

BROWN'S CREEK WATERSHED DISTRICT 2022 WATER MONITORING SUMMARY



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Several agencies and individuals were directly involved in many aspects of this project including data collection and analysis, as well as technical and administrative assistance.

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Bi-weekly	Every two weeks
CaCO ₃	Calcium Carbonate
CAMP	Citizen-Assisted Lake Monitoring Program
cfs	cubic feet per second
Chl- α	Chlorophyll- α
BCWD	Brown's Creek Watershed District
COD	Total Chemical Oxygen Demand
DO	Dissolved Oxygen
EIMS	Environmental Information Management System
<i>E. coli</i>	<i>Escherichia coli</i>
FAV	Final Acute Value
IESF	Iron Enhanced Sand Filter
MCES	Metropolitan Council Environmental Services
mg/L	milligrams per liter
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MPN	most probable number
NTU	nephelometric turbidity units
OHWL	Ordinary High Water Level
Ortho-P	Ortho-phosphorus
THPP	Trout Habitat Preservation Project
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TP	Total Phosphorus
TSI	Trophic State Index
TSMP	Trout Stream Mitigation Project/Diversion Structure
TSS	Total Suspended Solids
$\mu\text{g/L}$	micrograms per liter
μm	micrometers
$\mu\text{mhos/cm}$	micromhos per centimeter
VSS	Volatile Suspended Solids
WCD	Washington Conservation District

2022 Brown's Creek Watershed District Baseline Water Quality Monitoring

MONITORING SUMMARY

This report focuses on the summary of lake and stream water quality data collected by the Washington Conservation District (WCD) in 2022. References will also be made to the Brown's Creek and Long Lake 2020 Trend Analysis completed by Brown's Creek Watershed District's engineer, Emmons & Olivier Resources, Inc. (EOR). Additional information on the natural and cultural resources, improvement projects, and challenges related to water resources within the Brown's Creek Watershed District (BCWD) can be found in the BCWD 2017-2026 Watershed Management Plan, the 2010 Brown's Creek Biota TMDL, and past monitoring summaries.

The drought conditions observed in 2021 continued into 2022; a stark contrast to the extreme wet conditions of the late 2010's. Spring conditions were cooler than average, with overnight freezing temperatures persisting until the end of April. Most lakes in the district were ice-free one to two weeks later than historic median dates, and cool temperatures delayed significant algae growth into May. Summer precipitation patterns were very dry, with only ten inches of rain falling from June through October, compared to the thirty year average of 20.2 inches for this period. Of that ten inches, over half came in August alone, the only summer month with near average rainfall. Overall, precipitation was about seven inches below the thirty year average of 33.98 inches. According to the U.S. Drought Monitor, the watershed area entered moderate drought conditions in mid-July, and severe drought conditions by early August, which generally persisted until the end of the year. Existing high water levels in the district from recent years continued to recede throughout the year. Warm temperatures also impacted water conditions with eight days over 90 °F recorded by the National Weather Service in Stillwater. Ice-in was somewhat delayed due to warm temperatures extending into November, and heavy snow cover was present by mid-December. Despite the severe conditions, overall lake and stream water qualities were some of the best ever recorded, with some exceptions.

Lake Monitoring

BCWD monitored eighteen basins for nutrients, chlorophyll- α , Secchi disk transparency, temperature and dissolved oxygen profiles, elevation, and user perception rankings. Bass Lake East, Bass Lake West, Benz Lake, Goggins Lake, Jackson WMA Pond, Kismet Basin, Long Lake, Lynch Lake South, Masterman Lake, Plaisted Lake, South School Section Lake, and Woodpile Lake were monitored every other week, while Brewer's Pond, Heifort's Pond, July Avenue Wetland, Lynch Lake North, North School Section Lake, and Pat Lake were monitored every four weeks. Volunteers also monitored Brewer's Pond and Heifort's Pond every four weeks on an offset schedule with WCD, such that samples were collected every other week. All

lakes and an additional two ponds, Highway 12 & Kimbro Wetland and Highway 96 Wetland, were also sampled for chloride in spring and fall.

Most lakes experienced a slight improvement in water quality as measured by lake grade over the previous year. Four lakes experienced a decline in lake grade; Bass West, Benz, July Avenue Wetland, and Plaisted Lake. Goggins Lake, Lynch Lake North, Lynch Lake South, Masterman Lake, South School Section Lake, and Woodpile Lake maintained their grade from the year prior, and all other lakes improved in lake grade.

Of the eighteen lakes monitored, Brewer's Pond, Heifort's Pond, July Avenue Wetland, and Lynch Lake North summer averages exceeded (were poorer than) state impairment thresholds for total phosphorus, chlorophyll- α , and Secchi disk transparency. South School Section Lake exceeded the impairment threshold for chlorophyll- α only.

Peak elevation for the year on most lakes occurred in April or early May. Due to drought conditions, nearly every lake consistently declined in elevation, rising only for a major storm series in August. In 2022 nine basins had elevations early in the season above their Ordinary High Water (OHW) level, and by the end of the monitoring period six of those basins had receded below their OHW.

Stream and Stormwater Monitoring

Brown's Creek

Consistent with past years, Brown's Creek was monitored at four locations; Highway 15, McKusick Road, Stonebridge, and the Outlet. Automated storm composite and manual grab samples during storm and base flow conditions were collected at all sites and analyzed for nutrients, sediment, metals, and *Escherichia coli* (*E.coli*). Continuous (15 minute) stage, discharge, temperature, dissolved oxygen, turbidity, and specific conductivity were collected at all four stations, and continuous pH was also collected McKusick Road, Stonebridge and the Outlet.

Nutrients & Discharge

The total discharge to the St. Croix River in 2022 was 220,440,000 cubic feet of water, as recorded at the Outlet. The total phosphorus (TP) and total suspended solids (TSS) loads to the St. Croix River at the Outlet were 1,219 pounds of phosphorus (0.264 lbs/ac) and 172,589 pounds of sediment (37.32 lbs/ac), as calculated by Metropolitan Council Environmental Services (MCES). These were the second lowest and lowest totals, respectively, since load calculations began in 2000. The sampling strategy at the Outlet was changed by MCES in 2017 to a manual grab collected on the same weekday every other week, and composite samples collected in major storm events. This change in sampling method has resulted in an apparent

shift to lower annual loads, as the strategy is not biased towards runoff events as it was in the past, and the method used to calculate annual loads was altered to comply with MCES standard operating procedures. The creek exceeded the state standard of 0.100 mg/L of TP for parts of March, June, and July, but was below the standard for the majority of the year. Five of 28 applicable samples exceeded the TP standard. The creek met the TMDL goal of 23 mg/L of TSS during base flow, but exceeded the state standard of 10 mg/L from April 1 to September 30 in April, May, and July for a total of three of 13 applicable samples. TSS loading was well below the TMDL goal of 74 pounds per acre, primarily due to the lack of significant runoff events in 2022. Loading and conditions at individual sites are discussed in greater detail later in this summary.

Metals

One chronic standard exceedance of lead was recorded at McKusick Road, Stonebridge, and the Outlet on May 11, and one chronic standard exceedance of copper was recorded at the Outlet, also on May 11. The number and severity of metals standards exceedances in 2022 was very low compared to past years.

Bacteria

Samples taken during base flow at each station were above state standards for *E.coli*. Based on long term monitoring, bacteria concentrations at all stations are above the standard June through September, and at McKusick Road in the month of May. Sufficient data has not been collected at Highway 15, McKusick Road, or Stonebridge to compare to the standard in April.

Temperature & Dissolved Oxygen

Temperature and dissolved oxygen regimes were most suitable for trout survival at McKusick Road, Stonebridge and the Outlet. Although the threat level threshold of 18.3 °C was exceeded at McKusick Road, Stonebridge, and the Outlet 31, 37, and 6 days as measured by daily average temperature, respectively, the critical level threshold at which trout could not survive of 23.9 °C was never exceeded at any site. The number of threat level exceedances at all sites were the lowest in the last ten years when a full season of data was available, and the third lowest recorded at the Outlet since continuous temperature monitoring began in 2006. Dissolved oxygen concentrations were better than the state standard of 7 mg/L as a daily minimum for the entire season at Stonebridge and the Outlet, and were poorer than the standard only three days at McKusick Road, although some data in August was missing at this site due to sensor failure. Highway 15 is not suitable for trout during summer months due to low dissolved oxygen and warm temperatures. In past years McKusick Road has not typically had consistently favorable conditions for both temperature and dissolved oxygen, but high groundwater levels and possibly increased riparian shading and thermal load reduction projects appear to be improving conditions in this reach. The upper reaches of the creek around Highway 15 have been found to contain

invasive curly-leaf pondweed, which will hinder trout suitability by slowing the water, allowing for warmer temperatures and sediment deposition over spawning gravel.

Turbidity

Continuous turbidity and specific conductivity were monitored at each of the four stations on the creek. Average daily turbidity exceeding the TMDL goal of 10 NTU ranged from 0.5% to 7.9% of the days monitored across the four monitoring stations, although sensor failure influenced the analysis at McKusick Road. In 2022 the Outlet was the most turbid site, with 7.9% of the days monitored exceeding the 10 NTU goal. Specific conductivity data are not discussed, but are available upon request.

Biology

The MN DNR has a management plan to stock 1,000 yearling rainbow trout in the creek each spring. Due to difficulties of raising brown trout at state hatcheries to stock-able size, the agency shifted to stocking rainbow trout in 2019. Stillwater Area High School and the Minnesota Trout Unlimited – Trout in the Classroom program also raised and released several hundred fingerling rainbow trout into the creek. The rainbow trout thrive in similar conditions as brown trout, but grow faster and will provide better recreational opportunities to anglers.

Diversion Drainage

The diversion drainage was again monitored at the Trout Stream Mitigation Project (TSMP) Diversion Structure for nutrients, sediment, and metals, as well as continuous stage and discharge. A secondary level logger installed at the diversion weir shows no water overtopped the weir in 2022. A very small volume of water directly discharges via a small hole in the base of the structure designed to allow groundwater base flow into Brown's Creek. Total discharge to McKusick Lake was 41,610,620 cubic feet of water. The TP load was 389 pounds (0.101 lbs/ac) and the TSS load was 75,429 pounds (19.57 lbs/ac). Total discharge was below the ten year average, while the TP and TSS loads were the third and second lowest recorded, respectively, since load calculations began in 2006. The site is meeting the state standard for 2B waters for TSS, and for TP with some exceptions at base flow, but has historically had an extremely high storm loading rate. Erosional head cuts in the drainage tributaries have been identified as the source of the excessive loading rates through drone flights and surveys conducted by the District's engineer. Rock vanes and stabilization projects have been implemented by the District to reduce erosion and restore floodplain connectivity. Annual TSS and TP reductions as a result of these projects are estimated to be 70 pounds of sediment and 76 pounds of phosphorus per year.

Concentrations of metals were low in 2022 due to drought conditions. One chronic standard exceedance of lead was recorded, which is tied for the lowest amount of metals exceedances observed since metals analysis began in 2007. No bacteria samples were collected at the site in

2022, and previously collected samples have become too outdated to assess impairment status in this reach.

Long Lake Drainages

The Tributary to Long Lake at Marketplace Pond was monitored for nutrients, sediment, metals, and continuous stage and discharge, while the Tributary to Long Lake at 62nd Street was monitored for stage only. The total discharge to Long Lake at Marketplace Pond was 7,753,526 cubic feet, while the discharge at 62nd Street was estimated based on prior data at 274,469 cubic feet during the monitoring period. These were the second lowest and lowest annual discharge volumes, respectively, since monitoring began in 2005. The tributary at Marketplace Pond contributed 79 pounds of phosphorus (0.192 lbs/ac) and 7,112 pounds of sediment (17.35 lbs/ac). Although not classified as a 2B water, the state standard for TP was exceeded during base flow conditions in June and July, and the TSS standard is being met at the Marketplace Pond for all samples at base flow. Storm events at the tributary at Marketplace Pond exceeded the maximum standard for copper twice, and the chronic standard for lead one time.

McKusick Wetland Outlet

McKusick Wetland Outlet was added to the monitoring network in 2017. The outlet was monitored at its discharge point to Brown's Creek 100 feet upstream of the McKusick Road site for continuous stage, discharge, and temperature, as well as nutrients, sediment, and metals. Discharge to Brown's Creek during the period of monitoring (May 11 – October 26) was calculated at 5,153,850 cubic feet. The TP load for this period contributed 69.1 pounds of phosphorus, while the TSS load contributed 2,868 pounds of sediment. Although not a 2B water, when compared to state standards for TP and TSS the site meets the standard for TSS, but was well above the TP standard for three of four samples collected.

The Oak Glen Golf Course Irrigation Reuse project was completed in 2021, and directs flow from the wetland away from Brown's Creek to a pond to be used as irrigation water. This helps reduce thermal and nutrient loads to Brown's Creek and increases the suitability of the creek to support cold water species. As such, the outlet was intermittently or not discharging for a considerable portion of the season, from approximately June 23 to August 5. Continuous temperature data collected at the site show water discharged to the creek exceeded the TMDL threat level threshold 31.2% of the monitored period when flow was present, and the critical level threshold 3.5% of the period. This is substantially lower than recent years when water discharging from the wetland routinely exceeded the threat level threshold for more than 50% of the monitoring period.

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I. INTRODUCTION

Knowledge of the changes to water quality and quantity of our water resources through monitoring guides when, where, and how management activities should be implemented to protect or restore those resources. The Brown's Creek Watershed District (BCWD) utilizes monitoring and the data collected to make such decisions as outlined in its watershed management plan. In 2022 BCWD monitored 23 basins (lakes), four stations on Brown's Creek, a tributary to Brown's Creek, two stations in the Long Lake subwatershed, and one station in the diversion drainage at the Diversion Structure. A summary of monitoring locations and monitored parameters can be found in Table 1 and Figure 1.

The Washington Conservation District (WCD) also conducted special project and maintenance monitoring at several locations including the Iron Enhanced Sand Filter (IESF) on Morgan Avenue, Brown's Creek Rock Crib, Countryside Auto sediment chamber, McKusick Road sediment chambers, and the Oak Glen Golf Course Irrigation Reuse project. Comparable levels of data collection versus baseline sites occurred at each project, such as collection of continuous stage, discharge, and temperature, and measurement of sediment depths in complex monitoring situations. As this summary focuses on baseline monitoring data, special project monitoring will not specifically be discussed, although the locations of several projects are described. Individual monitoring summaries for each project will be prepared and made available in separate reports.

Table 1. Monitoring Site Location, Description, and Parameter(s) Monitored

Site Description	Map Site ID#	Site Name	General Site Location	Monitored Parameters
Stream Monitoring	1	Brown's Creek at Hwy 15	Hwy 15	Discharge and Water Quality Composite/Grab Samples
Stream Monitoring	2	Brown's Creek at McKusick Road	McKusick Road	Discharge and Water Quality Composite/Grab Samples
Stream Monitoring	3	Brown's Creek at Stonebridge Trail	Stonebridge Trail	Discharge and Water Quality Composite/Grab Samples
Stream Monitoring	4	Brown's Creek Outlet	Hwy 95 & 96	Discharge and Water Quality Composite/Grab Samples
Stream Monitoring	5	Brown's Creek Diversion	Neal Ave.	Discharge and Water Quality Composite/Grab Samples
Stream Monitoring	6	Tributary to Long Lake at 62nd St.	62nd St.	Stage
Stream Monitoring	7	Tributary to Long Lake at Marketplace Pond	Market Dr.	Discharge and Water Quality Composite/Grab Samples
BMP Effectiveness	8	Iron Enhanced Sand Filter (IESF)-1 Outlet	Morgan Ave. N.	Discharge and Water Quality Composite/Grab Samples
Stream Monitoring	9	McKusick Wetland Outlet	McKusick Road	Discharge and Water Quality Grab Samples
BMP Effectiveness	10	Brown's Creek Park Rock Crib (5 In-Crib Temperature Loggers and Outlet Discharge, 2 In-Stream Temperature Loggers)	Neal Ave.	Continuous Temperature, Discharge, Sediment Depth and Maintenance Requirements
BMP Maintenance	11	McKusick Road and Countryside Auto Sediment Chambers	McKusick Road	Sediment Depth and Maintenance Requirements
BMP Effectiveness	12	Oak Glen Pond Water Reuse	McKusick Road	Stage
			DNR ID	
Lake Monitoring	13	Kismet Basin	82-033400	Surface Water Quality Samples, Elevation
Lake Monitoring	14	Long Lake (North Basin)	82-002100	Surface Water Quality Samples, Elevation
Lake Monitoring	15	Goggins Lake	82-007700	Surface Water Quality Samples, Elevation
Lake Monitoring	16	South School Section Lake	82-015100	Surface Water Quality Samples, Elevation
Lake Monitoring	17	Benz Lake	82-012000	Surface Water Quality Samples, Elevation
Lake Monitoring	18	Masterman Lake	82-012600	Surface Water Quality Samples, Elevation
Lake Monitoring	19	Woodpile Lake	82-013200	Surface Water Quality Samples, Elevation
Lake Monitoring	20	Lynch Lake (North Basin)	82-004200	Surface Water Quality Samples, Elevation
Lake Monitoring	21	Lynch Lake (South Basin)	82-004202	Surface Water Quality Samples, Elevation
Lake Monitoring	22	Bass Lake (West)	82-012300	Surface Water Quality Samples, Elevation
Lake Monitoring	23	Bass Lake (East)	82-012400	Surface Water Quality Samples, Elevation
Lake Monitoring	24	July Avenue Pond	82-031800	Surface Water Quality Samples, Elevation
Lake Monitoring	25	Pat Lake	82-012500	Surface Water Quality Samples, Elevation
Lake Monitoring	26	Plaisted Lake	82-014800	Surface Water Quality Samples, Elevation
Lake Monitoring	27	Jackson Wildlife Management Area Pond (Sinnits Pond)	82-030500	Surface Water Quality Samples, Elevation
Lake Monitoring	28	Brewer's Pond	82-002200	Surface Water Quality Samples, Elevation
Lake Monitoring	29	Heifort's Pond	82-048500	Surface Water Quality Samples, Elevation
Lake Monitoring	30	North School Section	82-014900	Surface Water Quality Samples, Elevation
Lake Monitoring	31	Highway 12 & Kimbro Pond	82-034900	Chloride, Elevation
Lake Monitoring	32	Brown's Creek at Gateway Trail	82-030300	Elevation
Lake Monitoring	33	55th St. Pond	82-031600	Elevation
Lake Monitoring	34	Vanzwol Pond	82-012800	Elevation
Lake Monitoring	35	Highway 96 Wetland	82-033500	Chloride

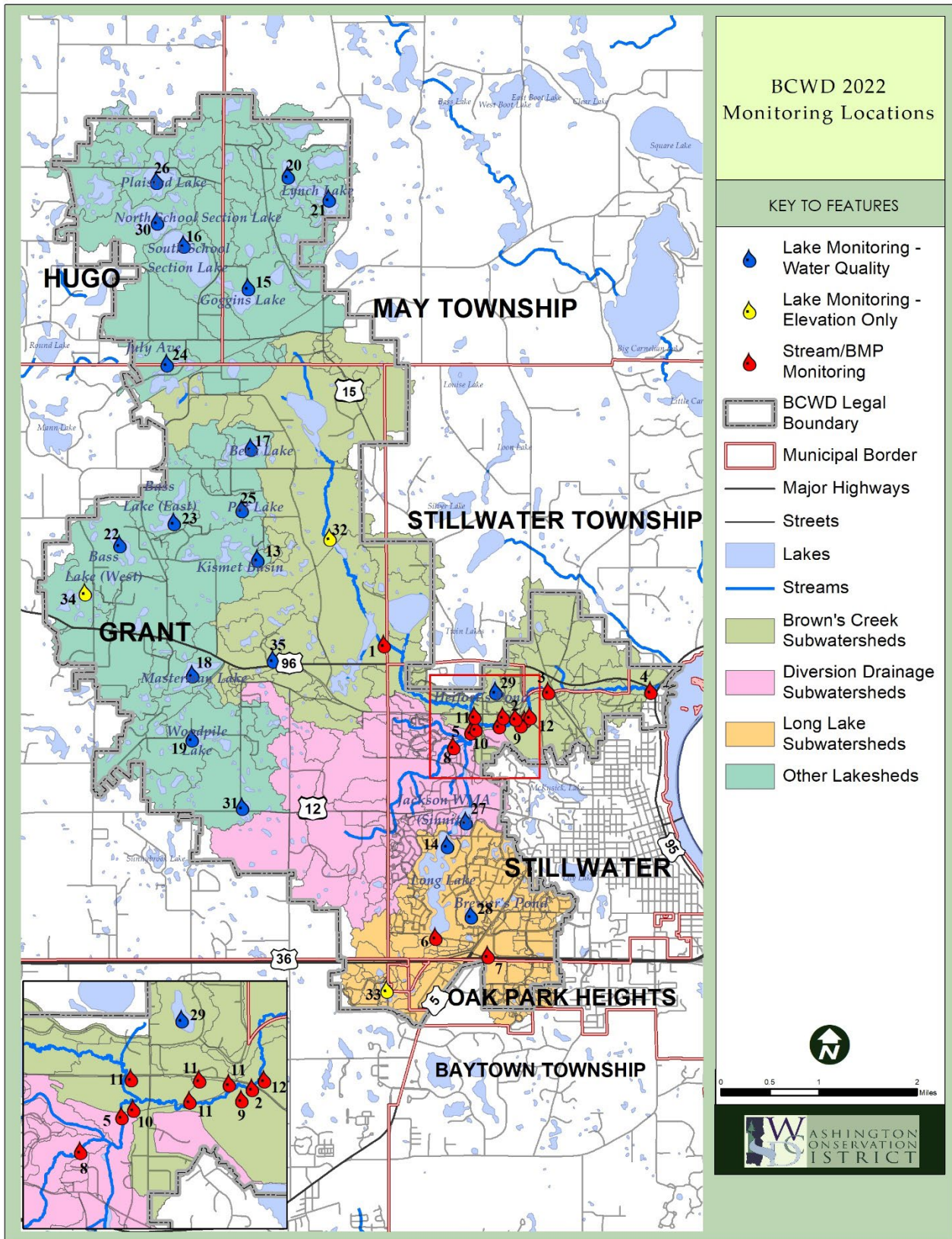


Figure 1. Brown's Creek Watershed District 2022 Sampling Locations

II. PURPOSE AND GOALS

BCWD uses a monitoring network to assess the quality of its water resources and maintains partnerships with the Minnesota Department of Natural Resources (MN DNR), Metropolitan Council, Washington Conservation District (WCD), Stillwater Area High School, and volunteers to collect and manage data. The general purpose of the baseline water monitoring program is to collect long term data to identify issues within the watershed and track changes towards meeting water quality goals described in the 2017-2026 Watershed Management Plan and the Brown's Creek TMDL Implementation Plan. The goals specific to this monitoring summary include the collection of useful data about the water resources of the District, production of an annual assessment of monitoring data, and the use of that data to determine the performance of District programs and regulations. Additional policies, goals, and implementation strategies related to monitoring data are more fully described in the watershed management plan.

III. LAKE MONITORING

III.A. Locations and Parameters

In 2022 water quality data were collected by the WCD on eighteen basins (lakes) (Table 1 and Figure 1). Each lake was sampled for total phosphorus (TP), total Kjeldahl nitrogen (TKN), chlorophyll- α , and Secchi disk transparency. A complete listing of nutrient and Secchi data by lake is available in Appendix A. One meter increment temperature and dissolved oxygen profiles as well as a user perception ranking (physical and recreational suitability) were also recorded. These data are available via request or on the Metropolitan Council's Environmental Information Management System (EIMS) Water Quality Database website (<https://eims.metc.state.mn.us>).

III.B. Methods

Each basin was sampled over seven consecutive months (April-October) using a two-meter (6.56 feet) integrated surface water column sampler from a watercraft, except for Brewer's Pond and Heifort's Pond, which were sampled from the surface only using a bucket to match citizen volunteer protocols. Bass Lake East, Bass Lake West, Benz Lake, Goggins Lake, Jackson WMA Pond, Kismet Basin, Long Lake, Lynch Lake South, Masterman Lake, Plaisted Lake, South School Section Lake, and Woodpile Lake were monitored bi-weekly, while Brewer's Pond, Heifort's Pond, July Avenue Wetland, Lynch Lake North, North School Section Lake, and Pat Lake were monitored every four weeks. Volunteers monitored Brewer's Pond and Heifort's Pond on an offset schedule with WCD so that samples were collected every other week. Chlorophyll- α samples were obtained by filtering water from the integrated sample through a 1.5 μm fiberglass filter using a hand pump. Samples collected for TP, TKN, and chlorophyll- α were analyzed by the Metropolitan Council Environmental Services Lab. The sampling methods above were developed by and consistent with Metropolitan Council's Citizen Assisted Monitoring Program (CAMP). Measurements obtained during the sampling season were averaged to allow comparison of individual lake dynamics from year to year. Trend analysis for

long term Secchi disk transparency, TP, and chlorophyll- α (corrected for pheophytin) trends were completed using a Kendall's Tau statistical test, presented in Appendix A, and only data collected by professional agencies were used to assess for trends. All other data were quality assured, quality controlled, and reviewed by WCD staff. Detailed standard operating procedures used by WCD for water sampling, monitoring, and data management are available on the WCD website (<https://www.mnwcd.org/water-monitoring>).

III.C. Results and Discussion

III.C.1. Lake Grades

The lake water quality grading system was developed following the 1989 sampling season by Metropolitan Council. This grading system ranks water quality characteristics by comparing summer averages to those of other lakes specific to the metro area. The grading curve represents percentile ranges for the May through September averages of total phosphorus concentration, uncorrected trichromatic chlorophyll- α concentration, and Secchi disk transparency for 119 lakes sampled from 1980 to 1988, and the ranges were re-confirmed in 2000 using more recent data. Percentile ranges for each parameter can be found in Table 2. A benefit of the lake grade system is that it was developed specifically for lakes in the metro area, and serves as a convenient way to compare water quality between lakes. Current grades for each lake can be found in Figure 2, and the latest ten years of grades for each lake can be found in Appendix A. In addition, comparison of June through September water quality averages (total phosphorus concentration, pheophytin-corrected chlorophyll- α , and Secchi disk transparency) will be made to state eutrophication standards for each lake as the Minnesota Pollution Control Agency (MPCA) uses this timeframe to assess impairment status. Beginning in 2019 volunteer data collected through the CAMP program on Brewer's Pond and Heifort's Pond were incorporated into lake grade and summer averages. June through September averages and impairment thresholds can be found in Table 3.

Table 2. Lake Grade Ranges

Grade	Percentile	TP ($\mu\text{g/L}$)	Chl- α ($\mu\text{g/L}$)	Secchi (m)
A	<10	<23	<10	>3.0
B	10 - 30	23-32	10-20	2.2-3.0
C	30-70	32-68	20-48	1.2-2.2
D	70-90	68-152	48-77	0.7-1.2
F	>90	>152	>77	<0.7

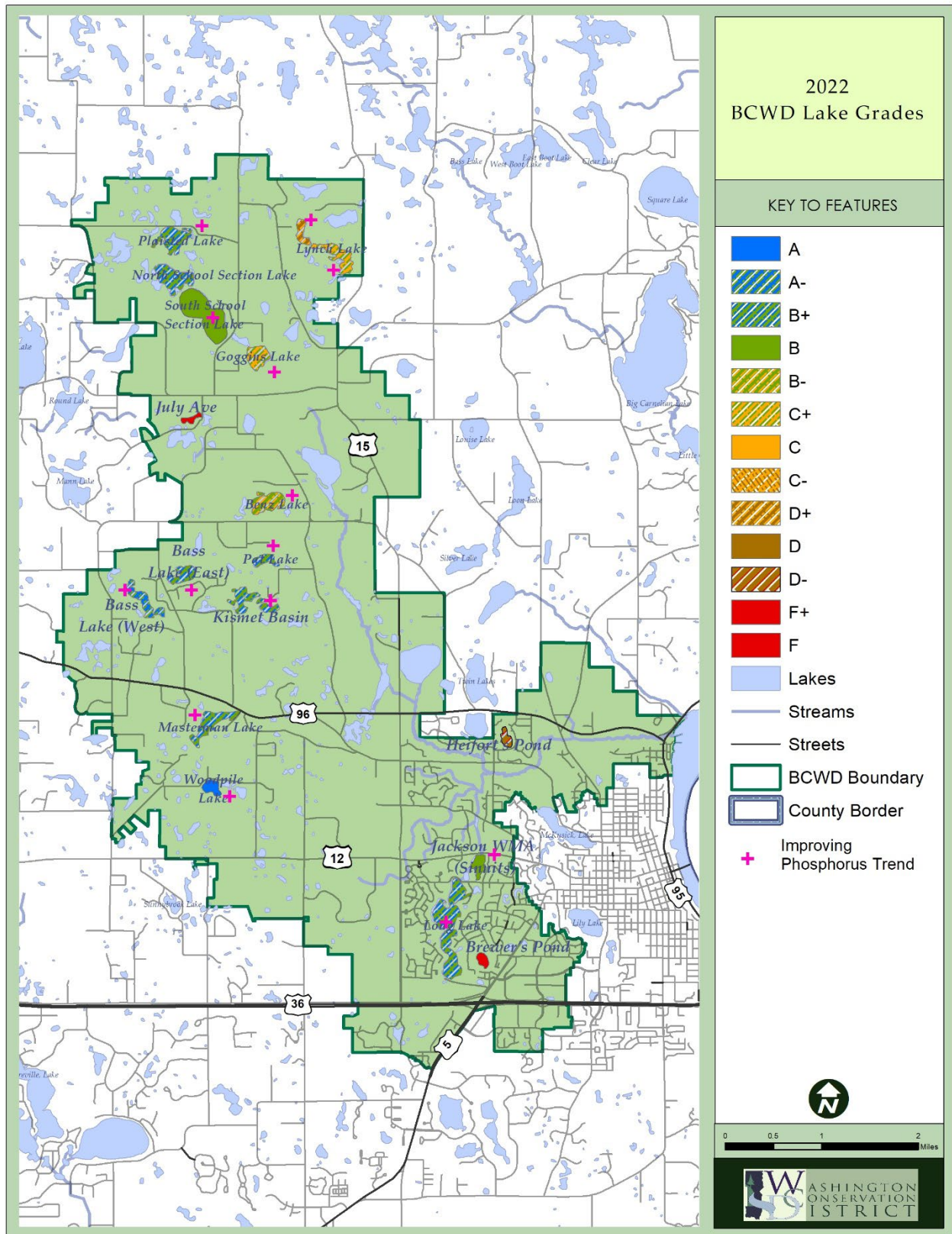


Figure 2. Brown's Creek Watershed District 2022 Lake Grades

Table 3. Impairment Thresholds and June Through September Average 2022 Parameters

Lake	Total Phosphorus (mg/L)	Pheophytin Corrected Chlorophyll- α (μ g/L)	Secchi (meters)	Total Kjeldahl Nitrogen (mg/L)
<i>Impairment Threshold- Shallow</i>	0.060	20.0	1.00	N/A
<i>Impairment Threshold- Deep</i>	0.040	14.0	1.40	N/A
Bass East	0.030	2.9	2.79	0.66
Bass West	0.023	5.2	2.79	0.62
Benz	0.028	3.2	1.12	0.57
Brewer's	0.090	94.9	0.31	3.31
Goggins	0.039	15.1	1.74	0.93
Heifort's	0.068	81.4	0.44	2.59
Jackson WMA	0.024	3.0	1.61	0.68
July Ave	0.197	128.3	0.23	4.35
Kismet	0.018	4.4	1.69	0.51
Long	0.025	3.6	2.68	0.71
Lynch North	0.070	36.5	0.72	1.38
Lynch South	0.037	14.4	1.71	0.91
Masterman	0.019	4.4	1.34	0.51
North School Section	0.027	8.9	2.51	0.73
Pat	0.030	7.3	2.17	0.70
Plaisted	0.021	4.0	2.00	0.51
South School Section*	0.034	18.8	2.24	0.85
Woodpile*	0.023	5.2	3.13	0.66
Exceeds impairment threshold				

*Indicates deep lake. All others are classified as shallow.

Lake grades slightly improved for most lakes in the District when compared to 2021. Four lakes experienced a decline in lake grade; Bass Lake East, Brewer’s Pond, July Avenue Wetland, and Plaisted Lake. Goggins Lake, Lynch Lake North, Lynch Lake South, Masterman Lake, South School Section Lake, and Woodpile Lake maintained their grade from the year prior, and all other lakes improved in lake grade. Conditions were similar to 2021 with warm temperatures and drought conditions, however the open water season started in mid-April for most waterbodies, which was likely a contributing factor to slight improvement in lake grades. An increased period of open water from early spring ice out can encourage algal growth, as seen in 2021.

The most notable shift in lake grade occurred on Long Lake with continued improvements in water quality from an F+ grade in 2016, to a B+ grade in 2022. This appears to be the result of lower chlorophyll- α concentrations and higher water clarity, which may be the product of a robust community of aquatic vegetation. South School Section Lake also continues to respond positively to treatments to remove curly-leaf pondweed. The lake was treated in 2017 and May of 2021, and has improved from a D+ grade in 2018 to a B grade in 2021-2022. The decline to a D+ grade in 2018 after the initial treatment was likely the result of a release in nutrients stored in the curly-leaf pondweed, before the remaining vegetative community recovered. Curly-leaf pondweed was also found in a small area of Goggins Lake near the connection between Goggins Lake and South School Section Lake. Goggins Lake was also treated for curly-leaf pondweed in 2021, but no significant changes in water quality have been observed.

III.C.2. Total Phosphorus

Phosphorus is a major nutrient involved in eutrophication and is generally associated with the growth of aquatic plants and algal blooms. Common sources of phosphorus include runoff from agricultural fields, livestock areas, urban areas, lakeshore lawns and improperly operating septic systems. In most lakes in this region, phosphorus is the least available nutrient; therefore, its abundance or scarcity controls the extent of algal growth. Algal growth in turn affects the clarity of the water and light penetration, and can control the extent of aquatic vegetation by shading out plants. The phosphorus flow path through the watershed can be found in Appendix C.

The state impairment threshold for total phosphorus (TP) is 0.060 mg/L in shallow lakes (generally greater than 50 acres and less than 15 feet deep, or more than 80% littoral area) and 0.040 mg/L in deeper lakes. In 2022 Brewer's Pond, Heifort's Pond, July Avenue Wetland, and Lynch Lake North summer average TP concentrations exceeded impairment standards (Table 3).

Trend analyses were completed on lakes where eight or more years, with at least six years occurring in the last ten years, of TP measurements had been collected to determine if lakes are improving, declining, or stable in terms of average summer TP. A two-tailed Kendall's Tau statistical test was completed using a p-value of <0.05 to determine statistical significance of the trend. Bass Lake East, Bass Lake West, Benz Lake, Goggins Lake, Jackson WMA Pond, Kismet Basin, Long Lake, Lynch Lake North, Lynch Lake South, Masterman Lake, Pat Lake, Plaisted Lake, South School Section Lake, and Woodpile Lake have improving trends for TP, meaning the average summer TP concentration is decreasing (Figure 2 and Appendix A). No statistically significant trend exists on July Avenue Wetland, and Brewer's Pond, Heifort's Pond, and North School Section Lake do not have enough years of data to calculate trends. South School Section Lake shifted from no trend in recent years to an improving TP trend starting in 2022. The Brown's Creek and Long Lake 2020 Trend Analysis completed by the District's engineer, Emmons & Oliver Resources, Inc. (EOR) also show an improving short term trend from 2011-2020, and a statistically significant improving trend over the long term, from 1995-2020, on Long Lake.

III.C.3. Chlorophyll- α

Chlorophyll- α is a photosynthetic compound found in algae and aquatic plants, and is a direct indicator of algal productivity. Lakes with high chlorophyll- α concentrations are often eutrophic or hypereutrophic. These lakes tend to have excessive algal growth, shading out rooted plants. Lakes with low chlorophyll- α concentrations can be mesotrophic or even oligotrophic, and tend to have more rooted plants to take up phosphorus, rather than phosphorus being used by algae within the water column which produces more chlorophyll- α .

The impairment threshold for chlorophyll- α is 20 $\mu\text{g/L}$ in shallow lakes and 14 $\mu\text{g/L}$ in deeper lakes. Brewer's Pond, Heifort's Pond, July Avenue Wetland, Lynch Lake North, and South

School Section Lake summer average concentrations exceeded the impairment threshold (Table 3).

Trend analyses were completed on lakes where eight or more years, with at least six years occurring in the last ten years, of chlorophyll- α measurements had been collected to determine if lakes are improving, declining, or stable in terms of algal productivity. A two-tailed Kendall's Tau statistical test was completed using a p-value of <0.05 to determine statistical significance of the trend. Bass Lake East, Benz Lake, Goggins Lake, Jackson WMA Pond, Kismet Basin, Long Lake, Lynch Lake North, Lynch Lake South, Masterman Lake, Pat Lake, Plaisted Lake, and Woodpile Lake show statistically significant long term trends for improving chlorophyll- α concentrations, meaning less algae is being produced (Appendix A). No statistically significant trends were present on Bass Lake West, July Avenue Wetland, or South School Section Lake. No lakes showed an increasing trend for chlorophyll- α concentration. There are not enough years of collected data to calculate trends on Brewer's Pond, Heifort's Pond, and North School Section Lake. EOR's trend analysis also shows a short term improving trend and a statistically significant long term improving trend on Long Lake.

III.C.4. Transparency

The measurement of depth of light penetration using a Secchi disk provides a simple measure of water transparency, or clarity. It can also serve as a proxy for turbidity in the water, as well as an indication of the trophic state of the lake. A reduction in water transparency is usually the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). Several lakes in the district, such as Benz Lake and Masterman Lake, are clearer than they are deep, meaning an accurate measure of transparency cannot be achieved because the disk rests on the lake bottom or is obscured by vegetation instead of reaching a depth where it is no longer visible. This can give the false appearance of low water clarity when considering average transparency, when in reality the true Secchi depth is much higher. Lakes which experience this phenomenon are noted in the summary points sections of Appendix A.

The impairment threshold for Secchi disk transparency is 1.00 meter in shallow lakes and 1.40 meters in deep lakes. Brewer's Pond, Heifort's Pond, July Avenue Wetland, and Lynch Lake North summer average transparencies were poorer than the state standard (Table 3).

Trend analyses were completed on lakes where eight or more years, with at least six years occurring in the last ten years, of Secchi disk measurements had been collected to determine if lakes are improving, declining, or stable in terms of average summer clarity. A two-tailed Kendall's Tau statistical test was completed using a p-value of <0.05 to determine statistical significance of the trend. Goggins Lake, Long Lake, Lynch Lake North, Lynch Lake South, and Woodpile Lake show statistically significant long term trends for improving water clarity (Appendix A). No significant trends have been observed on Pat Lake or South School Section

Lake. Bass Lake East, Bass Lake West, Benz Lake, Jackson WMA Pond, Kismet Basin, Masterman Lake, and Plaisted Lake are too shallow to determine an accurate trend, since the lakes are often clearer than they are deep. July Avenue Wetland is the only lake exhibiting a declining trend for clarity. There are not enough years of collected data to calculate trends on Brewer's Pond, Heifort's Pond, and North School Section Lake. EOR's trend analysis shows an improving short term trend and a statistically significant long term improving trend on Long Lake.

III.C.5. Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (TKN) measures the sum of ammonia and organic nitrogen present in the water column. An abundance of this nutrient can lead to excess plant growth and increase the rate of eutrophication, especially if it is the limiting nutrient in a lake. Sources of TKN are similar to those of TP. Although eutrophication standards do not exist at this time for TKN, June through September averages can be compared to the North Central Hardwood Forest ecoregion to assess if lakes may have excessive amounts of nitrogen. The ecoregion range for TKN is 0.60-1.20 mg/L. Brewer's Pond, Heifort's Pond, July Avenue Wetland, and Lynch Lake North were poorer than the ecoregion range, while Bass Lake East, Bass Lake West, Benz Lake, Goggins Lake, Jackson WMA Pond, Long Lake, Lynch Lake South, North School Section Lake, Pat Lake, South School Section Lake and Woodpile Lake were within the ecoregion range (Table 3). Kismet Basin, Masterman Lake, Plaisted Lake were better than the ecoregion range.

III.C.6. Temperature and Dissolved Oxygen

In addition to surface water measurements, temperature and dissolved oxygen data were recorded during each sampling event. Temperature and dissolved oxygen were recorded at one-meter increments from the surface to the lake bottom. The data collected from these profiles are housed by WCD and are available upon request, or are available via the MPCA website (<https://webapp.pca.state.mn.us/wqd/surface-water>).

These data show the extent of summer stratification and are useful in identifying the thermocline (the layer of water in which the temperature rapidly declines), if one exists. As a lake stratifies, the water column becomes more stable and mixing is less likely to occur. If mixing occurs during the growing season, benthic nutrients become available and can result in increased algal production. As a rule of thumb, shallow lakes are constantly mixed by wind, wave action, and precipitation, while lakes deeper than 20 feet often stratify. Shallow lakes can loosely stratify if they are protected from wind, during calm weather periods, or if enough algae and aquatic plants exist near the surface to block out solar radiation near the bottom.

In 2022 Bass Lake East, Long Lake, Lynch Lake South, Pat Lake, and Woodpile Lake stratified to some degree during the monitoring season. These lakes may have benefited from reduced internal loading due to the lack of mixing of nutrient-rich waters near the lake bottom. Details on

the depth of the thermocline for each lake that stratified can be found in Appendix A. The other thirteen lakes in the district did not significantly stratify in 2022, meaning nutrients from internal loading were available for algal growth during the entire growing season.

III.C.7. Elevations

Lake elevations throughout the watershed started high in 2022 due to snowmelt and spring precipitation events, but dropped rapidly throughout the monitoring season due to dry and drought conditions. Peak elevation for the year on nearly every lake occurred in April, after which water levels consistently dropped for the rest of the year, rising only briefly in late August. In 2020, twelve basins maintained elevations above their regulated Ordinary High Water (OHW) level. In contrast, only three basins were above their OHW by the end of the season in 2022; North School Section Lake, Plaisted Lake, and South School Section Lake. Goggins Lake, South School Section Lake, July Avenue Wetland, and an unnamed pond at County Road 12 and Kimbro Avenue had risen over ten feet from lows around 2010, and peaked in 2020 due to a series of wet years. By the end of the 2022 monitoring season these basins receded 4.92 feet, 3.94 feet, 7.84 feet, and 6.62 feet, respectively, since their recent peak, highlighting the impact of the drought. Also notable were the water level declines at Bass Lake East of 5.46 feet and Plaisted Lake of 3.79 feet since their peaks in 2020. Elevation charts for each lake monitored can be found in Appendix A or using the MN DNR’s Lake Finder (<http://www.dnr.state.mn.us/lakefind/index.html>).

III.C.8. Chloride

In 2022 two rounds of chloride samples were collected on twenty waterbodies in the District, with one sample collected in the spring and another in the fall. All chloride sample results were below the state chronic standard of 230 mg/L.

