

2015 Lake Water Quality Study

Westwood Lake

Prepared for
Bassett Creek Watershed Management Commission



January 2016



Executive Summary

Since 1970, the Bassett Creek Watershed Management Commission (BCWMC, formerly known as the Bassett Creek Flood Control Commission) has periodically monitored water quality conditions in the watershed's 10 major lakes and six ponds. The BCWMC goals for lakes, as specified in the *2015–2025 BCWMC Watershed Management Plan*, are to manage the lakes of the watershed to meet or exceed state standards and protect and enhance fish and wildlife habitat. The BCWMC monitors its priority waterbodies to detect changes or trends in the water quality over time and the effectiveness of efforts to preserve/improve water quality.

This report summarizes the results of water quality monitoring during 2015 in Westwood Lake. Westwood Lake is a 38 acre lake located within the Westwood Hills Nature Center in the City of St Louis Park. The lake has a maximum depth of 6 feet and an average depth of about 4 feet. The conclusions from this study are summarized below.

- In 2015, summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency met the BCWMC/Minnesota Pollution Control Agency (MPCA) standards.
- Trend analyses indicate significant reductions in summer average total phosphorus and chlorophyll *a* concentrations during the past 10 years. Secchi disc transparency depths have increased over that time period, but the increases are not significant. However, since the Secchi disc was visible to the lake bottom during all 2015 sampling events, additional improvements in water transparency cannot be measured. Overall, the lake's water quality has significantly improved over the past 10 years.
- From 1977 through 2015, 80 percent of the summer averages for total phosphorus and 95 percent for chlorophyll *a* and Secchi disc transparency met the MPCA standards. During the past 9 years, summer averages for these parameters have all met the MPCA standards.
- Specific conductance in Westwood Lake has remained relatively stable over time, ranging from about 400 to 500 $\mu\text{mhos/cm}$ @ 25°C during 2011 and 2015, well below the MPCA standard of 1,000 $\mu\text{mhos/cm}$ @ 25°C. Although chlorides have not been measured in Westwood Lake, chloride concentrations can be estimated by using a relationship between specific conductance and chlorides documented for Nine Mile Creek. Using that relationship, the estimated chloride concentrations in Westwood Lake during 2011 and 2015 ranged from about 40 to 50 mg/L, well below the MPCA chronic standard of 230 mg/L.
- In 2015, phytoplankton and zooplankton community compositions were consistent with previous years and the numbers of phytoplankton and zooplankton were within the range observed during the period of record.
- A healthy and diverse plant community was observed in Westwood Lake in 2015.

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- The change from a qualitative to a quantitative (point-intercept) plant survey method in 2015 provided a more detailed analysis of the plant community. The methodology change likely explains the increase in observed native species (from 7–10 in previous years to 15–17 in 2015). The quality of the plant community, as measured by floristic quality index (FQI), improved accordingly (from 11.3–14.3 in previous years to 14.7–16.2 in 2015).
 - In 2015, *Lynchnothamnus barbaratus* (bearded stonewort) was observed in Westwood Lake and Minnesota for the first time. Plant samples were sent to the New York Botanical Garden for DNA testing to determine whether the plants in Westwood Lake are genetically similar to the Wisconsin populations and/or other known populations in the world. The results of the genetic testing are not yet available.
 - Three of the species present in Westwood Lake in 2015, bearded stonewort (*Lynchnothamnus barbatus*), fetid stonewort (*Chara contraria*), and coontail (*Ceratophyllum demersum*), are strong nutrient absorbers. The absorption of nutrients by these plants likely reduced the concentrations of nutrients in the water column, subsequently improving water quality.
 - Only two non-native species were present in Westwood Lake: purple loosestrife (*Lythrum salicaria*) and curly-leaf pondweed (*Potamogeton crispus*). These plants are not problematic and do not require management at this time. In 2015, *Galerucella* beetles were present, causing heavy damage to the purple loosestrife plants and managing the infestation. Curly-leaf pondweed has been present in the lake since 1997, but has never been problematic

Recommendations from the study are summarized below:

- Because current watershed management practices are adequately protecting Westwood Lake water quality from degradation and have improved lake water quality over time, the recommendation is to make no changes in management practices.
- Continuation of the current water quality and biological monitoring program at a three-year frequency is recommended to periodically assess the condition of the lake's water quality and biological community. The assessment will determine whether the lake is stable or is changing over time. If changes are detected, the assessment will determine whether the changes are favorable or unfavorable for the lake.
- Addition of chloride monitoring to future programs is recommended to verify that the lake is currently meeting MPCA chloride standards and to determine impacts of deicing practices within the lake's watershed on lake water quality over time.

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1.0 Introduction

Since 1970, the Bassett Creek Watershed Management Commission (BCWMC, formerly known as the Bassett Creek Flood Control Commission) has periodically monitored water quality conditions in the watershed's 10 major lakes and six ponds. The BCWMC goals for lakes, as specified in the *2015–2025 BCWMC Watershed Management Plan*, are to manage the lakes of the watershed to meet or exceed state standards and protect and enhance fish and wildlife habitat. The BCWMC monitors its priority waterbodies to detect changes or trends in the water quality over time and the effectiveness of efforts to preserve/improve water quality. This report summarizes the results of water quality monitoring during 2015 in Westwood Lake.



Westwood Lake, pictured above and below, was monitored in 2015 as a part of the BCWMC lake sampling program.

In 1991, the BCWMC established an annual lake/pond water quality monitoring program that generally followed the recommendations of the Metropolitan Council (Osgood 1989a) for a "Level 1 Survey and Surveillance" data-collection effort. This sampling program generally involved monitoring the lakes/ponds on a 4-year rotating basis (three or four lakes/ponds per year). The *2015-2025 BCWMC Watershed Management Plan* established 10 lakes as BCWMC priority waterbodies and a proposed timeline for ongoing monitoring of priority lakes. In doing so, the BCWMC has dropped some of the water bodies from the program, including North Rice Pond, and South Rice Pond. Parkers Lake and Wirth Lake were added to the list of lakes to be monitored. Major lakes/ponds monitored by the BCWMC are listed in Table 1-1, with prior monitoring years noted parenthetically.



