



2014 Lakes Monitoring Report

MAY 28, 2015





Capitol Region Watershed District

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June 26, 2015

Dear Stakeholders and Interested Parties:

I am pleased to provide to you a copy of our 2014 Lakes Monitoring Report. Capitol Region Watershed District's (CRWD) 2014 monitoring program was enhanced by the contributions of numerous agencies and individuals, most notably: Ramsey County Environmental Services Staff, John Manske; and Ramsey Conservation District, Samantha Kreibich.

Prior to 2013, CRWD reported District Lake water quality data within the larger monitoring report that included stormwater data. For the second time in 2014, the District produced a stand-alone Lakes Monitoring Report. The report comprehensively reports chemical, physical, and biological data for each District lake, which provides a complete picture of factors influencing lake water quality and overall lake health. Data contained in this report will support ongoing future lake and watershed management decisions.

I would also like to recognize staff who assisted with the preparation of this report. Britta Suppes, Sarah Wein, Wyatt Behrends, and Joe Sellner had a major role in analyzing and reporting the data.

The 2014 CRWD Lakes Monitoring Report and the 2014 CRWD Stormwater Monitoring Report are also available at the District's website: www.capitolregionwd.org. If you have any questions pertaining to the enclosed report, contact District Monitoring Coordinator, Britta Suppes at (651) 644-8888 or britta@capitolregionwd.org.

Sincerely,

A handwritten signature in blue ink, appearing to read "Bob Fossum".

Bob Fossum
Water Resource Program Manager

enc: 2014 Capitol Region Watershed District Lakes Monitoring Report

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ACRONYMS AND ABBREVIATIONS

ac	Acre
BMP	Best Management Practice
cBOD	5-day Carbonaceous Biochemical Oxygen Demand
cf	Cubic feet
cfs	Cubic feet per second
Chl-a	Chlorophyll-a
Cl	Chloride
CRWD	Capitol Region Watershed District
CS	Chronic Standard
DNR	Department of Natural Resources
DO	Dissolved Oxygen
<i>E. coli</i>	<i>Escherichia coli</i>
EPA	Environmental Protection Agency
ft	Foot/Feet
GPS	Global Positioning System
ha	Hectare
IBI	Index of Biological Integrity
in	Inch
kg	Kilogram
L	Liter
lb	Pound
m	Meter
MCES	Metropolitan Council Environmental Services
MCWG	Minnesota Climatological Working Group
mg	Milligram
mL	Milliliter
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
MSP	Minneapolis-St. Paul International Airport
NA	Not Available
NCHF	North Central Hardwood Forest
NH ₃	Ammonia
NO ₂	Nitrite
NO ₃	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OHWL	Ordinary High Water Level

Ortho-P	Ortho-phosphate
RCD	Ramsey Conservation District
RCLML	Ramsey County Lake Management Laboratory
RCPW	Ramsey County Public Works
sec	Second
SRP	Soluble Reactive Phosphorus
TB	Trout Brook
TBI	Trout Brook Storm Sewer Interceptor
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
UMN	University of Minnesota-St. Paul Campus
WD	Watershed District
WMO	Watershed Management Organization

DEFINITIONS

Anthropogenic – resulting from the influence of human beings on nature.

Bathymetric – the measurement of water depth in a body of water.

Benthic – the ecological region at the bottom of a body of water.

Biomanipulation – the deliberate alteration of an ecosystem by adding or removing species.

Class 2 Waters – waters of the State that are designated for aquatic life and recreational use.

Chlorophyll-a – a type of chlorophyll pigment found in plants used in oxygenic photosynthesis; used as a measure of phytoplankton production in lakes and streams.

Conductivity – the measure of the ability of water to pass an electrical current; affected by the presence of inorganic dissolved solids and temperature.

Designated Use – the water quality standards regulation requires that States and authorized Indian Tribes specify appropriate water uses to be achieved and protected. Appropriate uses are identified by taking into consideration the use and value of the water body for public water supply, for protection of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes.

Epilimnion – the top layer of water in a lake, characterized in the summer by warm, circulating water. MPCA lake standards are based on water sampled from this layer.

Eutrophic – a water body with high nutrient concentrations and primary biological productivity. These waters are murky and an extensive macrophyte population. Algal blooms are common.

Fingerling – fish harvested from rearing ponds after one summer of growth.

Fry – newly hatched fish ready to be stocked.

Hardness – the concentration of calcium and magnesium salts (e.g. calcium carbonate, magnesium carbonate) in a water sample.

Hypereutrophic – a water body with excessive nutrient concentrations and primary biological productivity. These waters are characterized by very murky water, frequent algal blooms and fish kills, foul odor, and rough (or less desirable) fish.

Hypolimnion – the part of a lake below the thermocline made up of water that is stagnant and of essentially uniform temperature except during the period of overturn.

Impaired Waters – waters that are not meeting their designated uses because of excess pollutants violating water quality standards.

Littoral Area/Zone – area of a lake that is less than 15 feet in depth where the majority of plants are found.

Mesotrophic – a water body that has intermediate nutrient concentrations and primary biological productivity. These waters are moderately clear and are characterized by late-summer algal blooms, moderate macrophyte populations, and occasional fish kills.

Morphometric – describing parameters relating to external form.

Oligotrophic – a water body that has low nutrient concentrations and primary biological productivity, and is characterized by clear water, few macrophytes, and salmonid fish.

Phytoplankton – the autotrophic plant members of the plankton (drifting organisms) community.

Secchi depth – a measure of the transparency of lake water using a Secchi disk.

Stormwater – water that becomes runoff on a landscape during a precipitation event.

Stormwater Best Management Practices – activities, practices, and structures designed to reduce stormwater pollution and runoff volume and increase groundwater recharge.

Subwatershed – a delineated area of land within a larger watershed where surface waters and runoff drain to a single point before ultimately discharging from the encompassing watershed.

Thermal stratification – refers to the changes in temperature at different depths in a lake as a result of the different densities of water at different temperatures.

Thermocline – the region in a thermally stratified body of water which separates warmer surface water from cold deep water and in which temperature decreases rapidly with depth.

Total Maximum Daily Load – the maximum amount of a substance that can be received by a water body while still meeting water quality standards. This may also refer to the allocation of acceptable portions of this load to different sources.

Turbidity – a measure of the relative clarity of a liquid. Turbidity measurements can provide a simple indicator of potential pollution in a sample. Turbid water will appear cloudy or hazy.

Watershed – a delineated area of land where surface waters and runoff drain to a single point at a lower elevation.

Zooplankton – the heterotrophic animal members of the plankton (drifting organisms) community.

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1 EXECUTIVE SUMMARY

1.1 CAPITOL REGION WATERSHED DISTRICT

Capitol Region Watershed District (CRWD) in Ramsey County, Minnesota is a special purpose unit of government that manages, protects, and improves water resources within its watershed boundaries. CRWD is a 41 square mile subwatershed nested in the Upper Mississippi River basin that contains portions of five cities, including: Falcon Heights, Lauderdale, Maplewood, Roseville, and Saint Paul. CRWD is highly urbanized with a population of 245,000 and 42% impervious surface coverage. All runoff from CRWD eventually discharges to the Mississippi River from 42 outfall locations within the District.

One goal of CRWD is to understand and address the presence of pollutants and their impacts on water quality within the District in order to better protect, restore, and manage local water resources. To address this goal, CRWD established a monitoring program in 2004 to begin assessing water quality and quantity of various District subwatersheds and stormwater best management practices (BMPs) over time. CRWD collects water quality and continuous flow data from major subwatersheds, lakes, ponds, and stormwater BMPs.

1.2 PURPOSE OF REPORT

This annual report focuses on the water quality of the five District lakes (Como, Crosby, Little Crosby, Loeb, and McCarrons) during the 2014 monitoring season (May through October). Specific water quality data (total phosphorus, chlorophyll-a, and Secchi disk depth) for each lake from 2014 were compared to previous monitoring years. Additional biological and physical parameter results (i.e. phyto- and zooplankton, macrophytes, fisheries, lake morphometry, water levels) are also included in this report.

The purpose of this report is to characterize overall lake health and water quality in 2014 and examine trends over time, which in turn will inform lake management decisions for continued protection and improvement of District lakes. Previous annual monitoring reports (2005-2013) are available on the CRWD website at www.capitolregionwd.org.

1.3 LAKE MONITORING METHODS

Within CRWD, the five lakes are located in four of the sixteen major subwatersheds (Como, Crosby, McCarrons, and Trout Brook). CRWD organized the collection of water quality data for all of these lakes including information on chemical parameters (nutrients, pH, and conductivity), physical parameters (water clarity, dissolved oxygen, and temperature), and biological parameters (chlorophyll-a, aquatic vegetation type and abundance, and phytoplankton, zooplankton, and fisheries populations).

Lake data is collected by Ramsey County Public Works, Ramsey Conservation District, and the Minnesota Department of Natural Resources. Also, rainfall data was collected by CRWD from six precipitation gauges across the watershed.

1.4 2014 MONITORING RESULTS

The total amount of precipitation for the 2014 calendar year was 35.66 inches which was 5.05 inches greater than the NWS 30-year normal of 30.61 inches. June 2014 was the wettest June and wettest month overall in CRWD's modern record with 9.1 inches occurring, which was 4.85 inches above the 30-year normal. Along with a wet June, April and May 2014 were also particularly wet with both months being well-above the monthly normals. Cumulatively, the wet spring months of April, May, and June represented 57% of the total annual precipitation that occurred in 2014. In contrast, July and August were dry with both months recording below normal precipitation. Fall 2014 was also dry, with September and October 2014 being significantly below the 30-year normal.

In 2014, the water quality of the five District lakes (Como, Crosby, Little Crosby, Loeb, and McCarrons) varied by water body and by time of year. Based on the MPCA eutrophication numeric water quality standards, Loeb Lake and Lake McCarrons met the MPCA eutrophication water quality standards (for shallow/deep lakes) for all parameters during the 2014 growing season (May to September) (Table 1-1). Little Crosby met both the chlorophyll-a (Chl-a) concentration and Secchi disk depth standards, but failed to meet the standard for total phosphorus (TP) (Table 1-1). Como Lake and Crosby Lake did not meet the MPCA shallow lake standards for TP and Chl-a concentrations, but met the standards for Secchi disk depth during the entire 2014 growing season (Table 1-1). Como Lake was the only District lake designated as impaired on the MPCA's 2014 303(d) proposed impaired waters list, and has been listed on the MPCA 303(d) list since 2002.

Table 1-1: CRWD 2014 average, historical average, and lake standards for TP/Chl-a/Secchi depth

Lake	2014 Averages			Historical Averages			State Lake Standards		
	TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Como	160	32.3	1.2	175	33.9	1.5	<60	<20	≥1.0
Crosby	211	21.0	1.6	71	10.2	2.4	<60	<20	≥1.0
Little Crosby	129	19.4	1.9	79	7.1	2.7	<60	<20	≥1.0
Loeb	29	6.0	2.7	29	5.9	3.3	<60	<20	≥1.0
McCarrons	33	8.9	2.7	34	9.8	2.9	<40	<14	≥1.4
	Value does not meet the state standard								
	Value meets the state standard								

Lake grades were calculated for each lake based on the 2014 water chemistry data to provide a more understandable depiction of lake health and to better track lake water quality changes over

time. The seasonal means of TP, Chl-a, and Secchi depth were examined for 2014 and previous years and grades were based on scoring ranges for each parameter (Table 1-2). Based on the lake grading system, Lake McCarrons and Loeb Lake received good to excellent lake grades (respectively), where Loeb received the highest grade of 'B+' and Lake McCarrons received a grade of 'B'. Little Crosby Lake received a grade of 'C', and both Crosby Lake and Como Lake received the lowest grades of 'D+'.

Table 1-2: CRWD 2014 lake grades and historical lake grades for TP/Chl-a/Secchi depth.

Lake	2014 Lake Grade			2014 Average	Historical Lake Grade			Historical Average
	TP	Chl-a	Secchi		TP	Chl-a	Secchi	
Como	F	C	C	D+	F	C	C	D+
Crosby	F	C	C	D+	D	B	B	C+
Little Crosby	D	B	C	C	D	A	B	B
Loeb	B	A	B	B+	B	A	A	A
McCarrons	C	A	B	B	C	A	B	B

1.5 2015 RECOMMENDATIONS

Based on the results and findings of the *2014 Lakes Monitoring Report*, CRWD has several goals and recommendations for 2015 to continue improving the monitoring program and the water quantity and quality dataset. Specifically, CRWD aims to complete the following in 2015:

- Analyze additional chemical and physical parameters:** CRWD intends to expand the analysis of chemical and physical data previously collected but not fully analyzed in prior reports. Analysis of other water chemistry and physical attributes will allow a better understanding of overall lake health.
- Conduct sediment analyses of all District lakes:** CRWD will conduct sediment analyses on all lakes during the winter of 2015-2016 to establish current understanding of internal sediment loading.
- Complete a comparative analysis of all parameters measured:** CRWD will complete a comparative analysis of chemical, physical, and biological parameters and how they interact to effect overall lake health.
- Continue to conduct fish surveys:** CRWD plans to survey fish populations at Como, Crosby, and Little Crosby Lakes annually during years the DNR is not scheduled to survey those lakes. Also, CRWD will survey Lake McCarrons and Loeb Lake bi-annually (except for years the DNR is scheduled to survey) since these lakes exhibit stable fish populations. In 2015, CRWD will survey Como, Crosby, and Little Crosby Lakes.
- Complete an internal loading assessment of Lake McCarrons:** Internal loading (the release of phosphorus from lake sediments into the water column) can have a large effect on the amount of available phosphorus in a lake. Lake McCarrons received an alum

treatment in 2004 in order to reduce internal phosphorus loading and improve lake water quality. Since the alum treatment, lake water quality has drastically improved in comparison to pre-alum treatment conditions. The expected efficacy of an alum treatment is 8-20 years. Since it has been 10 years since the treatment, a deterioration in its effectiveness is expected. Consequently, degradation in epilimnetic water quality was observed in 2014, along with an increase in hypolimnetic phosphorus that has been observed in recent years. In 2015-2016 CRWD will investigate the changes to internal loading that have occurred since the 2004 alum treatment.

2 INTRODUCTION

2.1 CRWD BACKGROUND

Located in Ramsey County, Minnesota the Capitol Region watershed is a small urban subwatershed nested in the Upper Mississippi River basin with all runoff eventually discharging to the Mississippi River. Capitol Region Watershed District (CRWD) is a special purpose unit of government formed in 1998 to manage and protect all water resources within the Capitol Region watershed boundaries. CRWD contains portions of five cities, including: Falcon Heights, Lauderdale, Maplewood, Roseville, and Saint Paul (Figure 2-1). CRWD is highly urbanized with a population of 245,000 and 42% impervious surface coverage. Land use in the watershed is primarily residential with dense areas of commercial, industrial, and institutional uses.

2.2 CRWD WATER QUALITY ISSUES

Urban development in the watershed over time has significantly impacted the health and sustainability of the Mississippi River as well as CRWD lakes, wetlands, and streams. Impervious surfaces generate polluted stormwater runoff which causes poor water quality, increased peak storm flows, decreased groundwater recharge, increased flooding, and loss of biological habitat. Subsequently, stormwater runoff is one of the most significant sources of pollution to CRWD water resources. It delivers fertilizers, pesticides, pet and wildlife waste, nutrients, sediment, heavy metals, and other anthropogenic pollutants to local lakes and multiple ponds and wetlands located in the District. As stormwater runs off the urban landscape, it is collected and conveyed through an extensive network of underground storm sewer pipes that eventually drain to the Mississippi River.

Both historical and current water quality data of CRWD lakes, ponds, and the Mississippi River indicate that these water bodies are impaired for various pollutants (including nutrients, bacteria, and turbidity) and are not meeting their designated uses for fishing, aquatic habitat, and recreation. The Mississippi River and Como Lake are listed on the Minnesota Pollution Control Agency (MPCA) 2014 303(d) proposed impaired waters list (MPCA, 2015b). Impaired waters require a total maximum daily load (TMDL) study for pollutants of concern including nutrients, turbidity, metals, bacteria, and chloride.

The nutrient of primary concern in CRWD lakes is phosphorus. Phosphorus is a biological nutrient which limits the growth of algae in most lakes and streams and is often found in high concentrations in stormwater. Phosphorus occurs naturally in the environment, but in excess can cause the overgrowth of algae and aquatic plants in lakes and rivers which reduces dissolved oxygen levels and increases turbidity of the water column. Common sources of phosphorous include fertilizers from lawns and gardens, leaves and grass clippings, pet and wildlife waste, and automobile emissions.

CRWD is within the Northern Central Hardwood Forest (NCHF) ecoregion. It is one of seven ecoregions in Minnesota and is characterized as an area with fertile soils with agriculture as the dominant land use in rural areas. In most lakes in the NCHF ecoregion, phosphorous is the least available nutrient; therefore, the concentration of phosphorous controls the extent of algal growth. Algal growth in turn affects the clarity and recreational potential of lakes.

Chlorophyll-a (Chl-a) is a pigment present in algae. Measuring Chl-a concentration is a proxy for measuring algal population. Algal blooms can make recreation unpleasant and prevent it entirely, and certain species of algae are toxic to humans and other animals. In addition, as algae die and decompose, oxygen is consumed from the water column and made unavailable for fish and other aquatic animals. Chronic low dissolved oxygen concentrations (<5 mg/L) may result in fish kills and low diversity of aquatic species (Kalff, 2002).

Water transparency, or water clarity, (determined using a Secchi disk) is another concern in area lakes. Lakes with high water clarity are generally considered healthier, and are characterized by more submerged aquatic plant growth, as clear water allows light to permeate to lower depth levels (Kalff, 2002). Increased plant growth also provides better habitat for aquatic organisms, including fish. Poor water clarity is a result of increased turbidity caused by suspended sediments, organic matter, and/or phytoplankton (algae).

Chloride in water bodies is a contaminant of concern for CRWD. High concentrations of chloride can harm fish and plant life by creating a saline environment (Siegel, 2007). Also, once in dissolved form, chloride cannot be removed from a water body. Chloride is primarily sourced from road salt application for de-icing in the winter months.

2.3 CRWD LAKE MONITORING PROGRAM GOALS

CRWD was formed to understand and address these water quality impacts and to better protect and manage local water resources. In 2004, CRWD established a monitoring program to assess water quality and quantity of various District subwatersheds and stormwater best management practices (BMPs). Prior to the CRWD monitoring program, limited data was available on stormwater quantity and quality in the watershed. The objectives of the program are to identify water quality problem areas, quantify subwatershed runoff pollutant loadings, evaluate the effectiveness of BMPs, provide data for the calibration of hydrologic, hydraulic, and water quality models, and promote understanding of District water resources and water quality.

The *CRWD 2014 Lakes Monitoring Report* presents information on annual CRWD lake water quality monitoring, including data collection methods and results for water chemistry, physical parameters, and biological parameters. A climatological summary is also included to summarize the precipitation, snowpack, and notable climatic events from 2014. Previous annual monitoring reports (2005-2013) are available on the CRWD website at www.capitolregionwd.org. Results and analysis of CRWD stormwater monitoring and

stormwater BMPs are discussed in separate reports (CRWD, 2015; CRWD, 2012b), which are also available on the CRWD website.

2.4 OVERVIEW OF CRWD LAKES

There are five lakes within the boundaries of CRWD: Como Lake, Crosby Lake, Little Crosby Lake, and Loeb Lake in St. Paul, and Lake McCarrons in Roseville (Figure 2-1). The lakes are monitored by Ramsey County Public Works (RCPW) and CRWD to assess overall health and to determine if each lake supports their designated uses for swimming, fishing, and/or aesthetics. All of the lakes receive stormwater runoff (directly and/or indirectly) and are nested within the Mississippi River Basin.

Como Lake, Crosby Lake, Little Crosby Lake, and Loeb Lake are classified as shallow lakes and Lake McCarrons is classified as a deep lake. Shallow lakes have a maximum depth less than 15 ft, or more than 80% of the lake within the littoral zone (MPCA, 2014). The littoral zone is the near-shore area of the lake in which plants grow (Kalff, 2002). Deep lakes have a maximum depth greater than 15 ft, or less than 80% of the lake within the littoral zone (MPCA, 2014).

2.4.1 COMO LAKE

Como Lake (Chapter 6) is a 70.5 acre lake with a maximum depth of 15.5 ft and is located in the City of Saint Paul. The 1,856 acre Como Lake watershed land uses are primarily residential and parkland. Como Lake is classified as a shallow lake because nearly 100% of the lake is considered the littoral zone. The lake has been monitored since 1984, and although water quality has improved slightly over time, there has been an observed cyclical variation in water quality (Noonan, 1998). In an effort to improve water quality in the lake, the Como Lake Strategic Management Plan (CRWD, 2002) was developed in 2002 and can be found on the District website (www.capitolregionwd.org). Como Lake is listed on the MPCA's 2014 303(d) proposed impaired waters list for chloride impairment (MPCA, 2015b), and was also listed for nutrients (2002) and mercury (1998).

2.4.2 CROSBY LAKE & LITTLE CROSBY LAKE

Crosby Lake (45 acres) and Little Crosby Lake (8 acres) (Chapters 7 and 8) are shallow lakes situated in the Mississippi River floodplain in Saint Paul and part of the Crosby Farm Regional Park and the Mississippi River National River and Recreation Area. The lakes are located within the 1,522 acres of Crosby Lake subwatershed; 197 acres of the subwatershed drain to Crosby Lake while 37 acres drain to Little Crosby Lake. The lakes are divided into two separate water bodies by a marsh/bog area 825 ft long. Crosby Lake is classified as a shallow lake because it has a maximum depth of 17 ft and the littoral zone covers 100% of the lake area. Little Crosby Lake is also considered a shallow lake even though it has a maximum depth of 34 ft, because it has a littoral area of 90% (<15 ft in depth). The watershed land uses for both water bodies are primarily parkland, single family residential, and industrial. A management plan for Crosby Lake (which included information regarding Little Crosby Lake) was created in 2012 (CRWD, 2012a), and can be found on the District

website (www.capitolregionwd.org). Crosby Lake has been monitored since 2005; Little Crosby Lake has been monitored since 2011. Crosby Lake did not meet the MPCA shallow lake standards in 2014. Little Crosby has met the standards since it has been monitored in 2011. Water quality of both lakes, however, is greatly affected by the Minnesota and Mississippi Rivers, since it is located in the floodplain of their confluence.

2.4.3 LOEB LAKE

Loeb Lake (Chapter 9) is a 9.7 acre shallow lake with a maximum depth of 28 ft and has a littoral area of 81%. Located in Marydale Park in the City of Saint Paul, the predominant land uses in the surrounding drainage area (44 acres) are mixed residential and parkland. The lake has a small drainage area, with no outlets. Loeb Lake has been monitored since 2003 (with the exception of 2004). A management plan for the lake was created in 2009 (CRWD, 2009), and can be found on the District website (www.capitolregionwd.org). Loeb Lake is an unimpaired water body and is not currently on the MPCA 303(d) list.

2.4.4 LAKE MCCARRONS

Located in the City of Roseville, Lake McCarrons (Chapter 10) is a 74.7 acre lake with a maximum depth of 57 ft. It is considered a deep lake with less than a 34% littoral zone. Lake McCarrons has a watershed area of 1,070 acres, with land use of mainly mixed residential and open space, including the entire Villa Park wetland system, which outlets to the lake. Lake McCarrons has been monitored since 1988, and is the only District lake that allows swimming and has development (residential) directly on its shoreline. Lake McCarrons received an alum treatment in 2004 and water quality of the lake has shown improvement since this occurred. A management plan for the lake was created in 2003 (CRWD, 2003), and can be found on the District website (www.capitolregionwd.org). The lake is considered unimpaired and is not currently listed on the MPCA 303(d) list of impaired waters.



3 METHODS

3.1 MONITORING METHODS

3.1.1 LAKE LEVEL

Lake elevation monitoring is organized by the Minnesota Department of Natural Resources (DNR) Lake Level Minnesota Program (DNR, 2015k). This program coordinates the monitoring by organizations and volunteers to gather weekly data of elevations on lakes throughout the state. Lake levels are measured using staff gages that are placed near the lakeshore in a stable and accessible location. Data on lake levels is collected by Ramsey County staff and provided to the DNR for inclusion in the LakeFinder database that can be accessed online to view historical lake levels for a particular lake (DNR, 2015i). Lake elevation monitoring by the DNR within CRWD occurs on Como Lake, Loeb Lake, and Lake McCarrons. CRWD collected lake level data from June through October on Crosby Lake and Lake McCarrons.

As this data continues to be compiled, a lake elevation graph is updated in order to view historical fluctuations in lake levels. The ordinary high water level (OHWL) is one other parameter that is shown on these graphs (where applicable). The OHWL is defined as 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” (Scherek, 1993). The OHWL is used to determine regulatory controls, with the Minnesota DNR regulating activity below the OHWL and local units of government regulating activity above the OHWL. By including this as a part of the lake elevation graph, observations can be made as to how current and past years compare to the “normal” lake level. This does not always mean that the lake level ever reaches or surpasses the OHWL, as this level is based on landscape evidence indicating the historical water level and is not an average of past monitored water levels.

3.1.2 CHEMICAL AND PHYSICAL DATA COLLECTION

Lake water quality data for 2014 and the preceding years was collected by RCPW throughout the growing season (May through September), resulting in an average of eight samples for each year (RCPW, 2009). In 2014, lakes were monitored beginning in early May and ending in late October, resulting in a total of nine samples for Como Lake, Loeb Lake, and Lake McCarrons. Crosby and Little Crosby Lakes were only sampled seven times as a result of late spring/early summer flooding from the Mississippi River. At each lake, RCPW staff anchored a watercraft over the deepest part of the lake, and monitored for various water quality parameters. The physical and chemical parameters of depth, temperature, dissolved oxygen, conductivity, and pH were measured at one-meter sampling intervals for the full depth profile of the lake using a multi-probe. From these recordings, the depths of the epilimnion, thermocline, and hypolimnion were recorded.

Additionally, at the lake sampling location, water chemistry samples were collected at multiple depths along the profile of the lake. At all lakes, two samples were obtained within the epilimnion, or mixed water layer. If RCPW staff was able to identify thermal stratification (where depths for the divisions between the epilimnion, thermocline, and hypolimnion can be identified), additional water samples from other depths were collected. One additional water sample was collected from within the thermocline and two were collected from within the hypolimnion. Any water samples collected were then stored and transported back to the RCPW lab and analyzed for the following parameters: Chl-a, TP, soluble reactive phosphorous (SRP) (i.e.; ortho phosphorus), total Kjeldahl nitrogen (TKN), nitrate (NO₃), ammonia (NH₃), and chloride ion concentrations (Cl). Water transparency, or water clarity, was determined with the use of a Secchi disk. A Secchi disk is a black and white patterned disk that is connected to a line or pole. To take a measurement, the Secchi disk is lowered slowly into the water column until the pattern is no longer visible. The depth at which the disk is no longer visible is then recorded.

3.1.3 PHYTOPLANKTON AND ZOOPLANKTON COLLECTION

Phytoplankton and zooplankton data collection occurred at the same time as water quality data collection by RCPW for 2014 and previous monitoring years. For phytoplankton analysis, a composite sample was collected using a plastic tube that was inserted vertically 2 m into the upper layer of the water column. This sample was emptied into a bucket, thoroughly mixed, and a sub-sample was collected and preserved. This water sample was placed in an enclosed cooler and taken back to the lab for analysis (RCPW, 2012).

To collect a zooplankton sample, a net tow was lowered down to the observed thermocline (in order to collect samples from the oxygenated layer of the lake), allowed to settle, and then pulled back up to the water surface at a rate of 1 m/sec. The net and capture bucket were drained by swirling the capture bucket which allowed the water to drain out of the net and screen. Once the volume was reduced to 100 mL, the contents of the capture bucket were poured into another container and preserved in a 5% formaldehyde solution, then taken back to the RCPW lab for analysis (RCPW, 2012).

3.1.4 AQUATIC VEGETATION SURVEYS

Point-Intercept Survey Method

In 2014, all lakes were surveyed by the Ramsey Conservation District (RCD) for aquatic vegetation presence and abundance using the point-intercept method. This method consisted of using a GPS to pre-select specific monitoring points throughout the full area of the lake. At each evenly spaced (70 m distance) point, a double-tined metal rake was thrown out 1 m from the boat, dragged a distance of 1 m and brought back into the boat. Plant species were identified and given an abundance ranking based on the amount collected on the rake (Table 3-1). Any plants floating on the water surface were also identified. RCD surveyed Como, Loeb, and McCarrons three times throughout the course of the year: spring, summer, and early fall. Crosby and Little Crosby Lakes were surveyed in summer and early fall. These two lakes were flooded by the Mississippi River in late spring/early summer, so a survey during spring was not completed.

Table 3-1: Average abundance rating and description for aquatic vegetation (RCPW, 2009).

Percent Cover of Tines	Abundance Ranking
81-100	5
61-80	4
41-60	3
21-40	2
1-20	1

Biovolume Survey Method

To collect data on submerged aquatic vegetation as well as data about the lake bottom, RCD used a Lowrance HDS-5 GPS enabled depth finder to assess evenly spaced transects at a minimum distance of 40 meters. The sonar log data that was collected was then analyzed by CI BioBase software to determine the depth of the lake and the amount of aquatic vegetation (biomass) along each transect. These surveys also produced information estimating lake area and lake water volume.

3.1.5 FISH STOCKING AND SURVEYS

Fish stocking occurs annually through the Minnesota DNR in an effort to improve fishing conditions on selected Minnesota lakes. Roughly 25% of Minnesota's 5,400 fishing lakes have a set stocking schedule (DNR, 2015f). Fish are stocked at different life stages depending on the desired effect in the lake. Table 3-2 describes the different types of fish used for stocking.

Table 3-2: Minnesota DNR fish stocking size definitions (DNR, 2015f).

Fry	Fish stocked in lakes shortly after hatching from eggs.
Fingerling	Fish harvested from rearing ponds after one summer of growth.
Yearling	Fish that are a year old at the time of stocking.
Adult	Fish more than 1 year old, usually transferred from other waters.

Fish surveys are conducted every 5-10 years by the DNR on the majority of Minnesota lakes. Surveys occur more frequently, however, on lakes of higher fishing importance. Through fish surveys, the DNR gains information on the species of fish in a lake in order to make management decisions and understand changes in lake water quality. Fish are collected using various field techniques based on the type and size of fish to be collected. These survey techniques include: gill netting (to capture larger, predator fish), trap netting (to capture smaller panfish), trawl and shoreline seines (to capture young fish), and electrofishing (to survey for bass, crappies and young walleyes). Once captured, information is recorded on the species, count, weight, and length, as well as how these measures compare to the normal expected range for the species (DNR, 2015f). In 2014, the DNR surveyed Crosby Lake, Loeb Lake, and Lake McCarrons. CRWD contracted with Wenck Associates, Inc. to conduct surveys on Como Lake and Little

Crosby Lake. These additional surveys on Como and Little Crosby were conducted in 2014 in order to obtain more information about fish populations on all CRWD lakes. Wenck Associates staff followed DNR procedures for sampling of fish in these lakes.

3.2 DATA ANALYSIS METHODS

3.2.1 MORPHOMETRIC DATA

Morphometric data was compiled for each lake. This included information regarding lake surface area, mean and maximum depth, littoral area percentage, lake water volume, watershed area, and watershed-to-lake area ratio. The watershed-to-lake area ratio represents how large the watershed is compared to the size of the lake. A high ratio indicates a large portion of land for potential runoff to the lake, while a low ratio indicates a smaller area conducting runoff. In general, having a lower ratio in urban areas decreases external nutrient loading to lakes, which in turn can result in improved water quality.

3.2.2 WATER QUALITY STANDARDS COMPARISON

A lake is considered eutrophic if it has high nutrient levels, low dissolved oxygen concentrations, and frequent algal blooms. Although some lakes are naturally eutrophic, many have become eutrophic as a result of anthropogenic activities. In order to identify eutrophic water bodies in Minnesota, the MPCA establishes eutrophication numeric water quality standards in lakes for TP, Chl-a, and Secchi depth, which were updated in 2014 (Table 3-3) (MPCA, 2014). In the NCHF ecoregion, a different standard exists for shallow and deep lakes. Seasonal means were determined for each of these parameters based on the monitoring events that occurred between May and September of 2014. A lake is considered impaired under MPCA standards if it exceeds the standard for TP concentration and either the Secchi disk depth or Chl-a concentration. Lakes that do not meet the standards may be placed on the MPCA 303(d) list of impaired waters. To account for differences in natural trophic state, the standards vary by ecoregion and lake type.

Table 3-3: Deep and shallow lake state water quality standards (MPCA, 2014).

Parameter	Deep Lake Standard ^{a,b}	Shallow Lake Standard ^{a,c}	Units	Source
TP*	<40	<60	µg/L	Minn. Stat. § 7050.0222
Chlorophyll-a	<14	<20	µg/L	Minn. Stat. § 7050.0222
Secchi depth	≥1.4	≥1.0	m	Minn. Stat. § 7050.0222

^a Standards apply to Class 2B waters in the North Central Hardwood Forest ecoregion. Class 2B waters are designated for aquatic life and recreational use. All standard concentrations apply to chronic exposure.

^b A deep lake is defined as a lake with a maximum depth > 15 feet or one in which < 80% of the lake is in the littoral zone.

^c A shallow lake is defined as a lake with a maximum depth < 15 feet or one in which > 80% of the lake is in the littoral zone.

*MPCA standard for TP is listed in mg/L, but has been converted to µg/L.

In 2014, CRWD staff changed the calculation of summer averages for TP and Chl-a in comparison to previously reported data to meet MPCA protocols specified in the Guidance Manual for Assessing the Quality of Minnesota Surface Waters (MPCA, 2014). As described in the chemical monitoring methods above, water quality samples are collected at discrete depths in the water column. Previously, only the surface water quality sample was used for the calculation of the summer average. If two samples were collected within the epilimnion, however, the average of these values should be used to find the daily average TP and Chl-a values, which can then be used to calculate the seasonal mean.

For the 2014 data and all historical TP and Chl-a data for all lakes, staff recalculated all annual averages to meet MPCA protocols. Where two samples were collected in the upper 2m of the water column and both of these samples were considered to be in the epilimnion (i.e. the stratification depth on the day the samples were collected was deeper than 2m), so the average of these values was calculated. To determine the seasonal mean, the average of the daily means from May – September (the growing season for CRWD lakes) was calculated. If the lake stratified higher than 2m and only one sample was collected from the epilimnion, this value was taken as the respective TP or Chl-a value for that day. While these revised calculations slightly changed the seasonal average values for various years, no historical trends were altered significantly.

3.2.3 LAKE GRADING SYSTEM

CRWD uses a lake grading system in order to give a qualitative measure to the water quality data and compare between years monitored (Table 3-4). This is based on the Metropolitan Council's lake grading system that is used to compare lakes across the metro region and to offer a non-technical value of lake water quality that is more understandable to a wide variety of audiences (Osgood, 1989). The seasonal means of TP, Chl-a, and Secchi depth were examined for 2014 and previous years and grades were based on ranges for each parameter. The range is weighted such that a certain percentage of Minnesota lakes fall into each grade. Each grade corresponds not only to ranges in the three lake eutrophication parameters (TP, Chl-a, and Secchi depth), but also to a recreational value for the lake that provides a description of user quality (MC, 2015b). CRWD assigned each letter grade a numerical value (A = 5, B = 4, C = 3, D = 2, F = 1), and the average of these three values provided an overall lake grade (Table 3-5). The ranges in Table 3-5 are based off methods used by the Minnehaha Creek Watershed District in their monitoring reports (MCWD, 2015).

Table 3-4: Water quality parameter lake grade ranges, percentile ranges, and description of lake grade user quality (MC, 2015b; Osgood, 1989).

Grade	Percentile	TP (µg/l)	Chl-a (µg/l)	Secchi (m)	Description of User Quality
A	<10	<23	<10	>3.0	Full recreational use capability
B	10-30	23-32	10-20	2.2-3.0	Very good water quality but some recreational use impairment
C	30-70	32-68	20-48	1.2-2.2	Average water quality but are recreationally impaired
D	70-90	68-152	48-77	0.7-1.2	Severely impaired recreational use
F	>90	>152	>77	<0.7	Extremely poor water quality; little to no recreational use

Table 3-5: CRWD overall lake grade ranges.

Grade	Range
A	4.67 - 5.00
A-	4.34 - 4.66
B+	4.01 - 4.33
B+	3.67 - 4.00
B-	3.34 - 3.66
C+	3.01 - 3.33
C	2.67 - 3.00
C-	2.34 - 2.66
D+	2.01 - 2.33
D	1.67 - 2.00
D-	1.34 - 1.66
F	< 1.33

3.2.4 PHYTOPLANKTON AND ZOOPLANKTON LAB ANALYSIS

All methods for lab analysis of phytoplankton and zooplankton were obtained from Ramsey County Lake Management Laboratory (RCLML), a part of RCPW (RCPW, 2012). In the lab, the preserved phytoplankton sample was analyzed and identity/counts were recorded. The classes/phylums that were identified are listed and described in Table 3-6 (Kalff, 2002; UCMP, 2015).

Table 3-6: Phytoplankton types, taxonomic classification, description, and water quality significance.

Phytoplankton	Classification	Description	Water Quality Significance
Bacillariophyta	Class	Diatoms	Large populations suggest higher levels of dissolved silica needed to build external skeletons
Chlorophyta	Phylum	Green algae	Greatly contribute to freshwater lake species richness; contribute most significantly to biomass of eutrophic systems
Chrysophyta	Class	Golden-brown algae	Not overly abundant in eutrophic lakes; more plentiful in oligotrophic, clear-water lakes
Cryptophyta	Phylum	Cryptomonads	Most prevalent in oligotrophic and mesotrophic lakes; division does not contain an abundance of species types
Cyanophyta	Phylum	Blue-green algae	Indicative of highly nutrient-rich (eutrophic and hypereutrophic) lakes; large blooms are aesthetically displeasing and some can be toxic
Euglenophyta	Phylum	Euglenoids	Generally small contribution to overall biomass except in small, highly eutrophic bodies of water
Pyrrophyta	Phylum	Dinoflagellates	Typically contribute small portion of total biomass or species richness in temperate lakes

To analyze zooplankton, the preserved sample from the field was measured and a subvolume was analyzed for identity/counts. The zooplankton that were identified in this process are shown and described in Table 3-7 (Kalff, 2002). The Cladocerans identified during analysis consisted

of *Daphnia*, *Bosmina*, *Chydorus*, *Ceriodaphnia*, *Diaphnosoma*, and *Leptodora*. These genus-level organisms were combined and grouped under the heading ‘Cladocera’ for analysis.

Table 3-7: Zooplankton types, taxonomic classification, description, and water quality significance.

Zooplankton	Classification	Description	Water Quality Significance
Cyclopoida	Order	Carnivorous copepods	Primarily carnivorous crustaceans; feed on other zooplankton and fish larvae but also eat algae, bacteria, and detritus
Calanoida	Order	Omnivorous copepods	Crustaceans that feed on ciliates as well as algae; change diet based on multiple variables including season and food availability
Nauplii	Genus	Juvenile copepods	Classified as <i>nauplii</i> during the first 5 or 6 molts (moulting occurs 11 times before adulthood) during the life span of a copepod
Rotifera	Phylum	Soft-bodied, multicellular invertebrates	Name originates from rotating wheel of cilia by mouth; important among invertebrates as many species can produce multi-generations per year
Cladocera	Suborder	Type of crustacean	Mainly important filter-feeders covered by a hard cover; specific species <i>Daphnia</i> are main food source for planktivorous fish

Techniques for creation of phytoplankton and zooplankton figures in the ensuing individual lake results sections were based off methods used in the Minneapolis Park and Recreation Board 2012 Water Resources Report (MPRB, 2015). There are two figures for both phytoplankton and zooplankton. The first figure for phytoplankton compares total phytoplankton concentration and TP concentration from May to September. The first figure for zooplankton compares total zooplankton density and Chl-a concentration from May to September. The second figures depict the relative abundance of each type of phytoplankton and zooplankton in order to examine changes in their populations throughout the months monitored.

3.2.5 AQUATIC VEGETATION ANALYSIS

Biovolume Analysis

Sonar data was entered into CI BioBase software that generates aquatic vegetation and bathymetric maps (CIBB, 2015). The biovolume heat maps were coded by different color zones to highlight differences in cover of aquatic vegetation. Red indicates that 100% of the water column is being taken up by biovolume, or vegetation is growing to the water surface, and blue indicates 0%, or bare lake bottom. Statistics calculated along with the maps included plant biovolume (the percentage of the water column that is vegetation) and percent area covered (the amount of the lake area where vegetation exists) (CIBB, 2015).

Point-Intercept Analysis

Aquatic vegetation has been monitored infrequently in past years on CRWD lakes. Establishing a baseline of vegetation data for all lakes will be a key factor in making future monitoring decisions. Aquatic vegetation within a lake is dependent on many different factors, including: water clarity, water chemistry, and physical lake parameters (including depth, sediment substrate type, lake size/shape, and shoreline vegetation). Not only does aquatic vegetation stabilize bottom sediment, plants also provide habitat for aquatic animals and are usually the main

primary producers in shallow lakes (Kalff, 2002). Collecting data on aquatic vegetation provides baseline information on what vegetation is in the lake, where it exists on the lake, and how much is present. Measuring annual changes in these factors can help identify trends in aquatic vegetation and water quality.

Collecting data on aquatic vegetation using the point-intercept method allowed for two primary analyses to occur: computation of percent occurrence and average abundance. Percent occurrence represents the number of times a plant species was observed divided by the number of total sample sites where vegetation was observed. This information gives a good picture of the most common species of aquatic vegetation found on the lake. Average abundance is calculated as the average of the abundance rankings (measured at each location found) for a species. This shows how much vegetation of each species is occurring at the locations where vegetation is noted. A high average abundance ranking indicates thick cover of a species where it is observed. Conversely, a low average abundance ranking indicates minimal growth of a species.

4 CLIMATOLOGICAL SUMMARY

4.1 PRECIPITATION DATA COLLECTION METHODS

CRWD utilizes climatological data collected by the Minnesota Climatology Working Group (MCWG) at the University of Minnesota-St. Paul and National Weather Service (NWS) at the Minneapolis-St. Paul International Airport (MSP) to assist in calculating annual precipitation, runoff, and loading.

MCWG records precipitation every fifteen minutes from an automatic rain gauge located approximately two miles west of the CRWD office. The data is reported on a public website (<http://climate.umn.edu/>). Rainfall totals (15-minute and daily) were recorded by CRWD from the MCWG website (MCWG, 2015b). Snow and ice totals were not accurately reported by MCWG due to equipment limitations, so NWS snow and ice totals were used instead. The MCWG rain gauge was used as CRWD's primary precipitation monitoring station for rainfall because of the gauge's close proximity to the District.

The NWS weather station at MSP, located approximately ten miles south of the CRWD office, records many climate variables for each day, including: maximum, minimum, and average temperature; rainfall; snowfall and snow water equivalent; and depth of snowpack. Data is reported on a public website (<http://www.weather.gov/mpx/mspclimate>). If a snow or ice event occurred, the NWS daily precipitation totals were utilized by CRWD since their measurement equipment more accurately measures snow-water and ice-water equivalents than the MCWG gauge.

4.2 2014 PRECIPITATION RESULTS

Table 4-1 lists 2014 daily precipitation totals, 2014 monthly precipitation totals, the 30-year monthly normal (1981-2010) (NOAA, 2015a), and the 2014 departure from historical monthly normals. Monthly totals are compared to the 30-year monthly normals at MSP (Table 4-1 and 4-2; Figure 4-1).

In 2014, almost all precipitation data from January to April and November was provided by NWS because the events during this time period were either snow or ice (Table 4-2). The May through October precipitation data, as well as the majority of the December data, was provided by MCWG since it was primarily rainfall that occurred.

The 2005-2014 CRWD annual precipitation data was compared to the NWS 30-year normal for the Minneapolis-St. Paul region (Table 4-1; Figure 4-3). The NWS 30-year normal is recalculated every 10 years. In 2010, the NWS 30-year normal was recalculated for 1981-2010 to be 30.61 inches (formerly 29.41 inches (1971-2000)).

The total amount of precipitation recorded in CRWD in 2014 was 35.66 inches, which was 5.05 inches above NWS the 30-year normal (Table 4-1 and 4-2; Figure 4-3). This was also the fourth wettest year since monitoring began in CRWD in 2005. Figure 4-2 is a cumulative precipitation plot for 2014 which shows the total accumulated amount of precipitation throughout the entire year as well as fluctuations in precipitation trends and significant precipitation events. In general, precipitation throughout 2014 was inconsistent with extremely wet months followed by very dry months.

Table 4-1: CRWD annual precipitation totals and departure from the NWS 30-year normal.

Year	Precipitation (inches)^a	Departure from NWS Normal
2005	35.98	(+) 5.37"
2006	31.69	(+) 1.08"
2007	29.72	(-) 0.89"
2008	21.67	(-) 8.94"
2009	23.34	(-) 7.27"
2010	36.32	(+) 5.71"
2011	33.62	(+) 3.01"
2012	30.26	(-) 0.35"
2013	36.36	(+) 5.75"
2014	35.66	(+) 5.05"
NWS 30-Year Normal	30.61	--

^a Annual precipitation reported by the Minnesota Climatology Working Group (MCWG) and National Weather Service (NWS)

From January to March 2014, snowfall was a major source of precipitation which contributed to a significant amount of spring recharge and runoff. In total, 76.2 inches of snow fell during the winter of 2014, which was 21.8 inches greater than the 30-year normal (Table 4-4; Figure 4-4).

June 2014 was the wettest June and wettest month overall in Minnesota's modern record (DNR, 2015n) with 9.1 inches occurring, which was 4.85 inches above the 30-year normal (Table 4-2; Figure 4-1 and 4-2). Along with a wet June, April and May 2014 were also particularly wet with both months being well-above the monthly normals (Figure 4-1). Cumulatively, the wet spring months of April, May, and June represented 57% of the total annual precipitation that occurred in 2014.

In contrast, July and August were dry with both months recording below normal precipitation (Figure 4-1 and 4-2). Fall 2014 was also dry, with September and October 2014 being significantly below the 30-year normal.

Table 4-2: Daily and monthly precipitation totals for 2014 compared to the NWS 30-year normal.