Table 4. Chloride Lake Sample Results 2022

Lake	Spring Chloride Result (mg/L)	Fall Chloride Result (mg/L)	Lake	Spring Chloride Result (mg/L)	Fall Chloride Result (mg/L)
Bass East	6.7	8.5	Lynch North	< 5.0	< 5.0
Bass West	8.7	8.3	Lynch South	< 5.0	< 5.0
Benz	11.1	13.2	Masterman	16.4	20.3
Brewer’s	23.8	30.3	North School Section	15.6	14.6
Goggins	14.4	15.7	Pat	< 5.0	< 5.0
Heifort’s	28.2	30.6	Plaisted	27.5	26.1
Jackson WMA (Sinnits)	101.0	152.0	South School Section	12.6	14.7
July Ave	8.9	9.5	Wood Pile	15.5	19.1
Kismet	8.1	8.0	12 & Kimbro Pond	40.1	45.3
Long	89.4	154.0	Highway 96 Wetland	38.2	52.7

IV. STREAM AND STORMWATER MONITORING

IV.A. Locations and Parameters

In 2022, BCWD monitored four stations on Brown's Creek, two stations in the Long Lake subwatershed, one station at the Diversion Structure in the diversion drainage, and one tributary to Brown's Creek (Table 1 and Figure 1). The stations on Brown's Creek were located at Manning Avenue (Highway 15), McKusick Road, Stonebridge Trail (Stonebridge), and the intersection of Minnesota State Highways 95 & 96 (the Outlet). The two tributaries to Long Lake were monitored at 62nd Street and the Marketplace Pond. The tributary to Brown's Creek (McKusick Wetland Outlet) was monitored approximately 100 feet upstream of the McKusick Road station.

The four stations on Brown's Creek were monitored for continuous (15 minute) stage and discharge, total phosphorus (TP), dissolved phosphorus, total Kjeldahl nitrogen (TKN), total suspended solids (TSS), volatile suspended solids (VSS), copper, nickel, lead, zinc, cadmium, chromium, chloride, calcium, magnesium, nitrate, nitrite, ammonia, hardness, and *Escherichia coli* (*E.coli*). These sites were also monitored for continuous temperature, dissolved oxygen, specific conductivity, and turbidity, and continuous pH at Stonebridge and the Outlet. The Outlet was additionally sampled for sulfate, alkalinity, and ortho-phosphorus. The Tributary to Long Lake at Marketplace Pond was monitored for continuous stage and discharge, TP, dissolved phosphorus, TKN, TSS, VSS, copper, nickel, lead, zinc, cadmium, chromium, chloride, calcium, magnesium, nitrate, nitrite, ammonia, and hardness. The Tributary to Long Lake at 62nd Street was monitored for continuous stage only. The station at the Diversion Structure was monitored for continuous stage and discharge, TP, dissolved phosphorus, TKN, TSS, VSS, copper, nickel, lead, zinc, cadmium, chromium, chloride, calcium, magnesium, nitrate, nitrite, ammonia, and hardness. An additional level logger was placed at the base of the diversion structure weir to determine if water overtopped it and was discharged directly to Brown's Creek. A tributary to Brown's Creek, McKusick Wetland Outlet, was monitored for continuous stage, discharge, and temperature, and TP, dissolved phosphorus, TKN, TSS, VSS, copper, nickel, lead, zinc, cadmium, chromium, chloride, calcium, magnesium, nitrate, nitrite, ammonia, *E.coli*, and hardness. Continuous precipitation was monitored at Highway 15 and the tributary to Long Lake at Marketplace Pond.

IV.B. Methods

The Highway 15, McKusick Road, Stonebridge, Outlet, Marketplace Pond, and Diversion Structure monitoring stations utilized automated water quality samplers consisting of a stage/velocity sensor, data logger, bottle carousel containing 24 sample bottles, strainer, intake tubing, solar panel, deep cycle marine battery, and steel enclosure. Discharge was calculated using a rating curve based on permanent staff gauges at Highway 15, McKusick Road, Stonebridge, and the Outlet, while discharge at Marketplace Pond and the Diversion Structure

was calculated using an area-velocity relationship. Continuous precipitation data were collected at Highway 15 and Marketplace Pond using tipping bucket rain gauges to assist in loading calculations, but are not discussed in this summary. The samplers were programmed to collect automated flow weighted storm composite samples triggered by a rise in stage. Manual grab samples were taken during storm conditions if it was determined the automated sampler had malfunctioned or had not yet been installed. Monthly manual grab samples during base flow conditions were attempted at these sites, although the Tributary to Long Lake at Marketplace Pond is often dry or stagnant during non-event periods. *E.coli* samples were collected at the time as the base grab samples when possible. Continuous temperature, dissolved oxygen, specific conductivity, and turbidity at the four stations on Brown's Creek were collected using long term deployed sondes, and secondary temperature loggers were deployed to fill data gaps created by malfunctions of the primary sonde. Sondes were also used to collect continuous pH at McKusick Road, Stonebridge and the Outlet.

It must be noted the sampling strategy at the Outlet, at the direction of Metropolitan Council Environmental Services's (MCES) Watershed Outlet Monitoring Program (WOMP), was changed to a manual grab sample on the same day every other week regardless of flow conditions, and the composite sampler was to be programmed to capture only major events. MCES installed a new data logger and refrigerated sampler in 2019, and four storm composite samples were collected in 2022. Some analytes such as metals, sulfate, ortho phosphorus, alkalinity, and hardness were changed to be analyzed quarterly. The goal of this strategy is to create a more robust dataset that is better suited for long term statistical trend analysis and impairment assessment. However, the change in sampling methods causes an apparent shift to lower nutrient loading totals due to differences in load calculation methods, as well as the timing of samples with respect to precipitation events. A limitation of grab sampling is the sample occurs at a discrete point in time and often misses the peak load which is most likely to occur on the rising limb or at the peak flow of a storm. This can lead to artificially low loading estimates, whereas composite sampling captures multiple samples throughout the storm and can provide more accurate data for loading calculations but is less appropriate for trend analysis due to bias and variation in each storm event.

The Tributary to Long Lake at 62nd Street station was monitored using a stage sensor only, and discharge during the monitoring period was estimated based on stage and discharge data collected in previous years. The McKusick Wetland Outlet station was monitored using a stage/velocity sensor, and discharge was calculated using an area-velocity relationship. Similar to other stations, monthly manual grab samples were collected during base flow conditions, and grab samples were attempted during storm events.

All samples collected were analyzed by the MCES Lab and reviewed by WCD staff. All continuous data were quality assured, quality controlled, and analyzed by WCD staff, with the

exception of the Outlet stage, discharge, and loading, which were reviewed and analyzed by MCES. More detailed standard operating procedures used by WCD and MCES for water sampling, monitoring, and data management are available online (<http://www.mnwcsd.org/water-quality-water-monitoring/> and <https://eims.metc.state.mn.us/Documents>).

IV.C. Results and Discussion

IV.C.1. Brown’s Creek

Brown’s Creek is classified as a 2A water by the State of Minnesota, meaning it is designated for aquatic life and recreation, and should support a cold water fishery, aquatic life, and their habitats. The creek is listed as impaired by the MPCA due to a lack of cold water fish assemblages and low scores for indices of biological integrity (IBI) as described in the 2010 Brown’s Creek Biota TMDL, and two reaches are impaired for *E.coli*. The stressors identified which contribute to these conditions are high total suspended solids (TSS), high temperature, low dissolved oxygen, high copper concentrations, and high nitrate-nitrite concentrations. The lower reaches of the creek where groundwater inputs help to cool the stream do support a trout fishery with some natural reproduction, and is annually stocked by the MN DNR. The following sections will make comparisons between the parameters monitored and state standards for 2A waters as described in the Minnesota Administrative Rules Part 7050.0222, as well as recommendations and goals set forth in the TMDL study. A summary of the standards and goals can be found in Table 5.

Table 5. State Standards for 2A and 2B Waters and Brown’s Creek Biota TMDL Goals

Parameter	Class 2A Waters	Class 2B Waters	TMDL Goal
Total Phosphorus (TP)	0.100 mg/L	0.100 mg/L	N/A
Total Suspended Solids (TSS)	10 mg/L (Apr 1 to Sept 30)	30 mg/L (Apr 1 to Sept 30)	23 mg/L (10 NTU equivalent)
Chloride (Chronic)	>230 mg/L	>230 mg/L	N/A
Dissolved Oxygen (Daily Minimum)	7 mg/L	5 mg/L	7 mg/L
pH	<6.5 or >8.5	<6.5 or >8.5	N/A
Temperature	N/A	N/A	18.3 °C (Threat), 23.9 °C (Critical)

1a. Discharge

Total discharge decreased from the year prior at each station on Brown’s Creek. The total amount of water discharged to the St. Croix River as measured at the Outlet was 220,440,000 cubic feet, and is the second lowest annual discharge over the last ten years. Calculated discharge for each site can be seen in Table 10. The Brown’s Creek and Long Lake 2020 Trend Analysis completed by EOR shows there is a statistically significant increasing trend in overall streamflow at all stations except the Outlet, after construction of the Diversion Structure. Base flow also shows a statistically significant increasing trend at all sites except the Outlet. Increased base flow is considered beneficial for cooling the stream and maintaining dissolved oxygen concentrations.

According to the National Weather Service (NWS) station in Stillwater the total precipitation for 2022 was 27.03 inches; 6.95 inches below the thirty year average. Precipitation was well below average in June, July, September, and October, during which only roughly one-quarter of average precipitation was recorded. Drought conditions persisted for much of the summer, reaching the severe drought classification by August, according to the U.S. Drought Monitor. Minor temporary drought relief came in August during a series of storm events. The most significant precipitation event occurred from August 27 to 29, where a storm total of 2.27 inches of precipitation was recorded.

1b. Phosphorus & Sediment

The total phosphorus (TP) and total suspended solids (TSS) loads decreased at all sites when compared to 2021 (Table 10, Figure 3, and Figure 4). The TP load discharged to the St. Croix River at the Outlet was 1,219 pounds, which equates to 0.264 pounds per acre of watershed land. For reference, the load at the Outlet was the second lowest since load calculations began in 2000. The state standard for TP is 0.100 mg/L; monthly manual grab samples exceeded the standard for sites during snowmelt and storms in March, and following storm events in June and July. Nutrient water chemistry results for each site and sample can be found in Table 6-Table 9. TP flow weighted mean concentrations show a significant decreasing trend over the most recent ten year period at Stonebridge and the Outlet according to EOR's trend analysis. There are no significant long term trends, although the overall pattern for TP concentrations appears to be improving in the lower reaches of the creek. Short term trends show statistically significant improving conditions at Stonebridge and the Outlet

The TSS load exported to the St. Croix River was 172,589 pounds, or 37.32 pounds per acre of watershed land. The TMDL goal for the creek is 74 pounds per acre, which was met for the second year in a row since 2010. It is important to note that similar to 2021, the drought conditions significantly influenced this value, and efforts to reduce storm loading rates should continue. While the state standard for TSS is 10 mg/L from April 1 to September 30, the target concentration identified in the TMDL is 23 mg/L. The target concentration specific to Brown's Creek of 23 mg/L correlates to the former state standard for turbidity of 10 NTU, but has since been replaced by the river eutrophication standards which use TSS concentration to assess impairment status. The state TSS standard was exceeded at Stonebridge in June, and at the Outlet in April, May, and July. The TMDL goal was met at all sites under base flow conditions. Site and sample specific results can be found in Table 6-Table 9. No statistically significant long term trends in TSS exist at any station according to EOR's trend analysis. However, the most recent ten year period does show significant trends for decreasing flow weighted mean concentrations for TSS at McKusick Road, Stonebridge, and the Outlet.

A summary of site specific total loads and loading per acre of watershed area can be found in Table 10 and detailed loading tables describing hourly intervals for the year can be found in Appendix B. Discrete measurements of dissolved oxygen, temperature, pH, specific conductivity, and transparency can also be found in Appendix B. TP concentrations and loads moving on flow paths through the watershed can be seen in Appendix C.

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Table 6. Brown's Creek at Highway 15 2022 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	<i>E. coli</i> (mpn/100 mL)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L CaCO3)
Snowmelt Grab	3/16/2022 14:11	3/16/2022 14:11	4	3	0.66	0.117	0.074		<0.00050	<0.00050	<0.00050	<0.00500	<0.00010	<0.00100	14.4	<0.06	1.03	0.18	161
Storm Composite	5/11/2022 22:10	5/12/2022 13:52	213	110	1.50	0.203	~0.049		0.00280	0.00110	0.00091	0.00780	0.00018	<0.00100	11.5	<0.06	<0.20	<0.06	84
Storm Composite	8/19/2022 5:32	8/20/2022 18:29	16	9	1.00	0.169	0.053		0.00130	0.00064	<0.00050	0.00590	0.00010	<0.00100	10.8	<0.06	0.23	<0.06	149
Storm Composite	8/29/2022 1:00	8/29/2022 9:14	18	12	1.20	0.148	0.082		0.00120	0.00069	0.00058	<0.00500	0.00015	<0.00100	10.5	<0.06	0.23	<0.06	156
Base Grab	5/6/2022 8:43	5/6/2022 8:43	<3	<3	0.44	~0.045	~0.036	22							19.8	<0.06	0.36	<0.06	
Base Grab	6/17/2022 8:30	6/17/2022 8:30	6	<6	0.59	0.160	0.053	291							13.5	<0.06	0.69	0.10	
Base Grab	7/8/2022 8:14	7/8/2022 8:14	4	<3	0.41	0.113	0.070	404							14.7	<0.06	0.99	<0.06	
Base Grab	7/27/2022 13:28	7/27/2022 13:28	9	5	0.48	0.106	0.092	228							14.2	<0.06	0.99	<0.06	
Base Grab	8/26/2022 8:15	8/26/2022 8:15	3	3	0.26	0.090	0.066	236							12.9	<0.06	1.05	<0.06	
Base Grab	9/12/2022 13:03	9/12/2022 13:03	3	<3	0.30	~0.047	<0.020	98							13.7	<0.06	1.02	<0.06	
Base Grab	10/13/2022 9:26	10/13/2022 9:26	5	3	0.31	0.051	~0.031	255							15.8	<0.06	0.90	<0.06	

Exceeds Water Quality Standard
 No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

Table 7. Brown's Creek at McKusick Road 2022 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	<i>E. coli</i> (mpn/100 mL)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L CaCO3)
Snowmelt Grab	3/16/2022 14:41	3/16/2022 14:41	17	8	1.50	0.273	0.140		0.00150	0.00071	<0.00050	<0.00500	<0.00010	<0.00100	38.8	<0.06	0.86	0.49	154
Storm Composite	5/11/2022 21:13	5/12/2022 2:02	153	42	6.40	0.897	0.062		0.00760	0.00570	0.00590	0.03160	0.00021	0.00690	19.5	<0.06	0.35	0.09	98
Storm Composite	8/18/2022 18:45	8/19/2022 4:47	331	75	2.60	0.530	0.109		0.00340	0.00300	0.00310	0.02240	0.00018	0.00430	23.2	<0.06	0.71	<0.06	176
Storm Composite	8/29/2022 0:30	8/29/2022 9:40	258	72	3.60	0.767	0.081		0.00540	0.00400	0.00420	0.01850	0.00012	0.00560	23.8	<0.06	0.30	<0.06	151
Base Grab	5/6/2022 9:16	5/6/2022 9:16	3	<3	0.54	~0.039	~0.042	22							24.7	<0.06	0.25	<0.06	
Base Grab	6/17/2022 8:58	6/17/2022 8:58	6	<6	0.50	0.129	0.057	614							21.5	<0.06	0.70	<0.06	
Base Grab	7/8/2022 9:03	7/8/2022 9:03	6	3	0.40	0.134	0.071	1,414							24.2	<0.06	0.88	<0.06	
Base Grab	7/27/2022 14:00	7/27/2022 14:00	4	<3	0.31	0.078	~0.046	387							22.7	<0.06	0.90	<0.06	
Base Grab	8/26/2022 9:03	8/26/2022 9:03	4	3	0.25	0.075	0.061	228							22.0	<0.06	0.90	<0.06	
Base Grab	9/12/2022 14:14	9/12/2022 14:14	3	<3	0.21	0.079	0.057	178							22.5	<0.06	0.88	<0.06	
Base Grab	10/13/2022 10:48	10/13/2022 10:48	<3	<3	0.22	0.050	~0.035	210							24.3	<0.06	0.78	<0.06	

Exceeds Water Quality Standard
 No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

Table 8. Brown’s Creek at Stonebridge 2022 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	<i>E. coli</i> (mpn/100 mL)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L CaCO3)
Snowmelt Grab	3/16/2022 14:57	3/16/2022 14:57	21	9	1.50	0.239	0.131		0.00170	0.00075	<0.00050	0.00300	<0.00010	<0.00100	36.9	<0.06	0.80	0.55	146
Storm Composite	5/11/2022 21:24	5/12/2022 2:43	339	94	4.60	0.771	-0.042		0.00730	0.00510	0.00490	0.02570	0.00017	0.00640	16.5	<0.06	0.37	0.10	94
Storm Composite	8/19/2022 19:49	8/20/2022 14:09	55	29	1.40	0.266	0.074		0.00140	0.00120	0.00083	0.00740	0.00014	0.00160	18.4	<0.06	0.22	<0.06	164
Storm Composite	8/29/2022 0:30	8/29/2022 10:08	247	79	3.40	0.678	0.083		0.00530	0.00380	0.00380	0.01790	0.00016	0.00510	20.5	<0.06	0.27	<0.06	135
Base Grab	5/6/2022 9:31	5/6/2022 9:31	3	<3	0.63	0.053	-0.032	15							26.8	<0.06	0.33	<0.06	
Base Grab	6/17/2022 9:18	6/17/2022 9:18	15	<6	0.60	0.145	0.061	250							21.7	<0.06	0.72	<0.06	217
Base Grab	7/8/2022 8:43	7/8/2022 8:43	7	4	0.38	0.106	0.070	1,553							23.7	<0.06	0.81	<0.06	
Base Grab	7/27/2022 14:11	7/27/2022 14:11	4	<3	0.39	0.081	0.050	387							22.9	<0.06	0.84	<0.06	
Base Grab	8/26/2022 8:38	8/26/2022 8:38	6	3	0.27	0.094	0.058	438							22.2	<0.06	0.93	<0.06	
Base Grab	9/12/2022 14:45	9/12/2022 14:45	3	<3	0.26	0.053	<0.020	99							24.0	<0.06	0.86	<0.06	
Base Grab	10/13/2022 11:28	10/13/2022 11:28	14	4	0.33	0.105	-0.040	219							48.9	<0.06	0.56	<0.06	

Exceeds Water Quality Standard
 No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

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Table 9. Brown's Creek Outlet 2022 Primary Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Sulfate (mg/L)	Ortho P (mg/L as P)	Alkalinity (mg/L_CaCO3)	E. coli (mpn/100 mL)
Scheduled Grab	1/4/2022 9:30	1/4/2022 9:30	3	~1	~0.14	~0.030	~0.027		0.023		1
Scheduled Grab	1/19/2022 12:05	1/19/2022 12:05	8	~2	0.22	~0.043	<0.020		0.020		2
Scheduled Grab	2/2/2022 11:53	2/2/2022 11:53	4	<3	0.34	0.054	0.050		0.031		4
Scheduled Grab	2/16/2022 11:02	2/16/2022 11:02	4	<3	<0.08	~0.042	<0.020		0.021		2
Scheduled Grab	3/2/2022 11:15	3/2/2022 11:15	3	<3	0.30	~0.041	~0.028	9.23	0.026	204	13
Scheduled Grab	3/16/2022 9:03	3/16/2022 9:03	9	3	0.90	0.106	0.077		0.066		365
Scheduled Grab	3/23/2022 10:50	3/23/2022 10:50	61	18	1.50	0.209	0.073		0.051		150
Scheduled Grab	3/30/2022 14:52	3/30/2022 14:52	8	3	0.51	0.066	~0.029		0.025		150
Scheduled Grab	4/13/2022 14:32	4/13/2022 14:32	14	5	0.66	0.096	~0.041		0.035		26
Scheduled Grab	4/25/2022 13:41	4/25/2022 13:41	8	3	0.50	0.059	~0.026		0.031		4
Scheduled Grab	5/10/2022 8:24	5/10/2022 8:24	8	3	0.48	0.066	~0.036		0.033		4
Storm Composite	5/11/2022 22:02	5/11/2022 23:43	170	33	7.30	1.370	~0.029				46
Scheduled Grab	5/25/2022 8:53	5/25/2022 8:53	19	6	<0.08	0.099	0.085		0.046		125
Scheduled Grab	6/7/2022 8:35	6/7/2022 8:35	10	5	0.52	0.110	0.052	6.24	0.049	195	84
Scheduled Grab	6/21/2022 15:15	6/21/2022 15:15	10	<3	0.28	0.107	0.063		0.057		276
Scheduled Grab	7/6/2022 14:09	7/6/2022 14:09	14	6	0.48	0.122	0.053		0.048		242
Scheduled Grab	7/20/2022 9:40	7/20/2022 9:40	5	<3	0.28	0.075	0.051		0.045		
Scheduled Grab	8/3/2022 10:00	8/3/2022 10:00	4	<3	0.20	0.069	0.051		0.062		345
Storm Composite	8/7/2022 22:32	8/8/2022 4:20	103	33	0.91	0.190	0.051				
Scheduled Grab	8/17/2022 9:40	8/17/2022 9:40	3	3	0.22	0.055	0.052		0.059		131
Storm Composite	8/19/2022 21:15	8/20/2022 7:03	32	13	1.10	0.189	0.095				
Storm Composite	8/27/2022 22:45	8/28/2022 0:29	159	52	2.10	0.528	0.074				
Scheduled Grab	9/2/2022 9:13	9/2/2022 9:13	5	<3	0.23	0.086	0.071	7.35	0.043	208	261
Scheduled Grab	9/14/2022 14:10	9/14/2022 14:10	3	<3	0.22	0.081	~0.048		0.038		111
Scheduled Grab	9/28/2022 9:41	9/28/2022 9:41	3	<3	~0.14	~0.044	~0.038		0.034		107
Scheduled Grab	10/12/2022 8:45	10/12/2022 8:45	3	<3	~0.18	~0.048	~0.031		0.035		46
Scheduled Grab	10/24/2022 11:18	10/24/2022 11:18	3	<3	~0.19	~0.028	~0.037		0.033		23
Scheduled Grab	11/8/2022 13:56	11/8/2022 13:56	3	<3	0.32	~0.043	~0.025		0.024		23
Scheduled Grab	11/22/2022 9:01	11/22/2022 9:01	<3	<3	~0.19	~0.027	~0.047		0.020		40
Scheduled Grab	12/7/2022 9:48	12/7/2022 9:48	<3	<3	~0.15	~0.043	~0.032	9.56	0.019	212	25
Snowmelt Grab	12/14/2022 11:28	12/14/2022 11:28	4	<3	0.22	~0.032	~0.023		0.027		
Scheduled Grab	12/27/2022 10:45	12/27/2022 10:45	5	<3	0.38	0.068	~0.021		0.020		12
	Exceeds Water Quality Standard										

Table 10. Brown's Creek Historic Loading- Latest Ten Years

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Brown's Creek at Highway 15										
Discharge (cf)	84,243,848	160,221,727	97,159,132	152,081,358	135,660,983	129,764,024	201,962,562	148,727,410	117,049,943	98,760,517
Total pounds of Phosphorus exported	658	1,210	1,450	1,736	831	1,182	1,406	1,072	690	567
TP (lbs/ac/yr)	0.186	0.343	0.410	0.492	0.235	0.335	0.398	0.303	0.195	0.161
Total pounds of TSS exported	37,105	245,954	211,364	239,237	105,900	132,765	136,203	128,722	46,409	59,093
TSS (lbs/ac/yr)	10.51	69.64	59.84	67.73	29.98	37.59	38.56	36.44	13.14	16.73
Brown's Creek at McKusick Road										
Discharge (cf)	119,479,669	282,264,777	152,913,065	229,482,654	192,485,489	179,429,476	340,391,004	234,134,803	196,267,817	163,409,449
Total pounds of Phosphorus exported	1,292	2,460	2,248	3,059	1,766	1,602	4,062	2,204	1,386	1,282
TP (lbs/ac/yr)	0.323	0.615	0.562	0.765	0.442	0.401	1.016	0.551	0.347	0.321
Total pounds of TSS exported	701,242	1,464,447	728,640	1,646,798	638,650	404,296	978,014	471,464	234,226	172,292
TSS (lbs/ac/yr)	175.35	366.20	182.21	411.80	159.70	101.10	244.56	117.90	58.57	43.08
Brown's Creek at Stonebridge										
Discharge (cf)	136,723,177	203,037,716	Not Calculated	224,138,246	232,701,338	225,604,711	368,848,809	235,850,584	192,272,282	168,072,167
Total pounds of Phosphorus exported	1,297	1,978	Not Calculated	2,778	2,229	1,946	3,948	2,186	1,556	1,363
TP (lbs/ac/yr)	0.310	0.472	Not Calculated	0.663	0.532	0.465	0.942	0.522	0.371	0.325
Total pounds of TSS exported	604,065	1,419,775	Not Calculated	1,187,547	718,290	515,386	825,635	437,876	256,270	241,966
TSS (lbs/ac/yr)	144.20	338.93	Not Calculated	283.49	171.47	123.03	197.10	104.53	61.18	57.76
Brown's Creek Outlet										
Discharge (cf)	202,719,259	303,513,260	241,784,443	284,583,206	278,020,037	267,105,859	447,411,048	386,269,467	249,448,143	220,440,000
Total pounds of Phosphorus exported	1,755	2,233	3,156	3,514	2,275*	2,315*	4,833*	4,289*	1,566*	1,219*
TP (lbs/ac/yr)	0.380	0.483	0.683	0.760	0.492	0.501	1.045	0.928	0.339	0.264
Total pounds of TSS exported	454,456	1,123,783	1,119,632	1,114,674	498,032*	400,729*	1,286,424*	1,137,017*	317,962*	172,589*
TSS (lbs/ac/yr)	98.28	243.03	242.13	241.06	107.71	86.66	278.21	245.89	68.76	37.32
*Sampling regime and load estimation method changed										

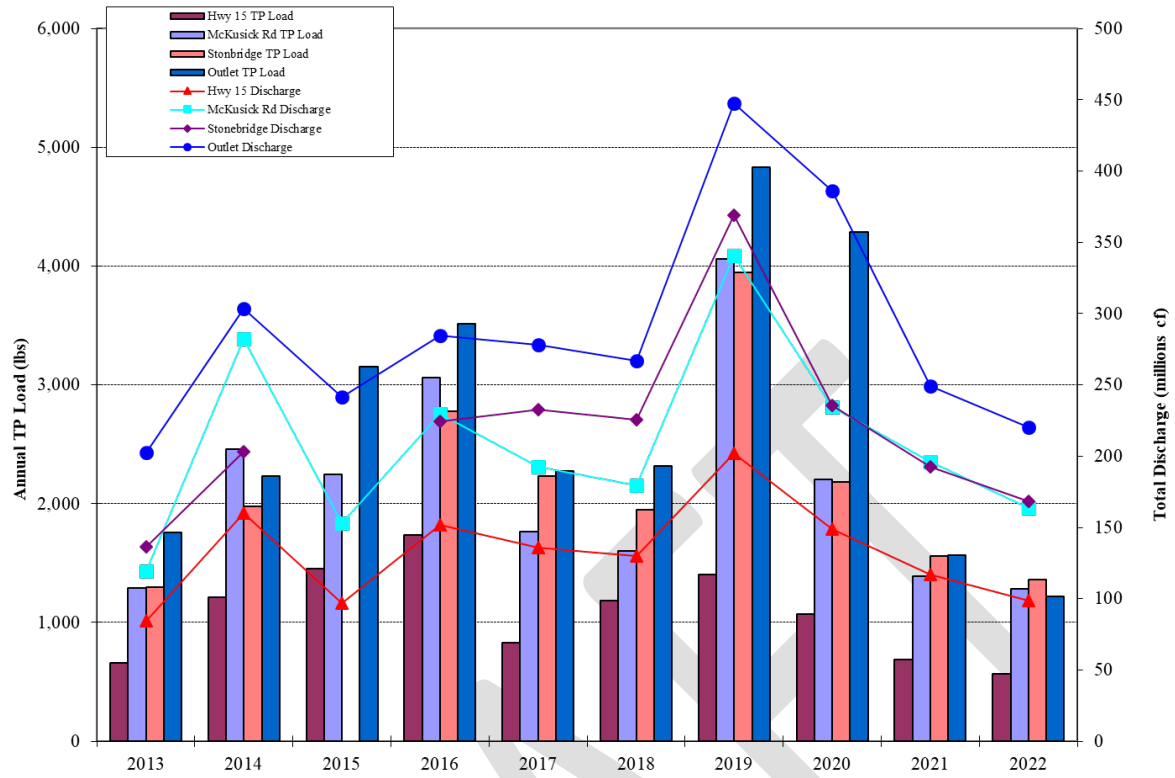


Figure 3. Brown's Creek Phosphorus Loading- Latest Ten Years

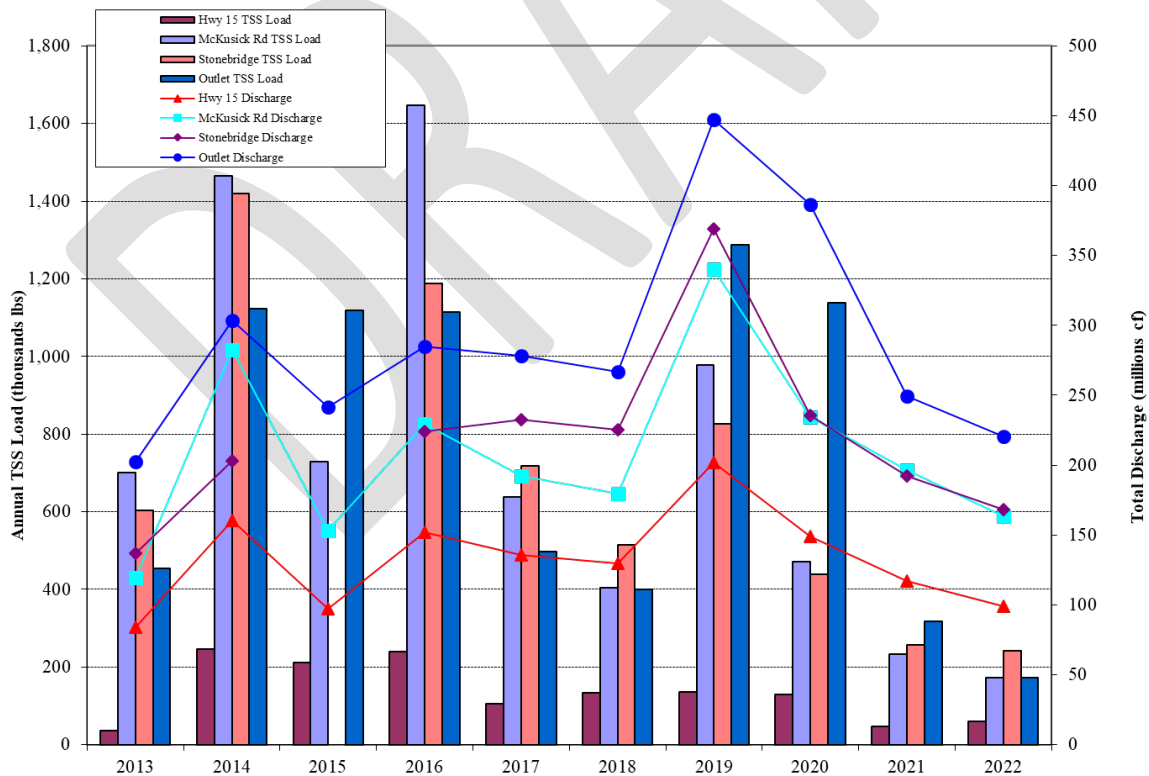


Figure 4. Brown's Creek Sediment Loading- Latest Ten Years

1c. Metals

One of the stressors identified in the TMDL study is high concentrations of copper, which are harmful to aquatic life. Additionally, other metals such as lead and zinc can be toxic to aquatic organisms. Standards for such metals are variable based on the hardness of the water which affects the level of toxicity a given concentration has. Under soft water conditions (low hardness) metals are more readily taken up by aquatic organisms, increasing the toxicity of the concentrations of metals in the water. Calculation of metals standards are described in the Minnesota Administrative Rules Part 7050.0222 and are divided into three categories of toxicity; chronic, maximum, and final acute value (FAV). The chronic standard protects organisms from long term exposure to a pollutant with minimal effects, the maximum standard from short term exposure with no or little mortality, and the FAV is the concentration at which mortality can be expected.

Heavy metals exceedances for each site and sample can be found in Table 6 through Table 8, and Table 11. No exceedances of any metal were detected at Highway 15. One chronic standard exceedance of lead was detected at McKusick Road, Stonebridge, and the Outlet during a storm event on May 11, and a chronic standard exceedance of copper was also recorded at the Outlet during the same event. The number and severity of metals exceedances in 2022 was very low compared to past years.

Chloride concentrations have not exceeded the state standard for chronic exposure of 230 mg/L, but the trend analysis completed by EOR shows there are statistically significant increasing loads for chloride at all monitoring stations. For reference, the highest chloride concentration recorded on the creek occurred at Stonebridge on October 13 at 48.9 mg/L. Unlike most other pollutants, chloride has no natural attenuation once it is in water, and there are no known cost-effective ways to treat water contaminated with chloride. The District should continue to investigate ways to promote reductions in salt use and smart salt management, especially for water softener and road de-icer applications.

Table 11. Brown’s Creek Outlet 2022 Secondary Chemistry Results

Sample Type	Start	End	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L CaCO3)
Scheduled Grab	1/4/2022 9:30	1/4/2022 9:30							31.2	<0.06	1.32	<0.06	
Scheduled Grab	1/19/2022 12:05	1/19/2022 12:05							32.5	<0.06	1.32	<0.06	
Scheduled Grab	2/2/2022 11:53	2/2/2022 11:53							29.3	<0.06	1.22	<0.06	
Scheduled Grab	2/16/2022 11:02	2/16/2022 11:02							27.0	<0.06	1.10	<0.06	
Scheduled Grab	3/2/2022 11:15	3/2/2022 11:15	0.00070	<0.00050	<0.00050	<0.00500	<0.00010	<0.00100	34.4	<0.06	1.26	<0.06	236
Scheduled Grab	3/16/2022 9:03	3/16/2022 9:03							33.1	<0.06	1.00	0.38	
Scheduled Grab	3/23/2022 10:50	3/23/2022 10:50							27.7	<0.06	0.36	0.33	
Scheduled Grab	3/30/2022 14:52	3/30/2022 14:52							27.7	<0.06	0.82	0.12	
Scheduled Grab	4/13/2022 14:32	4/13/2022 14:32							34.0	<0.06	0.56	0.07	
Scheduled Grab	4/25/2022 13:41	4/25/2022 13:41							22.2	<0.06	0.54	<0.06	
Scheduled Grab	5/10/2022 8:24	5/10/2022 8:24							26.7	<0.06	0.72	0.06	
Storm Composite	5/11/2022 22:02	5/11/2022 23:43	0.01670	0.01140	0.01100	0.07100	0.00040	0.01600	30.0	<0.06	0.40	0.23	148
Scheduled Grab	5/25/2022 8:53	5/25/2022 8:53							24.8	<0.06	0.23	<0.06	
Scheduled Grab	6/7/2022 8:35	6/7/2022 8:35	0.00053	0.00053	<0.00050	<0.00500	<0.00010	<0.00100	34.2	<0.06	0.91	<0.06	216
Scheduled Grab	6/21/2022 15:15	6/21/2022 15:15							28.0	<0.06	1.06	<0.06	
Scheduled Grab	7/6/2022 14:09	7/6/2022 14:09							29.1	<0.06	1.09	<0.06	
Scheduled Grab	7/20/2022 9:40	7/20/2022 9:40							32.0	<0.06	1.07	<0.06	
Scheduled Grab	8/3/2022 10:00	8/3/2022 10:00							32.8	<0.06	1.02	<0.06	
Storm Composite	8/7/2022 22:32	8/8/2022 4:20							25.2	<0.06	0.70	<0.06	
Scheduled Grab	8/17/2022 9:40	8/17/2022 9:40							28.3	<0.06	1.06	<0.06	
Storm Composite	8/19/2022 21:15	8/20/2022 7:03	<0.00100	0.00087	0.00071	0.02180	<0.00010	0.00130		<0.06	0.46	0.06	183
Storm Composite	8/27/2022 22:45	8/28/2022 0:29							20.6	<0.06	0.72	<0.06	
Scheduled Grab	9/2/2022 9:13	9/2/2022 9:13	<0.00050	<0.00050	<0.00050	<0.00500	<0.00010	<0.00100	28.6	<0.06	0.88	<0.06	232
Scheduled Grab	9/14/2022 14:10	9/14/2022 14:10							28.6	<0.06	0.96	<0.06	
Scheduled Grab	9/28/2022 9:41	9/28/2022 9:41							33.2	<0.06	1.02	<0.06	
Scheduled Grab	10/12/2022 8:45	10/12/2022 8:45							17.2	<0.06	1.03	<0.06	
Scheduled Grab	10/24/2022 11:18	10/24/2022 11:18							30.0	<0.06	0.78	<0.06	
Scheduled Grab	11/8/2022 13:56	11/8/2022 13:56							30.3	<0.06	0.99	<0.06	
Scheduled Grab	11/22/2022 9:01	11/22/2022 9:01							28.8	<0.06	1.37	<0.06	
Scheduled Grab	12/7/2022 9:48	12/7/2022 9:48	0.00610	0.00062	<0.00050	<0.00500	<0.00010	<0.00300	31.9	<0.06	1.28	<0.06	240
Snowmelt Grab	12/14/2022 11:28	12/14/2022 11:28							32.8	<0.06	1.07	<0.06	
Scheduled Grab	12/27/2022 10:45	12/27/2022 10:45							30.8	<0.06	1.16	<0.06	

No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

1d. Bacteria (*E.coli*)

The sites on Brown’s Creek are not meeting the state standard for *E.coli* for nearly all months regulated by the standard, and two reaches of the creek have been listed as impaired for bacteria. In 2022 samples collected at Stonebridge and the Outlet brought the geometric means below the standard for the month of May, which were previously above the standard. This was most likely due to cooler than average spring temperatures. A summary table by month and site can be found in Table 12. The standard is defined as follows, and is based on the latest ten years of data as per MPCA protocol:

“Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.”

Table 12. Monthly Geometric Means of *E.coli*- Latest Ten Years

Site	April	May	June	July	August	September	October
Highway 15	Insufficient Data	105	327	225	339	210	92
McKusick Road	Insufficient Data	129	542	528	308	219	73
Stonebridge	Insufficient Data	121	402	417	292	187	83
Brown's Creek Outlet	18	105	426	311	160	216	70
Diversion	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Trib at 62nd St	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
	Exceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month						
	10% of samples taken in the last 10 years exceed 1,260 #/100mL (Doesn't necessarily exceed geometric mean standard)						

Previous studies have excluded human borne *E.coli* as a significant source of bacteria, indicating failing septic systems and illegal straight pipes are not contributing to the high levels of bacteria. Likely sources of bacteria include large congregations of geese around the McKusick Road area, beavers and muskrat in the upper reaches of the creek, and nearby livestock operations. Further studies will focus on species of wildlife and livestock to determine sources of bacteria. The trend analysis completed by EOR has shown statistically significant long term trends for decreasing *E.coli* concentrations at McKusick Road and Stonebridge, and an increasing trend at the Outlet over the most recent ten year period.

1e. Temperature & Dissolved Oxygen

The 2010 Brown’s Creek Biota TMDL indicates a threat level temperature of 18.3 °C and a critical level temperature of 23.9 °C for trout survivability. The threat level impact as defined as physiological stress, reduced growth, and egg mortality. The critical level impact is defined as the point at which direct mortality can be expected. For the purposes of this summary, daily average temperatures are used to determine if impact levels have been reached.

Consistent with previous years, multi-parameter sondes were deployed at all four stations on the creek. Due to battery and logger malfunctions in years prior, secondary temperature loggers were deployed to minimize gaps in the temperature data created by the primary loggers. However, these gaps still exist in the dissolved oxygen period of record, as no secondary dissolved oxygen sensors were available.

The number of daily average threat level temperature exceedances in the creek in 2022, when excluding years with significant data gaps, was the lowest in the last ten years at all sites (Table 13). When excluding years with data gaps the number of threat level exceedances were the lowest recorded since continuous temperature monitoring began in 2006 at Highway 15 and Stonebridge, second lowest at McKusick Road, and third lowest at the Outlet. No daily average temperature at any site exceeded the critical level temperature. Cool groundwater inputs to the creek and increased base flow due to plentiful groundwater recharge from the recent wet years help regulate water temperatures even when air temperatures swelter. According to the NWS station in Stillwater air temperatures were in excess of 90 °F eight days of the season.

A Riparian Shading Study was completed in 2018 and describes the relationship of thermal loading via solar radiation and shade producing objects along the stream corridor. The study identified the least shaded (less than 60% shaded) reaches of the creek as immediately downstream of Highway 15, immediately west of Millbrook Park, a reach between Millbrook Park and McKusick Road, and the reach flowing through Oak Glen Golf Course north of McKusick Road. This study and the increase in the number of threat level temperature exceedances moving downstream from McKusick Road to Stonebridge indicate the buffer strip installations within the golf course have not reached full maturity. They are expected to provide up to 80% shade coverage when the final growth is achieved, but the District should continue to seek opportunities to improve stream shading in all areas identified by the study. The full Riparian Shading Study report is available on the District's website.

The cool temperatures recorded in 2022 are likely due to a combination of factors including plentiful groundwater recharge from wet years in the late 2010's, a colder than average spring, and restoration efforts in the watershed. It is especially encouraging that despite low flows and drought conditions, temperature regimes were some of the best ever recorded in terms of trout survival. This may also indicate thermal load reduction practices including riparian shade restorations, the Brown's Creek Park Rock Crib, and surface water diversions such as the Diversion Drainage and the Oak Glen Golf Course Irrigation Reuse projects are beginning to positively impact the creek.

