Middle St. Croix Watershed Management Organization 2020 Water Monitoring Summary

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Washington Conservation District

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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-α	Chlorophyll-α
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
NCHFE	North Central Hardwood Forest Ecoregion
OHW	Ordinary high water level
SOP	Standard operating procedure
TKN	Total Kjeldahl nitrogen
TMDL	Total maximum daily load
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
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 2020 as well as previous years. In 2020 the Middle St. Croix Watershed Management Organization (MSCWMO) monitored both water quality and water surface elevation on McKusick Lake and Lily Lake, flow and water quality at the Greeley Street Inlet to Lily Lake, flow at Perro Creek at the Diversion Structure, and fecal bacteria source at Perro Creek at 9th Street, Perro Creek at 6th Street, Perro Creek at the Diversion Structure, and Perro Creek at 3rd Avenue (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.

Lake Monitoring

Lily Lake was classified as eutrophic and received a B grade in 2020 (APPENDIX A). One sample exceeded the Minnesota Pollution Control Agency's (MPCA) standard for total phosphorus (TP), four samples exceeded the MPCA standard for chlorophyll-α (chl-α) corrected for pheophytin, three Secchi disk transparency readings exceeded the MPCA standard (APPENDIX A).

In 2020 McKusick Lake was classified as eutrophic and received a grade of B- (APPENDIX A). Three samples exceeded the MPCA shallow lake standard for TP. No samples exceeded the MPCA standard for chl-α corrected for pheophytin and no Secchi disk transparency measurements exceeded the MPCA shallow lake standard (APPENDIX A).

Stream and Stormwater Monitoring

Monitoring continued at the Greeley Street inlet to Lily Lake in 2020 and the total recorded discharge was the second highest recorded at the site at 6,923,500 cubic feet. The average TP concentration during baseflow was the lowest since monitoring began in 2015 at 0.046 mg/L,

while the average total suspended solids (TSS) during baseflow was similar to past years at 2 mg/L. Only one storm sample was collected in 2020 and, as in previous years, sample results were higher than the base sample averages for TP and TSS, 0.199 mg/L and 38 mg/L, respectively.

Water monitoring activities were reduced on Perro Creek in 2020 and no traditional WQ samples were collected. Recorded discharge to the St. Croix River at the Perro Creek at the Diversion Structure site was 40,645,328 cubic feet, which included discharge through the overflow structure. Samples were collected on Perro Creek at the same four locations as in 2019 (9th Street, 6th Street, Diversion Structure, and 3rd Avenue) to determine if human fecal DNA was present in the stream. Of the five samples collected at each location in 2019 and 2020, human fecal DNA was detected in three samples at 3rd Ave. (8/1/19, 10/2/19, and 7/29/20), one sample at the Diversion Structure (7/29/20), and no samples at 6th Street and 9th Street.

Discharge at the Brown's Creek Diversion Structure site decreased significantly from 2019 to 2020 due to drier conditions, with a volume of 68,165,935 cubic feet exported to McKusick Lake. The total annual TP and TSS loads also decreased significantly to 760 lbs. and 246,238 lbs., respectively. There were fewer exceedances of MPCA metal standards compared to past years, with only one copper result and three lead results exceeding the chronic standards.

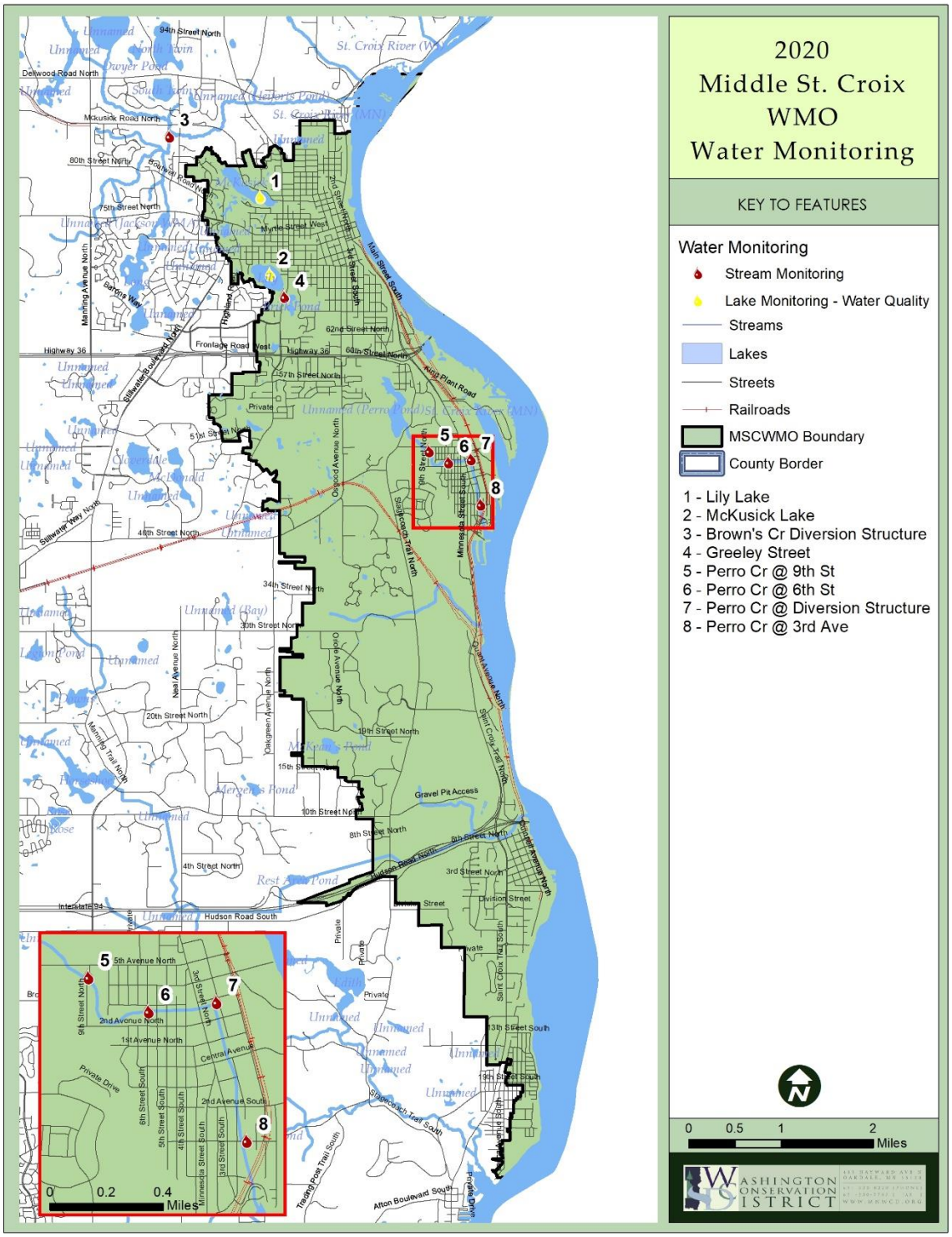

Figure 1. MSCWMO 2020 Water Monitoring Locations

LAKE MONITORING

A. METHODS, RESULTS AND DISCUSSION

In 2020 water quality data was collected biweekly on Lily Lake and McKusick Lake, over six consecutive months (May–October) by the Washington Conservation District (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 2020 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 2020 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 2020 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 2020 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.

Table 1. Lake Grade Ranges

Grade	Percentile	TP (µg/L)	Chl-α (µg/L)	SD (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	0.70-1.2
F	>90	>152	>77	<0.70

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 2020. 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. Changes in lake water elevation are often attributed to the changes in precipitation. The highest recorded elevation in 2020 for Lily Lake occurred on 6/29/2020 at 846.77 ft. and on 7/6/2020 at 854.40 ft. for McKusick Lake. Complete lake elevation data for 2020 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.

1. LILY LAKE

In 2020 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, a statistically significantly declining trend for chl-α and no trend was found for average Secchi disk transparency. Lily Lake had an average summertime TP concentration of 0.028 mg/L, which was lower than 2019 (Figure 2). One of the nine summertime results was greater than the MPCA lake nutrient impairment standard for TP. The 2020 average summertime concentration of chl-α was 15.4 μg/L, lower than the 21.5 μg/L measured in 2019 (Figure 3). Four of the nine water quality results for chl-α impairment exceeded the MPCA lake standard (APPENDIX A). Lily Lake had an average summertime TKN concentration of 0.76 mg/L in 2019; lower than the average of 0.91 mg/L in 2019 (Figure 4). Secchi disk readings were measured in 2020 with a summertime average of 2.25 meters (Figure 5), with three of the nine water quality readings exceeding the MPCA lake standard for Secchi disk transparency (APPENDIX A). Lily Lake received a grade of B in 2020, an improvement from the B- it

[1] Minnesota State Statutes defines the ordinary high water level (OHW) as follows: Minnesota Statutes 103G.005 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.

received in 2019. Temperature and DO profiles indicate that Lily Lake exhibited thermal stratification during the summer months with the thermocline between 4 and 5 meters; therefore the lake was less likely to completely mix throughout the summer. Lily Lake was below the OHW for three elevation readings, falling to its lowest recorded level of the monitoring season on 10/12/2020 with an elevation of 844.57 ft. The elevation was above the OHW for most of the monitoring season, reaching its highest recorded level on 6/29/2020 with a level of 846.77 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 and Secchi transparency, and no trend is present for chl-α. The McKusick Lake summertime average TP concentration in 2020 was 0.065 mg/L; higher than the 0.057 mg/L observed in 2019 (Figure 2), with three of the nine summertime water quality samples exceeding the MPCA TP impairment standard for shallow lakes (APPENDIX A). McKusick Lake had a summertime average chl-α concentration of 7.3 μg/L; lower than the chl-α average of 9.1 μg/L from 2019 (Figure 3). None of the nine summertime samples collected in 2020 exceeded the MPCA shallow lake standard for chl-α. The average summertime TKN concentration in 2020 was 0.71 mg/L, the same as 2019 (Figure 4). The 2020 summertime average water transparency measured by Secchi disk was 1.86 meters (Figure 5). None of the nine summertime Secchi disk readings in 2020 were worse than the MPCA shallow lake impairment standard. McKusick Lake received a grade of a B- in 2020, the same as 2019. 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 7/6/2020 with a level of 854.40 ft. and the lowest recorded level of the season occurred on 9/28/2020 with an elevation of 853.74 ft. A summary of all lake results is presented in APPENDIX A.

