2020 Pelican River Watershed District Monitoring Report

Pelican River watershed district

DISTRICT MISSION

To enhance the quality of water in the lakes within our jurisdiction. It is understood to accomplish this, the District must ensure wise decisions are made concerning the management of streams, wetlands, lakes, groundwater, and related land resources which affect these lakes.

Adam Mortenson
Water Resource Coordinator

1 Executive Summary

The Pelican River Watershed District (PRWD) performs an extensive monitoring operation to track trends and anomalies in the quality of District Waters. It is the intent of this program to maintain consistent and accurate water quality data to guide District practices and programs. This program was initiated in 1995 and has continued to the present date. Routine monitoring activities are performed according to the 10-Year Monitoring Plan adopted by the District in 2020.

In 2020, District Staff sampled water quality on 13 lakes and 18 locations on 5 different streams. Of the 13 lakes sampled, 2 lakes were sampled for the first time in 2020. An aquatic vegetation survey was performed on Big Floyd, North Floyd, and Little Floyd lakes. Shoreline surveys were performed on Muskrat, Sands, Fox, Meadow, and Johnson Lakes. Stream bank assessments were performed in partnership with the Minnesota Department of Natural Resources at several locations on Campbell Creek. Some diagnostic sampling of *E. coli* on the Pelican River between State Highway 34 and Detroit Lake occurred to locate the source of the pollutant.

Water quality in 2020 was at or above average on lakes across the District. Improvements to water quality may be attributed to zebra mussels, improved stormwater management, shoreline restoration, and perhaps some dilution factor. A marked improvement in water quality on St. Clair Lake in 2020 is likely attributed to effects caused by the Detroit Lakes Wastewater Treatment Plant. Water quality in streams was degraded from normal, with major erosion happening on Campbell Creek. The District plans to address this in future years with funding from the State of Minnesota and the United States Environmental Protection Agency. The vegetation survey on the Floyd Lakes shows a healthy aquatic system with no vegetative invasive species. Zooplankton sampling efforts continued in 2020, with samples sent to the Minnesota Department of Natural Resources for analysis.

Table 1.1. Lake water quality results from 2020 sampling efforts.

Water Management Area	Lake	2020 Average			Historical Averages (2000-2019)			MNPCA Lake Standards		
		TP (ppb)	Chl-a (ppb)	Secchi (feet)	TP (ppb)	Chl-a (ppb)	Secchi (feet)	TP (ppb)	Chl-a (ppb)	Secchi (feet)
Detroit/Rice	Big Detroit	18	3	15	25	9	10	<40	<14	>4.6
	Little Detroit	15	3	15	20	5	11	<40	<14	>4.6
Floyd/Campbell	Big Floyd	12	4	14	16	5	12	<40	<14	>4.6
	North Floyd	26	11	10	32	15	8	<40	<14	>4.6
	Little Floyd	25	10	8	24	10	9	<40	<14	>4.6
Sallie/Melissa	Sallie	26	5	15	34	15	8	<40	<14	>4.6
	Melissa	20	4	17	21	8	11	<40	<14	>4.6
	St. Clair*	57	18	4	88	43	3	<60	<20	>3.3
Brandy	Oak	49	44	5	-	-	-	<60	<20	>3.3
Pearl/Loon	Spear	30	7	9	-	-	-	<60	<20	>3.3
	Loon	14	4	9	22	8	7	<60	<20	>3.3
Small Lakes	Glawe	23	6	9	23	6	10	<60	<20	>3.3
	Meadow	13	4	13	17	4	16	<40	<14	>4.6

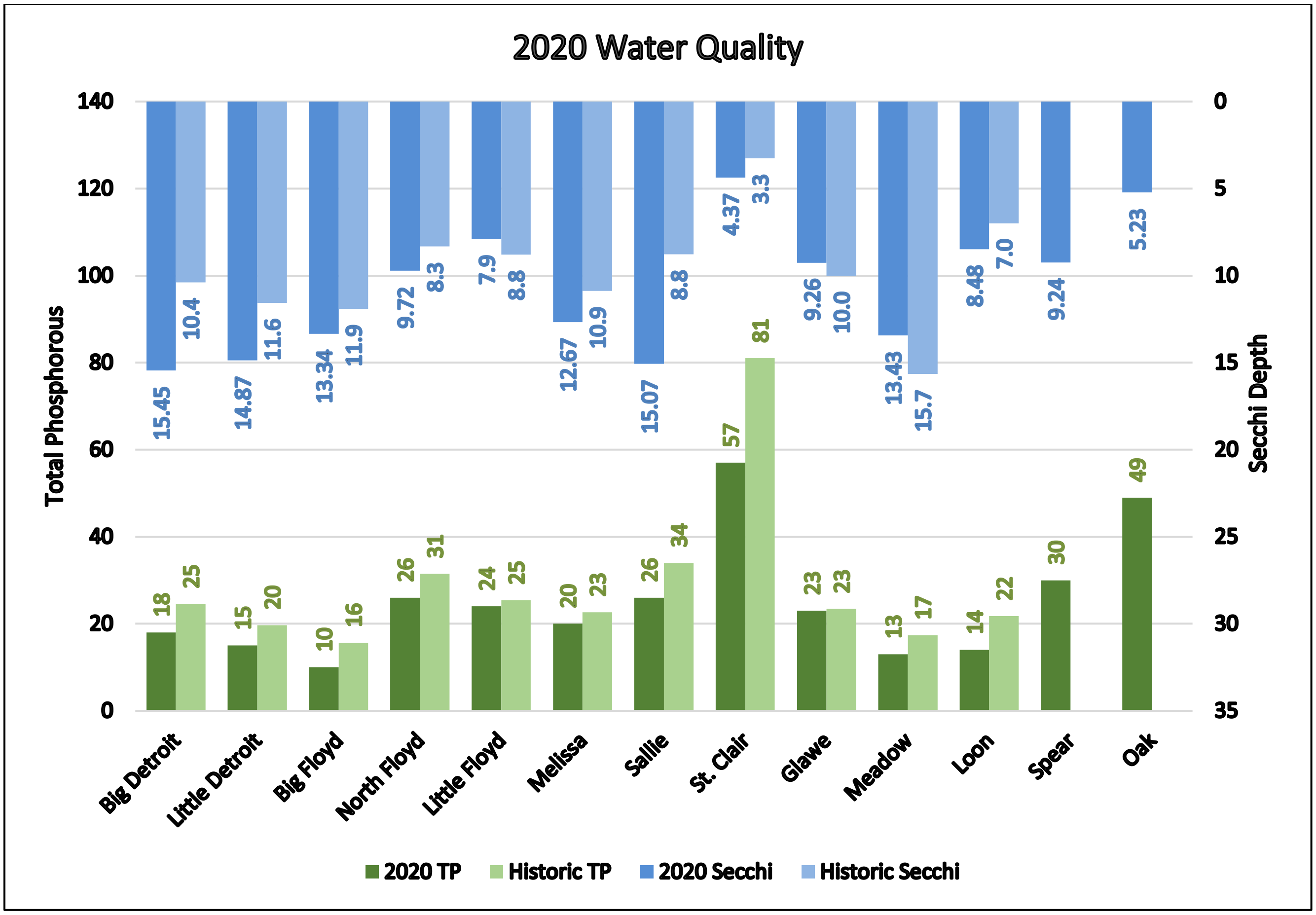

Figure 1.1. Lake water quality results from 2020 compared to historic averages.

Sampling efforts in 2021 will follow the 10-Year Monitoring Plan adopted in 2020. A total of 14 lake and 17 stream sites will be sampled for water quality. Lakes Sallie and Melissa will receive a vegetation survey, and the Floyd chain, Reeves, and Abbey Lakes will receive a shoreline survey.

Table 1.2. 2021 lake monitoring schedule.

Lake Name	WMA	Monitoring	Water Quality	Vegetation	Shoreline	Zooplankton
Big Floyd Lake	Floyd/Campbell	Major	X		X	X
North Floyd Lake	Floyd/Campbell	Major	X		X	X
Little Floyd Lake	Floyd/Campbell	Major	X		X	X
Big Detroit Lake	Detroit/Rice	Major	X			X
Little Detroit Lake	Detroit/Rice	Major	X			X
Long Lake	Long	Major	X			X
Saint Clair Lake	Sallie/Melissa	Major	X			
Lake Sallie	Sallie/Melissa	Major	X	X		X
Lake Melissa	Sallie/Melissa	Major	X	X		X
Campbell Lake	Floyd/Campbell	Minor	X			
Leitheiser Lake	Detroit/Rice	Minor	X			
Dart Lake	Pearl	Minor	X			
Pearl Lake	Pearl	minor	X			
Muskrat Lake	Sallie/Melissa	Minor	X			
Reeves Lake	Small Lakes	Minor			X	
Abbey Lake	Small Lakes	Minor			X	

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ALUM .... Aluminum Sulfate
AIS .... Aquatic Invasive Species
CHL-A .... Chlorophyll-a (pheophytin-a)
CLMP .... Citizen Lake Monitoring Program
CSAH .... County State Aid Highway
IBI .... Index of Biological Integrity
MN DNR .... Minnesota Department of Natural Resources
MPCA .... Minnesota Pollution Control Agency
MPN/100ml .... Most Probably Number per 100 milli-liters
MS4 .... Municipal Separate Stormwater System
MSL .... Mean Sea Level
OHW .... Ordinary High Waterline
OP .... Orthophosphate
PPB .... Parts per Billion
PRWD .... Pelican River Watershed District
SIZ .... Shore Impact Zone
SOP .... Standard Operating Procedures
TMDL .... Total Maximum Daily Load
TP .... Total Phosphorous
WMA .... Water Management Area
WWTP .... Wastewater Treatment Plant
TSS .... Total Suspended Solids
Secchi Depth .... Water Clarity
DO .... Dissolved Oxygen

2 Background

The Pelican River Watershed District (PRWD) is one of 46 watershed districts established in Minnesota with the purpose to conserve the natural resources of the state. This is accomplished by land use planning, flood control, and other conservation projects utilizing sound scientific principles for the protection of the public health and welfare and the prudent use of the natural resources.

Due to the deteriorating water quality in area lakes and streams in the 1950s and 1960s, residents petitioned the state of Minnesota to establish a watershed district in the upper Pelican River watershed to address the water quality issues. PRWD, established on May 27, 1966, was the first watershed district formed to address water quality issues rather than flooding issues associated with other watershed districts.

The District is 120 square miles in size and located primarily in Becker County (95%) with 5% in Ottertail County. The Pelican River watershed is part of the Ottertail River basin which eventually discharges to the Red River of the North. Eight major lakes including the Floyd Lake Chain, Big/Little Detroit Lakes, Long Lake, Lake Sallie, and Lake Melissa serve as the economic engine for the NW region of Minnesota. These lakes provide recreational opportunities for residents and visitors, including fishing, boating, and swimming.

Much of the land surrounding the lakes has been developed for housing and recreation, resulting in an increase of the nutrient runoff associated with lawns and impervious surfaces. The lakes in this region are typically found to be mesotrophic but are occasionally found to be slightly eutrophic, especially during mid-late summer, in shallower systems and in more highly developed areas.

The Pelican River Watershed is a “headwaters watershed” of the Ottertail River Basin, meaning the location is upstream from most other watersheds in the basin. The status of a “headwaters watershed” comes with benefit and responsibility; the benefit being the waters of the Pelican River are not negatively affected by upstream development, land use, or industry. However, downstream resources and communities are affected by the land use implications, policies, and decisions made within this drainage system. By caring for our own resources, we also act as good neighbors.

The Pelican River Watershed District is dedicated to protecting and improving not only the resources within its jurisdiction but helping protect the downstream neighbors as well. This is done through collaborative efforts, working with local, state, and federal agencies, to help reduce and manage stormwater runoff, educate the public about the benefits of responsible development, and promote the benefit of healthy lakes and rivers to the public. The District pursues implementation of projects which meet the mission, “to enhance the quality of water in the lakes”, by actively pursuing state and federal grant funds to supplement local tax dollars.

The Pelican River Watershed District has maintained a comprehensive water quality monitoring program since 1995, consistently monitoring lakes and stream throughout the District. The primary goal of the program is to be able to identify areas of decreased and impaired water quality so nutrient reduction efforts could be focused on the locations with the most benefit. A secondary goal of the program was to develop a database of water samples that could be used to identify trends in water quality. If a decreasing trend is observed, there is an opportunity to determine the cause and implement a remedy before the waterbody becomes impaired.

The District keeps all water quality records in a database in-house, including many water clarity samples collected through the Minnesota Pollution Control Agency's (MPCA) Citizen Lake Monitoring Program (CLMP). In addition to the PRWD database, District staff annually review and submit all water quality data to the MPCA's surface water database.

This program maintains an emphasis on tracking phosphorous as it travels through the watershed. Additional water quality metrics including water clarity (secchi depth), chlorophyll-a (CHL-A), total suspended solids (TSS), Dissolved oxygen (DO), etc. are captured at sample points to maintain a robust data set. This program also tracks changes to upland and riparian development through shoreline surveys and land use tracking. In the interest in maintaining healthy ecosystems within District waters, the District monitors the composition of aquatic vegetative communities and treats curly-leaf pondweed and flowering rush to control the spread of these aquatic invasive species (AIS). The District follows Standard Operating Procedures (SOP's) in all data collection (Adopted from Minnesota Pollution Control Agency and Red Lake Watershed District). For information on the District's sampling procedures and long-term planning, please see the 2020 10-Year Water Quality Monitoring Plan.

The data reported in this plan will be organized by Water Management Area (WMA) as outlined in the 2020 Pelican River Watershed District Revised Management Plan. It is important to emphasize the connectivity of the surface waters across WMA's and the District, as well as the impacts of weather patterns on water quality. With a total of 144 lakes and 49 miles of stream, it is important to prioritize monitoring activities. Select lakes are sampled on a rotating basis to ensure adequate data is collected to assess the health of the water body. In the same way, select stream sampling locations are established to assess the "load" of nutrients, sediment, and bacteria being transmitted through the system. This schedule can be found in the 2020 PRWD 10-Year Water Quality Monitoring Plan and the yearly Annual Monitoring Work Plans published by District Staff.

3 Climate Data

The District keeps a record of weather to track changes to District waters. Daily temperature and precipitation can help explain certain increases in nutrients and algal growth as well as increases in suspended sediment in streams. The big story of 2020 is heavy rainfall events throughout the year, but especially during the months of June and July. Between April and September, there were a total of 20 rainfall events which precipitated > 0.5" of rain and 11 events which precipitated >1" of rain with the largest event on June 8th and 9th precipitating a total of 4.41" (Table 3.1, Figure 3.1).

Table 3.1: List of rain events >0.5" April-September 2020. Data from Wething Field.

2020 Rainfall >0.5"

Date	Inches	Date	Inches	Date	Inches	Date	Inches
4/2/2020	*0.81*	*6/20/2020*	*0.73*	*7/11/2020*	*0.65*	7/25/2020	1.62
5/26/2020	*0.89*	6/25/2020	1.59	7/17/2020	1.62	*8/9/2020*	*0.85*
6/8/2020	1.16	*7/1/2020*	*0.62*	*7/18/2020*	*0.64*	8/14/2020	3.38
6/9/2020	3.25	7/8/2020	1.99	*7/20/2020*	*0.5*	8/31/2020	1.84
6/18/2020	3.07	*7/9/2020*	*0.8*	7/21/2020	1.7	9/12/2020	1.52

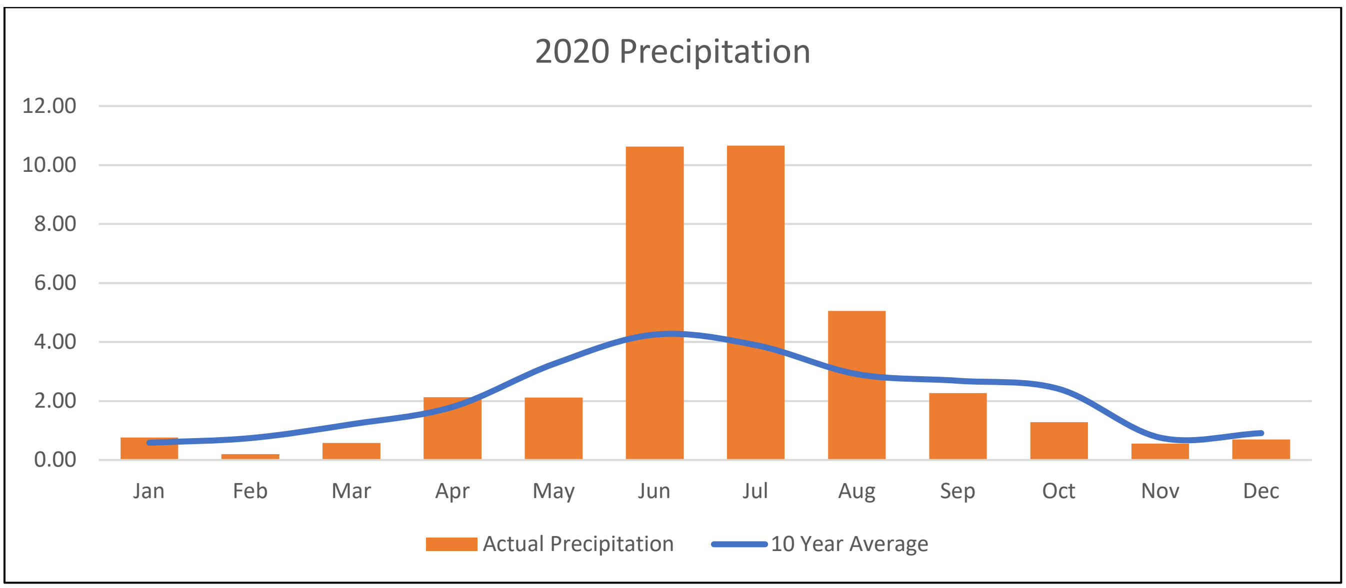


Figure 3.1. Monthly precipitation from 2020. Data from Wething Field.

The wettest months of the year were June and July, with 10.63" of rain in June and 10.66" in July. This is 6.38" and 6.76" over the June and July 10-year average for Becker County (MN DNR Climate Data). Snowfall for 2020 (38.9") was below average (48.27") for the year. An anomaly occurred in October with 9.4" of snow falling however, warmer temperatures melted the deposited snow shortly thereafter.

3.1 First Quarter 2020– Winter Months: January-March

Temperatures for the first quarter of 2020 were sporadically above and below the historic average (Figure 3.2). The coldest temperature for the year was on February 12th and 13th when temperatures bottomed out at -28°F. The warmest temperature for the quarter was on March 31st at 57°F. Fluctuations in temperatures are common during the first quarter as was observed in 2020. Between February 13th and 14th, temperatures swung from -28°F on the 13th to 23°F on the 14th, a 51°F change in 24hrs.

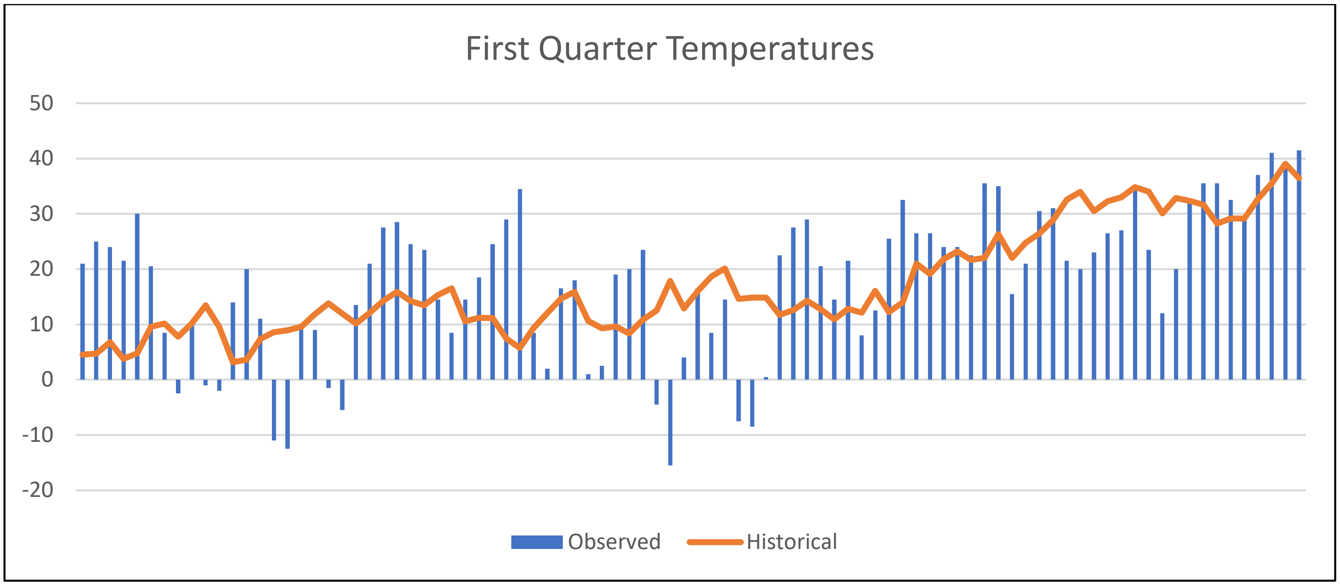


Figure 3.2. First Quarter 2020 daily average temperatures against historic daily averages. Data from Wething Field and MN DNR.

Water temperatures during this period tend to be isolated from weather patterns due to the thick lake ice and snowpack between the liquid water and the atmosphere. A winter temperature stratification is likely to occur in reverse of what can be seen in the summer. Warmer water will be at the bottom of the water column with water cooling to freezing temperatures at the surface.

3.2 Second Quarter - Spring Months: April-June

As 2020 progressed into the second quarter, temperatures reluctantly began to warm (Figure 3.3). Average daily temperatures trended cooler than average for much of the quarter with the average for the quarter at 44°F, 12°F cooler than the historic average of 56°F. The maximum temperature for the quarter and the year was 91.4° on June 17th and 18th while the minimum temperature was on April 16th at 9°F.

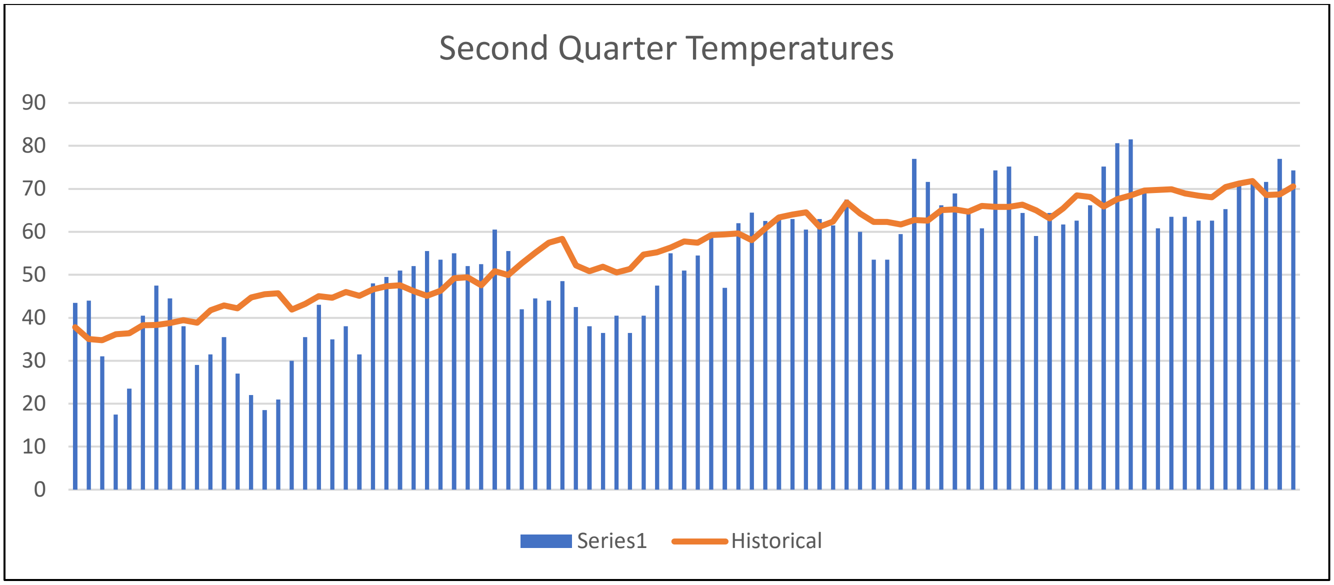


Figure 3.3. Second quarter 2020 daily average temperatures against historic daily averages. Data from Wething Field and MN DNR.

As temperatures rose, lakes in the region began the process of defrosting after the long winter. Detroit Lake opened on April 25th, the same day as 2019. Just as lakes will "flip" in the fall, they will also "flip" as the ice comes off. As warm air warms the water, cooler waters sink to the bottom and warmer waters rise to the top, mixing sediments, nutrients, and DO throughout the water column. The water quality sampling season started on April 1st when staff placed the automated stream gages at select locations throughout the District.

Precipitation started to pick up in June, with 10.63" of rain falling during the month. A total of 7.48" fell in the month came in 3 days, the 8th, 9th, and 18th. Residents reported damage to construction projects, erosion to shorelines, flooding of basements and high-water levels throughout the District. Detroit Lake maintained a water level well above its Ordinary High Waterline (OHW) for much of 2019 and 2020.

3.3 Third Quarter – Summer Months: July-September

Temperatures stabilized as summer kicked off in the lake's region (Figure 3.4). The extreme highs and lows of earlier months transitioned into more seasonal temperatures, with the average temperature for the quarter being 66.8°F, 0.7°F cooler than the historic average of 67.5°F. The average high for the period was 75.3°F and the average low was 58.4°F, 3.8°F lower and 11°F warmer than the historic averages. With the excessively warm lows, surface temperatures in lakes were driven up as the summer progressed, increasing plant growth and algae concentrations. Area residents noted more aquatic plants in places where there may not have historically been growth, or more submergent plants reaching the surface at deeper spots.

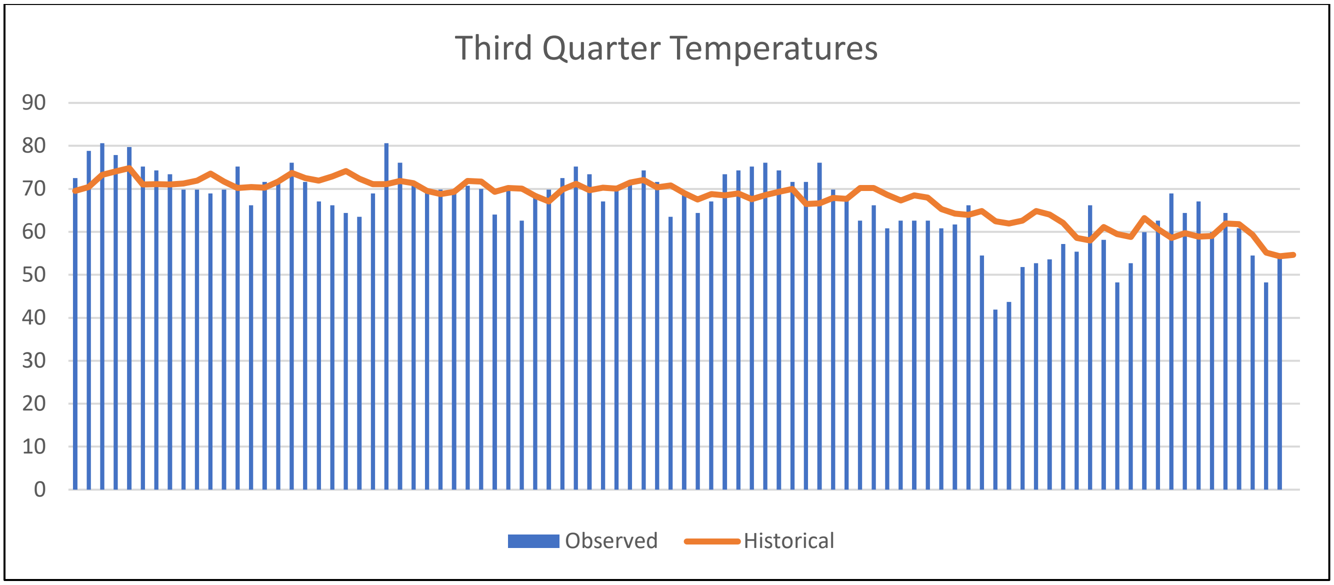


Figure 3.4. Third quarter 2020 daily average temperatures against historic daily averages. Data from Wething Field and MN DNR.

With warmer temperatures, many area lakes stratified through the summer, even some lakes that do not typically stratify did so for a short time. Stratified lakes have anoxic regions at the bottom of the water column where a chemical reaction releases phosphorous from bed sediments. When temperatures cool towards the end of the quarter, lakes will "flip" and bring these nutrients to the surface, sometimes triggering algal blooms.

After 10.66" of rain in July, precipitation started to slow. August saw 5.05" of rain (still 2.14" above average) and September saw 2.27" of rain (0.42" less than average). This drying trend was welcome by area residents, allowing lake levels to fall to more normal levels.

3.4 Fourth Quarter – Fall Months: October-December

As fall arrived, temperatures quickly began to drop (Figure 3.5). Temperatures fluctuated greatly throughout the fourth quarter, with spikes far above and below the average. Average daily temperatures (31.6°F) were 0.5°F above the historic average (31.1°F) for the quarter, but temperatures ranged from a high of 71.6°F on October 10th to a low of -14.8°F on Christmas Day (December 25th). The average daily highs (38.4°F) and low (24.1°F) were similar to historic average high (39.9°F) and low (22.3°F). Temperature fluctuations created poor conditions for lake freeze up, leaving hazardous ice throughout the region. Colder temperatures towards the end of December quickly increased ice thickness.

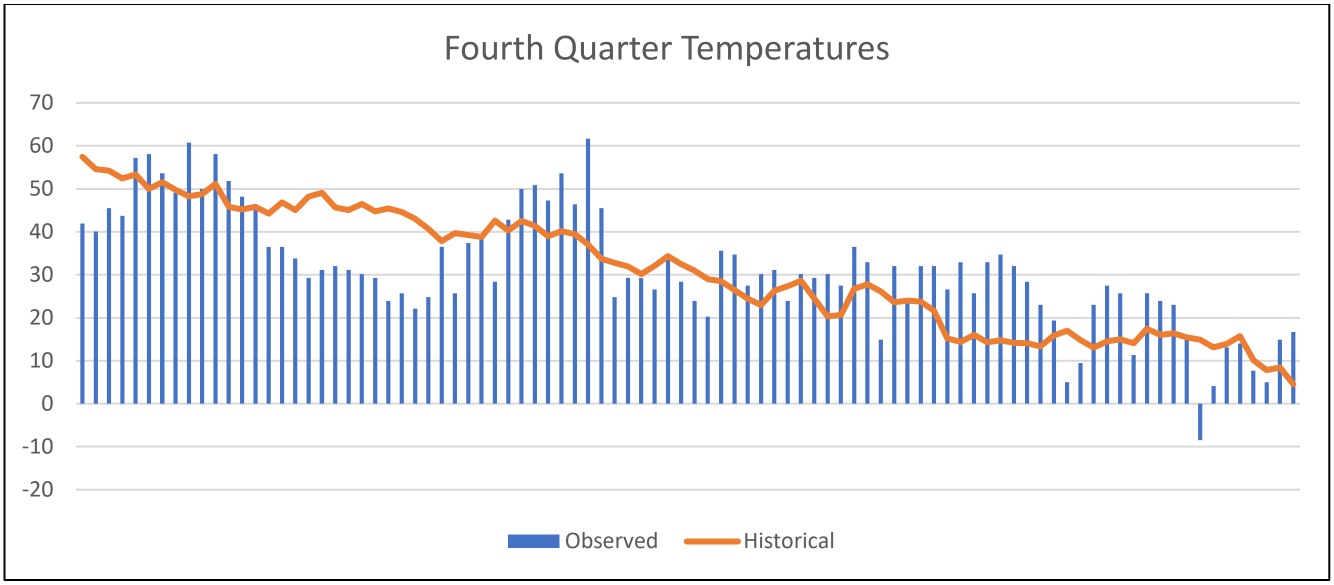


Figure 3.5. Third quarter 2020 daily average temperatures against historic daily averages. Data from Wething Field and MN DNR.

Precipitation for the quarter began to slow after the excessive rainfall of the summer months, with recorded rainfall/snowmelt closer to historic averages. Snowfall for the period was higher than historic, with 3 snowfall events dropping more than 1” snowfall accumulation (October 19th, 21st, and 23rd) for a total of 9.4” of snowfall for the month. After a warm, dry period in November, December delivered 14.4” of snowfall in 6 different events. Snowfall on December 24th (3”) brought the region’s first blizzard of the season with 40-60 mph winds.

4 Water Management Areas (WMA)

The District has designated 8 planning regions, called Water Management Areas (WMA), within its borders to focus monitoring and planning efforts (Figure 4.1). While all boundaries are based upon a subwatershed area, some subwatersheds were combined based on physical area, lake and land characteristics, water quality attributes or problems, development characteristics, and adjacency. The below chart is from the MPCA 2020 Draft Otter Tail Watershed Restoration and Protection Strategies (WRAPS). This chart shows status of District waters and strategies to restore and protect waters in the District.

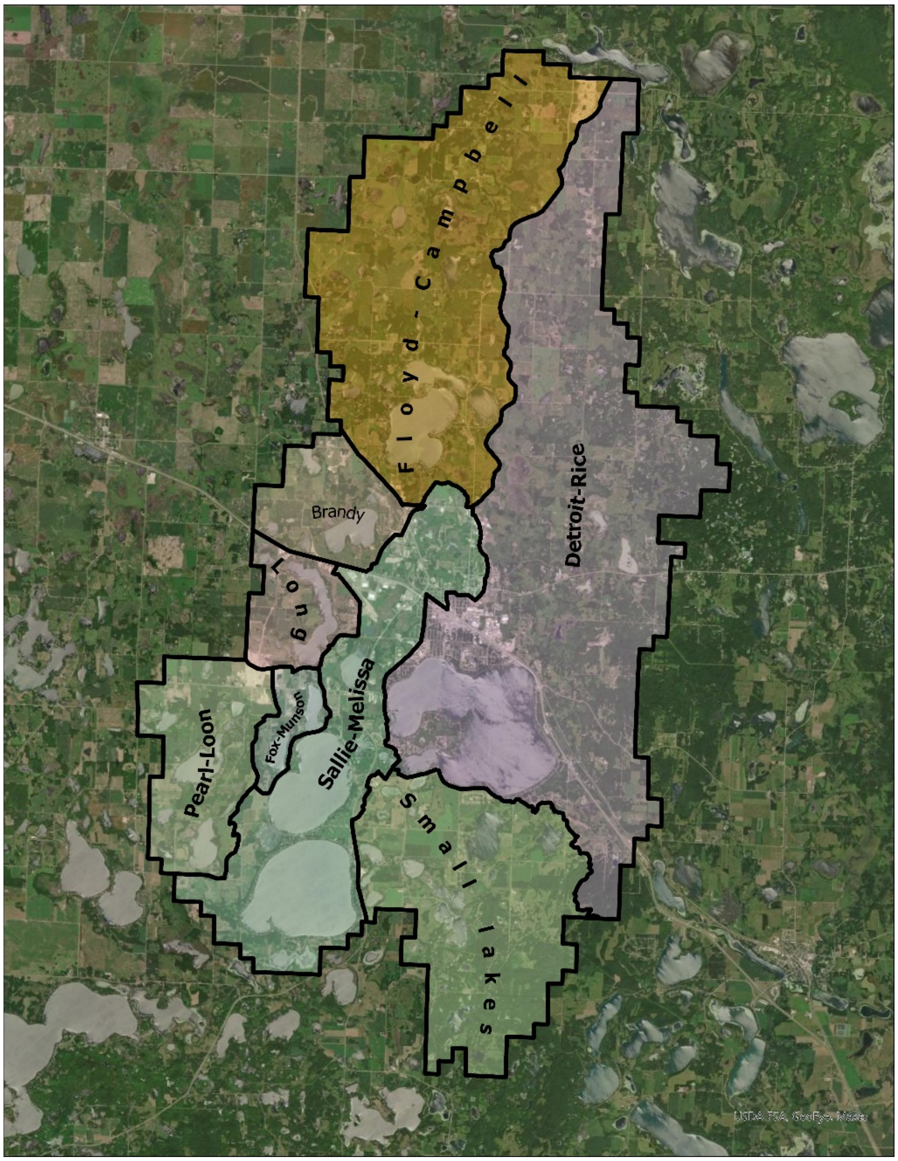
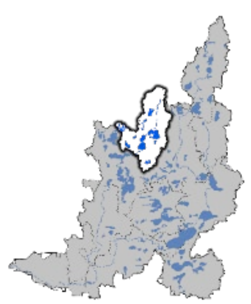
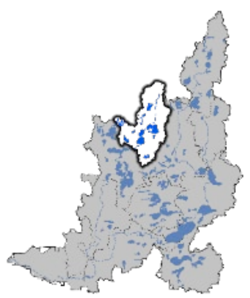
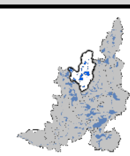
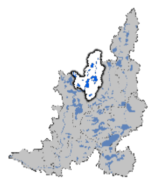


Figure 4.1. Water Management Areas.