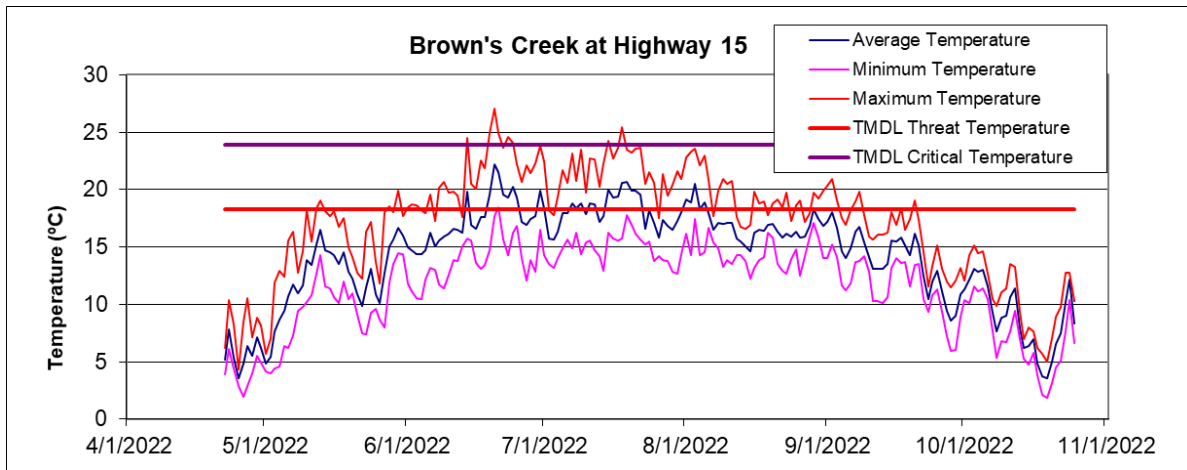


Figure 5. Brown's Creek at Highway 15 2022 Daily Temperature Summary

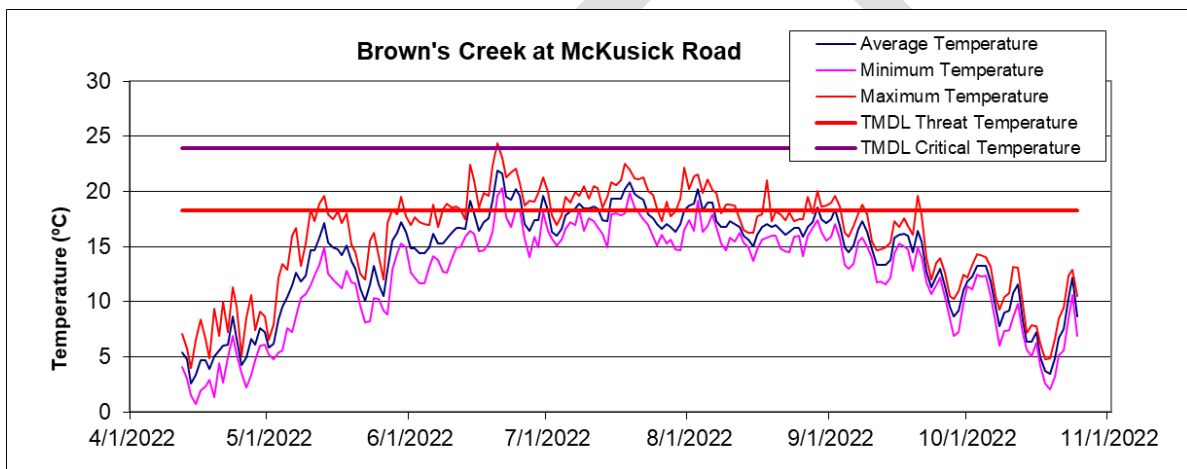


Figure 6. Brown's Creek at McKusick Road 2022 Daily Temperature Summary

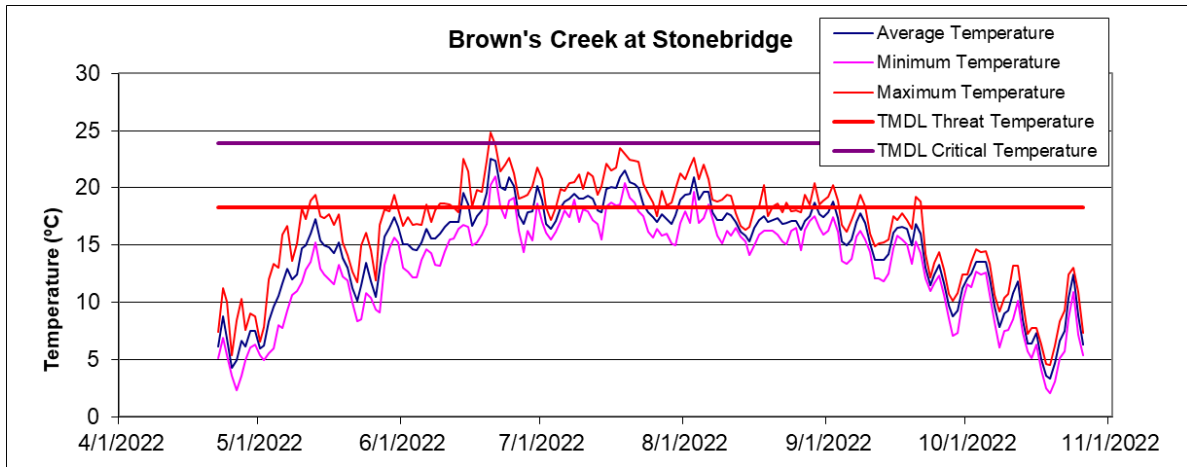


Figure 7. Brown's Creek at Stonebridge 2022 Daily Temperature Summary

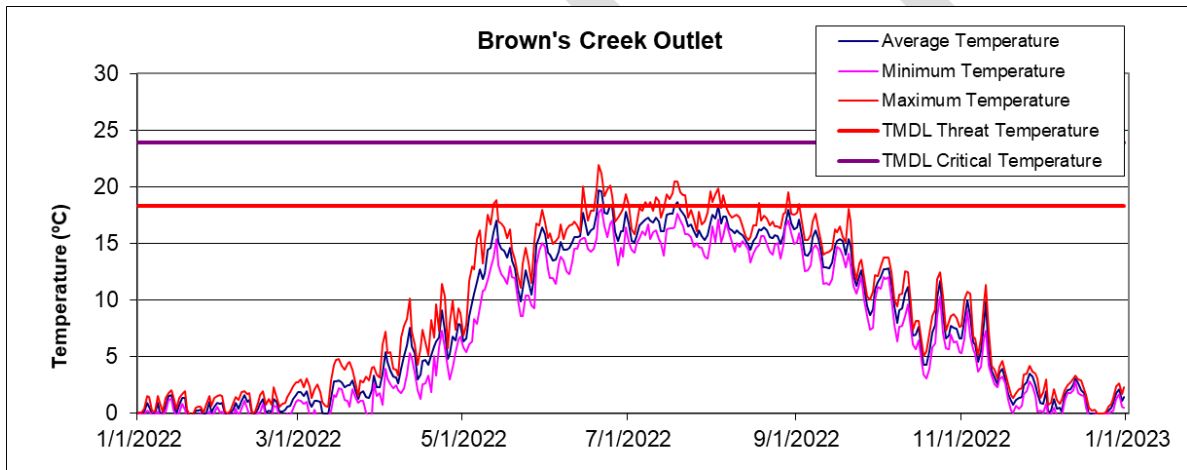


Figure 8. Brown's Creek Outlet 2022 Daily Temperature Summary

Table 13. Annual Occurrences of Brown's Creek Daily Average Temperature Greater than Threat and Critical Level Thresholds

Year	Exceedances at Highway 15		Exceedances at McKusick		Exceedances at Stonebridge		Exceedances at Outlet	
	18.3°C	23.9°C	18.3°C	23.9°C	18.3°C	23.9°C	18.3°C	23.9°C
2013	69	3	57	1	62	1	25	0
2014	54	0	46	0	59	0	17	0
2015	28*	0*	65	0	26*	0*	22	0
2016	14*	0*	17*	0*	71	0	35	0
2017	54	0	43	0	48	0	8	0
2018	61	0	54	0	66	0	19	0
2019	31	0	36	0	42	0	20	0
2020	38	0	42	0	48	0	23	0
2021	47	0	39	0	54	0	11	0
2022	28	0	31	0	37	0	6	0

* Based on severely limited period of record

The state standard for dissolved oxygen in 2A waters is 7 mg/L as a daily minimum. Logger malfunctions were minimal except at all sites except for McKusick Road, when the dissolved oxygen sensor failed August 1, and was not able to be replaced until September 9. Oxygen concentrations at Highway 15 were below the state standard 51% of the days monitored, and are unsuitable for trout survival (Table 14, Figure 9). The data collected show daily swings high above 7 mg/L at Highway 15 due to intense macrophyte growth, but drops well below the threshold at night.

Dissolved oxygen levels at McKusick Road tended to be higher than previous years likely due to cool groundwater contributions and stream shading, and the only times oxygen levels dropped below the standard were short periods immediately following major storm events. The redirection of warm, oxygen poor water inputs from McKusick Wetland Outlet to be used for the Oak Glen Golf Course Irrigation Reuse project also may have positively impacted conditions at McKusick Road, as the number of days below the standard in 2022 was the lowest ever recorded for the second year in a row. The data collected at the McKusick Wetland Outlet site are discussed later in this summary.

Stonebridge continues to exhibit better conditions for trout survival, with none of the days monitored below the standard. However, temperatures at Stonebridge were above the threat level threshold six days more than McKusick Road, indicating a slightly higher level of temperature stress as the creek flows through the golf course (Table 13 and Figure 7). Increased shading in the Oak Glen Golf Course buffer area will help to cool the water between the McKusick Road and Stonebridge sites, as well as increase oxygen levels.

Table 14. Daily Minimum Dissolved Oxygen Exceedances

Site	Days Monitored	Dissolved Oxygen Daily Minimum Below 7 mg/L	Percent of Days Exceeded	Record Completeness
Highway 15	187	95	50.8%	99.5%
McKusick Road	116	3	2.6%	61.7%
Stonebridge	188	0	0.0%	100.0%
Outlet	188	0	0.0%	100.0%

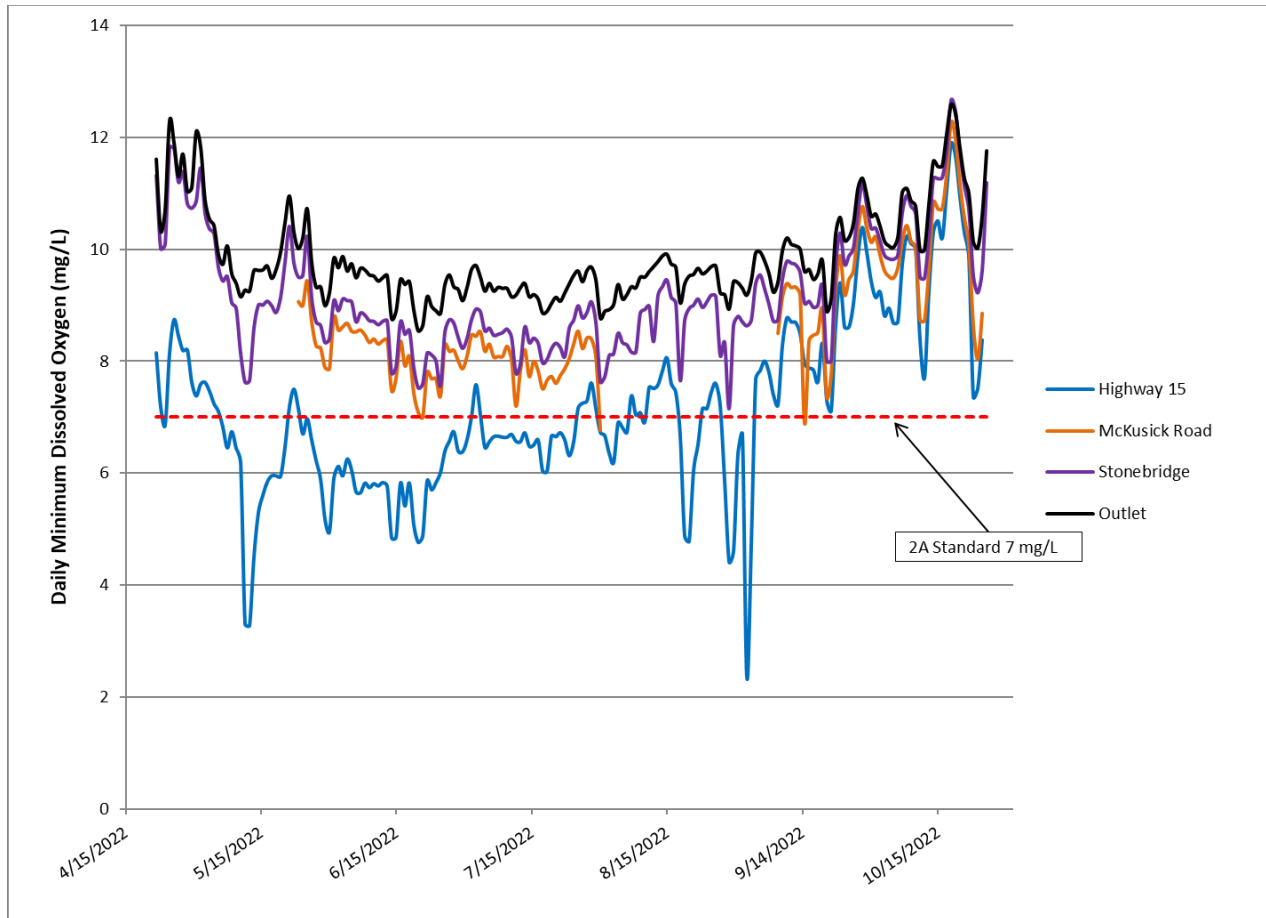


Figure 9. Daily Minimum Dissolved Oxygen in Brown's Creek

The Outlet continues to be the best location on Brown's Creek for trout survival. The average daily temperature exceeded the threat level threshold only six days during the season (Table 13). This is due to cold groundwater inputs in the gorge upstream of the Outlet and a robust tree canopy to shade the stream. Daily minimum oxygen concentrations were suitable for trout for the entire season (Figure 9 and Appendix B).

The trend analysis completed by EOR shows there is a statistically significant long term cooling trend at the Outlet, and a long term cooling pattern at Stonebridge that is not statistically significant. The study also shows a long term statistically significant warming trend at McKusick Road. Dissolved oxygen concentrations show no statistically significant trends at any site, except the Outlet since construction of the Diversion Structure.

1f. Turbidity & Specific Conductivity

Turbidity and specific conductivity can be helpful for determining the amount of particles and dissolved materials in a stream. Turbidity measures the amount of light scattered by particles such as suspended sediment, phytoplankton, and bacteria while specific conductivity measures electrical conductance of the water and is influenced by the amount

of dissolved ions in the water. Excess turbidity can be detrimental to trout, since they are primarily sight feeders. It also typically indicates a high sediment load which can clog gills and cover spawning areas.

Continuous turbidity and specific conductivity were monitored at all four stations on Brown’s Creek. Turbidity sensors on the multi-parameter sondes have the tendency to be covered by bedload sediment during storm events and can be fouled by algae growth on the sensor itself, and as such gaps in the record exist at some sites. To account for fouling continuous turbidity data were converted to a daily average where at least three quarters of a day was successfully logged for comparison to a 10 NTU threshold which correlates to the TMDL goal of 23 mg/L of TSS. Specific conductivity data are not discussed in this report as they do not directly apply to state standards or TMDL goals, but are available upon request. Turbidity data is also used to evaluate sediment and nutrient loading in the creek. A summary of days successfully monitored for turbidity at each site can be found in Table 15 and average daily turbidity can be viewed in Figure 10.

Table 15. Brown’s Creek Turbidity Standard Exceedances

Site	Days Monitored	Days Over 10 NTU	Percent of Days Exceeded	Record Completeness
Highway 15	188	1	0.5%	99.5%
McKusick Road	132	9	6.8%	69.8%
Stonebridge	189	5	2.6%	100.0%
Outlet	189	15	7.9%	100.0%

It is worth noting the creek tends to meet the 10 NTU goal during nearly all periods of base flow, indicating the majority of sediment and other sources of turbidity are being contributed during storm events (Figure 10). The percent of days monitored over the 10 NTU goal were the some of the lowest recorded since continuous turbidity monitoring began in 2015 and 2016. The highest daily average turbidity at Highway 15, McKusick Road, Stonebridge, and the Outlet were recorded during storms on May 11 (14 NTU), August 18 (28 NTU), May 12 (24 NTU), and August 29 (33 NTU), respectively.

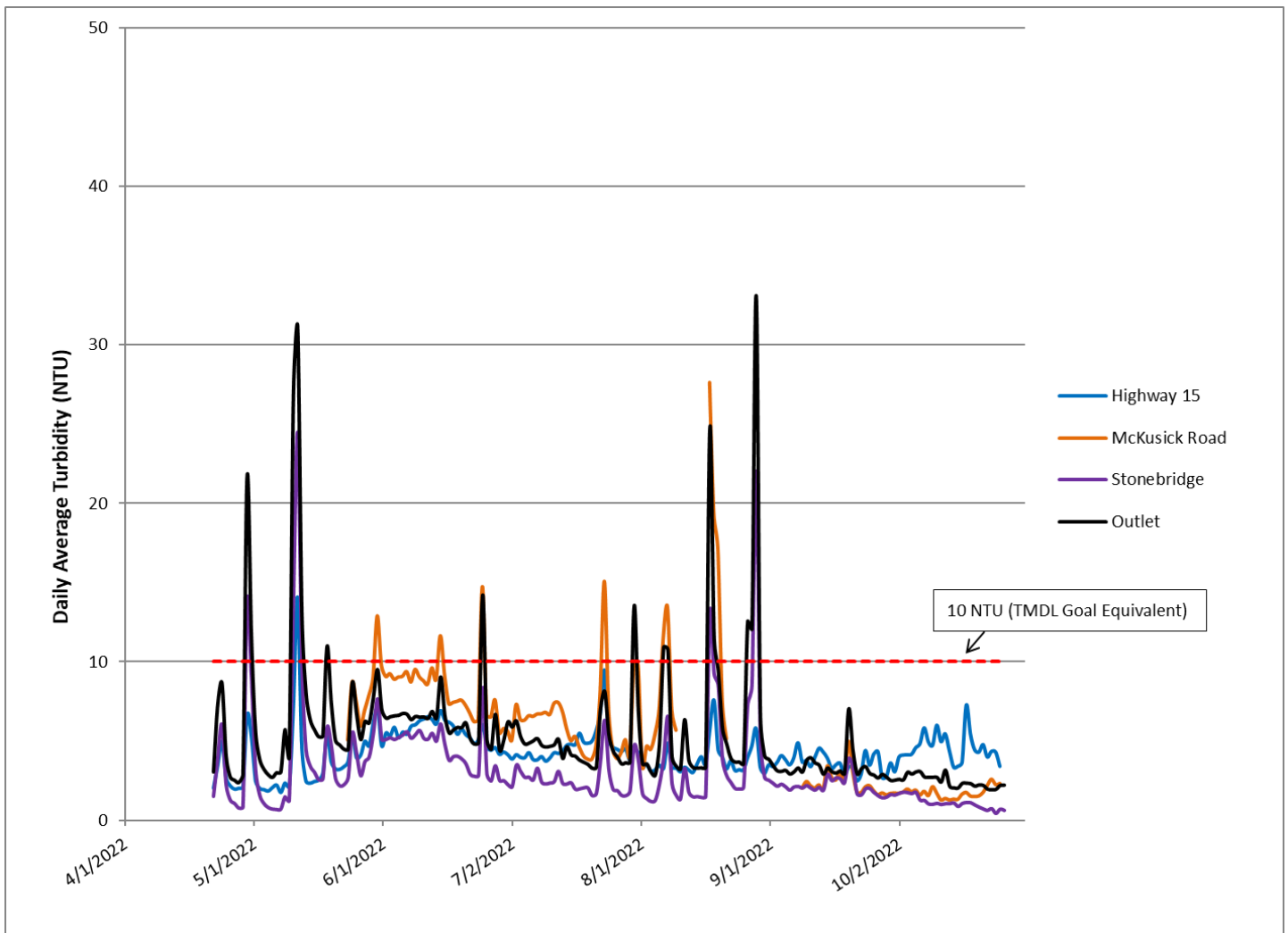


Figure 10. Brown's Creek Daily Average Turbidity

1g. Fisheries & Aquatic Invasive Species

Brown's Creek currently supports a brown and rainbow trout fishery dependent upon stocking in the lower reaches of the creek. Brown trout have been shown to have a limited amount of natural reproduction, and rainbow trout rely on stocking efforts. In 2020 the MN DNR switched from stocking brown trout to rainbow trout because they are easier to produce, grow larger and faster, and are stocked at a size that provides better recreational opportunity to anglers. Additionally, neither species is native to Minnesota, but they are considered naturalized and non-deleterious, and provide ecosystem and recreational benefits where native brook trout cannot survive. MN DNR has a management plan to stock 1,000 yearling rainbows at the Outlet annually. Stillwater Area High School (SAHS) and the Minnesota Trout Unlimited – Trout in the Classroom program also reared and stocked several hundred fingerling rainbow trout into the stream.

Fish and macroinvertebrate sampling conducted by the District's engineer and SAHS have identified many varieties of organisms present in the creek that need high quality, well oxygenated water to survive, such as rainbow darters. Results of fish and macroinvertebrate samplings can be found on the District's website or are available upon request.

Field staff continue to observe heavy growth of invasive curly-leaf pondweed in the upper reaches of the creek at Highway 15 and above McKusick Road. Dense mats of vegetation can alter flow rates, nutrient transport in the stream, hinder efforts to make stream improvements by slowing the water, and create conditions for warmer temperatures and increased sediment deposition on potential spawning areas. The BCWD should continue to work with partners to limit or prevent or manage the spread of curly-leaf pondweed downstream.

IV.C.2. Diversion Drainage

The Trout Stream Mitigation Project (TSMP), also known as the Diversion Structure, has been functioning since 2003 to divert warm water flows away from Brown's Creek through McKusick Lake to the St. Croix River (Table 1 and Figure 1). Diverting the water away from the creek protects it from additional thermal and sediment loads, improving conditions for trout and other cold water organisms. However, the water diverted away from the creek impacts its receiving waters: McKusick Lake and the wetland complex at the inlet to the lake. Therefore, monitoring is important to determine the load of pollutants discharged to the lake.

2a. Discharge

Discharge decreased from the year prior to 41,610,620 cubic feet exported to McKusick Lake, due to a second consecutive year of drought (Table 17). This volume of water is below the ten year average of roughly 57 million cubic feet. No water overtopped the Diversion Structure in 2022. The structure was designed to divert events up to the 1.5-year storm event under fully developed conditions. Since 2014 there have been five known events during which water has overtopped the structure and discharged directly to Brown's Creek, ranging from a few hours to a half-day. Although noteworthy, the volume of direct discharges has been minimal and have only occurred during major storm events, and likely have little impact on thermal and nutrient loads in the creek when the creek is already high with runoff. More importantly, the structure diverts the significantly warmer base flow and all moderate and minor events in the drainage away from the creek, reducing thermal loads to Brown's Creek.

2b. Phosphorus & Sediment

The TP load to McKusick Lake was 389 pounds, or 0.101 pounds of phosphorus per acre of watershed land (Table 17). The TP load was the third lowest since load calculations began in 2006. Water flowing through the site met the 2B phosphorus standard at base

flow for all but one sample, while storm event concentrations tended to be much higher (Table 16). However, the trend analysis study shows significant increasing concentrations of TP over both the short and long term in the drainage.

The TSS load was 75,429 pounds of sediment, equating to 19.57 pounds per acre of watershed land (Table 17). The state standard for 2B waters is 30 mg/L of TSS from April 1 to September 30. Water flowing through the site during this period met the standard during base flow conditions, and storm concentrations were much lower than previous years when concentrations sometimes exceeded 2,000 mg/L (Table 16). The TSS load was the second lowest recorded since calculations began in 2006. No significant trends exist for TSS in the drainage, although the overall pattern over the period of record appears to show increasing TSS concentrations.

A source of TP and TSS loading in the drainage are a number of erosional head cuts on the tributary branches of the creek, causing the tributaries to cut deeper into the stream bed and disconnect them from their floodplains. Erosion and channel incision was further aggravated by a cycle of above average precipitation in recent years. The District has worked since 2018 to repair head cuts and increase floodplain connectivity through the installation of rock vanes. The practices are estimated to reduce the TP load by 76 pounds per year, and the sediment load by 70 tons per year. Additionally, a beaver dam was noted immediately upstream of the monitoring site in August of 2022. The dam has further increased floodplain connectivity and settling of nutrients while improving habitat, and a resulting reduction in TP and TSS loads is likely reflected in the annual load. Due to these considerations the District opted to leave the dam in place. The Iron Enhanced Sand Filter (IESF) upstream of the monitoring site also continues to operate to reduce TP loads in the drainage. Monitoring data from the IESF is analyzed by EOR and summarized in an annual maintenance memo for the sand filter.

Table 16. Brown's Creek Diversion 2022 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L CaCO3)
Snowmelt Grab	3/16/2022 14:31	3/16/2022 14:31	30	9	1.40	0.215	0.107	0.00180	0.00120	0.00073	0.00360	<0.00010	<0.00100	81.2	<0.06	0.45	0.37	125
Storm Composite	5/11/2022 21:27	5/12/2022 8:08	176	45	3.00	0.517	0.097	0.00820	0.00530	0.00400	0.01940	0.00023	0.00500	44.0	<0.06	0.54	0.21	84
Storm Composite	8/18/2022 18:46	8/19/2022 8:26	301	87	2.90	0.793	0.115	0.00570	0.00630	0.00530	0.02340	0.00018	0.00630	43.7	<0.06	0.50	0.06	204
Storm Composite	8/29/2022 1:16	8/29/2022 9:42	132	40	2.10	0.474	0.093	0.00410	0.00370	0.00210	0.01210	0.00012	0.00320	36.0	<0.06	0.28	<0.06	115
Base Grab	5/6/2022 9:00	5/6/2022 9:00	3	<3	0.64	0.074	~0.025	<0.00050	<0.00050	<0.00050	<0.00500	<0.00010	<0.00100	93.9	<0.06	<0.20	<0.06	87
Base Grab	6/17/2022 8:47	6/17/2022 8:47	4	<3	0.63	0.092	~0.039	0.00050	0.00069	<0.00050	<0.00500	<0.00010	<0.00100	92.8	<0.06	0.29	0.06	171
Base Grab	7/8/2022 9:22	7/8/2022 9:22	16	5	0.56	0.158	0.068	0.00068	0.00098	<0.00050	<0.00500	<0.00010	<0.00100	50.8	<0.06	0.64	0.06	268
Base Grab	7/27/2022 13:52	7/27/2022 13:52	7	<3	0.33	0.089	~0.048	<0.00050	0.00061	<0.00050	<0.00500	<0.00010	<0.00100	43.9	<0.06	0.75	<0.06	268
Base Grab	8/25/2022 14:33	8/25/2022 14:33	7	3	0.37	0.096	0.070	<0.00050	0.00140	<0.00050	<0.00500	<0.00010	<0.00100	49.2	<0.06	0.72	<0.06	273
Base Grab	9/12/2022 13:50	9/12/2022 13:50	12	4	0.36	0.066	0.067	<0.00050	0.00074	<0.00050	<0.00500	<0.00010	<0.00100	46.6	<0.06	0.65	0.07	259
Base Grab	10/13/2022 9:58	10/13/2022 9:58	3	<3	0.25	0.052	~0.039	<0.00050	0.00095	<0.00050	<0.00500	<0.00010	<0.00100	23.5	<0.06	0.73	<0.06	235

Exceeds Water Quality Standard
 No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

Table 17. Brown's Creek Diversion Historic Loading- Latest Ten Years

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Brown's Creek Diversion Structure										
Discharge (cf)	46,435,271	53,519,017	46,276,327	70,780,581	39,625,672	45,453,990	112,468,888	68,165,935	46,792,341	41,610,620
Total pounds of Phosphorus exported	527	392	1,837	1,574	784	964	3,598	760	446	389
TP (lbs/ac/yr)	0.137	0.102	0.447	0.408	0.203	0.250	0.933	0.197	0.116	0.101
Total pounds of TSS exported	211,977	99,532	1,008,346	1,533,496	596,382	505,314	2,707,186	246,238	401,069	75,429
TSS (lbs/ac/yr)	54.99	25.82	261.57	397.79	154.70	131.08	702.25	63.87	104.01	19.57

2c. Metals

Heavy metals exceedances at the Diversion site can be seen in Table 16. The export of water high in metals to McKusick Lake and its wetland complex are particularly concerning due to the potential to destroy aquatic life in a short period of time, as opposed to nutrient or sediment loading which typically degrades habitat and populations of aquatic life over time. The chronic standard for lead was exceeded once, and no other exceedances were recorded in 2022. The number and severity of exceedances of metals standards in the drainage were tied for the lowest observed since metals analysis began in 2007. A lack of major runoff events due to drought conditions and improvements made to reduce erosion are the most likely drivers of this. In most cases, severe exceedances of metals seem to be associated with extreme TSS concentrations in this drainage. Sources of metals in the drainage may include improperly disposed wastes, such as deep cycle batteries. The combination and concentration of metals observed over time appear to point to this as a possible source.

2d. Bacteria (*E.coli*)

Historically, the diversion drainage has not met the standard for *E.coli* from June through September. A bacterial source assessment excluded anthropogenic sources of *E.coli* in the drainage, meaning wildlife and livestock are the likely culprits of the high levels of bacteria. No bacteria samples were collected in 2022, and historical results have become too dated to use in assessments after sampling ceased in 2017.

IV.C.3. Long Lake Drainage

The tributaries to Long Lake at 62nd St. and Marketplace Pond drain a high percentage of impervious surface and developed areas upstream of Long Lake (Table 1 and Figure 1). For the purposes of this report, the Tributary to Long Lake at Marketplace Pond will be compared to 2B water quality standards. The Tributary at Marketplace Pond is not classified as a 2B water, although its receiving water, Long Lake, is. The Tributary at 62nd Street will not be compared to state standards as water chemistry sampling at the site ceased following the 2016 monitoring season; only stage has been recorded since. The water discharged to Long Lake directly affects the quality of the lake, which has had significant issues caused by excess nutrients. Water from Long Lake makes its way downstream to Jackson WMA Pond, the diversion drainage, McKusick Lake and its wetland complex, and eventually to the St. Croix River. Monitoring subwatershed contributions to Long Lake can help determine locations for targeted management, as well as track improvements made upstream.

3a. Discharge

Annual discharge to Long Lake from the tributary at Marketplace Pond was 7,753,526 cubic feet. Only stage data was collected at the tributary at 62nd Street, and discharge was estimated during the period of logged data based on stage and discharge data from 2014.

Data from 2014 was used because it covered the widest range of observed stages and was representative of the average of other years of data collection. Discharge outside of logged data was not estimated, although the total volume outside of the period of record is likely negligible as the site freezes in the winter. Discharge to Long Lake from the tributary at 62nd Street was estimated at 274,469 cubic feet (Table 19). Flow in both systems is almost entirely event based, and flow often ceases during dry or winter conditions. Discharge was the second lowest in the last ten years at the tributary to Marketplace Pond, and the lowest at 62nd Street.

3b. Phosphorus & Sediment

The TP load at Marketplace Pond was 0.192 pounds per acre for a total of 79 pounds of phosphorus, and the TSS load was 17.35 pounds per acre for a total of 7,112 pounds of sediment (Table 19). It appears the tributary at Marketplace Pond is meeting the standard of 30 mg/L of TSS at base flow, but was above the 0.100 mg/L TP standard for two of three base flow samples (Table 18). Although storm composite samples are generally not compared to state standards, the concentrations of TSS were generally below the standard, and the TP concentrations were well above the standard. It should be noted the tributary at Marketplace Pond flows through several small settling ponds before discharging to Long Lake, and some additional settling of sediment and uptake of nutrients likely occurs. Sampling of the tributary at 62nd Street ceased after the 2016 monitoring season.

3c. Metals

Heavy metal exceedances for the tributary at Marketplace Pond can be found in Table 18. There were two chronic standard exceedances of copper and one chronic standard exceedance of lead recorded during storm events. Metals exceedances at this site were the lowest recorded since metals sampling began in 2007. The amount of heavy metals in the subwatershed is influenced by development and impervious surfaces, such as parking lots and Highway 36 where materials from vehicle leaks and brake dust tend to collect. The hardness of water in the subwatershed also tends to be very low, increasing the toxicity of metals. Metals contributed from this subwatershed have the potential to degrade aquatic life near the point of discharge to Long Lake before the water is fully integrated into the lake.

Table 18. Tributary to Long Lake at Marketplace Pond 2022 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L _CaCO3)
Storm Composite	5/25/2022 10:26	5/26/2022 4:25	26	12	1.40	0.219	0.067	0.00630	0.00140	0.00075	0.02090	0.00026	0.00120	166.0	<0.06	<0.20	0.11	40.2
Storm Composite	8/8/2022 0:00	8/8/2022 14:53	12	5	1.40	0.164	~0.032	0.00540	0.00150	0.00077	0.02420	0.00012	0.00450	118.0	<0.06	0.40	0.20	47.9
Storm Composite	8/18/2022 18:27	8/19/2022 0:06	47	14	1.10	0.206	0.054	0.00590	0.00170	0.00120	0.03110	0.00014	0.00350	55.4	0.17	0.26	0.12	38.6
Storm Composite	8/29/2022 0:20	8/29/2022 3:55	10	5	1.30	0.146								30.4				
Base Grab	6/16/2022 9:05	6/16/2022 9:05	7	<6	1.60	0.225	0.053	0.00310	0.00130	0.00051	0.00960	<0.00010	0.00110	99.3	<0.06	<0.20	0.15	55.2
Base Grab	7/25/2022 15:44	7/25/2022 15:44	5	4	1.10	0.114	0.060	0.00240	0.00083	<0.00050	<0.00500	<0.00010	<0.00100	206.0	<0.06	<0.20	<0.06	55.4
Base Grab	8/25/2022 14:11	8/25/2022 14:11	<3	<3	0.77	0.093	0.083	<0.00100	0.00068	<0.00050	<0.00500	<0.00010	<0.00100	73.2	<0.06	0.34	0.09	53.0

Exceeds Water Quality Standard
 No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

Table 19. Long Lake Drainage Historic Loading- Latest Ten Years

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Tributary to Long Lake at Marketplace Pond										
Discharge (cf)	18,276,274	7,444,468	22,983,609	23,534,188	15,250,645	16,492,464	28,970,261	14,353,605	13,899,568	7,753,526
Total pounds of Phosphorus exported	85	70	137	137	77	70	150	83	121	79
TP (lbs/ac/yr)	0.208	0.172	0.335	0.333	0.187	0.170	0.367	0.202	0.296	0.192
Total pounds of TSS exported	10,825	6,622	15,797	18,278	15,162	16,473	15,882	10,645	9,593	7,112
TSS (lbs/ac/yr)	26.40	16.15	38.53	44.58	36.98	40.18	38.74	25.96	23.40	17.35
Tributary to Long Lake at 62nd Street										
Discharge (cf)	2,922,109	3,687,553	1,413,178	2,824,017	1,811,811*	957,234*	3,403,761*	2,842,101*	584,566*	274,469*
Total pounds of Phosphorus exported	36	57	32	49	NA	NA	NA	NA	NA	NA
TP (lbs/ac/yr)	0.063	0.100	0.056	0.086	NA	NA	NA	NA	NA	NA
Total pounds of TSS exported	4,202	15,227	6,115	20,956	NA	NA	NA	NA	NA	NA
TSS (lbs/ac/yr)	7.31	26.48	10.63	36.45	NA	NA	NA	NA	NA	NA

*Flow not estimated outside of logged data

IV.C.4. McKusick Wetland Outlet

The tributary to Brown's Creek at McKusick Wetland Outlet discharges water through a pipe approximately 100 feet upstream of the McKusick Road monitoring station from a wetland complex at the headwaters of McKusick Lake. Based on aerial photo evidence it may also provide a "short circuit" for warm, nutrient rich water diverted by the Diversion Structure to be introduced into Brown's Creek after flowing through the wetland complex at the headwaters of McKusick Lake. In 2021 the Oak Glen Golf Course Irrigation Reuse Project was completed, which redirects water from the outlet to a holding pond. This reduces warm, nutrient rich and oxygen poor inputs of water to Brown's Creek. Although not classified as a 2B water, for the purposes of this summary, the data collected will be compared to 2B TP and TSS standards.

4a. Discharge

Discharge at McKusick Wetland Outlet was calculated using an area velocity relationship during the period of recorded data. Periods of flow outside of recorded data were not estimated due to the site freezing during winter months. The recorded discharge to Brown's Creek was 5,153,850 cubic feet (Table 21). High water levels in Brown's Creek occasionally created tailwater conditions at the site, making discharge calculations difficult during some periods. The outlet was also not flowing or intermittently flowing from approximately June 23 to August 5 due to the irrigation reuse project, except for brief periods following storm events.

4b. Phosphorus & Sediment

The TP load during recorded data was estimated at 69.1 pounds of phosphorus, while the estimated TSS load was 2,868 pounds of sediment (Table 21). The concentrations of TSS and TP were not precipitation or stage dependent, indicating the wetland complex "pulses" nutrients following storm events. As such, TP and TSS loads were calculated by averaging samples with similar concentrations based on seasonality, and applying the average concentration to the recorded discharge for the time period, which is consistent with past years. It is important to note the characteristics of the site and sampling strategy do not allow for load calculations as precise as other monitored strategies, i.e. composite sampling.

Samples collected show the site meets the 2B standard of 30 mg/L of TSS for all samples, but exceeds the standard of 0.100 mg/L of TP for nearly every sample (Table 20). The water discharging from the wetland is low in suspended sediment and other materials, but quite high in phosphorus, a large fraction of which is often dissolved phosphorus. This is typical of wetlands, which break down organic materials while filtering particulate matter, but can have negative effects on receiving waters by contributing nutrients that are readily available to organisms like algae.

Table 20. McKusick Wetland Outlet 2022 Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L CaCO3)
Storm Grab	5/12/2022 15:06	5/12/2022 15:06	9	4	1.20	0.156	0.061	0.00052	0.00091	<0.00050	<0.00500	<0.00010	<0.00100	31.0	<0.06	<0.20	<0.06	85
Base Grab	5/25/2022 13:25	5/25/2022 13:25	12	6	1.60	0.304	~0.027	<0.00050	0.00066	<0.00050	<0.00500	<0.00010	<0.00100	38.8	<0.06	<0.20	<0.06	136
Base Grab	6/17/2022 9:12	6/17/2022 9:12	9	<6	2.20	0.291	~0.045	<0.00050	0.00054	<0.00050	0.00680	<0.00010	<0.00100	21.1	<0.06	0.47	0.55	242
Base Grab	10/13/2022 11:18	10/13/2022 11:18	5	<3	0.33	0.088	<0.020	<0.00050	<0.00050	<0.00050	<0.00500	<0.00010	<0.00100	28.8	<0.06	<0.20	<0.06	245

Exceeds Water Quality Standard
 No Exceedance Determinable
 Exceeds Chronic Standard
 Exceeds Max Standard
 Exceeds Final Acute Standard

Table 21. McKusick Wetland Outlet 2022 Discharge and Loading Estimates

Site	Period	Total Flow (cf)	Total Flow (ac-ft)	Average TP Concentration (mg/L)	TP Range (mg/L)	Average TSS Concentration (mg/L)	TSS Range (mg/L)	TP Load (lbs.)	TSS Load (lbs.)
McKusick Wetland Outlet	5/11-9/1	4,033,410	92.64	0.250	0.156-0.304	10	9-12	62.9	2,518
McKusick Wetland Outlet	9/1-10/26	1,120,440	25.74	0.088	N/A	5	N/A	6.2	350
Total		5,153,850	118.38					69.1	2,868

Table 22. McKusick Wetland Outlet Historic Loading Data

	2017	2018	2019	2020	2021	2022
McKusick Wetland Outlet						
Discharge (cf)	18,610,746	8,319,145	43,988,560	18,179,910	5,072,806	5,153,850
Total pounds of Phosphorus exported	298.2	138.5	453.1	284.6	68.3	69.1
Total pounds of TSS exported	9,055	5,072	13,275	10,927	2,327	2,868
Values reported are totals during the monitoring period only.						

4c. Temperature

Historic thermal data recorded at McKusick Wetland Outlet show temperatures roughly 2.5 °C higher, on average, than those recorded at McKusick Road during similar time periods. The wetland is warmed by solar radiation and frequently reaches high temperatures. Although the wetland outlet is not intended to be suitable for trout, when compared to TMDL thresholds of 18.3 °C (threat level) and 23.9 °C (critical level), water temperatures exceeded the thresholds 31.2% and 3.5%, respectively, of the monitoring period when flow was present. It is important to compare temperatures to these thresholds because they directly influence temperatures in Brown’s Creek when discharged upstream of the McKusick Road site. Trout have been observed and stocked in the reach of Brown’s Creek the wetland outlet discharges to, but only during spring and fall when water temperatures are cooler. The redirection of flow for use as irrigation appears to have had positive impacts on the McKusick Road monitoring site by reducing the number of days dissolved oxygen concentrations were below the state standard to the lowest recorded, and limiting the number of days temperatures were above the threat level threshold to the ten year average, even during severe droughts. The wetland outlet was effectively “offline” during some of the warmest parts of summer from approximately June 23 to August 5, significantly reducing thermal loading. Continuous temperature data can be seen in Figure 11, where temperature data has been removed during periods of zero water discharge, alongside the daily average temperature at McKusick Road.

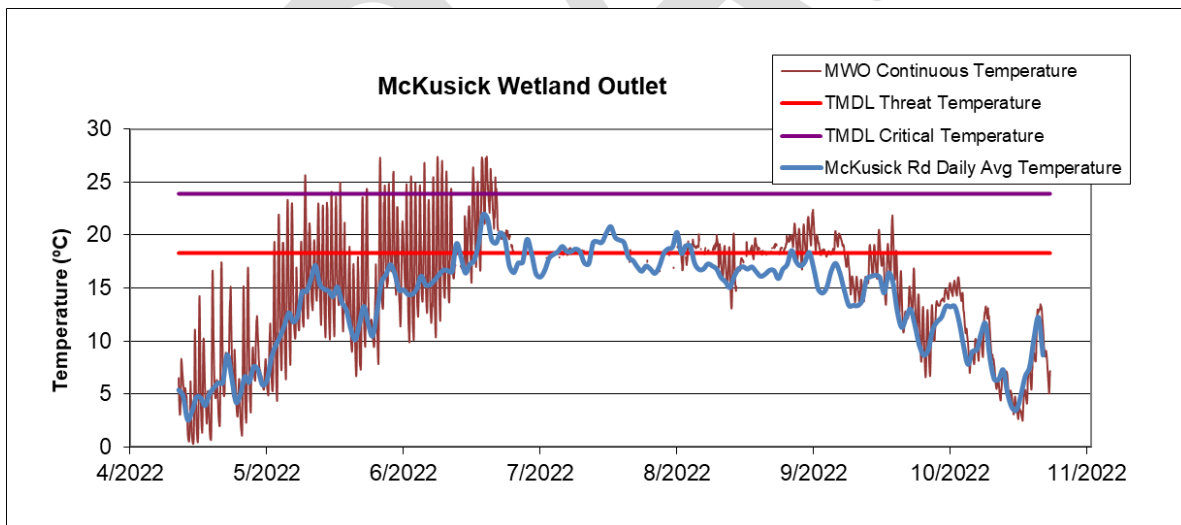


Figure 11. McKusick Wetland Outlet 2022 Continuous Temperature

V. RECOMMENDATIONS

- Continue chloride monitoring on lakes likely to be impacted by salt use.
- Perform macrophyte surveys on lakes that are lacking data.
- Continue collecting water quality and continuous discharge data at existing monitoring stations to track changes in the watershed and provide baseline data for modeling and other uses.
- Continue identifying salt use reduction strategies to limit chloride loading.
- Continue identifying cooperative opportunities with landowners to implement stream shading projects.
- Continue monitoring repairs to erosional issues in the diversion drainage to prevent degradation of McKusick Lake.
- Consider modifying sampling on Brown's Creek to match Metropolitan Council's WOMP program using unbiased sampling regimes as opposed to storm/event based sampling to allow for more rigorous statistical trend analysis.

