Middle St. Croix Watershed Management Organization 2014 Water Monitoring Report

Prepared For:

Prepared by:

Washington Conservation District

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ACKNOWLEDGEMENTS

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

Middle St. Croix WMO (MSCWMO) Board of Managers

City of Stillwater
Stillwater City Council
Shawn Sanders

Washington Conservation District
Mike Isensee, MSCWMO Administrator

Metropolitan Council
Dave Fuchs
Brian Johnson

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 access to our monitoring locations.

TABLE OF CONTENTS

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

BCWD	Brown's Creek Watershed District
Benthic	Lake bottom
biweekly	Every other week
BMP	Best Management Practice
cf	cubic feet
cfs	cubic feet per second
Chl-*a*	Chlorophyll-*a*
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
MCES	Metropolitan Council Environmental Services
mg/L	milligram per liter
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
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	microgram 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 water quality data collected by the Washington Conservation District (WCD) in 2014 as well as previous years. In 2014 the Middle St. Croix Watershed Management Organization (MSCWMO) monitored both water quality and elevation on McKusick Lake and Lily Lake. Information from the Brown's Creek Diversion Structure site is also included in this report as this affects the water quality of McKusick Lake. The purpose of the monitoring program is to assess and document current water quality conditions of the lakes, as well as continuing a long-term monitoring program that will enable the MSCWMO to identify trends associated with best management practices (BMP's) and land use changes in the watershed.

Lily Lake was classified as eutrophic (Table 2) and received a B+ grade in 2014 (Table 3). Total phosphorous (TP), cholorphyll-*a* (chl-*a*), total Kjeldahl nitrogen (TKN), and Secchi disk transparency readings were all within the NCHFE range for the 2014 monitoring season. One of the fourteen samples collected exceeded the MPCA threshold for TP, and three of the fourteen samples collected exceeded the MPCA threshold for chl-*a*. Three of the Secchi disk transparency readings exceeded the MPCA threshold.

In 2014 McKusick Lake was classified as eutrophic (Table 2), and received a grade of C (Table 3). McKusick Lake was above the NCHFE range for chl-*a* and within the NCHFE range for TP, TKN, and Secchi disk transparency. Four of the twelve water quality samples exceeded the MPCA shallow lake threshold for TP, and four samples exceeded the MPCA threshold for chl-*a*. No Secchi disk transparency measurements exceeded the MPCA shallow lake threshold. Samples were analyzed for metals and no results exceeded MPCA thresholds (Table 4).

The Brown's Creek Diversion Structure site showed an increase in discharge in 2014 to 53,519,017 cf from 46,735,271 cf in 2013. The phosphorus load decreased from 527 lbs in 2013 to 392 lbs. in 2014. TSS also showed a decreased export to McKusick Lake, from 211,977 lbs in 2013 to 99,532 lbs. in 2014 (Table 5). The total discharge was the highest recorded value since monitoring the Brown's Creek Diversion Structure began. The phosphorous load and TSS export in 2014 were the lowest recorded values since water quality has been monitored.

In 2014 the MSCWMO discontinued monitoring of Brick Pond, Perro Creek and Perro Pond. The MSCWMO will instead focus on problem investigation monitoring strategies for Lily Lake and Brick Pond in 2015 and 2016. This approach will enable the MSCWMO to better determine sources of pollutants and more effectively implement management strategies and practices to address those sources.

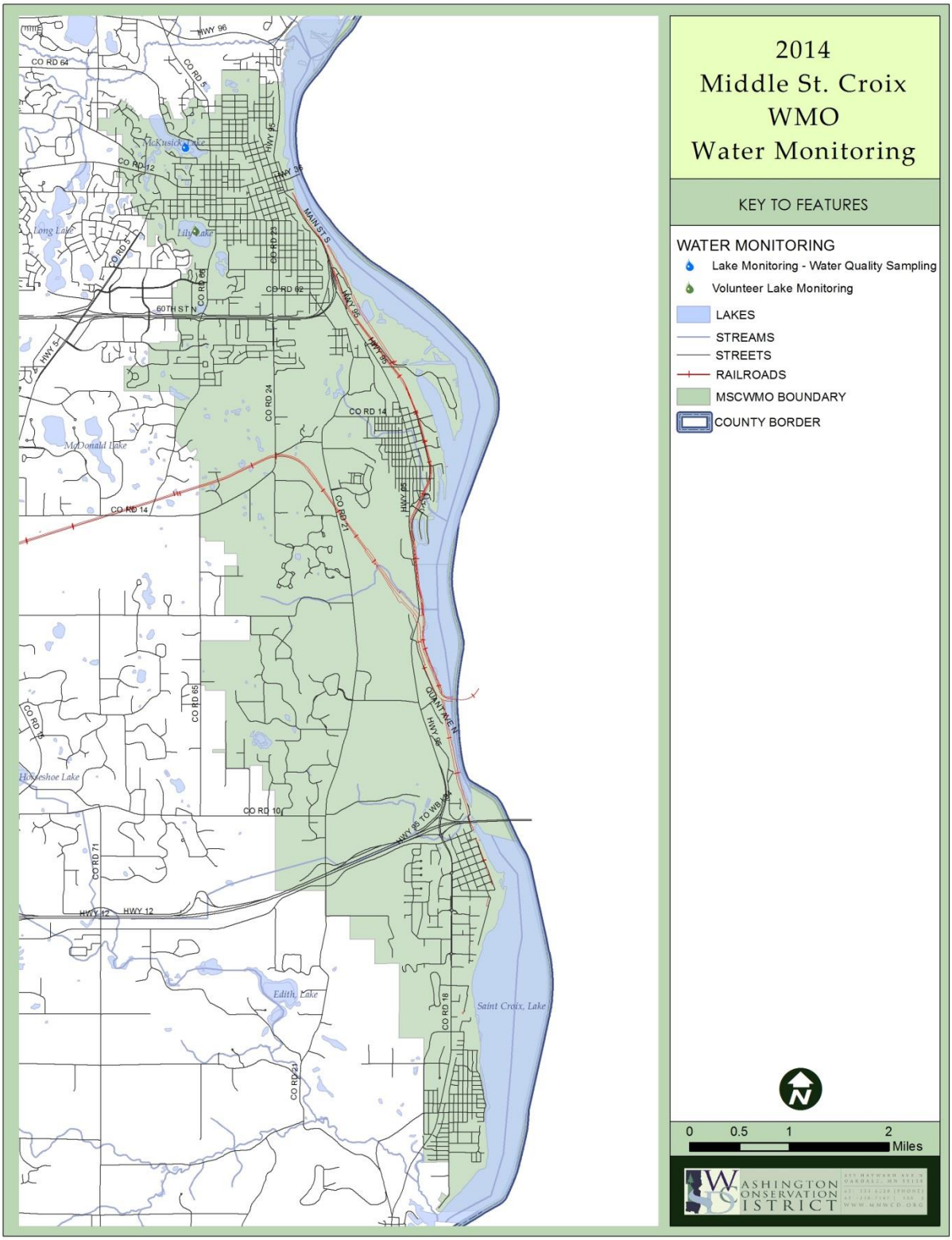

Figure 1. MSCWMO 2014 Water Monitoring Locations

LAKE MONITORING

A. METHODS, RESULTS AND DISCUSSION

In 2014 water quality data was collected biweekly on Lily and McKusick Lakes, over six consecutive months (May–October). Measurements obtained during the summer sampling season (June 1-September 30) are averaged for a comparison of individual lake dynamics from year to year between lakes within the watershed, and to the average NCHFE values. Average values for all parameters, as well as typical ranges for lakes in the NCHFE are presented in APPENDIX A, Figure 4, Figure 5, Figure 6, and Figure 7 which show the current and historic summer averages for each parameter. Water quality samples were collected with a two-meter (6.56 feet) integrated surface water column sampler. The MCES Laboratory analyzed the surface water samples for TP, chl-*a*, and total Kjeldahl nitrogen (TKN) on all MSCWMO lakes as well as heavy metals on McKusick Lake. A full description of WCD Standard Operating Procedures is available on the Washington Conservation District website at http://www.mnwcd.org/water-quality-water-monitoring/.

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. Algal growth, in turn, affects the clarity, or transparency, and light penetration of the water. The typical range of the NCHFE for TP is 0.023 – 0.050 mg/L. The MPCA has set thresholds for impairment of nutrients with TP limits of 0.040 mg/L or 0.060 mg/L, depending on the depth of the lake (greater than or less than 15 feet). The 2014 summer average of TP values of MSCWMO lakes can be found in Figure 4.

Chlorophyll-*a* is measured as it is the photosynthetic component found in algae and aquatic plants and is an indication of algal productivity. The typical range of the NCHFE for chl-*a* is 5 – 22 µg/L. The MPCA has also set thresholds for impairment with limits of 14 µg/L or 20 µg/L, depending on the depth of the lake (greater than or less than 15 feet). The 2014 summer average chl-*a* concentrations of MSCWMO lakes can be found in Figure 5.

Several forms of nitrogen exist in lakes and the form that is analyzed in MSCWMO lakes is TKN, which is the sum of organic nitrogen and ammonia. TKN is tested as it can increase the rate of lake eutrophication and can cause many health problems in the young and elderly. The NCHFE range for TKN is 0.60-1.20 mg/L. There is no threshold for TKN set by the MPCA because TP is the parameter used in their assessments. The 2014 summer average TKN concentrations of MSCWMO lakes can be found in Figure 6.

Table 1. North Central Hardwood Forest Ecoregion Values and Average 2014 Parameters

2014 MSCWMO Lakes Summer Averages (June-September)					
Lake/Units	**Total Phosphorus (mg/L)**	**Chlorophyll-*a* (ug/L)**	**Total Kjeldahl Nitrogen (mg/L)**	**Secchi Disk (meters)**	**Deep Or Shallow**
Eco-Region Value	*0.023-0.050*	*5.0-22.0*	*0.60-1.20*	*1.5-3.2*	
MPCA Deep Lake Impairment Threshold	*0.040*	*14.0*		*1.40*	
MPCA Shallow Lake Impairment Threshold	*0.060*	*20.0*		*1.00*	
Lily	*0.021*	*10.6*	*0.81*	*2.21*	Deep
McKusick	*0.057*	*20.5*	*0.94*	*1.86*	Shallow

2014 was the third year metals samples were collected in McKusick Lake. Heavy metals are tested because many are known to be extremely toxic to aquatic organisms. Results can be found in APPENDIX A.

Field measurements are also recorded while collecting lake samples. Measurements include Secchi disk transparency, dissolved oxygen (DO) and temperature profiles, and lake elevation.

The measurement of light penetration using a Secchi disk gives a simple measure of water transparency, or clarity. It is a possible indication of turbidity in the water and an indication of the trophic state of the lake. A reduction in water transparency is typically the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). Typical ranges for transparency in the NCHFE are between 1.5 – 3.2 meters. The MPCA has set thresholds for Secchi disk readings of 1.4 meters or 1.0 meters depending on the depth of the lake (greater than or less than 15 feet).