Day	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
1	0.00	0.00	0.00	0.02	0.07	0.76	0.00	0.08	0.08	0.63	0.00	0.00	
2	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.57	0.00	0.00	
3	0.12	0.00	0.02	0.68	0.00	0.00	0.00	0.00	0.27	0.14	0.00	0.00	
4	0.02	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.00	
5	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.10	0.00	
6	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.01	0.00	
7	0.00	0.00	0.00	0.00	0.11	1.07	0.48	0.00	0.00	0.00	0.03	0.01	
8	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.71	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.31	0.10	0.00	0.28	0.00	
11	0.00	0.00	0.00	0.00	0.55	0.21	0.92	0.13	0.00	0.00	0.04	0.00	
12	0.00	0.03	0.00	0.11	0.26	0.00	0.65	0.01	0.00	0.00	0.00	0.00	
13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
14	0.26	0.00	0.00	0.00	0.00	1.33	0.17	0.00	0.00	0.00	0.00	0.03	
15	0.03	0.12	0.00	0.00	0.00	0.57	0.00	0.00	0.08	0.00	0.16	0.19	
16	0.05	0.00	0.00	0.68	0.00	0.45	0.00	0.00	0.00	0.00	0.01	0.04	
17	0.00	0.32	0.06	0.00	0.00	0.07	0.00	0.28	0.00	0.00	0.00	0.00	
18	0.17	0.00	0.15	0.00	0.00	0.26	0.00	0.01	0.00	0.00	0.00	0.02	
19	0.00	0.00	0.06	0.16	1.81	3.16	0.00	0.07	0.00	0.00	0.02	0.00	
20	0.01	0.83	0.00	0.06	0.00	0.00	0.00	0.01	0.23	0.00	0.00	0.00	
21	0.02	0.06	0.00	0.07	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.19	
22	0.01	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.01	0.00	0.00	0.08	
23	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.08	0.03	0.00	
24	0.08	0.01	0.08	0.68	0.00	0.00	0.00	0.11	0.08	0.00	0.01	0.00	
25	0.11	0.00	0.00	0.01	0.03	0.00	0.41	0.00	0.00	0.00	0.00	0.00	
26	0.09	0.00	0.00	0.12	0.21	0.00	0.00	0.01	0.00	0.00	0.17	0.05	
27	0.00	0.00	0.44	2.29	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.22	
28	0.00	0.04	0.00	1.03	0.00	0.95	0.00	0.03	0.00	0.00	0.08	0.00	
29	0.00		0.00	0.60	0.00	0.03	0.00	1.21	0.10	0.00	0.00	0.00	
30	0.44		0.00	0.07	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	
31	0.00		0.03		0.73		0.00	0.71		0.00		0.00	Total
Monthly Total	1.42	1.41	0.84	6.95	4.42	9.1	2.74	3.85	1.67	1.46	0.96	0.84	35.66
Monthly Normal	0.9	0.77	1.89	2.66	3.36	4.25	4.04	4.3	3.08	2.43	1.77	1.16	30.61
Departure from Normal	0.52	0.64	-1.05	4.29	1.06	4.85	-1.3	-0.45	-1.41	-0.97	-0.81	-0.32	5.05
	Data supplied by NWS-MSP												
	Data supplied by UMN Climatological Observatory												
	No Date												

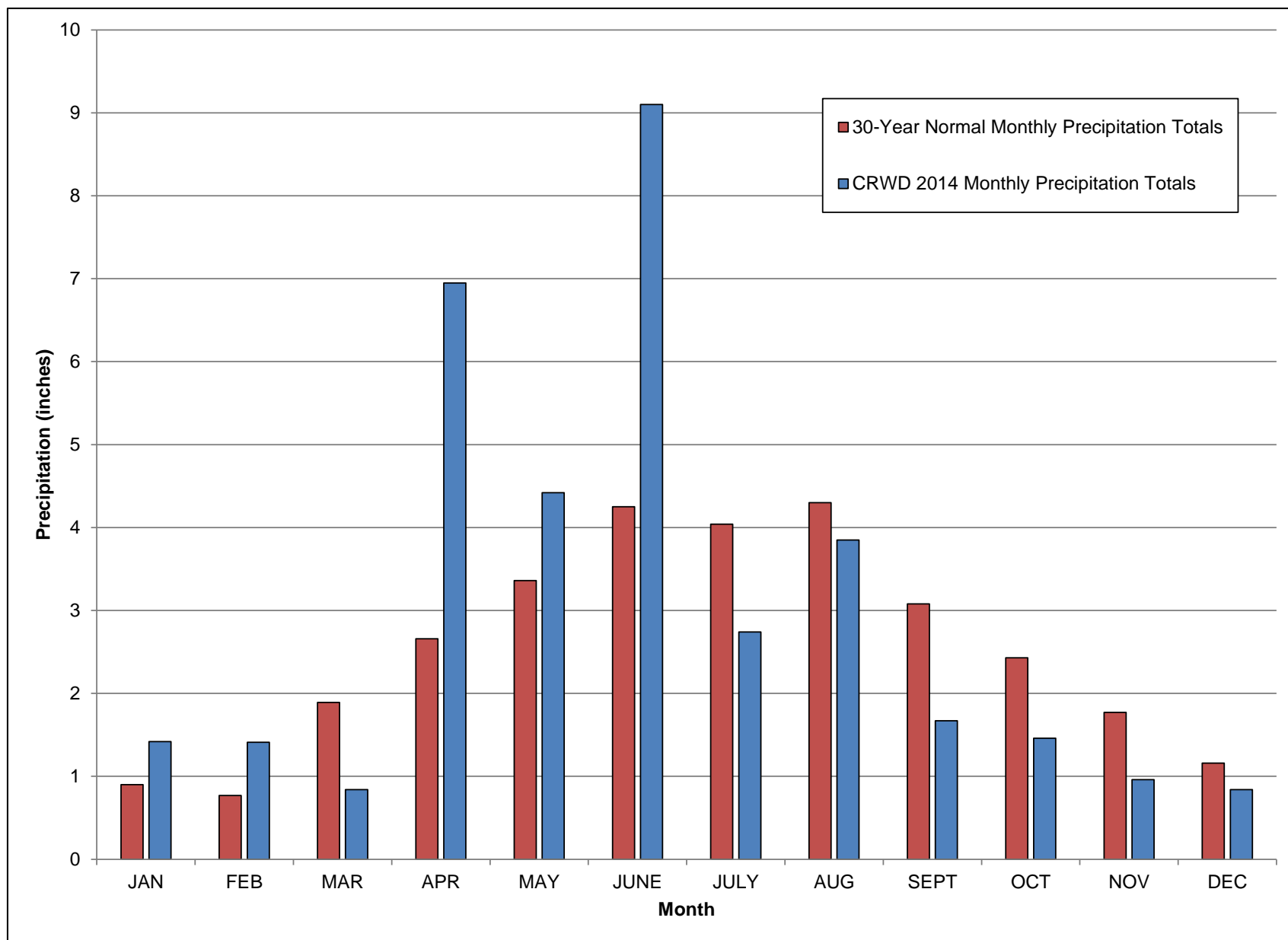


Figure 4-1: 30-year normal and 2014 monthly precipitation totals for CRWD.

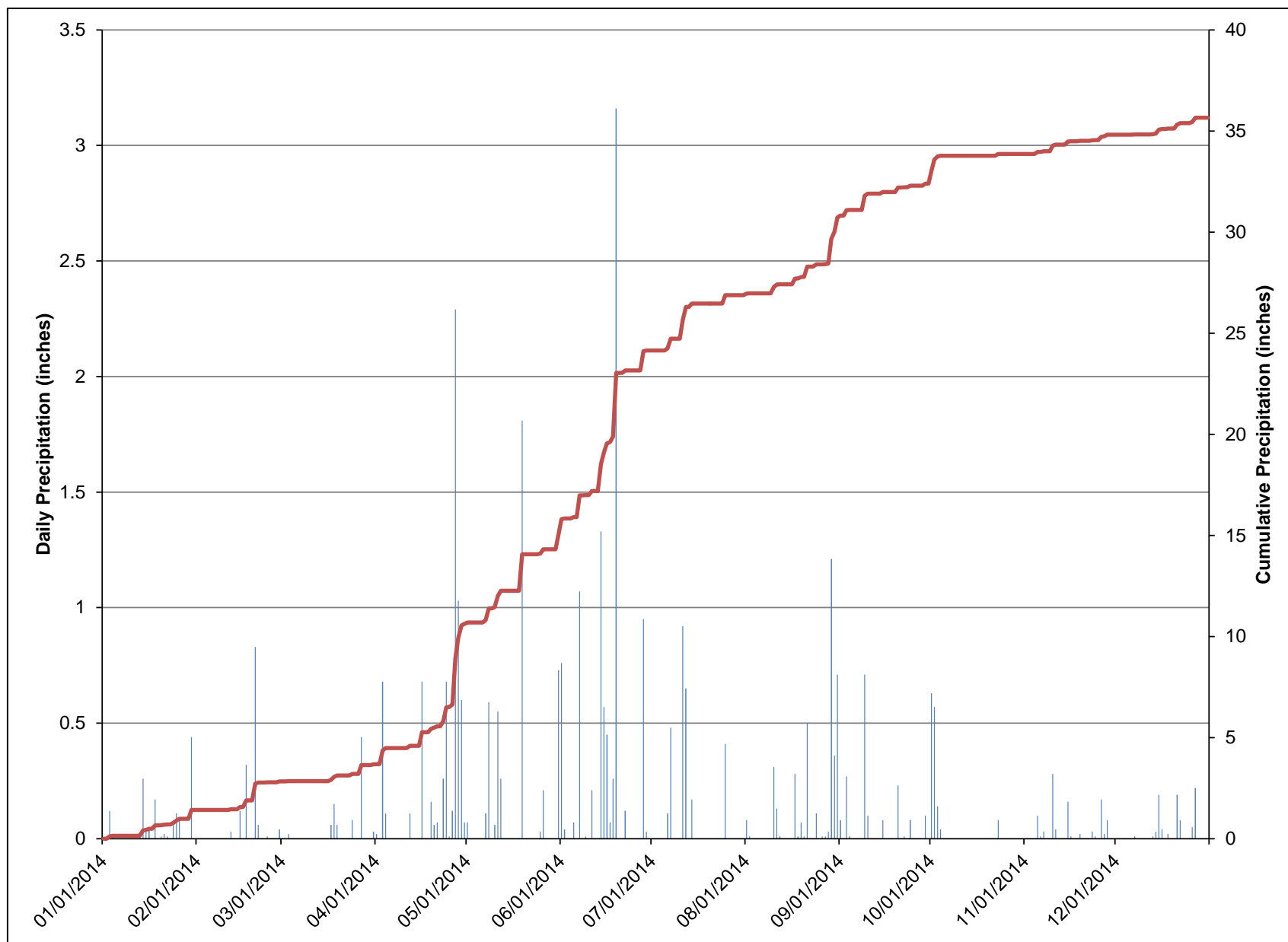


Figure 4-2: Daily precipitation totals and cumulative precipitation for January to December 2014.

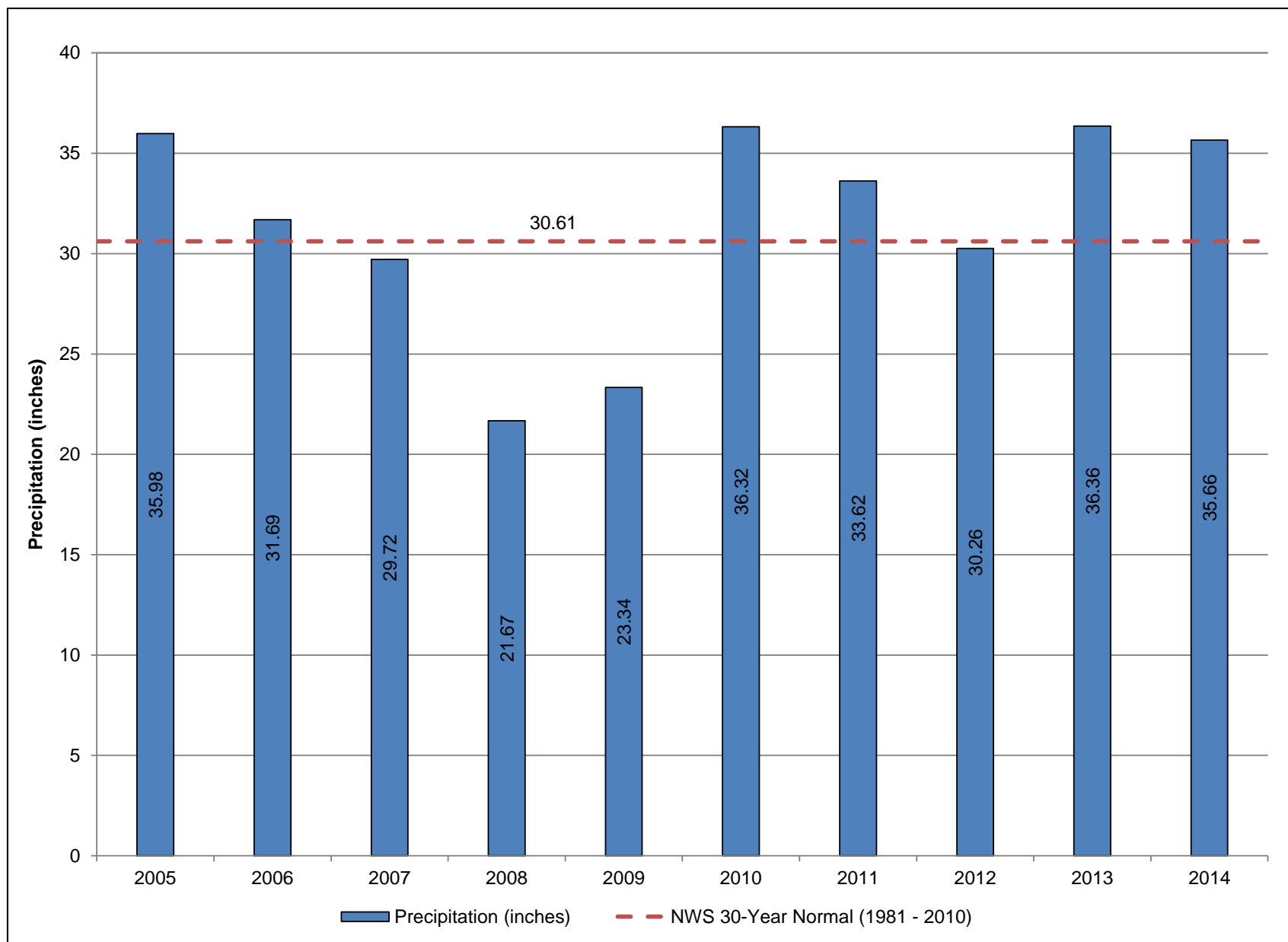


Figure 4-3: Annual precipitation totals (2005-2014) observed in CRWD by MCWG.

4.3 2014 NOTABLE CLIMATOLOGICAL EVENTS

In 2014, climatic patterns were unique by fluctuating between extreme wet and dry periods with several high intensity, short duration precipitation events. Also, 2014 was unique in that the winter was extraordinarily cold with deep snow and a very late spring start.

Table 4-3 shows the most intense rain events in 15-minute, 1-, 6-, and 24-hour intervals during 2014. The most intense precipitation event occurred on June 19, 2014, which recorded the most intense 15-minute, 1-, 6-, and 24-hour intervals for the entire year (Table 4-3). It was also the highest daily total for June ever recorded at MSP Airport (NOAA, 2015b). During this event, 3.16 inches fell in 24 hours, with three 15-minute intervals recording over a quarter-inch of rain (Table 4-3). There were also a few other notable events in 2014, including a 2.4 inch in 24-hour event on April 27, a 1.78 inch in 6-hour event on May 19, and a 0.81 inch in 1-hour event on August 29 (Table 4-3).

Table 4-3: Rainfall intensity statistics for 2014 from MCWG rain gauge data.

Rainfall Intensity		
Time Period	Date & Event End Time	Amount (in)
15-minute	6/19/14 8:15	0.39
	6/19/14 3:15	0.39
	6/19/14 3:30	0.38
1-hour	6/19/14 3:30	1.18
	8/29/14 16:45	0.81
	6/7/14 7:45	0.78
6-Hour	6/19/14 8:30	2.43
	5/19/14 15:00	1.78
	6/15/14 1:00	1.33
24-Hour	6/19/14 19:30	3.16
	4/27/14 18:15	2.4
	6/15/14 8:45	1.88

Snowpack in CRWD was also a significant climatic variable in 2014. The 2014 snowfall total of 76.2 inches measured at MSP was 21.8 inches higher than the 30-year normal of 54.5 inches (Table 4-4). The last date with a 1 inch snowpack measured at MSP was April 5 (NWS, 2015) (Figure 4-4). This was only 5 days later than the normal date of March 31 (DNR, 2015l).

Daily snowpack depths recorded at MSP were plotted against daily high temperature in Figure 4-4 (NWS, 2015). A complete melt was observed from March 27 to March 30 (2 inches to 0 inches). There was a brief two-day period of snowpack recorded again from April 4 to April 6 (resulting from a storm that dropped 5 inches on April 3 and 1.5 inches on April 4), before melting away permanently for the spring. Snowpack reached a maximum depth of 24 inches on February 21, and stayed deeper than 15 inches until March 11 when the temperature began

warming. Significant snowfall events occurred on February 20 (8.4 inches), January 20 (6.4 inches), and April 3 (5 inches). The February 20 storm event was unique in that a “thundersnow” occurred, in which thunder accompanied the snowfall during this storm event.

Snowmelt is a significant driver of hydrology in late winter and early spring and is dependent upon many factors such as the amount of snowpack and temperature. Snowpack levels stayed consistently high as a result of multiple significant snowfall events early on in the season, as well as record-low temperatures that did not cause significant melt events to occur. Therefore, there was a lot of snow present to impact snowmelt and runoff in the spring.

Table 4-4: Summary of 2014 climatological events.

2014 Climate Summary			
Variable	2014	Average	Notes
Total Precipitation (inches)	35.66	30.61	5.05" higher than 30-yr normal
Total Snow (inches)	76.2	54.4	21.8" higher than 30-yr normal
Last Significant Snowfall	4/4 (1.5")	N/A	Variable - No data on averages
Last Spring date with greater than 1" snowpack	4/5 (4")	4/2	3 days later than normal
Spring Ice Out	4/18	4/5	13 days later than normal
Fall Leaf Off	10/27	N/A	Later than normal

Another unique climatic pattern in 2014 was extreme cold temperatures that occurred from January to March 2014. The jet stream swung down from the Arctic and positioned itself over Minnesota for much of January, February, and March with periods of daily high temperatures not exceeding 0 degrees (Figure 4-4). This cold phenomenon was referred to as the “Polar Vortex”.

Due to extraordinarily cold winter and spring temperatures, ice out on CRWD lakes occurred generally two weeks later than normal in 2014. Historical median ice out dates have not been established for any of the five CRWD lakes, nor were any observations made by CRWD on the lakes in 2014 (DNR, 2015j; DNR, 2015m). However, the DNR has collected annual and historical median ice out dates for lakes nearby CRWD, including the five observed in Table 4-5.

Table 4-5: Summary of ice out dates for Twin Cities lakes nearby CRWD (DNR, 2015j; DNR, 2015m).

Lake Name	2014 Ice Out Date	Historical Median Ice Out Date
Lake Nokomis	April 17	April 5
Powderhorn Lake	N/A	April 4
Lake Josephine	N/A	April 7
Lake Owasso	April 18	April 6
Lake Phalen	April 18	April 5

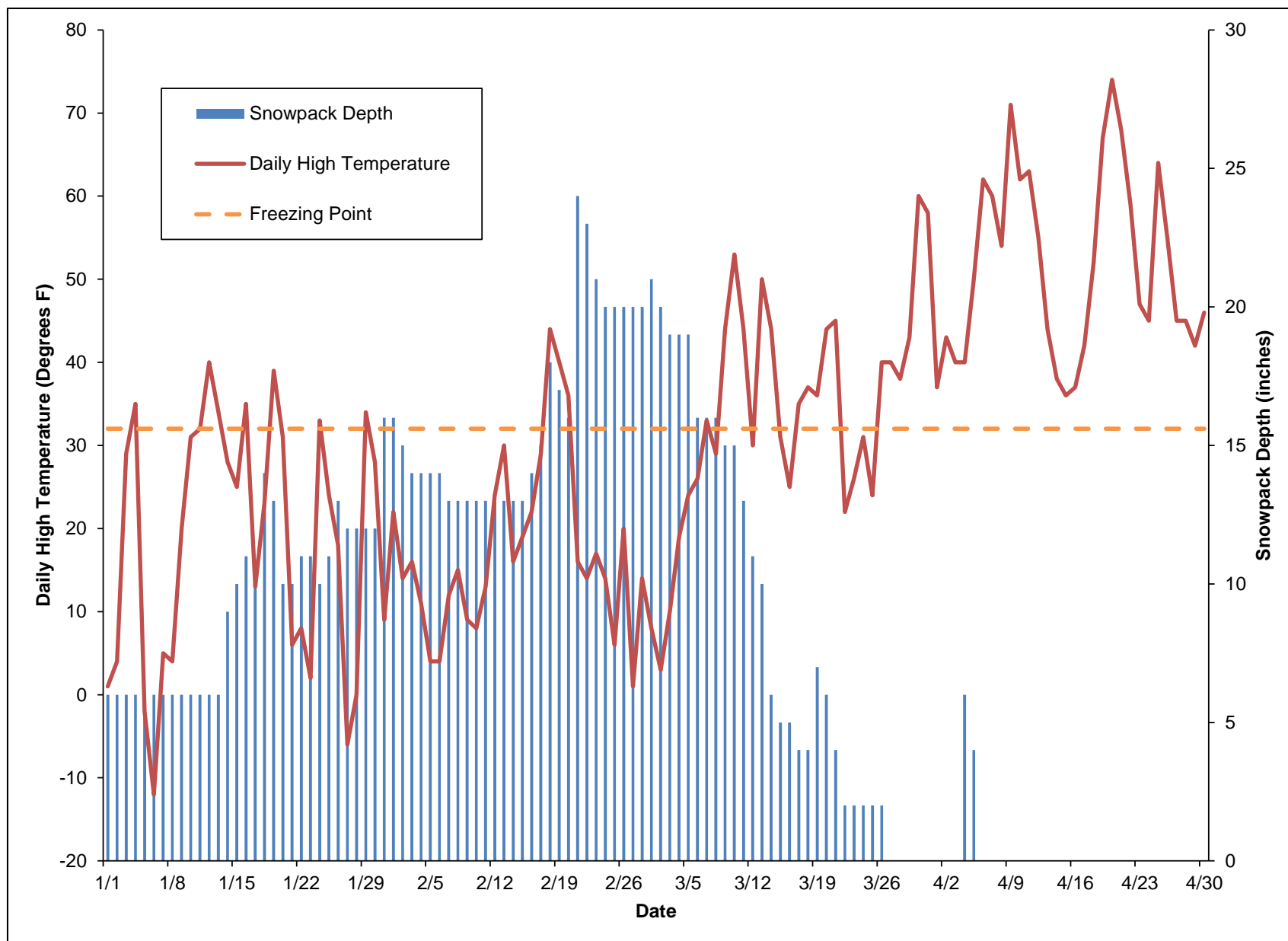


Figure 4-4: Daily temperature highs and snowpack depths from January to April 2014 as observed at MSP (NWS, 2015).

5 CRWD LAKES RESULTS SUMMARY

5.1 OVERALL DISTRICT LAKES RESULTS

Table 5-1 shows the 2014 averages, historical averages, and lake standards for TP and Chl-a concentrations and Secchi depth for each lake. The data is shown graphically in Figures 5-1, 5-2, and 5-3. As stated in the methods, a lake is considered impaired if it does not meet the MPCA standard for TP and either Chl-a or Secchi disk depth. In 2014, Como Lake and Crosby Lake did not meet the standards. Little Crosby Lake, Loeb Lake, and Lake McCarrons all met the MPCA eutrophication standards. Crosby Lake, Little Crosby Lake, and Lake McCarrons all exhibited a decline in water quality compared to 2013. Como Lake showed slight improvements in water quality over 2013, while Loeb remained consistent with past years of stable water quality.

In 2014, CRWD determined lake grades for each of its lakes based on the lake grade system created by the Metropolitan Council (Table 5-2) (Osgood, 1989). Two out of the five CRWD lakes were given good grades, with Loeb Lake receiving the highest grade of 'B+' and McCarrons receiving the good grade of 'B'. An average water quality grade of 'C' was given to Little Crosby Lake, whereas both Como and Crosby Lake received the lowest grade of 'D+'. All five of the lakes were relatively close to their average historical grades in 2014, but there were no improvements for any of the lake grades compared to the historic average (Table 5-2). Crosby and Little Crosby both decreased by a full grade and Loeb decreased by half a grade point in 2014 compared to their historical average grade. Como Lake and Lake McCarrons received the same lake grade for 2014 compared to the historical average.

Table 5-1: CRWD 2014 average, historical average, and lake standards for TP/Chl-a/Secchi depth.

Lake	2014 Averages			Historical Averages			State Lake Standards		
	TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TP (µg/L)	Chl-a (µg/L)	Secchi (m)	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Como	160	32.3	1.2	175	33.9	1.5	<60	<20	≥1.0
Crosby	211	21.0	1.6	71	10.2	2.4	<60	<20	≥1.0
Little Crosby	129	19.4	1.9	79	7.1	2.7	<60	<20	≥1.0
Loeb	29	6.0	2.7	29	5.9	3.3	<60	<20	≥1.0
McCarrons	33	8.9	2.7	34	9.8	2.9	<40	<14	≥1.4
	Value does not meet the state standard								
	Value meets the state standard								

Table 5-2: CRWD 2014 and historical lake grades and averages for TP/Chl-a/Secchi depth.

Lake	2014 Lake Grade			2014 Average	Historical Lake Grade			Historical Average
	TP	Chl-a	Secchi		TP	Chl-a	Secchi	
Como	F	C	C	D+	F	C	C	D+
Crosby	F	C	C	D+	D	B	B	C+
Little Crosby	D	B	C	C	D	A	B	B
Loeb	B	A	B	B+	B	A	A	A
McCarrons	C	A	B	B	C	A	B	B

5.2 SUMMARY OF INDIVIDUAL LAKES RESULTS

5.2.1 COMO LAKE

Como Lake has been monitored since 1984, so historical averages represent 30 years of data. Como Lake degraded in water quality for all three of the eutrophication parameters in 2014 in comparison to the historical average (Figures 5-1, 5-2, and 5-3). Como Lake has historically not met shallow lake state standards for TP and Chl-a concentrations. This was the case in 2014 as well. Como Lake has historically met shallow lake state water quality standards for Secchi depth, and did once again in 2014.

5.2.2 CROSBY LAKE

Crosby Lake has been monitored since 1999, so historical averages represent 15 years of data. Crosby Lake degraded in water quality for TP concentration and Chl-a concentration in 2014, and did not change for Secchi depth when compared to the historical average (Figures 5-1, 5-2, and 5-3). The 2014 average TP concentration (211 µg/L) was 197% higher than the historical average (71 µg/L). Crosby Lake has historically been impaired for TP concentration, which was also the case in 2014. Crosby Lake has historically met water quality standards for Chl-a concentration and Secchi depth, which was the case for Secchi depth, but not Chl-a concentrations in 2014. As a result, 2014 was the first year that Crosby Lake did not meet the MPCA state eutrophication standards, as it was the first time in the monitoring record that it did not meet both TP and Chl-a.

5.2.3 LITTLE CROSBY LAKE

Little Crosby Lake has been monitored since 2011, so historical averages represent only three years of data. In 2014, Little Crosby Lake degraded in water quality when compared to the historical averages for all three eutrophication parameters (Figures 5-1, 5-2, and 5-3). Little Crosby Lake has historically not met shallow lake standards for TP, but met standards for Chl-a and Secchi depth. This was the case as well for 2014.

5.2.4 LOEB LAKE

Loeb Lake has been monitored annually since 2003, so historical averages represent 11 years of data. In 2014, Loeb Lake degraded in water quality when compared to the historical averages of all three water quality parameters, but only by slight amounts (Figures 5-1, 5-2, and 5-3). Loeb Lake has historically met all of the shallow lake state standards. Although the lake had poorer water quality in 2014 compared to previous years, the lake still met the eutrophication standards and exhibits the best water quality of any of the District Lakes.

5.2.5 LAKE MCCARRONS

Lake McCarrons has been monitored annually since 1988, so historical averages represent 26 years of data. When compared to the historical average, the lake improved for Chl-a, showed no change for TP, and degraded for Secchi depth for the 2014 monitoring year (Figures 5-1, 5-2, and 5-3). The historical averages, however, are skewed towards worse water quality as a result of including the years of monitoring data prior to the 2004 alum treatment in the average. Since the alum treatment occurred in 2004, 2014 showed the most degraded water quality values for all three parameters. Nevertheless, Lake McCarrons still met all of the deep lake standards in 2014; the historical averages met all of the deep lake standards as well.

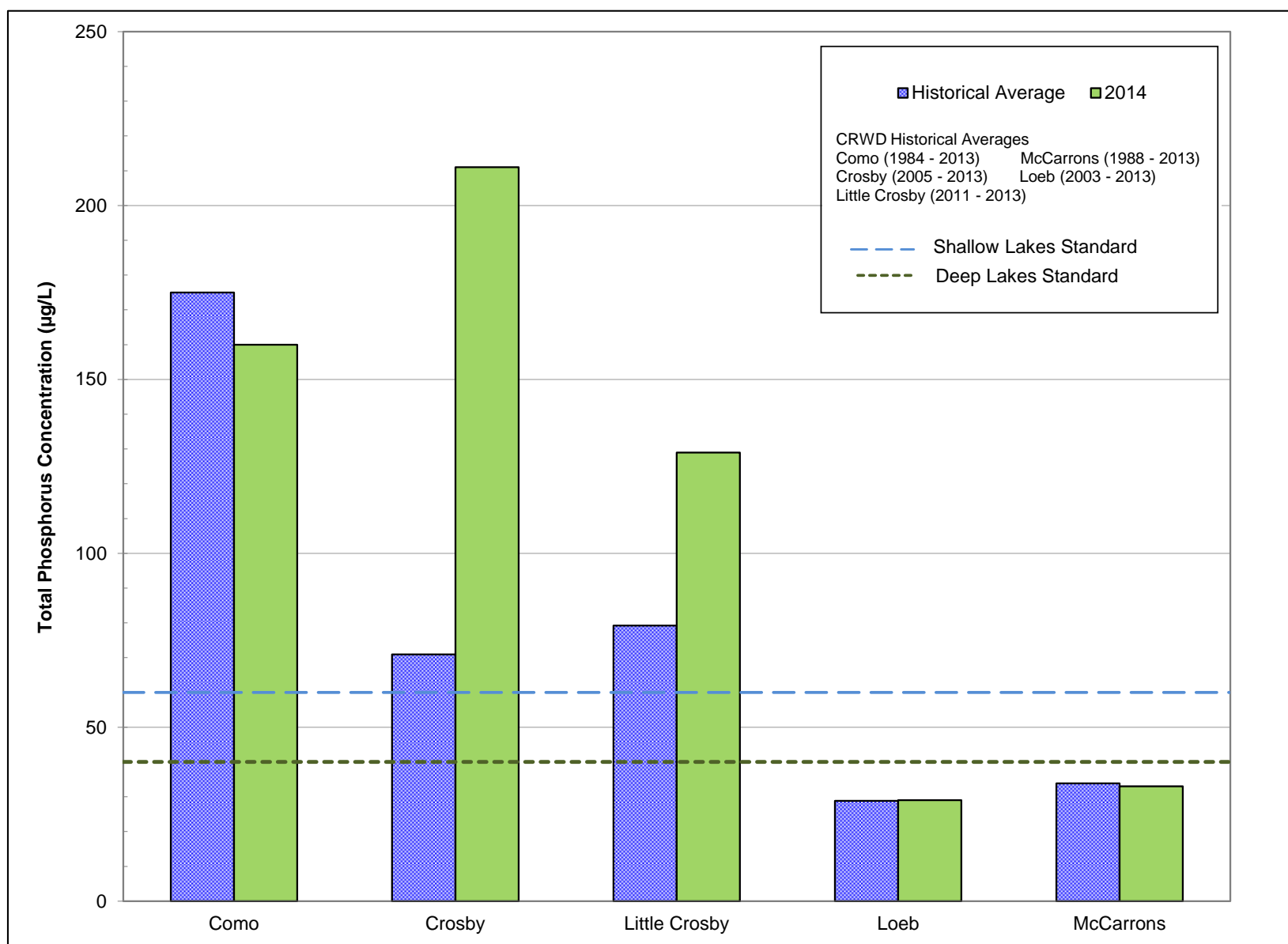


Figure 5-1: CRWD 2014 vs. historical average TP concentrations and lake standard comparisons.

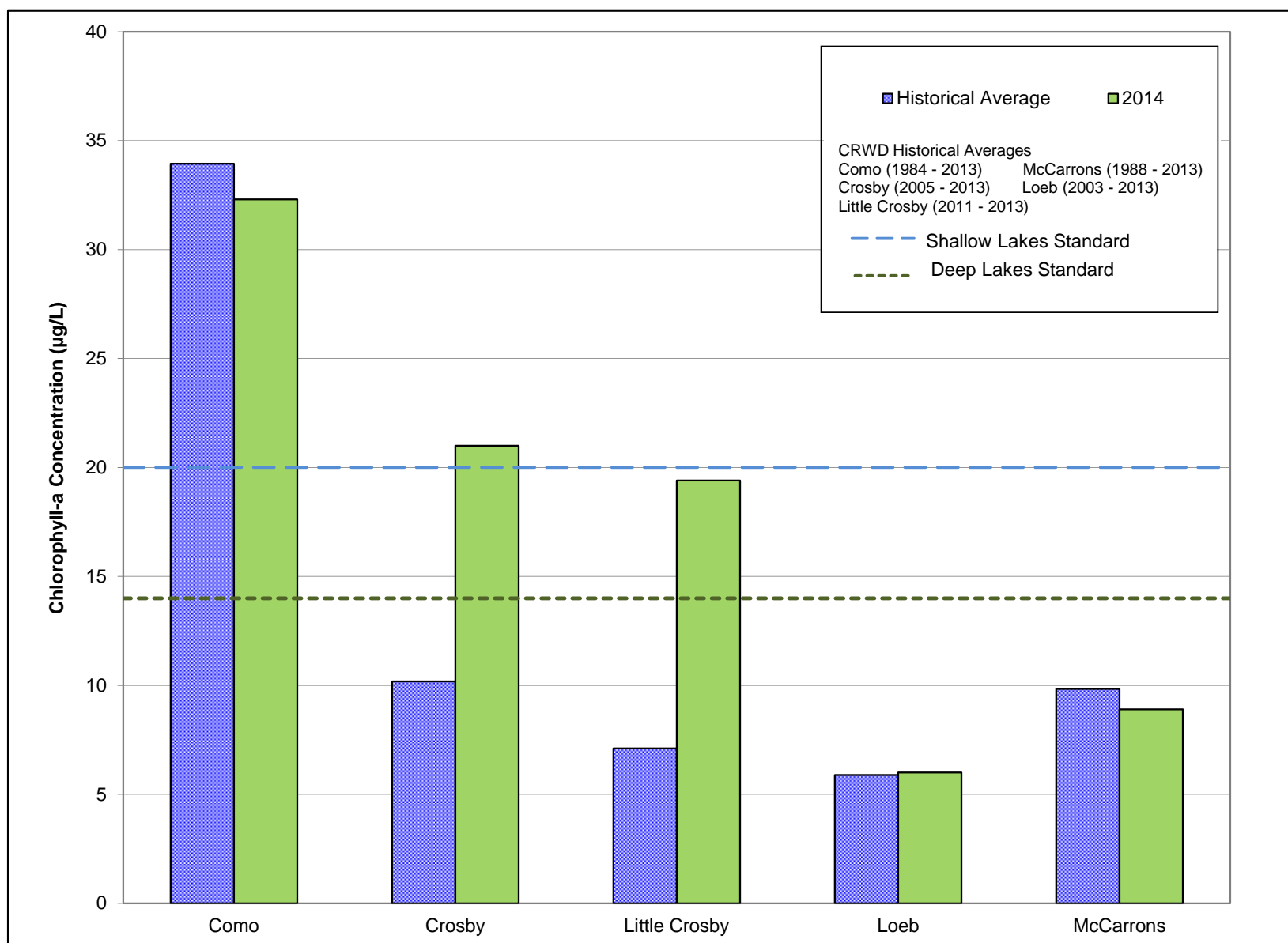


Figure 5-2: CRWD 2014 vs. historical average Chl-a concentrations and lake standard comparisons.

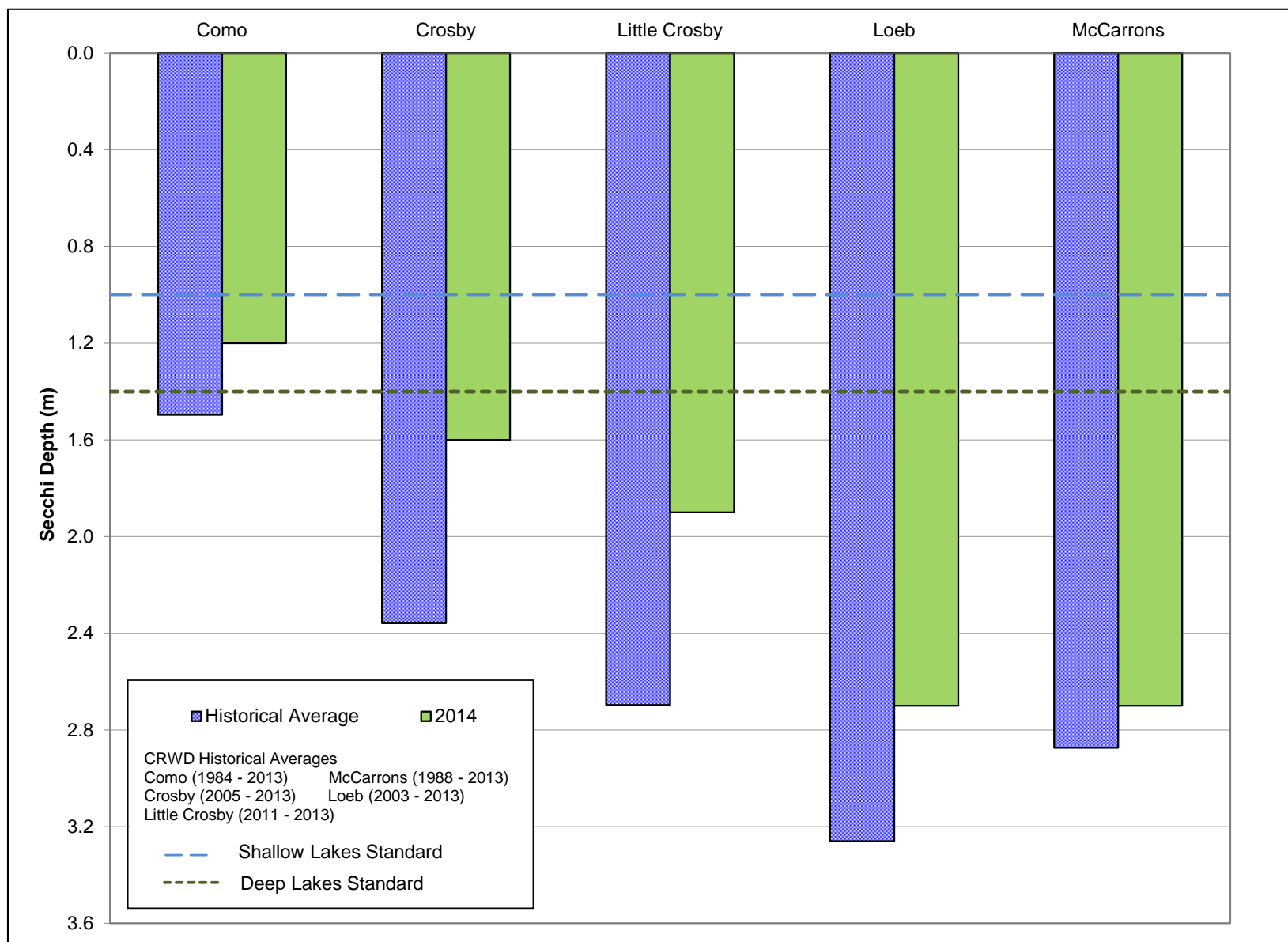


Figure 5-3: CRWD 2014 vs. historical average Secchi depths and lake standard comparisons.

6 COMO LAKE RESULTS

6.1 COMO LAKE BACKGROUND



Figure 6-1: View of the northwest shoreline of Como Lake.

Como Lake, a 70.5 acre shallow lake located in St. Paul's 348 acre Como Regional Park, is one of the most popular lakes in the area. In 2013, Como Regional Park was the second most frequently visited park in the Twin Cities Regional Parks System, with almost 4.5 million visits over the course of the year (MC, 2015a). The lake is frequented by residents and visitors who come for various forms of outdoor recreation, including running/walking and fishing. The lake does not offer swimming opportunities and only allows non-motorized cartop-carried boats and electric trolling motors on the lake for fishing/recreation purposes.

With a volume of 468.8 acre-ft, a littoral area that covers 100% of the lake, and a maximum depth at 15.5 ft, Como is a shallow urban lake (Table 6-1; Figure 6-2). Como Lake receives

water from the surrounding watershed (1,856 acres), which consists of runoff from primarily residential areas, as well as from Como Golf Course (Figure 6-3). Runoff from the residential areas is directed to the lake through a system of stormwater pipes located under the streets. Located upstream of Como Lake, Gottfried's Pit receives drainage from Roseville, Falcon Heights, Ramsey County right-of-ways, and the City of St. Paul before being pumped into Como Lake. Water occasionally outflows from the lake at the southeast corner, discharging into the Trout Brook storm sewer system which is routed to the Mississippi River (CRWD, 2002). The shallow depth of the lake, coupled with the large nutrient inputs from upland runoff sources, has had significant negative impacts to the lake's overall health.

Table 6-1: Como Lake morphometric data.

Surface Area (acres)	Maximum Depth (ft)	Littoral Area	Volume (acre-ft)	Watershed Area (acres)	Watershed: Lake Area (ratio)
70.5	15.5	100%	469	1,856	26.3



Figure 6-2: Como Lake bathymetric map.

One of the largest problems Como Lake faces is the excessive amount of sediment entering the lake from construction, roads, and general erosion. This has led to the formation of sediment deltas near stormwater inlets to the lake, which reduces overall lake volume, increases water turbidity, and decreases habitat value for the lake's fish populations. Sediment also provides a means by which other pollutants, including metals and hydrocarbons, can be transported to the lake. To address this problem, in 2001-2002, the lake was dredged to reduce the sediment deltas seen on the southwest side of the lake. This dredging reduced the amount of sediment that had accumulated in the lake and increased lake volume, giving the lake a higher capacity to absorb nutrient inflows.

In addition, low oxygen levels during winter months caused partial fish kills dating back to 1945, leading Ramsey County to install an aerator in 1985 (CRWD, 2002). Renovation and a complete restocking of the fish populations in the lake occurred in 1985 after installation of the aerator in an effort to improve water quality through biomanipulation. The original aerator was replaced in the winter of 2014-2015 by two floating aerators that improved the efficiency and breadth of aeration on the lake. Fish kills are now a rare occurrence in the lake, resulting only if there were to be equipment failure or an especially cold winter.

Various shoreline improvement projects have been completed on the lake since 2003 by the City of St. Paul and Ramsey Conservation District, with help from CRWD and other organizations. These projects have stabilized the shoreline, reduced erosion, increased habitat for wildlife, replaced non-native invasive plants with native species and improved the aesthetics of the shoreline for visitors. Harvesting of aquatic plants has occurred at various times since the 1980s in order to enhance recreational opportunities.

Numerous BMPs have been installed by CRWD, the City of St. Paul, and others in the Como Lake subwatersheds to reduce pollutant loading to the lake. Starting in 2007, the Arlington-Pascal Stormwater Improvement Project was constructed upland of Como Lake in the Como 7 subwatershed, which consisted of a series of BMPs including raingardens, infiltration trenches, an underground facility, and stormwater ponds. Improvements in water quality have been measured in the lake since the completion of the project. More information about these BMPs may be found in the CRWD *Stormwater BMP Performance Assessment and Cost-Benefit Analysis* (CRWD, 2012b).

Despite this upland watershed restoration, Como Lake is still a hypereutrophic lake and was listed on the MPCA's 2012 303(d) list of impaired waters (MPCA, 2012). It is currently listed on the MPCA's 2014 303(d) proposed impaired waters list for chloride impairment (MPCA, 2015b). Como Lake was first listed in 1998 for mercury in fish tissue (TMDL plan approved in 2008) and in 2002 for nutrient/eutrophication biological indicators (TMDL plan approved in 2010) (MPCA, 2012). Odor problems due to end-of-summer algal blooms also continue to be a problem and have been recorded since 1945. It is hypothesized that the water quality (referring to the TP, Chl-a, and Secchi disk depth) in Como Lake displays a cyclical trend, fluctuating every five to six years between fair and poor water quality (Figure 6-7) (Noonan, 1998). This suggests that the interactions among the biological, chemical, and physical parameters of the lake need to be better understood in order to make informed management decisions to improve the lake's health.



Figure 6-3: Como Lake and subwatershed boundary.

6.2 LAKE LEVEL

The level of Como Lake has fluctuated around the OHWL (881.4 ft) since monitoring of the lake level began in 1978 with a range of 4.3 ft, varying between 879.2 ft to 883.5 ft. The lowest of the range extremes occurred in June 1987, and the highest occurred in October of 2007 (Figure 6-4). The average level for 2014 was 881.35 ft indicating that, on average, normal fluctuations in water level were seen for the lake in 2014. Water level increased from January until the end of April, then fluctuated during the month of May before reaching the maximum level in June as a result of an intense mid-June storm (Figure 6-5). The level then decreased during a dry July, increased throughout August, and reached a fall peak level of 882.6 ft in mid-September following a key late-August storm. Lake levels then steadily decreased through the fall months (Figure 6-5).

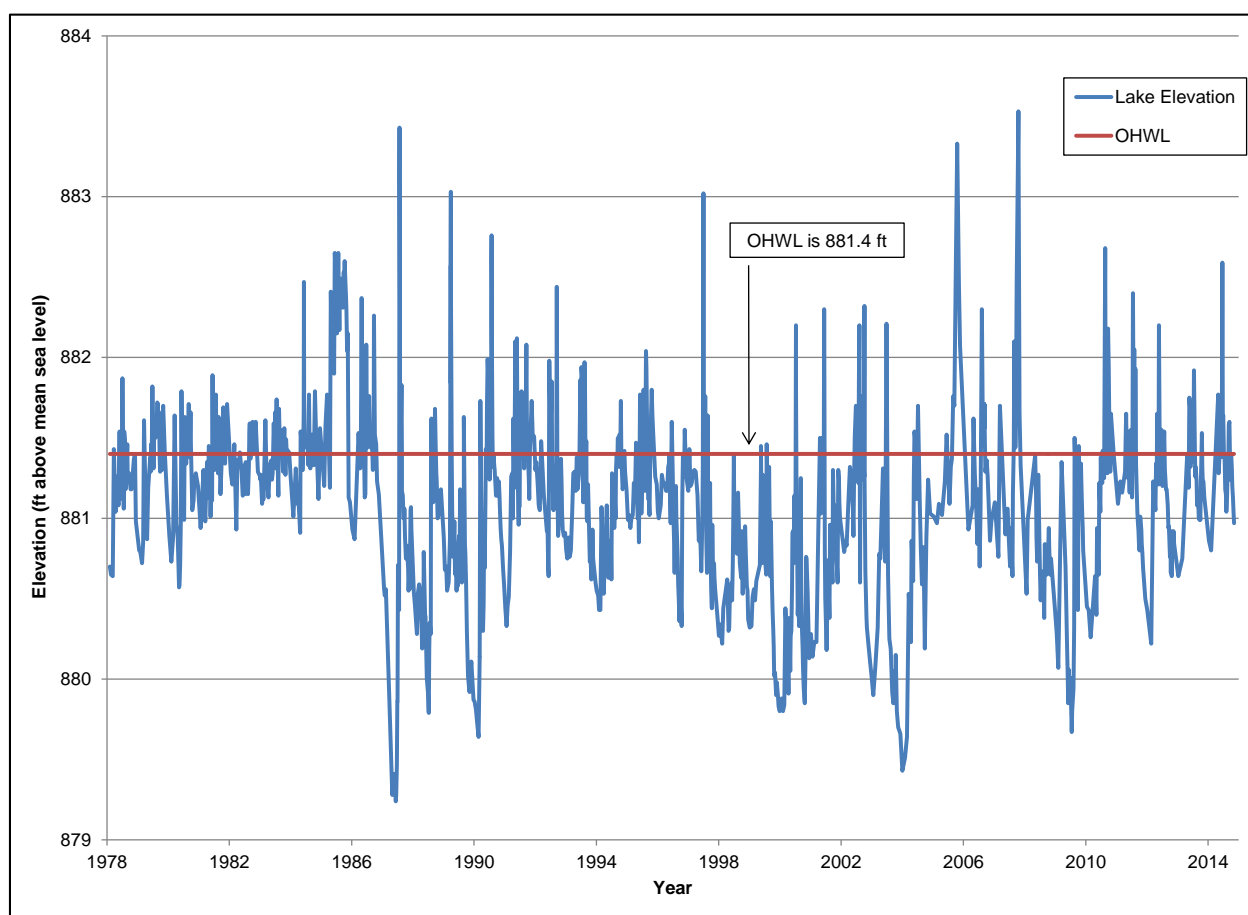


Figure 6-4: Como Lake historical lake elevations and the OHWL (DNR, 2015i).

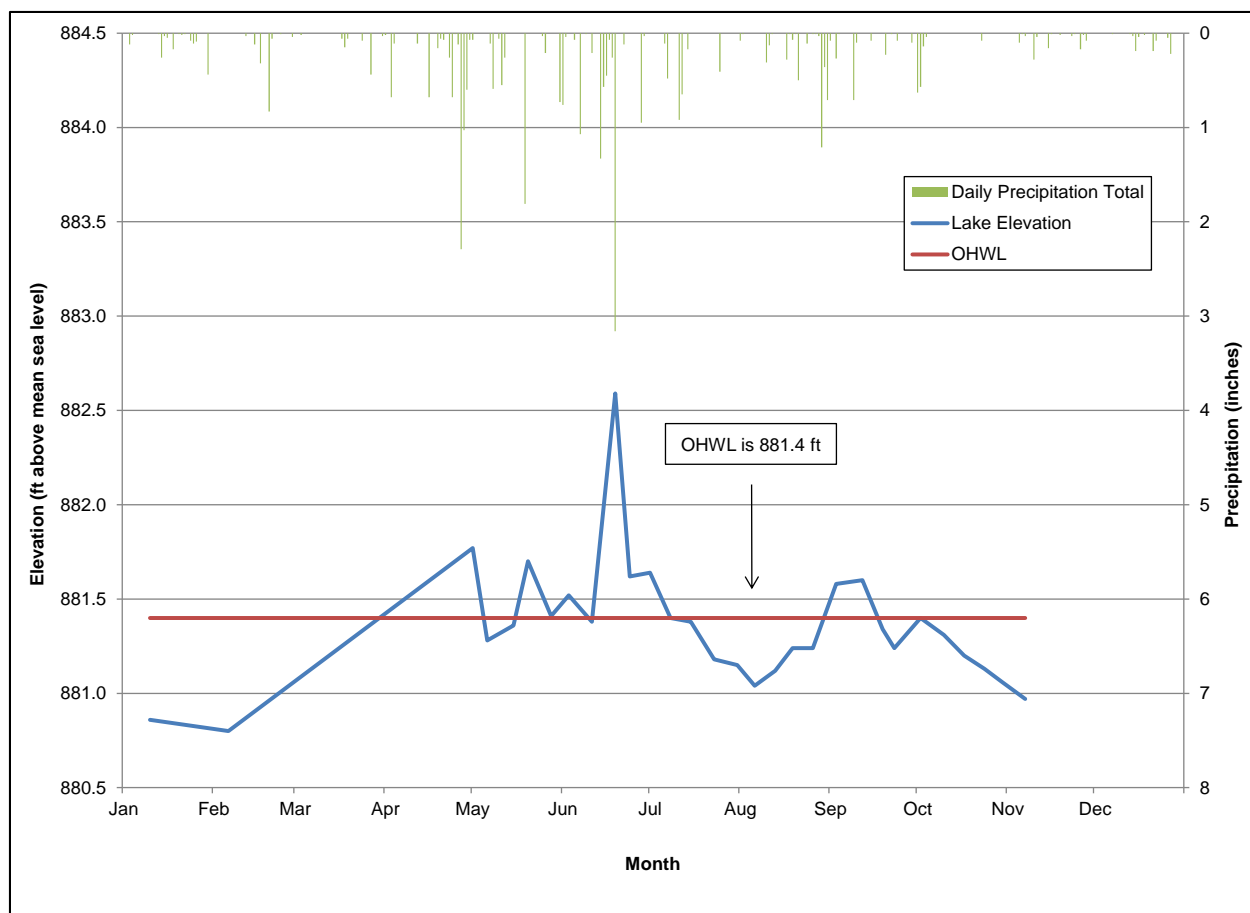


Figure 6-5: Como Lake 2014 lake elevations, OHWL, and daily precipitation events (DNR, 2015i; MCWG, 2015b).