APPENDIX A - WATER QUALITY DATA – BY LAKE

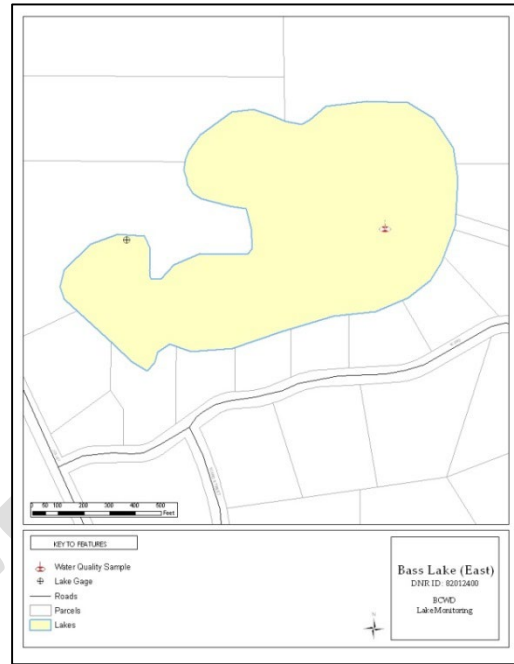
Brown's Creek Watershed Lakes: Bass East, Bass West, Benz, Brewer's Pond, Goggins, Heifort's Pond, Jackson WMA (Sinnits Pond), July Avenue, Kismet, Long (North Basin), Lynch North, Lynch South, Masterman, North School Section, Pat, Plaisted, South School Section, and Woodpile

Lake grades are assessed using the Metropolitan Council's lake grade system. Grades are determined based on May through September averages of total phosphorus concentration, uncorrected trichromatic chlorophyll- α concentration, and Secchi disk transparency.

The Minnesota Pollution Control Agency (MPCA) uses the June through September average to assess impairment status of a lake based on total phosphorus concentration, pheophytin-corrected chlorophyll- α concentration, and Secchi disk transparency. The MPCA sets lake eutrophication standards for aquatic life and recreation. The standard for TP is 0.040 mg/L for deep lakes and 0.060 mg/L for shallow lakes. In general, shallow lakes are defined as less than 15 feet deep, with greater than 80% littoral area, and less than 10 acres.

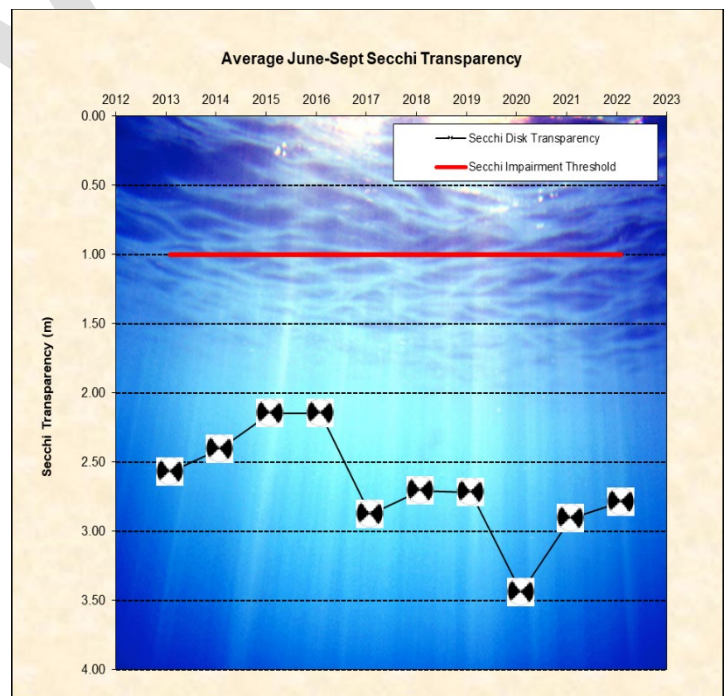
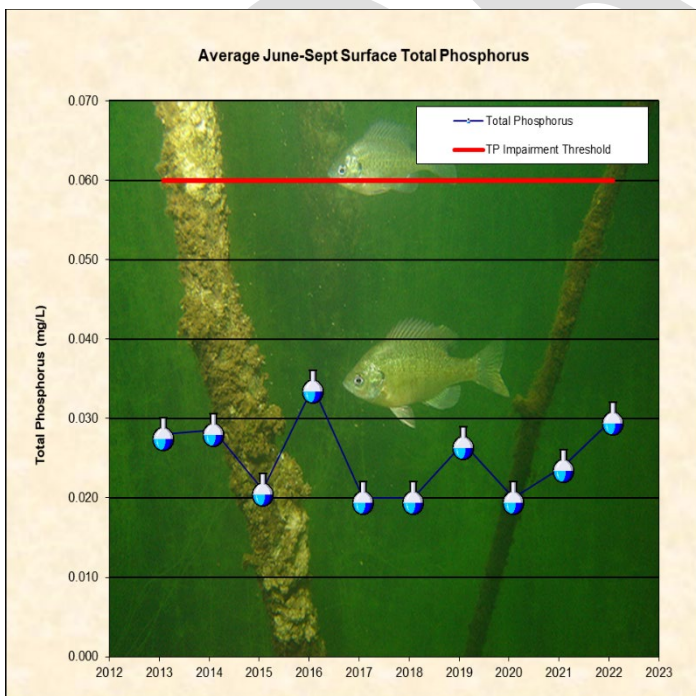
Bass Lake (East) 2022 Lake Grade: B+

- DNR ID #: 820124
 - Municipality: City of Grant
 - Location: Section 10, T30N-R21W
 - Lake Size: 29 Acres
 - Maximum Depth (2022): 18 ft
 - Ordinary High Water Mark: 960.20 ft
 - 100-Year High Water Level: 960.40 ft
 - 99% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for average total phosphorus and average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is rural/agricultural.
- The lake stratified in 2022 with a thermocline around 3 meters.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



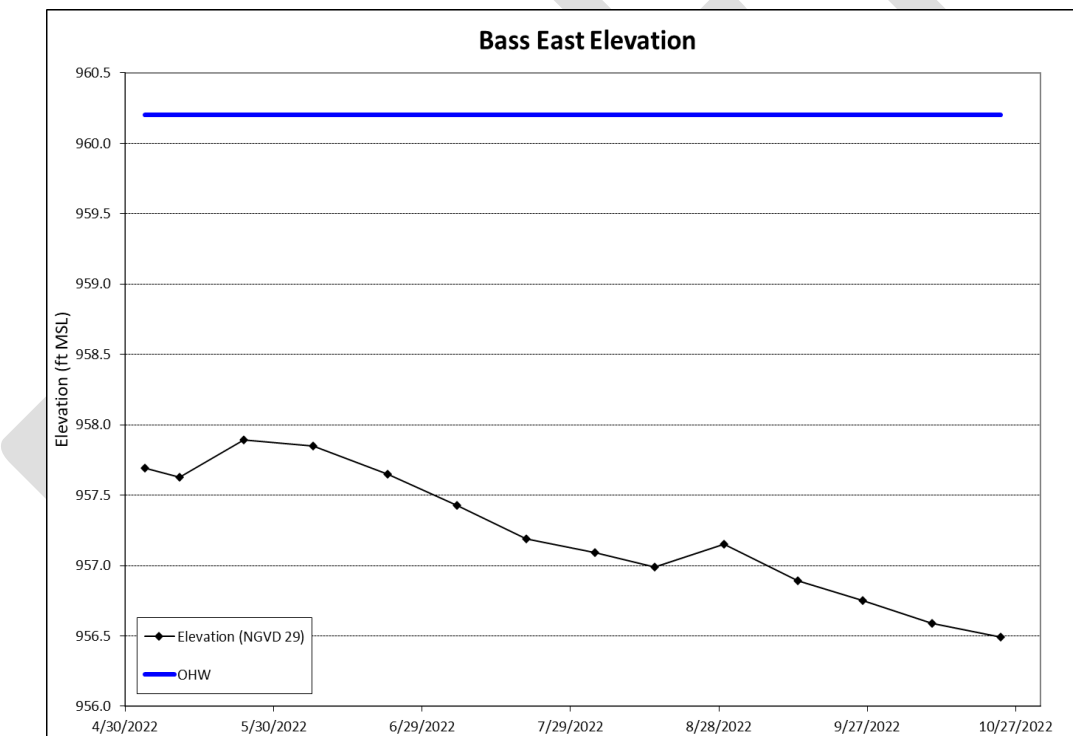
Date/Time	Total Phosphorus (mg/L)	Trichromatic Uncorrected Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 13:44	0.022	5.6	4.3	0.62	2.74	8.6	11.66
5/11/2022 13:23	0.012	4.7	3.7	0.67	2.90	18.1	9.93
5/24/2022 14:40	0.019	1.6	1.3	0.51	3.20	19.1	9.44
6/7/2022 10:34	0.023	1.4	1.6	0.66	3.51	21.6	8.97
6/22/2022 11:15	NA	2.4	2.1	NA	2.59	26.7	7.98
7/6/2022 9:05	0.037	3.8	3.0	0.80	2.44	25.2	7.49
7/20/2022 10:04	0.015	2.5	2.0	0.66	2.29	26.3	6.16
8/3/2022 13:46	0.050	3.9	3.8	0.82	2.29	27.3	12.71
8/15/2022 11:36	0.035	4.6	3.8	0.61	2.90	23.3	11.38
8/29/2022 13:40	0.027	3.0	3.4	0.54	2.74	24.0	10.10
9/13/2022 9:09	0.034	3.9	3.5	0.63	3.20	21.5	9.65
9/26/2022 10:58	0.017	3.6	2.7	0.59	3.20	17.2	6.75
10/10/2022 9:56	0.022	5.8	4.5	0.58	4.11	14.1	9.62
2022 Average	0.026	3.6	3.1	0.64	2.93	21.0	9.37
2022 Summer Average	0.030	3.2	2.9	0.66	2.79	23.7	9.02

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	957.89	5/24/2022	956.49	10/24/2022	957.23

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

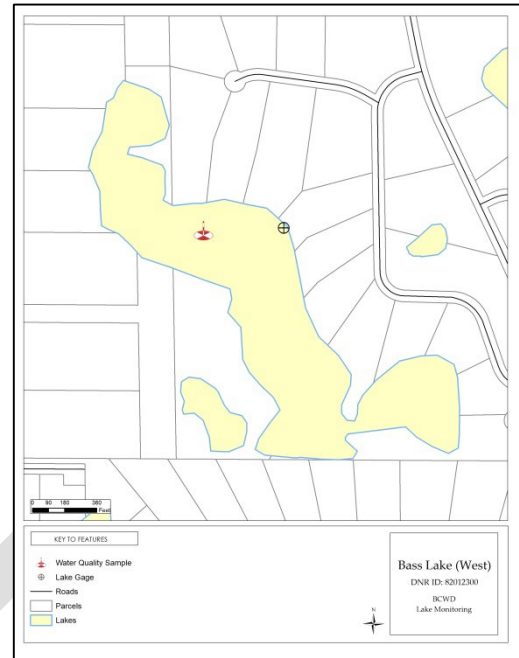


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	A	A	B	A	A	C	A	B	B
Chlorophyll-a (ug/l)	A	A	A	A	A	A	A	A	A	A
Secchi depth (ft)	B	B	A	B	B	B	B	C	B	B
Overall	B+	A-	A	B+	A-	A-	B	B+	B+	B+

Bass Lake (West) 2022 Lake Grade: A-

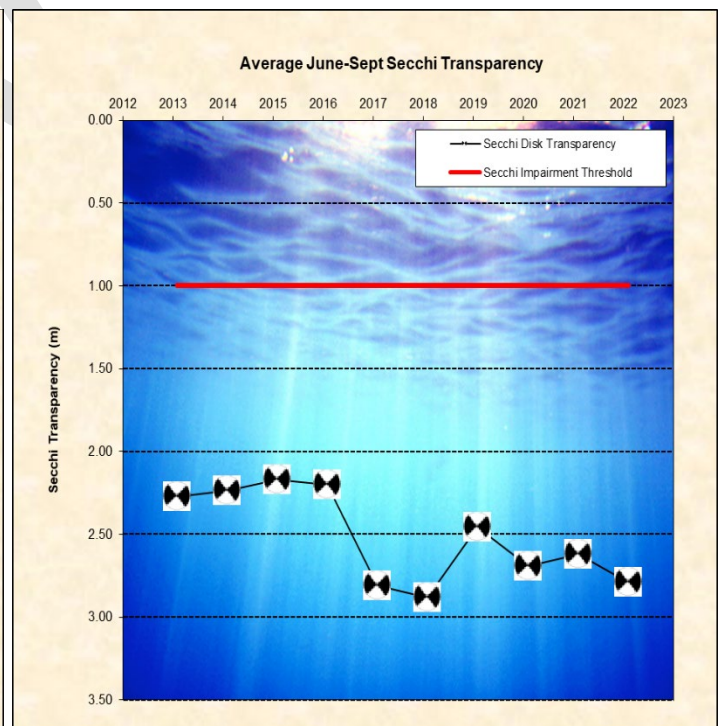
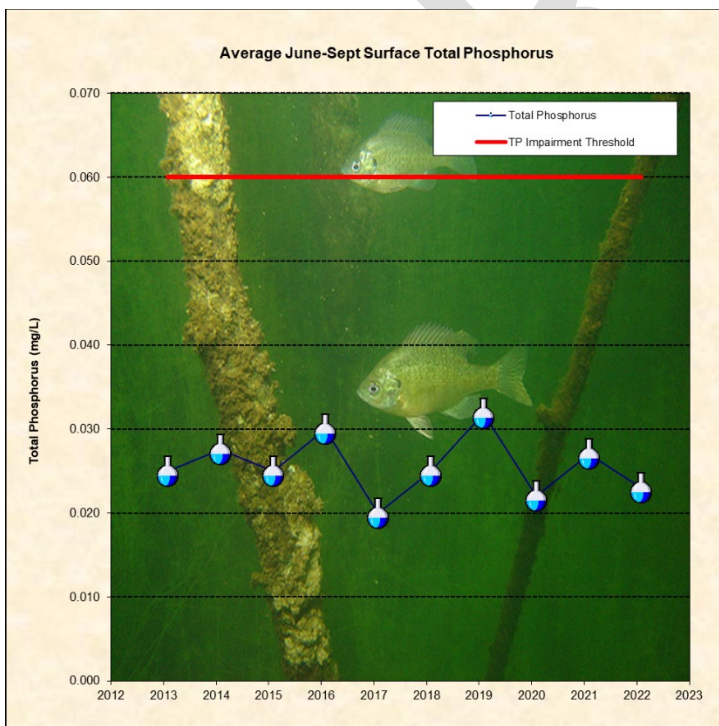
- DNR ID #: 820123
- Municipality: City of Grant
- Location: Section 10, T30N-R21W
- Lake Size: 72 Acres
- Maximum Depth (2022): 16 ft
- Ordinary High Water Mark: 952.60 ft
- 100-Year High Water Level: 955.90 ft
- 100% Littoral

Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for average total phosphorus, no trend for average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.

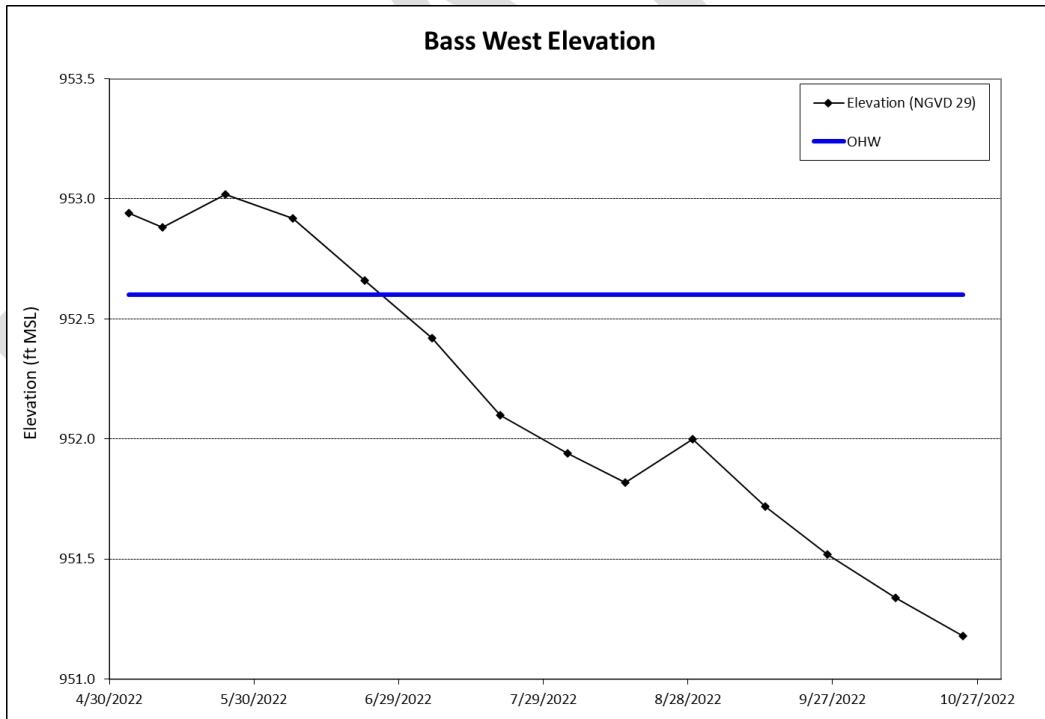


Date/Time	Total Phosphorus (mg/L)	Trichromatic Uncorrected Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 13:19	0.021	5.7	4.5	0.55	2.74	8.1	11.05
5/11/2022 12:56	0.017	4.6	4.0	0.55	2.29	17.5	9.45
5/24/2022 14:11	0.028	3.4	2.7	0.64	2.29	18.4	9.53
6/7/2022 11:00	0.025	2.4	1.9	0.62	3.96	21.2	9.09
6/22/2022 10:54	0.024	4.4	4.4	0.54	2.74	26.2	7.93
7/6/2022 8:43	0.022	5.1	4.5	0.58	2.74	25.2	7.75
7/20/2022 9:42	0.028	6.7	6.4	0.65	1.83	26.4	7.34
8/3/2022 13:18	0.022	5.5	5.3	0.60	2.90	26.6	12.96
8/15/2022 11:07	0.029	10.0	9.6	0.71	1.22	22.9	9.22
8/29/2022 13:17	0.019	3.5	3.3	0.54	3.66	23.8	10.48
9/13/2022 8:49	0.018	4.5	3.5	0.64	3.35	21.5	8.36
9/26/2022 11:22	NA	8.3	7.7	0.74	2.74	17.3	7.49
10/10/2022 10:23	0.028	6.1	5.1	0.60	2.59	14.3	9.40
2022 Average	0.023	5.4	4.8	0.61	2.70	20.7	9.23
2022 Summer Average	0.023	5.6	5.2	0.62	2.79	23.5	8.96

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	953.02	5/24/2022	951.18	10/24/2022	952.18

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

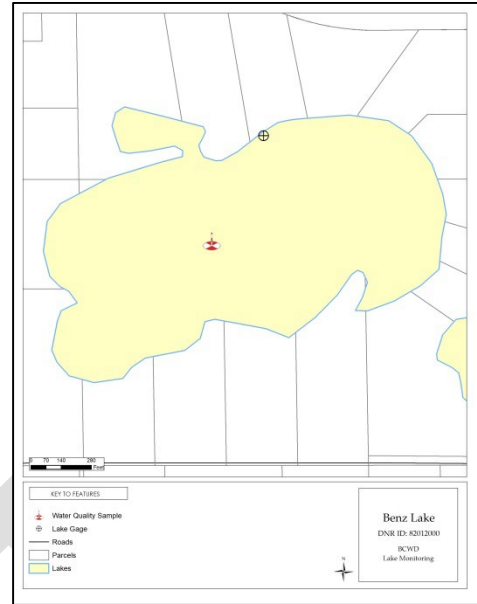


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	A	B	A	B	B	A	B	B	B	B
Chlorophyll-a (ug/l)	A	A	A	A	A	A	A	A	A	A
Secchi depth (ft)	B	B	A	B	B	B	B	C	B	B
Overall	A-	B+	A	B+	B+	A-	B+	B	B+	B+

Benz Lake

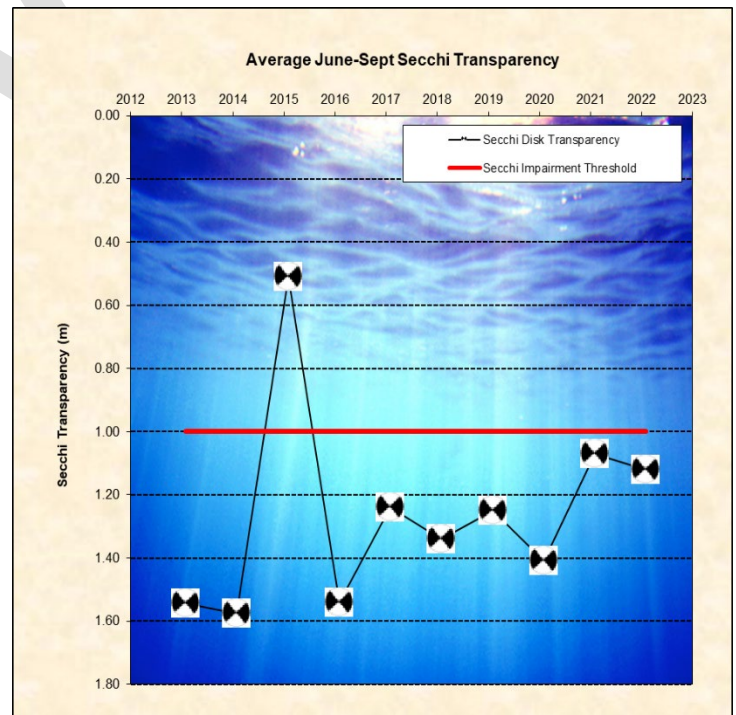
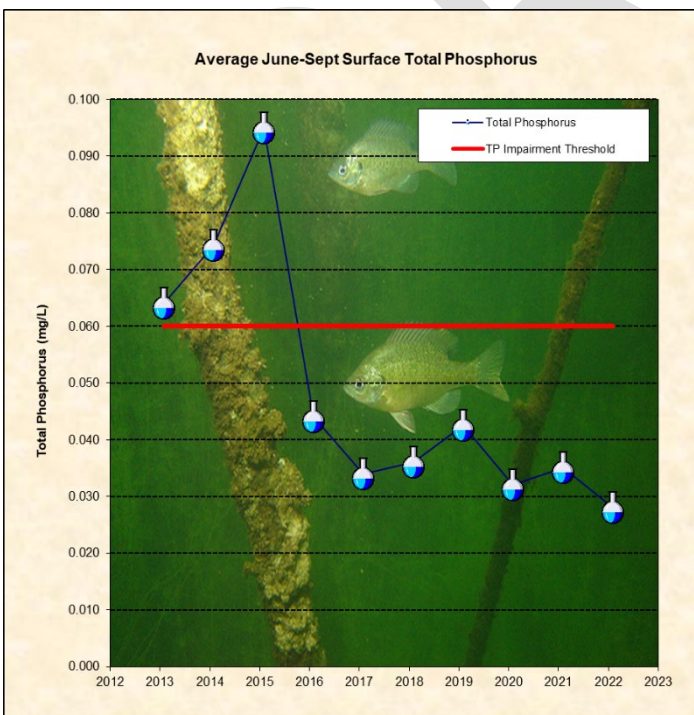
2022 Lake Grade: B-

- DNR ID #: 820120
 - Municipality: City of Grant
 - Location: SE^{1/4} Section 2, T30N-R21W
 - Lake Size: 40 Acres
 - Maximum Depth (2022): 7 ft
 - Ordinary High Water Mark: 958.90 ft
 - 100-Year High Water Level: 956.20 ft
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for average total phosphorus and average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.
- Benz Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.

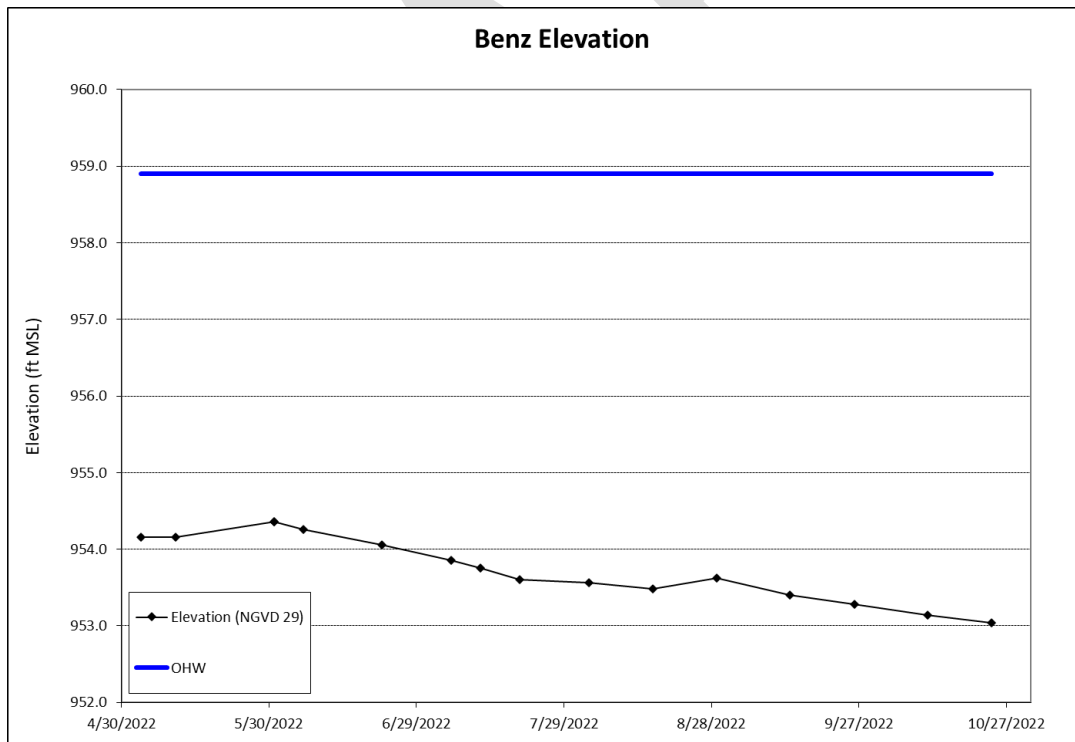


Date/Time	Total Phosphorus (mg/L)	Trichromatic Uncorrected Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 11:21	0.017	5.2	4.5	0.45	1.07	7.6	11.67
5/11/2022 14:20	0.020	5.1	4.3	0.56	1.07	19.0	9.90
5/26/2022 9:42	0.035	3.4	2.7	0.48	1.07	15.7	8.03
6/6/2022 11:49	0.036	2.5	2.7	0.48	1.68	21.8	10.48
6/22/2022 13:00	0.041	3.5	3.1	0.54	1.68	26.4	8.91
7/6/2022 10:05	0.030	NA	NA	0.67	1.07	24.5	10.20
7/20/2022 11:28	0.045	3.1	2.2	0.70	1.07	25.4	6.67
8/3/2022 11:50	0.024	8.2	7.5	0.70	1.52	26.5	14.96
8/16/2022 10:53	0.023	4.8	4.4	0.58	0.76	22.4	14.31
8/29/2022 11:49	0.024	2.3	1.9	0.48	0.76	23.4	12.39
9/13/2022 10:30	0.021	2.8	1.9	0.46	0.76	20.7	10.74
9/26/2022 10:34	0.011	2.2	1.6	0.50	0.76	15.9	6.89
10/11/2022 9:17	0.081	2.8	2.1	0.63	1.22	13.1	12.22
2022 Average	0.031	3.8	3.2	0.56	1.11	20.2	10.57
2022 Summer Average	0.028	3.7	3.2	0.57	1.12	23.0	10.62

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	954.36	5/31/2022	953.04	10/24/2022	953.76

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

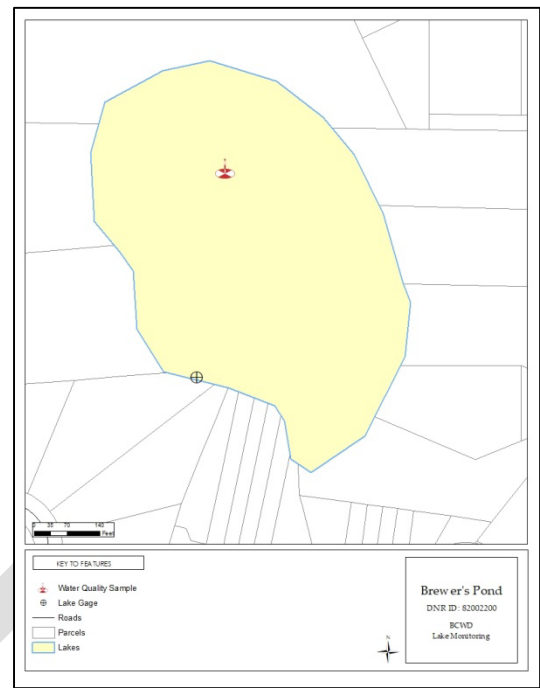


	Lake Water Quality Summary									
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	C	B	C	C	C	C	D	D	C
Chlorophyll-a (ug/l)	A	A	A	C	A	A	A	D	B	B
Secchi depth (ft)	D	D	C	C	C	D	C	F	C	C
Overall	B-	C+	B	C	B-	C+	B-	D-	C	C+

Brewer's Pond

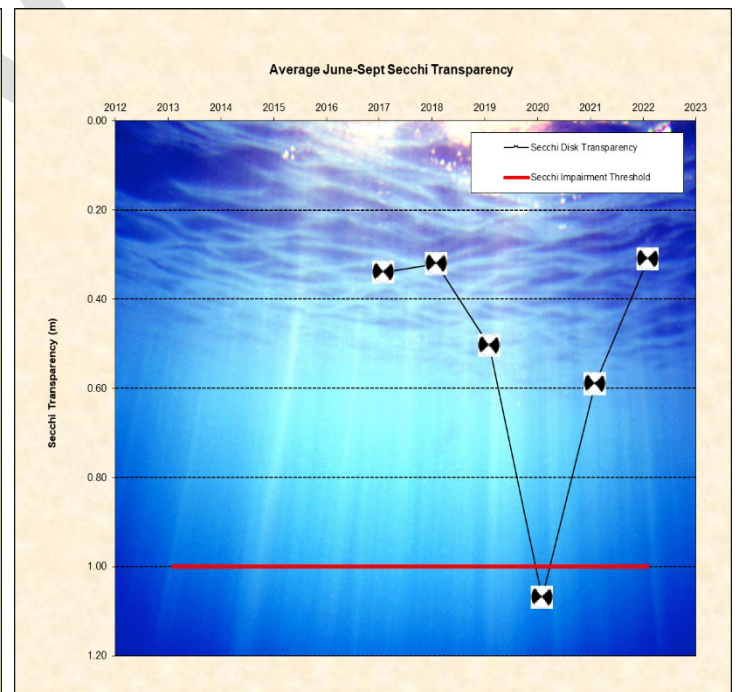
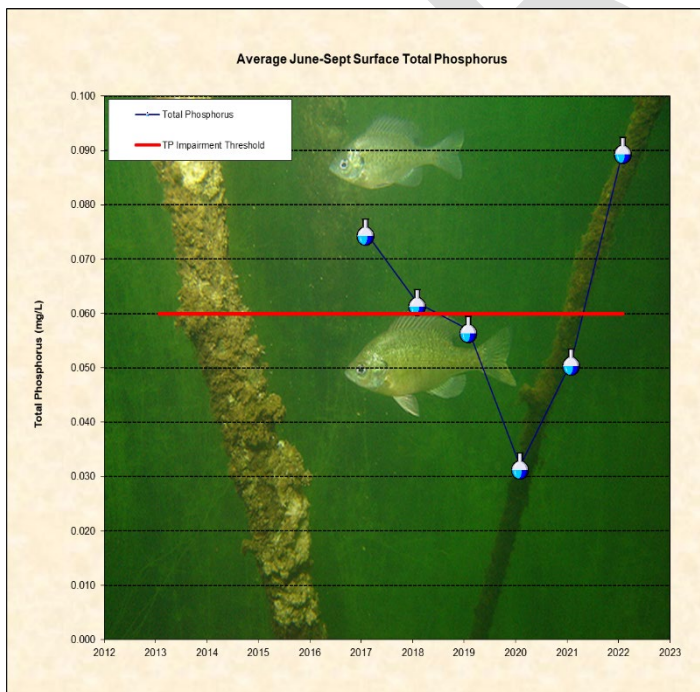
2022 Lake Grade: F+

- DNR ID #: 820022
 - Municipality: City of Stillwater
 - Location: SE^{1/4} Section 31, T30N-R20W
 - Lake Size: 9 Acres
 - Maximum Depth (2022): 15 ft
 - Ordinary High Water Mark: 891.90 ft
 - 100-Year High Water Level: 893.85ft
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as hypereutrophic according to the Carlson Trophic State Index.
- There are an insufficient number of years of data to determine a trend for the average total phosphorus, average chlorophyll- α , and the average Secchi transparency.
- The major land use is urban/residential.
- The lake stratified in 2022 with a thermocline around 3 meters.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 14:46	0.096	110.0	100.0	2.90	0.15	10.7	12.02
5/18/2022 14:00	0.073	47.0	44.0	2.10	0.50	22.2	NA
5/26/2022 13:13	0.092	54.0	52.0	2.40	0.15	15.7	9.42
6/7/2022 19:00	0.078	27.0	26.0	2.00	0.90	23.2	NA
6/22/2022 9:41	0.116	35.0	33.0	2.10	0.46	26.7	7.68
7/19/2022 16:05	0.117	130.0	130.0	3.80	0.15	28.3	12.32
8/4/2022 16:30	0.115	180.0	180.0	4.10	0.20	32.4	NA
8/16/2022 11:30	0.087	150.0	150.0	4.00	0.15	22.8	18.52
8/30/2022 19:30	0.059	96.0	94.0	3.40	0.20	24.3	NA
9/12/2022 13:49	0.051	67.0	64.0	3.00	0.15	21.7	10.94
9/30/2022 9:45	0.094	80.0	82.0	4.10	0.30	15.9	NA
10/11/2022 11:20	0.108	43.0	44.0	4.00	0.15	14.2	8.80
2022 Average	0.091	84.9	83.3	3.16	0.29	21.5	11.39
2022 Summer Average	0.090	95.6	94.9	3.31	0.31	24.4	12.37

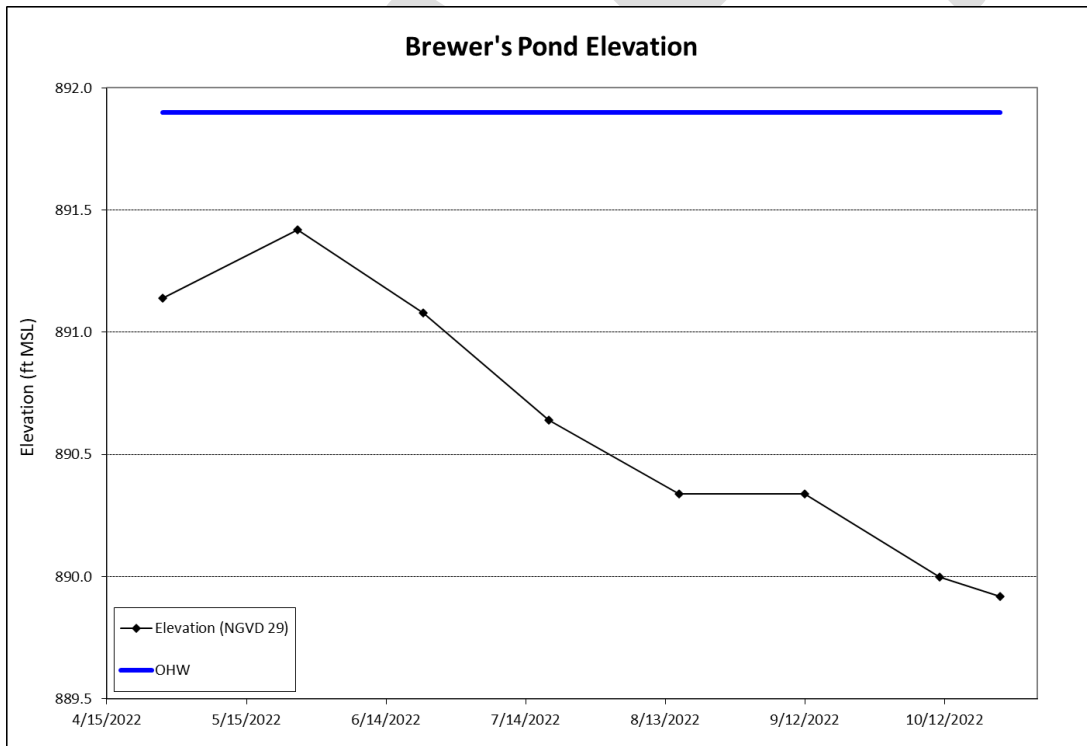
Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

Samples collected by a volunteer

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	891.42	5/26/2022	889.92	10/24/2022	890.61

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

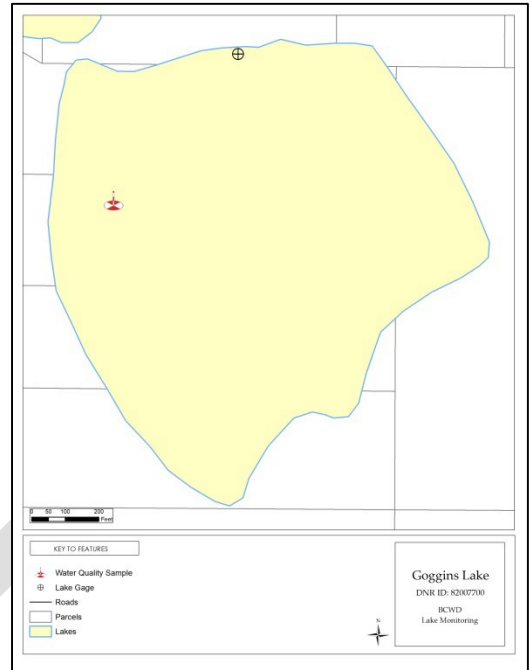


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	D	C	C	C	C	D	NA	NA	NA	NA
Chlorophyll-a (ug/l)	F	C	C	C	D	D	NA	NA	NA	NA
Secchi depth (ft)	F	F	D	F	F	F	NA	NA	NA	NA
Overall	F+	D+	C-	D+	D	D-	NA	NA	NA	NA

Goggins Lake

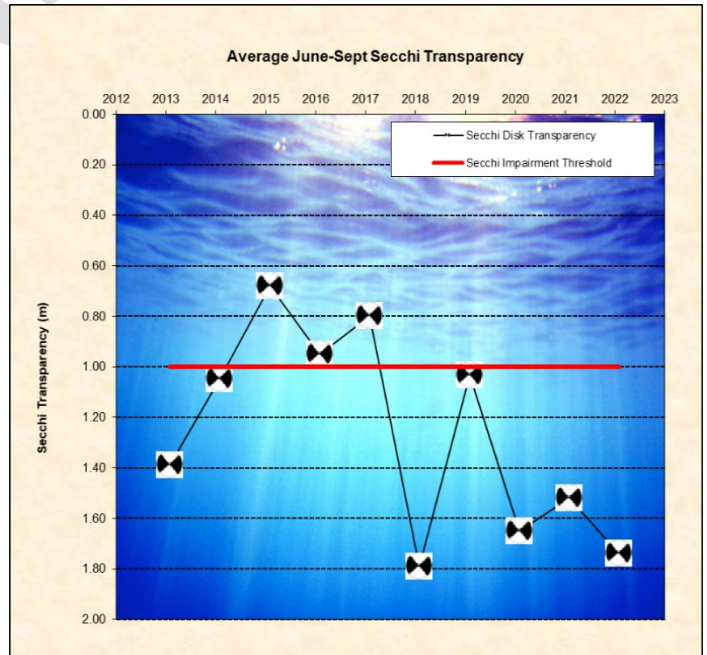
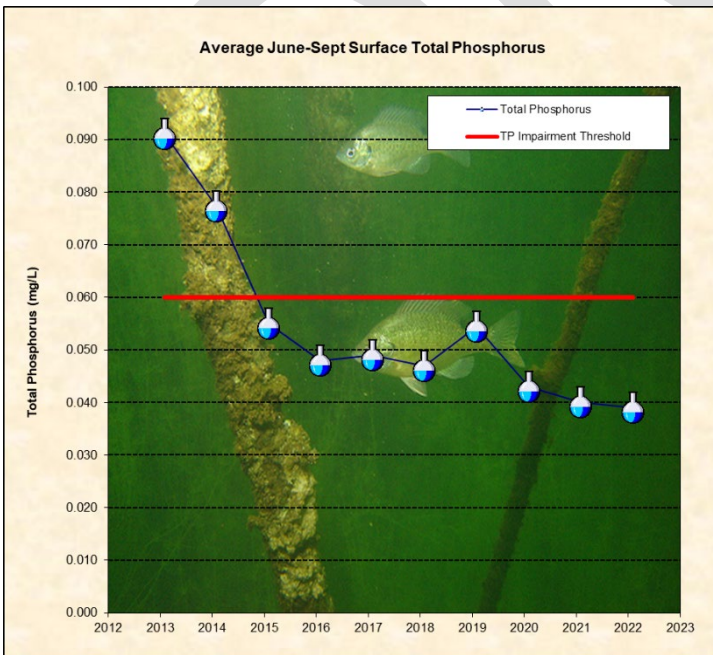
2022 Lake Grade: C+

- DNR ID #: 820077
 - Municipality: May Township
 - Location: NW^{1/4} Section 31, T31N-R20W
 - Lake Size: 85 Acres
 - Maximum Depth (2022): 15 ft
 - Ordinary High Water Mark: 966.50 ft
 - 100-Year High Water Level: 972.20 ft
 - 99% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as eutrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average total phosphorus, average chlorophyll- α , and average Secchi transparency.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.
- Goggins Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.