User perception and physical/recreational suitability of lakes were recorded, along with temperature and dissolved oxygen profile measurements taken by the WCD during each sampling event. Profiles are recorded at 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 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, they turn from producers of DO into consumers through the respiration of decomposers. Data collected from the rankings and profiles are contained in a database at the WCD, as well as on the MPCA website at http://cf.pca.state.mn.us/water/watershedweb/wdip/index.cfm

The Carlson Trophic State Index (TSI) is used to quantify the relationship between water quality data and trophic status. Many water quality scientists classify lakes according to their trophic state. Average summer values of TP, chl-*a*, and Secchi disk transparency are the parameters most often used to determine a lake's trophic state. Oligotrophic lakes, such as lakes common in the northeastern part of Minnesota, have low biological activity as a result of low phosphorus concentrations, low chl-*a* concentrations, and high Secchi disk transparency readings. Mesotrophic lakes have slightly more biological production, and are characteristic of the majority of the lakes found in the NCHFE of Minnesota. On the other end of the spectrum, lakes with high biological productivity characterized by high phosphorus concentrations, high chl-*a* concentrations, and low Secchi disk transparencies are classified as eutrophic or even hypereutrophic. Lakes classified as eutrophic or hypereutrophic typically receive excess nutrient loading from sources within their watersheds and receive large amounts of runoff from the surrounding drainage area. A percentage of these nutrients, however, can also be attributed to internal loading within the lake itself, which is typical of shallow, sediment-rich lakes (Table 2).

Table 2. Trophic State Index and Ranges

	Trophic State Index	TP (ug/L)	Chl-*a* (ug/L)	Secchi (m)
Oligotrophic	<40	<12	<2.6	>4.0
Mesotrophic	40-50	12 - 24	2.6 - 6.4	4.0 - 2.0
Eutrophic	50-70	24 - 96	6.4 - 56	2.0 – 0.5
Hypereutrophic	>70	>96	>56	<0.5

A Lake Grading System is also used in this report, 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 Dick Osgood, formerly of the Metropolitan Council. 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 June through September average values of TP, chl-*a*, and Secchi disk transparency. These percentiles use ranked data from 119 lakes sampled from 1980-1988 and are shown in Table 3. 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 good correlation when comparing the Lake Trophic Status and the Lake Grading System. Summaries of all lake results are presented in APPENDIX A.

Table 3. Lake Grade Ranges

Grade	Percentile	TP (ug/l)	CLA (ug/l)	SD (m)
A	<10	<23	<10	>3.00
B	10-29	23-31	10-19	2.20-3.00
C	30-69	32-67	20-47	1.20-2.19
D	70-90	68-152	48-77	0.70-1.19
F	>90	>152	>77	<0.70

Lake elevation gages, monitored by WCD staff, are located on two MSCWMO lakes, Lily and McKusick, and are compared to the lakes Ordinary High Water level (OHW)[1]. Both water bodies reflected significant decreases in elevation towards the end of the 2014 monitoring season, when precipitation was below normal. Lily lake showed a slight rebound for the last readings despite precipitation readings being below the monthly average (Figure 8). Complete lake elevation data for 2014 can be found in Figure 2 and

Figure **3**. For historical lake elevations, visit the MN DNR Lake Finder webpage at http://www.dnr.state.mn.us/lakefind/index.html.

1. MCKUSICK LAKE

The McKusick Lake summertime average TP concentration in 2014 was 0.057 mg/L, close to the 0.064 mg/L that was seen in 2013, with four of the twelve water quality samples collected exceeding the MPCA TP impairment threshold for shallow lakes (Figure 4). McKusick Lake had a summertime average chl-*a* concentration of 20.5 μg/L, higher than the chl-*a* result of 13.0 μg/L from 2013 and outside of the NCHFE range (Figure 5). Of the twelve samples collected in 2014, four exceeded the MPCA shallow lakes threshold for chl-*a*. The average summertime TKN concentration for 2014 was 0.94 mg/L, slightly lower from the 1.08 mg/L measured in 2013 (Figure 6). There is no MPCA lake impairment threshold for TKN. The 2014 summertime average water transparency measured by Secchi disk was 1.86 meters. All Secchi disk readings in 2014 were better than the MPCA lake impairment threshold. Temperature and DO profiles indicate that McKusick Lake exhibited thermal stratification during the summer months of 2014

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

with the thermocline around 3 meters; therefore the lake was less likely to completely mix throughout the summer. 2014 was the third year that metals were analyzed for in McKusick Lake and none of the samples exceeded the threshold limits for any of the metals analyzed, as was the case in 2013 and 2012. The elevation of McKusick Lake remained above the OHW for the entire 2014 monitoring season, reaching its highest recorded level on 6/2/2014 with a level of 855.08 ft. and falling to its lowest recorded level on 7/29/2014 with an elevation of 853.86 ft. (Figure 2). Summaries of all lake results are presented in APPENDIX A.

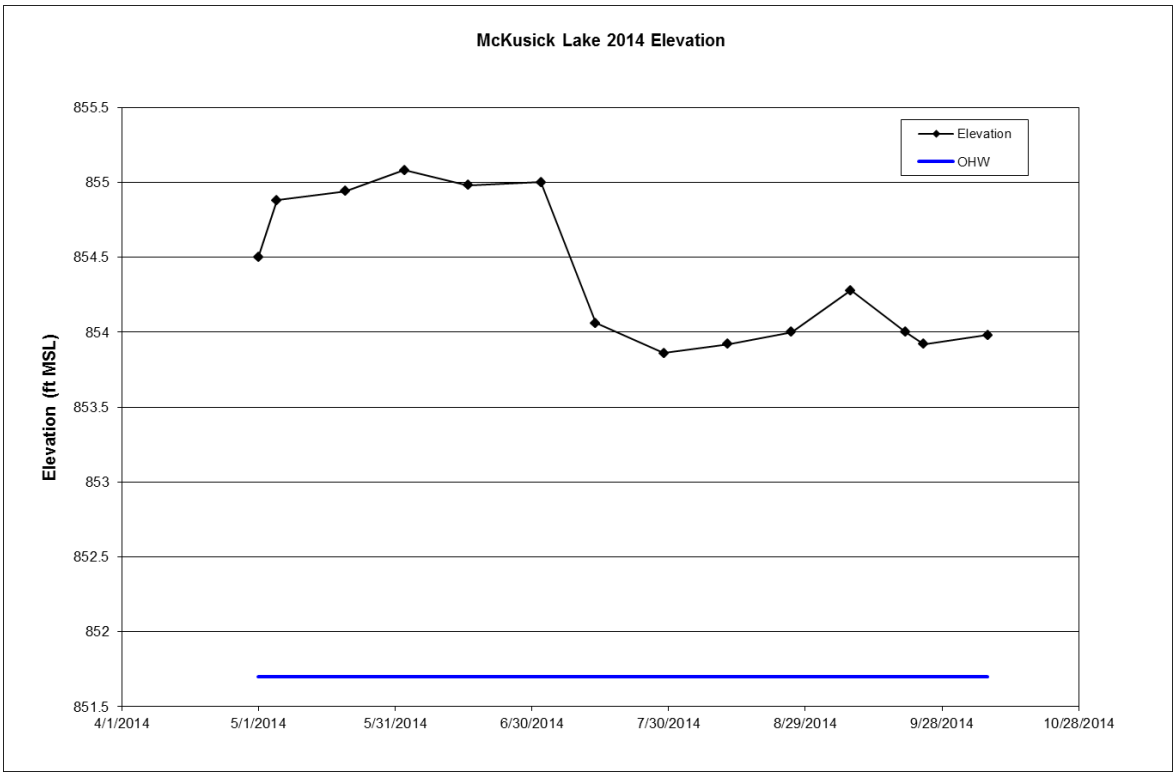

Figure 2. McKusick Lake 2014 Elevations

Table 4. McKusick Lake 2014 Sample Metal Chemistry Results.

Sample Type	Sample Date	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Hardness (mg/L_CaCO3)
Surface	5/5/2014 9:10	0.00170	0.00032	0.00044	0.0105	0.00020	0.00023	74
Surface	6/16/2014 8:40	0.00120	0.00250	0.00051	0.0085	0.00020	0.00019	56
Benthic	6/16/2014 8:40	0.00380	0.00170	0.00040	0.0175	0.00020	0.00010	70
Surface	7/2/2014 9:05	0.00095	0.00019	0.00048	0.0128	0.00020	0.00018	50
Surface	7/29/2014 14:43	0.00044	0.00015	0.00035	0.0039	0.00020	0.00012	68
Surface	8/26/2014 11:20	0.00062	0.00028	0.00030	0.0118	0.00020	0.00012	76
Benthic	8/26/2014 11:20	0.00250	0.00430	0.00030	0.0344	0.00020	0.00034	92
Surface	10/8/2014 9:24	0.00180	0.00027	0.00045	0.0105	0.00041	0.00019	106

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

2. LILY LAKE

Lily Lake had an average summertime TP concentration of 0.021 mg/L, lower than the 2013 average summertime TP concentration of 0.030 mg/L, well below the MPCA lake nutrient impairment threshold for TP (Figure 4). One of the fourteen samples had values greater than the MPCA lake nutrient impairment threshold for TP. The 2014 average summertime concentration of chl-*a* was 10.6 μg/L, lower than the 11.1 μg/L measured in 2013, with three of the fourteen water quality samples exceeding the MPCA lake threshold for chl-*a* impairment (Figure 5). Lily Lake had an average summertime TKN concentration of 0.81 mg/L in 2014, lower than the 0.99 mg/L seen in 2013 (Figure 6). There is no MPCA lake impairment threshold for TKN. Secchi disk readings were measured in 2014 with a summertime average of 2.21 meters, with three of the fourteen water quality readings exceeding the MPCA lake threshold for Secchi disk transparency impairment (Figure **7**). Temperature and DO profiles were not collected for 2014; therefore, the thermocline cannot be determined. At the start of the monitoring season the water level of Lily Lake was below the OHW, at 844.43 ft. The elevation gage was not read by the volunteer the rest of the monitoring season (

Figure **3**). Summaries of all lake results are presented in APPENDIX A.

There were no elevation readings for 2014.