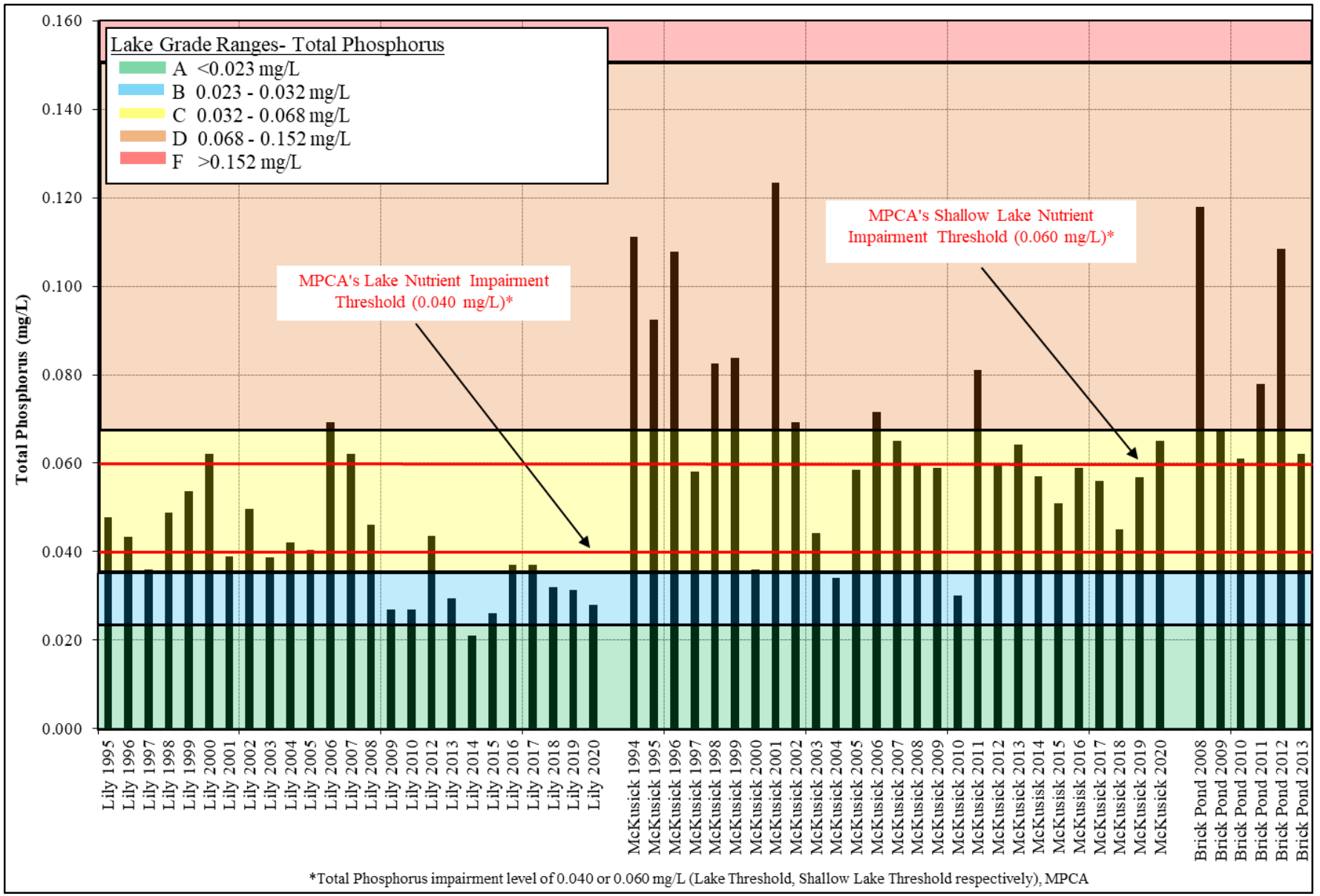

Figure 2. MSCWMO Historic Summer Average Total Phosphorus

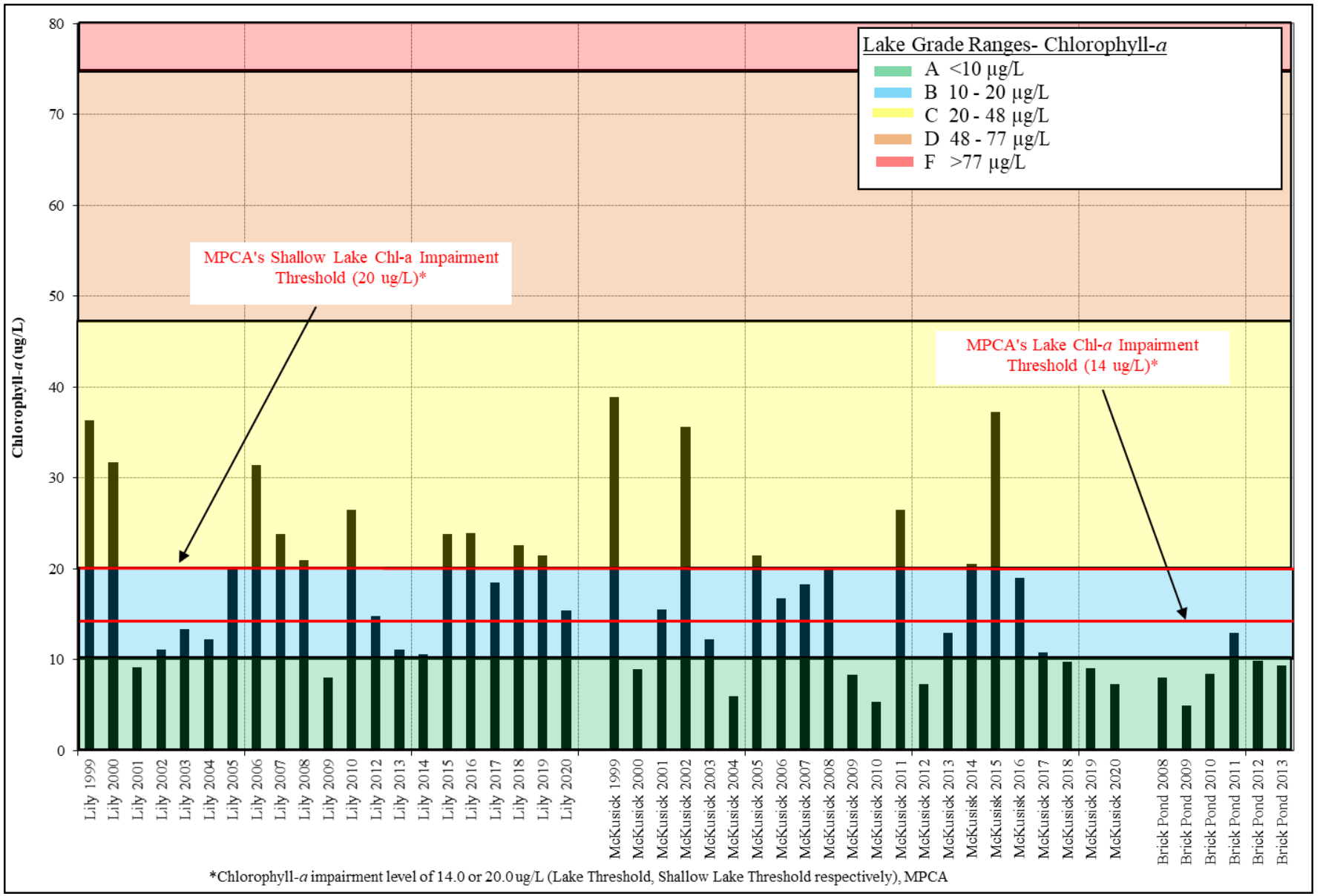

Figure 3. MSCWMO Historic Summer Average Chlorophyll-α

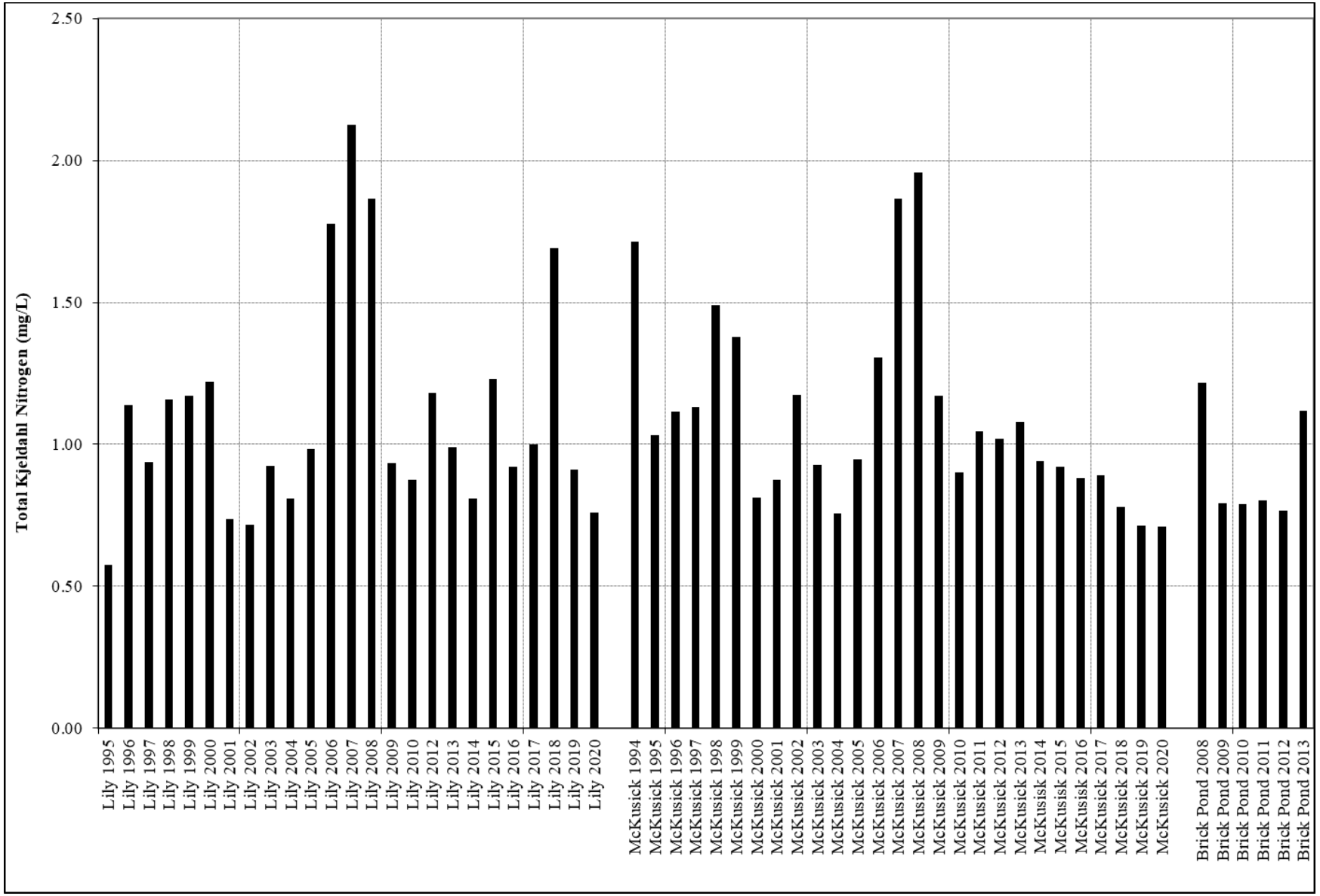

Figure 4. MSCWMO Historic Summer Average Total Kjeldahl Nitrogen

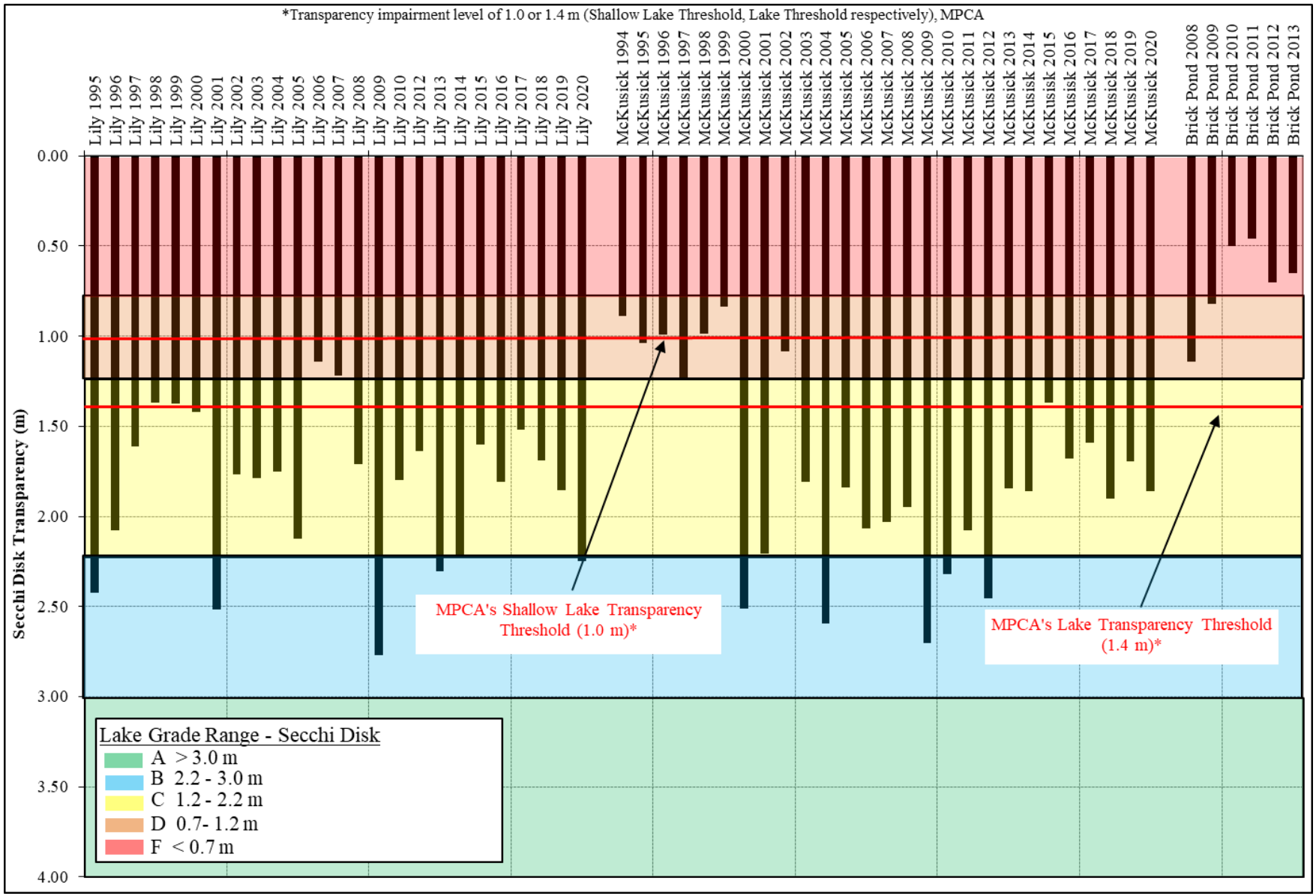

Figure 5. MSCWMO Historic Summer Average Secchi Disk Transparency

3. 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 2020, 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 could 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 significantly from 2019 to 2020 due to drier conditions, with a volume of 68,165,935 cubic feet exported to McKusick Lake (Table 2 and Table 3). All stream flow and chemistry data from 2020 can be found in Table 2, Table 3, and Table 4.

The TP load to McKusick Lake was 760 pounds, or 0.197 pounds of phosphorus per acre of watershed land, and the TSS load was 246,238 pounds of sediment, or 63.87 pounds per acre (Table 2 and Table 3). 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 is planning to do more work to repair and stabilize the head cut areas. The Iron Enhanced Sand Filter (IESF) upstream of the monitoring site also continues to operate to reduce TP loads in the drainage.

There were four exceedances of the MPCA metal standards in 2020. The calculation of 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. There was one copper result and three lead

results that exceeded the chronic standards for those parameters, and no results exceeded the maximum or FAV standards for any parameters. The occurrence of heavy metal exceedances exported to McKusick Lake and its wetland complex are particularly concerning due to the potential to kill aquatic life at high concentrations, as opposed to nutrient or sediment loading which typically degrades habitat and populations of aquatic life over time. One possible source of these elevated metals is the streambank and bed erosion occurring upstream of the site. Additional sources may be from unseen deposits of improperly disposed waste, such as batteries.