Parameter	Waterbody and location			Water quality					Strategies to achieve final water quality goal		
										Best Management Practice (BMP) Scenario	
Pollutant/ Stressor	Aggregated HUC-12 Sub-watershed	Waterbody (ID)	Location & County	Current WQ conditions conc. µg/L load lbs/yr	Trend	P Load Focus (HSPF)	Risks and Qualities	WQ Goal (load to reduce)	Strategy type	BMPs/Actions	Interim 10-yr Milestone
Phosphorus	**Upper Pelican River 902010307-01** 	**Floyd** (03-0387-00)	Becker, PRWD	19 µg/L 1,137 lbs/yr	→	Tributary	High Bio Sig. and Highest P Sensitivity	Protect	Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Continue Campbell Creek and Rice Lake restoration projects. Maintain current forests and lakeshore buffers, protection, lakeshore infiltration practices and agricultural BMPs. Fix noncompliant septic systems.
		Little Floyd (03-0386-00)	Becker, PRWD	25 µg/L 1,257 lbs/yr	→	Nearshore	Outstanding Bio Sig	Protect			
		Big Detroit (03-0381-00)	Becker, PRWD	24 µg/L 4,069 lbs/yr	↓	Tributary	Highest P Sensitivity	679 lbs/yr	Lakeshore protection Infiltration on developed properties Urban stormwater management	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Install retention areas. See strategies for Phosphorus in Table 22	5% reduction (203 lbs/yr)
		Little Detroit (03-0381-00)	Becker, PRWD	load included with Big Detroit	↑	Tributary	-	Protect	Lakeshore protection Infiltration on developed properties Urban stormwater management	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Install retention areas. See strategies for Phosphorus in Table 22	Maintain current forests and lakeshore buffers and increase forest management, protection, lakeshore infiltration practices, and urban stormwater practices.
		Curfman (03-0363-00)	Becker, PRWD	23 µg/L 89 lbs/yr	→	Not included in HSPF model	-	Protect			
		St. Clair (03-0382-00)	Becker, PRWD	68 µg/L 1,190 lbs/yr	↓	Tributary	-	286 lbs/yr	Infiltration on developed properties Urban stormwater management Point source reduction. Lake Internal load management	Install infiltration practices such as rain gardens. Install retention areas. Wastewater treatment plant upgrades in Detroit Lakes Alum treatment See strategies for Phosphorus in Table 22	5% reduction (60 lbs/yr)
		Muskrat (03-0360-00)	Becker, PRWD	35 µg/L 3,175 lbs/yr	→	Tributary	-	Protect	Lakeshore protection Infiltration on developed properties	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. See strategies for Phosphorus in Table 22	Maintain lakeshore buffers and increase lakeshore infiltration practices and agricultural BMPs. Fix non-compliant septic systems.
		Sallie (03-0359-00)	Becker, PRWD	40 µg/L 7,118 lbs/yr	→	Nearshore	**Eutrophication stressor in Lake IBI Report**	1,069 lbs/yr	Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	5% reduction (356 lbs/yr)
		Melissa (03-0475-00)	Becker, PRWD	23 µg/L 5,626 lbs/yr	↑	Tributary	-	Protect	Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff	Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Maintain lakeshore buffers and increase lakeshore infiltration practices and agricultural BMPs. Fix non-compliant septic systems.
		Abbey (03-0366-00)	Becker, PRWD	47 µg/L 97 lbs/yr	↓	Not included in HSPF model	-	16/lbs/yr	Forest protection Lakeshore protection Infiltration on developed properties Improve upland/field surface runoff	Forest Stewardship Plans, 2c, SFIA, Easements Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	5% reduction (5 lbs/yr)
		Wine (03-0398-00)	Becker, PRWD	100 µg/L 72 lbs/yr	→	Nearshore	-	30 lbs/yr	Infiltration on developed properties Improve upland/field surface runoff	Install infiltration practices such as rain gardens. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	5% reduction (4 lbs/yr)

Parameter	Waterbody and location			Water quality					Strategies to achieve final water quality goal		
										Best Management Practice (BMP) Scenario	
Pollutant/ Stressor	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**Location & County**	**Current WQ conditions** conc. µg/L load lbs/yr	**Trend**	**P Load Focus (HSPF)**	**Risks and Qualities**	**WQ Goal** (load to reduce)	**Strategy type**	**BMPs/Actions**	**Interim 10-yr Milestone**
Phosphorus	**Upper Pelican River 902010307-01** 	**Brandy** (03-0400-00)	Becker, PRWD	NA	↑	Not included in HSPF model	-	Protect	Forest protection Lakeshore protection Infiltration on developed properties Improve upland/field surface runoff	Forest Stewardship Plans, 2c, SFIA, Easements Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Maintain current forests and lakeshore buffers and increase forest management, protection, lakeshore infiltration practices and agricultural BMPs.
		Long (03-0383-00)	Becker, PRWD	15 µg/L 183 lbs/yr	↑	Tributary	Highest P Sensitivity	Protect	Forest protection Lakeshore protection Infiltration on developed properties Septic system improvement Improve upland/field surface runoff.	Forest Stewardship Plans, 2c, SFIA, Easements Implement shoreline restoration projects. Install infiltration practices such as rain gardens. Septic system improvement Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Maintain current forests and lakeshore buffers and increase forest management, protection, lakeshore infiltration practices and agricultural BMPs. Fix noncompliant septic systems.
		Fox (03-0358-00)	Becker, PRWD	15 µg/L 32 lbs/yr	↑	Not included in HSPF model	Highest P Sensitivity	Protect			
		Munson (03-0357-00)	Becker, PRWD	20 µg/L 58 lbs/yr	↑	Not included in HSPF model	Highest P Sensitivity	Protect			
		Pearl (03-0486-00)	Becker, PRWD	29 µg/L 316 lbs/yr	→	Not included in HSPF model	-	Protect			
		Campbell Creek (-543) **Pelican River** (-771, -772)	Becker County, PRWD	"Nearly" Impairment Risk	-	-	-	Enhance	Infiltration on developed properties Urban stormwater management Improve upland/field surface runoff	Install infiltration practices such as rain gardens. Install retention areas. Agricultural BMPs (Crop and Pasture) See strategies for Phosphorus in Table 22	Model implementation scenario for P reduction in PTMApp.

Parameter	Waterbody and location			Water quality		Strategies to achieve final water quality goal		
							Location & County	
Pollutant/ Stressor	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**Location & County**	**Pollutant/ Stressor**	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**BMPs/Actions**	**Interim 10-yr Milestone** (% to reduce)
Bacteria	**Upper Pelican River 0902010307-01** 	**Pelican River** (-772)	Becker, PRWD	241.0 org/100mL	48%	Sanitation (failing SSTS and WWTPS)	Investigate sources in the City of Detroit Lakes See strategies for Bacteria in Table 22.	7% (16.9 org/100 mL)

Parameter	Waterbody and location			Water quality		Strategies to achieve final water quality goal		
							Best Management Practice (BMP) Scenario	
Pollutant/ Stressor	**Aggregated HUC-12 Sub-watershed**	**Waterbody (ID)**	**Location & County**	**Current WQ conditions** conc. mg/L	**WQ Goal** (overall load to reduce)	**Strategy type**	**BMPs/Actions**	**Interim 10-yr Milestone**
Sediment	**Upper Pelican River 902010307** 	**Campbell Creek** (-543)	Becker County, PRWD	91.2 mg/L	67%	In stream erosion Bank erosion Surface runoff Surface runoff, Open tile intakes	Use surface sediment controls to prevent sediment mobilization and transport including conservation tillage, cover crops, removing open tile intakes, or strategic implementation of sediment reducing BMPs. Increase runoff filtration or detention in cultivated fields to trap/settle eroded sediment (e.g., grassed waterways or water and sediment control basins). Manage pastures to prevent overgrazing and direct stream access by livestock. Maintain riparian vegetation (native vegetation). Implement streambank stabilization/buffer enhancements - in areas to provide the most benefit to threatened, high value property. Incorporate the principles of natural channel design. See strategies for Sediment in Table 25. See strategies for Hydrology in Table 25.	4% Reduction (3.6 mg/L) CLEAN WATER LAND & LEGACY AMENDMENT

5 Floyd/Campbell Water Management Area

The Floyd/Campbell WMA is at the top of the watershed and is about 16,000 acres in size (Figure 5.1). Campbell Creek flows south from Campbell lake to North Floyd Lake. Ditch 11 flows into Campbell Lake from the North. Several small "potholes" exist throughout the WMA, most of which are isolated basins with no surface connection to the rest of the watershed. Major issues of the WMA include stream channelization and bank erosion, intensive agriculture, shoreline modifications, and altered hydrology. Campbell Creek from Campbell lake to North Floyd has an impairment caused by excess sediment loading due to channel erosion, causing North Floyd Lake to be at risk of impairment from eutrophication.

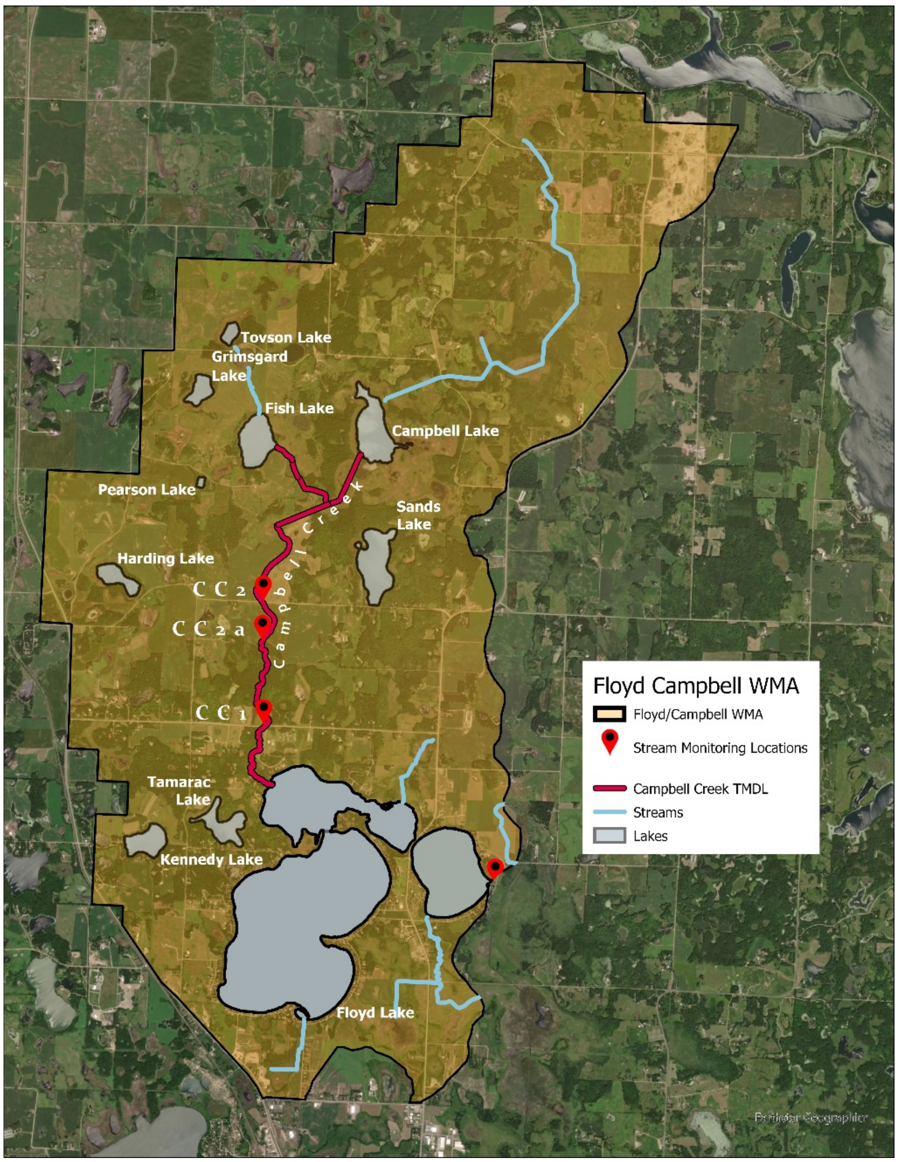


Figure 5.1. The Floyd/Campbell WMA.

5.1 Lakes

Lakes monitored by the District in the WMA include the Floyd Chain of Lakes (Big Floyd, North Floyd, and Little Floyd), Sands Lake, Kennedy Lake, Tamarack Lake, Campbell Lake and Fish Lake. In 2020, the District performed a water quality survey, aquatic plant survey, and zooplankton survey on the Floyd Chain of Lakes. In 2021, the District will perform a water quality survey and shoreline survey on the Floyd Chain of Lakes, and a water quality survey on Campbell Lake.

5.1.1 Floyd Chain of Lakes

Floyd Lake, a 1,178-acre, general development lake with heavily developed shoreline, is located north of the City of Detroit Lakes. The lake is divided into two distinct basins, known locally as Big Floyd and North Floyd. The lakes are heavily used for game fishing, boating, and other summer, or winter recreational activities. The larger of the two basins, Big Floyd, is 862 acres in size, reaches a maximum depth of 25 feet, and has approximately 5.5 miles of shoreline. The littoral area (<15 ft) of the lake accounts for nearly 70% of the lake area and emergent aquatic plants are common. North Floyd is smaller, with 316 acres of surface area, 2.2 miles of shoreline, and a maximum depth of 34 feet. North Floyd littoral area (<15 ft) coverage is approximately 60%. There is one MN DNR owned public access located on the southeast side of Big Floyd. North Floyd Lake does not have a public access but is accessible via a channel between the two basins.

Little Floyd Lake is a 214-acre lake with a maximum depth of 34 ft. It has a moderately developed shoreline. Little Floyd sub-watershed area is approximately 342 acres including surface water area. Little Floyd receives most of its water from North Floyd, which outlets to Little Floyd through the Becker CSAH 21 road, though there are some small natural drainage ways that lead to the lake. The littoral area (< 15ft depth) of the lake accounts for 95 acres (45%) with an extensive emergent (cattail and hard stem bulrush) vegetation area located on the northeast side. There is an abundant native plant community. There is one MN DNR public access on Little Floyd located on the south end.

The major water source into North Floyd is Becker County Drainage Ditch 12/Campbell Creek located on the west side of North Floyd along with one minor inlet on the southwest side of Big Floyd. It appears that most of the time Big Floyd also contributes some flow to North Floyd, although it is thought the source of this water is mainly from groundwater. Other minor water sources include overland flows and groundwater seeps and springs. The outflow is located on the east side of North Floyd and connects to Little Floyd through the Becker CSAH 21 road culvert. Little Floyd Lake has two outlets located on the south side. Historically, the lake had one outlet, located near the present-day public access, however, a new outlet was constructed in 1919, when the Becker County Drainage System 13 was built to channelize the Pelican River between Little Floyd lake and Big Detroit lake. In 1936, the Civilian Conservation Corps built a concrete weir dam on Becker Drainage System 13. This structure controls Little Floyd, as well as North and Big Floyd’s water levels.

Both Big and North Floyd Lakes are dimictic lakes. Most of the time Big Floyd’s water is clear, with moderate phosphorus and algae concentrations, good game fish populations, and moderate aquatic plant growth. Big Floyd, a mesotrophic lake, exhibits above average water quality when compared with other District Lakes with annual averages of 12.5’ secchi depth (clarity) and 18 ppb in-lake phosphorus concentrations. In comparison, North Floyd suffers from poorer water clarity, high phosphorus, and severe algal blooms as a result of almost of 100 years of elevated phosphorus and sediment loading from

Campbell Creek. In North Floyd, there is a phenomenon occurring known as "internal phosphorus loading" which recycles and releases phosphorus back into the water column causing algae blooms. This is due to decades of legacy phosphorus that has accumulated in the lake sediment. In late summer, after water "turnover", North Floyd experiences occasional algae blooms caused by the release of phosphorus from the enriched lake sediments. North Floyd is considered borderline eutrophic as the annual average of in-lake phosphorus concentrations have remained in the 32-34 ppb range. Little Floyd Lake is classified as a mesotrophic lake based on the Tropic State Index average for phosphorous, chlorophyll-a, and water clarity. In-lake phosphorus concentrations can vary between 20ppb to 34ppb and are highly responsive to storm-events and heavy rainfall patterns. The 10-year (2008-2017) average is 25 ppb in-lake phosphorus concentration.

A citizen scientist submits ice-on and ice-off data for the Floyd Lakes as part of the District's CLMP. The District has data from 1971 to 2020 to track trends in relation to climate change. For 2020, there were 219 days without ice cover on Floyd Lake, and 164 days of ice cover in the winter of 2019-2020. The number of ice cover days is a slight decrease from the 10-year average of 222, but an increase from the historic average of 215 days. The number of ice cover days from the winter of 2019-2020 was increased from the historic average of 149 days and the 10-year average of 143 days.

<u>Water Quality/Quantity</u>

Water Quantity – Floyd Chain of Lakes

Big Floyd, Little Floyd, and North Floyd maintain similar water levels. The OHW for all 3 basins is set at the same elevation (1354.8' MSL) by the MN DNR. There is a fixed crest weir on the outlet of Little Floyd Lake that sets the elevation for the 3 lakes. Water Levels in 2020 were similar to 2019 (Figure 5.2; Figure 5.3).

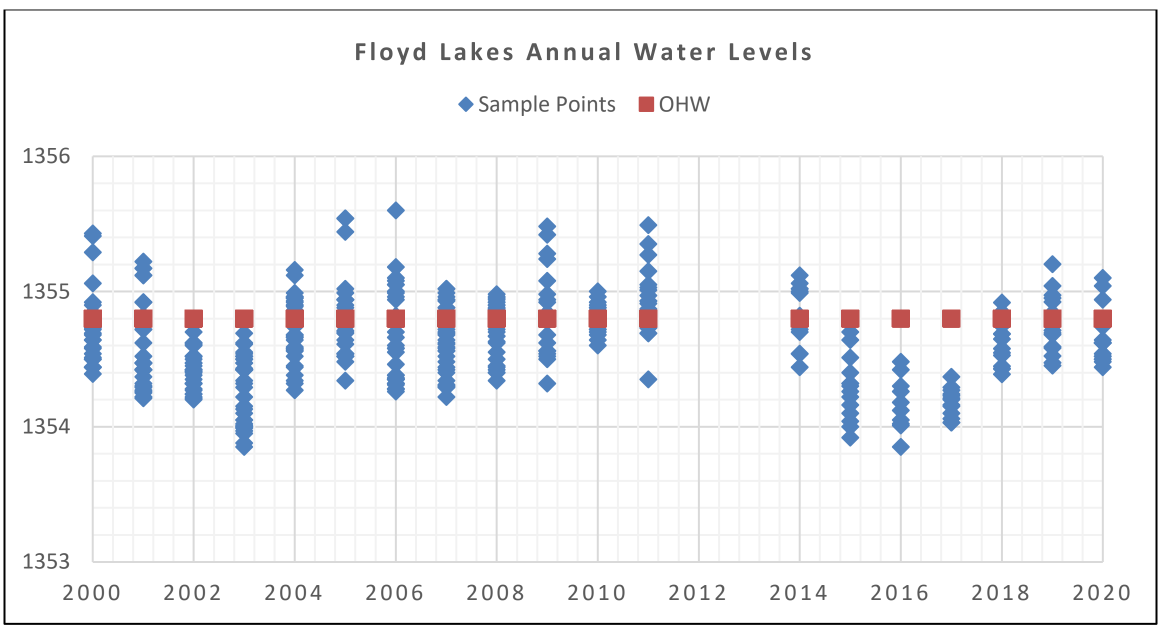


Figure 5.2. Floyd Lake's water levels from 2000-2020. Data from 2012 and 2013 absent.

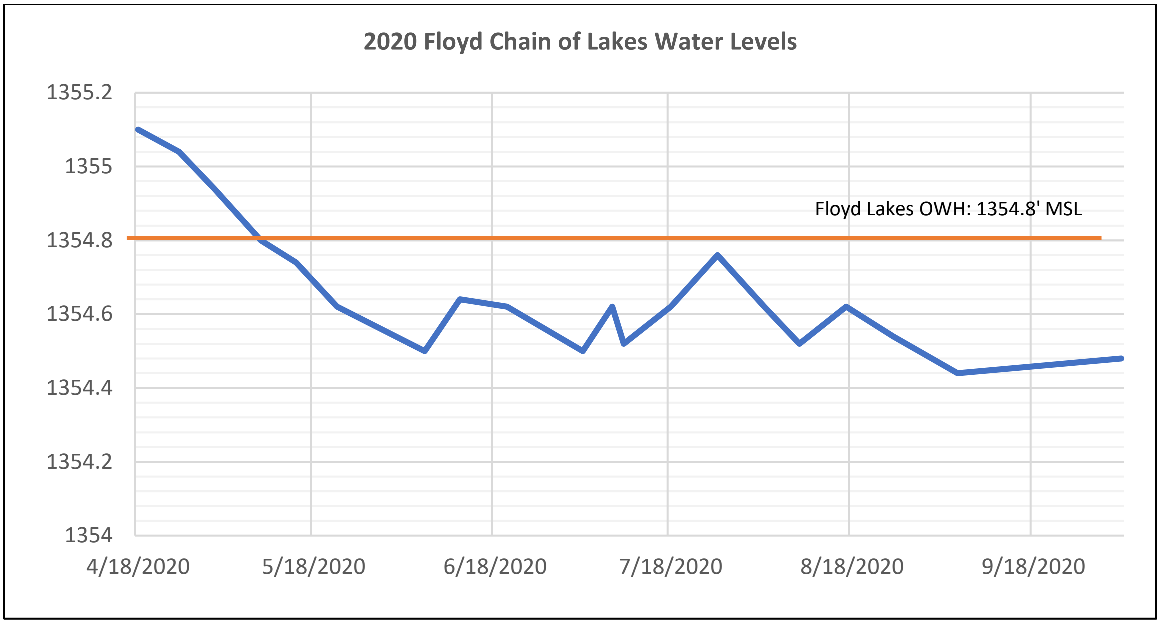


Figure 5.3. Floyd Lake's water levels in 2020.

Water Quality - Big Floyd Lake

Big Floyd Lake had "better than average" water quality in 2020. The average TP (Figure 5.4), CHL-A (Figure 5.5), and secchi depths (Figure 5.6) were 12 ppb, 4.3 ppb and 13.9' all below the respective 20-year averages of 16ppb, 4.8ppb, and 12'. CHL-A steadily increased as the summer progressed, but TP started at 16ppb on June 19th dropping to 10 ppb on July 28th, before peaking to 16 ppb on August 25th, then decreasing as the last sample of the year was taken on September 13th at 13 ppb.

This improvement in water quality may be attributed to a recent infestation of zebra mussels (*Dreissena polymorpha)* (2018). Zebra mussels filter contaminants from the water column, increasing water clarity. Increased water clarity can increase algae and plant growth at increased depths. Effects of zebra mussels may be more pronounced in future years as populations increase in density. It is also possible the effects of the zebra mussels were negated by the excessive number of rainfall events occurring in 2020 and more pronounced effects may be observed in coming years.

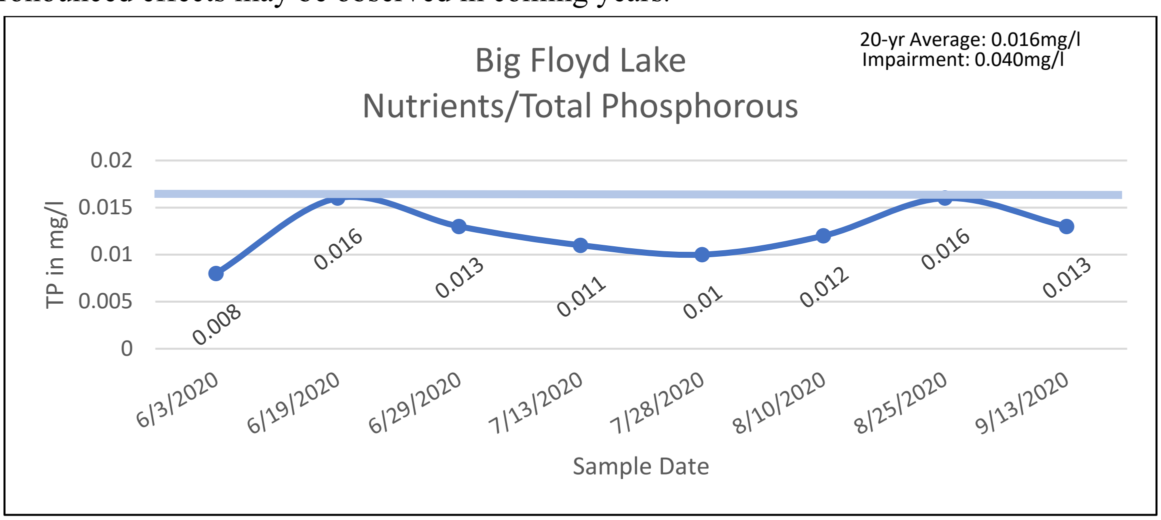


Figure 5.4. Big Floyd Lake 2020 total phosphorous.

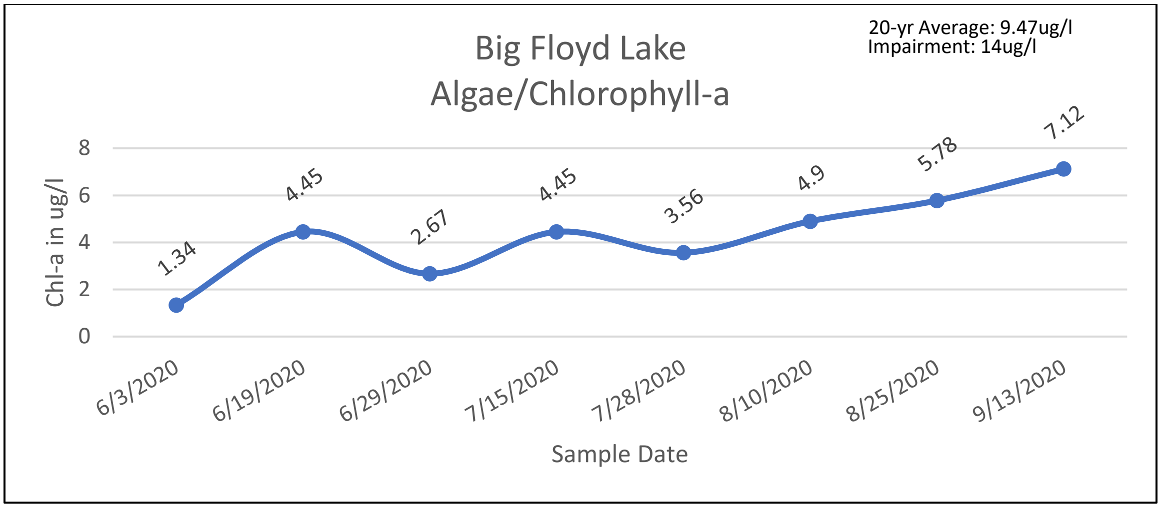


Figure 5.5. Big Floyd Lake 2020 chlorophyll-a.

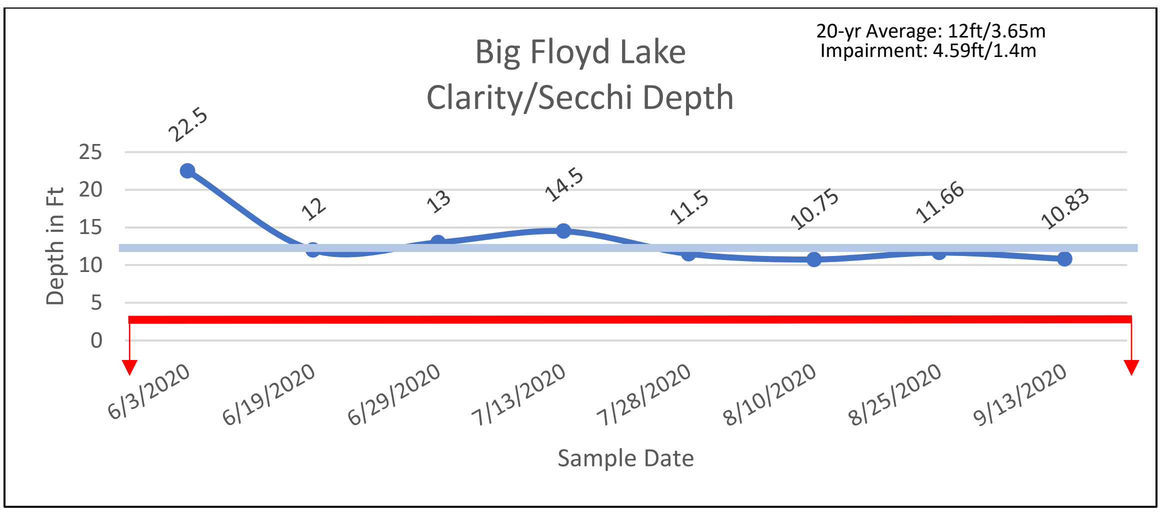


Figure 5.6. Big Floyd Lake 2020 secchi depth.

Water Quality - North Floyd Lake

North Floyd experienced "better than average" water quality, with an average TP (Figure 5.7) of 26 ppb, 7ppb less than the historic average of 32 ppb. CHL-A (Figure 5.8) and secchi depths (Figure 5.9) also experienced improvements with averages of 10.88 ppb and 9.72', 3.22 ppb and 1.17' less than the 20-year average. As the summer progressed, a marked increase in CHL-A and TP can be observed. This is likely caused by nutrients released from bottom sediments after lake turnover at the end of the summer.

This improvement in water quality may be attributed to a recent infestation of zebra mussels (2018). Zebra mussels filter contaminants from the water column, increasing water clarity. Increased water clarity can increase algae and plant growth at increased depths. Effects of zebra mussels may be more pronounced in future years as populations increase in density. It is also possible the effects of the zebra mussels were negated by the excessive number of rainfall events occurring in 2020 and more pronounced effects may be observed in coming years.

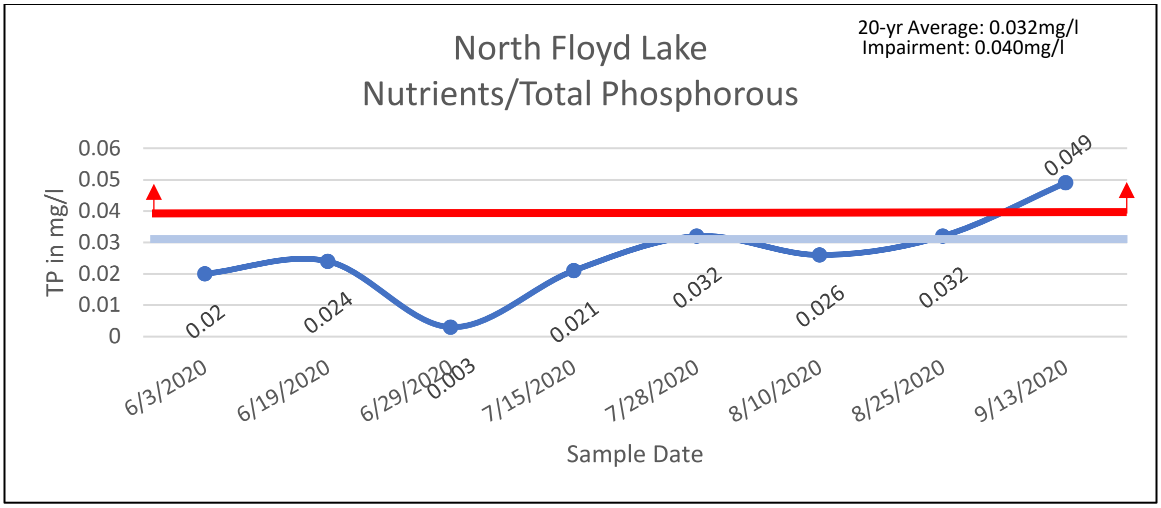


Figure 5.7. North Floyd Lake 2020 total phosphorous.

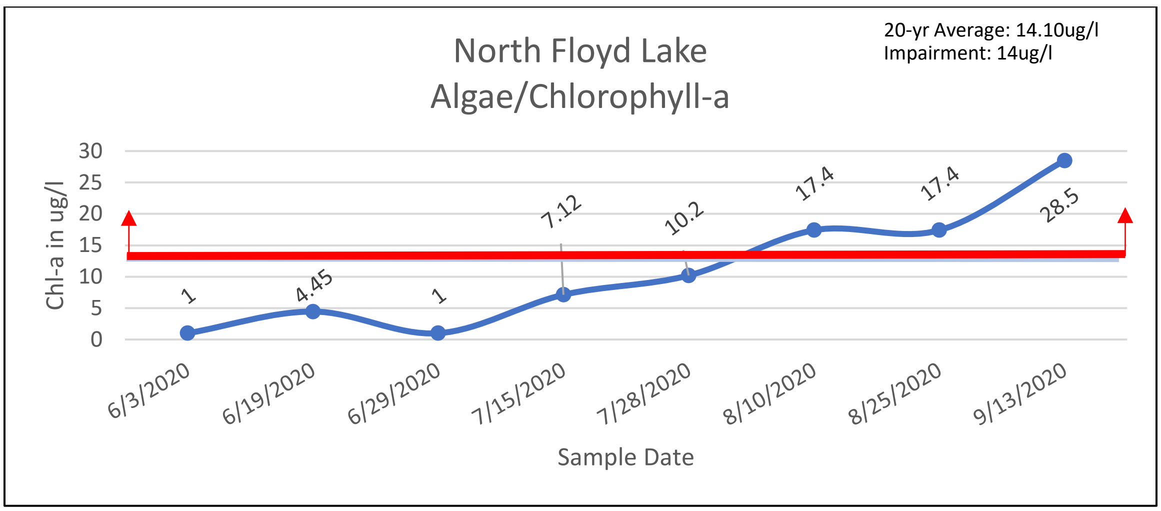


Figure 5.8. North Floyd Lake 2020 chlorophyll-a.

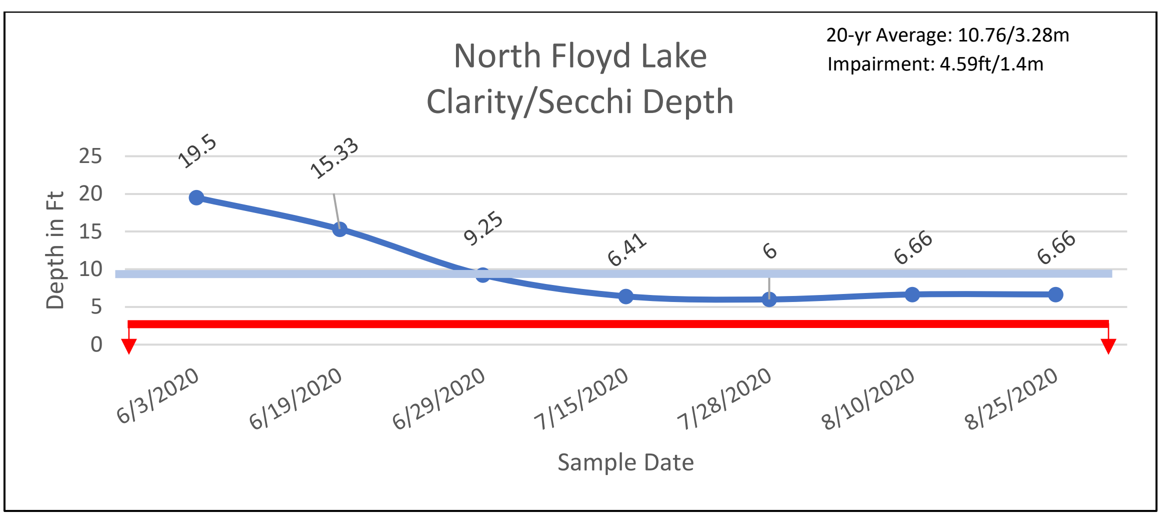


Figure 5.9. North Floyd Lake 2020 secchi depth.

Water Quality - Little Floyd Lake

Little Floyd Lake experienced an “average” water quality year. Average TP (Figure 5.10), CHL-A (Figure 5.11), and secchi depths (Figure 5.12) of 25ppb, 9.5ppb, and 7.9’ were similar to their respective historic averages of 25ppb, 9.5ppb and 9’. Secchi depth decreased by 1.1’ in 2020, possibly due to an influx of sediment from Campbell Creek via North Floyd Lake. Water quality steadily decreased as the summer progressed, with one CHL-A sample (9/13/20-20.9ppb) above the chronic impairment level (14ppb), and one secchi reading (9/13/20-4.5’) below the MPCA impairment level (4.59’). TP remained below impairment levels for the entirety of the sampling season.

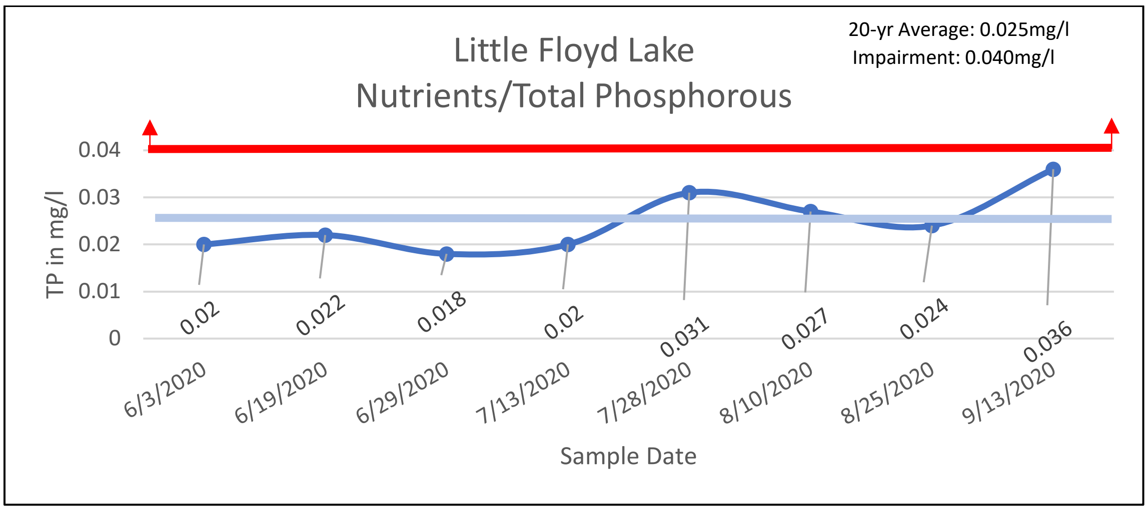


Figure 5.10. Little Floyd Lake 2020 total phosphorous.

