

Technical Memorandum

To: Black Dog Watershed Management Organization (BDWMO)
From: Kevin Menken, Barr Engineering
Subject: Lac Lavon 2019 Water Quality Assessment
Date: March 10, 2020
Project: 23190375

This memorandum presents the results of 2019 management-level water quality monitoring of Lac Lavon, as well as discussion of aquatic macrophyte surveys conducted in June 2019 and August 2019. Management-level water quality monitoring was conducted by Barr Engineering Co. (Barr) on behalf of the BDWMO in 2019. Monitoring was also performed by a citizen volunteer participating in the Metropolitan Council sponsored Citizen Assisted Monitoring Program (CAMP).

Introduction and Background

Lac Lavon lies on the Burnsville/Apple Valley border, and its 184-acre watershed encompasses portions of both Burnsville and Apple Valley. The only surface water outlet from Lac Lavon is a 12-inch diameter emergency overflow outlet to Keller Lake. A valve controls the flows in the overflow pipe; normally the valve is closed. Lac Lavon is unique in that it is an abandoned gravel pit and therefore not part of the original Minnesota Department of Natural Resources (MDNR) public waters inventory. However, the MPCA considers Lac Lavon to be a fully-supporting deep lake that can be listed on the impaired waters list.

The lake's primary water source is groundwater. Lac Lavon's surface area is approximately 60 acres, with 65 percent of the lake less than 15 feet (4.6 meters) deep, and a maximum depth of approximately 32 feet (9.8 meters).

The Lac Lavon watershed land use is low density residential and park. Two city parks are located on Lac Lavon—a City of Burnsville park on the west shore, and a City of Apple Valley park on the northeast shore. Very little, if any, change in land use development is expected in the Lac Lavon watershed. Lac Lavon is used for a variety of recreational purposes, including fishing, swimming, aesthetic viewing, and wildlife habitat. The City of Burnsville park has access for launching canoes and the City of Apple Valley park has a path to a fishing pier on the shoreline. These park amenities provide for most of the recreational use of the lake. There is no public boat ramp for launching trailered boats on Lac Lavon.

2019 Water Quality Monitoring Activities

The BDWMO Watershed Management Plan calls for "management-level" water quality monitoring of Lac Lavon once every three years. Management-level monitoring involves a more detailed collection of water

quality data than the Metropolitan Council's Citizen-Assisted Monitoring Program (CAMP). This expanded effort was conducted by Barr in 2019 and included collection of the following data:

- Measurement of Secchi disc transparency (a measure of water clarity).
- Field probe measurements of water temperature, dissolved oxygen concentration, specific conductivity, and pH levels at 1-meter depth intervals.
- Composite water samples from the surface of Lac Lavon (0–2 meters); these samples were sent to Pace Analytical for analyses of total phosphorus and chlorophyll *a* concentrations. Chlorophyll *a* is a pigment that algae use for photosynthesis, and concentrations indicate the abundance of algae in the water. Phosphorus is the nutrient that drives algae growth in most Minnesota lakes.
- Water samples from 3 meters to 9 meters, taken at 1-meter depth intervals; these samples were sent to Pace Analytical for analyses of total phosphorus concentrations.

Also, a citizen volunteer conducted CAMP water quality monitoring in 2019. Tabulated water quality data collected by Barr (Table 2) and the CAMP volunteer (Table 3) are attached at the end of this memorandum.

The 2019 Barr and CAMP measurements of Secchi disc transparency (SDT), total phosphorus, and chlorophyll *a* measurements are plotted in Figure 1, with Barr and CAMP data identified separately. Chlorophyll *a* results were very similar between Barr and CAMP measurements, while total phosphorus concentrations were generally higher in Barr-collected samples than CAMP samples. Barr measurements of SDT were generally not as deep (worse) than CAMP measurements as well. SDT measurements are somewhat subjective, and can be influenced by time of day of measurements (e.g. wave action and sun angle). Observed differences in Barr and CAMP measurements of total phosphorus concentrations could be due to the manner of sample collection – a composite of top 2 meters of lake water (Barr) versus dipping sample container below the lake surface (CAMP).

Summer Averages of Water Quality Parameters and Associated Goals

The 2019 summer (June–September) averages of water quality parameters were calculated for Lac Lavon, and plotted with previous years' summer averages. The summer averages for Secchi disc transparency, total phosphorus, and chlorophyll *a* are plotted in Figure 2. The BDWMO classified Lac Lavon as a Category I water body (supporting swimming and other direct contact recreational activities). The water quality action level for summer average (June–September) Secchi disc transparency (SDT) for Lac Lavon in 2019 is 4.2 meters (13.8 feet). When a statistical trend analysis indicates that water transparency has degraded beyond this level (i.e. SDT less than 4.2 meters), then a diagnostic study of potential causes is recommended according to the BDWMO's Watershed Management Plan. The summer average SDT in 2019 was 4.0 meters (13.1 feet), which is worse than the action level of 4.2 meters. However, there was a statistically significant trend (90% confidence interval) of improving water quality in summer average SDT for the most recent 10 year period. There were no statistically significant trends in summer averages of total phosphorus and chlorophyll *a* for the most recent 10-year period, but summer averages of total

