2020 Lake Orono Water Quality Monitoring Summary

Data collected by Lake Orono Improvement Association volunteers
Report by Sherburne Soil & Water Conservation District, Jan 2021

Introduction

In 2020 as well as years past, trained volunteers with the Lake Orono Improvement Association collected water quality in several locations on Upper and Lower Lake Orono. The map below shows the approximate sampling locations.

The following parameters were collected in 2020:

- Total Phosphorus: monthly May-Sept, Sites 202 and 206
- Chlorophyll-a: monthly May-Sept, Sites 202 and 206
- Secchi Disk Clarity: monthly May-Sept, Sites 204,205,202 and 206
- Total Suspended Solids: monthly May-Sept, Sites 202 and 206
- True Color: monthly May-Sept, Sites 202 and 206

The next few pages display the collected data graphically and provides short interpretations on the relationships observed between these parameters. Datasets are provided in Appendix A.

Phosphorus, Chlorophyll-a and Secchi Disk Clarity 2020 Trends

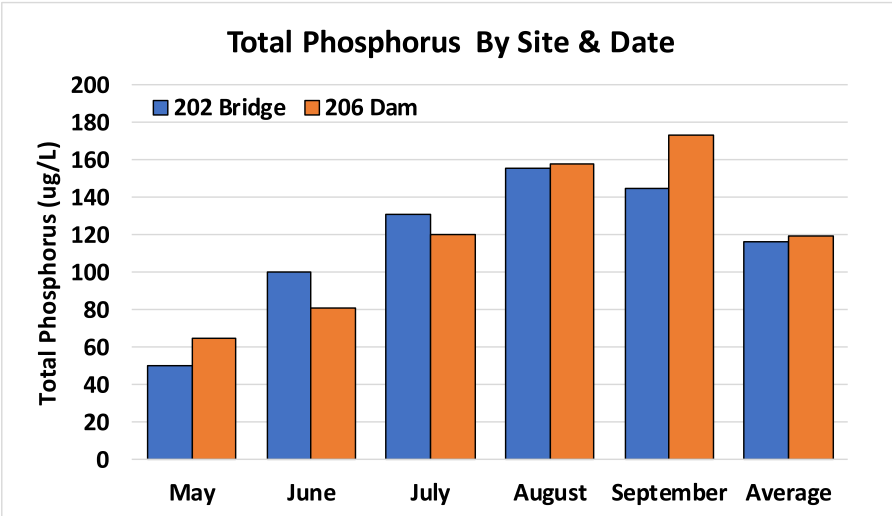

Figure 1: Total phosphorus content remained fairly consistent between upstream and downstream sites in 2020. The shallow lake standard is 60 ug/L, which was exceeded in 9 out of 10 samples. The river standard for the Elk River upstream is 100 ug/L.

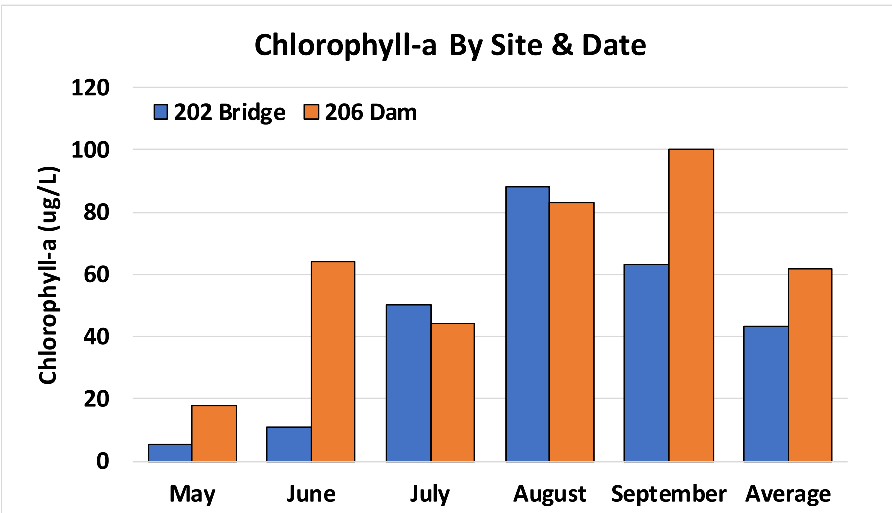

Figure 2: Chlorophyll-a varied greatly in June and September, with moderate differences between sites in other months. The chlorophyll-a standard of 20 ug/L was exceeded in 7 of 10 samples.