Table 2. Brown's Creek Diversion Structure Drainage 2020 Total Suspended Solids (TSS) and Total Phosphorus (TP) Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*9*	*0.078*	*1/1/2020 0:00*	*3/28/2020 20:00*	*7,588,800*	*174.31*	*4,264*	*36.95*
*Storm**			*442*	*0.798*	*3/28/2020 20:00*	*3/29/2020 13:00*	*520,200*	*11.95*	*14,354*	*25.91*
*Base**			*9*	*0.078*	*3/29/2020 13:00*	*4/27/2020 16:00*	*3,145,500*	*72.25*	*1,767*	*15.32*
Base			*9*	*0.078*	*4/27/2020 16:00*	*4/28/2020 10:00*	*136,584*	*3.14*	*77*	*0.67*
Storm			*442*	*0.798*	*4/28/2020 10:00*	*4/29/2020 22:00*	*543,999*	*12.50*	*15,010*	*27.10*
Base			*9*	*0.078*	*4/29/2020 22:00*	*5/4/2020 19:00*	*908,120*	*20.86*	*510*	*4.42*
Unknown Event			*190*	*0.378*	*5/4/2020 19:00*	*5/5/2020 16:00*	*168,866*	*3.88*	*2,003*	*3.98*
Base			*9*	*0.078*	*5/5/2020 16:00*	*5/17/2020 2:00*	*1,568,810*	*36.03*	*881*	*7.64*
Storm Composite	5/17/2020 4:46	5/17/2020 19:04	792	1.260	5/17/2020 2:00	5/17/2020 20:00	839,692	19.29	41,516	66.05
Base Grab	5/21/2020 12:20	5/21/2020 12:20	21	0.085	5/17/2020 20:00	5/22/2020 13:00	3,101,960	71.25	4,067	16.46
Base			*9*	*0.078*	*5/22/2020 13:00*	*5/26/2020 18:00*	*1,045,590*	*24.02*	*587*	*5.09*
Storm Composite	5/26/2020 18:54	5/27/2020 9:04	126	0.402	5/26/2020 18:00	5/28/2020 8:00	4,497,190	103.30	35,374	112.86
Base			*9*	*0.078*	*5/28/2020 8:00*	*6/2/2020 17:00*	*4,885,930*	*112.22*	*2,745*	*23.79*
Storm			*442*	*0.798*	*6/2/2020 17:00*	*6/3/2020 0:00*	*151,429*	*3.48*	*4,178*	*7.54*
Base			*9*	*0.078*	*6/3/2020 0:00*	*6/9/2020 16:00*	*2,136,250*	*49.07*	*1,200*	*10.40*
Storm			*442*	*0.798*	*6/9/2020 16:00*	*6/10/2020 15:00*	*320,336*	*7.36*	*8,839*	*15.96*
Base			*9*	*0.078*	*6/10/2020 15:00*	*6/18/2020 19:00*	*1,641,580*	*37.71*	*922*	*7.99*
Storm			*442*	*0.798*	*6/18/2020 19:00*	*6/19/2020 7:00*	*190,280*	*4.37*	*5,250*	*9.48*
Base Grab	6/24/2020 9:37	6/24/2020 9:37	11	0.080	6/19/2020 7:00	6/25/2020 10:00	1,126,300	25.87	773	5.62
Base			*9*	*0.078*	*6/25/2020 10:00*	*6/28/2020 19:00*	*475,974*	*10.93*	*267*	*2.32*
Storm Composite	6/28/2020 21:56	6/29/2020 16:31	89	0.346	6/28/2020 19:00	7/1/2020 0:00	6,727,930	154.53	37,380	145.32
Base			*9*	*0.078*	*7/1/2020 0:00*	*7/18/2020 3:00*	*7,709,490*	*177.08*	*4,331*	*37.54*
Storm			*442*	*0.798*	*7/18/2020 3:00*	*7/18/2020 8:00*	*54,575*	*1.25*	*1,506*	*2.72*
Base			*9*	*0.078*	*7/18/2020 8:00*	*7/21/2020 8:00*	*542,349*	*12.46*	*305*	*2.64*
Storm			*442*	*0.798*	*7/21/2020 8:00*	*7/21/2020 13:00*	*47,498*	*1.09*	*1,311*	*2.37*
Base			*9*	*0.078*	*7/21/2020 13:00*	*7/25/2020 19:00*	*813,620*	*18.69*	*457*	*3.96*
Storm Composite	7/25/2020 22:46	7/26/2020 11:26	312	0.804	7/25/2020 19:00	7/26/2020 14:00	664,714	15.27	12,947	33.36
Base Grab	7/30/2020 9:09	7/30/2020 9:09	10	0.060	7/26/2020 14:00	7/31/2020 9:00	3,226,630	74.11	2,014	12.09
Base			*9*	*0.078*	*7/31/2020 9:00*	*8/14/2020 20:00*	*1,673,950*	*38.45*	*940*	*8.15*
Storm			*442*	*0.798*	*8/14/2020 20:00*	*8/15/2020 1:00*	*63,287*	*1.45*	*1,746*	*3.15*
Base			*9*	*0.078*	*8/15/2020 1:00*	*8/18/2020 9:00*	*374,651*	*8.61*	*210*	*1.82*
Base Grab	8/19/2020 8:28	8/19/2020 8:28	3	0.085	8/18/2020 9:00	8/20/2020 9:00	146,737	3.37	27	0.78
Base			*9*	*0.078*	*8/20/2020 9:00*	*8/28/2020 5:00*	*518,286*	*11.90*	*291*	*2.52*
Storm			*442*	*0.798*	*8/28/2020 5:00*	*8/28/2020 12:00*	*42,037*	*0.97*	*1,160*	*2.09*
Base			*9*	*0.078*	*8/28/2020 12:00*	*8/31/2020 3:00*	*226,202*	*5.20*	*127*	*1.10*
Storm			*442*	*0.798*	*8/31/2020 3:00*	*8/31/2020 17:00*	*110,004*	*2.53*	*3,035*	*5.48*
Base			*9*	*0.078*	*8/31/2020 17:00*	*9/14/2020 13:00*	*1,221,650*	*28.06*	*686*	*5.95*
Base Grab	9/15/2020 13:15	9/15/2020 13:15	7	0.100	9/14/2020 13:00	9/16/2020 13:00	151,617	3.48	66	0.95
Base			*9*	*0.078*	*9/16/2020 13:00*	*9/28/2020 8:00*	*779,212*	*17.90*	*438*	*3.79*
Base Grab	9/29/2020 8:42	9/29/2020 8:42	6	0.083	9/28/2020 8:00	9/30/2020 15:00	169,932	3.90	64	0.88
Unknown Event			*190*	*0.378*	*9/30/2020 15:00*	*10/1/2020 22:00*	*295,033*	*6.78*	*3,499*	*6.96*
Base			*9*	*0.078*	*10/1/2020 22:00*	*10/12/2020 1:00*	*717,293*	*16.48*	*403*	*3.49*
Storm Composite	10/12/2020 2:32	10/12/2020 13:39	893	1.180	10/12/2020 1:00	10/12/2020 14:00	324,283	7.45	18,078	23.89
Base			*9*	*0.078*	*10/12/2020 14:00*	*10/23/2020 15:00*	*1,235,990*	*28.39*	*694*	*6.02*
Unknown Event			*190*	*0.378*	*10/23/2020 15:00*	*10/24/2020 22:00*	*631,961*	*14.52*	*7,496*	*14.91*
Base			*9*	*0.078*	*10/24/2020 22:00*	*10/26/2020 14:00*	*199,261*	*4.58*	*112*	*0.97*
Base Grab	10/27/2020 14:51	10/27/2020 14:51	4	0.056	10/26/2020 14:00	11/2/2020 12:00	648,753	14.90	162	2.27
*Base**			*9*	*0.078*	*11/2/2020 12:00*	*1/1/2021 0:00*	*3,855,600*	*88.56*	*2,166*	*18.77*
Storm Average			442	0.798						
Base Average			9	0.078						
All Average			190	0.378						
Total							**68,165,935**	**1,566**	**246,238**	**760**
Brown's Creek Major Subwatershed Total Acres							3,855			
Total TSS/TP(lb/ac/yr)									63.87	0.197
Total TSS/TP (kg/ha/yr)									71.59	0.221

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 Diversion Structure Drainage Historical Annual Discharge and Loading Amounts

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brown's Creek Diversion Structure										
Discharge (cf)	52,981,553	21,810,789	46,435,271	53,519,017	46,276,327	70,780,581	39,625,672	45,453,990	112,468,888	68,165,935
Total pounds of Phosphorus exported	2,099	251	527	392	1,837	1,574	784	964	3,598	760
TP (lbs/ac/yr)	0.544	0.065	0.137	0.102	0.447	0.408	0.203	0.250	0.933	0.197
Total pounds of TSS exported	1,387,050	127,435	211,977	99,532	1,008,346	1,533,496	596,382	505,314	2,707,186	246,238
TSS (lbs/ac/yr)	359.81	33.06	54.99	25.82	261.57	397.79	154.70	131.08	702.25	63.87

Table 4. Brown's Creek Diversion Structure Drainage 2020 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	5/17/2020 4:46	5/17/2020 19:04	792	245	6.50	1.260	0.059	0.01290	0.01390	0.00940	0.05210	~0.000450	0.01310	39.2	<0.06	0.29	~0.03	139.17
Storm Composite	5/26/2020 18:54	5/27/2020 9:04	126	37	2.60	0.402	0.085	0.00510	0.00460	0.00300	0.01660	~0.000120	0.00410	26.0	<0.06	0.23	~0.04	87.60
Storm Composite	6/28/2020 21:56	6/29/2020 16:31	89	24	1.60	0.346	0.092	0.00290	0.00290	0.00160	0.00960	~0.000130	0.00240	34.0	<0.06	<0.20	<0.06	81.53
Storm Composite (Duplicate)	6/28/2020 21:56	6/29/2020 16:31	84	24	1.30	0.241	0.081	0.00280	0.00280	0.00150	0.00920	~0.000140	0.00250	34.3	<0.06	<0.20	0.09	79.34
Storm Grab (Emergency Overflow Structure)	6/30/2020 9:52	6/30/2020 9:52	7	~2	0.61	0.132	0.088	0.00110	0.00110	~0.00039	~0.00240	<0.000063	0.00069	37.7	<0.06	<0.20	<0.06	57.39
Storm Composite	7/25/2020 22:46	7/26/2020 11:26	312	85	4.00	0.804	0.073	0.00610	0.00610	0.00420	0.02150	~0.000200	0.00570	37.0	<0.06	0.25	<0.06	127.65
Storm Composite	10/12/2020 2:32	10/12/2020 13:39	893	248	5.30	1.180	0.082	0.01030	0.01080	0.00880	0.03630	<0.000500	0.01000	54.9	<0.06	0.27	<0.06	155.13
Base Grab	5/21/2020 12:20	5/21/2020 12:20	21	7	0.74	0.085	<0.020	<0.00034	0.00082	~0.00037	~0.00170	<0.000063	0.00066	66.3	<0.06	<0.20	<0.02	85.80
Base Grab	6/24/2020 9:37	6/24/2020 9:37	11	3	0.56	0.080	~0.039	<0.00034	0.00250	~0.00026	~0.00250	<0.000063	0.00250	61.6	<0.06	0.46	<0.06	198.30
Base Grab	7/30/2020 9:09	7/30/2020 9:09	10	3	0.63	0.060	<0.020	~0.00055	0.00057	<0.00026	<0.00120	<0.000063	~0.00035	71.2	<0.06	<0.20	<0.06	76.87
Base Grab	8/19/2020 8:28	8/19/2020 8:28	3	~1	0.39	0.085	~0.031	~0.00038	<0.00500	<0.00026	<0.00120	<0.000063	0.00062	52.3	<0.06	0.70	<0.06	254.43
Base Grab	9/15/2020 13:15	9/15/2020 13:15	7	~2	0.47	0.100	~0.046	<0.00100	0.00700	<0.00100	<0.00500	<0.000500	<0.00050	51.8	<0.06	0.65	<0.06	252.14
Base Grab	9/29/2020 8:42	9/29/2020 8:42	6	~2	0.38	0.083	~0.040	0.00110	0.00081	<0.00100	<0.00500	<0.000500	<0.00050	54.8	<0.06	0.62	<0.06	257.61
Base Grab	10/27/2020 14:51	10/27/2020 14:51	4	~2	0.42	0.056	<0.020	<0.00200	0.00160	<0.00200	<0.01000	<0.001000	<0.00100	59.0	<0.06	0.52	<0.06	189.08

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

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 2020 focused on the Greeley Street catchment. Continuous 15-minute stage and velocity data were collected from a sensor located at the catchment, which was installed 5/6/20 – 10/22/20. Discharge was calculated using an area/velocity relationship and the recorded discharge to Lily Lake in 2020 was 6,923,500 cubic feet, which was a decrease from 2019 (Table 5, Figure 6, and Figure 7). There were periods of low or no flow throughout the entire monitoring season, with an extended period in September and October. Six water quality grab samples were collected and analyzed for total phosphorus, total Kjeldahl nitrogen, and total suspended solids (Table 6). Similar to previous years, storm sampling in 2020 was limited by the nature of the site as storm events at the Greeley Street Inlet can be flashy. Urban storm runoff is transported quickly and this makes capturing a sample more difficult during these periods.