Table 1-1 Lakes Monitored by the Bassett Creek Watershed Management Commission
(years with sampling data are in parenthesis)

<ul style="list-style-type: none"> • Crane (1977, 1982, 1993, 1994, 1997, 2001, 2007¹, 2011) 	<ul style="list-style-type: none"> • Sunset Hill (Cavanaugh) (1977, 1982, 1994, 1998)
<ul style="list-style-type: none"> • Lost (1977, 1982, 1993, 1997) 	<ul style="list-style-type: none"> • Sweeney² (1977, 1982, 1985, 1992, 1996, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014)
<ul style="list-style-type: none"> • Medicine (1977, 1982, 1983, 1984, 1988, 1994¹, 1999¹, 2006¹, 2010¹) 	<ul style="list-style-type: none"> • Twin (1977, 1982, 1992, 1996, 2000, 2005, 2008, 2009, 2014)
<ul style="list-style-type: none"> • Northwood² (1972, 1977, 1982, 1992, 1996, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009¹, 2010, 2011, 2012, 2013) 	<ul style="list-style-type: none"> • Westwood² (1977, 1982, 1993, 1997, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015)
<ul style="list-style-type: none"> • North Rice Pond (1994, 1998, 2009, 2013) 	<ul style="list-style-type: none"> • South Rice Pond² (1994, 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2013)

Although located within the BCWMC watershed, Wirth Lake is monitored annually by the Minneapolis Park and Recreation Board. Medicine Lake is monitored annually by the Three Rivers Park District (TRPD); however, the BCWMC periodically assists TRPD in monitoring a second Medicine Lake site. Westwood Lake, Sweeney Lake, Northwood Lake, and Parkers Lake have been monitored annually since 2000 by citizen volunteers participating in the Metropolitan Council’s Citizen Assisted Monitoring Program (CAMP). Crane Lake was monitored almost annually by Ridgedale Center from 1975 through 1988.

The BCWMC lake sampling program has occasionally included limited monitoring of other water bodies. These are listed below, with the year sampled noted in parenthesis.

- Cortlawn, East Ring, and West Ring Ponds (1993)
- Grimes Pond (1996)

This report presents the results of the 2015 water quality monitoring efforts in Westwood Lake (location shown on Figure 1). The lake was monitored for water quality and biota, specifically phytoplankton, zooplankton, and macrophytes (aquatic plants). Results are summarized in Section 3.0.

The discussion of water quality conditions focuses on the three principal nutrient-related water quality indicators: total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disc transparency. Phosphorus is a nutrient that usually limits the growth of algae. Chlorophyll *a* is the primary photosynthetic pigment in lake algae; therefore, the concentration of chlorophyll *a* in a lake sample

¹ Monitoring performed jointly with Three Rivers Park District (formerly Suburban Hennepin Regional Park District).

² Includes monitoring by citizens as a part of the Metropolitan Council’s Citizen Assisted Monitoring Program (CAMP)

indicates the amount of algae present. Secchi disc transparency is a measure of water clarity and is inversely related to algal abundance.

The water quality conditions were classified by trophic state, based on total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency (Table 1-2).

Table 1-2 Trophic State Classifications for Total Phosphorus, Chlorophyll *a*, and Secchi Disc Transparency

Trophic State	Total Phosphorus (micrograms/liter)	Chlorophyll <i>a</i> (micrograms/liter)	Secchi Disc Transparency (feet and meters)
Oligotrophic (nutrient-poor)	Less than 10 µg/L	Less than 2 µg/L	Greater than 15 ft (4.6 m)
Mesotrophic (moderate nutrient levels)	10 µg/L–24 µg/L	2 µg/L–7.5 µg/L	15 ft–6.6 ft (4.6 m–2.0 m)
Eutrophic (nutrient-rich)	24 µg/L–57 µg/L	7.5 µg/L–26 µg/L	6.6 ft–2.8 ft (2.0 m–0.85 m)
Hypereutrophic (extremely nutrient rich)	Greater than 57 µg/L	Greater than 26 µg/L	Less than 2.8 ft (0.85 m)

In addition to chemically based water quality parameters, biological data were collected and evaluated. Phytoplankton, zooplankton, and macrophyte data can help determine the health of aquatic systems and can also indicate changes in nutrient status over time. Biological communities in lakes interact with each other and influence both short- and long-term variations in observed water quality.

Phytoplankton (algae) forms the base of the food web in lakes and directly influences fish production and recreational use. Chlorophyll *a*, the main pigment found in algae, is a general indicator of algal biomass in lake water. The identification of species and their abundance provides additional information about the health of a lake and can indicate changes in lake status, as algal populations change over time. The presence of some types of algae is indicative of the quality of food available for small animals living in the lake. Larger algal species that are difficult to consume or those of low food quality are less desirable for zooplankton (microscopic crustaceans) and can limit overall productivity in a lake.



Phytoplankton, such as the *Rhizoclonium hieroglyphicum*, pictured above, form the base of the food web in lakes and directly influence fish production and recreational use.

