Integrated Monitoring Report
2019 Season

Clyde River Subwatershed

Mississippi Valley Conservation Authority

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Cover photos
Top: Palmerston Lake, 2019.
Bottom: Ready to launch on Crotch Lake, 2019.

Executive Summary

The purpose of this integrated monitoring report is to present an overview of the monitoring that Mississippi Valley Conservation Authority (MVCA) undertook during the 2019 season. As such, the emphasis of this report is on lake monitoring results but also includes water levels and flow, snow pack, and stream monitoring data. Each subwatershed within the Mississippi Valley is part of a five-year rotation for this more in-depth results analysis. This strategy will provide readers with a more holistic understanding of each of the subwatersheds. The Clyde River watershed was the primary focus for 2019. Additionally, four lakes along the main stem of the Mississippi River were sampled in 2019.

The most significant factor affecting the lakes and streams in the summer of 2019 was the spring high flows followed by late season dry conditions. Water levels were high in the spring due to an above average flood event with peak flows on April 21st, and then there was a hotter than usual summer. MVCA issued a Level 1 Low Water Condition Statement on in mid-September which was in place until the end of October.

Our lake monitoring results returned several higher than usual total phosphorus (TP) results in 2019. It is hard to determine what the exact cause of all of these high values were as there are many variables at play when taking samples outside of a controlled lab environment. Some of the high values are likely due to rain events occurring in the days previous to sampling, these events wash nutrients off the land and into the surface waters of a lake or river. These nutrients are then either consumed by the algae and aquatic plants or are flushed further downstream. High values in the lower waters could be due to a combination of three suspected causes. The first of which is the potential inaccurate use of a new piece of equipment resulting in contaminated samples. The second is the potential for disturbing and subsequently collecting the nutrient rich sediments while getting a sample from 1 meter off bottom. The third possibility is the chemical process that happens when nutrient rich sediments are in a low oxygen environment (less than 2 mg/L, also known as anoxic conditions), where phosphorus bound to the sediment becomes distributed in the water again. Sampling this low oxygen water could return high phosphorus results. When doing field work and interpreting results there are always a number of uncontrolled variables to account for. This is why MVCA visits the lakes more than once in a season as well as returns year after year to build up a long-term data set that helps us interpret if a high value is part of the natural character of the lake, an outlier or an indicator of something else happening.

Through the stream monitoring program, 16 sites were targeted in 2019 for fish population and thermal habitat assessment. Five of these sites were found to support cold water fish species. This report emphasizes the value of the combined monitoring conducted through MVCA's Water Management, Lake Monitoring, and Stream Monitoring programs. The information gathered through these efforts supports our stewardship program as well as our planning and regulations department.

Introduction

The Lake Monitoring Program (also known as Watershed Watch) was initiated at the Mississippi Valley Conservation Authority (MVCA) in 1998 in partnership with the Mississippi Valley Lake Stewardship Network. The goal of the program is to accumulate reliable environmental data on the 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. It continues to provide valuable baseline data while promoting stewardship of these important features.

The main goal of the lake monitoring program is to collect environmental data and monitor trends on the lakes of the Mississippi Valley watershed. Ideally the program would sample every lake annually. However, due to the large number of lakes monitored within the MVCA area (45 lakes monitored, over 300 total), a rotational sampling program is undertaken with the goal to collect baseline data and to monitor general trends. MVCA collects relatively simple data on parameters that are easy to repeat yet play an important role in water quality assessments. The data MVCA collects is insufficient on its own for 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 should consider the Lake Partner Program (LPP) which is coordinated through the Dorset Environmental Science Centre. Relying on volunteer effort, this program provides equipment and an excellent framework for yearly data collection. It is also an excellent means to promote awareness and ownership of lake health to lake communities.

Accompanying the lake monitoring program is MVCA's Stream Monitoring program. This program collects valuable information on stream temperature, as well as fish and benthic communities of the watershed's many tributaries. It follows Ontario Stream Assessment Protocol (OSAP) methods to conduct stream site identifications, electrofishing, benthic surveys, and temperature monitoring at various sites throughout the year. In 2019, MVCA sampled 7 stream sites representing the Clyde River subwatershed and 8 sites distributed across four other Mississippi River subwatersheds.

The goal of MVCA's fish data collection is largely to determine the presence or absence of cold or cool water species. These species are indicators of the thermal regime of a stream as they require very specific conditions to thrive. Changes in their abundance may indicate habitat trends. MVCA has been monitoring the water temperature at select sites to confirm the potential thermal habitat available as well as tracking thermal trends between years for longer term climate analysis.

Water Quantity Monitoring

Summary

Three types of water quantity monitoring occurred in the Clyde subwatershed in 2019; snow pack, water levels, and water flow. Figure 1 portrays the locations of the various gauges used to collect water level and flow data, the locations of snow courses where snow pack water content is measured, and the lakes monitored in 2019.

There are seven water level gauge stations in the Clyde River subwatershed; Palmerston Lake, Canonto Lake, Widow Lake, Gordon Rapids, Clydesville, the Lanark bridge at Highway 511 and the Lanark Dam on the Clyde River at Mill Road. Two of these stations (Gordon Rapids and Clydesville) also have stream flow and rain gauges.

The spring flood of 2019 was one of the largest floods recorded on the Mississippi River producing record highs in the majority of the river system. The start of the year saw above average snow pack, by mid-April, flows had picked up as a result of snowmelt but were well below even normal spring peak conditions. Dams along the Clyde River were operated to pass flows as they increased. Significant rainfall (in excess of 100 mm) over a five day period from April 15th to 20th coupled with warmer weather generated a quick melt and release of water from the snow pack that entered streams and rivers at very high flow rates. The Clyde River flows were not as high as experienced in 1998 but were significantly higher than normal spring peak conditions.

Summer brought warmer than normal conditions, causing flows and levels to drop below average on the Clyde River. A level one minor drought declaration was issued mid-September, but due to a wet October that declaration was terminated by the end of the month.

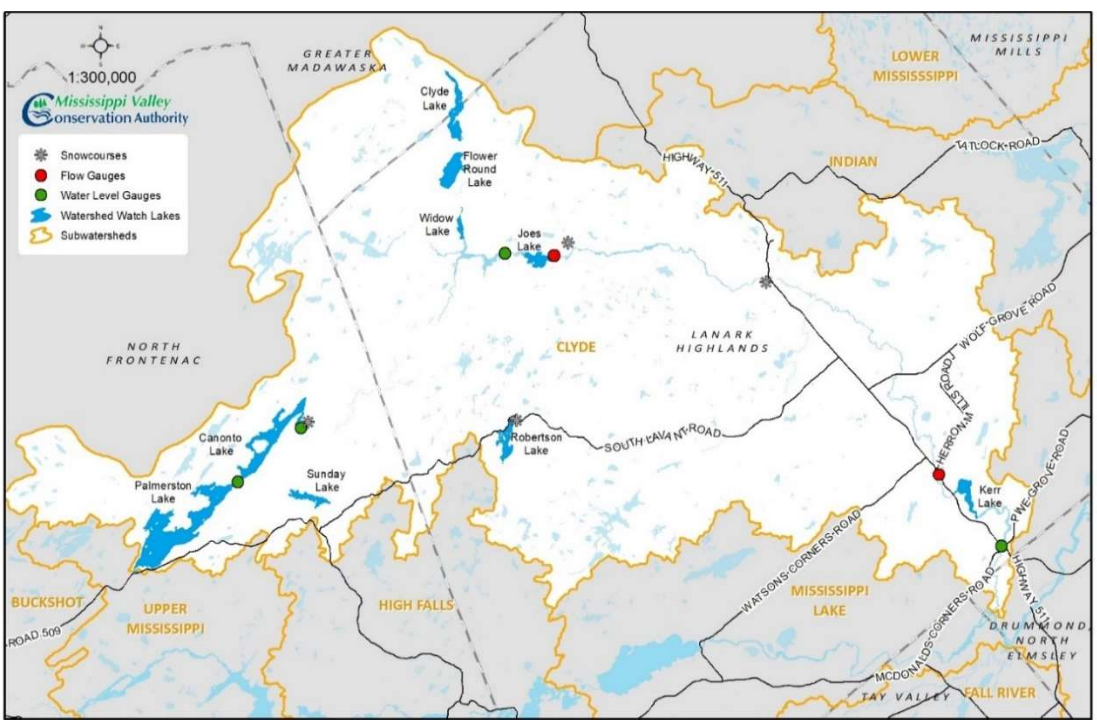


Figure 1: The various water quantity monitoring sites in the Clyde River subwatershed, plus the Clyde watershed lakes monitored in 2019.

Snow Pack

Snow pack is measured at 16 sites within the MVCA's jurisdiction. The data collected with this program provides MVCA with information on the expected spring runoff for that year. This assists in decisions related to dam management and flood forecasting. These water management efforts are critical to minimizing flood damage, maintaining flows and water levels for fish and wildlife, and meeting the target levels for summer recreational activities. There are four snow courses in the Clyde Watershed; Canonto, Lavant Station, Gordon Rapids and Brightside. The snow pack results for 2019 can be seen in Figure 2.

Measuring snow depth and equivalent water content

It is evident that with the exception of an event in early January most of the Clyde River subwatershed was above average for snow water content in 2019. The area was then clearing of snow by mid-April. The snow courses in the rest of the Mississippi Valley showed a similar trend.

The spring melt as well as the rain events after the mid-April snow pack readings resulted in an above average spring flood season with peak flows occurring on April 21, 2019.

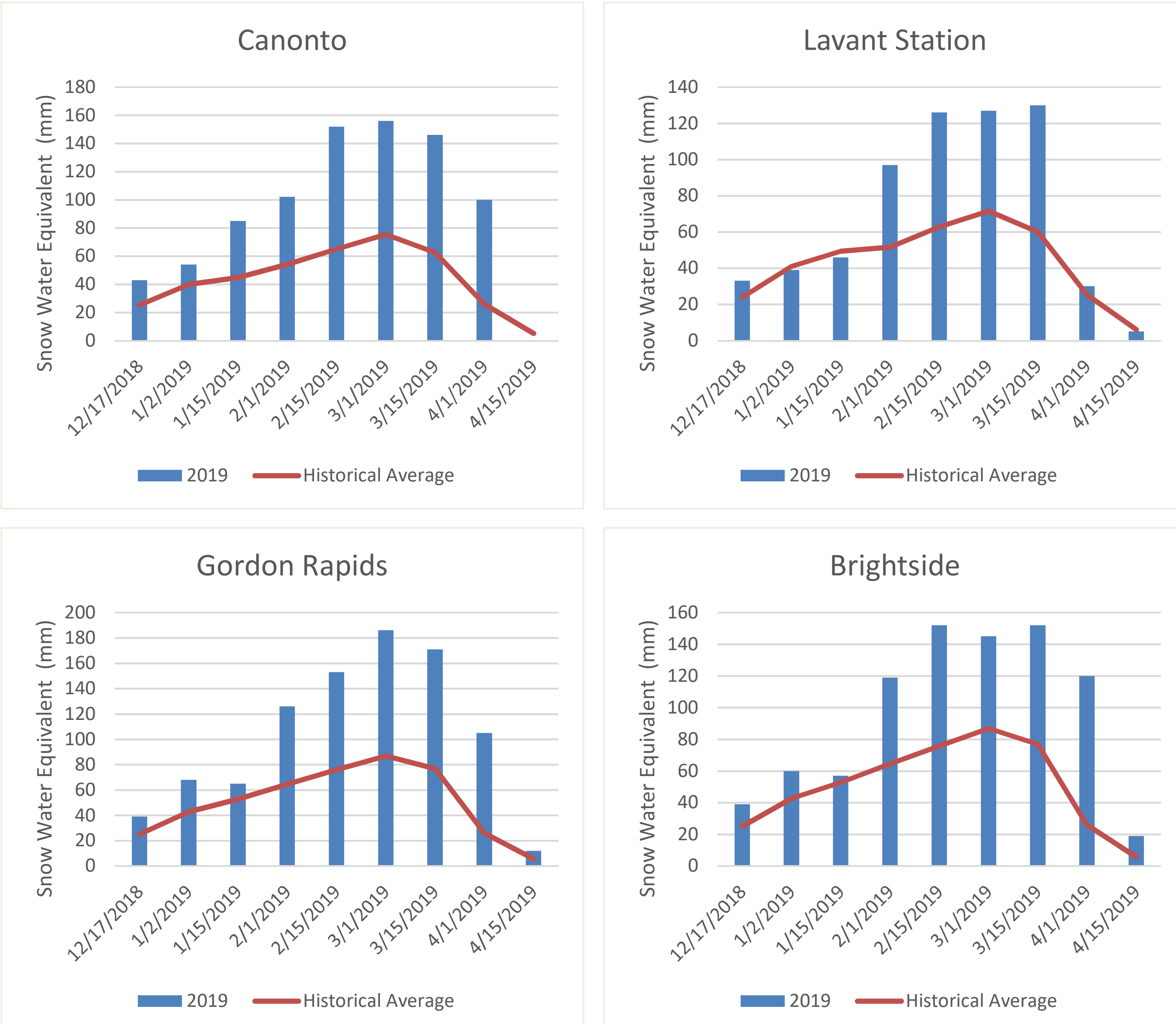


Figure 2: 2019 Clyde River subwatershed snow water equivalent levels vs. historical averages sampled at each of the Clyde River subwatershed snow course station.

Stream Flow and Precipitation

Precipitation gauges are located with streamflow gauge stations across the watershed. These gauges inform us of the conditions which influence water levels on the Mississippi River. This report will focus on 2019 data from the stream flow and rain gauge station at Gordon Rapids (just downstream of Joe's Lake) and the stream flow and rain gauge station near Clydesville (upstream of the village of Lanark). The daily total rainfall and the daily mean flows at these two gauge stations can be seen below in Figure 3 and Figure 4.

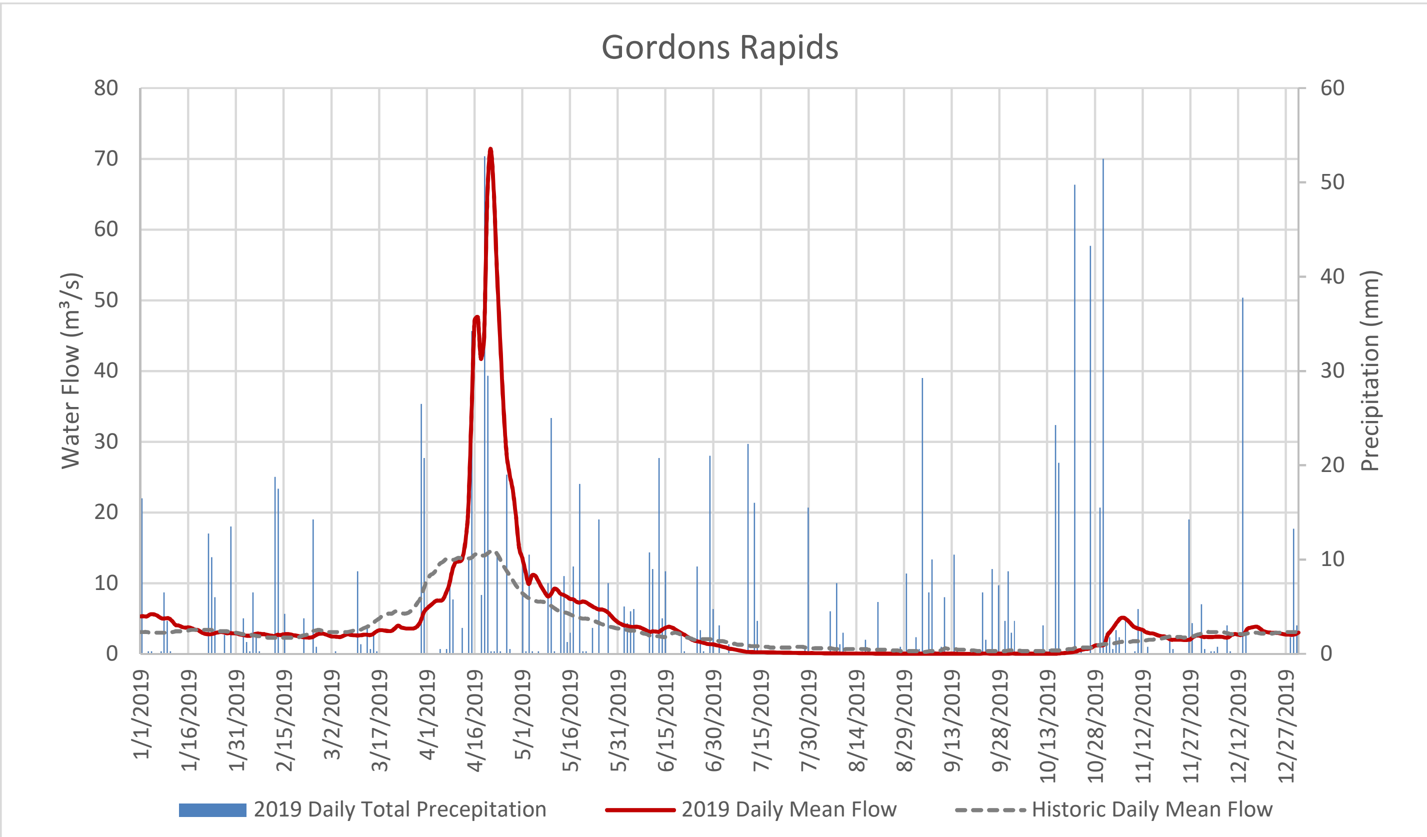


Figure 3: Daily total precipitation and daily mean water flows at the Gordon Rapids gauge station for 2019 compared to the historic daily mean flows for the site.