Four water quality samples were collected during monthly baseflow sampling (5/21, 6/25, 7/27, and 8/19), one sample was collected after a rain event when high flow was only coming from Brick Pond and was more representative of a base sample (6/29), and one sample was collected during a rain event that had low flow containing street runoff and was considered a storm sample (8/12). The Greeley Street catchment baseflow grab samples had low levels of TP and TSS, with the exception of the 8/19 sample which had very high TP and TKN results but low TSS. This sample was collected at the outlet of the pipe at Lily Lake during a very low discharge period, and it contained large amounts of duckweed flowing from Brick Pond. The sample was considered to be representative of the conditions at the time of sampling, but the TP results were excluded from the annual baseflow average because it was an outlier for the year. The 2020

average TP during baseflow was 0.046 mg/L, which was the lowest since monitoring began in 2015 (Table 7). The 2020 baseflow average TSS concentration was 2 mg/L, which was the same as in 2019 and 2016 (Table 5 and Table 7). The TP concentration for the one storm event sample collected in 2020 was 0.199 mg/L. This result was higher than the 2019 storm concentration of 0.110 mg/L and lower than the 2018 storm concentration (0.316 mg/L). The TSS storm conc**e**ntration in 2020 was 38 mg/L which is higher than the 2019 result (8 mg/L), lower than the 2018 result (518 mg/L), and similar to the 2017 average storm concentration (35 mg/L). Storm sample comparisons between 2020 and previous years are difficult to make because of the small sample size. The TP load to Lily Lake from Greeley Street was 19.9 lbs., which was lower than the load of 41.1 lbs. in 2019 (Table 5 and Figure 6). The TSS load was 864 lbs., lower than the 978 lbs. in 2019 (Table 5 and Figure 7).

Table 5. Greeley Street 2020 Total Phosphorus (TP) and Total Suspended Solids (TSS) Loading

Site	Date range	Discharge (cf)	Discharge (ac-ft)	Average TP Concentration (mg/L)	TP Range (mg/L)	TP Load (lbs)	Average TSS Concentration (mg/L)	TSS Range (mg/L)	TSS Load (lbs)
Greeley St. Baseflow[1]	5/6/20 - 10/22/20	6,923,500	159.02	0.046	0.036 - 0.791	19.9	2	1 - 3	864

[1] *8/12 & 8/19 results excluded from TP/TSS averages*

Table 6. Greeley Street 2020 Water Quality Results

Date	Greeley Street				
	Sample Type	TP (mg/L)	TSS (mg/L)	TKN (mg/L)	Discharge (cfs)
5/21/20 15:29	Base	~0.036	3	0.54	0.46
6/25/20 10:40	Base	0.054	~1	0.81	0.20
6/29/20 8:54	Base/Storm	0.054	~2	0.59	6.98
7/27/20 14:30	Base	~0.040	~2	0.64	1.81
8/12/20 12:25	Storm[1]	0.199	38	1.40	0.38
8/19/20 8:31	Base[1 2]	0.791	~2	3.00	0.06

[1] *Results excluded from averages*

[2] *Sample was collected at pipe outlet at Lily lake and contained duckweed flowing from Brick Pond*

Table 7. Greeley Street Historical TP and TSS Averages and Ranges

Greeley Street Sample Type	2015	2016	2017	2018[a]	2019[a]	2020[a]
TP (mg/L) - Baseflow Avg	0.091	0.070	0.060	0.066	0.077	0.046
TP (mg/L) - 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*
TP (mg/L) - Stormflow Avg	0.219	0.437	0.104	0.316	0.110	0.199
TP (mg/L) - Stormflow Range	*0.063 - 0.382*	*0.059 - 0.744*	*0.089 - 0.119*	*NA*	*NA*	*NA*
TSS (mg/L) - Baseflow Avg	4	2	3	4	2	2
TSS (mg/L) - Baseflow Range	*1 - 9*	*1 - 6*	*1 - 7*	*1 - 8*	*1 - 3*	*1 - 3*
TSS (mg/L) - Stormflow Avg	48	233	35	518	8	38
TSS (mg/L) - Stormflow Range	*2 - 132*	*10 - 616*	*28 - 41*	*NA*	*NA*	*NA*