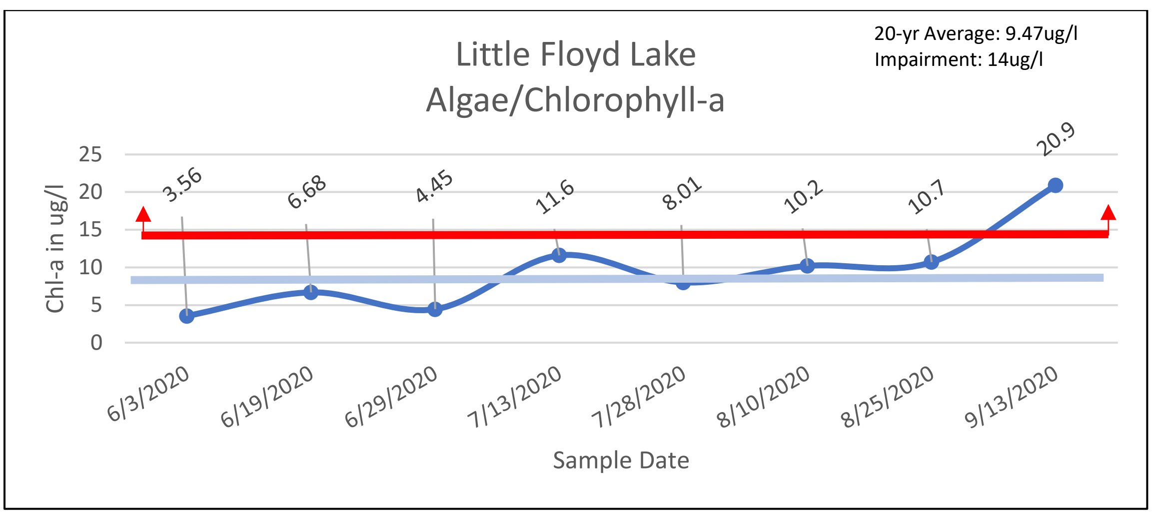


Figure 5.11. Little Floyd Lake 2020 chlorophyll-a.

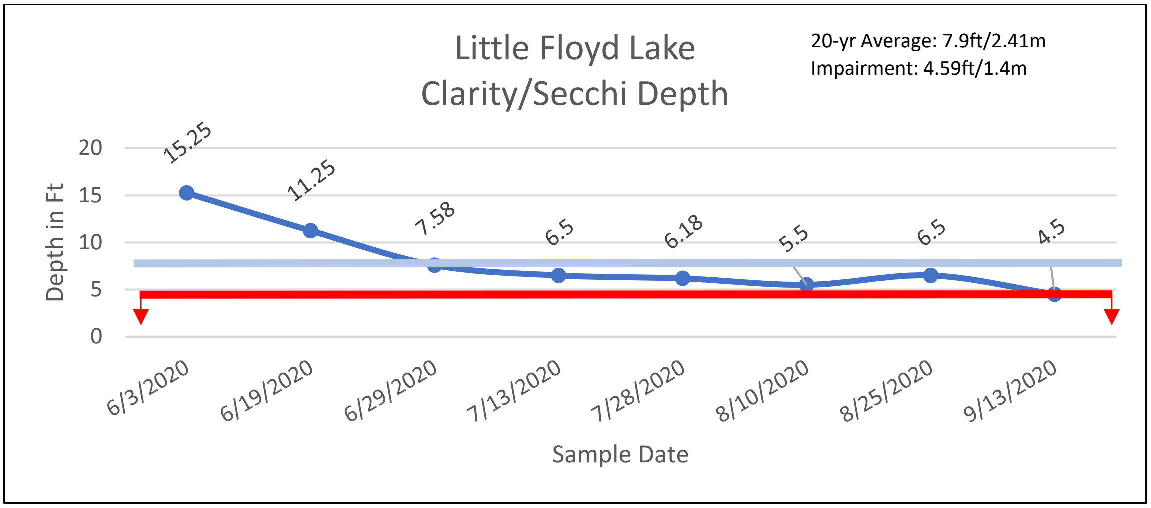


Figure 5.12. Little Floyd Lake 2020 secchi depth.

Ecological Integrity

Vegetation survey - Floyd Chain of Lakes Summary

The District performed a point-intercept vegetation survey on all 3 of the Floyd Chain of Lakes in 2020. A total of 344 points were sampled to assess the aquatic vegetation community (Figure 5.13). 13 species were observed, 9 of which were submerged species and 4 floating/emergent species (Table 5.1). The most common species observed were macroalgae (*Chara spp. or Nitella spp.)*, with 308 of the 365 points having one or the other. The second most common species was common bladderwort (*Utricularia macrorhiza),* a native, perennial, carnivorous plant common to the region. Its multiple bladders fill with air to make the stems float to the surface and are used to capture and digest small insects. Four native species of the genus *Potamogeton (*Pondweeds) were found in various densities at 80 different points. Staff were unable to sample 22 points due to dense emergent vegetation, mostly cattails *(Typha spp.*) but some hardstem bulrush (*Schoenoplectus acutus)* was observed. Composition of dense emergent vegetation was not recorded. No AIS were observed during the survey, but District Staff did note zebra mussels attached to some of the plants sampled. The 3 basins have different yet similar compositions of aquatic plants and should be assessed both as one lake and as separate lakes. (Figure 5.14).

When compared to a previous vegetation survey completed by RMB Environmental Laboratories, Inc in 2015, the density of *Chara* increased from 68% to 90% frequency, and common bladderwort (*Utricularia macrorhiza*) increased from 22% to 42%. Species such as coontail (*Ceratophyllum demersum)* remained at a similar density from 2015 to 2020 (14% to 18%). There were 5 species (*Najas flexilis, Vallisneria americana, Potamogeton zosteriformis, Potamogeton pectinatus, Potamogeton natans)* found in 2015 not found in 2020, and 3 species (*Potamogeton foliosus, Potamogeton praelongus, Utricularia gibba)* found in 2020, but not found in 2015. This may have been caused by misidentification of plants (by either party), or changes in community structures making some plants less frequent than others.

Overall, the aquatic vegetation community of the Floyd Lakes is healthy. High densities of rooted native plants help hold sediments in place, create habitat for fishes and macroinvertebrates, increase DO, and uptake nutrients from the water column. Tall species such as pondweeds, coontail, or bladderwort can provide excellent cover for smaller panfish, decreasing predation and increasing populations. Species of macroalgae such as *Chara* or *Nitella* species stabilize bottom sediments and proved a food source for multiple species of waterfowl.

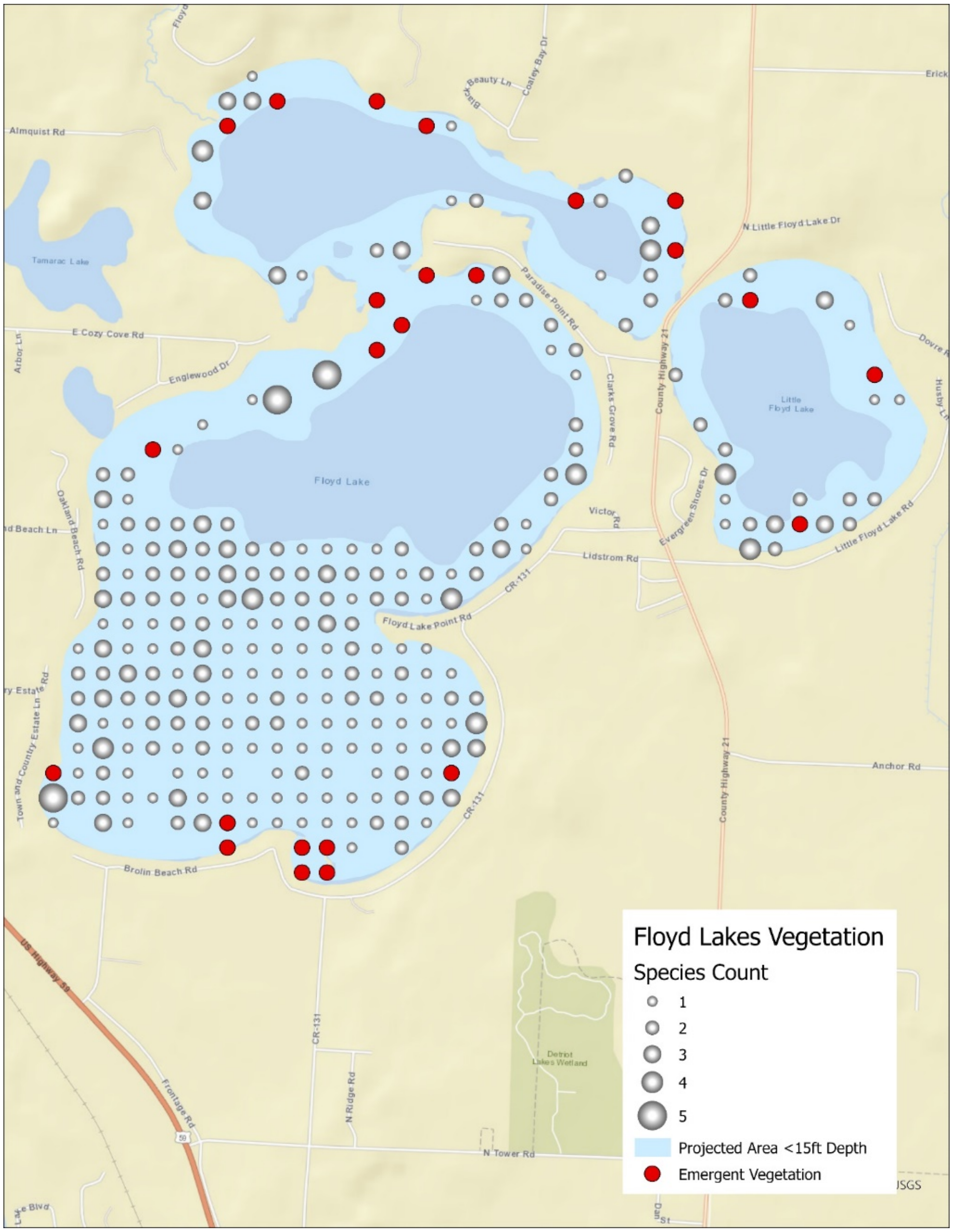


Figure 5.13. Vegetation survey points on the Floyd Chain of Lakes.

Table 5.1: Summary of 2020 Floyd Lake vegetation survey.

Floyd Lake 2020 Vegetation Survey Summary

Scientific Name	Common Name	Average Density/Point	Site Count	% Frequency
Chara spp./Nitella spp.	Macroalgae	2.41	308	84%
Ceratophyllum demersum	Coontail	2.32	61	17%
Drepanocladus spp.	Water Moss	1.66	19	5%
Lemna trisulca	Star Duckweed	1.22	26	7%
Myriophyllum sibricum	Northern Watermilfoil	1.65	40	11%
Nuphar variegata	Pond Lily	1.00	1	0%
Nymphaea odorata	Water Lily	0.50	2	1%
Potamogeton foliosus	Leaf Pondweed	1.22	50	14%
Potamogeton illinoensis	Illinois Pondweed	1.49	16	4%
Potamogeton praelongus	Whitestem Pondweed	0.81	8	2%
Potamogeton richardsonii	Richardson's Pondweed	0.92	6	2%
Utricularia gibba	Creeping Bladderwort	1.00	4	1%
Utricularia macrorhiza	Common Bladderwort	1.47	144	39%
Points with Emergent Vegetation	-	-	23	6%
Empty Points	-	-	35	10%
Total Points	-	-	366	100%

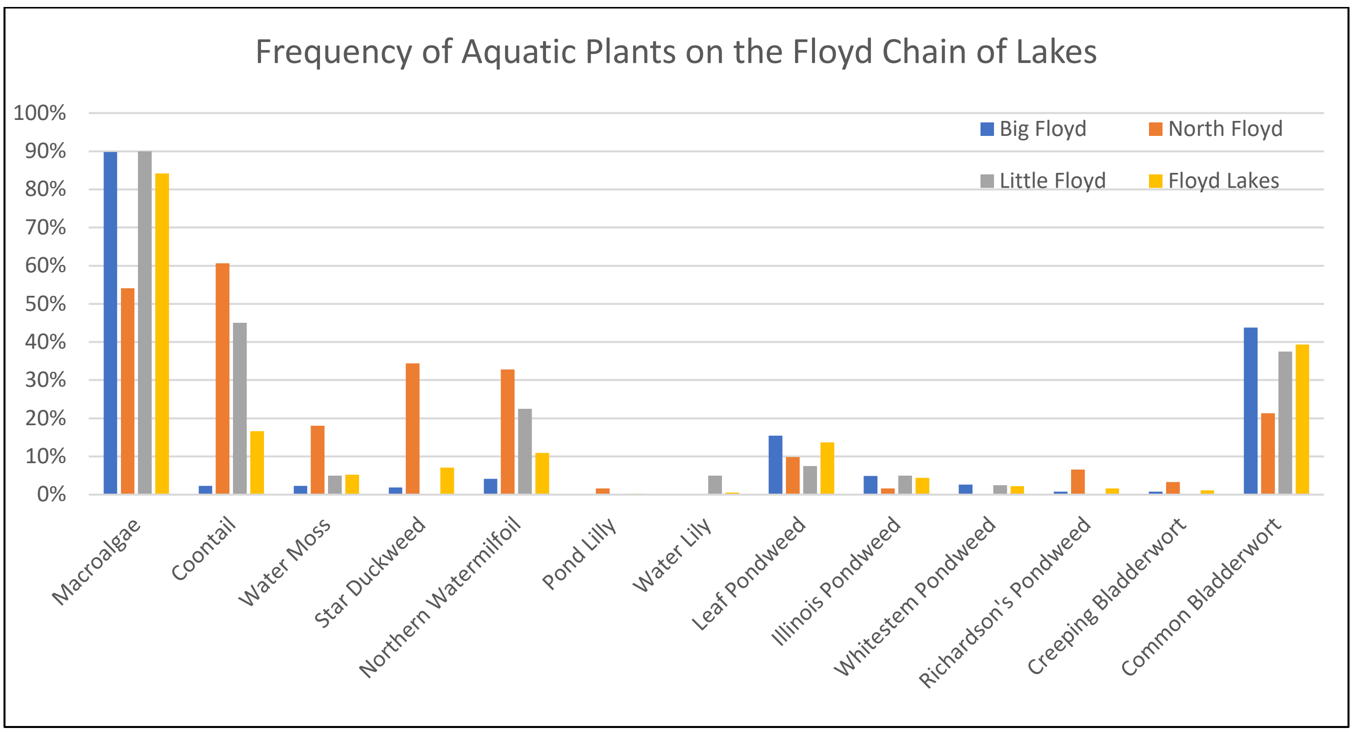


Figure 5.14. Frequency of aquatic plants on the Floyd Chain of Lakes.

Vegetation Survey - Big Floyd Lake

Big Floyd Lake is the largest of the three basins with the most points in the littoral area (total of 265 points). The most common sampled plant in the lake was macroalgae with 90% frequency followed by common bladderwort with 44% frequency (Table 5.2). A total of 21 points (8%) were sampled with no plants returned, while 10 points (4%) were inaccessible due to emergent vegetation. There were three species (macroalgae, leafy pondweed, and common bladderwort) that had >5% occurrence, the other eight species had 5% or less occurrence.

Table 5.2. Results from 2020 Big Floyd Lake vegetation survey.

Big Floyd Lake 2020 Vegetation Survey

Scientific Name	Common Name	Average Density/Point	Site Count	% Frequency
Chara spp./Nitella spp.	Macroalgae	2.67	238	90%
Ceratophyllum demersum	Coontail	2.05	6	2%
Drepanocladus spp.	Water Moss	1.67	6	2%
Lemna trisulca	Star Duckweed	2.00	5	2%
Myriophyllum sibricum	Northern Watermilfoil	1.73	11	4%
Nuphar variegata	Pond Lily	0.00	0	0%
Nymphaea odorata	Water Lily	0.00	0	0%
Potamogeton foliosus	Leaf Pondweed	1.32	41	15%
Potamogeton illinoensis	Illinois Pondweed	1.46	13	5%
Potamogeton praelongus	Whitestem Pondweed	1.43	7	3%
Potamogeton richardsonii	Richardson's Pondweed	1.00	2	1%
Utricularia gibba	Creeping Bladderwort	1.00	2	1%
Utricularia macrorhiza	Common Bladderwort	1.68	116	44%
Points with emergent vegetation	-	-	10	4%
Points with no vegetation	-	-	21	8%
Total Points	-	-	265	100%

The results of this survey were similar to the RMB survey in 2015. Big Floyd Lake had a high density of microalgae followed by common bladderwort and coontail. Other species observed occurred in intermittent dispersed pockets throughout the basin. Big Floyd lake is heavily developed and experiences extensive disturbance from both recreation and natural occurrences (example strong winds creating large waves on the large, generally shallow basin). Big Floyd Lake also has good water quality, limiting the nutrients available for plant growth, and a sandy bottom, limiting the ability of plants to anchor into the substrate.

Vegetation Survey - North Floyd Lake

North Floyd Lake is the "in-between" lake in the Floyd Chain of Lakes. North Floyd is a deeper basin, with less littoral area (total of 61 points). The most common species in North Floyd was coontail with 61% frequency (Table 5.3). The plant community in North Floyd is more evenly distributed than that of Big Floyd or Little Floyd, with 7 of the 10 species occurring at >5% frequency. There was more area with no plant growth (18%) than was observed on Big Floyd (10%) or Little Floyd (8%), but there was also more area with dense emergent plant growth (16%) compared to Big Floyd (4%), and Little Floyd (8%).

Table 5.3. Results from 2020 North Floyd Lake vegetation survey.

North Floyd Lake 2020 Vegetation Survey

Scientific Name	Common Name	Average Density/Point	Site Count	% Frequency
Chara spp./Nitella spp.	Macroalgae	2.30	33	54%
Ceratophyllum demersum	Coontail	2.30	37	61%
Drepanocladus spp.	Water Moss	1.82	11	18%
Lemna trisulca	Star Duckweed	1.67	21	34%
Myriophyllum sibricum	Northern Watermilfoil	1.90	20	33%
Nuphar variegata	Pond Lily	3.00	1	2%
Nymphaea odorata	Water Lily	0.00	0	0%
Potamogeton foliosus	Leaf Pondweed	1.33	6	10%
Potamogeton illinoensis	Illinois Pondweed	2.00	1	2%
Potamogeton praelongus	Whitestem Pondweed	0.00	0	0%
Potamogeton richardsonii	Richardson's Pondweed	1.75	4	7%
Utricularia gibba	Creeping Bladderwort	2.00	2	3%
Utricularia macrorhiza	Common Bladderwort	1.38	13	21%
Points with emergent vegetation	-	-	10	16%
Points with no vegetation	-	-	11	18%
Total Points	-	-	61	100%

North Floyd Lake exhibits a healthy diverse plant community most likely due to a higher nutrient load. North Floyd Lake receives a large amount of nutrient and sediment from Campbell Creek, causing water quality to degrade. With more nutrients for aquatic plants and a "mucky" bottom, vascular plants are able to grow and anchor better than they would in a clear, sandy lake such as Big Floyd. The increased amount of area without plant growth can be attributed to decreased clarity in North Floyd Lake. The decreased clarity decreases the depth of the littoral zone (the area that can support aquatic plant growth), limiting plant growth in the areas close to 15ft in depth. The "mucky" substrate can also increase the areas of dense emergent vegetation.

Vegetation Survey - Little Floyd Lake

Little Floyd Lake is the smallest and last basin in the chain. Little Floyd had 40 points sampled. The most common species was macroalgae (90%) distantly followed by coontail (45%), and common bladderwort (38%) (Table 5.4). The plant community in Little Floyd Lake had 5 of the 9 species at >5% occurrence. A total of 8% of the points were inaccessible due to emergent vegetation, and 8% did not have any growth observed. Water lily only occurred in 2 sites on Little Floyd Lake. This may be misleading, due to this species occurring in dense mats limiting access by staff. Some of the points labeled as "emergent vegetation" may have been dense beds of water lily limiting access.

Table 5.4. Results from 2020 Little Floyd Lake vegetation survey.

Little Floyd Lake 2020 Vegetation Survey				
Scientific Name	Common Name	Average Density/Point	Site Count	% Frequency
Chara spp./Nitella spp.	Macroalgae	2.28	37	90%
Ceratophyllum demersum	Coontail	2.61	18	45%
Drepanocladus spp.	Water Moss	1.50	2	5%
Lemna trisulca	Star Duckweed	0.00	0	0%
Myriophyllum sibricum	Northern Watermilfoil	1.33	9	23%
Nuphar variegata	Pond Lily	0.00	0	0%
Nymphaea odorata	Water Lily	1.50	2	5%
Potamogeton foliosus	Leaf Pondweed	1.00	3	8%
Potamogeton illinoensis	Illinois Pondweed	1.00	2	5%
Potamogeton praelongus	Whitestem Pondweed	1.00	1	3%
Potamogeton richardsonii	Richardson's Pondweed	0.00	0	0%
Utricularia gibba	Creeping Bladderwort	0.00	0	0%
Utricularia macrorhiza	Common Bladderwort	1.33	15	38%
Points with emergent vegetation	-	-	3	8%
Points with no vegetation	-	-	3	8%
Total Points	-	-	40	100%

Little Floyd Lake's plant community is a mix of Big Floyd Lake and North Floyd Lake, similar to its water quality. Little Floyd has less nutrients than North Floyd, but more than Big Floyd. The same is true for clarity, Little Floyd has increased clarity from North Floyd, but decreased from Big Floyd. The aquatic plant community of Little Floyd is less evenly distributed than North Floyd, but not as patchy as Big Floyd. Duckweed occurred in denser beds on Big Floyd than on North Floyd, but none was found on Little Floyd.

Fish Kill - Little Floyd Lake

A summer fish kill was observed on Little Floyd Lake in 2020 after a rapid spring warm up and heavy winds. Large amounts of panfish washed up along the south shore of Little Floyd Lake cause residents concern about possible chemical dumping or pollution. Panfish already experiencing stress from breeding and warming temperatures likely succumbed to an infection from the bacterium *Chondrococcus columnaris*. This bacterium is always present in healthy fish populations but may cause fish kills when populations are stressed. MN DNR stated these fish kills usually do not cause significant effects on numbers, and populations quickly rebound.

Zooplankton Survey – Floyd Chain of Lakes

District Staff have been involved in a cooperative project with the MN DNR and Concordia College in Moorhead to examine the effect of zebra mussels on the microscopic communities of zooplankton that form the base of the food web. Zebra mussels filter large amounts of water and strip the water column of resources. Through this study, District Staff collect monthly zooplankton samples and preserve them for later analysis. Analysis of these samples requires specialized identification knowledge. Staff from MN

DNR and Concordia College will analyze the samples and report to the District once multiple years of population data has been collected. This project is on-going.

5.1.2 Sands Lake

Sands Lake is small (104 acres) natural environment lake to the North of the Floyd Chain of Lakes (Figure 5.15). Sands is a shallow lake, with a maximum depth of 11 feet and a natural wetland fringe around the edge. The lake is land locked, with no significant surface inlets or outlets. Water quality in Sands lake is marginal, with a summer average phosphorous concentration of 30 ppb and a secchi depth of 9.5ft. Aquatic plant growth is dense throughout, but especially so in depths less than 5ft.

Figure 5.15. Sands Lake.

Shoreline Survey-6 Parcels

A Shoreline Survey was conducted on Sands Lake in 2020. Sands has remained mostly undeveloped with 83% of the shoreline being natural. Surveys have been conducted on Sands in 2020, 2011 and 2006. Since 2006, Sands has seen increases in the number of docks and personal watercraft such as motorized and non-motorized boats and it has seen decreases in the number of boat lifts (Figure 5.16). The 2006 survey showed 1 boat launch as the only lakeside structure and no lakeside structures have been recorded in the most recent surveys.

Any future development on Sands lake is expected to be minimal. With only six parcels around the lake, it is unlikely more properties will be established. These parcels are large tracts of land mostly used for hunting or agriculture, not residential development.

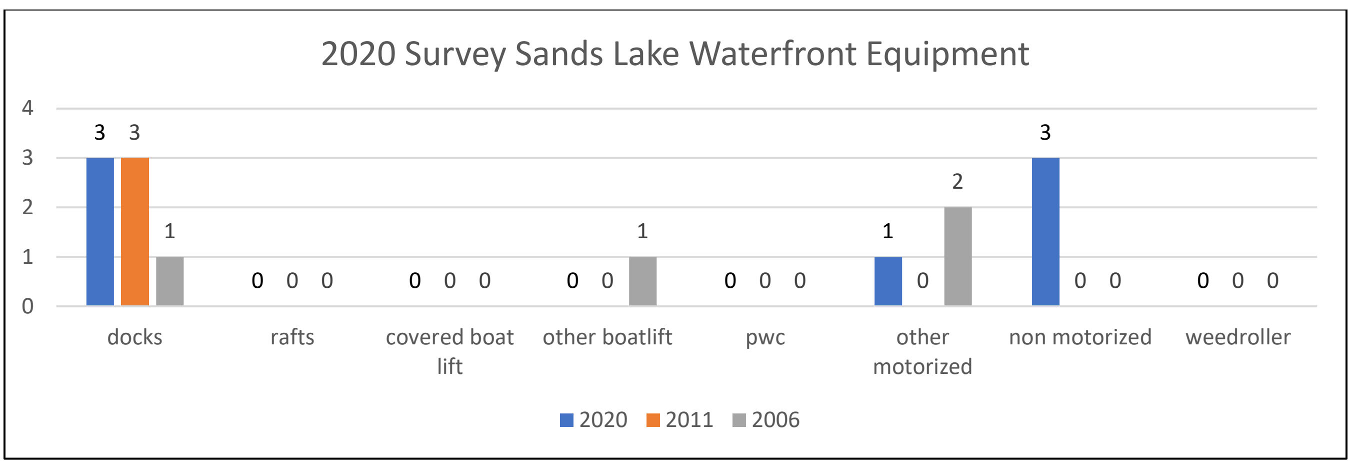


Figure 5.16: Waterfront equipment on Sands Lake.

5.2 Streams/Ditches- Campbell Creek -Ditch 11/12

Campbell Creek is an intermittent, high gradient stream and is the major nutrient source to North Floyd Lake. Sections of Campbell Creek were ditched and straightened in the early 1900s for agricultural benefit and included partially drawing down Campbell Lake and draining surrounding wetland areas. Also known as Becker County Ditch 11-12, Campbell Creek drops almost 80 feet in 2 miles before reaching North Floyd. Through the lower reach, Campbell Creek flows through highly erodible soils, and carries a heavy sediment load to North Floyd.

Extensive conservation work has been completed in the agricultural areas between Campbell Lake and North Floyd Lake including ditch buffers, sedimentation basins, and wetland restorations. These practices have decreased loads of sediment and phosphorous to Campbell Creek, but other issues still need to be addressed (e.g., drain tile and stream bank erosion).

Water Quality/Quantity

Campbell Creek experienced one of its worst years for water quality in 2020. Loads at CC2 (Campbell Creek at 230th St) reached 875 lbs/yr of TP and 65 tons/yr of TSS (Figure 5.17). Loads of TP and TSS reached 3,400 lbs/yr and 532 tons/yr at station CC1 (Campbell Creek at CSAH 149). Total discharge to North Floyd Lake reached 1,041 million gallons, about four times greater than the average year. Discharge from CC2 to CC1 increased by a factor of 2.5 (399 million gallons to 1,041 million gallons). The flashy flow regime observed at CC2 is magnified by the time it reaches CC1 (Figure 5.18). This is caused by multiple factors including: wetland ditching, channel straightening, stream channel erosion, drain tile, and beaver removal.

This increase in loads through Campbell Creek can be attributed to the multiple large rainfall events that occurred in 2020. There were 11 rainfall events >1” from May to October, with 3 events dropping >3” in a 24-hr. period (6/9/20, 6/18/20, 8/14/20). These large rainfall events forced water through Campbell Creek causing flushes of sediment and nutrients to find their way to North Floyd Lake. As more and more heavy rainfall events occur, erosion to Campbell Creek increases. The District will be attempting to repair this situation in the coming years by implementing best management practices in Campbell Creek and in the surrounding uplands.

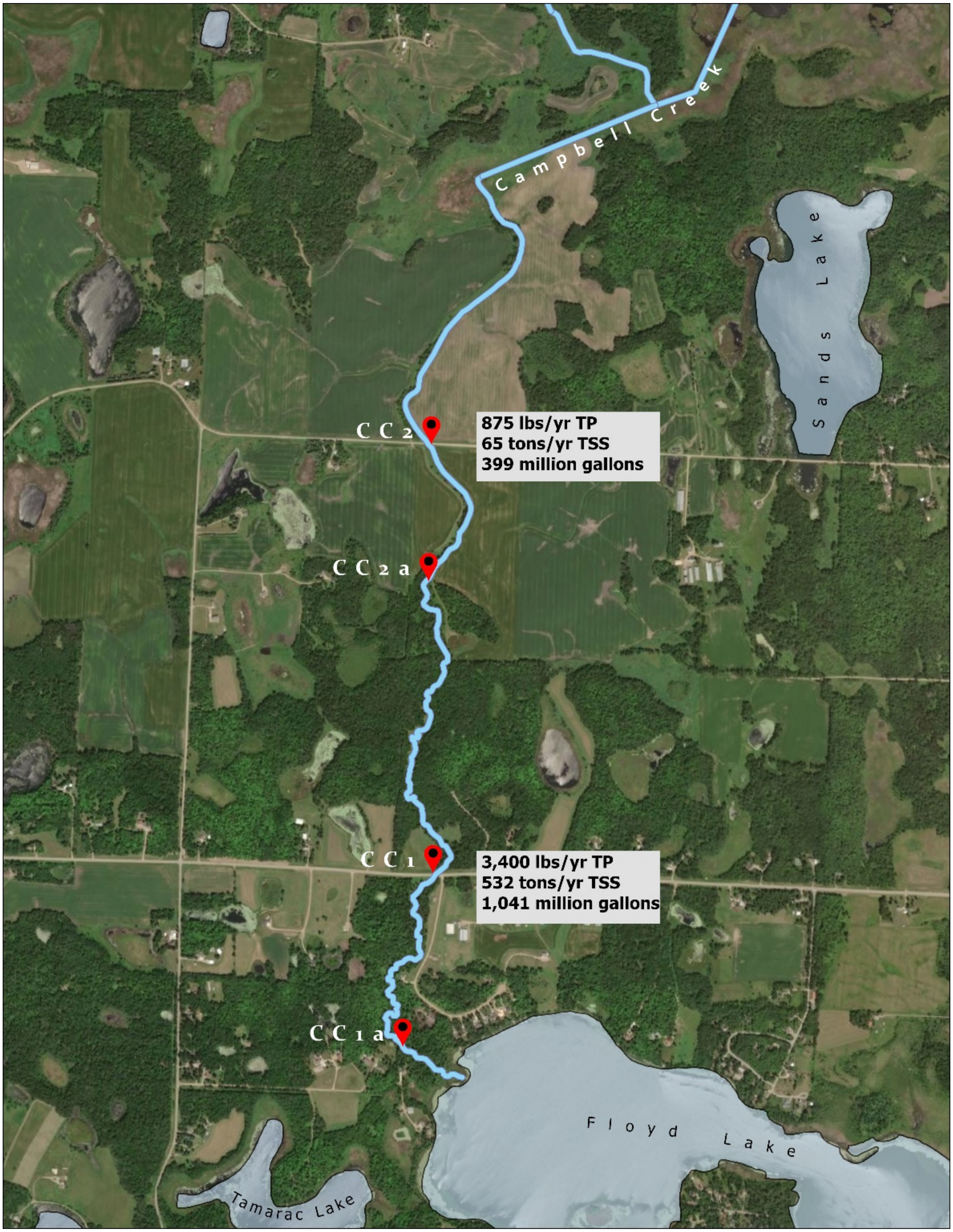


Figure 5.17. Pollutant loading on Campbell Creek.

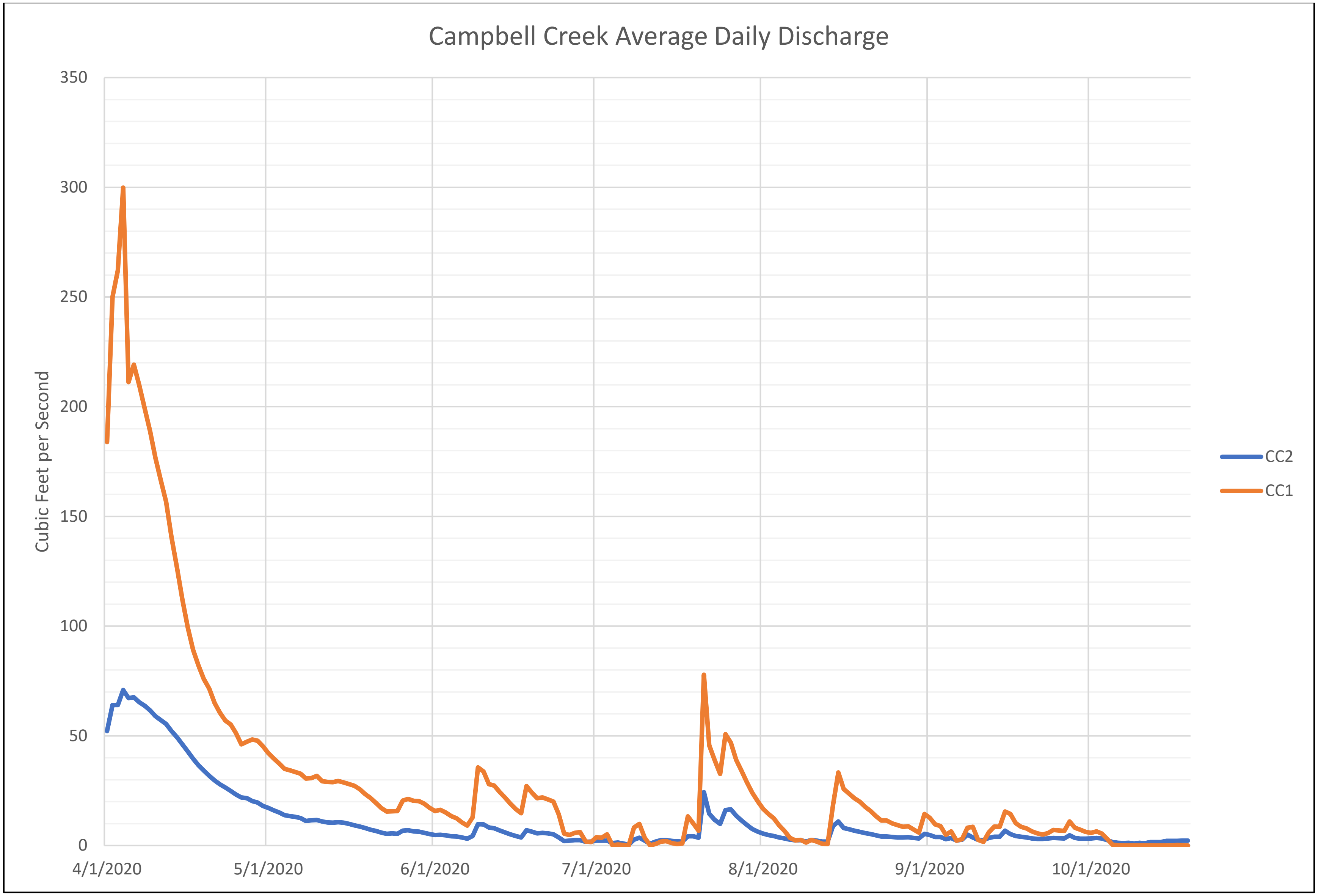


Figure 5.18. Average daily flows in Campbell Creek. Data from Campbell Creek at 230th St (CC2) and CSAH 149 (CC1).

Ecological Integrity

In 2020 the District continued its cooperative partnership with the MN DNR to study stream channel erosion on Campbell Creek from Campbell Lake to Floyd Lake. District Staff joined MN DNR Staff for three days of survey in October. Staff noted downcutting of the channel bed, undercut banks, and extensive erosion to outer stream banks. The area North of CSAH 149 is seasonally grazed by livestock, and no exclusion fence is present. Livestock have been destabilizing stream banks and stream riffles. Staff also suspect high stream velocity is to blame. (Insert Picture of example of cross section)

Figure 5.19. Example of bank erosion on Campbell Creek. North of CSAH 149.