The stream flow and rain gauge station at Gordon Rapids

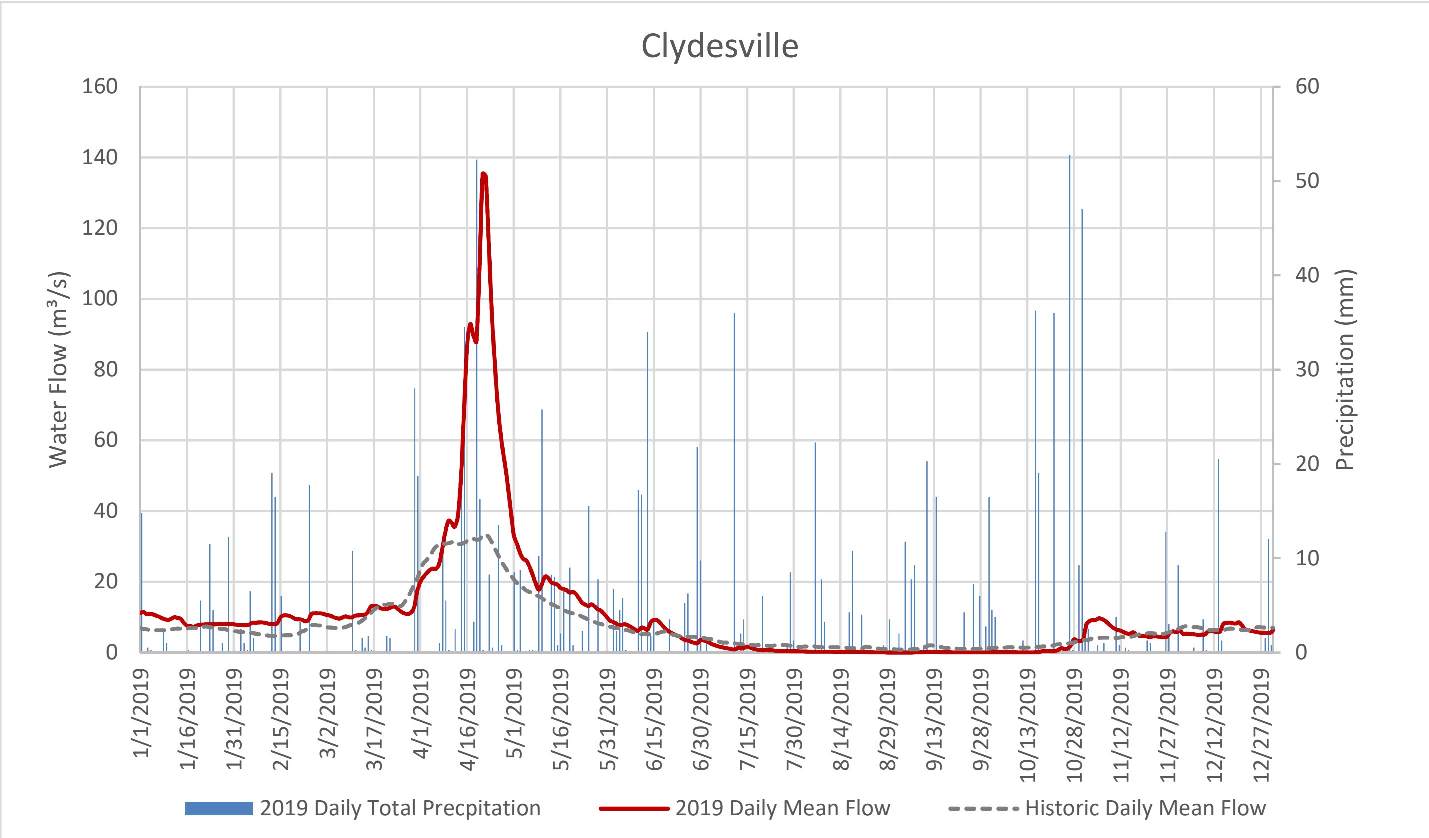


Figure 4: Daily total precipitation and daily mean water flows at the Clydesville gauge station for 2019 compared to the historic daily mean flows for the site.

Figures 3 and 4 show peak flows occurred on April 21st and 22nd, respectively, during a higher than average spring flood season. Later in the year, MVCA issued a Level 1 Low Water Condition Statement on September 17, 2019, indicating that the watershed was experiencing drought conditions. The low flow conditions lasted until October 31, 2019 when the Level 1 Low Water Condition Statement was lifted.

Both Figure 3 and 4 show a large number of precipitation events occurring throughout the year. However, when the data is further analyzed, Gordon Rapids recorded precipitation on 156 days. 120 (77%) of those days contributed 10 mm or less rain to the upstream areas of the Clyde River. The lower portion of the Clyde River subwatershed had similar but slightly dryer conditions with 144 days of precipitation and 107 (74%) of them contributing 10 mm or less rain to this part of the subwatershed.

Due to the hot summer season experienced in 2019, the rain that did fall infiltrated the soil leaving little surface runoff to contribute to the stream water levels or flows.

The stream flow and rain gauge station on the Clyde River near Clydesville at Hwy 511.

Lake Water Levels

MVCA operates 18 dams throughout the watershed. Water levels in six of the lakes monitored in 2019 are managed by dams (Palmerston Lake, Canonto Lake, Widow Lake, Mazinaw Lake, Crotch Lake and Mississippi Lake). Water levels are measured from gauges installed at many dams and gauge stations around the watershed. In the Clyde River subwatershed there are water level gauges on the dams at the outlets of Palmerston Lake (Figure 5), Canonto Lake (Figure 6) and Widow Lake (Figure 7).

Due to the wet spring, the lakes started the season with high water levels. However, the summer was warmer than normal and a level 1 minor drought was declared by mid-September which was terminated at the end of October.

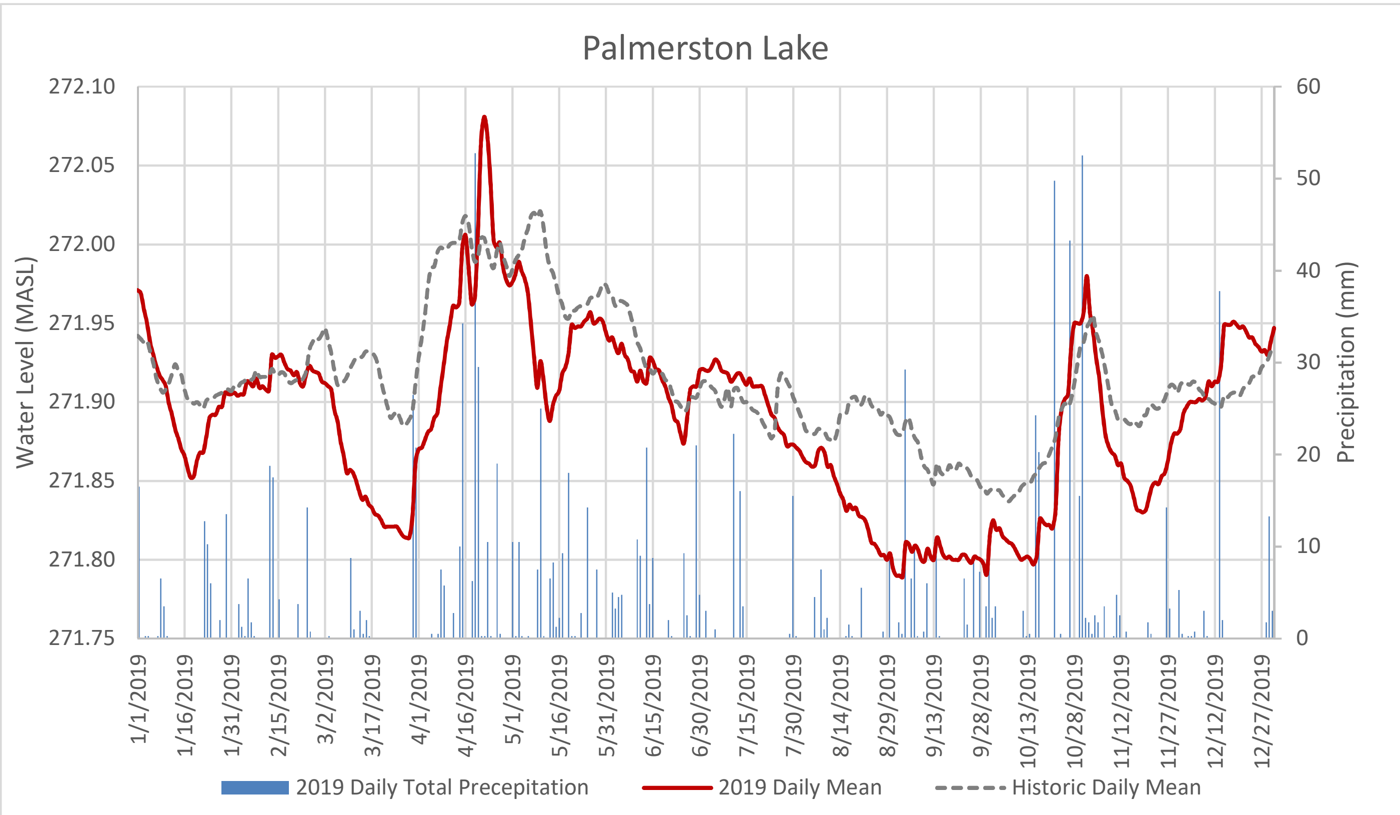


Figure 5: 2019 and historic daily mean water levels (meters above sea level - MASL) at the Palmerston Lake dam compared to the 2019 daily total precipitation at Gordon Rapids.

The dam and gauge at the outlet of Palmerston Lake

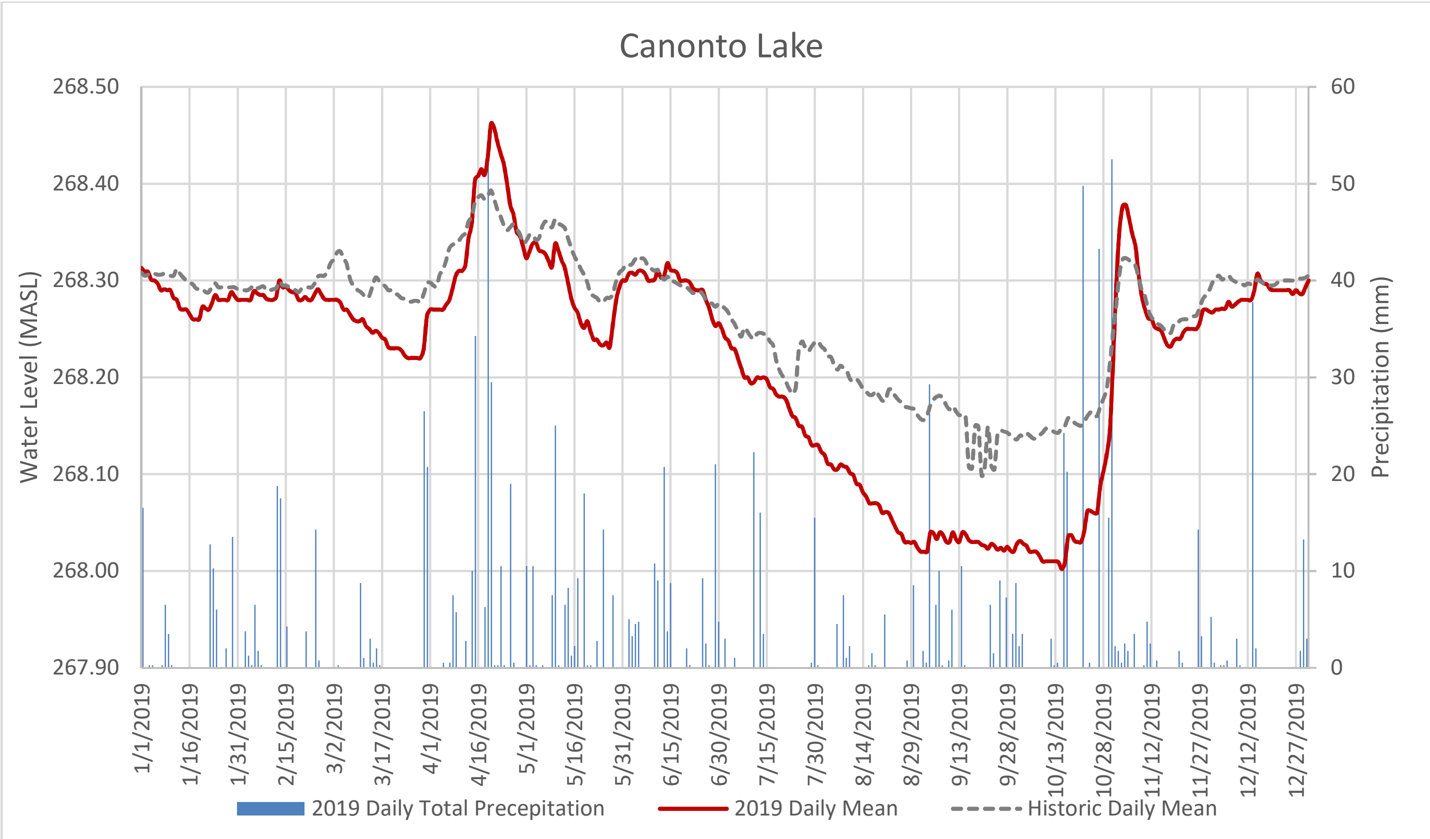
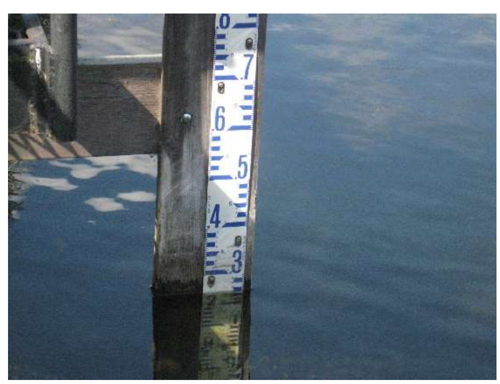


Figure 6: 2019 and historic daily mean water levels (MASL) at the Canonto Lake dam compared to the 2019 daily total precipitation at Gordon Rapids.

The dam at the outlet of Canonto Lake



Staff gauge at the Canonto Lake dam

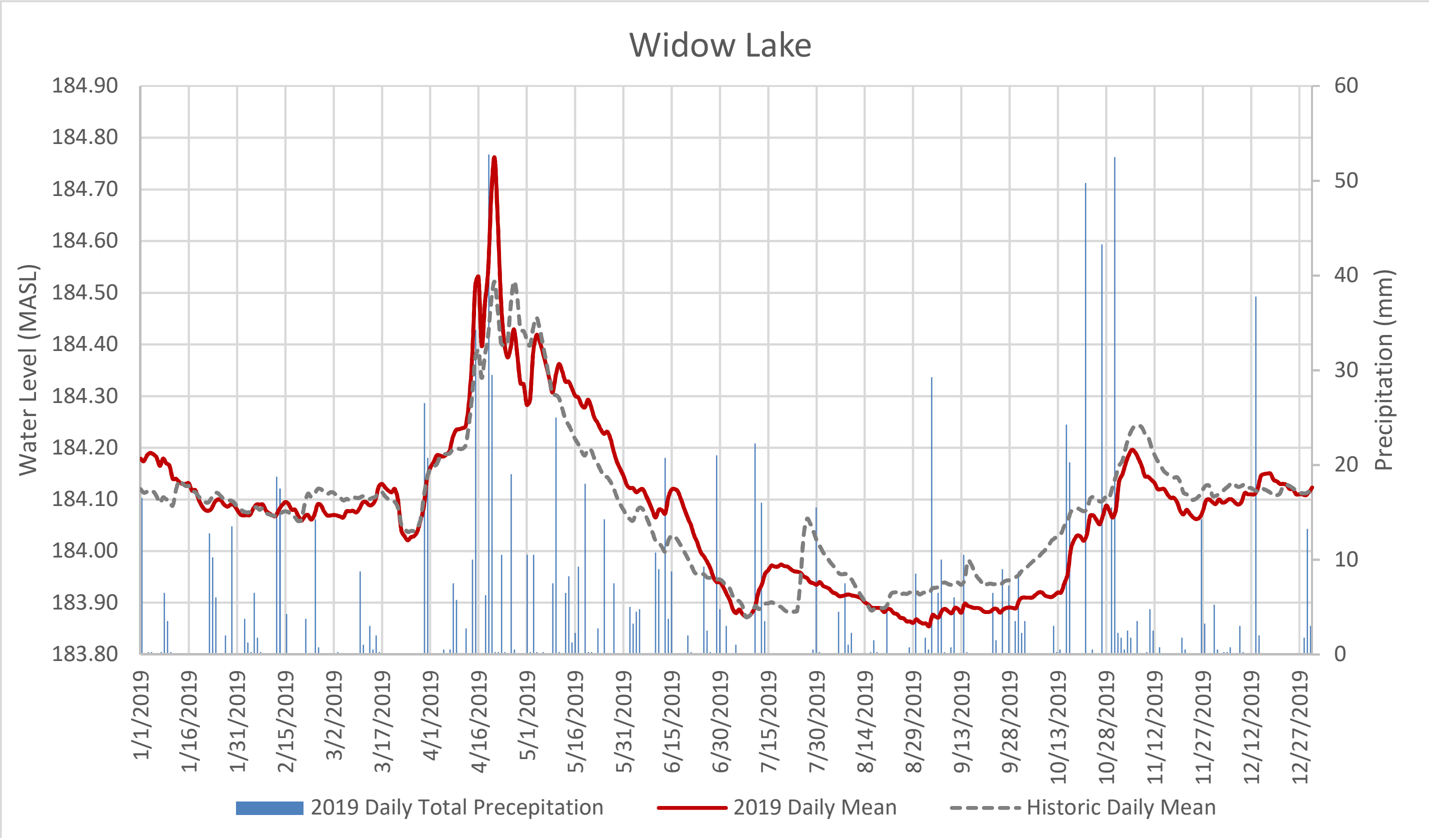


Figure 7: 2019 and historic daily mean water levels (MASL) at the Widow Lake dam compared to the 2019 daily total precipitation at Gordon Rapids.