Figure 1a: Lac Lavon 2019 Secchi Disc Transparency

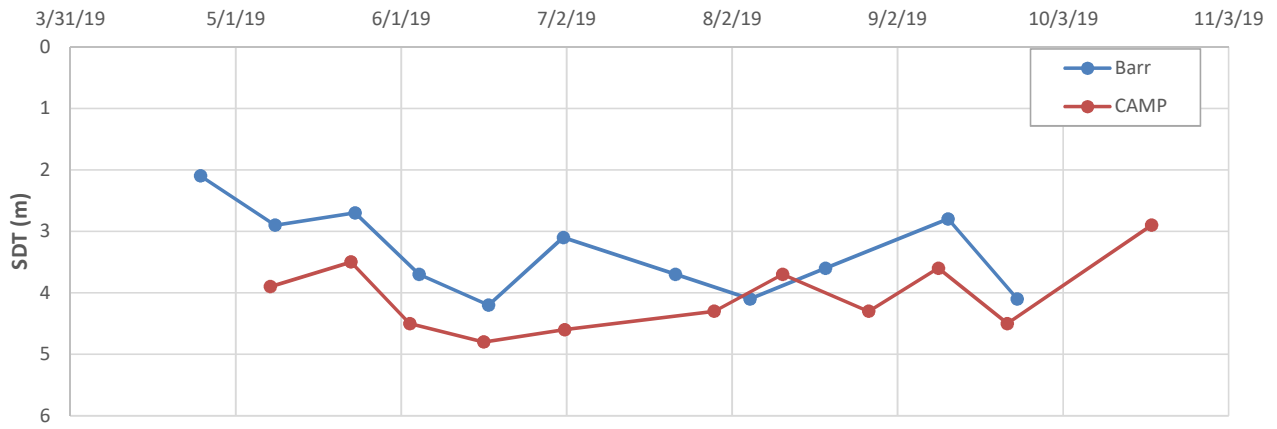


Figure 1b: Lac Lavon 2019 Chlorophyll *a*

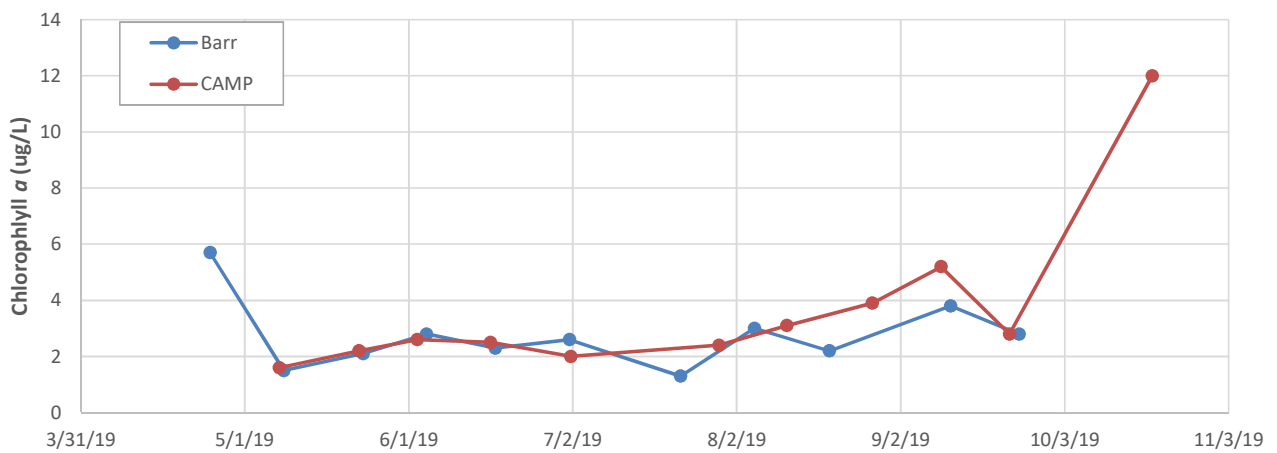


Figure 1c: Lac Lavon 2019 Total Phosphorus

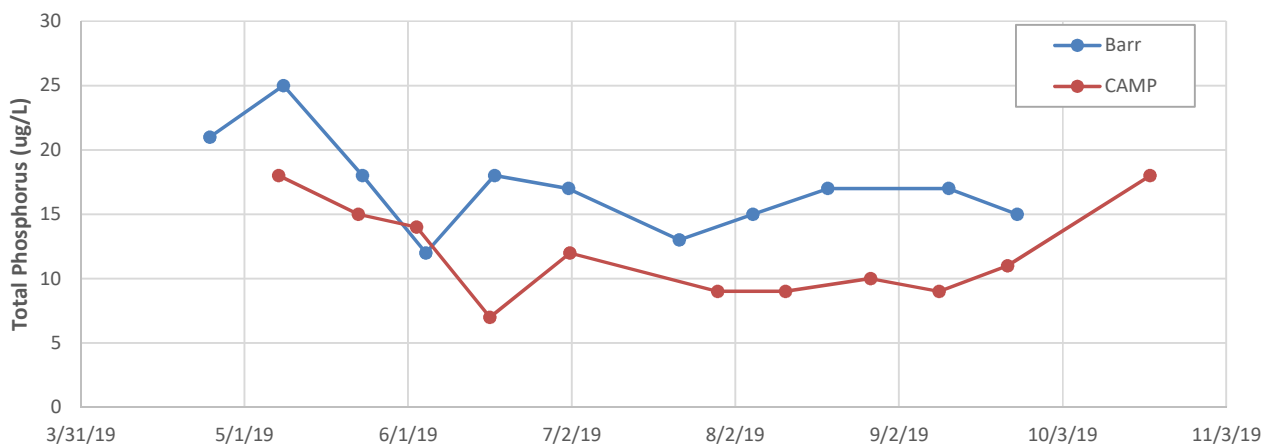