Figure 3 . Lily Lake 2014 Elevations

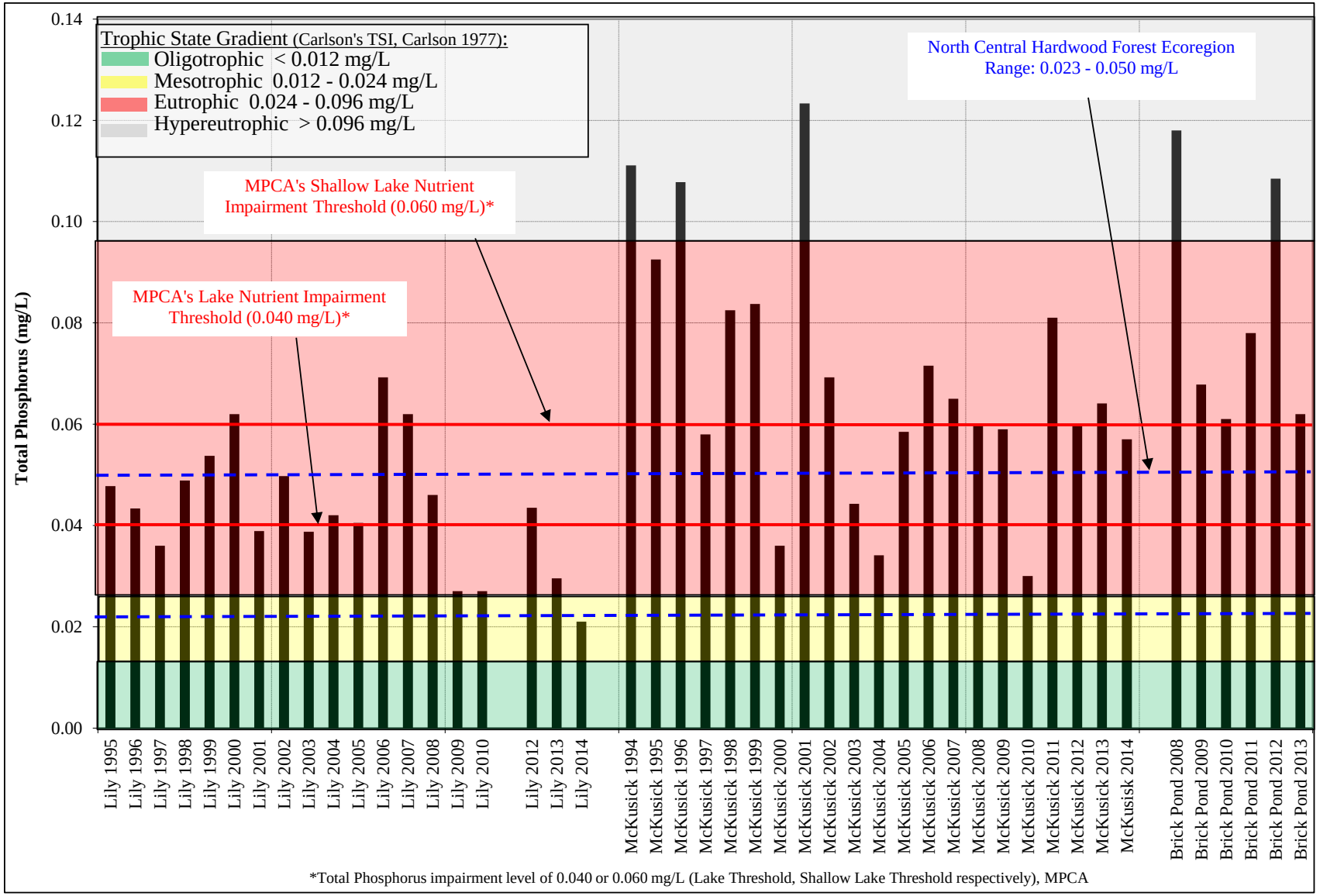

Figure 4. MSCWMO Historic Summer Average Total Phosphorus Data

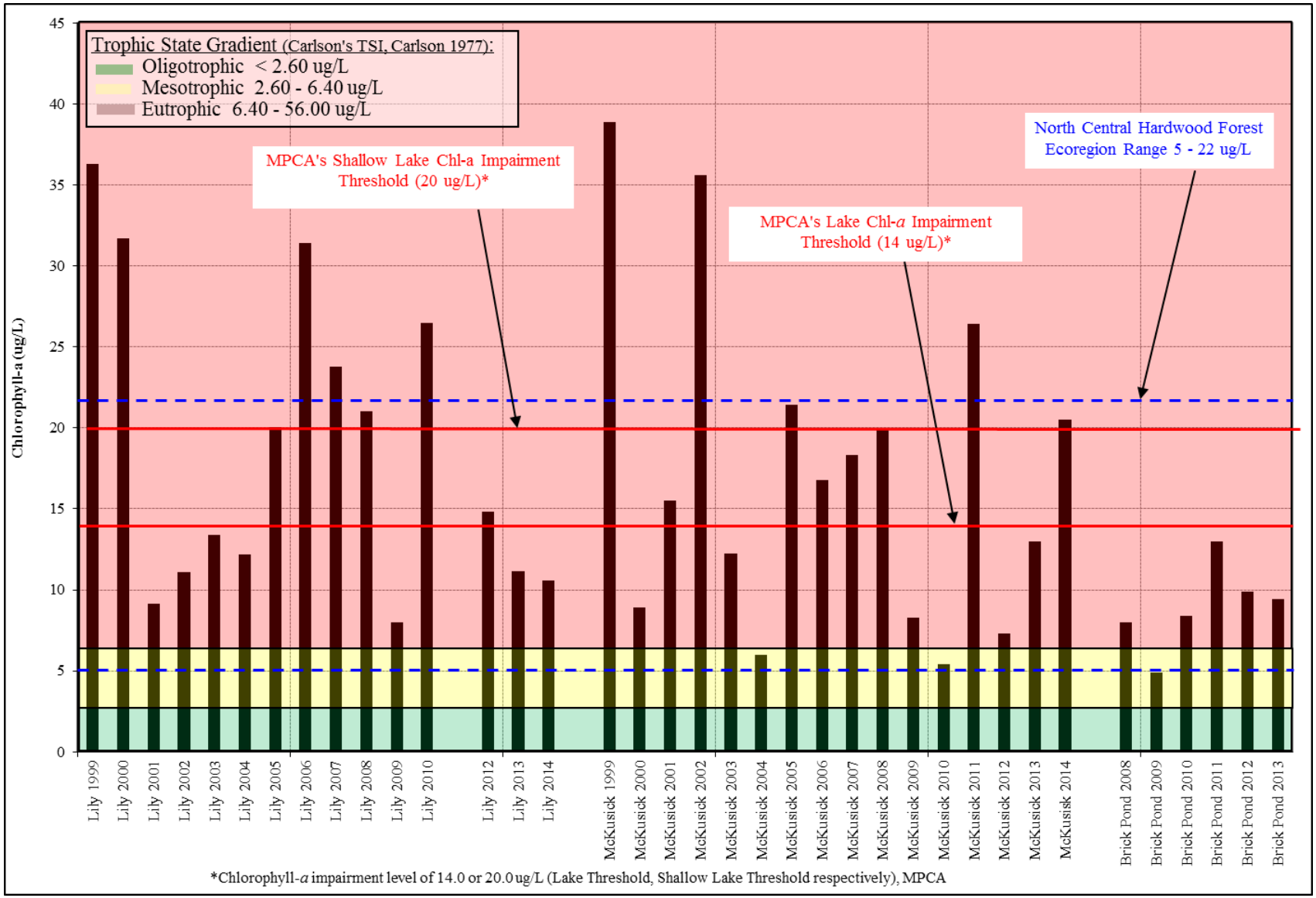

Figure 5. MSCWMO Historic Summer Average Chlorophyll-*a* Data

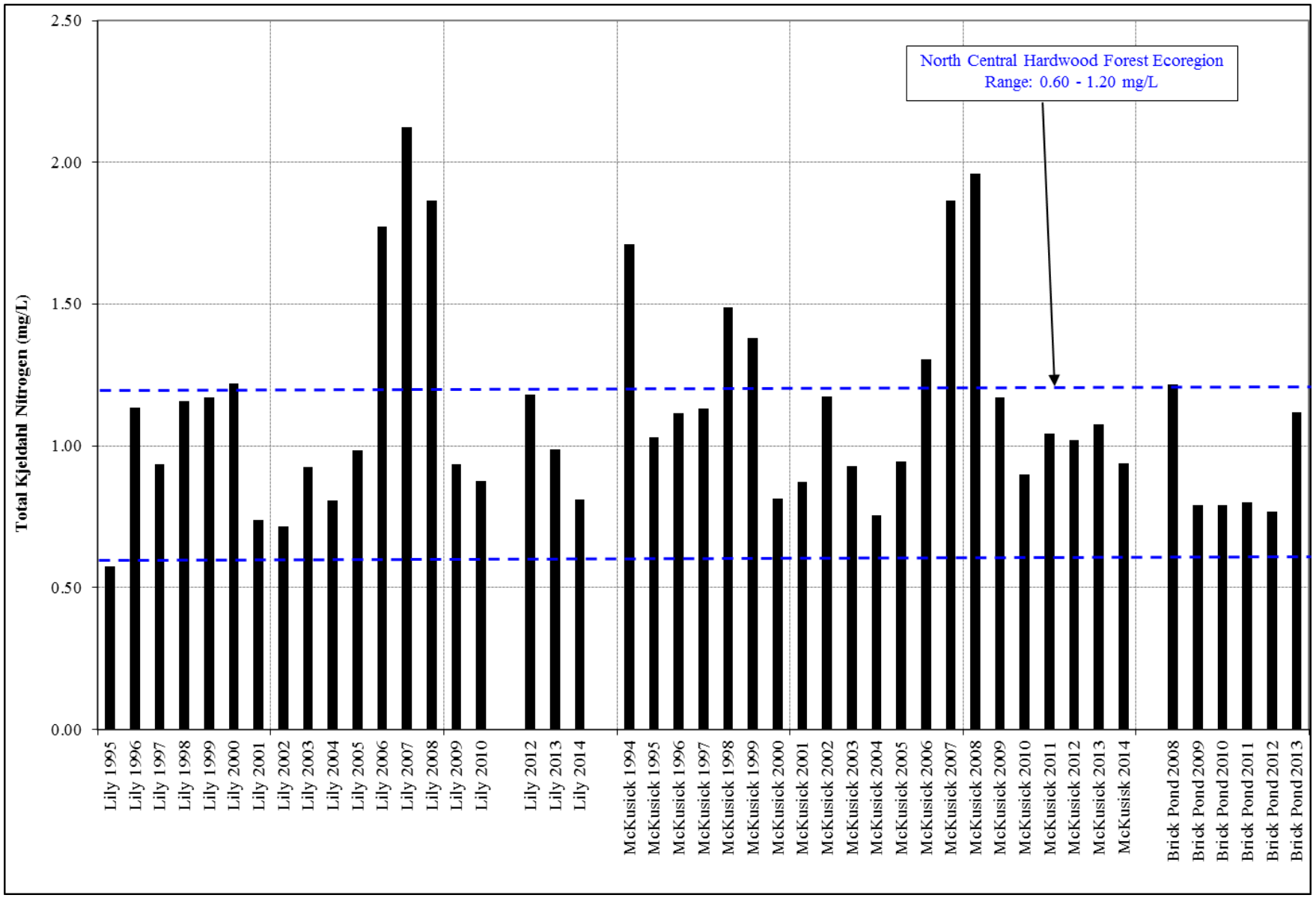

Figure 6. MSCWMO Historic Summer Average Total Kjeldahl Nitrogen Data

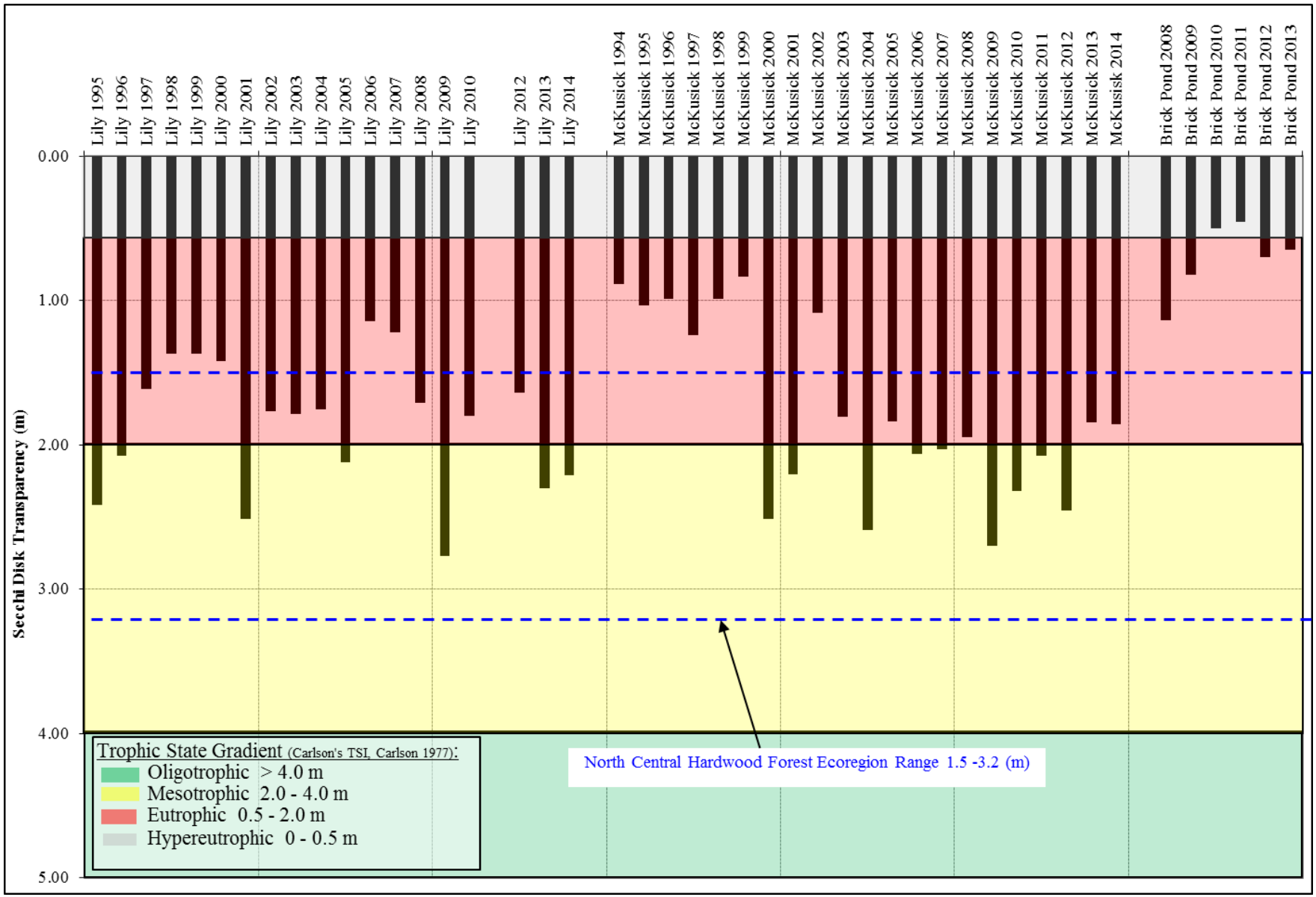

Figure 7. MSCWMO Historic Summer Average Secchi Data

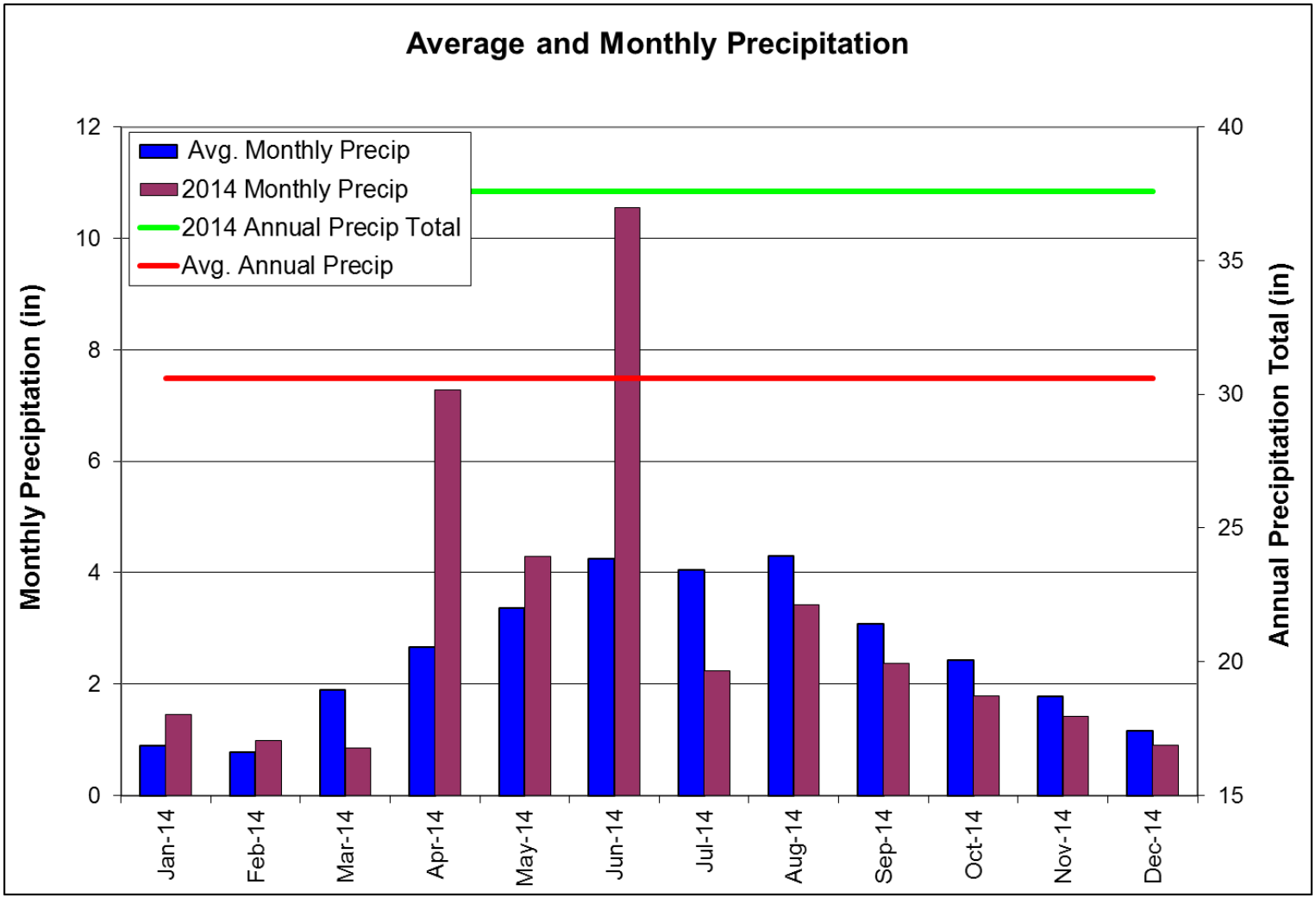

Figure 8. 2014 Annual Precipitation; Historical 30-Year* Average Annual Precipitation; Historical 30-Year* Average Monthly Precipitation; and 2014 Monthly Precipitation

2014 Data from Stillwater NWS gauge T 30N R 20W Sec 31

*Average monthly precipitation totals derived from historical 30-year (1981-2010) average for this region

B. MSCWMO LAKES: CONCLUSIONS AND RECOMMENDATIONS

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. Some low water quality ratings of MSCWMO lakes are most likely due to long-term periods of urban runoff (Lily Lake) or from the shallowness of the lake (McKusick Lake). Shallow lakes typically exist in a low algal production, clear-water state or 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 thick algal blooms. This is unlike in deeper, stratified lakes where phosphorus below the thermocline is not available for primary production.

The MPCA had listed both Lily and McKusick Lake on the 303(d) Impaired Waters list for nutrient/eutrophication impairment, with McKusick Lake now officially delisted. 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 MPCA, along with the MSCWMO, BCWD, and City of Stillwater, decided to postpone the TMDL. The MSCWMO, BCWD, and the City of Stillwater will utilize the City of Stillwater's exiting Lake Management Plan, as well as the completed Lily and McKusick Lake subwatershed assessments 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.

2014 data shows that Lily Lake's summertime average for TP was lower than the 2013 values, and within the NCHFE range (Figure 4). There was no statistically significant trend found in the historical summer TP data. Average summertime value for chl-*a* in 2014 was lower than what was measured in 2013, and within the NCHFE range (Figure 5). There is no MPCA lake impairment threshold for TKN, but the average 2014 summertime TKN result for Lily Lake was lower than what was