavoy Lake	Sharbot Lake	
	Kishkebus Lake	Bennett Lake	
	Shabomeka Lake		
	Marble Lake		

Lake Planning Activity

MVCA has a mandated role to address natural hazard issues such as flooding and erosion in the review of planning applications under the Planning Act. In addition, in an advisory role, we review applications within the context of natural heritage values such as wetlands, wildlife habitat and fish habitat; and water quality and quantity. We also administer Ontario Regulation 153/06. The purpose of this regulation is to prevent loss of life and property due to flooding and erosion, and to conserve and enhance natural resources. In MVCA regulated areas, permission is required from MVCA for development, interference with wetlands, and alterations to shorelines and watercourses.

On average MVCA reviews 30 planning applications and 55 permit applications on Watershed Watch lakes per year. Approximately half of these applications occur on Mississippi Lake.

Having reliable information about the health of a lake is essential for providing appropriate and effective recommendations on development applications. By collecting environmental data and documenting water quality conditions, the Watershed Watch program provides this information. It also serves to encourage and assist shoreline residents, both seasonal and permanent, to become personal stewards of their lake by taking an active role in restoring and enhancing their shoreline. Stewardship projects that aid water quality include temporarily storing water (eg. rain barrels), directing runoff away from the lake (eg. installing properly working eaves troughs), infiltrating more water (eg. rain gardens), and planting trees and shrubs along the shoreline.

Tree Planting Program

Shoreline tree planting is an effective way to protect water quality as trees and shrubs serve to combat erosion, clean the water, and create healthy habitat for fish, birds, and wildlife. To help with this, MVCA provides a free shoreline planting service to various lakes around the watershed. On a rotational basis, residents around the Watershed Watch lakes are offered up to 15 shoreline friendly trees or shrubs per property. In 2017, MVCA handed out over 680 plants to property owners on Mazinaw, Sharbot, Malcolm/Ardoch, Dalhousie and Canonto Lakes. Kashwakamak and Big Gull Lake will be targeted in 2018.

Lake Capacity Assessment

Lakeshore capacity assessment is a planning tool that is used to predict how much development can take place along the shoreline of a lake without impairing water quality. Factors that affect a lake's development capacity include density of shoreline development, amount of available developable land, recurring water quality problems, etc. Coldwater lakes are particularly sensitive to overcrowding as coldwater fish species require very specific temperature and oxygen conditions to survive. Six of the lakes sampled by MVCA in 2017 were coldwater lakes. Their lake management statuses are listed in Table 5.

Table 5: Lake Capacity of Coldwater 2017 Lakes

At Capacity	Not at Capacity
Buckshot Lake	Mazinaw Lake (Upper and Lower)
Kishkebus Lake	
Shabomeka Lake	
Sharbot Lake (West Basin)	
Silver Lake	

Results

Lakes

Overall, the lakes sampled in 2017 maintained historic trends for total phosphorus levels, secchi depth, and pH. The main result of interest this year was significantly higher values for euphotic zone total phosphorus during the July sample. We observed this in almost all lakes sampled, with the following lakes having exceedances of the Provincial Water Quality Objective for TP (20µg/L):

- Kishkebus (July: 21µg/L)
- Shabomeka (July: 22µg/L)
- Bennett South Basin (July: 29µg/L)
- Bennett North Basin (May: 34µg/L)
- Sharbot SouthWest Basin (Sep: 51µg/L)

We believe these results were caused by the precipitation events and flood conditions present throughout the watershed in June and July. These two months saw 149 mm and 245 mm of rain, respectively. Heavy precipitation events cause higher TP values in lakes and rivers because runoff accumulates nutrients. Once the water has time to move through the system, levels generally returned to normal. This occurred for all lakes, as values decreased to typical levels by September after a couple of drier months (August: 113 mm, September: 54 mm) (*Historical Climate Data Online, Environment and Climate Change Canada*). One exception occurred in the South West Basin of Sharbot Lake where TP increased dramatically in September to 51 µg/L. The cause of this increase is unknown but will be monitored to detect any trends.

For several years, Dalhousie Lake has produced exceptionally high results for the bottom sample Total Phosphorus, especially during the fall season. This past year was no exception with values of 279 µg/L and 266 µg/L for July and September, respectively. Often when there are high values like this we consider the possibility of sampling error, as lake sediment has extremely high levels of phosphorus, and even small amounts in the sample will cause a large spike in the result. This error can happen on occasion but the frequency with which these results occur on Dalhousie Lake suggests that there are other factors involved. In this case it is possible that the sediment layer of Dalhousie Lake is highly suspended (with lots of free floating sediment a meter or more above lake bottom), so even samples that are taken well above the bottom contain traces of sediment. This effect may be greater in the fall as lake turnover would serve to further disturb the sediment layer.

Finally, water clarity decreased on average for most lakes in 2017. In correspondence with the higher July TP levels, most lakes had lower July Secchi depth levels. This is a common interaction because increased phosphorus is often caused by increased organic matter in the water which tends to decrease the clarity. Similar to TP, Secchi depth readings returned to historical normals in September.

Main Mississippi Line Lakes

Crotch Lake

North Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/16/2017	11:30:00	3.1	23	21	8	16
07/04/2017	11:57:00	3.1	9	14	n/a	n/a
08/30/2017	12:10:00	2.75	11	10	n/a	n/a

South Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/16/2017	10:45:00	2.5	25	7	9	16
07/04/2017	10:45:00	3.5	29	14	8.4	n/a
08/30/2017	11:10:00	3.25	11	11	n/a	n/a

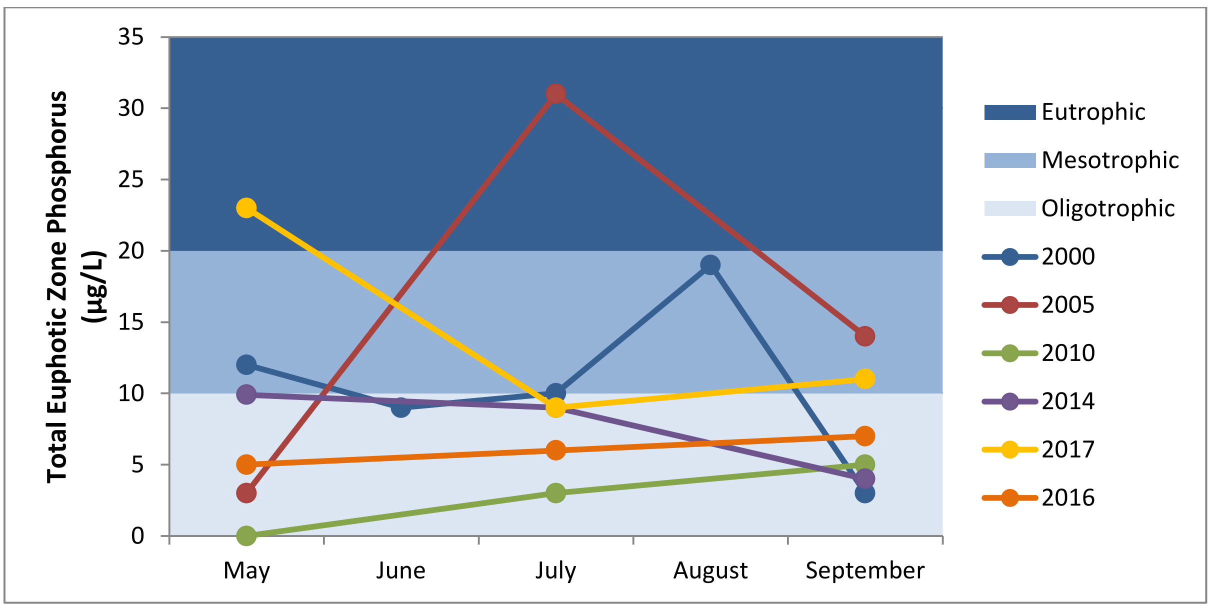


Figure 10. Crotch Lake North Basin Total Euphotic Zone Phosphorus results.

Crotch Lake is a very hydrologically important lake in the watershed. Its size and position allow it to serve as a large reserve for the Mississippi River system. On average, Crotch Lake has total phosphorus results suggesting oligotrophic status, with a few values in the mesotrophic and eutrophic ranges. One exceedance of the Provincial Water Quality Objective occurred this year on Crotch Lake in May (23 µg/L). This is an anomalous value and is likely not indicative of an upward trend.

Dissolved oxygen and temperature profiles suggest habitat suitable to support a warm water fishery, which is what we find in Crotch Lake. Fishing for Smallmouth Bass, Northern Pike, Walleye, and Whitefish is common.

Dalhousie Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/25/2017	11:30:00	3.5	12	12	5.6	32
07/20/2017	10:54:00	4.5	11	279	6.7	n/a
09/14/2017	10:30:00	3.5	11	266	8.31	n/a

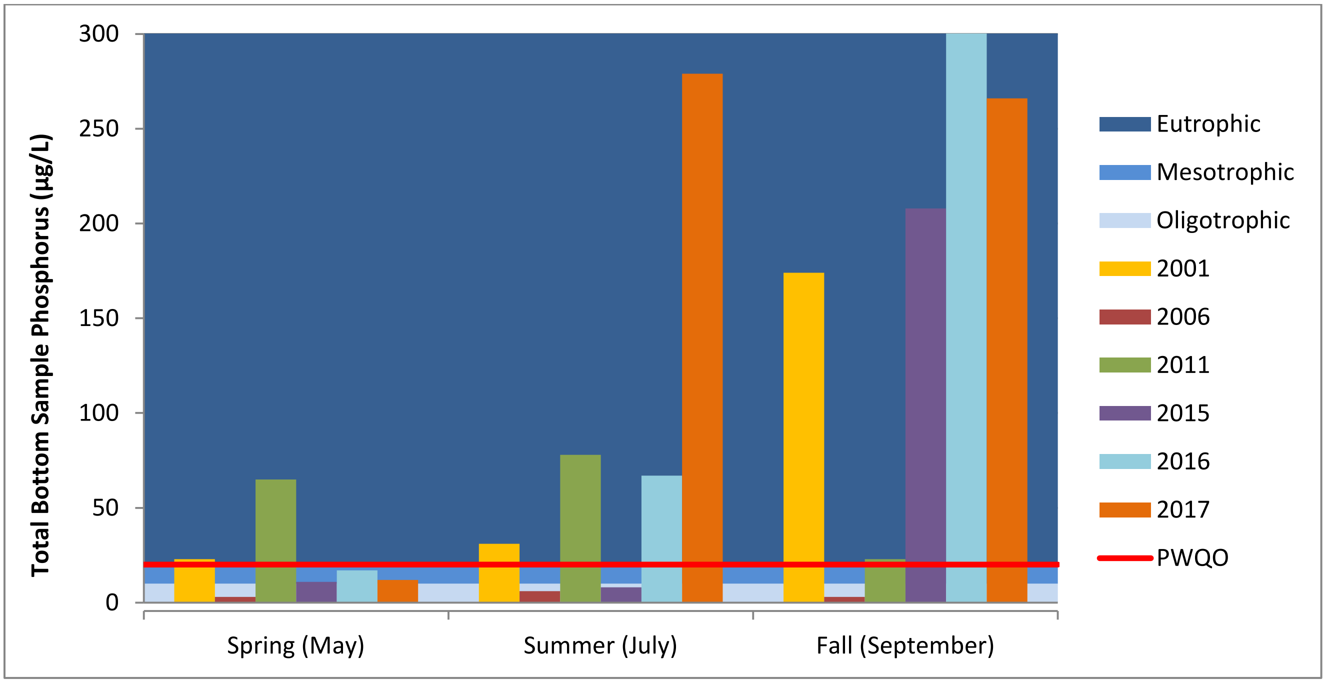
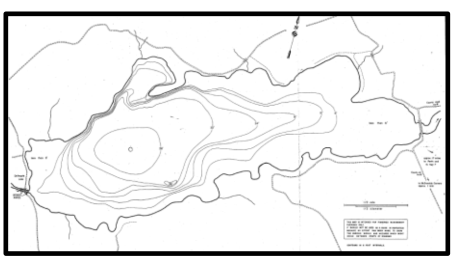


Figure 11. Dalhousie Lake Bottom Sample Phosphorus results by season.