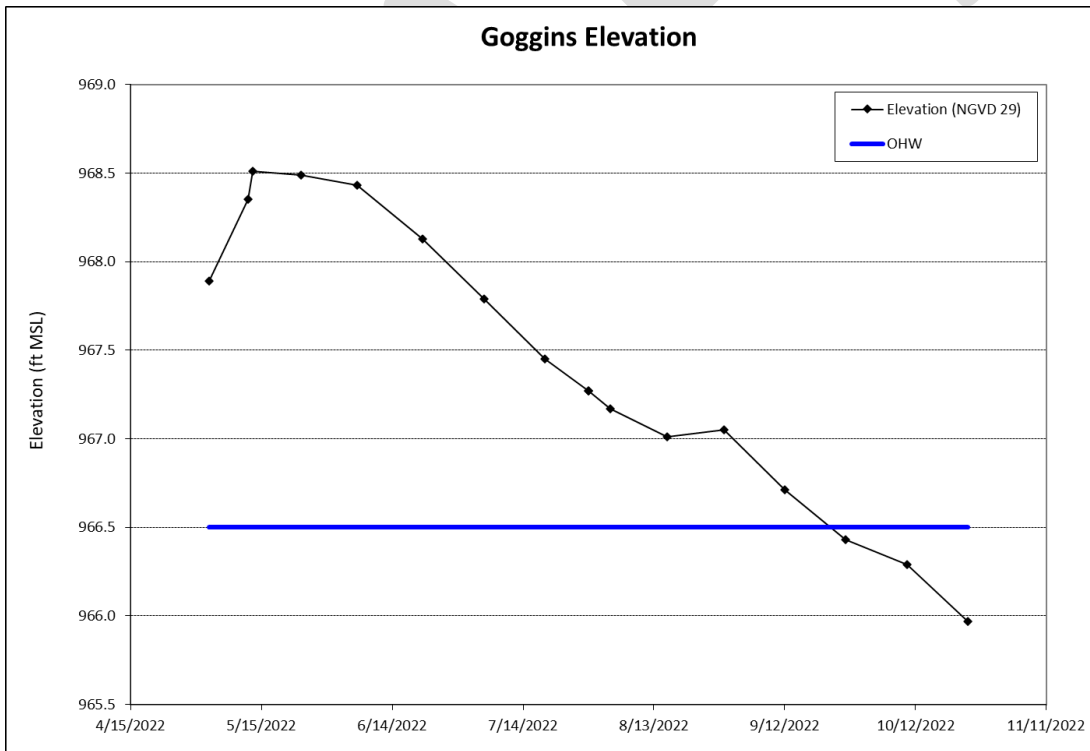


Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 8:45	0.043	13.0	12.0	1.00	1.22	7.2	11.63
5/12/2022 9:30	0.045	12.0	10.0	0.91	1.37	16.8	8.70
5/24/2022 10:32	0.044	2.5	2.1	0.88	3.66	17.4	8.11
6/6/2022 10:30	0.049	7.7	7.2	0.86	3.05	20.8	9.43
6/21/2022 11:33	0.040	6.8	6.1	0.85	1.83	26.4	8.24
7/5/2022 12:23	0.032	12.0	11.0	0.84	1.83	25.0	8.93
7/19/2022 11:03	0.030	6.1	5.7	0.82	2.44	27.6	8.90
8/3/2022 10:27	0.031	16.0	15.0	0.99	1.68	25.9	12.48
8/16/2022 14:00	0.038	17.0	15.0	1.00	1.22	24.0	13.31
8/29/2022 10:45	0.045	30.0	28.0	0.95	1.52	23.5	11.12
9/12/2022 10:58	0.048	23.0	20.0	1.00	1.22	21.9	9.90
9/26/2022 14:35	0.040	30.0	28.0	1.10	0.91	17.4	9.53
10/10/2022 14:11	0.047	16.0	14.0	1.10	1.07	14.8	11.74
2022 Average	0.041	14.78	13.39	0.95	1.77	20.7	10.16
2022 Summer Average	0.039	16.51	15.11	0.93	1.74	23.6	10.20

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

2022 Elevation (ft)	High	High Date	Low	Low Date	Average
	968.51	5/13/2022	965.97	10/24/2022	967.42

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

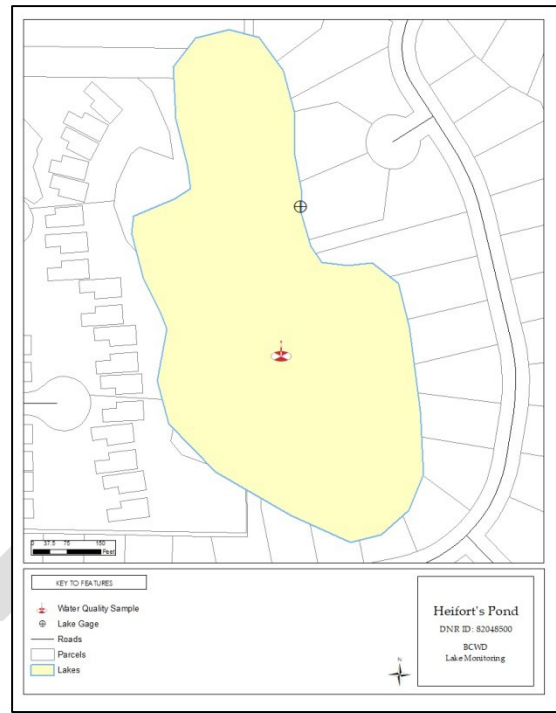


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	C	C	C	C	C	C	C	C	D	D
Chlorophyll-a (ug/l)	B	B	B	C	B	C	C	C	C	C
Secchi depth (ft)	C	C	C	C	C	D	D	F	D	C
Overall	C+	C+	C+	C	C+	C-	C-	D+	D+	C-

Heifort's Pond

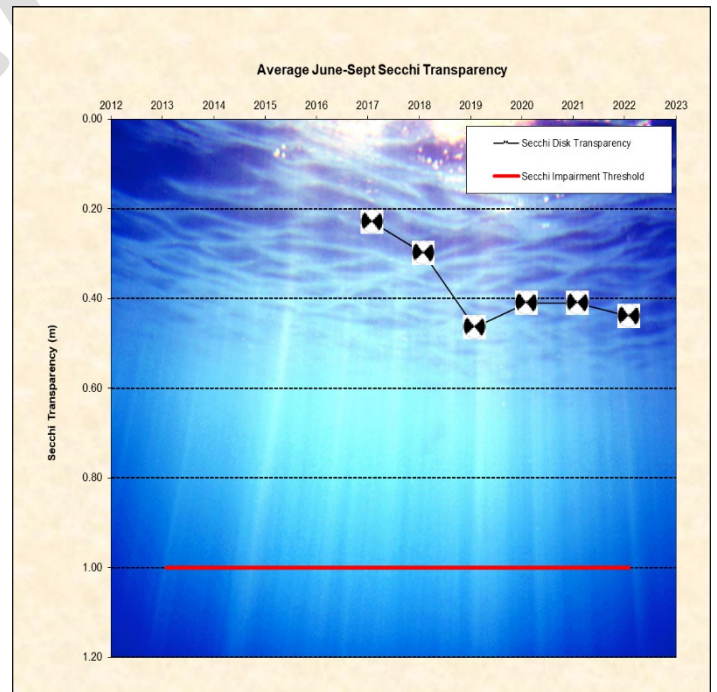
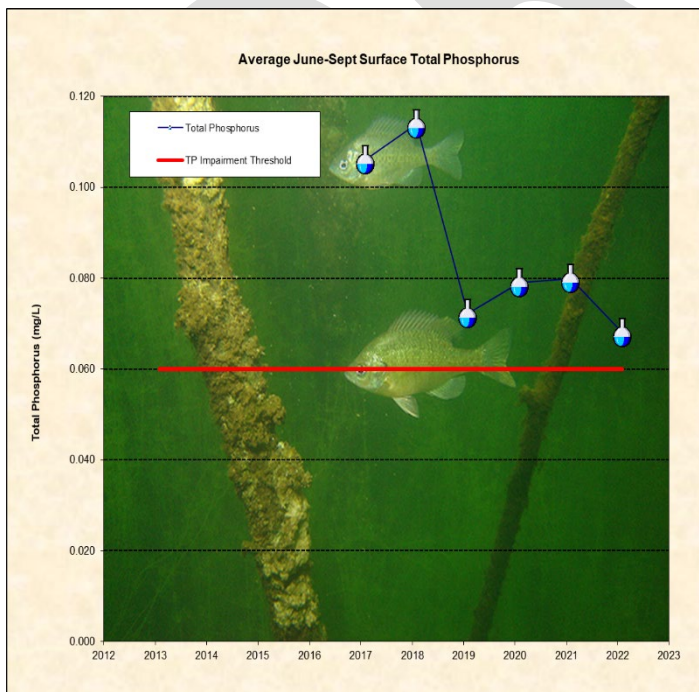
2022 Lake Grade: D-

- DNR ID #: 820485
 - Municipality: City of Stillwater
 - Location: NW^{1/4} Section 20, T30N-R20W
 - Lake Size: 6 Acres
 - Maximum Depth (2022): 9 ft
 - Ordinary High Water Mark: 883.9 ft
 - 100-Year High Water Level: 885.42 ft
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as hypereutrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there are an insufficient number of years of data to determine a trend for the average total phosphorus, average chlorophyll- α , and the average Secchi transparency.
- The major land use is urban/residential.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/22 14:13	0.090	53.0	49.0	1.90	0.61	9.3	12.08
5/10/22 12:44	0.082	44.0	41.0	1.90	0.70	17.0	NA
5/26/22 9:03	0.067	27.0	23.0	1.70	0.61	15.5	6.70
6/6/22 13:32	0.056	21.0	18.0	1.60	0.90	22.7	NA
6/22/22 11:55	0.055	34.0	32.0	2.00	0.46	27.1	8.07
7/6/22 11:15	0.085	150.0	150.0	2.80	0.40	25.2	NA
7/19/22 14:45	0.063	120.0	120.0	2.80	0.15	29.2	12.85
8/2/22 11:35	0.054	110.0	100.0	2.90	0.30	26.2	NA
8/16/22 13:30	0.062	110.0	100.0	3.00	0.15	24.1	18.05
8/29/22 12:43	0.106	90.0	85.0	2.70	0.40	24.5	NA
9/13/22 11:03	0.048	61.0	59.0	2.70	0.61	21.2	8.71
9/28/22 15:25	0.080	71.0	69.0	2.80	0.60	16.9	NA
10/11/22 13:50	0.054	61.0	58.0	2.60	0.46	14.8	12.53
2022 Average	0.069	73.2	69.5	2.42	0.49	21.1	11.28
2022 Summer Average	0.068	85.2	81.4	2.59	0.44	24.1	11.92

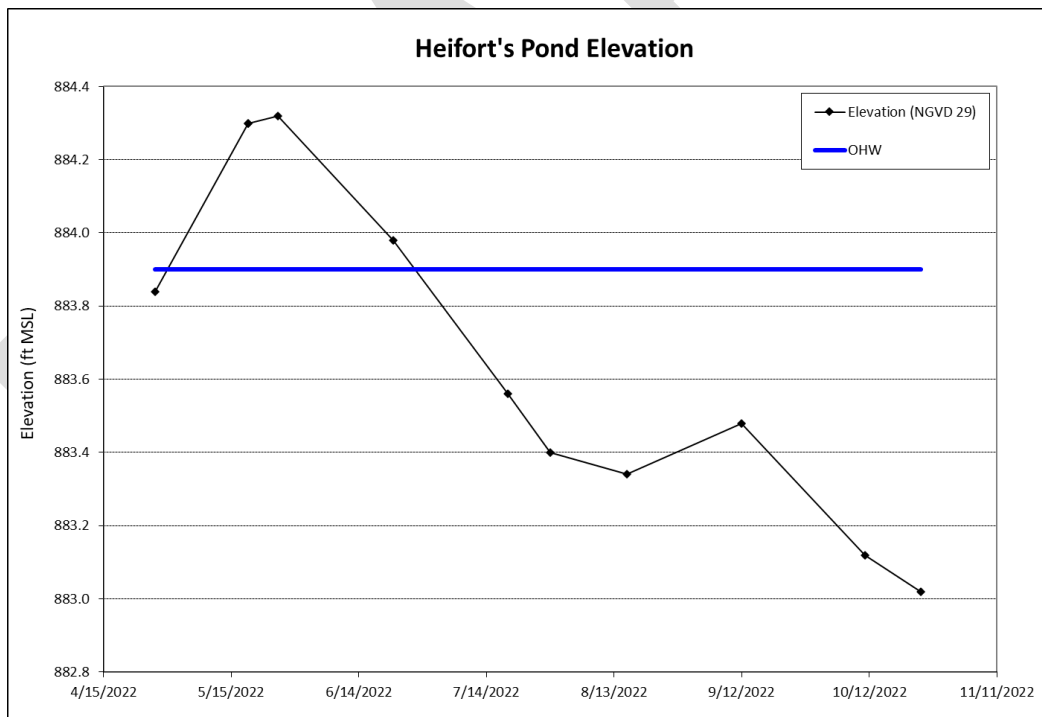
Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

Samples collected by a volunteer

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	884.32	5/26/2022	883.02	10/24/2022	883.70

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

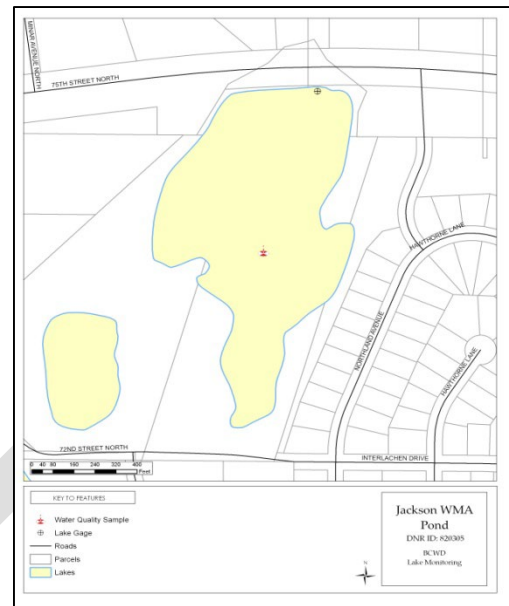


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	D	D	D	D	D	D	NA	NA	NA	NA
Chlorophyll-a (ug/l)	D	F	D	D	F	F	NA	NA	NA	NA
Secchi depth (ft)	F	F	F	F	F	F	NA	NA	NA	NA
Overall	D-	F+	D-	D-	F+	F+	NA	NA	NA	NA

Jackson WMA (Sinnits) Pond

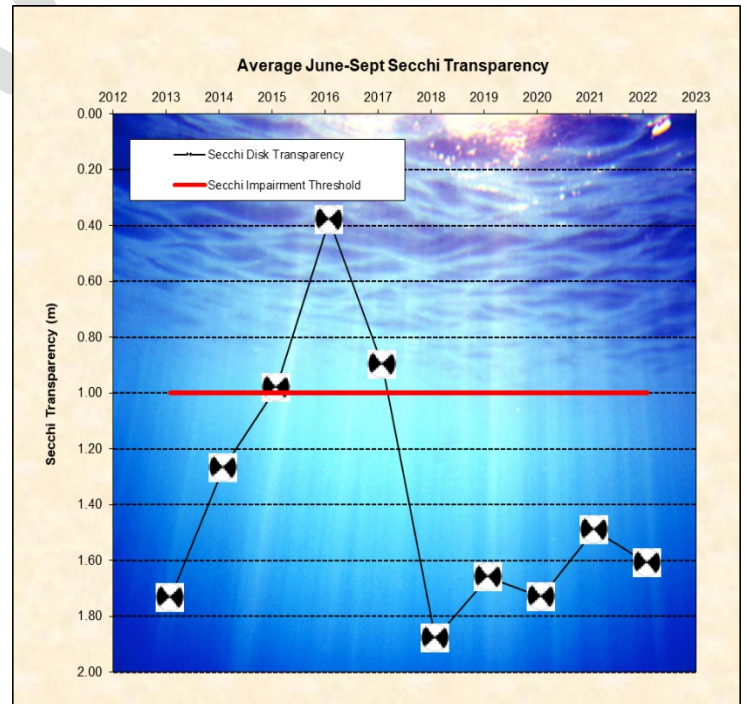
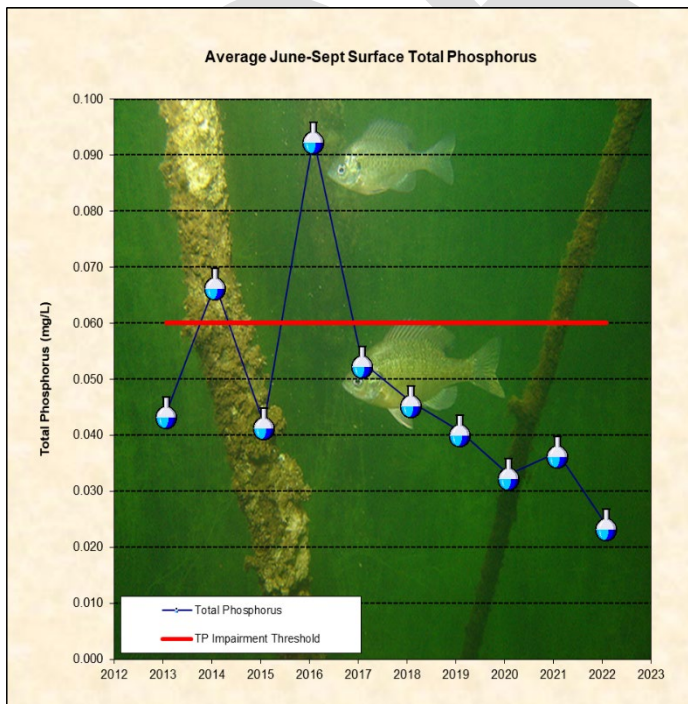
2022 Lake Grade: B

- DNR ID #: 820305
 - Municipality: City of Stillwater
 - Location: SE^{1/4} Section 30, T30N-R20W
 - Lake Size: 14.3 Acres
 - Maximum Depth (2022): 9 ft
 - Ordinary High Water Mark: NA
 - 100-Year High Water Level: NA
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as eutrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for average total phosphorus and for average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is urban/residential.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



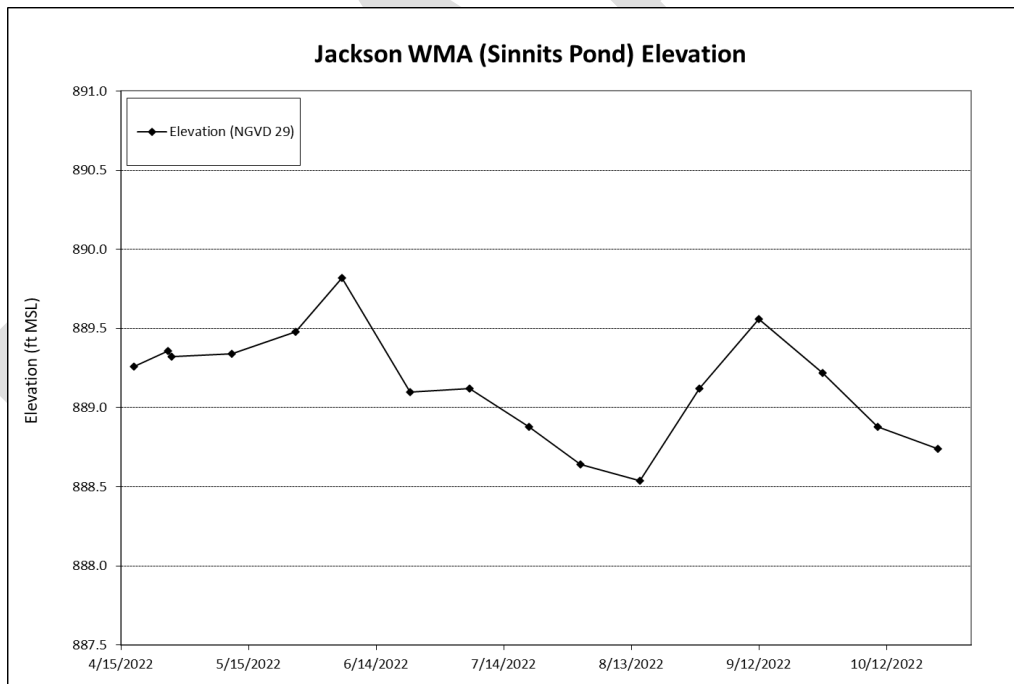
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/26/2022 13:01	0.039	15.0	13.0	0.75	1.98	8.1	11.07
5/11/2022 14:51	0.027	8.2	7.2	0.80	1.07	19.5	8.53
5/26/2022 13:58	0.040	9.1	12.0	0.75	1.68	16.2	7.32
6/6/2022 14:38	0.026	2.7	2.7	0.57	2.13	23.6	8.95
6/22/2022 14:24	0.021	2.6	2.6	0.64	2.29	27.4	9.47
7/6/2022 11:11	0.027	3.8	3.2	0.58	1.52	25.0	9.88
7/20/2022 15:11	0.026	2.3	2.0	0.77	0.91	28.1	8.34
8/1/2022 15:10	0.028	2.7	2.3	0.70	1.52	26.4	15.81
8/15/2022 14:45	0.025	3.5	3.3	0.72	1.52	22.6	8.62
8/29/2022 14:12	0.024	3.9	4.0	0.73	1.22	24.1	10.73
9/12/2022 14:38	0.019	3.8	3.2	0.68	1.52	22.5	12.26
9/27/2022 9:26	0.022	4.1	3.5	0.77	1.83	16.1	6.17
10/10/2022 14:53	0.037	9.5	8.8	0.72	2.13	14.7	10.84
2022 Average	0.028	5.5	5.2	0.71	1.64	21.1	9.85
2022 Summer Average	0.024	3.3	3.0	0.68	1.61	24.0	10.03

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

2022 Elevation (ft)	High	High Date	Low	Low Date	Average
	889.82	6/6/2022	888.54	8/15/2022	889.15

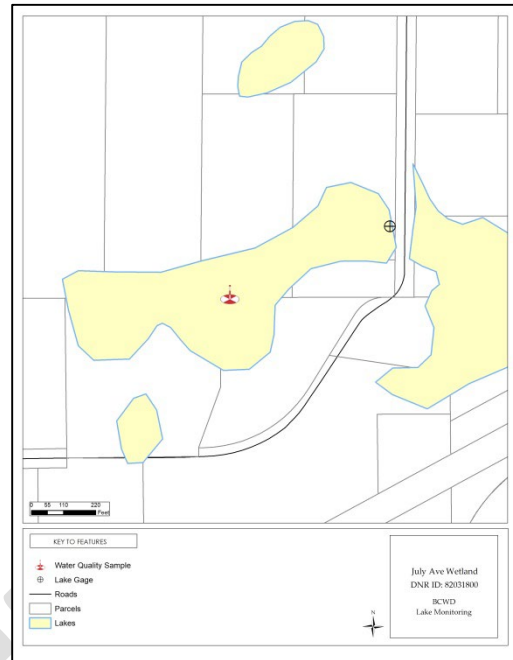
*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	C	C	C	C	C	D	C	C	C
Chlorophyll-a (ug/l)	A	A	A	C	A	B	F	B	D	B
Secchi depth (ft)	C	C	C	C	C	D	F	D	C	C
Overall	B	B-	B-	C	B-	C	F+	C	C-	C+

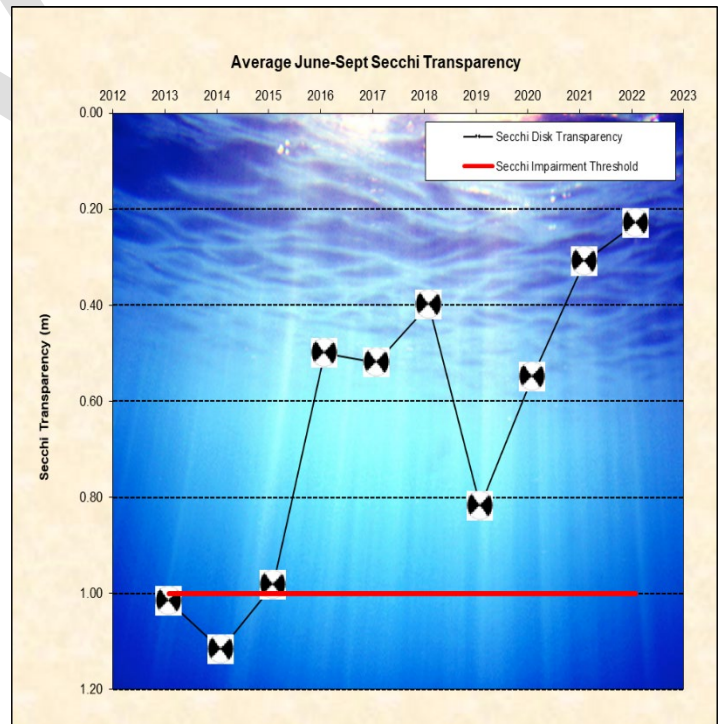
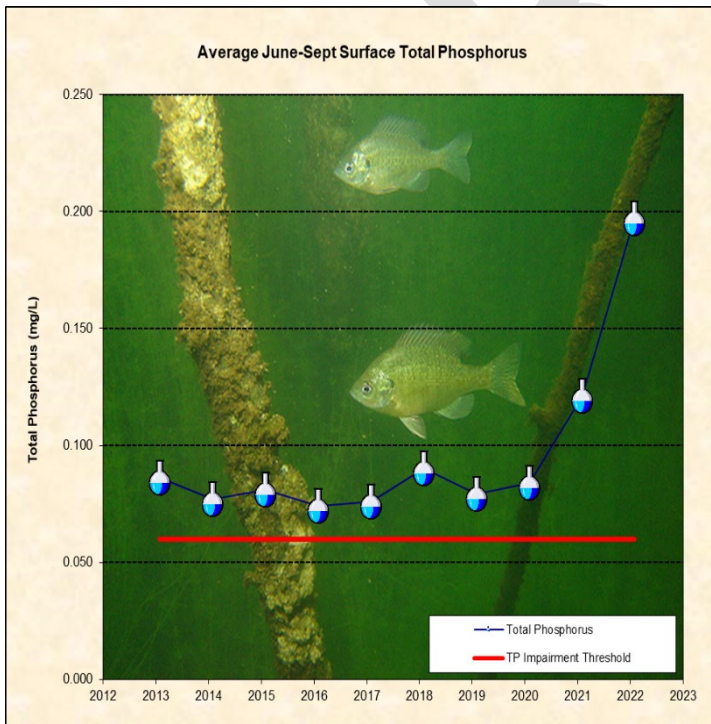
July Ave Wetland 2022 Lake Grade: F

- DNR ID #: 820318
 - Municipality: City of Grant
 - Location: Section 3, T30N-R21W
 - Lake Size: 12 Acres
 - Maximum Depth (2022): 9 ft
 - Ordinary High Water Mark: NA
 - 100-Year High Water Level: 979.20 ft
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as hypereutrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **declining** trend for the average Secchi transparency, and no trend for average total phosphorus and average chlorophyll- α .
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.

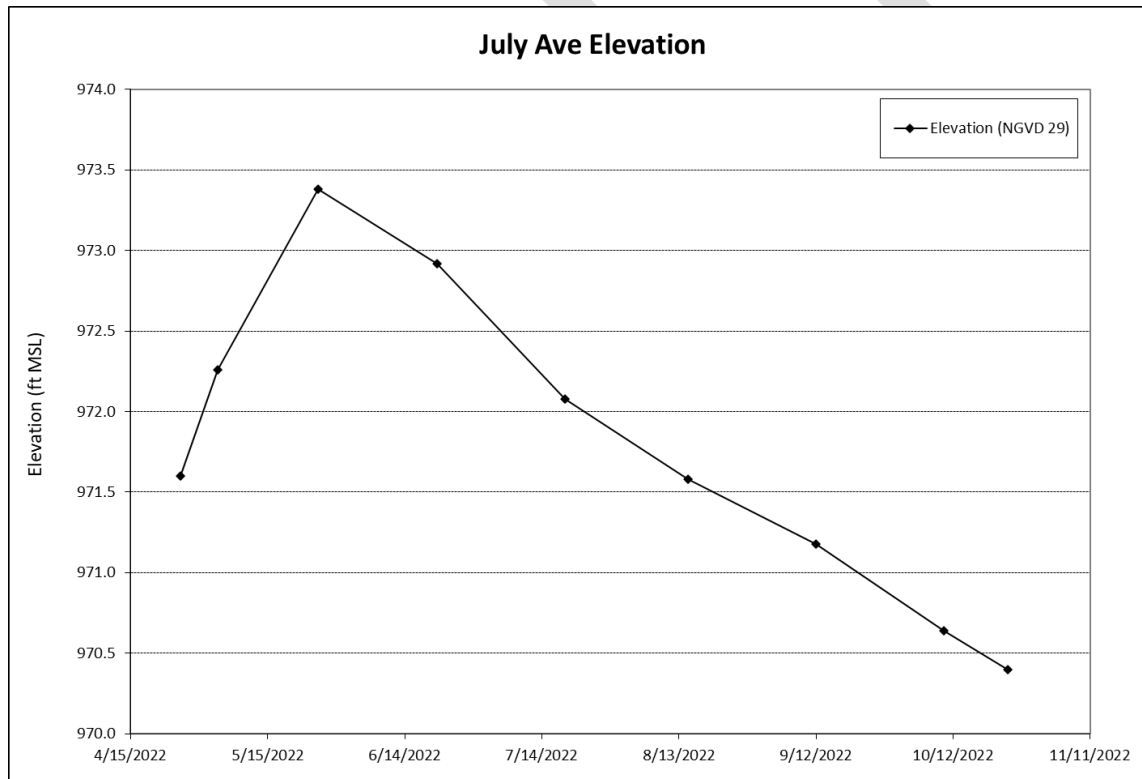


Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 9:57	0.125	81.0	73.0	2.00	0.46	7.7	11.91
5/26/2022 10:06	0.108	29.0	24.0	1.90	0.46	15.6	5.40
6/21/2022 12:00	0.227	65.0	61.0	2.70	0.61	28.0	8.23
7/19/2022 11:45	0.173	170.0	12.0	3.60	0.08	26.9	4.12
8/15/2022 10:23	0.212	250.0	230.0	5.60	0.15	22.5	14.44
9/12/2022 11:21	0.175	220.0	210.0	5.50	0.08	21.4	12.12
10/10/2022 9:28	0.124	81.0	74.0	5.10	0.15	12.4	6.34
2022 Average	0.163	128.0	97.7	3.77	0.28	19.2	8.94
2022 Summer Average	0.197	176.3	128.3	4.35	0.23	24.7	9.73

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	973.38	5/26/2022	970.40	10/24/2022	971.78

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



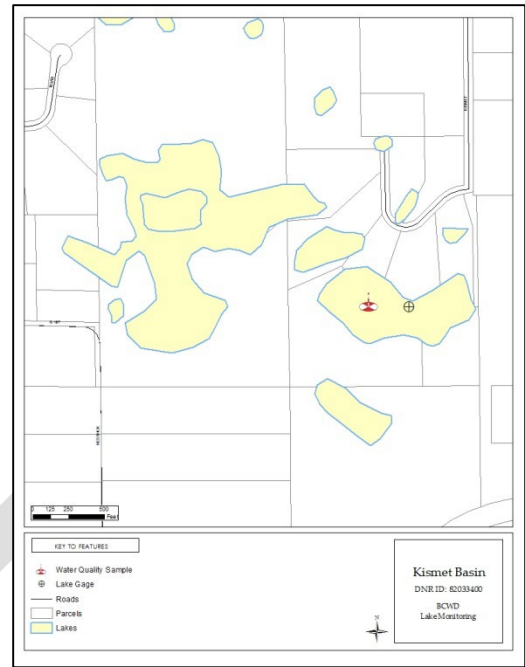
Lake Water Quality Summary											
	Lake Grades (May-Sept)										
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	
Total Phosphorus (mg/l)	F	D	D	D	D	C	D	D	D	D	
Chlorophyll-a (ug/l)	F	F	D	D	D	D	D	D	C	C	
Secchi depth (ft)	F	F	F	D	F	F	F	F	D	D	
Overall	F	F+	D-	D	D-	D	D-	D-	D+	D+	

Kismet Basin

2022 Lake Grade: B+

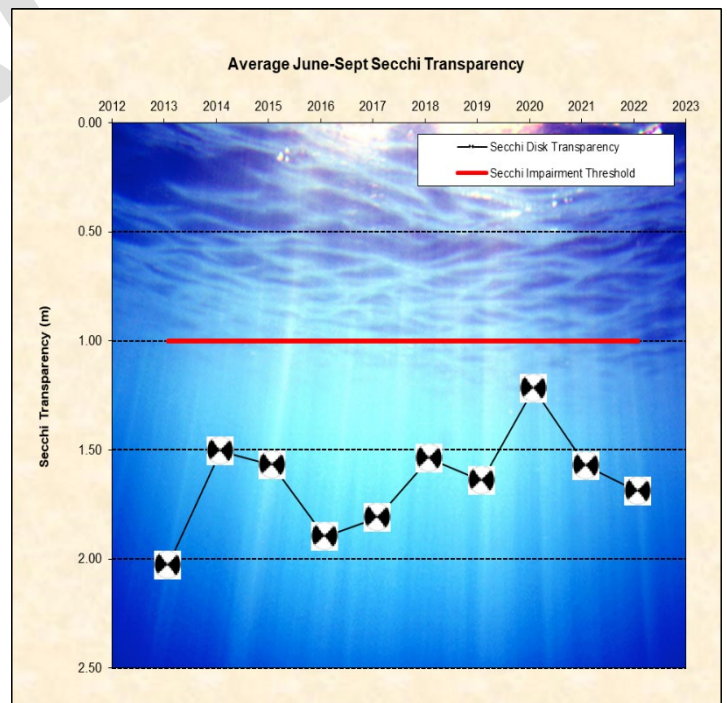
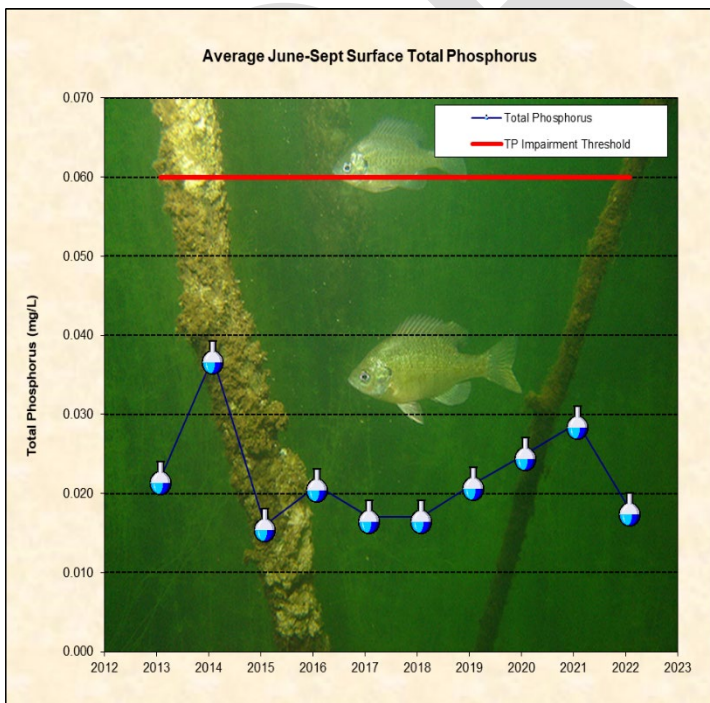
- DNR ID #: 820334
- Municipality: City of Grant
- Location: S^{1/2} Section 11, T30N-R21W
- Lake Size: 70 Acres
- Maximum Depth (2022): 11 ft
- Ordinary High Water Mark: 943.50 ft
- 100-Year High Water Level: 944.90 ft
- 100% Littoral

Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average total phosphorus and the average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



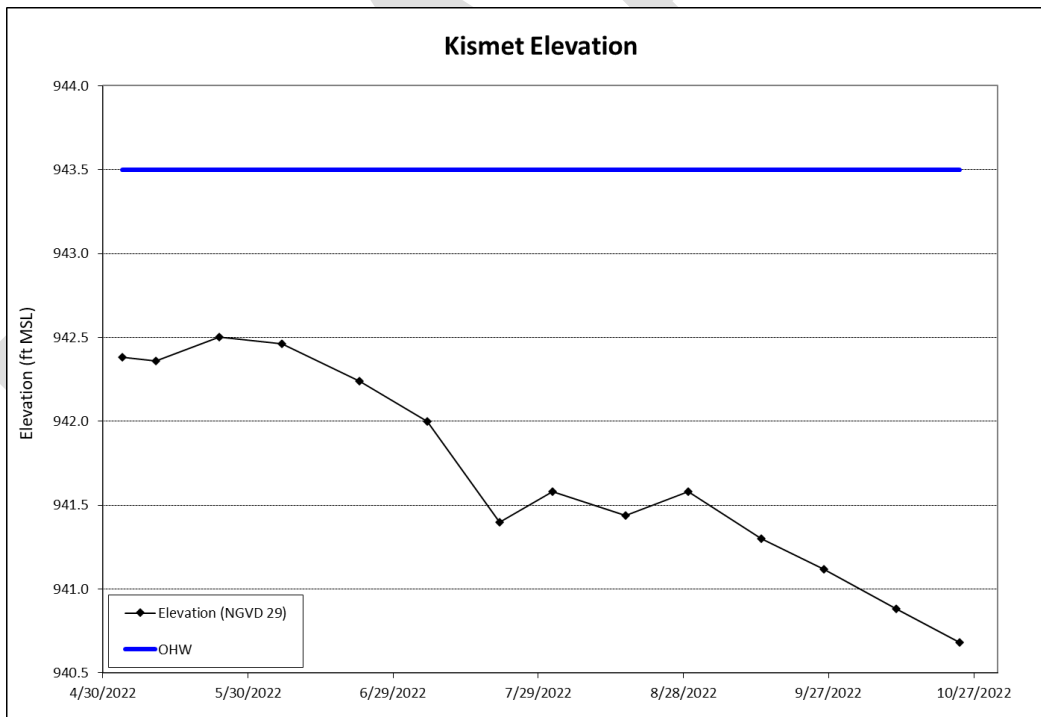
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 12:14	0.038	5.7	4.8	0.48	2.13	8.3	10.70
5/11/2022 13:56	0.015	4.6	3.7	0.53	2.29	18.7	8.31
5/24/2022 13:40	0.023	4.8	4.0	0.51	1.98	18.6	8.70
6/6/2022 12:15	0.015	3.0	5.1	0.45	2.13	22.2	9.44
6/22/2022 13:55	0.016	4.0	3.4	0.53	1.98	27.1	7.89
7/6/2022 9:40	0.019	4.8	4.0	0.51	1.68	24.5	6.59
7/21/2022 8:45	0.029	2.9	1.9	0.58	1.37	25.7	8.22
8/1/2022 11:45	0.017	5.4	4.8	0.50	1.98	24.4	9.51
8/16/2022 9:22	0.017	5.4	4.7	0.53	1.52	21.8	6.49
8/29/2022 12:12	0.028	8.7	7.9	0.51	0.91	23.2	8.37
9/13/2022 10:07	0.010	5.9	5.3	0.53	1.98	20.0	4.11
9/26/2022 10:02	0.013	3.7	2.7	0.46	1.68	15.4	4.66
10/11/2022 10:24	0.020	6.3	5.3	0.56	1.83	13.2	8.33
2022 Average	0.020	5.0	4.4	0.51	1.81	20.2	7.79
2022 Summer Average	0.018	4.9	4.4	0.51	1.69	22.7	7.25

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	942.50	5/24/2022	940.68	10/24/2022	941.71

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

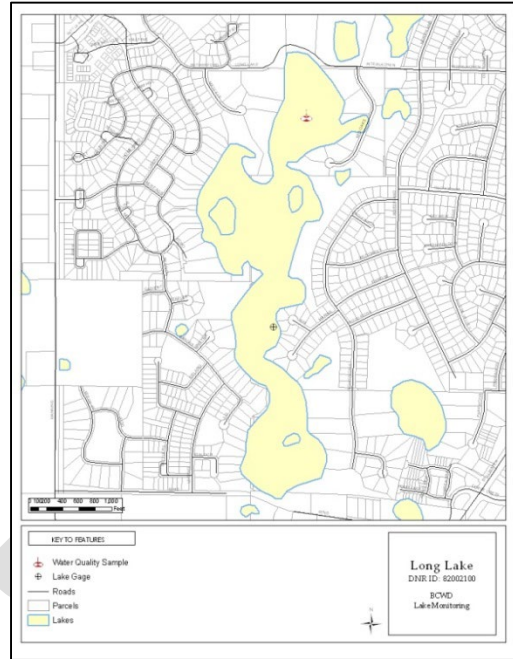


	Lake Water Quality Summary									
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	A	B	B	A	A	A	B	A	C	A
Chlorophyll-a (ug/l)	A	C	A	A	A	A	A	B	C	A
Secchi depth (ft)	C	C	C	C	C	C	C	C	C	C
Overall	B+	C+	B	B+	B+	B+	B	B	C	B+

Long Lake

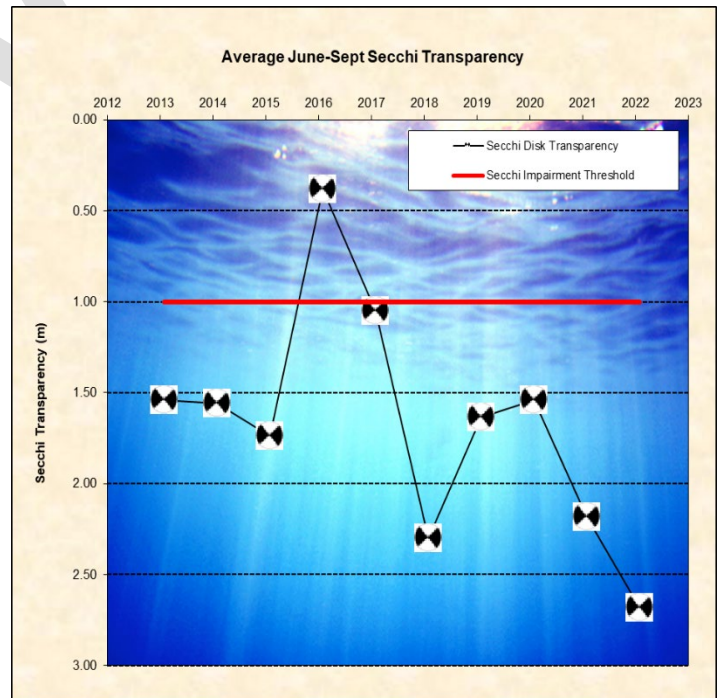
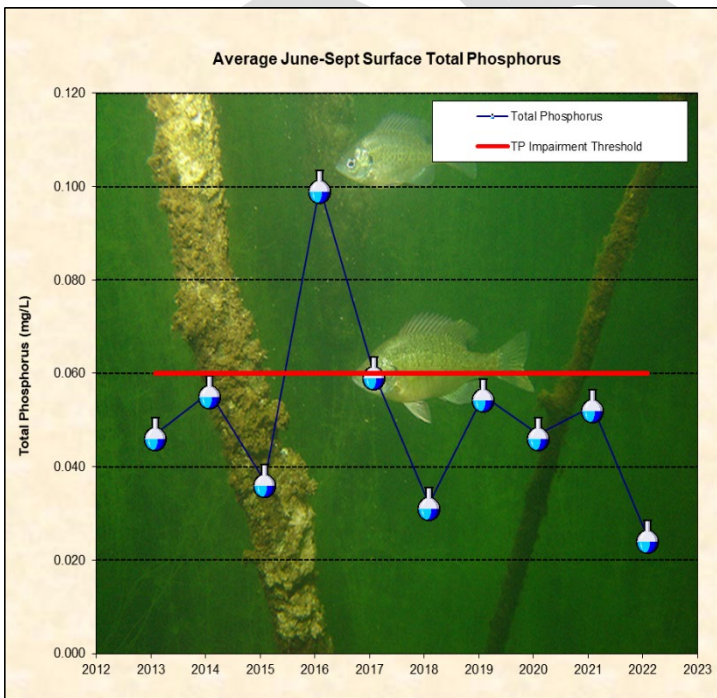
2022 Lake Grade: B+

- DNR ID #: 820021
 - Municipality: City of Stillwater
 - Location: Section 30, T30N-R20W
 - Lake Size: 110 Acres
 - Maximum Basin Depth (2022): 21 ft
 - Ordinary High Water Mark: 891.50 ft
 - 100-Year High Water Level: 893.20 ft
 - 95% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average Secchi transparency, average chlorophyll- α , and average total phosphorus.
- The major land use is urban/residential.
- The lake stratified in 2022 with a thermocline around 4 meters.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.
- Long Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.