seen in 2013, and still within the NCHFE range (Figure 6). The Secchi disk transparency for Lily Lake was shallower in 2014 than what was observed in 2013, but still was within the NCHFE range. No significant trend in Secchi disk transparency could be determined. Lily Lake received a grade of B+ in 2014, up from the B it received for 2013. Summertime TP, chl-*a*, and Secchi disk transparency averages have remained relatively consistent over the last ten years in Lily Lake with the exceptions of 2001, 2009 and 2013, where overall water quality dramatically improved (Figure 7). Summaries of all lake results are presented in APPENDIX A. In 2001 phosphorus and chl-*a* levels dropped and the lake grade improved significantly. There have been copper sulfate treatments on Lily Lake in the past, but the dates are unknown to the WCD. Those results point towards a copper sulfate treatment in Lily Lake near 2001. In 2006 and 2007, summer average TP, chl-*a*, and Secchi disk transparency deteriorated when compared to the averages seen from 2001 to 2005. In 2009 Lily Lake improved over previously recorded years and received a B+ lake grade, 2010 and 2012 sample results deteriorated, indicating that Lily Lake may have returned back to the long term normal, but improved again this year with a grade of a B+. The cause of these one-year increases (2013, 2009, 2001, and 1995) in water quality is presently unknown, and there may be many possible explanations which could be investigated further in the future. Lake water quality best management practices on Lily Lake known to WCD staff are the completion of a native buffer planting at the public access in mid-2010, and copper sulfate treatments. The Lily Lake watershed underwent a sub-watershed assessment in 2010. As a result, fifteen raingardens were constructed in the Lily Lake watershed in 2011, and more residential raingardens were completed in 2012. With a new round of funding, there were seven raingardens planned for installation in the spring of 2013, but due to complications with utilities the raingarden installation was postponed until summer 2014. Instead of seven smaller raingardens, there are now six larger raingardens planned. The first effects of these BMPs may have been seen in the 2013 and 2014 monitoring season, but future monitoring is needed to see if the long term trends improve the longer the BMPs are installed.