Figure 2a: Lac Lavon June-Sept. Secchi Disc Transparency

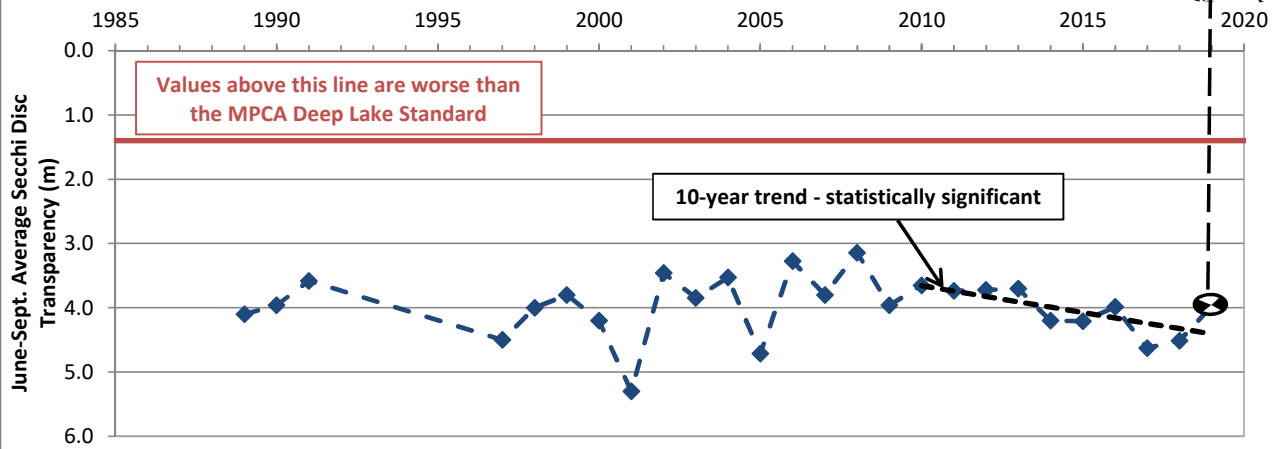


Figure 2b: Lac Lavon June-Sept. Average Chlorophyll a

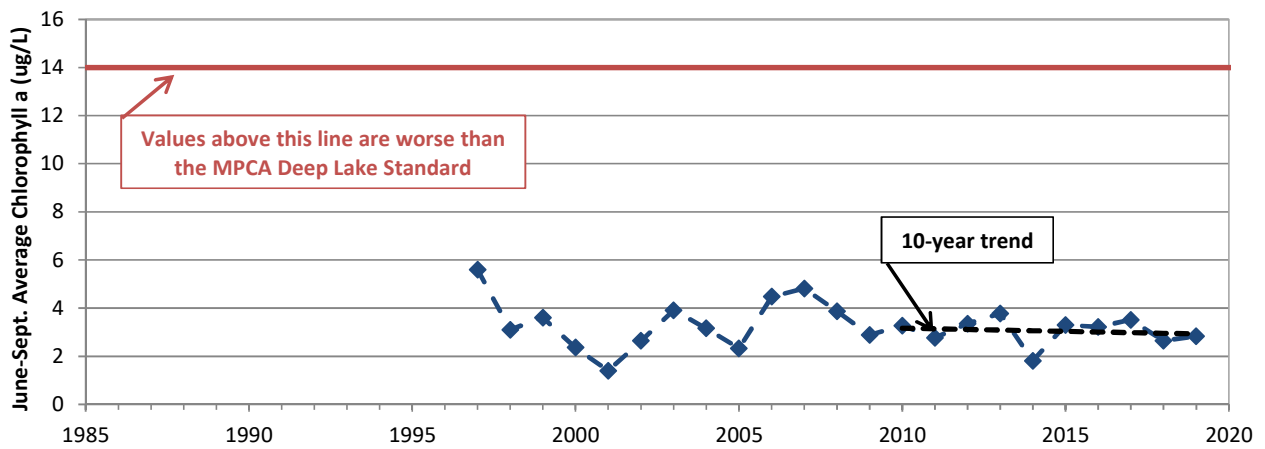
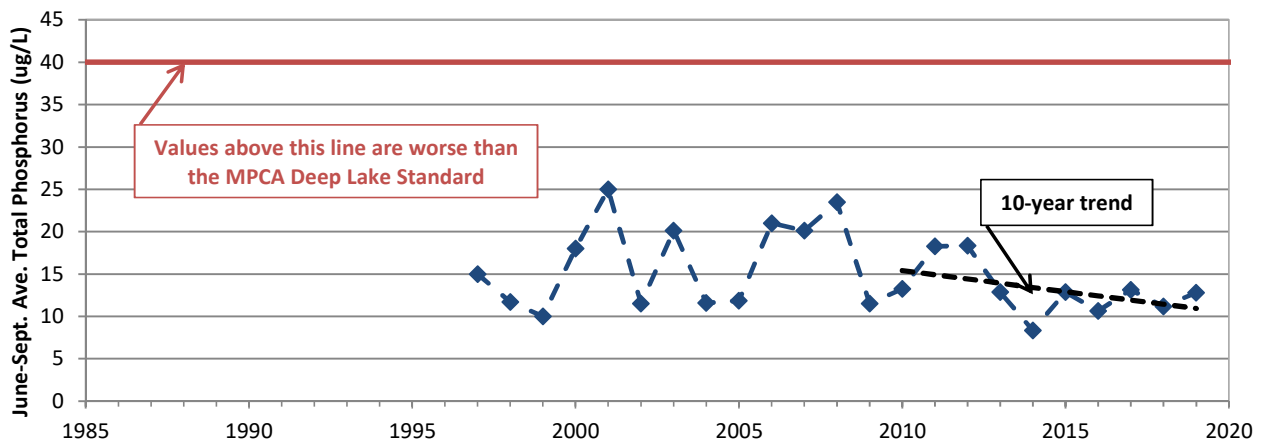


