Middle St. Croix Watershed Management Organization 2022 Water Monitoring Summary



Prepared For:



Prepared by:



This Page Intentionally Left Blank.

ACKNOWLEDGEMENTS

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

Middle St. Croix WMO (MSCWMO) Board of Managers

Annie Perkins, Secretary John Dahl Avis Peters Brian Zeller, Chair Joe Paiement Tom McCarthy, Vice Chair Mike Runk Beth Olfelt-Nelson, Treasurer Ryan Collins Dan Kyllo

Washington Conservation District

Matthew Downing, MSCWMO Administrator

Metropolitan Council

Brian Johnson Monica Lorentz Steven Louwerse Mike Moger Patricia Phua Mallory Vanous Sarah Voth

Minnesota Department of Natural Resources (MN DNR)

Sandy Fecht

The WCD would also like to thank the volunteers and landowners who assist with data collection and allow property access.

TABLE OF CONTENTS

ABBREVIATIONS, DEFINITIONS, ACRONYMS, AND SYMBOLS	.4
EXECUTIVE SUMMARY	.5
LAKE MONITORING	.8
A. METHODS, RESULTS AND DISCUSSION	8
1. LILY LAKE	1
2. MCKUSICK LAKE 1	2
STREAM AND STORMWATER MONITORING	17
A. LILY LAKE INLET TARGETED MONITORING 1	17
B. PERRO CREEK MONITORING	21
C. BROWN'S CREEK DIVERSION STRUCTURE	27
MSCWMO: CONCLUSIONS AND RECOMMENDATIONS	30
A. LAKES	30
B. TARGETED MONITORING	32
C. STREAMS	33
APPENDIX AA	1
WATER QUALITY DATA – LILY LAKE AND MCKUSICK LAKE	\ 1

ABBREVIATIONS, DEFINITIONS, ACRONYMS, AND SYMBOLS

Anoxic	Lacking oxygen
BCWD	Brown's Creek Watershed District
Benthic	The area nearest lake bed
Biweekly	Every two weeks
BMP	Best management practice
cf	cubic feet
cfs	cubic feet per second
Chl-a	Chlorophyll-a
DO	Dissolved oxygen
E. coli	Escherichia coli
IESF	Iron enhanced sand filter
Littoral zone	The area of a body of water where sunlight penetrates to the sediment and allows aquatic
	plants (macrophytes) to grow
MCES	Metropolitan Council Environmental Services
mg/L	milligram per liter
mL	milliliter
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MPN	Most probable number
MSCWMO	Middle St. Croix Watershed Management Organization
NAVD 88	North American Vertical Datum of 1988, used for determining lake elevations
NGVD 29	National Geodetic Vertical Datum of 1929, used for determining lake elevations
OHW	Ordinary high water level
SOP	Standard operating procedure
TKN	Total Kjeldahl nitrogen
TP	Total phosphorus
TSI	Trophic State Index
TSMP	Trout Stream Mitigation Project
TSS	Total suspended solids
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
VSS	Volatile suspended solids
WCD	Washington Conservation District

EXECUTIVE SUMMARY

This report focuses on the summary and comparison of lake and stream water quality data collected by the Washington Conservation District (WCD) in 2022, as well as previous years. In 2022 the Middle St. Croix Watershed Management Organization (MSCWMO) monitored water quality and water surface elevation on McKusick Lake and Lily Lake, and flow and water quality at the Greeley Street Inlet to Lily Lake and at Perro Creek at the Diversion Structure (Figure 1). The purpose of this monitoring is to assess and document current water quality conditions of the lakes and streams, as well as continuation of a long-term monitoring program that will enable the MSCWMO to identify trends associated with best management practice (BMP) implementation and land use changes in the watershed. Also included in this report is data collected at the Brown's Creek Diversion Structure, which is a tributary to McKusick Lake that is monitored by the WCD for the Brown's Creek Watershed District (BCWD).

Lake Monitoring

Lily Lake was classified as mesotrophic and received an A grade in 2022 (APPENDIX A). All samples collected June – September met the Minnesota Pollution Control Agency's (MPCA) standards for total phosphorus (TP) and for chlorophyll- α (chl- α) corrected for pheophytin. All Secchi disk transparency measurements also met the MPCA standard (APPENDIX A). In 2022, Lily Lake was delisted from the MPCA's 303(d) Impaired Waters list for nutrient/eutrophication impairment, due to restoration activities. The lake was treated with alum on May 24th 2022.

In 2022 McKusick Lake was classified as mesotrophic and received a grade of B (APPENDIX A). One sample collected June – September exceeded the MPCA shallow lake standard for TP. All samples met the MPCA standard for chl-α corrected for pheophytin and all Secchi disk transparency measurements met the MPCA shallow lake standard (APPENDIX A).

Stream and Stormwater Monitoring

Monitoring continued at the Greeley Street inlet to Lily Lake in 2022 and the total recorded discharge was the lowest recorded at the site at 748,616 cubic feet. This was due in large part to

the second consecutive year of severe drought conditions, as well as datalogger malfunction early in the monitoring season. This was a decrease from 2021 during the same monitored time period. Only one water quality grab sample was collected during monthly baseflow sampling from Brick Pond and two grab samples were collected during storm events. The baseflow sample had higher than average TP and total suspended solids (TSS) concentrations for this site but were within historic ranges for baseflow. The average TP concentration from storm samples collected in 2022 was 0.093 mg/L, which was the lowest storm average since monitoring began in 2015. The average TSS concentration from storm samples was 13 mg/L, which was the second lowest since 2015. TP and TSS loads to Lily Lake were calculated during monitored periods using sample results from 2020-22. In 2022 the TP load was 4.0 lbs and the TSS load was 288 lbs.