Euphotic Zone Total Phosphorus levels for Dalhousie Lake consistently place it in the Oligotrophic to Mesotrophic range, with one exception in September 2011 (25 µg/L). In 2017, results were very consistent with values of 12, 11, and 11 µg/L in the May, July, and September samples respectively.

As seen in Figure 11, Bottom Sample TP for Dalhousie is often very high, especially for the fall sample. In 2017, two high values occurred, in July and September. As mentioned in the results section, these large values are often seen when sediment contaminates a sample. The sediment at the bottom of any lake is much higher in phosphorus than the lake water itself. Any contamination of the sample with even small amounts of sediment can cause huge spikes in the results. While this sampling error occurs on occasion, the frequency with which it occurs on Dalhousie suggests that this lake may have higher levels of suspended sediment at lake-bottom, especially during the fall. This could be caused by high flows near the sampling spot that agitates the bottom sediment layer, or possibly by fall turnover.

Mazinaw Subwatershed Lakes

Mackavoy Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/11/2017	12:15:00	2.75	9	11	8	n/a
07/10/2017	12:18:00	1.5	18	13	8.06	n/a
09/19/2017	11:30:00	3	9	10	9.77	n/a

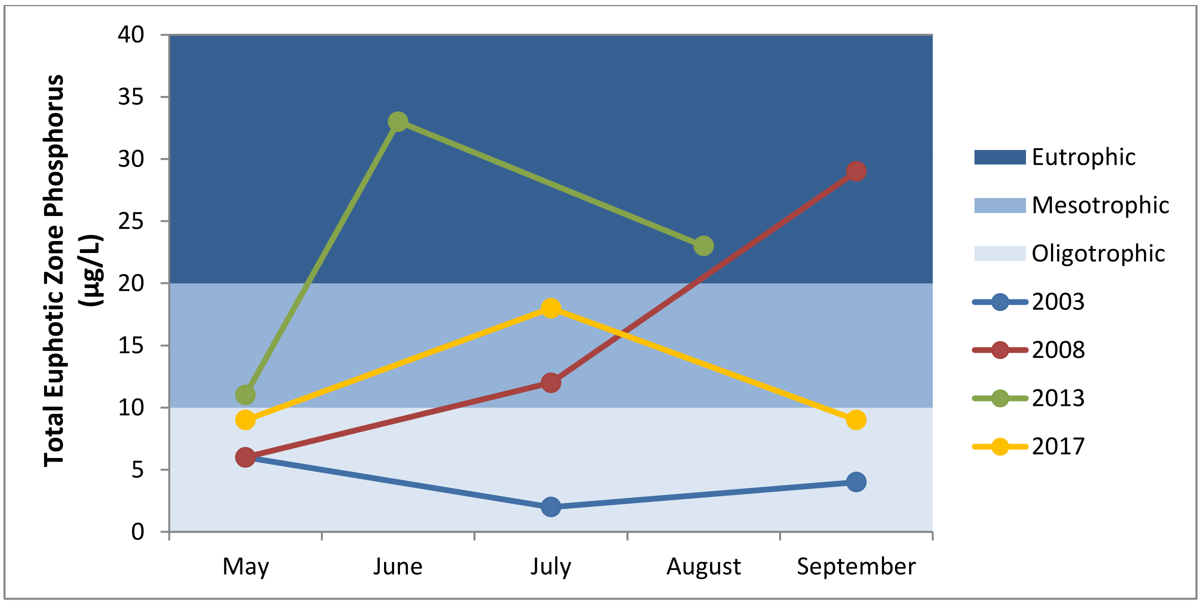
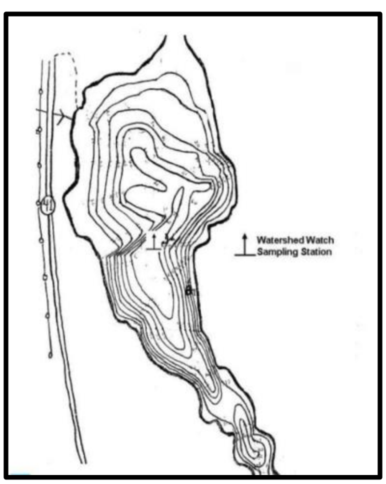


Figure 12. Mackavoy Lake Total Euphotic Zone Phosphorus results.

Mackavoy Lake is a headwater lake of the Mississippi River located just upstream of Mazinaw Lake. It is a relatively small lake with a perimeter of 2.9 kilometers and one basin with a depth of approximately 20 meters.



Total Euphotic Zone Phosphorus levels for this year were consistent with previous years, placing Mackavoy Lake in the mesotrophic range. Water clarity, as shown by Secchi depth results, decreased in 2017 compared to historical results with an average of 2.4 meters. The reason for this is unclear however it is possible that sampling occurred after rain events which result in runoff and sedimentation, generally decreasing water clarity for a short time. Results will be monitored in the future to identify a possible trend.

Historically, Mackavoy Lake has supported a warm water fishery including Walleye, Northern Pike, Smallmouth Bass, Yellow Perch, White Sucker, Brown Bullhead, and Pumpkinseed. The profiles for 2017 support this, with temperate/dissolved oxygen levels consistent with the preferences of warm water species.

Kishkebus Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
06/01/2017	13:45:00	2	15	7	7.8	16
07/18/2017	12:38:00	2.75	21	13	8.53	n/a
09/13/2017	13:40:00	2.75	7	4	7.36	n/a

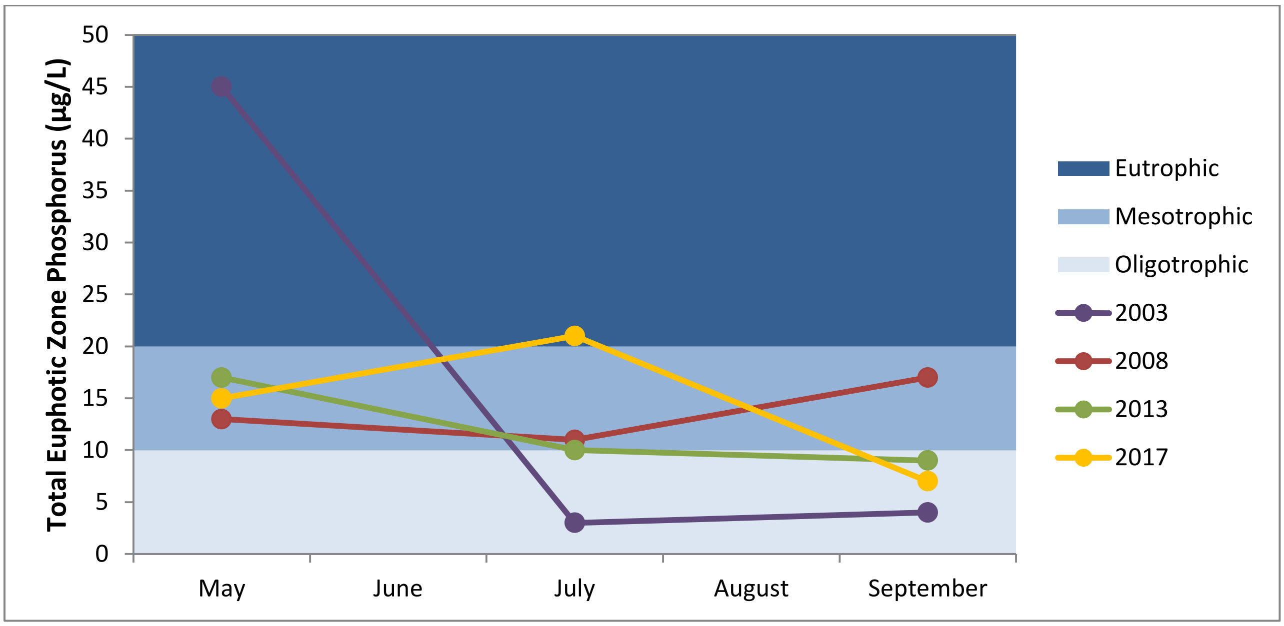
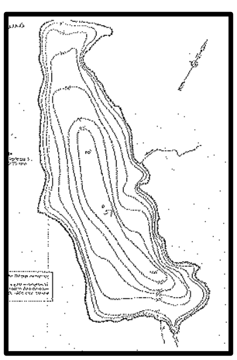


Figure 13. Kishkebus Lake Total Euphotic Zone Phosphorus results.



Kishkebus is a small cold water lake located entirely within the boundaries of Bon Echo Provincial Park in the Mazinaw subwatershed. It is a headwater lake which outlets into Shabomeka Lake, which then feeds into Lower Mazinaw Lake. It has one basin with a maximum depth of 32.9 meters and a perimeter of 4.9 kilometers. Two exceedances of the PWQO for Total Phosphorus have occurred on Mackavoy Lake, once in May 2003 (45 µg/L) and again in July 2017 (21 µg/L). These were likely a result of high phosphorus levels in the runoff following either spring snow melt or a heavy rain event. Averages for TP levels still show consistently mesotrophic values and the lake is considered to be in good condition.

As a cold water lake, Kishkebus has been known to support a cold water fishery, in particular Lake Trout. D.O. profiles reveal excellent conditions for these fish with plenty of habitat in the lower depths of the lake. According to its lake plan, Kishkebus is considered at capacity for development around the lake.