Figure 2c: Lac Lavon June-Sept. Average Total Phosphorus



phosphorus and chlorophyll *a* indicate continued excellent water quality in Lac Lavon. Based on results of 2019 water quality monitoring, a diagnostic study of Lac Lavon is not required or recommended.

The MPCA's lake eutrophication standards include numeric criteria for summer averages (June-September) of Secchi disc transparency, total phosphorus concentrations, and chlorophyll *a* concentrations. The eutrophication standards for a deep lake within the North Central Hardwood Forest ecoregion are provided in Table 1, along with the averages of the most recent 10 years (2010-2019) of monitoring for Lac Lavon. Summer averages of Lac Lavon water quality parameters are consistently much better than the MPCA's lake eutrophication standards.

Table 1 Lac Lavon Water Quality and the MPCA's Lake Eutrophication Standards for Deep Lakes in North Central Hardwood Forest

Water Quality Parameter	MPCA Lake Eutrophication Standard	Lac Lavon 10-yr Average (2010-2019)
Total Phosphorus ($\mu\text{g/L}$)	≤ 40	13
Chlorophyll <i>a</i> ($\mu\text{g/L}$)	≤ 14	3.0
Secchi Disc Transparency (m)	≥ 1.4	4.0

Aquatic Plant (Macrophyte) Surveys

Barr contracted with Endangered Resource Services, LLC to conduct point-intercept surveys in June and August of 2019. Results of the point-intercept surveys, as well as habitat monitoring conducted by Barr in 2019, are detailed in a separate memo (2019 Lac Lavon Habitat Monitoring, February 2019 draft). Barr previously conducted aquatic plant (macrophyte) surveys in 2013, 2014, and 2016. Three aggressive aquatic invasive plants were identified previously in Lac Lavon: curly-leaf pondweed, Eurasian watermilfoil, and brittle naiad. Purple loosestrife, an emergent plant that is also an aggressive non-native species, has been found along the shoreline of Lac Lavon. Curly-leaf pondweed, Eurasian watermilfoil, and purple loosestrife were all found in Lac Lavon in 2019, but brittle naiad was not reported in the 2019 surveys. Brittle naiad (*Najas minor*) was first reported in Lac Lavon in 2003, and has been observed in the lake in 2013, 2014, and 2016 during the August surveys. Brittle naiad was observed at multiple locations in Lac Lavon during the August 2016 survey. Unlike curly-leaf pondweed and Eurasian watermilfoil, which are widespread in many Minnesota lakes, brittle naiad has only been reported in a handful of Minnesota lakes. Brittle naiad grows much shorter than curly-leaf pondweed and Eurasian watermilfoil, which can create dense surface mats; therefore, brittle naiad is less of a nuisance in Lac Lavon than the other non-native invasive plants.

In June 2019, curly-leaf pondweed was found at 29% of sampling points shallow enough for plant growth. Curly-leaf pondweed can create dense, nuisance growths, and can also have negative impacts on water quality due to its earlier seasonal life cycle than native aquatic plants. Curly-leaf pondweed dies back in early to mid-summer, resulting in the release of phosphorus from the decaying plant tissue, as well as consumption of oxygen due to decomposition. The decrease in oxygen can further lead to phosphorus

release from lake sediments. The water quality of Lac Lavon remained excellent throughout the summer months; therefore, curly-leaf pondweed does not appear to be degrading Lac Lavon water quality. Eurasian watermilfoil can create dense, nuisance growths at the lake surface, and have a negative impact on recreational activities, including swimming and boating. Eurasian water milfoil may also crowd out native plant species. In August 2019, Eurasian watermilfoil was found at 56% of sampling points where water was shallow enough for plant growth.

The 2019 Lac Lavon Habitat Monitoring memo describes in detail calculations of a Floristic Quality Index (FQI) for the submergent zone of Lac Lavon. The FQI utilizes species richness (the number of different species present) and the Mean Coefficient of Conservatism (C-value) for the observed species. A higher C-value is given to species that are sensitive to anthropogenic disturbances or eutrophication, while a lower C-value is given to species that are opportunistic invaders or do well in disturbed environments, including degraded water quality associated with eutrophication. Three species were identified in 2019 that have a C-value of 7 and would therefore be considered indicative of good water quality: long-leaf pondweed, muskgrass, and white water crowfoot. The total number of native species found in the submergent zone of Lac Lavon was reported as high (12). The 2019 average native plant density rating was rated as moderate (1.5), and the average exotic species density was rated as moderate (1.7). The Mean C-Value rating was determined to be moderate (4.5). Averaging these four criteria results in a moderate rating overall for the submergent zone of Lac Lavon.