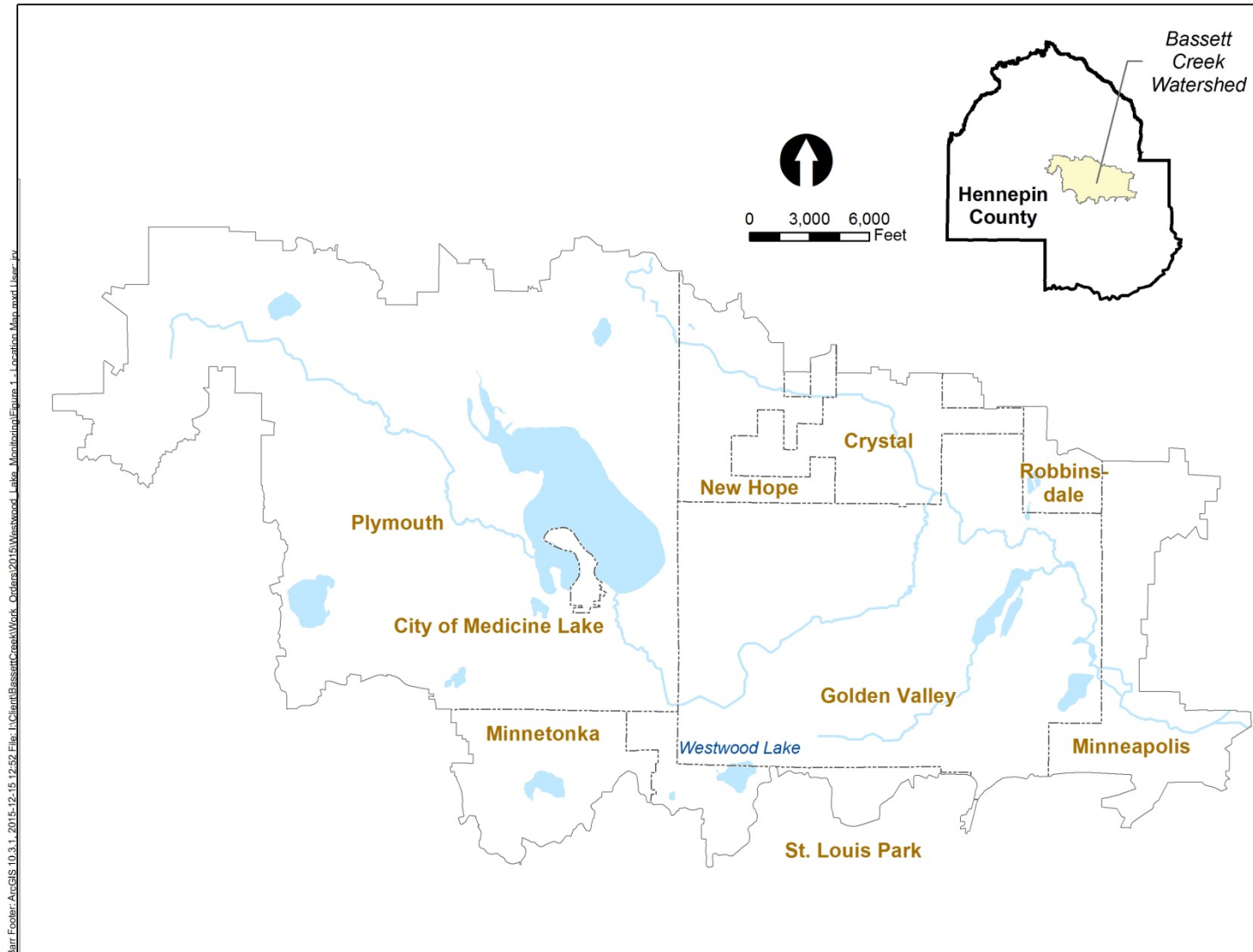


Figure 1 Location of Westwood Lake

Zooplankton (microscopic crustaceans) are vital to the health of a lake's ecosystem because they feed on phytoplankton and provide food for many fish species. They are also important to a lake's water quality. Proper water quality management practices protect the lake's zooplankton community and, subsequently, the lake's fishery. The zooplankton community includes three groups: Cladocera, Copepoda, and Rotifera. Large, abundant Cladocera can decrease the number of algae and improve water transparency.

Macrophytes (large aquatic plants) grow in the shallow (littoral) area of a lake. They are a natural part of lake communities and provide many benefits to fish, wildlife, and people. Macrophytes are primary producers in the aquatic food web, providing food for other life forms in and around the lake.



Macrophytes, such as flat-stem pondweed, pictured above, are primary producers, providing food for other life forms in and around the lake.



Zooplankton, such as the *Cyclops*, pictured above, is vital to the health of a lake ecosystem because they feed on the phytoplankton and provide food for fish.

2.0 Methods

2.1 Water Quality Sampling

As part of the BCWMC water quality monitoring program, water samples were collected from Westwood Lake in 2015. These samples were taken at the deepest location in the lake basin on six occasions from April through September as follows:

- One sample was collected within two weeks of ice out (late April)
- One sample was collected in mid-June
- One sample was collected in mid-July
- Two samples were collected in August (bi-weekly, during the first and third weeks)
- One sample was collected during the first week of September

Table 2-1 lists the water quality parameters and specifies the depths at which samples or measurements were collected during each sample event. Dissolved oxygen, temperature, specific conductance, pH, oxidation reduction potential (ORP), Secchi disc transparency (Secchi depth), and turbidity were measured in the field. Water samples were analyzed in the laboratory for total phosphorus, soluble reactive phosphorus, total nitrogen, and chlorophyll *a*.

Table 2-1 Lake Water Quality Parameters

Parameters	Depth (meters)
Dissolved oxygen	Surface-to-bottom profile at 1-meter intervals (0 and 1 meters)
Temperature	Surface-to-bottom profile at 1-meter intervals (0 and 1 meters)
Specific conductance	Surface-to-bottom profile at 1-meter intervals (0 and 1 meters)
pH	Surface-to-bottom profile at 1-meter intervals (0 and 1 meters)
Oxidation reduction potential (ORP)	Surface-to-bottom profile at 1-meter intervals (0 and 1 meters)
Secchi disc	Measured from surface
Total phosphorus	0–1 meter composite sample
Soluble reactive phosphorus	0–1 meter composite
Total nitrogen	0–1 meter composite sample
Chlorophyll <i>a</i>	0–1 meter composite sample
Turbidity	0–1 meter composite sample

2.2 Ecosystem Data

Ecosystem data were collected from June to September 2015.

Phytoplankton (algae)—Five water samples for phytoplankton were collected at Westwood Lake from June through September (see Section 2.1 for schedule). The samples were taken at a depth of 0–1 meters. Sample analysis included identification and enumeration of phytoplankton species.

Zooplankton (microscopic crustaceans)—Five zooplankton samples (bottom to surface tow) were collected at Westwood Lake from June through September (see Section 2.1 for schedule). Sample analysis included identification and enumeration of species.

Macrophytes (aquatic plants)—Macrophyte surveys were completed in June and August using the point-intercept method. The plant surveyor located equally spaced, preset points using a global positioning system (GPS) and took measurements at each point, including the following:

1. Individual species present
2. Overall density of plants, as measured by rake method
3. Density of individual species, as measured by rake method
4. Water depth
5. Dominant sediment type

The following statistics from the macrophyte survey were compiled:

- **Number of species**—the number of plant species that were either collected on the rake or observed in the lake (e.g., water lilies or cattail beds not collected on the rake but observed). This number includes both invasive and native species.
- **Maximum depth of plant growth**—the maximum depths at which plants were found in the lake.
- **Frequency of occurrence**—the frequencies with which plants were found in water shallower than the maximum depth of plant growth.
- **Average rake fullness**—the density of plant growth, as measured by rake fullness on a scale of 1 to 4, where:
 - 1 = less than 1/3 of the rake head full of plants
 - 2 = from 1/3 to 2/3 of the rake head full of plants
 - 3 = more than 2/3 of the rake head full of plants
 - 4 = rake head is full, with plants overtopping



A rake was used to collect plants for the surveys. The fullness of the rake above (at a Westwood Lake sampling location) was measured at 2: from 1/3 to 2/3 of the rake head is full of plants.