The dam at the outlet of Widow Lake

Lake Monitoring Program

In 2019, the sampling focus was on the Clyde River subwatershed, located in the north central portion of the watershed, it flows from Ompah to the village of Lanark. The Clyde River is the largest tributary to the Mississippi River, is 48.5 km long[1] and has a watershed area of 667 km^2. Nine lakes were sampled in the Clyde River subwatershed and four additional lakes were sampled to represent the main Mississippi River for a total of thirteen lakes sampled in 2019. Table 1 lists the lakes sampled under the subwatershed they are within, listed in order upstream to downstream. Figure 8 highlights the lake sites where sampling occurred in 2019 in a bolder blue than the rest of the lakes on the map.

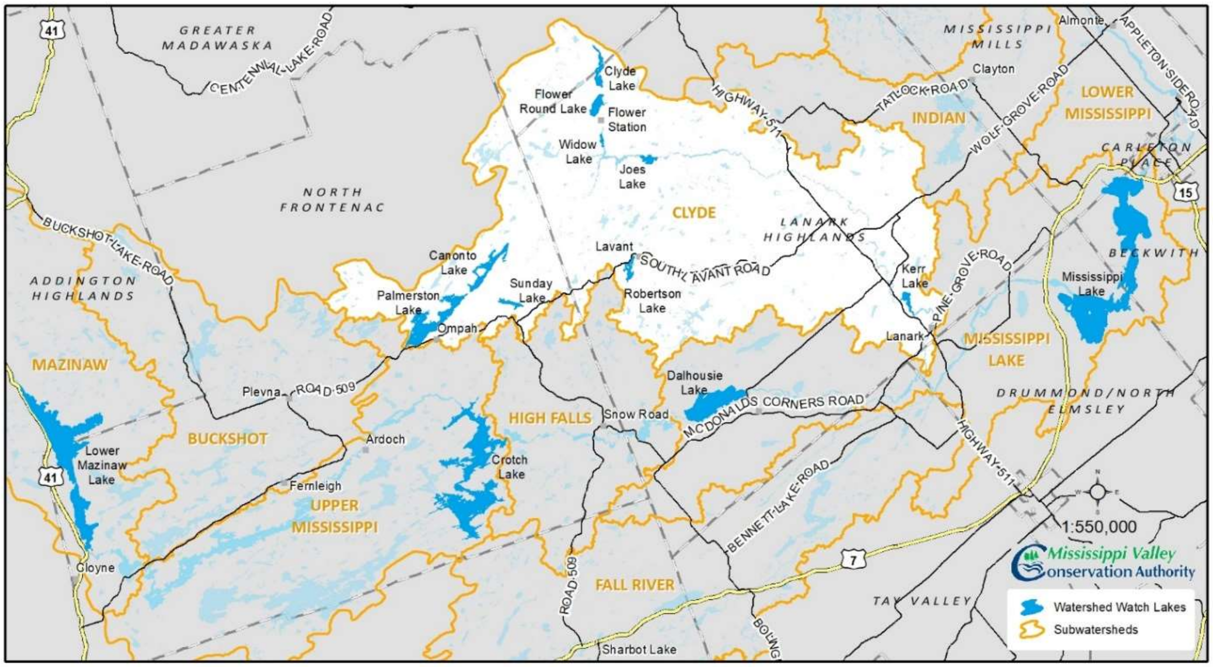


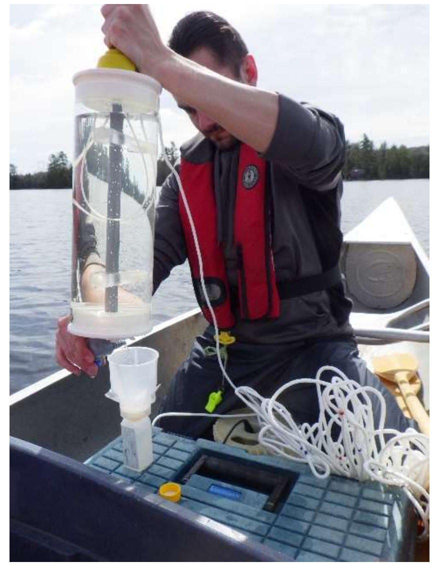
Figure 8: The lakes shown in darker blue are the 13 lakes monitored in 2019. The Clyde subwatershed is shown here in white, 9 lakes sampled in 2019 were within this watershed.

Table 1: Lakes sampled in 2019.

Mississippi Main Stem	Clyde River Subwatershed
Mazinaw Lake	Palmerston Lake
Crotch Lake	Canonto Lake
Dalhousie Lake	Sunday Lake
Mississippi Lake	Clyde Lake
	Flower Round Lake
	Widow Lake
	Joe’s Lake
	Robertson Lake
	Kerr Lake

1 River length starts at the confluence of the north, south and middle branch Clyde Rivers in the Clyde Forks area.

Results Summary


Filtering a bottom sample

This year there were 36 sample results which exceeded The Provincial Water Quality Objective (PWQO) for TP of 20 µg/L. Based on other variables we measure, as well as historical data, these results can possibly be interpreted as; a) part of the usual character and patterns for the lake, b) due to a natural or explainable causes such as a large rainfall or run off event, c) due to the way phosphorus interacts with water and sediment in low oxygen (anoxic) environments, or d) due to a sampling/processing error resulting in sample contamination. Although we cannot provide one reason for any particular TP exceedances seen in 2019, we believe it is likely that a combination of the above may have occurred within the 2019 season.

A possible reason for many of the high TP results we received in 2019 from the bottom sample water could have been due to internal phosphorus loading. This is a process in which phosphorus is mobilized (redistributed) into the water column (Revised Water Quality Model and Lake System Health Program, Hutchinson Enviro Ltd. 2016) when there are low dissolved oxygen levels (< 2 mg/L) in the water. Through analysis of the TP values against the dissolved oxygen profiles it can be seen that some lake samples returned high total phosphorus results when there was less than 2 mg/L dissolved oxygen in the bottom waters. This situation fits the definition/requirements of internal phosphorus loading and could be the reason for many of the high bottom water TP results.

Another possible explanation for some of the high 2019 bottom TP results is a change in the sampling equipment used. In 2019 MVCA acquired a new Kemmerer bottle (bottom sampler). The in-field use of the new equipment resulted in slight changes in sampling methodology which may have led to contamination of samples. Due to the potential for sampling errors during the use of this equipment MVCA will be reviewing and updating the Watershed Watch Program Operation Manual to ensure all components of the sample collection procedure are clearly laid out and consistently undertaken.

Overall, the lakes sampled in 2019 maintained historic trends for TP levels, Secchi depth and trophic status, despite the numerous exceedances of the PWQO for TP (20 µg/L) in 2019. The lakes will continue to be sampled as part of the regular rotation to further support that these high TP results are one-off occurrences and not drastic changes in the lake's characteristics. The 2019 TP results are a key example of why long-term lake monitoring is so important overall and in regards to determining outliers. Without historical knowledge of these lake systems the TP values would be of greater concern. However, we do not believe these exceedances to be of concern for lake users as most of these values occur outside of the historical normal TP ranges for those respective lakes and are not occurring as part of a seasonal or annual trend. We feel confident making these conclusions based on the many years of data we have for most of our lakes. In 2020, MVCA will conduct replicate samples to increase confidence in the integrity of the samples collected.

To help interpret and display the results of the lake monitoring program a box and whisker plot has been used. This type of chart is used to highlight the range of the middle 50% of the results. It shows the median value with a line indicating the middle of the data set, and this type of graph shows if any results are considered outliers from the data set as dots above/below the whiskers. As seen in the examples below (Figure 9 and 10). We have chosen to use Box and Whisker plots in order to help interpret the high TP results seen in 2019 against the full data set for each of our sampling locations. If a result is between the minimum and maximum values, we could say more confidently that the value was a part of the natural variance in the lake. When a TP result is determined to be beyond the minimum or maximum values, it is labeled an outlier, indicating that the result could be attributed to sampling error or contamination. The lakes will continue to be monitored as part of our regular sampling rotation which enhances the depth of our long-term data set and improves our understanding of the results from 2019.

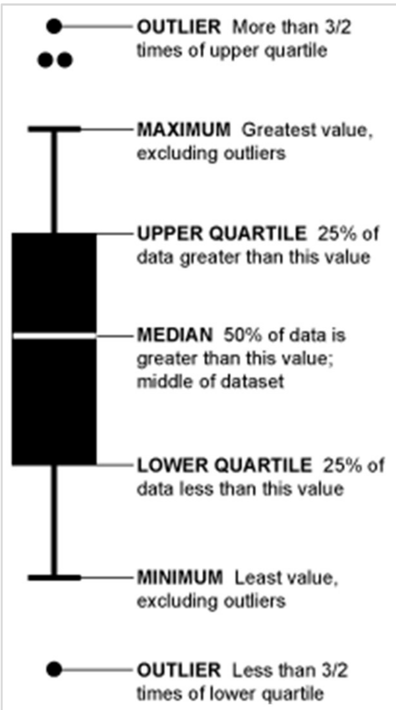


Figure 9: How to interpret a Box and Whisker Plot.

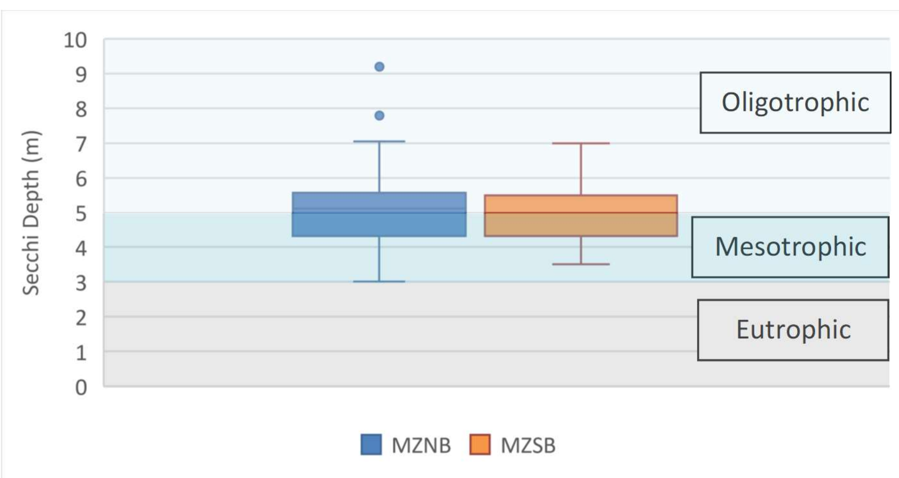


Figure 10: An example of a box and whisker plot from Mazinaw Lake's Secchi depth results compared to trophic statuses.

Lake Monitoring Indicators and Methodology

The Lake Monitoring 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. These parameters are further described below.

Total Phosphorus

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 there tends to be 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 (TP) is measured in micrograms per liter (μg/L).

Kemmerer Bottle

As part of the Lake Monitoring program, two types of total phosphorus levels are measured at each sampling location: euphotic zone phosphorus (TPA) and bottom phosphorus (TPB). All TP samples are filtered through an 80-micron mesh to remove zooplankton which could skew results. The euphotic zone is defined as twice the Secchi depth and is the depth to which light can reach and influence plant growth.

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 when the weight hits the bottle, 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 2 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 even within years, so it is important to look at larger trends rather than one or two exceptional years.

Table 2: Interpreting total phosphorus results.

Total Phosphorus Level	Lake Trophic Status
< 10 μg/L	Oligotrophic – unenriched, few nutrients
10.1 – 19.9 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 keep phosphorus below this level in order to maintain aquatic health and 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 to the point where it can no longer be seen. The greater your Secchi depth, the clearer your lake is. 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 or the presence of other suspended materials in the water. Secchi depth can also be influenced by the presence of zebra mussels as they filter the water and feed on the algae and zooplankton, making the water clearer and increasing possible Secchi depths. Often a decrease in Secchi depth occurs in unison with an increase in phosphorus. The following guideline shown in Table 3 is used to determine your lake's nutrient status according to Secchi depth.

Secchi disc

Table 3: 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, MVCA measures 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.

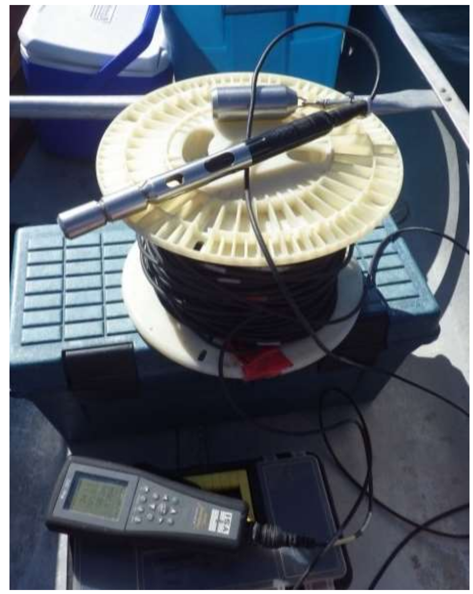
Calcium enters a lake largely through the mineral weathering of rocks (especially marbles and limestones). It is then either used by aquatic organisms for bones or shells or as a component in the cell walls of aquatic plants, and eventually deposits into the sediment of the lake. Because of its importance 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 are also required for zebra mussels to thrive.

Dissolved Oxygen

Adequate dissolved oxygen (D.O.) levels 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.

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 (the steep temperature gradient between the warm sunlight epilimnion water and the cooler hypolimnion water below). Also, during the fall the phytoplankton that have been active during the summer months begin to die and settle to the bottom of the lake. The bacteria that decompose the phytoplankton consume large amounts of dissolved oxygen, further depleting stores in the hypolimnion. The low levels of D.O. in the bottom depths of a lake decrease the amount of critical habitat available for cool water fish species to thrive.



Optical Dissolved Oxygen Probe

Dissolved oxygen is measured using an Optical Dissolved Oxygen Probe. This instrument, pictured above, is lowered through the water at one-meter intervals, where it takes both temperature and D.O. readings. This creates a dissolved oxygen profile where changes in temperature and D.O. can be recorded as depth increases. Table 4 shows the optimal temperature/D.O. combinations for cold, cool, and warm water fish habitat. Results from the D.O. and water temperature profiles for each of the 2019 lake monitoring sites are available in the Appendix A.

Table 4: 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.

Main Mississippi River Lakes

Mazinaw Lake

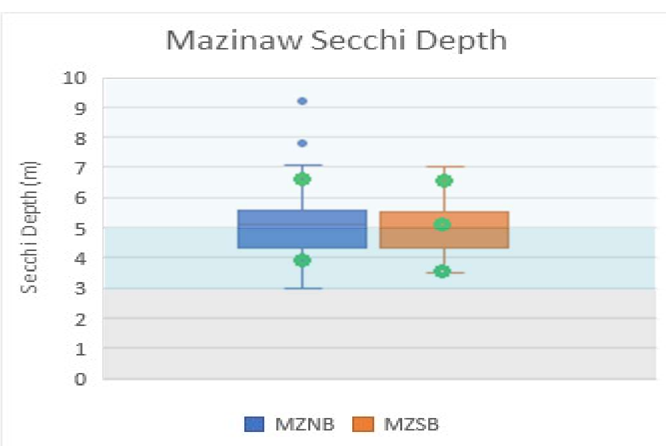
Mazinaw Lake is a large and deep lake on the western edge of the Mississippi Valley watershed. A large section of the lake is part of Bon Echo Provincial Park. It has a maximum depth of 145 meters (m), making it the seventh deepest lake in Ontario and the deepest lake in the Mississippi Valley watershed. It also features a picturesque rock wall standing over 100 m tall 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. The 2019 season is no different with the majority of the samples near or within the oligotrophic range with low total phosphorus concentrations and moderate to deep Secchi depth measurements (Table 5, Figure 11).