Water quality sampling continued on Perro Creek at the Diversion Structure in 2022 and the total recorded discharge to the St. Croix River was 8,243,553 cubic feet, which included discharge through the overflow structure and was a decrease from 2021. This decrease was due in large part to the severe drought conditions and the fact that the City of Bayport didn't open the Perro Pond outlet until early July. The average TP concentration from baseflow samples was 0.015 mg/L, which was the lowest since monitoring began at this station in 2016. The average baseflow TSS concentration was 3 mg/L, which was similar to the baseflow averages since 2018. The average storm sample TP concentration in 2022 was 0.279 mg/L, which was the lowest since 2018. The average storm sample TSS was 86 mg/L, which was lower than in 2021. TP and TSS loads to the St. Croix River were calculated only during monitored periods, and in 2022 the TP load was 12.1 lbs and the TSS load was 2,733 lbs.

Discharge at the Brown's Creek Diversion Structure site decreased from 2021 to 2022 due to the drought conditions, with a volume of 41,610,620 cubic feet exported to McKusick Lake. The total annual TP and TSS loads also decreased and were 389 lbs. and 75,429 lbs., respectively. Concentrations of metals tended to be lower in 2022. There was one lead result that exceeded MPCA chronic standards.



Figure 1. MSCWMO 2022 Water Monitoring Locations

LAKE MONITORING

A. METHODS, RESULTS AND DISCUSSION

In 2022 water quality data was collected biweekly on Lily Lake and McKusick Lake, over seven consecutive months (April–October) by the WCD. Measurements obtained during the summer sampling season (June–September) are averaged for a comparison of individual lake dynamics from year to year between lakes within the watershed and to the Minnesota Pollution Control Agency's (MPCA) impairment standards. Lake grades are based on the averages of samples collected May–September. Average values for all parameters are presented in APPENDIX A and Figure 2 through Figure 5, which show the current and historic summer averages for each parameter. Water quality samples were collected by the WCD with a two-meter (6.56 feet) integrated surface water column sampler. A full description of WCD Standard Operating Procedures (SOP) is available on the Washington Conservation District website at http://www.mnwcd.org/water-monitoring. The Metropolitan Council Environmental Services (MCES) Laboratory analyzed the surface water samples for TP, chl- α , and total Kjeldahl nitrogen (TKN).

Total phosphorus is analyzed as it is a major nutrient involved in the eutrophication of lakes and is generally associated with the growth of aquatic plants and/or algal blooms. Common sources of phosphorus include runoff from agricultural fields, livestock areas, urban areas, lakeshore lawns, and improperly operating septic systems. With most lakes in this region, phosphorus is the least available nutrient; therefore, its abundance or scarcity controls the extent of algal growth. Excess algal growth, in turn, negatively affects the clarity, or transparency, and ability of light to penetrate the water. 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. The 2022 summer average of TP values of MSCWMO lakes can be found in Figure 2.

Chlorophyll- α is measured because it's the photosynthetic component found in algae and aquatic plants and is an indicator of algal productivity. The MPCA standard for pheophytin-corrected

chl- α is 14 µg/L for deep lakes and 20 µg/L for shallow lakes. The 2022 summer average chl- α concentrations of MSCWMO lakes can be found in Figure 3.

TKN, the sum of organic nitrogen and ammonia, was analyzed in MSCWMO lakes. While no standard exists for TKN because TP is often the limiting nutrient, TKN can contribute to eutrophication. The 2022 summer average TKN concentrations of MSCWMO lakes can be found in Figure 4.

Field measurements are recorded while collecting lake samples, including Secchi disk transparency. The measurement of light penetration using a Secchi disk gives a simple measure of water transparency, or clarity. A reduction in water transparency is typically the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). The MPCA standard for Secchi disk transparency is 1.4 meters for deep lakes and 1.0 meter for shallow lakes. The 2022 summer average transparency of MSCWMO lakes can be found in Figure 5.

User perception and physical/recreational suitability of lakes were recorded, along with temperature and dissolved oxygen (DO) profile measurements taken by the WCD during each sampling event. Profiles are recorded at one-meter increments from the water surface to the lake bottom. The data show the extent of summer stratification and are useful in identifying the development of a thermocline (the layer of water in which the temperature rapidly declines). As a lake stratifies, the water column becomes more stable and mixing is less likely to occur. If mixing occurs during the growing season, nutrients from the lake bottom become available and can result in increased algal production. Lake DO profile data is useful in determining excessive production (algae/plants) in a lake. Increased production creates more DO, for a time, but as plants and algae die off and decay, the bacteria that decompose them consume DO. Low DO conditions may stress fish populations and under anoxic conditions nutrients may be released from the sediment. Data collected from the rankings and profiles are contained in a database at the WCD, and can be obtained by request, as well as on the MPCA website at https://webapp.pca.state.mn.us/surface-water/search.

A lake grading system is used in this summary, to allow for a better understanding of lake water quality data and to aid in the comparison of lakes. The lake water quality grading system was developed following the 1989 sampling season by MCES. The concept of the lake grading system is a ranking of water quality characteristics by comparing measured values to those of other metro area lakes. The grading system represents percentile ranges for three water quality indicators: the May through September average values of TP, uncorrected trichromatic chl- α , and Secchi disk transparency. These percentiles use ranked data from 119 lakes sampled from 1980-1988 and are shown in Table 1. This method has since been replicated and the grading system has been verified with more recent data. The variables used in the grading system strongly correlate to open-water nuisance aspects of a lake (i.e. algal blooms), which can indicate accelerated aging (cultural eutrophication). There is a strong correlation when comparing trophic status to the lake grade. Summaries of all lake results are presented in APPENDIX A.

Grade	Percentile	TP (µg/L)	Chl-α (μg/L)	SD (m)
А	<10	<23	<10	>3.0
В	10-30	23-32	10-20	2.2-3.0
С	30-70	32-68	20-48	1.2-2.2
D	70-90	68-152	48-77	0.70-1.2
F	>90	>152	>77	< 0.70

Table 1. Lake Grade Ranges

There are several metrics and systems that can also be used to assess lakes including the Carlson Trophic State Index (TSI) and ecoregion values. The Carlson Trophic State Index is used to quantify the relationship between water quality data and trophic status. Trophic states vary from oligotrophic (low biological activity and high clarity) to hypereutrophic (highly productive with very low clarity). The MSCWMO is located in the North Central Hardwood Forest Ecoregion where lakes are often mesotrophic. Ecoregion values are assigned for TP, TKN, chl- α, and Secchi disk transparency. This report will focus on the methods used by the MPCA and the Metropolitan Council, as previously discussed.