For more information about the Lily Lake sub-watershed assessment refer to the Lily Lake Stormwater Retrofit Assessment found at http://mscwmo.org/wp-content/subwatershed/LILY-Assessment-Report-FINAL.pdf

TP summertime average for McKusick Lake in 2014 was lower than what was seen in 2013, and was within the NCHFE range for 2014. Overall, McKusick Lake has seen statistically significant improvements ($p<0.01$) for TP from 1994 to the present (Figure 4). The 2014 summertime average for chl-*a* was higher than the average from 2013, and falls outside of the NCHFE value range for chl-*a*. The average 2014 summertime TKN value was within the NCHFE range for TKN, and slightly lower than what was measured in 2013 (Figure 6). Secchi disk transparency for 2013 is about the same as what was observed in 2013, improving by 0.01 meters, and falls within the NCHFE range Secchi disk transparency. Overall there has been statistically significant improvements ($p<0.01$) seen in Secchi transparency from 1994 through the present (Figure 7). The overall water quality of McKusick Lake has degraded slightly when compared to last year, receiving a grade of C for 2014, down from a C+ in 2013. Summaries of all lake results are presented in APPENDIX A. In June 2003 the City of Stillwater completed the Trout Stream Mitigation Project (TSMP) that has been functioning to divert stormwater from the 1,800-acre annexation area, away from Brown's Creek, through McKusick Lake, and ultimately to the St. Croix River. This diversion structure is designed to keep the warmer, urban stormwater from the southern tributary of Brown's Creek out of the temperature and nutrient sensitive Brown's Creek Ravine. Local residents' concerns about the amount of water and nutrients entering McKusick Lake are being investigated by the Brown's Creek Watershed District (BCWD) and the City of Stillwater. In 2006 the BCWD initiated stream flow monitoring and water quality sampling on the diversion structure drainage to assist in answering some of the water quality and quantity concerns. All associated data can be found in Table 5, Table 6, Table 7, Table 8, and Table 9. There was a sub-watershed assessment conducted on the McKusick Lake watershed in 2010. In 2011 six raingardens were constructed as a result of the sub-watershed assessment. With renewed funding, seven additional raingardens were to be installed in the McKusick Lake watershed in 2013 but because of issues with utilities, 5 larger raingardens were installed in 2014. The impacts of previously installed raingardens were not seen in the 2013 lake monitoring results, but the MSCWMO remain hopeful results will be seen

in the future. For more information on the McKusick Lake sub-watershed assessment refer to the McKusick Lake Stormwater Retrofit Assessment found at http://mscwmo.org/wp-content/subwatershed/McKUSICK-Assessment-Report-FINAL.pdf

Water elevation monitoring was conducted on one lake, McKusisk, from May to October 2014 (Figure 2). Changes in lake water level elevation are mostly attributed to the changes in monthly precipitation. Precipitation was normal to above normal from January through June, with the exception of March. From July until the end of the year, precipitation was well below normal and all MSCWMO lake elevations dropped during that time period. Total annual precipitation for 2014 was 33.61 inches, with the majority of that occurring in the first half of the year and below average precipitation in the second half of the year. That total is 3 inches above the 30 year (1981-2010) historical annual average of 30.61 inches (Figure 8). The highest recorded elevations in 2014 occurred around the first part of the summer. McKusick Lake recorded a high reading on 6/2/2014. The level on Lily Lake was only read once during the summer on 4/21/2014.

The following are WCD recommendations to the MSCWMO:

- Continue to monitor water levels of MSCWMO lakes.
- Continue to monitor the water quality of MSCWMO lakes.
- Investigate monitoring inlets to Lily Lake to determine where the majority of the nutrient load is coming from.

1. BROWN'S CREEK DIVERSION STRUCTURE

As additional data provided to the MSCWMO, the WCD took grab samples and automated flow-weighted samples during both base flow and storm event conditions at the Brown's Creek Diversion Structure for BCWD in 2014. The City of Stillwater constructed the diversion structure in June of 2003, as part of the completion of the 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 will keep the warmer urban stormwater runoff from the southern tributary out of the temperature and nutrient sensitive Brown's Creek Ravine, it means that this water will be entering McKusick Lake, and could affect the lake water quality. Data collected at this site by the WCD includes total discharge and water quality sample analysis. All stream flow and chemistry data from 2014 can be found in Table 5, Table 6, Table 7, Table 8, and **Table 9**.

Using a combination of composite and grab samples, phosphorus and TSS loads were calculated at the Brown's Creek Diversion Structure site. Phosphorus exported from the Brown's Creek Diversion Structure decreased to 392 lbs in 2014 from 527 lbs in 2013. TSS also showed a decrease between 2013 and 2014, with 99,532 lbs exported to Lake McKusisk in 2014 and 211,977 lbs exported to Lake McKusick in 2013 (Table 5, **Table 9**).

Water quality results showed six out of the eleven event flow samples exceeded the standard for TSS. Out of the four *E. coli* samples one exceeded the water quality standard (Table 6). There were eleven event flow samples and five base flow samples that were tested for metals in 2014. There were no exceedances of metal standard thresholds for base flow samples. One event flow sample exceeded the chronic standard for lead. There were no other exceedances of metals (Table 7). Water quality results showed one out of six field data measurements exceeded the standard threshold for pH, and one field data measurement exceeded the standard threshold for dissolved oxygen (mg/L) (Table 8**Error! Reference source not found.**).