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- **Simpson diversity index value**—used to measure plant diversity, which assesses the overall health of the lake’s plant communities. This index, with scores ranging from 0 to 1, considers both the number of species and the evenness of species distribution. The scores represent the probability that two randomly selected plants will belong to different species. A high score indicates a more diverse plant community—a higher probability that two randomly selected plants will represent different species.
 - **C value**—scale of values used to measure the average tolerance of the plant community to degraded conditions. Plant species are assigned C values on a scale of 0 to 10; increasing values indicate plants are less tolerant of degraded conditions and, hence, of higher quality. An average of the C values for individual species within a lake’s plant community indicates the average tolerance of the community to degraded conditions.
 - **Floristic quality index (FQI) value**—FQI was used to assess the quality of the plant communities in Westwood Lake. FQI considers both the quality of the individual native species found in the lake (C value) and the number of native species collected on the rake. Although Minnesota has not kept a record of FQI values, recorded Wisconsin FQI values range from 3 (degraded plant communities) to 49 (diverse native plant communities). The median FQI for Wisconsin is 22.

3.0 Westwood Lake

3.1 Site Description

Westwood Lake (Minnesota Department of Natural Resources public water # 27-0711) is a 38-acre lake located within the Westwood Hills Nature Center in the city of St. Louis Park in the southern portion of the Bassett Creek watershed (Figure 1). Although the lake does not have a public beach, the adjacent park land and Westwood Hills Nature Center trails provide residents opportunities for canoeing or kayaking, aesthetic viewing, birding, and hiking.



Westwood Lake, pictured above, is surrounded by park land and the Westwood Hills Nature Center. The lake is used for canoeing, kayaking, aesthetic viewing, birding, and hiking.

Westwood Lake is a BCWMC “priority 1” shallow lake, with a maximum depth of 6 feet, a normal water elevation of 886.0 feet (NGVD1929 datum), and a 100-year elevation of 889.0 feet (NGVD1929 datum). The majority of the shallow lake bottom is covered with submerged vegetation; emergent vegetation can be found around the lake’s entire circumference. Westwood Lake has a watershed area of approximately 463 acres. Portions of the cities of St. Louis Park, Golden Valley, and Minnetonka drain towards the lake. Runoff draining to Westwood Lake enters through five storm sewers around its edge. The landuse of the watershed draining to the lake through the five storm sewers is residential and a golf course. A 400-foot-long open channel at the north side of the lake discharges to a 27-inch reinforced-concrete pipe (RCP) storm sewer at an elevation of 886.0. The discharge is conveyed to a stormwater pond (Loop F pond) and eventually is conveyed to Bassett Creek.

3.2 BCWMC/MPCA Water Quality Standards

For priority water waterbodies, such as Westwood Lake, the BCWMC has adopted water quality standards consistent with Minnesota Pollution Control Agency (MPCA) water quality standards, as published in Minnesota Rules 7050 for lakes within the North Central Hardwood Forest Ecoregion. These rules apply to water bodies within the BCWMC, regardless of their BCWMC classification, and differ for lakes classified by the MPCA as shallow or deep. Shallow lakes are defined as those with a maximum depth less than 15 feet or littoral area greater than 80% of the total lake area; Westwood Lake is classified as a shallow lake. The BCWMC/MPCA water quality standards for Westwood Lake are as follows:

1. Average summer total phosphorus concentration not to exceed 60 µg/L
2. Average summer chlorophyll *a* concentration not to exceed 20 µg/L

- Average summer Secchi disc transparency of at least 1.0 meter or 3 feet (Minn. R. Ch. 7050.0222 Subp. 4)

As shown in Figure 2, Figure 3, and Figure 4, the summer average total phosphorus, chlorophyll *a*, and Secchi disc transparency in Westwood Lake met the BCWMC/MPCA water quality standards in 2015.