Mazinaw Lake maintains optimal and critical cold-water fish habitat throughout the ice-free season persisting at depths greater than 9 m into the fall (Appendix A). Mazinaw Lake has historically supported thriving populations of lake trout in its deeper waters, and warm water species such as pike, walleye, and bass in the shallower and warmer areas. The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 5: 2019 sampling summary for Mazinaw Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L) *	pH	Calcium (Ca2+) (mg/L)
North Basin	06/03/2019	4.0	2	4	6.23	16
North Basin	08/02/2019	6.5	9	9	8.37	
North Basin	09/18/2019	4.0	9	12	n/a	
South Basin	06/03/2019	3.5	5	4	7.00	16
South Basin	08/02/2019	6.5	8	14	8.03	
South Basin	09/18/2019	5.0	14	16	n/a	

*Total phosphorus bottom samples are typically taken 1 m off bottom, however in the case of Mazinaw Lake's south basin it is taken between 47 m and 50 m deep.



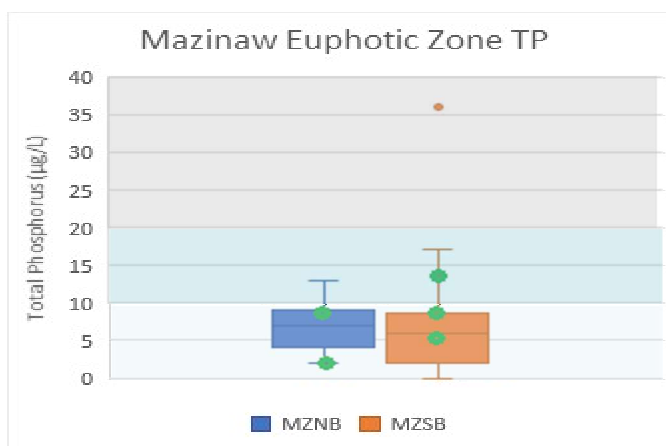


Figure 11: Secchi Depth and Euphotic Zone Total Phosphorus results from six sampling years for both basins of Mazinaw Lake, compared to the 2019 results shown with a green dot. as compared to the trophic level classifications.

Crotch Lake

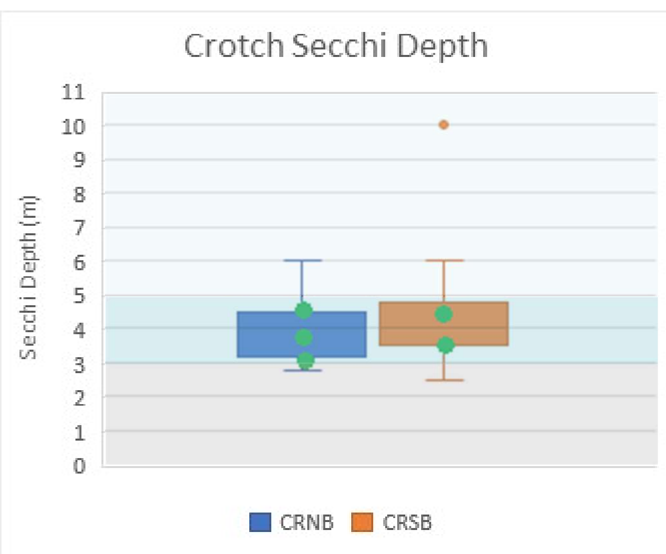
Crotch Lake is a very hydrologically important lake in the watershed. Its size and position within the watershed allow it to serve as the largest reserve on the Mississippi River system. The lake is approximately 24 m deep in the south basin, however due to the lake's role as a reservoir the actual depth of the lake varies by 3 – 4 m within an average year and is influenced by melt/rain events as well as summer drought conditions. The lake supports warm water fish species such as Smallmouth Bass, Northern Pike, and Walleye. The lake is also known to support the cold-water lake whitefish. Despite its size the lake has very few private shoreline properties and is mostly surrounded by Crown Land.

The results from the 2019 monitoring season are shown in Table 6 and are compared to past years results in Figure 12. Within the seven years of monitoring Crotch Lake the Secchi depths have predominantly stayed within the mesotrophic range of 3–5 m depth and the majority of total phosphorus results are near or below 10 µg/L indicating an oligotrophic status. There have been a few occurrences of euphotic zone total phosphorus results being greater than 20 µg/L however, they do not occur as a pattern or trend within the dataset and are considered outliers.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 6: 2019 sampling summary for Crotch Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca^{2+}) (mg/L)
North Basin	05/30/2019	3.0	9	4	7.66	
North Basin	07/15/2019	4.75	36	32	8.50	
North Basin	09/19/2019	3.75	9	19	n/a	
South Basin	05/30/2019	3.5	4	6	7.94	16
South Basin	07/15/2019	4.5	31	20	n/a	
South Basin	09/19/2019	3.5	16	14	n/a	



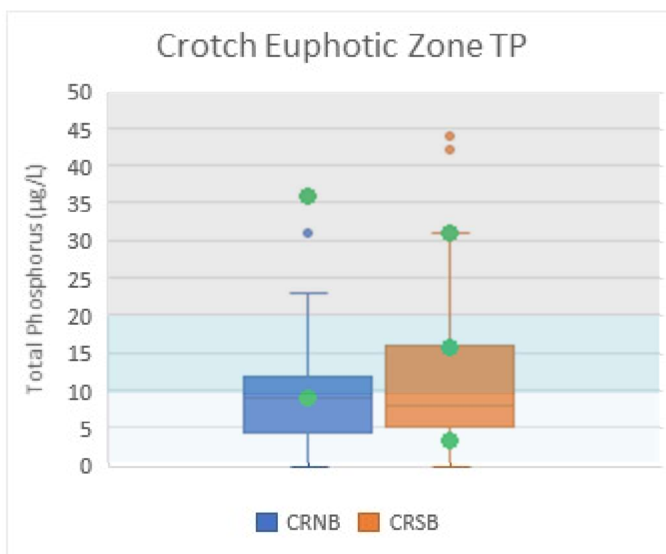


Figure 12: Secchi Depth and Euphotic Zone Total Phosphorus results from seven sampling years for both basins of Crotch Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Dalhousie Lake

Dalhousie Lake is the last main river lake before the Clyde and Fall Rivers join the Mississippi near Lanark. It is a wide and shallow lake with the deepest area of 17 meters in the western half. The lake provides warm water habitat to northern pike, small and large mouth bass, walleye and other fish species.

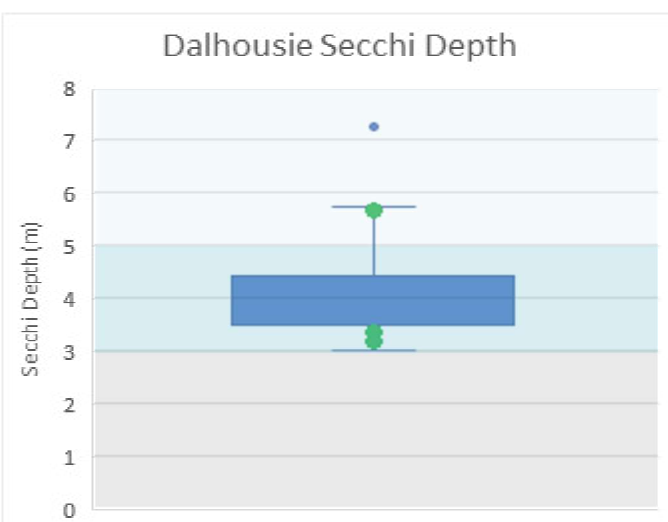
The results from the 2019 season are shown in Table 7 and are compared to past years results in Figure 13.
Based on Secchi depth and surface water total phosphorus results from seven sampling seasons, the lake maintains its mesotrophic classification.

As seen in Table 7, bottom sample total phosphorus results for Dalhousie Lake are often very high. In 2017 and 2018, high bottom sample values also occurred. In 2019 Dalhousie Lake experienced really low (< 2 mg/L) levels of dissolved oxygen in the bottom 4 to 7 m of the water column during both the July and September sampling events. Dalhousie Lake can have a high flushing rate due to the high riverine flows passing through this part of the watershed at certain times of year. However, during the summer months when river flows are reduced, the mixing and flushing of the bottom lake water is also reduced. As a large main river lake, Dalhousie will continue to be monitored frequently to track the lake's condition, in particular the high total phosphorus in the bottom waters.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 7: 2019 sampling summary for Dalhousie Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca2+) (mg/L)
Main Basin	05/15/2019	3.2	< 2	4	7.47	40
Main Basin	07/19/2019	3.25	14	214	8.42	
Main Basin	09/16/2019	5.75	19	n/a	n/a	



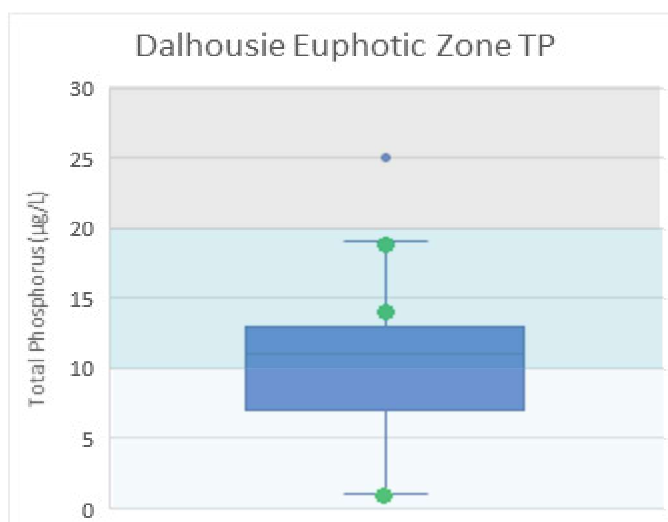
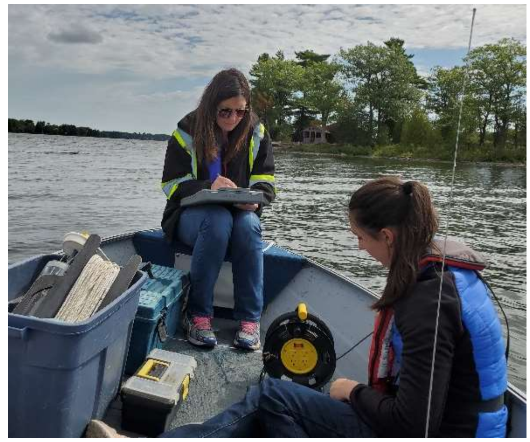


Figure 13: Secchi Depth and Euphotic Zone Total Phosphorus results from seven sampling years for the main basin of Dalhousie Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Mississippi Lake



Mississippi Lake is a large and shallow warm water lake in Lanark County. It is the most downstream lake on the main stem of the Mississippi River system and its outlet is at the town of Carleton Place. It has a maximum depth of 10 meters. MVCA began monitoring Mississippi Lake in 2002, and has now monitored it through 15 ice free seasons. A summary of the results from the 2019 survey are found below in Table 8.

Figure 14 illustrates how this year's results for Secchi depth and euphotic zone total phosphorus samples relate to the overall data set for each of the four sampling points on the lake. This year the inlet site had one sample at 20 µg/L and one at 27 µg/L which is at the threshold for an eutrophic classification. Figure 14 shows all historical Secchi depth and euphotic zone TP data for Mississippi Lake. When the whole dataset is compared it is clear that the 2019 data is within the normal range. While there are past outliers in the dataset, we feel this data doesn't show a trend and can be attributed to contamination or unique events on the landscape. The overall historical trend for both the Secchi depth results and the TP results is that the lake is predominantly within the mesotrophic classification and the 2019 results maintain this classification.

Water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 8: 2019 sampling summary for Mississippi Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L) *	pH	Calcium (Ca2+) (mg/L)
Inlet (MLI)	5/29/2019	2.5	27	17	6.3	40
Inlet	7/9/2019	4	13	23	7.81	
Inlet	9/6/2019	5.25	20	127	n/a	
Inlet	10/15/2019	4.5	6	7	n/a	
Burnt Island (MLB)	5/29/2019	2	16	13	6.65	40
Burnt Island	7/9/2019	4	14	12	8.02	
Burnt Island	9/6/2019	2.75	19	82	n/a	
Burnt Island	10/15/2019	2.5	12	11	n/a	
Pretties Island (MLP)	5/29/2019	2.5	15	<2	7.05	
Pretties Island	7/9/2019	4	15	n/a	8.12	
Pretties Island	9/6/2019	3.25	16	n/a	n/a	
Pretties Island	10/15/2019	4	11	n/a	n/a	
Outlet (MLO)	5/29/2019	2.5	12	n/a	7	
Outlet	7/9/2019	2	14	n/a	8.29	
Outlet	9/6/2019	2	15	n/a	n/a	
Outlet	10/15/2019	2.5	8	n/a	n/a	

*Total Phosphorus samples are only taken from 1 m off the bottom of the lake if the euphotic zone does not extend to the bottom.

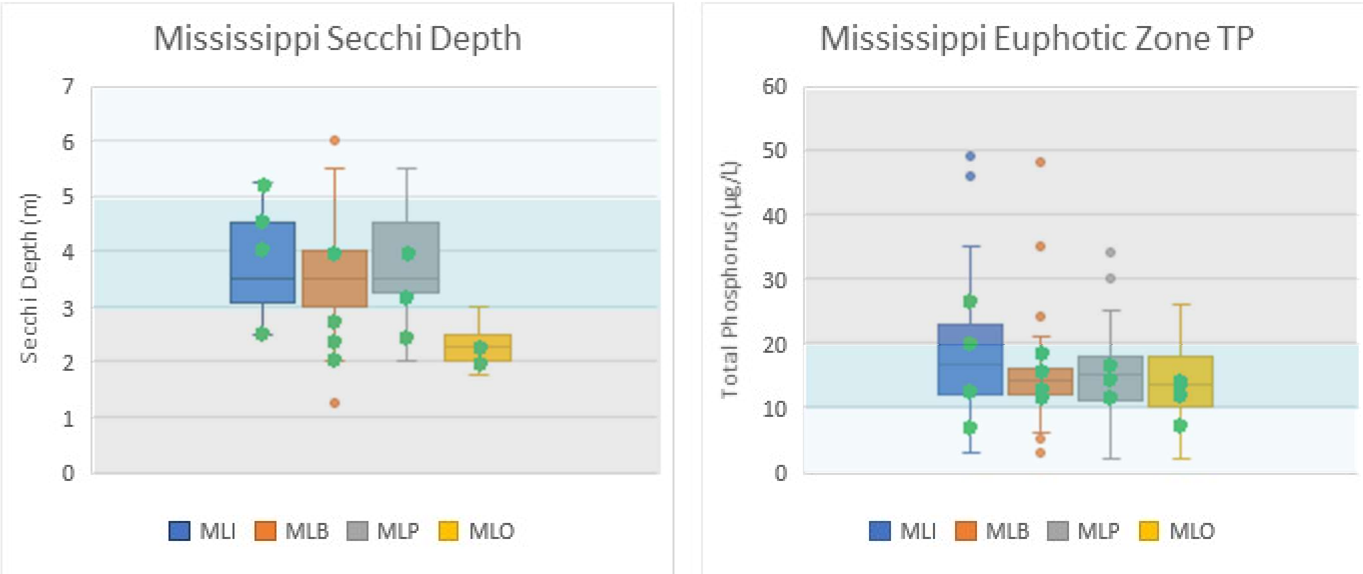
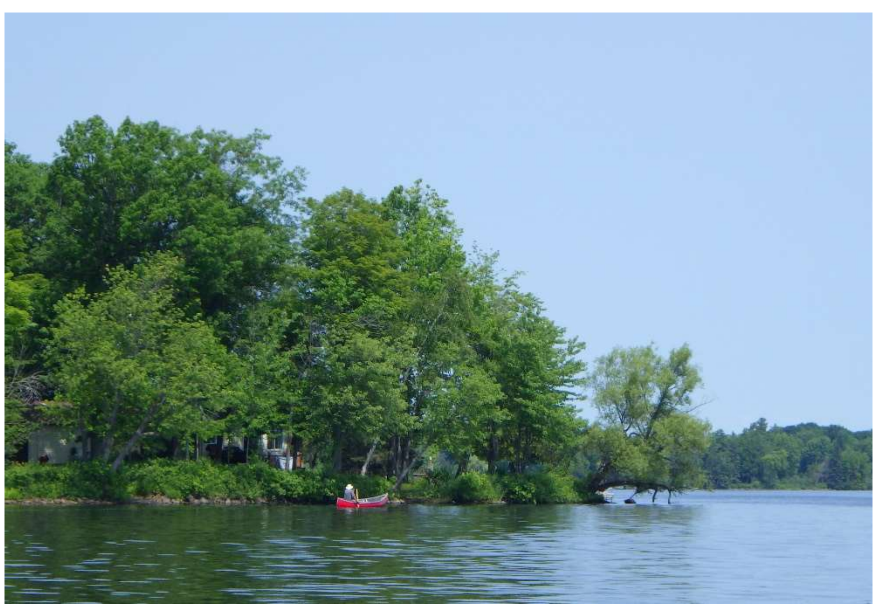


Figure 14: Secchi Depth and Euphotic Zone Total Phosphorus results from 15 sampling years for all four sites, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications. Note: the maximum Secchi depth possible at the outlet site is limited by the water depth (3 m) and by a thick bed of aquatic plants inhabiting the area.



Clyde River Subwatershed Lakes

Palmerston Lake

Palmerston Lake is a deep cold-water Canadian Shield lake in the western headwaters of the Clyde River subwatershed. It is 58 meters deep and supports cold-water fish species such as Lake Trout and Lake Whitefish. Warmer water fish such as smallmouth bass can also be found here.