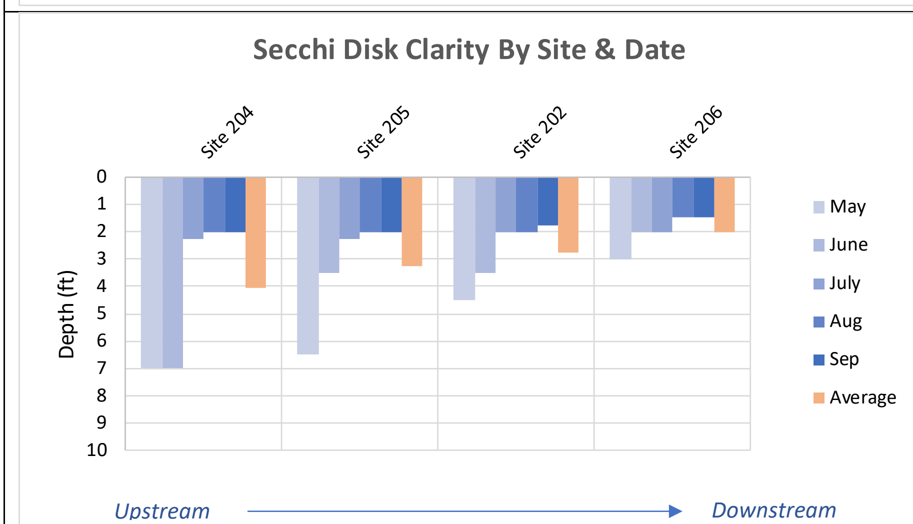

Figure 3: Secchi disk clarity decreased substantially from May/June into the middle and late summer. Average summer values also decreased from upstream to downstream sites from 4.0 ft, 3.25 ft, 2.75 ft and 2.0 ft. The shallow lake standard is 3.3 ft.

Phosphorus, Chlorophyll-a and Secchi Disk Clarity Long-Term Trends

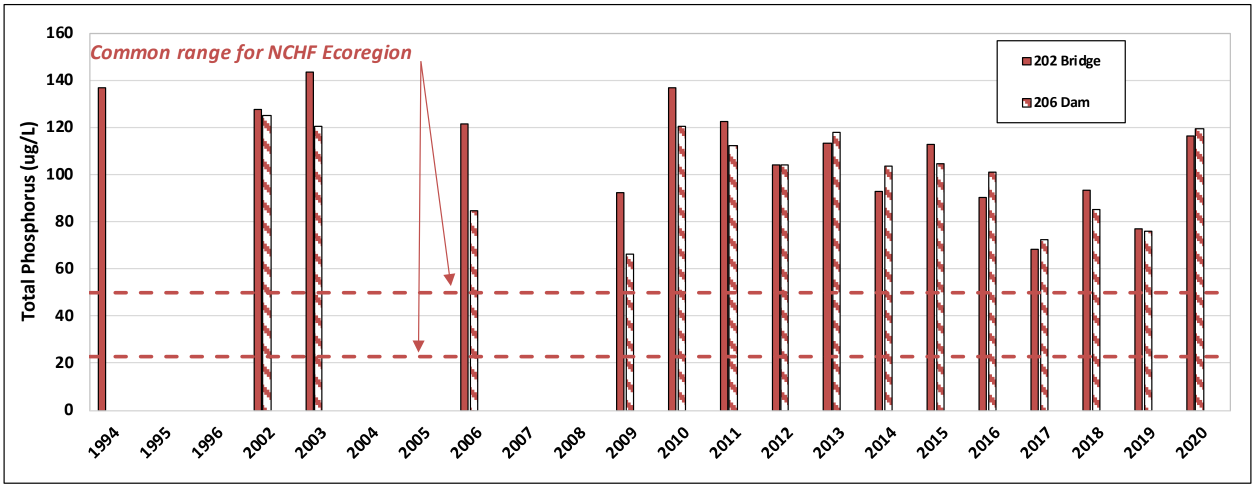

Figure 4: Lake Orono Long-Term Water Quality Data (Total Phosphorus)