6.3 WATER QUALITY RESULTS

During 2014, Como Lake was sampled nine times from May 2 to October 20 (Figure 6-6). As in previous years, Como Lake was generally characterized by high TP and Chl-a concentrations, and low Secchi depths (Figure 6-7). Sampling shows that TP concentrations were lower in the epilimnion of the lake during the beginning of the season (early May to early August) than at the end of the season (late August to late October). The average TP concentration for the last three samples (272 $\mu\text{g/L}$) was 124% higher than the average of the first six samples (122 $\mu\text{g/L}$), indicating a strong decrease in water quality between the beginning and the end of the monitoring season.

Epilimnetic Chl-a concentrations and Secchi disk depth exhibited similar trends. For Chl-a, the average concentration of the final three samples (57.9 $\mu\text{g/L}$) was 190% higher than the average concentration of the first six samples collected (20.0 $\mu\text{g/L}$).

For Secchi disk depth, water transparency had severely diminished (reduced by 70%) during the final three visits (average depth of 0.4 m), compared with the first five visits when water transparency met the shallow lake standard (average depth of 1.4 m). During 2014, as in previous years, higher TP concentrations were generally correlated with higher Chl-a concentrations and lower Secchi depths. This suggests that phosphorus was a primary driver for water clarity in Como Lake during 2014.

Figure 6-7 shows average annual historical TP concentrations, Chl-a concentrations, and Secchi disk depths graphically. In general, Como Lake has seen overall improvements in water quality since monitoring began in 1984, though each parameter tends to fluctuate annually. It is hypothesized that the lake is cyclic in water quality and biological response, fluctuating between poor and fair water quality generally every five to six years (Figure 6-7) (Noonan, 1998).

The average annual TP concentration increased from 2009-2012, then decreased in 2013 and again in 2014 (Figure 6-7). The average annual Chl-a concentration has remained relatively fixed over the last four years, with 2014 exhibiting the lowest annual average since 2009 (Figure 6-7). Average annual Secchi depth was at its deepest in recent years in 2008-2009, but became shallower until 2012 (Figure 6-7). Secchi disk depth appears to be improving in water quality, with the most recent two years exhibiting deeper average annual values with each successive year. Similar to the results from 2014, historical Secchi depth appears to be inversely proportional to TP concentration during the period of record for Como Lake, indicating that phosphorus has consistently been a primary driver for water clarity.

Yearly average historical TP concentrations, Chl-a concentrations, Secchi depths, and their comparisons to lake standards are shown in Table 6-2. Como Lake TP yearly average concentrations have exceeded the MPCA standards for all years of monitoring, including 2014. Chl-a concentrations have also exceeded the standard for 2014 and the majority of years monitored. Conversely, almost 75% of the historical Secchi depth yearly averages met the standards. In 2014, CRWD issued a 'D+' grade for Como Lake based on the average eutrophication parameters, which was only a slight improvement over 2013 (Table 6-3). In other years, the lake mainly received grades of 'C' and 'D', with only two years in 1998 and 1999 receiving a 'B' grade.

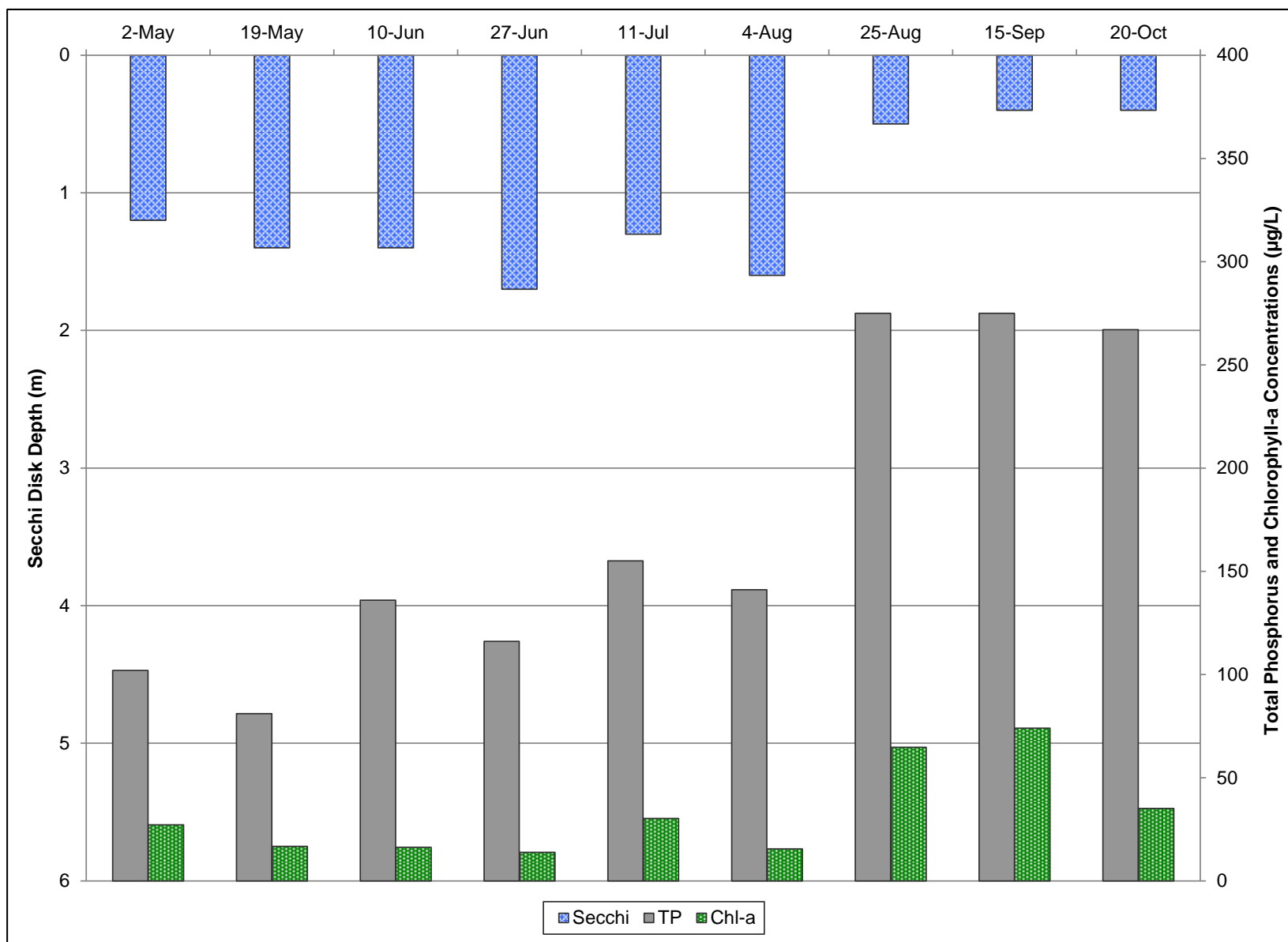


Figure 6-6: Como Lake 2014 Secchi/TP/Chl-a comparison.

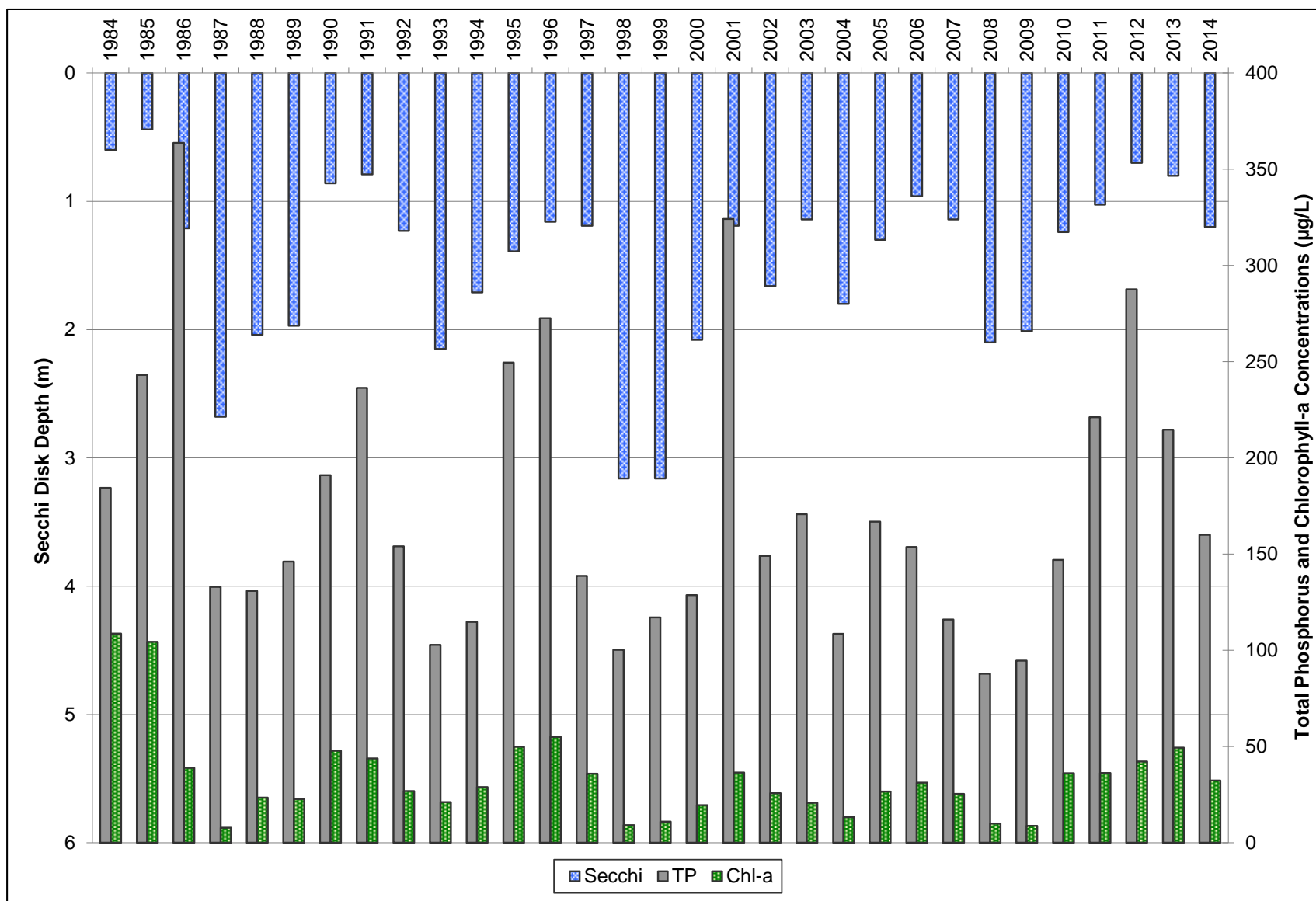


Figure 6-7: Como Lake historical annual average Secchi/TP/Chl-a comparison.

Table 6-2: Como Lake historical yearly TP/Chl-a/Secchi depth averages compared to shallow lake state standards.

Year	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
1984	184	108.7	0.6
1985	243	104.4	0.4
1986	364	39.0	1.2
1987	133	7.8	2.7
1988	131	23.5	2.0
1989	146	22.7	2.0
1990	191	47.9	0.9
1991	236	43.9	0.8
1992	154	26.8	1.2
1993	103	21.2	2.2
1994	115	29.0	1.7
1995	250	50.0	1.4
1996	273	55.1	1.2
1997	139	35.9	1.2
1998	100	9.2	3.2
1999	117	11.0	3.2
2000	129	19.6	2.1
2001	324	36.5	1.2
2002	149	25.8	1.7
2003	171	20.8	1.1
2004	109	13.4	1.8
2005	167	26.7	1.3
2006	154	31.3	1.0
2007	116	25.4	1.1
2008	88	10.0	2.1
2009	95	8.8	2.0
2010	147	36.1	1.2
2011	221	36.2	1.0
2012	288	42.2	0.7
2013	215	49.4	0.8
2014	160	32.3	1.2
	Value does not meet state standard*		
	Value meets state standard		

*MPCA shallow lake standards are not to exceed 60 µg/L for TP and 20.0 µg/L for Chl-a, with a Secchi disk depth of at least 1.0 m.

Table 6-3: Como Lake historical lake grades.

Year	TP Grade	Chl-a Grade	Secchi Grade	Overall Grade
1984	F	F	F	F
1985	F	F	F	F
1986	F	C	C	D+
1987	D	A	B	C+
1988	D	C	C	C
1989	D	C	C	C
1990	F	C	D	D
1991	F	C	D	D
1992	F	C	C	D+
1993	D	C	C	C
1994	D	C	C	C
1995	F	D	C	D
1996	F	D	D	D
1997	D	C	D	D+
1998	D	A	A	B
1999	D	B	A	B
2000	D	B	C	C
2001	F	C	D	D
2002	D	C	C	C
2003	F	C	D	D
2004	D	B	C	C
2005	F	C	C	D+
2006	F	C	D	D
2007	D	C	D	D+
2008	D	A	C	C+
2009	D	A	C	C+
2010	D	C	C	C
2011	F	C	D	D
2012	F	C	D	D
2013	F	D	D	D
2014	F	C	C	D+

6.4 PHYTOPLANKTON AND ZOOPLANKTON

During 2014, Como Lake was sampled for phytoplankton and zooplankton eight and nine times, respectively, from May 2 to October 20. In 2014, two main species dominated the phytoplankton community: Chlorophyta (green algae) from May to mid-June, replaced by Cyanophyta (blue-green algae) from mid-June through the remainder of the growing season (Figure 6-10). The species dominance of green and blue-green algae was attributed to the steady increase in TP during the same time period (Figure 6-8) (Kalff, 2002). Overall phytoplankton concentrations decreased from June through the beginning of August, and then increased to a final peak in mid-September.

Zooplankton communities in Como Lake were mainly dominated by Rotifers during the month of May, with smaller numbers of Cyclopoids, Nauplii, and Cladocerans observed as well (Figure 6-11). Cladocerans dominated from May through the end of the monitoring season at the end of September. Cladocerans, including the genus *Daphnia*, are important filter feeders in lake environments. Populations of calanoids were only observed in moderate numbers from mid-July through mid-September. Overall zooplankton density peaked in late June, was at its lowest at the beginning of August, and then increased again in mid-September, reaching its highest for the year at the end of the growing season in late October (Figure 6-9).

Total zooplankton concentration followed a similar overall yearly trend to phytoplankton, with populations increasing and decreasing roughly 1.5 months following any phytoplankton high and low concentrations (Figures 6-8 and 6-9).

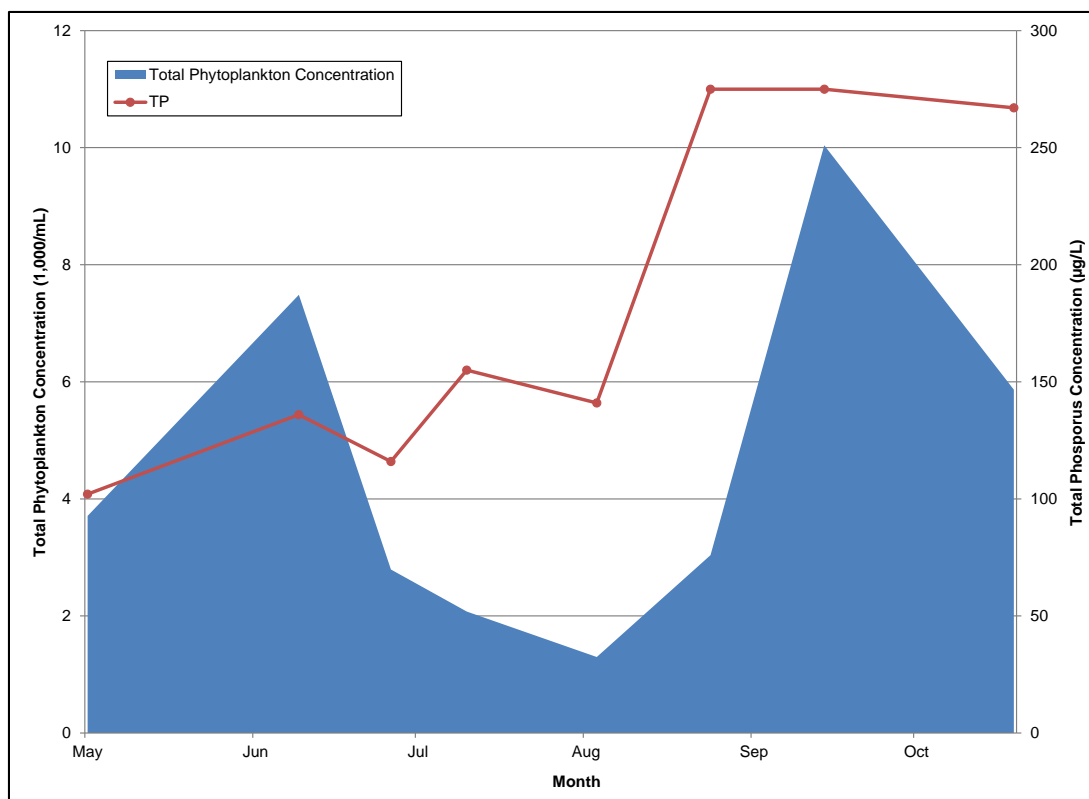


Figure 6-8: Como Lake 2014 total phytoplankton concentration and TP concentration.

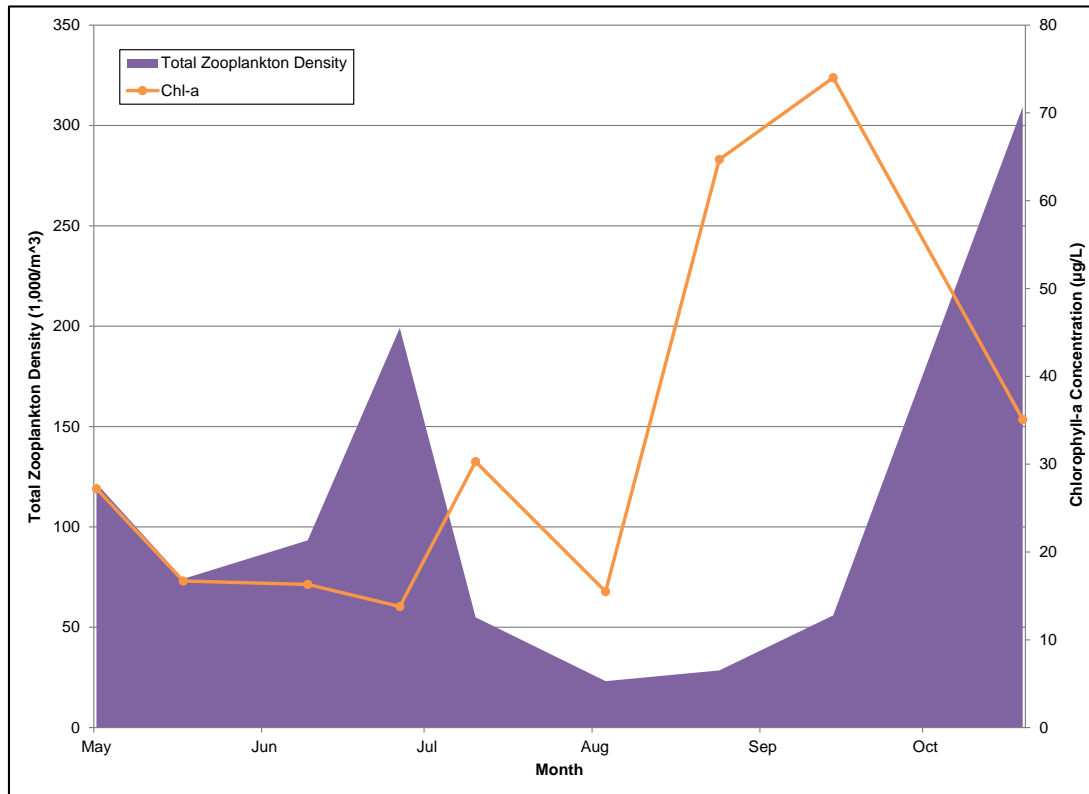


Figure 6-9: Como Lake 2014 total zooplankton density and Chl-a concentration.

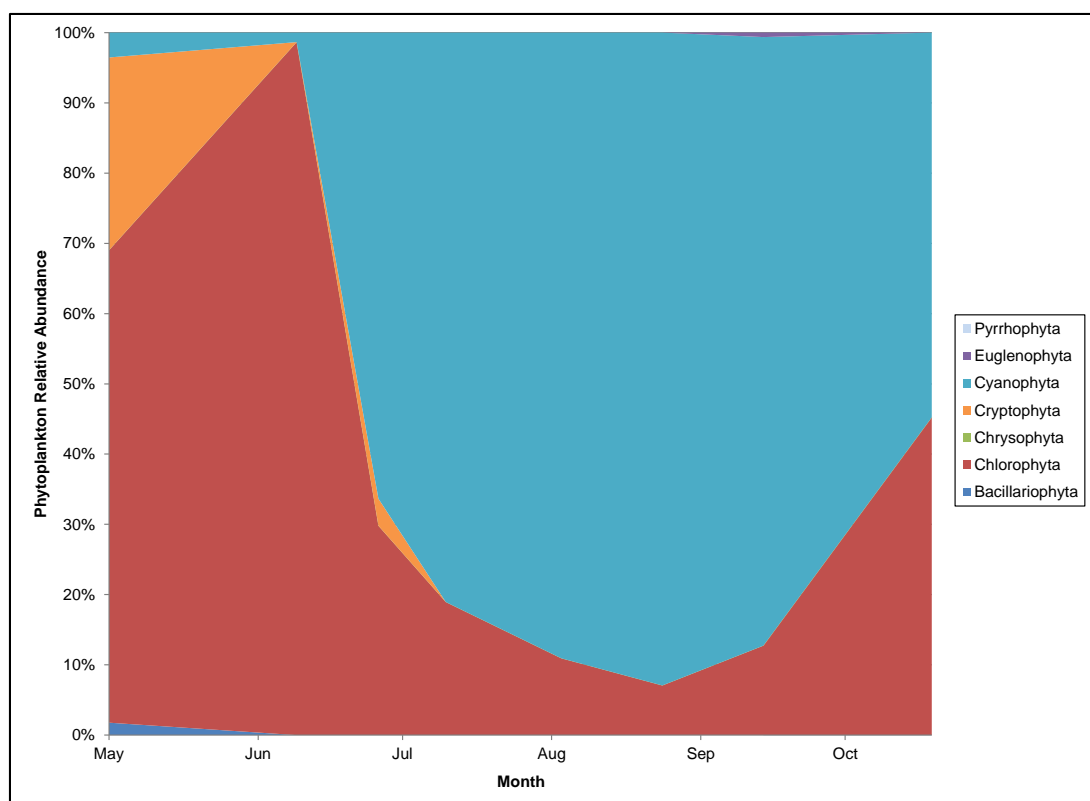


Figure 6-10: Como Lake 2014 phytoplankton relative abundance.

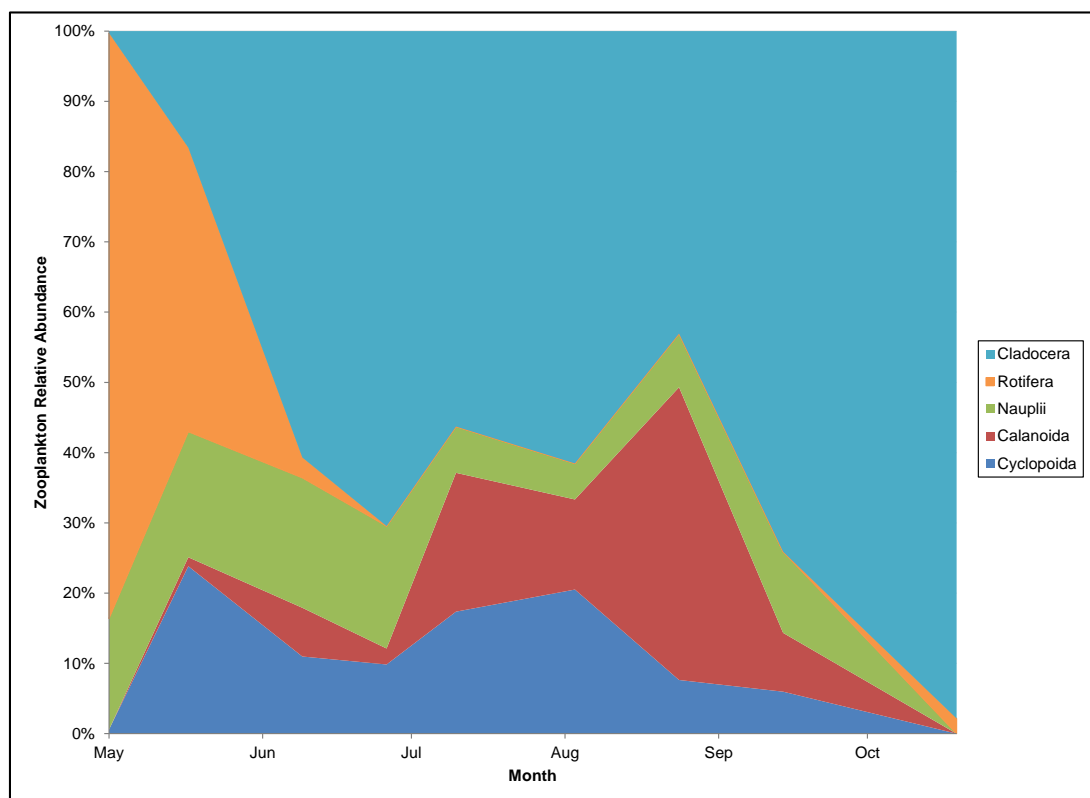


Figure 6-11: Como Lake 2014 zooplankton relative abundance.

6.5 AQUATIC VEGETATION ---

6.5.1 BIOVOLUME ANALYSIS

As shown by the biovolume heat maps of seasonal vegetation changes in Como Lake, the majority of the lake vegetation in 2014 was observed along the shoreline (Figure 6-12). Overall, Como Lake exhibited extensive aquatic vegetation growth in June and July, with decreasing plant coverage observed in late August with spots of heavy growth occurring off the shoreline. Aquatic plants stabilize bottom sediment which prevents re-suspension of sediments that decreases water clarity (DNR, 2015h). Aquatic plants also intake nutrients for growth, making those nutrients unavailable for use by algae, which reduces algal overabundance and improves water quality.

6.5.2 POINT-INTERCEPT SURVEYS

In June of 2014, plant species observed in Como Lake were curly-leaf pondweed, Canada waterweed, sago pondweed, filamentous algae, coontail, and muskgrass (Figure 6-13). The species occurring at the most locations throughout the lake in July was Canada waterweed, with curly-leaf pondweed, filamentous algae, coontail, and flatstem pondweed all occurring at less than 50% of locations surveyed. By the end of August, Canada waterweed increased in abundance to over 90% of survey locations, followed by filamentous algae which occurred at almost 65% of locations. Coontail, lesser duckweed, leafy pondweed, and blue-green algae were also observed in August but to lesser extents. All species throughout the summer received below average abundance rankings, indicating that where species were observed, none were overly abundant (Figure 6-14). The presence of Eurasian watermilfoil has not yet been observed in Como Lake. In general, observing Canada waterweed throughout the course of the growing season at higher percent occurrences is good overall for the health of the lake, as it is a native plant, a good producer of oxygen, and has a good structure for providing habitat to small aquatic organisms (DNR, 2015b).

During the late-August survey, blue-green algae was observed at roughly 6% of surveyed locations with a low abundance ranking (Figures 6-13 and 6-14). While not overly abundant, the observance of this species is still a high concern. Although it is not always toxic, blue-green algae (cyanobacteria) can be harmful to humans and animals at high levels during blooms, which can occur during late summer when water temperatures are high and water clarity is very low (MPCA, 2015a). This bloom was also observed during a routine staff visit in mid-September. Phytoplankton data from 2014 (Figures 6-8 and 6-10) corroborate this observation.

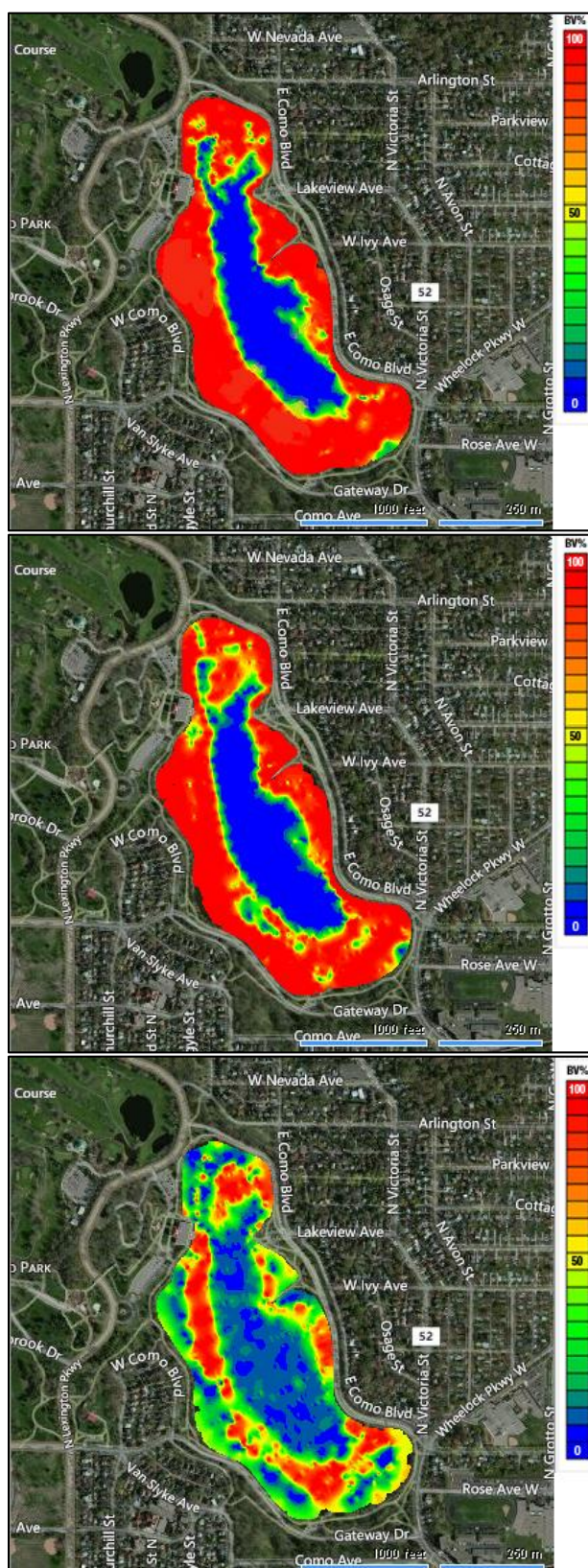


Figure 6-12: Como Lake 2014 seasonal vegetation changes (6/13/14, 7/23/14, 8/28/14).

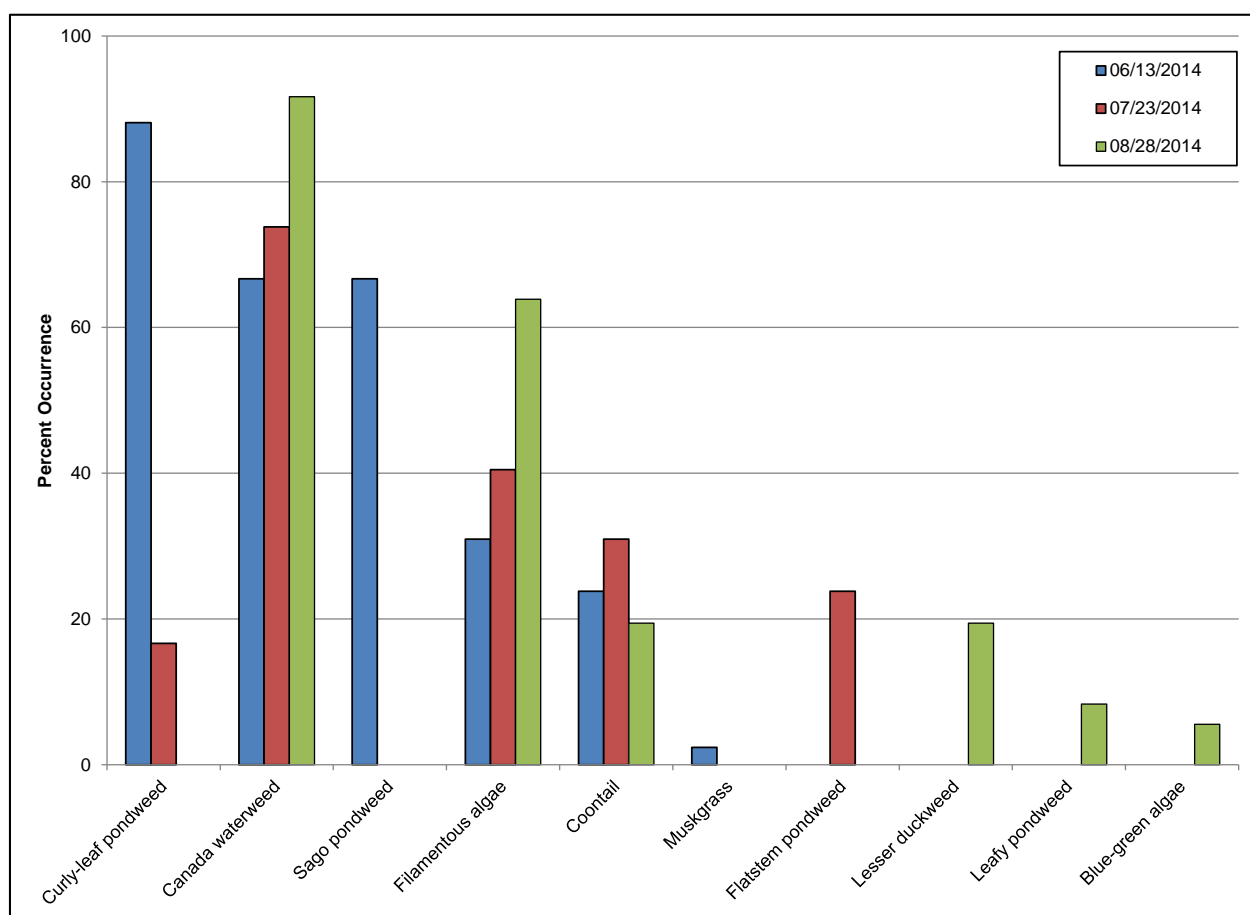


Figure 6-13: Como Lake 2014 percent occurrence of vegetation present.

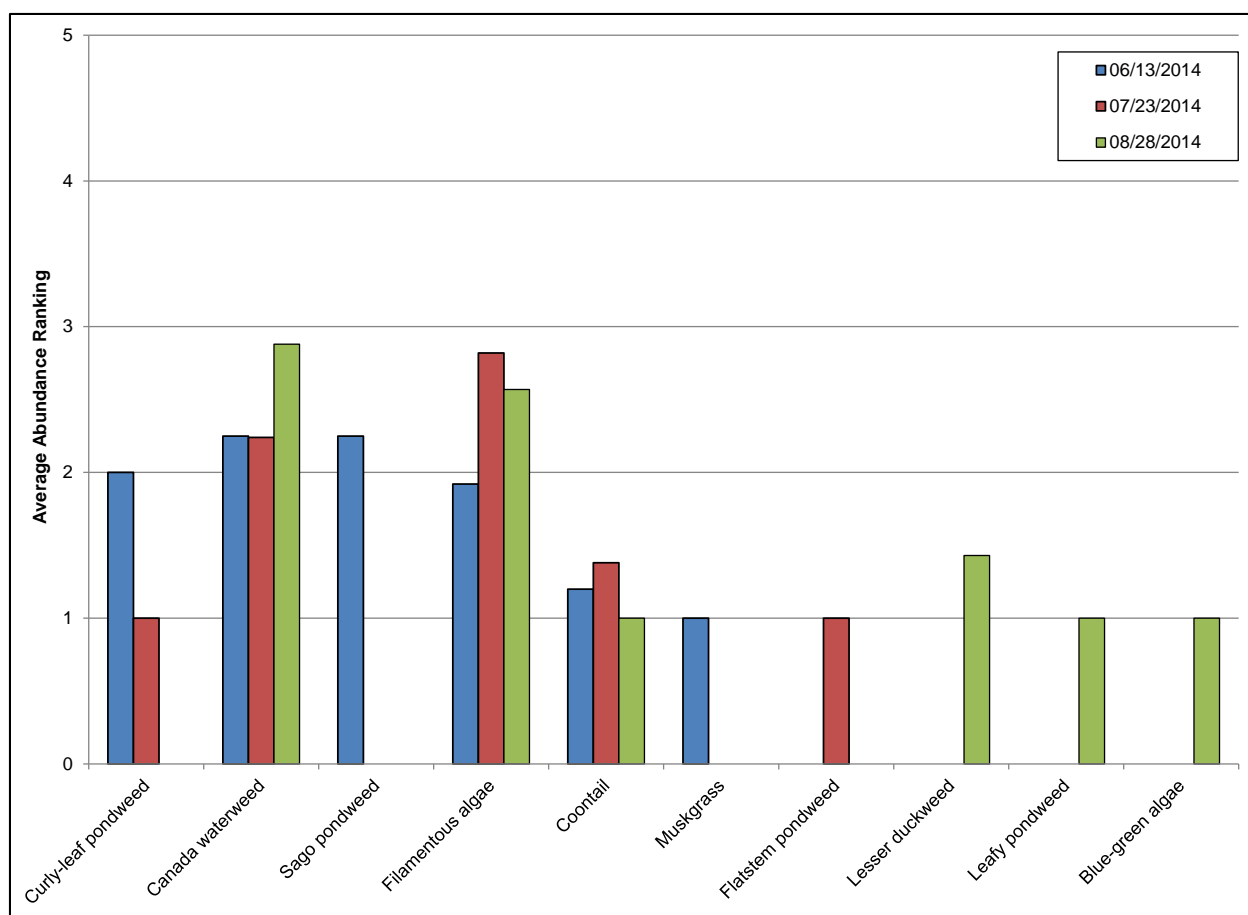


Figure 6-14: Como Lake 2014 average abundance ranking of vegetation present.

6.6 FISH STOCKING AND SURVEYS

While fish stocking in Como Lake has historically focused on bluegill and channel catfish because they are primary management species for the lake, walleye were the main species stocked in 2014 (Table 6-4). Como Lake is part of the Minnesota DNR's "Fishing in the Neighborhood" program, which increases angling opportunities for residents in urban environments, encourages environmental stewardship, and improves knowledge of natural resources (DNR, 2015g). Therefore, these lakes are generally stocked with fish that are better for general angling activities.

In the 2014 fish survey (conducted by CRWD) of Como Lake, the most prevalent fish found were black crappie, which was similar to the previous survey completed in 2011 (Table 6-5) (Appendix A). Additional information regarding the 2014 survey and comparisons to the 2011 survey can be found in Appendix A: 2014 Fish Surveys – Como and Little Crosby Lakes. In addition to black crappie, a wide variety of panfish were present in the lake, including bluegill, pumpkinseed sunfish, and yellow perch. Also similar to the 2011 survey, a few kinds of piscivorous fish were identified in the 2014 survey, with small populations of northern pike and

walleye observed. The northern pike surveyed in both years were relatively large given the size and type of the lake (Appendix A). Although largemouth bass were stocked in the lake in 2007 and 2014, no fish of this species were found in the current year's survey. This is not unusual given that they were not stocked in large amounts. The next survey date by the Minnesota DNR for Como Lake is set for 2016, but CRWD plans on resurveying the lake in 2015.

Table 6-4: Como Lake historical record of fish stocking.

Year	Bluegill	Channel catfish		Largemouth bass		Walleye			Yellow perch	
	Adult	Adult	Yearling	Adult	Yearling	Fry	Yearling	Fingerling	Adult	Yearling
2014			130	8		71,000		4,108	1211	
2013								486		
2011		124	3900					3593		
2010	24	91	3900				4			
2009			3457						816	1200
2008		155	4502							
2007	284	150	3864	179	414					
2006	1384									
2005										
2004	959									

Table 6-5: Como Lake 2014 fish populations.

Species	Number of fish caught in each category (inches)								Total
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	
Black bullhead	0	0	13	1	0	0	0	0	14
Black crappie	2	119	0	0	0	0	0	0	121
Bluegill	2	4	0	0	0	0	0	0	6
Channel catfish	0	0	1	1	1	0	0	0	3
Golden shiner	1	17	0	0	0	0	0	0	18
Northern pike	0	1	2	0	0	3	7	2	15
Pumpkinseed sunfish	4	0	0	0	0	0	0	0	4
Walleye	0	0	0	0	5	1	0	0	6
Yellow perch	0	10	3	0	0	0	0	0	13

6.7 OVERALL LAKE EVALUATION

Como Lake experiences a cyclic variation in water quality and biological response, fluctuating between poor and fair water quality generally every five to six years (Noonan, 1998). The period of record indicates that phosphorus has consistently been a primary driver for water clarity. It has historically received lower lake grades (including in 2014 when the lake received a “D+” grade), indicating lower user quality. The lake generally supports a fair variety of fish and contains a moderate amount of aquatic vegetation. In 2014, Como Lake showed improvement in water quality from 2013, exhibiting lower TP and Chl-a annual averages, and a deeper average Secchi disk depth. Even with these improvements, however, neither TP nor Chl-a met the MPCA state eutrophication standards.

7 CROSBY LAKE RESULTS

7.1 CROSBY LAKE BACKGROUND



Figure 7-1: View of the southwest shoreline of Crosby Lake.

Crosby Lake is situated within Crosby Farm Regional Park in Saint Paul and is also a part of the National Park Service's Mississippi National River and Recreation Area (CRWD, 2012a). The park itself is 736 acres and consists of floodplain and bluff areas. It offers various outdoor activities for fishing, canoeing, walking, hiking and winter cross-country skiing. The park has diverse wetland and forest habitats that support a large variety of plants, trees, and wildlife. Crosby Lake is 45 acres and has a maximum depth of 17 ft with a 100% littoral area (Table 7-1; Figure 7-2). It is located in the floodplain area of the park between a large bluff and the main channel of the Mississippi River.

Table 7-1: Crosby Lake morphometric data.

Surface Area (acres)	Maximum Depth (ft)	Littoral Area	Volume (acre-ft)	Watershed Area (acres)	Watershed: Lake Area (ratio)
45.0	17.0	100%	130	197	4.4



Figure 7-2: Crosby Lake bathymetric map.

Crosby Lake has a relatively small watershed area of only 197 acres (Table 7-1; Figure 7-3). Water flows into the lake during high water periods from wetlands on the east and north sides via culverts. Seepage from the base of the bluff (consisting of sandstone and limestone) is also an input to Crosby Lake. The major groundwater input to the lake comes from the St. Peter aquifer to the west.

CRWD developed a lake management plan for Crosby Lake that assessed the current condition of the Lake and characteristics of its watershed, identified the issues of greatest concern, and

established management goals and an implementation plan for addressing identified issues (CRWD, 2012a). A key piece of understanding that came out of the plan was the interaction between Crosby Lake and the Mississippi River. As Crosby Lake sits within the floodplain of the Mississippi River, it is intermittently flooded during periods of high water. The normal water level (or ordinary water level) of the lake is 694 ft. The normal pool elevation of the river is 687 ft (CRWD, 2012a). Therefore, under normal, non-flood conditions, groundwater flows from the lake to the river. The lake does not normally directly output to the river. Under high water conditions, however, the river will overflow to the lake near the northeast corner.

CRWD determined that a 49,000 cfs flow (equivalent of a stage of 697 ft) would cause an exchange between the river and the lake to occur, equating to a 3-year storm event, meaning that this has a 33% chance of occurring each year (CRWD, 2012a). Looking at the historical record since 1982, only 2.5% of recorded river flows have been high enough for an exchange to occur. Table 7-1 shows the number of days the Mississippi River interacted with Crosby Lake during the historical monitoring period for the lake. During these exchanges, the water bodies interchange not only water, but nutrients, other pollutants, and biological organisms contained within.

Table 7-2: Historical record of Mississippi River interaction with Crosby Lake.

Year	Number of Days Mississippi River Interacts with Crosby Lake
1999	14
2000	0
2001	63
2002	0
2003	0
2004	0
2005	0
2006	19
2007	0
2008	0
2009	15
2010	36
2011	103
2012	10
2013	13
2014	50

Since the start of development of the Crosby Lake Management Plan, a number of water quality improvement projects have been implemented by CRWD, the City of Saint Paul and others to reduce stormwater runoff to Crosby Lake. In 2010, the City of Saint Paul installed filtration swales as part of the reconstruction of the Samuel Morgan pedestrian and bikeway trails along Shepard Road. CRWD provided the City of Saint Paul a grant in 2012 for the installation of a

rain garden and swale during the reconstruction of the east end parking lot in Crosby Farm Regional Park. In addition, CRWD supports the Friends of the Mississippi River's efforts to restore the native prairie areas in Crosby Farm Regional Park. Lastly, as part of the reconstruction of the Madison-Benson Streets area near Crosby Lake in 2013, the City of Saint Paul constructed boulevard tree trench systems and rain gardens to treat street and sidewalk runoff.

Management efforts need to take into account the dynamic relationship between the lake and the river. Although water quality has been good in the past, with TP concentrations below the state standards, recent years have shown increasing TP concentrations that have surpassed the standard (Figure 7-7; Table 7-3). The source of these high nutrient concentrations could be from high flow periods of the Mississippi river where large sediment loads enter the lake. For example, the lake was inundated by the river for 103 days in 2011 (CRWD, 2012a). Water quality data observed in the years following the inundation showed average TP concentrations well above the normal historical values (Figure 7-7; Table 7-3). From a management perspective, this relationship could make it hard to control and improve Crosby Lake water quality in the long-term.