Table 5. Brown's Creek Diversion Structure Drainage 2014 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**			*7*	*0.077*	*1/1/2014 0:00*	*4/7/2014 7:00*	*83,196*	*1.91*	*36*	*0.40*
Snowmelt Grab*	4/7/2014 10:39	4/7/2014 10:39	36	0.152	4/7/2014 7:00	4/7/2014 18:00	336,600	7.73	756	3.19
*Base**			*7*	*0.077*	*4/7/2014 18:00*	*4/9/2014 10:45*	*513,450*	*11.79*	*224*	*2.47*
Base			*7*	*0.077*	*4/9/2014 10:45*	*4/11/2014 21:45*	*588,599*	*13.52*	*257*	*2.83*
*Base**			*7*	*0.077*	*4/11/2014 21:45*	*4/14/2014 11:00*	*606,375*	*13.93*	*265*	*2.91*
Base			*7*	*0.077*	*4/14/2014 11:00*	*4/24/2014 7:00*	*2,300,720*	*52.84*	*1,005*	*11.06*
Storm Grab	4/24/2014 11:10	4/24/2014 11:10	69	0.106	4/24/2014 7:00	4/24/2014 15:00	91,490	2.10	394	0.61
Base			*7*	*0.077*	*4/24/2014 15:00*	*4/27/2014 6:00*	*735,979*	*16.90*	*322*	*3.54*
Storm Grab	4/28/2014 11:15	4/28/2014 11:15	157	0.189	4/27/2014 6:00	4/28/2014 4:00	1,001,370	23.00	9,814	11.81
*Base**			*7*	*0.077*	*4/28/2014 4:00*	*4/30/2014 7:00*	*642,600*	*14.76*	*281*	*3.09*
Storm Grab*	4/30/2014 9:30	4/30/2014 9:30	26	0.099	4/30/2014 7:00	4/30/2014 22:00	540,000	12.40	876	3.34
*Base**			*7*	*0.077*	*4/30/2014 22:00*	*5/7/2014 16:15*	*2,453,220*	*56.35*	*1,072*	*11.79*
Base			*7*	*0.077*	*5/7/2014 16:15*	*5/12/2014 1:15*	*1,503,900*	*34.54*	*657*	*7.23*
Storm			*139*	*0.306*	*5/12/2014 1:15*	*5/12/2014 10:15*	*172,306*	*3.96*	*1,495*	*3.29*
Base			*7*	*0.077*	*5/12/2014 10:15*	*5/12/2014 20:15*	*201,558*	*4.63*	*88*	*0.97*
Storm			*139*	*0.306*	*5/12/2014 20:15*	*5/13/2014 13:15*	*397,121*	*9.12*	*3,446*	*7.59*
Base			*7*	*0.077*	*5/13/2014 13:15*	*5/19/2014 13:15*	*1,974,050*	*45.34*	*863*	*9.49*
Storm Grab	5/19/2014 13:49	5/19/2014 13:49	220	0.407	5/19/2014 13:15	5/20/2014 9:15	874,305	20.08	12,007	22.21
Base			*7*	*0.077*	*5/20/2014 9:15*	*5/20/2014 23:15*	*493,525*	*11.34*	*216*	*2.37*
Base Grab*	5/29/2014 8:57	5/29/2014 8:57	8	0.074	5/20/2014 23:15	5/30/2014 13:15	5,382,000	123.62	2,688	24.86
Base			*7*	*0.077*	*5/30/2014 13:15*	*5/31/2014 23:15*	*589,517*	*13.54*	*258*	*2.83*
Storm			*139*	*0.306*	*5/31/2014 23:15*	*6/1/2014 15:15*	*468,932*	*10.77*	*4,069*	*8.96*
Base			*7*	*0.077*	*6/1/2014 15:15*	*6/2/2014 6:15*	*379,007*	*8.71*	*166*	*1.82*
Storm			*139*	*0.306*	*6/2/2014 6:15*	*6/2/2014 21:15*	*425,390*	*9.77*	*3,691*	*8.13*
*Base**			*7*	*0.077*	*6/2/2014 21:15*	*6/4/2014 0:15*	*557,195*	*12.80*	*243*	*2.68*
Base			*7*	*0.077*	*6/4/2014 0:15*	*6/7/2014 8:15*	*1,304,060*	*29.95*	*570*	*6.27*
Storm			*139*	*0.306*	*6/7/2014 8:15*	*6/7/2014 20:15*	*181,950*	*4.18*	*1,579*	*3.48*
Base			*7*	*0.077*	*6/7/2014 20:15*	*6/10/2014 11:15*	*927,638*	*21.31*	*405*	*4.46*
*Base**			*7*	*0.077*	*6/10/2014 11:15*	*6/12/2014 3:00*	*462,877*	*10.63*	*202*	*2.22*
Base			*7*	*0.077*	*6/12/2014 3:00*	*6/14/2014 21:00*	*594,663*	*13.66*	*260*	*2.86*
Storm			*139*	*0.306*	*6/14/2014 21:00*	*6/15/2014 11:00*	*424,502*	*9.75*	*3,684*	*8.11*
Base			*7*	*0.077*	*6/15/2014 11:00*	*6/15/2014 22:00*	*288,090*	*6.62*	*126*	*1.38*
Storm Grab	6/16/2014 13:48	6/16/2014 13:48	22	0.091	6/15/2014 22:00	6/16/2014 10:00	294,006	6.75	404	1.67
*Base**			*7*	*0.077*	*6/16/2014 10:00*	*6/18/2014 4:00*	*831,600*	*19.10*	*363*	*4.00*
*Storm**			*139*	*0.306*	*6/18/2014 4:00*	*6/18/2014 20:00*	*518,400*	*11.91*	*4,498*	*9.90*
*Base**			*7*	*0.077*	*6/18/2014 20:00*	*6/19/2014 4:30*	*198,900*	*4.57*	*87*	*0.96*
Storm Grab*	6/19/2014 14:26	6/19/2014 14:26	9	0.269	6/19/2014 4:30	6/19/2014 22:30	1,296,000	29.77	728	21.76
*Base**			*7*	*0.077*	*6/19/2014 22:30*	*6/28/2014 18:15*	*7,623,000*	*175.09*	*3,331*	*36.64*
*Storm**			*139*	*0.306*	*6/28/2014 18:15*	*6/29/2014 23:15*	*1,566,000*	*35.97*	*13,589*	*29.91*
*Base**			*7*	*0.077*	*6/29/2014 23:15*	*6/30/2014 15:00*	*283,500*	*6.51*	*124*	*1.36*
Base			*7*	*0.077*	*6/30/2014 15:00*	*7/7/2014 8:00*	*1,476,060*	*33.90*	*645*	*7.10*
*Base**			*7*	*0.077*	*7/7/2014 8:00*	*7/7/2014 15:00*	*50,400*	*1.16*	*22*	*0.24*
*Storm**			*139*	*0.306*	*7/7/2014 15:00*	*7/8/2014 9:45*	*337,500*	*7.75*	*2,929*	*6.45*
Base Grab	7/10/2014 11:02	7/10/2014 11:02	11	0.107	7/8/2014 9:45	7/11/2014 9:45	466,869	10.72	321	3.12
Base			*7*	*0.077*	*7/11/2014 9:45*	*8/1/2014 20:45*	*2,290,070*	*52.60*	*1,001*	*11.01*
Storm			*139*	*0.306*	*8/1/2014 20:45*	*8/2/2014 2:45*	*25,560*	*0.59*	*222*	*0.49*
Base			*7*	*0.077*	*8/2/2014 2:45*	*8/2/2014 17:45*	*49,489*	*1.14*	*22*	*0.24*
Storm			*139*	*0.306*	*8/2/2014 17:45*	*8/3/2014 0:45*	*29,130*	*0.67*	*253*	*0.56*
Base			*7*	*0.077*	*8/3/2014 0:45*	*8/11/2014 3:45*	*469,259*	*10.78*	*205*	*2.26*
Storm			*139*	*0.306*	*8/11/2014 3:45*	*8/11/2014 23:45*	*66,700*	*1.53*	*579*	*1.27*
Base Grab	8/13/2014 8:57	8/13/2014 8:57	4	0.077	8/11/2014 23:45	8/17/2014 21:45	297,955	6.84	74	1.43
Storm			*139*	*0.306*	*8/17/2014 21:45*	*8/18/2014 7:45*	*29,902*	*0.69*	*259*	*0.57*
Base			*7*	*0.077*	*8/18/2014 7:45*	*8/18/2014 18:45*	*34,279*	*0.79*	*15*	*0.16*
Storm			*139*	*0.306*	*8/18/2014 18:45*	*8/19/2014 1:45*	*38,137*	*0.88*	*331*	*0.73*
Base			*7*	*0.077*	*8/19/2014 1:45*	*8/21/2014 6:45*	*174,154*	*4.00*	*76*	*0.84*
Storm Composite	8/21/2014 8:02	8/21/2014 12:30	220	0.467	8/21/2014 6:45	8/21/2014 22:45	110,535	2.54	1,518	3.22
Base			*7*	*0.077*	*8/21/2014 22:45*	*8/29/2014 3:45*	*543,293*	*12.48*	*237*	*2.61*
Storm			*139*	*0.306*	*8/29/2014 3:45*	*8/29/2014 18:45*	*46,997*	*1.08*	*408*	*0.90*
Storm			*139*	*0.306*	*8/29/2014 18:45*	*8/30/2014 10:45*	*75,427*	*1.73*	*654*	*1.44*
Base			*7*	*0.077*	*8/30/2014 10:45*	*8/31/2014 23:45*	*161,739*	*3.71*	*71*	*0.78*
Storm Composite	9/1/2014 5:20	9/1/2014 9:15	368	0.754	8/31/2014 23:45	9/1/2014 17:45	112,870	2.59	2,593	5.31
Base			*7*	*0.077*	*9/1/2014 17:45*	*9/3/2014 10:45*	*199,420*	*4.58*	*87*	*0.96*
Storm Composite	9/3/2014 21:33	9/5/2014 8:20	160	0.376	9/3/2014 10:45	9/5/2014 8:45	481,436	11.06	4,809	11.30
Base			*7*	*0.077*	*9/5/2014 8:45*	*9/9/2014 22:45*	*637,163*	*14.63*	*278*	*3.06*
Storm			*139*	*0.306*	*9/9/2014 22:45*	*9/10/2014 19:45*	*129,214*	*2.97*	*1,121*	*2.47*
Base Grab	9/15/2014 9:39	9/15/2014 9:39	6	0.080	9/10/2014 19:45	9/20/2014 17:45	1,019,470	23.42	382	5.09
Storm			*139*	*0.306*	*9/20/2014 17:45*	*9/21/2014 6:45*	*56,372*	*1.29*	*489*	*1.08*
Base			*7*	*0.077*	*9/21/2014 6:45*	*10/1/2014 9:45*	*686,061*	*15.76*	*300*	*3.30*
Storm			*139*	*0.306*	*10/1/2014 9:45*	*10/1/2014 19:45*	*63,463*	*1.46*	*551*	*1.21*
Base			*7*	*0.077*	*10/1/2014 19:45*	*10/2/2014 12:45*	*84,404*	*1.94*	*37*	*0.41*
Storm Composite	10/2/2014 16:34	10/2/2014 23:26	280	0.464	10/2/2014 12:45	10/3/2014 8:45	148,627	3.41	2,598	4.31
Base			*7*	*0.077*	*10/3/2014 8:45*	*10/26/2014 8:45*	*1,982,720*	*45.54*	*866*	*9.53*
Base Grab	10/27/2014 9:51	10/27/2014 9:51	6	0.048	10/26/2014 8:45	10/30/2014 9:45	223,781	5.14	84	0.67
*Base**			*7*	*0.077*	*10/30/2014 9:45*	*11/20/2014 9:45*	*453,600*	*10.42*	*198*	*2.18*
*Base**			*7*	*0.077*	11/20/2014 9:45	*1/1/2015 0:00*	*359,370*	*8.25*	*157*	*1.73*
Storm Average			139	0.306						
Base Average			7	0.077						
All Average			100	0.235						
Total							**53,519,017**	**1,229**	**99,532**	**392**
Brown's Creek Major Subwatershed Total Acres							3,855			
Total TSS/TP(lb/ac/yr)									25.82	0.102
Total TSS/TP (kg/ha/yr)									28.94	0.114

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

*Interval volumes from 1/1/14 0:00 to 4/14/14 11:00, 6/16/14 10:00 to 7/8/14 9:45 and 10/30/14 9:45 to 1/1/15 0:00 were estimated using similar flow conditions.

Table 6. Brown's Creek Diversion Structure Drainage 2014 Primary Water Quality Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	*E. coli* (mpn/100 mL)	Iron (mg/L)	Dissolved Iron (mg/L)
Snowmelt Grab	4/7/2014 10:39	4/7/2014 10:39	36	14	1.40	0.152	~0.048			~0.17
Storm Grab	4/24/2014 11:10	4/24/2014 11:10	69	25	1.50	0.106	~0.025		1.50	~0.11
Storm Grab	4/28/2014 11:15	4/28/2014 11:15	157	44	1.90	0.189	~0.036			~0.11
Storm Grab	4/30/2014 9:30	4/30/2014 9:30	26	~9	1.30	0.099	<0.020		~0.64	~0.09
Storm Grab	5/19/2014 13:49	5/19/2014 13:49	220	81	3.20	0.407	~0.029			~0.09
Storm Grab	6/16/2014 13:48	6/16/2014 13:48	22	8	1.00	0.091	~0.026		~0.99	~0.34
Storm Grab	6/19/2014 14:26	6/19/2014 14:26	9	~3	0.99	0.269	0.141		1.80	~0.83
Storm Composite	8/21/2014 8:02	8/21/2014 12:30	220	78	3.00	0.467	~0.049		6.90	~0.02
Storm Composite	9/1/2014 5:20	9/1/2014 9:15	368	136	4.50	0.754				
Storm Composite	9/3/2014 21:33	9/5/2014 8:20	160	50	2.70	0.376	<0.020		3.70	~0.15
Storm Composite	10/2/2014 16:34	10/2/2014 23:26	280	100	2.90	0.464	~0.030		5.90	~0.06
Base Grab	5/29/2014 8:57	5/29/2014 8:57	8	~4	1.00	0.074	~0.042	38	~0.58	~0.25
Base Grab	7/10/2014 11:02	7/10/2014 11:02	11	4	0.75	0.107	~0.028	71	1.10	~0.15
Base Grab	8/13/2014 8:57	8/13/2014 8:57	4	~2	0.39	0.077	~0.035	131	~0.56	~0.12
Base Grab	9/15/2014 9:39	9/15/2014 9:39	6	3	0.73	0.080	~0.033	120	~0.53	~0.11
Base Grab	10/27/2014 9:51	10/27/2014 9:51	6	~2	0.57	~0.048	~0.036			~0.06

Exceeds Water Quality Standard

Exceeds Water Quality Standard for Turbidity(TSS Value used to calculate)

Table 7. Brown's Creek Diversion Structure Drainage 2014 Secondary Water Quality Results