6 Detroit/Rice Water Management Area

The Detroit Rice WMA is the largest in the district at about 25,000 acres (Figure 6.1). The Pelican River travels South from its Headwaters in Little Floyd Lake and through the Rice Lake Wetland Complex, a large, drained wetland outside the city limits of Detroit Lakes. From there the Pelican River drains into Detroit Lake from the North. Sucker Creek, a designated trout stream, also drains into Detroit Lake from the Southeast. From Detroit lake, the Pelican River flows Southwest to the Sallie/Melissa WMA. The main issues facing the WMA is wetland drainage and urban development. The Pelican River from Highway 34 to Detroit Lake is impaired for low fish and benthic macroinvertebrate index of biological integrity (IBI) scores, low DO, and high *E. coli* loads.

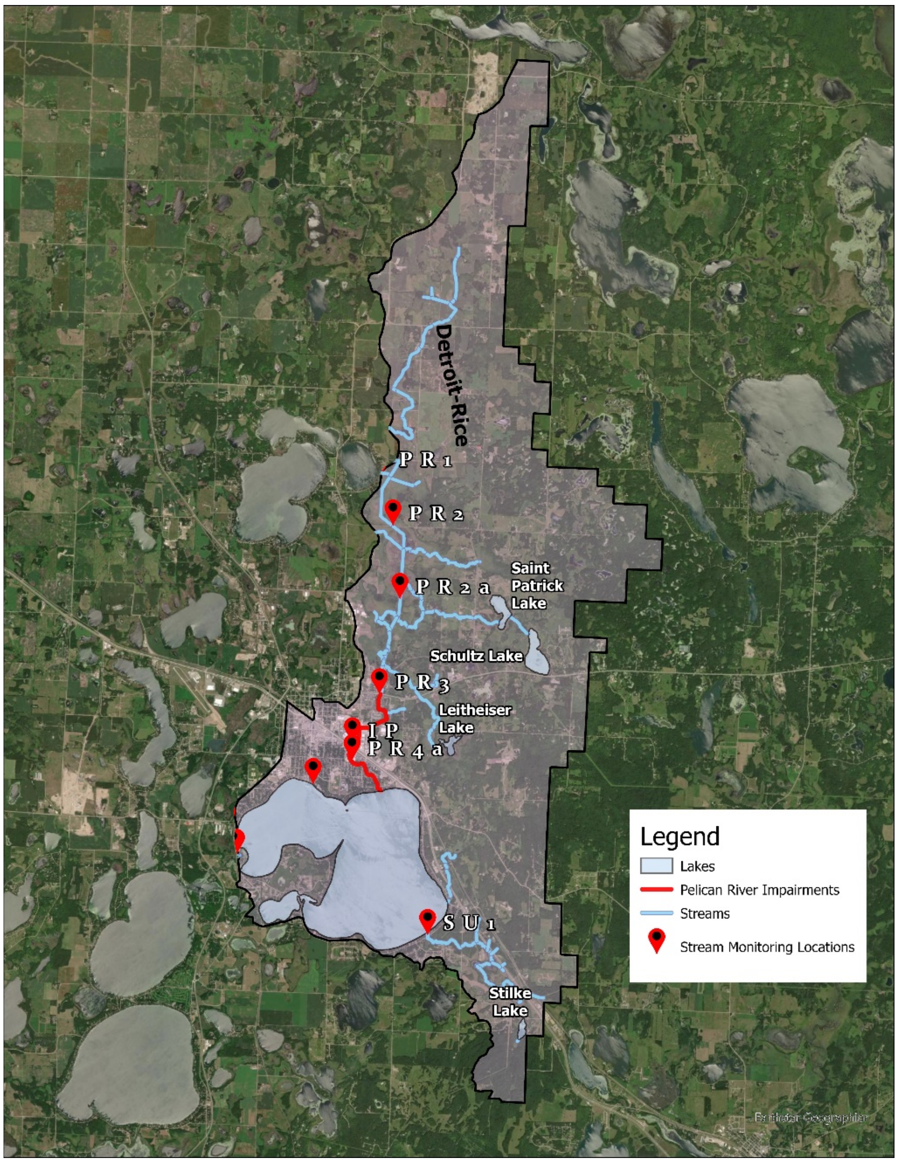


Figure 6.1. Detroit/Rice Water Management Area.

6.1 Lakes

The Detroit/Rice WMA has 5 lakes within its borders (Detroit, Curfman, Saint Patrick, Schultz, Leitheiser, and Stilke), 3 of which will be sampled in the 2020-2030 Monitoring Plan (Saint Patrick, Schultz, and Curfman), and 1 (Detroit) is sampled annually and split into 2 basins (Big Detroit and Little Detroit). In 2020, the only water quality sampling in the WMA was on Detroit Lake. In 2021, the District will sample water quality on Detroit Lake and Leitheiser. Detroit Lake received chemical treatments for flowering rush (*Butomus umbellatus)* and curly-leaf pondweed (*Potamogeton crispus)* in 2020.

6.1.1 Detroit Lake

At 3,067 acres, Detroit Lake is the largest lake within the PRWD, and lies entirely within the City of Detroit Lakes municipal boundaries. As typical with urban lakes, its shoreline is extensively developed with residential homes, commercial businesses, and some industrial buildings. The lakes are heavily used for game fishing, boating, and other summer, and winter recreational activities. The drainage area of Detroit is 9770 acres in size, which is comprised primarily of Forest (42%), Grassland (27%), and Developed Land (18%).

Detroit Lake, locally known as Big Detroit and Little Detroit, has two distinct basins that are separated by a shallow gravel bar. The larger of the two basins, Big Detroit has a maximum depth of 82 feet (18.4-foot average) with 37.5 % of its surface within the littoral area (< 15 ft depth) and has 7.84 miles of shoreline. Little Detroit littoral area (< 15ft depth) encompasses the entire water basin, with a lake depth average of 8.5 feet and a maximum depth of 16 feet, with 4.9 miles of shoreline.

The primary inlet and outlet for Detroit Lake is the Pelican River, flowing into the north side of Big Detroit and exiting the southwest side of Little Detroit. In addition to the Pelican River, Sucker Creek drains to the Lake along with two small wetland flowages, all on the southeast portion of Big Detroit. There are no water control structures, however, the lake level is controlled further downstream by the rock rapids located between Muskrat and Sallie lakes.

Big Detroit is a dimictic lake while Little Detroit is polymictic, however, both exhibit mesotrophic characteristics with moderately clear water and support all recreation/aesthetic uses. Occasionally, after large rain events or during hot summer months, the lake becomes borderline eutrophic with visible algal blooms. This is due, in part, to Rice Lake, an upstream degraded wetland complex which releases phosphorous following large rain events. Urban and residential stormwater runoff are also contributors of nutrients to the lake.

AIS have a large effect on lake health and in turn, lakeshore property value. Because of the high level of recreational use of Detroit Lake, this makes it very susceptible for invasive species introduction. The aquatic invasive plants Flowering Rush and Curly-leaf pondweed are both present in the lake, along with invasive invertebrates Zebra Mussels and Chinese Mystery snails. Both Flowering Rush and Curly-leaf Pondweed are assessed and managed annually via herbicide applications. The City of Detroit Lakes recognizes the economic value of the lake and assists the District in managing invasive plants.

Little and Big Detroit were completely frozen over on Tuesday, November 17, 2020. That date is about 3 days earlier than the average of 110 years for which record have been kept, but about eleven days earlier than the last twenty years.

The earliest ice-on date was October 25, 1919, but the earliest ice-on in the last 20 years, was last year on November 11. We had December ice-on in 2001, 2004, 2009, 2016, 2017. Area residents enjoyed 206 days of open water in 2020, about 8 days less than the all-year average and 19 days less than the average of the last 20 years. The longest ice-free season was 256 days in 2016. Based upon the averages, 140-150 days of ice-cover can be expected. The average ice-out date is April 20th.

While Little Detroit remained frozen after November 17, a large part of Big Detroit opened up, and was subject to some freezing and thawing for the next 13 days. Open water accounted for perhaps 40% of the Big Detroit basin on November 29. It finally did freeze again on the morning of November 30.

<u>Water Quality/Quantity</u>

Lake Levels

The Lakes do share a common outlet and OHW. The water level for Detroit Lake is measured at the outlet under County HWY 6/West Lake Drive. For 2020, water levels remained high for most of the year (Figure 6.3). Detroit Lake remined above its OHW for the entirety of the season, as it had done in 2019 (Figure 6.2). By the end of the year, Detroit Lake finally returned to its OHW. The last reading the District took was on October 19th, at an elevation of 1334.39' MSL. The multiple rainfall events in 2019 and 2020 are to blame for the high water.

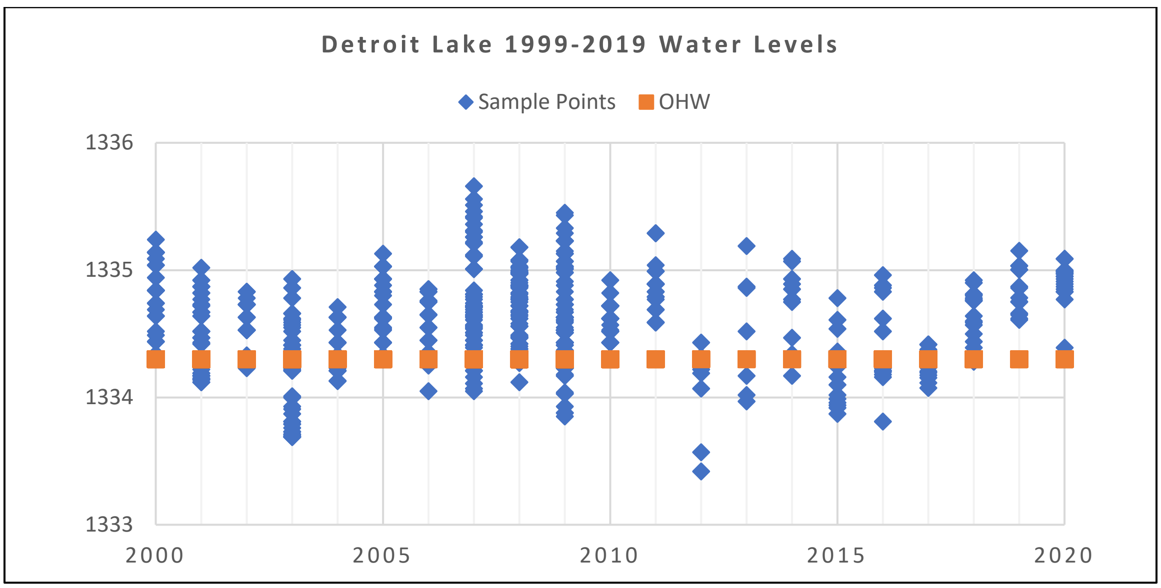


Figure 6.2. Detroit Lake Water Levels from 2000-2020.

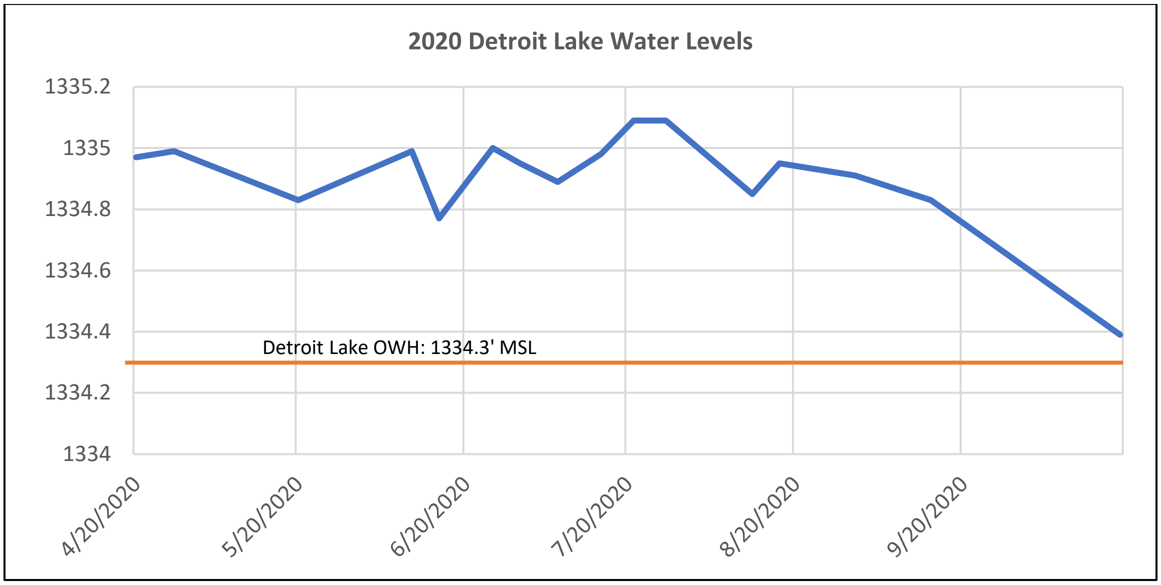


Figure 6.3. Detroit Lake Water Levels in 2020.

Water Quality - Big Detroit Lake

Big Detroit Lake had "better than average" water quality in 2020. The average TP (Figure 6.4), CHL-A (Figure 6.5), and secchi depths (Figure 6.6) were 18ppb, 3.3ppb, and 15.5', all below their respective averages of 23ppb, 8.46ppb, and 10.8'. TP remained fairly constant for the duration of the summer except the sample on 6/29/20 (22 ppb). CHL-A started higher, but decreased to a constant state for most of the summer. Secchi depth started high at 21.5' before moving to 13'-14' for the remainder of the summer, with spike to 16' on 7/15/20.

All samples came in below their respective annual averages indicating improved water quality. This may be attributed to improved stormwater management as a result of Distict Rules enacted in 2003. Another important influence on water quality comes from the presence of zebra mussels. Detroit Lake has been infested with zebra mussels since 2016 and has been showing drastically increased water quality each year since. Zebra mussels increase secchi depth and decrease in CHL-A by filtering the water column.

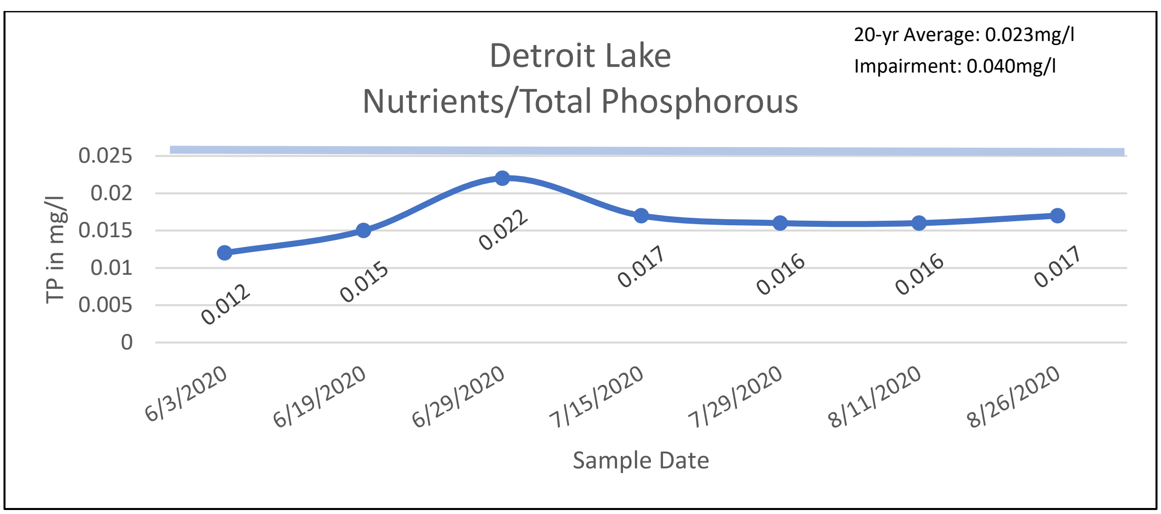


Figure 6.4. Big Detroit Lake 2020 total phosphorous.

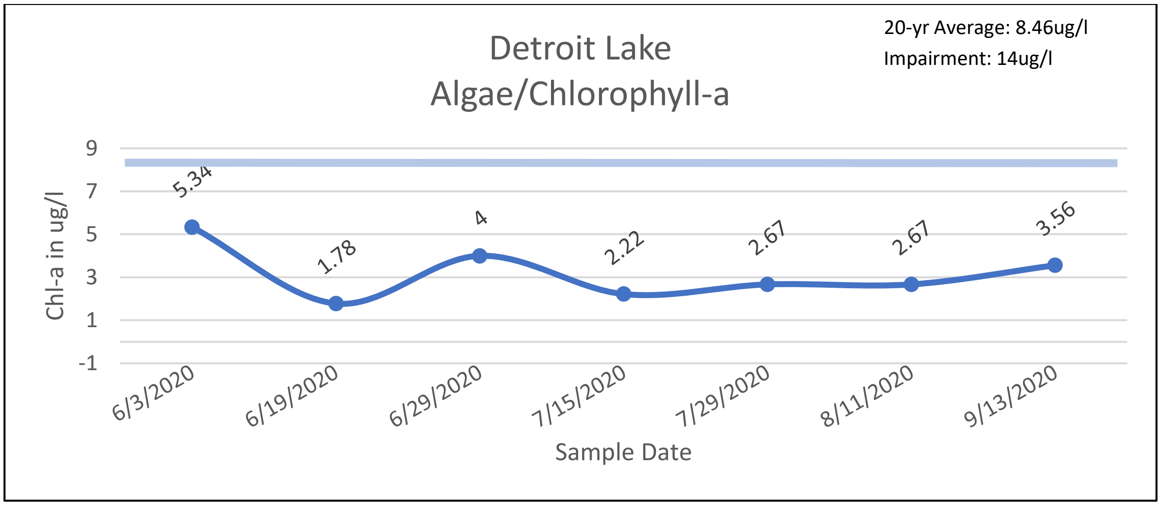


Figure 6.5. Big Detroit Lake 2020 chlorophyll-a.

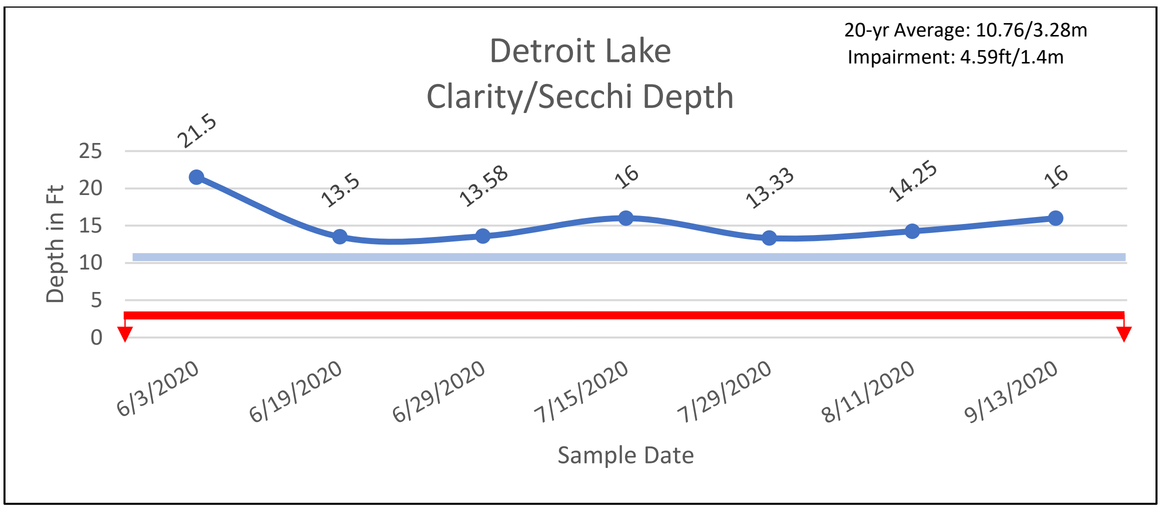


Figure 6.6. Big Detroit Lake 2020 secchi depth.

Water Quality – Little Detroit Lake.
Lake also experienced a "better than average" water quality year. The average TP (Figure 6.7), CHL-A (Figure 6.8), and secchi depths (Figure 6.9) of 14ppb, 2.9ppb, and 14' were all improved from their respective 20-year averages of 19ppb, 4.5ppb, and 11.9'. Readings fluctuated more on Little Detroit throughout the summer than they had on Big Detroit. TP readings spiked above the average of 19ppb twice during the summer (6/29/20, and 8/26/20), slumping to 10-12ppb in between. all but one sample on 6/3/20, CHL-A readings remained below the 20-year average for the duration of the summer, bottoming out at 0.5ppb on 7/15/20.

CHL-A did not follow TP concentrations as observed on other lakes, concentrations of CHL-A were decoupled from TP concentrations. Zebra mussels are the cause this phenomenon due to filtering algae from the water column. Since Little Detroit is a shallow basin, the effects of zebra mussels are more pronounced (individuals are active in photic zone of the water column). While this improves water quality and clarity, it may alter the food web, leaving less available resources for game fish and wildlife.

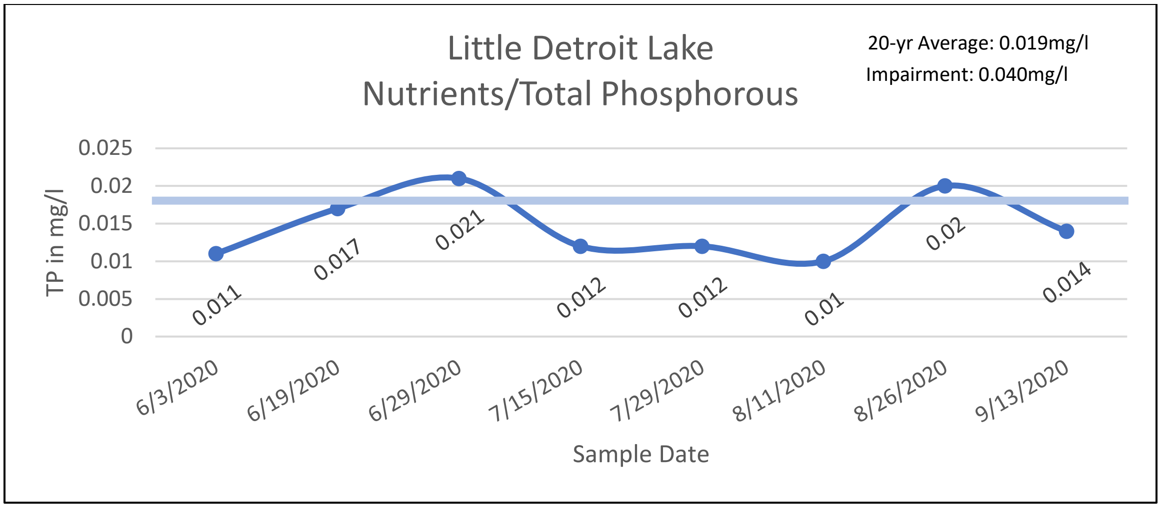


Figure 6.7. Little Detroit Lake 2020 total phosphorous.

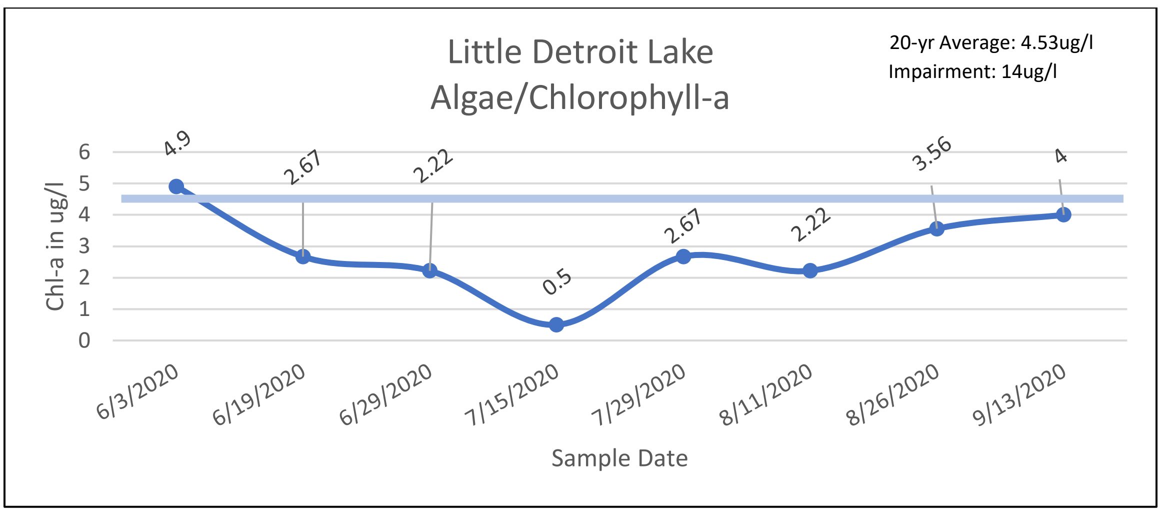


Figure 6.8. Little Detroit Lake 2020 chlorophyll-a.

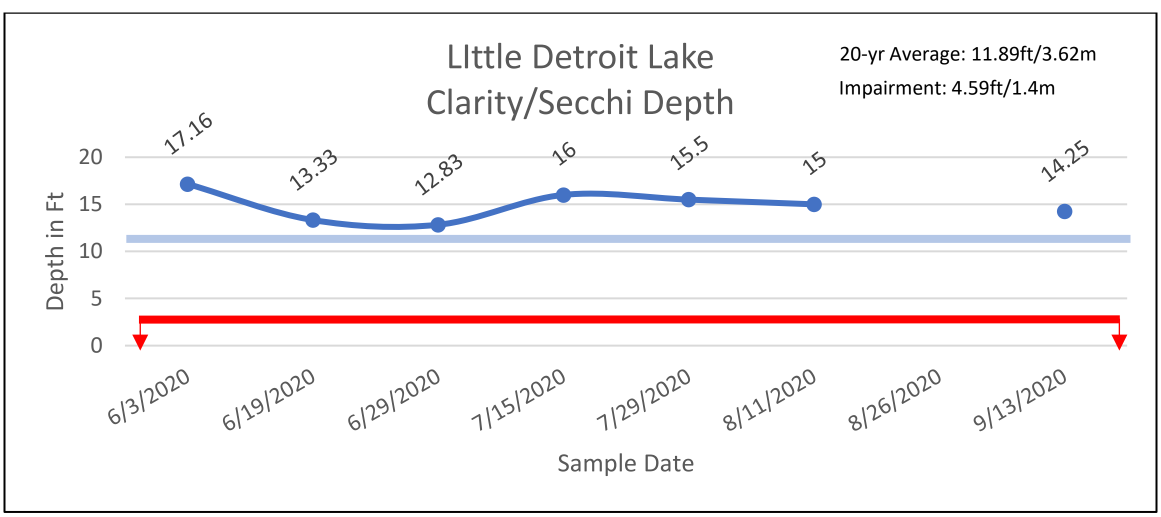


Figure 6.9. Little Detroit Lake 2020 secchi depth.

Ecological Integrity

Aquatic Invasive Species Control

Detroit Lake was treated with chemical for flowering rush and curly-leaf pondweed in 2020. A total of 26.8 acres of curly-leaf pondweed and 11.75 acres of flowering rush were treated (Figure 6.10). The 11.75 acres of flowering rush were treated twice, once on July 7th and once on August 11th. These treatments are greatly reduced from historic treatments (maximum of 172.7 acres of flowering rush in 2013, 60% reduction of curly-leaf pondweed from 2019) signaling the effectiveness of the District's chemical AIS treatments. The District will continue to monitor and treat AIS on Detroit Lake in the coming years.

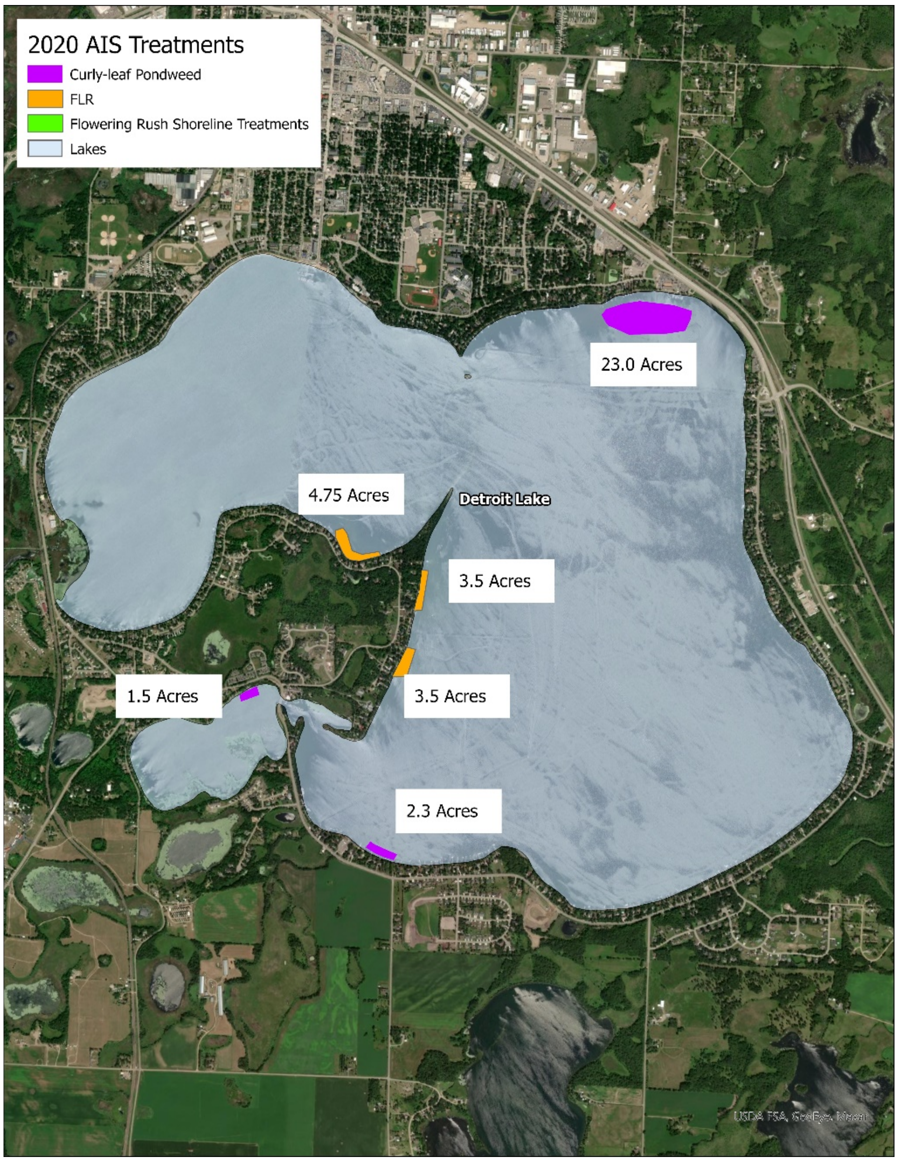


Figure 6.10. Aquatic invasive species treatments on Detroit Lake in 2020.

6.2 Streams

The Pelican River originates at Little Floyd Lake on the boundary of the Detroit Rice WMA. Also known as Ditch 13, the Pelican River flows south through the Rice Lake Wetland Complex, through the City of Detroit Lakes, before entering Big Detroit Lake on the North Shore. The Pelican river stretches 6 miles between Little Floyd Lake and Detroit Lake, only loosing 20ft of elevation. As the river flows through the Rice Lake Wetland Complex, it picks up heavy loads of phosphorous which it carries to Detroit Lake. The District is planning a restoration project to limit loading from the Rice Lake Wetland.

The Pelican River is impaired from Highway 34 to Detroit Lake for benthic macroinvertebrate IBI, fish IBI, low DO, and high *E. coli* loads. The District is currently investigating the cause of these impairments to target and correct the issues.

Sucker Creek is a natural creek that flows into the Southeast shore of Big Detroit Lake. Sucker Creek is protected by the Sucker Creek Nature Preserve, a protection area aimed to preserve the natural state of Sucker Creek and educate people about the benefits of natural systems. Sucker Creek is the District's only designated trout stream. Because if its unique natural state, the District monitors water quality at one point on the creek.

<u>Water Quality/Quantity</u>

Pelican River/Ditch 13

The Pelican River experienced a poor water quality year in 2020 (Figure 6.11). Phosphorous loading to PR4a (last sampling point before Detroit Lake) was 3,747 lbs/yr of total phosphorous, and 1,664 lbs/yr of orthophosphate (plant available phosphorous) compared to their respective 10-year averages of 2,713 lbs/yr and 1664 lbs/yr. The majority of this phosphorous is from the Rice Lake Wetland, where phosphorous is "flushed" through the system during heavy rainfall events in 2020. Concentrations of TP and OP increased from 23ppb and 4ppb to 55ppb and 25ppb by the end of the Rice Lake Wetland. Fluctuating water levels in the wetland complex increase the solubility of legacy phosphorous and contributes to the eutrophication of Detroit Lake. The District intends to rectify this situation with the restoration of the wetland complex's hydrology and stabilize water levels.

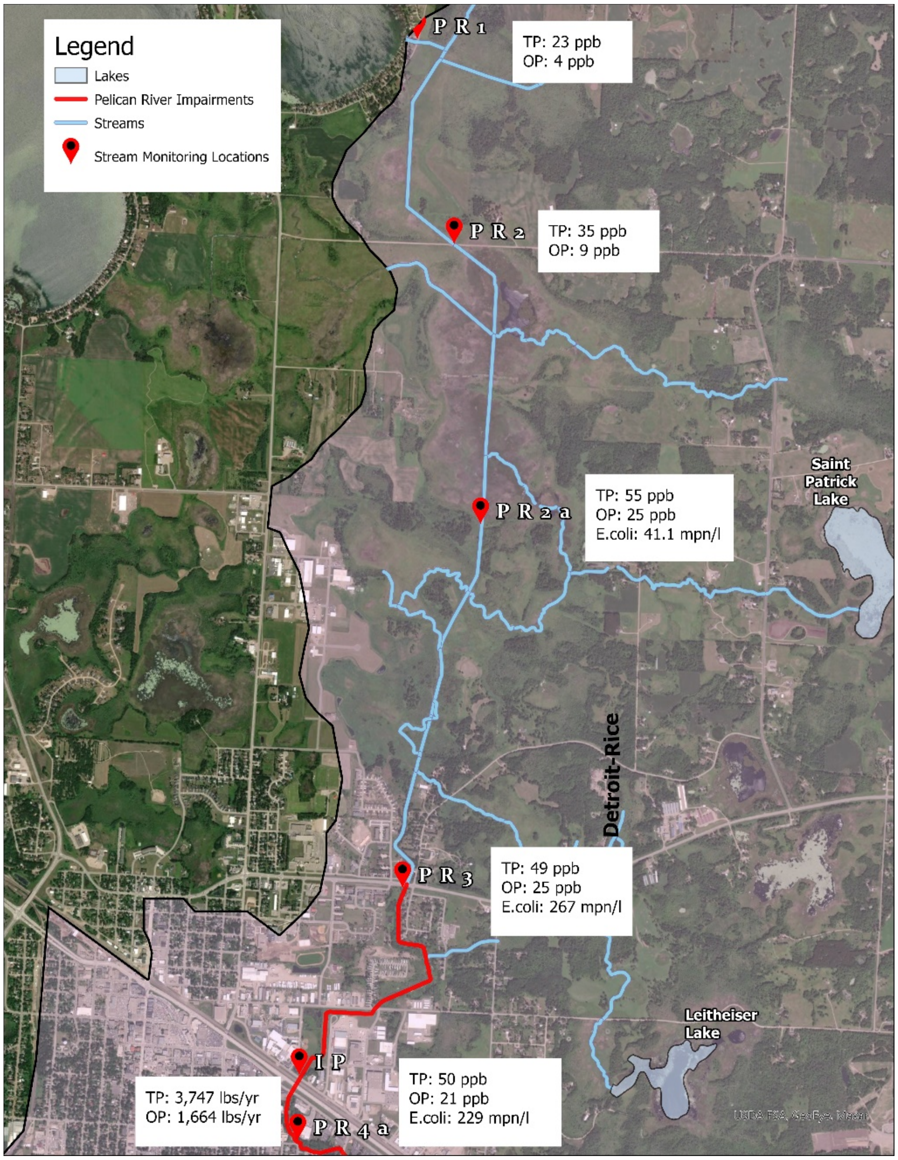


Figure 6.11. Pelican River sampling in the Detroit/Rice WMA.

The impairments on the Pelican River are directly related to low DO in river. The District purchased an automated DO sampler in 2019 and deployed it in Pelican River North of HWY 10 (Figure 6.12). Extreme daily fluctuations in DO were observed, with some readings bottoming out at 0.54 mg/l on August 24th. For reference, Walleye (*Sander vitreus)* prefer concentrations above 5.0 mg/l, can survive down to 2.0 mg/l, and anything below 1.0 mg/l is deadly. Every type of aquatic life form has different tolerances to DO concentrations, which is why IBI scores can be used to judge the health of a stream. The low IBI scores assigned to the Pelican River shows it is not hospitable for very many species of aquatic life. Drivers of this low DO can vary, but the District suspects high *E. coli* loads, and the altered hydrology of the Rice Lake Wetland as factors. As can be seen in Figure 6.12, spikes in *E. coli* loads are followed by dips in DO. This is caused by the microorganisms dying and decomposing, a process that uses large amounts of DO.