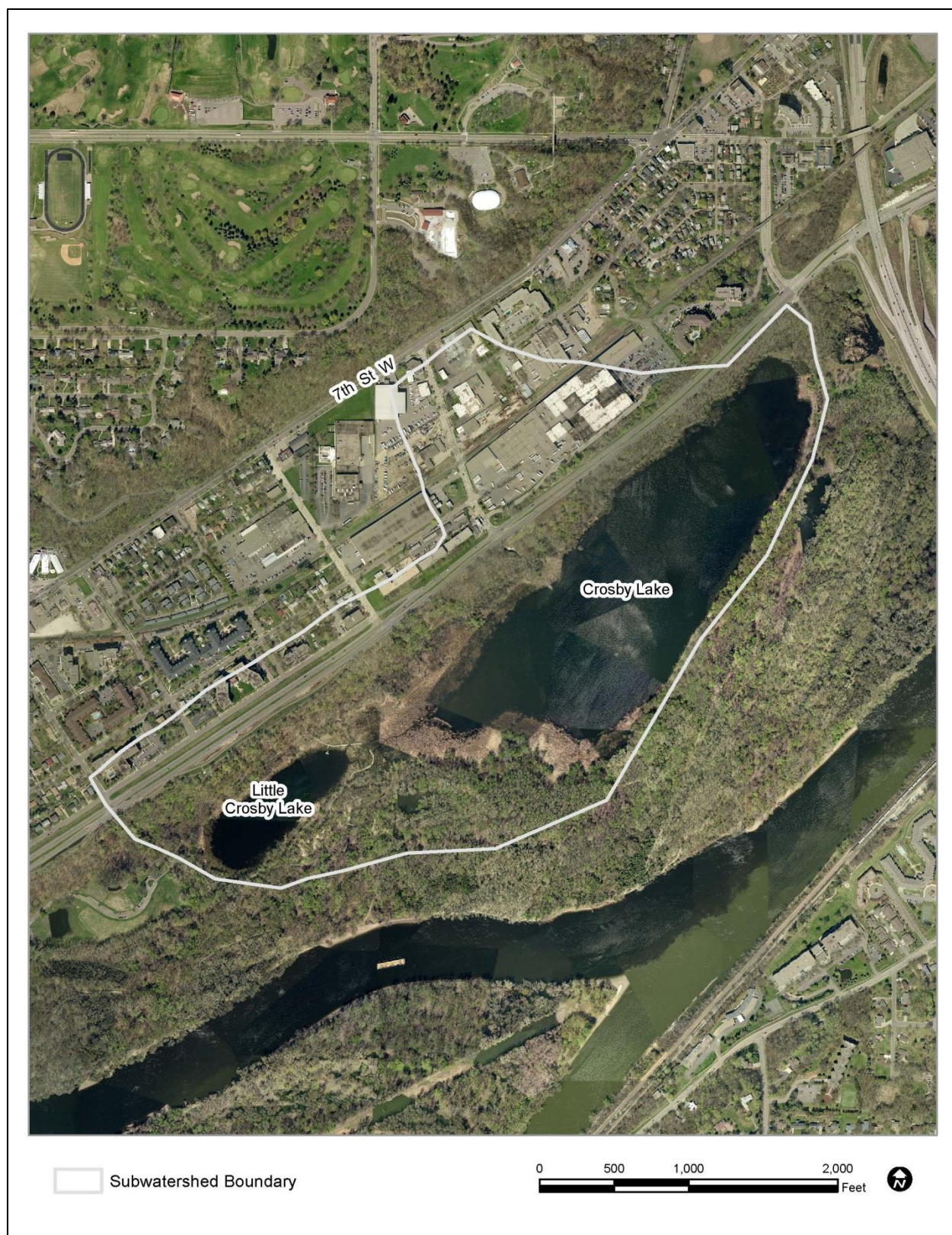


Figure 7-3: Crosby and Little Crosby Lakes and subwatershed boundary.

7.2 LAKE LEVEL

There is no historical lake level data for Crosby Lake from the Minnesota DNR, so CRWD began monitoring Crosby Lake level in 2014 (from June 13 to November 3). Figure 7-4 shows the fluctuation in Crosby Lake level in 2014, which is greatly influenced by flooding from the Mississippi River. Given that a flow of 49,000 cfs is the threshold at which the river and lake interact, Figure 7-5 shows the river flow for 2014 that caused inundation during the year. In 2014, which had an especially wet spring, the lake was inundated by the river for a total of 50 days from May 1 to May 21, and again from June 3 to July 11 (Table 7-2).

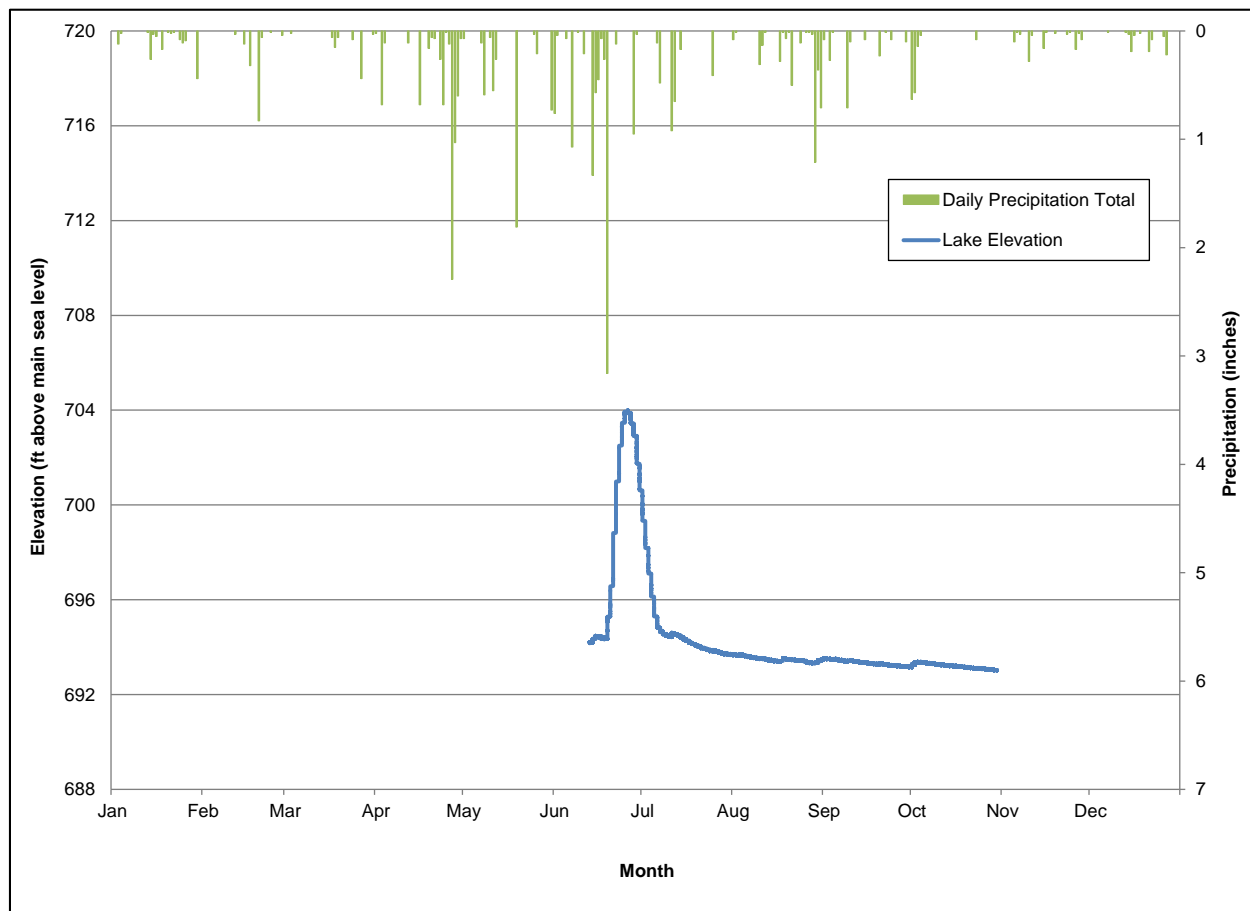


Figure 7-4: Crosby Lake 2014 lake elevations and daily precipitation events (MCWG, 2015b).

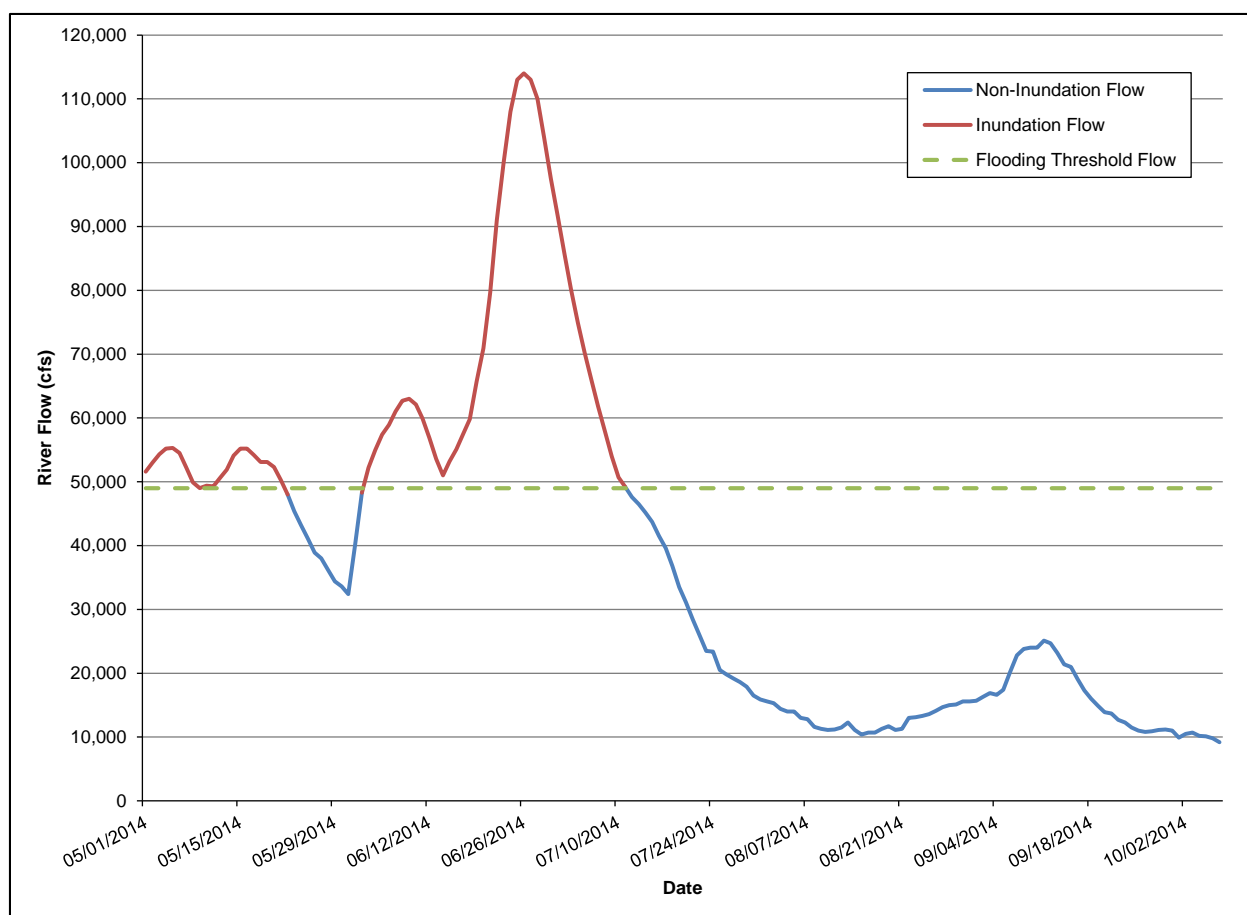


Figure 7-5: Mississippi River 2014 non-inundation, inundation, and flooding threshold flow to Crosby Lake (USGS, 2015).

7.3 WATER QUALITY RESULTS

Crosby Lake was sampled seven times during 2014, from May 13 to October 16 (Figure 7-6). As in previous years, Crosby Lake was characterized by high TP concentrations, but moderate Chl-a concentrations and Secchi depths (Figure 7-6). Samples show TP concentrations in the lake exceeded state standards throughout the monitoring season but were lowest at the beginning of the season (May 13 and June 5) with an average of 71 $\mu\text{g/L}$. The five samples for the remainder of the season collected July 30 to October 16 averaged 260 $\mu\text{g/L}$; 267% higher than the beginning-of-the-season average.

Epilimnetic Chl-a concentrations varied throughout the year, with a peak in early September; but the levels were above the state standard from August 14 through October 16 (Figure 7-6). During 2014, fluctuations in Chl-a concentration were not generally associated with fluctuations in TP concentration, indicating that there could be other drivers of algae growth in the lake. Water transparency peaked on June 5 (exhibiting a Secchi depth of 3.9 m), decreased drastically

by the end of July, and increased gradually until the end of the growing season (with a Secchi depth average of 1.6 m) (Figure 7-6).

Figure 7-7 shows yearly average historical TP concentrations, Chl-a concentrations, and Secchi disk depths graphically. Crosby Lake has been characterized by high epilimnetic TP concentrations over the last five years. The average TP concentration from 1999-2009 was 53.2 µg/L, while the average TP concentration from 2010-2014 was 138.0 µg/L, a 159% increase from the previous time period. This corresponded to longer flooding events from the Mississippi River during each of these years (Table 7-2).

Chlorophyll-a concentrations have exhibited higher trends since 2007, and do not appear to follow historical TP trends (Figure 7-7). However, the data suggests that water clarity is principally affected by Chl-a concentration during the period of record. In the first year Crosby Lake was monitored (1999) the Secchi depth average was the deepest on record at 3.8 m. Since then, Secchi depths have fluctuated annually but have generally decreased as Chl-a concentrations increased. It is noteworthy that despite a record TP concentration average in 2012, the yearly average Chl-a concentration and Secchi depths were similar to historical values (years with lower TP concentrations).

Yearly average historical TP concentrations, Chl-a concentrations, Secchi depths, and their comparisons to lake standards are shown in Table 7-3. Historically, Crosby Lake has met the standards for Chl-a and Secchi depth, with only three years exceeding TP standards from 1999-2009 (Table 7-3). Since 2010, however, it has consistently exceeded the standards for TP, and in 2014, Chl-a did not meet the standard for the first time in the monitoring record. In 2014, Crosby Lake received a grade of “D+”, the lowest ranking grade on record (Table 7-4). Based on historical lake grades, the water quality in Crosby Lake has been consistently decreasing over the last 16 years. While all water quality parameters have been degrading, the most notable has been the steadily increasing TP concentration.

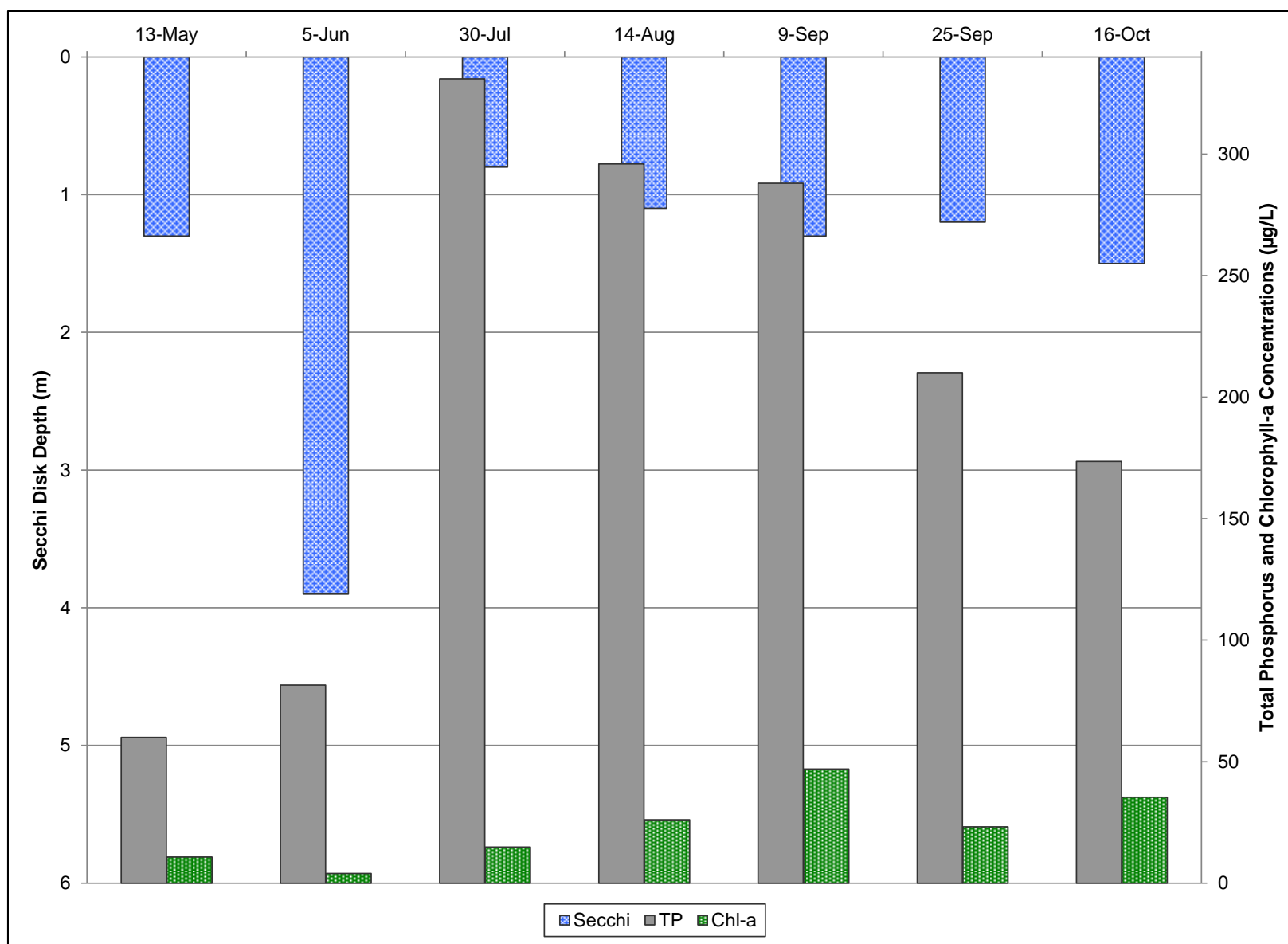


Figure 7-6: Crosby Lake 2014 Secchi/TP/Chl-a comparison.

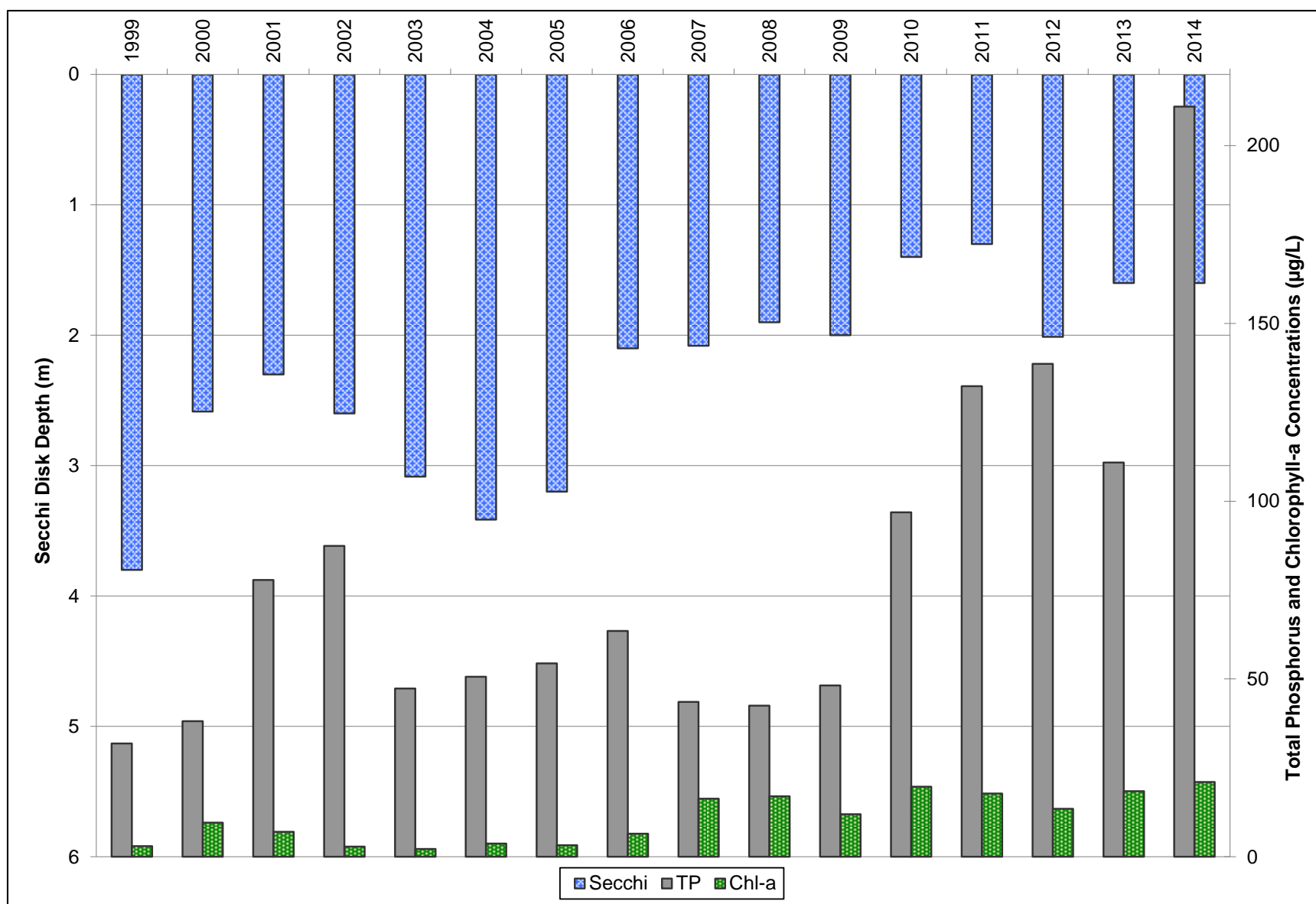


Figure 7-7: Crosby Lake historical annual average Secchi/TP/Chl-a comparison.

Table 7-3: Crosby Lake historical yearly TP/Chl-a/Secchi depth averages compared to shallow lake state standards.

Year	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
1999	32	3.0	3.8
2000	38	9.6	2.6
2001	78	7.0	2.3
2002	87	2.9	2.6
2003	47	2.2	3.1
2004	51	3.7	3.4
2005	54	3.2	3.2
2006	64	6.5	2.1
2007	44	16.3	2.1
2008	43	17.0	1.9
2009	48	12.0	2.0
2010	97	19.7	1.4
2011	132	17.8	1.3
2012	139	13.5	2.0
2013	111	18.4	1.6
2014	211	21.0	1.6
	Value does not meet state standard*		
	Value meets state standard		

*MPCA shallow lake standards are not to exceed 60 µg/L for TP and 20.0 µg/L for Chl-a, with a Secchi disk depth of at least 1.0 m.

Table 7-4: Crosby Lake historical lake grades.

Year	TP Grade	Chl-a Grade	Secchi Grade	Overall Grade
1999	B	A	A	A
2000	C	A	B	B
2001	D	A	B	B
2002	D	A	B	B
2003	C	A	A	B+
2004	C	A	A	B+
2005	C	A	A	B+
2006	C	A	C	B
2007	C	B	C	C+
2008	C	B	C	C+
2009	C	B	C	C+
2010	D	B	C	C
2011	D	B	C	C
2012	D	B	C	C
2013	D	B	C	C
2014	F	C	C	D+

7.4 PHYTOPLANKTON AND ZOOPLANKTON

Crosby Lake was sampled for phytoplankton and zooplankton seven times during 2014 from May 13 to October 16. There was a diverse phytoplankton community observed throughout the year (Figure 7-10). Generally, populations of Euglenophyta dominated from mid-May to mid-June, populations of Chlorophyta dominated from June through mid-August, and populations of Cryptophyta dominated from mid-August through the end of the year, with a small bloom of Chrysophyta in mid-September. Total concentration of phytoplankton peaked at the end of August, which lagged roughly one month behind the peak in zooplankton concentration in mid-July (Figures 7-8 and 7-9). Total phytoplankton concentration generally did not follow the TP concentration pattern during 2014 (Figure 7-8).

Cladoceran (important lake filter-feeders including the order *Daphnia*) populations were the most prominent zooplankton type during the entire monitoring season (Figure 7-11). Populations of Cyclopoids and Nauplii were observed throughout the year, with a small bloom of Rotifers at the beginning of August. Overall zooplankton concentration increased steadily to a peak in late July, then steadily decreased throughout the end of the year, and generally did not follow the Chl-a concentration pattern during 2014 (Figure 7-9).

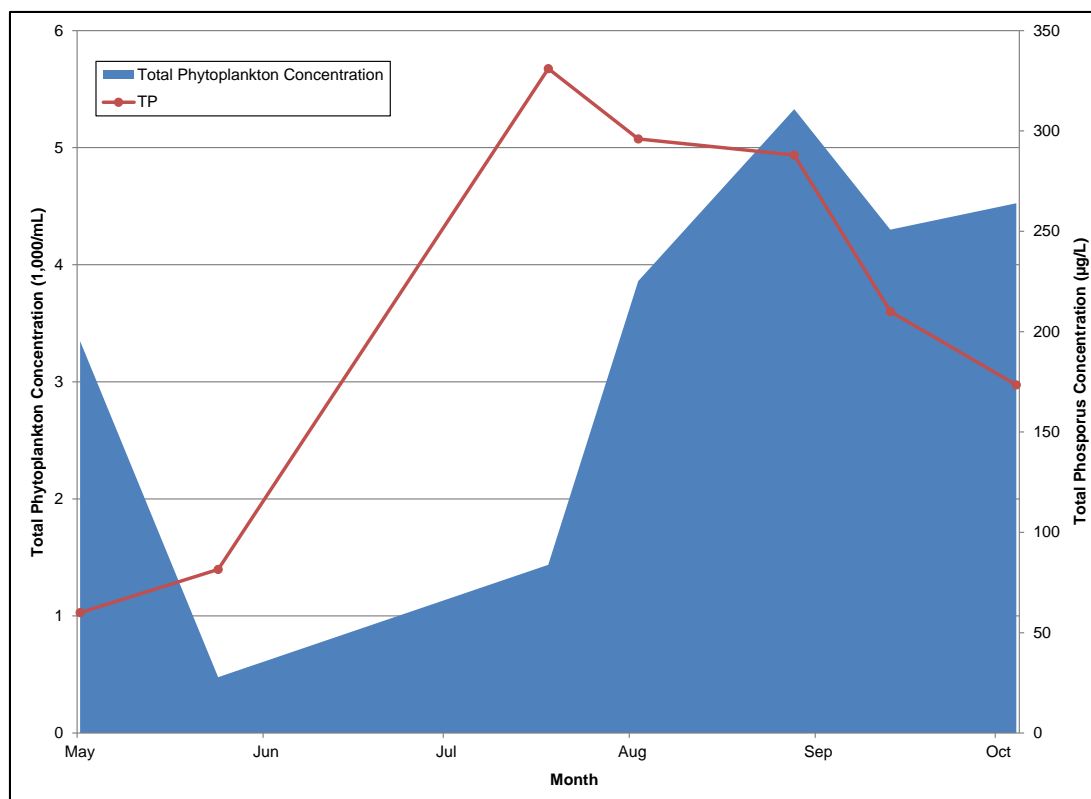


Figure 7-8: Crosby Lake 2014 total phytoplankton concentration and TP concentration.

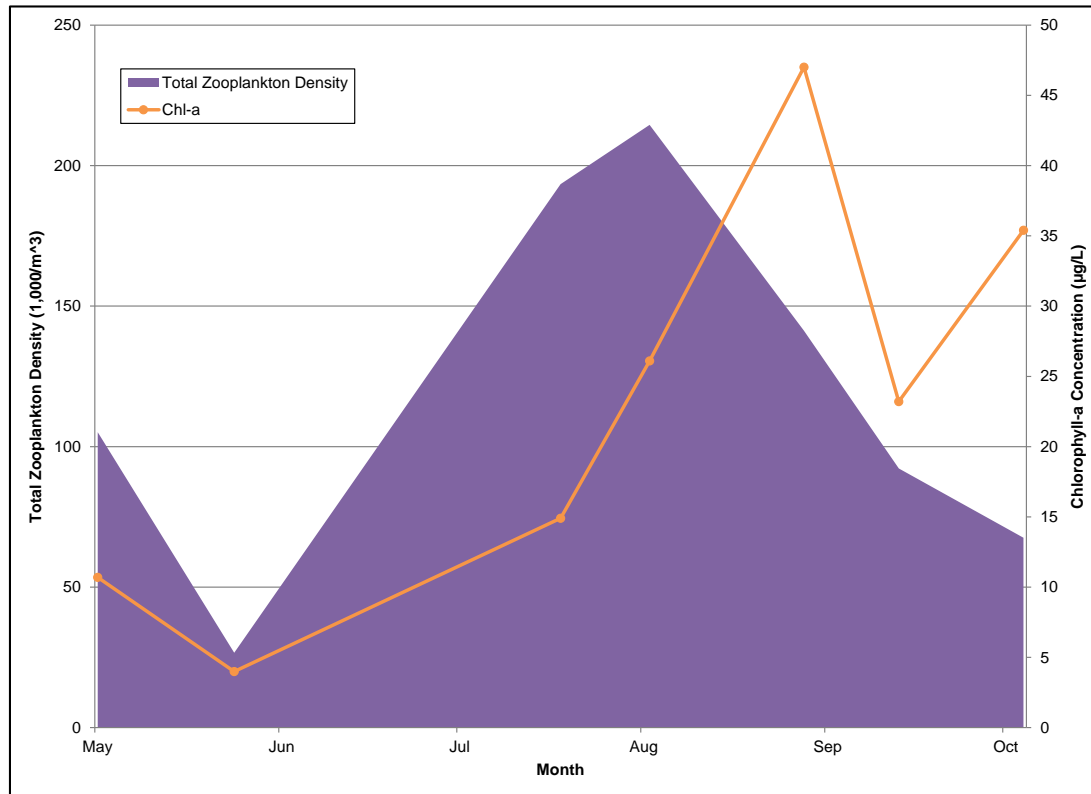


Figure 7-9: Crosby Lake 2014 total zooplankton density and Chl-a concentration.

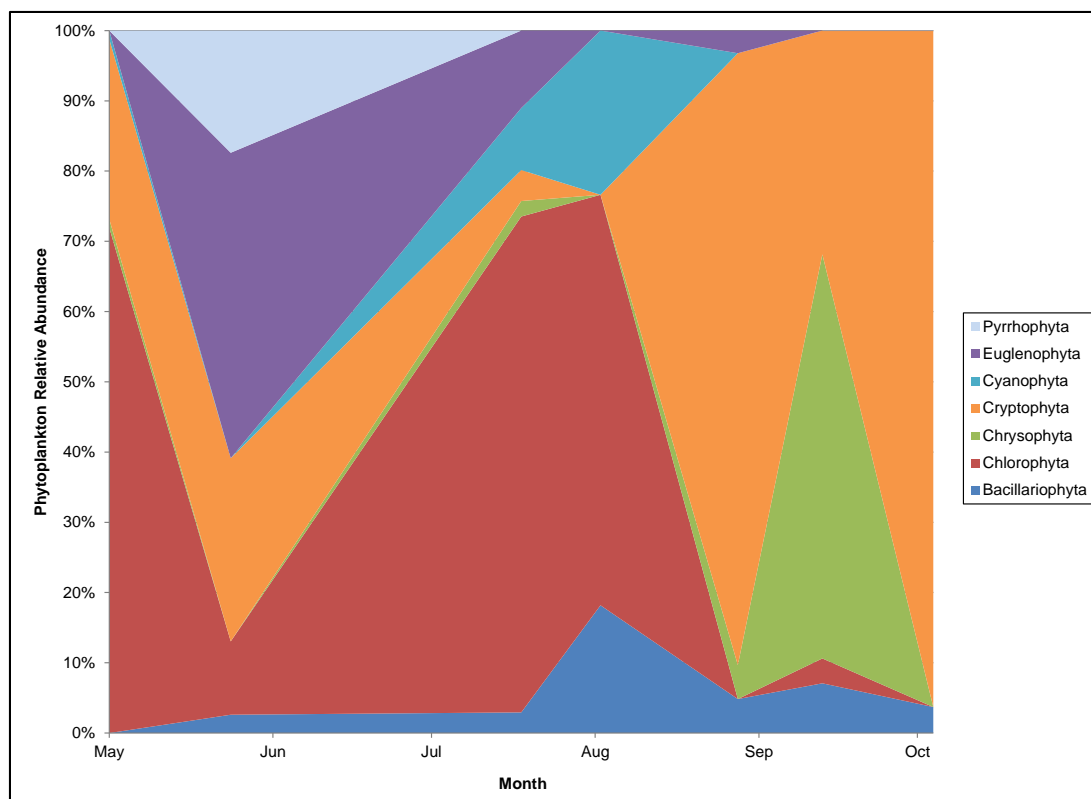


Figure 7-10: Crosby Lake 2014 phytoplankton relative abundance.

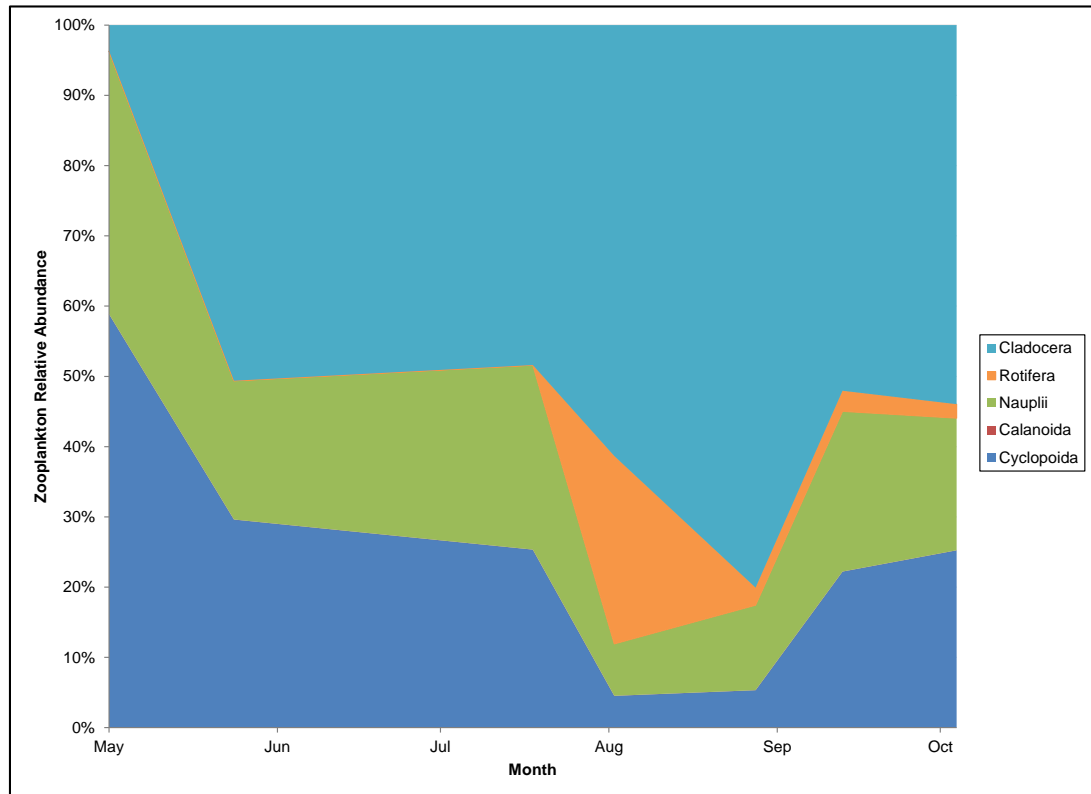


Figure 7-11: Crosby Lake 2014 zooplankton relative abundance.

7.5 AQUATIC VEGETATION

7.5.1 BIOVOLUME ANALYSIS

As viewed in the biovolume heat maps of vegetation for Crosby Lake (Figure 7-9), aquatic vegetation makes up a majority of the lake's water column. Higher vegetation areas are denoted with red, where no vegetation is shown as blue) (Figure 7-12). There is a small increase in vegetation coverage from late July to mid-September.

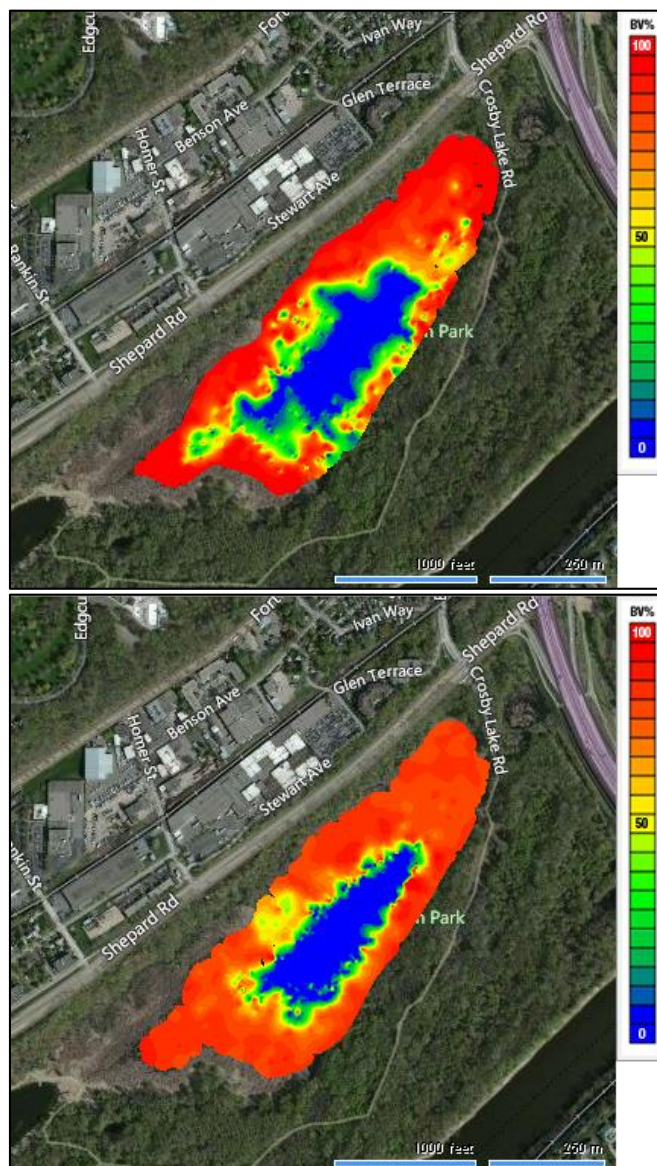


Figure 7-12: Crosby Lake 2014 seasonal vegetation changes (7/24/14 and 9/16/14)

7.5.2 POINT-INTERCEPT SURVEYS

In July, dominant vegetation species on Crosby Lake included white water lily, coontail, lesser duckweed, star duckweed, and filamentous algae, all of which were observed at mid-to-high percent occurrences and receiving average abundance rankings (Figures 7-13 and 7-14). By September, the most abundant species had reduced to white water lily and coontail, at 64% and 82% respectively. These two plant species were observed at high abundance during both surveys, making them the most dominant plant species in the lake. There were 11 different plant species observed in the lake throughout the summer.

The presence of Eurasian watermilfoil has not yet been observed in Crosby Lake. However, curly-leaf pondweed appeared for the first time in the 2013 survey, and was again observed in 2014. While it was not found at many locations in the lake in 2014 (Figure 7-13) and was not overly abundant at the locations in which it was found (Figure 7-14), this is still an undesirable species to see emerge. Curly-leaf pondweed is a non-native invasive species. It causes problems by displacing other native plants and forming thick mats on the surface of a lake that disrupt boating and recreation (DNR, 2005). In addition, when the plants die back in mid-summer, the resulting increase in phosphorus from the decomposing plant material causes disruptive algal blooms (DNR, 2005).

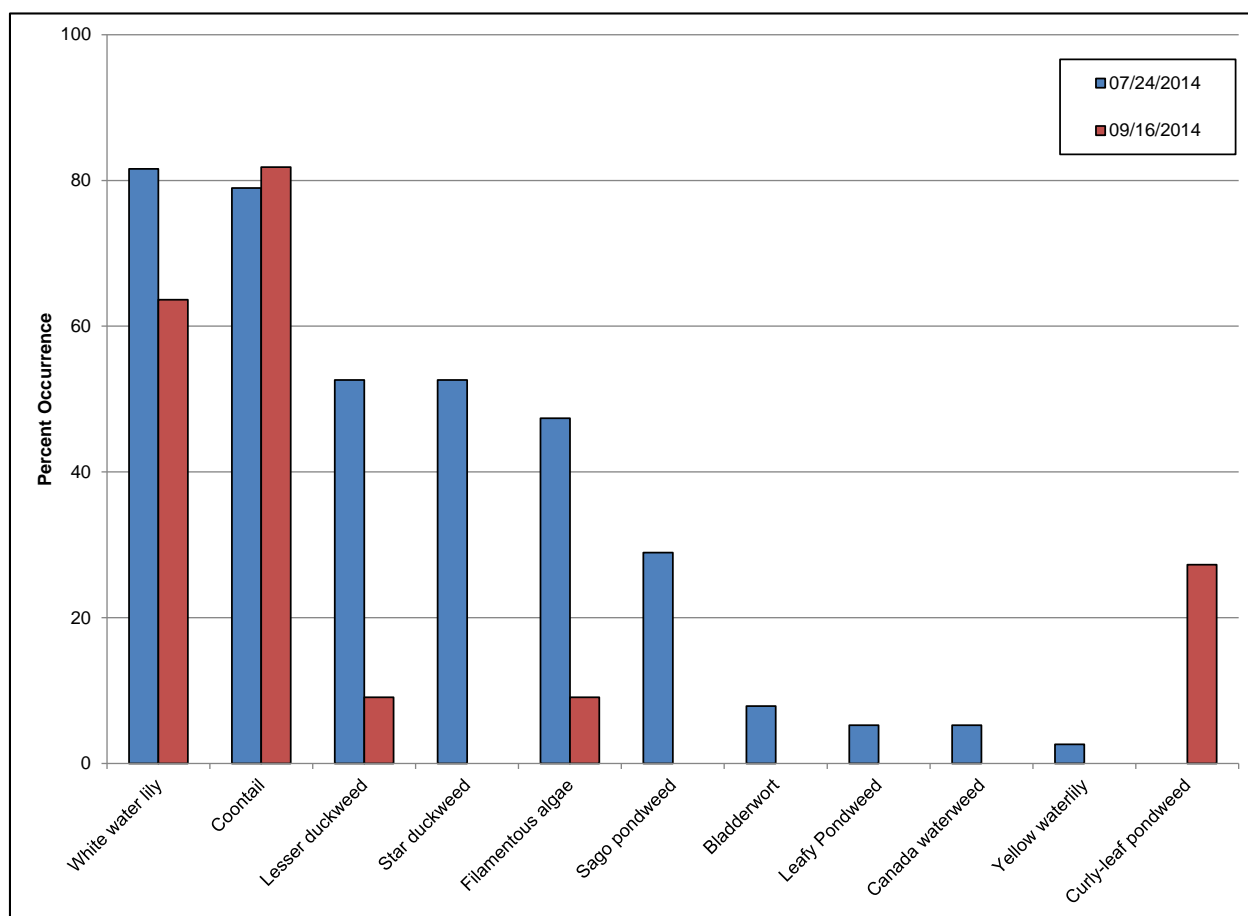


Figure 7-13: Crosby Lake 2014 percent occurrence of vegetation present.

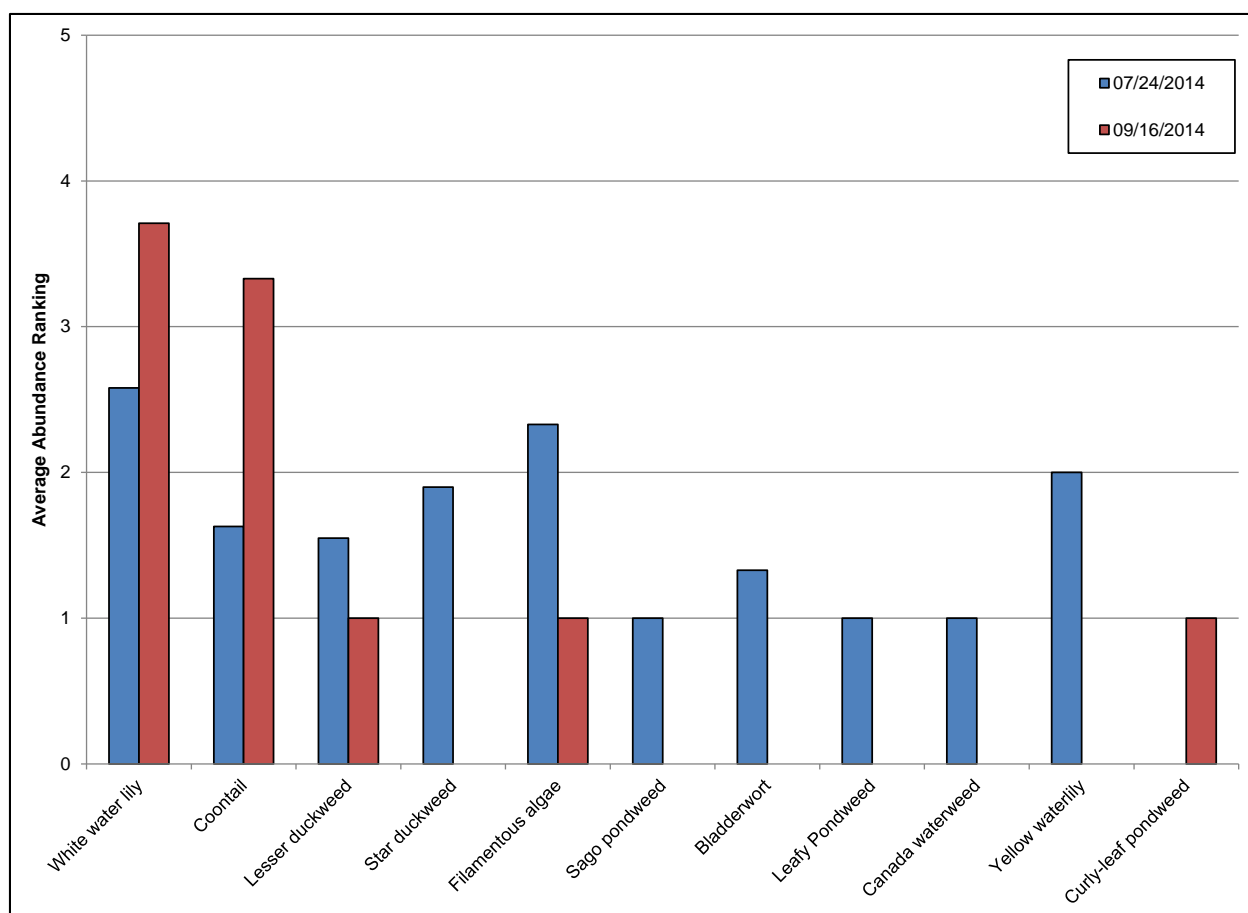


Figure 7-14: Crosby Lake 2014 average abundance ranking of vegetation present.

7.6 FISH STOCKING AND SURVEYS

The last survey of fish populations in Crosby Lake was completed in 2014 by the Minnesota DNR (Table 7-5). The DNR does not stock this lake, so populations observed are naturally present in the lake and are influenced by overflow from the Mississippi River during high water levels. The largest population of fish observed in 2014 were black bullhead and bluegills, followed by hybrid sunfish and white crappie. This indicates that a majority of the fish in Crosby Lake are planktivorous panfish. Northern pike were observed, but not in high abundance. Dogfish, common carp, golden shiner, and white sucker were also found in low abundance in Crosby Lake during the 2014 survey. Crosby Lake is scheduled to be surveyed again in the summer of 2015 by CRWD.

Table 7-5: Crosby Lake 2014 fish populations.

Species	Number of fish caught in each category (inches)								Total
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	
Black bullhead	11	27	18	1	0	0	0	0	57
Bluegill	45	12	0	0	0	0	0	0	57
Bowfin (Dogfish)	0	0	0	0	0	1	0	0	1
Common carp	0	1	0	0	0	0	0	0	1
Golden shiner	3	1	0	0	0	0	0	0	4
Hybrid sunfish	9	2	0	0	0	0	0	0	11
Largemouth bass	1	0	0	3	0	0	0	0	4
Northern pike	0	0	2	0	1	0	0	0	3
White crappie	10	1	0	0	0	0	0	0	11
Yellow perch	1	1	0	0	0	0	0	0	2

7.7 OVERALL LAKE EVALUATION

In 2014, Crosby Lake showed the highest average annual TP value on record, while exhibiting similar Chl-a concentration and Secchi Disk depth to previous years. This suggests that factors in addition to phosphorus could be contributing to algal growth and changes in water transparency in Crosby Lake. Crosby Lake was inundated by the Mississippi River for 50 days in 2014 during spring flooding. Though it declined in 2014 to a “D+”, Crosby Lake has historically received average lake grades, indicating that it generally has average water quality. The lake contained extensive vegetation during the 2014 surveys and average populations of planktivorous fish.

8 LITTLE CROSBY LAKE RESULTS

8.1 LITTLE CROSBY LAKE BACKGROUND



Figure 8-1: View of the south shoreline of Little Crosby Lake.

Little Crosby Lake is 8 acres with an average depth of 7 ft and a maximum depth of 34 ft. Little Crosby Lake is a shallow lake with a littoral area of 88% and has a small watershed area of only 37 acres (Table 8-1). Little Crosby Lake is connected to Crosby Lake through a marsh/bog area 825 ft long. For information on Little Crosby Lake Background, see Crosby Lake Background (page 55).

Table 8-1: Little Crosby Lake morphometric data.

Surface Area (acres)	Maximum Depth (ft)	Littoral Area	Volume (acre-ft)	Watershed Area (acres)	Watershed: Lake Area (ratio)
8.0	34.0	88%	59	37	4.6

Little Crosby Lake has only been monitored since 2011. In the past four years of monitoring for TP, it exceeded the state standards for all four years (Table 8-2). The source of these high nutrient concentrations could be from high flow periods of the river, bringing large sediment loads into the lake. Little Crosby Lake was inundated by spring flooding of the Mississippi River for 50 days during 2014 (Table 7-2; Figure 7-5).