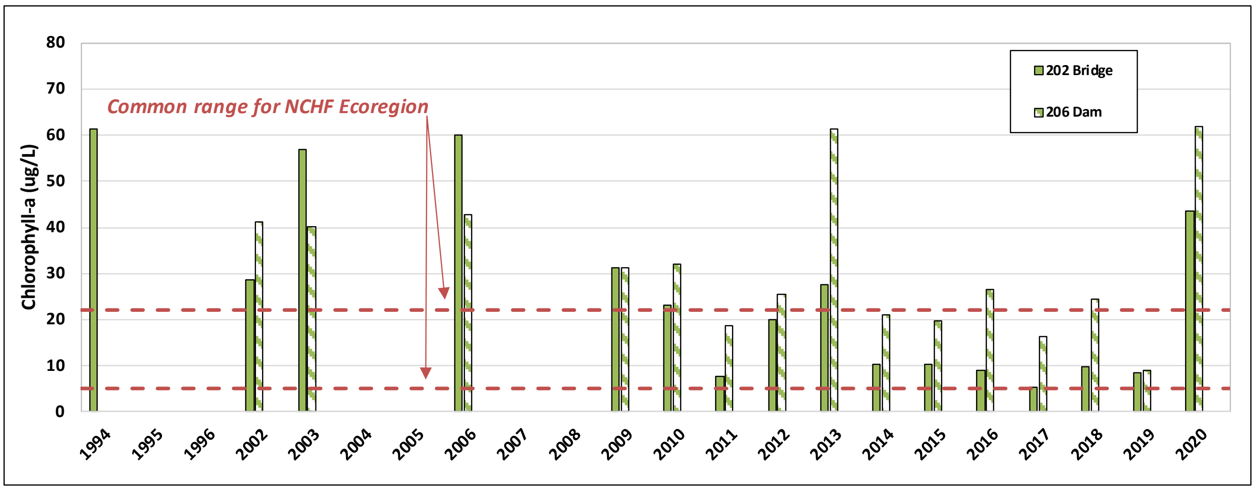

Figure 5: Lake Orono Long-Term Water Quality Data (Chlorophyll-a)

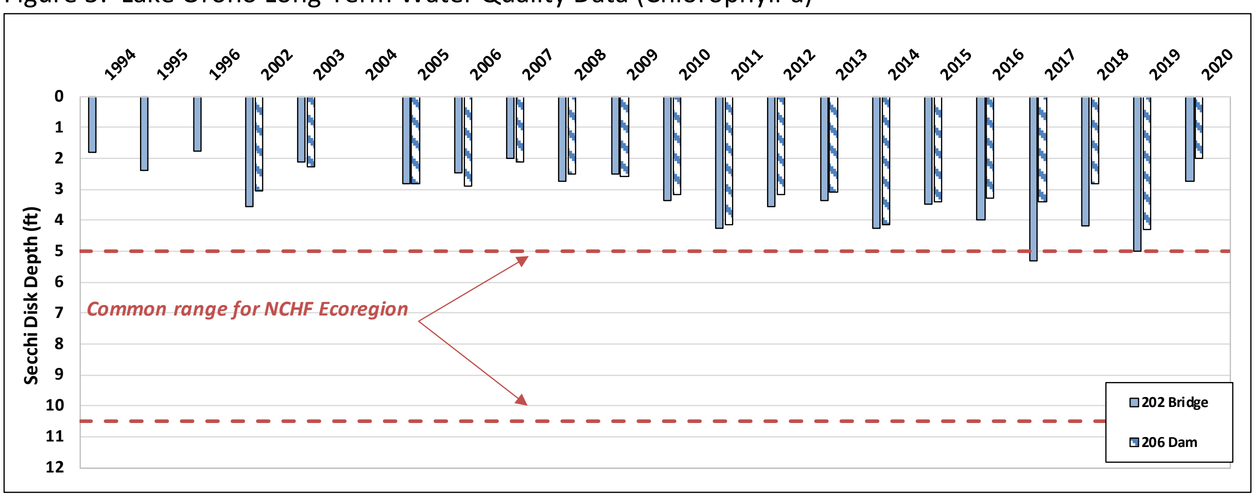

Figure 6: Lake Orono Long-Term Water Quality Data (Secchi Disk Clarity)

The 2020 water quality data shows a sharp departure from the improving trends observed from the past decade of records (Figures 4, 5 and 6). Total phosphorus and chlorophyll-a levels in 2020 are similar to those seen in 2013, and the clarity in 2020 was the worst noted since 2007. average at site 202 and 206 were calculated to be 116.4 ug/L and 119.4 ug/L, respectfully. A trend that has been noted in years past and persists again in 2020 is a relatively small change in total phosphorus between basins, yet a large difference in chlorophyll-a between basins. A slight difference in Secchi disk clarity, consistent with higher chlorophyll-a, can be observed between basins but may not be considered substantial.

Common ranges for regional lakes are included in each chart above (red dashed lines). Lake Orono standards for the three parameters are 60 ug/L (phosphorus), 20 ug/L (chlorophyll-a) and 3.3 ft (Secchi disk).