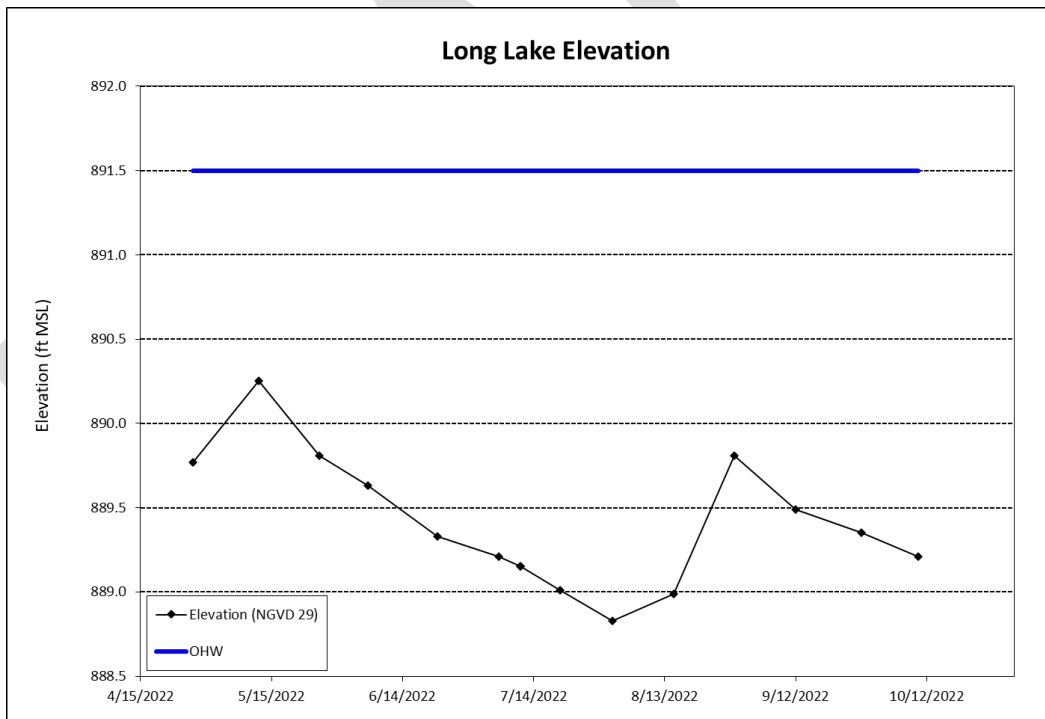
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/26/2022 12:33	0.072	34.0	32.0	0.87	1.52	7.7	9.87
5/12/2022 10:49	0.041	13.0	12.0	0.84	1.07	18.7	8.14
5/26/2022 13:36	0.039	6.2	5.3	0.77	2.44	16.3	7.51
6/6/2022 14:17	0.044	4.7	3.7	0.81	1.83	22.7	8.95
6/22/2022 14:45	0.021	2.4	1.9	0.64	2.74	27.6	8.60
7/6/2022 11:30	0.025	4.7	4.1	0.64	2.44	25.1	8.73
7/20/2022 14:00	0.021	2.1	1.7	0.59	2.13	27.1	7.47
8/1/2022 14:38	0.034	2.8	2.7	0.74	3.66	26.6	13.91
8/15/2022 14:15	0.028	8.0	7.7	0.84	2.74	22.9	11.74
8/29/2022 14:40	0.016	5.1	4.3	0.64	3.05	24.2	10.72
9/12/2022 14:15	0.020	3.3	2.7	0.72	3.35	22.3	12.47
9/27/2022 9:47	0.016	4.2	3.5	0.75	2.13	18.9	7.55
10/10/2022 15:23	0.033	4.5	4.3	0.92	1.98	15.1	10.55
2022 Average	0.032	7.3	6.6	0.75	2.39	21.2	9.71
2022 Summer Average	0.025	4.1	3.6	0.71	2.68	24.2	10.02

Water quality thresholds are 0.04 mg/L TP, 14 ug/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 ug/L CL-a, 1.0 m Secchi depth*

2022 Elevation (ft)	High	High Date	Low	Low Date	Average
	890.25	5/12/2022	888.83	8/1/2022	889.40

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



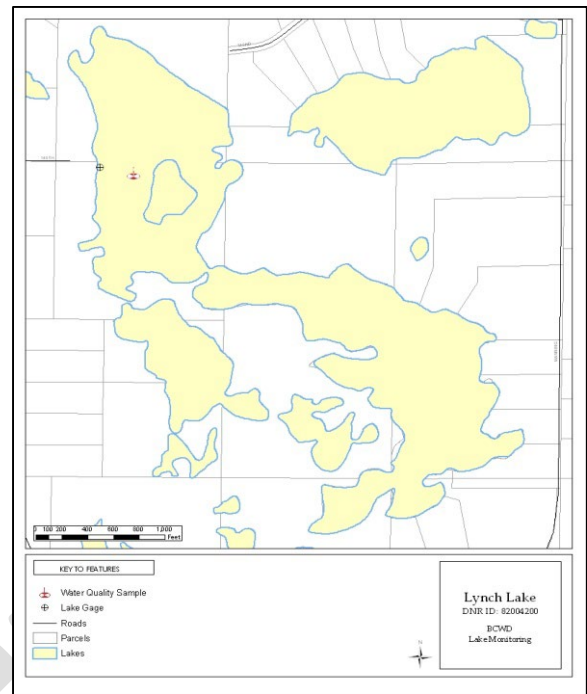
Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	C	C	C	C	C	D	C	C	C
Chlorophyll-a (ug/l)	A	A	B	C	A	B	F	B	C	B
Secchi depth (ft)	B	B	C	C	B	D	F	C	C	C
Overall	B+	B	C+	C	B	C	F+	C+	C	C+

Lynch Lake – North Basin

2022 Lake Grade: D+

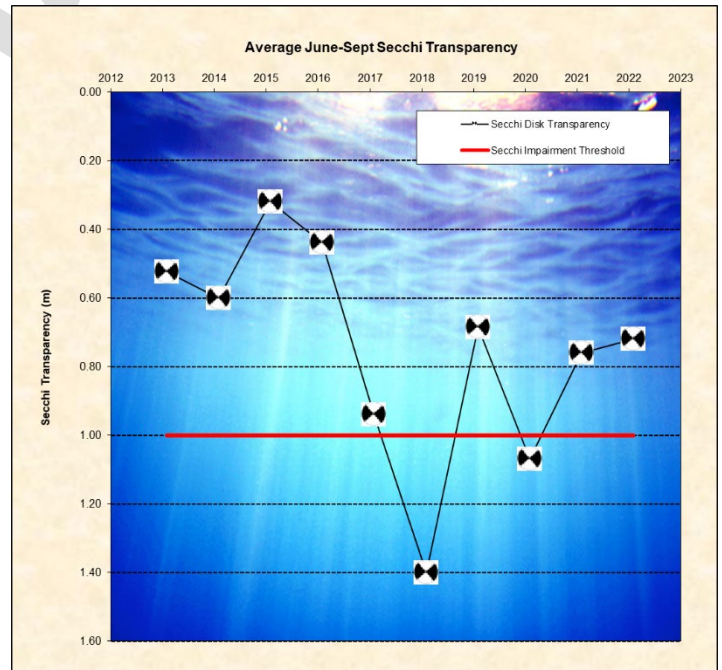
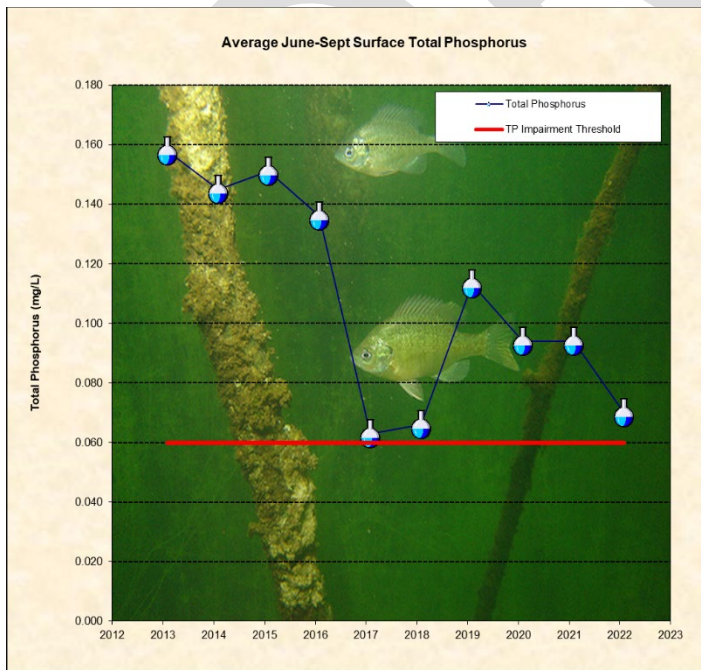
- DNR ID #: 820042
- Municipality: May Township
- Location: Section 30, T31N-R20W
- Lake Size: 87 Acres
- Maximum Depth (2022): 6 ft
- Ordinary High Water Mark: 1005.30 ft
- 100-Year High Water Level: 1008.10 ft
- 100% Littoral

Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as eutrophic according to the Carlson Trophic State Index.
- Using the Kendall’s Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average Secchi transparency, average chlorophyll- α , and average total phosphorus.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency’s standards.
- Lynch Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency’s Impaired Waters List.



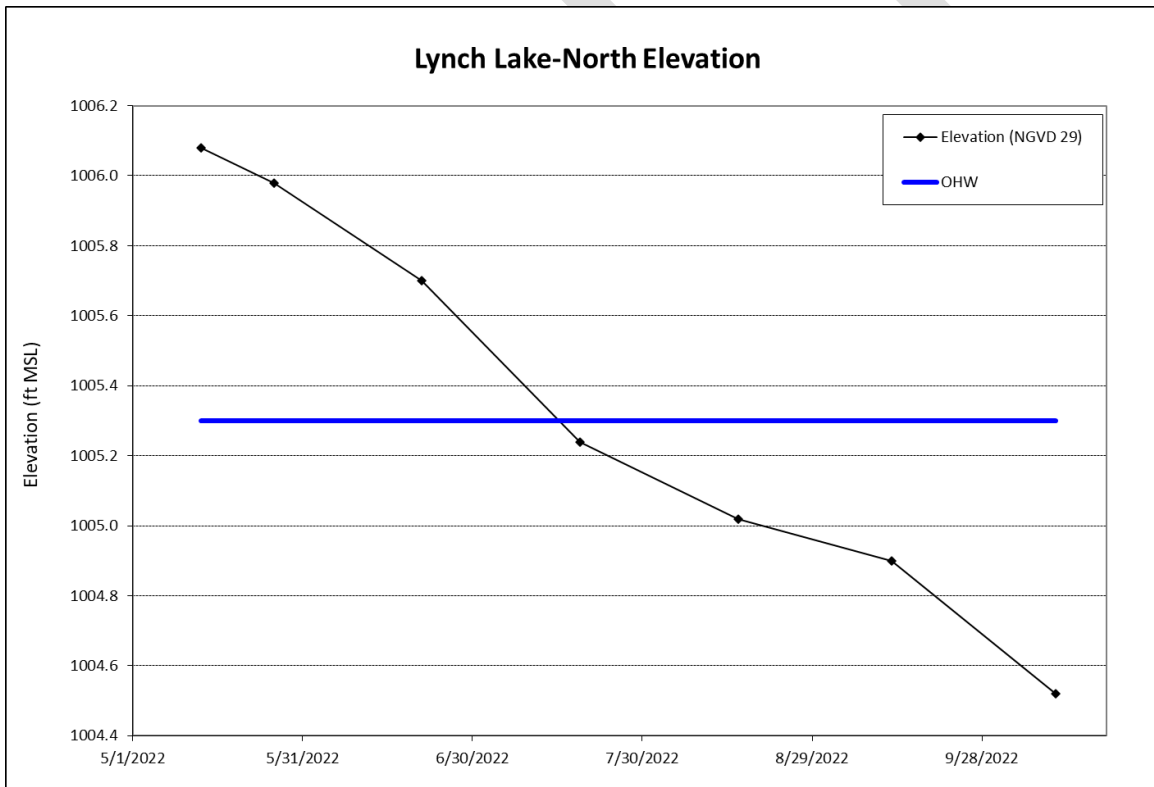
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 10:28	0.081	22.0	19.0	1.10	0.76	7.2	11.01
5/26/2022 10:28	0.089	28.0	22.0	1.20	0.61	15.0	8.79
6/21/2022 14:20	0.089	35.0	32.0	1.40	0.76	28.3	9.79
7/19/2022 14:07	0.090	40.0	36.0	1.40	0.61	28.1	10.29
8/16/2022 8:49	0.055	54.0	51.0	1.50	0.61	21.7	17.77
9/12/2022 13:13	0.046	30.0	27.0	1.20	0.91	20.7	14.60
10/11/2022 8:12	0.074	24.0	20.0	1.30	0.61	12.7	9.24
2022 Average	0.075	33.3	29.6	1.30	0.70	19.1	11.64
2022 Summer Average	0.070	39.8	36.5	1.38	0.72	24.7	13.11

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

2022 Elevation (ft)	High	High Date	Low	Low Date	Average
	1006.08	5/13/2022	1004.52	10/11/2022	1005.348571

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



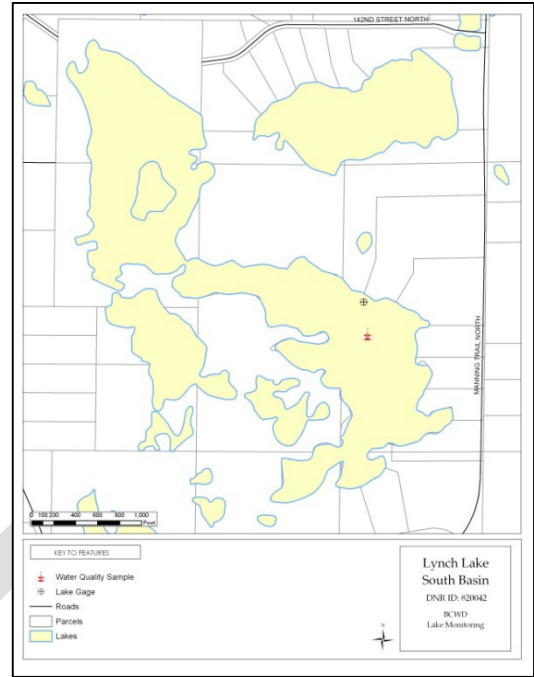
Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	D	D	D	D	C	C	D	D	D	F
Chlorophyll-a (ug/l)	C	C	C	D	B	C	D	F	F	F
Secchi disk (ft)	D	D	D	D	C	D	F	F	F	F
Overall	D+	D+	D+	D	C+	C-	D-	F+	F+	F

Lynch Lake – South Basin

2022 Lake Grade: C+

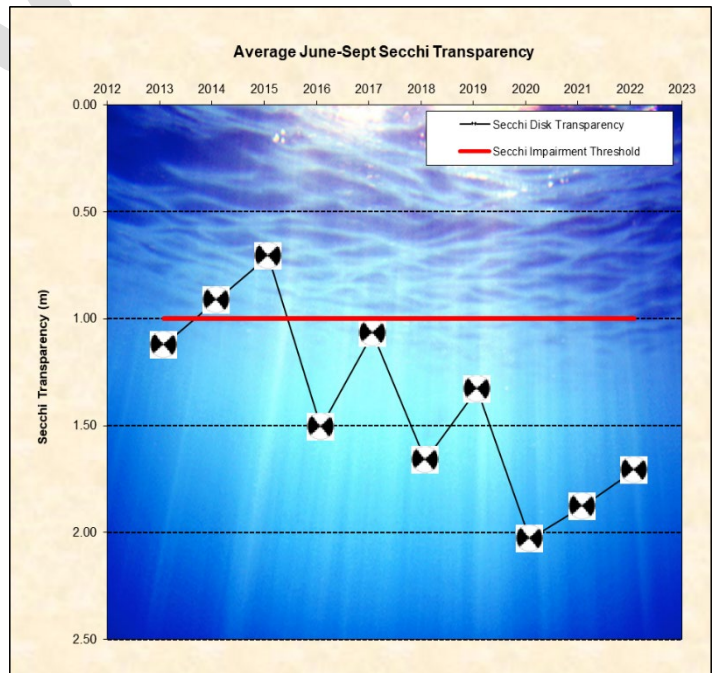
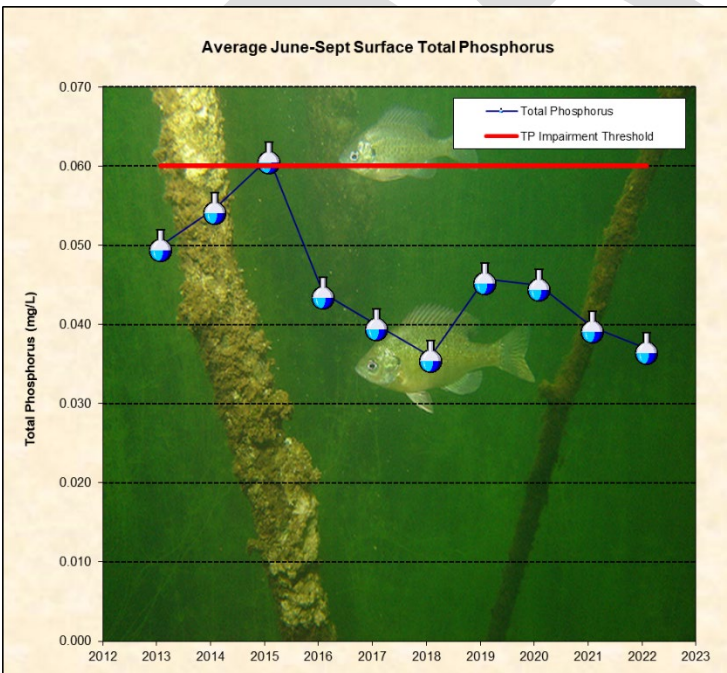
- DNR ID #: 820042
- Municipality: May Township
- Location: Section 30, T31N-R20W
- Lake Size: 87 Acres
- Maximum Depth (2022): 18 ft
- Ordinary High Water Mark: 1005.30 ft
- 100-Year High Water Level: 1008.10 ft
- 99% Littoral

Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as eutrophic according to the Carlson Trophic State Index.
- Using the Kendall’s Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average Secchi transparency, average chlorophyll- α , and average total phosphorus.
- The major land use is rural/agricultural.
- The lake stratified in 2022 with the thermocline around 4 meters.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency’s standards.
- Lynch Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency’s Impaired Waters List.

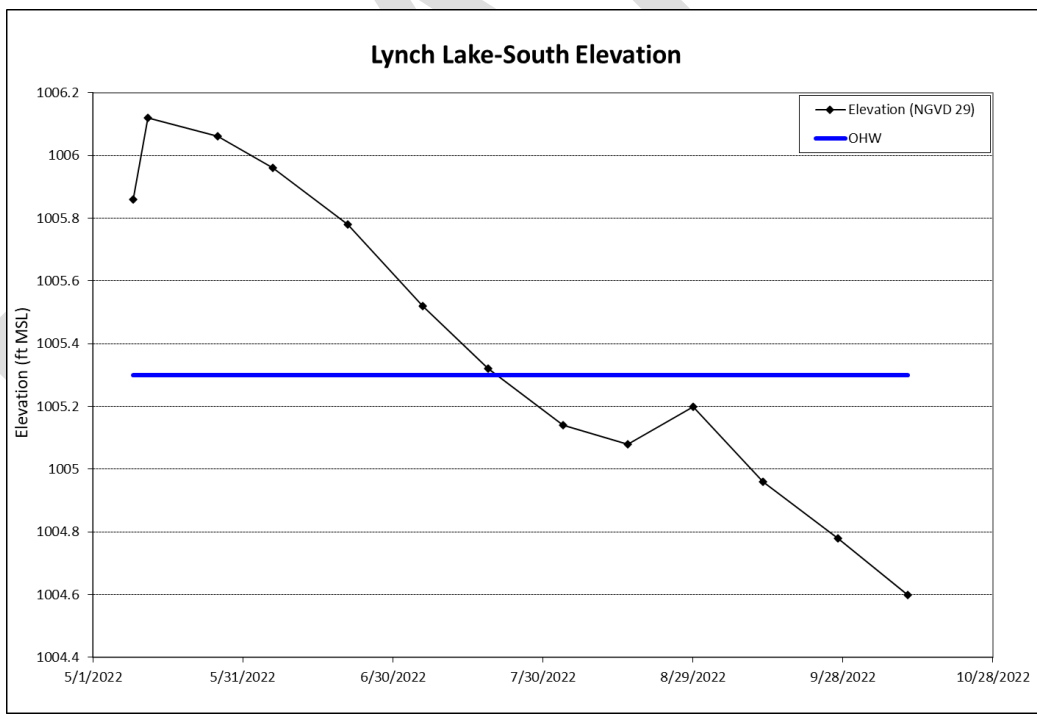


Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 10:52	0.038	11.0	8.5	1.00	1.83	7.5	10.97
5/12/2022 9:58	0.040	6.5	4.8	0.87	1.07	17.3	8.48
5/26/2022 10:52	0.040	11.0	8.8	0.88	1.22	16.0	7.97
6/6/2022 11:21	0.043	12.0	11.0	0.80	1.83	21.3	9.17
6/21/2022 13:52	0.057	6.4	5.9	1.10	2.13	27.6	8.30
7/6/2022 10:32	0.036	13.0	12.0	0.94	1.68	24.8	9.41
7/19/2022 13:35	0.034	11.0	11.0	0.95	1.52	28.4	9.12
8/3/2022 11:08	0.030	12.0	11.0	0.90	2.13	26.0	13.09
8/16/2022 10:21	0.036	15.0	14.0	0.87	1.68	23.1	13.60
8/29/2022 11:18	0.025	17.0	16.0	0.81	1.68	23.4	12.44
9/12/2022 11:45	0.027	26.0	26.0	0.88	1.22	22.1	13.68
9/27/2022 8:54	0.048	26.0	23.0	0.95	1.52	16.7	8.06
10/11/2022 8:42	0.048	20.0	17.0	1.10	1.37	14.2	9.23
2022 Average	0.039	14.4	13.0	0.93	1.61	20.6	10.27
2022 Summer Average	0.037	15.4	14.4	0.91	1.71	23.7	10.76

Water quality thresholds are 0.04 mg/L TP, 14 ug/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 ug/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	1006.12	5/12/2022	1004.60	10/11/2022	1005.41

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

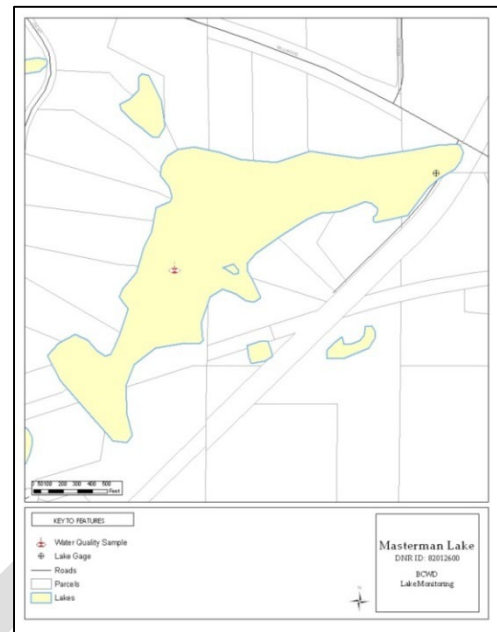


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	C	C	C	C	C	C	C	C	C	C
Chlorophyll-a (ug/l)	B	B	A	C	B	B	C	C	C	B
Secchi depth (ft)	C	C	C	C	C	D	C	D	D	D
Overall	C+	C+	B-	C	C+	C	C	C-	C-	C

Masterman Lake 2022 Lake Grade: B+

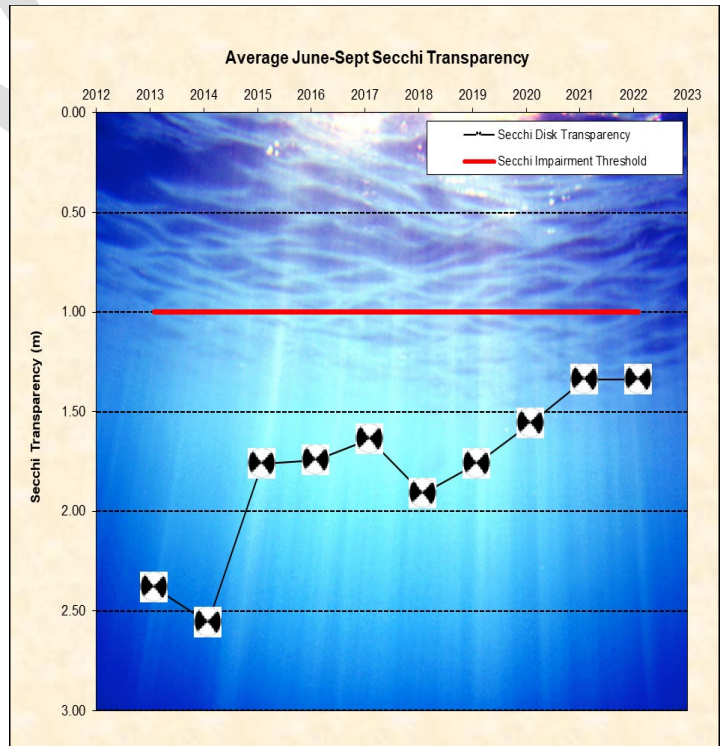
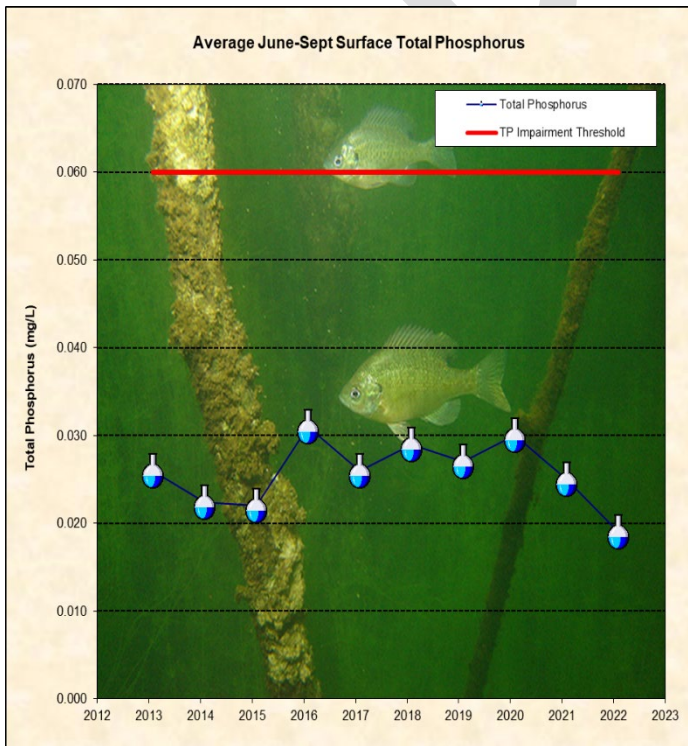
- DNR ID #: 820126
- Municipality: City of Grant
- Location: Section 23, T30N-R21W
- Lake Size: 40 Acres
- Maximum Depth (2022): 8 ft
- Ordinary High Water Mark: 955.70 ft
- 100-Year High Water Level: 955.90 ft
- 100% Littoral

Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average total phosphorus and average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



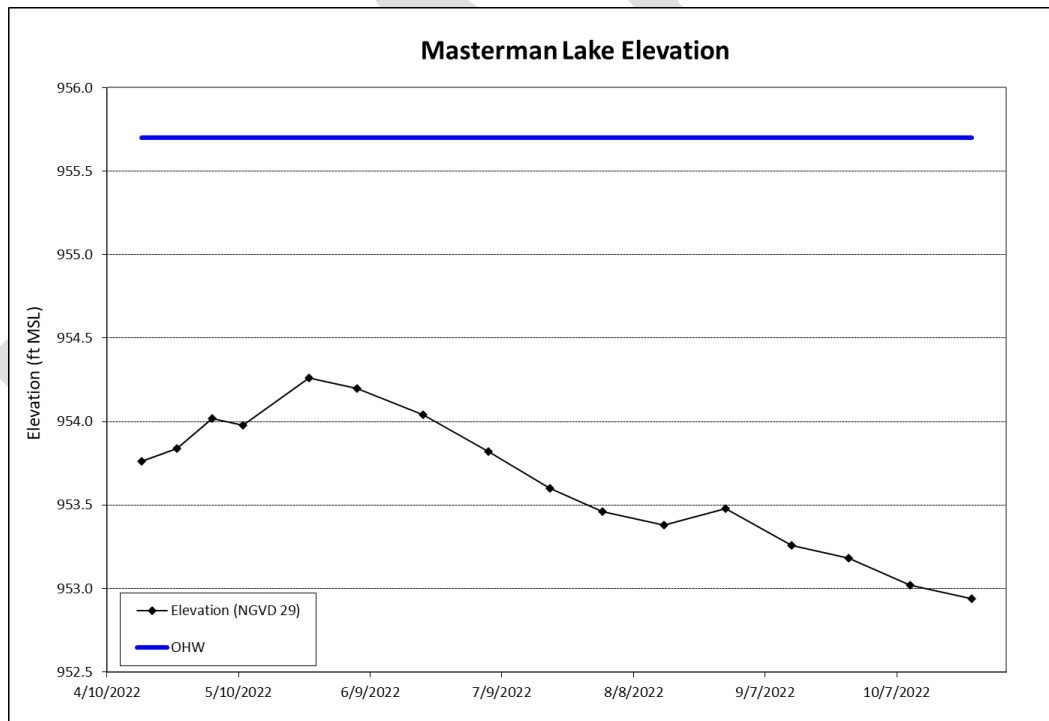
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/26/2022 8:43	0.047	4.8	3.5	0.60	1.68	6.5	10.48
5/11/2022 11:52	0.017	3.8	3.2	0.47	1.52	18.1	9.33
5/26/2022 8:39	0.018	3.5	2.7	0.42	1.52	16.3	7.16
6/6/2022 13:45	0.024	2.1	1.6	0.44	1.52	22.5	9.35
6/21/2022 14:49	0.018	2.0	1.9	0.51	1.98	28.3	8.14
7/6/2022 8:19	0.022	5.4	4.5	0.54	1.52	24.4	7.24
7/20/2022 10:30	0.024	9.9	8.5	0.53	1.22	25.4	6.28
8/1/2022 11:06	0.010	4.6	3.8	0.56	1.22	24.8	12.70
8/15/2022 13:36	0.023	3.2	2.8	0.53	1.22	22.2	8.37
8/29/2022 8:57	0.024	7.5	10.0	0.52	1.07	22.0	8.46
9/13/2022 8:27	0.013	5.3	4.5	0.54	1.37	20.2	6.69
9/26/2022 9:38	0.014	2.3	1.9	0.46	0.91	16.2	4.82
10/10/2022 10:57	0.029	3.5	2.9	0.45	1.22	13.1	7.36
2022 Average	0.022	4.5	4.0	0.51	1.38	20.0	8.18
2022 Summer Average	0.019	4.7	4.4	0.51	1.34	22.9	8.01

Water quality thresholds are 0.04 mg/L TP, 14 ug/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 ug/L CL-a, 1.0 m Secchi depth*

2022 Elevation (ft)	High	High Date	Low	Low Date	Average
	954.26	5/26/2022	952.94	10/24/2022	953.64

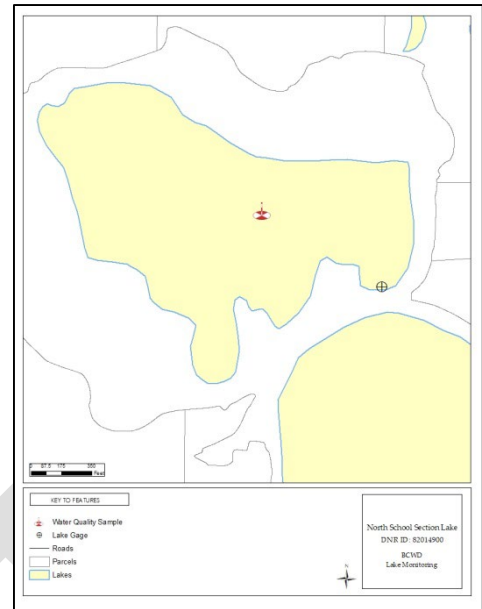
*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	A	A	B	B	B	B	B	A	A	B
Chlorophyll-a (ug/l)	A	A	B	A	A	B	B	A	A	A
Secchi depth (ft)	C	C	C	C	C	C	C	C	B	B
Overall	B+	B+	B-	B	B	B-	B-	B+	A-	B+

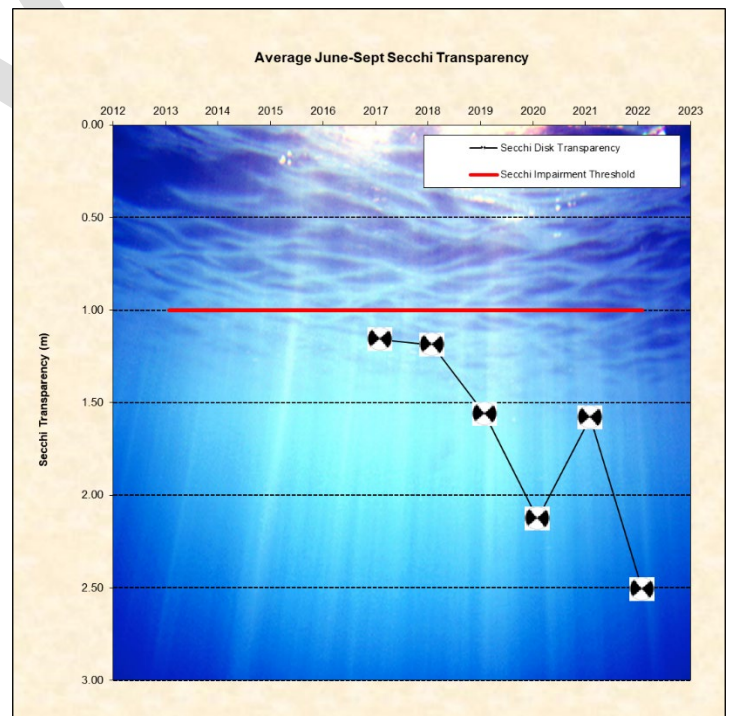
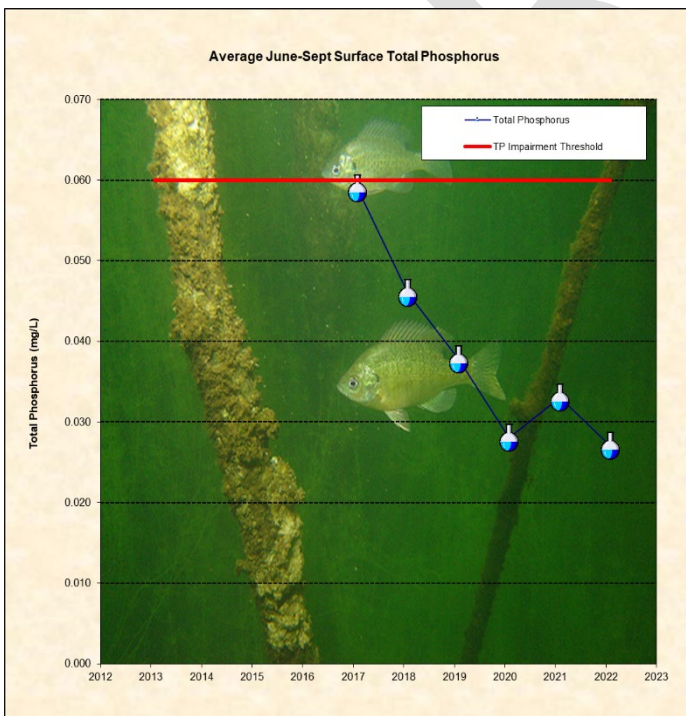
North School Section Lake 2022 Lake Grade: B+

- DNR ID #: 820149
 - Municipality: City of Hugo
 - Location: SW ¼ Section 25, T31N-R21W
 - Lake Size: 40 Acres
 - Maximum Depth (2022): 15 ft
 - Ordinary High Water Mark: 963.2 ft
 - 100-Year High Water Level: 970.42
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as eutrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there are an insufficient number of years of data to determine a trend for the average total phosphorus, average chlorophyll- α , and average Secchi transparency.
- The major land use is rural/agricultural.
- The North and South School Section basins were connected in 2022.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.

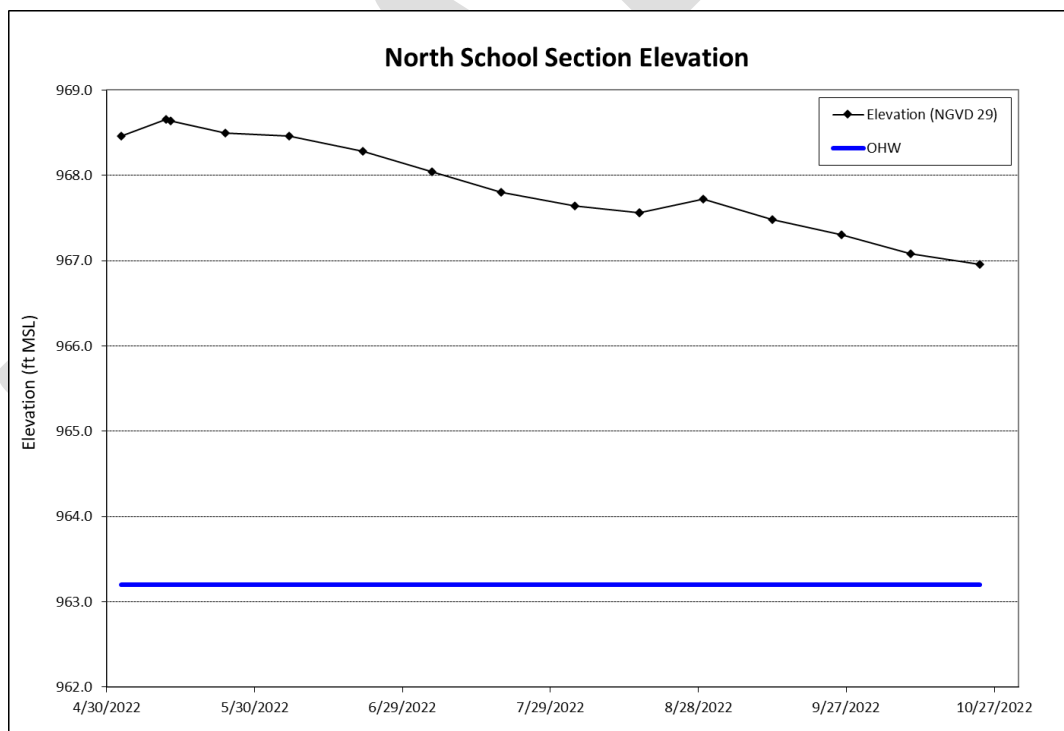


Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 9:25	0.026	7.6	6.1	0.72	2.44	7.1	10.66
5/24/2022 11:30	0.034	3.2	2.4	0.72	3.66	17.3	9.12
6/21/2022 10:55	0.020	6.3	6.0	0.66	3.05	25.9	8.47
7/19/2022 10:30	0.028	5.7	5.3	0.72	2.90	27.2	8.36
8/16/2022 14:42	0.029	10.0	9.3	0.74	2.29	23.4	12.66
9/12/2022 10:30	0.031	16.0	15.0	0.79	1.83	21.6	9.39
10/10/2022 13:30	0.024	6.5	5.9	0.66	3.35	14.3	11.99
2022 Average	0.027	7.9	7.1	0.72	2.79	19.5	10.09
2022 Summer Average	0.027	9.5	8.9	0.73	2.51	24.5	9.72

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	968.66	5/12/2022	966.96	10/24/2022	967.88

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

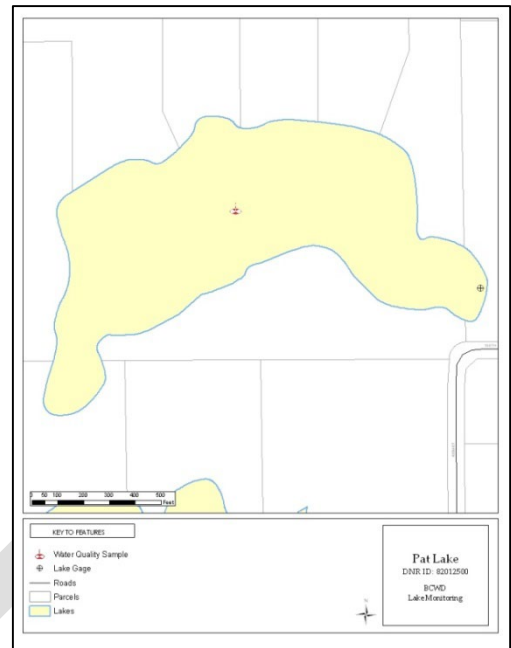


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	B	C	C	C	C	NA	NA	NA	NA
Chlorophyll-a (ug/l)	A	B	A	C	C	C	NA	NA	NA	NA
Secchi depth (ft)	B	C	B	C	C	C	NA	NA	NA	NA
Overall	B+	B-	B	C	C	C	NA	NA	NA	NA

Pat Lake

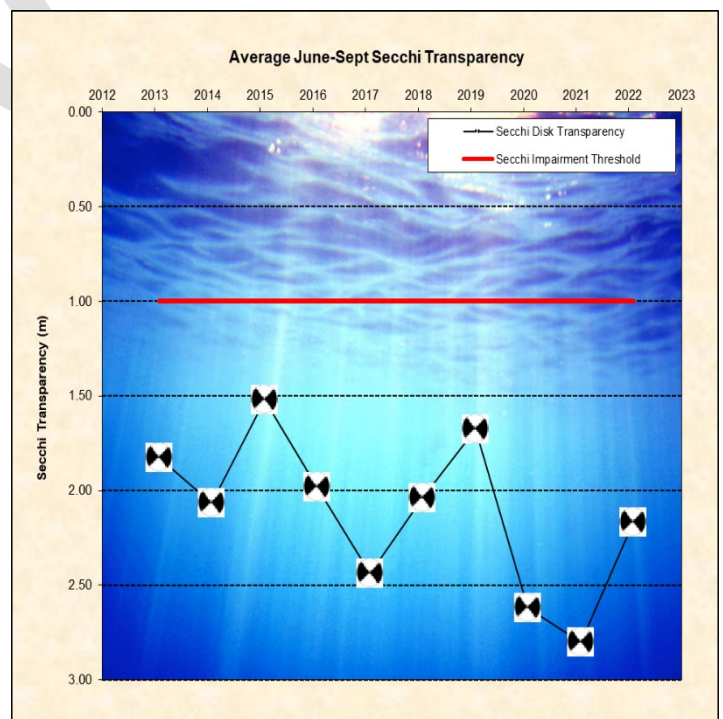
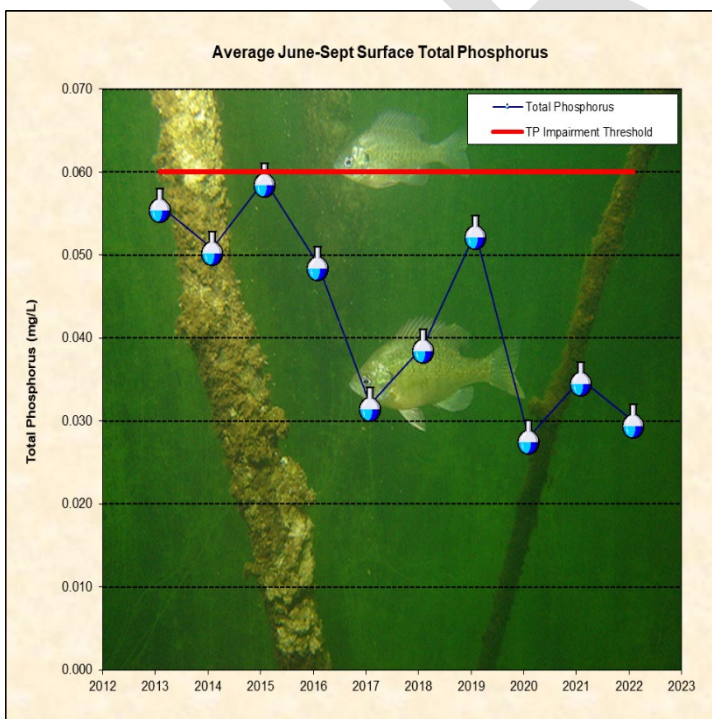
2022 Lake Grade: B+

- DNR ID #: 820125
 - Municipality: City of Grant
 - Location: Section 11, T30N-R21W
 - Lake Size: 20 Acres
 - Maximum Depth (2022): 18 ft
 - Ordinary High Water Mark: 941.80 ft
 - 100-Year High Water Level: 949.10 ft
 - 99% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average total phosphorus and average chlorophyll- α , and no trend for average Secchi transparency at this time.
- The major land use is rural/agricultural.
- The lake stratified in 2022 with a thermocline around 3 meters.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.