Sample Type	Start	End	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L _CaCO3)
Snowmelt Grab	4/7/2014 10:39	4/7/2014 10:39	0.00180	0.00150	0.00053	0.0067	<0.0002	0.00110	59.6	<0.03	0.81	0.14	82
Storm Grab	4/24/2014 11:10	4/24/2014 11:10	0.00150	0.00160	0.00085	0.0073	<0.0002	0.00120	80.6	<0.03	0.38	~0.04	90
Storm Grab	4/28/2014 11:15	4/28/2014 11:15	0.00200	0.00200	0.00120	0.0131	<0.0002	0.00140	98.5	<0.03	0.30	<0.02	74
Storm Grab	4/30/2014 9:30	4/30/2014 9:30	0.00110	0.00075	~0.00043	0.0068	<0.0002	0.00065	94.3	<0.03	0.11	<0.02	60
Storm Grab	5/19/2014 13:49	5/19/2014 13:49	0.0046	0.0048	0.0035	0.0171	<0.0002	0.00470	68.1	<0.03	0.14	0.07	102
Storm Grab	6/16/2014 13:48	6/16/2014 13:48	0.00100	0.00110	~0.00039	0.0038	<0.0002	0.00066	91.6	<0.03	<0.05	<0.02	44
Storm Grab	6/19/2014 14:26	6/19/2014 14:26	0.00170	0.00160	~0.00048	0.0038	<0.0002	0.00039	30.0	<0.03	<0.05	<0.02	58
Storm Composite	8/21/2014 8:02	8/21/2014 12:30	0.00740	0.00610	0.00400	0.0219	~0.00034	0.00520	42.4	<0.03	0.31	~0.02	156
Storm Composite	9/1/2014 5:20	9/1/2014 9:15											
Storm Composite	9/3/2014 21:33	9/5/2014 8:20	0.00380	0.00330	0.00170	0.0132	<0.0002	0.00250	56.1	<0.03	0.36	<0.02	118
Storm Composite	10/2/2014 16:34	10/2/2014 23:26	0.00470	0.00700	0.00290	0.0177	~0.00023	0.00440	56.0	<0.03	0.09	<0.02	152
Base Grab	5/29/2014 8:57	5/29/2014 8:57	0.00065	0.00075	~0.00019	~0.0013	<0.0002	0.00035	96.8	<0.03	0.07	0.06	104
Base Grab	7/10/2014 11:02	7/10/2014 11:02	0.00072	0.00098	~0.00014	0.0058	<0.0002	0.00047	70.0	<0.03	0.24	~0.02	96
Base Grab	8/13/2014 8:57	8/13/2014 8:57	~0.00053	0.00086	~0.00013	<0.0008	<0.0002	0.00053	64.2	<0.03	0.5	~0.05	174
Base Grab	9/15/2014 9:39	9/15/2014 9:39	~0.00053	0.00074	~0.00013	~0.0013	<0.0002	0.00039	66.2	<0.03	0.28	~0.02	112
Base Grab	10/27/2014 9:51	10/27/2014 9:51	~0.00043	0.00078	<0.0001	<0.005	<0.0002	0.00035	61.1	<0.03	0.50	~0.06	220

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

Table 8. Brown's Creek Diversion Structure Drainage 2014 Field Measurement Results

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/7/2014 10:39	48	1.7	12.53	364	8.6
5/29/2014 8:57	>100	18.5	7.42	513	
6/19/2014 14:26	55	19.2	4.12	218	7.3
7/10/2014 11:02	85	20.4	6.3	416	7.9
8/13/2014 8:57	>100	16.2	8.28	533	8.1
9/15/2014 9:39					7.3

Exceeds Water Quality Standard

Table 9. Brown's Creek Diversion Structure Drainage Historical Annual Discharge and Loading Amounts

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Brown's Creek Diversion Structure									
Discharge (cf)	33,916,362	49,768,967	29,397,219	31,166,264	38,197,468	52,981,553	21,810,789	46,435,271	53,519,017
Total pounds of Phosphorus exported	676	653	206	544	608	2,099	251	527	392
TP (lbs/ac/yr)	0.175	0.169	0.053	0.141	0.158	0.544	0.065	0.137	0.102
Total pounds of TSS exported	455,793	232,190	59,313	227,372	353,007	1,387,050	127,435	211,977	99,532
TSS (lbs/ac/yr)	118.23	60.23	15.39	58.98	91.57	359.81	33.06	54.99	25.82

C. MSCWMO STREAMS: CONCLUSIONS AND RECOMMENDATIONS

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The following is WCD recommendation to the MSCWMO:

- Continue to evaluate loading estimates at the Brown's Creek Diversion Structure Drainage site to determine if future water quality improvement projects are helping to reduce loading to McKusick Lake.

APPENDIX A
Water Quality Data– McKusick Lake, Lily Lake

McKusick Lake

2014 Lake Grade: C

- DNR ID #: 820020
- Municipality: City of Stillwater
- Location: NE ¼ Section 29, T30N-R20W
- Lake Size: 46 Acres
- Maximum Depth (2014): 15.5ft
- 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.

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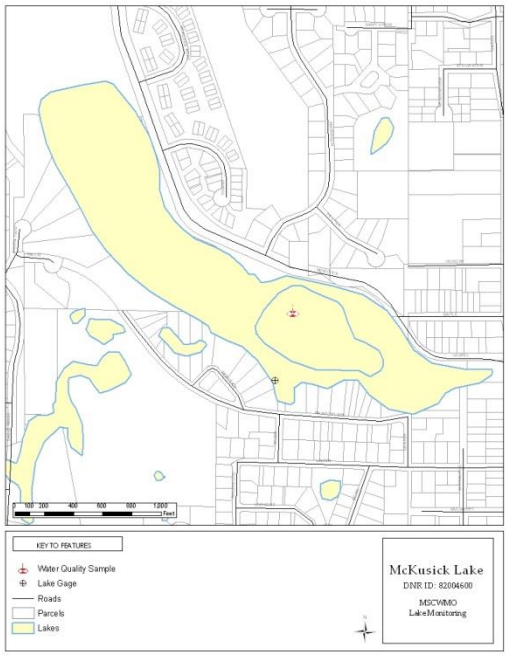
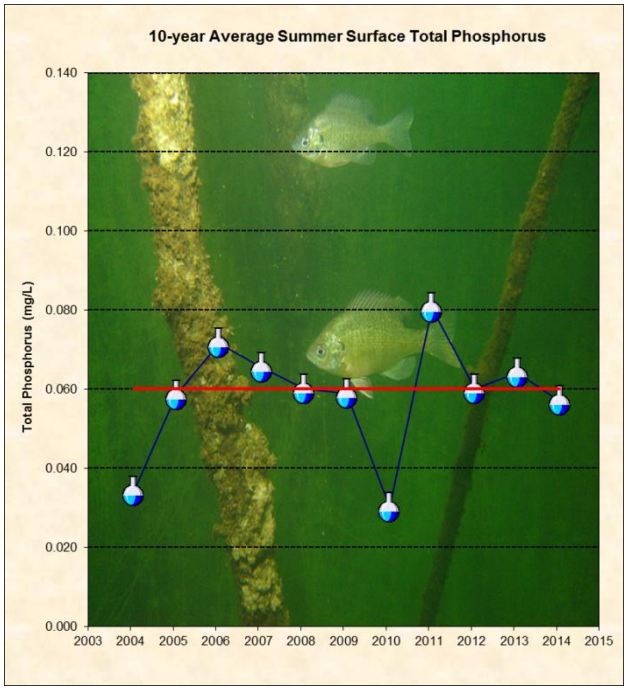
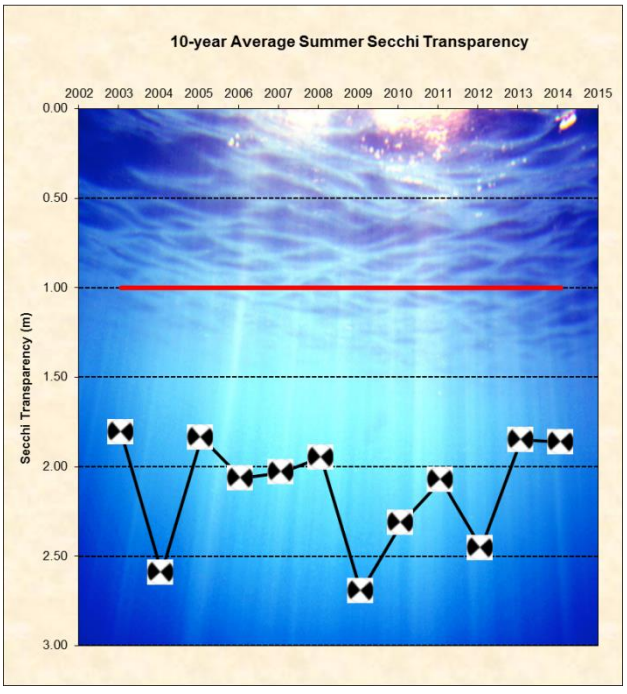


Summary Points

- Based on the chlorophyll-*a* results McKusick Lake was considered eutrophic in 2014, according to the Carlson Trophic State Index.
- Using a Kendal Tau correlation test ($p<0.01$), there is a statistically significant **improving trend** for average Secchi transparency and for average total phosphorus.
- The major land use is urban/residential.
- The lake stratified in 2014 with the thermocline around 3 meters deep.
- McKusick Lake has been delisted for its impairment for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
5/5/14 9:10	0.057	22.0	1.50	1.37	10.9	12.89
5/20/14 14:55	0.047	9.9	0.80	1.37	17.2	7.79
6/2/14 15:15	0.084	11.0	1.00	1.83	24.5	6.61
6/16/14 8:40	0.079	9.9	0.70	2.59	20.1	8.01
7/2/14 9:05	0.064	13.0	0.90	1.52	21.5	6.12
7/14/14 14:43	0.063	20.0	1.00	1.68	22.9	7.00
7/29/14 10:32	0.051	12.0	1.20	2.13	23.5	6.73
8/12/14 13:17	0.059	34.0	0.80	1.22	24.4	4.86
8/26/14 11:20	0.060	44.0	1.10	1.37	23.9	4.76
9/8/14 12:14	0.033	28.0	0.80	2.13	20.4	7.73
9/24/14 10:36	0.020	13.0	1.00	2.29	17.8	10.50
10/8/14 9:24	0.030	11.0	1.00	2.90	10.4	10.85
2014 Average	0.054	19.0	0.98	1.87	19.8	7.82
2014 Summer Average	0.057	20.5	0.94	1.86	22.1	6.92

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

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

	High	High Date	Low	Low Date	Average
2014 Elevation (ft)	855.08	6/2/2014	853.86	7/29/2014	854.39