8.2 LAKE LEVEL

There is no historical lake level data for Little Crosby Lake from the Minnesota DNR. CRWD began monitoring Crosby Lake level in 2014. General trends in lake level can be seen by looking at Crosby Lake level (Figure 7-4), as these two bodies of water are hydrologically connected.

8.3 WATER QUALITY RESULTS

Little Crosby Lake was sampled seven times in 2014, from May 13 to October 16 (Figure 8-2). As in the previous three years, Little Crosby Lake exhibited high TP concentrations in 2014 (the highest observed since monitoring began in 2011), but these TP concentrations are much lower in comparison to Como and Crosby Lakes. In 2014, it had higher Chl-a concentrations and shallower Secchi depths than previous years, but still met state standards. Samples show epilimnetic TP concentrations peaked in late July roughly two weeks after the end of the period of flooding (June 3-July 11), and generally decreased through the end of the monitoring season.

The Chl-a concentration peaked early to mid-September and decreased through the end of the season (Figure 8-2). Water clarity did not show any strong trends, but always met the state standard. During 2014, the August peak in Chl-a lagged the July peak in TP by approximately one month. In addition, higher Chl-a concentrations were generally associated with shallower Secchi depths in 2014.

Figure 8-3 shows yearly average historical TP concentrations, Chl-a concentrations, and Secchi disk depths graphically. Little Crosby Lake had improved with respect to TP and Chl-a concentrations between each year for the first three years of monitoring, but saw higher concentrations for TP and Chl-a and shallower Secchi depths for 2014 than any other year. Throughout the last four years, high water transparency has been associated with lower TP and Chl-a concentrations.

Yearly average historical TP concentrations, Chl-a concentrations, Secchi depths, and their comparisons to lake standards are shown in Table 8-2. Little Crosby Lake TP concentrations exceeded the MPCA standards from 2011-2014, while Chl-a and Secchi depth both met the lake standards. The overall lake grade was reduced to a 'C' after receiving a 'B+' grade in both 2012 and 2013. Little Crosby received grades of 'A' for both Chl-a and Secchi depth in 2012 and 2013, but as a result of an average TP grade, received an overall grade of 'B+' for these years (Table 8-3). Little Crosby Lake exhibited moderate water quality for the years monitored. In the future, a larger data set with more monitoring seasons will provide better information to interpret trends in water quality.

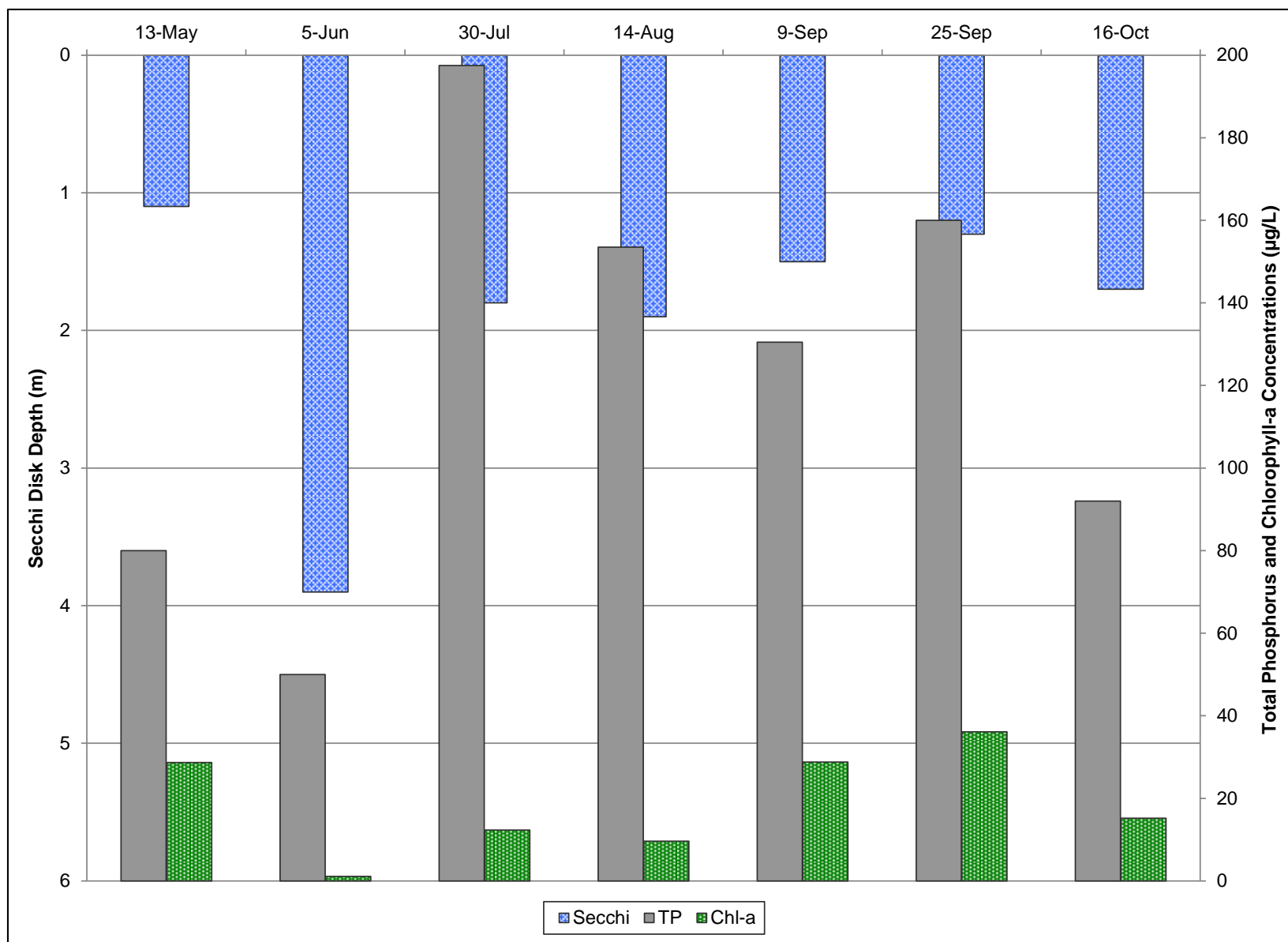


Figure 8-2: Little Crosby Lake 2014 Secchi/TP/Chl-a comparison.

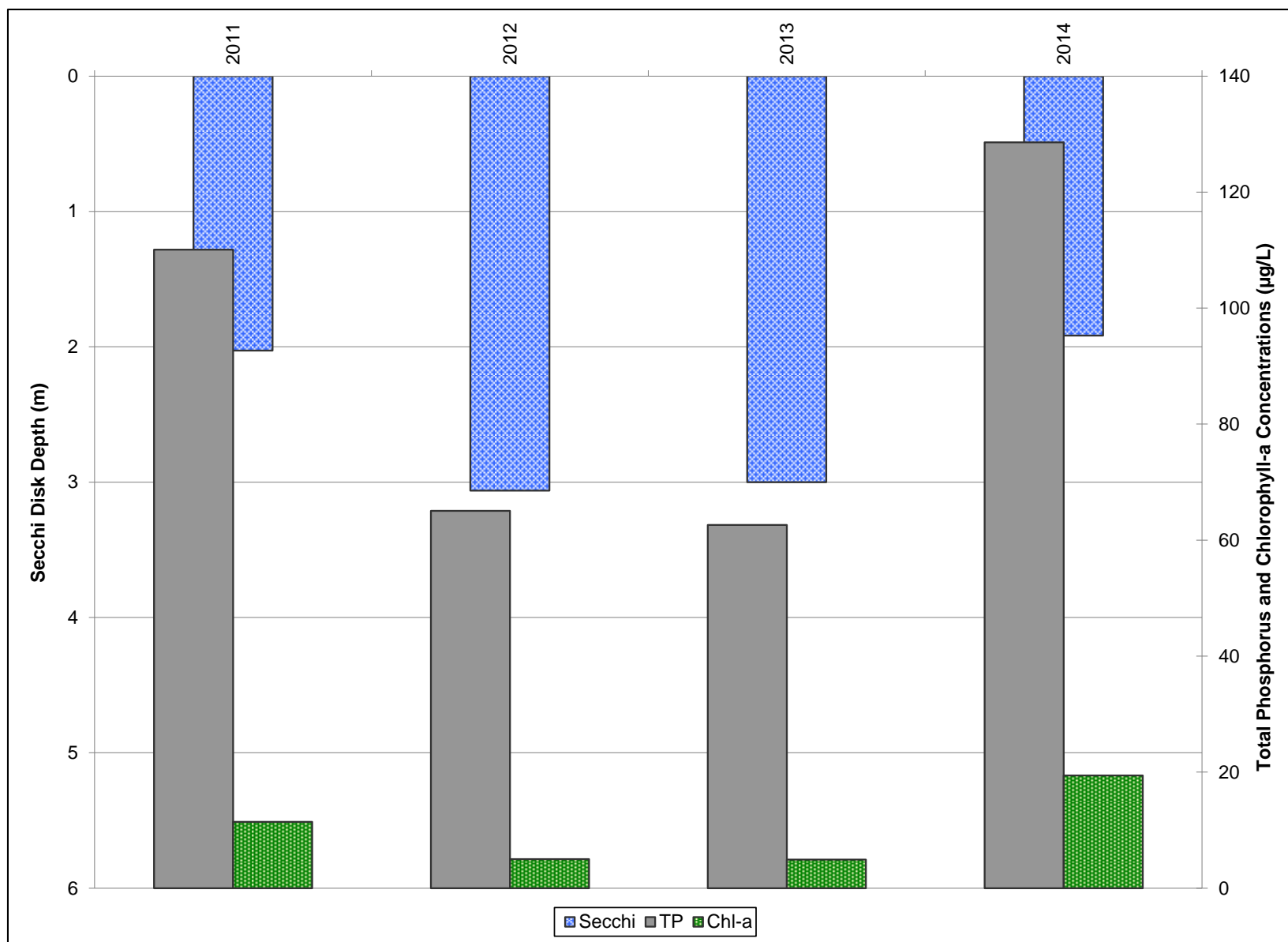


Figure 8-3: Little Crosby Lake historical annual average Secchi/TP/Chl-a comparison.

Table 8-2: Little Crosby Lake historical yearly TP/Chl-a/Secchi depth averages compared to shallow lake state standards.

Year	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
2011	110.1	11.4	2.0
2012	65.1	5.0	3.1
2013	62.6	4.9	3.0
2014	128.6	19.4	1.9
	Value does not meet state standard*		
	Value meets state standard		

*MPCA shallow lake standards are not to exceed 60 µg/L for TP and 20.0 µg/L for Chl-a, with a Secchi disk depth of at least 1.0 m.

Table 8-3: Little Crosby Lake historical lake grades.

Year	TP Grade	Chl-a Grade	Secchi Grade	Overall Grade
2011	D	B	C	C
2012	C	A	A	B+
2013	C	A	A	B+
2014	D	B	C	C

8.4 PHYTOPLANKTON AND ZOOPLANKTON

Little Crosby Lake was sampled for phytoplankton and zooplankton seven times in 2014, from May 13 to October 16. Chlorophyta were the dominant type of phytoplankton during the months of May and June in Little Crosby Lake, and was a consistent population throughout the year (Figure 8-6). Chlorophyta commonly occurs in smaller ponds, giving the water a grass-green color (Kalff, 2002). From June until the end of the season, however, phytoplankton populations varied between all listed species. There are increases of Bacillariophyta at the beginning of August and Chrysophyta at the end of August. Overall, the levels of Cyanophyta (blue-green algae) are low throughout the year. The increase in phytoplankton concentration observed at the end of September corresponds to a decrease in zooplankton concentration at the same time (Figures 8-4 and 8-5). Total phytoplankton concentrations were high at the beginning and end of the season, but stayed low between June and September. TP concentration throughout the year was generally a poor predictor of the total phytoplankton concentration (Figure 8-4).

Cyclopoids were the dominant species at the beginning of the monitoring season at Little Crosby Lake (Figure 8-7). Cladoceran (important lake filter-feeders including the order Daphnia) populations were the most prominent zooplankton type from the end of May through the rest of the monitoring season. Populations of Nauplii and Rotifers were also more prominent during July, August, and September, while Calanoids were barely observed in June only. Density steadily increased throughout the year and peaked in the middle of September, closely following Chl-a concentration during the year (Figure 8-5).

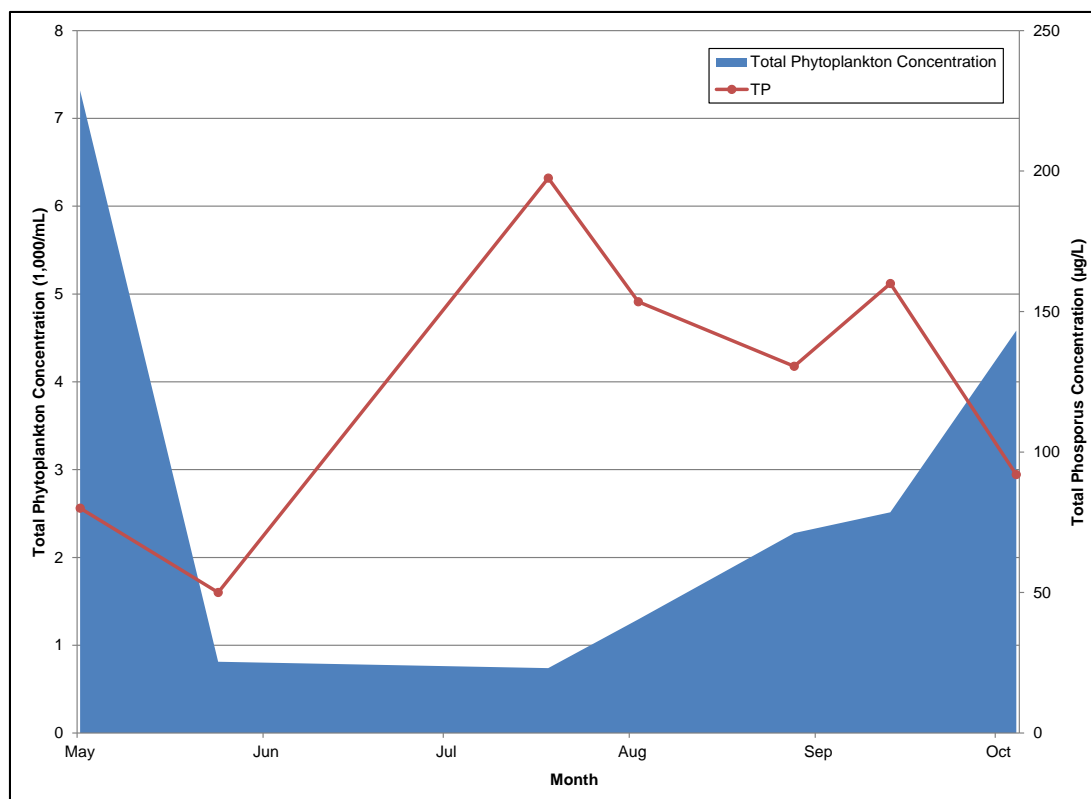


Figure 8-4: Little Crosby Lake 2014 total phytoplankton concentration and TP concentration.

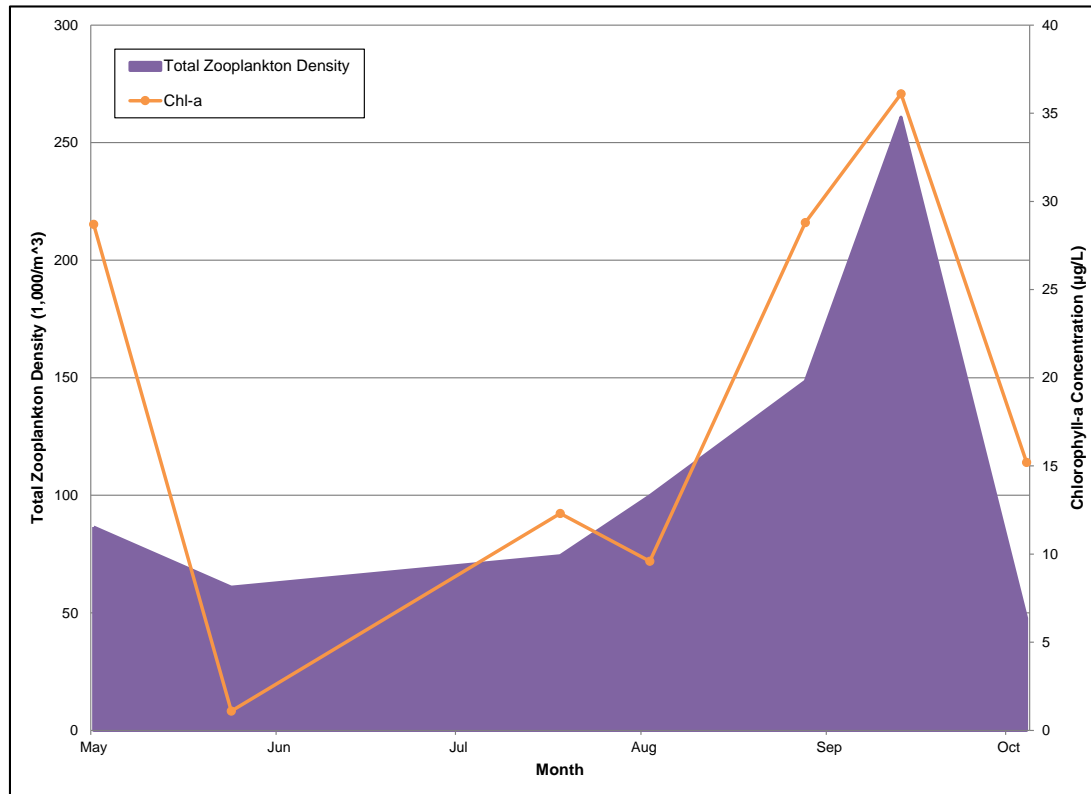


Figure 8-5: Little Crosby Lake 2014 total zooplankton density and Chl-a concentration.

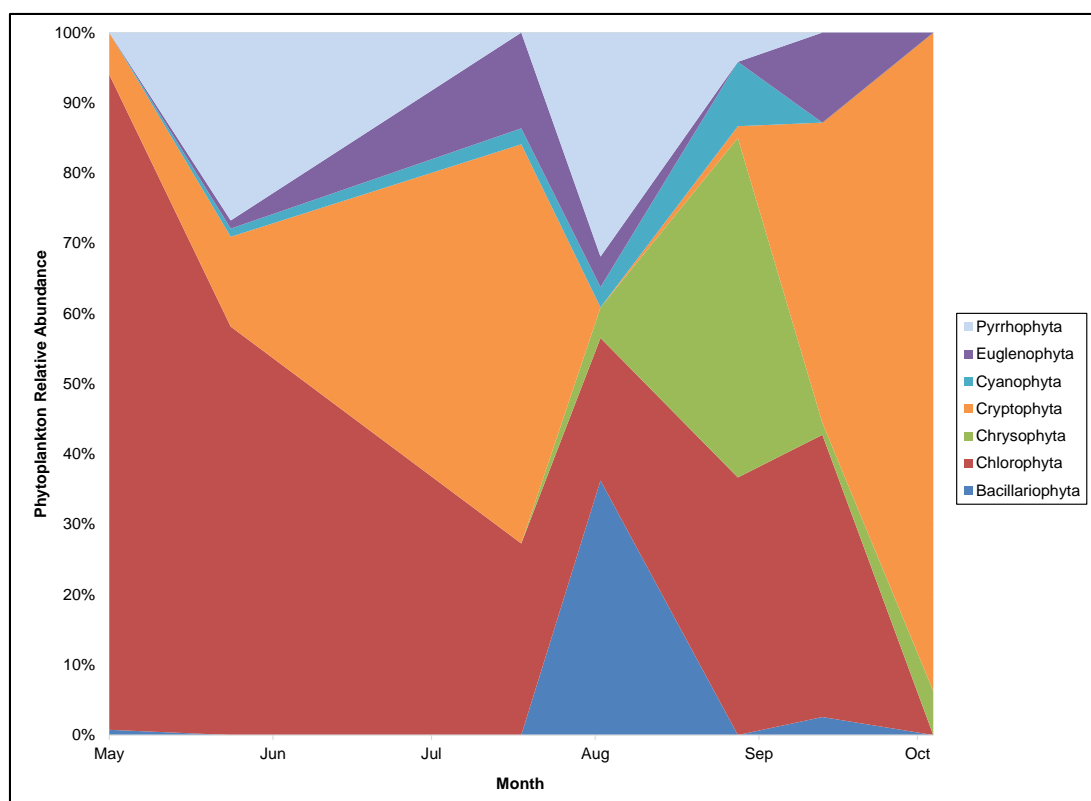


Figure 8-6: Little Crosby Lake 2014 phytoplankton relative abundance.

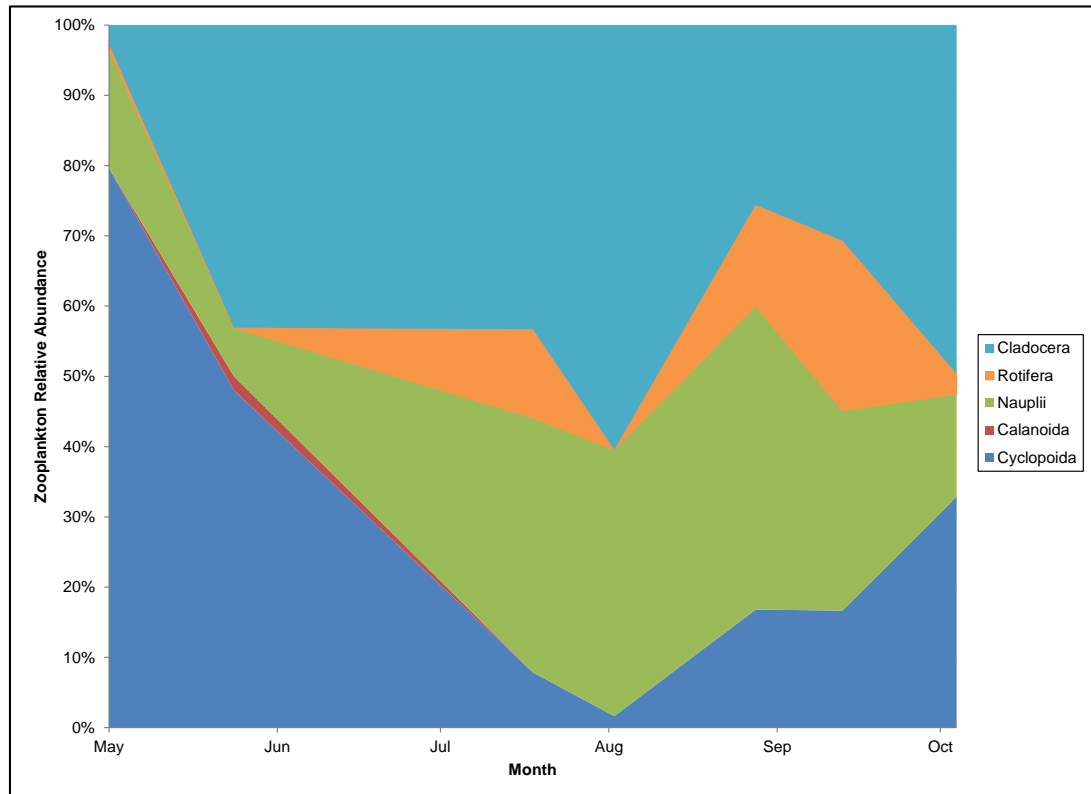


Figure 8-7: Little Crosby Lake 2014 zooplankton relative abundance.

8.5 AQUATIC VEGETATION

8.5.1 BIOVOLUME ANALYSIS

As viewed in Figure 8-8, the majority of Little Crosby Lake contains aquatic vegetation, with this vegetation consuming the full water column in almost all locations where vegetation is observed. Throughout the lake, vegetation generally occurs where lake depth is less than 5 ft. Vegetation stayed consistent between the July and September survey dates.

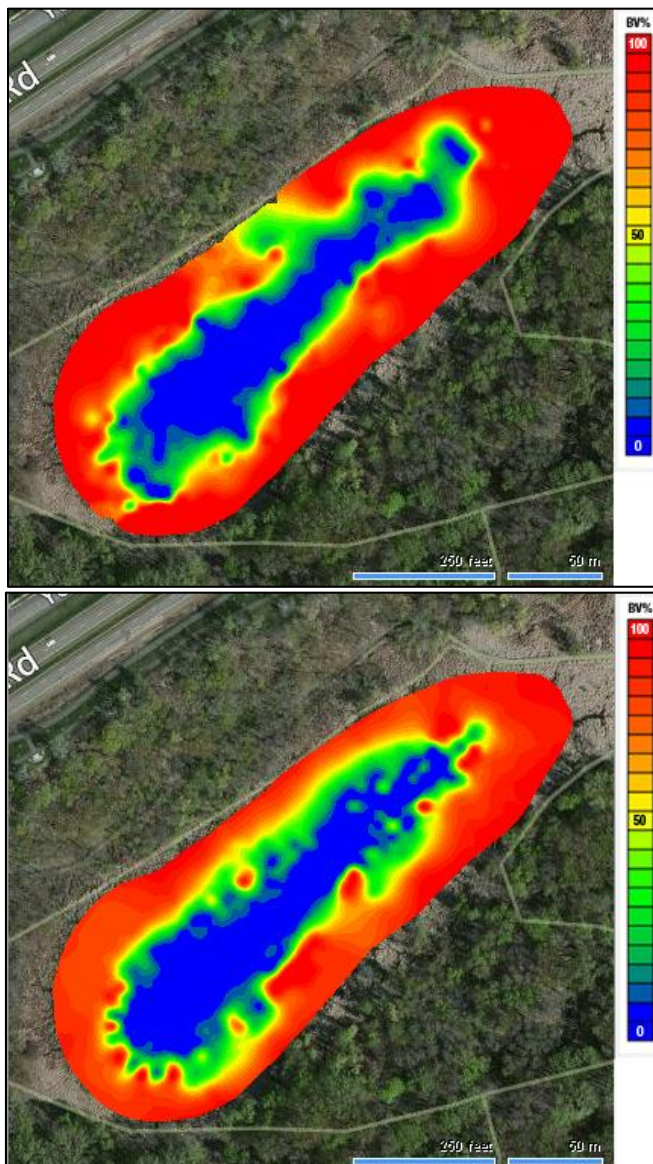


Figure 8-8: Little Crosby Lake 2014 seasonal vegetation changes (7/29/14 and 9/16/14).

8.5.2 POINT-INTERCEPT SURVEYS

In 2014, Little Crosby Lake had an aquatic vegetation community consisting of eight different species of plants observed in late summer, decreasing to five species in mid-September (Figure 8-9 and 8-10). Filamentous algae, slender naiad, and sago pondweed were the highest occurring species on the lake in July (all observed at 67% of locations), transitioning to coontail (observed at 100% of locations) in mid-September. At all locations where vegetation was observed, filamentous algae, slender naiad and coontail were the most abundant in July, with flatstem pondweed, slender naiad and coontail exhibiting the most prominence in September.

Curly-leaf pondweed, a non-native invasive species, was only present in the July survey at 33% of locations where vegetation was found (Figure 8-9) and at a low abundance ranking (Figure 8-10). It was previously observed in the lake in 2011 and 2013, but was absent in 2012 surveys. Curly-leaf pondweed causes problems by displacing other native plants and forming thick mats on the surface of a lake that disrupt boating and recreation. In addition, when the plants die back in mid-summer, the resulting increase in phosphorus from the decomposing plant material causes disruptive algal blooms (DNR, 2005).

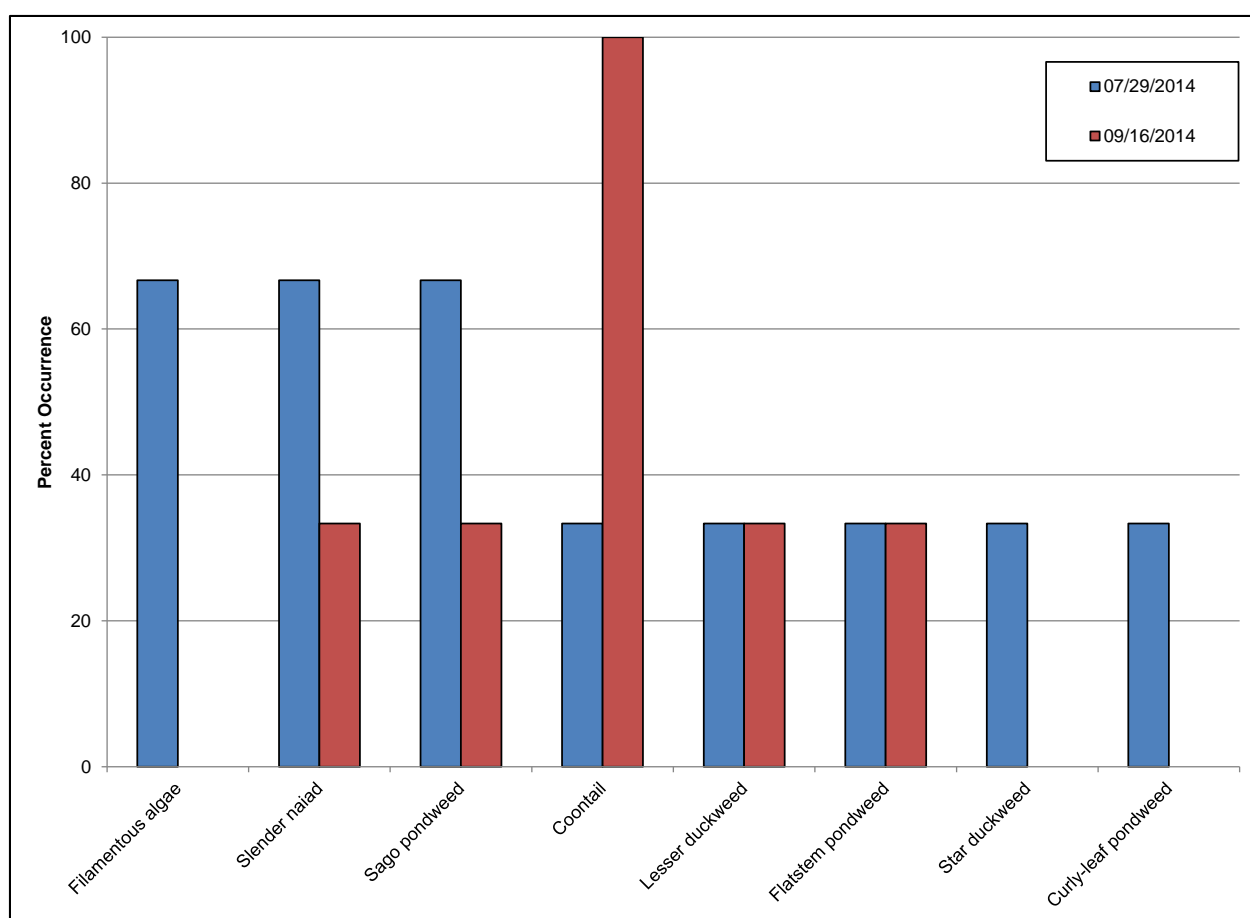


Figure 8-9: Little Crosby Lake 2014 percent occurrence of vegetation present.

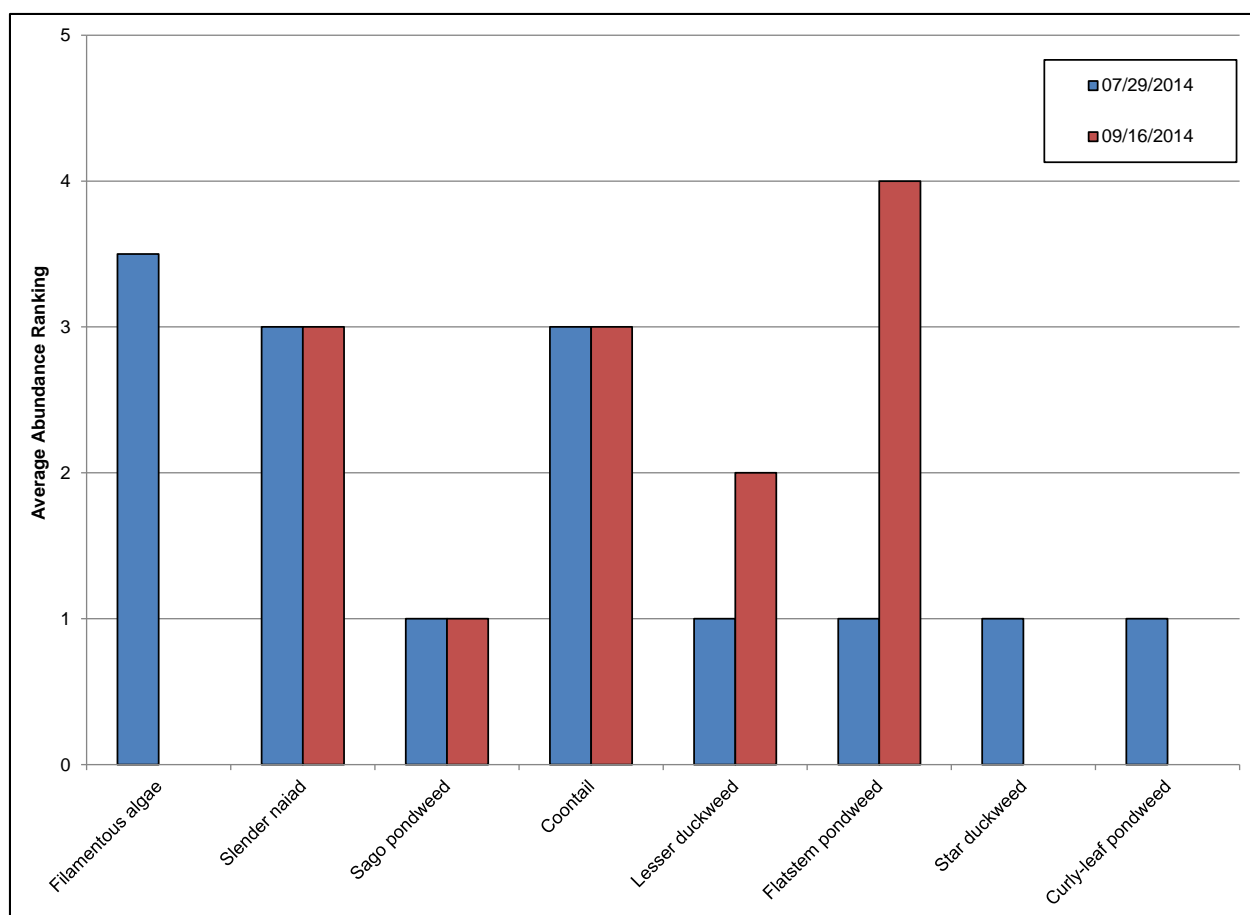


Figure 8-10: Little Crosby Lake 2014 average abundance ranking of vegetation present.

8.6 FISH STOCKING AND SURVEYS

There is no history of fish stocking for Little Crosby Lake by the Minnesota DNR.

The first survey of fish populations in Little Crosby Lake was completed by CRWD August 2014 (Appendix A). Additional information regarding the 2014 survey can be found in Appendix A: 2014 Fish Surveys – Como and Little Crosby Lakes. The largest population of fish observed during the 2014 survey were black bullhead (Table 8-4). All of the species observed (except for pumpkinseed sunfish) were also observed in the 2014 Crosby Lake fish survey (Table 7-5), which is expected given that they are hydrologically connected. There were more species of fish, however, observed in the Crosby Lake survey, which could be a result of its larger size and hydrology.

The large number of bullhead that were found in the 2014 Little Crosby survey could also be an indication of poor water quality, as these fish are more tolerant of lower water quality and oxygen levels than some of the other more desirable fish (DNR, 2015a). While Little Crosby Lake has a maximum depth of 34 ft, this only occurs in a small area in the middle of the basin.

Dissolved oxygen was also measured during the survey, and was found to be less than 2.0 mg/L at depths lower than 5 ft at this middle-basin deep location (Appendix A). Moderately tolerant species of fish require DO levels of at least 2-5 mg/L at the minimum to sustain a healthy population (Kalff, 2002). This presents an environment unable to support a healthy population of a broader range of fish species. Therefore, it is unsurprising that so many black bullhead were observed, as they are a more tolerant species. The lake also has the potential to contain species found in the Mississippi River due to periods of river inundation. Little Crosby Lake is scheduled to be surveyed again in the summer of 2015 by CRWD.

Table 8-4: Little Crosby Lake 2014 fish populations.

Species	Number of fish caught in each category (inches)								Total
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	
Black bullhead	7	41	4	0	0	0	0	0	52
Bluegill	1	0	0	0	0	0	0	0	1
Hybrid sunfish	1	0	0	0	0	0	0	0	1
Northern pike	0	0	0	0	0	0	0	1	1
Pumpkinseed sunfish	1	1	0	0	0	0	0	0	2
Yellow perch	2	3	0	0	0	0	0	0	5

8.7 OVERALL LAKE EVALUATION

Little Crosby Lake has a relatively short monitoring record when compared to the other District lakes. From 2011-2013, it exhibited relative improvements in TP and Chl-a concentrations and deeper Secchi disk depths, but 2014 had the highest TP and Chl-a concentrations and shallowest Secchi Disk depth on record. The lake was affected by flooding from the Mississippi River for a portion of June and July in 2014. Much of the lake area was covered by extensive vegetation in 2014, and contained a moderate diversity of plant species by mid-summer. Fish populations exhibited low diversity, and larger relative numbers of black bullhead, a highly tolerant species that can be indicative of poor water quality.

9 LOEB LAKE RESULTS

9.1 LOEB LAKE BACKGROUND



Figure 9-1: View of the northwest shoreline of Loeb Lake.

Loeb Lake, located in Marydale Park in the northwestern portion of the City of St. Paul, is a 9.7 acre lake with a maximum depth of 28 feet and an 81% littoral area (Table 9-1). The area has a walking path, children's play area, picnic areas, a fishing pier, and a boat launch. The surrounding area is primarily residential land use.

Table 9-1: Loeb Lake morphometric data.

Surface Area (acres)	Maximum Depth (ft)	Littoral Area	Volume (acre-ft)	Watershed Area (acres)	Watershed: Lake Area (ratio)
9.7	28.0	81%	84	44	4.5

The watershed area contributing inflow to the lake is 44 acres (Table 9-1; Figure 9-2). Water enters the lake from the north half of the watershed through sheet flow traveling through Marydale Park, as well as a storm sewer that collects runoff from Mackubin Street between Maryland and Jessamine Avenues (CRWD, 2009). Runoff from the south half of the watershed enters Loeb Lake through two different storm sewers. The storm sewers drain streets on the south and east sides of the lake, discharging to a stormwater pond on the southeast corner. A pipe directly connects this pond to Loeb Lake. There are no direct outlets from Loeb Lake.

Loeb Lake has been monitored since 2003 and has had relatively stable TP, Chl-a, and Secchi disk depth values that have consistently met the state standards. Therefore, lake conditions have appeared to remain stable in the past nine years. Previous winter kills of fish have been observed in Loeb Lake, but have not occurred since 2000, when an aerator was installed in the lake (CRWD, 2009). Future management efforts on Loeb Lake should focus on reduced loading in the surrounding watershed and naturalizing the shoreline (CRWD, 2009). Both of these actions would reduce the subsequent influx of nutrients into the lake. While water quality is currently stable, good management efforts around the lake to prevent further increases in nutrient inputs will be key in preventing lake degradation.

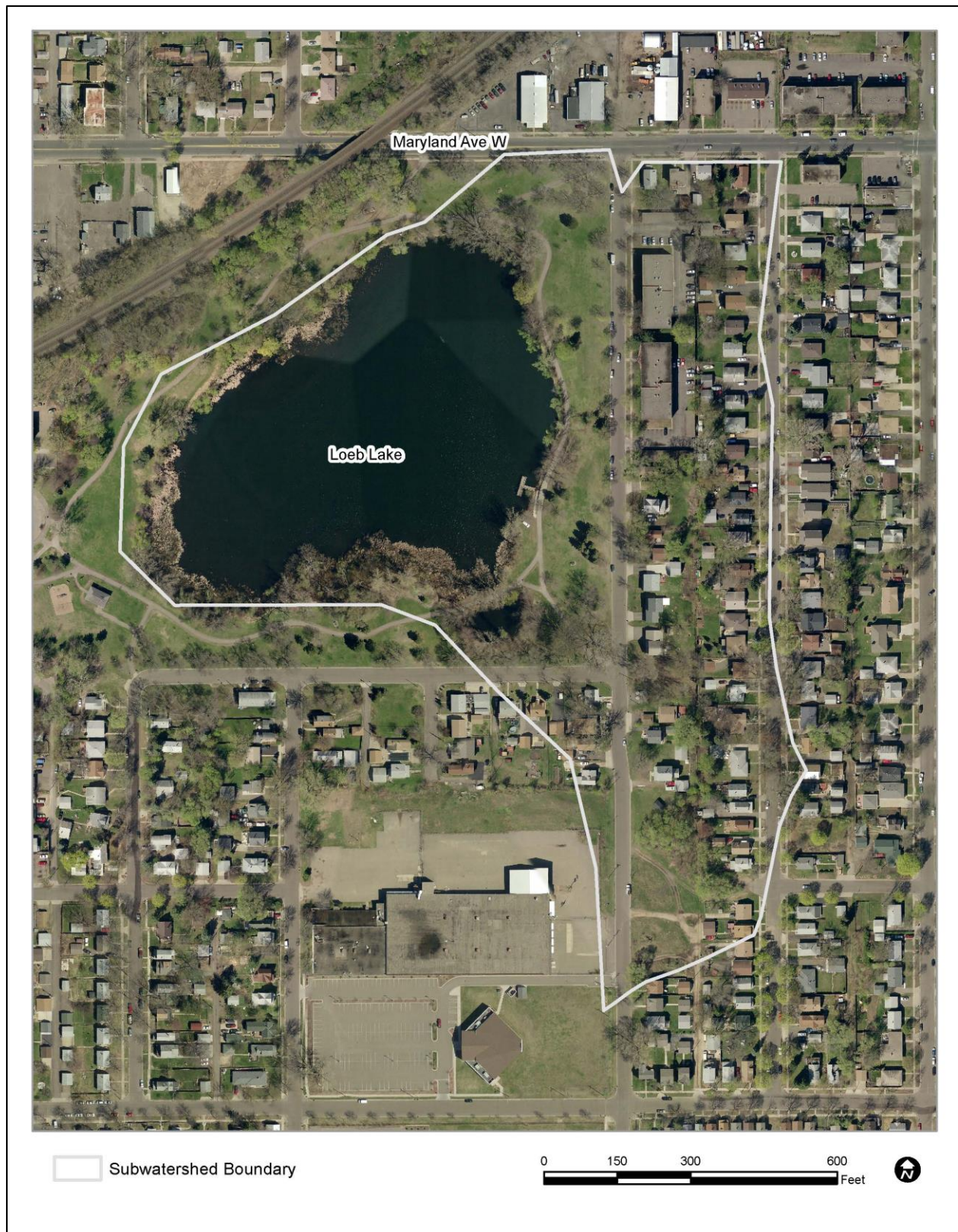


Figure 9-2: Loeb Lake and subwatershed boundary.

9.2 LAKE LEVEL

Loeb Lake level has been monitored since 2003, with the exception of May 2004 through February 2006 when level data was not available (Figure 9-3). Loeb Lake does not have an OHWL to compare the current year to historical “normal” lake levels. The lowest recorded water level of the lake occurred in May 2009 at a level of 848.6 ft. In July 2014, the lake reached the highest level on record at 852.32 ft. This occurred after a record-setting June 19th storm event, in which 3.16 inches of rain fell in a 24 hr period. The previous record high was in August of 2011 at a height of 851.63 ft. In 2014, lake level increased from January until it peaked on July 1 (after one of the wettest June months on record in Minnesota), then steadily decreased until the end of the year (Figure 9-4).

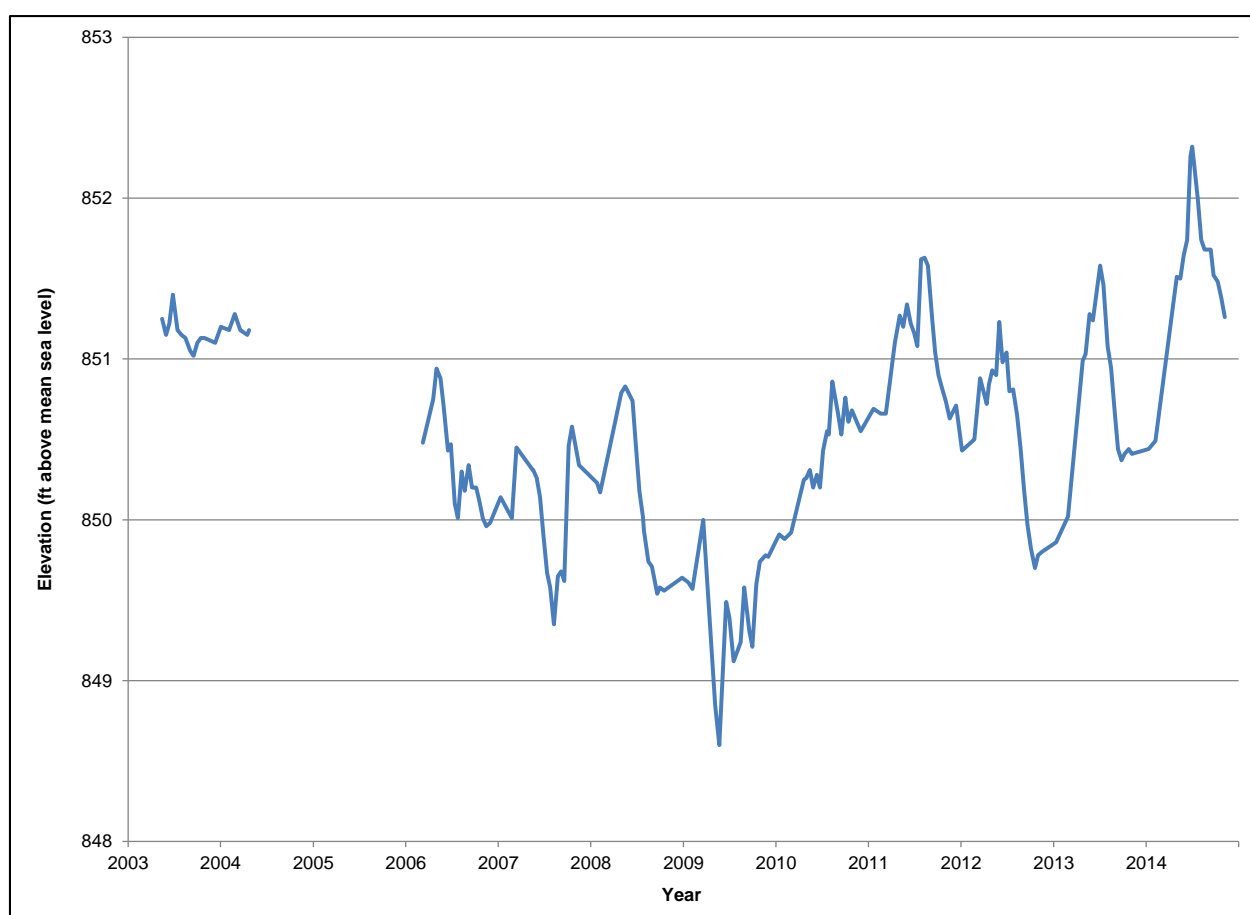


Figure 9-3: Loeb Lake historical lake elevations (DNR, 2015i).