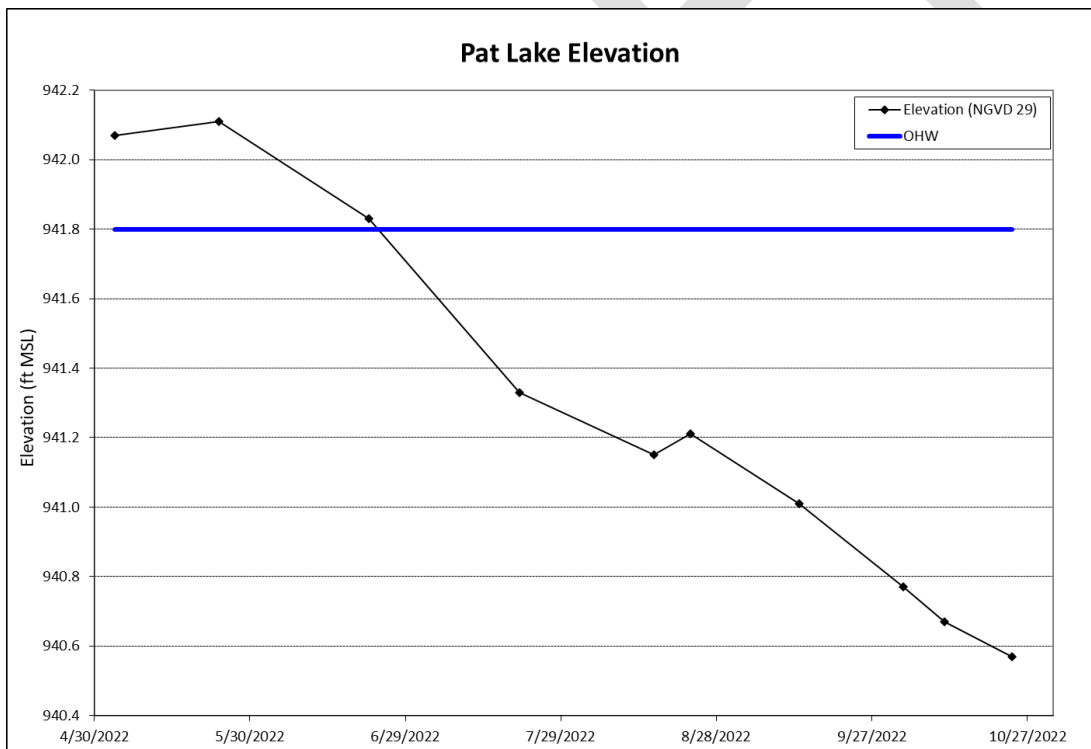
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 11:48	0.020	5.1	4.3	0.54	3.35	7.9	11.37
5/24/2022 13:11	0.031	2.1	1.3	0.60	3.35	18.6	9.19
6/22/2022 13:28	0.027	8.5	7.4	0.76	1.98	27.1	8.65
7/21/2022 10:50	0.042	6.1	5.4	0.78	2.13	26.7	9.95
8/16/2022 9:45	0.024	8.9	8.0	0.66	2.13	22.9	10.42
9/13/2022 9:45	0.028	9.5	8.3	0.60	2.44	21.4	11.29
10/11/2022 9:50	0.134	4.7	3.7	2.00	3.96	14.0	11.59
2022 Average	0.044	6.4	5.5	0.85	2.76	19.8	10.35
2022 Summer Average	0.030	8.3	7.3	0.70	2.17	24.5	10.08

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	942.11	5/24/2022	940.57	10/24/2022	941.27

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."

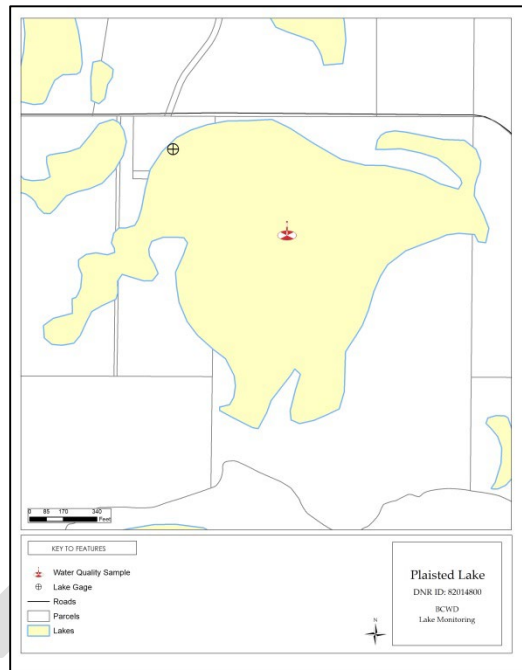


Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	C	B	C	C	B	C	C	C	C
Chlorophyll-a (ug/l)	A	A	A	B	B	A	B	C	B	B
Secchi depth (ft)	B	B	B	C	C	B	C	C	C	C
Overall	B+	B	B+	C+	C+	B+	C+	C	C+	C+

Plaisted Lake

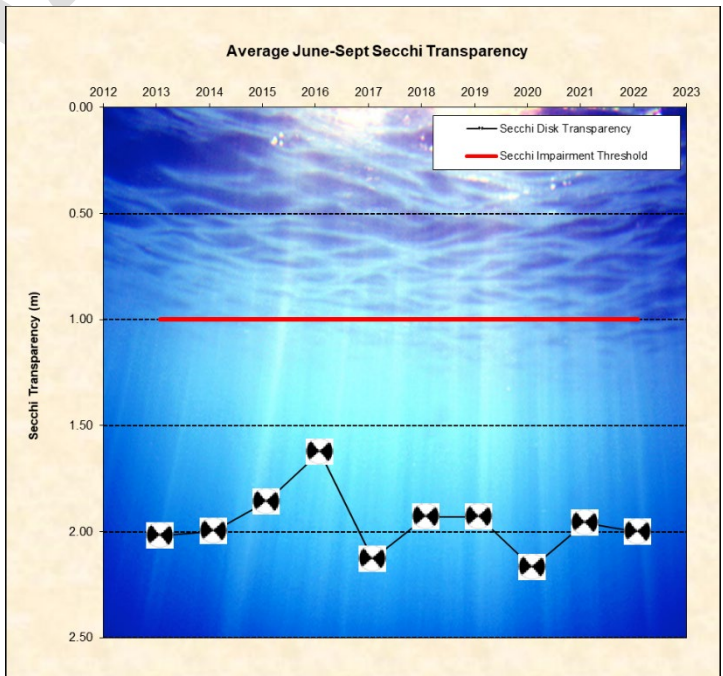
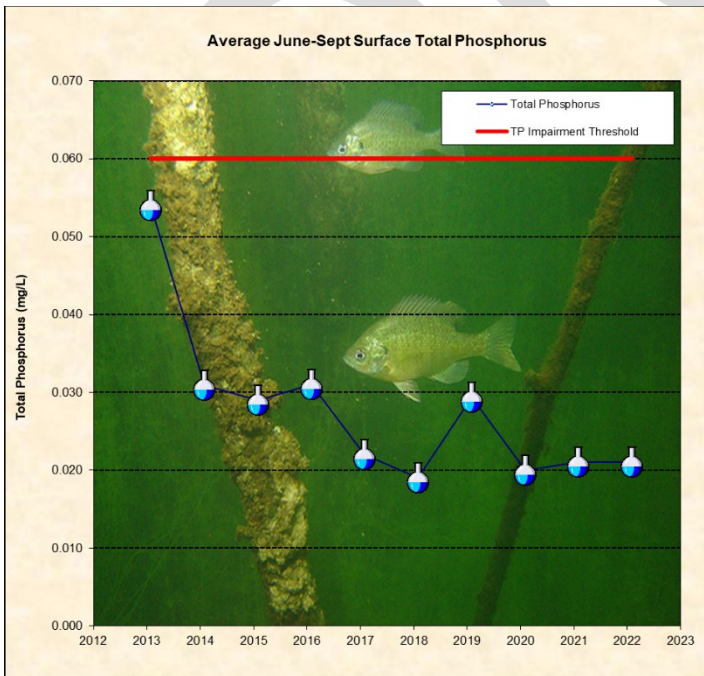
2022 Lake Grade: B+

- DNR ID #: 820148
 - Municipality: City of Hugo
 - Location: Section 25, T31N-R21W
 - Lake Size: 70 Acres
 - Maximum Depth (2022): 12 ft
 - Ordinary High Water Mark: 966.00 ft
 - 100-Year High Water Level: NA
 - 100% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average total phosphorus and average chlorophyll- α , and the trend for the average Secchi transparency is skewed due to vegetation limiting the transparency.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- This lake is categorized as shallow according to the Minnesota Pollution Control Agency's standards.
- Plaisted Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.



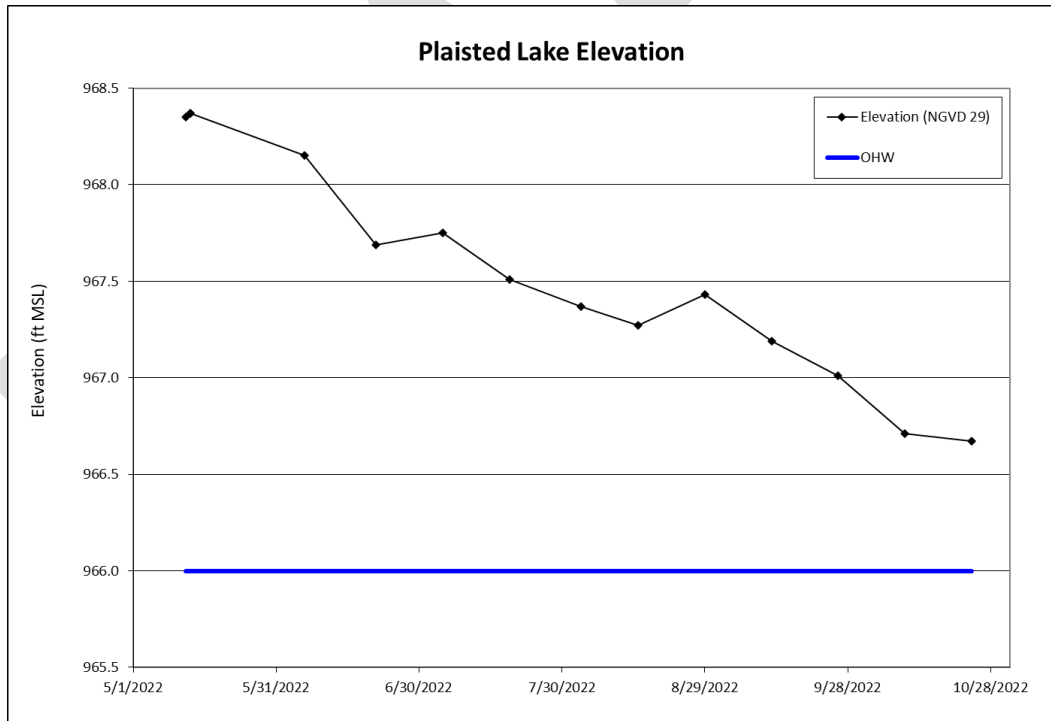
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 8:24	0.027	3.9	3.2	0.56	2.74	7.2	10.59
5/12/2022 8:45	0.017	2.8	2.1	0.42	2.74	17.2	8.42
5/24/2022 10:02	0.021	2.1	1.6	0.42	2.29	17.8	9.36
6/6/2022 9:43	0.030	1.8	1.6	0.45	2.44	21.0	9.88
6/21/2022 10:19	0.032	11.0	11.0	0.63	2.13	26.8	9.19
7/5/2022 11:24	0.023	12.0	10.0	0.62	2.13	25.3	8.15
7/19/2022 9:45	0.019	2.9	2.4	0.54	2.29	28.2	9.05
8/3/2022 9:24	0.023	2.6	2.4	0.56	1.83	26.1	12.74
8/15/2022 9:45	0.021	2.6	2.1	0.46	1.98	22.6	8.81
8/29/2022 9:53	0.017	3.0	2.9	0.45	1.83	23.0	9.27
9/12/2022 9:45	0.012	2.4	1.9	0.45	1.83	21.4	6.60
9/26/2022 13:45	0.014	2.0	1.9	0.45	1.52	17.4	5.69
10/10/2022 12:03	0.034	3.2	2.7	0.42	2.44	14.2	10.77
2022 Average	0.022	4.0	3.5	0.49	2.17	20.6	9.12
2022 Summer Average	0.021	4.5	4.0	0.51	2.00	23.5	8.82

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	968.37	5/13/2022	966.67	10/24/2022	967.56

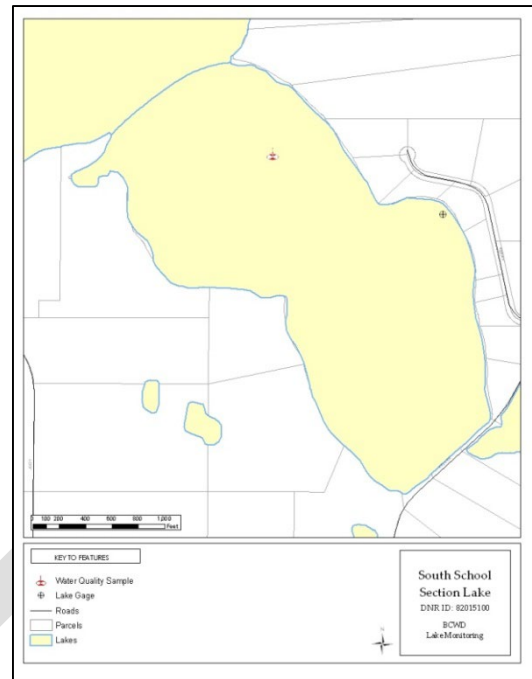
*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	A	A	A	B	A	A	B	B	B	C
Chlorophyll-a (ug/l)	A	A	A	A	A	A	B	A	A	C
Secchi depth (ft)	C	B	B	C	C	C	C	C	C	C
Overall	B+	A-	A-	B	B+	B+	B-	B	B	C

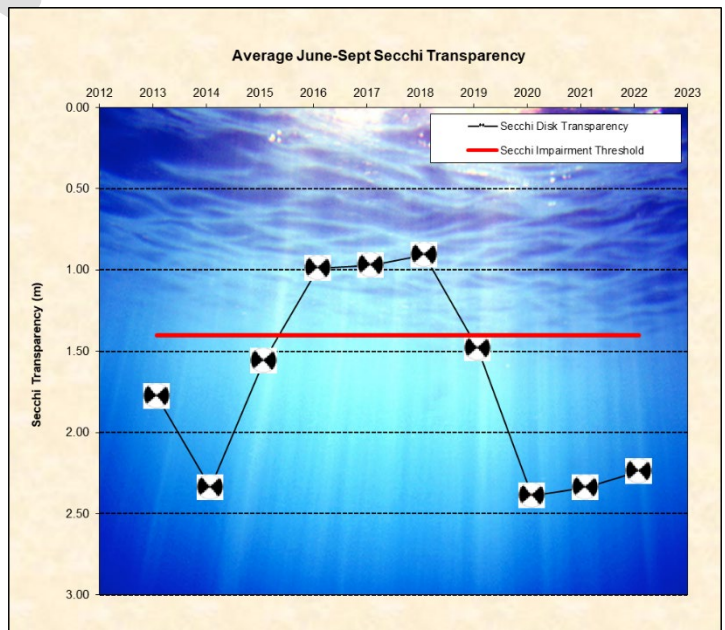
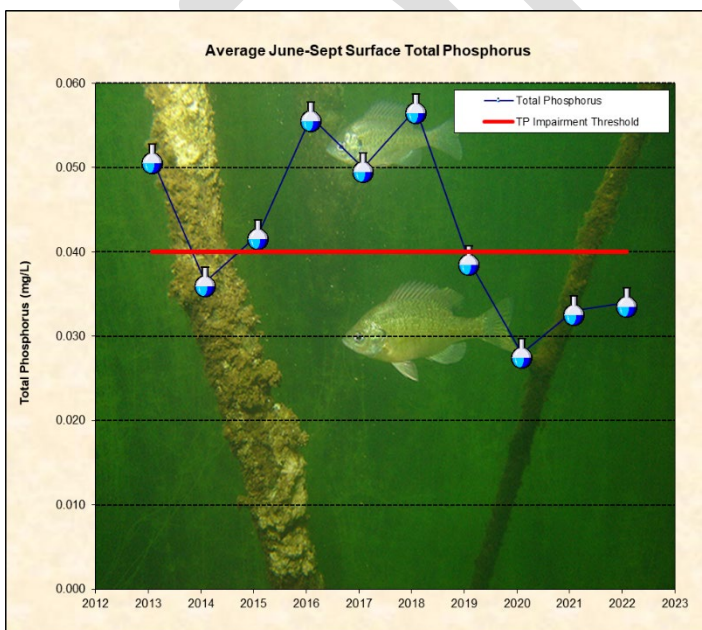
South School Section Lake 2022 Lake Grade: B

- DNR ID #: 820151
 - Municipality: City of Hugo
 - Location: S ½ Section 25, T31N-R21W
 - Lake Size: 115 Acres
 - Maximum Depth (2022): 23 ft
 - Ordinary High Water Mark: 965.30 ft
 - 100-Year High Water Level: 972.20 ft
 - 41% Littoral
- Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as eutrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) there is a statistically significant **improving** trend for the average total phosphorus and average chlorophyll- α , and no trend for average Secchi transparency at this time.
- The major land use is rural/agricultural.
- The lake did not stratify in 2022.
- The North and South School Section basins were connected in 2022.
- This lake is categorized as a deep lake according to the Minnesota Pollution Control Agency's standards.
- South School Section Lake is listed as impaired for nutrients on the Minnesota Pollution Control

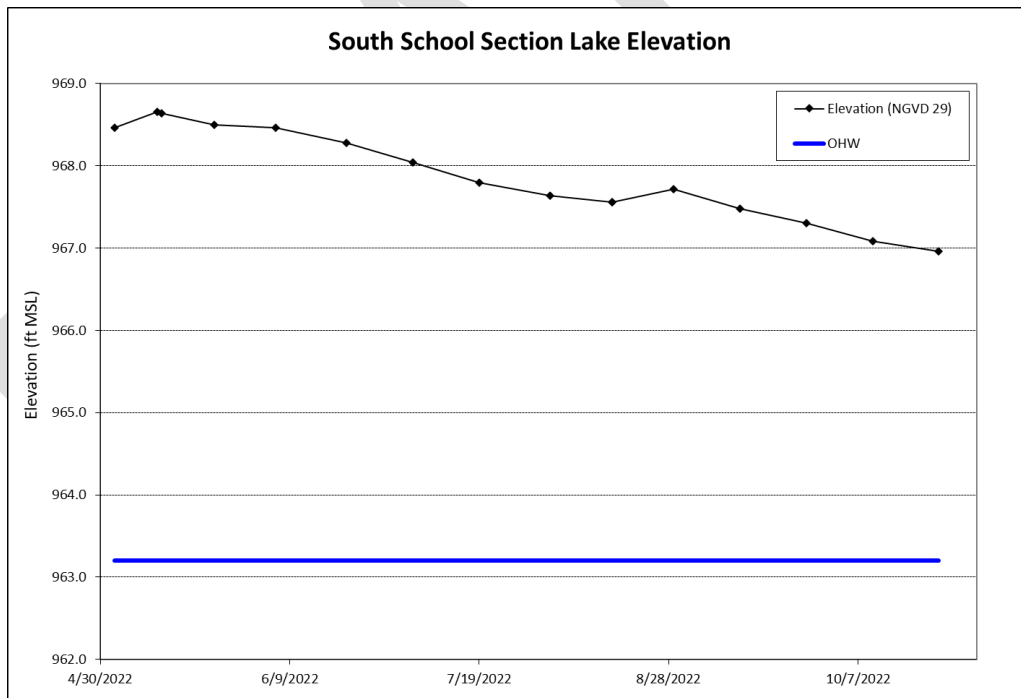


Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/27/2022 9:10	0.025	6.1	4.8	0.72	3.05	6.4	11.57
5/12/2022 9:08	0.032	11.0	9.3	0.79	2.29	14.9	10.06
5/24/2022 11:11	0.019	3.3	3.5	0.64	3.96	16.8	9.30
6/6/2022 10:06	0.023	4.6	4.0	0.72	4.27	19.8	9.14
6/21/2022 11:05	0.013	5.2	5.1	0.63	3.35	25.4	8.57
7/5/2022 11:55	0.040	8.7	7.8	0.72	2.29	24.8	8.06
7/19/2022 10:15	0.052	5.3	5.1	0.72	3.35	27.5	8.39
8/3/2022 9:56	0.032	15.0	14.0	0.82	2.13	25.2	12.31
8/16/2022 14:26	0.037	25.0	24.0	0.94	1.07	24.3	13.16
8/29/2022 10:19	0.032	36.0	36.0	0.97	1.22	23.0	9.77
9/12/2022 10:15	0.047	43.0	40.0	1.00	1.22	21.9	8.93
9/26/2022 14:11	0.029	34.0	33.0	1.10	1.22	17.9	8.42
10/10/2022 13:15	0.053	23.0	21.0	0.99	1.68	15.1	9.95
2022 Average	0.033	16.9	16.0	0.83	2.39	20.2	9.82
2022 Summer Average	0.034	19.6	18.8	0.85	2.24	23.3	9.64

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	968.66	5/12/2022	966.96	10/24/2022	967.88

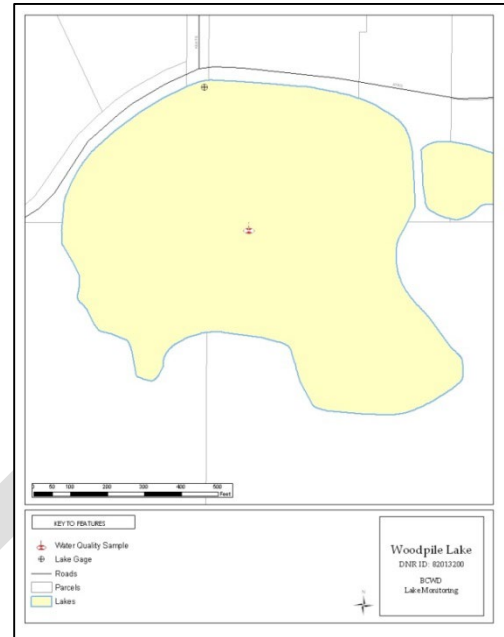
*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	B	B	B	C	C	C	C	C	C	C
Chlorophyll-a (ug/l)	B	B	B	C	D	C	C	C	B	C
Secchi depth (ft)	B	B	B	C	D	D	C	C	B	C
Overall	B	B	B	C	D+	C-	C	C	B-	C

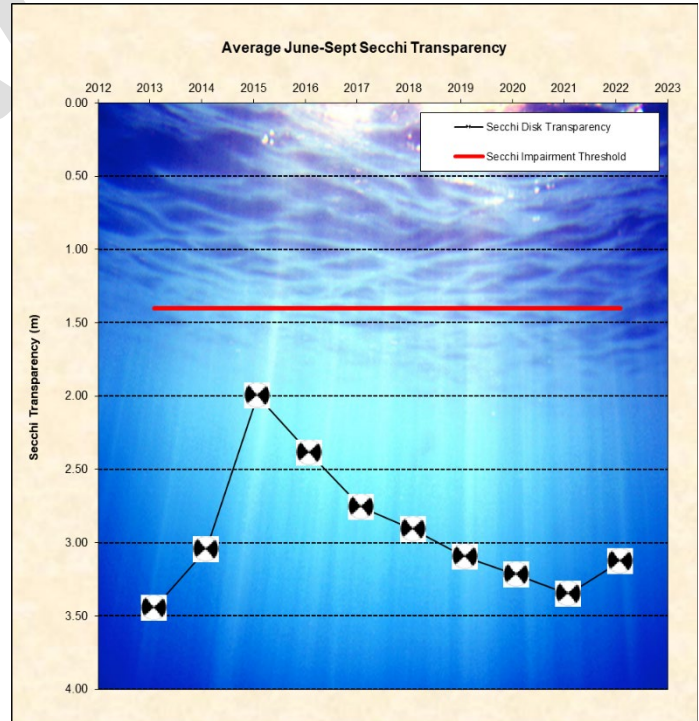
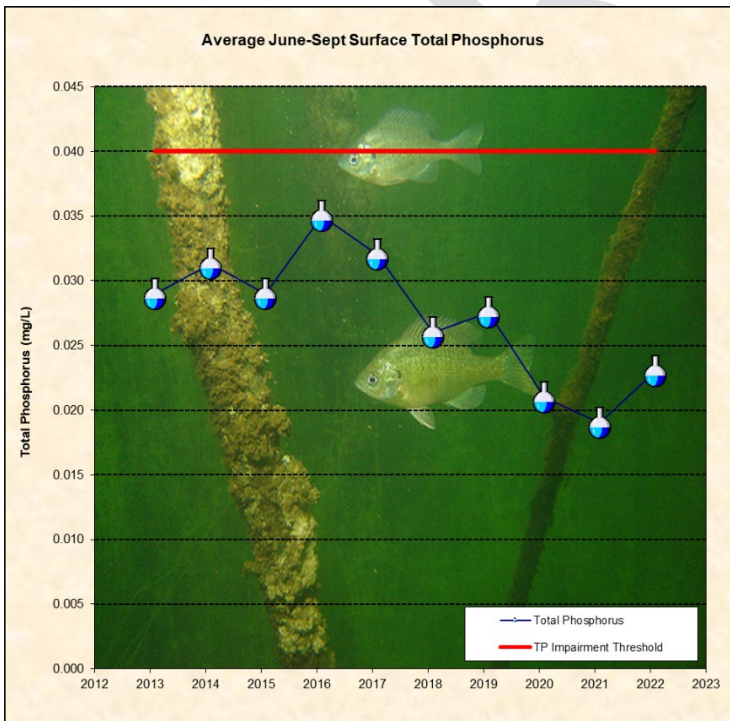
Woodpile Lake 2022 Lake Grade: A

- DNR ID #: 820132
- Municipality: City of Grant
- Location: Section 23, T30N-R21W
- Lake Size: 15 Acres
- Maximum Depth (2022): 28 ft
- Ordinary High Water Mark: 968.50 ft
- 100-Year High Water Level: 971.00 ft
- 8% Littoral
Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on chlorophyll- α data, the lake is classified as mesotrophic according to the Carlson Trophic State Index.
- Using the Kendall's Tau correlation test ($p < 0.05$) a statistically significant **improving** trend for the average Secchi transparency, average chlorophyll- α , and average total phosphorus.
- The major land use is rural/agricultural.
- The lake stratified in 2022 with a thermocline between 4 and 5 meters.
- This lake is categorized as a deep lake according to the Minnesota Pollution Control Agency's standards.

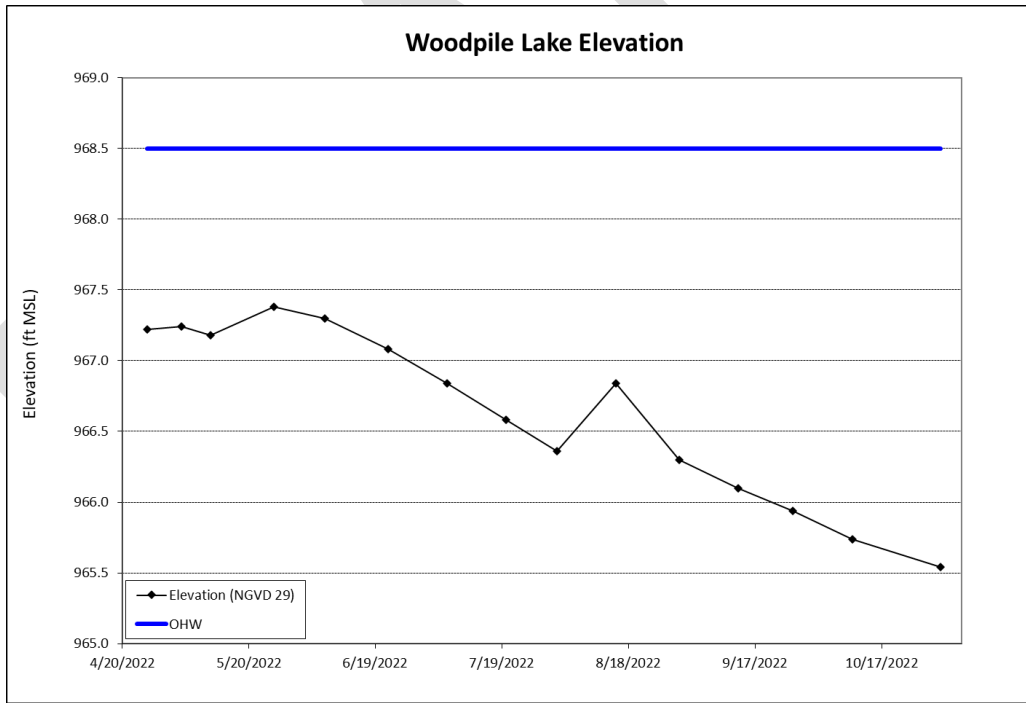


Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-a (ug/L)	Pheophytin-Corrected Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
4/26/2022 8:14	0.033	8.4	7.2	0.75	1.68	6.9	12.47
5/11/2022 11:30	0.013	1.4	1.3	0.66	3.20	16.8	9.01
5/26/2022 8:15	0.024	3.4	2.7	0.57	3.35	16.2	8.86
6/7/2022 10:00	0.016	1.9	1.9	0.64	3.66	20.8	9.06
6/22/2022 10:27	0.023	5.2	4.9	0.64	3.66	26.2	7.93
7/6/2022 7:57	0.036	6.3	5.6	0.69	3.20	24.9	8.26
7/20/2022 10:55	0.028	5.9	4.9	0.67	3.05	26.5	7.71
8/1/2022 10:28	0.020	7.2	6.4	0.69	3.35	24.9	12.92
8/15/2022 13:00	0.029	8.3	7.4	0.68	2.44	23.3	9.93
8/30/2022 8:30	0.024	6.6	6.0	0.61	2.13	22.9	10.35
9/13/2022 8:00	0.014	6.5	5.6	0.64	3.20	21.5	9.72
9/26/2022 9:11	0.018	4.4	3.7	0.65	3.51	17.6	6.97
10/10/2022 11:21	0.029	4.5	3.7	0.58	3.05	14.7	10.27
2022 Average	0.024	5.4	4.7	0.65	3.04	20.2	9.50
2022 Summer Average	0.023	5.8	5.2	0.66	3.13	23.2	9.21

Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*
 Shallow lake water quality thresholds are 0.06 mg/L TP, 20 µg/L CL-a, 1.0 m Secchi depth*

	High	High Date	Low	Low Date	Average
2022 Elevation (ft)	967.38	5/26/2022	965.54	10/31/2022	966.64

*Data requirements and determinations of use assessment according to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters: "Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-a (chl-a corrected for pheophytin), and Secchi are required. Data used for phosphorus and chlorophyll-a calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step, all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-a, and Secchi depth. These values are then compared to the standards and the assessment is made."



Lake Water Quality Summary										
	Lake Grades (May-Sept)									
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Total Phosphorus (mg/l)	A	A	A	B	B	B	C	B	B	B
Chlorophyll-a (ug/l)	A	A	A	A	A	A	A	B	A	A
Secchi depth (ft)	A	A	A	A	B	B	B	C	A	A
Overall	A	A	A	A-	B+	B+	B	B-	A-	A-

APPENDIX B –STREAM DATA

Total Phosphorus and Total Suspended Solids Loading Tables

Table 1. Brown’s Creek at Highway 15 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Table 2. Brown’s Creek at McKusick Road 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Table 3. Brown’s Creek at Stonebridge Trail 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Table 4. Tributary to Long Lake at Marketplace Pond 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Table 5. Brown’s Creek Diversion Structure Drainage 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Field Water Quality Data Tables

Table 6. Brown’s Creek at Highway 15 2022 Field Water Quality Results

Table 7. Brown’s Creek at McKusick Road 2022 Field Water Quality Results

Table 8. Brown’s Creek at Stonebridge Trail 2022 Field Water Quality Results

Table 9. Brown’s Creek Outlet 2022 Field Water Quality Results

Table 10. Brown’s Creek Diversion Structure Drainage 2022 Field Water Quality Results

Table 1. Brown's Creek at Highway 15 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Sample Type	Sample Collection Time		TSS (mg/L)	TP (mg/L)	Loading Interval		Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
	Start	End			Start	End				
Base*			5	0.087	1/1/2022 0:00	3/5/2022 0:00	16,329,600	375.07	5,097	88.69
Storm/Snowmelt*			4	0.117	3/5/2022 0:00	3/5/2022 16:00	259,200	5.95	65	1.89
Base*			5	0.087	3/5/2022 16:00	3/16/2022 12:00	2,808,000	64.50	876	15.25
Snowmelt Grab*	3/16/2022 14:11	3/16/2022 14:11	4	0.117	3/16/2022 12:00	3/20/2022 9:00	1,506,600	34.60	376	11.00
Base*			5	0.087	3/20/2022 9:00	3/22/2022 11:00	630,000	14.47	197	3.42
Storm*			82	0.173	3/22/2022 11:00	3/23/2022 0:00	234,000	5.37	1,198	2.53
Base*			5	0.087	3/23/2022 0:00	4/25/2022 14:30	10,161,900	233.41	3,172	55.19
Base			5	0.087	4/25/2022 14:30	4/30/2022 1:30	1,230,760	28.27	384	6.68
Storm			82	0.173	4/30/2022 1:30	5/1/2022 12:30	1,254,990	28.83	6,424	13.55
Base			5	0.087	5/1/2022 12:30	5/5/2022 8:30	2,124,650	48.80	663	11.54
Base Grab	5/6/2022 8:43	5/6/2022 8:43	2	0.045	5/5/2022 8:30	5/7/2022 8:30	643,100	14.77	80	1.81
Base			5	0.087	5/7/2022 8:30	5/11/2022 20:30	1,194,020	27.43	373	6.48
Storm Composite	5/11/2022 22:10	5/12/2022 13:52	213	0.203	5/11/2022 20:30	5/12/2022 21:30	1,459,060	33.51	19,401	18.49
Base			5	0.087	5/12/2022 21:30	6/16/2022 8:30	11,838,400	271.91	3,695	64.30
Base Grab	6/17/2022 8:30	6/17/2022 8:30	6	0.160	6/16/2022 8:30	6/18/2022 8:30	672,538	15.45	252	6.72
Base			5	0.087	6/18/2022 8:30	7/7/2022 8:30	6,337,790	145.57	1,978	34.42
Base Grab	7/8/2022 8:14	7/8/2022 8:14	4	0.113	7/7/2022 8:30	7/9/2022 8:30	657,052	15.09	164	4.63
Base			5	0.087	7/9/2022 8:30	7/23/2022 13:30	3,516,710	80.77	1,098	19.10
Storm			82	0.173	7/23/2022 13:30	7/24/2022 14:30	357,430	8.21	1,830	3.86
Base Grab	7/27/2022 13:28	7/27/2022 13:28	9	0.106	7/24/2022 14:30	7/28/2022 13:30	1,029,290	23.64	578	6.81
Base			5	0.087	7/28/2022 13:30	8/18/2022 17:30	4,414,320	101.39	1,378	23.97
Storm Composite	8/19/2022 5:32	8/20/2022 18:29	16	0.169	8/18/2022 17:30	8/20/2022 18:30	803,929	18.47	803	8.48
Base Grab	8/26/2022 8:15	8/26/2022 8:15	3	0.090	8/20/2022 18:30	8/28/2022 23:30	1,801,410	41.38	337	10.12
Storm Composite	8/29/2022 1:00	8/29/2022 9:14	18	0.148	8/28/2022 23:30	8/29/2022 9:30	164,709	3.78	185	1.52
Base			5	0.087	8/29/2022 9:30	9/11/2022 13:30	2,667,290	61.26	833	14.49
Base Grab	9/12/2022 13:03	9/12/2022 13:03	3	0.047	9/11/2022 13:30	9/13/2022 13:30	339,518	7.80	64	1.00
Base			5	0.087	9/13/2022 13:30	10/12/2022 9:30	5,541,658	127.29	1,730	30.10
Base Grab	10/13/2022 9:26	10/13/2022 9:26	5	0.051	10/12/2022 9:30	10/14/2022 9:30	448,873	10.31	140	1.43
Base			5	0.087	10/14/2022 9:30	10/26/2022 14:30	2,558,070	58.76	798	13.89
Base*			5	0.087	10/26/2022 14:30	1/1/2023 0:00	15,775,650	362.35	4,924	85.68
Storm Average			82	0.173						
Base Average			5	0.087						
All Average			26	0.114						
Total							98,760,517	2,268	59,093	567
Brown's Creek Major Subwatershed Total Acres							3,532			
Total TSS/TP(lb/ac/yr)									16.73	0.161
Total TSS/TP (kg/ha/yr)									18.75	0.180

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes were estimated using similar flow conditions.