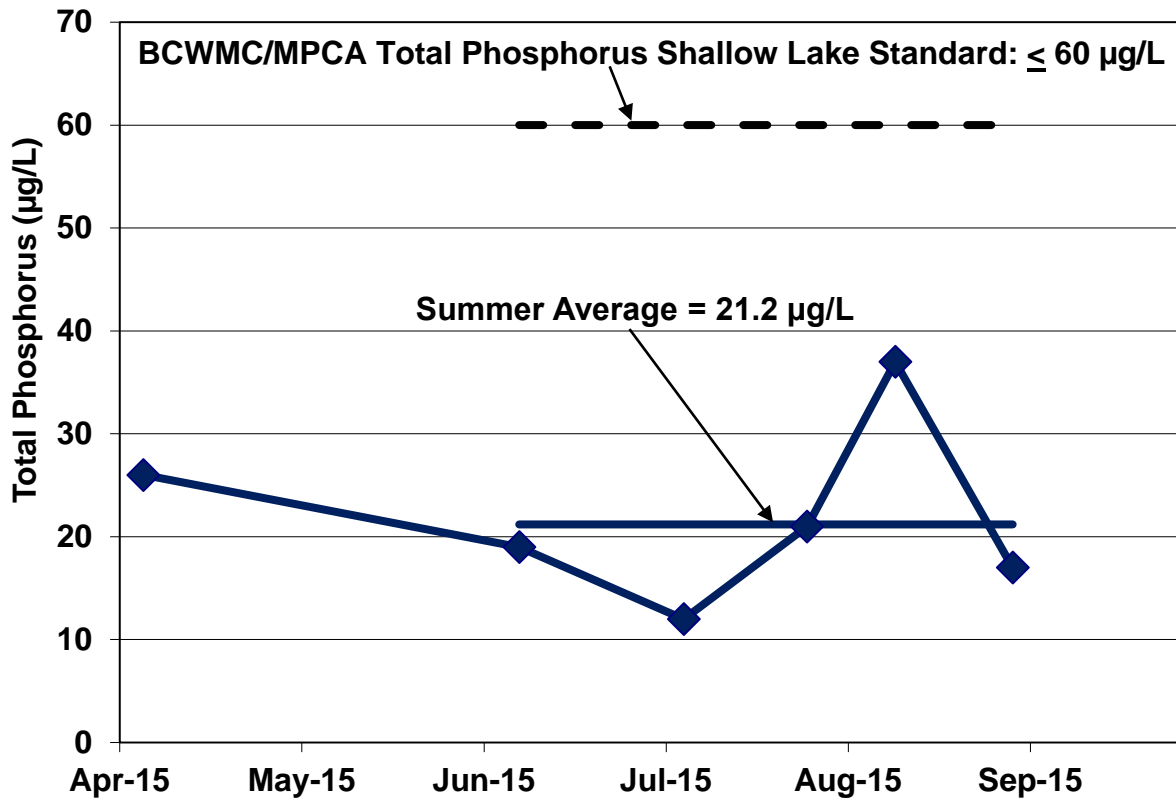


Figure 2 2015 Westwood Lake Total Phosphorus Concentrations Compared to BCWMC/MPCA Total Phosphorus Standard for Shallow Lakes within the North Central Hardwood Forest Ecoregion

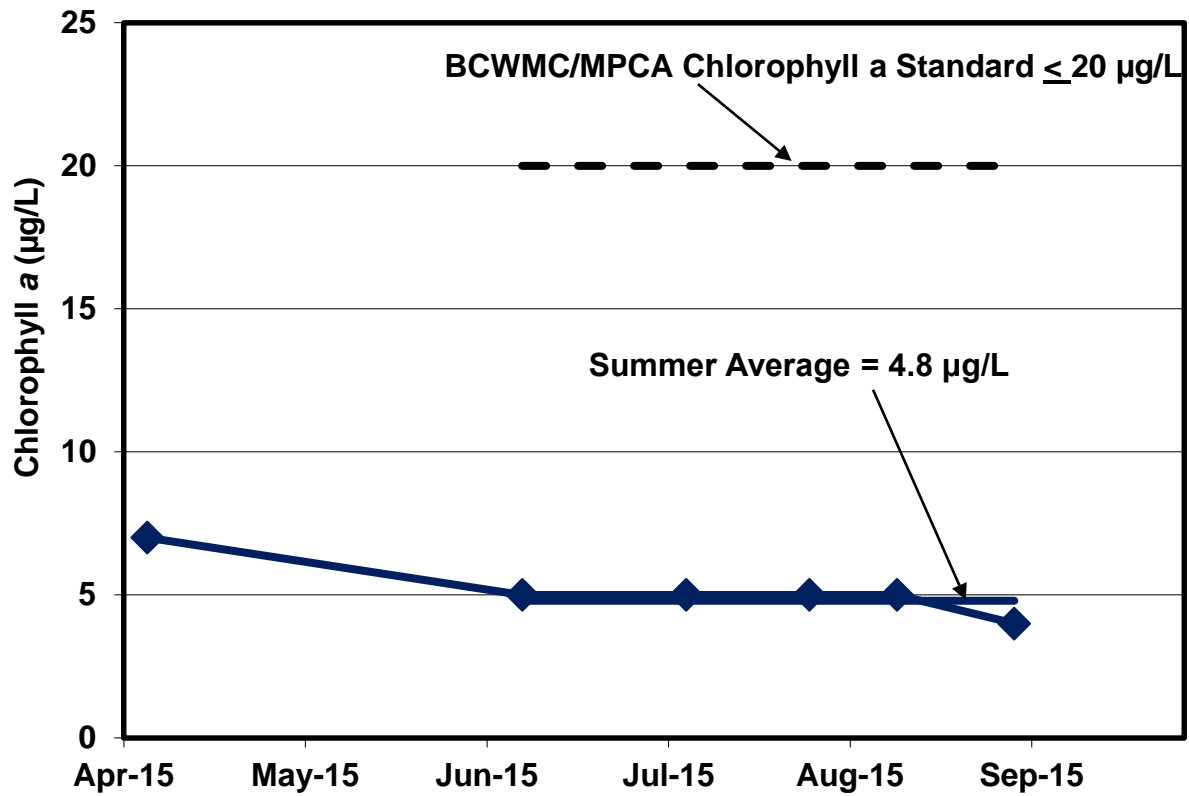


Figure 3 2015 Westwood Lake Chlorophyll a Concentrations Compared to BCWMC/MPCA Chlorophyll a Standard for Shallow Lakes within the North Central Hardwood Forest Ecoregion