True Color and Total Suspended Solids - 2020

The Lake Orono Water Quality Committee (LOWQC) has been observing the above noted trends between the northern and southern basin for some time. In 2019 and 2020, additional parameters were monitored to attempt to gather more information regarding these note differences. In 2019, dissolved oxygen and temperature were monitored numerous times through the growing season to determine if differences in oxygen and temperature content were apparent between basins. The results of this effort were that, in 2019, no apparent differences were noted between these parameters in between basins. At all sites, similar oxygen and temperature content was found throughout the entire water column. The results of the 2019 monitoring can be found in a “Lake Orono 2019 WQ Summary Report”.

In 2020, the LOWQC collected data on two other parameters, True Color and Total Suspended Solids.

- True Color: The observed color of lake water is the result of light backscattered upward from the water after it has passed through various depths and undergone selective adsorption. Colors are the result of suspended and dissolved substances in the water column primarily, but also can be influenced by the lake bottom color, depth of lake, and color (wavelength) of light reflecting off the water towards your eyes.
  - *Apparent color* is what the human eye sees and describes (colorless or clear, blue, green, yellow, brown, etc.).
  - *True Color* is a standardized way of measuring the color of a waterbody without influence of outside factors or differences in human eyesight. Often the value range is similar for a lake, but may fluctuate following a change in environmental conditions such as a large rain event or a severe drought which may increase or decrease dissolved components in a lake system.
  - *True Color* is the color of water considering only dissolved substances; all other factors are removed and the resulting color is not concealed by these extra factors. True color is determined by filtering a water sample to remove suspended particles, then the sample is compared to a specific color scale using a spectrophotometer in a laboratory. The scale used is typically the platinum-cobalt color scale, comprised of 1,000 color units. True color can be referenced as unitless but often relates to this color scale and can be accompanied by the unit notation "PCU" or "Pt-Co units".

- The vast majority of all freshwater lakes have a True Color value less than 50, though some lakes may have a True Color of several hundred PCU if they hold high amounts of dissolved organic matter (bogs are a type of lake that would fit this category).

- Total Suspended Solids: This parameter can be described as particles that are larger than 2 microns (1 micon = 0.001 milimeter) found in the water column. These particles may include anything drifting or floating in the water including sediment, silt, plankton (algae or zooplankton), or other organic or inorganic particles.
    - A water sample is filtered using a 2 micron sieve to strain the water of these contents
    - Where True Color gives us a measurement of *dissolved particulates* in a water sample, TSS measures directly the *particulate content* above the 2 micron size threshold.

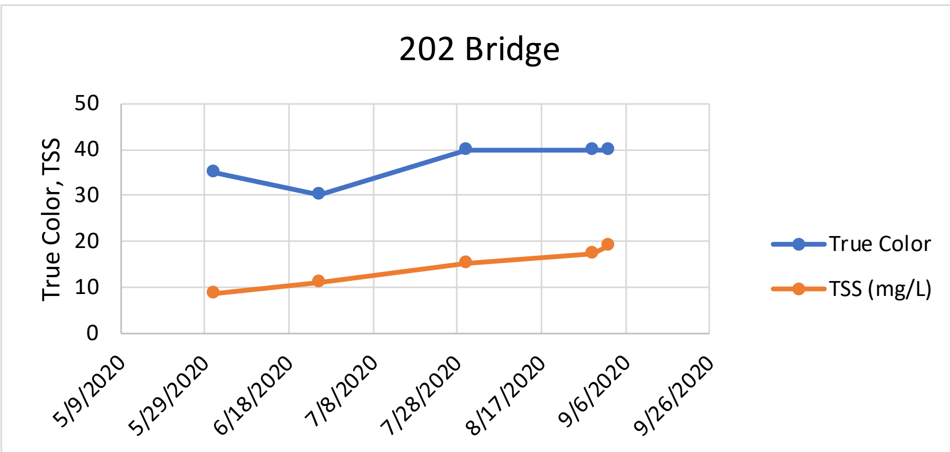

Figure 7: Lake Orono True Color and Total Suspended Solids, Site 202, 2020.