Shabomeka Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
06/01/2017	11:45:00	3.25	15	9	7.7	16
07/18/2017	14:12:00	3.25	22	12	7.75	n/a
09/13/2017	11:30:00	4.25	10	11	7.81	n/a

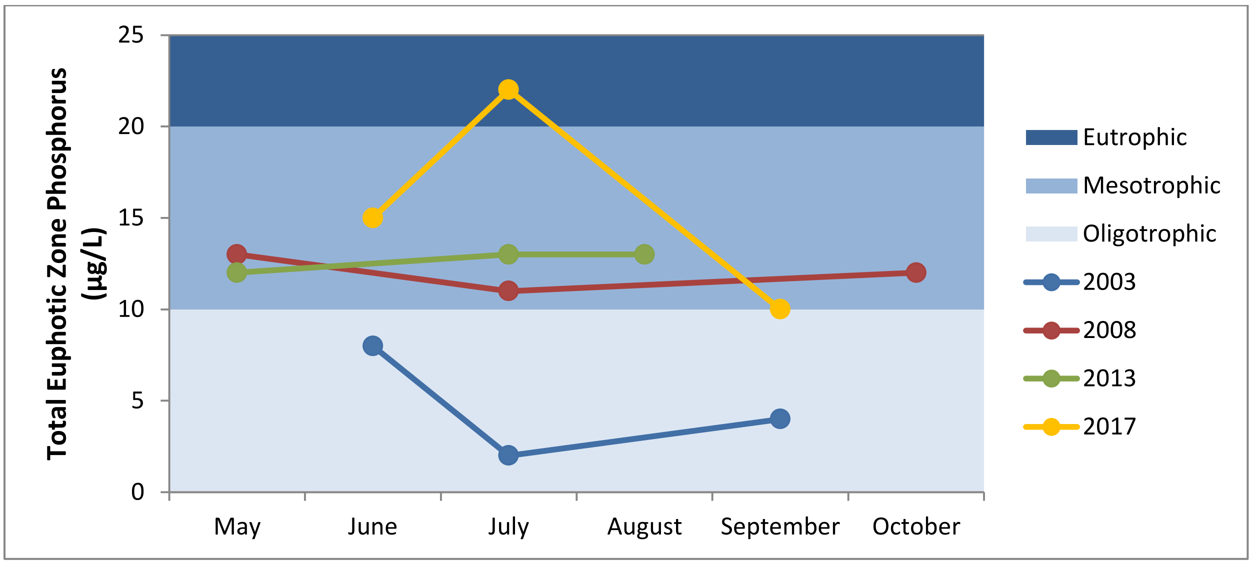
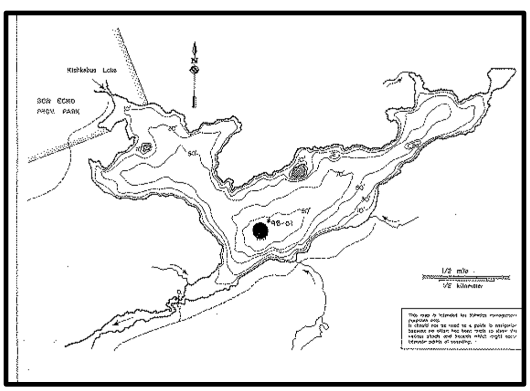


Figure 14. Shabomeka Lake Total Euphotic Zone Phosphorus results.



Shabomeka Lake is a deep, cold water lake located just downstream of Kishkebus Lake. It has a perimeter of 14 kilometers and its deepest point is 32 meters. The outlet of Shabomeka Lake is outfitted with a dam and feeds into Lower Mazinaw Lake. Historically the Total Euphotic Zone Phosphorus values have indicated an oligotrophic or mesotrophic status. One value this year, in July, placed it in the eutrophic range (22 µg/L). An interesting trend that seems to be occurring in Shabomeka over the four sampling years is an increase in the average Total Phosphorus, and an associated decrease in water clarity. As high TP values often cause higher levels of organic matter and increased turbidity, a decrease in clarity with increase in TP is not surprising. However, a continued increase in TP could be detrimental to the ecological health and recreational value of the waterbody, and conditions will continue to be monitored.

Shabomeka continues to provide the appropriate combination of temperature and dissolved oxygen levels to support a cold water fishery. In 2017, depths below an average of 9 meters provided optimal habitat for fish such as Lake Trout. Shabomeka Lake is a coldwater lake and is at capacity for shoreline development.

Mazinaw Lake

North Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/24/2017	12:40:00	3.5	4	4	n/a	16
07/06/2017	12:30:00	4.25	12	17	7.78	n/a
09/29/2017	11:40:00	4.5	7	8	9.14	n/a

South Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/24/2017	11:45:00	4.25	7	15	n/a	16
07/06/2017	11:37:00	3.5	17	15	7.85	n/a
09/29/2017	10:30:00	4	8	11	9.13	n/a

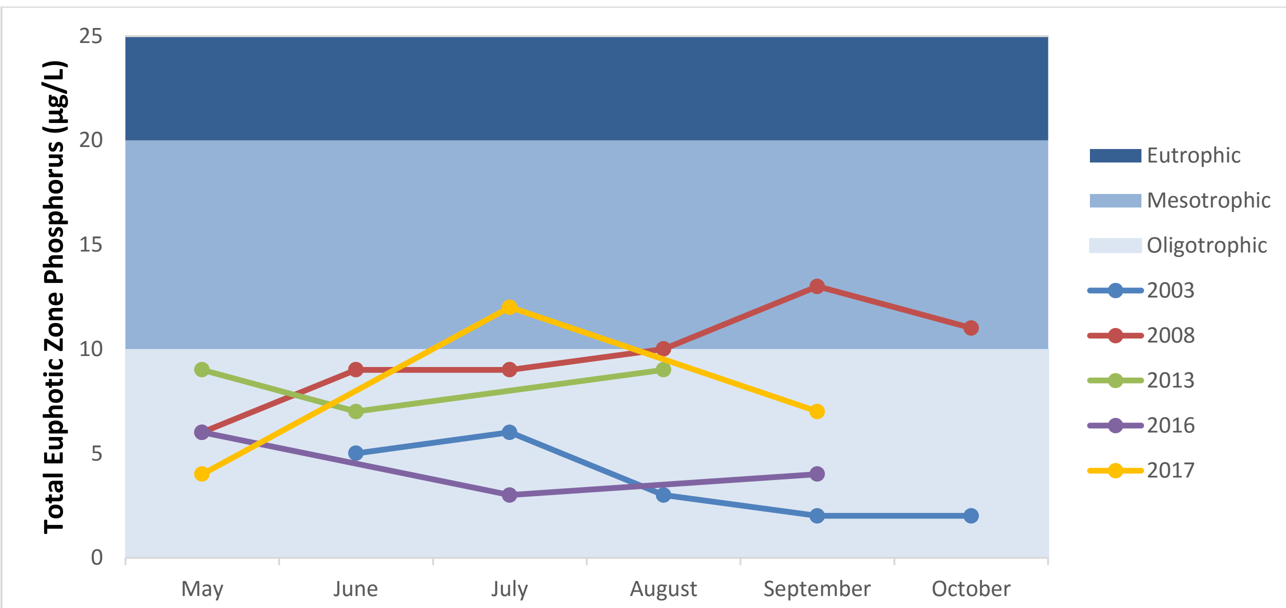


Figure 15. Mazinaw Lake North Basin Total Euphotic Zone Phosphorus results.

Mazinaw is a large and deep lake on the western edge of the Mississippi Valley watershed. A large section of the lake is part of Bon Echo Provincial Park. It has a maximum depth of 140 meters, making it one of the deepest inland lakes in Ontario. It also features a picturesque rock wall standing over 100 meters on the eastern side of the lake. Due to its depth, it is no surprise that Mazinaw Lake is a cold water lake that consistently shows an oligotrophic status in both the North and South basins. Results in 2017 maintain this trend.

Dissolved oxygen and temperature profiles also show an oligotrophic status and plenty of suitable habitat for cold water fish species. Mazinaw has historically supported thriving populations of lake trout at its deeper points, and warm water species such as pike, walleye, and bass in the shallower and warmer shoal areas. Both Upper and Lower Mazinaw are *not* at capacity for shoreline development.

Marble Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/18/2017	12:00:00	4.25	7	6	8	16
07/13/2017	11:10:00	3.75	12	18	7.97	n/a
09/22/2017	10:25:00	5.5	4	4	n/a	n/a

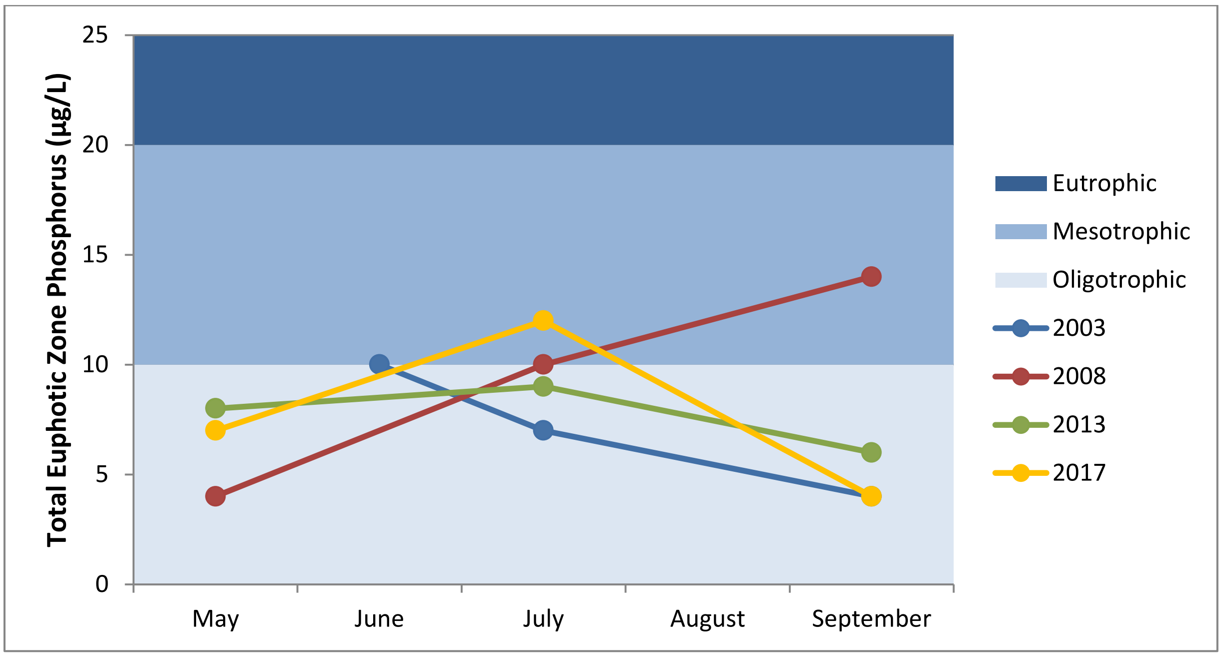
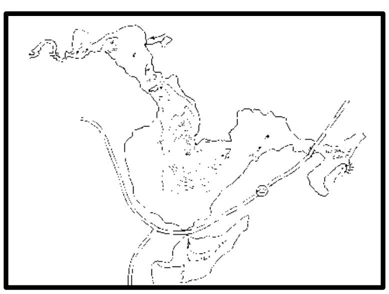


Figure 16. Marble Lake Total Euphotic Zone Phosphorus results.