Based on Secchi depth and surface water total phosphorus results in 2019 (Table 9, Figure 15) the lake maintains an oligotrophic status. Both the July surface samples are so out of character for the lake they are considered to be outliers and are excluded when analyzing the state of the lake. We believe this is reasonable based the historical range of TP levels and the rest of the 2019 TP results on the lake. Additionally, Secchi depth readings were within expected acceptable ranges when TP was elevated, which supports that the high TP results are outliers.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 9: 2019 sampling summary for Palmerston Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca2+) (mg/L)
North Basin	05/21/2019	4.0	< 2	< 2	6.08	
North Basin	07/18/2019	7.0	110	74	8.15	
North Basin	09/09/2019	6.25	9	12	6.75	
South Basin	05/21/2019	4.0	< 2	< 2	6.60	48
South Basin	07/18/2019	9.0	35	7	8.25	
South Basin	09/09/2019	6.25	11	10	7.32	

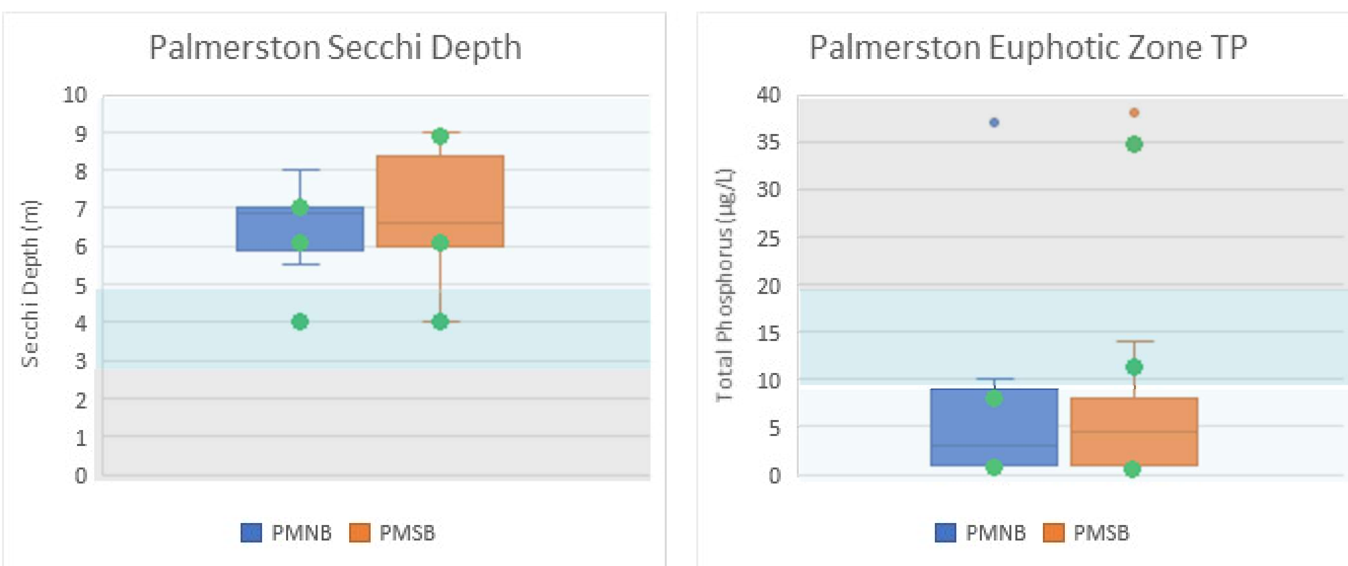


Figure 15: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for both basins in Palmerston Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Canonto Lake

Canonto Lake is a large Canadian Shield lake in the headwaters of the south branch of the Clyde River. Palmerston Lake is immediately upstream and is only separated by a dam managed by MVCA. It is 21 m deep and is known to support warm water fish such as northern pike, small and largemouth bass as well as walleye. The results from the 2019 season are shown in Table 10 and the results from both basins are compared to past years results in Figure 16.

Based on Secchi depth and surface water total phosphorus results from the 2019 season, the lake maintains its oligotrophic classification. As seen in Table 10, the north basin appears to have experienced a higher than normal total phosphorus value in July. This value does not accurately represent the concentration of total phosphorus within Canonto Lake when compared to other sampling events in the lake and is deemed an outlier and the result does not fit with the other TP results or Secchi depth readings.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 10: 2019 sampling summary for Canonto Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca2+) (mg/L)
North Basin	05/31/2019	4.0	3	9	7.93	
North Basin	07/25/2019	5.5	25	85	8.92	
North Basin	09/11/2019	5.1	10	20	8.98	
South Basin	05/31/2019	4.0	10	16	7.64	40
South Basin	07/25/2019	5.9	2	15	8.90	
South Basin	09/11/2019	5.3	9	48	8.82	

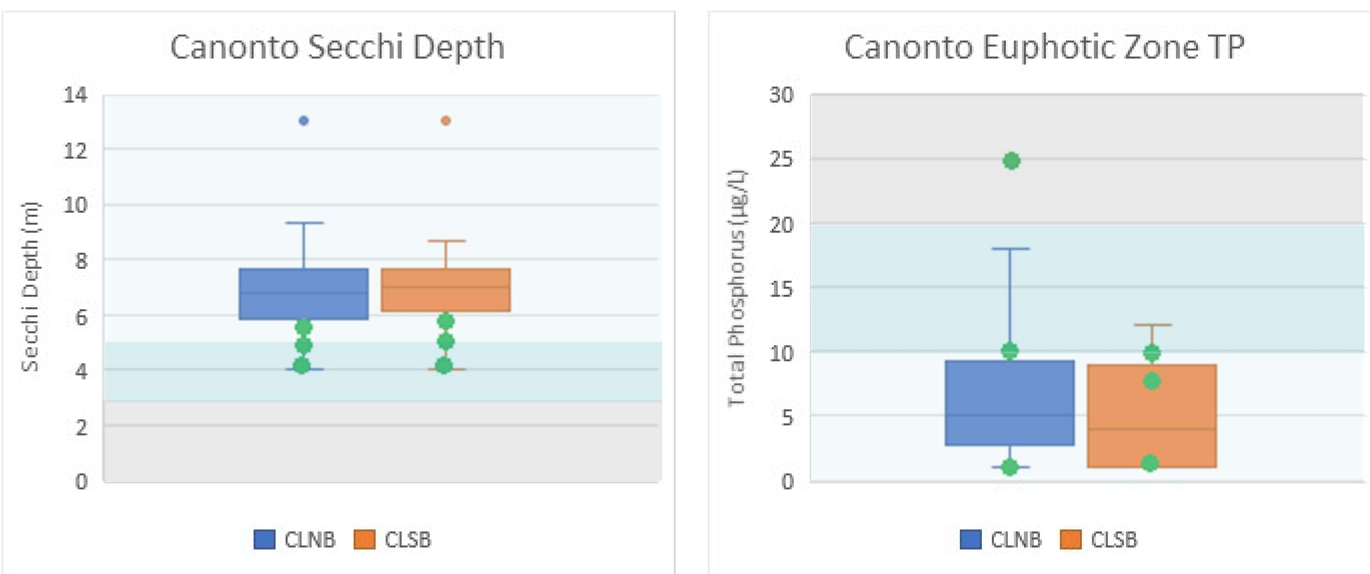


Figure 16: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for both basins in Canonto Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Sunday Lake

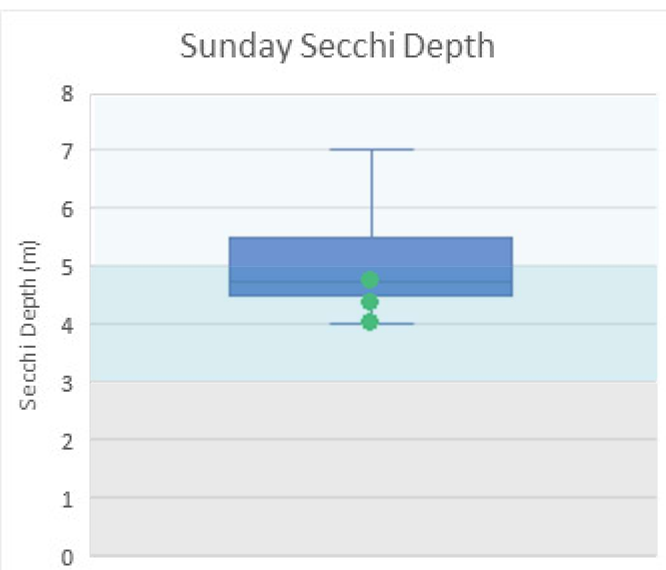
Sunday Lake is a headwaters lake that flows into Sunday Creek, which then joins the south branch of the Clyde River near Folger. It is a narrow 15 m deep lake with wetlands at the inlets and outlet that supports northern pike and other fish species.

The results from the 2019 season are shown in Table 11 and are compared to past years results in Figure 17. Based on Secchi depths and average euphotic zone total phosphorus results from five sampling seasons the lake is classified as meso-oligotrophic. The Secchi depth readings done in 2019 were consistent throughout the year and are consistent with the historic depths. The July Euphotic Zone Total Phosphorus result of 38 µg/L is beyond characteristic and is considered an outlier. Long term consistent monitoring allows us to identify the high TP results in the euphotic zone as well as in the bottom waters and process this information appropriately in the context of the lake.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 11: 2019 sampling summary for Sunday Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca^{2+}) (mg/L)
Main Basin	05/17/2019	4.0	< 2	3	8.21	40
Main Basin	07/15/2019	4.5	38	101	8.89	
Main Basin	08/30/2019	4.75	14	57	8.65	



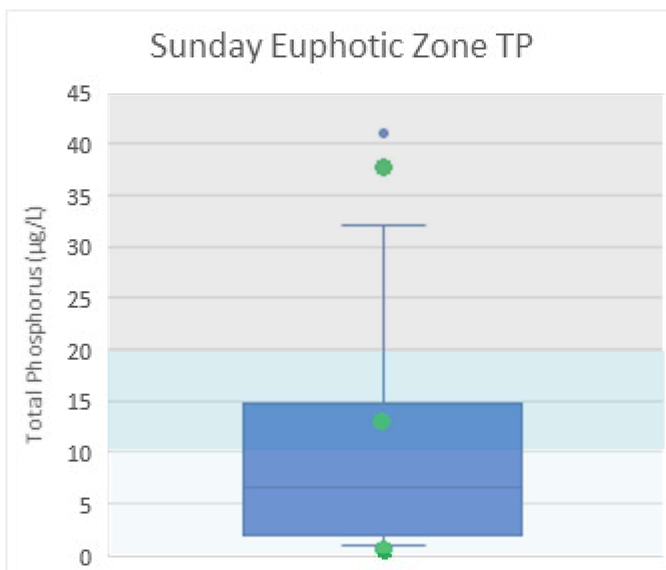


Figure 17: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for the main basin of Sunday Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Clyde Lake

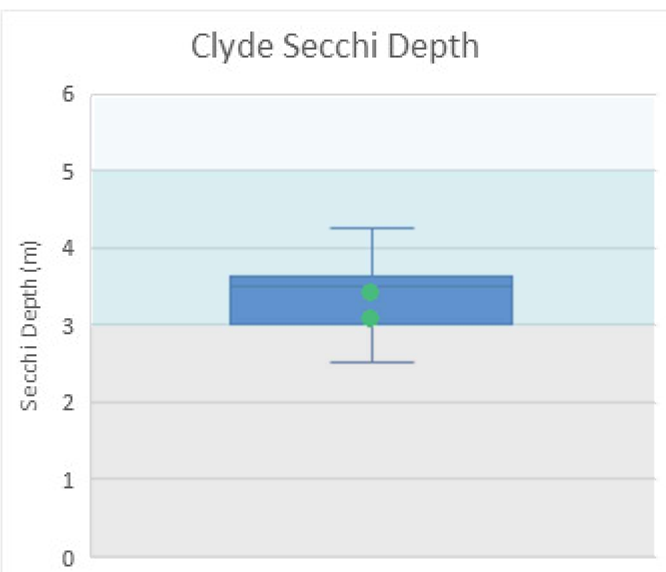
Clyde Lake is the most northern lake in our watershed that we monitor. It is part of the north branch of the Clyde River and is located beside the K & P Trail. It is 12 m deep and supports a population of northern pike, as well as small and largemouth bass.

Based on Secchi depths and average euphotic zone total phosphorus results from four sampling seasons the lake is classified as mesotrophic. The results from the 2019 season are shown in Table 12 and are compared to past years results in Figure 18. The July Euphotic Zone Total Phosphorus result of 148 µg/L is beyond characteristic and is considered an outlier.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 12: 2019 sampling summary for Clyde Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca2+) (mg/L)
Main Basin	05/09/2019	3.5	< 2	68	8.65	24
Main Basin	07/19/2019	3.0	148	237	8.22	
Main Basin	09/17/2019	3.0	28	55	n/a	



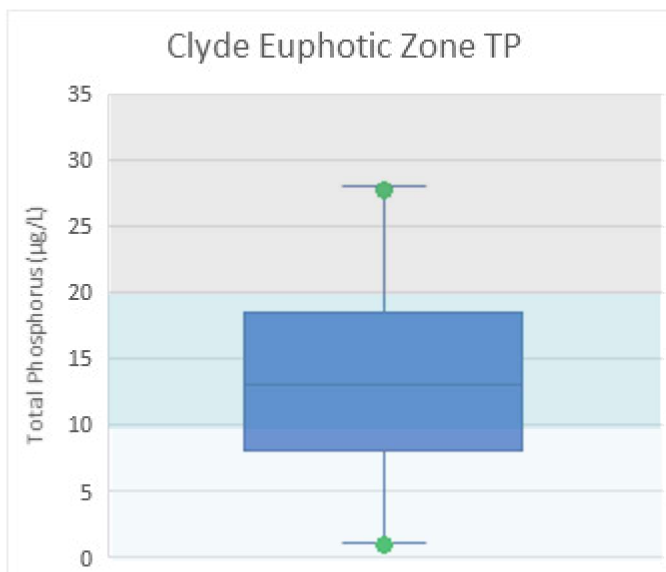


Figure 18: Secchi Depth and Euphotic Zone Total Phosphorus results from four sampling years for the main basin of Clyde Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Flower Round Lake

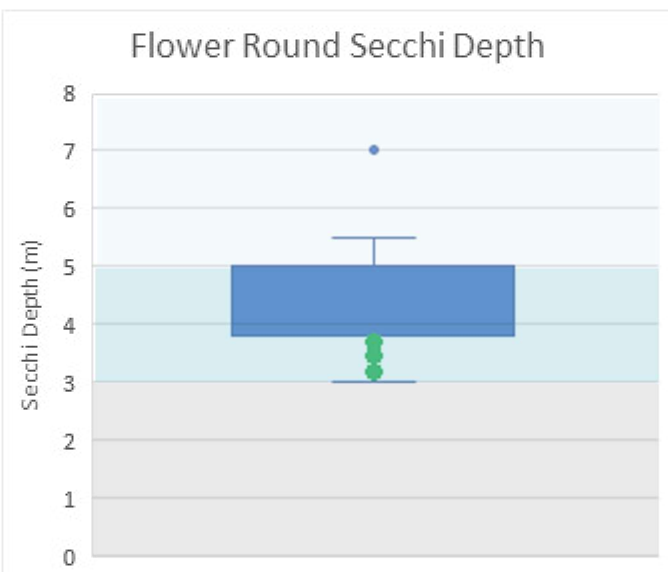
Flower Round Lake is part of the north branch of the Clyde River downstream of Clyde Lake, near Flower Station on the K & P Trail. It is 13 m deep, and is known to have northern pike, small and large mouth bass, walleye, and burbot.

The 2019 Secchi depths and the average surface total phosphorus results from five summers of data indicate a mesotrophic condition for Flower Round Lake. The results from the 2019 season are shown in Table 13 and are shown in relation to all the lake's results in Figure 19.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 13: 2019 sampling summary for Flower Round Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca2+) (mg/L)
Main Basin	05/08/2019	3.5	< 2	4	9.03	24
Main Basin	07/16/2019	3.75	28	116	7.89	
Main Basin	09/10/2019	3.25	12	73	7.91	



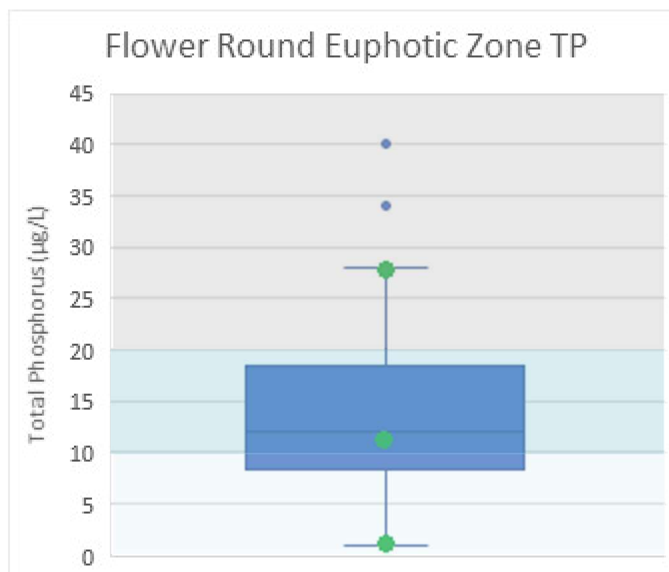


Figure 19: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for the main basin of Flower Round Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Widow Lake

Widow Lake a narrow, shallow lake with a depth of 6 meters, south of Flower Station. Warm water fish species such as Northern Pike, Small and Largemouth Bass, and Walleye can be found in this lake. This lake has both locally and provincially significant wetlands that are a part of this lake's ecosystem which provide habitat and breeding areas for fish and other wildlife. The outlet of Widow Lake is the Clyde Forks where the north, middle and south branches of the Clyde River join and flow east then south to Lanark.