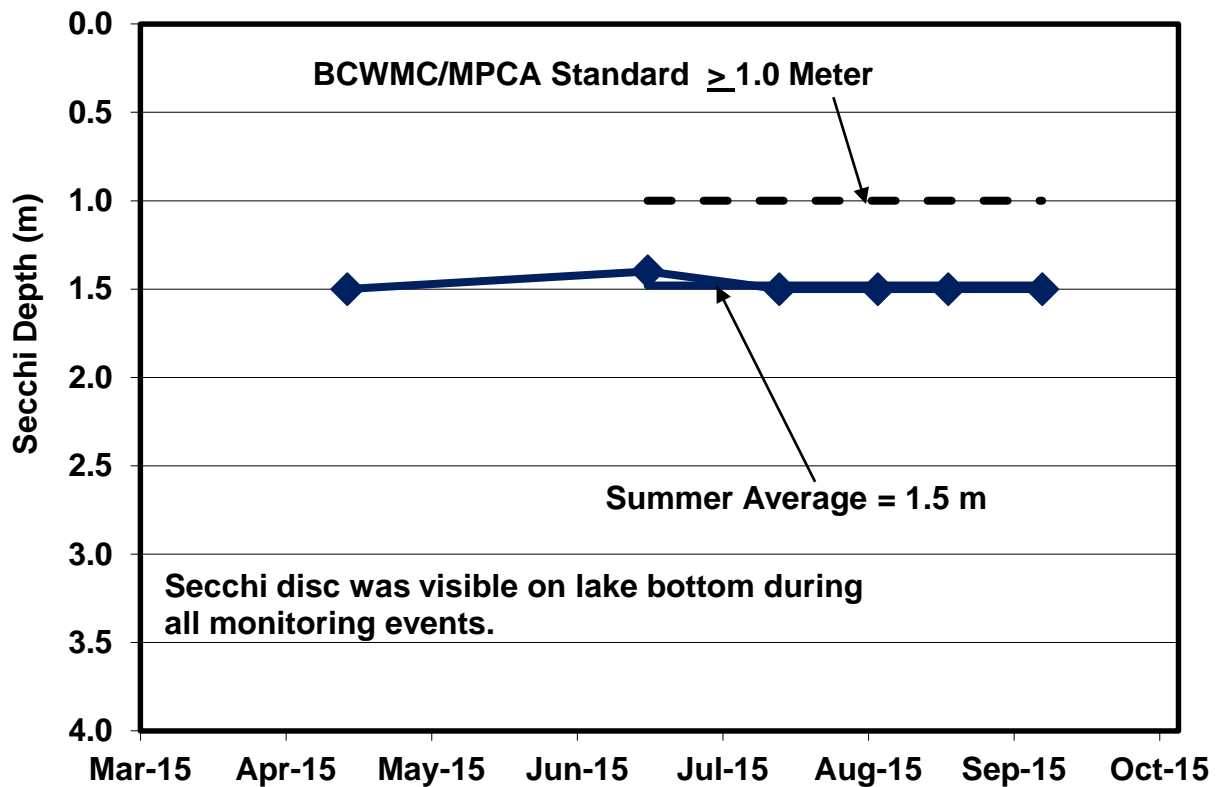


Figure 4 2015 Westwood Lake Secchi Disc Water Transparency Compared to BCWMC/MPCA Secchi Disc Standard for Shallow Lakes within the North Central Hardwood Forest Ecoregion

3.3 Water Quality Monitoring Results

Water quality monitoring results for temperature, dissolved oxygen, specific conductance, total phosphorus, chlorophyll *a*, and Secchi disc transparency are summarized in this section.

3.3.1 Temperature

Vertical profiles of temperatures collected during 2015 show the lake was mixed throughout the monitoring period (Figure 5). The vertical lines in Figure 5 show that temperature was the same from surface to bottom. Change in temperature is represented by changes in color. The change in color from dark green at the far left (i.e., spring) to light yellow in the center (i.e., mid-summer) shows that the lake warmed during the growing season. As shown, water temperatures increased from about 16° C in spring to about 26° C in mid-summer and then cooled to about 20 to 22° C in late summer.

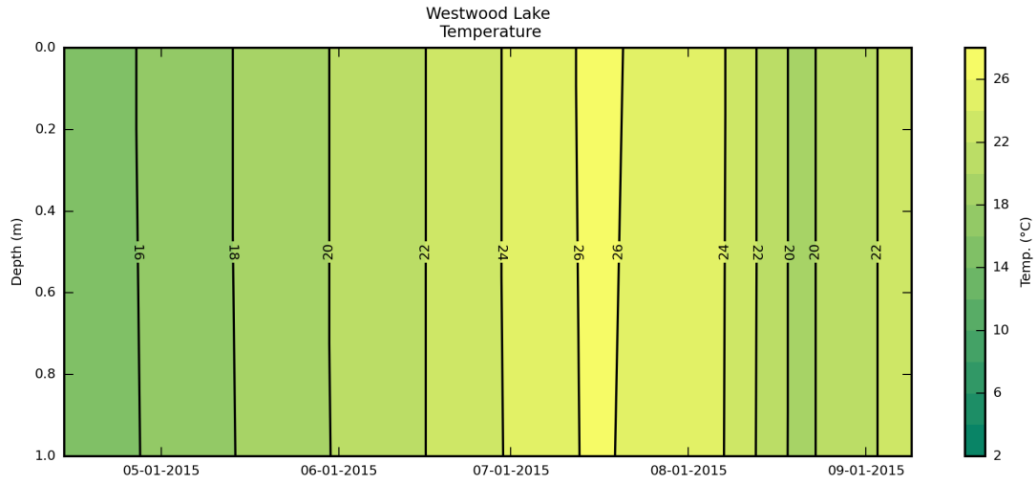


Figure 5 2015 Westwood Lake Temperature Isoleths

3.3.2 Dissolved Oxygen

The amount of oxygen dissolved in water depends on water temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering the lake (2004 Shaw et al.).

As shown in Figure 6, Westwood Lake was well-oxygenated throughout 2015. The maximum oxygen level was observed in spring when water temperatures were lowest. As water temperatures increased, oxygen levels decreased; this is expected, since oxygen becomes less soluble as water temperatures increase. All measured oxygen levels were above the 5 mg/L threshold required for the full support of fish and aquatic life (Minn. R. Ch. 7050.0222 Subp. 4).

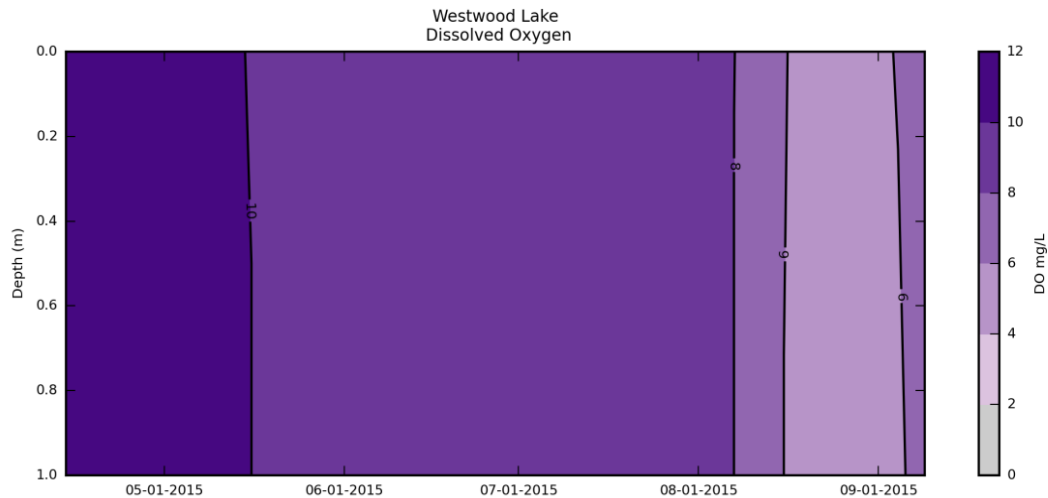


Figure 6 2015 Westwood Lake Dissolved Oxygen Isoleths

3.3.3 Specific Conductance

Conductivity is the measure of a material's ability to conduct an electrical current. In the case of water, it also serves as an indicator of total dissolved inorganic compounds. Since conductivity is temperature-related, reported values are normalized at 25 degrees Celsius and termed "specific conductance." Specific conductance increases as the concentration of dissolved compounds in a lake increases (Shaw et al. 2004). Chlorides, a dissolved compound added to lakes from road and parking lot runoff during snowmelt, increases specific conductance levels.