Marble Lake is a relatively small lake located downstream of Mazinaw Lake, at the corner of Highway 506 and Marble Lake Road. It has a maximum depth of 20 meters and is home to over 70 cottages and 4 resorts. As seen in Figure 16, Marble Lake maintains a consistent oligotrophic status according to Total Euphotic Zone Phosphorus results.

The most critical time of the year to conduct dissolved oxygen and temperature profiles is after August 31st. At this time, the vegetation and algae from the summer season has settled to the bottom of the lake, using up oxygen as it decomposes, and oxygen levels are at their lowest. While Marble Lake is deep enough to stratify during the summer months it does not have dissolved oxygen levels consistently high enough to support cold water species of fish. Instead it supports a warm water fishery. Seine netting performed in 2017 supported this with the identification of juvenile Smallmouth Bass.

Fall River Subwatershed Lakes

Sharbot Lake

East Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/10/2017	13:15:00	3.5	10	12	8	n/a
07/19/2017	12:55:00	5	12	34	8.5	n/a
09/20/2017	13:30:00	5.75	11	22	n/a	n/a

South West Basin

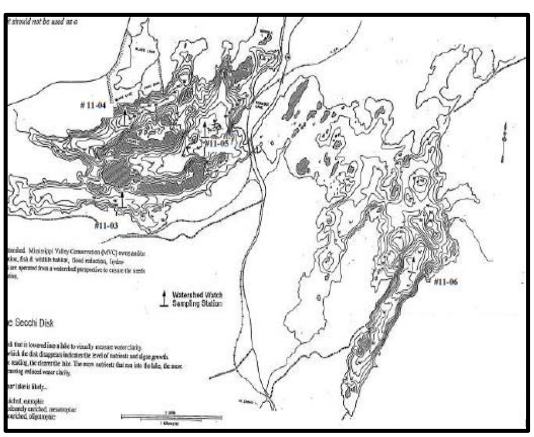
Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/10/2017	11:10:00	3.25	11	10	8	n/a
07/19/2017	12:20:00	3.25	15	18	9	n/a
09/20/2017	11:25:00	5.25	51	71	8.92	n/a

Main West Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/10/2017	12:10:00	4.25	16	12	8	n/a
07/19/2017	11:05:00	3.5	11	23	8.64	n/a
09/20/2017	12:05:00	5.25	10	26	8.3	n/a

North West Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/10/2017	11:30:00	4.25	11	17	8	n/a
07/19/2017	11:40:00	3.75	15	9	8.73	n/a
09/20/2017	11:00:00	5.25	8	16	n/a	n/a



Sharbot Lake is the largest lake in the Fall River subwatershed and is located just south of Highway 7, on both sides of the Village of Sharbot Lake. It consists of two large basins, East and West; East being warm water and West being deeper and cold water. The two basins are separated by a small bottle neck at Highway 38. With a maximum depth of 32 meters and over 100 islands, Sharbot Lake is a complex system with diverse habitat for both vegetation and wildlife. It was created by glaciers and is fed by deep springs. TP results reflect this with values largely in the oligotrophic and mesotrophic ranges. Sharbot West is considered coldwater and according to their lake plan is at capacity for shoreline development.

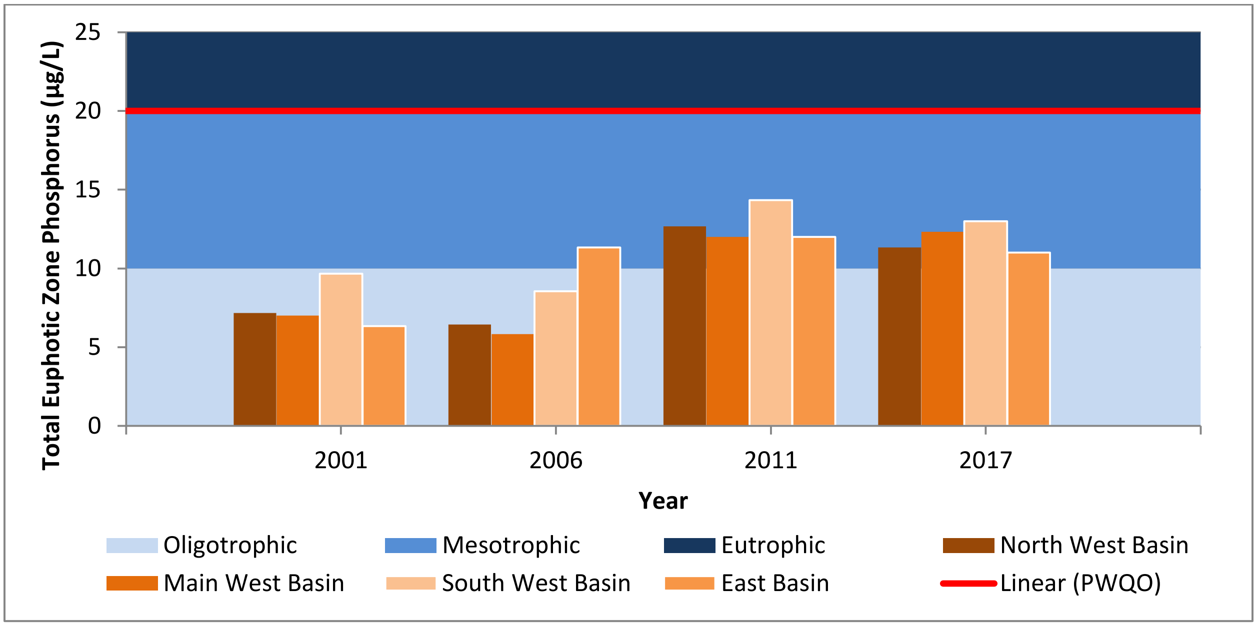
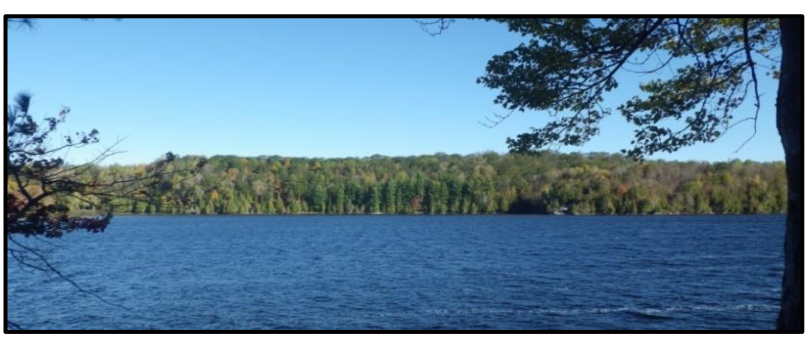


Figure 17: Sharbot Lake Total Euphotic Zone Phosphorus levels by basin over four sampling years.

As seen in Figure 17, Total Euphotic Zone Phosphorus results for Sharbot Lake in 2017 were consistent with those in 2011, and slightly higher on average than those in 2001 and 2006. Both 2011 and 2017 happened to be flood years, where the increased runoff from rain events caused widespread increases in total phosphorus levels. This has resulted in a mesotrophic status for Sharbot Lake over those two years, in contrast to the oligotrophic status in 2001 and 2006. Sampling will occur again in 2020. Monitoring will be looking for any suggestion of an upward trend.

Another interesting result from this year's sampling is the responsiveness of the Main West Basin to spring snow melt. This basin has had consistently higher TP values in the spring, which then return to historical trends for the rest of the season. The reason behind this is unclear but may be related to its position in the lake. The Main West Basin is the deepest sampling point and is in close proximity to the bottleneck where the West Basin drains into East Basin. As such, a large portion of the water residing in the West Basin has to move through this point in order to outlet to the East Basin and eventually exit the lake. The spike in TP that we see in the spring may be because this point is inundated with the snow melt from around the entire West Basin. Snow melt, similar to runoff, is generally high in phosphorus.



Finally, the increase in both euphotic zone and bottom sample TP in the South West Basin in the fall sample of 2017 is thought to be a product of increased turbulence disturbing the sediment layer and infiltrating the samples. This is similar to the effect believed to occur on Dalhousie Lake.

Silver Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/23/2017	10:08:00	5.5	9	18	7.76	40
07/17/2017	10:40:00	5	16	10	8.82	n/a
09/12/2017	11:30:00	5	4	4	8.44	n/a

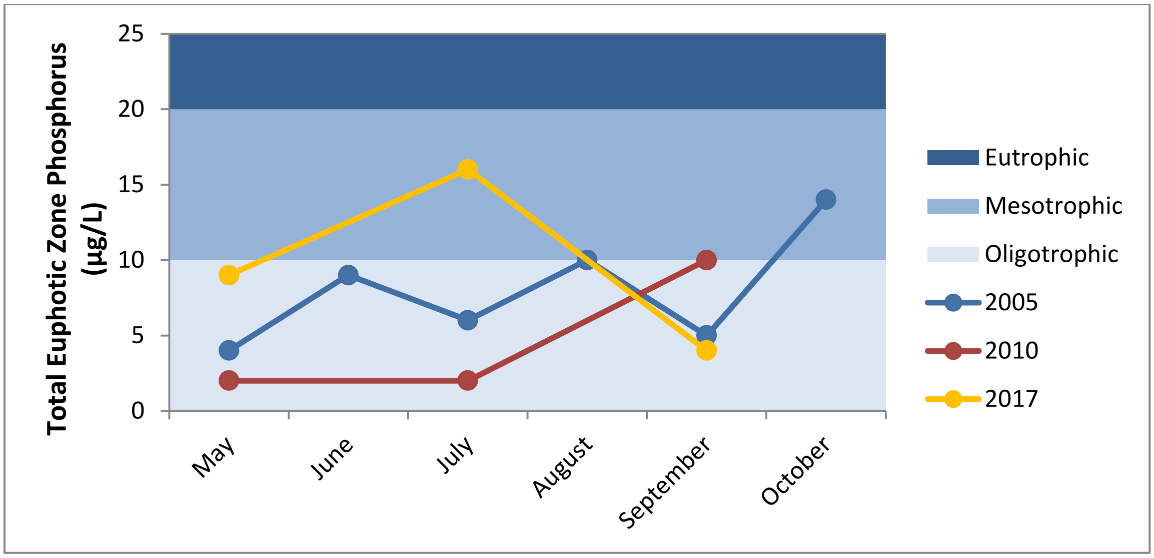
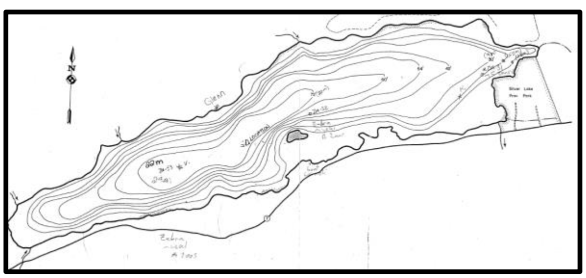


Figure 18: Silver Lake Main Basin Total Euphotic Zone Phosphorus results.