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

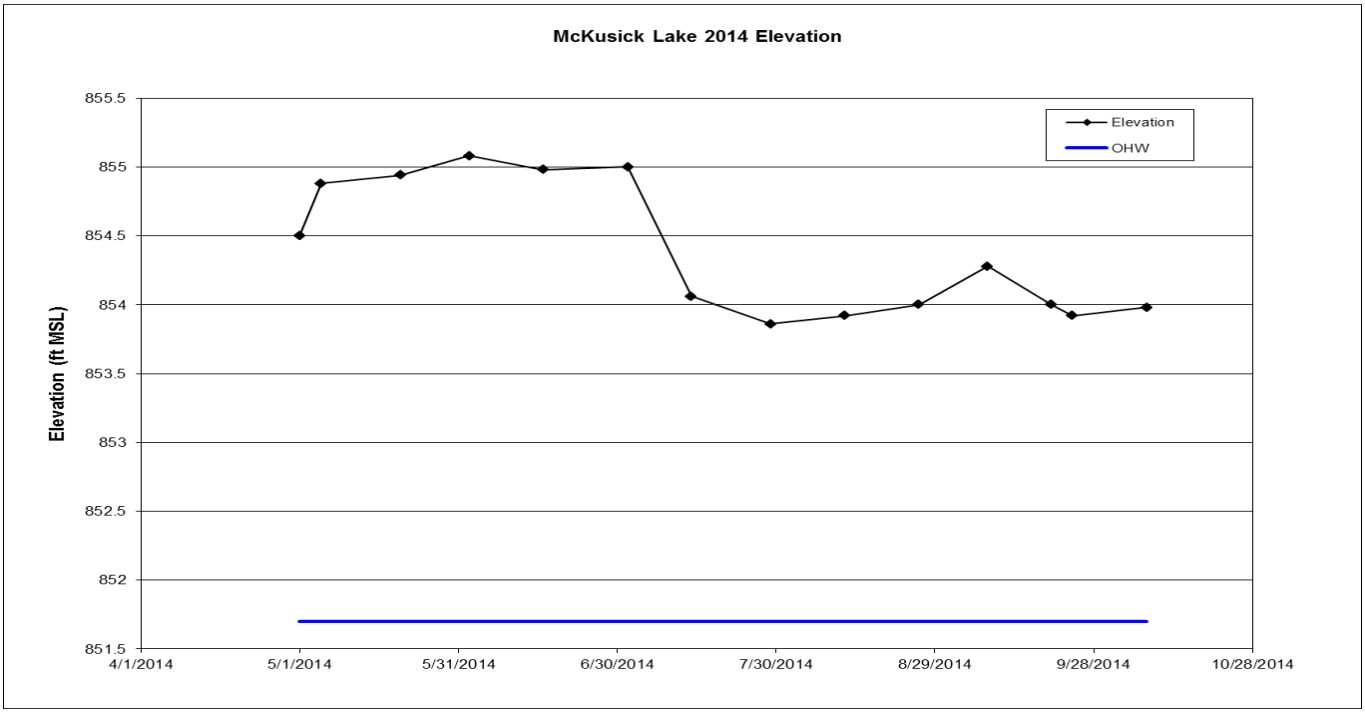


Table 4. McKusisk Lake 2014 Sample Metals and Chemical Results								
Sample Type	Sample Date	Copper (mg/L)	Lead (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Hardness (mg/L_CaCO3)
Surface	5/5/2014 9:10	0.00170	0.00032	0.00044	0.0105	0.00020	0.00023	74
Surface	6/16/2014 8:40	0.00120	0.00250	0.00051	0.0085	0.00020	0.00019	56
Benthic	6/16/2014 8:40	0.00380	0.00170	0.00040	0.0175	0.00020	0.00010	70
Surface	7/2/2014 9:05	0.00095	0.00019	0.00048	0.0128	0.00020	0.00018	50
Surface	7/29/2014 14:43	0.00044	0.00015	0.00035	0.0039	0.00020	0.00012	68
Surface	8/26/2014 11:20	0.00062	0.00028	0.00030	0.0118	0.00020	0.00012	76
Benthic	8/26/2014 11:20	0.00250	0.00430	0.00030	0.0344	0.00020	0.00034	92
Surface	10/8/2014 9:24	0.00180	0.00027	0.00045	0.0105	0.00041	0.00019	106

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

Lake Water Quality Summary											
		Summertime Lake Grades									
	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	C	C	C	D	B	C	C	C	D	C	C
Chlorophyll-*a* (ug/L)	C	B	A	C	A	A	B	B	B	B	A
Secchi depth (ft)	C	C	B	C	B	B	C	C	C	C	B
Overall	**C**	**C+**	**B**	**C-**	**B+**	**B**	**C+**	**C+**	**C**	**C+**	**B**

Lily Lake

2014 Lake Grade: B+

- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth (2014): 47.5 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.
- Public access and public beach present

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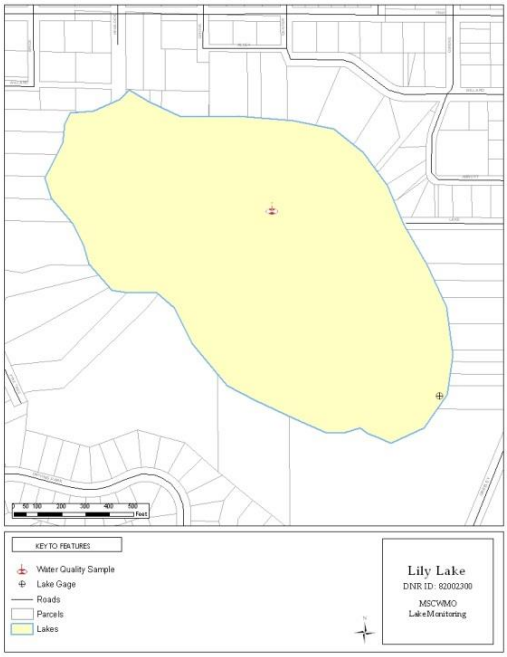
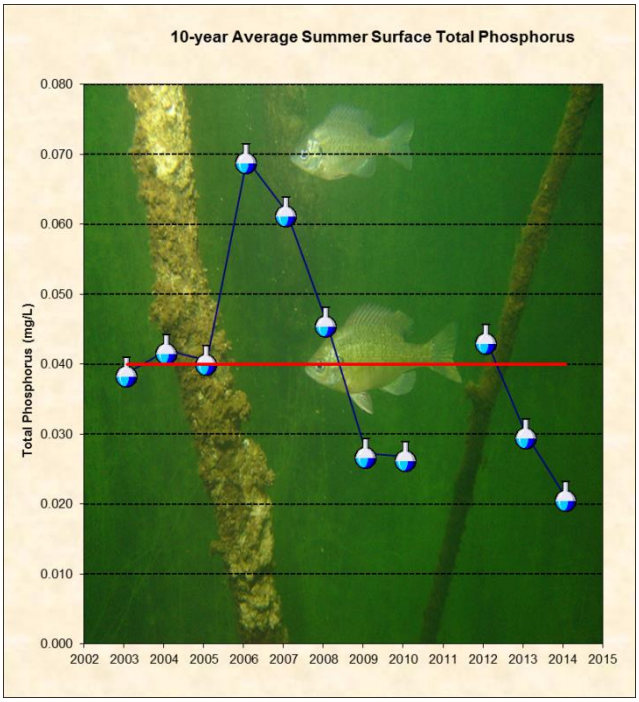
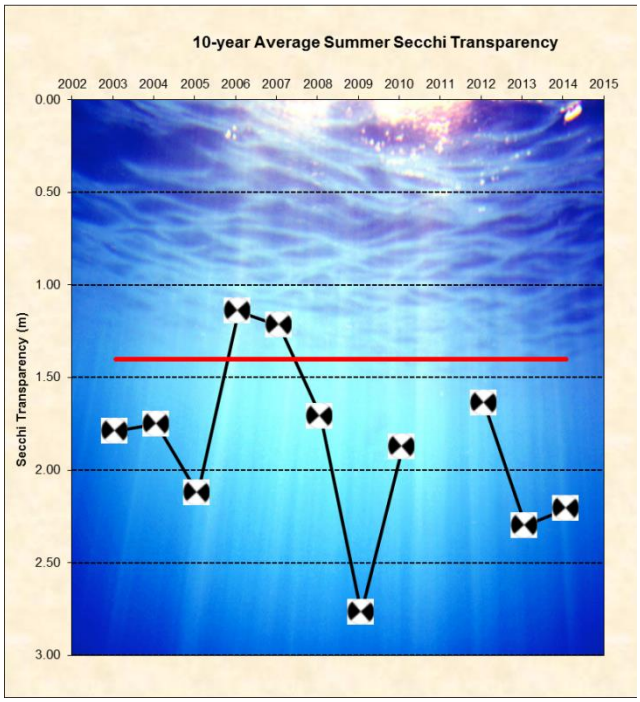


Summary Points

- Based on the chlorphyll-*a* results Lily Lake was considered mesotrophic in 2014, according to the Carlson Trophic State Index.
- Using a Kendal Tau correlation test ($p<0.01$), there is a statistically significant **improving trend** for average average total phosphorus and no statistically significant trend is present for Secchi transparency
- The major land use is urban/residential.
- Lily Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's





Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Temperature Levels (Celsius)	Surface Dissolved Oxygen Levels (mg/L)
4/25/14 17:30	0.031	10.0	0.88	1.70	10.0	
5/7/14 17:00	0.024	7.5	0.80	1.80	13.0	
5/23/14 19:00	0.018	1.0	0.78	2.80	21.0	
6/5/14 19:30	0.016	2.5	0.66	4.40	23.9	
6/18/14 19:00	0.018	5.1	0.67	3.80	25.4	
7/3/14 19:30	0.020	6.6	0.66	2.50	25.6	
7/17/14 19:30	0.017	11.0	0.67	2.20	24.8	
7/30/14 19:30	0.024	16.0	0.99	1.70	26.9	
8/14/14 19:50	0.028	24.0	0.92	1.30	27.2	
8/28/14 19:50	0.025	17.0	1.20	1.10	24.3	
9/12/14 18:00	0.014	8.2	0.80	1.20	18.6	
9/28/14 18:00	0.023	4.8	0.71	1.70	22.5	
10/11/14 17:00	0.047	4.7	0.71	2.80	13.3	
10/19/14 17:00	0.018	4.4	0.69	2.70	13.2	
2014 Average	0.023	8.8	0.80	2.26	20.7	
2014 Summer Average	0.021	10.6	0.81	2.21	24.4	

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	
2013 Elevation (ft)	846.15	5/8/2013	844.17	9/23/2013	844.95	

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) for paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary											
		Summertime Lake Grades									
	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total Phosphorus (mg/L)	A	B	C	NA	B	B	C	C	D	C	C
Chlorophyll-*a* (ug/L)	B	B	B	NA	C	A	C	C	C	B	B
Secchi depth (ft)	B	B	C	NA	C	B	C	C	D	C	C
Overall	**B+**	**B**	**C+**	**NA**	**C+**	**B+**	**C**	**C**	**D+**	**C+**	**C+**

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