Water elevation monitoring was conducted on two lakes, McKusick and Lily, from April to October 2022. Lake elevation readings are compared to the lake's Ordinary High Water level (OHW)¹. The OHW for Lily and McKusick Lakes are 844.8 ft. and 851.7 ft., respectively (NGVD 29). Changes in lake water elevation are often attributed to the changes in precipitation. The highest recorded elevation in 2022 for Lily Lake occurred on 5/12/2022 at 846.52 ft. and on 5/12/2022 at 854.82 ft. for McKusick Lake. Complete lake elevation data for 2022 can be found in APPENDIX A. For historical lake elevations, visit the MN DNR Lake Finder webpage at http://www.dnr.state.mn.us/lakefind/index.html.

Water elevation monitoring also occurred on Brick Pond by a volunteer, July to November. The lowest recorded elevation was on 8/2/2022 at 846.87 ft and the highest was on 8/30/2022 at 848.47 ft (NAVD 88).

1. LILY LAKE

In 2022 WCD staff conducted two-tailed Kendall's Tau statistical analysis based on data collected by professional agencies for both lakes monitored in MSCWMO to determine trends for TP, Secchi, and chl- α (p<0.05). Lily Lake had a statistically significant improving trend for TP, and no trend was found for average Secchi disk transparency and chl- α . Lily Lake had an average summertime TP concentration of 0.013 mg/L, which was lower than 2021 average of 0.039 (Figure 2). All nine summertime results met the MPCA lake nutrient impairment standard for TP. The 2022 average summertime concentration of chl- α was 3.4 µg/L, lower than the 14.1 µg/L measured in 2021 (Figure 3). All nine water quality results for chl- α met the MPCA lake impairment standard (APPENDIX A). Lily Lake had an average summertime TKN concentration of 0.61 mg/L in 2022; lower than the average of 0.88 mg/L in 2021 (Figure 4). Secchi disk

¹ Minnesota State Statutes defines the ordinary high water level (OHW) as follows: <u>Minnesota Statutes 103G.005</u> Subd. 14. Ordinary High Water Level. "Ordinary high water level" means the boundary of water basins, watercourses, public waters and public waters wetlands, and: The ordinary high water level is an elevation delineating the highest water level that has been maintained for a sufficient period of time to leave evidence upon the landscape, commonly the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial;

¹⁾ For watercourses, the ordinary high water level is the elevation of the top of the bank of the channel; and

²⁾ For reservoirs and flowages, the ordinary high water level is the operating elevation of the normal summer pool.

readings were measured in 2022 with a summertime average of 5.05 meters (Figure 5), with all nine water quality readings meeting the MPCA lake standard for Secchi disk transparency (APPENDIX A). Lily Lake received an A grade in 2022, an improvement from the C+ it received in 2021. Temperature and DO profiles indicate that Lily Lake exhibited thermal stratification during the summer months with the thermocline between 4 and 6 meters; therefore, the lake was less likely to completely mix throughout the summer. The elevation was above the OHW for the beginning and end of the monitoring season, with the highest recorded level occurring on 5/12/2022 with a level of 846.52 ft. The lowest recorded level of the monitoring season occurred on 8/16/2022 with an elevation of 844.48 ft. A summary of all lake results is presented in APPENDIX A.

2. MCKUSICK LAKE

A two-tailed Kendall's Tau analysis based on data collected by professional agencies showed that McKusick Lake has statistically significant (p<0.05) improving trends for TP, chl- α , and Secchi transparency. The McKusick Lake summertime average TP concentration in 2022 was 0.035 mg/L; lower than the 0.039 mg/L observed in 2021 (Figure 2), with one water quality sample exceeding the MPCA TP impairment standard for shallow lakes (APPENDIX A). McKusick Lake had a summertime average chl- α concentration of 5.0 µg/L; lower than the chl- α average of 8.7 μ g/L from 2021 (Figure 3). All nine summertime samples collected in 2022 met the MPCA shallow lake standard for chl-a. The average summertime TKN concentration in 2022 was 0.83 mg/L, higher than the 0.78 mg/L in 2021 (Figure 4). The 2022 summertime average water transparency measured by Secchi disk was 2.37 meters (Figure 5). All nine summertime Secchi disk readings in 2022 met the MPCA shallow lake impairment standard. McKusick Lake received a grade of a B in 2022, an improvement from the B- it received from 2019-2021. No temperature and DO profiles were collected so the occurrence of thermal stratification in the deepest part of the lake cannot be determined. A majority of McKusick Lake is very shallow and does not stratify, and therefore is likely to have mixed throughout the summer. The elevation of McKusick Lake remained above the OHW for the entire monitoring season, reaching its highest recorded level of the season on 5/12/2022 with a level of 854.82 ft. and the lowest recorded level of the season occurred on 6/7/2022 with an elevation of 853.70 ft. A summary of all lake results is presented in APPENDIX A.



Figure 2. MSCWMO Historic Summer Average Total Phosphorus



Figure 3. MSCWMO Historic Summer Average Chlorophyll-a



Figure 4. MSCWMO Historic Summer Average Total Kjeldahl Nitrogen



Figure 5. MSCWMO Historic Summer Average Secchi Disk Transparency

STREAM AND STORMWATER MONITORING

A. LILY LAKE INLET TARGETED MONITORING

In 2015 the MSCWMO received grant funding to conduct targeted water quality monitoring on Lily Lake with the goal of identifying priority areas for nutrient load reduction to the lake. The MSCWMO worked closely with the WCD to develop and implement a monitoring plan to achieve this goal.