Silver Lake is a spring fed, headwaters system that flows into the Fall River just east of Sharbot Lake and north of Highway 7. It is a fairly deep lake with a maximum depth of 24 meters. In the three years of sampling, Silver Lake has maintained an oligotrophic status with total phosphorus levels generally below 10 µg/L. As seen in other lakes this year, the July sample showed a higher than average value of TP (16 µg/L). The May and September values were in the oligotrophic range. While Silver Lake is spring-fed, the high July result may indicate that it is also influenced by runoff.

Known to support a cold water fishery, including Lake Trout, in 2017 Silver Lake continues to have sufficient temperature and dissolved oxygen levels for cold water species habitat (oxygen levels above 6 mg/L and temperatures below 10°C throughout the summer months). Nearshore seine netting produced juvenile Bluegill, Pumpkinseed, Banded Killifish, Bluntnose Minnow, and Largemouth Bass. Silver Lake is a coldwater lake and is at capacity in terms of shoreline development.

Bennett Lake

North Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/31/2017	10:25:00	2.5	34	9	7	40
07/05/2017	11:15:00	2.5	6	13	n/a	n/a
09/15/2017	10:40:00	3.25	9	n/a	9.44	n/a

South Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/31/2017	10:50:00	3.25	7	24	7.1	32
07/05/2017	11:55:00	3.5	29	9	n/a	n/a
09/15/2017	11:15:00	3.5	5	512	8.8	n/a

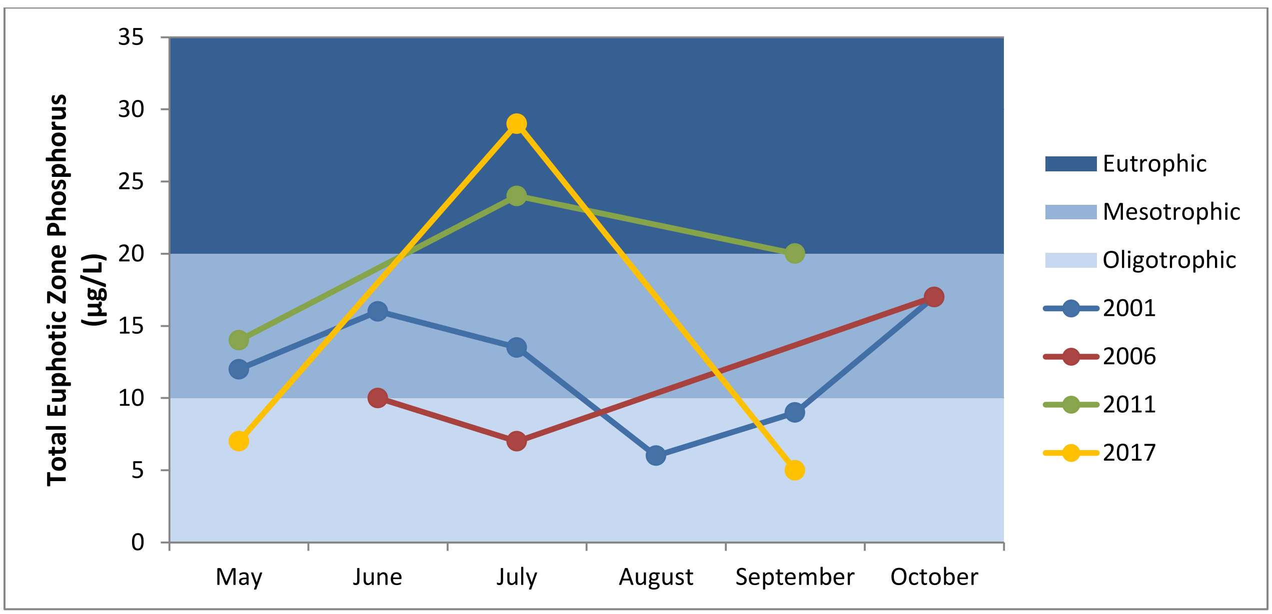


Figure 19: Bennett Lake South Basin Total Euphotic Zone Phosphorus levels.

Bennett Lake is a shallow warm water lake located along the Fall River system, southwest of the town of Lanark. It is the last lake on the system before it outlets into the Mississippi River. Due to its shallow depth, we expect Bennett Lake to lie in the mesotrophic to eutrophic range and this is on average what we see over four sampling years. In 2017, the July sample exceeded the PWQO for total phosphorus with a result of 29 µg/L. This high value was seen on many of the lakes sampled during July of this year and may be the result of flood conditions bringing excess runoff and nutrients into the system.

Dissolved oxygen levels in Bennett Lake are supportive of a warm water fishery.

Auxiliary Lakes

Buckshot Lake

Main Basin

Date	Time	Secchi depth (m)	Total P – Euphotic zone (µg/L)	Total P – Bottom sample (µg/L)	pH	Calcium(Ca^{2+}) (mg/L)
05/12/2017	11:36:00	4.75	6	5	8	n/a
07/12/2017	11:13:00	3	9	3	8.2	n/a
08/31/2017	11:15:00	2.5	4	3	n/a	n/a

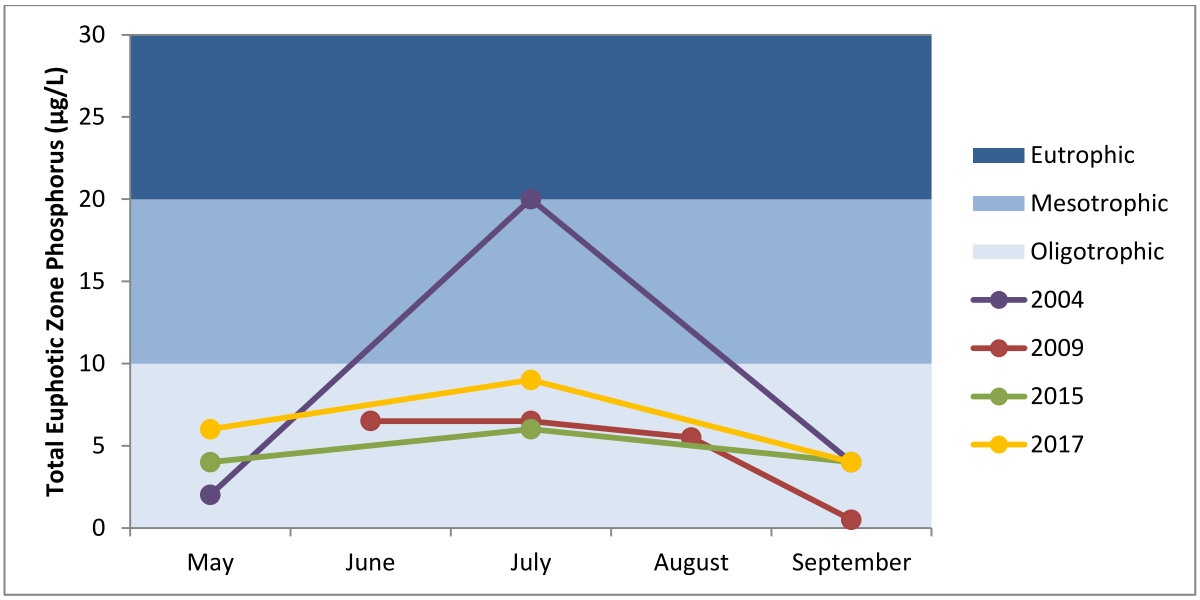
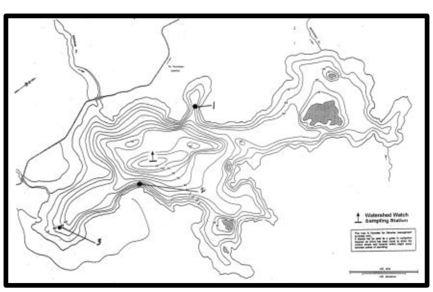


Figure 20. Buckshot Lake Total Euphotic Zone Phosphorus results.

Buckshot Lake is a large cold water lake located in the township of North Frontenac and Addington Highlands. It has a perimeter of 26.2 km and is 33 meters deep at its deepest point. According to its lake plan it is at capacity for shoreline development. As seen in Figure 20, TP values place in consistently in the oligotrophic range with one exception in July of 2004 (20 µg/L). This outlier may have been caused by increased runoff due to a significant rain event the day before sampling (34 mm of rain).



Historically Buckshot Lake has supported a cold water fishery including Lake Trout, as well as other sport fish like Walleye, Small and Largemouth Bass. Dissolved Oxygen and temperature profiles show that the lake continues to have sufficient critical habitat for the support of these species. Seine netting in 2017 produced young of Yellow Perch, Smallmouth and Largemouth Bass.

Stream Results

The highlight of stream sampling in 2017 was finding two previously unknown locations of Brook Trout habitat: Donnelly Creek and Mosquito Creek. Donnelly Creek, shown in Figure X, is a large tributary that begins in the northern most corner of the Mazinaw subwatershed. It moves south until it outlets into Kilpecker Creek just upstream of Mackavoy Lake. This is the first year MVCA sampled this creek, but we will return in the future to ensure the population is consistent. Figure 21 and 22 show the location of the streams sampled for fish in 2017, and the presence or absence of coldwater fish species.