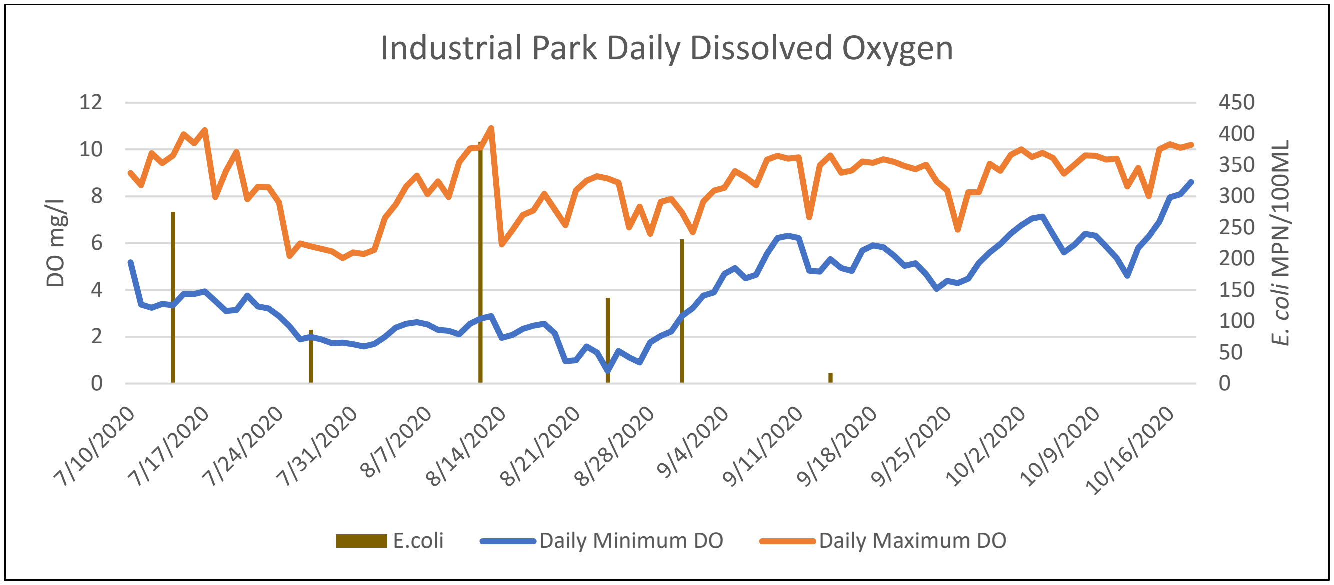


Figure 6.12. Dissolved oxygen fluctuations in the Pelican River. Readings taken in the Industrial Park North of Minnesota Highway 10.

In 2020, the District routinely sampled *E. coli* concentrations at 3 locations (PR2a, PR3, and PR4a; Figure 6.11) and after storm events at 1 location (IP). Samples ranged from 3.1 MPN/100ml at PR2a on 4/27/20 to topping the lab's readings at >2,419.6 MPN/100ml at IP on 6/18/20 and 7/8/20 and also at PR4a on 7/8/20. This data supports the MPCA listed impairment for *E. coli* loads (average >126 MPN/100ml or >10% of sample above 1260 MPN/100ml).

The high *E. coli* loads in the Pelican River is a perplexing problem. As of 2020 the District is unsure what is contributing to these loads. Previous studies of the City of Detroit Lake sanitary sewer system have not found any leaks into the Pelican River. *E. coli* source testing performed in 2018 has been inconclusive as to the source of the *E. coli* as well. The District has been incrementally testing the Pelican River to see if there is an area where concentrations spike, but results have been inconclusive. Staff sampled stormwater ponds in the Industrial Park area North of HWY 10 adjacent to the Pelican River and found some spikes in concentrations (up to 631 MPN/100ml on 8/31/20). More investigation will be required in 2021 to narrow the source.

Water levels on the Pelican River through Rice lake slowly fluctuated in response to rain events. (Figure 6.13; Figure 6.14) This is caused by the large area flooded as water levels rise. This also increases the time required for draw down after levels crest. It is important to note a sudden drop in water levels around 4/20/20, caused by removal of a downstream beaver dam by District Staff. *E. coli* levels show 2 different possible sources of the *E. coli* loading (Figure 6.14). An increasing concentration with decreasing levels indicates a constant influx of *E. coli,* no matter the water level (example: a failing septic system; *E. coli* is diluted as water levels rise, and concentrated when they recede). The other source would come from surface runoff (concentrations spike after rain events which cause the sharp increase in water levels).

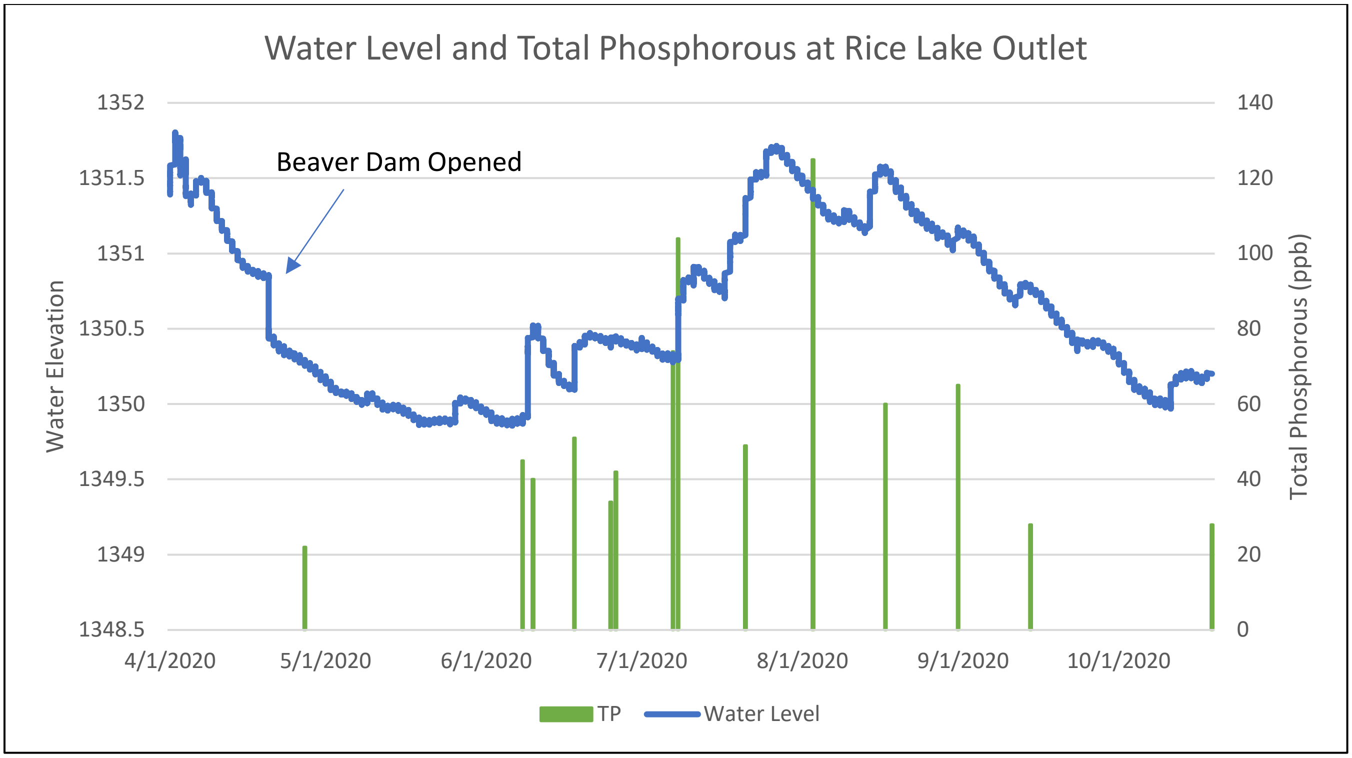


Figure 6.13. Water Level and total phosphorous at Rice Lake Outlet.

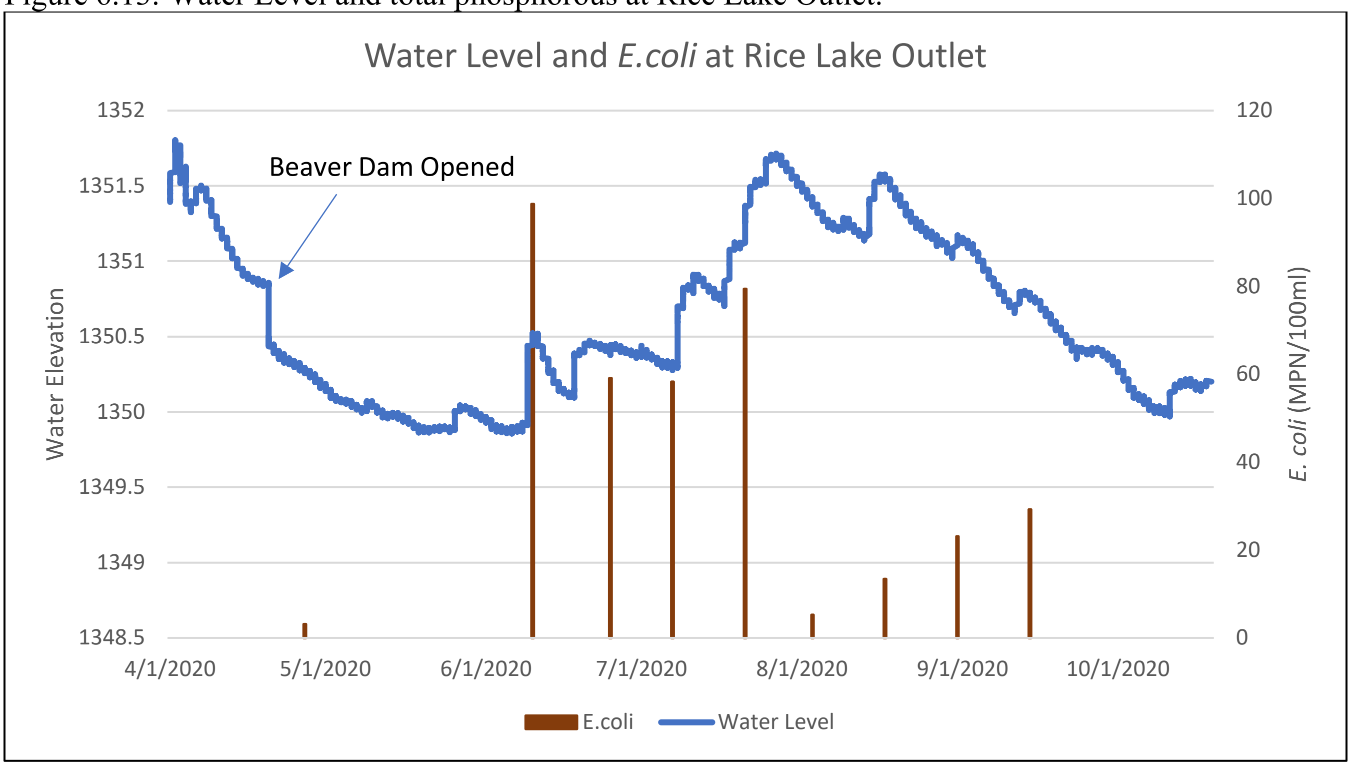


Figure 6.14. Water levels and *E. coli* at Rice Lake Outlet.

Water levels in the City of Detroit Lakes tended to be "flashier" than those at the outlet from Rice Lake (Figure 6.15; Figure 6.16). This is likely caused by less flood plain through the city combined with increased velocity of inputs (stormwater runoff from impervious surfaces). It should be noted 2 spikes in flow were caused by removing upstream beaver dams on 4/15/20 and 4/20/20. Spikes in *E. coli* here tended to be more closely related to rainfall events indicating a runoff issue. It is possible the same constant inflow of *E. coli* seen at the Rice Lake outlet is still present but being covered by extensive surface runoff.

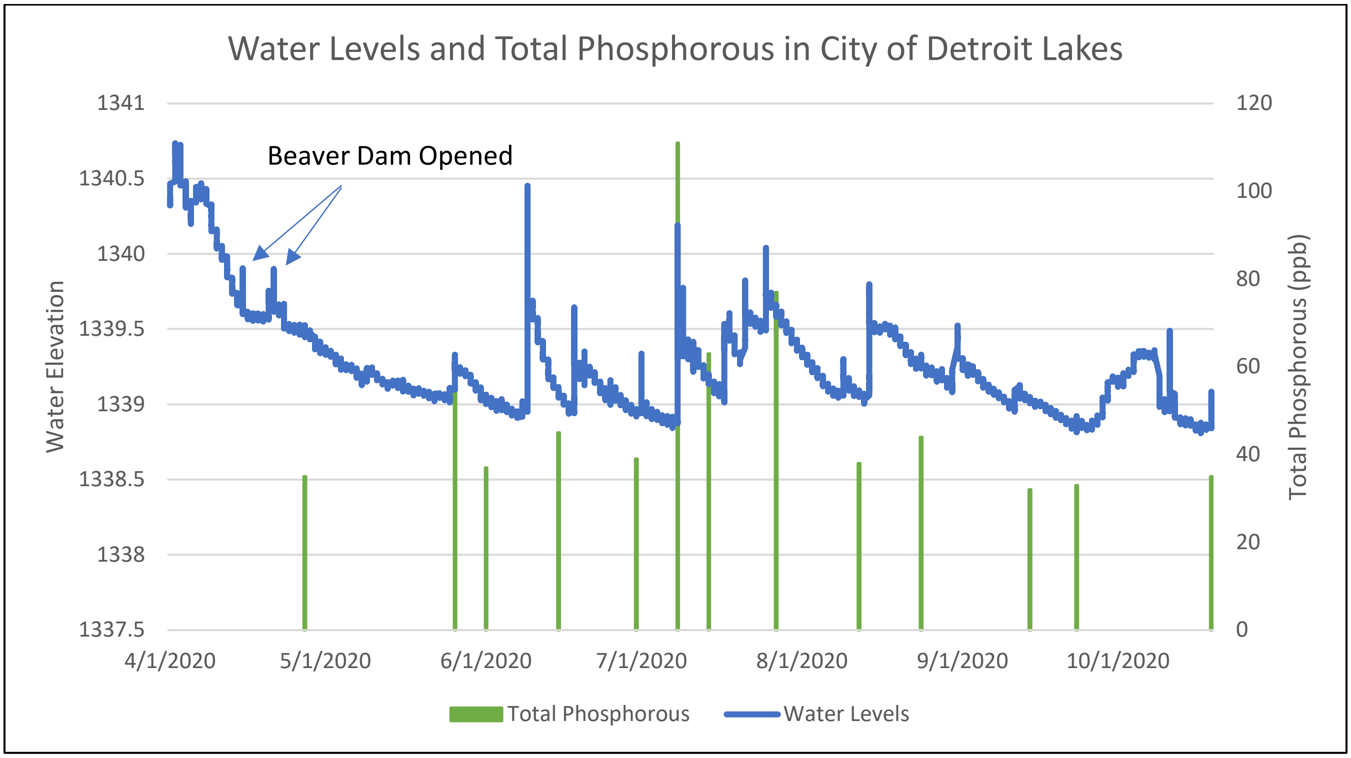


Figure 6.15. Water levels and total phosphorous in City of Detroit Lakes. Samples taken at location PR4a, near Jackson Ave. Storage units.

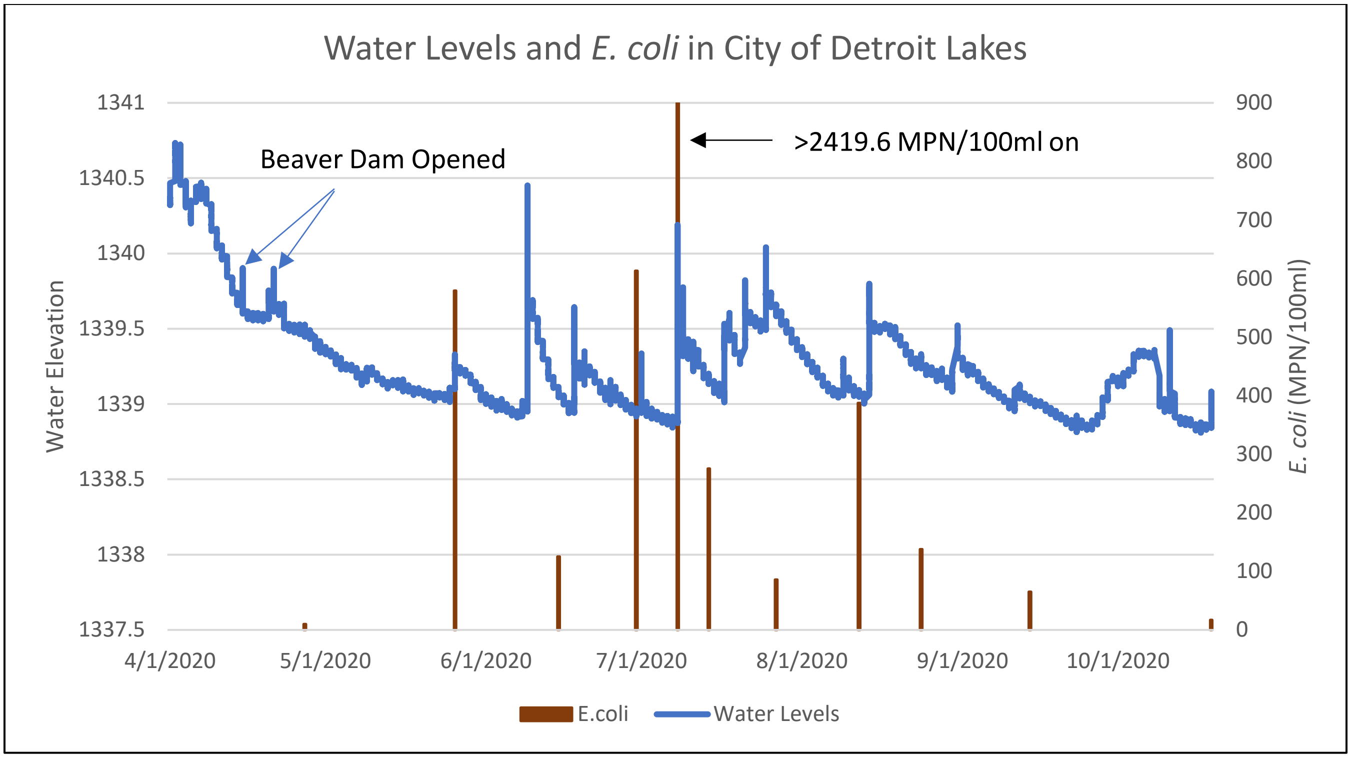


Figure 6.16. Water levels and *E. coli* in City of Detroit Lakes. Samples taken at location PR4a, near Jackson Ave. storage units. Sample on 7/8/20 reached >2419.6 MPN/100ml.

Sucker Creek

The District sampled 1 location on Sucker Creek in 2020 to judge the health of the system (Figure 6.17). Staff visited the location SU1 a total of 27 times to collect water quality samples. DO readings averaged 7.8 mg/l, sufficient for trout to use the stream for spawning. Average TP, OP, and TSS were at 35 ppb, 15 ppb, and 4.6 ppb.

Figure 6.17. Sucker Creek sampling location.

Water levels fluctuate greatly on Sucker Creek in response to rain events, then return to the lower level fed by ground water. The multiple rain events triggered momentary surges in water level accompanied by surges in TP (Figure 6.18). While concentrations where high, discharge was generally low, the 4 discharge readings were all below 7 CFS (6/16/20- 4.6 CFS, 7/1/20-6.86 CFS, 8/7/20-2.79 CFS, 8/13/20-4.48 CFS). The District will collect more discharge readings in the coming years to assess high flow discharges and create a stream rating curve.

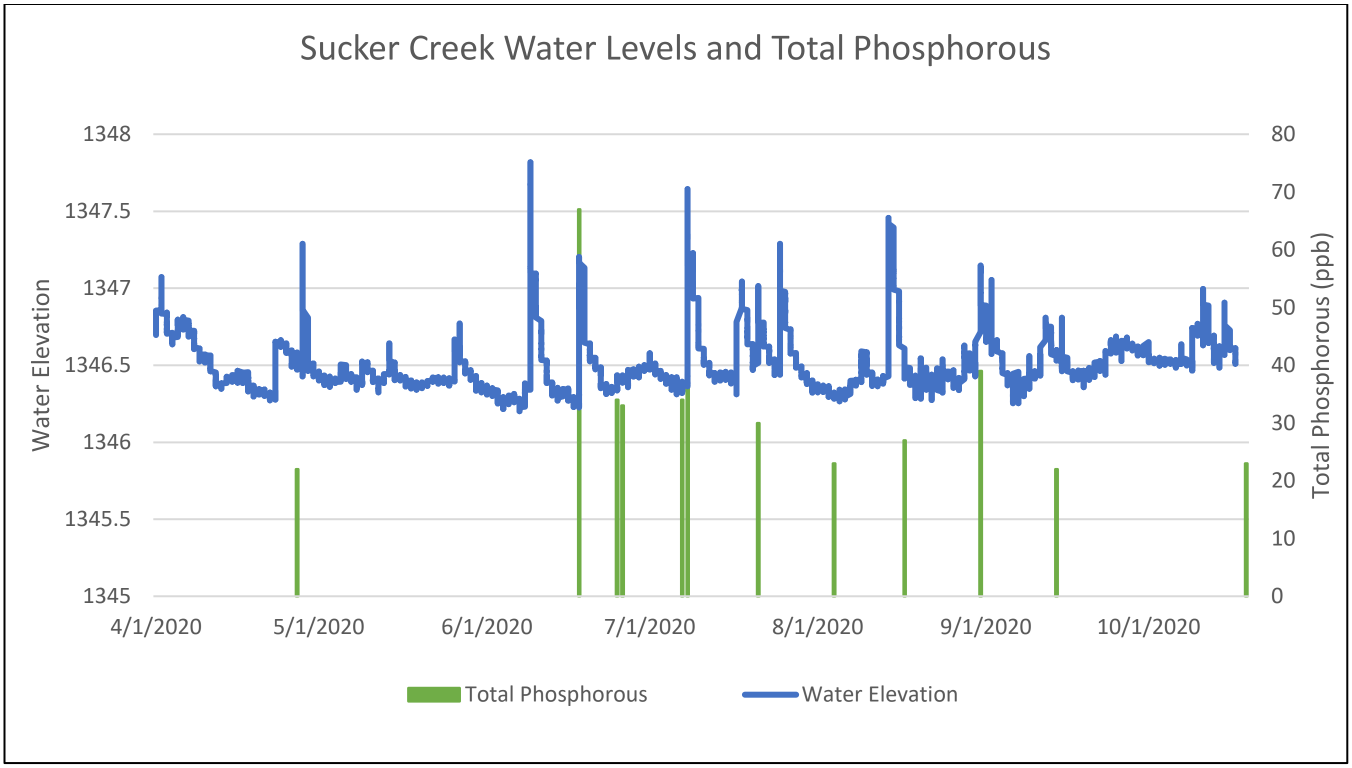


Figure 6.18. Sucker Creek water levels and total phosphorous.

7 Sallie/Melissa Water Management Area

The Sallie/Melissa WMA is the last WMA in the District before the Pelican River exits to the south (Figure 4.1). This 11,400-acre WMA contains Lakes Sallie and Melissa, St. Clair Lake, Muskrat Lake, and Mill Pond. The Pelican River leave Detroit Lake and flows to Muskrat Lake, the reservoir created by Dunton Locks (now Dunton Rapids). From there it flows through Lakes Sallie and Melissa before entering Mill Pond, the reservoir created by Bucks Mill Dam and the last stop in the District. Ditch 14, the ditch draining St. Clair Lake (the former sewage pond for the City of Detroit Lakes) and the numerous wetlands surrounding it, empties into the Pelican River just after it leaves Detroit Lake, dumping a heavy load of phosphorous into the system. St. Clair Lake is impaired by high nutrient loads caused by historic pollution. Half of the City of Detroit Lakes drains into Ditch 14 via the City's Municipal Separate Storm Sewer System (MS4).

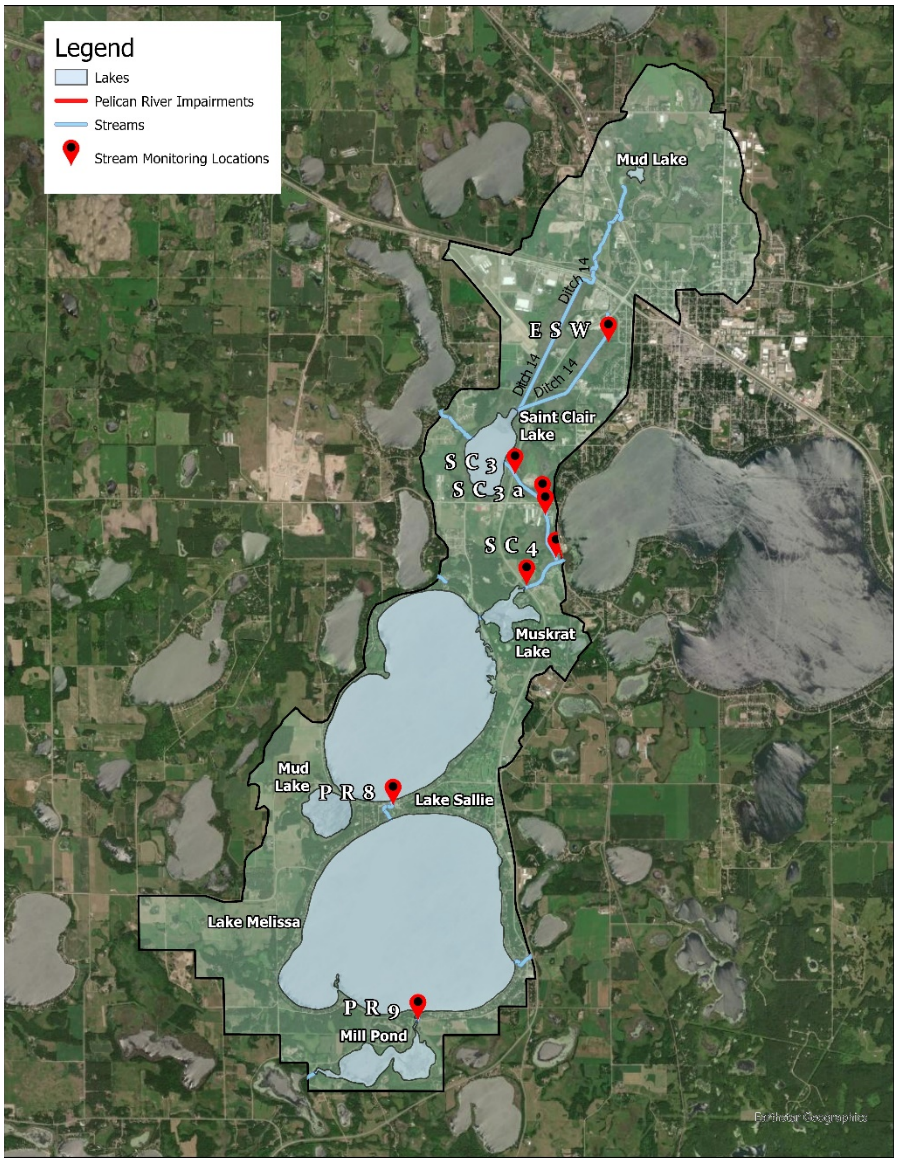


Figure 7.1. Sallie/Melissa Water Management Area.

7.1 Lakes

The Sallie/Melissa WMA has 6 lakes within its borders (Mill Pond, Lake Melissa, Mud Lake, Lake Sallie, Muskrat Lake, and St. Clair Lake), all of which are sampled in the 2020-2030 Monitoring Plan (Mud Lake is not sampled). In 2020, The District sampled St. Clair Lake, Lake Sallie, and Lake Melissa for water quality. Muskrat Lake had a shoreline survey. Lakes Sallie, Melissa, and Muskrat received chemical treatments for flowering rush and/or curly-leaf pondweed.

7.1.1 Lake St. Clair

Lake St. Clair originally was a 591-acre lake located west of the Detroit Lakes. In about 1915 the lake was drained to its present size of 140 acres because of the "awful stench" it presented to the local residents. This was caused by more than seventy years of untreated sewage from the City of Detroit lakes. A modern sewage treatment plant was constructed in 1976, which reduced phosphorus loadings to St. Clair by approximately 90%. The City continues to discharge treated effluent wastewater on the north side of the lake. Lake bottom sediments are up to 16 feet thick in portions of the lake and are attributed to the lake's history of receiving sewage prior to modern wastewater treatment.

Two ditches bring water to St. Clair, including much of the City of Detroit Lake's stormwater runoff. A natural outlet from Long Lake enters from the west, which contributes only minor amounts of water and nutrient load. St. Clair discharges to the southwest via Becker County Ditch 14 to the Pelican River, entering Muskrat and Sallie Lakes. Ditch 14 flows through a partially drained wetland which contributes additional phosphorus prior to outlet to the Pelican River.

The Pelican River Watershed District applied aluminum sulfate (ALUM) to Lake St. Clair in October 1998. This treatment was a phased approach intended to reduce the unacceptable phosphorus level in Lake Sallie. Following the ALUM treatment, in-lake phosphorus concentrations in St. Clair Lake were reduced by over 50% from 131ppb to 72ppb, with a similar reduction in orthophosphate. Phosphorus level began to trend upward beginning in the early 2010's showing that the ALUM treatments effectiveness had begun to wear and that another dose will be required to maintain a phosphorus concentration below 80 ppb.

In 2016, the MPCA accepted the St. Clair lake Total Maximum Daily Load (TMDL) study. The study showed that the lake is capable of a daily loading capacity of 2.75 lbs. of phosphorus a day. This equates to a 24% reduction of the current load. The TMDL report allowed for an increase in nutrient load for the City of Detroit Lakes Wastewater Treatment Facility by 95 lbs/yr, a 28% increase to allow for population growth and annexation within the city. To meet the reduction goal, the total reduction of phosphorus in non-point sources (stormwater runoff from within the City of Detroit Lakes) is 277 lbs/yr, a 49% decrease from the existing condition.

<u>Water Quality/Quantity</u>

Water Quality

Lake St. Clair experienced a dramatic improvement in water quality in 2020. Average TP (Figure 7.2), CHL-A (Figure 7.3), and secchi depths (Figure 7.4) of 57 ppb, 17.8 ppb, and 4.37' were improved from the historic averages of 96 ppb, 39 ppb, and 3.09'. More than half of the TP and CHL-A samples taken were below the MPCA impairment standards of 60 ppb and 20 ppb. Only 1 secchi depth was recorded below the MPCA impairment standard of 3.28' (3' on 8/6/20).

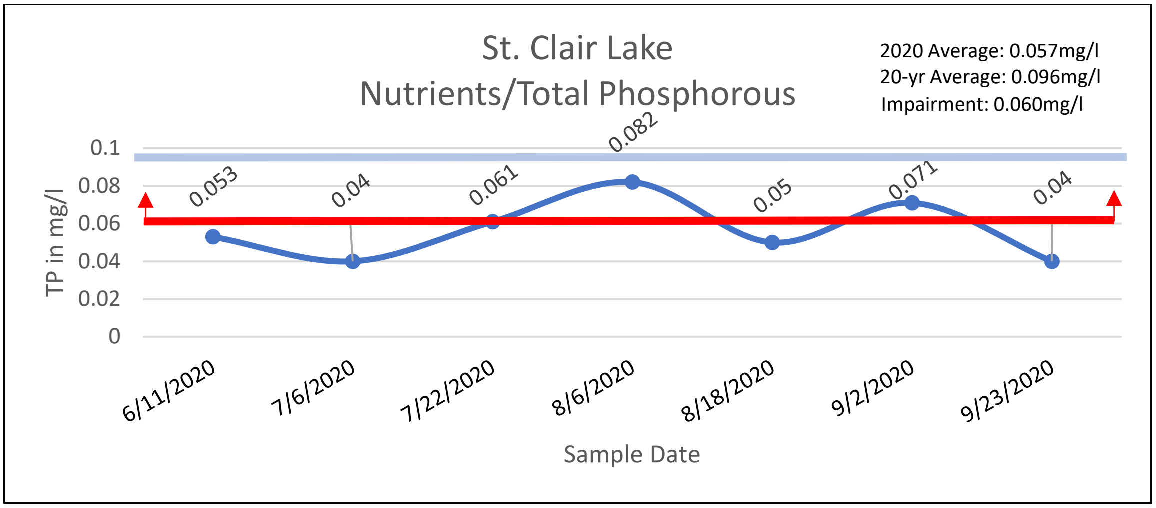


Figure 7.2. St. Clair Lake total phosphorous.

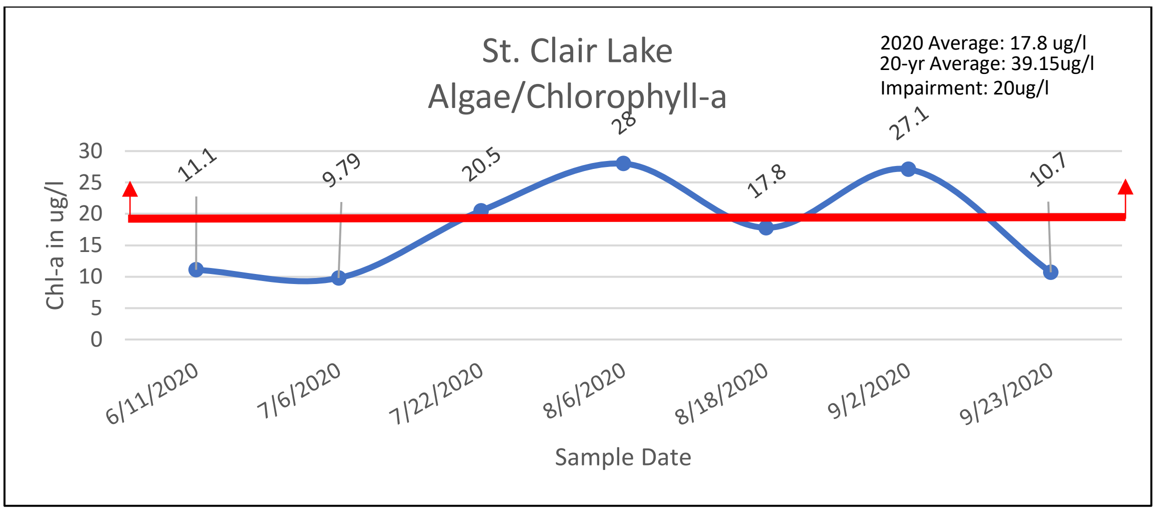


Figure 7.3. St. Clair Lake chlorophyll-a.

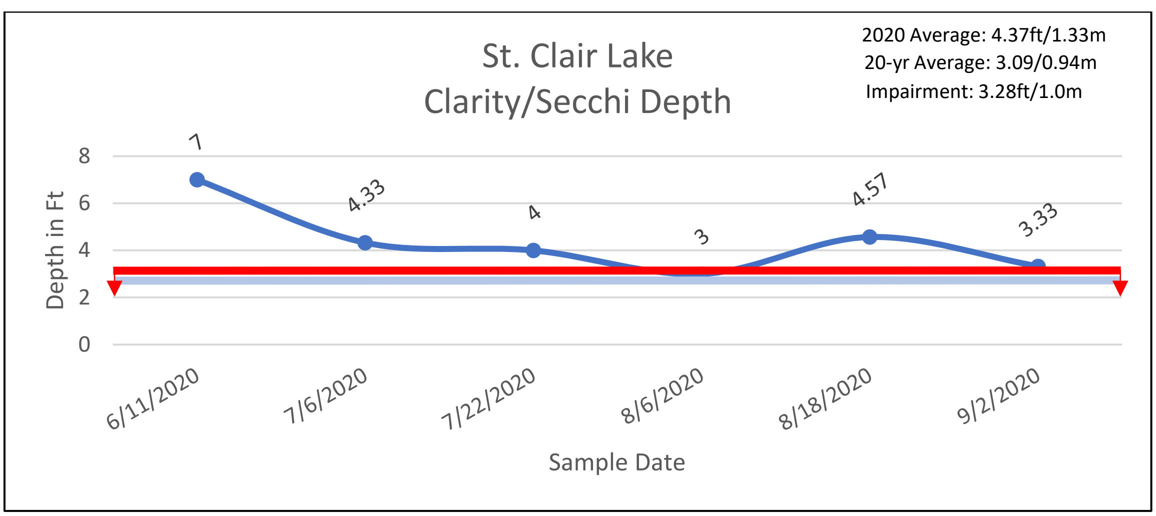


Figure 7.4. St. Clair Lake 2020 secchi depth.

The sudden improvement of water quality on Lake St. Clair is somewhat of a mystery to the District. While numerous stormwater management improvements have been made within the City of Detroit Lakes, as well as a new wastewater treatment plant (WWTP) which went online in 2019, there is no one event that seems to have triggered this improvement in water quality. The new WWTP discharges directly into Lake St. Claire whereas the old one used spray irrigation, rapid infiltration basins and holding ponds to treat the sewage effluent. More volume of water is being discharged directly into Lake St. Clair than under the previous system, possibly diluting concentrations of nutrients. The District will be consulting with MPCA and studying the cause of this decrease in water quality in the coming year.

Lake Levels
Lake St. Clair experienced high water levels in 2019 and 2020. Although the District does record water levels of Ditch 14 downstream of Lake St. Clair, no gage is available on the Lake. The District will install a gage in 2021 to track the rise and fall of lake levels. Multiple landowners around the basin reported the lake encroaching on their properties. The District inspected Ditch 14 and its culverts for blockages, removing several blockages on HWY 59, but finding no blockages in the ditch itself. After a period of time, water levels began slowly receding to a high but manageable level. Finally, after the severe rain events of the summer stopped, the water level began to recede in September.