As in prior years, the monitoring in 2022 focused on the Greeley Street catchment. A datalogger was installed on 5/17/22, but due to malfunctions with the internal battery all recorded data was lost. A new datalogger was installed and continuous 15-minute stage and velocity data were collected in the catchment basin from 7/11/22 – 10/27/22. Discharge was calculated during this period using an area/velocity relationship and the recorded discharge to Lily Lake in 2022 was 748,616 cubic feet, which was a decrease from 2021 during this same time period (Table 2, Figure 6, and Figure 7). As in 2021, this decrease in discharge was due in large part to severe drought conditions. After a cool, wet spring, there were extended periods of very low or no flow throughout the entire monitoring season. Because of these low flow conditions and few rain events, only three water quality grab samples were collected and analyzed for total phosphorus, total Kjeldahl nitrogen, and total suspended solids in 2022 (Table 3). Storm sampling has historically been limited by the nature of the site as storm events at the Greeley Street catchment can be flashy. Urban storm runoff is transported quickly and this makes capturing a sample more difficult during these periods.

One water quality grab sample was collected during monthly baseflow sampling from Brick Pond 9/6/22 and two grab samples were collected during storm events on 5/25/22 and 8/12/22. The baseflow sample had higher than average TP, TKN, and TSS concentrations for this site but were within historic ranges for baseflow (Table 4). The average TP concentration from storm samples collected in 2022 was 0.093 mg/L, which was the lowest storm average since monitoring began in 2015 (Table 4). The 8/12 sample was collected during a low flow storm event (<1 cfs) and discharge could not be calculated for the 5/25 sample. The average TSS concentration from storm samples was 13 mg/L, which was the second lowest since 2015. TP and TSS loads to Lily Lake were calculated during monitored periods, and in 2022 the TP load was 4.0 lbs (Table 2 and Figure 6) and the TSS load was 288 lbs (Table 2 and Figure 7). The 2022 dataset was not considered robust for calculating loads, and therefore sample results from 2020-22 were used to calculate the TP and TSS loads.

Table 2. Greeley Street 2022 Monitored Discharge and TP & TSS Loading

		Discharge	Discharge	Percent of Total	TP Load	Percent of TP	TSS Load	Percent of TSS
Site	Date range	(cf)	(ac-ft)	Discharge	(lbs)	Load	(lbs)	Load
Greeley St. Baseflow ¹	7/11/22 - 10/27/22	699,903	16.08	93%	3.2	80%	175	61%
Greeley St. Stormflow ¹	7/11/22 - 10/27/22	48,713	1.12	7%	0.8	20%	113	39%
Tota	748,616	17.19	100%	4.0	100%	288	100%	

¹ TP and TSS averages from 2020-22 data were used for load calculations (Only 3 total samples were collected in 2022)

Table 3. Greeley Street 2022 Water Quality Results

Date	Sample Type	TP (mg/L)	TSS (mg/L)	TKN (mg/L)	Discharge (cfs)
5/25/22 13:06	Storm	0.100	6	1.40	NA
8/12/22 8:45	Storm	0.086	20	0.72	0.12
9/6/22 9:45	Base	0.166	9	1.20	0.02

Table 4. Greeley	Street Historical T	P and TSS	Averages and	Ranges
------------------	---------------------	-----------	--------------	--------

Greeley Street Sample Type	2015	2016	2017	2018	2019	2020	2021	2022
Baseflow Samples	3	6	5	8	6	5	4	1
Stormflow Samples	6	5	2	1	1	1	4	2
TP (mg/L) - Baseflow Average	0.091	0.070	0.060	0.066	0.077	0.046	0.081	0.166
Baseflow Range	0.028 - 0.210	0.029 - 0.122	0.045 - 0.083	0.040 - 0.126	0.046 - 0.134	0.036 - 0.791	<0.020 - 2.09	NA
TP (mg/L) - Stormflow Average	0.219	0.437	0.104	0.316	0.110	0.199	0.360	0.093
Stormflow Range	0.063 - 0.382	0.059 - 0.744	0.089 - 0.119	NA	NA	NA	0.214 - 0.593	0.086 - 0.100
TSS (mg/L) - Baseflow Average	4	2	3	4	2	2	5	9
Baseflow Range	1-9	1-6	1-7	1-8	1-3	1-3	2 - 220	NA
TSS (mg/L) - Stormflow Average	48	233	35	518	8	38	49	13
Stormflow Range	2 - 132	10 - 616	28 - 41	NA	NA	NA	32 - 88	6 - 20



The datalogger in 2022 was installed for a shorter time period (7/11 - 10/27). July - Oct. discharge is graphed for each year as reference.

Figure 6. Greeley Street Monitored Discharge and Total Phosphorus Load



The datalogger in 2022 was installed for a shorter time period (7/11 - 10/27). July - Oct. discharge is graphed for each year as reference.

Figure 7. Greeley Street Monitored Discharge and Total Suspended Solids Load

B. PERRO CREEK MONITORING

The goal of monitoring Perro Creek in 2016-2017 was to identify where the greatest contribution of nutrients and sediment to the St. Croix River was occurring. Monitoring continued in 2018 and 2019 to further refine previous observations. In 2020 water monitoring activities were reduced on Perro Creek and no traditional water quality samples were collected. In 2021 and 2022 water quality sampling was conducted on Perro Creek at the Diversion Structure site by collecting in-stream grabs samples during baseflow periods and using an automated sampler to collect flow-weighted composite storm samples. The automated sampler allowed for multiple samples to be collected during storm events, which were then combined into one sample representing the storm event. This methodology can provide more accurate data for calculating nutrient loads during storm events than grab samples alone. Continuous 15-minute stage and velocity data were collected at the site and in the Diversion Structure Overflow from 6/21/22 - 10/26/22. Discharge was calculated using an area/velocity relationship, and the recorded discharge in 2022 to the St. Croix River was 8,243,553 cubic feet (Table 5).