Specific conductance in Westwood Lake has remained relatively stable over time, ranging from about 400 to 500 $\mu\text{mhos/cm}$ @ 25°C during 2011 and 2015 (Figure 7 and BCWMC 2012), well below the MPCA standard of 1,000 $\mu\text{mhos/cm}$ @ 25°C. In 2015, the maximum specific conductance value was observed in spring. Values declined from spring through summer (Figure 7).

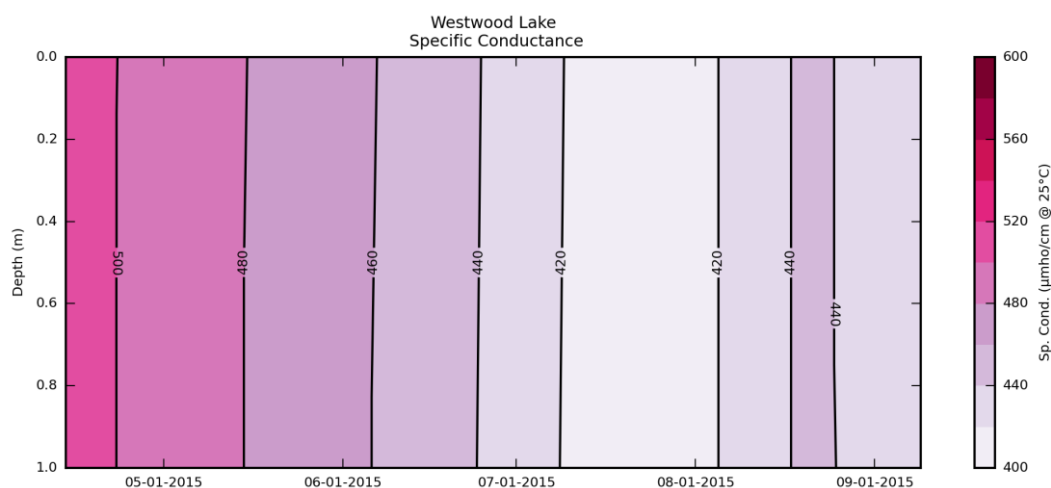


Figure 7 2015 Westwood Lake Specific Conductance Isopleths

3.3.4 Total Phosphorus

Phosphorus is necessary for plant and algae growth in lakes. It occurs naturally in soils, rocks, and the atmosphere and can make its way into lakes through groundwater and watershed runoff. While phosphorus is necessary for plant and animal growth, excessive amounts lead to an overabundance of growth. This can decrease water clarity and lead to water quality impairment (Shaw et al. 2004). The BCWMC/MPCA standard for phosphorus in Westwood Lake is a summer average total concentration not to exceed 60 $\mu\text{g/L}$ (Minn. R. Ch. 7050.0222 Subp. 4). This standard was selected to prevent nuisance algal blooms in shallow Minnesota lakes.

Total phosphorus concentrations for Westwood Lake, measured by the 0–1 meter composite (surface or epilimnetic) sample, are summarized in Table 3-1. Phosphorus concentrations ranged from a low of 12 $\mu\text{g/L}$ in July to a high of 37 $\mu\text{g/L}$ in late August (Table 3-1). Total phosphorus concentrations were generally within the mesotrophic category (moderate nutrient levels), indicating good water quality. Exceptions include a spring concentration that bordered between eutrophic (nutrient rich) and

mesotrophic (moderate nutrients) and a late summer concentration that was eutrophic (nutrient rich). The summer average concentration of 21 µg/L was within the mesotrophic category and met the BCWMC/MPCA standard (Table 3-1 and Figure 8).

Table 3-1 Total Phosphorous Concentrations for Westwood Lake: Low, High, and Summer Average

Total Phosphorous Concentration (0–1 meters)	Westwood Lake
Low	12 µg/L (July)
High	37 µg/L (late August)
Summer Average	21 µg/L