[a] *Only 1 storm sample was collected for the year*

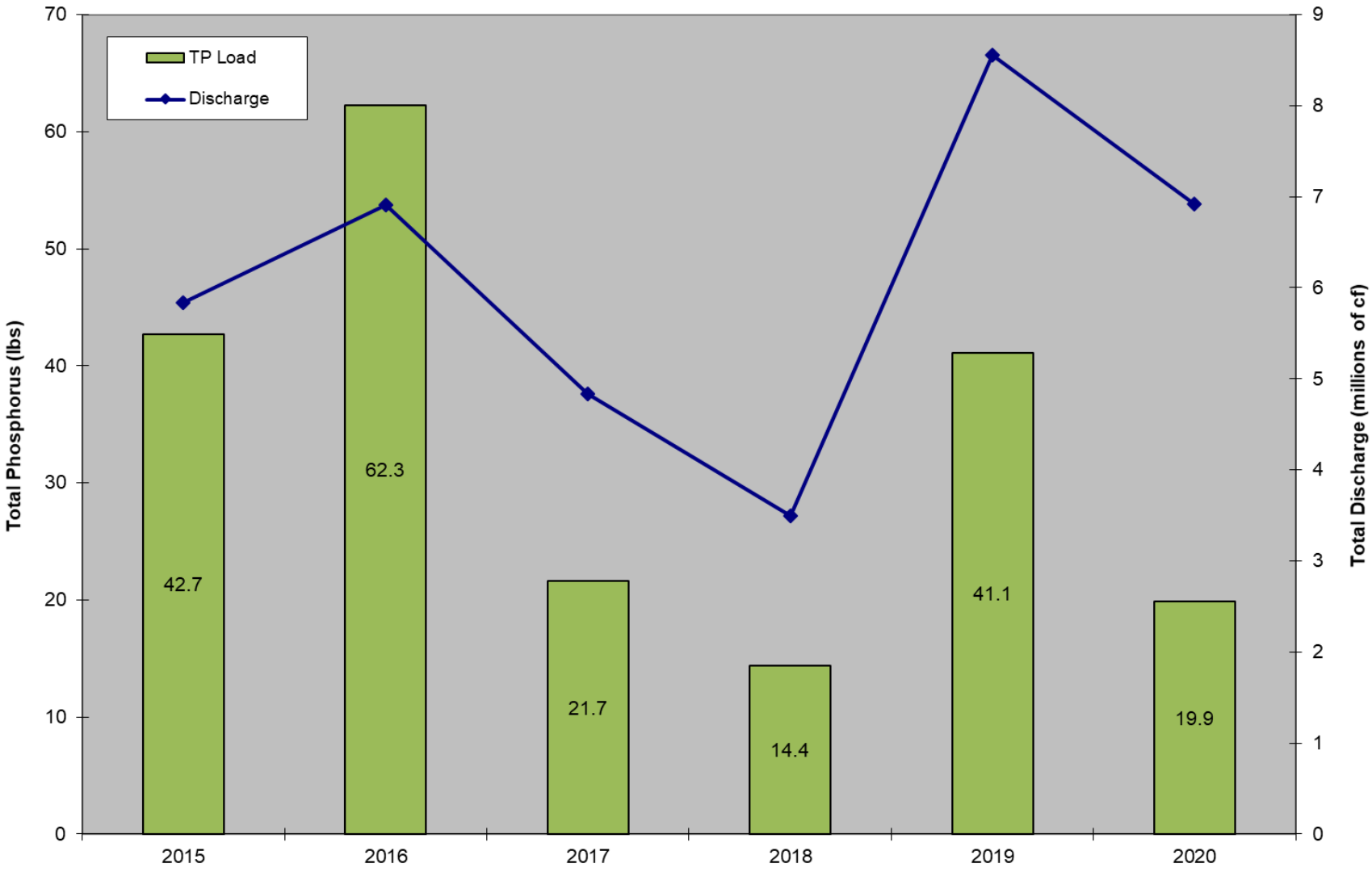

Figure 6. Greeley Street Annual Discharge and Total Phosphorus Load

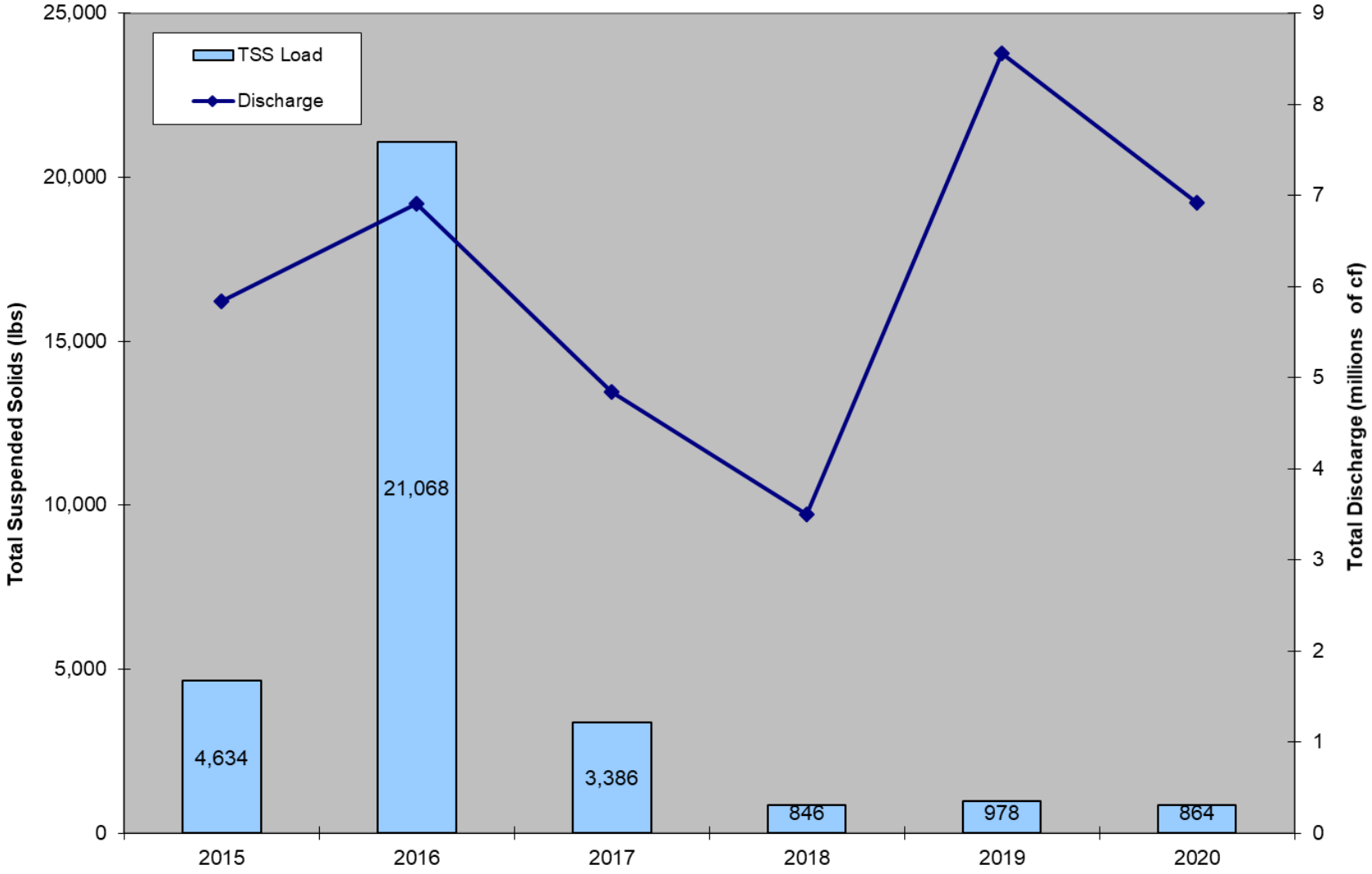

Figure 7. Greeley Street Annual Discharge and Total Suspended Solids Load

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 Saint 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. Continuous 15-minute stage and velocity data were collected at the Perro Creek at the Diversion Structure site from 4/24/20 – 10/19/20. Discharge was calculated using an area/velocity relationship, and the recorded discharge in 2020 to the St. Croix River was 40,645,328 cubic feet (Table 8).

Perro Creek is listed as impaired for *E. coli* bacteria on the MPCA's 303(d) Impaired Waters List. This impairment is based on samples collected at the 6th Street monitoring location previous to 2011. *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. Samples were collected on Perro Creek in 2020 at the same four locations as in 2019 (9th Street, 6th Street, Diversion Structure, and 3rd Avenue) to determine if human fecal DNA was present in the stream. The samples were submitted to Source Molecular Corporation in Miami Lakes, Florida to be analyzed for the presence of human fecal gene biomarkers. Of the five samples collected at each location in 2019 and 2020, human fecal DNA was detected in three samples at 3rd Ave. (8/1/19, 10/2/19, and 7/29/20), one sample at the Diversion Structure (7/29/20), and no samples at 6th Street and 9th Street (Table 9). No fecal DNA samples are planned to be collected in 2021.

Table 8. Perro Creek 2020 Total Discharge

Site	Discharge (cf)	Discharge (ac-ft)	Percent of Total Discharge
Perro at Diversion Structure Base 4/24-10/19/20	34,911,074	801.87	86%
Perro at Diversion Structure Storm 4/24-10/19/20	443,856	10.19	1%
Perro at Diversion Overflow Base 4/24-9/10/20	4,775,533	109.69	12%
Perro at Diversion Overflow Storm 4/24-9/10/20	514,865	11.83	1%
Total Discharge to the St. Croix River	40,645,328	933.58	N/A

Table 9. Perro Creek 2019 and 2020 Human Fecal DNA Detection Results

Perro Creek Human Fecal DNA Analytical Results				
Flow Direction ---------->				
Date	**9th Street**	**6th Street**	**Diversion Structure**	**3rd Avenue**
8/1/2019	ND	ND	ND	**Detected**
8/28/2019	ND	ND	ND	ND
10/2/2019	ND	ND	ND	**Detected**
7/29/2020	ND	ND	**Detected**	**Detected**
9/9/2020	ND	ND	ND	ND

ND = Not Detected

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; however, McKusick Lake was delisted in 2012. If a water body is listed, it indicates that it does not currently meet water quality criteria. In order to meet those criteria, a total maximum daily load (TMDL) must be implemented. A TMDL outlines what pollutants are degrading the water quality and what will need to be done in order to meet current water quality standards. The MPCA had tentatively scheduled a three lake TMDL for Long Lake (Brown's Creek Watershed District), Lily Lake, and McKusick Lake in 2010, but because of improving water quality trends in those lakes over recent years the TMDL has been postponed. The MSCWMO, BCWD, and the City of Stillwater will utilize the City of Stillwater's existing Lake Management Plan, the completed Lily and McKusick Lake subwatershed assessments, and Lily Lake inlet monitoring data to further guide project implementation in an effort to continue to improve the water quality of the lakes. The MPCA will consider the need for a TMDL again in the future.

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 2020 Lily Lake received a grade of a B, better than 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 2018-2020 the City of Stillwater and the Lily Lake Association did not request any large-scale herbicide and algaecide treatments but individual landowner treatment did occur. 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. The effects of these BMPs may have been seen from 2012 to 2020 monitoring seasons with the 2016-2020 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 http://www.mscwmo.org/subwatershed-assessments.

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-

2020 with statistically significant ($p<0.05$) improving trends for average TP and average Secchi disk transparency. For more information on the McKusick Lake subwatershed assessment refer to the McKusick Lake Stormwater Retrofit Assessment found at http://www.mscwmo.org/subwatershed-assessments.

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 results in 2020 support previous years' conclusions that TP and TSS concentrations from samples collected during baseflow are on average lower than concentrations during storm events. The baseflow average TP concentration was 0.046 mg/L and TSS was 2 mg/L, while the only storm event sample collected had a TP result of 0.199 mg/L and TSS result of 38 mg/L. An exception was the 8/19/20 sample, which was collected during very low baseflow (0.06 cfs) and had a low TSS concentration (~2 mg/L) but a very high TP concentration (0.791 mg/L). This sample was collected downstream of the Greely Street catchment at the pipe outlet at Lily Lake and contained duckweed flowing from Brick Pond. The sample is an outlier but may indicate that the pond was contributing higher concentrations of TP during this period, possibly if the pond had experienced anoxic conditions. Because this was during a very low flow period, the phosphorus load was small compared to storm events. Baseflow samples should continue to be collected during all flow periods to help evaluate possible changes in nutrient 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 potential BMPs installed in the Greeley Street catchment.

C. STREAMS

Stream monitoring on Perro Creek was reduced in 2020 compared to past years but still included the collection of continuous 15-minute stage, velocity, and discharge data at Perro Creek at the Diversion Structure and in the Diversion Structure Overflow. In 2020, total monitored discharge to the St. Croix River through this location was 40,645,328 cf, with approximately 2% of that discharge occurring during storm events. Water quality samples were not collected on Perro Creek in 2020 but will be again at the Diversion Structure in 2021, including automated storm samples. Samples will be analyzed for TP, TSS, and TKN, and will be used to calculate loadings to the St. Croix River during storm and baseflow periods.

Human fecal DNA was detected in samples collected on 7/29/20 at Perro Creek at the Diversion Structure and Perro Creek at 3rd Ave., which are the two furthest downstream sampling locations on the stream. Of the five samples collected in 2019 and 2020 at the 3rd Ave. location, three samples had a positive detection result for human fecal DNA. The 7/29/20 sample was the only positive detection from any of the five samples collected at the Diversion Structure. No human fecal DNA was detected in any of the samples collected at the 9th Street and 6th Street locations in 2019 and 2020. The *E. coli* impairment on the MPCA's 303(d) Impaired Waters List is based on samples collected at the 6th Street location and there were no positive detections of human fecal DNA found at that site or upstream in 2019 or 2020. Therefore, the sample results do not indicate that human sources are the cause of the impairment. No fecal DNA samples are planned to be collected in 2021 but it's recommended that samples be collected in future years and analyzed for other possible sources. Additionally, it's recommended that MSCWMO consider investigating potential sources of possible human fecal contamination downstream of the Diversion Structure.