Fifteen water quality samples were collected and analyzed for several parameters, including total phosphorus, total Kjeldahl nitrogen, and total suspended solids (Table 6). A snowmelt grab sample was collected in March before monitoring equipment was installed. Four baseflow grab samples were collected monthly July – October and a baseflow composite sample was collected in July when the Perro Pond outlet was opened for the year. A storm grab sample was collected in May and eight composite storm samples were collected July – August. The average TP concentration in 2022 during baseflow was 0.015 mg/L, which was the lowest since monitoring began at this station (Table 7). Baseflow samples collected on 8/25, 9/13, and 10/12 had TP and TSS results that were less than the reporting limit and results were divided in half when calculating averages. The results from the automated composite sample collected after the pond outlet was opened in July were excluded from the baseflow averages, since the sample was not an in-stream grab sample and not representative of baseflow conditions. The 2022 baseflow average TSS concentration was 3 mg/L, which was similar to the baseflow averages since 2018. The TSS result from the 9/13 sample was considered an outlier and was excluded from the baseflow averages. The average TP concentration from storm samples collected in 2022 was

0.279 mg/L, which was the lowest storm average since 2018 (Table 7). The 5/25 storm grab sample was considered an outlier and the results were excluded from the stormflow averages. The average TSS concentration from storm samples was 86 mg/L, which was lower than in 2021. TP and TSS loads to the St. Croix River were calculated for both the creek and the Diversion Structure Overflow during monitored periods. In 2022 the TP load was 12.1 lbs (Table 5 and Figure 8) and the TSS load was 2,733 lbs (Table 5 and Figure 9).

Perro Creek is listed as impaired for TSS on the MPCA's 303(d) Impaired Waters List. The stream is in the Central River Nutrient Region and the MPCA standard is 30 mg/L for class 2B waters. The MPCA's protocols for assessments are as follows:

"A stream is considered to exceed the standard for TSS if 1) the standard is violated more than 10% of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and 2) at least three measurements violate the standard. A stream is considered to meet the standard for TSS if the standard is met at least 90% of the days of the assessment season. A designation of meeting the standard for TSS generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least two different years. However, if it is determined that the data set adequately targets periods and conditions when exceedances are most likely to occur, a smaller number of measurements may suffice."

Perro Creek is also listed as impaired for *E. coli* bacteria on the MPCA's 303(d) Impaired Waters List. *E.* coli is used as an indicator in waterbodies for the possible presence of fecal contamination, including pathogens. The primary source of *E. coli* is human and animal waste, making high *E. coli* presence a concern for human health. A summary table by month can be found in Table 8. The MPCA 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."

				Percent of	ТР	Percent	TSS	Percent
		Discharge	Discharge	Total	Load	of TP	Load	of TSS
Site	Date range	(cf)	(ac-ft)	Discharge	(lbs)	Load	(lbs)	Load
Perro at Diversion Structure Baseflow ¹	6/21/22 - 10/26/22	7,341,487	168.63	89%	6.6	55%	1146	42%
Perro at Diversion Structure Stormflow ¹	6/21/22 - 10/26/22	158,933	3.65	2%	2.8	23%	853	31%
Perro at Diversion Overflow Baseflow ¹²	6/21/22 - 10/26/22	624,547	14.35	8%	0.6	5%	97	4%
Perro at Diversion Overflow Stormflow ¹²	6/21/22 - 10/26/22	118,585	2.72	1%	2.1	17%	637	23%
Total to the St. Croix River		8,243,553	189.34	100%	12.1	100%	2,733	100%

Table 5. Perro Creek 2022 Monitored Discharge and TP & TSS Loading

¹ 3/16, 5/25, and 7/11 results were excluded from the TP/TSS averages used for load calculations

² Results averages from samples collected in-stream at the Diversion Structure were used for Diversion Overflow loading calculations

Start	End	Sample Type	TP (mg/L)	TSS (mg/L)	TKN (mg/L)	Ammonia Nitrogen (mg/L)	Nitrate N (mg/L)	Nitrite N (mg/L)	<i>E. coli</i> (mpn/100 mL)
7/11/22 14:38	7/11/22 16:54	Base Composite ¹	0.065	18	0.65	<0.06	0.31	<0.06	
7/27/22 14:37	7/27/22 14:37	Base Grab	~0.028	3	0.40				365
8/25/22 15:05	8/25/22 15:05	Base Grab ²	< 0.020	<3	0.29				114
9/13/22 7:58	9/13/22 7:58	Base Grab ²³	< 0.020	15	0.20				13
10/12/22 9:05	10/12/22 9:05	Base Grab ²	<0.020	3	0.24				548
3/16/22 14:15	3/16/22 14:15	Snowmelt Grab ¹	1.100	170	4.30	1.24	0.24	< 0.06	
5/25/22 13:49	5/25/22 13:49	Storm Grab ¹	< 0.020	10	<0.08	0.07	0.28	< 0.06	1986
7/23/22 14:32	7/23/22 15:59	Storm Composite	0.524	134	4.70	0.61	0.76	0.06	
7/31/22 20:12	7/31/22 21:50	Storm Composite	0.289	58	1.70	0.36	0.70	< 0.06	
8/6/22 9:54	8/6/22 11:36	Storm Composite	0.087	24	0.50	0.12	0.70	< 0.06	
8/7/22 21:32	8/7/22 21:52	Storm Composite	0.134	87	0.78	0.13	0.58	< 0.06	
8/12/22 7:43	8/12/22 9:25	Storm Composite	0.068	3	0.49	0.10	0.54	< 0.06	
8/18/22 18:18	8/18/22 19:22	Storm Composite	0.522	131	2.10	0.37	0.60	< 0.06	
8/19/22 13:05	8/19/22 13:59	Storm Composite	0.352	154	1.90	<0.06	0.33	< 0.06	
8/27/22 21:32	8/27/22 22:30	Storm Composite	0.259	97	1.30	0.15	0.47	< 0.06	

Table 6. Perro Creek at Diversion Structure 2022 Water Quality Results

¹ Results excluded from averages

² TP/TSS results that are less than the Reporting Limit were divided in half when calculating averages