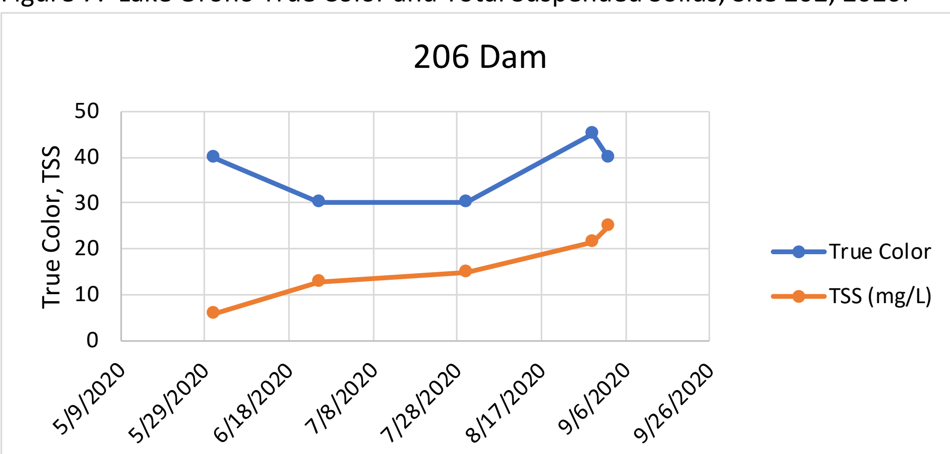

Figure 8: Lake Orono True Color and Total Suspended Solids, Site 206, 2020.

In 2020 the True Color ranged between 30 and 40 for Site 202 (bridge) and averaged 37 between five samples. For Site 206, the range was 30 to 45 and an average of 37 across five samples was calculated. True Color is measured in intervals of 5 across a scale of 0-1,000, so in other words a sample measurement of “30” is very close to a sample that measures “35” or “40”. Between basins, the difference in True Color measurements never exceeded a value of 5 indicating very little difference between basins for this parameter. The range of 30-40 is quite a common range for lakes in Minnesota, particularly lakes which may be classified as drainage lakes such as Lake Orono.

Total suspended solids data shows an increasing pattern at both sites as the summer season progresses. TSS was measured at 8.8 mg/L (Site 202) and 6.0 mg/L (Site 206) in late May. At each sampling event following the TSS increased, reaching 19.2 mg/L at Site 202 and 24.8 mg/L at Site 206 in early September. A correlation analysis shows that TSS was highly positively correlated with chlorophyll-a and phosphorus in each basin (as TP and Chl-a increases, TSS increases) and highly negatively correlated with Secchi disk clarity (TSS increases are observed as SD decreases).

The parameter TSS measures all particles greater than 2 microns in size. This may include organic as well as inorganic particles; meaning that it can measure sand and silt as well as algae. Upstream of Lake Orono at County Rd 15, the Sherburne SWCD has monitored water quality for several years through a cooperative agreement with the Minnesota Pollution Control Agency. Water at this site is part of a flowing system (the Elk River) so particles are likely to be suspended. That same water, as it reaches Lake Orono and slows in velocity, may drop particulates that were previously suspended. Most TSS measurements from the Elk River at County Rd 15 are found to be less than 10 mg/L – the exception would be measurements made following heavy rains which increase the rivers discharge and velocity, so higher TSS measurements (>20 mg/L) can be observed.

Given that the flowing water upstream generally holds TSS values of less than 10 mg/L, and under baseflow conditions often under 5 mg/L, a bulk of the TSS component from Lake Orono samples may be organic material (as opposed to inorganic sands/silts). This is particularly relevant for the late summer values that fell near or above 20 mg/L for both Sites 202 and 206, during these periods both high TSS and high Chlorophyll-a were noted. However; while the data indicate that a general higher TSS and higher Chlorophyll-a relationship is observed, the data do not indicate a correlation between basins that would explain the long-noticed difference in water quality between the north and south Lake Orono basins. Explaining this another way, TSS is noted to increase with increasing CHL-a values in both basins, but during sampling events that displayed drastic differences between CHL-a or Secchi Disk clarity, the level of difference between site TSS values was not corresponding accordingly.

Conclusions:

1. True Color - True Color values are as expected and range between 30 and 45. In a flow-through system such as Lake Orono, dissolved substances can be variable based upon what is flowing into the lake from upstream. This is also highly dependent upon rainfall rates and groundwater saturation in upstream locations. It is unlikely that True Color (dissolved elements) are impacting the noted difference in water quality between the north and south basins of Lake Orono.

2. Total Suspended Solids - A correlation was seen between TSS and other water quality parameters. TSS is measuring some inorganic materials in Lake Orono (sediment/silt) but a large portion of the parameter is likely organic, so Chlorophyll-a is a good indicator parameter. An unknown variable would be other organic material such as zooplankton, which are likely picked up in the TSS sample. Overall, it is unlikely that Total Suspended Solids (particulate elements) are impacting the noted difference in water quality between the north and south basins of Lake Orono.