Lake Levels

Lac Lavon has no regularly flowing outlet, and the lake level changes in response to precipitation, evaporation, and groundwater flux. City of Apple Valley staff collected lake elevation data for years 2010 through 2014, 2018, and 2019. During that period, the lake elevation had fluctuated from a low of 927.6 feet on June 2, 2010 to a high of 932.71 feet on September 19, 2019, a difference of 5.11 feet (Figure 3). The high lake levels flooded the path leading to the fishing dock in 2019 (Photograph 1). Many landlocked lakes in the Twin Cities experienced high water levels in 2019 due to record-breaking precipitation in 2019, combined with above-average precipitation in prior recent years.

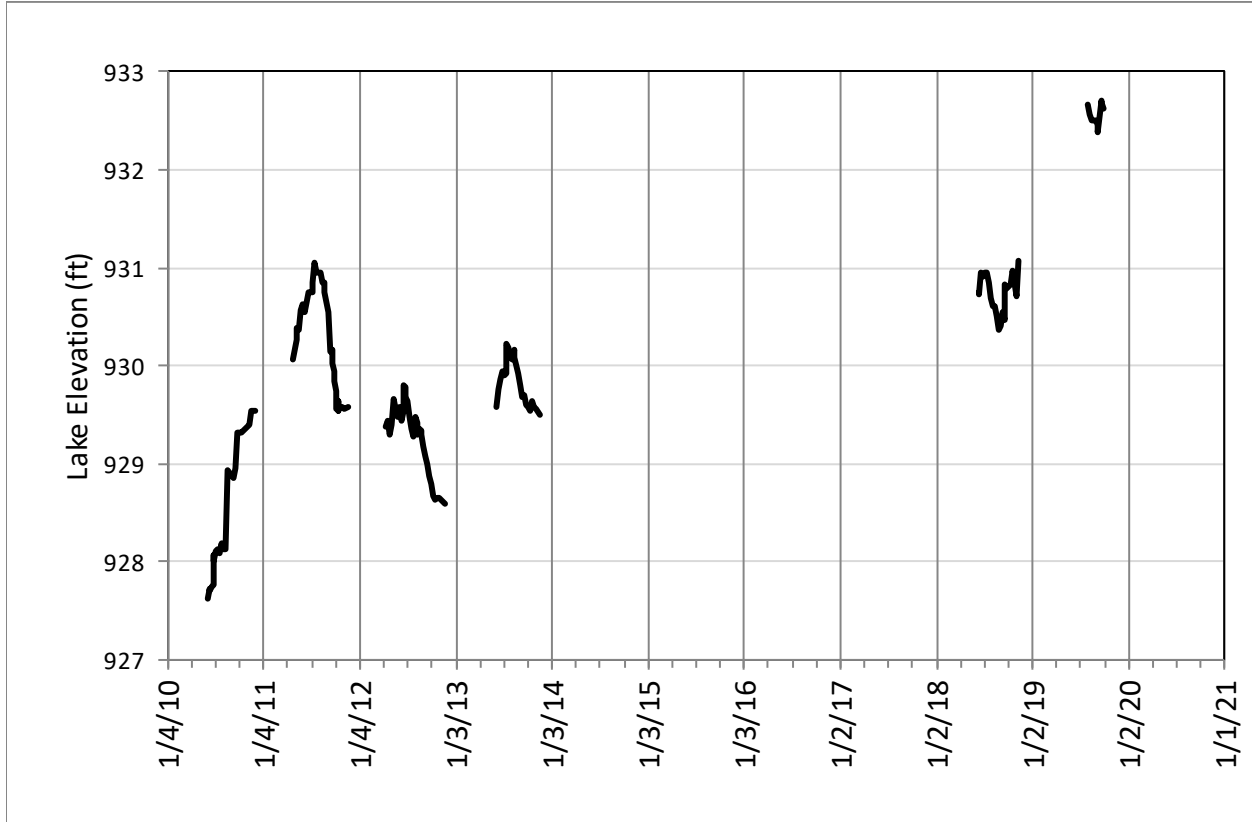


Figure 3: Lac Lavon Water Surface Elevation



Photograph 1: High lake levels in 2019 preventing access to the Lac Lavon fishing dock in city park.