³ TSS results excluded from averages

Perro @ Diversion Sample Type	2016	2017	2018	2019	2020	2021 ^a	2022 ^a
Baseflow Samples	8	6	8	6	No Samples	6	5
Stormflow Samples	5	5	4	3	No Samples	8	9
TP (mg/L) - Baseflow Average	0.051	0.046	0.036	0.034	No Samples	0.035	0.015
Baseflow Range	~0.023 - 0.090	<0.020 - 0.120	0.020 - 0.058	0.021 - 0.065		0.024 - 0.210	<0.020 - 0.065
TP (mg/L) - Stormflow Average	0.435	0.108	0.124	0.372	No Samples	0.427	0.279
Stormflow Range	0.126 - 1.330	~0.023 - 0.218	0.047 - 0.252	0.133 - 0.597		0.185 - 0.862	<0.020 - 0.524
TSS (mg/L) - Baseflow Average	16	12	4	2	No Samples	2	3
Baseflow Range ^b	<1 - 77	~1 - 60	1 - 16	1-3		1 - 33	<3 - 18
TSS (mg/L) - Stormflow Average	118	36	20	58	No Samples	217	86
Stormflow Range ^b	32 - 308	12 - 76	8 - 31	21 - 97		75 - 429	3 - 154

Table 7. Perro Creek Historical TP and TSS Averages and Ranges

^a Results from base composite sample excluded from averages (Sampled during initial opening of Perro Pond outlet)

^b Beginning in 2022, the laboratory changed TSS reporting to as low as the Reporting Limit (3 mg/L) rather than the Method Detection Limit (1 mg/L)

able 6. Montiny Geometric Means of E. cou- Latest ren rears										
Site	April	May	June	July	August	September	October			
Perro at Diversion Structure ¹	Insufficient Data	111	392	235	157	451	205			
	Exceeds geometric m	cceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month, collected in last 10 yrs								

Table 8. Monthly Geometric Means of E. coli- Latest Ten Years

¹ >10% of samples collected in the last 10 years exceeded 1,260 #/100mL



2021 was the first year where automated storm samples were collected instead of storm grab samples.

Figure 8. Perro Creek at Diversion Structure Monitored Discharge and Total Phosphorus Load



2021 was the first year where automated storm samples were collected instead of storm grab samples.

Figure 9. Perro Creek at Diversion Structure Monitored Discharge and Total Suspended Solids Load

C. BROWN'S CREEK DIVERSION STRUCTURE

As part of Brown's Creek Watershed District's long-term monitoring, the WCD collected grab samples and automated flow-weighted samples during both baseflow and storm event conditions at the Brown's Creek Diversion Structure for BCWD in 2022, and that data is provided to the MSCWMO. The City of Stillwater constructed the diversion structure in June of 2003, as part of the completion of the Trout Stream Mitigation Project (TSMP). It has been functioning to divert water from the 1,800-acre annexation area away from Brown's Creek through McKusick Lake, and ultimately to the St. Croix River. While this diversion structure keeps the warmer urban stormwater runoff from the southern tributary out of the temperature and nutrient sensitive Brown's Creek Ravine, it means that this is discharged to McKusick Lake and does affect the lake water quality. Data collected at this site by the WCD includes continuous stage and total discharge, and water quality samples analyzed for nutrients, sediment, and metals. Discharge decreased from 2021 to 41,610,620 cubic feet exported to McKusick Lake, due to a second consecutive year of drought (Table 9). All stream flow and chemistry data from 2022 can be found in Table 9 and Table 10.

The TP load to McKusick Lake was 389 lbs., or 0.101 lbs. of phosphorus per acre of watershed land, and the TSS load was 75,429 lbs. of sediment, or 19.57 lbs. per acre (Table 9). Erosional head cuts on the tributary branches of the creek have been identified as a source of TP and TSS loads. BCWD repaired one large head cut in 2018 and additional rock vanes were installed between September and October of 2021 to reconnect the drainage tributaries with their floodplains and stabilize the stream bed. The Iron Enhanced Sand Filter (IESF) upstream of the monitoring site also continues to operate to reduce TP loads in the drainage. In early 2021 the City of Stillwater removed 1,246 cubic yards of sediment from the wetland complex at the head of McKusick Lake, in the area where the Diversion Structure drainage discharges to the lake.

The calculation of MPCA metal standards is 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. 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 at this site 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, more 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.

	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

Table 9. Brown's Creek Diversion Historic Annual Discharge and Loading- Latest Ten Years

Table 10. 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 Qu	ality Standard																

Exceeds Water Quality Standard Exceeds Chronic Standard Exceeds Max Standard

Exceeds Final Acute Standard

MSCWMO: CONCLUSIONS AND RECOMMENDATIONS

A. LAKES

Lake monitoring in MSCWMO continues to provide valuable baseline water quality information. To determine the health of the lakes in MSCWMO, physical and chemical parameters are compared on a year-to-year basis and to other lakes in the region. Water quality in a lake depends on a number of different variables such as: size of the contributing watershed, external nutrient sources, depth of the lake, and the current amount of nutrients available to be periodically released from the lake bottom. Low water quality ratings of MSCWMO lakes are most likely due to long-term contribution of urban runoff (Lily Lake) or due to the sensitivity of shallow lakes being prone to summertime mixing (McKusick Lake). Shallow lakes typically exist in a low algal production, clear-water state with abundant aquatic macrophytes or in a high-algal production, turbid water state. Shallow lakes may not completely stratify in the summer, and therefore have the capability to continually mix throughout the summer. That mixing causes phosphorus to be distributed throughout the water column, causing more frequent and heavy algal blooms. This is unlike deeper, stratified lakes where phosphorus below the thermocline is not available for primary production.

The MPCA listed both Lily and McKusick Lake on the 303(d) Impaired Waters list for nutrient/eutrophication impairment. If a water body is listed, it indicates that it does not currently meet water quality criteria. McKusick Lake was delisted in 2012 because restoration activities within its watershed led the lake to meet the water quality standards. In 2022, the MPCA delisted Lily Lake because the lake was meeting the standards due to restoration activities within its watershed.