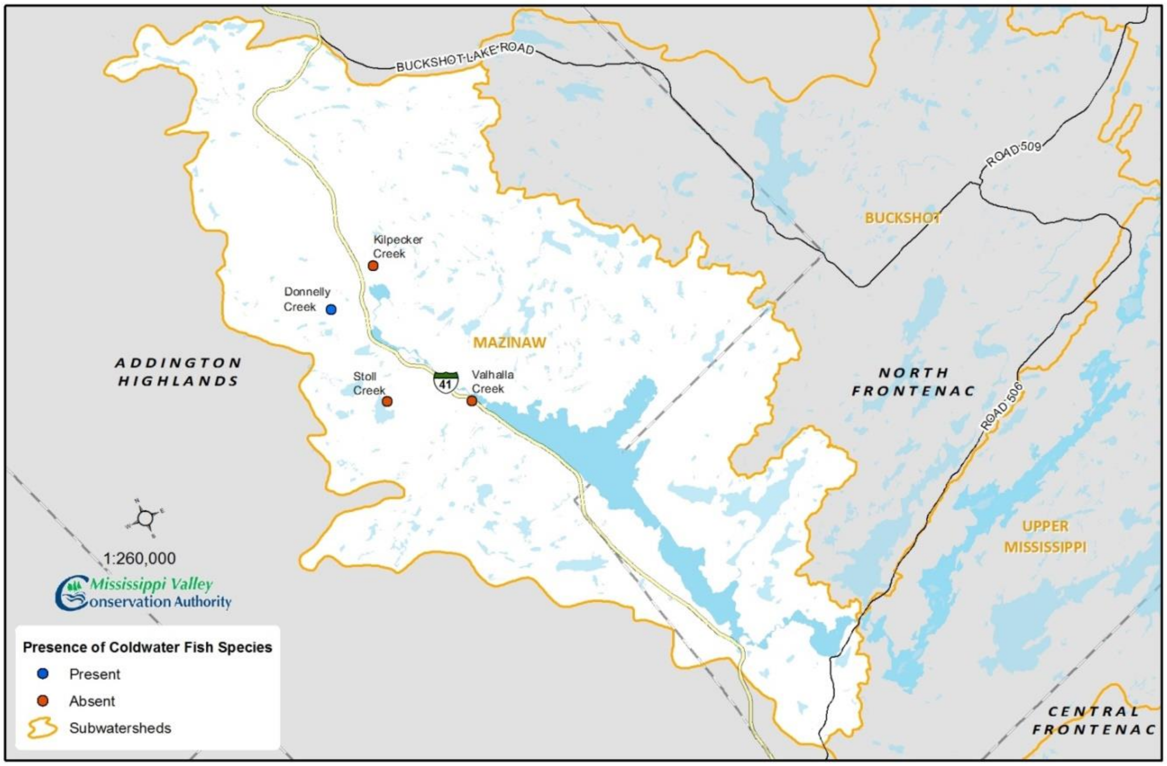


Figure 21. Coldwater Fish Presence in the Mazinaw subwatershed in 2017.

Mosquito Creek is a fairly small creek in the High Falls subwatershed that outlets into Stump Lake. One Brook Trout was caught during the 2017 sampling, although none were found in 2016. Trombleys Lake, just downstream of the sampling site was historically stocked with Brook Trout, but not since the early 1970s. Therefore this may be a self-sustaining population. We will continue to return to the site to observe any changes to the community.

Brook Trout

Another interesting development this year was the absence of Burbot at a site on Easton's Creek where they were previously found. While not catching a species does not necessarily signify absence (electrofishing results are affected to some degree by sampler experience, equipment function, and daily conditions), this result will be noted and the stream returned to next year.

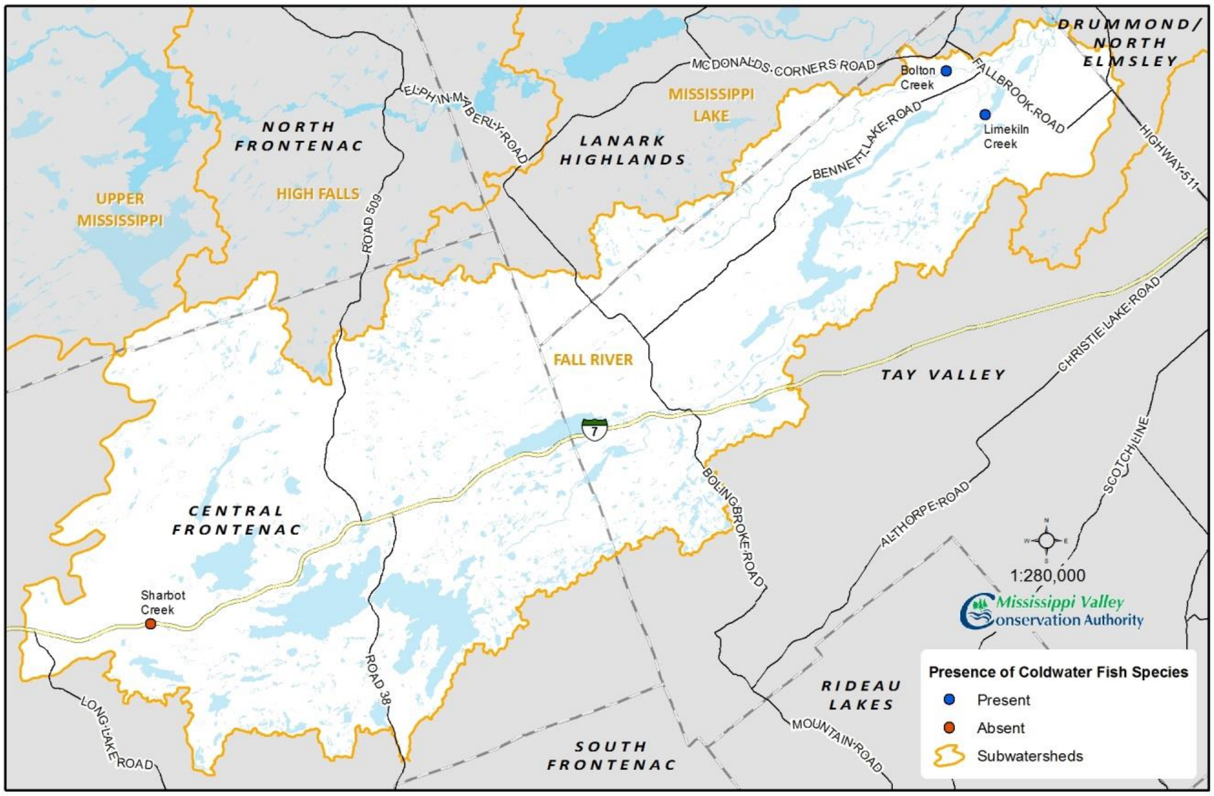


Figure 22. Coldwater Fish Presence in the Fall River subwatershed in 2017.

Coldwater species were caught at two sites in the Fall River subwatershed this year (Figure 22). Bolton Creek, a large tributary which is known to support coldwater species such as Burbot and Brook Trout, was confirmed for Burbot in 2017. Limekiln Creek, a smaller tributary sampled for the first time, produced one Spottail Shiner, a cold/cool water fish.

While benthic samples were collected at all streams sites during the fall of 2017, the processing of these samples is completed in our lab over the winter and into the following summer. Therefore, at the time of publishing we do not have any analysis of the results to share.

Benthic Sampling

Crew performing an Electrofishing Survey

Appendix

Bennett Lake

North Basin

	May 31/2017		July 5/2017		September 15/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	18.4	9	23.5	9.57	20.9	10.08
1	18.4	8.96	22.5	9.62	20.6	10.15
2	18.3	8.92	22.4	9.58	20	9.84
3	18.3	8.87	22.2	9.05	19.8	9.7
4	18.2	8.84	21.8	8.34	19.4	9.02
5	18.2	8.78	21.6	7.75	19.2	8.24
6	15.7	5.71	21.1	6.01	19	5.4

South Basin

	May 31/2017		July 5/2017		September 15/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	17.7	8.6	24.5	8.58	21.6	9.34
1	17.7	8.54	23.6	8.38	21.2	9.23
2	17.6	8.48	22.8	8.23	20.2	9.56
3	17.5	8.35	22	7.96	19.4	9.34
4	17	7.68	21.5	7.43	19	8.87
5	15.2	6.83	20.7	5.95	18.7	8.27
6	13.3	6.51	15.6	2.63	18.4	7.26
7	12.2	6.55	12.8	1.65	16.5	1.63
8	10.8	5.21	11.7	0.89	13.4	0.29
9	9.7	4.62	10.6	0.21	11.5	0.08
10			9.7	0.02	10.5	-0.02
11					9.9	-0.08
12					9.7	-0.12

Buckshot Lake

	May 12/2017		July 12/2017		August 31/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.2	11.17	22.6	8.56	20.2	8.95
1	9.9	1.21	22.7	8.52	20.3	8.88
2	9.6	11.21	22.7	8.47	20.4	8.8
3	9.2	11.19	22.7	8.4	20.4	8.76
4	9.1	11.16	22.6	8.31	20.4	8.71
5	9.1	11.12	21.5	7.58	20.4	8.66
6	9	11.09	18.2	6.65	20.3	8.56
7	8.9	11.05	15.5	6.32	20	8.2
8	8.3	0.95	14.1	6.43	13.9	3.82
9	8	10.9	12.2	6.69	13	4.04
10	8	10.85	10.8	7.12	12.1	4.33
11	8	10.79	10.1	7.28	10.7	5.06
12	7.8	10.78	9.9	7.47	9.6	5.87
13	7.7	10.71	8.8	7.77	9	6.18
14	7.6	10.62	8.3	7.78	8.8	6.25
15	7.2	10.37	7.8	7.98	8.6	6.28
16	6.9	10.3	7.2	8	8.5	6.32
17	6.7	10.14	7.1	7.96	7.9	6.43
18	6.5	10.05	6.9	8.02	7.6	6.47
19	6.2	9.95	6.8	8.02	7	6.38
20	6	9.88	6.5	7.72	6.8	6.23
21	5.8	9.84	6.3	7.52	6.7	6.2
22	5.7	9.77	6.3	7.46	6.4	5.67
23	5.6	9.69	6.2	7.32	6.4	5.34
24	5.5	9.54	6.2	7.14	6.3	5.06
25	5.4	9.43	6.1	6.93	6.3	4.92
26	0.4	9.353	6.1	6.73	6.3	5.03
27	5.3	9.27	6	6.4	6.3	5.06
28	5.2	9.2	6	5.69	6.3	5.09
29	5.2	9.06	6	0.54		

Crotch Lake

North Basin

	May 16/2017		July 4/2017		August 30/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	12.5	11.58	22.2	9.16	22.6	8.88
1	11.4	11.59	22	9.16	21.9	8.85
2	11.1	11.36	21.5	9.25	21.6	8.8
3	11	11.16	21.3	9.31	21.5	8.69
4	10.9	10.97	21.2	9.21	21.4	8.71
5	10.7	10.89	20.8	8.59	21.4	8.72
6	10.6	10.83	19.8	7.17	21.3	8.42
7	10.5	10.74	18.1	6.02	20.5	6.63
8	10.4	10.72	16	6.01	16.7	1.95
9	10.3	10.7	13.4	6.22	15.5	1.98
10	10.2	10.69	12.4	6.27	13.1	2.37
11	9.5	10.57	11.3	6.15	12	2.47
12	9.3	10.46	10.7	6.06	10.8	2.55
13	9.2	10.38	10.1	5.71	10.3	2.25
14	8.6	10.21	9.9	5.58	10	1.98
15	8.5	10.09	9.7	5.54	9.7	1.67
16	8.3	10.02	9.5	5.37	9.4	1.45
17	7.7	9.76	9.5	5.3	9.3	1.1
18	7.4	9.45	9.4	5.26	9.1	0.66
19	7.1	9.25			9	0.42
20	6.9	8.92			8.9	0.06