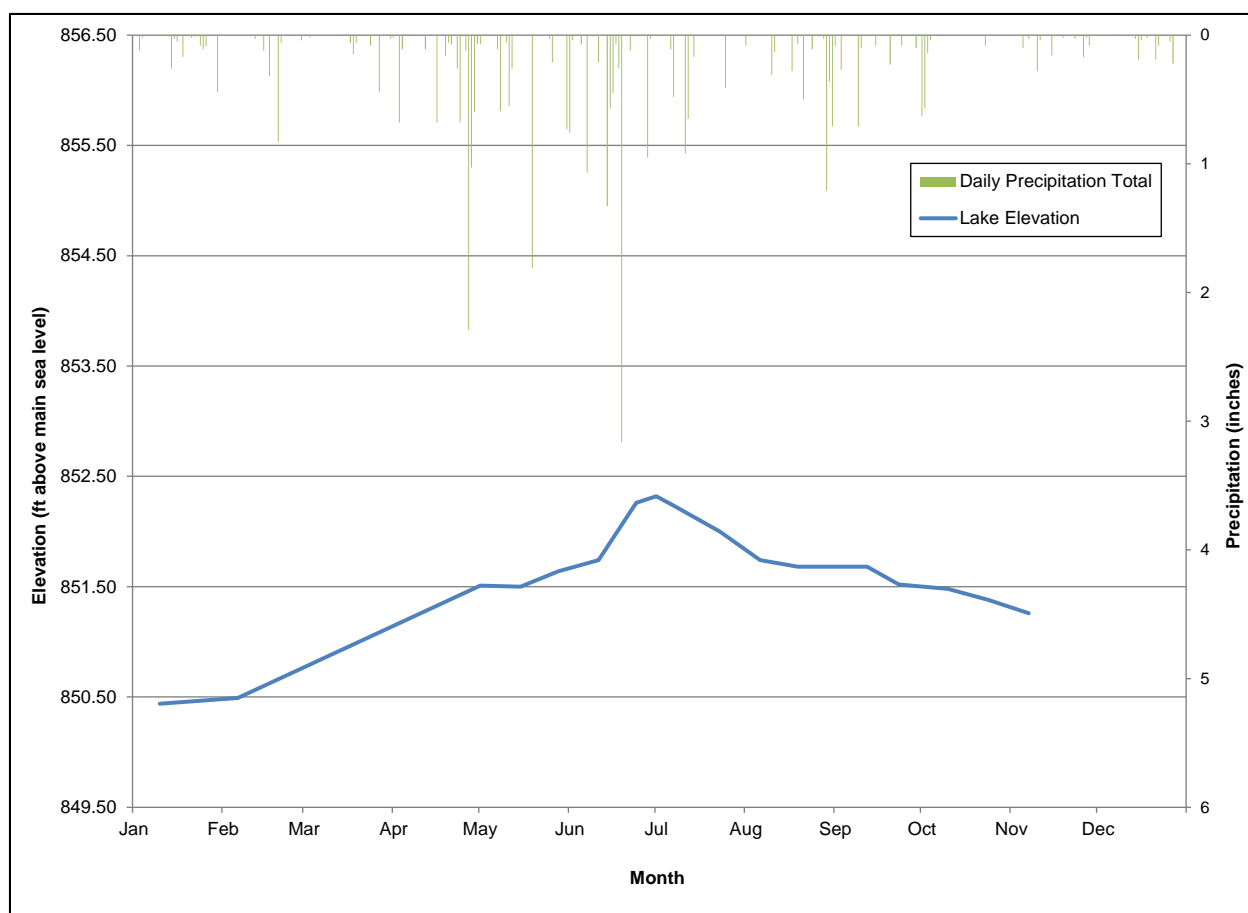


Figure 9-4: Loeb Lake 2014 lake elevations and daily precipitation events (DNR, 2015i; MCWG, 2015b).

9.3 WATER QUALITY RESULTS

Loeb Lake was sampled nine times during 2014 from May 5 to October 20 (Figure 9-5). As in previous years, Loeb Lake was characterized by low TP and Chl-a concentrations, and deep Secchi depths. TP levels were highest (44 $\mu\text{g/L}$) during the first sampling event on May 5. Samples show decreasing TP concentrations until early July, increasing until August, then decreasing slightly through the end of the season.

Chlorophyll-a concentrations began with a season high value of 15.2 $\mu\text{g/L}$ on May 5 and decreased by the end of June to a consistent value of 2-4 $\mu\text{g/L}$ through the end of the season. Secchi depths were generally shallower during the first two samples (average 1.35 m) and deeper during the last 7 samples (average 3.2 m). The data suggests that during 2014, higher water clarity was generally associated with lower TP and Chl-a concentrations.

Figure 9-6 shows yearly average historical TP concentrations, Chl-a concentrations, and Secchi disk depths graphically. Based on the historical data since 2003, water quality has been fairly steady in Loeb Lake. Total phosphorus concentrations decreased from 2003-2008, but have been

increasing since 2009. Overall concentrations, however, are the lowest of any District Lake, and also low compared with other area lakes (Table 5-1) (DNR, 2015i).

Chl-a concentrations have been low and varied only slightly throughout the period of record. Concentrations for Chl-a were lower from 2005-2012 and 2014, whereas 2003, 2004, and 2013 were characterized by slightly higher Chl-a concentrations (Figure 9-6). Secchi depths were shallowest in 2003 (2.7m), deepest in 2005 and 2006 (3.8 m and 3.7 m) and have been generally getting shallower since. As with 2014, higher water transparency was generally associated with lower Chl-a concentrations throughout the period of record.

Yearly average historical TP concentrations, Chl-a concentrations, Secchi depths, and their comparisons to lake standards are shown in Table 9-3. Loeb Lake has had a stable and consistent water quality history. It has not exceeded the average summer TP, Chl-a or Secchi disk depth water quality standards in its monitoring history. The overall lake grade has historically been an 'A', with only one 'B' grade occurring in 2003 and three 'B+' grades in 2004, 2005, and 2014 (Table 9-4). The drop from an 'A' grade in 2013 to a 'B+' grade in 2014 was the result of the slight decrease in Secchi disk depth observed between the two years. The high water quality lake grades associated with Loeb Lake indicate that it continues to be one of the highest water quality lakes in the District.

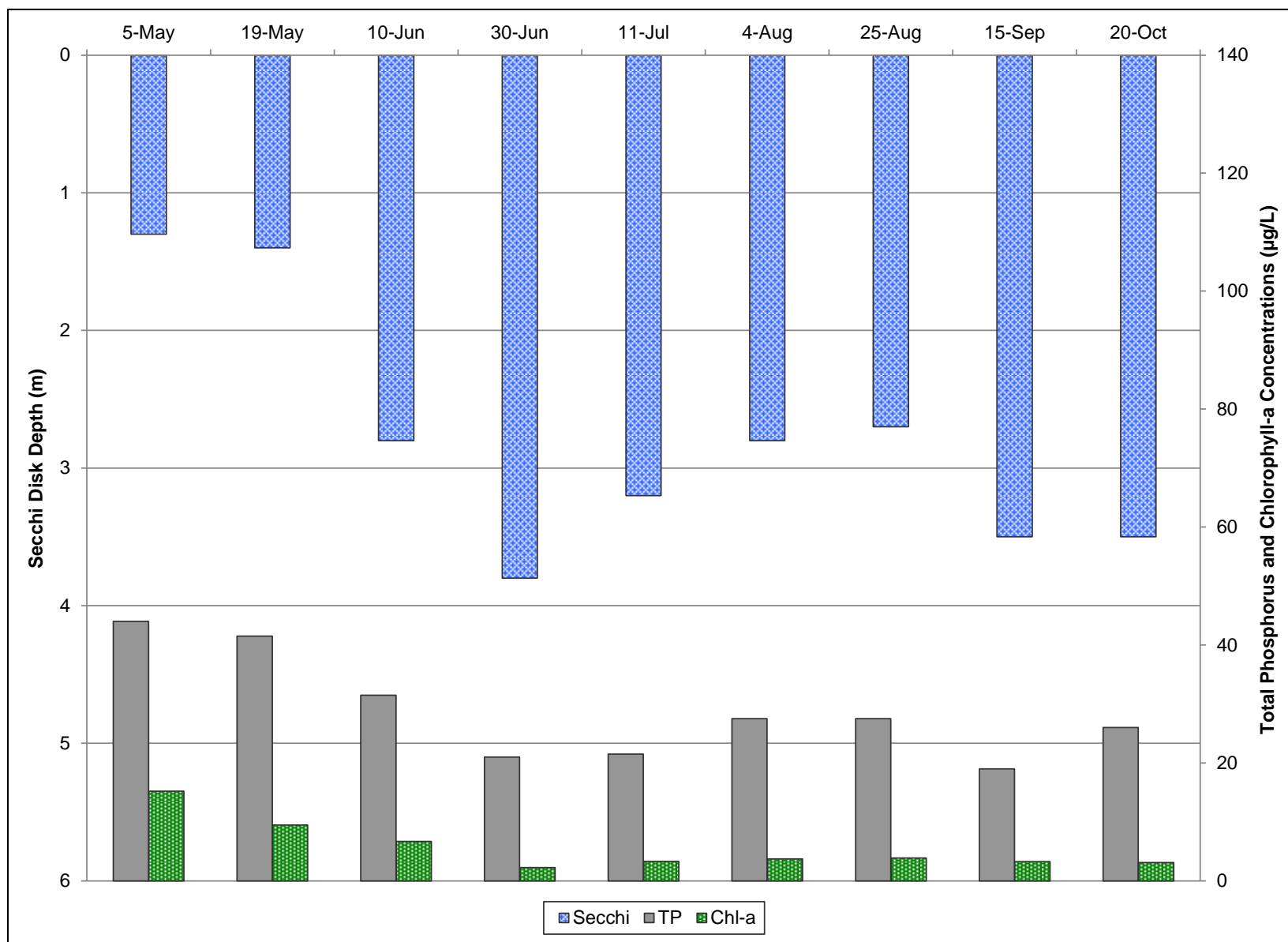


Figure 9-5: Loeb Lake 2014 Secchi/TP/Chl-a comparison.

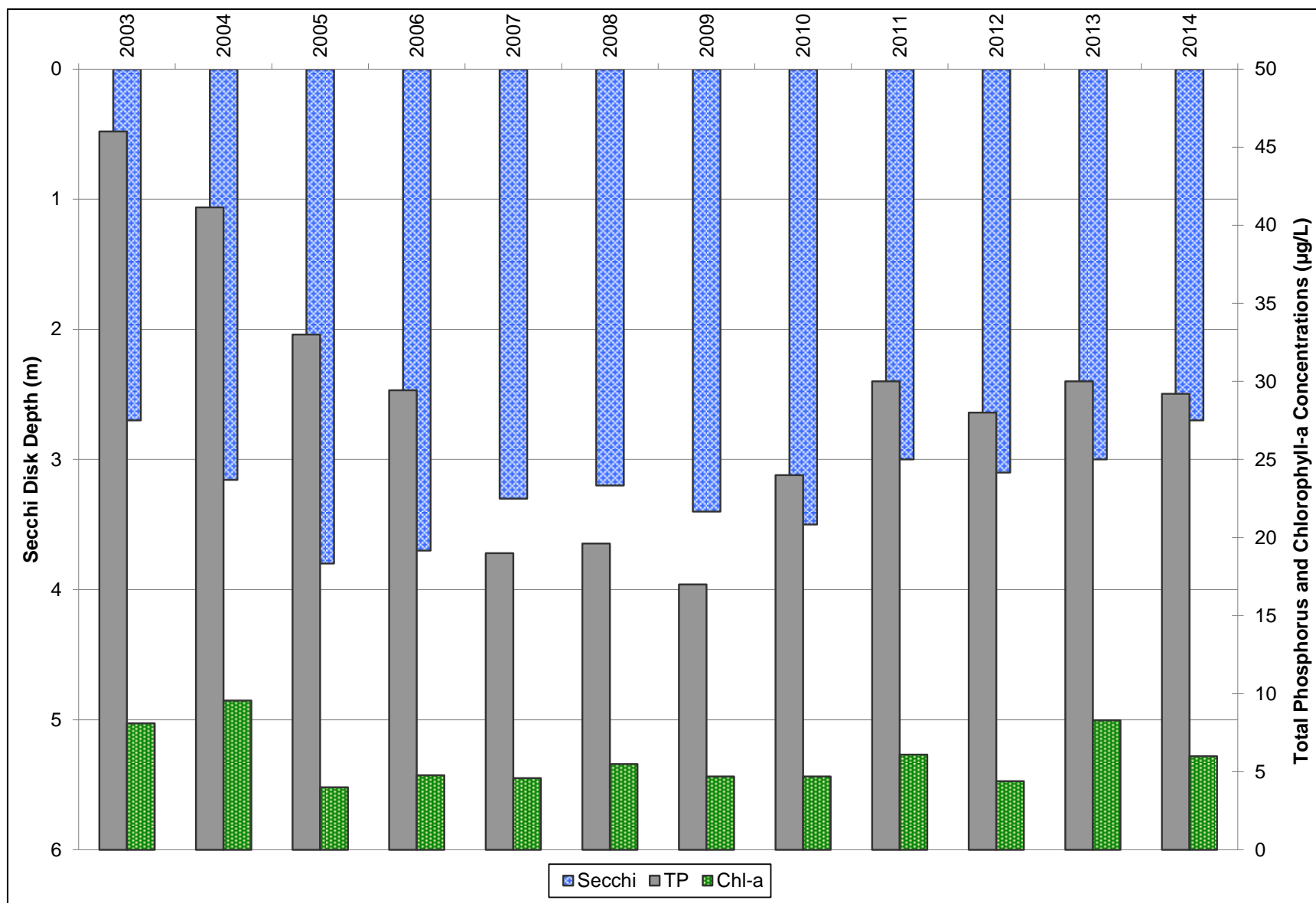


Figure 9-6: Loeb Lake historical annual average Secchi/TP/Chl-a comparison.

Table 9-3: Loeb Lake historical yearly TP/Chl-a/Secchi depth averages compared to shallow lake state standards.

Year	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
2003	46	8.1	2.7
2004	41	9.6	3.2
2005	33	4.0	3.8
2006	29	4.8	3.7
2007	19	4.6	3.3
2008	20	5.5	3.2
2009	17	4.7	3.4
2010	24	4.7	3.5
2011	30	6.1	3.0
2012	28	4.4	3.1
2013	30	8.3	3.0
2014	29	6.0	2.7
	Value does not meet state standard*		
	Value meets state standard		

*MPCA shallow lake standards are not to exceed 60 µg/L for TP and 20.0 µg/L for Chl-a, with a Secchi disk depth of at least 1.0 m.

Table 9-4: Loeb Lake historical lake grades.

Year	TP Grade	Chl-a Grade	Secchi Grade	Overall Grade
2003	C	A	B	B
2004	C	A	A	B+
2005	C	A	A	B+
2006	B	A	A	A
2007	A	A	A	A
2008	A	A	A	A
2009	A	A	A	A
2010	B	A	A	A
2011	B	A	A	A
2012	B	A	A	A
2013	B	A	A	A
2014	B	A	B	B+

9.4 PHYTOPLANKTON AND ZOOPLANKTON

During 2014, Loeb Lake was sampled for phytoplankton and zooplankton eight and nine times, respectively, from May 5 to October 20. From May to mid-June in Loeb Lake, concentrations of Chlorophyta, Crysophyta, and Cryptophyta were the dominant species (Figure 9-9). Phytoplankton concentrations were dominated by Cyanophyta from mid-June through mid-August, then varied among Chlorophyta, Cryptophyta, and Cyanophyta from mid-August through the end of the monitoring season. There was a small population increase in Euglenophyta during the month of August, but this population was otherwise not observed during the rest of the year. Pyrrophyta is observed in low concentrations from May through late August. Total phytoplankton concentration was at its highest at the beginning of May, then steadily decreased throughout the monitoring season, generally following fluctuations in total phosphorus concentration (Figure 9-7).

Dominance of the zooplankton community shifted from Cyclopoids during the month of May to Cladocerans during the month of June. From July through October, both Cyclopoids and Cladocerans still made up a portion of the population, but the other species of Calanoids, Nauplii, and Rotifers increased during this time period (Figure 9-10). Nauplii were also present early in May. Total zooplankton density was high at the beginning of the year and at its lowest in early July, both events corresponding to observed Chl-a concentrations. Zooplankton density does not follow Chl-a fluctuations, however, for the rest of the year after they both reach their lowest levels in July. Total zooplankton population reached a peak for the year in mid-September before drastically decreasing by the end of October (Figure 9-8).

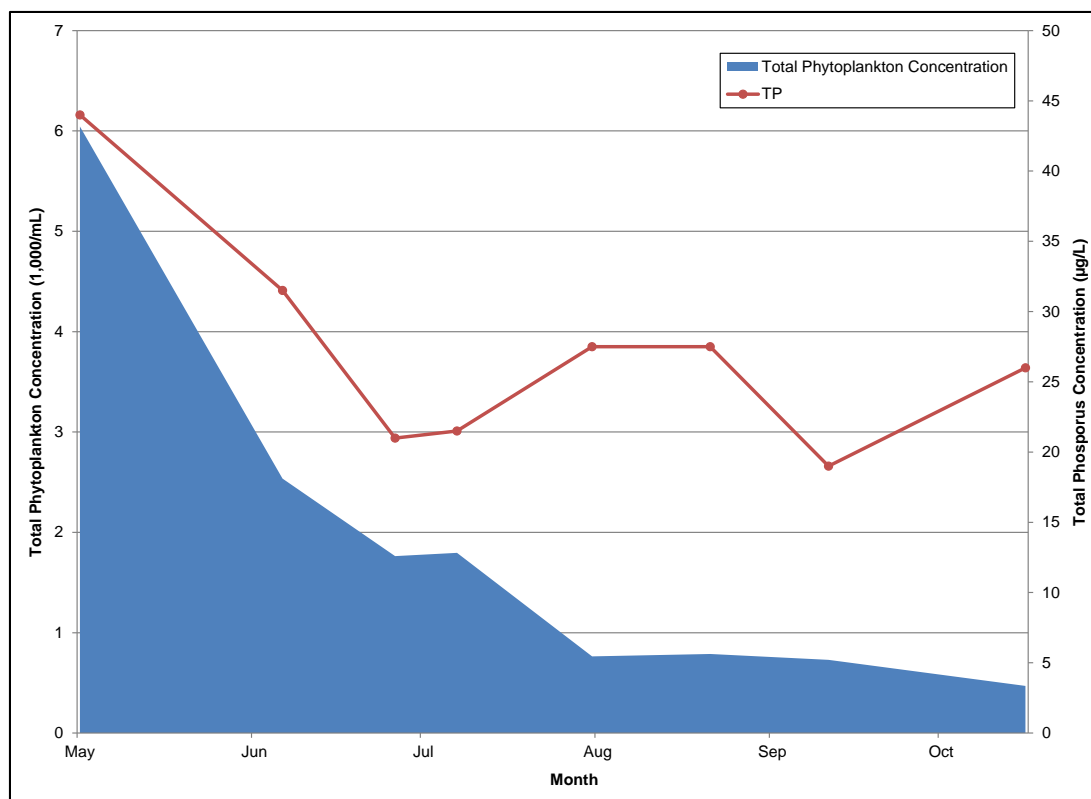


Figure 9-7: Loeb Lake 2014 total phytoplankton concentration and TP concentration.

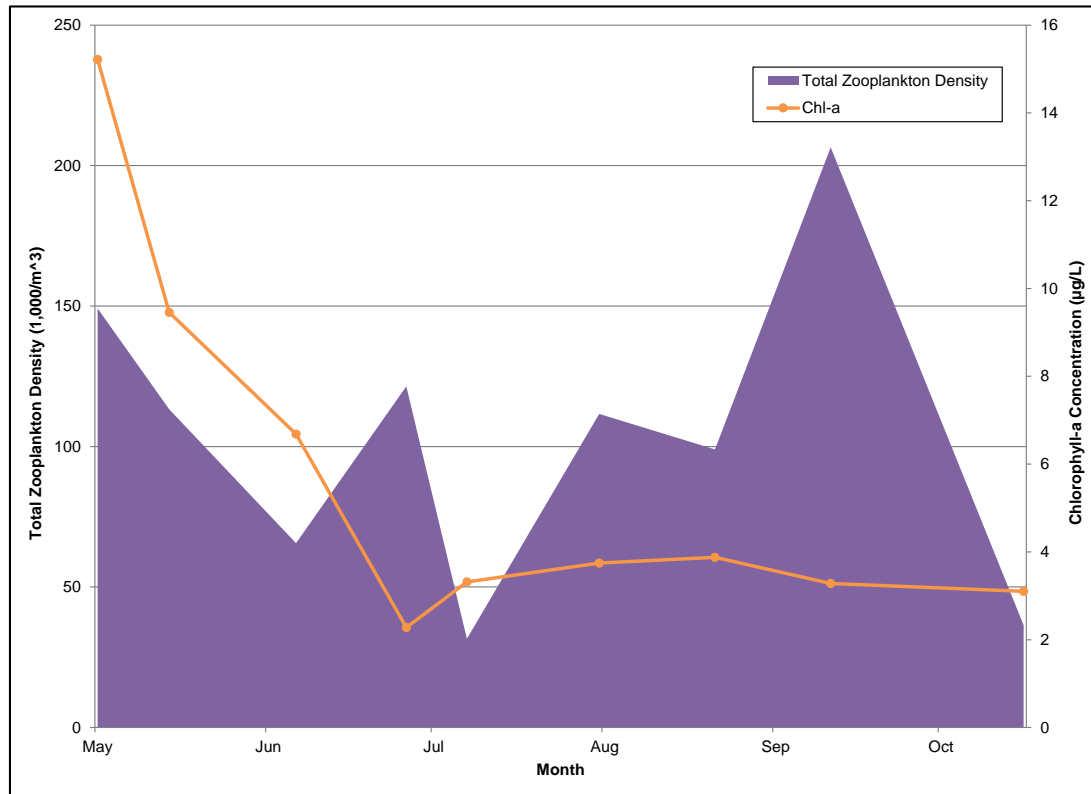


Figure 9-8: Loeb Lake 2014 total zooplankton density and Chl-a concentration.

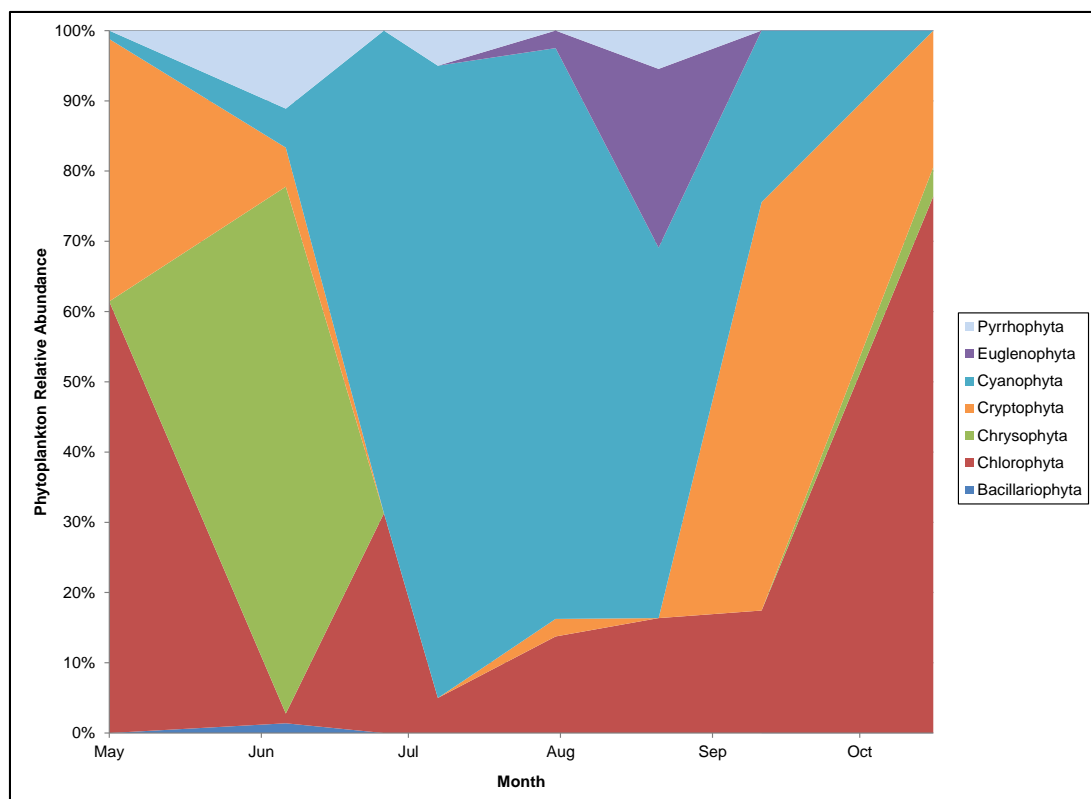


Figure 9-9: Loeb Lake 2014 phytoplankton relative abundance.

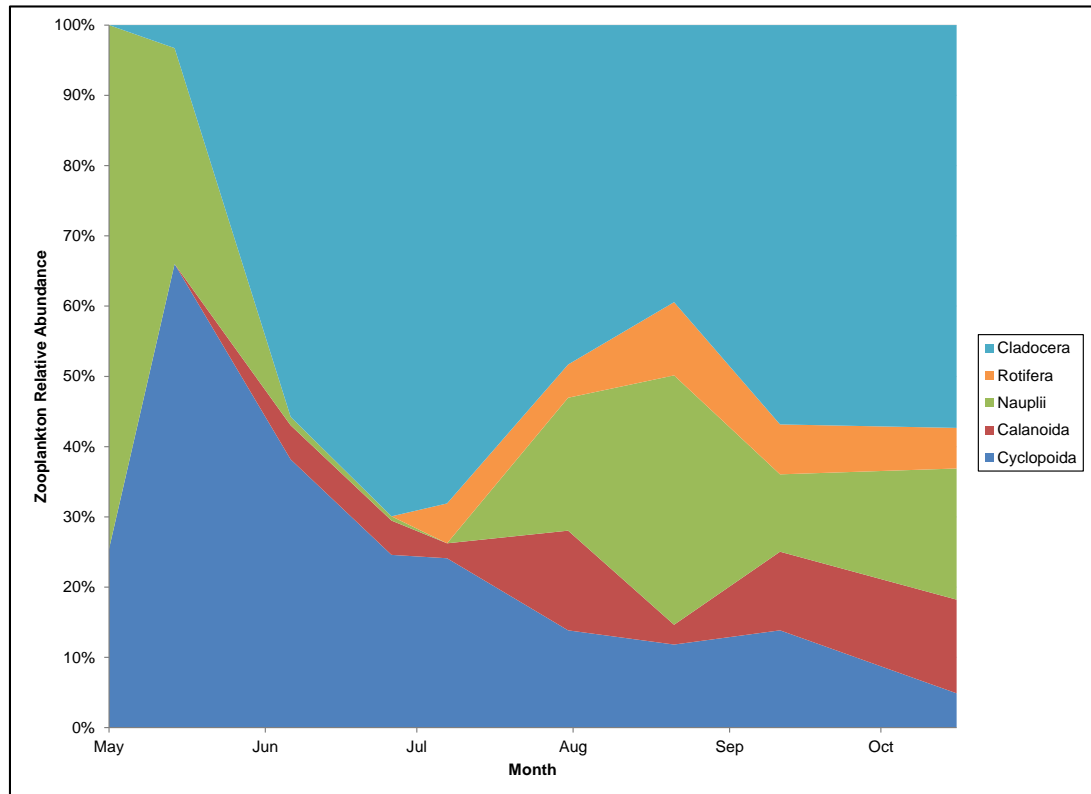


Figure 9-10: Loeb Lake 2014 zooplankton relative abundance.

9.5 AQUATIC VEGETATION

9.5.1 BIOVOLUME ANALYSIS

Figure 9-11 shows that a large majority of Loeb Lake has extensive vegetation, as indicated by the areas in red where 100% of the water column contains vegetation. The deepest area of the lake does not contain any vegetation. Extensive vegetation is also observed throughout the monitoring season at Loeb Lake, increasing in coverage throughout the year, and is almost 100% covered by September with the exception of the deepest point (Figure 9-11).

9.5.2 POINT-INTERCEPT SURVEYS

As compared to 2013 when there were only three plant species observed in June, there was a much wider variety of plant species at the beginning of the monitoring year in Loeb Lake (Figure 9-12). Of the eight species observed, however, two of the three species (curly-leaf pondweed and Eurasian watermilfoil), were non-native invasive species. Coontail was observed throughout the year at almost all of the locations on the lake where vegetation was observed, and at average abundances (Figure 9-13). As curly-leaf pondweed and Eurasian watermilfoil both experience die-off around mid-summer, they were not spotted when surveyed again at the end of July (curly-leaf pondweed) or were significantly reduced in occurrence and abundance by the September survey date (Eurasian watermilfoil). Instead, additional vegetation such as lesser duckweed, filamentous algae, and slender naiad were observed alongside coontail throughout the rest of the summer. Other plant types identified were less abundant and not observed at a large majority of lake locations.

The presence of both curly-leaf pondweed and Eurasian watermilfoil in Loeb Lake presents potential problems for future management decisions. Curly-leaf pondweed and Eurasian watermilfoil are both non-native invasive species, causing problems by displacing other native plants, and forming thick mats on the surface of a lake that disrupt boating and recreation (DNR, 2015d; DNR, 2005). In addition, when curly-leaf pondweed plants die back in mid-summer, the resulting increase in phosphorus from the decomposing plant material can cause disruptive algal blooms (DNR, 2005). The spreading of Eurasian watermilfoil makes it an especially difficult plant to manage, as a new plant can grow from just a tiny piece of an original plant. This makes it easy to float and grow quickly in other areas of a lake, as well as be transported between lakes on boat trailers and fishing gear (WSDE, 2015). Both species have been observed in Loeb Lake since 2005.

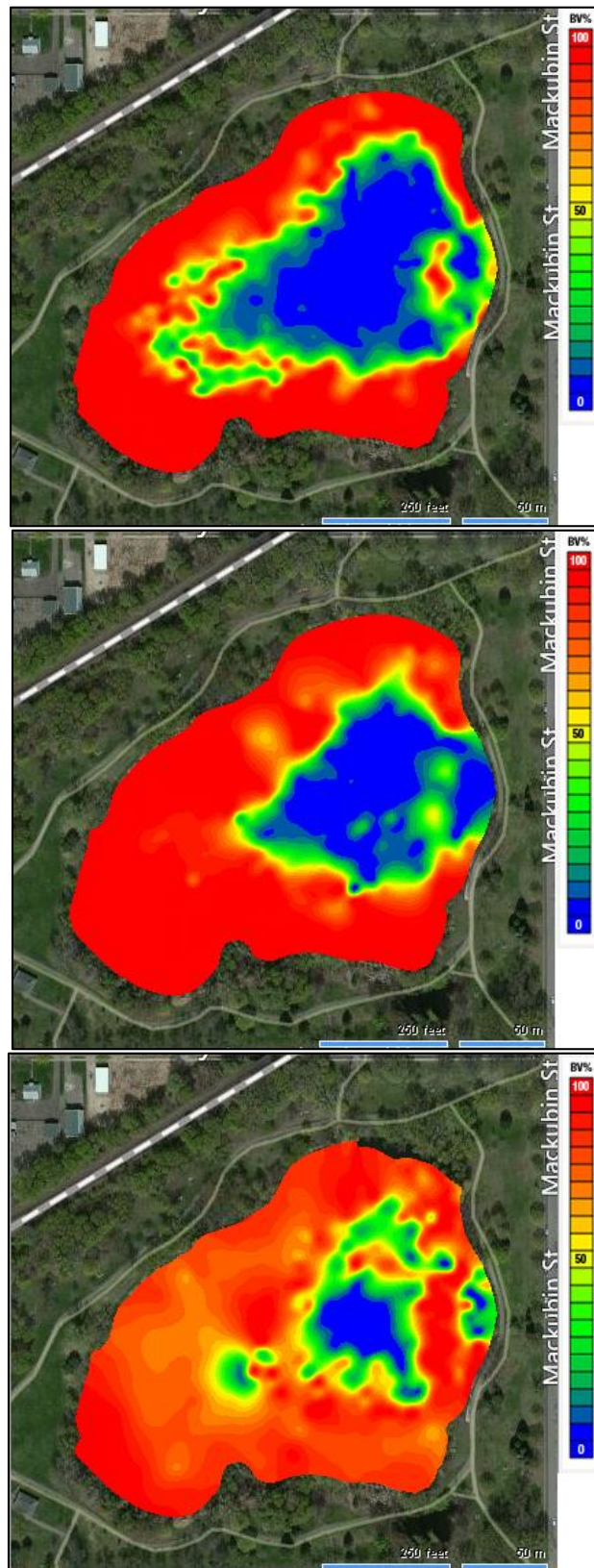


Figure 9-11: Loeb Lake 2014 seasonal vegetation changes (6/18/14, 7/23/14, and 9/9/14)

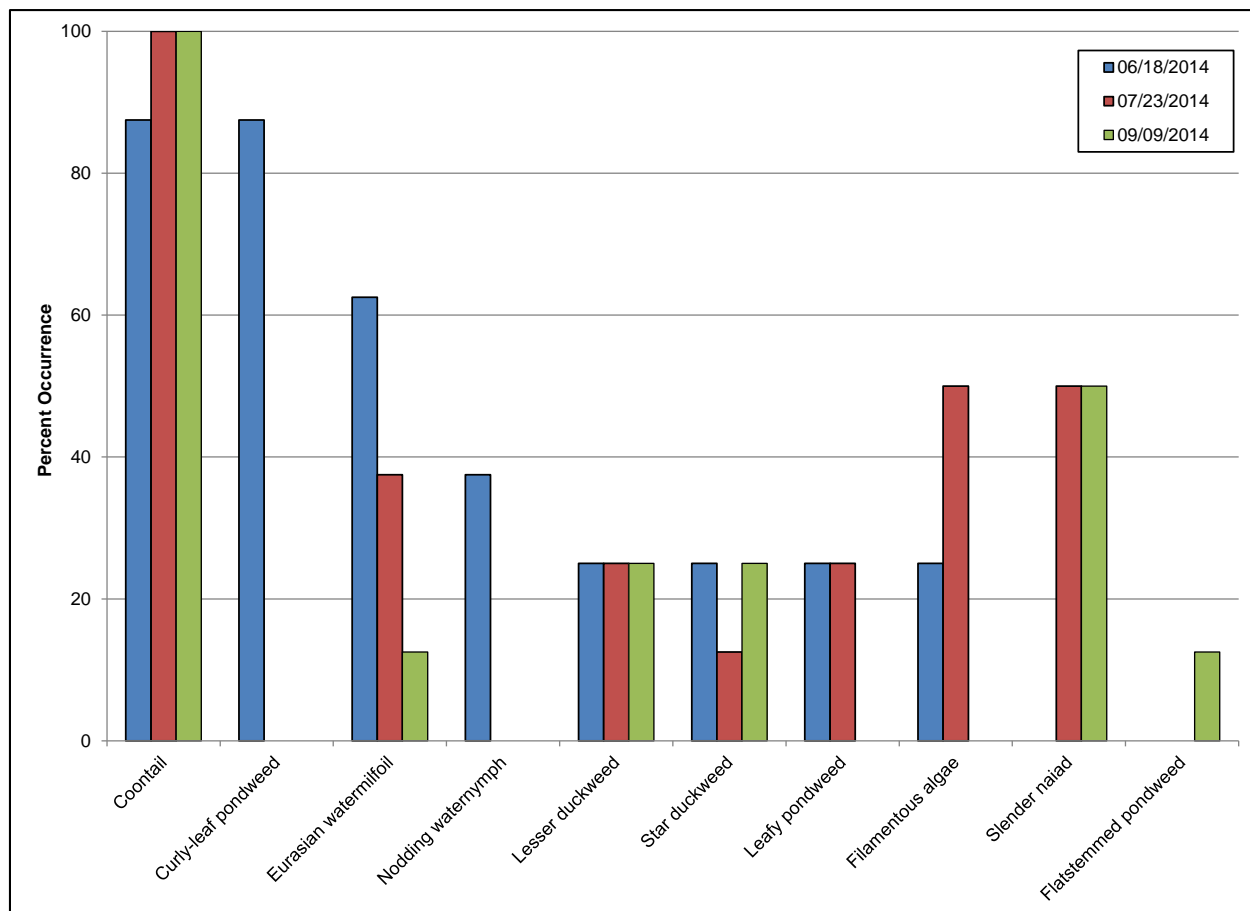


Figure 9-12: Loeb Lake 2014 percent occurrence of vegetation present.

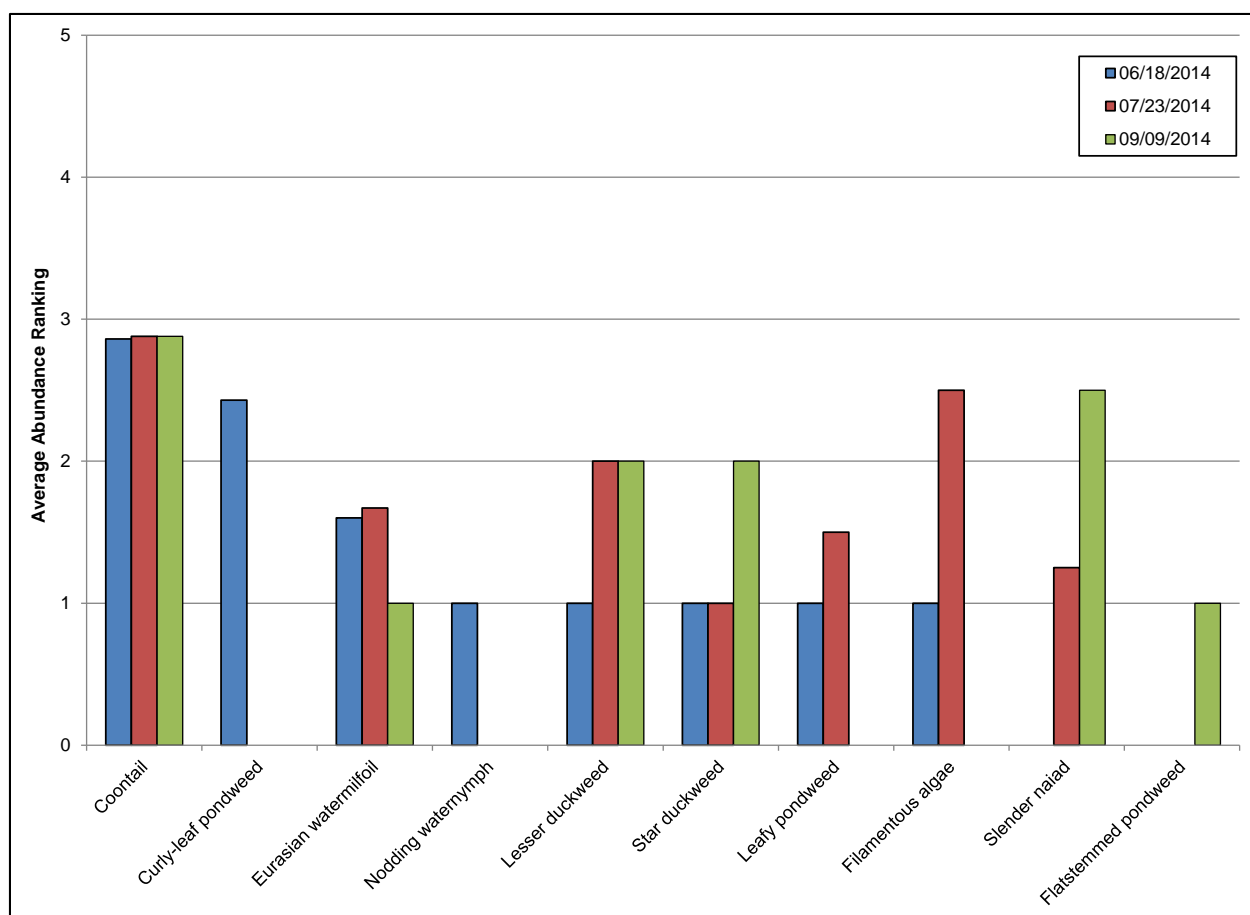


Figure 9-13: Loeb Lake 2014 average abundance ranking of vegetation present.

9.6 FISH STOCKING AND SURVEYS

Loeb Lake is part of the Minnesota DNR's "Fishing in the Neighborhood" program which provides angling opportunities for children and families in urban environments, encourages environmental stewardship, and improves knowledge of natural resources (DNR, 2015g). Therefore, these lakes are stocked with fish that are better for general angling activities. As seen in Table 9-5, the main fish types stocked in Loeb Lake in recent years are adult bluegill, along with black crappie, catfish and walleye (important management species in the past). Bluegill and hybrid sunfish were the most abundant observed fish types in the 2014 Loeb Lake survey conducted by the Minnesota DNR (Table 9-6). Species diversity and relative abundance of fish populations in 2014 closely mirrored the 2008 survey conducted, suggesting that the lake has a relatively stable population of fish (CRWD, 2014a).

Table 9-5: Loeb Lake historical record of fish stocking.

Year	Black crappie	Bluegill		Channel catfish		Largemouth bass		Walleye		
	Adult	Adult	Yearling	Adult	Yearling	Adult	Yearling	Yearling	Fingerling	Fry
2014		289							380	
2013		185							610	
2012		152								
2011	26	144			689				709	
2010		74		50	1211					
2009	207	106		47	622					
2008	244	380		55	1290					
2007	69	1018		38	1040	138	630			13,000
2006		524							34	10,000
2005	9	242	627						19	10,000
2004		444						3	149	10,000

Table 9-6: Loeb Lake 2014 fish populations.

Species	Number of fish caught in each category (inches)								Total
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	
Black bullhead	0	0	1	0	0	0	0	0	1
Black crappie	0	2	0	0	0	0	0	0	2
Bluegill	21	1	0	0	0	0	0	0	22
Green sunfish	4	0	0	0	0	0	0	0	4
Hybrid sunfish	14	0	0	0	0	0	0	0	14
Largemouth bass	0	0	1	0	0	0	0	0	1
Pumpkinseed sunfish	5	0	0	0	0	0	0	0	5
Walleye	0	1	1	0	0	0	0	0	2

9.7 OVERALL LAKE EVALUATION

Loeb Lake exhibits the best water quality of any District lake, and has historically received an ‘A’ lake grade, indicating high water quality and user quality. In 2014, the lake received a ‘B+’ lake grade as a result of a shallower-than-normal Secchi disk depth. All historical years of monitoring have met the MPCA state standards for TP, Chl-a, and Secchi disk depth. Loeb Lake held an abundant amount of aquatic vegetation in 2014, but most species monitored (aside from coontail) only showed moderate abundance throughout the lake area. The 2014 fish survey found population amounts and diversity of fish species to be very similar to the previous survey conducted in 2006, indicating stable fish populations in Loeb Lake.

10 LAKE MCCARRONS RESULTS

10.1 LAKE MCCARRONS BACKGROUND



Figure 10-1: View of the fishing pier on the southeast shoreline of Lake McCarrons.

Lake McCarrons is a 74.7 acre, deep lake located in the City of Roseville. With a maximum depth of 57 ft and a 36% lake littoral area, it supports a variety of activities including swimming, boating, and fishing (Table 10-1; Figure 10-2). Lake McCarrons County Park, located on the east shore of the lake, supports visitors to the lake with a beach building, picnic shelter, and boat access with car/trailer parking.

Table 10-1: Lake McCarrons morphometric data.

Surface Area (acres)	Maximum Depth (ft)	Littoral Area	Volume (acre-ft)	Watershed Area (acres)	Watershed: Lake Area (ratio)
74.7	57.0	34%	1,892	1,070	14.3



Figure 10-2: Lake McCarrons bathymetric map.

The 1,070 acre watershed of Lake McCarrons consists of residential properties, commercial and public areas, highway, wetland/grassland/woodland areas, and a park bordering it on the east side (Figure 10-3). The outlet of the Villa Park Wetland Treatment System located on the western edge of the lake is the primary inlet to Lake McCarrons. A secondary inlet enters on the north side of the lake via William Street Pond. It has one main outlet at the east end of the lake. This outlet is the headwaters of the Trout Brook-West Branch Subwatershed, where water enters the Trout Brook Storm Sewer Interceptor (CRWD, 2003).

Multiple projects to improve water quality have been completed in recent years in the watershed draining to Lake McCarrons. In 1987, the Villa Park Wetland Treatment System became operational, which consisted of a 2.4 acre pond that empties into a series of five wetland cells. These cells then drain to a final terminal wetland which overflows at high levels to Lake McCarrons. The purpose of this system is to channel stormwater through a series of wetlands that decreases flow velocity. This allows sediments and bound nutrients to settle before entering the lake. This system reduced the amount of TP and dissolved phosphorus entering the lake (CRWD, 2003). In 2004, improvements to the system were made which removed the pipes connecting the wetland treatment cells, improved the berms, and constructed timber weirs at each of the wetland outflows to provide a fixed and stable overflow. In 2013, CRWD dredged several of the wetland cells in the Villa Park System. A total of more than 17,000 cubic yards of sediment was removed from the system to improve stormwater treatment and residence time before water flows into Lake McCarrons. Because the Villa Park sub-subwatershed is the largest in the McCarrons subwatershed and contains a significant amount of the drainage area of the lake (roughly 70% of the 1,070 watershed area of the lake), it has been a high-priority focus for management efforts (CRWD, 2010).

In October of 2004, CRWD completed an alum treatment on Lake McCarrons, in order to reduce the amount of total phosphorus in the lake. In this type of treatment, aluminum sulfate is applied below the lake surface and binds to free phosphorus particles causing them to drop out of the water column and settle on the bottom of the lake (Kennedy and Cook, 1982). This removes phosphorus from the water column, as well as prevents additional phosphorus release from the bottom sediments (CRWD, 2003). Water quality after this alum treatment showed improvements when compared to pre-alum treatment water quality.

One of the primary water quality concerns continues to be the flow of phosphorus into the lake, as stormwater is still the largest portion of inflow to the lake. Currently, Lake McCarrons is considered unimpaired and is not listed on the MPCA 303(d) list of impaired waters. While Lake McCarrons currently exhibits good water quality and is considered unimpaired, it still has concerns that need to be addressed annually in order to maintain its integrity. For example, intermittent fish kills have occurred in Lake McCarrons in the past. These are caused by incomplete fall lake mixing, and early winter freeze and snow (CRWD, 2003). When this occurs, there is not enough oxygen in the lake to support fish populations, resulting in a full or partial fish kill. Another on-going management issue is the presence of invasive species on the lake including carp, Eurasian watermilfoil, and curly-leaf pondweed, all of which have been observed in recent years. Excessive aquatic vegetation growth on the west end of the lake has become a management concern, and CRWD coordinated plant removal on this area of the lake in June and August of 2014. CRWD will again help lead efforts for plant removal on this part of the lake in 2015.

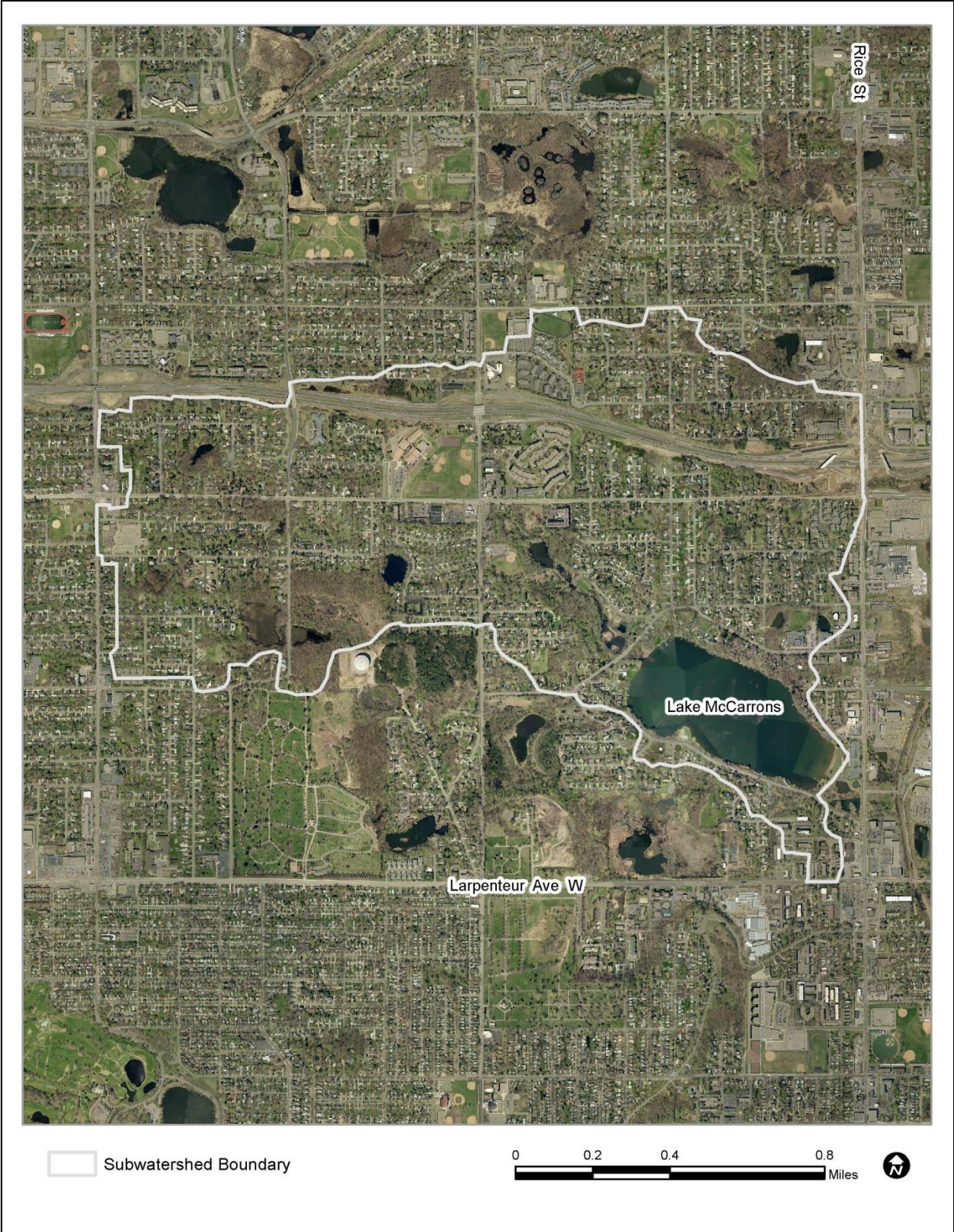


Figure 10-3: Lake McCarrons and subwatershed boundary.