Summertime (June-September) TP, chlorophyll- α , and Secchi disk transparency averages have remained relatively consistent over the last twenty years in Lily Lake with the exceptions of 1995, 2001, 2009, 2013, and 2014 where overall water quality dramatically improved (Figure 2, Figure 3, and Figure 5). In 2001 phosphorus and chl- α levels dropped and the lake grade improved significantly. In 2006-2008, summer average TP, chl- α , and Secchi disk transparency deteriorated when compared to the averages seen from 2001 to 2005. In 2022 Lily Lake received a grade of an A, well above the long-term average lake grade of a C+.

The cause of these one-year increases (1995, 2001, 2009, 2013, and 2014) in water quality is presently unknown, and there may be several possible explanations which could be investigated further in the future. Lily Lake has received herbicide and algaecide treatments from 1995-2011 and 2016-2018. In 2018-2021 the City of Stillwater and the Lily Lake Association did not request any large-scale herbicide and algaecide treatments but individual landowner treatments have occurred. In 2010 a native buffer planting was installed at the public access and the Lily Lake watershed underwent a subwatershed assessment. As a result, fifteen raingardens were constructed in the Lily Lake watershed from 2011-2012, six large raingardens were installed in 2014, a gully stabilization project installed at Lakeview Hospital discharging to Brick Pond in 2017, and a large gully stabilization and stormwater treatment system discharging to Brick Pond in 2018. In 2019 another raingarden was installed. Construction of a large infiltration basin in the Greeley storm catchment subwatershed was completed in 2022 and the lake was treated with alum on May 24th, 2022. The effects of these BMPs may have been seen from 2012 to 2022 monitoring seasons with the 2016-2022 seasons having a statistically significant (p<0.05) improving trend for total phosphorus. Continued monitoring is needed to show changes to long term trends due to the implementation of these BMPs. In 2019 the Lily Lake Phosphorus Reductions for Delisting grant was secured. More information about the Lily Lake Impaired Waters Delisting Road Map can be found at <u>http://www.mscwmo.org/subwatershed-assessments</u>.

A subwatershed assessment was conducted on the McKusick Lake watershed in 2010. In 2011 six raingardens were constructed as a result of the subwatershed assessment. With renewed funding, seven additional raingardens were planned to be installed in the McKusick Lake watershed in 2013 but were not due to issues with utilities; instead, six larger raingardens were installed in 2014. The impacts of previously installed raingardens may have been seen in 2017-2022 with statistically significant (p<0.05) improving trends for average TP and average Secchi disk transparency, and a statistically significant trend for average chl- α as of 2022. For more information on the McKusick Lake subwatershed assessment refer to the McKusick Lake Stormwater Retrofit Assessment found at <u>http://www.mscwmo.org/subwatershed-assessments.</u>

B. TARGETED MONITORING

The targeted monitoring of Lily Lake had the goal of more accurately identifying the major sources of nutrients to the lake and to help steer targeting and design of stormwater management practices. Based on 2016 results, approximately 78% of phosphorus loading to Lily Lake occurs during storm events and the Greeley Street catchment was one of the highest contributing stormwater catchments during those events. The remaining 22% of the phosphorus load was from Brick Pond discharging to Lily Lake during baseflow conditions. Baseflow from Brick Pond accounted for 65% of the total discharge to the lake in 2016 but the average TP concentrations during those periods were lower than during storm events.

The drought conditions in 2022 caused a decrease in flow and affected baseflow and stormflow sampling. Brick Pond was low or not flowing out for most of the monitored period. The baseflow sample results were higher than the average values in past years and at least one of the two storm samples was collected when discharge was low (<1.0 cfs). Stormflow periods in 2022 accounted for only 7% of the monitored discharge to Lily Lake, but 20% of the TP load and 39% of the TSS load occurred during these periods.

Baseflow samples should continue to be collected during all flow periods to help evaluate possible changes in TP and TSS loading to Lily Lake. More storm samples should also be collected to calculate more accurate TP and TSS loadings and to better characterize storm events. Continued monitoring will also help assess the impact of BMPs installed in the Greeley Street catchment.

C. STREAMS

Water quality sampling continued on Perro Creek at the Diversion Structure in 2022. Drought conditions caused a decrease in flow and affected baseflow and stormflow sampling. On July 21st, the City of Bayport reported that Perro Pond was very low and that the Perro Pond outlet was opened in early July. Stormflow periods accounted for only 3% of the monitored discharge to the St. Croix River but 40% of the TP load and 55% of the TSS load occurred during these periods in 2022. Flow-weighted composite samples should continue to be collected to more accurately calculate TP and TSS loads during storm events.

Perro Creek is listed as impaired for TSS on the MPCA's 303(d) Impaired Waters List and is assessed using an unbiased dataset. Flow-weighted composite samples are considered biased towards higher flow periods because more samples are collected during the higher flows, and these samples are therefore not used for TSS assessments. In 2022 there were no TSS results from grab samples collected April – September that exceeded the MPCA standard of 30 mg/L for class 2B waters. Water quality grab samples should continue to be collected at Perro Creek during different levels of flow to provide an unbiased dataset for assessing the stream for the TSS impairment.

Perro Creek is listed as impaired for *E. coli* bacteria on the MPCA's 303(d) Impaired Waters List. Samples collected in 2022 at the Diversion Structure in August and September were less than the monthly geometric means from the last 10 years of data for that site, while the May, July, and October samples were higher than the monthly geometric mean. No sample was collected in June. The 10-year geometric means in June – October exceed the MPCA standard. Monthly *E. coli* samples should continue to be collected from May through October at Perro Creek to expand the dataset for calculating monthly geometric means.

APPENDIX A WATER QUALITY DATA – LILY LAKE AND MCKUSICK LAKE

This Page Intentionally Left Blank.

LILY LAKE

2022 Lake Grade: A

- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth (2022): 45 ft
- Ordinary High Water Mark: 844.8 ft
- 55%Littoral Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.
- Publicly accessible



Summary Points

- Based on the chlorophyll-α results Lily Lake was considered mesotrophic in 2022, according to the Carlson Trophic State Index.
- Using a Kendall's Tau correlation test (p<0.05) there is a statistically significant **improving** trend for average total phosphorus, and no trend is present for average Secchi transparency or average chlorophyll- α .
- The major land use is urban/residential.
- The lake stratified in 2022 with the thermocline between 4-6 meters deep.
- The lake was treated with alum on May 24th, 2022.
- Lily Lake was delisted in 2022 for its impairment for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.