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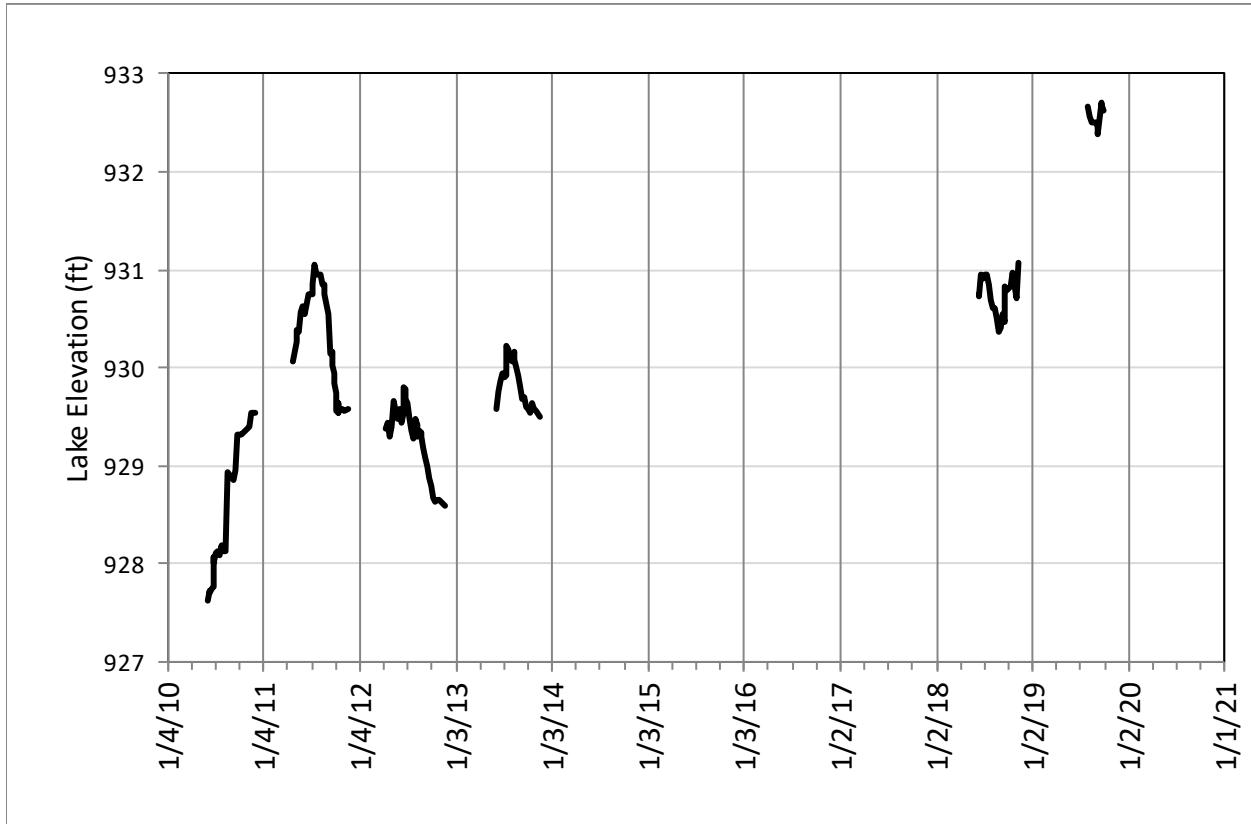


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Discussion of 2019 Lac Lavon Water Quality and Macrophyte Monitoring

Lac Lavon continues to experience excellent water quality. Summer averages of Secchi disc transparency, chlorophyll *a*, and total phosphorus are consistently better than the MPCA's eutrophication standards. A statistical analysis shows an improving trend (90% confidence) of summer averages of Secchi disc transparency for the recent 10-year period of 2010-2019. Barr recommends continuation of the yearly CAMP level water quality monitoring of Lac Lavon, and continuation of the management-level water quality monitoring once every 3 years.

A variety of native and non-native aquatic plants grow in Lac Lavon. Several species of native plants that are indicative of good water quality were identified in 2019. However, dense growths of non-native curly-leaf pondweed and Eurasian watermilfoil are occurring in some areas of the lake. Barr recommends periodic macrophyte surveys to monitor the aquatic plant community of Lac Lavon.