10.2 LAKE LEVEL

Lake McCarrons level has been consistently below the OHWL of 842.2 ft throughout the historical lake level record (Figure 10-4). The water level came close to the OHWL in 1984 and 1997. A significantly low water level period occurred from 1932-1939. The water level has consistently stayed within 840-842 ft for the past 35 years. The 2014 lake level reported here was a combination of the weekly staff gauge readings completed by the DNR from January to November, and the 15-min level logger data collected from June to October by CRWD (Figure 10-5). In 2014, lake level rose slightly from the beginning of the year until late-April, decreased during May and June, then increased to a peak level on June 19 after abnormally high precipitation rates for the month of June.

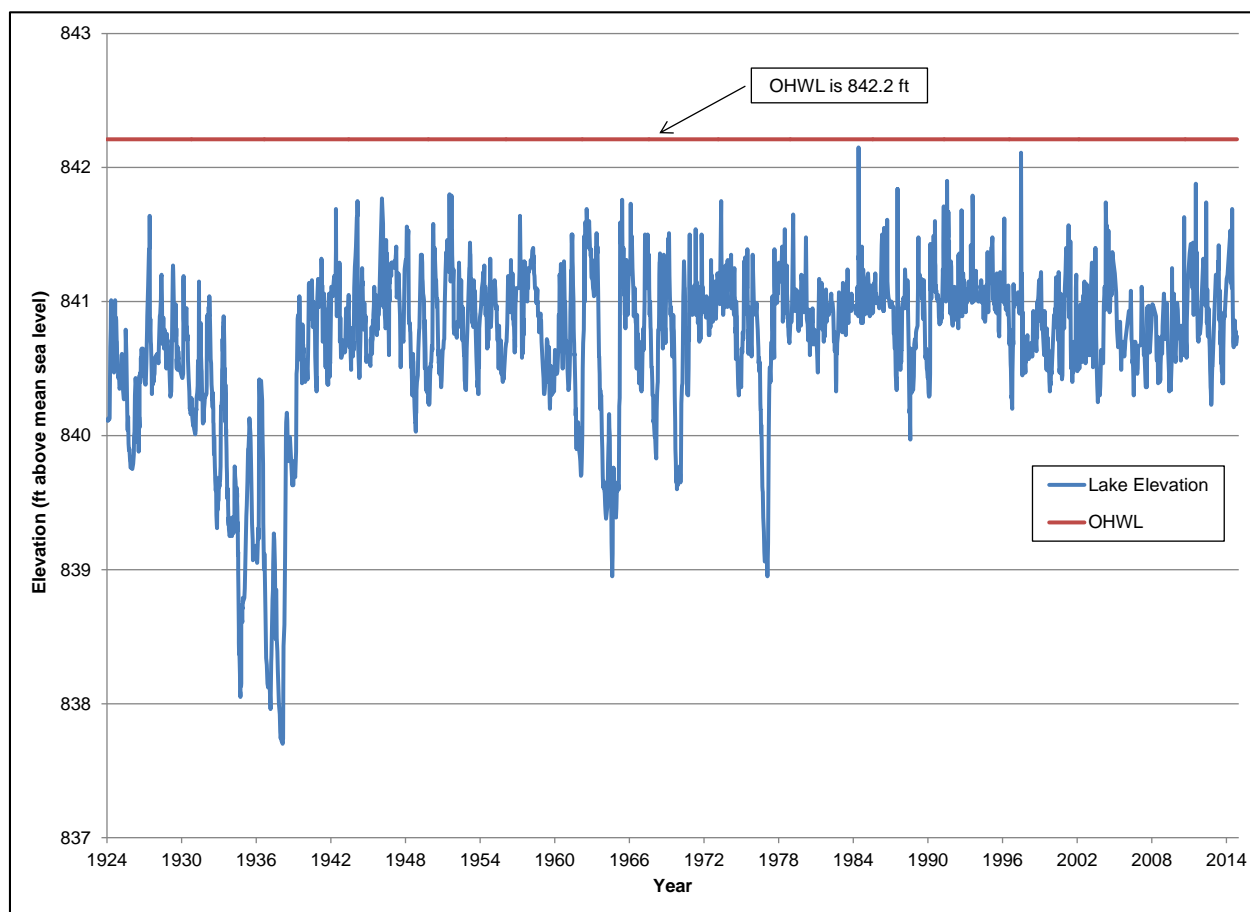


Figure 10-4: Lake McCarrons historical lake elevations and the OHWL (DNR, 2015i).

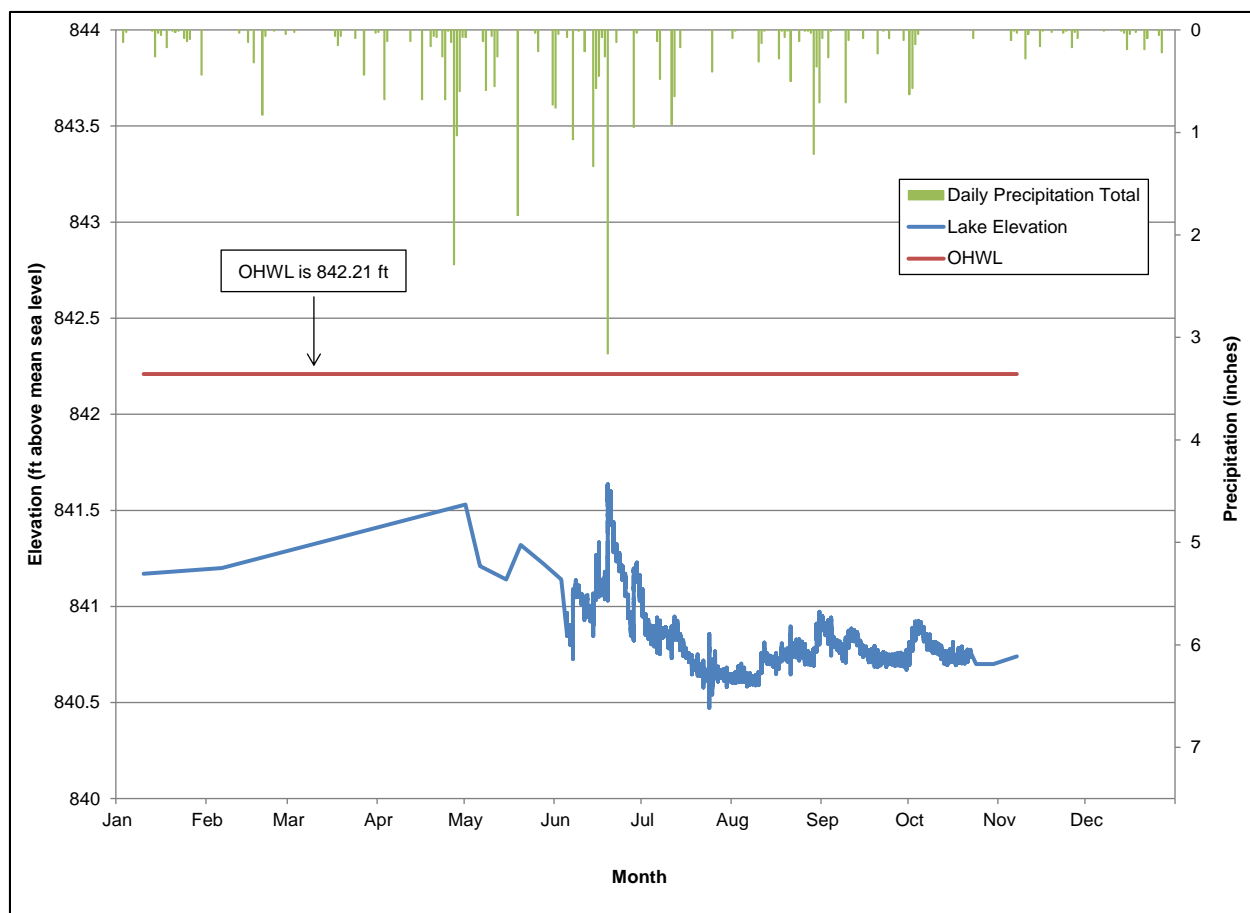


Figure 10-5: Lake McCarrons 2014 lake elevations, OHWL, and daily precipitation events (DNR, 2015i; MCWG, 2015b).

10.3 WATER QUALITY RESULTS

Lake McCarrons was sampled nine times in 2014 from May 5 to October 20 (Figure 10-6). Sampling shows the highest epilimnetic TP concentration (74 $\mu\text{g/L}$) during the first sampling event on May 5, which then dropped significantly to 20 $\mu\text{g/L}$ by the June 11 monitoring date. After May, TP concentration increased through mid-July, then stayed relatively low (below 25 $\mu\text{g/L}$) for the remainder of the season.

Chl-a concentrations were variable throughout the season, and followed the same trend as TP. Concentrations were highest for the first sampling date (27 $\mu\text{g/L}$), then dropped to a season low in mid-June (2.7 $\mu\text{g/L}$) (Figure 10-6).

Water transparency was highest in mid-June (with a Secchi depth of 4.8 m) (Figure 10-6). Water transparency then decreased until the end of June, followed by an increase through the end of the season. High water transparency was generally associated with low TP and Chl-a concentrations

throughout the season, which indicated TP was a major driver of water transparency during 2014.

Figure 10-7 shows yearly average historical TP concentrations, Chl-a concentrations, and Secchi disk depths graphically. Since the 2004 alum treatment, the lake has experienced a significant improvement in water quality. The average TP concentration from 2005-2014 (18.5 µg/L) is 57% lower than the 1988-2004 average TP concentration (42.9 µg/L). The average Chl-a concentration from 2005-2014 (4.5 µg/L) is 65% lower than the 1988-2004 average Chl-a concentration (12.9 µg/L). The average Secchi depth from 2005-2014 (3.7 m) is 54% deeper than the 1988-2004 average depth (2.4 m). Overall, the alum treatment is still shown to be helpful in maintaining water quality in the lake, and will likely remain helpful for many more years. The efficacy of the treatment (which can vary between 8-20 years) will continue to be monitored in upcoming years.

Recent years (2011-2014) have shown gradually increasing TP and Chl-a concentrations, resulting in shallower Secchi disk depths (Figure 10-7). The period from 2011-2014, as compared to 2005-2010, showed the average Secchi disk depth drop from 4.1 m to 3.0 m, Chl-a increase from 3.3 µg/L to 6.3 µg/L, and the average TP increase from 14.9 µg/L to 23.9 µg/L. Average annual TP and Chl-a concentrations in 2014 were the highest observed since the alum treatment, and Secchi was also at the shallowest observed.

The decrease in water quality of the 2014 annual average TP and Chl-a concentrations, and Secchi depth can be partially attributed to an early May sample date that had values of 74 µg/L for TP, 27 µg/L for Chl-a, and 1.9 m for Secchi disk depth. These poor May 2014 sample values could be related to climatic variables (such as an early ice-out date on the lake and early spring storm events contributing large amounts of runoff), or a potential reduction in effectiveness of the 2004 alum treatment.

Throughout the period of record (before and after alum treatment), high Chl-a concentrations have generally been associated with high TP concentrations (Figure 10-7). Low Secchi depths have generally been associated with high Chl-a and TP concentrations, indicating that they are primary drivers for water clarity in Lake McCarrons.

Yearly average historical TP concentrations, Chl-a concentrations, Secchi depths, and their comparisons to MPCA lake standards are shown in Table 10-2. Lake McCarrons has exceeded the state standards for TP for one-third of the years monitored and just under one-third of the years monitored for Chl-a, all prior to the alum treatment in 2004. It has always been within the deep lake standard for Secchi disk depth. With the exception of 2014 when the lake received a 'B' due to the high May samples for TP and Chl-a, the lake has received an 'A' lake grade since 2004, indicating that it has had consistently high water quality since the alum treatment (Table 10-3).

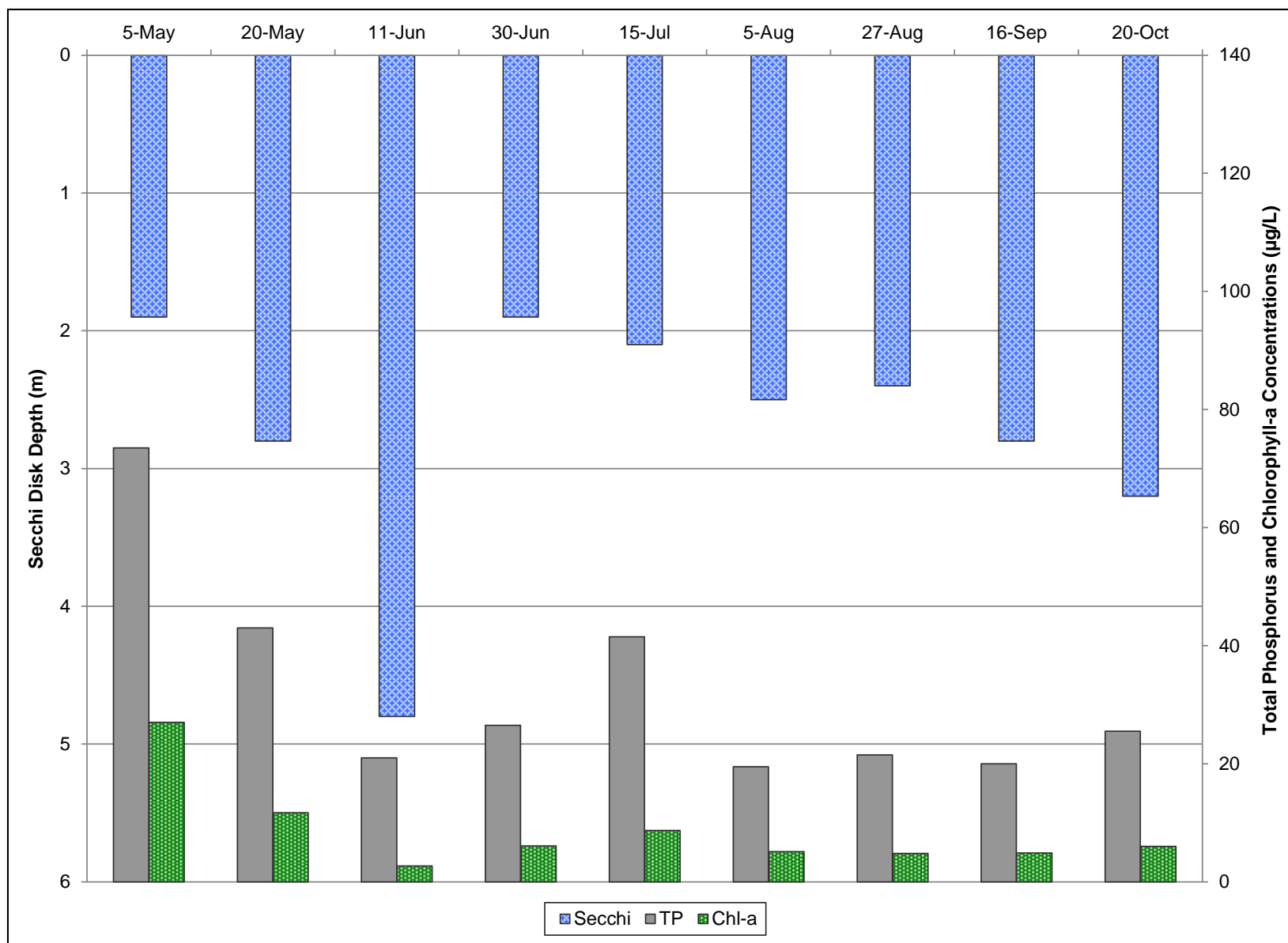


Figure 10-6: Lake McCarrons 2014 Secchi/TP/Chl-a comparison.

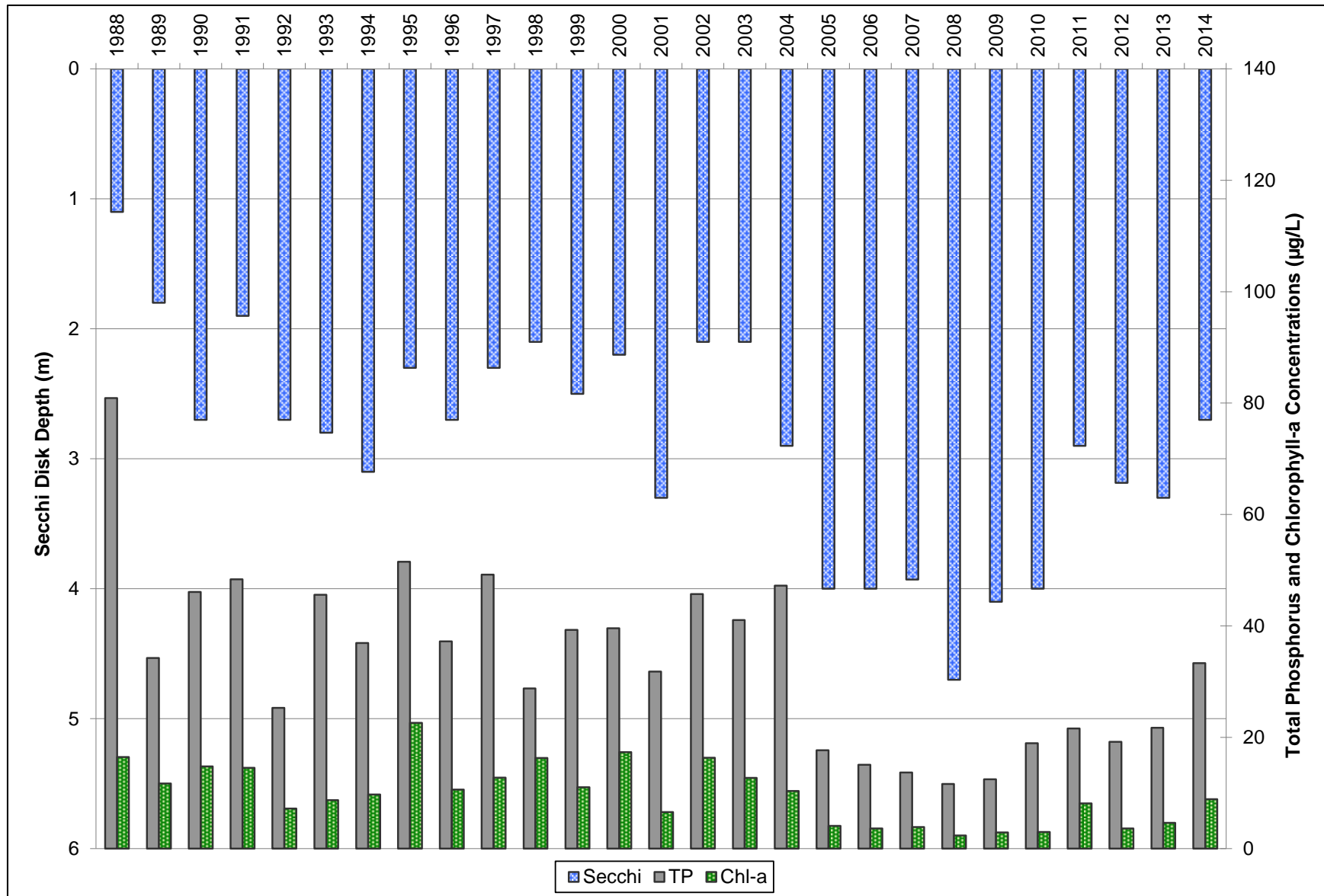


Figure 10-7: Lake McCarrons historical annual average Secchi/TP/Chl-a comparison.

Table 10-2: Lake McCarrons historical yearly TP/Chl-a/Secchi depth averages compared to deep lake state standards.

Year	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
1988	81	16.4	1.1
1989	34	11.7	1.8
1990	46	14.8	2.7
1991	48	14.5	1.9
1992	25	7.2	2.7
1993	46	8.7	2.8
1994	37	9.7	3.1
1995	52	22.6	2.3
1996	37	10.6	2.7
1997	49	12.8	2.3
1998	29	16.3	2.1
1999	39	11.0	2.5
2000	40	17.3	2.2
2001	32	6.6	3.3
2002	46	16.3	2.1
2003	41	12.7	2.1
2004	47	10.4	2.9
2005	18	4.1	4.0
2006	15	3.6	4.0
2007	14	3.9	3.9
2008	12	2.4	4.7
2009	12	2.9	4.1
2010	19	3.0	4.0
2011	22	8.1	2.9
2012	19	3.6	3.2
2013	22	4.6	3.3
2014	33	8.9	2.7
	Value does not meet state standard*		
	Value meets state standard		

*MPCA deep lake standards are not to exceed 40 µg/L for TP and 14.0 µg/L for Chl-a, with a Secchi disk depth of at least 1.4 m.

Table 10-3: Lake McCarrons historical lake grades.

Year	TP Grade	Chl-a Grade	Secchi Grade	Overall Grade
1988	D	B	D	C
1989	C	B	C	C+
1990	C	B	B	B
1991	C	B	C	C+
1992	B	A	B	B+
1993	C	A	B	B
1994	C	A	A	B+
1995	C	C	B	C+
1996	C	B	B	B
1997	C	B	B	B
1998	B	B	C	B
1999	C	A	B	B
2000	C	B	B	B
2001	B	A	A	A
2002	C	B	C	C+
2003	C	B	C	C+
2004	C	B	B	B
2005	A	A	A	A
2006	A	A	A	A
2007	A	A	A	A
2008	A	A	A	A
2009	A	A	A	A
2010	A	A	A	A
2011	A	A	B	A
2012	A	A	A	A
2013	A	A	A	A
2014	C	A	B	B

10.4 PHYTOPLANKTON AND ZOOPLANKTON

Lake McCarrons was sampled eight and nine times, respectively, for phytoplankton and zooplankton in 2014 from May 5 to October 20. In the spring, phytoplankton populations are dominated by Chlorophyta, Cryptophyta, and Cyanophyta (Figure 10-10). Cyanophyta are the main species observed throughout the majority of the summer, with a small increase in Pyrrophyta during June, and an increase in Bacillariophyta in August. The early spring bloom of phytoplankton was likely a result of high nutrient availability (as seen by a peak in TP concentration) and increased light availability (Figure 10-8) (Kalff, 2002; UWE, 2004). Phytoplankton concentration closely followed the TP trend for the entire monitoring season, indicating that populations were highly driven by the total amount of phosphorus in the system. After this early bloom occurred, overall phytoplankton concentration decreased and stayed relatively low (generally below 1,000/mL) for the remainder of the year (Figure 10-8).

The zooplankton population of Lake McCarrons was divided among populations of Cyclopoids, Calanoids, Nauplii, and Cladocerans for the entire monitoring season (Figure 10-11). A small amount of Rotifers were observed during the month of August. Overall, the population peaked in mid-May, late-June, and late-August. Between these peaks, overall concentration stayed relatively high ($>20,000/\text{m}^3$) during the rest of the season (Figure 10-9). Total zooplankton concentration generally did not follow the Chl-a concentration fluctuations observed in 2014.

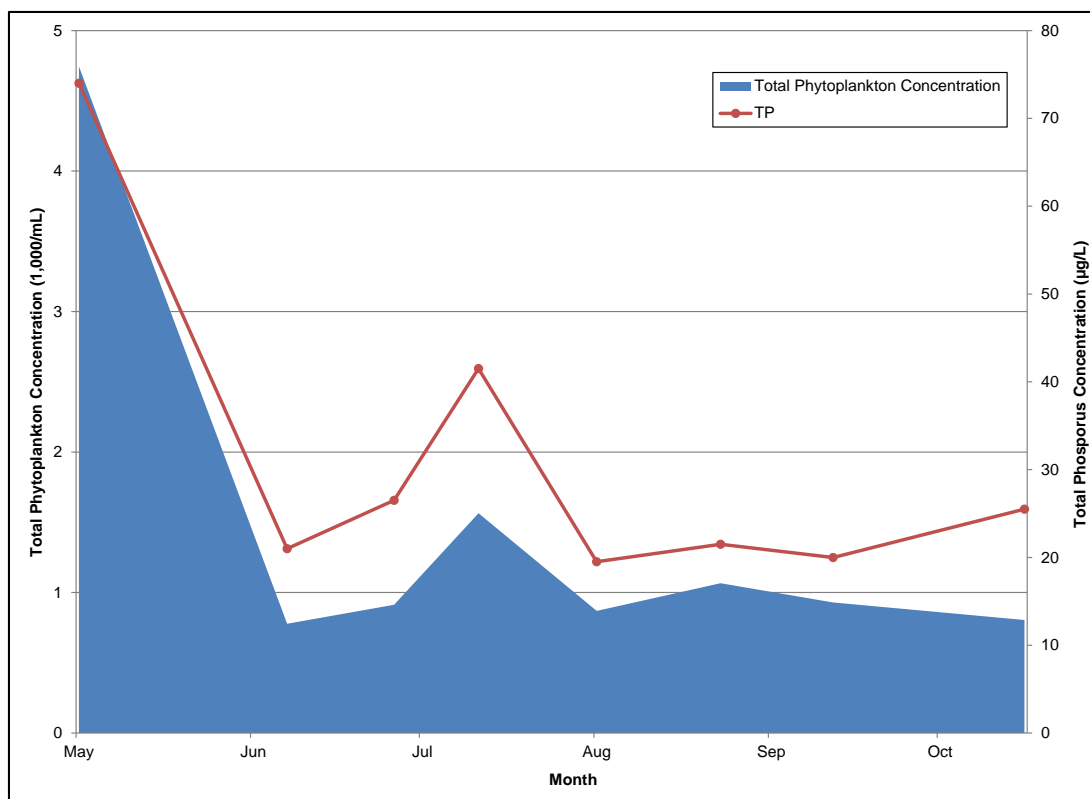


Figure 10-8: Lake McCarrons 2014 total phytoplankton concentration and TP concentration.

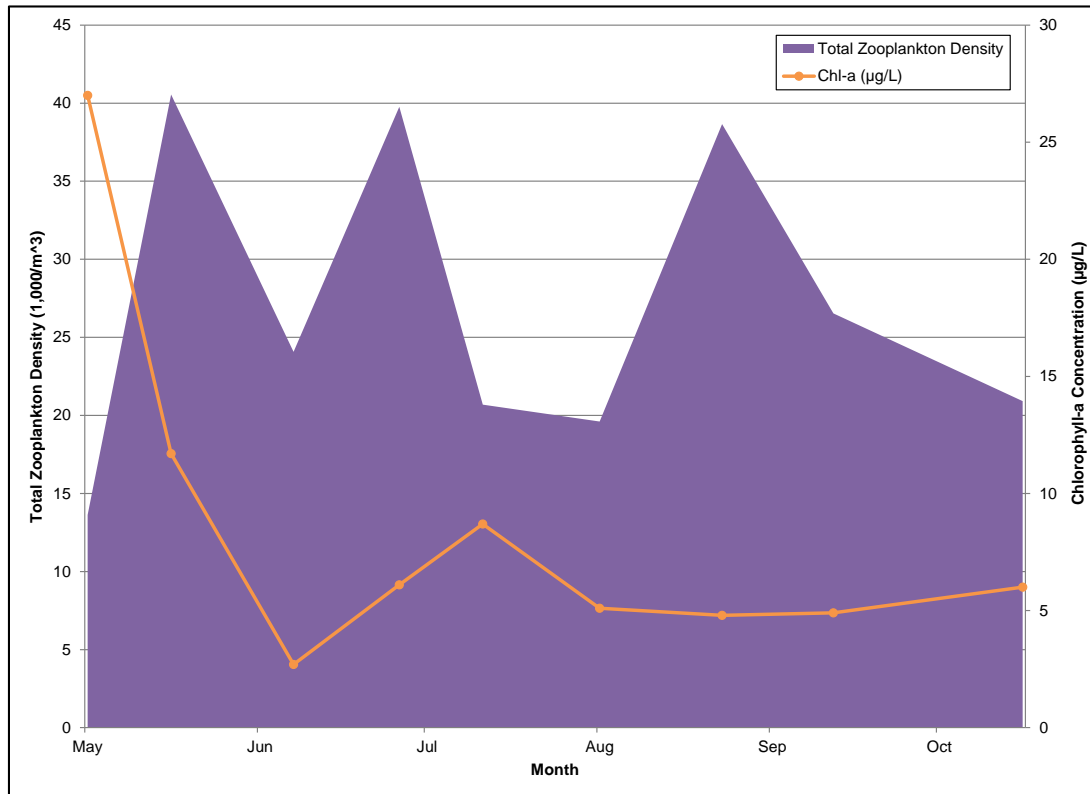


Figure 10-9: Lake McCarrons 2014 total zooplankton density and Chl-a concentration.

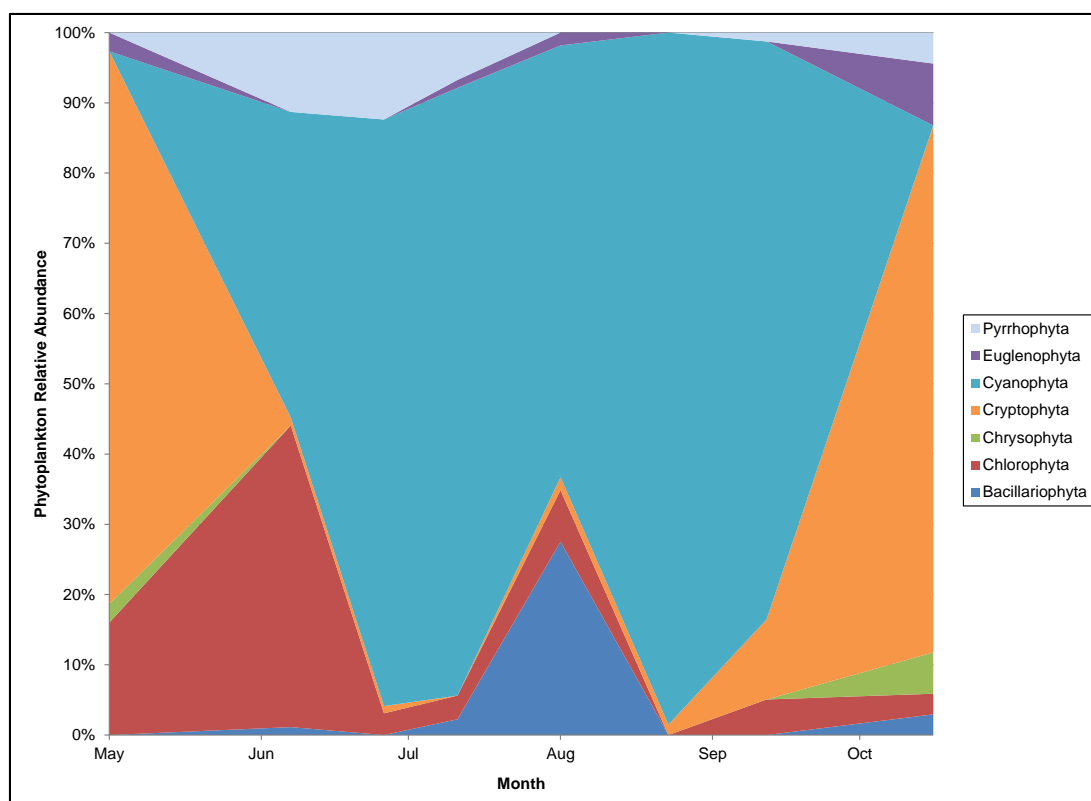


Figure 10-10: Lake McCarrons 2014 phytoplankton relative abundance.

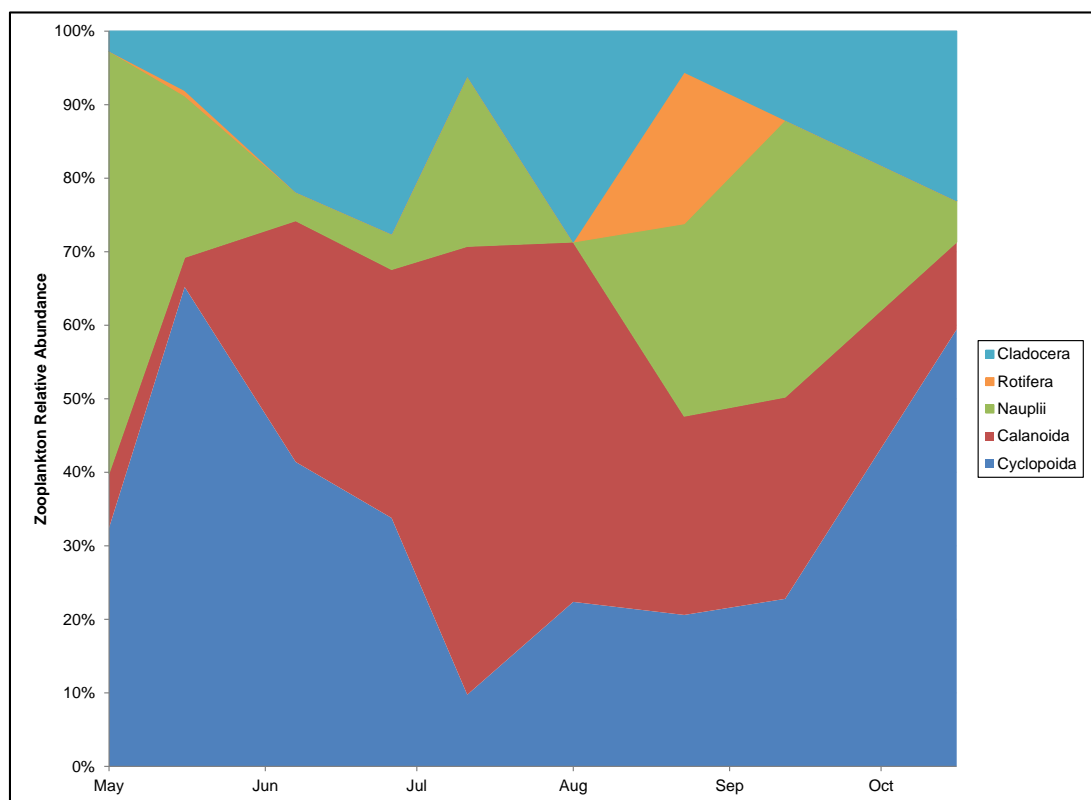


Figure 10-11: Lake McCarrons 2014 zooplankton relative abundance.

10.5 AQUATIC VEGETATION

10.5.1 BIOVOLUME ANALYSIS

The biovolume heat maps of Lake McCarrons show that the majority of the aquatic vegetation in the lake in 2014 occurred in the shallow areas (less than 15 ft) near the shoreline (Figure 10-12). Aquatic plants were most abundant along the western end of the lake, where the red color indicates that 100% of the water column contained aquatic vegetation.

In June and August of 2014, CRWD partnered with homeowners to hire a contractor to perform vegetation harvesting on the west end of the lake. Harvesting removed some of the nuisance plant growth observed by homeowners and improved their recreational access to the lake.

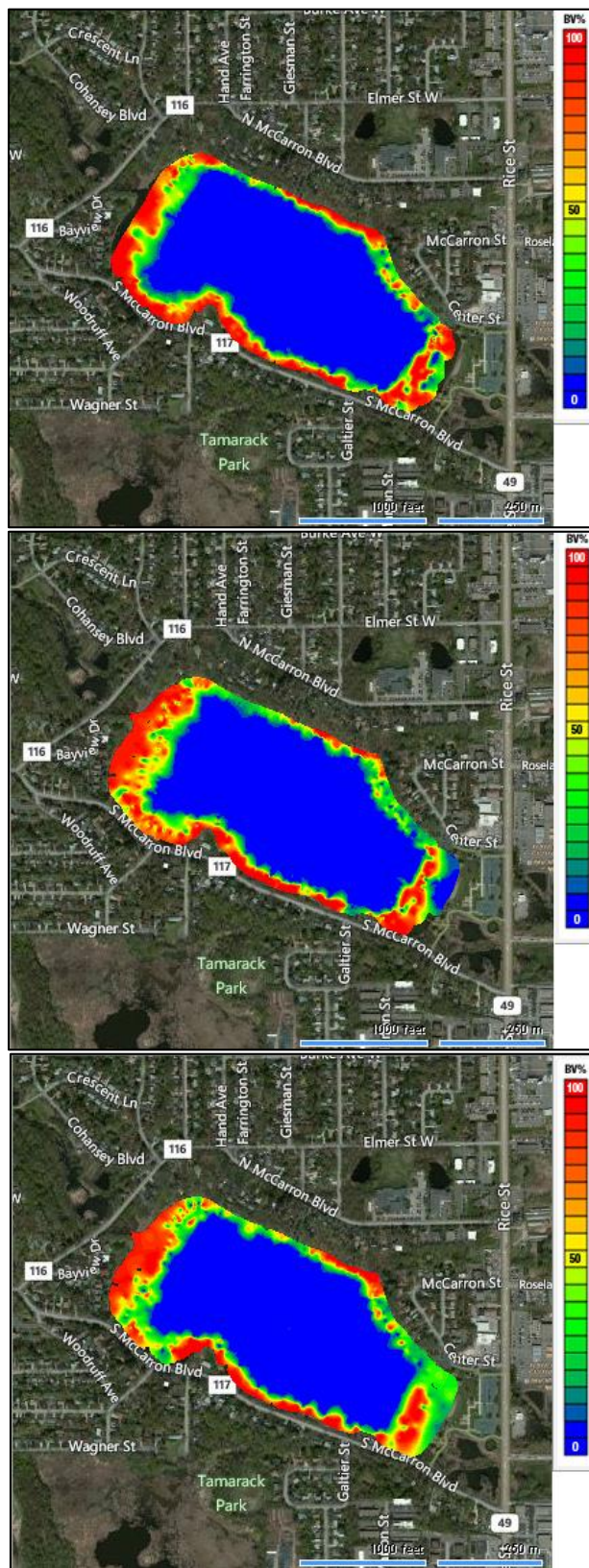


Figure 10-12: Lake McCarrons 2014 seasonal vegetation changes (5/30/14, 7/18/14, and 9/9/14)

10.5.2 POINT-INTERCEPT SURVEYS

Coontail was the most frequently occurring plant in Lake McCarrons in 2014 with respect to the number of locations in which it was observed, and the abundance at the observed locations. (Figures 10-13 and 10-14). The highest-occurring plants were coontail, Eurasian watermilfoil, and filamentous algae in May and July, and coontail, Eurasian watermilfoil, and slender naiad in September (Figure 10-13). Coontail and filamentous algae were both observed at an average of 50% and 42%, respectively, of the locations over the course of the surveys. None of the most frequently occurring species observed, however, were found in high abundance (with rankings ranging from 1.3 to 2.6) (Figure 10-14). While there was a large diversity of plant species observed in Lake McCarrons by mid-to-late summer, the majority of these occurred infrequently throughout the lake.

Filamentous algae received below average abundance rankings in both June and July (Figure 10-14). Filamentous algae can become a nuisance species when in high abundance as it forms thick, green mats on the water surface that can impede lake activities. It is also indicative of the presence of excessive nutrients (especially phosphorus) in a lake, which is common in urban lakes like Lake McCarrons (DNR, 2015e).

As shown in Figures 10-13 and 10-14, the presence of Eurasian watermilfoil and curly-leaf pondweed were observed in Lake McCarrons in 2014, and have been observed in surveys since 2005. Curly-leaf pondweed and Eurasian watermilfoil are both non-native, invasive species, causing problems by displacing other native plants and forming thick mats on the surface of a lake that disrupt boating and recreation (DNR, 2015d; DNR, 2005). In addition, when curly-leaf pondweed plants die back in mid-summer, the resulting increase in phosphorus from the decomposing plant material causes disruptive algal blooms (DNR, 2005). Eurasian watermilfoil spreads easily, as a new plant can grow from just a tiny piece of an original plant. It can easily float and grow quickly in other areas of a lake, as well as be transported between lakes on boat trailers and fishing gear (WSDE, 2015).

While neither Eurasian watermilfoil nor curly-leaf pondweed is especially abundant and the lake still has a robust composition of plants, the presence of these two species is still a management concern. In 2014, the June and August vegetation harvesting of the west end of the lake removed mostly coontail and Eurasian watermilfoil. While the removal of Eurasian watermilfoil is a positive step as it is an invasive species, the removal of too much coontail, a native plant species, needs to be taken into consideration before removal occurs. Native vegetation that is well established in a lake is the best preventative measure for invading invasive species (DNR, 2015d). Therefore, vegetation removal, especially on a lake with documented populations of non-native species, needs to occur with knowledge and forethought as to how the removal affects the remaining habitat for the potential increased growth of non-native species.

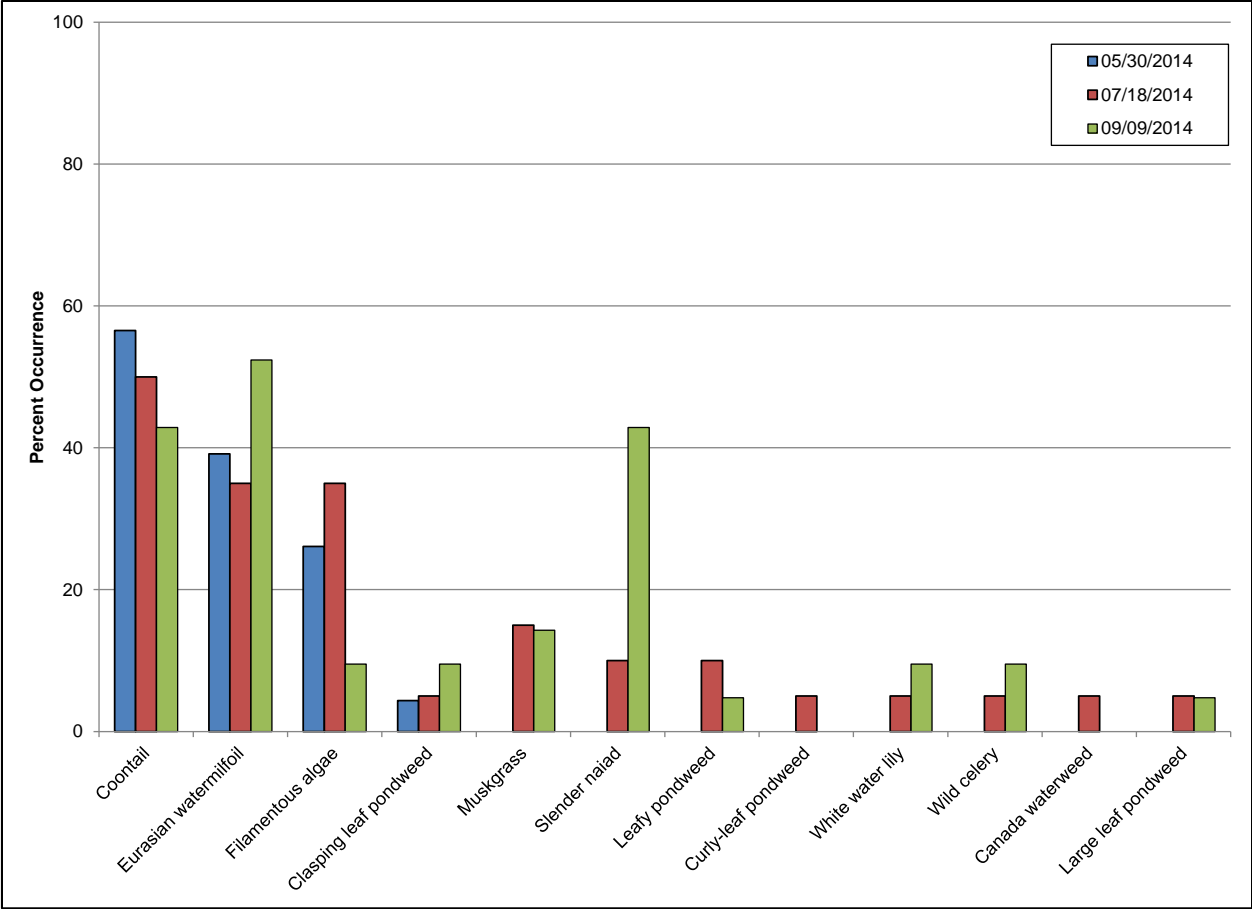


Figure 10-13: Lake McCarrons 2014 percent occurrence of vegetation present.

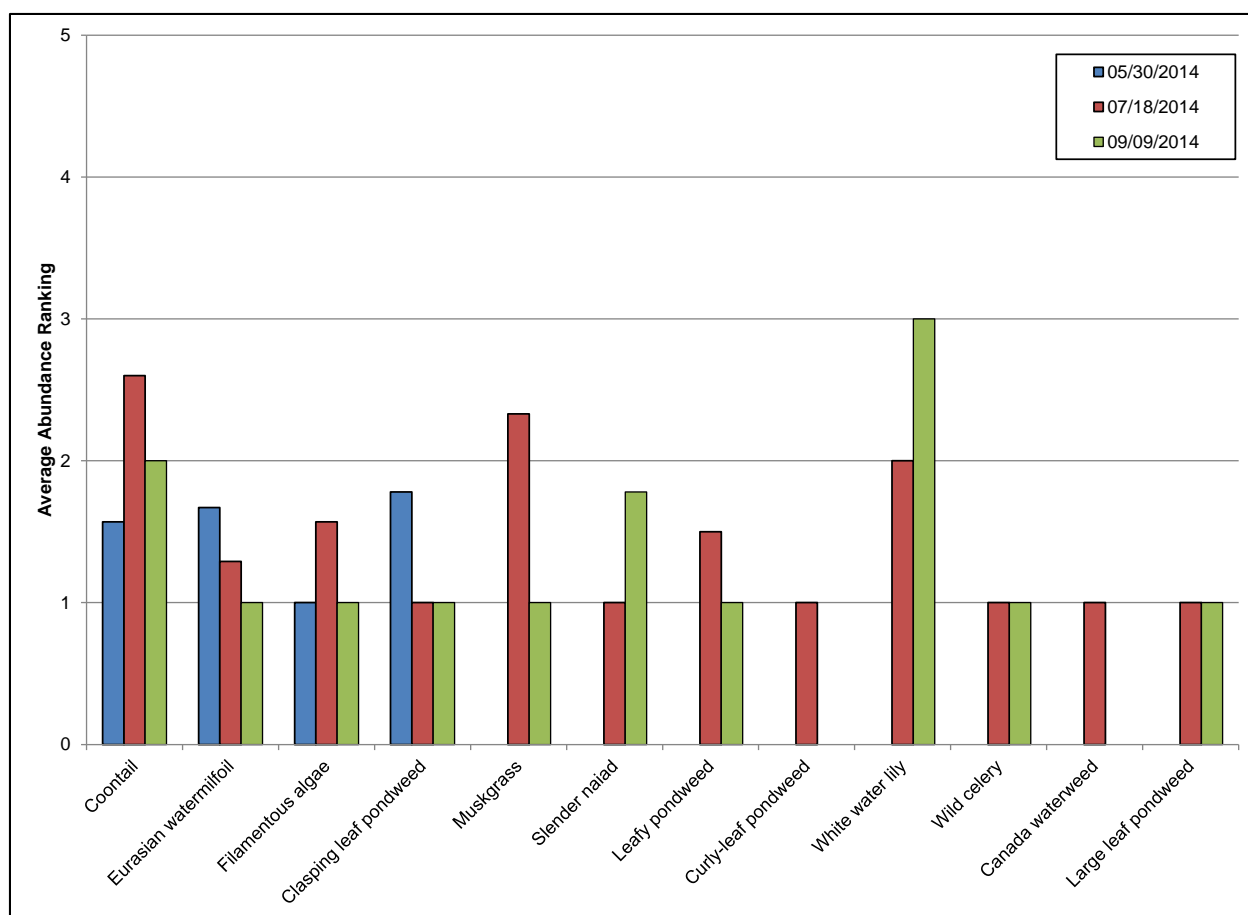


Figure 10-14: Lake McCarrons 2014 average abundance ranking of vegetation present.

10.6 FISH STOCKING AND SURVEYS

Previous stocking in Lake McCarrons has included black crappie, northern pike, and walleye, which has occurred intermittently in previous years (Table 10-4). Before being surveyed in 2014 by the Minnesota DNR, the previous survey of fish populations was in 2008, which showed a large variety of panfish. The 2014 survey reflected the same pattern, with a significant number of bluegills, as well as black crappie and perch (Table 10-5). A number of northern pike were also observed. While two common carp were caught in the 2008 survey and observed on the lake spawning in large numbers during a visit that year (DNR, 2015i), there were no common carp observed in the 2014 survey.

Table 10-4: Lake McCarrons historical record of fish stocking.

Year	Black crappie	Northern pike		Walleye
	Adult	Adult	Yearling	Fry
2009		80		
2007	630			
2005			124	
2004				75,000

Table 10-5: Lake McCarrons 2014 fish populations.

Species	Number of fish caught in each category (inches)								Total
	0-5	6-8	9-11	12-14	15-19	20-24	25-29	30+	
Black crappie	16	17	3	0	0	0	0	0	36
Bluegill	106	152	0	0	0	0	0	0	258
Hybrid sunfish	4	0	0	0	0	0	0	0	4
Northern pike	0	0	0	2	1	7	3	0	13
Pumpkinseed sunfish	8	1	0	0	0	0	0	0	9
Yellow perch	7	7	0	0	0	0	0	0	14

10.7 OVERALL LAKE EVALUATION

Lake McCarrons has displayed significant improvements in water quality since the 2004 alum treatment to reduce TP levels in the lake. During 2014, however, the lake showed the highest TP levels since this alum treatment occurred. This is reflected in the ‘B’ lake grade that the lake received in 2014, compared with ‘A’ grades the lake was given in the years since the alum treatment. While the lake exceeded the eutrophication parameter state standards multiple times in its monitored history, these occurred prior to the alum treatment.