APPENDIX A
WATER QUALITY DATA – LILY LAKE AND MCKUSICK LAKE

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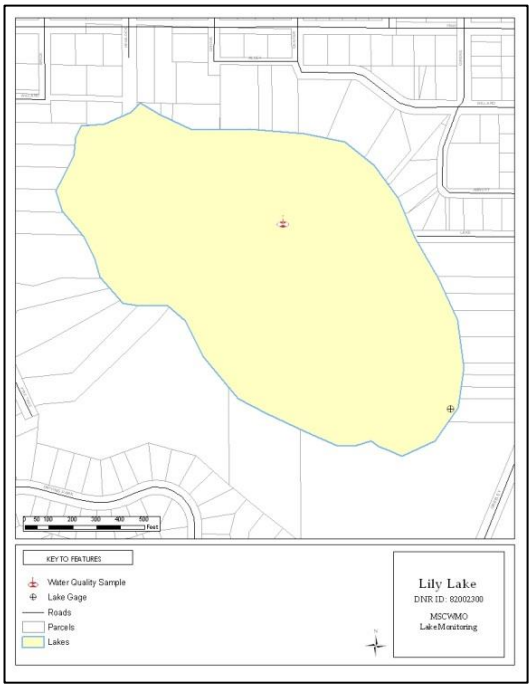
LILY LAKE

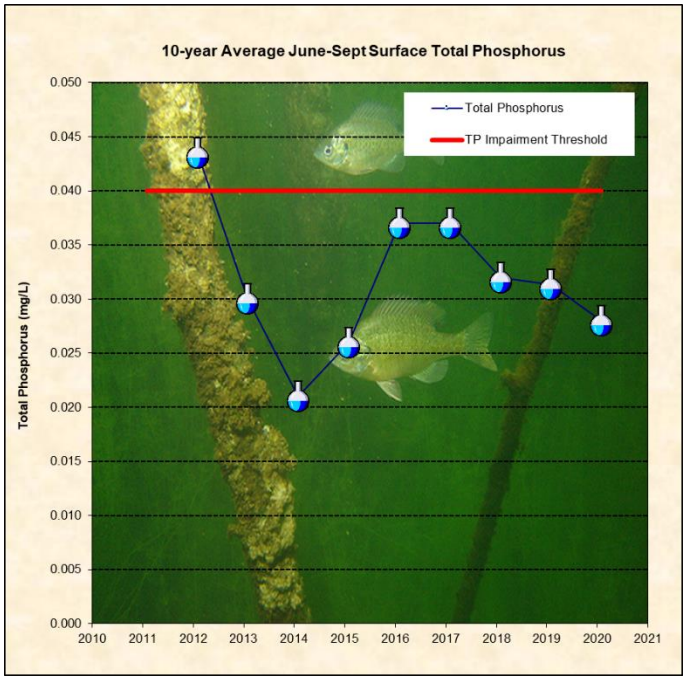
2020 Lake Grade: B

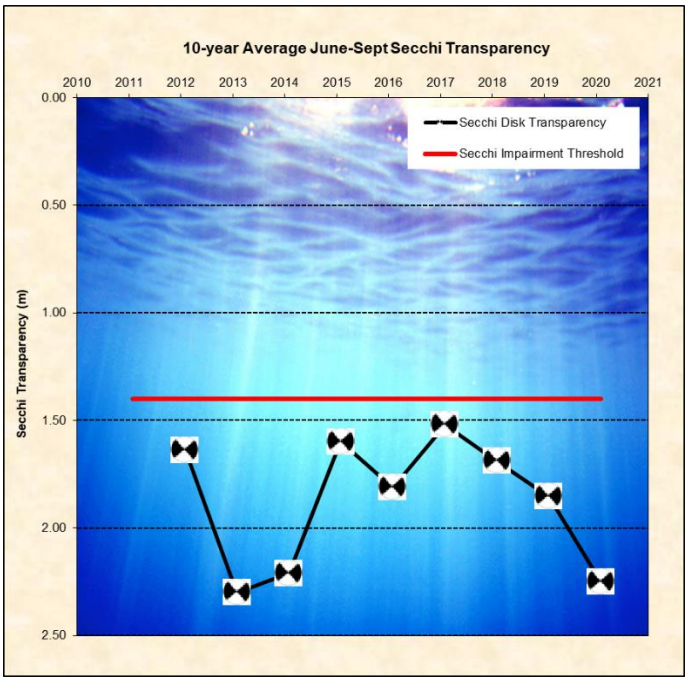
- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth (2020): 45.5 ft
- Ordinary High Water Mark: 844.8 ft
- 55%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.
- Publicly accessible



Summary Points

- Based on the chlorophyll-α results Lily Lake was considered eutrophic in 2020, 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, a statistically significant **declining** trend for average chlorophyll-α, and no trend is present for average Secchi transparency.
- The major land use is urban/residential.
- The lake stratified in 2020 with the thermocline between 4-5 meters deep.
- Lily Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





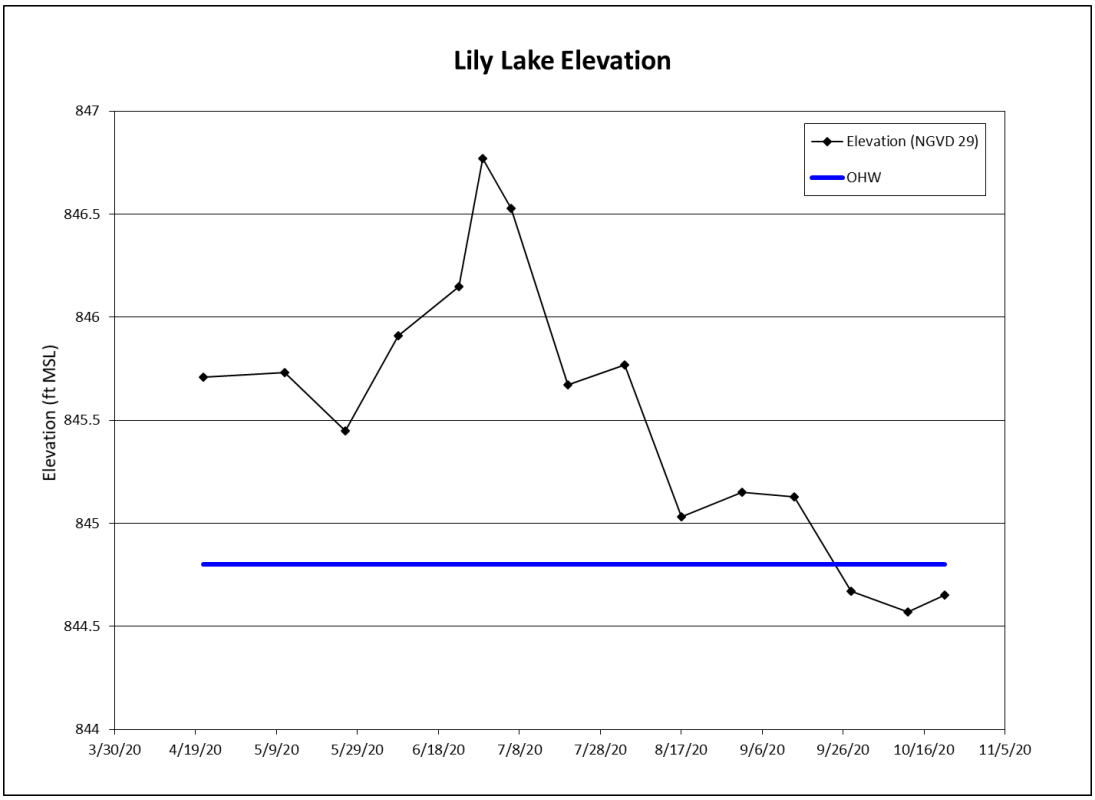
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-*a* (ug/L)	Pheophytin-Corrected Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
5/11/2020 8:27	0.019	2.0	1.6	0.57	5.94	12.8	9.58
5/26/2020 8:27	0.015	2.3	1.8	0.48	4.42	20.8	8.44
6/8/2020 8:12	0.017	2.8	2.3	0.59	4.11	23.4	7.88
6/23/2020 8:04	0.021	5.7	5.8	0.59	3.05	22.8	7.26
7/6/2020 7:56	0.010	3.6	3.1	0.43	3.05	28.9	6.41
7/20/2020 8:55	0.026	30.0	30.0	0.95	1.07	26.3	7.14
8/3/2020 8:15	0.034	38.0	39.0	1.10	0.76	24.4	5.72
8/17/2020 8:20	0.040	25.0	23.0	1.00	1.22	24.7	7.51
9/1/2020 9:36	0.047	19.0	18.0	0.74	1.68	23.7	5.77
9/14/2020 8:36	0.026	9.5	8.7	0.81	2.44	19.5	6.90
9/28/2020 11:42	0.032	9.3	9.1	0.67	2.90	17.7	9.43
10/12/2020 13:06	0.023	11.0	10.0	0.64	2.59	14.6	9.76
2020 Average	0.026	13.2	12.7	0.71	2.77	21.6	7.65
2020 Summer Average	0.028	15.9	15.4	0.76	2.25	23.5	7.11

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*

	High	High Date	Low	Low Date	Average
2020 Elevation (ft)	846.77	6/29/2020	844.57	10/12/2020	845.53

*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."