7.1.2 Muskrat Lake
Muskrat is a small lake totaling 69 acres in surface area with 64 of those classified as littoral (<15 feet deep). The maximum depth of the lake is 18 feet. Muskrat lake is located within the Lake Sallie drainage area with the Pelican River flowing through it. Because the river is navigable from Detroit Lake, Muskrat has experienced more aggressive development than is typically observed on similar lakes. A tram was constructed to allow the movement of watercraft from Muskrat to Lake Sallie, which would otherwise not be possible due to a constructed rapid between the two lakes. The shallow lake is fertile with aquatic plants that grow to the surface in the deepest region of the lake.

A Concrete lock-and-dam system (Dunton Locks) was installed during the depression era by the Civilian Conservation Corps between Lake Sallie and Muskrat Lake to replace a historic lock-and-dam used to allow steamboat transport down the Pelican River. This structure was removed in 2001 and replaced with a constructed rock rapids outfall at the historic water outlet elevation and no longer allows for any water level manipulation. The primary goal of the barrier removal was to allow for fish passage from Sallie to Muskrat (and Detroit via the Pelican River). The rapid has become a valuable asset for the MN DNR, which has a fisheries facility located in the area. Annual walleye netting is conducted for egg takes, which are grown and released back into area lakes which are not capable of sustaining a high enough rate of natural reproduction. The passage has also aided in the muskellunge (*Esox masquinongy*) fishery by allowing the passage between the lakes.

Water quality in Muskrat Lake is variable and highly influenced by the nutrient load from discharge from Detroit Lake via the Pelican River and from St. Clair Lake via Ditch 14. The lake is classified as mesotrophic; however, it tends to exhibit some eutrophic tendencies (lake wide algal blooms and dense macrophyte growth) during warmer summer months. It should be noted, beginning the 2018 the City of Detroit Lake began to upgrade the WWTP which discharges wastewater effluent into St. Clair Lake. While the water will be low in nutrients, the volume will increase to about 1 million gallons per day, which was previously land applied during summer months. This may increase the nutrient load from the Ditch 14 wetlands.

Ecological Integrity

Shoreline Survey-23 Parcels

Muskrat Lake's shoreline is 30% natural, 10% minimally altered, 43% moderately altered, and 17% greatly altered. Since the last survey in 2017, there was a significant increase in the number of docks, while the number of boat lifts, motorized, and non-motorized boats decreased (Figure 7.5). The number of waterfront structures remained constant between the surveys (2 sheds in both surveys), but the 2020 survey saw a decrease in decks, from 3 in 2017, to 0 in 2020.

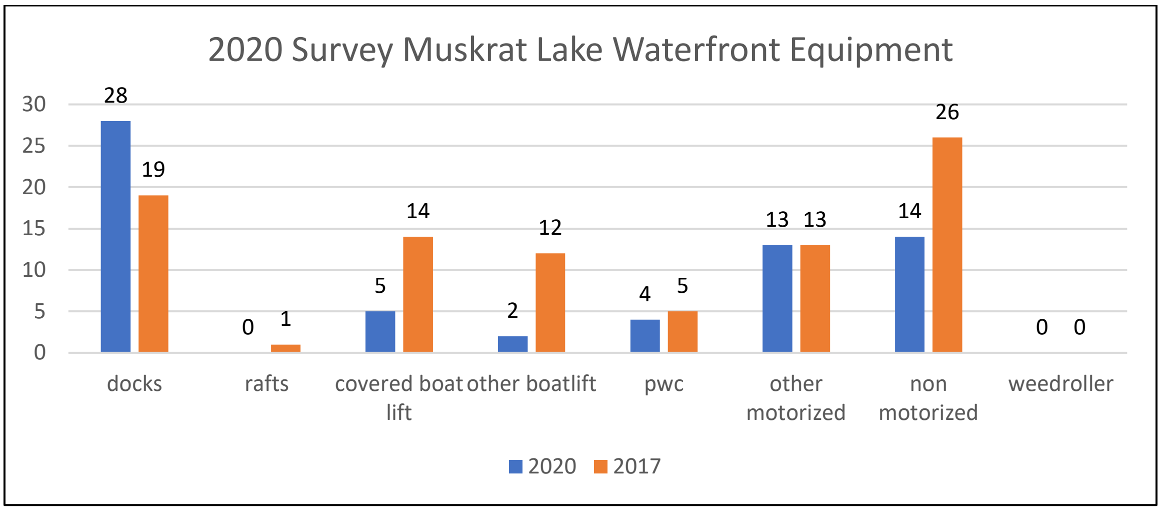


Figure 7.5. Waterfront equipment on Muskrat Lake.

Aquatic Invasive Species Control

The District treated a total of 2.4 acres of curly-leaf pondweed on Muskrat Lake in 2020 (Figure 7.6). A mixture of Endothall and Diquat were used to treat this bed. Unfortunately, the treatment was not effective, and the bed persisted after the treatment. Since Muskrat Lake is a small reservoir, water flow through the system is faster than other lakes, limiting the chemical's contact time. The District has tried treating AIS in Muskrat Lake several times with little success. The District needs to explore new methods to increase chemical contact time in this system.

There are a few patches of flowering rush around the edges of the lake the District has not been able to treat due to the flowing water issue. If a new treatment method is found, the District will treat the flowering rush as well.

Figure 7.6. Curly-leaf pondweed treatment on Muskrat Lake in 2020.

7.1.3 Lake Sallie

Lake Sallie is a 1,273-acre polymictic lake which reaches a maximum depth of 50 feet, with 45% of its surface area is considered littoral. Lake Sallie is classified as a borderline eutrophic lake, vulnerable to nutrient impairment. The Pelican River passes through the lake, entering from Muskrat to the North, exiting to Melissa on the south.

Historically, Lake Sallie has had poor water quality, partly due to the City of Detroit Lakes use of upstream St. Clair Lake as a discharge point for wastewater. Prior to the construction of the original WWTP in 1929, untreated wastewater was discharged into Lake St. Clair, which resulted in phosphorus levels in Lake Sallie approximately 54 ppb, nearly 3 times that of similar lakes. In 1979, the WWTP was upgraded. Sallie responded with a decline in phosphorus levels ranging from 46 ppb to 48 ppb. The current facility, upgraded in 2002, further reduced load to Lake Sallie, resulting in the current mean summer levels between 35 ppb and 37 ppb.

While it has greatly improved since the 1970's, moderate to severe algal blooms are common, often continuous in July and August. These appear to be brought on in part by internal nutrient recycling, whereby nutrient rich water from the bottom layers is brought to the oxygen rich upper layers during lake mixing periods, often triggered by storm events and high winds.

Much of the nutrient load comes from upstream sources, specifically from nutrient rich water from partially drained Lake St. Clair via Becker County Ditch 14. An alum treatment in Lake St. Clair conducted in 1998 reduced internal loading to the lake, and in effect, reduced nutrient loading to the downstream Muskrat and Sallie Lakes. Stormwater Best Management Practices in the City of Detroit Lake has also aided in Lake Sallie improvements by reducing stormwater runoff loads to Little Detroit Lake, which outlets to Sallie.

In the fall of 2016, zebra mussels were located at the public access of the lake. The District continues to monitor how the infestation impacts water quality. Water clarity has increased to a summer average of 13'-14' (compared to the previous 10-year average of 7 ft.).

A Concrete lock-and-dam system (Dunton Locks) was installed during the depression era by the Civilian Conservation Corps between Lake Sallie and Muskrat Lake to replace a historic lock-and-dam used to allow steamboat transport down the Pelican River. This structure was removed in 2001 and replaced with a rock rapids at the historic water outlet elevation and no longer allows for any water level manipulation. The primary goal of the barrier removal was to allow for fish passage from Sallie to Muskrat (and Detroit via the Pelican River). The rapid has become a valuable asset for the MN DNR, which has a fisheries facility located in the area. Annual walleye netting is conducted for egg harvesting. The harvested eggs are grown and released back into area lakes to increase the rate of walleye recruitment. The passage has also improved the muskellunge fishery by allowing passage between the lakes.

The Pelican River flows out to Lake Melissa through a culvert under Becker CSAH 22 approximately 200' downstream of Lake Sallie. The velocity of flow between the outlet of Sallie and the culvert suggests that the elevation of the culvert may be slightly lower than the true water level in the Lake. There is also a slight hydraulic restriction that appears to control lake level.

Water Quality/Quantity

Lake Sallie experienced improved water quality in 2020 compared to historic averages. The annual average TP (Figure 7.7), CHL-A (Figure 7.8) and secchi depth (Figure) of 25 ppb, 4.58 ppb, and 14.52' were drastic improvements from the historic averages of 32 ppb, 12.89 ppb, and 8.72'. These improved readings are likely due to multiple factors including improvement of upstream phosphorous sources (impervious surfaces in the City of Detroit Lakes, St. Clair loading, Detroit Lake water quality improvement etc.), shoreline restorations and stabilizations, outflow of in lake nutrients over the years, and zebra mussels. The District has performed extensive work in the area upstream of Lake Sallie to reduce the nutrient load reaching the lake. Multiple projects reducing the phosphorus loading to Lake St. Clair has directly affected the phosphorus loading to Lake Sallie. As the load has been reduced entering the lake, the lake has had the opportunity to flush nutrients out downstream. The effects of zebra mussels also cannot be negated as seen in the increase in secchi depth and decreasing CHL-A. Even the worst readings for both did not reach the 20-year average.

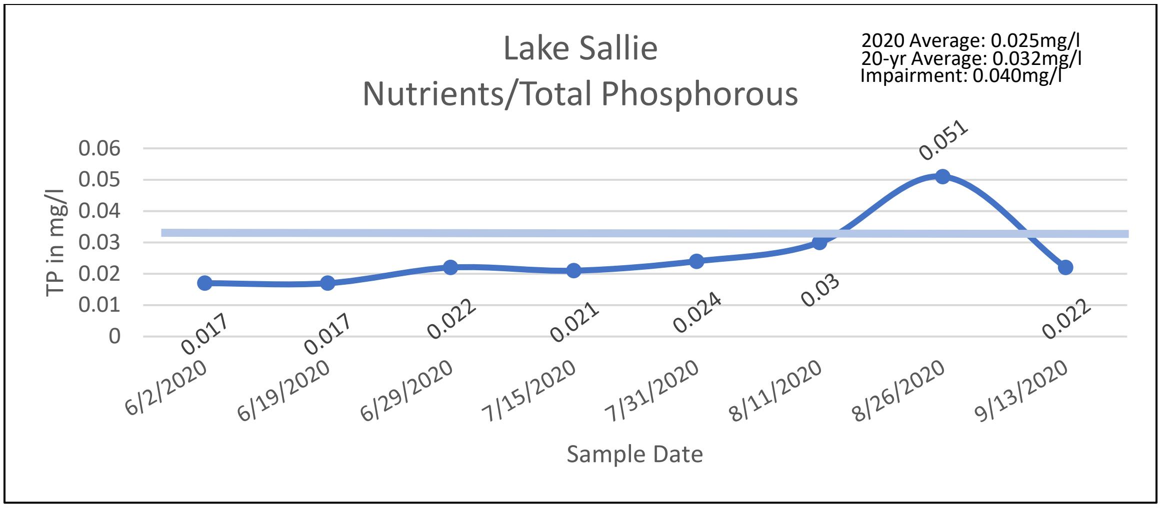


Figure 7.7. Lake Sallie 2020 total phosphorous.

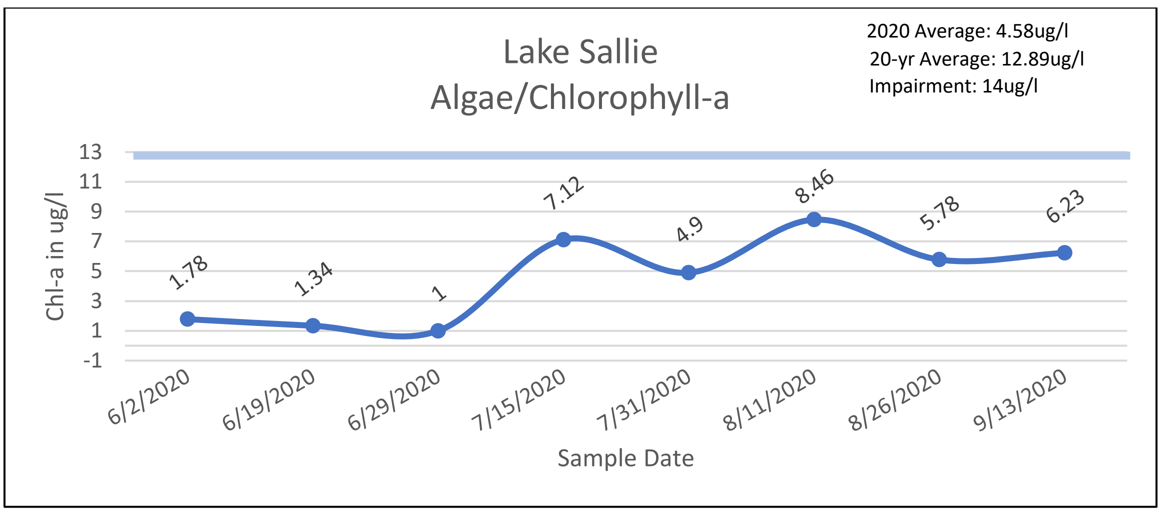


Figure 7.8. Lake Sallie 2020 chlorophyll-a.

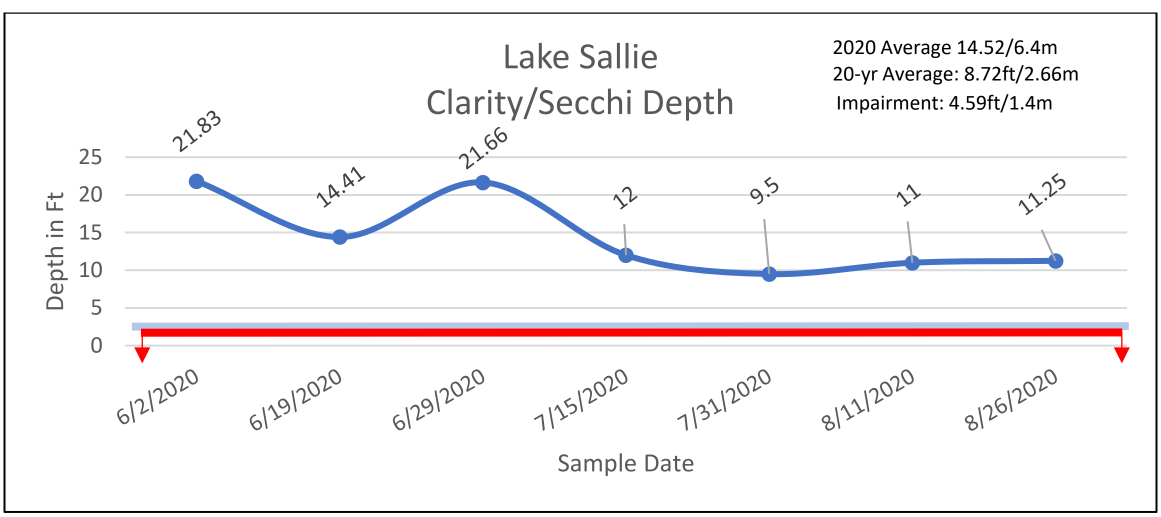


Figure 7.9. Lake Sallie 2020 secchi depth.

Water levels on Lake Sallie are recorded at the outlet, at County HWY 22. Water Levels in 2020 were similar to previous years (Figure 7.10), falling below the OHW for the majority of the year (Figure 7.11). Water levels fluctuated between the low 1329.7' MSL on 6/15/20 to high of 1330.09' MSL on 7/27/20.

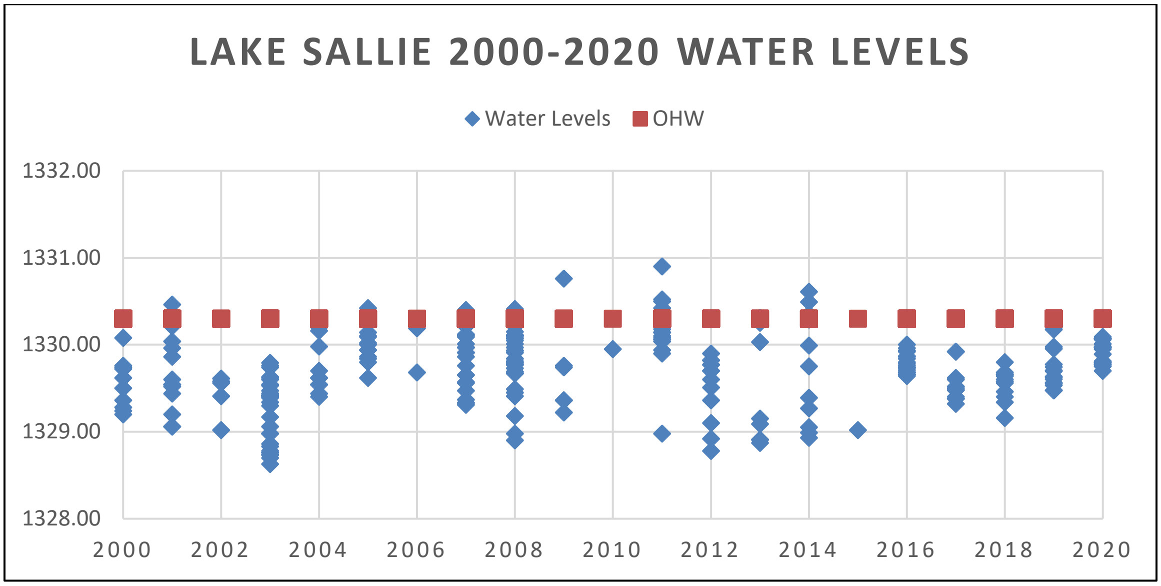


Figure 7.10. Lake Sallie water levels from 2000-2020.

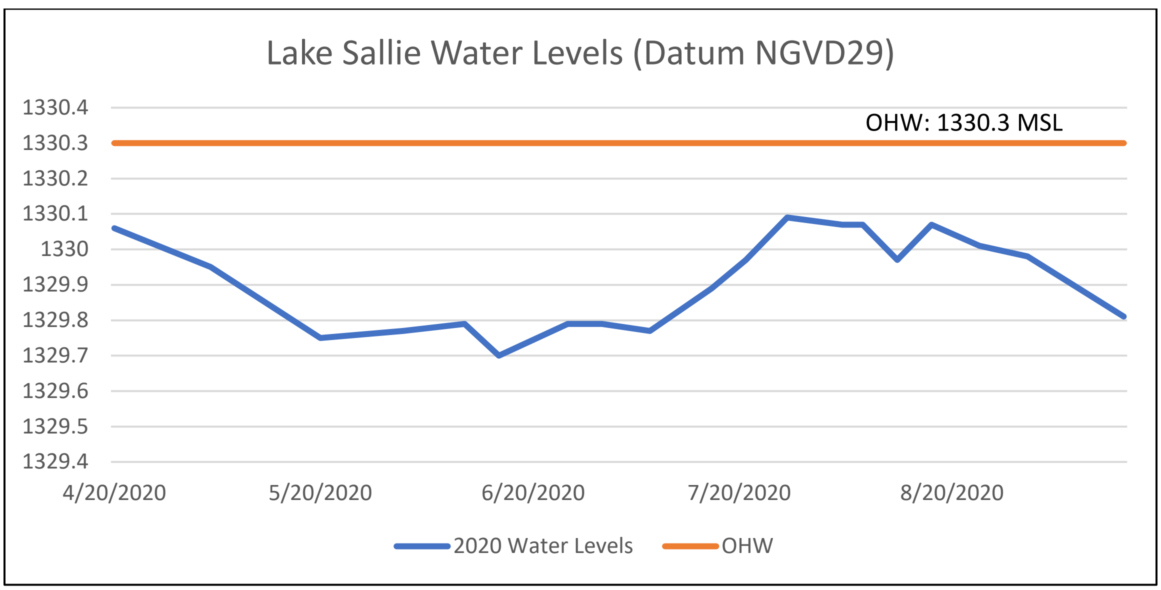


Figure 7.11. Lake Sallie water levels in 2020.

<u>Ecological Integrity</u>

Aquatic Invasive Species Control

The District performed reduced chemical treatments of flowering rush, and no treatments of curly leaf pondweed on Lake Sallie in 2020 (Figure 7.12). For the 33-acre bed on the East shore of Lake Sallie, 2 treatments with Diquat were performed (July 7th and August 11th). This stand is intermixed with hardstem bullrush, making it difficult to access. There is also a flowing water problem associated with where the Pelican River drains into Lake Sallie. The next step to effectively control this patch is to control the flow of water and increase contact time between the chemical and the plant. The District will begin investigating methods to achieve this in 2021. Possible methods include using a silt curtain or a “bubble curtain”, a device that inhibit water flow by producing a wall of air bubbles from the bottom to the surface.

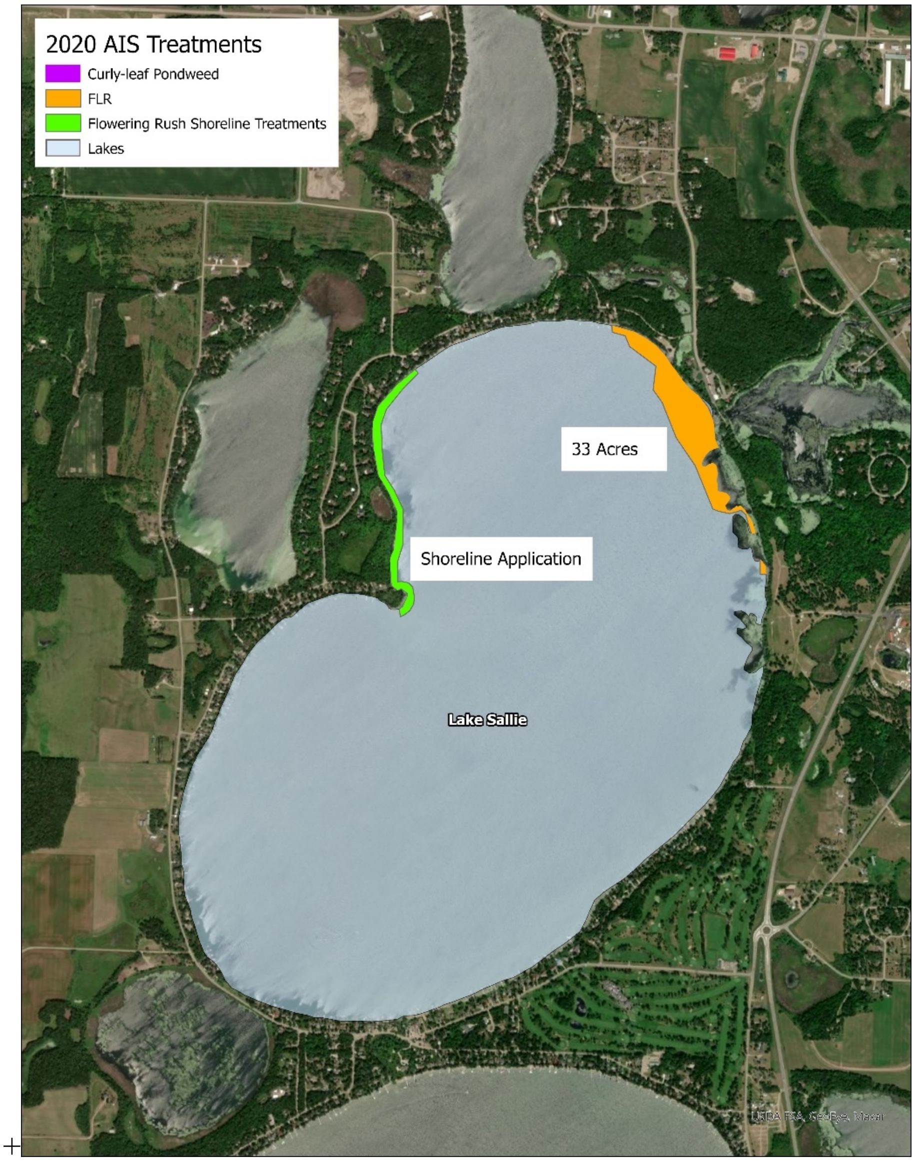


Figure 7.12. Aquatic invasive species treatments on Lake Sallie in 2020.

7.1.4 Lake Melissa

Lake Melissa is the second largest lake within the Pelican River Watershed District. It totals 1,850 acres and reaches a maximum depth of 37 feet, with about half of its surface area is littoral. Lake Melissa is classified as a mesotrophic lake with good water quality. The Pelican River passes through the lake, entering on the north end from Lake Sallie, with an outlet on the south end to Mill Pond. Late summer algal blooms have been observed, typically caused by nutrient movement from the borderline eutrophic Lake Sallie through the Pelican River.

The invasive zebra mussel was observed in Lake Melissa in 2014. Since then, there has been a significant increase in water clarity. Prior to the infestation, mean summer clarity ranged from 8 to 12 feet (9.5 feet average). Subsequent years after the infestation, clarity increased to 12.5 (2015), 14.5 (2016), and 16.5 (2017). There has also been a significant reduction in chlorophyll level, indicating a shift from free floating to benthic (bottom dwelling) algae, which is common with infested lakes.

Lake Melissa is also known to be infested with the invasive aquatic plant Flowering Rush and Curly-leaf Pondweed. The District actively surveys and chemically treats nuisance population annually to manage the plant density and minimize recreational and environment impacts.

The shoreline on Lake Melissa has been experiencing intense development in recent years to what was already a highly developed lake shore. There has also been a conversion from small, seasonal cottages, to larger, year-round homes. Residential lots are relatively small, which also contributes to the dense development and shoreline modifications.

There are several water control structures in the Lake Melissa vicinity. The remnant of a lock and dam system is located approximately 100 feet upstream of Lake Melissa. This lock is no longer active and there are no water level manipulation abilities with the remnant structure, which does not inhibit fish passage. There is a bridge located at the outlet of lake Melissa that forms a slight hydraulic constriction. There are no other dam components, such as piers, stops, or concrete crest present. Approximately 300 feet downstream of the outlet is a large culvert below South Melissa Drive. There is a noticeable difference between the headwater and tailwater elevations at the culvert. Also, the velocity of flow in the channel from the lake to the culvert suggests that the headwater elevation at the culvert is slightly lower than the actual elevation of Lake Melissa.

Bucks Mill Dam is approximately 1.35 miles downstream of lake Melissa. Historically, a water wheel was utilized at the original dam for Buck's Mill, which is no longer present. At a later date, a second dam was constructed approximately 100 feet upstream of the original. The new dam is used to adjust water level in Mill Pond and provide water to a downstream MN DNR Fisheries rearing pond. Due to the difference in water lever, this dam has virtually no impact on Lake Melissa water levels.

<u>Water Quality/Quantity</u>

Water Quality

Lake Melissa experienced average water quality in 2020. The average TP (Figure 7.13) and secchi depths (Figure 7.15) of 20 ppb and 12.67' were similar to historic averages of 20 ppb and 11.25'. The average CHL-A (Figure 7.14) of 4.35 ppb was decreased from the historic average of 7.17 ppb. The effects of zebra mussels have been less pronounced on Lake Melissa. Other lakes have experienced a dramatic increase in secchi depth and decrease in CHL-A. While a decrease in CHL-A has been observed, samples still peaked above the average on 8/11/20 (8.46 ppb). Both TP and secchi depth remained average throughout the season. Overall, water quality is good with little changes from previous years.

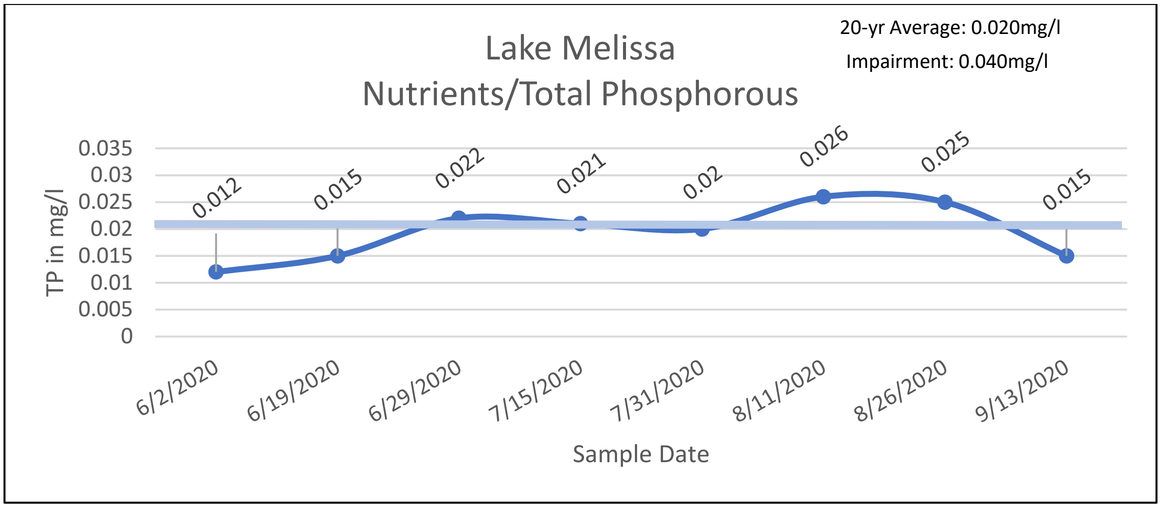


Figure 7.13. Lake Melissa 2020 total phosphorous.

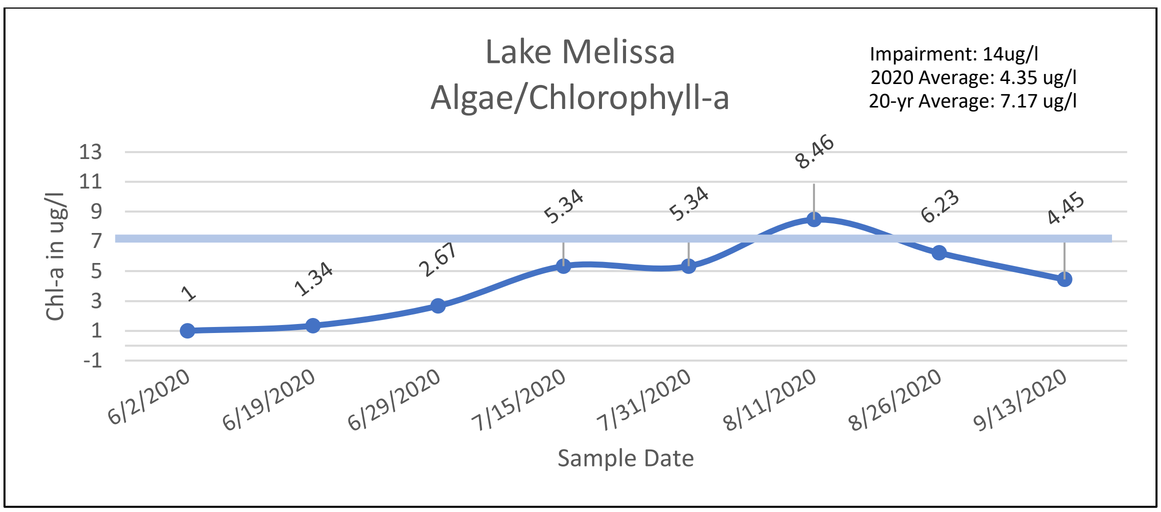


Figure 7.14. Lake Melissa 2020 chlorophyll-a.

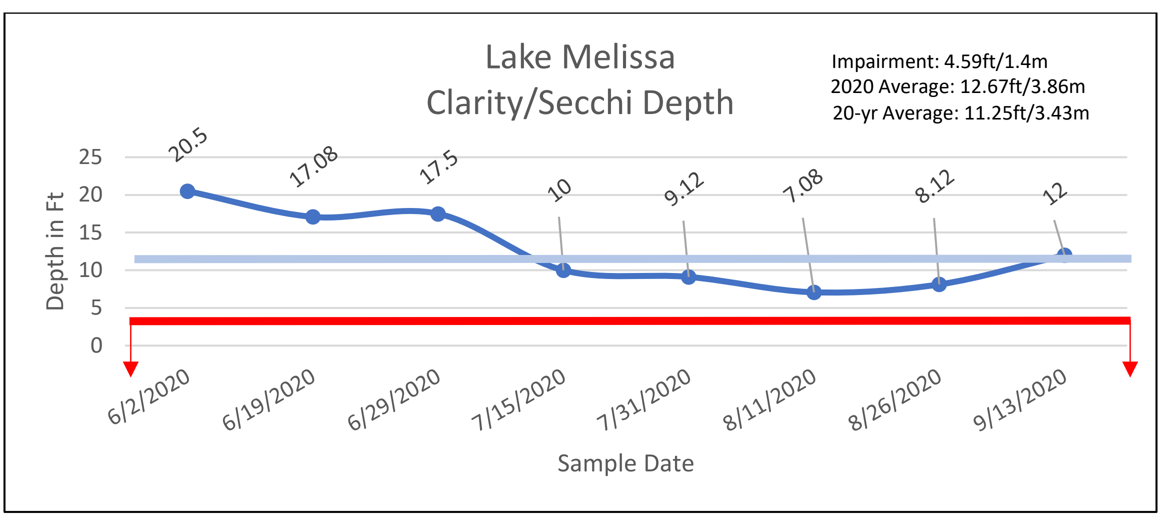


Figure 7.15. Lake Melissa 2020 secchi depth.

Lake Levels

Water Levels on Lake Melissa in 2020 were similar to average, staying slightly above and below OHW for the season (Figure 7.16). Water levels fluctuated between 1328.58' MSL and 1328.8' MSL throughout the season (Figure 7.17).

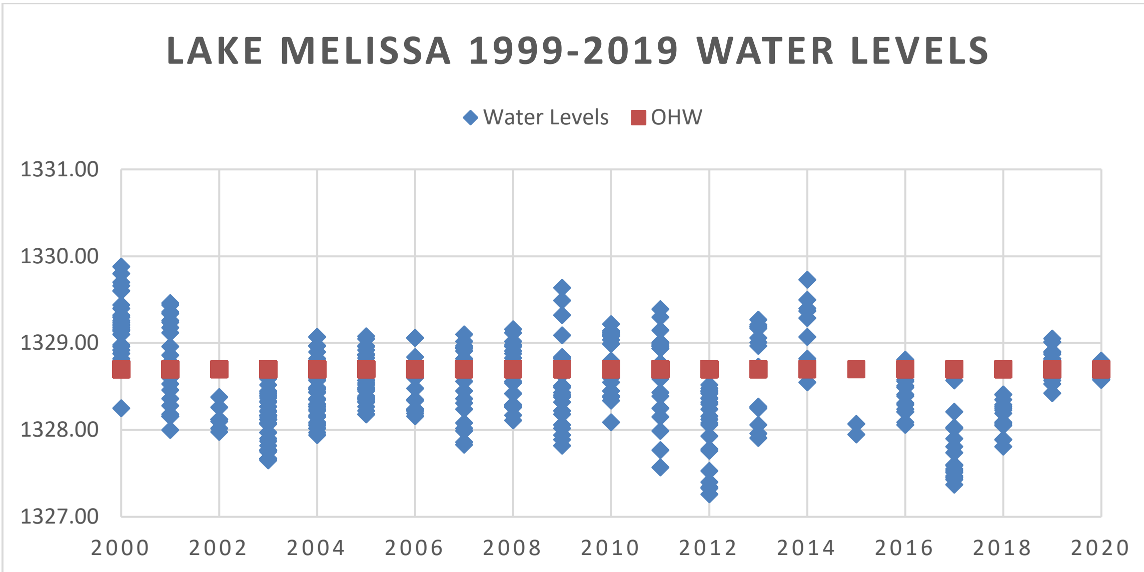


Figure 7.16. Water levels on Lake Melissa from 2000-2020.

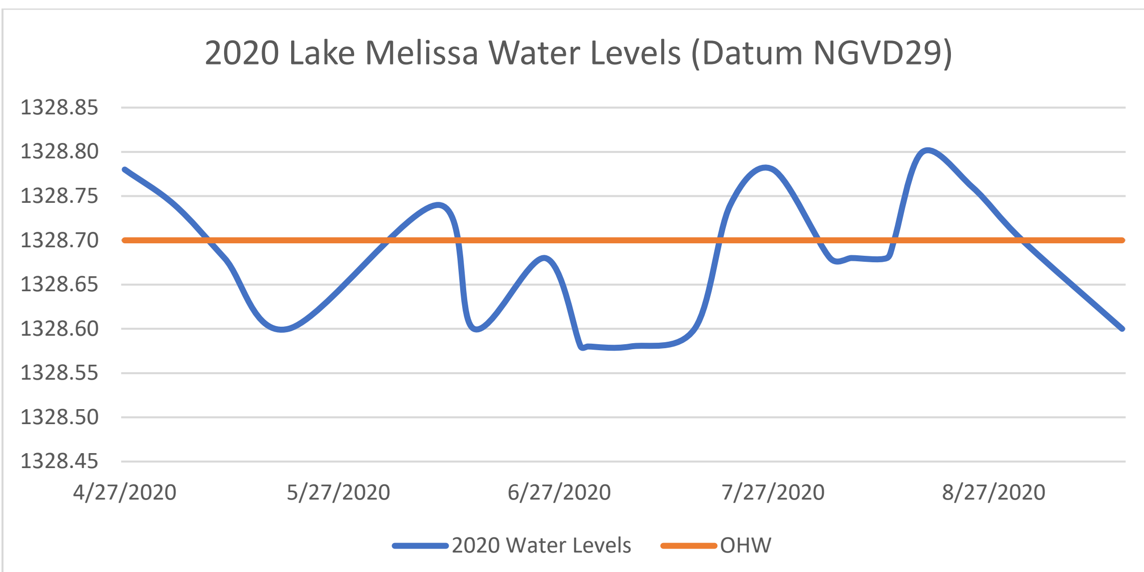


Figure 7.17. Water levels on Lake Melissa in 2020.