The management of extensive vegetation on the west end of Lake McCarrons is a priority, with the presence of Eurasian watermilfoil and the potential for the growth of this invasive plant in other areas of the lake. In 2014, the District began working with lakeshore owners to address these vegetation concerns. In general, fish populations have been relatively stable for the past number of years of monitoring in Lake McCarrons. The 2014 fish survey by the DNR reflects similar species and abundances as the 2008 survey.

11 CONCLUSIONS & RECOMMENDATIONS

11.1 CONCLUSIONS

In 2014, the water quality of the five District lakes (Como, Crosby, Little Crosby, Loeb, and McCarrons) varied by water body and by time of year. In comparing 2014 water quality results to 2013 results, Como Lake improved in water quality, while the other lakes (Crosby, Little Crosby, Loeb, and McCarrons) degraded by varying degrees.

Based on the MPCA eutrophication numeric water quality standards, Loeb Lake and Lake McCarrons met the MPCA standards for all parameters (TP, Chl-a, Secchi) during the 2014 growing season. Little Crosby Lake met the MPCA shallow lake standards for Chl-a concentration and Secchi disk depth, but failed for TP concentration in 2014. Como Lake and Crosby Lake did not meet the MPCA shallow lake standards for TP concentration or Chl-a concentration, but met the standards for Secchi disk depth during the 2014 growing season.

Total phosphorus was an important driver for water quality in all five District lakes in 2014. High phosphorus in lakes can cause overgrowth of algae (measured by Chl-a concentrations) and aquatic plants, which reduces water clarity. Phosphorus will continue to be a contaminant of concern in CRWD as inputs of fertilizers, leaves, grass clippings, and pet/wildlife waste in this urban watershed are very prevalent and difficult to control. Water quality improvement projects upstream of lakes that reduce the amount of phosphorus runoff will continue to be a priority in the District. Chlorophyll-a can also be a principle driver of water quality, which was observed in Crosby and Little Crosby Lakes in 2014.

Invasive species (both plant and animal) will continue to be a threat to District lakes, though they are not currently observed in significant amounts in any CRWD lake. In 2014, curly-leaf pondweed was observed in all lakes, Eurasian watermilfoil was observed in Loeb Lake and Lake McCarrons, and common carp were observed in Crosby Lake. Invasive species can cause harm to lakes through displacement of native species and disruption of the food chain, both of which can affect overall lake health.

CRWD lakes are an important District resource, providing both economic (e.g. recreational resources) and environmental (e.g. flood attenuation) benefits. Understanding overall health of CRWD lakes in order to improve them for both kinds of benefits will be beneficial for the District and the region. Each District lake is an important community resource that is easily viewed and accessed by many people on a daily basis. Therefore, these lakes will continue to be a focal point for management by CRWD.

Como Lake has exhibited a cyclical pattern in water quality for the monitored eutrophication parameters in past years, which will continue to be studied and analyzed in order to understand

the lake's water quality. Loeb Lake and Lake McCarrons have had historically good water quality, but will continue to be monitored in the future to identify annual changes and trends. Crosby and Little Crosby Lakes will also continue being monitored in order to better understand the dynamic interaction between the lakes and the Mississippi River and how that influences lake water quality.

This report also contained additional information on biological data that was previously reported upon beginning in the 2013 Lakes Monitoring Report (CRWD, 2014a), including phytoplankton and zooplankton populations, aquatic vegetation communities, and fish populations. All of these parameters affect lake water quality and are important components in analyzing overall lake health. This report also focuses on reporting results of additional biological data that was collected in 2014. Future reports will contain more analysis of biological data, in conjunction with the chemical and physical data monitored, as there will be more historical data from which to analyze trends and compare across years.

11.2 RECOMMENDATIONS

11.2.1 ACCOMPLISHMENTS IN 2014

It is the goal of CRWD to continually improve the monitoring program with new ideas in order to advance the program in quality, efficiency, and usefulness. The monitoring program aims to collect and analyze high quality data from District lakes to better understand the water quality in individual lakes as well as how the watershed as a whole could be affecting lake water quality. Data collection and analysis through the monitoring program helps to further CRWD's mission "to protect, manage and improve the water resources of the Capitol Region Watershed District."

In 2014, CRWD made progress towards the goals stated in the *2013 Lakes Monitoring Report* (CRWD, 2014a) for monitoring and reporting. These goals were:

1. Enhanced lake elevation monitoring:

CRWD established continuous lake level monitoring with level loggers in Como Lake, Crosby Lake, and Lake McCarrons in 2014 from the ice-out to ice-in period. Crosby Lake had not been historically monitored for lake level by the Minnesota DNR. By monitoring lake level on Crosby Lake, Mississippi River interactions with the lake can be better understood. Since Little Crosby Lake is hydrologically connected to Crosby Lake, it was not monitored for lake level.

2. Extended the monitoring season of all District Lakes:

CRWD extended the lakes monitoring season to gather more data over a greater time period in order to capture seasonal variability in lake water quality and improve statistical confidence for trend assessments. The season was expanded for chemical/physical monitoring, aquatic vegetation monitoring, and phytoplankton and zooplankton monitoring, including:

- *Physical and chemical monitoring:* Extended sampling dates to early spring (April) and late fall (October) on all CRWD lakes, depending on climatological factors (e.g. ice-out and ice-in dates).
- *Vegetation monitoring:* A third vegetation survey was added to the 2014 monitoring schedule. By collecting data on aquatic vegetation, information on seasonal and annual fluctuations in vegetation type, location, and density can be established, which can directly influence or indicate water quality.
- *Phytoplankton and zooplankton monitoring:* Extended early spring (April) and late fall (October) monitoring of phytoplankton and zooplankton on all CRWD lakes, depending on climatological factors (e.g. ice-out and ice-in dates).

3. Initiated fisheries surveys on all District Lakes:

CRWD initiated fisheries surveying on all lakes in 2014 in order to capture annual variation in fish populations and to better understand how the biological community affects water quality. Fisheries surveys are conducted by Minnesota DNR staff, who survey most lakes in the state on a 5-10 year cycle. In 2014, the DNR conducted fish surveys on McCarrons, Loeb, and Crosby Lakes. CRWD conducted surveys on Como and Little Crosby Lakes.

4. Installed temperature monitoring equipment in Como Lake and Lake McCarrons:

CRWD installed temperature monitoring equipment in Como Lake and Lake McCarrons in 2014 to determine influence of higher temperature runoff to lake temperature.

11.2.2 RECOMMENDATIONS FOR 2015

For 2015, CRWD has several goals and recommendations that are aimed at improving the lake monitoring program. Goals for 2015 include:

1. Analyze additional chemical and physical parameters:

CRWD intends to expand the analysis of chemical and physical data previously collected but not fully analyzed in prior reports. Previous CRWD analyses have focused mainly on three water quality parameters: TP, Chl-a, and Secchi disk depth. Analysis of other water chemistry and physical attributes will allow a better understanding of overall lake health, such as:

- *Nitrogen:* This includes Ammonia-Nitrogen ($\text{NH}_3\text{-N}$), nitrate as nitrogen ($\text{NO}_3\text{-N}$), and Total Kjeldahl Nitrogen (TKN). While the limiting factor for algal

growth in CRWD lakes is most often phosphorus, other nutrients such as nitrogen could also be playing a role in temporal blooms.

- *Temperature profile*: Temperatures at different depths within the water column are currently measured by RCPW during their summer lake visits. Graphically creating temperature profiles of the lake throughout the monitoring season may also be helpful in explaining water quality trends.
- *Hypolimnetic water quality*: Reports have historically focused on the nutrient concentration of the epilimnion (mixed surface layer) of lakes, since MPCA standards are based on this lake layer. Future reporting will examine hypolimnetic water quality data to determine possible internal phosphorus loading from in-lake sediments. This could help better determine, for example, impacts of flooding from the Mississippi River on Crosby Lake and Little Crosby Lake water quality (CRWD, 2012a).
- *Chloride*: It is a contaminant of concern in metro area lakes. Como Lake was listed on the draft 2014 303(d) Impaired Waters List for chloride (MPCA, 2014b), so this contaminant is becoming more of a management concern in CRWD lakes.

2. Conduct sediment analyses of all District lakes:

CRWD will conduct sediment analyses on all lakes during the winter of 2015-2016 to establish current understanding of internal sediment loading.

- Previous sediment analyses on CRWD lakes were only completed for two lakes for specific projects (i.e. the 2004 Lake McCarrons alum project and the 2008 Crosby Lake sediment analysis).

3. Complete a comparative analysis of all parameters measured:

CRWD will complete a comparative analysis of chemical, physical, and biological parameters and how they interact to increase understanding of what these parameters are indicating about overall lake health. CRWD will work with limnologists or other lake experts to conduct thorough analyses of all data and their complex interactions to evaluate water quality and overall lake health. CRWD will expand comparisons of lakes to other similar metro-area lakes to see how the District's lakes relate to those outside of CRWD.

4. Continue to conduct fish surveys:

CRWD plans to survey fish populations at Como, Crosby, and Little Crosby Lakes annually during years the DNR is not scheduled to survey those lakes. Also, CRWD will survey Lake McCarrons and Loeb Lake bi-annually (except for years the DNR is

scheduled to survey) since these lakes exhibit stable fish populations. In 2015, CRWD will survey Como, Crosby, and Little Crosby Lakes.

5. Complete an internal loading assessment of Lake McCarrons:

Internal loading (the release of phosphorus from lake sediments into the water column) can have a large effect on the amount of available phosphorus in a lake. Lake McCarrons received an alum treatment in 2004 in order to reduce internal phosphorus loading and improve lake water quality. Since the alum treatment, lake water quality has drastically improved in comparison to pre-alum treatment conditions. The expected efficacy of an alum treatment is 8-20 years. Since it has been 10 years since the treatment, a deterioration in its effectiveness is expected. Consequently, degradation in epilimnetic water quality was observed in 2014, along with an increase in hypolimnetic phosphorus that has been observed in recent years. In 2015-2016 CRWD will investigate the changes to internal loading that have occurred since the 2004 alum treatment.

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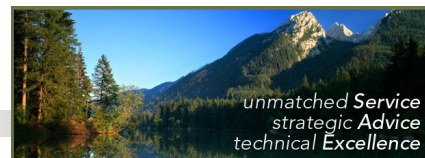
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APPENDIX A: 2014 FISH SURVEYS — COMO AND LITTLE CROSBY LAKES



2014 Fish Surveys: Como and Little Crosby Lakes



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1.0 Project Introduction

The Capitol Region Watershed District (CRWD or District) is located in Ramsey County, Minnesota. The District covers over 40 square miles in portions of five cities. The CRWD is tasked with monitoring and maintaining the water quality of the water resources within the district boundary which includes numerous streams and several lakes. All water bodies within the district ultimately drain to the Mississippi River. There are five lakes within the district boundary, which includes Loeb Lake, Como Lake, Crosby Lake, Little Crosby Lake and Lake McCarrons. Fish populations from these lakes are monitored by the Minnesota Department of Natural Resources (DNR). The lakes are monitored on a five-year rotational basis with a subset of lakes monitored each year, which is the typical practice of the DNR both across the state and within the CRWD. In 2014, the DNR conducted fish monitoring in Crosby Lake, Loeb Lake and Lake McCarrons. The CRWD contracted Wenck Associates (Wenck) to complete the fish monitoring on two additional lakes in the District in 2014, Como Lake and Little Crosby Lake. The goal of the fish monitoring program is to analyze the fish community in conjunction with other lake data sets, including water quality and aquatic vegetation in an effort to track lake health and annual patterns. The two lakes monitored by Wenck are both located within the City of St Paul, with Como Lake in the north-central part of the District and Little Crosby Lake in the southwest corner (Figure 1). A brief description of the two lakes sampled in 2014 is provided.

Como Lake

Como Lake is a shallow lake that is 68 acres in size and located in the City of St. Paul within Como Regional Park. The maximum depth of the lake is approximately 15 feet with an average depth around seven feet. Water clarity is relatively low within Como Lake, with transparency depths less than one meter much of the summer. The lake is part of the DNR Fishing in the Neighborhood (FIN) program which includes fish stocking to create recreational fishing opportunities in urban/metro lakes around the Twin Cities. A variety of species have been stocked in Como Lake over the past ten years, including bluegill, channel catfish, largemouth bass, walleye and yellow perch. The fish community was last assessed by the DNR in 2011. The primary management species within Como Lake are bluegill sunfish and channel catfish.

Little Crosby Lake

Little Crosby Lake is a small basin, approximately 10 acres in size that lies to the southwest of the main Crosby Lake basin. The lakes are connected by a small channel that flows through a wetland. Both lakes are within the Crosby Farm Park in the City of St Paul, which lies within the Mississippi River flood plain. Due to their close proximity to the Mississippi River, both the main Crosby Lake basin and Little Crosby Lake can become flooded by the river during high flows, which can connect the two basins. Little Crosby

Lake is shallow along the shore but has a very deep hole over 25 feet in the southwest corner. Detailed lake bathymetry data is not available. The fish community in Little Crosby Lake is not monitored by DNR, with current assessments only being conducted in the main Crosby Lake basin. The DNR Lakefinder website does not list a primary management species for Crosby Lake but the lake includes species such as bluegill, black crappie, black bullhead and northern pike.

2.0 Fish Monitoring Methods

In order to conduct fish surveys in lakes or streams within waters of the State in Minnesota, a permit from the DNR is required. A survey permit request was submitted to the DNR by Wenck in July 2014, with the request to cover both trap and gill net surveys in both Como and Little Crosby Lakes. The Permit was issued to Wenck as Special Permit Number 19909 (Appendix A) and requires that fish community data collected during the surveys be submitted to the DNR. Data from this project will be submitted as required by the terms of the permit.

The DNR has established standard methods for conducting fish community surveys. In most lakes in Minnesota the assessments include a combination of trap nets and gill nets. Both of these sampling methods are considered “passive gear” where the nets are placed into the water and the fish swim into them and become trapped or entangled. Standard or routine fish community assessments do not include “active” survey methods such as benthic trawls or electrofishing, however special assessments that include electrofishing are sometimes conducted in certain lakes.

Trap nets are a near-shore gear that are actually anchored on shore and then set perpendicular to the shore, typically in water from three to six feet deep. A trap net includes a 50 ft. long lead net that is anchored to the shore and connects into two, 4 ft. by 6 ft. frames. The frames include a throat that direct fish into a series of hoops, with ½ inch mesh covering the frame and hoops. The fish follow the lead net into the frames; pass through the throat and become trapped in the hoops, without being able to escape. Most of the fish collected by the trap net are alive when the net is retrieved and can be released back into the lake. The main species targeted by trap nets include bluegills (and other sunfish), crappies and bullheads.

The DNR uses an experimental gill net for lake surveys, which is a 6ft. deep net that is 250 ft. long consisting of five panels each 50 ft. in length. Each 50 ft. panel has a different mesh size ranging from 1.5 inches up to 3.5 inches. A fish swims into the mesh of the gill net and becomes entangled, typically by their gills but also potentially by their fins or spines. The different mesh sizes help to catch fish of different sizes. Gill nets are typically set in water that is at least nine feet deep. Fish mortality with gill nets is very high, with most fish expiring prior to retrieving the net. The area of the lake that is surveyed by an individual gill net is small so the impact to fish populations from gill net mortality is small. The target species sampled by gill nets include northern pike, walleye and yellow perch; however, gill nets are effective at collecting other species including bullheads and catfish.

The two main DNR sampling gears, trap nets and gill nets, were used for the CRWD fish monitoring on Como and Little Crosby Lakes in 2014. The number of both trap and gill nets set (or deployed) for a lake

fish assessment is dependent on lake size (i.e. large lakes include more total net locations than smaller lakes). For Como Lake, all nets were deployed at established DNR monitoring locations which included eight trap net locations and two gill net locations (Figure 2), which is a typical number of net locations for lakes less than 100 acres in size. For Little Crosby Lake there were no previously established monitoring locations, so the nets were distributed across the basin to sample representative areas of the lake. Due to the small size of the basin, the number of nets was reduced compared to Como Lake, with four trap nets and one gill net deployed in Little Crosby Lake (Figure 3). Both trap and gill nets were set one day and then retrieved the following day, after being allowed to “soak” overnight. Trap nets were anchored on shore as described above, while gill nets were set out in the open water of each lake, held in place with boat anchors and large buoys. After being deployed when a net was retrieved the following day, all fish were removed from the net and placed into tubs. Each fish was identified, weighed and measured. Fish that were alive were released back into the lake. Dead fish were also placed back into the lake (after puncturing their swim bladder), which were then likely consumed by turtles. The depth, substrate and location of each net were recorded. Field photos from Como Lake and Little Crosby Lake are provided in Appendix B and Appendix C, respectively.

All equipment used during surveying was dried out and cleaned in between lake sampling efforts so as not to transfer any aquatic invasive species between lakes. While neither Como nor Little Crosby Lake are on the DNR Infested Waters List, steps for cleaning equipment after being on an infested water were followed in order to minimize the chances of transferring any undesirable plants (e.g. Curly-leaf pondweed) to other area lakes.

3.0 Project Results and Discussion

Fish monitoring was conducted over three days in August from the 4th through the 6th in Como Lake. In Little Crosby Lake the fish monitoring was conducted over two days, August 11th and 12th. A summary of the results from each lake is provided.

Como Lake

Fish monitoring in Como Lake included eight trap net sets and two gill net sets (Figure 2). Water depth for trap nets where the hoops were set ranged from as shallow as two feet at Location 5 to as deep as five feet at Locations 2, 3, 4 and 9 (Table 1). The most common substrate at the trap net locations was some combination of sand, silt and muck. There were some locations with firm sand-silt or sand-gravel substrates. In some trap net locations, the submerged aquatic vegetation was very thick around the lead line of the net as well as the trap frames and hoops, with the main species being coontail. Gill nets were set in deep water in the open portions of the lake. There was no submerged vegetation present at either gill net location. Gill net Location 1 was set with the smallest mesh to the north in the shallower depth of 7.5 feet, and the net was then deployed to the south with the largest mesh in the deeper water at 10 feet (Table 1). Gill net Location 2 was set in the same orientation as Location 1 with the small mesh to the north and the large mesh to the south. However, this orientation placed the small mesh in the deepest water at 11.5 feet and the larger mesh in the shallow water at 8.5 feet.

Table 1: Como Lake trap and gill net survey results

Location	Depth	Substrate	Northing	Easting	Set	Retrieved	Total Fish
Trap Net 1	2–4 ft.	Muck	N 44 58' 40.2"	W 93 08' 14.6"	08/05/14	08/06/14	30
Trap Net 2	3–5 ft.	Sand/Gravel	N 44 58' 50.5"	W 93 08' 24.6"	08/04/14	08/05/14	47
Trap Net 3	5 ft.	Sand/Gravel	N 44 58' 56.8"	W 93 08' 26.5"	08/04/14	08/05/14	20
Trap Net 4	3–5 ft.	Sand/Silt/Muck	N 44 58' 59.1"	W 93 08' 34.9"	08/04/14	08/05/14	5
Trap Net 5	2 ft.	Sand	N 44 58' 49.2"	W 93 08' 36.6"	08/05/14	08/06/14	6
Trap Net 6	2–4 ft.	Sand/Silt/Muck	N 44 58' 34.2"	W 93 08' 16.5"	08/05/14	08/06/14	29
Trap Net 7	2–4 ft.	Sand/Silt/Muck	N 44 58' 43.3"	W 93 08' 33.7"	08/05/14	08/06/14	10
Trap Net 9	3–5 ft.	Sand/Silt	N 45 59' 02.2"	W 93 08' 27.9"	08/04/14	08/05/14	2
Gill Net 1	7.5–10 ft.	Silt/Muck	N 44 58' 53.4"	W 93 08 29.8"	08/04/14	08/05/14	48
Gill Net 2	8.5–11.5 ft.	Silt/Muck	N 44 58' 42.0"	W 93 08' 24.8"	08/05/14	08/06/14	35

There were a total of 232 fish collected in Como Lake during the survey. The total fish collected in trap nets ranged from two to 47, while total fish collected in each gill net ranged from 34 to 48 (Table 1). There were 10 species collected from Como Lake. Black Crappies were the most numerous fish collected, totaling 145 fish combined between trap nets and gill nets, accounting for 62 percent of the total catch (Table 2). All other species collected comprised less than ten percent of the total catch. There

were similar numbers of golden shiners, northern pike, black bullhead and yellow perch collected, each totaling between 14 and 19 individuals and accounting for between six and eight percent to the combined total catch (Table 2). There were less than ten individuals collected for the remaining five species with each accounting for one to three percent of the combined total catch, including seven bluegills, seven pumpkinseed, six walleyes, three channel catfish and one yellow bullhead. In general, the nets effectively collected the main target species for each gear type with the majority of the bluegill, crappies and pumpkinseeds collected in trap nets and the majority of black bullheads, channel catfish, golden shiner, northern pike, walleyes and yellow perch collected by the gill nets.

The total combined catch in Como Lake was significantly less than the total catch from the last DNR survey in 2011 where 736 fish were collected (Table 2). While the total catch in 2014 was much lower, the total number of species was very similar between the two surveys, with ten species collected in 2014 and 11 species collected in 2011 (Table 2). The only species that was not collected in 2014 that was present in the 2011 survey were white suckers. Most species were collected in lower numbers in 2014 as compared to 2011, with the largest difference being for bluegills where only seven were collected in 2014 compared to 237 in 2011. Golden shiner was the only species collected in higher numbers in 2014 compared to 2011. Essentially the same numbers of walleyes were collected during the 2014 and 2011 surveys (six compared to five) and yellow perch were collected in similar numbers during both surveys (14 in 2014; 16 in 2011).

Table 2: Comparison of Como Lake results from CRWD 2014 survey and DNR 2011 survey

Species	DNR - 2011		CRWD – 2014	
	Total Catch	Percent of Catch	Total Catch	Percent of Catch
Black Bullhead	71	9.6%	14	6.0%
Black Crappie	272	37.0%	145	62.5%
Bluegill	237	32.2%	7	3.0%
Channel Catfish	19	2.6%	3	1.3%
Golden Shiner	2	0.3%	19	8.2%
Northern Pike	49	6.7%	16	6.9%
Pumpkinseed	29	3.9%	7	3.0%
Walleye	5	0.7%	6	2.6%
White Sucker	3	0.4%	--	--
Yellow Perch	16	2.2%	14	6.0%
Yellow Bullhead	33	4.5%	1	0.4%
Total	736	100.0%	232	100.0%

When removing the large discrepancy between the bluegill catch from the overall total catch, several species collected in 2014 comprised similar percentages of the total catch compared to 2011, such as northern pike, black bullheads, pumpkinseed and channel catfish. The percentage of black crappies collected in 2014 appears much higher than in 2011, but again if the bluegill catch were removed, crappies would comprise a similar percent of the total catch between the two surveys. Stated another

way, the 2014 total catch was lower than 2011 but the total species pool was very similar and the percentage each species comprised of the total catch was also similar.

Table 3: Species catch information for Como Lake

Species*	Sample Gear	Total Fish	Number Fish/Net	Avg. Length	Avg. Weight
Black Bullhead	Trap Net	0	0.0	0.0	0
	Gill Net	14	7.0	9.5	0.56
Black Crappie	Trap Net	123	15.4	6.7	0.15
	Gill Net	22	11.5	6.6	0.16
Bluegill	Trap Net	7	0.8	6.1	0.20
	Gill Net	0	0.0	0.0	0
Channel Catfish	Trap Net	0	0.0	0.0	0
	Gill Net	3	1.5	13.2	1.21
Golden Shiner	Trap Net	6	0.8	6.2	0.10
	Gill Net	13	6.5	6.9	0.17
Northern Pike	Trap Net	4	0.5	14.7	1.56
	Gill Net	12	6.0	26.8	5.01
Pumpkinseed	Trap Net	7	0.9	5.4	0.15
	Gill Net	0	0.0	0.0	0
Walleye	Trap Net	0	0.0	0.0	0
	Gill Net	6	3.0	18.7	2.24
Yellow Perch	Trap Net	1	0.1	8.1	0.27
	Gill Net	13	6.0	8.6	0.35

* : only one yellow bullhead was collected; it was partially eaten by a turtle so no length/weight data was taken.

Average lengths and weights of each species are presented in Table 3. There were some fish collected in both trap and gill nets that were partially consumed by turtles or some other animal. These partial fish were counted in the total number of fish collected (presented in Tables 1 -3) but were not measured for length or weight. Therefore the average weights and lengths are calculated based on whole, intact fish only. The black crappies collected appeared to all be from the same year class, with very little variation in length and weights of the collected fish. These fish would be considered small in terms of “keepable” size fish for anglers; however they were still large enough to be “catchable”. The bluegills and yellow perch were similar to the black crappies, in the fish were large enough to be caught but not necessarily of a quality size to be kept by anglers. The northern pike collected were large for a lake of this size and type averaging almost 27 inches and five pounds, with the largest fish measuring 31 inches and weighing just less than seven pounds. Northern Pike of this size and weight would be considered high quality catchable fish for anglers, even in lakes that are much larger or with more status as a recreational fishery. There were low numbers of channel catfish and walleye collected but the size of these species was similar to the northern pike, where the individuals were would be considered large and high quality size fish for anglers.

The reasons behind the differences in total catch from 2014 compared to the 2011 DNR survey are not known. With the exception of the large decrease in bluegills, it seems likely that collection of the other species is within the variation that would be expected from one survey to the next with these gear types. The majority of the bluegills and sunfish collected in 2011 were small fish less than six inches in size. Fish of this size were basically absent from the 2014 survey. It is possible that there was poor recruitment in one of the year classes from either 2013 or 2014 for these species and that there were very few of these size individuals present to be collected. An additional factor is the very thick aquatic vegetation that was present at many of the trap net locations. It is possible that the small, young bluegills, sunfish and even crappies were hiding in the very thick submerged vegetation and not out moving freely in the lake, which would keep them from being collected by the trap nets. One method that could be added to the surveys in the future to check this theory would be to use a bag seine in areas near the trap nets to survey sections of shoreline for young/smaller bluegills, sunfish or even other species such as minnows or suckers.

Little Crosby Lake

Fish monitoring had not previously been conducted by the DNR in Little Crosby Lake. As a result no previous survey locations were available. Due to the small size of the basin, the total number of nets used for the survey was four trap nets and one gill net. The nets were placed around the lake to sample various areas of the shoreline and open water (Figure 3). The water depth near the shore where the trap nets were set was consistently two to three feet deep with little variation (Table 4). The substrate at all of the trap net locations and the gill net location was muck and submerged vegetation was thick around most of the trap nets. There was no submerged vegetation in the area where the gill net was set, however the lake is narrow in this area (Figure 3) and the gill net was not very far from shore where more vegetation was present.

The total number of fish collected from the trap nets was very low, with only two to five fish collected from each net (Table 4). The thick vegetation at the trap net locations may have impacted the total catch. There were schools of very small (~two to three inch long) bullheads and sunfish observed in the vegetation near the trap net locations. However these fish were not collected in the trap nets. The gill net was placed in the northeast corner of the lake. The southwest corner of the lake has a very deep hole (over 25 feet) and dissolved oxygen concentrations were very low (less than 2.0 mg/L) at depths below five feet. As a result, the very deep hole was avoided and the net was deployed with the smallest mesh to the northeast in approximately five feet of water and the largest mesh in the deeper water approximately 12 feet. There were 58 fish collected from the gill net (Table 4).

Table 4: Little Crosby Lake trap and gill net survey results

Location	Depth	Substrate	Northing	Easting	Set	Retrieved	Total Fish
Trap Net 1	2.5 ft.	Muck	N 44 53' 56.3"	W 93 09' 37.4"	08/11/14	08/12/14	4
Trap Net 2	2.5 ft.	Muck	N 44 54' 00.5"	W 93 09' 39.2"	08/11/14	08/12/14	1
Trap Net 3	3.5 ft.	Muck	N 44 54' 04.3"	W 93 09' 30.6"	08/11/14	08/12/14	3
Trap Net 4	2.5 ft.	Muck	N 44 54' 02.7"	W 93 09' 27.5"	08/11/14	08/12/14	5
Gill Net 1	5 – 12 ft	Muck	N 44 54' 01.5"	W 93 09' 32.8"	08/11/14	08/12/14	58

There were 71 total fish and seven species collected during the surveys in Little Crosby Lake (Table 5). The most numerous species collected was black bullhead, which accounted for 57 of 71 fish collected during the survey, equating to just over 80 percent of the total catch. Yellow perch were the second most abundant fish collected; however, the total number collected was low, with six individuals equaling just over eight percent of the catch. For each of the remaining five species collected, there were only one or two individuals collected, including two individuals each for bluegills, northern pike and pumpkinseed and one individual each for golden shiner and hybrid sunfish.

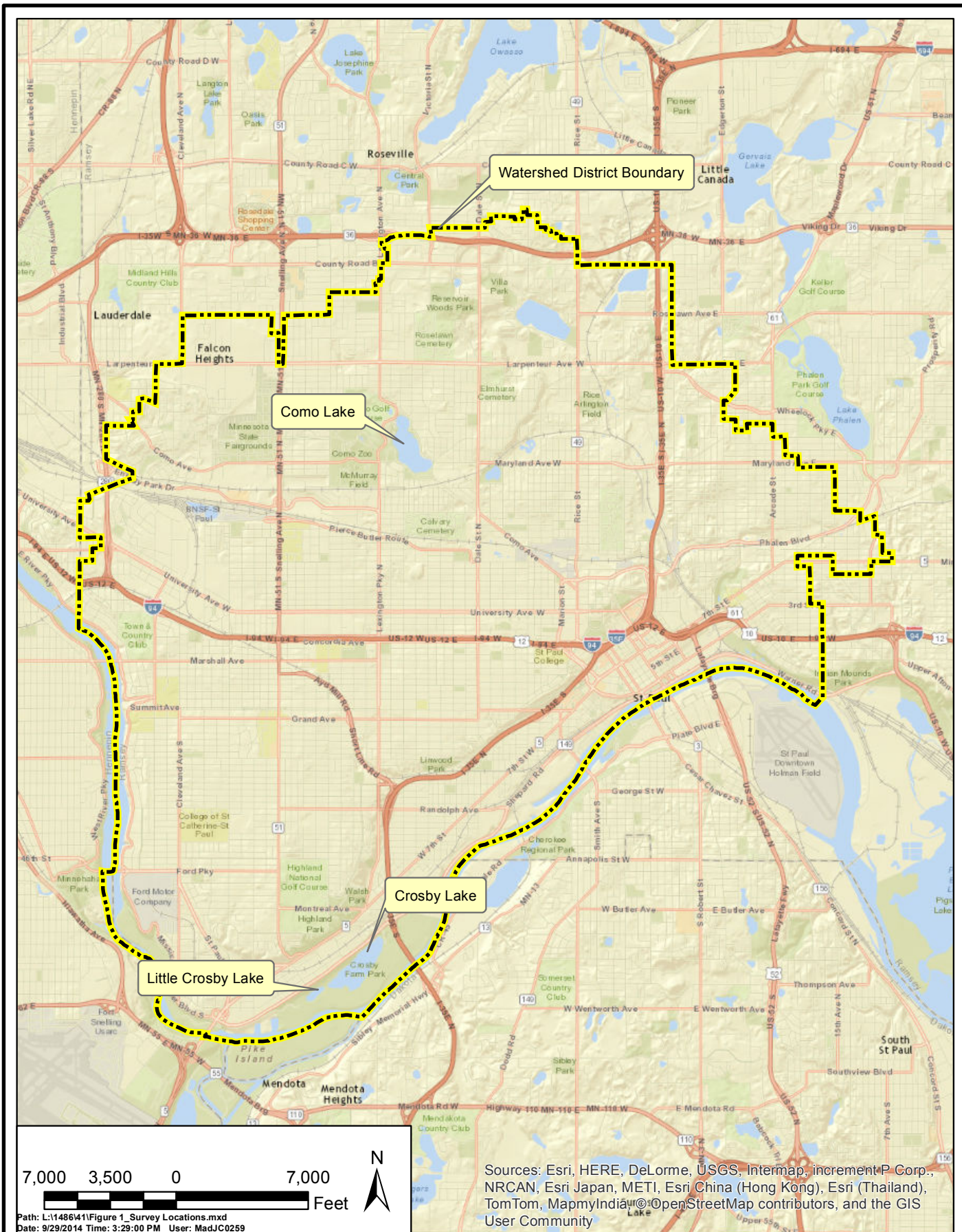
Table 5: Species breakdown from Little Crosby Lake survey

Species	Total Catch	Percent of Catch
Black Bullhead	57	80.3%
Bluegill	2	2.8%
Golden Shiner	1	1.4%
Hybrid Sunfish	1	1.4%
Northern Pike	2	2.8%
Pumpkinseed	2	2.8%
Yellow Perch	6	8.5%
Total	71	100.0%

Partial fish were not measured or weighed, although if identifiable they were included in the total count for each species/net location. There were turtles collected in each trap net and also evidence of turtles eating fish entangled in the gill net. There were eight partial fish collected, which were not included in the length and weight averages for each species. The majority of the black bullheads were collected by the gill net (53 of 57 fish) and they were similar in size. The overall average for all black bullheads was 8 inches and 0.30 pounds. The largest black bullhead was approximately ten inches and weighed 0.6 pounds. The yellow perch ranged from five to seven inches, and averaging six inches and 0.13 pounds. There were only two northern pike collected and one fish was only a partial fish (most of the body was consumed by turtles). The intact fish was a large specimen and was still alive in the gill net. It was measured at 31.5 inches but then released alive to preserve the fish (the fish was stressed, making it difficult to get an accurate weight). All of the sunfish species (bluegill, pumpkinseed, hybrid sunfish) were small individuals, three to six inches in length.

Compared to the most recent survey on the main Crosby Lake basin (conducted by the DNR in 2004) there were less total fish and less species collected in Little Crosby Lake in 2014. There were large numbers of bluegills and pumpkinseeds in the main Crosby Lake survey, significantly more (over 180 total fish from these two species) than were found in Little Crosby Lake. It is possible these fish are not as prevalent in Little Crosby Lake or that the field conditions during the survey (thick near shore vegetation or low dissolved oxygen) impacted the collection. Other species such as black crappie, bowfin (a.k.a. dogfish), common carp and white sucker were collected by the DNR in the main Crosby Lake basin and not from Little Crosby Lake. It is not known if these species are present in Little Crosby Lake and were not collected during 2014 efforts or if these species are absent entirely from the smaller basin. In addition, the Mississippi River periodically floods in spring, connecting the river and both lakes within the floodplain. Therefore, fish species observed in either lake could potentially be influenced by this flooding.

Figures



CAPITOL REGION WATERSHED DISTRICT

2014 Fish Lake Survey Locaitons



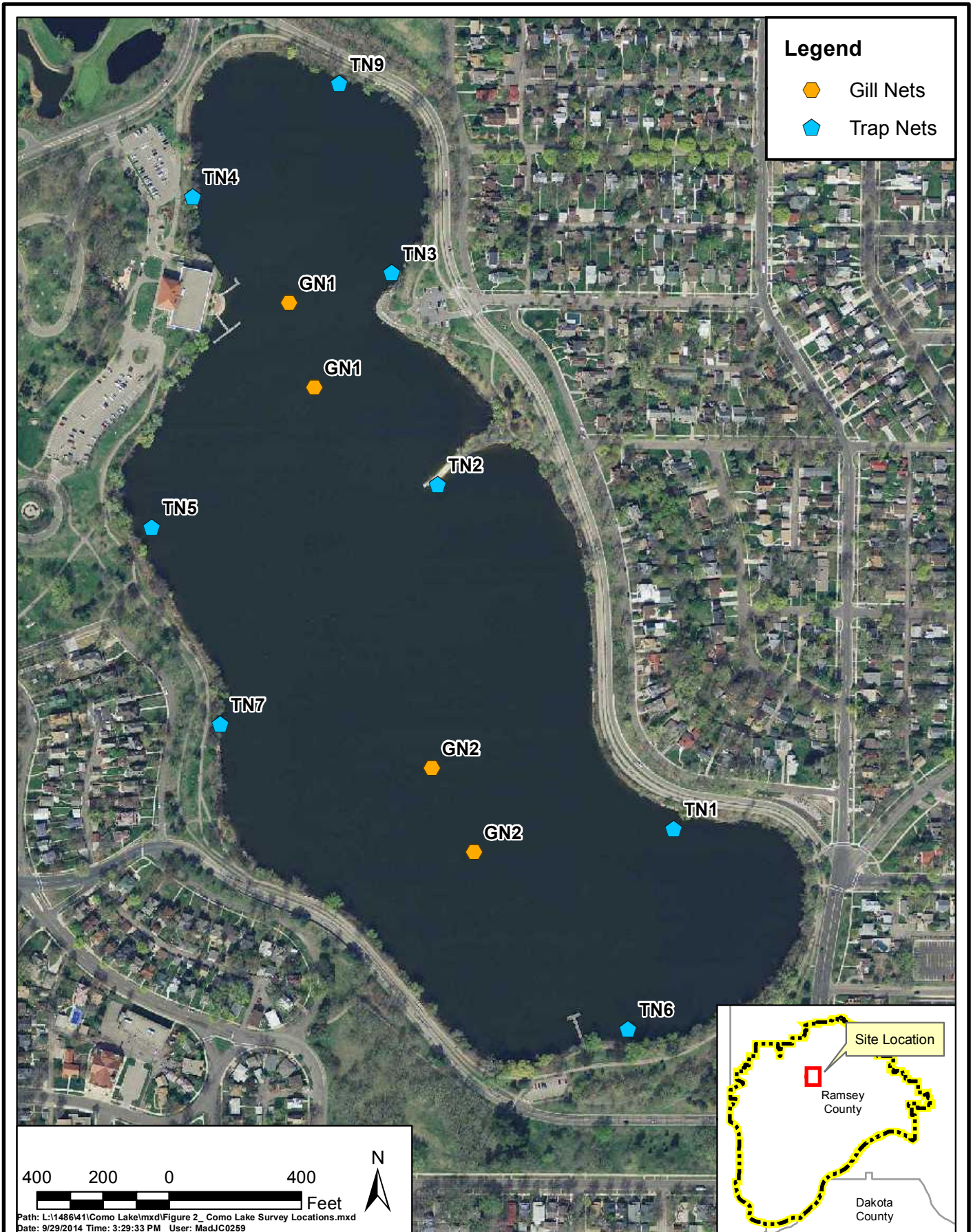
Engineers - Scientists
Business Professionals
www.wenck.com

Wenck

1800 Pioneer Creek Center
Maple Plain, MN 55359-0429
1-800-472-2232

SEPT 2014

Figure 1



CAPITOL REGION WATERSHED DISTRICT

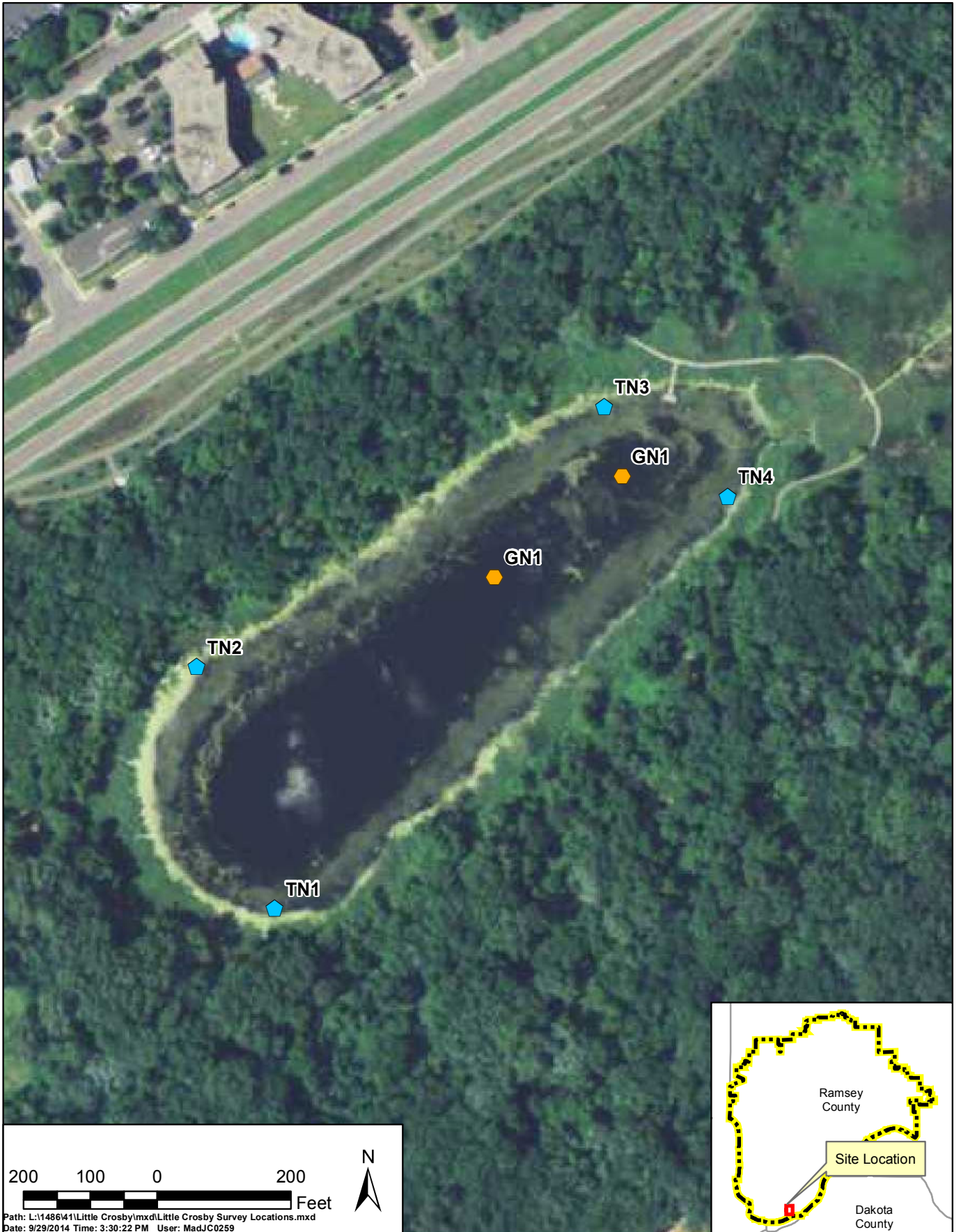
Como Lake - Fish Survey Locations


 Engineers - Scientists
 Business Professionals
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Wenck
 1800 Pioneer Creek Center
 Maple Plain, MN 55359-0429
 1-800-472-2232

SEPT 2014

Figure 1



CAPITOL REGION WATERSHED DISTRICT

Fish Survey Locations - Little Crosby Lake



Engineers - Scientists
Business Professionals
www.wenck.com

Wenck

1800 Pioneer Creek Center
Maple Plain, MN 55359-0429
1-800-472-2232

SEPT 2014

Figure 3

Appendix A

DNR Survey Permit No: 19909

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
Fish Management Section, Division of Fish and Wildlife
500 Lafayette Road
St. Paul, MN 55155-4020
PH: (651) 259-5236
e-mail: fisheries.permits@state.mn.us

SPECIAL PERMIT NO. 19909
(General and Miscellaneous)
Date: 9 July 2014

TO WHOM IT MAY CONCERN:

Permission is hereby granted to: Jeff Madejczyk
Wenck Associates, Inc.
1800 Pioneer Creek Center
P.O. Box 249
Maple Plain, MN 55359-0249

to collect fish through trap net and gill net sampling from Como (62005500) and Little Crosby (aka Upper Lake 62022500) lakes in Ramsey County for fish community monitoring. Fish may be identified, weighed, and measured prior to release.

All nets will be clearly marked with permittee name and permit number. Net set locations will approximate DNR netting locations whenever possible. Any dead or moribund fish shall be disposed of by incineration or burial in a landfill. A copy of this permit shall be carried while sampling.

No endangered or threatened species may be collected without a separate permit from the DNR's Endangered Species Coordinator

Condition #1 - Applies to All Permits for Work in Any State Water

- Before conducting work under this permit in state waters, permittees must decontaminate all equipment that has been used for other activities in infested waters in Minnesota or other locations.
- Permittees must do the following *before* leaving the water access:
 - **Clean** off all aquatic plants and animals (e.g., snails, zooplankton) **and drain** water from equipment; and
 - **Drain** water from watercraft and livewells and transport with drain plugs open.

Condition #2 - Applies to All Permits for Live Transport or Collection of Prohibited Invasive Species

- Live specimens may be transported only in uninfested tap, bottled, or ground water that you brought to the collection site, and only if your permit allows.
- You must obtain a *Prohibited Invasive Species Permit* to collect any prohibited invasive species (see attachment for list and permit application information).

Condition #3 - Permits for Work Exclusively in Infested Waters

- State regulations prohibit transport of water from designated infested waters and special precautions are required as conditions of this permit (download list of waters at http://files.dnr.state.mn.us/eco/invasives/infested_waters.pdf). You must obtain an *Infested Waters Appropriation Permit* if it is critical to transport aquatic species in infested water (see attachment for permit application information). Always use caution so you do not introduce additional invasive species into any water body.
- Permittees using waders, hip boots, or other footwear in infested waters shall decontaminate the footwear before reuse in other waters. Tags are not required on footwear.
- Permittees using hook and line (angling), trot lines, hand-held dip nets, backpack electrofishing, or scuba equipment in infested waters shall decontaminate this equipment before reuse in other waters. Tags are not required on this equipment.
- Watercraft do not need to be tagged, but must be fully decontaminated after work is completed in infested waters, and should not be left in infested waters overnight.
- All other traps, nets, and gear used in designated infested waters shall be tagged with orange *Infested Waters Only* tags supplied by DNR and not used in other waters. Tags must be attached in a manner that prohibits their removal without cutting the tag. Decontamination procedures must still be followed for tagged gear after completion of your field work.
- The permittee must decontaminate equipment specific to the aquatic invasive species present in the waterbody. The following procedures are required before the tagged equipment may be used in uninfested waters or other types of infested waters:
 - **zebra mussel** – rinse with 140 degree F water at the point of contact for at least 10 seconds, or 120 degrees F for at least 2 minutes;
 - **faucet snail** – rinse with 140 degree F hot water for at least one minute;
 - **spiny water flea** – equipment must be thoroughly dry for at least 24 hours; and
 - **Eurasian watermilfoil, flowering rush** – all plant parts must be removed.

Condition #4 - Permits for Work in Both Infested and Uninfested Waters

Option 1

- The permittee may use one set of gear provided:
 - Gear used under this permit shall be used in uninfested waters and then used in infested waters; and
 - Gear shall be tagged after use in uninfested waters and then decontaminated upon final use in infested waters.

Option 2

- The permittee working alternately in infested and uninfested waters shall have two sets of gear – one for infested waters that must be tagged as described above in Condition #3 and one for uninfested waters.
- Tagged infested waters gear and uninfested gear may not be comingled during transport or storage. If infested and uninfested gear are carried in the same compartment of a vehicle (open or closed), then at least one of the sets of gear should be boxed or bagged in such a way that prohibits physical contact between the sets of gear.

This does not permit that any tags may be removed and the previously tagged gear used in any uninfested waters. A separate new permit will be required (see Condition #5).

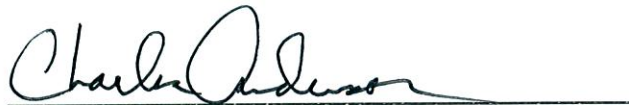
This permit is only for sampling on State property, unless the permittee has explicit permission from the land owners; including the National Park Service, or County. A separate permit is needed from the Division of Parks and Trails to collect within a State Park. A copy of this permit shall be carried while sampling.

The Area Fisheries Supervisor and Regional Enforcement Manager must be notified by e-mail in advance of sampling. A hard copy of the notifications shall be attached to the year-end activity report. Your letter of application does not constitute advance notification of your intent to sample.

A report detailing collection activities (species, numbers, and collection sites) will be submitted to DNR - Division of Fish and Wildlife by **31 January of each year**. A copy of any report or publication resulting from this research will be provided to the Division of Fish and Wildlife upon its completion.

This permit is valid from date of issuance through **31 December 2014**, but may be revoked at any time.

CHARLES ANDERSON
Fisheries Research Supervisor



I hereby certify that I have read and understand the provisions of this permit and understand that this permit is not valid unless it is signed by me.

Permittee Signature	Title	Date

cc: **Division of Fish and Wildlife**

TJ Debates, East Metro Area Fisheries Supervisor, St. Paul
(e-mail timothy.debates@state.mn.us, phone 651-259-5770)
Brad Parsons, Regional Fisheries Manager, St. Paul
(e-mail bradford.parsons@state.mn.us; phone 651-259-5789)

Division of Enforcement

Capt. Gregory Salo, Regional Enforcement Manager, St. Paul
(e-mail gregory.salo@state.mn.us, phone 651-259-5882)