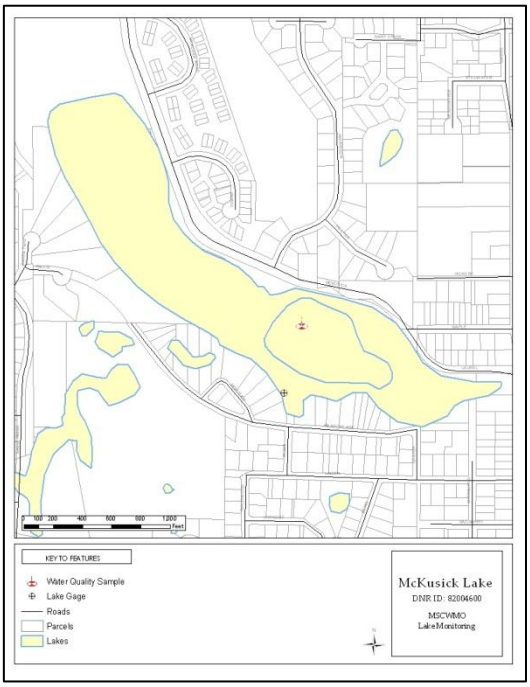
Lake Water Quality Summary										
	Summertime Lake Grades (May-Sept)									
	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Total Phosphorus (mg/L)	B	B	B	C	C	B	A	B	C	NA
Chlorophyll-*a* (ug/L)	B	B	B	B	C	C	B	B	B	NA
Secchi depth (ft)	B	C	C	C	B	C	B	B	C	NA
Overall	**B**	**B-**	**B-**	**C+**	**C+**	**C+**	**B+**	**B**	**C+**	**NA**

MCKUSICK LAKE

2020 Lake Grade: B-

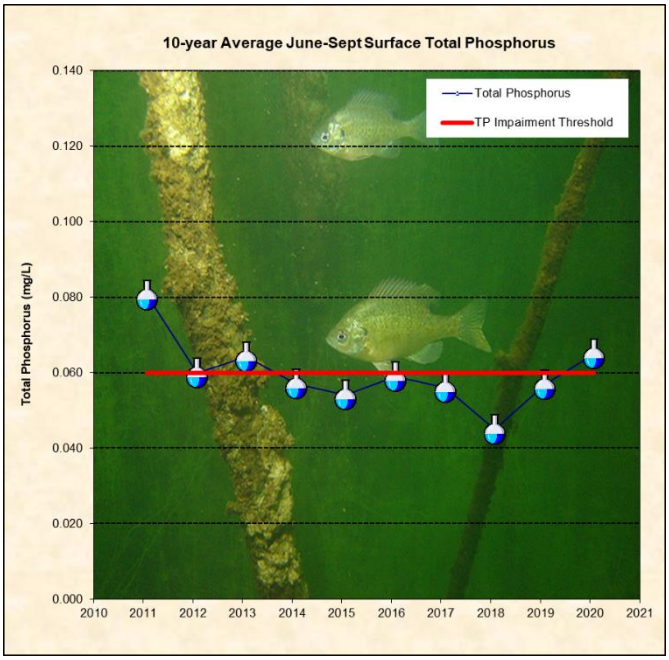
DNR ID #: 820020

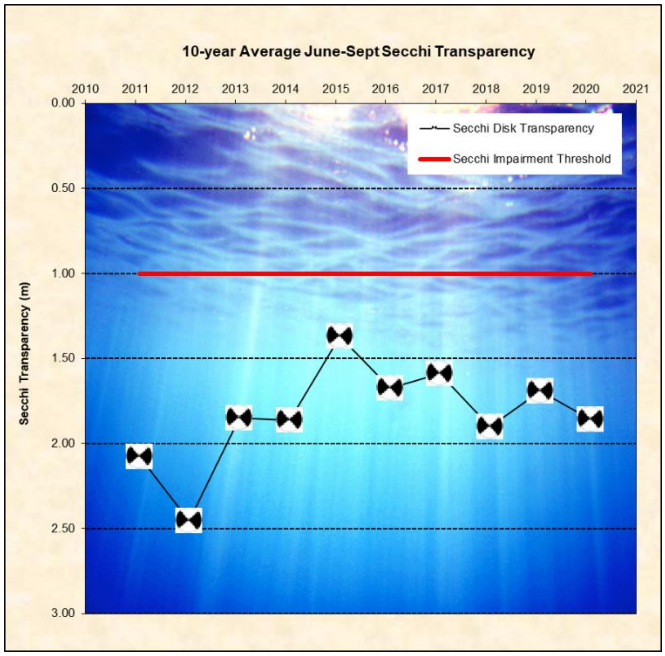
- Municipality: City of Stillwater
- Location: NE ¼ Section 29, T30N-R20W
- Lake Size: 46 Acres
- Maximum Depth (2020): 15 ft
- Ordinary High Water Mark: 851.7 ft
- 100% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Based on the chlorophyll-α results McKusick Lake was considered eutrophic in 2020, 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 and average total phosphorus, and no trend for average chlorophyll-α.
- The major land use is urban/residential.
- Temperature and dissolved oxygen profiles were not collected in 2020 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.





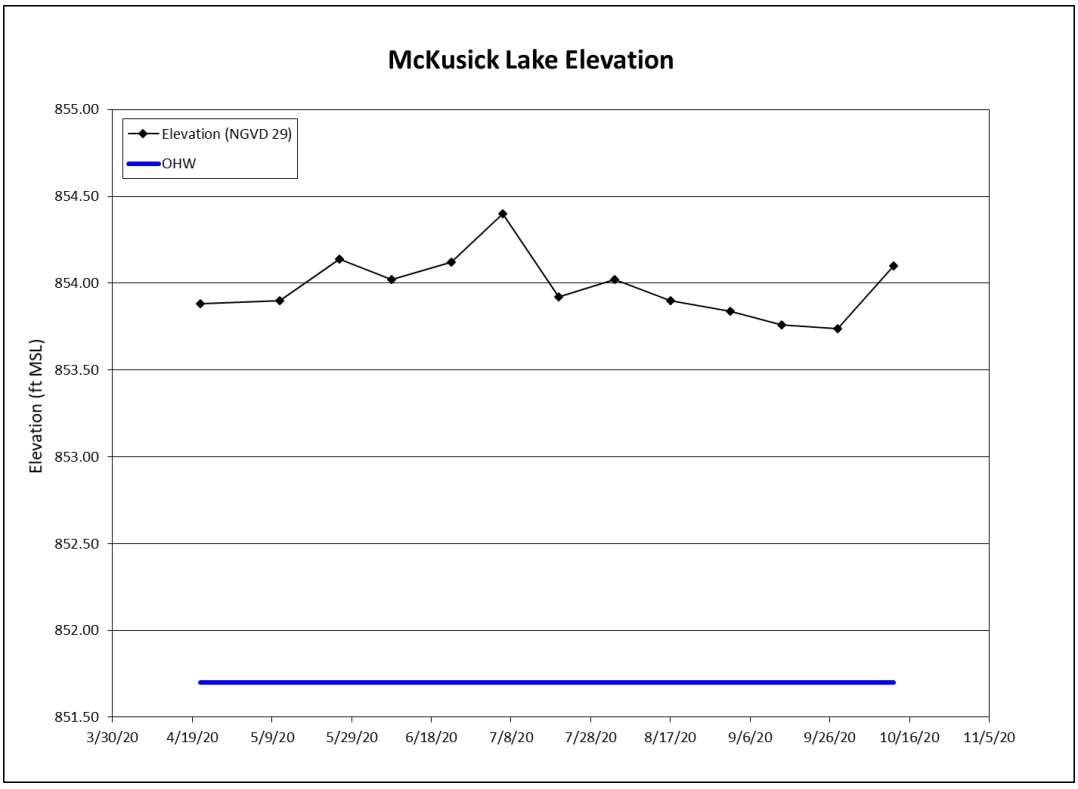
Date/Time	Total Phosphorus (mg/L)	Uncorrected Trichromatic Chlorophyll-*a* (ug/L)	Pheophytin-Corrected Chlorophyll-*a* (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)	Surface Temperature (Celsius)	Surface Dissolved Oxygen (mg/L)
5/11/2020 8:59	0.040	7.0	5.5	0.62	1.98	12.3	8.25
5/26/2020 8:55	0.038	12.0	11.0	0.57	1.83	21.8	8.60
6/8/2020 8:40	0.046	2.5	2.2	0.76	2.59	24.1	8.28
6/23/2020 8:32	0.042	4.4	3.8	0.61	2.90	22.4	7.50
7/6/2020 8:24	0.129	10.0	8.2	0.82	1.68	27.8	7.09
7/20/2020 9:25	0.156	25.0	20.0	1.10	1.22	24.7	2.25
8/3/2020 8:41	0.045	7.0	6.3	0.66	1.22	22.7	8.31
8/17/2020 8:49	0.055	13.0	10.0	0.73	2.13	23.4	4.91
9/1/2020 9:58	0.065	7.7	6.5	0.57	1.52	22.5	2.14
9/14/2020 9:17	0.026	6.9	6.3	0.61	1.83	18.0	6.35
9/28/2020 10:16	0.021	3.6	2.1	0.50	1.68	17.2	6.80
10/12/2020 13:34	0.013	4.4	2.5	0.57	2.29	14.4	9.83
2020 Average	0.056	8.6	7.0	0.68	1.91	20.9	6.69
2020 Summer Average	0.065	8.9	7.3	0.71	1.86	22.5	5.96

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
2020 Elevation (ft)	854.40	7/6/2020	853.74	9/28/2020	853.98

*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)									
	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
Total Phosphorus (mg/L)	C	C	C	C	C	C	C	C	C	D
Chlorophyll-*a* (ug/L)	A	A	B	B	B	C	C	B	A	C
Secchi depth (ft)	C	C	C	C	C	C	C	C	B	C
Overall	**B-**	**B-**	**C+**	**C+**	**C+**	**C**	**C**	**C+**	**B**	**C-**