3. <u>Total Phosphorus, Chlorophyll-A and Secchi Disk Clarity</u> - 2020 water quality variables were quite high in both north and south Lake Orono basins when compared to the record of historic values, particularly within the past decade. The reason for this is unknown. Being a drainage system, Lake Orono is highly dependent upon activities occurring upstream in its ~630 square mile watershed. As water discharge increases into Lake Orono, more material such as sediment and nutrients (phosphorus) may be moved into the lake. However, at the same time, as discharge increases from the river the residence time of the lake (length of time before the lake replaces its water volume) decreases as well. The charts below show the discharge of the Elk River in 2017-2020, note the scale on the left-hand side on each graph for reference.

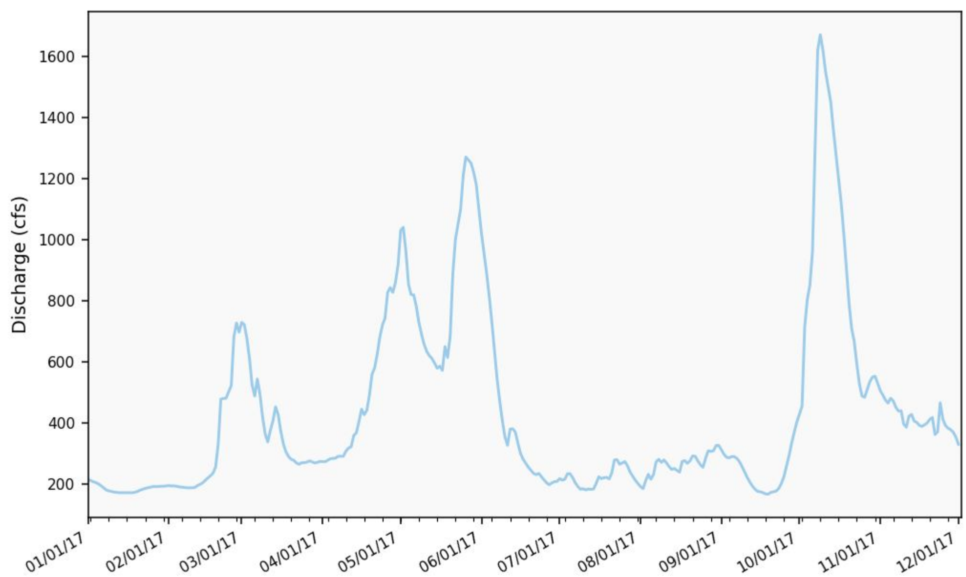

Figure 9: Elk River Cty Rd 15 discharge, 2017

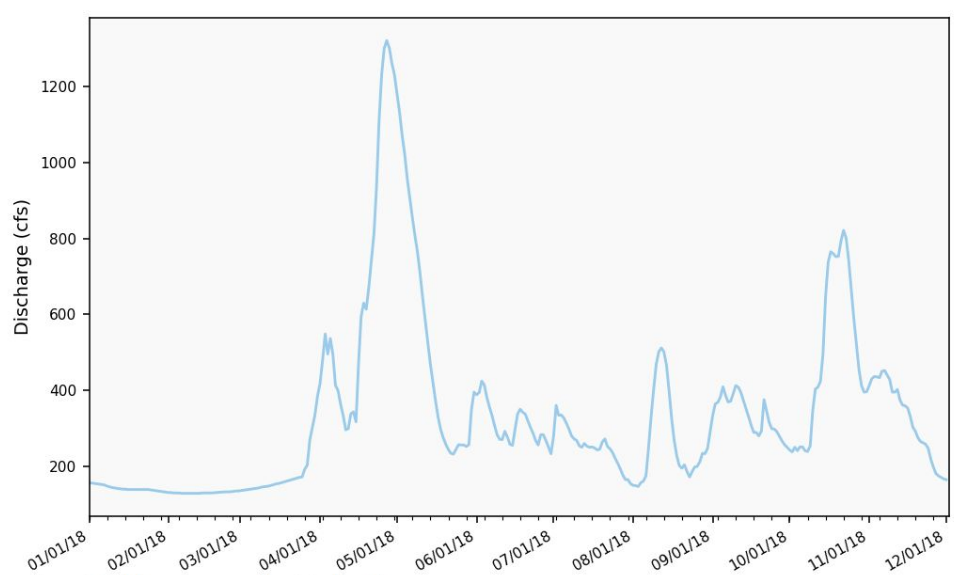

Figure 10: Elk River Cty Rd 15 discharge, 2018

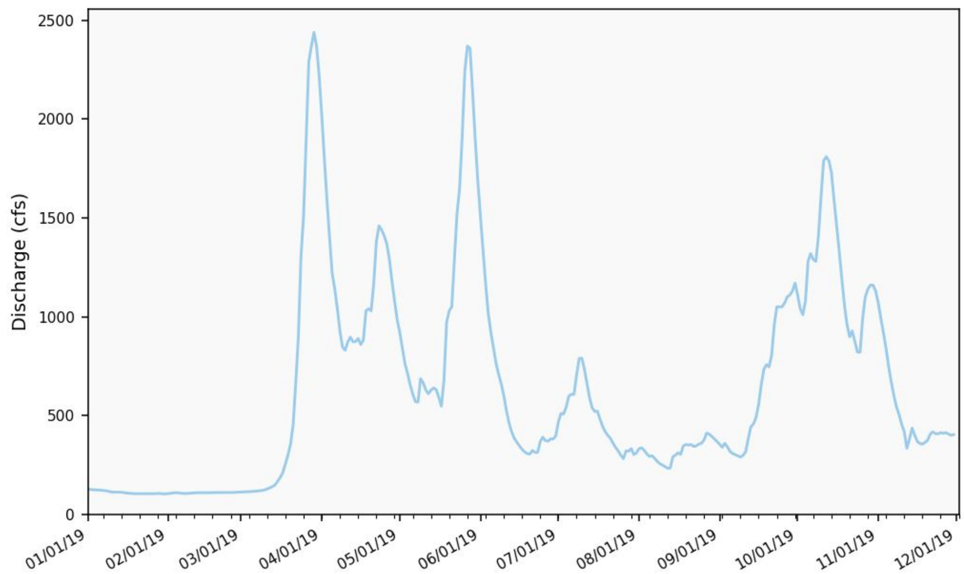

Figure 11: Elk River Cty Rd 15 discharge, 2019

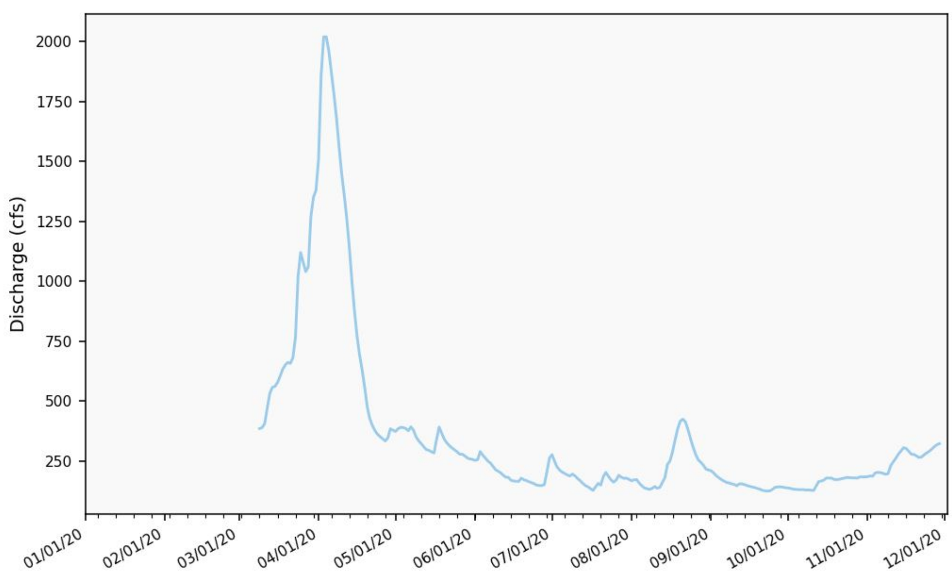

Figure 12: Elk River Cty Rd 15 discharge, 2019

2019 was one of the wettest years on record in Minnesota, and Lake Orono had relatively great water quality this year. Lake Orono also had great water quality in 2017 and 2018, when discharge was moderate but several spikes in precipitation created larger flow events. In 2020, abundant snowmelt water as well as rain in the month of April resulted in a large spike in water flow from the Elk River, then low water conditions persisted through the rest of the year.