Table 2
Lac Lavon 2019 Water Quality Measured by Barr Engineering
BDWMO

Date	Sample Depth	Field Measurements						Laboratory Analyses	
		Dissolved oxygen [mg/l]	pH	Specific conductance @ 25 °C [umhos/cm]	Water Temperature [°C]	Secchi disc [m]	Turbidity [NTU]	Chlorophyll a, pheophytin-adjusted [ug/l]	Phosphorus, total, as P [mg/l]
4/24/2019	0 - 2 m	--	--	--	--	2.1	2.6	5.7	0.021
4/24/2019	0 m	11.8	8.2	572	11.6	--	--	--	--
4/24/2019	1 m	12.0	8.2	573	11.9	--	--	--	--
4/24/2019	2 m	12.2	8.2	573	10.7	--	--	--	--
4/24/2019	3 m	12.3	8.1	572	9.0	--	--	--	0.018
4/24/2019	4 m	11.1	7.9	574	7.5	--	--	--	0.016
4/24/2019	5 m	10.6	7.8	574	6.8	--	--	--	0.020
4/24/2019	6 m	9.0	7.6	574	6.2	--	--	--	0.016
4/24/2019	7 m	8.1	7.5	577	5.9	--	--	--	0.018
4/24/2019	8 m	7.7	7.5	578	5.9	--	--	--	0.020
4/24/2019	9 m	6.9	7.4	580	5.6	--	--	--	0.021
5/08/2019	0 - 2 m	--	--	--	--	2.9	1.7	1.5	0.025
5/08/2019	0 m	11.1	8.2	582	14.3	--	--	--	--
5/08/2019	1 m	11.2	8.2	581	14.3	--	--	--	--
5/08/2019	2 m	11.2	8.3	582	14.3	--	--	--	--
5/08/2019	3 m	11.5	8.3	581	13.8	--	--	--	0.027
5/08/2019	4 m	12.2	8.2	575	10.8	--	--	--	0.019
5/08/2019	5 m	12.3	8.0	571	7.8	--	--	--	0.026
5/08/2019	6 m	9.1	7.7	575	6.7	--	--	--	0.021
5/08/2019	7 m	6.2	7.4	580	6.3	--	--	--	0.030
5/08/2019	8 m	4.4	7.2	580	6.0	--	--	--	0.032
5/08/2019	9 m	0.2	7.1	643	5.9	--	--	--	0.042
5/23/2019	0 - 2 m	--	--	--	--	2.7	2.1	2.1	0.018
5/23/2019	0 m	9.8	8.2	565	13.7	--	--	--	--
5/23/2019	1 m	9.8	8.2	565	13.7	--	--	--	--
5/23/2019	2 m	9.8	8.3	565	13.7	--	--	--	--
5/23/2019	3 m	9.8	8.3	566	13.7	--	--	--	0.025
5/23/2019	4 m	9.8	8.3	566	13.7	--	--	--	0.022
5/23/2019	5 m	9.8	8.3	566	13.6	--	--	--	0.020
5/23/2019	6 m	9.8	8.3	565	13.6	--	--	--	0.030
5/23/2019	7 m	10.6	7.8	580	9.0	--	--	--	0.030
5/23/2019	8 m	1.2	7.5	584	7.1	--	--	--	0.041
5/23/2019	9 m	0.1	7.3	685	6.3	--	--	--	0.038
6/04/2019	0 - 2 m	--	--	--	--	3.7	1.2	2.8	0.012
6/04/2019	0 m	10.7	8.4	560	20.6	--	--	--	--
6/04/2019	1 m	10.7	8.5	560	20.5	--	--	--	--
6/04/2019	2 m	10.7	8.5	560	20.4	--	--	--	--
6/04/2019	3 m	11.5	8.4	556	18.3	--	--	--	0.0092
6/04/2019	4 m	11.4	8.4	566	16.1	--	--	--	0.014
6/04/2019	5 m	9.8	8.1	571	13.7	--	--	--	0.012
6/04/2019	6 m	9.3	7.7	582	9.8	--	--	--	0.011
6/04/2019	7 m	6.2	7.4	584	7.9	--	--	--	0.017
6/04/2019	8 m	0.8	7.2	598	7.1	--	--	--	0.020
6/17/2019	0 - 2 m	--	--	--	--	4.2	1.8	2.3	0.018
6/17/2019	0 m	9.6	8.5	535	21.7	--	--	--	--
6/17/2019	1 m	9.7	8.5	535	21.7	--	--	--	--
6/17/2019	2 m	9.7	8.5	535	21.6	--	--	--	--
6/17/2019	3 m	9.7	8.5	535	21.5	--	--	--	0.0092
6/17/2019	4 m	11.2	8.4	549	19.4	--	--	--	0.016
6/17/2019	5 m	12.6	8.4	557	15.1	--	--	--	0.018
6/17/2019	6 m	10.0	7.9	566	11.0	--	--	--	0.033
6/17/2019	7 m	4.5	7.6	574	8.9	--	--	--	0.024
6/17/2019	8 m	0.2	7.1	610	7.6	--	--	--	0.038
6/17/2019	9 m	0.1	7.1	666	7.2	--	--	--	0.058
7/01/2019	0 - 2 m	--	--	--	--	3.1	1.6	2.6	0.017
7/01/2019	0 m	9.0	8.4	517	24.2	--	--	--	--
7/01/2019	1 m	9.0	8.4	517	24.2	--	--	--	--
7/01/2019	2 m	9.1	8.4	519	24.2	--	--	--	--
7/01/2019	3 m	9.0	8.4	516	24.1	--	--	--	0.015
7/01/2019	4 m	7.1	7.9	555	21.8	--	--	--	0.016
7/01/2019	5 m	10.4	8.1	574	18.2	--	--	--	0.022
7/01/2019	6 m	8.8	7.6	584	11.7	--	--	--	0.029
7/01/2019	7 m	4.5	7.2	602	9.8	--	--	--	0.027