Ecological Integrity

Aquatic Invasive Species Control

No submerged chemical treatments were required in 2020. The only treatments the District performed were foliar applications along the shoreline of the lake (Figure 7.18). The District could not find any submerged beds with enough density to justify treatments. The District will continue to assess the lake for flowering rush and curly leaf pondweed in 2021.

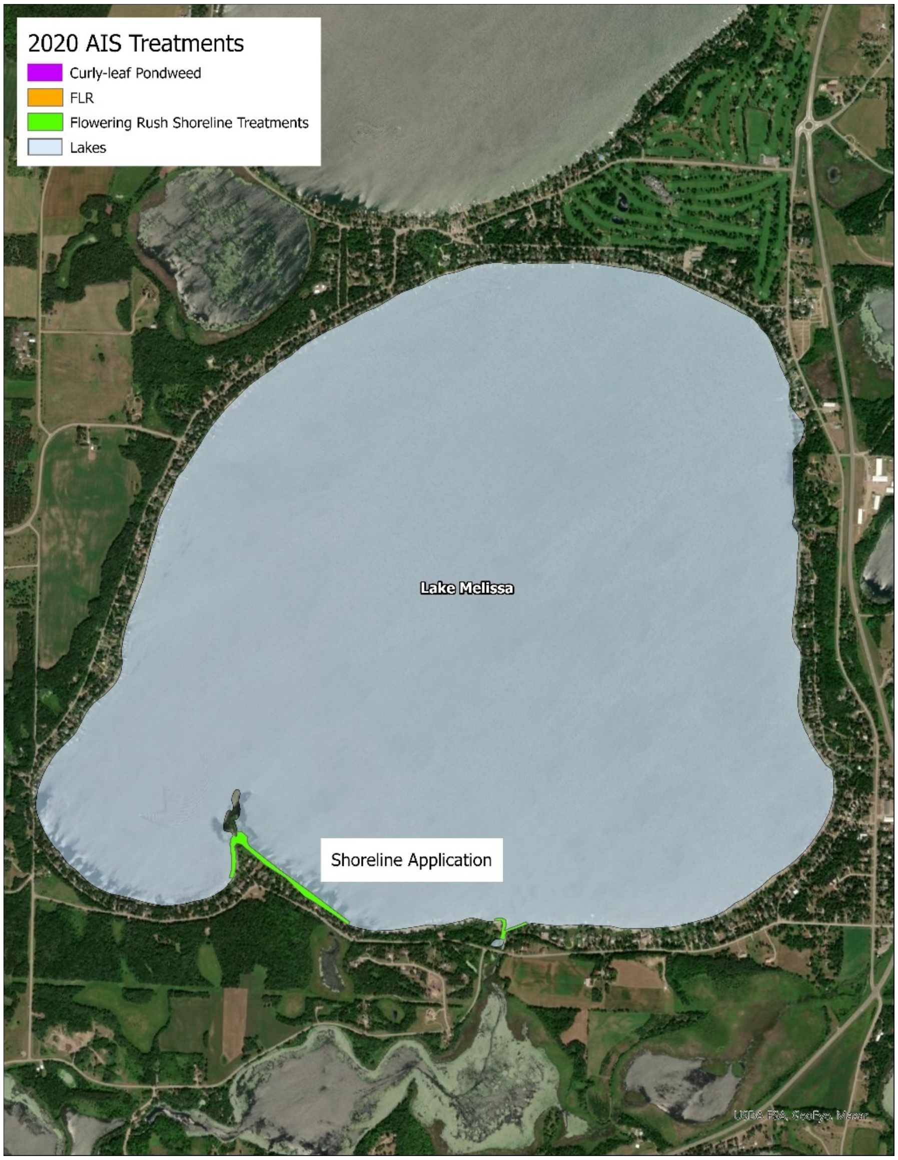


Figure 7.18. Aquatic invasive species treatments on Lake Melissa in 2020.

Zooplankton Survey- Lakes Sallie and Melissa
District Staff have been involved in a cooperative project with the MN DNR and Concordia College in Moorhead to examine the effect of zebra mussels on the microscopic communities of zooplankton which form the base of the food web. Zebra mussels filter large amounts of water and strip the water column of resources. Through this study, District Staff collect monthly zooplankton samples and preserve them for later analysis. Analysis of these samples requires specialized identification knowledge. Staff from MN DNR and Concordia College will analyze the samples and report to the District once multiple years of population data has been collected. This project is on-going.

7.2 Streams

The District monitors 8 locations along the streams and ditches in the Sallie/Melissa WMA. Half of these sites are along Ditch 14 and the other half on the Pelican River. Ditch 14 carries heavy phosphorous loads from Lake St. Clair into the Pelican River, which passes the phosphorous onto Lake Sallie. The location at the outlet of Detroit Lake (PR6) sets the tone for water quality in the WMA. Water quality here is similar to that of Detroit Lake, generally giving the same readings. The same can be said for the sites at the outlet of Lake Sallie (PR8) and Lake Melissa (PR9). Total suspended solids are not measured in the WMA due to insignificant readings (water flow is not enough to cause shoreline erosion or carry sediments in the water column). Recent chloride samples suggest a possible impairment in Ditch 14. Only a few samples were taken due to equipment failure. High specific conductance throughout the season suggests the problem prevailed throughout the season. The District will assess the chlorides in the system in 2021 using a new sonde.

7.2.1 Ditch 14

Water Quality/Quantity

Ditch 14 receives the heavy phosphorous loads from Lake St. Clair and the wetlands between St. Clair and the Pelican River. Phosphorous concentrations in Ditch 14 from the outlet of St. Clair increase by 70% by the time it reaches the Pelican River (Figure 7.19). Concentrations of OP also increases as it flows through these wetlands, by almost 40%. Specific conductance, a surrogate for chlorides, remains high throughout the ditch (most lakes are around 400 micro-siemens, Ditch 14 runs about 850 micro-siemens), possibly caused by residential water softeners, road salt, and fertilizer runoff.

The District took minimal samples from the Fairgrounds Stormwater Basin, the stormwater basin built by the City of Detroit Lakes to treat the effluent from the Municipal Separate Storm Sewer System (MS4). This basin treats about half of the City of Detroit Lake's stormwater runoff before discharging into the Ditch 14 wetlands North of St. Clair. Concentrations of TP and OP out of this basin were quite high, averaging 154 ppb and 42 ppb respectively (n=4). Specific conductance was also high, averaging 1201 micro-siemens. A low number of samples were taken, possibly skewing results, but all readings were high. The District will take more samples in 2021 to re-assess this issue.

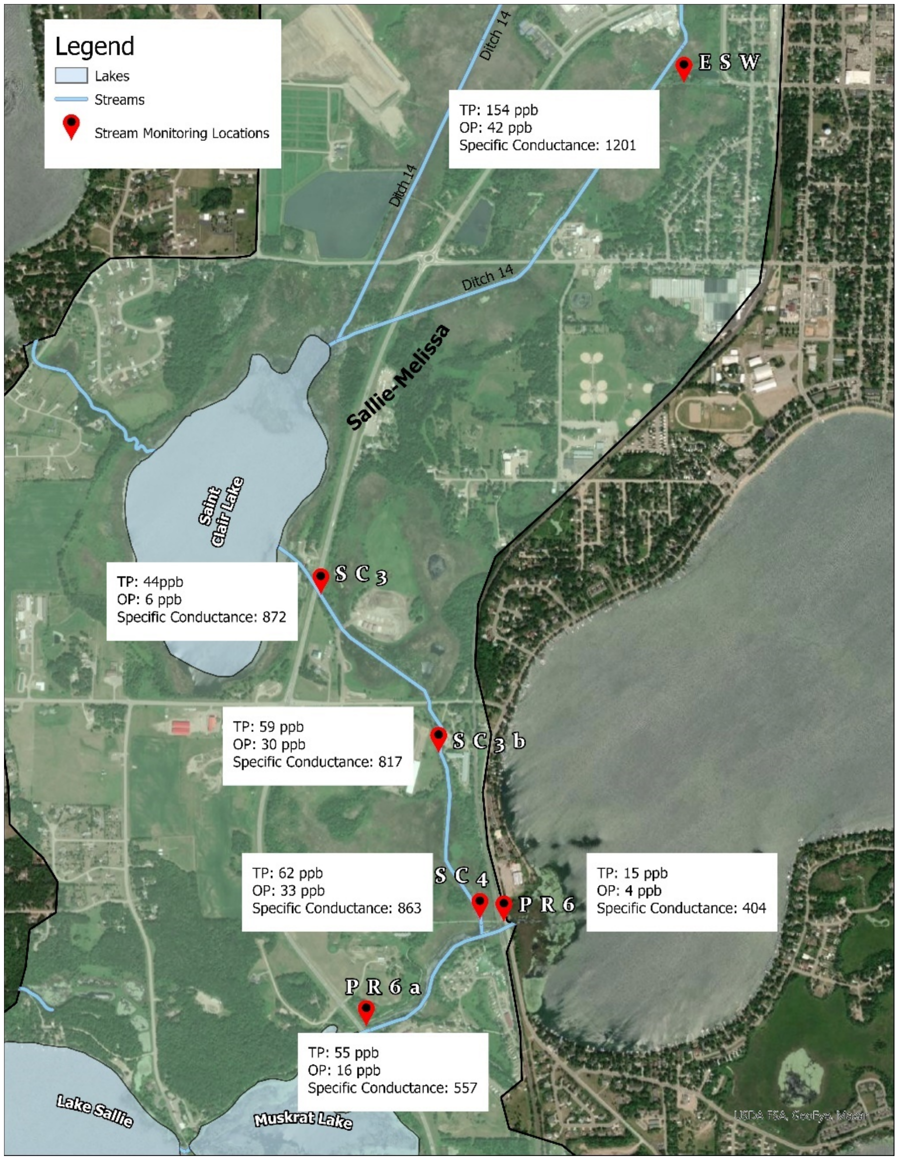


Figure 7.19. Nutrient concentrations on Ditch 14 in 2020.

8 Brandy Water Management Area

The Brandy WMA contains about 3,000 acres (Figure 8.1). Four named lakes exist within this area; Brandy, Wine, Oak and Oar, however several small unnamed lakes and wetlands also dot the WMA. Brandy Lake is the largest lake, at 323 acres. The other lakes are smaller and have small watersheds. Land in the Brandy WMA is mostly used for cultivated crops or pasture, and shoreline along the lakes is mostly undeveloped. This is partly because the shallow nature of these lakes makes them ill-suited for recreation. Approximately 10 percent of the WMA is owned by the U.S. Fish and Wildlife Service. Brandy Lake historically suffered from poor water quality from the former Becker County Landfill but has improved through remediation. Wine Lake is impaired due to excess nutrients, and the District will work with MPCA to develop a TMDL. Oak lake was sampled in 2020 for water quality.

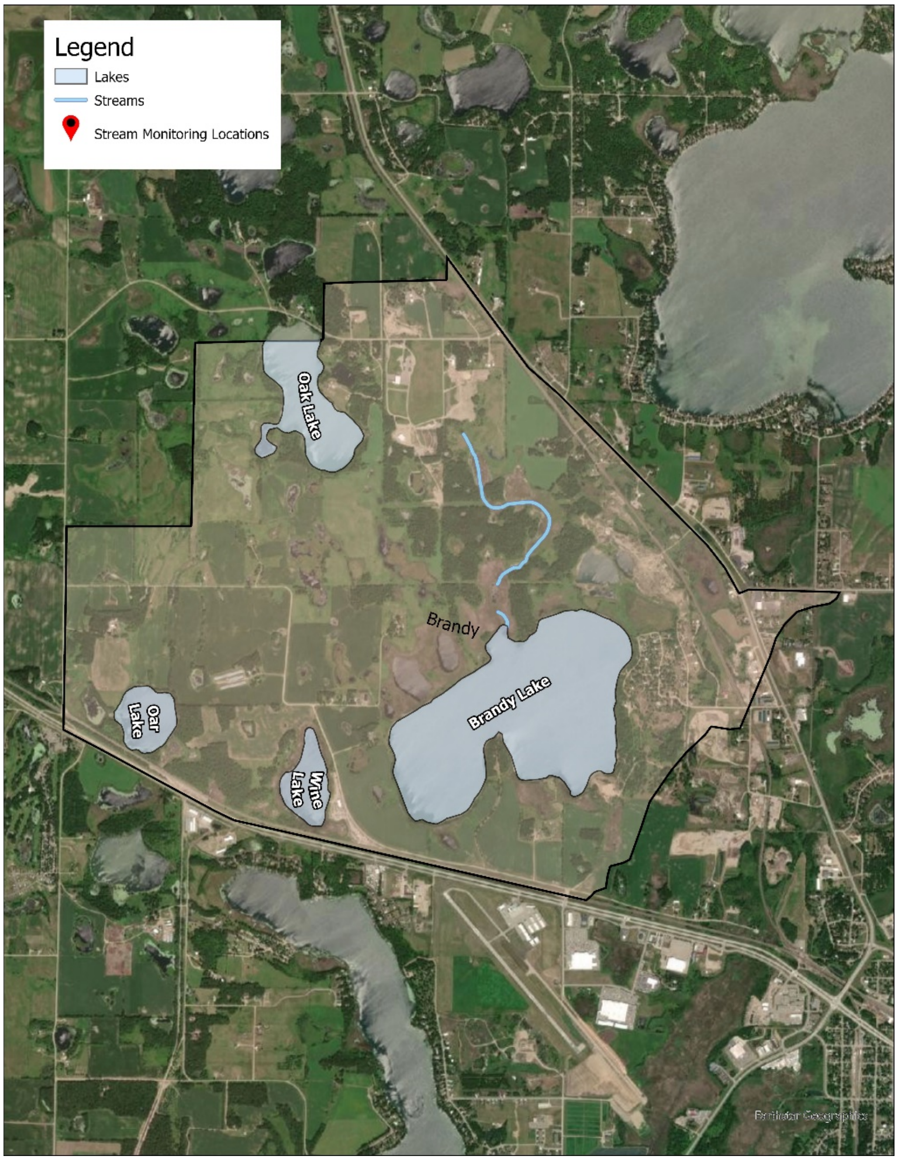


Figure 8.1. The Brandy Water Management Area.

8.1 Lakes

There are 4 lakes in the Brandy WMA, 3 of which are assessed by the District. Brandy Lake is improving from historical pollution from the Becker County Landfill, Wine Lake was found to be impaired from eutrophication and is being assessed for a TMDL, and Oak Lake was sampled for the first time in 2020.

8.1.1 Oak Lake

Oak Lake is an 86-acre, natural environment lake with a maximum depth of 16ft (Figure 8.1). The lake is boarded by United States Fish and Wildlife Service property on the Northwest and Southeast sides of the lake, with some private land ownership. Little is known about Oak lake other than a vegetation survey performed by the MN DNR in 2018. The survey found plants only in area less than 8ft deep, indicating poor water clarity. A nearby landowner indicated water levels had increased in last 50 years, and livestock were previously kept in an area currently flooded, possibly causing internal loading.

Water Quality

Oak lake is a borderline eutrophic/hypertrophic lake. CHL-A readings averaged above impairment, with 5 of the 8 samples taken above impairment (Figure 8.2). Total phosphorous (Figure 8.3) and secchi depth (Figure 8.4) averages were below impairment, but multiple samples were above impairment. This was the first year of sampling water quality in Oak Lake, so more data will be required to accurately assess the health of the lake.

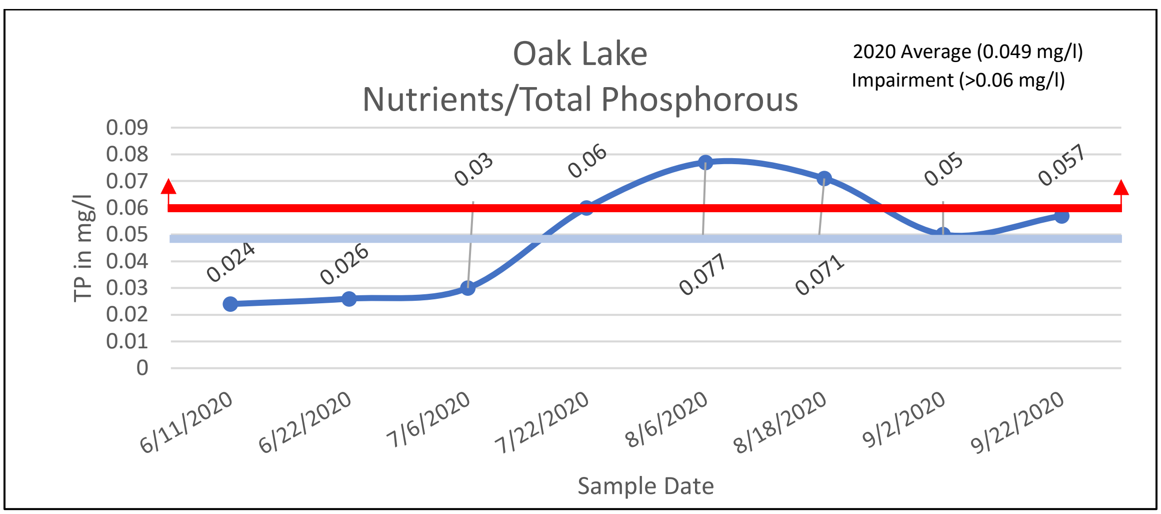


Figure 8.2. Oak Lake 2020 total phosphorous.

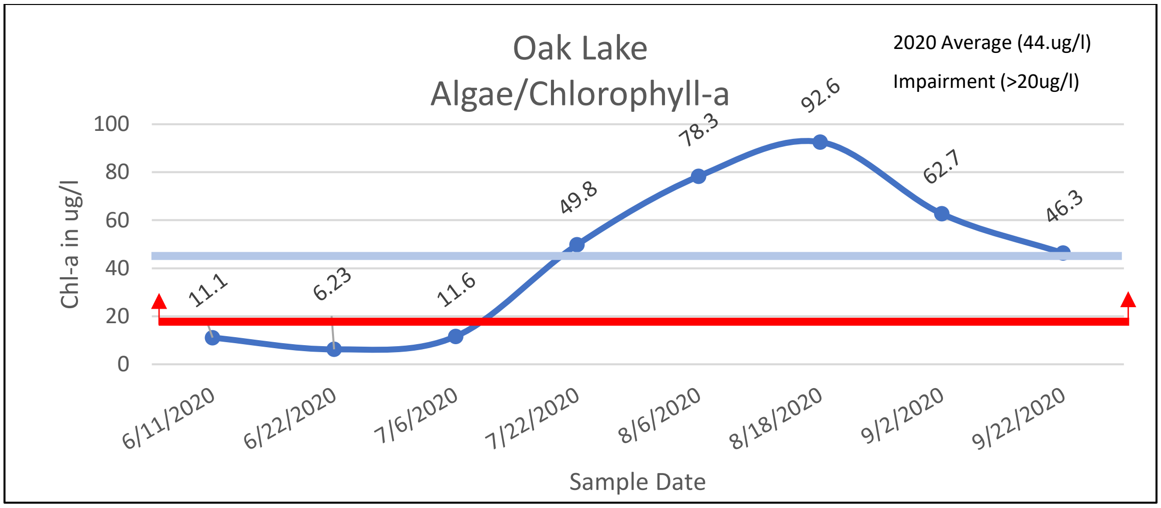


Figure 8.3. Oak Lake 2020 chlorophyll-a.

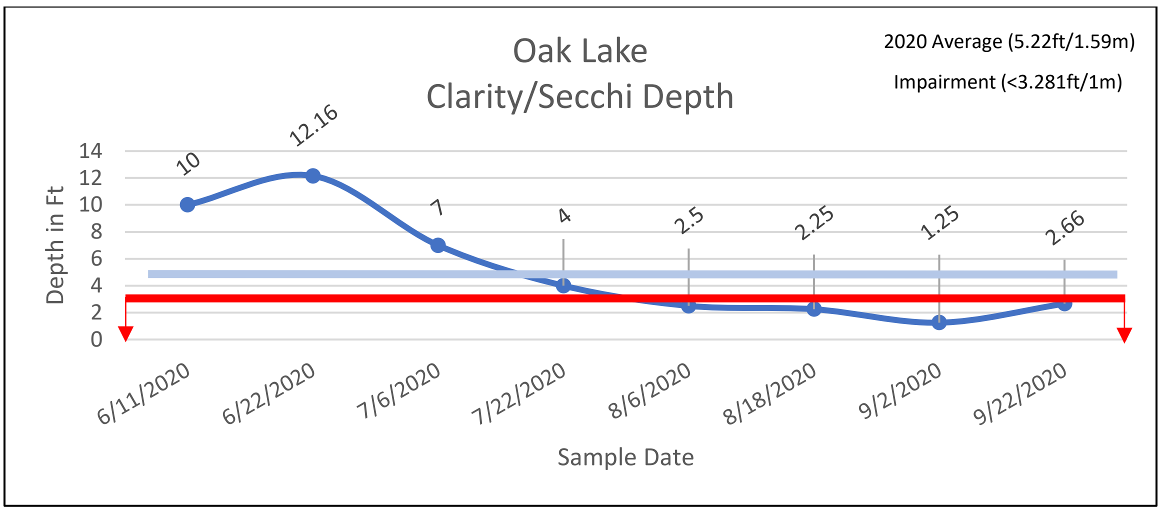


Figure 8.4. Oak Lake 2020 secchi depth.

9 Pearl/Loon Water Management Area

The Pearl/Loon WMA is about 5,400 acres on the Western edge of the District (Figure 9.1). All these lakes are relatively small and shallow waterbodies in the western edge of the District, and all depend primarily upon groundwater. Most land in this WMA is used for agricultural purposes. Water quality data has only been collected for Pearl and Loon Lakes. The District began to collect water quality data on Pearl Lake in 1998. Pearl exhibits relatively clear conditions, but phosphorus and chlorophyll-a levels are much higher than would be expected, given the lake's clarity. An MPCA Clean Water Partnership diagnostic study was completed on Pearl Lake in 2012 which noted large annual fluctuations in water quality and water level, concluding the primary sources of nutrients is lake sediments, agricultural runoff, and shoreline alteration. Curly-leaf pondweed has also spread throughout Pearl Lake since 2010 when it was discovered. Loon Lake was sampled 2006 to 2008 and demonstrated good water quality for a shallow lake. No data has been collected on any of the other smaller lakes.

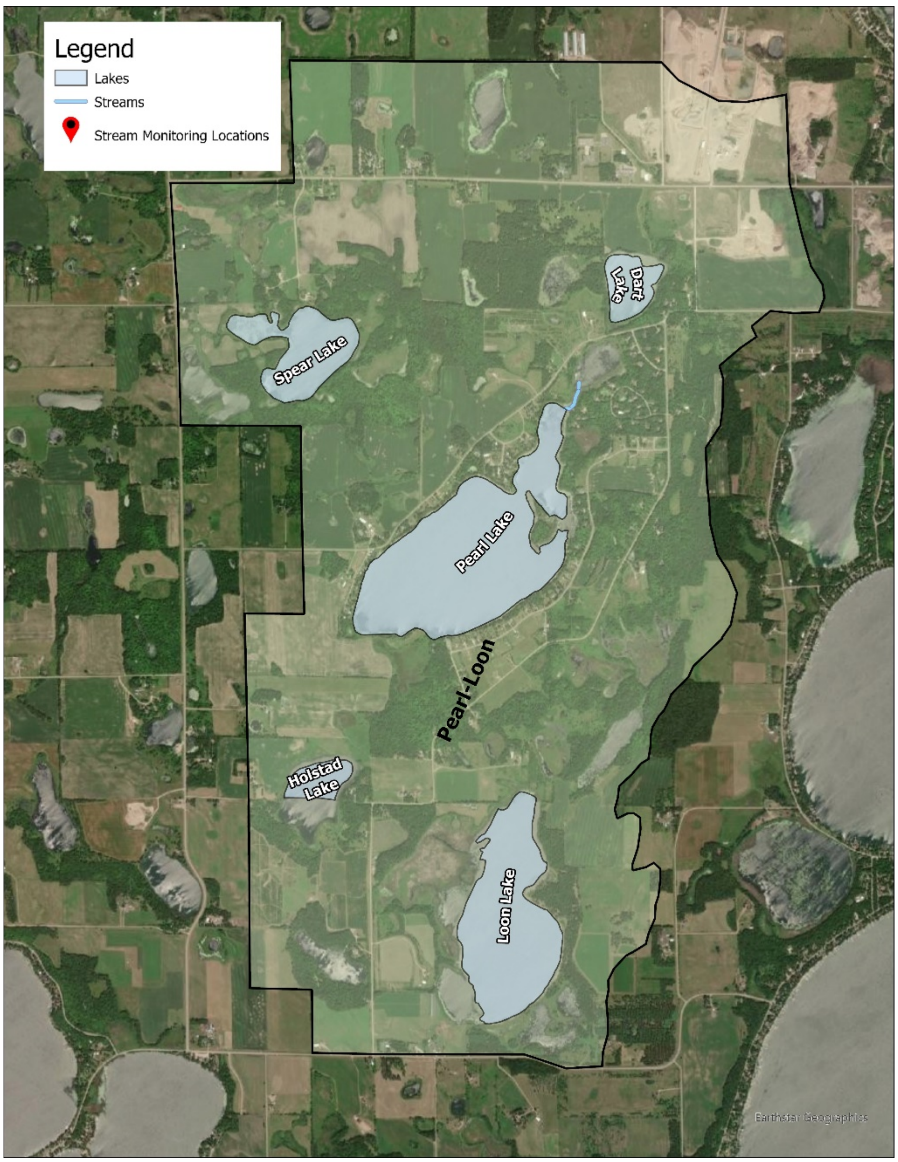


Figure 9.1. The Pearl/Loon Water Management Area.

9.1.1 Spear Lake

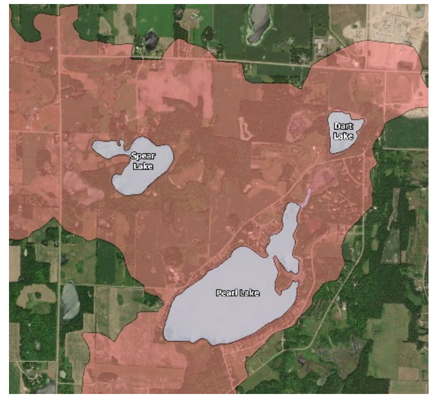


Figure 9.2. Spear Lake

Spear Lake is 71-acre natural environment lake on the Western boundary of the District (Figure 9.2). Not much is known about the lake due to its small size and lack of surface connection to other District waters. The shoreline is undeveloped except 1 parcel on the North end of the lake. The rest of the lake has a healthy natural buffer around the shoreline. No public accesses are present on the lake. The District will assess the health of the lake as part of the 2020-2030 Monitoring Plan.

<u>Water Quality</u>

The District sampled water quality on Spear Lake in 2020 and observed excellent water quality for a shallow lake. All samples were below impairment levels. Average TP (Figure 9.3), CHL-A (Figure 9.4) and secchi depth (Figure 9.5) were 30 ppb, 7.28 ppb, and 9.23'. It is important to note most secchi readings were limited by lake depth. Total phosphorous did not fluctuate much throughout the sampling season, indicating very little nutrients from surface runoff entering the lake. Spear lake seems to be an unaltered lake in good "reference" condition.

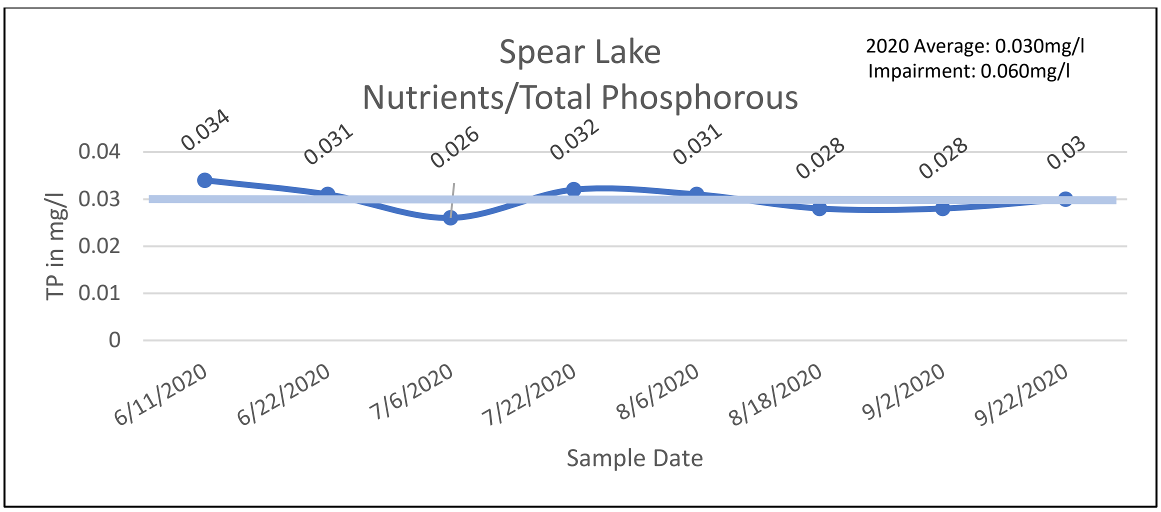


Figure 9.3. Spear Lake 2020 total phosphorous.

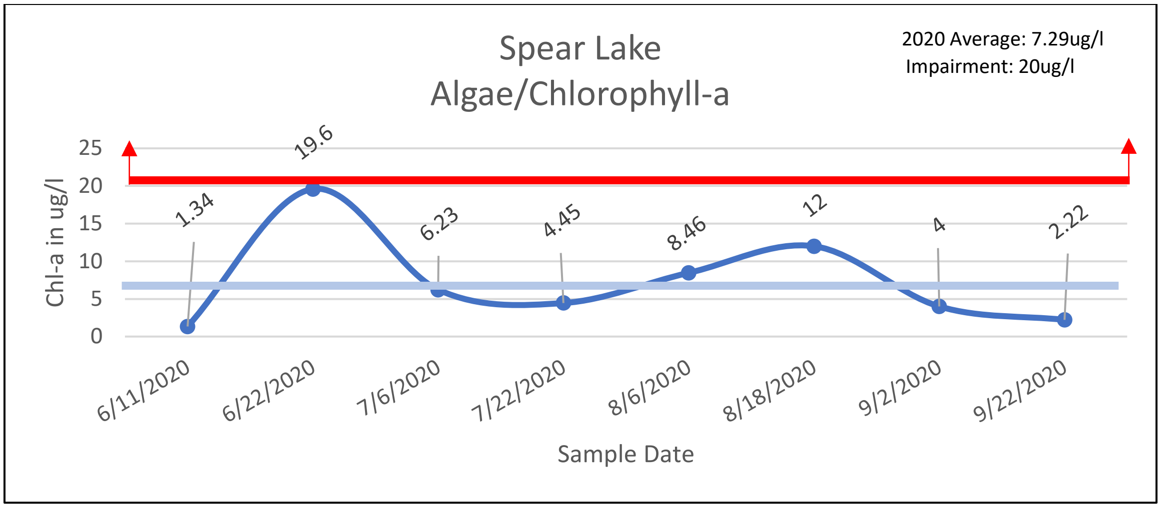


Figure 9.4. Spear Lake 2020 chlorophyll-a.

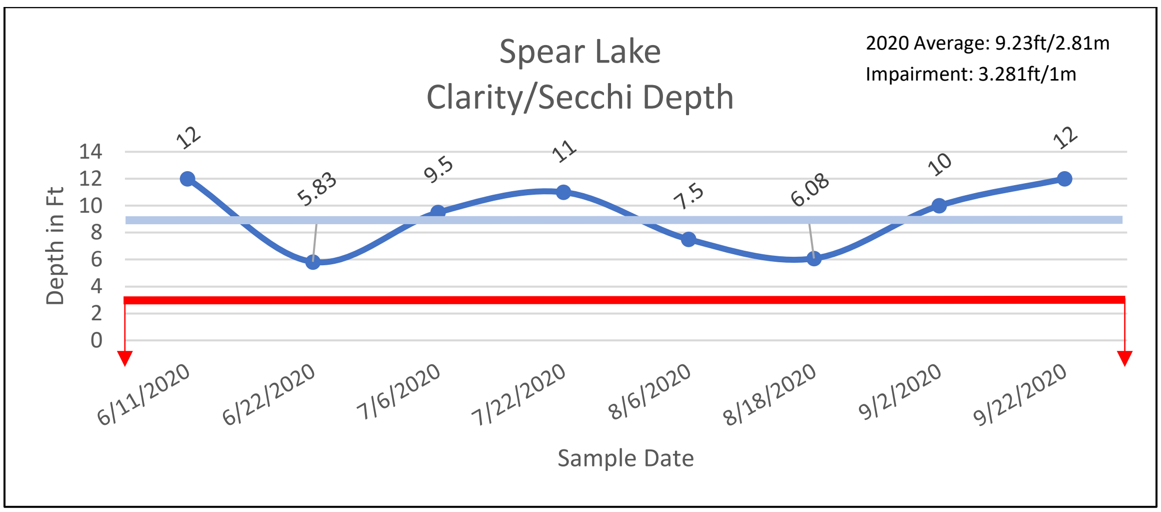


Figure 9.5. Spear Lake 2020 secchi depth. Note: All samples were limited by lake depth.

9.1.2 Loon Lake

Loon Lake is a shallow 264-acre natural environment lake with little residential development (Figure 9.6). There are 2 single family homes on the west side of the lake, and one cattle pasture on the south shore. It is apparent the pasture extends to the shoreline and is potentially used as a water source which may be a significant source of nutrients. There is a prominent wetland fringe along the western and northern shoreline. Loon is a landlocked lake, meaning there is no surface water inlet or outlet, and is disconnected from all surface watercourses. Wild rice exists but is very sparse around much of the northern half of the lake. About 65% of the lake has an excellent cattail and bulrush fringe, mainly on the west shore. The deepest known point on the lake is 11'. Detroit Lakes MN DNR Fisheries had used the lake as a rearing pond for many years.

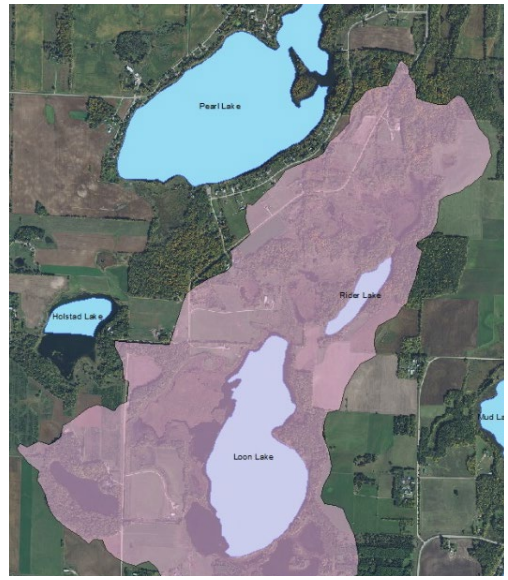


Figure 9.6. Loon Lake

Water quality

Loon Lake experiences exceptional water quality compared to other shallow lakes in the region. When compared to the averages from sampling activities in the early 2000's, water quality has improved. Average total phosphorous (Figure 9.7) CHL-A (Figure 9.8) and secchi depth (Figure 9.9) of 16 ppb, 4 ppb, and 8.5' were all less than their historic average of 24 ppb, 9 ppb, and 6.6'. It should also be noted secchi depth readings were taken at bottom depth. Even with extensive agriculture in the upland area, Loon Lake is still able to maintain favorable water quality.

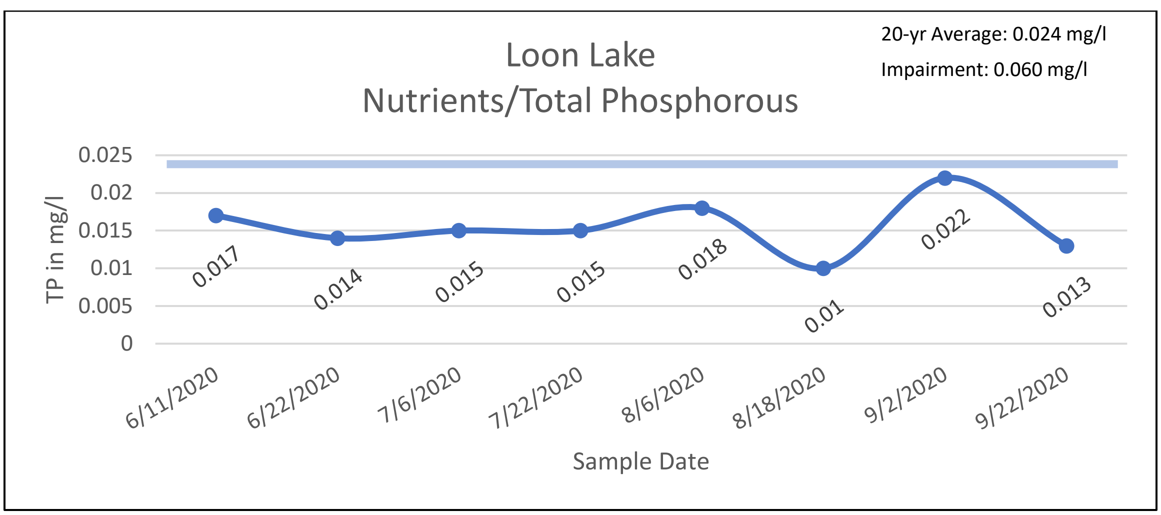


Figure 9.7. Loon Lake 2020 total phosphorous.