Table 2. Brown's Creek at McKusick Road 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Sample Type	Sample Collection Time		TSS (mg/L)	TP (mg/L)	Loading Interval		Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
	Start	End			Start	End				
Base*			4	0.083	1/1/2022 0:00	3/5/2022 0:00	24,494,400	562.61	6,116	126.91
Storm/Snowmelt*			17	0.273	3/5/2022 0:00	3/6/2022 0:00	777,600	17.86	825	13.25
Base*			4	0.083	3/6/2022 0:00	3/15/2022 14:00	5,382,000	123.62	1,344	27.89
Snowmelt Grab*	3/16/2022 14:41	3/16/2022 14:41	17	0.273	3/15/2022 14:00	3/20/2022 9:00	5,175,000	118.86	5,492	88.19
Base*			4	0.083	3/20/2022 9:00	3/22/2022 10:00	3,175,200	72.93	793	16.45
Storm*			247	0.731	3/22/2022 10:00	3/23/2022 1:00	1,512,000	34.73	23,314	69.00
Base*			4	0.083	3/23/2022 1:00	3/30/2022 1:00	7,862,400	180.59	1,963	40.74
Storm*			247	0.731	3/30/2022 1:00	3/30/2022 11:00	396,000	9.10	6,106	18.07
Base*			4	0.083	3/30/2022 11:00	4/5/2022 17:00	3,780,000	86.82	944	19.59
Storm*			247	0.731	4/5/2022 17:00	4/6/2022 3:00	432,000	9.92	6,661	19.71
Base*			4	0.083	4/6/2022 3:00	4/20/2022 14:00	8,744,400	200.85	2,184	45.31
Storm*			247	0.731	4/20/2022 14:00	4/20/2022 21:00	264,600	6.08	4,080	12.07
Base*			4	0.083	4/20/2022 21:00	4/23/2022 20:00	1,853,100	42.56	463	9.60
Storm*			247	0.731	4/23/2022 20:00	4/24/2022 1:00	198,000	4.55	3,053	9.04
Base*			4	0.083	4/24/2022 1:00	4/30/2022 2:00	3,027,600	69.54	756	15.69
Storm*			247	0.731	4/30/2022 2:00	4/30/2022 5:00	108,000	2.48	1,665	4.93
Base*			4	0.083	4/30/2022 5:00	4/30/2022 8:00	105,300	2.42	26	0.55
Storm*			247	0.731	4/30/2022 8:00	4/30/2022 15:00	554,400	12.73	8,548	25.30
Base*			4	0.083	4/30/2022 15:00	5/5/2022 9:00	4,924,800	113.12	1,230	25.52
Base Grab*	5/6/2022 9:16	5/6/2022 9:16	3	0.039	5/5/2022 9:00	5/7/2022 9:00	1,123,200	25.80	210	2.73
Base*			4	0.083	5/7/2022 9:00	5/11/2022 15:00	2,478,600	56.93	619	12.84
Base			4	0.083	5/11/2022 15:00	5/11/2022 21:00	145,231	3.34	36	0.75
Storm Composite	5/11/2022 21:13	5/12/2022 2:02	153	0.897	5/11/2022 21:00	5/12/2022 3:00	1,226,200	28.16	11,712	68.66
Base			4	0.083	5/12/2022 3:00	5/19/2022 16:00	12,873,600	295.69	3,215	66.70
Storm			247	0.731	5/19/2022 16:00	5/19/2022 20:00	156,747	3.60	2,417	7.15
Base			4	0.083	5/19/2022 20:00	5/28/2022 4:00	6,813,910	156.51	1,701	35.31
Base*			4	0.083	5/28/2022 4:00	5/30/2022 22:00	1,936,440	44.48	484	10.03
Storm*			247	0.731	5/30/2022 22:00	5/31/2022 10:00	432,000	9.92	6,661	19.71
Base*			4	0.083	5/31/2022 10:00	5/31/2022 16:15	209,250	4.81	52	1.08
Base			4	0.083	5/31/2022 16:15	6/15/2022 12:15	6,905,750	158.62	1,724	35.78
Storm			247	0.731	6/15/2022 12:15	6/15/2022 17:15	85,886	1.97	1,324	3.92
Base Grab	6/17/2022 8:58	6/17/2022 8:58	6	0.129	6/15/2022 17:15	6/18/2022 9:15	964,286	22.15	361	7.77
Base			4	0.083	6/18/2022 9:15	6/25/2022 4:15	1,817,570	41.75	454	9.42
Storm			247	0.731	6/25/2022 4:15	6/25/2022 11:15	118,505	2.72	1,827	5.41
Base			4	0.083	6/25/2022 11:15	6/27/2022 20:15	620,819	14.26	155	3.22
Base*			4	0.083	6/27/2022 20:15	7/7/2022 11:45	2,416,860	55.51	604	12.52
Base Grab	7/8/2022 9:03	7/8/2022 9:03	6	0.134	7/7/2022 11:45	7/12/2022 18:45	1,265,970	29.08	474	10.59
Storm			247	0.731	7/12/2022 18:45	7/13/2022 0:45	62,361	1.43	962	2.85
Base			4	0.083	7/13/2022 0:45	7/23/2022 13:45	2,339,980	53.75	584	12.12
Storm			247	0.731	7/23/2022 13:45	7/24/2022 10:45	247,350	5.68	3,814	11.29
Base Grab	7/27/2022 14:00	7/27/2022 14:00	4	0.078	7/24/2022 10:45	7/31/2022 20:45	1,755,750	40.33	438	8.55
Storm			247	0.731	7/31/2022 20:45	8/1/2022 4:45	98,348	2.26	1,516	4.49
Base			4	0.083	8/1/2022 4:45	8/7/2022 20:45	1,497,500	34.40	374	7.76
Storm			247	0.731	8/7/2022 20:45	8/8/2022 8:45	200,160	4.60	3,086	9.13
Base			4	0.083	8/8/2022 8:45	8/12/2022 6:45	953,804	21.91	238	4.94
Storm			247	0.731	8/12/2022 6:45	8/12/2022 15:45	113,165	2.60	1,745	5.16
Base			4	0.083	8/12/2022 15:45	8/18/2022 16:45	1,412,700	32.45	353	7.32
Storm Composite	8/18/2022 18:45	8/19/2022 4:47	331	0.530	8/18/2022 16:45	8/19/2022 5:45	284,847	6.54	5,886	9.42
Storm			247	0.731	8/19/2022 5:45	8/20/2022 14:45	793,004	18.21	12,228	36.19
Base Grab	8/26/2022 9:03	8/26/2022 9:03	4	0.075	8/20/2022 14:45	8/27/2022 20:45	1,835,030	42.15	458	8.59
Storm			247	0.731	8/27/2022 20:45	8/28/2022 5:45	194,828	4.47	3,004	8.89
Base			4	0.083	8/28/2022 5:45	8/28/2022 23:45	351,186	8.07	88	1.82
Storm Composite	8/29/2022 0:30	8/29/2022 9:40	258	0.767	8/28/2022 23:45	8/29/2022 9:45	491,140	11.28	7,910	23.52
Base			4	0.083	8/29/2022 9:45	9/11/2022 14:45	3,665,730	84.20	915	18.99
Base Grab	9/12/2022 14:14	9/12/2022 14:14	3	0.079	9/11/2022 14:45	9/13/2022 14:45	441,774	10.15	83	2.18
Base			4	0.083	9/13/2022 14:45	9/20/2022 19:45	1,657,750	38.08	414	8.59
Storm			247	0.731	9/20/2022 19:45	9/21/2022 0:45	64,788	1.49	999	2.96
Base			4	0.083	9/21/2022 0:45	10/12/2022 10:45	5,105,850	117.28	1,275	26.46
Base Grab	10/13/2022 10:48	10/13/2022 10:48	2	0.050	10/12/2022 10:45	10/14/2022 10:45	548,290	12.59	68	1.71
Base			4	0.083	10/14/2022 10:45	10/26/2022 14:45	3,499,840	80.39	874	18.13
Base*			4	0.083	10/26/2022 14:45	11/8/2022 19:00	3,984,750	91.53	995	20.65
Storm*			72	0.277	11/8/2022 19:00	11/10/2022 12:00	959,400	22.04	4,312	16.59
Base*			4	0.083	11/10/2022 12:00	12/13/2022 20:00	10,080,000	231.53	2,517	52.23
Storm/Snowmelt*			72	0.277	12/13/2022 20:00	12/16/2022 13:00	1,404,000	32.25	6,311	24.28
Base*			4	0.083	12/16/2022 13:00	1/1/2023 0:00	5,008,500	115.04	1,251	25.95
Storm Average			247	0.731						
Base Average			4	0.083						
All Average			72	0.277						
Total							163,409,449	3,753	172,292	1,282
Brown's Creek Major Subwatershed Total Acres							3,999			
Total TSS/TP (lb/ac/yr)									43.08	0.321
Total TSS/TP (kg/ha/yr)									48.29	0.359

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes were estimated using similar flow conditions.

Table 3. Brown's Creek at Stonebridge Trail 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Sample Type	Sample Collection Time		TSS (mg/L)		TP (mg/L)		Loading Interval		Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
	Start	End			Start	End						
Base*			7	0.091	1/1/2022 0:00	3/5/2022 0:00			28,576,800	656.38	12,488	162.34
Storm/Snowmelt*			21	0.239	3/5/2022 0:00	3/6/2022 0:00			864,000	19.85	1,133	12.89
Base*			7	0.091	3/6/2022 0:00	3/15/2022 14:00			5,961,600	136.93	2,605	33.87
Snowmelt Grab*	3/16/2022 14:57	3/16/2022 14:57	21	0.239	3/15/2022 14:00	3/20/2022 9:00			6,210,000	142.64	8,141	92.65
Base*			7	0.091	3/20/2022 9:00	3/22/2022 10:00			3,616,200	83.06	1,580	20.54
Storm*			241	0.572	3/22/2022 10:00	3/23/2022 1:00			1,728,000	39.69	25,997	61.70
Base*			7	0.091	3/23/2022 1:00	3/30/2022 1:00			9,676,800	222.26	4,229	54.97
Storm*			241	0.572	3/30/2022 1:00	3/30/2022 11:00			468,000	10.75	7,041	16.71
Base*			7	0.091	3/30/2022 11:00	4/5/2022 17:00			4,050,000	93.02	1,770	23.01
Storm*			241	0.572	4/5/2022 17:00	4/6/2022 3:00			540,000	12.40	8,124	19.28
Base*			7	0.091	4/6/2022 3:00	4/20/2022 14:00			9,056,700	208.02	3,958	51.45
Storm*			241	0.572	4/20/2022 14:00	4/20/2022 21:00			277,200	6.37	4,170	9.90
*Base			7	0.091	4/20/2022 21:00	4/23/2022 20:00			1,917,000	44.03	838	10.89
*Storm			241	0.572	4/23/2022 20:00	4/24/2022 1:00			216,000	4.96	3,250	7.71
*Base			7	0.091	4/24/2022 1:00	4/25/2022 15:00			1,368,000	31.42	598	7.77
Base			7	0.091	4/25/2022 15:00	4/30/2022 2:00			2,426,830	55.74	1,060	13.79
Storm			241	0.572	4/30/2022 2:00	4/30/2022 5:00			114,065	2.62	1,716	4.07
Base			7	0.091	4/30/2022 5:00	4/30/2022 8:00			110,830	2.55	48	0.63
Storm			241	0.572	4/30/2022 8:00	4/30/2022 15:00			597,049	13.71	8,982	21.32
Base			7	0.091	4/30/2022 15:00	5/5/2022 9:00			6,084,440	139.75	2,659	34.56
Base Grab	5/6/2022 9:31	5/6/2022 9:31	3	0.053	5/5/2022 9:00	5/7/2022 9:00			1,143,970	26.28	214	3.78
Base			7	0.091	5/7/2022 9:00	5/11/2022 21:00			2,214,770	50.87	968	12.58
Storm Composite	5/11/2022 21:24	5/12/2022 2:43	339	0.771	5/11/2022 21:00	5/12/2022 3:00			987,057	22.67	20,889	47.51
Storm			241	0.572	5/12/2022 3:00	5/13/2022 2:00			3,126,980	71.82	47,044	111.66
Base			7	0.091	5/13/2022 2:00	5/19/2022 16:00			5,962,530	136.95	2,606	33.87
Storm			241	0.572	5/19/2022 16:00	5/19/2022 20:00			127,274	2.92	1,915	4.54
Base			7	0.091	5/19/2022 20:00	6/16/2022 9:00			11,730,900	269.45	5,126	66.64
Base Grab	6/17/2022 9:18	6/17/2022 9:18	15	0.145	6/16/2022 9:00	6/18/2022 9:00			586,337	13.47	549	5.31
Base			7	0.091	6/18/2022 9:00	6/25/2022 5:00			1,624,570	37.31	710	9.23
Storm			241	0.572	6/25/2022 5:00	6/25/2022 11:00			108,050	2.48	1,626	3.86
Base			7	0.091	6/25/2022 11:00	7/7/2022 9:00			2,794,060	64.18	1,221	15.87
Base Grab	7/8/2022 8:43	7/8/2022 8:43	7	0.106	7/7/2022 9:00	7/9/2022 9:00			456,742	10.49	200	3.02
Base			7	0.091	7/9/2022 9:00	7/26/2022 14:00			3,475,740	79.83	1,519	19.74
Base Grab	7/27/2022 14:11	7/27/2022 14:11	4	0.081	7/26/2022 14:00	7/31/2022 20:00			1,026,270	23.57	256	5.19
Storm			241	0.572	7/31/2022 20:00	8/1/2022 2:00			80,545	1.85	1,212	2.88
Base			7	0.091	8/1/2022 2:00	8/7/2022 21:00			1,408,350	32.35	615	8.00
Storm			241	0.572	8/7/2022 21:00	8/8/2022 3:00			130,347	2.99	1,961	4.65
Base			7	0.091	8/8/2022 3:00	8/18/2022 18:00			2,463,030	56.57	1,076	13.99
Storm			241	0.572	8/18/2022 18:00	8/19/2022 19:00			535,732	12.31	8,060	19.13
Storm Composite	8/19/2022 19:49	8/20/2022 14:09	55	0.266	8/19/2022 19:00	8/20/2022 15:00			432,415	9.93	1,485	7.18
Base Grab	8/26/2022 8:38	8/26/2022 8:38	6	0.094	8/20/2022 15:00	8/27/2022 21:00			1,875,130	43.07	702	11.00
Storm			241	0.572	8/27/2022 21:00	8/28/2022 4:00			192,692	4.43	2,899	6.88
Base			7	0.091	8/28/2022 4:00	8/28/2022 23:00			411,856	9.46	180	2.34
Storm Composite	8/29/2022 0:30	8/29/2022 10:08	247	0.678	8/28/2022 23:00	8/29/2022 11:00			658,648	15.13	10,156	27.88
Base			7	0.091	8/29/2022 11:00	9/11/2022 14:00			4,056,610	93.18	1,773	23.04
Base Grab	9/12/2022 14:45	9/12/2022 14:45	3	0.053	9/11/2022 14:00	9/12/2022 15:00			255,389	5.87	48	0.84
*Base			7	0.091	9/12/2022 15:00	9/20/2022 20:00			2,056,680	47.24	899	11.68
*Storm			241	0.572	9/20/2022 20:00	9/21/2022 3:00			100,800	2.32	1,517	3.60
*Base			7	0.091	9/21/2022 3:00	9/30/2022 8:30			2,392,200	54.95	1,045	13.59
Base			7	0.091	9/30/2022 8:30	10/12/2022 11:30			3,121,390	71.69	1,364	17.73
Base Grab	10/13/2022 11:28	10/13/2022 11:28	14	0.105	10/12/2022 11:30	10/14/2022 11:30			619,989	14.24	542	4.06
Base			7	0.091	10/14/2022 11:30	10/27/2022 14:30			4,510,700	103.61	1,971	25.62
Base*			7	0.091	10/27/2022 14:30	11/8/2022 19:00			4,212,000	96.74	1,841	23.93
Storm*			65	0.236	11/8/2022 19:00	11/10/2022 12:00			996,300	22.88	4,043	14.68
Base*			7	0.091	11/10/2022 12:00	12/13/2022 20:00			11,520,000	264.60	5,034	65.44
Storm/Snowmelt*			65	0.236	12/13/2022 20:00	12/16/2022 13:00			1,474,200	33.86	5,982	21.72
Base*			7	0.091	12/16/2022 13:00	1/1/2023 0:00			5,342,400	122.71	2,335	30.35
Storm Average			241	0.572								
Base Average			7	0.091								
All Average			65	0.236								
Total									168,072,167	3,860	241,966	1,363
Brown's Creek Major Subwatershed Total Acres									4,189			
Total TSS/TP(lb/ac/yr)											57.76	0.325
Total TSS/TP (kg/ha/yr)											64.74	0.365

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes were estimated using similar flow conditions.

Table 4. Tributary to Long Lake at Marketplace Pond 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Sample Type	Sample Collection Time		TSS (mg/L)	TP (mg/L)	Loading Interval		Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
	Start	End			Start	End				
Intermittent Flow*			5	0.144	1/1/2022 0:00	3/5/2022 0:00	5,443	0.13	2	0.05
Storm/Snowmelt*			16	0.167	3/5/2022 0:00	3/5/2022 10:00	36,000	0.83	36	0.38
Intermittent Flow*			5	0.144	3/5/2022 10:00	3/15/2022 12:00	8,712	0.20	3	0.08
Snowmelt*			16	0.167	3/15/2022 12:00	3/22/2022 12:00	60,480	1.39	60	0.63
Storm*			24	0.184	3/22/2022 12:00	3/23/2022 0:00	302,400	6.95	453	3.47
Base*			5	0.144	3/23/2022 0:00	3/30/2022 1:00	91,260	2.10	28	0.82
Storm*			24	0.184	3/30/2022 1:00	3/30/2022 11:00	99,000	2.27	148	1.14
Base*			5	0.144	3/30/2022 11:00	4/4/2022 11:00	64,800	1.49	20	0.58
Storm*			24	0.184	4/4/2022 11:00	4/6/2022 1:00	273,600	6.28	410	3.14
Base*			5	0.144	4/6/2022 1:00	4/12/2022 20:00	88,020	2.02	27	0.79
Storm*			24	0.184	4/12/2022 20:00	4/13/2022 6:00	82,800	1.90	124	0.95
Base*			5	0.144	4/13/2022 6:00	4/20/2022 14:00	63,360	1.46	20	0.57
Storm*			24	0.184	4/20/2022 14:00	4/20/2022 21:00	57,960	1.33	87	0.67
Base*			5	0.144	4/20/2022 21:00	4/23/2022 19:00	37,800	0.87	12	0.34
Storm*			24	0.184	4/23/2022 19:00	4/24/2022 0:00	45,000	1.03	67	0.52
Base*			5	0.144	4/24/2022 0:00	4/30/2022 2:00	78,840	1.81	25	0.71
Storm*			24	0.184	4/30/2022 2:00	4/30/2022 17:00	378,000	8.68	566	4.34
Base*			5	0.144	4/30/2022 17:00	5/9/2022 17:00	116,640	2.68	36	1.05
Storm*			24	0.184	5/9/2022 17:00	5/9/2022 20:00	5,400	0.12	8	0.06
Base*			5	0.144	5/9/2022 20:00	5/11/2022 21:00	17,640	0.41	6	0.16
Storm*			24	0.184	5/11/2022 21:00	5/12/2022 9:00	388,800	8.93	583	4.47
Base*			5	0.144	5/12/2022 9:00	5/17/2022 10:00	65,340	1.50	20	0.59
Base			5	0.144	5/17/2022 10:00	5/19/2022 16:00	33,762	0.78	11	0.30
Storm			24	0.184	5/19/2022 16:00	5/20/2022 5:00	107,699	2.47	161	1.24
Base			5	0.144	5/20/2022 5:00	5/25/2022 2:00	244,709	5.62	76	2.20
Storm Composite	5/25/2022 10:26	5/26/2022 4:25	26	0.219	5/25/2022 2:00	5/26/2022 5:00	266,999	6.13	433	3.65
Base			5	0.144	5/26/2022 5:00	6/13/2022 8:00	491,674	11.29	153	4.42
Storm			24	0.184	6/13/2022 8:00	6/13/2022 12:00	5,943	0.14	9	0.07
Base			5	0.144	6/13/2022 12:00	6/15/2022 12:00	17,251	0.40	5	0.16
Storm			24	0.184	6/15/2022 12:00	6/15/2022 22:00	41,459	0.95	62	0.48
Base Grab	6/16/2022 9:05	6/16/2022 9:05	7	0.225	6/15/2022 22:00	6/17/2022 9:00	74,493	1.71	33	1.05
Base			5	0.144	6/17/2022 9:00	6/21/2022 2:00	57,786	1.33	18	0.52
Storm			24	0.184	6/21/2022 2:00	6/21/2022 6:00	5,591	0.13	8	0.06
Base			5	0.144	6/21/2022 6:00	6/25/2022 5:00	25,052	0.58	8	0.23
Storm			24	0.184	6/25/2022 5:00	6/25/2022 19:00	24,424	0.56	37	0.28
Base			5	0.144	6/25/2022 19:00	6/28/2022 6:00	33,695	0.77	11	0.30
Storm			24	0.184	6/28/2022 6:00	6/28/2022 11:00	8,686	0.20	13	0.10
Base			5	0.144	6/28/2022 11:00	7/3/2022 3:00	63,640	1.46	20	0.57
Storm			24	0.184	7/3/2022 3:00	7/3/2022 7:00	7,432	0.17	11	0.09
Base			5	0.144	7/3/2022 7:00	7/12/2022 19:00	120,140	2.76	37	1.08
Storm			24	0.184	7/12/2022 19:00	7/13/2022 0:00	7,327	0.17	11	0.08
Base			5	0.144	7/13/2022 0:00	7/23/2022 13:00	28,759	0.66	9	0.26
Storm			24	0.184	7/23/2022 13:00	7/23/2022 19:00	34,043	0.78	51	0.39
Base Grab	7/25/2022 15:44	7/25/2022 15:44	5	0.114	7/23/2022 19:00	7/31/2022 20:00	133,045	3.06	42	0.95
Storm			24	0.184	7/31/2022 20:00	7/31/2022 23:00	11,560	0.27	17	0.13
Base			5	0.144	7/31/2022 23:00	8/6/2022 9:00	50,743	1.17	16	0.46
Storm			24	0.184	8/6/2022 9:00	8/6/2022 13:00	19,497	0.45	29	0.22
Base			5	0.144	8/6/2022 13:00	8/7/2022 21:00	65,867	1.51	21	0.59
Storm Composite	8/8/2022 0:00	8/8/2022 14:53	12	0.164	8/7/2022 21:00	8/8/2022 15:00	293,234	6.74	220	3.00
Base			5	0.144	8/8/2022 15:00	8/12/2022 7:00	151,480	3.48	47	1.36
Storm			24	0.184	8/12/2022 7:00	8/12/2022 12:00	35,200	0.81	53	0.40
Base			5	0.144	8/12/2022 12:00	8/18/2022 17:00	188,805	4.34	59	1.70
Storm Composite	8/18/2022 18:27	8/19/2022 0:06	47	0.206	8/18/2022 17:00	8/19/2022 1:00	246,840	5.67	724	3.17
Storm			24	0.184	8/19/2022 1:00	8/19/2022 19:00	351,130	8.07	526	4.03
Base Grab	8/25/2022 14:11	8/25/2022 14:11	2	0.093	8/19/2022 19:00	8/27/2022 21:00	386,297	8.87	48	2.24
Storm			24	0.184	8/27/2022 21:00	8/28/2022 11:00	473,689	10.88	710	5.44
Base			5	0.144	8/28/2022 11:00	8/29/2022 0:00	236,698	5.44	74	2.13
Storm Composite	8/29/2022 0:20	8/29/2022 3:55	10	0.146	8/29/2022 0:00	8/29/2022 4:00	191,499	4.40	120	1.75
Base			5	0.144	8/29/2022 4:00	9/1/2022 7:00	435,118	9.99	136	3.91
Base*			5	0.144	9/1/2022 7:00	9/7/2022 14:30	54,540	1.25	17	0.49
Intermittent Flow			5	0.144	9/7/2022 14:30	9/20/2022 19:30	6,852	0.16	2	0.06
Storm			24	0.184	9/20/2022 19:30	9/21/2022 1:30	40,719	0.94	61	0.47
Intermittent Flow			5	0.144	9/21/2022 1:30	10/12/2022 2:30	120,499	2.77	38	1.08
Storm			24	0.184	10/12/2022 2:30	10/12/2022 5:30	1,233	0.03	2	0.01
Intermittent Flow			5	0.144	10/12/2022 5:30	10/12/2022 13:30	16	0.00	0	0.00
Storm			24	0.184	10/12/2022 13:30	10/12/2022 19:30	3,803	0.09	6	0.04
Intermittent Flow			5	0.144	10/12/2022 19:30	10/27/2022 15:30	10,210	0.23	3	0.09
Intermittent Flow*			5	0.144	10/27/2022 15:30	11/8/2022 18:00	1,046	0.02	0	0.01
Storm*			24	0.184	11/8/2022 18:00	11/10/2022 10:00	108,000	2.48	162	1.24
Intermittent Flow*			5	0.144	11/10/2022 10:00	12/13/2022 20:00	2,887	0.07	1	0.03
Storm/Snowmelt*			16	0.167	12/13/2022 20:00	12/14/2022 12:00	57,600	1.32	58	0.60
Intermittent Flow*			5	0.144	12/14/2022 12:00	1/1/2023 0:00	7,560	0.17	2	0.07
Storm Average			24	0.184						
Base Average			5	0.144						
All Average			16	0.167						
Total							7,753,526	178	7,112	79
Brown's Creek Major Subwatershed Total Acres							410			
Total TSS/TP(lb/ac/yr)									17.35	0.192
Total TSS/TP (kg/ha/yr)									19.44	0.215

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes were estimated using similar flow conditions.

Table 5. Brown's Creek Diversion Structure Drainage 2022 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

Sample Type	Sample Collection Time		Loading Interval		Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)		
	Start	End	TSS (mg/L)	TP (mg/L)					Start	End
Base*			7	0.090	1/1/2022 0:00	3/5/2022 0:00	2,721,600	62.51	1,189	15.29
Snowmelt*			30	0.215	3/5/2022 0:00	3/5/2022 10:00	144,000	3.31	270	1.93
Base*			7	0.090	3/5/2022 10:00	3/15/2022 14:00	1,098,000	25.22	480	6.17
Snowmelt Grab*	3/16/2022 14:31	3/16/2022 14:31	30	0.215	3/15/2022 14:00	3/19/2022 22:00	1,684,800	38.70	3,155	22.61
Base*			7	0.090	3/19/2022 22:00	3/22/2022 12:00	558,000	12.82	244	3.14
Storm*			203	0.595	3/22/2022 12:00	3/23/2022 4:00	460,800	10.58	5,839	17.12
Base*			7	0.090	3/23/2022 4:00	3/30/2022 1:00	1,782,000	40.93	779	10.01
Storm*			203	0.595	3/30/2022 1:00	3/30/2022 11:00	234,000	5.37	2,965	8.69
Base*			7	0.090	3/30/2022 11:00	4/5/2022 17:00	1,620,000	37.21	708	9.10
Storm*			203	0.595	4/5/2022 17:00	4/6/2022 3:00	252,000	5.79	3,193	9.36
Base*			7	0.090	4/6/2022 3:00	4/20/2022 14:00	3,123,000	71.73	1,365	17.55
Storm*			203	0.595	4/20/2022 14:00	4/20/2022 21:00	151,200	3.47	1,916	5.62
Base*			7	0.090	4/20/2022 21:00	4/21/2022 11:45	185,850	4.27	81	1.04
Base			7	0.090	4/21/2022 11:45	4/23/2022 19:45	652,667	14.99	285	3.67
Storm			203	0.595	4/23/2022 19:45	4/24/2022 0:45	107,299	2.46	1,360	3.99
Base			7	0.090	4/24/2022 0:45	4/30/2022 1:45	1,655,360	38.02	723	9.30
Storm			203	0.595	4/30/2022 1:45	4/30/2022 17:45	492,923	11.32	6,247	18.31
Base			7	0.090	4/30/2022 17:45	5/5/2022 8:45	3,176,020	72.95	1,388	17.84
Base Grab	5/6/2022 9:00	5/6/2022 9:00	3	0.074	5/5/2022 8:45	5/7/2022 8:45	707,617	16.25	133	3.27
Base			7	0.090	5/7/2022 8:45	5/9/2022 17:45	494,335	11.35	216	2.78
Storm			203	0.595	5/9/2022 17:45	5/9/2022 20:45	36,467	0.84	462	1.35
Base			7	0.090	5/9/2022 20:45	5/11/2022 20:45	438,551	10.07	192	2.46
Storm Composite	5/11/2022 21:27	5/12/2022 8:08	176	0.517	5/11/2022 20:45	5/12/2022 8:45	1,450,200	33.31	15,933	46.80
Base			7	0.090	5/12/2022 8:45	5/17/2022 14:45	3,960,740	90.97	1,731	22.25
Unexplained Event			63	0.239	5/17/2022 14:45	5/19/2022 1:45	503,578	11.57	1,980	7.51
Base			7	0.090	5/19/2022 1:45	5/19/2022 13:45	61,752	1.42	27	0.35
Storm			203	0.595	5/19/2022 13:45	5/19/2022 19:45	89,543	2.06	1,135	3.33
Base			7	0.090	5/19/2022 19:45	5/24/2022 14:45	786,194	18.06	344	4.42
Storm			203	0.595	5/24/2022 14:45	5/25/2022 1:45	205,195	4.71	2,600	7.62
Base			7	0.090	5/25/2022 1:45	6/7/2022 15:45	2,269,610	52.13	992	12.75
Unexplained Event			63	0.239	6/7/2022 15:45	6/8/2022 2:45	167,286	3.84	658	2.50
Base			7	0.090	6/8/2022 2:45	6/13/2022 10:45	328,143	7.54	143	1.84
Unexplained Event			63	0.239	6/13/2022 10:45	6/15/2022 3:45	391,843	9.00	1,541	5.85
Base			7	0.090	6/15/2022 3:45	6/15/2022 12:45	31,820	0.73	14	0.18
Storm			203	0.595	6/15/2022 12:45	6/15/2022 19:45	51,985	1.19	659	1.93
Base Grab	6/17/2022 8:47	6/17/2022 8:47	4	0.092	6/15/2022 19:45	6/20/2022 15:45	394,198	9.05	98	2.26
Unexplained Event			63	0.239	6/20/2022 15:45	6/21/2022 16:45	118,581	2.72	466	1.77
Base			7	0.090	6/21/2022 16:45	6/25/2022 4:45	139,156	3.20	61	0.78
Storm			203	0.595	6/25/2022 4:45	6/25/2022 8:45	17,377	0.40	220	0.65
Base			7	0.090	6/25/2022 8:45	7/7/2022 9:45	526,264	12.09	230	2.96
Base Grab	7/8/2022 9:22	7/8/2022 9:22	16	0.158	7/7/2022 9:45	7/9/2022 9:45	75,727	1.74	76	0.75
Base			7	0.090	7/9/2022 9:45	7/26/2022 13:45	507,456	11.66	222	2.85
Base Grab	7/27/2022 13:52	7/27/2022 13:52	7	0.089	7/26/2022 13:45	7/28/2022 13:45	62,177	1.43	27	0.35
Base			7	0.090	7/28/2022 13:45	8/7/2022 20:45	275,737	6.33	120	1.55
Storm			203	0.595	8/7/2022 20:45	8/8/2022 2:45	38,955	0.89	494	1.45
Base			7	0.090	8/8/2022 2:45	8/18/2022 17:45	399,319	9.17	174	2.24
Storm Composite	8/18/2022 18:46	8/19/2022 8:26	301	0.793	8/18/2022 17:45	8/19/2022 8:45	139,885	3.21	2,628	6.92
Base			7	0.090	8/19/2022 8:45	8/24/2022 14:45	255,516	5.87	112	1.44
Base Grab	8/25/2022 14:33	8/25/2022 14:33	7	0.096	8/24/2022 14:45	8/27/2022 20:45	109,031	2.50	48	0.65
Storm			203	0.595	8/27/2022 20:45	8/28/2022 4:45	82,532	1.90	1,046	3.07
Base			7	0.090	8/28/2022 4:45	8/28/2022 23:45	211,623	4.86	92	1.19
Storm Composite	8/29/2022 1:16	8/29/2022 9:42	132	0.474	8/28/2022 23:45	8/29/2022 9:45	320,265	7.36	2,639	9.48
Base			7	0.090	8/29/2022 9:45	9/11/2022 13:45	1,294,600	29.74	566	7.27
Base Grab	9/12/2022 13:50	9/12/2022 13:50	12	0.066	9/11/2022 13:45	9/13/2022 13:45	60,856	1.40	46	0.25
Base			7	0.090	9/13/2022 13:45	9/23/2022 17:45	318,303	7.31	139	1.79
Unexplained Event			63	0.239	9/23/2022 17:45	9/27/2022 5:45	339,945	7.81	1,337	5.07
Base			7	0.090	9/27/2022 5:45	9/29/2022 15:45	82,837	1.90	36	0.47
Unexplained Event			63	0.239	9/29/2022 15:45	10/2/2022 6:45	187,631	4.31	738	2.80
Base			7	0.090	10/2/2022 6:45	10/12/2022 9:45	313,752	7.21	137	1.76
Base Grab	10/13/2022 9:58	10/13/2022 9:58	3	0.052	10/12/2022 9:45	10/14/2022 9:45	74,187	1.70	14	0.24
Base			7	0.090	10/14/2022 9:45	10/26/2022 10:45	510,987	11.74	223	2.87
Base*			7	0.090	10/26/2022 10:45	11/9/2022 16:00	552,825	12.70	242	3.11
Storm*			203	0.595	11/9/2022 16:00	11/10/2022 2:00	108,000	2.48	1,369	4.01
Base*			7	0.090	11/10/2022 2:00	1/1/2023 0:00	2,018,520	46.36	882	11.34
Storm Average			203	0.595						
Base Average			7	0.090						
All Average			63	0.239						
Total							41,610,620	956	75,429	389
Brown's Creek Major Subwatershed Total Acres							3,855			
Total TSS/TP(lb/ac/yr)									19.57	0.101
Total TSS/TP (kg/ha/yr)									21.93	0.113

Italics indicate estimated concentrations based on average base and storm flow concentrations.

*Interval volumes were estimated using similar flow conditions.

Table 6. Brown's Creek at Highway 15 2022 Field Water Quality Results

Date/Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
3/16/2022 14:11	5.1	10.67		8.18
5/6/2022 8:43	6.4	9.43	327	7.87
6/17/2022 8:30	13.1	7.87	392	7.50
7/8/2022 8:14	16.2	8.06	362	8.01
7/27/2022 13:28	18.7	9.80	415	8.19
8/26/2022 8:15	12.3	8.50	321	7.76
9/12/2022 13:03	13.6	10.47	413	7.76
10/13/2022 9:26	7.3	9.80	325	7.63

Exceeds Water Quality Standard

Table 7. Brown's Creek at McKusick Road 2022 Field Water Quality Results

Date/Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
3/16/2022 14:41	4.1	12.90	391	8.12
5/6/2022 9:16	7.7	11.68	242	8.07
5/12/2022 2:02	14.4	10.02	346	8.20
6/17/2022 8:58	18.2	8.40	466	8.24
7/8/2022 9:03	17.4	9.08	401	8.33
8/26/2022 9:03	13.9	9.74	366	8.21
9/12/2022 14:14	13.7	10.24	361	8.34
10/13/2022 10:48	7.9	10.50	543	8.36

Exceeds Water Quality Standard

Table 8. Brown's Creek at Stonebridge Trail 2022 Field Water Quality Results

Date/Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
3/16/2022 14:57	3.6	13.20	379	8.09
5/6/2022 9:31	8.0	11.64	371	8.15
6/17/2022 9:18	15.2	11.50	348	8.27
7/8/2022 8:43	19.0	8.66	420	8.28
7/27/2022 14:11	18.9	8.81	444	8.39
8/26/2022 8:38	14.4	9.98	369	8.23
9/12/2022 14:45	14.8	9.72	443	8.22
10/13/2022 11:28	8.1	11.02	539	8.23
Exceeds Water Quality Standard				

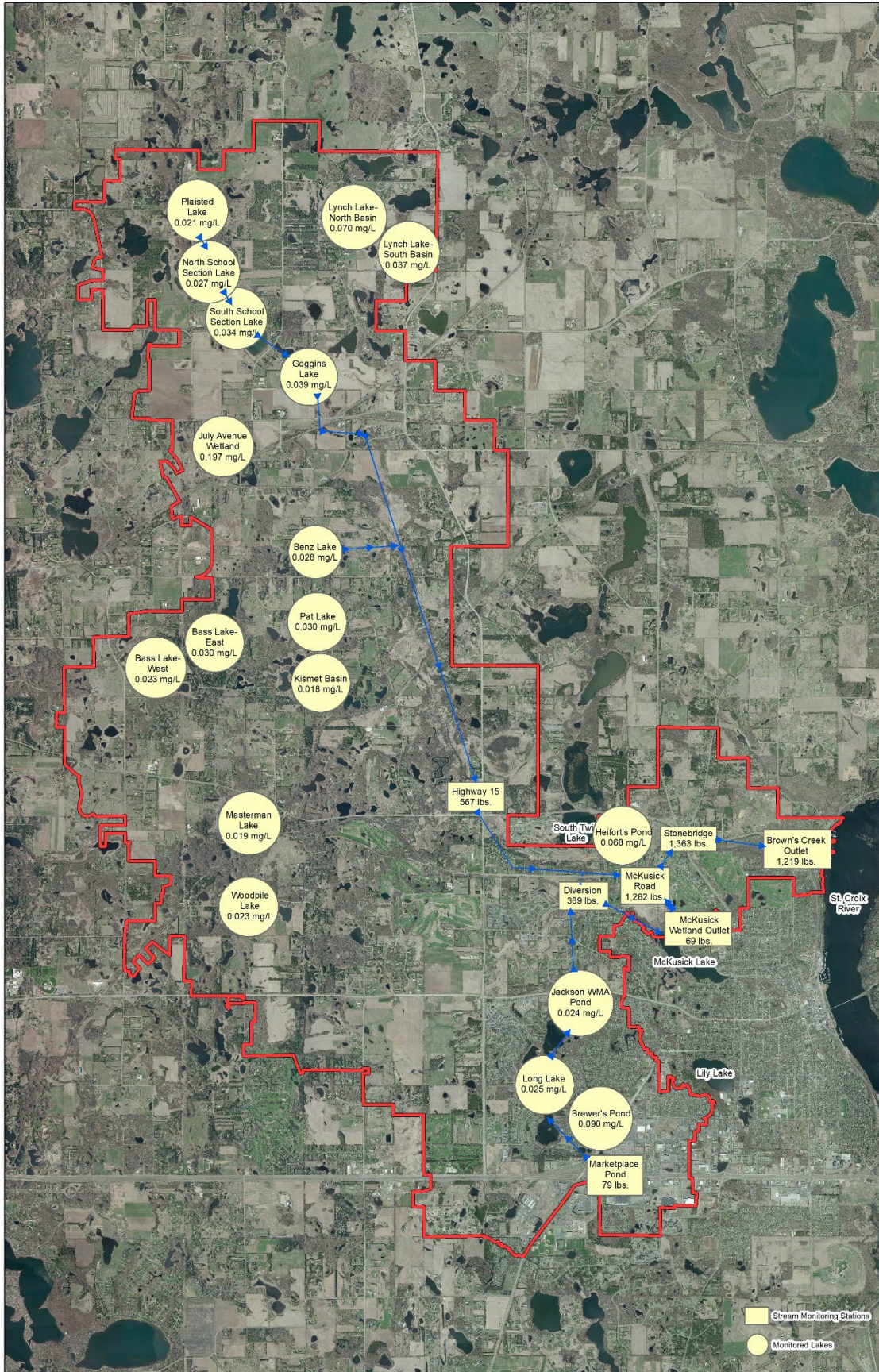
Table 9. Brown's Creek Outlet 2022 Field Water Quality Results

Date/Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
1/4/2022 9:30	0.7	14.88		8.26
1/19/2022 12:05	-0.2	14.40	542	9.24
2/2/2022 11:53	0.0	14.46	338	8.90
2/16/2022 11:02	1.5	13.06	262	8.76
3/2/2022 11:15	2.2	13.46	617	8.46
3/16/2022 9:03	2.4	14.24	425	8.39
3/30/2022 14:52	2.1	14.20	464	8.09
4/13/2022 14:32	5.3	12.75	212	8.13
4/25/2022 13:41	4.8	13.62	214	8.32
5/10/2022 8:24	11.8	10.55	405	8.12
5/25/2022 8:53	11.5	10.71	342	8.31
6/7/2022 8:35	13.6	9.26		8.37
6/21/2022 15:15	20.9	9.33	468	8.36
7/6/2022 14:09	17.1	10.12	492	8.42
7/20/2022 9:40	17.1	9.52	498	8.42
8/3/2022 10:00	17.5	9.45	413	8.29
8/17/2022 9:40	14.6	10.22	385	8.20
9/2/2022 9:13	15.9	9.68	398	8.36
9/14/2022 14:10	13.9	10.90	414	8.56
9/28/2022 9:41	7.4	11.49	289	8.62
10/12/2022 8:45	11.0	10.80		8.77
10/24/2022 11:18	12.1	10.33		8.23
11/8/2022 13:56	6.3	12.60	418	8.02
11/22/2022 9:01	1.4	14.98		8.27
12/7/2022 9:48	0.5	14.55		8.07
12/14/2022 11:28	2.7	15.34		8.18
12/27/2022 10:45	0.9	14.98	474	8.67
Exceeds Water Quality Standard				

Table 10. Brown's Creek Diversion 2022 Field Water Quality Results

Date/Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
3/16/2022 14:31	2.1	12.61	486	7.95
5/6/2022 9:00	11.2	9.95	502	7.96
6/17/2022 8:47	16.9	6.78	578	7.90
7/8/2022 9:22	18.8	4.64	593	7.79
7/27/2022 13:52	16.8	5.78	588	7.86
8/25/2022 14:33	16.5	6.14	515	7.88
9/12/2022 13:50	13.2	7.03	467	7.86
10/13/2022 9:58	8.7	7.21	697	7.80
	Exceeds Water Quality Standard			

APPENDIX C – 2022 BROWN’S CREEK TOTAL PHOSPHORUS FLOW CHART



GLOSSARY

Anoxic- Lacking oxygen.

Best Management Practice (BMP)- Any practice or constructed feature designed to reduce pollution, erosion, or other environmental degradation such as silt fence, rain gardens, storm water pollution prevention plans, buffer strips, etc.

Biota- Living organisms such as plants, animals, and bacteria.

Chronic Standard- The highest water concentration or fish tissue concentration of a toxicant or effluent to which aquatic life, humans, or wildlife can be exposed indefinitely without causing chronic toxicity.

Composite Sample- A collection of individual samples taken over the course of a storm and combined into a single sample to represent conditions throughout the entire storm event.

Discharge- The amount of water moving past a given point in a stream, usually measured in cubic feet per second, but may also be discussed as the total volume of water that flowed through a site in a year, measured in cubic feet.

Eutrophic- Bodies of water with high levels of biological productivity characterized by high amounts of aquatic vegetation with clear water, or minimal vegetation with green water due to algal growth shading out larger plants. These waters are often shallow, have excessive nutrients, and may experience severe algal blooms resulting in anoxic conditions and potential fish kills. Most district lakes fall within this classification.

External Load- Nutrients or pollution contributed from outside a water body such as atmospheric deposition or inlets from streams or pipes.

Final Acute Value (FAV)- An estimate of the concentration of a pollutant corresponding to the cumulative probability of 0.05 in the distribution of all the acute toxicity values for the genera or species from the acceptable acute toxicity tests conducted on a pollutant. This concentration is severe enough to rapidly induce a response, normally observed in 96 hours or less. Acute mortality can be expected above this concentration.

Gaining Stream- A stream which gains water through the stream bed from groundwater.

Hypereutrophic- Bodies of water with extremely high biological productivity and nutrients which often experience severe algal blooms, very low clarity, and limited aquatic life beyond algae and vegetation. Often have the appearance of “pea soup” in mid-summer.

Impaired Waters List/303(d) List- A section of the Clean Water Act which lists water bodies impaired by one or more pollutants for which a TMDL study should be completed.

Internal Load- Nutrients or pollution cycled within a lake from sediments, vegetation, or other sources within a water body.

Littoral- The area of a lake less than 15 feet deep dominated by aquatic vegetation.

Load/Loading- The amount of nutrients or pollutants from a source, usually expressed as pounds or pounds per acre.

Losing Stream- A stream which loses water through the stream bed to the groundwater.

Maximum Standard- The highest concentration of a toxicant in water to which aquatic organisms can be exposed for a brief time with zero or slight mortality. The max standard is half of the final acute value.

Mesotrophic- Bodies of water with an intermediate amount of biological productivity. These waters are typically clear water with healthy aquatic vegetation, some algal growth, and an intermediate amount of nutrients. When stratified, these waters may become anoxic near the bottom.

Non-point Source- A source of pollution from a undefined area such as runoff from a landscape.

Nutrients- Discussed in this report as total phosphorus (TP), total suspended solids (TSS) or sediment, and total Kjeldahl nitrogen (TKN).

Ordinary High Water Level (OHWL)- The boundary of public waters and wetlands determined by a level of water maintained with enough time to leave evidence upon the landscape, such as a change in natural vegetation from terrestrial to aquatic, or the top of the bank of a channel.

Oligotrophic- Bodies of water with low biological productivity characterized by clear water, low algal growth, low nutrient concentrations, minimal aquatic vegetation, and well-oxygenated water.

Point Source- A source of pollution from a single defined outlet such as a pipe.

Shallow Lake- A lake 50 acres or greater in size and less than 15 feet deep, or has greater than 80% littoral area.

Stratification- Separation of water within a lake based on density as a result of differences in water temperature from warm water near the surface and heavy, cold water near the bottom.

Thermocline/metalimnion- The boundary between warm and cold water within a stratified lake characterized by a sudden change in temperature and dissolved oxygen.

Total Maximum Daily Load (TMDL)- Defined by the Clean Water Act as the amount of a pollutant a water body can receive and still meet water quality standards. TMDL studies will often assign a point source load, non-point source load, internal load, and a margin of safety to each pollutant to guide management activities for load reductions from each source.