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		Dissolved oxygen [mg/l]	pH	Specific conductance @ 25 °C [umhos/cm]	Water Temperature [°C]	Secchi disc [m]	Turbidity [NTU]	Chlorophyll a, pheophytin-adjusted [ug/l]	Phosphorus, total, as P [mg/l]
7/01/2019	8 m	0.08	7.0	638	8.4	--	--	--	0.038
7/01/2019	9 m	0.05	6.9	713	7.7	--	--	--	0.045
7/22/2019	0 - 2 m	--	--	--	--	3.7	1.8	1.3	0.013
7/22/2019	0 m	8.5	8.5	506	26.0	--	--	--	--
7/22/2019	1 m	8.6	8.6	504	26.1	--	--	--	--
7/22/2019	2 m	8.6	8.6	504	26.0	--	--	--	--
7/22/2019	3 m	8.6	8.6	505	26.0	--	--	--	0.012
7/22/2019	4 m	8.6	8.5	507	26.0	--	--	--	0.014
7/22/2019	5 m	8.2	7.8	533	20.5	--	--	--	0.018
7/22/2019	6 m	9.8	7.8	592	15.3	--	--	--	0.024
7/22/2019	7 m	3.1	7.2	605	11.4	--	--	--	0.020
7/22/2019	8 m	0.2	7.0	652	9.2	--	--	--	0.025
7/22/2019	9 m	0.1	7.0	749	8.2	--	--	--	0.058
8/05/2019	0 - 2 m	--	--	--	--	4.1	0.3	3.0	0.015
8/05/2019	0 m	10.1	8.9	513	26.9	--	--	--	--
8/05/2019	1 m	10.0	8.9	512	27.0	--	--	--	--
8/05/2019	2 m	10.1	8.9	513	27.0	--	--	--	--
8/05/2019	3 m	10.0	8.9	514	27.0	--	--	--	0.015
8/05/2019	4 m	6.9	8.8	570	26.5	--	--	--	0.012
8/05/2019	5 m	8.5	8.0	600	22.0	--	--	--	0.020
8/05/2019	6 m	8.6	7.8	607	16.3	--	--	--	0.034
8/05/2019	7 m	1.7	7.3	628	12.4	--	--	--	0.042
8/05/2019	8 m	0.4	7.2	662	9.8	--	--	--	0.076
8/05/2019	9 m	0.1	7.2	789	8.2	--	--	--	0.17
8/19/2019	0 - 2 m	--	--	--	--	3.6	1.4	2.2	0.017
8/19/2019	0 m	8.6	8.7	504	25.0	--	--	--	--
8/19/2019	1 m	8.7	8.7	504	24.6	--	--	--	--
8/19/2019	2 m	8.6	8.7	504	24.5	--	--	--	--
8/19/2019	3 m	8.4	8.7	502	24.4	--	--	--	0.016
8/19/2019	4 m	6.1	7.8	576	22.9	--	--	--	0.013
8/19/2019	5 m	8.1	7.8	596	17.7	--	--	--	0.014
8/19/2019	6 m	1.2	7.2	621	13.2	--	--	--	0.016
8/19/2019	7 m	0.7	7.0	667	10.5	--	--	--	0.015
8/19/2019	8 m	0.6	7.1	788	8.6	--	--	--	0.030
8/19/2019	9 m	0.4	7.1	804	8.5	--	--	--	0.092
9/11/2019	0 - 2 m	--	--	--	--	2.8	1.3	3.8	0.017
9/11/2019	0 m	8.4	8.5	515	20.2	--	--	--	--
9/11/2019	1 m	8.3	8.3	515	20.2	--	--	--	--
9/11/2019	2 m	8.3	8.5	515	20.1	--	--	--	--
9/11/2019	3 m	8.1	8.5	515	20.1	--	--	--	0.014
9/11/2019	4 m	8.1	8.5	515	20.1	--	--	--	0.014
9/11/2019	5 m	8.1	8.5	515	20.1	--	--	--	0.015
9/11/2019	6 m	4.6	7.8	545	19.2	--	--	--	0.016
9/11/2019	7 m	0.5	7.4	630	14.6	--	--	--	0.042
9/11/2019	8 m	0.4	7.2	686	11.1	--	--	--	0.036
9/11/2019	9 m	0.4	7.2	814	8.9	--	--	--	0.056
9/24/2019	0 - 2 m	--	--	--	--	4.1	1.6	2.8	0.015
9/24/2019	0 m	9.2	8.6	514	20.9	--	--	--	--
9/24/2019	1 m	9.1	8.7	514	20.9	--	--	--	--
9/24/2019	2 m	9.1	8.7	512	20.9	--	--	--	--
9/24/2019	3 m	9.1	8.6	512	20.8	--	--	--	0.012
9/24/2019	4 m	7.6	8.4	518	19.8	--	--	--	0.013
9/24/2019	5 m	5.8	8.2	518	19.3	--	--	--	0.017
9/24/2019	6 m	2.3	7.7	528	18.5	--	--	--	0.014
9/24/2019	7 m	0.3	7.4	636	15.3	--	--	--	0.032
9/24/2019	8 m	0.2	7.3	684	11.8	--	--	--	0.036
9/24/2019	9 m	0.2	7.4	813	9.4	--	--	--	0.094

-- Not analyzed

Table 3: Lac Lavon Water Quality Measured by CAMP Volunteer

Sample Date	Sample Depth [m]	Secchi Disc Transparency [m]	Water Temperature [°C]	Chlorophyll-a, Pheophytin Corrected [µg/L]	Nitrogen, Total Kjeldahl [mg/L]	Total Phosphorus [ug/L]
5/7/2019	0	3.9	13.1	1.6	0.58	18
5/22/2019	0	3.5	14.3	2.2	0.55	15
6/2/2019	0	4.5	25.5	2.6	0.53	14
6/16/2019	0	4.8	21.8	2.5	0.59	~7
7/1/2019	0	4.6	25.9	2.0	0.41	12
7/29/2019	0	4.3	26.6	2.4	0.40	~9
8/11/2019	0	3.7	25.0	3.1	0.34	~9
8/27/2019	0	4.3	22.3	3.9	0.47	10
9/9/2019	0	3.6	20.7	5.2	0.48	~9
9/22/2019	0	4.5	21.2	2.8	0.44	11
10/19/2019	0	2.9	11.4	12	0.60	18

Notes

~9 - Value is less than the laboratory's method reporting limit, and is therefore an approximate value.