	Total Phosphorus	Uncorrected Trichromatic Chlorophyll-a	Pheophytin- Corrected Chlorophyll- <i>a</i>	Total Kjeldahl Nitrogen	Secchi Disk Depth	Surface Temperature	Surface Dissolved Oxygen			
Date/Time	(mg/L)	(ug/L)	(ug/L)	(mg/L)	(m)	(Celsius)	(mg/L)			
4/26/2022 11:25	0.043	13.0	10.0	0.79	2.13	6.2	11.48			
5/12/2022 11:45	0.051	6.6	5.3	1.00	1.22	18.2	9.16			
5/17/2022 10:30	0.017	4.5	4.0	0.74	3.35	19.4	8.03			
5/26/2022 11:58	0.013	1.1	1.0	0.53	5.18	15.9	8.89			
6/7/2022 12:07	0.010	1.0	1.0	0.48	7.77	21.0	9.01			
6/22/2022 8:38	0.011	1.0	1.0	0.46	7.62	25.4	8.15			
7/5/2022 14:00	0.018	1.6	1.6	0.55	6.55	25.8	7.68			
7/20/2022 13:24	0.015	3.5	3.3	0.55	4.11	26.5	7.38			
8/1/2022 13:50	0.004	2.0	1.9	0.60	3.81	25.3	12.04			
8/16/2022 8:38	0.025	7.8	7.6	1.00	4.27	23.1	6.99			
8/30/2022 9:55	0.018	7.2	6.2	0.59	3.20	23.2	11.22			
9/13/2022 11:58	0.008	4.5	4.3	0.58	4.11	22.4	10.27			
9/26/2022 8:03	0.008	4.6	4.0	0.64	3.96	18.3	8.08			
10/11/2022 13:03	0.031	5.7	5.3	0.56	4.27	15.5	10.55			
2022 Average	0.019	4.6	4.0	0.65	4.40	20.4	9.21			
2022 Summer Average	0.013	3.7	3.4	0.61	5.05	23.4	8.98			
Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*										
Shallow lake water qu	ality thresholds a	re 0.06 mg/L TP, 2	20 µg/L CL-a, 1.0 r	n Secchi dep	th*					
	High	High Date	Low	Low Date	Average					
2022 Elevation (ft)	846.52	5/12/2022	844.48	8/16/2022	845.10					

*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												
	Summertime Lake Grades (May-Sept)											
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013		
Total Phosphorus (mg/L)	А	С	В	В	В	С	С	В	Α	В		
Chlorophyll-a (ug/L)	А	С	В	В	В	В	С	С	В	В		
Secchi depth (ft)	А	В	В	С	С	С	В	С	В	В		
Overall	Α	C+	В	B-	B-	C+	C+	C+	B+	В		

MSCWMO 2022 Water Monitoring Summary



- Based on the chlorophyll-α results McKusick Lake was considered mesotrophic in 2022, according to the Carlson Trophic State Index.
- Using a Kendall's Tau correlation test (p<0.05) there is a statistically significant **improving** trend for average Secchi transparency, average total phosphorus, and average chlorophyll- α .
- The major land use is urban/residential.
- Temperature and dissolved oxygen profiles were not collected in 2022 so stratification cannot be determined.
- McKusick Lake was delisted in 2012 for its impairment for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.



Date/Time	Total Phosphorus (mɑ/L)	Uncorrected Trichromatic Chlorophyll- <i>a</i> (ug/L)	Pheophytin- Corrected Chlorophyll- <i>a</i> (uɑ/L)	Total Kjeldahl Nitrogen (mɑ/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mq/L)			
4/26/2022 10:56	0.086	20.0	18.0	0.77	1.68	7.1	10.26			
5/12/2022 11:16	0.037	12.0	11.0	0.74	1.22	19.1	8.04			
5/26/2022 11:34	0.065	11.0	9.6	0.96	1.83	15.9	8.23			
6/7/2022 11:35	0.037	5.6	5.1	0.64	2.59	21.4	10.47			
6/22/2022 9:07	0.030	2.5	2.4	0.69	3.35	24.9	8.02			
7/5/2022 13:33	0.025	1.0	1.0	0.63	2.59	25.5	7.01			
7/20/2022 12:57	0.068	5.4	4.6	0.98	1.98	25.4	3.94			
8/1/2022 13:21	0.024	3.3	3.0	0.85	2.74	24.8	10.50			
8/16/2022 9:08	0.041	8.0	7.6	1.20	1.52	22.1	5.12			
8/30/2022 9:27	0.031	6.2	5.1	0.79	1.68	22.4	7.62			
9/13/2022 11:33	0.030	11.0	10.0	0.86	2.13	21.0	9.28			
9/26/2022 8:32	0.031	7.1	6.1	0.85	2.74	16.2	7.70			
10/11/2022 11:57	0.033	5.7	5.3	0.78	3.05	14.2	11.75			
2022 Average	0.041	7.6	6.8	0.83	2.24	20.0	8.30			
2022 Summer Average	0.035	5.6	5.0	0.83	2.37	22.6	7.74			
Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*										
Shallow lake water quali	ty 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)
 854.82
 5/12/2022
 853.70
 6/7/2022
 854.09

 *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												
	Summertime Lake Grades (May-Sept)											
2022 2021 2020 2019 2018 2017 2016 2015 2									2014	2013		
Total Phosphorus (mg/L)	С	С	С	С	С	С	С	С	С	С		
Chlorophyll-a (ug/L)	А	Α	Α	Α	В	В	В	С	С	В		
Secchi depth (ft)	В	С	С	С	С	С	С	С	С	С		
Overall	В	B-	B-	B-	C+	C+	C+	С	С	C+		

MSCWMO 2022 Water Monitoring Summary