South Basin

	May 16/2017		July 4/2017		August 30/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	11.5	12.11	22.1	9.41	22.1	9.13
1	11.1	12.09	21.6	9.41	21.7	9.16
2	10.6	12.07	21.2	9.42	21.4	9.15
3	10.4	12.05	21.1	9.39	21.3	9.09
4	10.3	12.02	20.7	9.25	21.3	9.02
5	10.1	11.93	20.6	9.18	21.2	8.98
6	10	11.82	19.2	7.67	21.2	8.9
7	9.8	11.81	16.5	6.35	20.1	5.29
8	9.3	11.7	14.3	5.62	15.9	1.38
9	9.1	11.6	12.1	6.18	12.8	2.18
10	8.4	11.39	11	6.24	11.3	3.12
11	8.2	11.31	10.2	6.37	10.4	3.46
12	8.2	11.25	9.2	6.97	9.8	3.73
13	8.1	11.7	9	6.99	9.3	3.89

14	8	11.09	8.8	6.97	9.1	3.77
15	7.9	10.96	8.5	6.95	8.8	3.6
16	7.7	10.79	8.4	6.89	8.4	3.39
17	7.5	10.52	8.2	6.69	8.3	3.27
18	7.4	10.38	8.1	6.62	8.1	2.78
19	7.2	10.17	8	6.12	7.9	2.47
20	7.2	10.07	8	5.99	7.8	1.42
21	7.1	10.01	7.9	5.83	7.8	1.08
22	7.1	9.92	7.9	5.72	7.7	0.89
23	7	9.81	7.9	5.71	7.7	0.39
24	7	9.75	7.9	5.57	7.6	0.02
25					7.6	0.01
26					7.6	-0.14

Dalhousie Lake

	May 25/2017		July 20/2017		September 14/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	15.8	10.4	24.6	8.63	20.2	9.55
1	15.8	10.39	23.7	8.64	19.3	9.57
2	15.8	10.35	23.5	8.59	19.2	9.45
3	15.7	10.31	23.3	8.46	19.1	9.39
4	15.1	10.13	23.2	8.35	19.1	9.34
5	15	10.03	23.1	8.22	18.7	8.72
6	14.5	9.94	22.1	7.65	18.5	8.62
7	14.4	9.87	21.7	6.92	18.5	7.97
8	14.4	9.8	20.2	4.84	18.3	7.43
9	14.3	9.77	18.5	2.2	18.2	7.1
10	14.2	9.65	16.8	0.56	17.8	5.01
11	13.5	9.43	15.5	0.05	16.3	0.54
12	13	8.94	15.1	-0.04	15.5	0.15
13	12.1	8.57	13.6	-0.1	14.1	0.01
14	11.5	8.6	13.2	-0.13		
15	10.8	7.94	12.8	-0.15		
16			12.5	-0.16		
17			11.7	-0.19		

Kishkebus Lake

	June 1/2017		July 18/2017		September 13/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	17.5	9.51	25.6	8.56	21.1	9.39
1	17.6	9.43	25.1	8.52	19.3	9.42
2	17.5	9.38	22.6	8.72	18.2	9.42
3	17.4	9.36	20.4	6.3	17.6	8.99
4	13.1	9.68	18.3	6.23	16.9	7.94
5	9.5	9.69	14.6	6.49	15.3	5.75
6	8.2	9.48	9.9	7.38	10.8	5.71
7	7.6	9.29	8.4	7.55	8.9	6.21
8	6.8	8.98	7.7	7.57	7.5	6.37
9	6.2	8.8	6.8	7.53	7.1	6.53
10	5.8	8.64	6.3	7.53	6.5	6.6
11	5.4	8.51	5.9	7.44	6	6.62
12	5.2	8.41	5.7	7.36	5.6	6.59
13	5.1	8.3	5.3	7.31	5.3	6.48
14	4.9	8.24	5.1	7.24	5.2	6.41
15	4.8	8.23	5	7.17	5	6.33
16	4.8	8.11	4.8	7.03	4.9	6.07
17	4.7	8.04	4.8	6.96	4.8	6.07
18	4.6	7.98	4.7	6.86	4.7	5.6
19	4.6	7.92	4.7	6.74	4.6	5.24
20	4.6	7.82	4.6	6.43	4.6	4.61
21	4.5	7.74	4.5	6.08	4.5	3.9
22	4.5	7.61	4.5	5.72	4.5	3.13
23	4.5	7.42	4.5	5.38	4.5	2.35
24	4.4	6.97	4.5	4.83		
25	4.4	6.82	4.5	0		

Mackavoy Lake

	May 11/2017		July 10/2017		September 19/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	9.8	10.29	21.3	7.4	21	8.85
1	9.7	10.37	20.6	7.2	20.7	7.6
2	0.2	10.29	20	6.77	18.2	8.22
3	8.6	10.26	19.1	6.09	16.5	6.43
4	8.2	10.16	14.7	5.45	13.8	2.66
5	7.8	10.07	10.5	6.81	10.3	4.45
6	7.5	10	8.4	7.31	8	4.5
7	7.4	9.93	7.3	6.77	7.1	4.57
8	7	9.75	6.6	5.92	6.3	3.64

9	6.5	9.42	6.4	5.82	5.9	2.76
10	5.2	8.06	5.7	5.2	5.4	2.05
11	4.8	7.43	5.2	4.07	5	1.44
12	4.3	5.96	4.6	2.89	4.7	0.89
13	4.1	4.99	4.3	1.65	4.5	0.13
14	4	4.5	4.2	1.4	4.4	-0.17
15	4	4.18	4.2	0.95	4.3	-0.27
16	4	2.73	4.1	0.78	4.3	-0.33
17	3.9	2.05	4.1	0.63	4.3	-0.34
18	3.9	1.2	4.1		4.2	-0.35
19	3.9	0.52			4.2	-0.36
20					4.2	-0.37
21					4.2	-0.37

Marble Lake

	May 18/2017		July 13/2017		September 22/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	14.5	11.09	21.2	8.66	23	9.11
1	14.1	11.18	21.5	8.59	23	9.07
2	13.9	11.24	21.7	8.53	22.4	9.34
3	13.8	11.27	21.7	8.5	20.2	9.46
4	13.8	11.25	21.7	8.43	19.1	9.15
5	13.4	11.24	19.1	7.58	18.5	8.87
6	12.6	11.15	14.6	8.09	17.7	8.28
7	12.1	11.15	11.9	8.18	15.3	6.18
8	11	11.24	9.9	8.16	12.1	3.73
9	10.2	11.2	9.1	7.64	9.6	3.41
10	9.5	11.23	8.4	7.54	8.5	3.21
11	8.7	11.08	8	7.52	8	3
12	8.2	11.08	7.6	7.22	7.4	2.88
13	8.2	11.1	7.3	6.74	7.3	2.4
14	8.2	11.1	7.1	6.56	7.2	2.31
15	8.1	11.07	6.9	6.09	7.1	2.02
16	8	11.06	6.8	5.54	7	1.71
17	7.8	11.03	6.7	5.32	6.9	1.42
18	7.3	10.85	6.7	4.53	6.9	1.2
19	7.1	10.76			6.9	0.97
20	6.9	10.61			6.8	0.78
21					6.8	0.57

Mazinaw Lake

North Basin

	May 24/2017		July 6/2017		September 29/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	13.7	10.95	23	9.02	20	9.31
1	13.3	11.8	22.5	9.06	20.1	9.27
2	12.2	11.23	22.3	9.01	20.2	9.22
3	11.8	11.27	22.2	8.95	20.1	9.18
4	11.4	11.25	20.8	8.84	19.8	9.18
5	11.2	11.27	20.2	8.74	19.3	9.14
6	11	11.21	17.2	9.04	18.6	8.94
7	10.9	11.2	14.3	9.48	18	8.65
8	10.5	11.02	13.3	9.58	16	7.96
9	8.3	11.06	11.2	9.75	13	7.99
10	7.4	11.1	10.5	9.9	10.3	8.52
11	6.9	11.15	10.2	9.87	9.3	8.76
12	6.5	11.1	8.7	9.99	8.8	8.94
13	6.3	11.05	8.3	9.99	8.4	8.99
14	6.1	11.04	7.7	10	8.1	9.02
15			7.1	10.06	7.4	9.24
16			6.7	10.16	7.1	9.35
17			6.5	10.18	6.9	9.45
18			6.2	9.6	6.6	9.58
19					6.3	9.66
20					6.1	9.7

South Basin

	May 24/2017		July 6/2017		September 29/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	14.5	11.05	23	9.03	19.4	9.46
1	14.3	10.98	22.9	9.03	20	9.39
2	12.8	11.13	22.5	8.99	20	9.35
3	12.4	11.1	21.6	9.06	19.8	9.37
4	11.9	11.09	20.9	8.95	19.7	9.39
5	11.6	11.04	19.9	8.93	19.5	9.44
6	11.4	10.99	17.6	9.06	18.8	9.33
7	10.7	10.99	14	9.23	18.1	8.86
8	10.1	11.02	11.9	9.34	16.6	7.97
9	9.7	11.03	10.8	9.48	12.2	7.52
10	9.3	11.02	9.6	9.56	10.6	7.75
11	8.7	11.02	8.7	9.73	9.3	7.8
12	8.3	11	8.1	9.74	8.7	7.79
13	7.9	10.98	7.8	9.67	8.4	7.81

14	7.6	11.01	7.6	9.64	8.1	7.87
15	7.3	10.97	7.6	9.6	7.9	7.88
16	7.2	10.94	7.4	9.6	7.8	7.9
17	7	10.89	7.2	9.68	7.6	8
18	6.9	10.87	7	9.71	7.5	8.01
19	6.8	10.88	6.8	9.69	7.4	8.12
20	6.7	10.85	6.7	9.64	7.4	8.16
21	6.5	10.8	6.6	9.62	7.3	8.16
22	6.4	10.73	6.4	9.64	7.2	8.05
23	6.1	10.67	6.3	9.58	7.1	7.85
24	5.8	10.58	6.1	9.56	6.7	8.14
25	5.5	10.51	6	9.59	6.5	8.29
26	5.3	10.46	5.8	9.64	6.3	8.36
27	5.3	10.4	5.6	9.53	6.3	8.42
28	5.2	10.38	5.5	9.44	6.3	8.5
29	5.2	10.33	5.4	9.4	6.3	8.47
30	5.1	10.32	5.3	9.4	6.2	8.45
31	5.1	10.27	5.3	9.35	6.1	8.4
32	5.1	10.24	5.2	9.33	6	8.33
33	5	10.22	5.2	9.3	5.8	8.37
34	5	10.17	5.2	9.28	5.7	8.41
35	5	10.12	5.2	9.25	5.6	8.37
36	4.9	10.1	5.2	9.21	5.4	8.32
37	4.9	10.06	5.2	9.18	5.4	8.28
38	4.9	10.02	5.2	9.15	5.3	8.25
39	4.9	9.99	5.1	9.14	5.3	8.18
40	4.9	9.95	5.1	9.11	5.3	8.13
41	4.9	9.93	5.1	9.08	5.3	8.1
42	4.9	9.9	5.1	9.05	5.3	8.11
43	4.9	9.87	5.1	9.02	5.3	8.07
44	4.8	9.85	5.1	8.98	5.3	8.05
45	4.8	9.83	5.1	8.88	5.3	8.02
46	4.8	9.8	5.1	0.03	5.3	7.98
47	4.8	9.77			5.3	7.92
48	4.8	9.73			5.3	7.9
49	4.8	9.7			5.3	7.87
50	4.8	9.67			5.3	7.86