Based on Secchi depth results and average euphotic zone total phosphorus results from the past four years of sampling the lake is classified as meso-eutrophic. The majority of past year's Secchi depth results have been at or close to 3 m, and past summer total phosphorus results have been in the 14-24 µg/L range, resulting in both sampling variables for the lake ranging across the meso-eutrophic classification thresholds. For this reason, the 2019 September total phosphorus result of 32 µg/L and Secchi depth of 1.5 m (Table 14) are not considered overly uncharacteristic. However, the summer reading of 149 µg/L is beyond characteristic and is considered an outlier due to sampling error and has not been incorporated into Figure 20.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 14: 2019 sampling summary for Widow Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L) *	pH	Calcium (Ca^{2+}) (mg/L)
Main Basin	05/22/2019	2.5	3	6	7.47	24
Main Basin	07/12/2019	3.0	149	n/a	8.51	
Main Basin	09/13/2019	1.5	32	36	n/a	

*Total Phosphorus samples are only taken from 1 m off the bottom of the lake if the euphotic zone does not extend to the bottom.

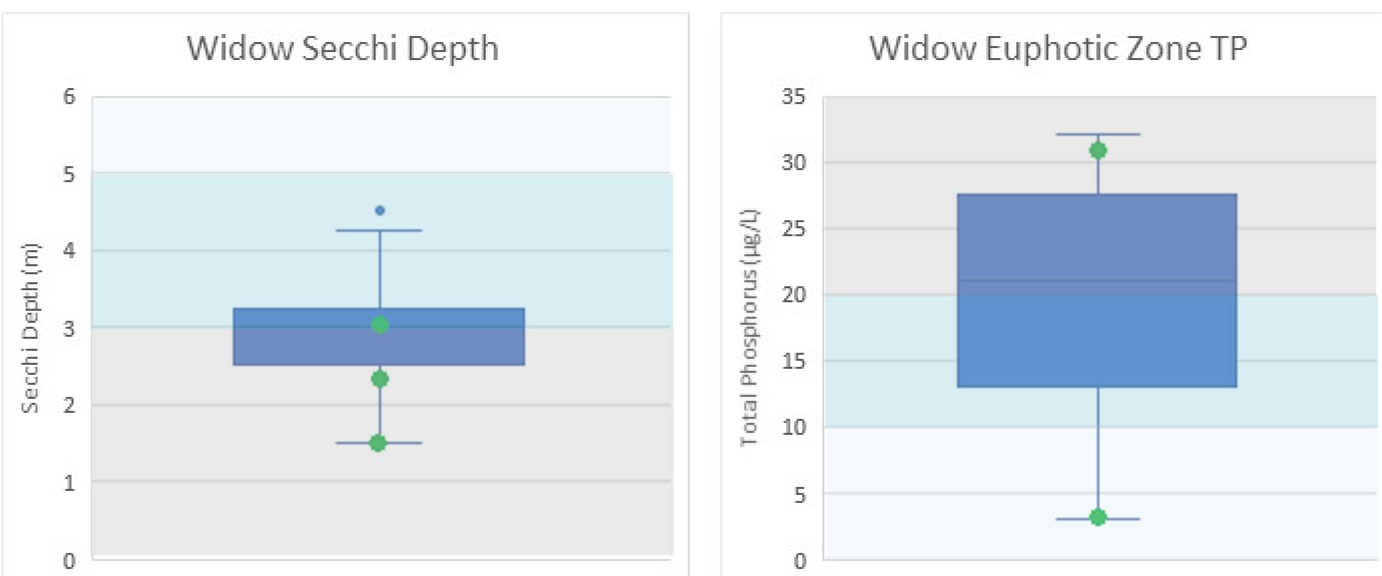


Figure 20: Secchi Depth and Euphotic Zone Total Phosphorus results from four years sampling the main basin of Widow Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Joe's Lake

The lake is shallow (4 meters) and is found downstream of the Joe's Lake Provincially Significant Wetland which extends from the outlet of Widow Lake to the inlet of Joe's Lake. This wetland habitat supports a warm water fish species such as northern pike, small and large mouth bass, and walleye which will make use of the wetland habitat at the inlet for breeding and shelter.

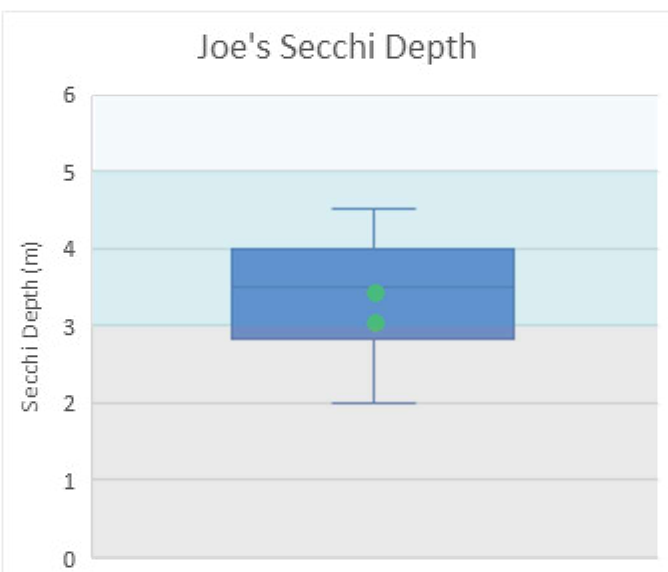
Based on Secchi depths and average euphotic zone total phosphorus results from five summers of sampling the lake is classified as mesotrophic. The results from the 2019 season are shown in Table 15 and are compared to past years results in Figure 21. The Secchi depth readings were consistent throughout the year and are consistent with the historic average depths. The July Euphotic Zone Total Phosphorus result of 175 µg/L is beyond characteristic and is considered an outlier due to sampling error and has not been incorporated into Figure 21. The July 1 m off bottom total phosphorus result is also uncharacteristically high (97 µg/L) and is likely the result of an equipment malfunction or sediment contamination.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 15: 2019 sampling summary for Joe's Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L) *	pH	Calcium (Ca^{2+}) (mg/L)
Main Basin	05/07/2019	3.5	11	19	9.07	32
Main Basin	07/08/2019	3.5	175	97	7.42	
Main Basin	09/03/2019	3.0	12	n/a	9.52	

*Total Phosphorus samples are only taken from 1 m off the bottom of the lake if the euphotic zone does not extend to the bottom.



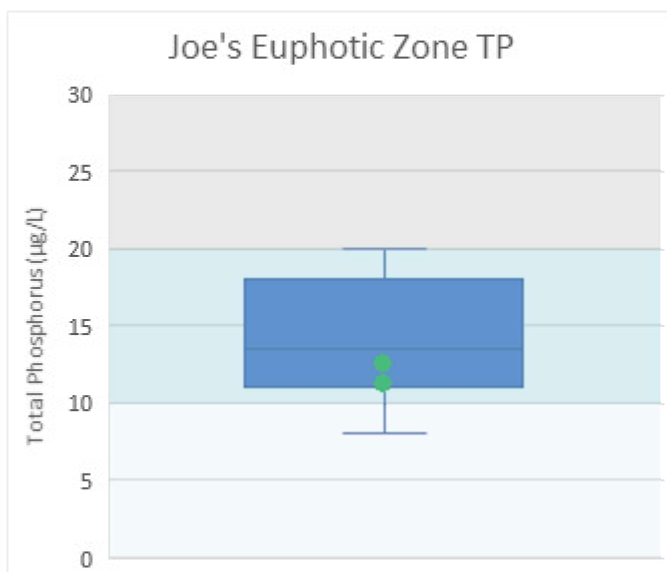


Figure 21: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for the main basin in Joe's Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Robertson Lake

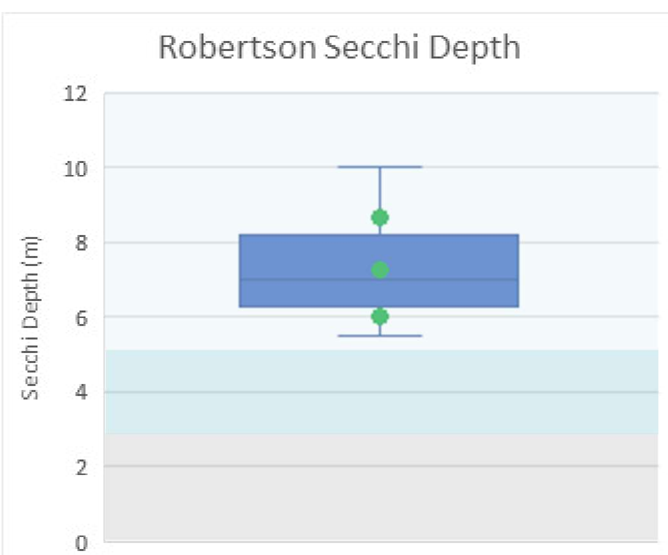
Robertson Lake is a deep (30 m) headwater lake within the Clyde River subwatershed. The lake supports warm water fish species such as northern pike, small and large mouth bass and walleye. As there is very little drainage area upstream of the lake it relies on rain and snow melt from the surrounding lands to provide nutrient inputs and flows. As such the lake was very clear in 2019 and combined with the average seasonal TP results this indicates that the lake is closest to an oligotrophic status despite a few uncharacteristic total phosphorus readings over the five years of sampling (most recently, July 2019). The results from the 2019 season are shown in Table 16 and are compared to past years results in Figure 22. Unfortunately, due to unforeseen circumstances we were not able to process the September 2019 TP samples. Based on the deep Secchi depths measured throughout the summer it is expected that the summer TP result (31 µg/L) is an uncharacteristic outlier in the dataset and that total phosphorus levels would have been closer to a normal range in September had we been able to process that sample.

Beyond 12 m deep the lake experienced low dissolved oxygen levels and anoxic conditions during all three of our sampling visits. The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

The lake will continue to be monitored as part of our regular sampling rotation which will improve our understanding of the results from 2019.

Table 16: 2019 sampling summary for Robertson Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L)	pH	Calcium (Ca2+) (mg/L)
Main Basin	05/14/2019	6.0	< 2	162	5.97	40
Main Basin	07/23/2019	8.5	31	260	8.82	
Main Basin	09/27/2019	7.0	n/a	n/a	8.71	



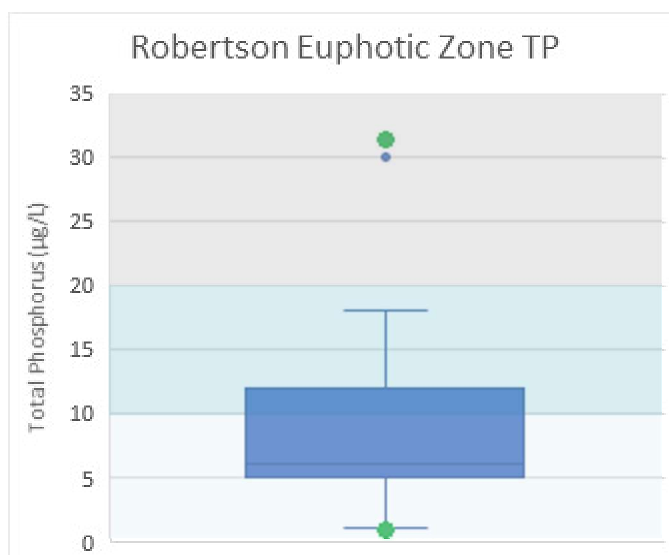


Figure 22: Secchi Depth and Euphotic Zone Total Phosphorus results from five sampling years for the main basin of Robertson Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications.

Kerr Lake

Kerr lake is a shallow (3 meters) warm water lake surrounded by the Gillies Lake – Kerr Lake Provincially Significant Wetland. The habitat conditions in the lake support populations of northern pike, small mouth bass and walleye. Kerr Lake experiences very low flows during the summer and into the fall, which can inhibit fall sampling from occurring. Due to these seasonal low rates of flow and the nutrient rich environment surrounding Kerr Lake, it may be part of the lake's natural fluctuations for the total phosphorus levels rise above 20 µg/L in the low water season(s).

Based on Secchi depth and surface water total phosphorus results from the 2019 season the lake is classified as mesotrophic. This lake has only been sampled by MVCA for three nonconsecutive seasons. Further sampling is required to help interpret the summer total phosphorus values which have been greater than 20 µg/L. The results from the 2019 season are shown in Table 17 and are compared to past years results in Figure 23.

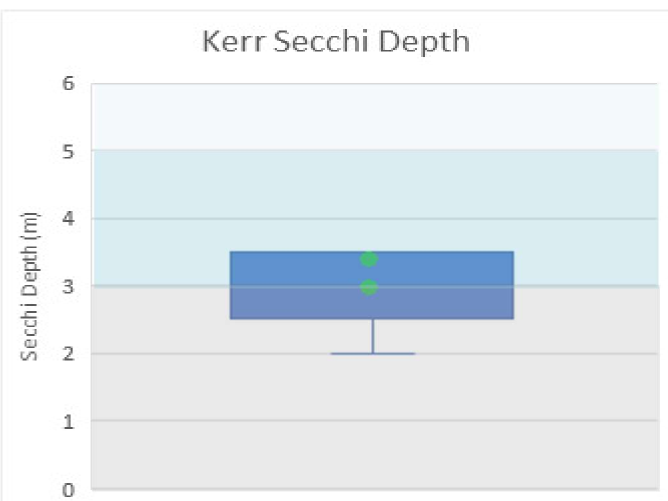
To date Kerr Lake has only been sampled eight times over three seasons. This results in a much smaller data set being used to create the graphs in Figure 23 when compared to the data sets used to interpret the other lake results shown throughout this report.

The water temperature and dissolved oxygen profile data from the 2019 sampling events are available in Appendix A.

Table 17: 2019 sampling summary for Kerr Lake.

Site	Date	Secchi Depth (m)	Total P – Euphotic Zone (µg/L)	Total P – Bottom Sample (µg/L) *	pH	Calcium (Ca2+) (mg/L)
Main Basin	05/16/2019	3.5	< 2	< 2	7.64	40
Main Basin	07/11/2019	3.0	29	n/a	8.31	
Main Basin	08/22/2019	3.5	16	n/a	6.80	

*Total Phosphorus samples are only taken from 1 m off the bottom of the lake if the euphotic zone does not extend to the bottom.



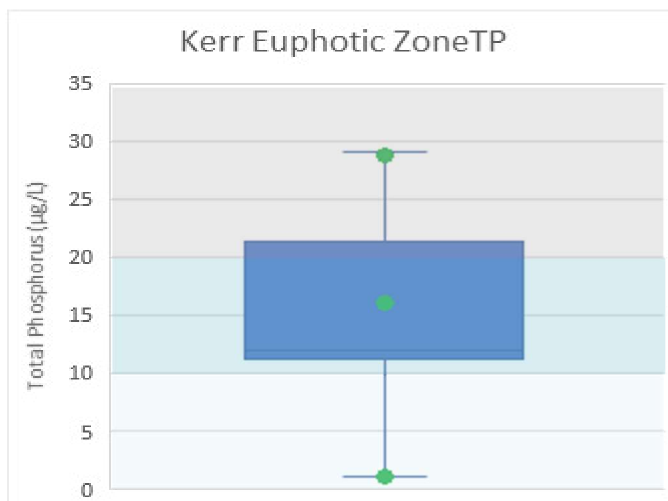


Figure 23: Secchi Depth and Euphotic Zone Total Phosphorus results from three sampling years for the main basin of Kerr Lake, compared to the 2019 results shown with a green dot, as compared to the trophic level classifications. Note: Kerr Lake is approximately 3 m deep, so there is a limit to how deep the Secchi Depth readings can be.

Stream Monitoring Program

Summary

Brook Trout

While the monitoring program does focus efforts on particular subwatershed(s) each year on a rotational basis, stream sampling is conducted at select additional sites throughout the Mississippi River watersheds to help expand MVCA's knowledge of our smaller systems. The highlight of stream monitoring in 2019 was confirmation of the presence of brook trout in two streams and rainbow trout in a third stream.

Due to limitations in the various sampling protocols, the extent of time they take to perform, the season in which they are undertaken and equipment availability it is not possible to sample every monitoring site for both fish community and thermal classification in the same year. Table 18 summarizes the stream monitoring protocols MVCA performed in 2019, and Figure 24 illustrates the locations of these sites across the Mississippi River watershed.

Table 18: A summary of the Mississippi River watershed stream sites sampled in 2019 along with their thermal classification results. The Clyde subwatershed is shown in light grey and is the focus of this report.