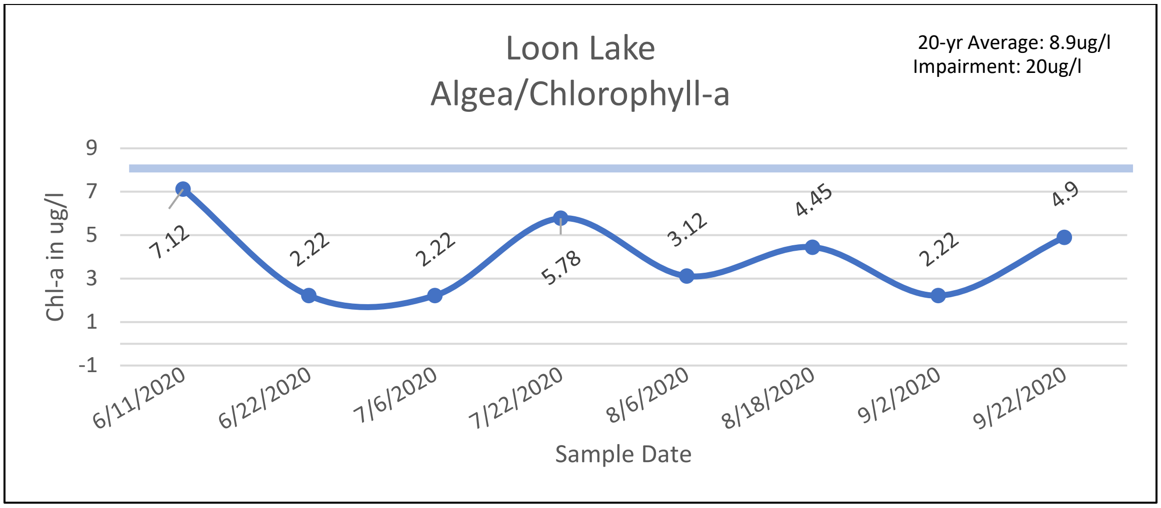


Figure 9.8. Loon Lake 2020 chlorophyll-a.

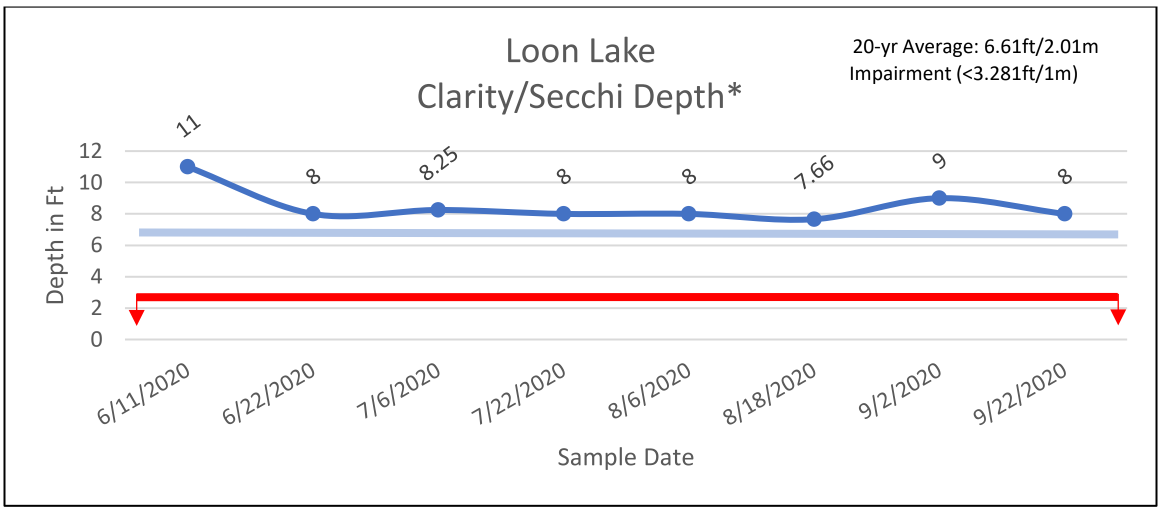


Figure 9.9. Loon Lake 2020 secchi depth. Note: All samples were limited by lake depth.

10 Small Lakes Water Management Area

The Small Lakes WMA consists of about 11,000 acres in the southeastern corner of the District (Figure 10.1). This WMA extends into Ottertail County and contains numerous small lakes and wetland areas. Many of the lakes are connected by means of wetlands, and the overall drainage of the area is indistinct. Land use in this WMA can be roughly divided into the northwest half and the southeast half. The northwest half of the WMA contains significant agricultural areas, as well as most of the lakes and wetlands in the WMA. The southeast half of the WMA is mostly forested with steep slopes. Less than 2 percent of the WMA is covered by impervious surface. The shorelines of the lakes in this WMA are sparsely settled but have recently seen more development interest, Johnson and Reeves Lakes in particular. Water quality data has been collected for Abbey, Meadow, Johnson, Reaves, Lind, and Glawe. Lind drains into Melissa Lake in the Sallie-Melissa WMA, making it the last lake in the WMA.

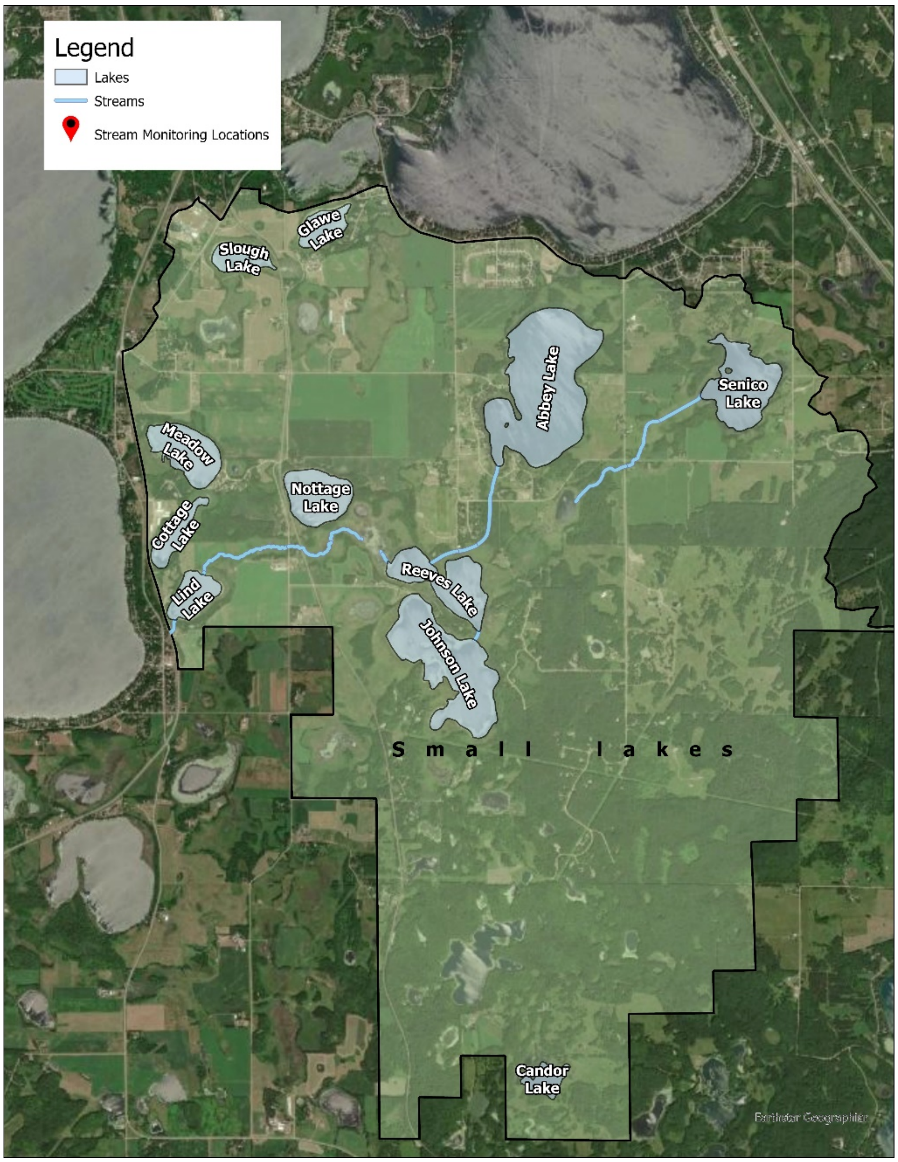


Figure 10.1. The Small Lakes Water Management Area.

10.1 Lakes

There are multiple lakes in the Small Lakes WMA, hence the name. The District monitors 6 of the 10 in the 10-year monitoring plan. In 2020, the District sampled water quality on Meadow and Glawe Lakes and performed a shoreline survey on Meadow and Johnson Lakes. In 2021, the District will be performing shoreline surveys on Reeves and Abbey Lakes.

10.1.1 Glawe Lake

Glawe is a small natural environment lake totaling about 40 acres and reaching a depth of 20 feet (Figure 10.2). It is separated from Curfman Lake by a 250-foot-wide land bridge along its northern shoreline. Water quality on Lake Glawe has remained stable and the lake is classified as mesotrophic. Development around the lake has increased in recent years with the construction of the Golden Bay Shores development along the NE shoreline. Stormwater from the development is treated via stormwater ponds on the north side of the lake prior to discharge to Glawe. A new single family residential development is also under construction on the east side of the lake. Shoreline vegetation removal from residential home construction should be minimized to avoid negative impacts to these small, sensitive lakes.

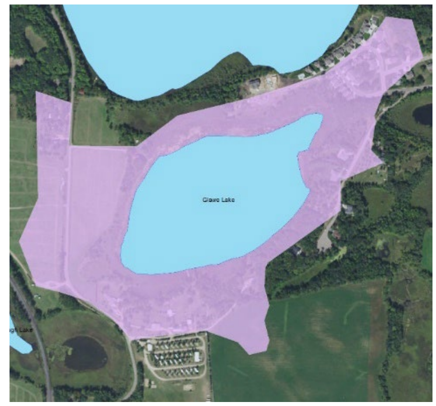


Figure 10.2. Glawe Lake.

In addition to the residential development, there is a commercial campground located along the southern shoreline. The majority of the campground sites are outside of the drainage area but do allow lake access for clients for non-motorized lake use. Currently there is no watercraft access and there is no motorized boat use.

<u>Water Quality</u>

Glawe Lake experienced an “average “water quality year in 2020. The average TP (Figure 10.3) CHL-A (Figure 10.4) and secchi depths (Figure 10.5) of 23 ppb, 5.8 ppb and 9.00’ were similar to the historic averages of 23 ppb, 5.8 ppb, and 10.14’. Due to errors in sampling, staff did not collect 8 secchi readings on Glawe Lake in 2020, so the average may be inaccurate. There is no reason to suspect the average clarity would be any different than the historic average. There is little developmental pressure on Glawe Lake as of 2020, and no surface connections to other lakes. It is likely water quality on Glawe will remain average in the coming years barring extensive development.

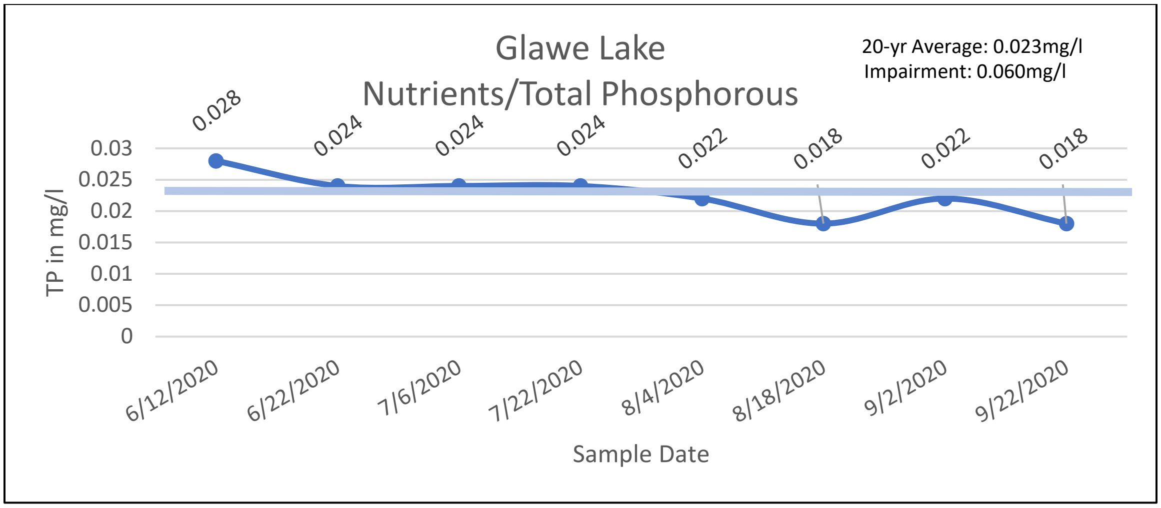


Figure 10.3. Glawe Lake 2020 total phosphorous.

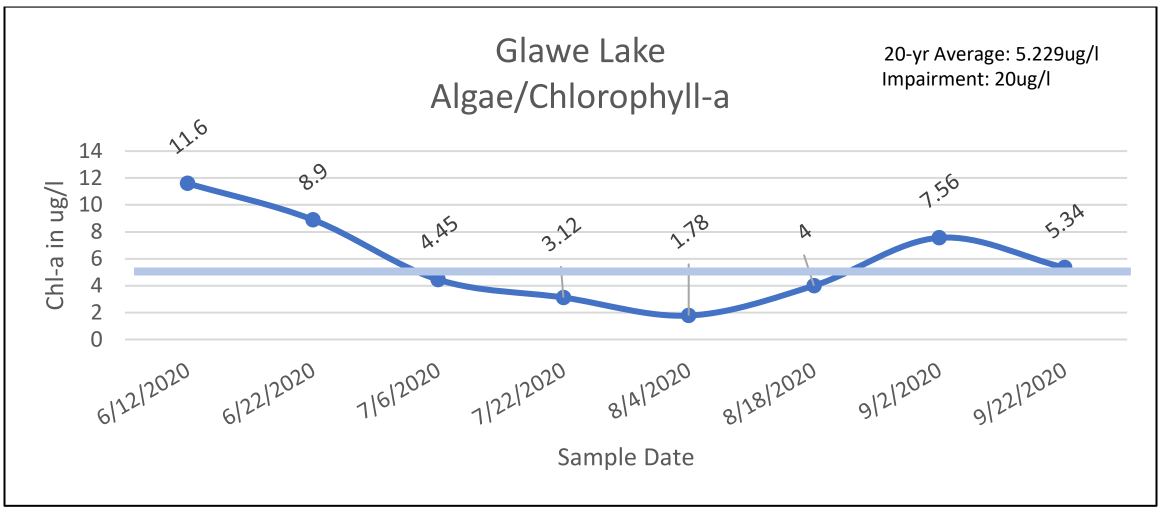


Figure 10.4. Glawe Lake 2020 chlorophyll-a.

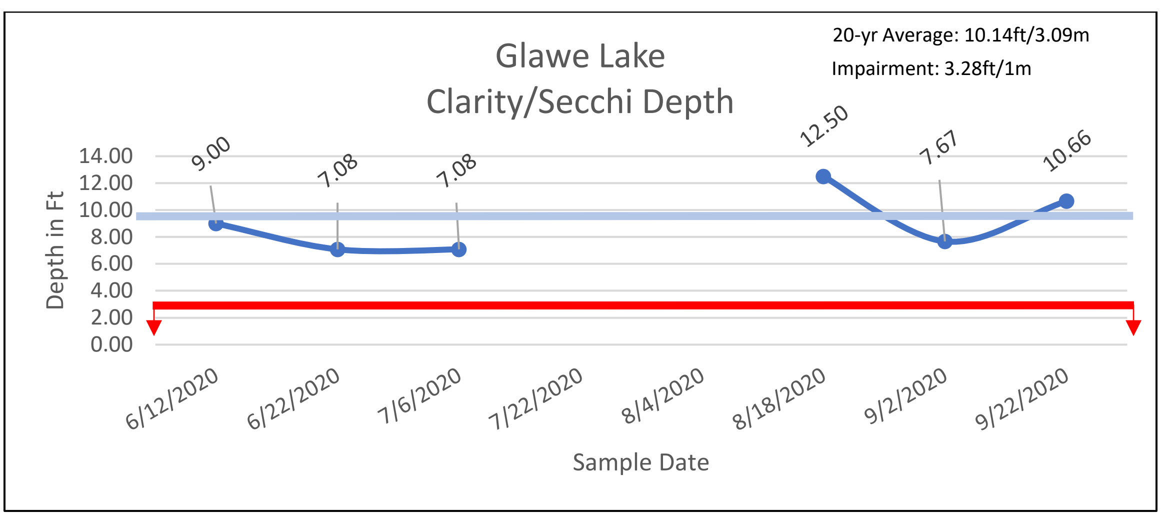


Figure 10.5. Glawe Lake 2020 secchi depth.

10.1.2 Meadow

Figure 10.6. Meadow Lake

Meadow is a 71-acre natural environment lake located approximately 4.5-miles SW of the City of Detroit Lakes (Figure 10.6). Despite its relatively small size, the lake is quite deep, reaching a maximum depth of 72 feet. Meadow has no surface water inlet and is recharged primarily by groundwater interaction and some surface water runoff. There is no true outlet to the lake, however, there is a culvert below HWY 59 that connects Meadow to a wetland and another culvert below CSAH 17 that connects the wetland to Lake Melissa.

Attempts were made by the MN DNR between 1987 through 2009 to regularly stock Rainbow (*Oncorhynchus mykiss)* and Brown Trout (*Salmo trutta*) with limited success. The MN DNR began stocking walleye in 2010, however, further study found that the lake best supports largemouth bass (*Micropterus salmoides*), bluegill, (*Lepomis spp.* crappie (*Pomoxis nigromaculatus*), and northern pike (*Esox Lucius)* population, so stocking efforts ceased. There is a small trout population remaining.

There are three residential homes on the western shoreline and a campground located on the Southeast portion. There is some agricultural (row crop) activity to the North of the lake that is separated from the lake by a forested buffer, 150-300 feet wide. Emergent vegetation is present along most of the shoreline except for about 1000 feet near the campground, which may have been removed for the installation of a sand beach and docking area. There is moderate macrophyte growth in the littoral area of the lake (<15 ft). Lake depths begin to drop sharply about 150-250' offshore, where plant growth becomes much more limited.

<u>Water Quality</u>

Meadow Lake had an "average" water quality year in 2020. The average TP (Figure 10.7), CHL-A (Figure 10.8) and secchi depths (Figure 10.9) of 13 ppb, 3.83 ppb, 13.4' were similar to the historic averages of 16 ppb, 3.73 ppb, 15.5'. Secchi depth and CHL-A degraded, but this may be caused by increased water temperatures in 2020. Most lakes in the district observed increased surface water temperatures, increasing aquatic plant and algae growth. It is possible the slight increase in CHL-A on Meadow lake caused the decrease in average secchi depth. It is also of note one secchi depth was not collected by District Staff.

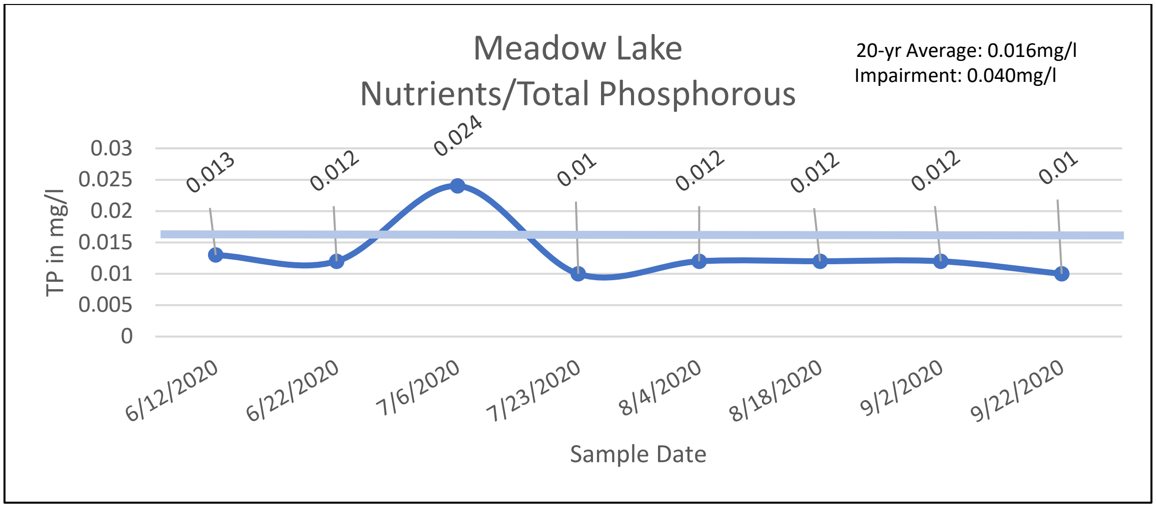


Figure 10.7. Meadow Lake 2020 total phosphorus.

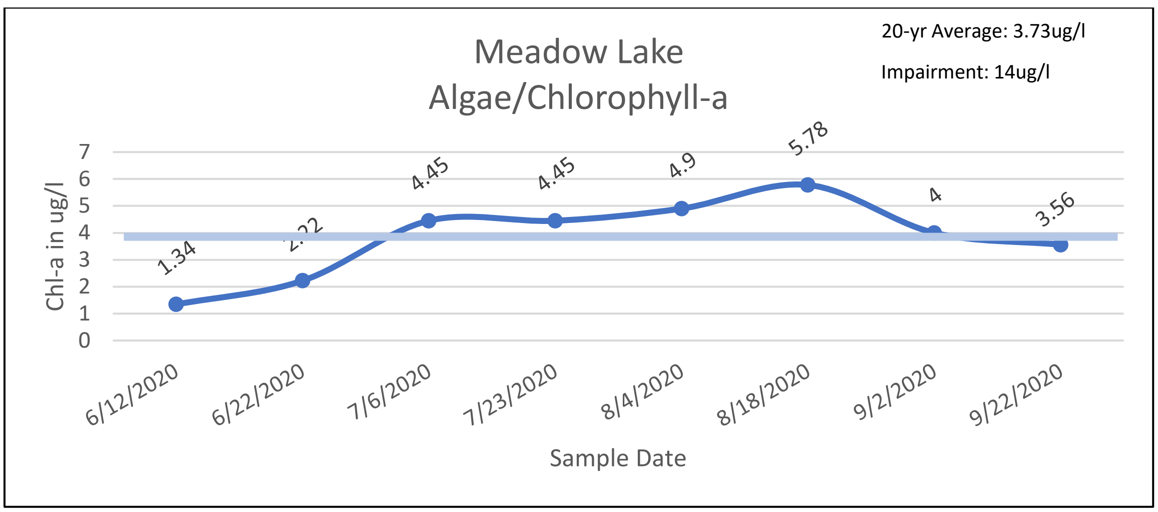


Figure 10.8. Meadow Lake 2020 chlorophyll-a.

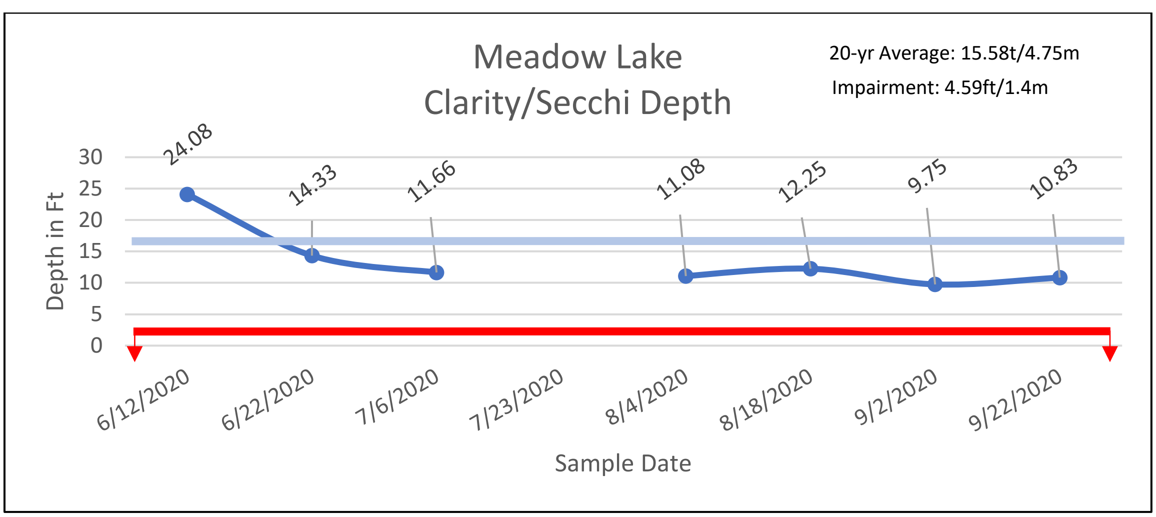


Figure 10.9. Meadow Lake 2020 secchi depth.

<u>Ecological Integrity</u>

Shoreline Survey-10 Parcels

Meadow's shoreline is composed of 40% natural shoreline, 20% minimally altered, 30 percent moderately altered, and 10% greatly altered. The campground on the south east end of the lake marks the only greatly altered parcel. There has been a significant decrease in the number of storage sheds and decks in the Shore Impact Zone (SIZ) (6 in 2010 to 1 in 2020; 4 in 2010 to 0 in 2020). The number of boat launches has increased by one with the addition of the boat launch at the campground. Since the last survey, there have been significant increases in the number of docks, motorized boats, and non-motorized boats (Figure 10.10). Meadow Lake has seen decreases in the number of boat lifts over the last decade.

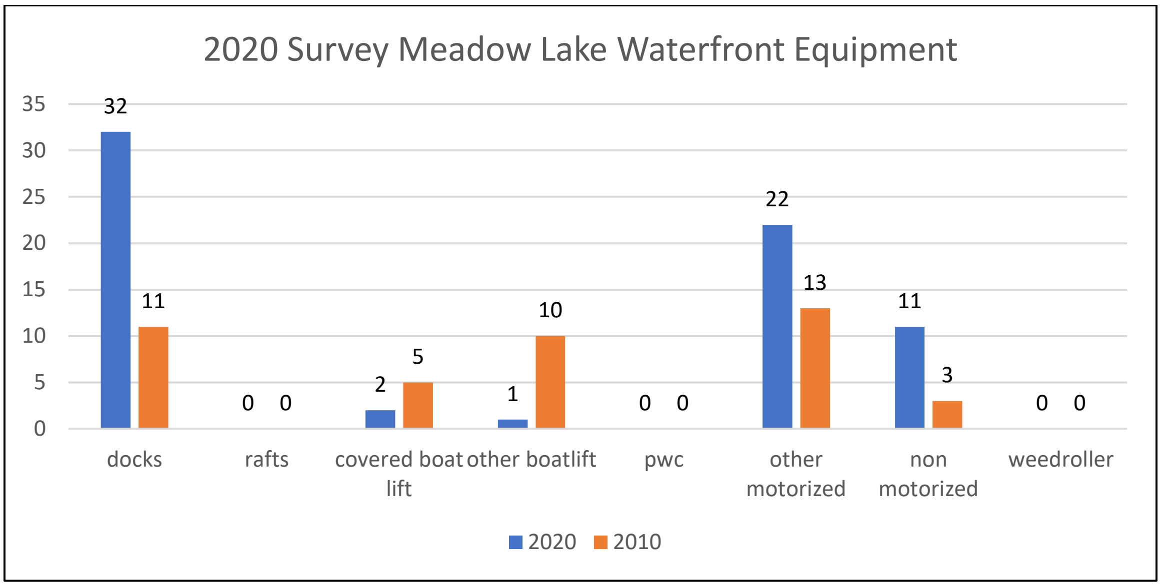


Figure 10.10. Waterfront equipment on Meadow Lake.

10.1.3 Johnson Lake

Johnson Lake is a moderately developed, natural environment lake located south of the City of Detroit Lakes (Figure 10.11). Johnson lake is connected to Reeves Lake via a small natural channel on the Northeast shore of the lake. A prominent wetland fringe surrounds the lake, uprooted portions of wetland vegetation often detach and move around the lakes by wind and water currents. The channel between the two lakes sometimes becomes blocked by floating bogs, making watercraft passage between the two impossible. Johnson lake lies to the south of Reeves, totaling 219.6 acres in size and reaching a depth of 30 feet.

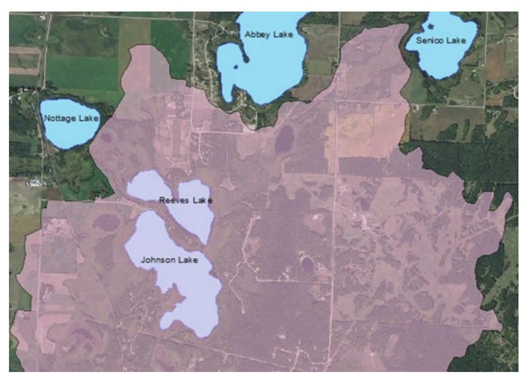


Figure 10.11. Johnson Lake.

The primary source of surface water input to the lake is stormwater runoff from the large drainage area of 4,576 acres. Johnson Lake outlets to Reeves Lake to the North. Groundwater interactions also play a role in the water budget.

Residential development is located on the peninsula which extends between the two lakes from the west. There is also a small campground located on that peninsula, which contains the only boat access to the lake (private access). Due to the extensive wetland fringe on the lake, only a few locations allow lake access from riparian properties. In some locations where the wetland fringe is not as prominent, access to the lake has been obtained by removing portions of the wetland vegetation.

<u>Ecological Integrity</u>

Shoreline Survey-26 Parcels

Johnson is still a mostly natural lake with 57% of the shoreline being natural. The rest of the shoreline consists of 23% minimally altered, 12% moderately altered and 8% greatly altered. In the last decade, Johnson lake has seen increases in the presence of storage sheds (0 in 2004 to 5 in 2020), boat launches (0 in 2004 to 1 in 2020) and decks in the shoreline impact zone (0 in 2004 to 1 in 2020). Johnson lake has also seen changes in the amount of waterfront equipment on the lake as well (Figure 10.12). The most notable changes are increases in the number of docks, motorized boats, and non-motorized boats.

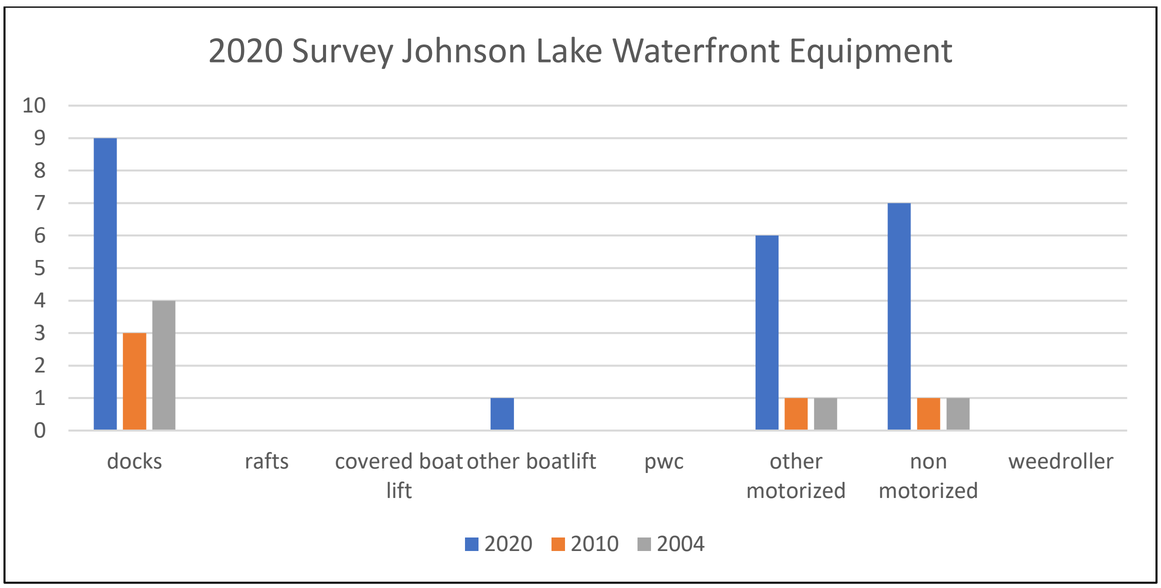


Figure 10.12. Waterfront equipment on Johnson Lake.

11 Munson/Fox Water Management Area

The Munson-Fox WMA contains about 1,350 acres (Figure 11.1). The only lakes in this WMA are Munson and Fox Lakes. Both are small lakes, at 129 and 138 acres, respectively, but both are also elongated, giving them good amounts of shoreline. Both lakes are fed by groundwater and have adjacent wetlands and some shoreline runoff, but neither has a significant inlet stream. Both lakes have small outlets. Munson and Fox lakes have relatively small watersheds. Land within these watersheds is a little more than 25 percent forested, 23 percent water, 50 percent cultivated, grassland or pastureland, and less than 2 percent impervious surface. Some major gravel mining operations are found in the area.

Figure 11.1. The Munson/Fox Water Management Area.

11.1 Lakes

There are 2 lakes in the Munson/Fox WMA, Munson Lake and Fox Lake. The District monitors water quality, shoreline development, and aquatic vegetation on these two lakes in accordance with the 2020-2030 Water Monitoring Plan.

11.1.1 Fox Lake

Fox lake is a small, heavily developed lake totaling 143 acres and reaching a depth of 24 feet. Approximately 60% (86 acres) of the lake is considered littoral and less than 15 feet. There is no surface water inlet, and the lake receives water primarily from stormwater runoff and groundwater interactions. There is one outlet to the lake which flows south through a wetland to Lake Sallie.

The majority of residential lake development occurred between the 1960s and 1990 where the number of homes more than doubled from 24 to 55. The MN DNR owns a 3 acres tract of land that contains approximately 1300 feet of shoreline on the north side of the lake that remains protected.

Prior to 2004, a 40-acre parcel just north of the lake was used for ag purposes with turkey manure being applied to the land periodically. The lake showed signs of degradation with nuisance algal bloom and poor water clarity. The turkey manure application ceased in 2004. The lake responded with drastic and immediate increases in water clarity and reductions of in-lake phosphorus levels.

<u>Ecological Integrity</u>

Shoreline Survey-76 parcels

Fox's shoreline is 23% natural, 17% minimally altered, 39% moderately altered, and 21% greatly altered. The last survey conducted on Fox Lake was done in 2004. In that survey, waterfront structures were not counted. On Fox Lake in 2020, there were 5 storage sheds in the SIZ and 2 boat launches. Waterfront equipment, aside from personal watercraft and motorized boats, were also not recorded. Since the survey in 2004, there has been a slight increase in personal watercraft on the lake and a decrease in the number of motorized boats (Figure 11.2).

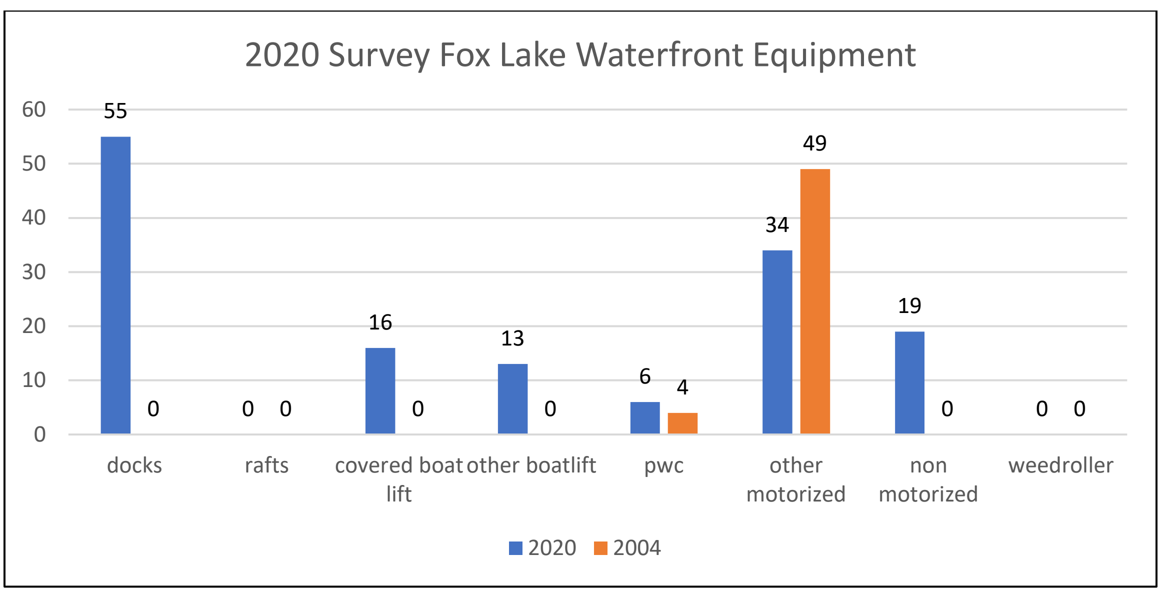


Figure 11.2. Waterfront equipment on Fox Lake in 2020.