Shabomeka Lake

	June 1/2017		July 18/2017		September 13/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	15.8	10.56	24.3	9.03	20.2	9.72
1	15.9	10.55	23.7	9.04	19.7	9.74
2	15.9	10.53	22.8	9.18	19.3	9.71
3	15.9	10.51	22.5	9.15	19	9.72
4	15.8	10.52	21.9	8.91	18.8	9.7
5	15.6	10.51	21.1	8.93	18.6	9.52
6	10.7	11.46	17.1	9.01	18.4	9.38
7	9.9	11.38	13.4	9.4	15.9	9.23
8	9.3	11.2	10.9	9.39	11.1	7.66
9	8.8	11.12	9	9.04	9.4	7.19
10	7.5	10.56	8.1	8.78	8.2	7.14
11	7.1	10.31	7.6	8.7	7.6	7.17
12	6.9	10.11	7.2	8.63	7.1	7.12
13	6.8	9.93	6.9	8.5	6.9	7.07
14	6.5	9.71	6.7	8.29	6.6	6.97
15	6.4	9.56	6.6	8.02	6.5	6.57
16	6.4	9.47	6.5	7.64	6.4	6.27
17	6.2	9.3	6.3	7.67	6.3	5.28
18	5.9	8.91	6.2	7.6	6.2	5.44
19	5.8	8.79	6.1	7.72	6.1	5.97
20	5.8	8.63	5.9	7.72	6	5.04
21	5.7	8.56	5.8	7.49	5.9	4.68
22	5.7	8.48	5.6	6.91	5.7	4.64
23	5.6	8.43	5.6	6.36	5.7	4.02
24	5.6	8.37	5.6	6.36	5.6	3.65
25	5.6	8.33	5.5	6.29	5.5	3.56
26	5.5	8.29	5.5	6.13	5.4	3.31
27	5.5	8.33	5.4	5.96	5.4	2.75
28	5.4	8.25	5.4	5.68	5.4	2.25
29	5.4	8.16	5.4	5.11	5.4	1.79
30	5.2	7.43	5.3	4.09	5.3	0.79
31			5.3	3.19		

Sharbot Lake

East Basin

	May 10/2017		July 19/2017		September 20/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	9.8	11.77	23.8	9.24	22.9	9.54
1	9.8	11.67	23.8	9.23	22.7	9.62
2	9.7	11.65	23.7	9.2	22.6	9.62
3	9.7	11.61	23.6	9.14	22.5	9.63
4	9.6	11.59	22.3	8.25	20.1	8.85
5	9.5	11.57	21.8	7.75	19.6	8.71
6	9.5	11.54	21.7	7.65	19.2	8.27
7	9.4	11.4	21.2	7.06	18.9	7.65
8	9.4	11.31	17.5	4.02	18.5	6.9
9	9.4	11.26	15.4	3.66	16.7	2.82
10	9.3	11.24	13.6	4.17	14	0.22
11	9.3	11.2	11.5	4.42	12.4	0.17
12	9.3	11.18	11	4.57	11.4	0.05
13	9.3	11.15	10.4	4.77	10.8	0.36
14	9.2	11.01	10	5.14	10.3	1.05
15	8.2	10.39	9.6	4.99	9.7	1.46
16	7.8	10.12	9.1	5.27	9.4	1.63
17	7.6	10.07	8.9	5.42	9.1	1.82
18	7.5	10.03	8.6	5.26	8.9	1.85
19	7.4	10.04	8.3	5.32	8.6	1.81
20	7.3	10	8.2	5.3	8.4	1.77
21	7.1	9.88	8.1	4.87	8.2	1.79
22	7	9.74	8	4.88	8.2	1.64
23	6.9	9.7	7.9	4.74	8.1	1.44
24	6.8	9.68	7.8	4.55	8	1.34
25	6.8	9.6	7.8	4.32	7.9	0.83
26	6.7	9.4	7.8	4.17	7.9	0.67
27	6.6	9.12	7.7	3.97	7.9	0.61
28	6.5	9.02			7.9	0.47
29	6.5	8.85			7.8	0.14
30					7.7	-0.31

Main West Basin

	May 10/2017		July 19/2017		September 20/2017	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	8.9	11.68	24.1	9.16	22.4	9.3
1	8.9	11.6	24.1	9.15	22.2	9.31
2	8.8	11.56	24	9.14	22	9.34
3	8.8	11.55	22.5	8.68	20.7	9.22

4	8.7	11.53	21.8	8.4	19.7	8.69
5	8.5	11.41	21.5	7.92	19.3	8.18
6	8.5	11.32	19.9	5.84	18.8	7.72
7	8.5	11.28	16.6	4.64	18.2	7.12
8	8.5	11.21	13.5	5.49	15.8	2.61
9	8.4	11.13	11.9	6.24	12.7	3.28
10	8.4	11.08	10.9	6.58	11.3	3.91
11	8.4	11.04	10	6.86	10.1	4.49
12	8.4	10.99	9.3	7.1	8.9	5.05
13	8.4	10.91	8.7	7.19	8.4	5.16
14	8.3	10.77	8.1	7.14	7.6	5.03
15	7	10.13	7.6	7.05	7.1	5.05
16	6.6	9.9	7	6.97	6.8	4.98
17	6.4	9.74	6.7	6.96	6.6	4.95
18	6.2	9.65	6.6	6.81	6.5	4.71
19	6.1	9.55	6.4	6.6	6.4	4.57
20	6	9.47	6.3	6.4	6.3	4.17
21	5.9	9.34	6.1	6.01	6.2	3.79
22	5.9	9.27	6.1	5.83	6.1	3.43
23	5.8	9.19	6	5.73	6	3
24	5.7	9.12	5.9	5.55	6	2.78
25	5.6	9.01	5.9	5.4	5.9	2.17
26	5.5	8.89	5.9	5.25	5.8	1.64
27	5.4	8.74	5.8	4.75	5.8	1.14
28	5.3	8.67	5.8	3.84	5.8	0.82
29	5.3	8.58	5.7	2.7	5.8	-0.25
30	5.3	8.43				

North West Basin

	May 10/2017		July 19/2017		September 20/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	9.2	11.63	23.1	9.32	22.9	9.43
1	9.2	11.59	23.1	9.33	22.9	9.41
2	9	11.55	23.1	9.28	22.4	9.45
3	8	11.51	23	9.23	20.2	8.91
4	8.7	11.42	21.8	8.63	19.5	8.44
5	8.6	11.44	21.4	7.97	19.1	7.92
6	8.5	11.37	19.3	5.2	18.7	7.64
7	8.5	11.32	15.4	5.03	18.2	7.06
8	8.5	11.3	13	5.85	16.7	3.91
9	8.5	11.23	11.5	6.34	13.1	3.25
10	8.3	10.86	10.5	6.66	11.3	3.91

11	7.9	10.4	9.8	6.89	10.3	4.15
12	7.6	10.33	9	6.71	9.4	4.15
13	7.3	10.15	8.3	6.55	8.5	3.89
14	7	10.04	8	6.17	8.1	3.42
15	6.9	9.9	7.8	6.03	7.9	3.15
16	6.7	9.69	7.6	5.52	7.8	2.64
17	6.4	9.43	7.6	5.26	7.7	2.59
18	6.4	9.36	7.8	5.41	7.6	2.38
19	6.4	9.32	7.6	5.16	7.6	2.04
20	6.3	9.21	7.6	5.09	7.5	1.81
21	6.3	9.17	7.5	4.97	7.5	1.6
22	6.3	9.15	7.5	4.86	7.5	1.49
23	6.3	9.12	7.5	4.8	7.5	1.42
24			7.4	4.62	7.4	1.43
25			7.4	4.49	7.4	1.31
26			7.3	4.42	7.4	1.29
27					7.4	1.24
28					7.4	1.14
29					7.3	0.58

South West Basin

	May 10/2017		July 19/2017		September 20/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	9.5	10.75	24.1	9.22	22.7	9.48
1	9.3	10.68	24.1	9.2	22.6	9.49
2	9.1	10.62	23.9	9.14	22.4	9.45
3	9	10.56	22.4	8.57	21	9.36
4	9	10.48	21.7	8.13	20.1	9.04
5	8.9	10.47	21.3	6.97	19.3	7.75
6	8.9	10.42	20	5.75	18.8	6.92
7	8.9	10.3	15.3	3.77	17.5	2.88
8	8.8	10.1	11.8	1.94	13.6	0
9	8.7	9.8	11.1	0.97	11.7	-0.14
10	8.6	9.58	10.6	0.51	11.1	-0.17
11	8.6	9.43	10.2	0.06		
12	8.5	9.47				
13	8.2	7.32				

Silver Lake

	May 23/2017		July 17/2017		September 12/2017	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	13.9	11.1	22.6	9.32	19.5	9.42
1	13.8	11.11	22.6	9.3	19.4	9.44
2	13.8	11.09	22.4	9.28	19.3	9.41
3	13.5	11.05	22.3	9.25	19.2	9.39
4	13.3	11.03	22.2	9.25	19.1	9.34
5	12.5	11.03	22.1	9.21	19	9.3
6	11.8	11	20.9	8.42	18.9	9.18
7	10.9	10.98	18.3	8.13	18.8	9.1
8	10.1	10.83	14.6	8.05	18.2	8.24
9	9.4	10.63	12.8	7.79	14.2	5.55
10	8.7	10.47	11.1	7.69	11.6	5.22
11	8.5	10.4	10.3	7.64	10.6	5.2
12	8.2	10.25	9.4	7.59	9.5	5.28
13	8	10.11	8.9	7.62	9	5.33
14	7.6	9.94	8.5	7.66	8.6	5.38
15	7.5	9.8	8.3	7.67	8.2	5.49
16	7.4	9.72	8	7.53	7.9	5.29
17	7.3	9.66	7.8	7.42	7.7	5.05
18	7.2	9.48	7.6	7.32	7.5	4.6
19	7.1	9.34	7.5	7.19	7.4	4.13
20	6.8	9.12	7.4	6.91	7.2	3.42
21	6.7	9	7.3	6.76	7.1	2.97
22	6.7	8.89	7.2	5.98	7	2.15
23	6.7	8.81	7	4.84	6.9	1.37
24	6.7	8.76	6.9	4.31	6.9	0.61
25	6.6	8.73				