Subwatershed	Stream Name	Electrofished	2019 Thermal Classification
Clyde River	Clyde at Joe's Lake – upstream		Warm
Clyde River	Clyde at Hopetown – downstream		Cool-Warm
Clyde River	Easton's Creek – upstream		Cool
Clyde River	Easton's Creek – lower midstream	Yes	Cool-Warm
Clyde River	Easton's Creek – downstream	Yes	
Clyde River	Graham Creek	Yes	Cool-Warm
Clyde River	Sunday Creek	Yes	Cool-Warm
Fall River	Bolton Creek	Yes	Warm
Fall River	Limekiln	Yes	
High Falls	Mosquito Creek		Cold-Cool
Indian River	Indian River – upstream	Yes	Cool-Warm
Indian River	Indian River – downstream		Warm
Mississippi Lake	Long Sault Creek	Yes	Cool
Mississippi Lake	McIntyre Creek		Cool-Warm
Mississippi Lake	Paul's Creek	Yes	Cool-Warm

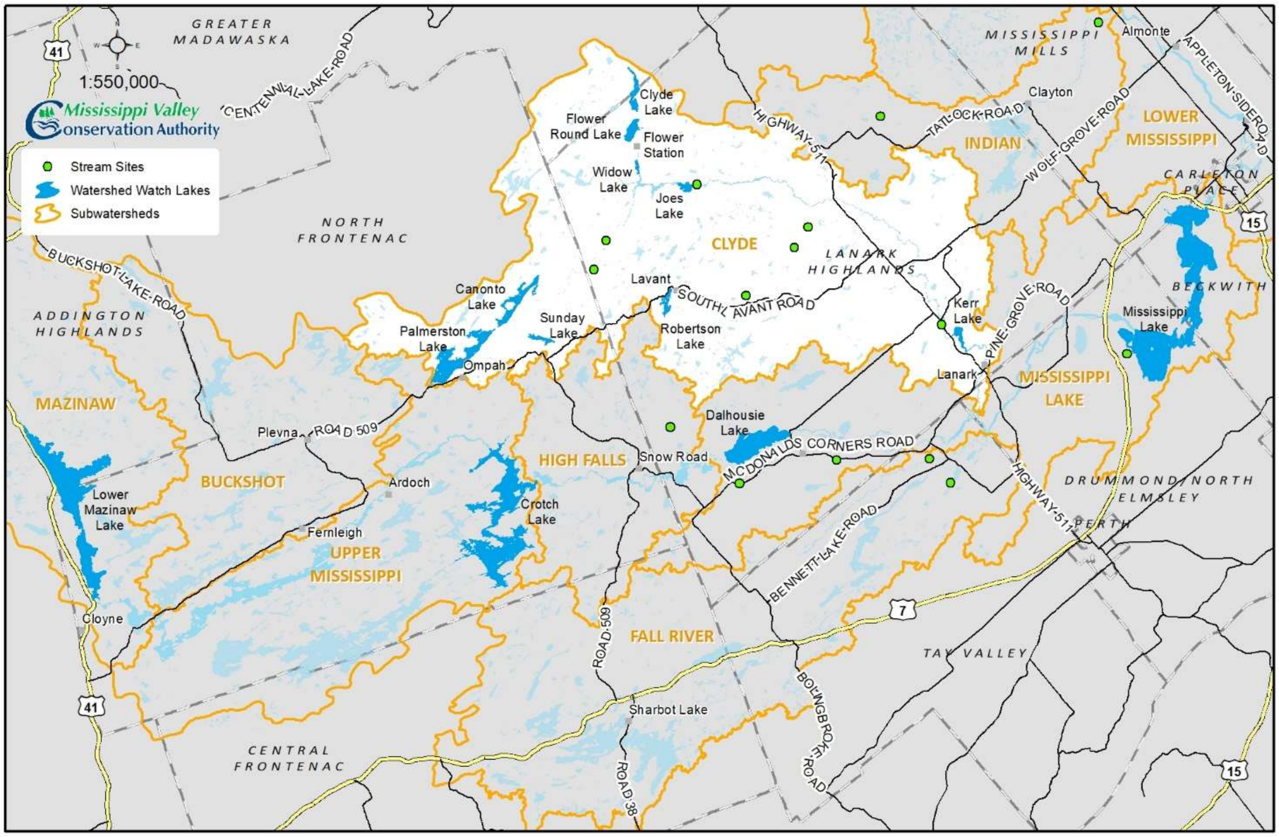


Figure 24: 2019 stream sampling site locations.

Fish Community Monitoring

MVCA uses a sampling technique called electrofishing to safely and temporarily stun the fish by passing a mild electrical current through the water. This allows the crew to net then identify and measure the fish before they are released back into the water.

Nine stream sites within the Mississippi River's subwatersheds were electrofished in 2019. Sites were chosen in order to learn more about the tributaries in the Clyde River subwatersheds, as well as to check on sites known to support cold to cool water fish species. Refer to Table 18 for the complete list of the stream sites sampled. Coldwater fish species were found at five sites. MVCA has continued to successfully capture burbot in Bolton Creek and Easton's Creek. Brook trout were collected in Long Sault Creek and Paul's Creek and rainbow trout was collected from Graham Creek.

Crew performing an electrofishing survey in Easton's Creek

These sites will continue to be monitored as part of the sampling rotation to account for annual variations in species abundances and to document habitat characteristics.

Temperature Monitoring

Temperature loggers were launched at 13 of the stream sites in the Mississippi River watershed with the intent to investigate thermal habitat availability within the watershed and to continue monitoring known cold to cool water streams for potential variations in available thermal habitat due to changes in annual climate. For example, Burbot, a cold-water fish, continues to be caught in Bolton Creek however analysis of the data from the temperature loggers have classified that reach as warm water habitat in both 2018 and 2019.


Deploying a temperature logger

Many factors can influence fluctuations in stream temperature, including springs, tributaries, precipitation runoff, discharge pipes and stream shading from riparian vegetation. Water temperature is used along with the maximum air temperature (using the revised Stoneman and Jones method by Cindy Chu *et al, 2009*) to classify a watercourse as either cold, cold-cool, cool, cool-warm, or warm water. Refer to Table 18 for a summary of the thermal classification results from the 2019 season. The natural year to year variations of water temperatures can be influenced by many factors, (duration and frequency of rain events, flow rates from springs, changes in stream shading, etc.) and can have many impacts on the stress levels and success rates of the cold to cool water fish species that are found in the creek.

The 2019 season started with an above average flood event. However, summer brought warmer than normal conditions. By September, Mississippi Valley was in a Level 1 drought which lasted until the end of October. Analysis of the temperature logger data indicates that the warm, dry conditions influenced the in-stream water temperatures. This highlights the need for continued monitoring at these stations to determine if this fluctuation is a trend or part of a normal variation in the stream temperature due to the hot dry conditions experienced in 2018 and 2019.

Water temperature in Paul's Creek has now been monitored for 3 consecutive ice-free seasons. In 2017 the creek was classified as cool, however in 2018 the system warmed to a cool-warm classification. In 2019, it again was classified as cool-warm, however the median water temperature from the classification data in 2019 was slightly cooler than it was in the 2018 season. Bolton Creek had a similar warming between a cool-warm classification in 2017 and a warm classification in 2018. In 2019 it was again classified as warm. Unlike Paul's Creek the median water temperature for Bolton Creek's classification data was slightly higher in 2019 than in previous years. These are only 3 seasons of data and more years of observations are required to analyze for trends and natural variations. Cold water fish are still found in both systems indicating that there are sufficient refuges near the study sites to maintain these populations.

While warmer waters were maintained in Paul's and Bolton Creeks, Mosquito Creek dropped a classification level to cold-cool in 2019 and Long Sault Creek maintained its cool water classification.

Easton's Creek was cool near its upper reaches and cool-warm further downstream near Dalhousie Concession 2. This logger was placed just downstream of a large open wetland area where the creek would experience some warming due the water flowing slowly through an area with little shade. Watersheds Canada coordinated a shoreline planting event for this site supported by Cabela's Canada Outdoor Fund. With onsite help from the Lanark County Stewardship Council, The Lanark Fish and Game Club and MVCA, 74 trees were planted along the creek's shore. As these trees grow they will provide much needed refuges for cold water fish.

Only one logger was deployed in the Indian River subwatershed in 2018. Due to the low water conditions experienced during the summer, the logger was out of the water during the time range required to do the habitat classification. In 2019 MVCA revisited the Indian River with two loggers, one upstream of Clayton Lake, one downstream at the Blakeney Gauge station. Both loggers stayed wet all season and returned the results that the upstream site was classified as cool-warm water habitat, while the downstream site was classified as warm water habitat.

Shoreline Stewardship

MVCA's Tree Planting Programs

Shoreline tree planting is an effective way to protect water quality, combat erosion, clean the water, and create healthy habitat for fish, birds, pollinators and other wildlife. To help with this, MVCA has two programs that distribute native species of trees and shrubs to waterfront properties within the watershed.

MVCA administers a small scale shoreline planting program where MVCA staff perform a site visit then work with the property owners to design a shoreline planting plan that will suit their property's needs. MVCA then orders, delivers and installs the plants according to the agreed upon plan. In 2019, this program resulted in 245 trees and shrubs being planted across 10 properties.

For the past three years MVCA has been working with a select number of lake associations on a rotational basis to pilot a free tree event, where property owners from the lakes monitored in the MVCA watershed are offered up to 15 shoreline plant species per property. In 2019, MVCA partnered with the Palmerston Lake Association and the Silver and Area Environmental Protection Association to distribute 268 plants to 21 properties. Due to the continued success of this program within the lake community, two lakes in the Buckshot Subwatershed will be selected for 2020.

Lake Planning

2019 Activity Summary

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. Additionally, in an advisory role, applications are reviewed within the context of natural heritage values such as wetlands, wildlife and fish habitat; as well as water quality and quantity. MVCA also administers 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 (floodplains and shorelines), permission is required from MVCA for development, interference with wetlands, and alterations to shorelines and watercourses.

In 2019 MVCA planning and regulations staff reviewed 58 permit applications on the lakes monitored in 2019. This represents 23% of the total permits issued in 2019.

Having reliable information about the health of a lake is essential for providing appropriate and effective recommendations on development applications. Data from the lake monitoring program assists MVCA in making such recommendations. 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 (e.g. installing properly working eavestroughs), creating or enhancing surfaces to allow more water to infiltrate rather than run off along the surface (e.g. rain gardens), and planting trees and shrubs along the shoreline. All of these initiatives protect and enhance water quality.

Appendix A: Water Temperature and Dissolved Oxygen Profile Details

The results from the 2019 temperature and dissolved oxygen profiles from all the lake sampling events are found below in alphabetical order. For the lakes with appropriate cool to cold water conditions, a colour code has been applied to the table representing optimal cold-water habitat conditions (in blue) and the fringe vital conditions for survival (in pink) as defined in Table A-1. Some of the warm water lakes may be shown to have these conditions periodically but they do not last throughout the season and thus they only support a warm water fishery.

Table A-2 summarizes the thermal classifications for the lakes sampled in 2019. Some of the cold-water lakes may no longer support certain cold-water fish species (such as lake trout) due to historical stocking activities or water level management efforts.

Table A-1: Optimal and vital habitat conditions for cold water fish species such as trout.

	Optimal Habitat for Cold Water Fisheries (Trout) = DO > 6 mg/L at < 10°C
	Vital Habitat for Cold Water Fisheries (Trout) = DO > 4 mg/L at < 15.5°C

Table A-2: List of cold water and warm water lakes monitored in 2019.

Cold Water Lakes	Warm Water Lakes
Canonto Lake	Clyde Lake
Mazinaw Lake	Crotch Lake
Palmerston Lake	Dalhousie Lake
Robertson Lake	Flower Round Lake
Sunday Lake	Joe’s Lake
	Kerr Lake
	Mississippi Lake
	Widow Lake

Canonto Lake

North Basin

	31-May-19		25-Jul-19		11-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	15.90	9.87	25.40	8.11	19.40	9.35
1	15.30	10.17	25.90	8.16	19.40	9.32
2	15.00	10.21	24.90	8.22	19.30	9.31
3	14.90	10.18	24.80	8.18	19.20	9.30
4	14.80	10.18	24.70	8.16	19.20	9.25
5	14.80	10.15	24.20	8.12	19.10	9.24
6	11.40	11.05	19.70	10.11	19.00	9.13
7	10.00	11.25	15.10	10.55	18.70	9.09
8	8.90	10.79	11.60	10.23	16.00	9.16
9	7.40	9.22	9.30	8.80	11.00	7.11
10	6.70	8.01	7.90	7.50	9.00	4.94
11	6.40	7.70	7.30	5.86	8.20	2.70
12	6.20	7.45	6.90	4.80	7.60	2.36
13	6.00	6.74	6.60	4.31	7.20	1.28
14	5.90	6.34	6.30	3.55	6.80	0.62
15	5.80	6.48	6.10	1.90	6.30	0.42
16	5.70	6.25	5.70	0.68		
17	5.50	5.80	5.60	0.47		
18	5.50	5.59	5.50	0.42		

South Basin

	31-May-19		25-Jul-19		11-Sep-19	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	14.90	10.18	25.20	8.08	19.80	9.34
1	14.80	10.18	25.00	8.11	19.50	9.36
2	14.60	10.19	24.90	8.13	19.30	9.39
3	14.50	10.20	24.80	8.10	19.30	9.37
4	14.50	10.19	24.70	8.04	19.20	9.37
5	14.20	10.43	24.00	8.60	19.20	9.33
6	11.60	10.87	18.80	10.66	19.20	9.29
7	10.80	11.07	14.40	11.29	18.90	9.35
8	9.80	10.96	10.90	11.37	14.20	11.39
9	8.80	10.91	9.30	10.99	10.60	10.27
10	7.80	10.45	8.00	10.01	9.00	8.62
11	6.50	9.25	7.20	7.96	7.90	6.42
12	6.00	8.47	6.50	6.45	7.30	4.89
13	5.80	7.83	6.20	5.30	6.80	3.06
14	5.60	7.44	5.80	3.19	6.40	2.52
15	5.30	6.38	5.70	2.52	6.10	0.62
16			5.70	1.96	5.90	0.49
17			5.60	1.31	5.70	0.45
18					5.70	0.39
19					5.60	0.37

Clyde Lake

Main Basin

	9-May-19		19-Jul-19		17-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	12.50	10.91	25.50	8.41	18.60	9.62
1	12.40	10.93	25.10	8.50	18.00	9.59
2	12.40	10.89	24.90	8.37	17.80	9.61
3	11.30	10.72	24.70	8.11	17.60	9.48
4	9.00	10.09	20.70	8.08	17.50	9.30
5	7.20	9.15	15.40	2.39	17.40	9.16
6	5.90	5.27	10.80	0.99	15.20	3.60
7	4.90	1.16	7.30	0.46	9.40	2.04
8	4.40	0.49	5.90	0.37	7.10	0.58
9	4.40	0.40	5.50	0.35	6.10	0.45
10	4.40	0.38	5.20	0.34	5.80	0.42
11	4.40	0.37	5.00	0.34		
12	4.50	0.35	4.90	0.33		

Crotch Lake

North Basin

	30-May-19		15-Jul-19		19-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	15.20	13.13	26.20	8.25	19.00	9.34
1	15.20	13.14	25.60	8.31	18.90	9.36
2	15.10	13.16	25.30	8.34	18.70	9.37
3	15.10	13.13	25.10	8.34	18.30	9.34
4	15.10	13.10	24.00	8.07	17.90	9.18
5	15.00	13.08	21.40	7.17	17.60	9.07
6	14.60	12.68	18.30	6.11	17.40	8.89
7	12.70	12.32	16.00	5.88	16.80	8.00
8	12.10	12.11	13.80	5.91	12.80	2.66
9	10.50	12.29	12.20	5.95	10.60	1.94
10	9.80	12.26	10.40	5.81	9.40	1.55
11	9.10	12.10	9.70	5.75	8.90	1.43
12	8.60	12.07	8.80	5.88	8.70	1.48
13	8.30	11.95	8.40	5.47	8.30	1.10
14	7.60	11.70	8.10	5.48	8.20	0.94
15	7.20	11.71	8.00	5.35	8.00	0.83
16	7.10	11.49	7.80	5.19	7.90	0.69

17			7.60	4.95	7.80	0.48
18			7.50	4.71	7.60	0.36

South Basin

	30-May-19		15-Jul-19		19-Sep-19	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	14.60	13.55	26.20	8.22	18.60	9.45
1	14.50	13.72	25.50	8.32	18.40	9.48
2	14.30	13.76	25.20	8.30	18.30	9.45
3	14.10	13.78	25.10	8.29	18.10	9.40
4	13.90	13.76	23.50	8.83	17.90	9.38
5	13.70	13.72	20.10	8.35	17.60	9.11
6	12.60	13.51	16.70	6.74	17.30	8.51
7	11.50	13.04	14.10	5.68	15.20	4.74
8	10.40	12.80	12.50	5.52	11.10	1.69
9	9.80	12.55	10.80	5.76	9.40	1.64
10	9.10	12.38	9.60	5.75	8.70	1.84
11	8.30	12.08	9.00	6.02	8.30	1.33
12	7.40	11.85	8.30	5.90	8.00	1.16
13	7.20	11.69	7.80	5.69	7.70	0.97
14	6.90	11.49	7.60	5.48	7.50	1.29
15	6.80	11.35	7.40	5.69	7.30	1.16
16	6.60	11.06	7.20	5.44	7.20	0.93
17	6.50	11.08	7.10	5.31	7.20	0.91
18	6.40	11.05	7.00	5.10	7.10	0.77
19	6.30	10.89	6.90	5.02	7.00	0.65
20	6.20	10.84	6.80	4.82	6.90	0.57
21	6.20	10.81	6.80	4.51	6.90	0.48
22	6.20	10.80	6.70	4.25	6.80	0.38
23	6.20	10.81	6.70	4.15	6.70	0.35
24	6.20	10.80	6.70	4.10	6.70	0.34
25	6.10	10.60	6.60	4.10		