2021 Monitoring - The Lake Orono ecosystem will undergo a major disruption in 2020 due to the Lake Orono Restoration and Enhancement (LORE) project which includes a fall-winter drawdown and dredging in the north basin. With this, data from 2021 may not be comparable to previous years. It is recommended that continued monitoring of Total Phosphorus, Chlorophyll-a and Secchi Disk clarity be continued as this is a long-standing program for the lake. If the different water quality observations made in the past are again noticed between the north and south basins in 2021, additional investigations may be considered in 2022 and beyond. Additional investigations may include:

1. Zooplankton study: A comparative analysis of the zooplankton community between the north and south basins of the lake. As mentioned in the 2019 water quality report, zooplankton feed on algae and can impact the amount of algae (thus Chlorophyll-a) in a lake. Zooplankters rely on dense aquatic vegetation to hide from predatory fish, so it is plausible that the northern basin (with abundant plant growth) harbors a more populated zooplankton community which aids in reducing algae through their grazing. In the more exposed southern basin, the zooplankton community may be less populated and so more algae are able to proliferate.

2. Examine stormwater inputs to south basin: The City of Elk River and Sherburne SWCD teamed up in 2015-2016 to conduct a sub-watershed analysis of contributing areas of the stormwater system to the lake. Many areas surrounding the lake were found to be non-contributing, that is, stormwater ponds were found to be in great functioning condition and of sufficient size to hold stormwater and not discharge to the lake. Several other areas that likely discharge to the lake could be examined to estimate their flow contribution, and event-based samples collected to determine if excessive phosphorus is reaching the lake through these avenues. The amount of stormwater potentially entering the southern basin through neighboring communities is certainly minimal compared to the volume of water transported by the Elk River, as well as connecting Ditch 28 and Ditch 31. And, though this investigation may shed light on some inputs of nutrients to the south basin of Lake Orono it would not explain why there is an observed difference in chlorophyll-a between basins but not a difference in total phosphorus between basins. However, this remains as an unknown factor of potential water and nutrient contribution to the Lake Orono system. Coordination and input from City of Elk River staff would help to shed light on the potential inputs from storm sewer systems and which areas might be targeted for closer examination.

Appendix A: Compiled Water Quality Monitoring Data

	202 Bridge					206 Dam				
Date	True Color	TSS (mg/L)	SD (ft)	Chl-A (mg/L)	TP (mg/L)	True Color	TSS (mg/L)	SD (ft)	Chl-A (mg/L)	TP (mg/L)
5/31/2020	35.0	8.8	4.5	5.3	50.0	40.0	6.0	3.0	18.0	65.0
6/25/2020	30.0	11.2	3.5	11.0	100.0	30.0	12.8	2.0	64.0	81.0
7/30/2020	40.0	15.2	2.0	50.0	131.0	30.0	14.8	2.0	44.0	120.0
8/29/2020	40.0	17.2	2.0	88.0	156.0	45.0	21.4	1.5	83.0	158.0
9/2/2020	40.0	19.2	1.8	63.0	145.0	40.0	24.8	1.5	100.0	173.0
Average	37.0	14.3	2.8	43.5	116.4	37.0	16.0	2.0	61.8	119.4
Min	30.0	8.8	1.8	5.3	50.0	30.0	6.0	1.5	18.0	65.0
Max	40.0	19.2	4.5	88.0	156.0	45.0	24.8	3.0	100.0	173.0

1994 - 2018 Growing Season Averages						
Site	202	206	202	206	202	206
Year	Secchi		Chla		TP	
1994	1.8		61.3		137.0	
1995	2.4					
1996	1.8					
2002	3.5	3.0	28.5	41.2	127.4	125.2
2003	2.1	2.3	56.8	40.3	143.3	120.3
2004						
2005	2.8	2.8				
2006	2.4	2.9	60.0	42.8	121.2	84.8
2007	2.0	2.1				
2008	2.7	2.5				
2009	2.5	2.6	31.3	31.3	92.2	66.4
2010	3.3	3.1	23.1	32.0	136.5	120.5
2011	4.3	4.1	7.7	18.8	122.3	112.3
2012	3.5	3.1	20.1	25.6	104.2	104.2
2013	3.3	3.1	27.6	61.3	113.0	118.0
2014	4.3	4.1	10.3	21.0	93.0	103.5
2015	3.5	3.4	10.4	19.8	112.5	104.8
2016	4.0	3.3	9.1	26.4	90.0	100.8
2017	5.3	3.4	5.4	16.4	68.4	72.4
2018	4.2	2.8	9.8	24.4	93.4	85.2
2019	5.0	4.3	8.4	9.0	77.2	75.8
2020	2.8	2.0	43.5	61.8	116.4	119.4
Avg	**3.2**	**3.1**	**25.8**	**31.5**	**109.2**	**100.9**