Dalhousie Lake

Main Basin

	15-May-19		19-Jul-19		17-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.90	11.01	25.80	8.35	18.80	8.46
1	10.90	10.99	25.70	8.38	18.70	8.45
2	10.80	10.99	25.50	8.37	18.60	8.41
3	10.80	10.98	25.30	8.34	18.50	8.40
4	10.80	10.96	24.60	8.04	18.50	8.37
5	10.80	10.95	22.60	6.17	18.50	8.33
6	10.80	10.92	20.20	5.30	18.40	8.30
7	10.80	10.89	17.50	3.76	18.40	8.28
8	10.80	10.87	15.50	1.37	18.40	8.26
9			14.00	0.46	18.30	8.26
10			13.50	0.39	15.00	0.71
11			13.00	0.37	13.30	0.51
12			12.70	0.35	12.60	0.46
13					12.40	0.44
14					12.30	0.42
15					12.10	0.41
16					12.00	0.38

Flower Round Lake

Main Basin

	8-May-19		17-Jul-19		10-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.20	11.61	24.40	8.25	18.70	9.24
1	10.10	11.57	24.40	8.23	18.90	9.18
2	9.30	11.41	24.50	8.24	18.90	9.15
3	8.50	10.98	24.50	8.23	18.90	9.12
4	8.10	10.76	24.30	8.15	19.00	9.08
5	7.60	10.63	18.30	6.50	18.90	9.01
6	5.80	8.85	13.90	5.06	18.50	8.64
7	5.40	7.38	10.20	3.48	13.30	0.70
8	5.00	4.57	8.10	0.90	10.10	0.53
9	4.80	2.20	7.50	0.51	8.70	0.48
10	4.70	1.42	6.90	0.43	7.80	0.44
11	4.70	0.68	6.90	0.39	7.20	0.41
12			6.70	0.37	7.00	0.41

Joe's Lake

Main Basin

	7-May-19		8-Jul-19		3-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	13.70	10.62	26.20	8.82	21.20	8.67
1	13.50	10.45	25.80	9.14	21.20	8.64
2	13.00	9.89	25.70	9.22	21.00	8.61
3	9.00	12.31	21.90	9.63	20.90	8.22
4	7.60	0.59	21.10	9.42	20.70	4.89

Kerr Lake

Main Basin

	16-May-19		11-Jul-19		22-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	12.02	10.02	26.40	8.68	24.50	8.96
1	12.10	9.99	26.40	8.65	24.60	8.43
2	11.90	9.97	25.70	8.54	24.30	7.98
3	11.90	9.93	23.80	6.98	23.70	7.09
4	11.80	9.89	20.10	0.67	23.30	4.01
5	11.80	9.82			22.50	1.20

Mazinaw Lake

North Basin

	3-Jun-19		2-Aug-19		18-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	11.40	10.96	25.20	8.06	18.40	9.52
1	11.50	10.94	25.00	7.98	18.20	9.54
2	11.40	10.92	24.70	7.99	17.90	9.55
3	11.30	10.92	24.60	7.96	17.80	9.56
4	11.30	10.90	24.40	7.94	17.70	9.52
5	11.20	10.90	24.10	7.91	17.70	9.46
6	11.20	10.88	18.50	8.58	17.60	9.43
7	11.20	10.86	14.40	8.95	17.50	9.43
8	11.20	10.85	13.10	9.06	16.90	9.15
9	11.30	10.81	12.30	9.06	14.10	9.01
10	11.20	10.85	10.60	9.23	11.70	8.95
11	11.20	10.79	9.70	9.35	9.90	9.17
12	11.20	10.77	9.10	9.39	9.00	9.26
13	11.20	10.75	8.70	9.42	8.60	9.32

South Basin

	3-Jun-19		2-Aug-19		18-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	12.50	10.85	26.00	7.98	18.40	9.51
1	12.70	10.81	25.30	8.01	18.20	9.52
2	12.70	10.79	25.20	7.98	17.90	9.52
3	12.70	10.75	24.90	7.93	17.90	9.50
4	12.70	10.74	24.50	7.89	17.90	9.46
5	12.70	10.72	23.00	8.03	17.80	9.46
6	9.20	10.83	18.60	8.27	17.80	9.41
7	8.90	10.84	13.00	8.54	17.60	9.26
8	8.50	10.82	10.60	8.67	15.50	8.71
9	7.90	10.83	9.20	8.91	9.90	8.51
10	7.70	10.82	8.20	8.92	8.70	8.39
11	7.20	10.78	7.70	8.98	8.10	8.38
12	7.00	10.72	7.40	9.01	7.70	8.36
13	6.90	10.7	7.20	8.92	7.40	8.29
14	6.70	10.68	7.00	8.88	7.10	8.30
15	6.50	10.65	6.90	8.85	7.00	8.32
16	6.40	10.65	6.80	8.85	6.90	8.35
17	6.30	10.62	6.70	8.9	6.80	8.44
18	6.10	10.6	6.60	8.9	6.80	8.63
19	6.00	10.58	6.50	8.91	6.70	8.65
20	5.90	10.57	6.30	8.92	6.60	8.75
21	5.80	10.56	6.20	8.91	6.40	8.76
22	5.70	10.55	6.10	8.91	6.30	8.72
23	5.60	10.53	6.00	8.93	6.20	8.76
24	5.60	10.5	6.00	8.94	6.10	8.68
25	5.60	10.44	5.80	8.92	6.00	8.67
26	5.50	10.42	5.70	8.92	5.90	8.77
27	5.40	10.41	5.60	8.9	5.70	8.79
28	5.30	10.4	5.50	8.87	5.60	8.76
29	5.30	10.38	5.40	8.87	5.60	8.74
30	5.30	10.38	5.40	8.86	5.50	8.72
31	5.20	10.35	5.30	8.87	5.50	8.69
32	5.20	10.33	5.30	8.87	5.40	8.70
33	5.20	10.3	5.40	8.89	5.40	8.68
34			5.40	8.87	5.40	8.66
35			5.30	8.88	5.40	8.65
36			5.30	8.86	5.40	8.64
37			5.30	8.85	5.30	8.66

38			5.30	8.84	5.30	8.65
39			5.30	8.83	5.30	8.63
40			5.30	8.79	5.30	8.62
41			5.20	8.79	5.30	8.61
42			5.20	8.76	5.30	8.62
43			5.20	8.74	5.30	8.61
44					5.30	8.60
45					5.30	8.58
46					5.30	8.56
47					5.30	8.54
48					5.30	8.52
49					5.30	8.41

Mississippi Lake

Inlet

	29-May-19		9-Jul-19		6-Sep-19	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	15.60	10.02	26.40	8.28	20.90	8.47
1	15.60	9.96	26.30	8.24	20.80	8.51
2	15.60	9.92	26.10	8.15	20.70	8.49
3	15.60	9.90	25.60	7.50	20.60	8.42
4	15.50	9.83	23.60	5.89	2.50	8.36
5	15.50	9.83	22.70	5.13	20.40	8.05
6	15.50	9.81	21.70	3.94	20.40	7.79
7	15.50	9.80	19.90	2.06	20.20	7.36
8	15.50	9.76	17.90	0.99		
9	15.50	9.74	16.10	0.49		
10	15.50	9.72				

Burnt Island

	29-May-19		9-Jul-19		6-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	16.90	11.76	26.60	8.96	21.10	8.98
1	16.20	11.71	25.80	8.80	21.00	9.03
2	16.10	11.55	25.30	8.67	20.80	8.67
3	16.10	11.28	25.10	8.55	20.70	8.81
4	16.00	10.93	25.00	8.56	20.70	8.90
5	15.90	10.45	23.70	6.44	20.60	8.77
6	15.80	10.18	22.20	3.99	20.60	8.75
7	15.60	10.06	22.00	3.84	20.60	8.58
8	15.50	9.30	21.70	3.29	20.60	8.30
9	15.30	8.76	21.60	3.10	20.50	7.24
10	15.10	8.29				

Pretties Island

	29-May-19		9-Jul-19		6-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	16.40	11.79	27.10	8.73	21.40	9.19
1	16.00	11.75	26.70	8.75	21.40	9.18
2	15.80	11.48	26.30	8.81	21.30	9.21
3	15.70	11.38	25.70	8.42	21.20	9.18
4	15.70	11.31	25.00	7.31	20.60	7.92
5	15.70	11.21	22.90	4.79	20.50	6.91
6			22.60	4.29	20.50	6.67

Outlet

	29-May-19		9-Jul-19		6-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	16.10	11.94	27.40	9.12	20.60	9.56
1	16.00	11.89	26.50	9.66	20.30	10.30
2	15.90	11.89				

Palmerston Lake

North Basin

	29-May-19		9-Jul-19		6-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.60	11.25	25.10	8.67	19.70	9.30
1	10.60	11.24	24.90	8.62	19.60	9.27
2	10.60	11.22	24.60	8.62	19.60	9.25
3	10.60	11.21	24.50	8.62	19.50	9.26
4	10.50	11.22	24.40	8.60	19.50	9.23
5	10.50	11.22	22.90	9.30	19.50	9.21
6	10.10	11.23	20.70	10.44	19.50	9.18
7	9.70	11.23	16.40	11.45	19.40	9.19
8	9.40	11.25	13.30	11.75	17.80	11.29
9	7.70	11.03	11.10	11.73	13.80	12.05
10	6.80	10.71	9.20	11.46	10.50	11.22
11	6.70	10.59	7.90	11.04	8.90	10.59
12	6.60	10.51	7.40	10.51	8.00	9.81
13	6.20	10.36	6.90	9.96	7.50	9.20
14	5.80	10.15	6.70	9.65	7.20	8.59
15	5.70	10.05	6.50	9.38	6.90	8.44
16	5.60	9.93	6.40	9.05	6.70	8.28
17	5.50	9.80	6.20	8.88	6.60	8.08
18	5.30	9.73	6.10	8.75	6.50	7.89
19	5.30	9.66	6.10	8.69	6.40	7.86
20	5.20	9.64	6.00	8.62	6.40	7.70
21	5.20	9.60	6.00	8.39	6.30	7.59
22	5.20	9.57	5.90	8.24	6.20	7.49
23	5.10	9.56	5.90	8.13	6.20	7.36
24	5.10	9.54	5.90	7.92	6.20	7.25
25	5.10	9.51	5.80	7.64	6.10	6.96
26	5.10	9.48	5.80	7.26	6.10	6.56

South Basin

	29-May-19		9-Jul-19		6-Sep-19	
Depth (m)	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**	**Temp (°C)**	**D.O. (mg/L)**
0.1	10.50	11.29	25.90	8.50	19.90	9.29
1	10.50	11.32	25.00	8.56	19.80	9.39
2	10.40	11.30	24.40	8.65	19.50	9.32
3	10.30	11.29	24.20	8.66	19.50	9.26
4	10.20	11.29	24.00	8.68	19.40	9.23
5	10.20	11.27	23.90	8.68	19.40	9.23
6	9.50	11.17	21.40	10.46	19.30	9.24
7	8.80	11.03	16.50	11.42	19.30	9.23
8	7.70	10.90	13.00	11.71	19.30	9.17
9	7.60	10.83	10.90	11.84	14.00	12.49
10	7.00	10.68	8.80	11.54	10.60	12.28
11	6.60	10.52	8.00	11.19	8.60	11.34
12	6.50	10.46	7.30	10.60	8.20	10.76
13	6.30	10.43	6.90	10.51	7.70	10.37
14	6.20	10.38	6.70	10.31	7.10	9.92
15	5.90	10.28	6.40	9.95	6.90	9.63
16	5.80	10.22	6.20	9.64	6.70	8.62
17	5.60	10.22	6.00	9.41	6.50	8.38
18	5.40	9.98	5.90	9.15	6.40	8.00
19	5.30	9.91	5.90	8.97	6.20	7.85
20	5.30	9.85	5.80	8.88	6.10	7.95
21	5.30	9.82	5.70	8.71	6.00	8.05
22	5.20	9.80	5.60	8.68	5.90	7.88
23	5.10	9.75	5.50	8.70	5.80	7.74
24	5.00	9.67	5.50	8.60	5.70	7.70
25	4.90	9.57	5.40	8.59	5.50	7.58
26	4.80	9.48	5.30	8.52	5.40	7.49
27	4.70	9.46	5.20	8.50	5.30	7.38
28	4.70	9.43	5.10	8.46	5.20	7.34
29	4.70	9.39	5.00	8.44	5.10	7.30
30	4.70	9.37	5.00	8.21	5.00	7.28
31			4.90	8.09	4.90	7.22
32			4.80	8.10	4.90	7.18
33			4.80	8.13	4.80	7.12
34			4.70	8.11	4.70	7.11
35			4.70	8.08	4.70	7.08
36			4.70	7.97	4.70	6.94
37			4.60	7.93	4.60	6.91

38			4.50	60.10	4.60	6.84
39			4.50	7.71	4.60	6.67
40			4.50	7.72	4.50	6.60
41			4.50	7.56	4.50	6.49
42			4.50	7.42	4.50	6.39
43			4.40	7.26	4.50	6.19
44			4.40	7.11	4.50	5.17
45			4.40	7.05	4.50	5.09
46					4.40	3.95
47					4.40	3.47
48					4.40	7.69
49					4.40	2.23

Robertson Lake

Main Basin

	14-May-19		23-Jul-19		27-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	10.70	11.40	25.10	8.31	18.50	9.23
1	10.93	10.93	25.20	8.29	18.40	9.24
2	10.90	10.92	25.20	8.28	18.30	9.24
3	10.90	10.91	25.20	8.25	18.30	9.24
4	10.90	10.89	25.10	8.22	18.20	9.22
5	10.90	10.87	23.50	8.50	18.20	9.16
6	9.10	10.98	17.60	9.82	18.10	9.04
7	7.60	10.51	14.70	9.94	17.90	8.89
8	6.80	10.34	11.30	9.68	16.50	8.65
9	6.20	8.53	9.50	7.95	12.40	6.16
10	5.60	5.34	7.70	4.53	9.50	2.02
11	5.30	4.07	7.10	2.37	8.20	0.45
12	5.00	2.03	6.40	0.61	7.50	0.40
13	4.90	0.89	6.10	0.53	6.90	0.38
14	4.80	0.45	5.80	0.48	6.20	0.37
15	4.70	0.39	5.60	0.44	5.80	0.35
16	4.70	0.36	5.20	0.39	5.50	0.35
17	4.60	0.34	5.00	0.37	5.20	0.35
18	4.60	0.33	4.80	0.35	5.00	0.34
19	4.60	0.32	4.80	0.35	4.90	0.33
20	4.50	0.32	4.70	0.34	4.80	0.33
21	4.50	0.31	4.70	0.34	4.70	0.33
22	4.50	0.30	4.60	0.33	4.70	0.32
23	4.50	0.30	4.60	0.33	4.70	0.31
24	4.50	0.29	4.60	0.32	4.70	0.31
25	4.50	0.29	4.60	0.32	4.70	0.31
26	4.50	0.29	4.60	0.32	4.60	0.31
27	4.50	0.28	4.60	0.31	4.60	0.30
28	4.50	0.27	4.60	0.31		
29	4.50	0.27	4.60	0.31		
30	4.50	0.26	4.60	0.30		
31			4.60	0.30		

Sunday Lake

Main Basin

	17-May-19		15-Jul-19		30-Aug-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	12.40	10.66	25.40	8.31	21.60	8.87
1	12.50	10.73	25.10	8.25	21.60	8.85
2	12.10	10.79	24.90	8.29	21.60	8.83
3	11.90	10.81	24.60	8.09	21.60	8.87
4	11.50	10.77	20.30	10.49	21.70	8.80
5	8.90	9.79	14.10	12.32	18.50	12.40
6	7.00	8.87	10.20	8.91	12.10	11.08
7	6.20	7.81	7.60	6.33	8.70	5.62
8	5.50	6.20	6.30	4.39	7.20	3.88
9	5.20	4.90	5.80	2.29	6.20	0.59
10	4.80	2.81	5.20	0.69	5.60	0.53
11	4.50	1.60	4.80	0.53	5.30	0.50
12	4.40	1.01	4.70	0.48	5.00	0.41
13	4.40	0.67	4.60	0.45		
14	4.40	0.60	4.50	0.43		
15	4.40	0.52	4.50	0.42		
16	4.30	0.47				

Widow Lake

Main Basin

	22-May-19		12-Jul-19		13-Sep-19	
Depth (m)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)	Temp (°C)	D.O. (mg/L)
0.1	14.60	9.58	25.00	7.91	18.20	9.34
1	13.90	9.49	25.20	7.88	18.30	9.19
2	13.60	9.50	25.20	7.84	18.10	8.97
3	12.50	9.26	22.10	8.64	18.10	9.03
4	11.30	8.29	16.40	7.74	18.10	8.48
5	9.40	6.24	12.90	1.40		
6	7.80	6.98				