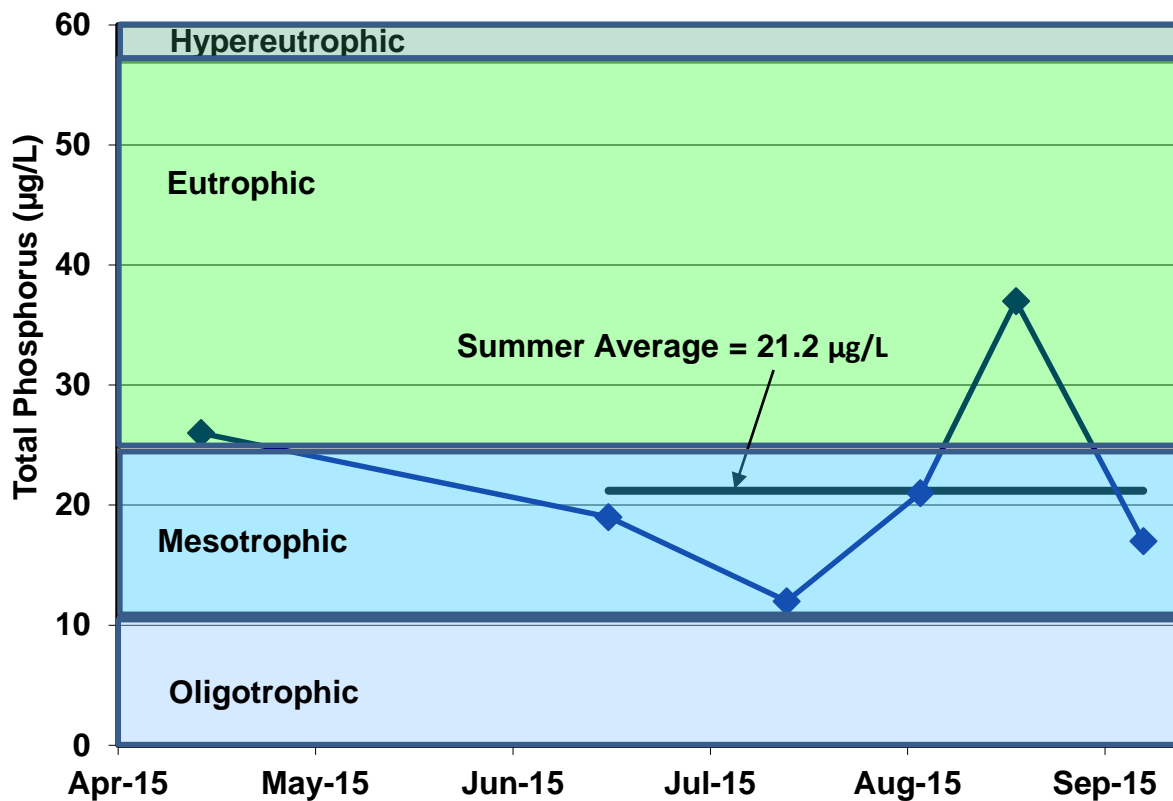


Figure 8 2015 Westwood Lake Total Phosphorus Data

3.3.5 Chlorophyll a

Chlorophyll *a* is a pigment in plants and algae necessary for photosynthesis. It is also an indicator of a lake’s water quality; chlorophyll *a* generally reflects the amount of algae growth in a lake, with greater chlorophyll *a* values indicating greater amounts of algae. Lakes which appear clear generally have chlorophyll *a* levels less than 15 µg/L (Shaw et al. 2004). The chlorophyll *a* water quality standard for

Westwood Lake is 20 µg/L (Minn. R. Ch. 7050.0222 Subp. 4). This standard has been selected to limit algal growth and prevent nuisance algal blooms.

Chlorophyll *a* concentrations, measured by 0–1 meter composite samples, are summarized in Table 3-2. These concentrations declined from spring through June, were stable from June through August, and decreased in September. All chlorophyll *a* concentrations were within the mesotrophic category (good water quality), ranging from a low of 4.0 µg/L to a high of 7.0 µg/L (Table 3-2). The summer average was 4.8 µg/L (Table 3-2), which met the BCWMC/MPCA standard (Figure 9).

Table 3-2 Chlorophyll *a* Concentrations for Westwood Lake: Low, High, and Summer Average

Chlorophyll <i>a</i> Concentration (0–1 meters)	Westwood Lake
Low	4.0 µg/L ()
High	7.0 µg/L ()
Summer Average	4.8 µg/L

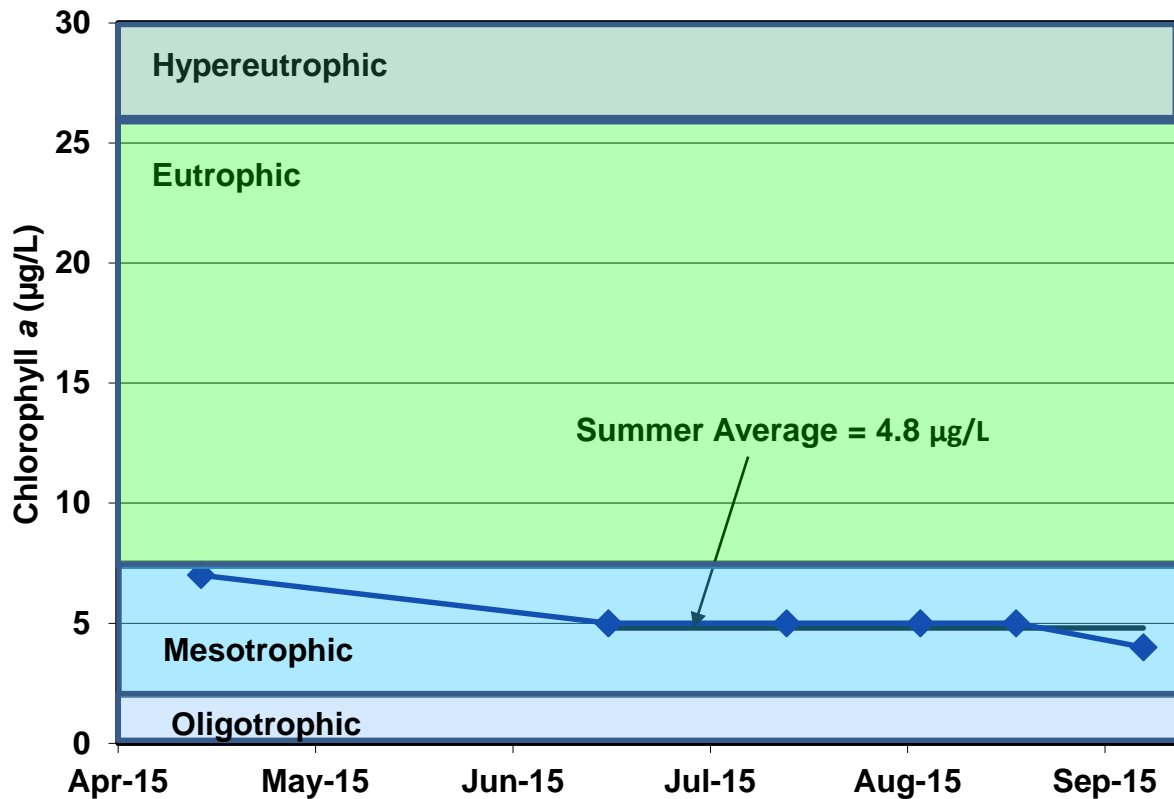


Figure 9 2015 Westwood Lake Chlorophyll *a* Data

3.3.6 Secchi Disc

The ability of light to penetrate the water column is often determined by the abundance of algae or other photosynthetic organisms in a lake. One method of measuring light penetration is with a Secchi disc—a black-and-white disc mounted on a pole or a line. The depth at which the pattern on the disc is no longer visible after being lowered into the water is considered a measure of the water’s transparency (i.e., Secchi disc transparency depth). A greater Secchi disc transparency depth indicates greater water clarity (Shaw et al. 2004). Minnesota’s Secchi disc transparency standard for shallow lakes in the North Central Hardwood Forest Ecoregion is at least 1.0 meter (Minn. R. Ch. 7050.0222 Subp. 4).

Secchi disc data are summarized in Figure 10. The Secchi disc was visible on the lake bottom during all sampling events. Because the transparency measurement was limited by the lake bottom, we don’t know the actual depth at which the Secchi disc was no longer visible. Hence, we don’t know the actual transparency of the lake. We just know that it is greater than 1.5 meters.

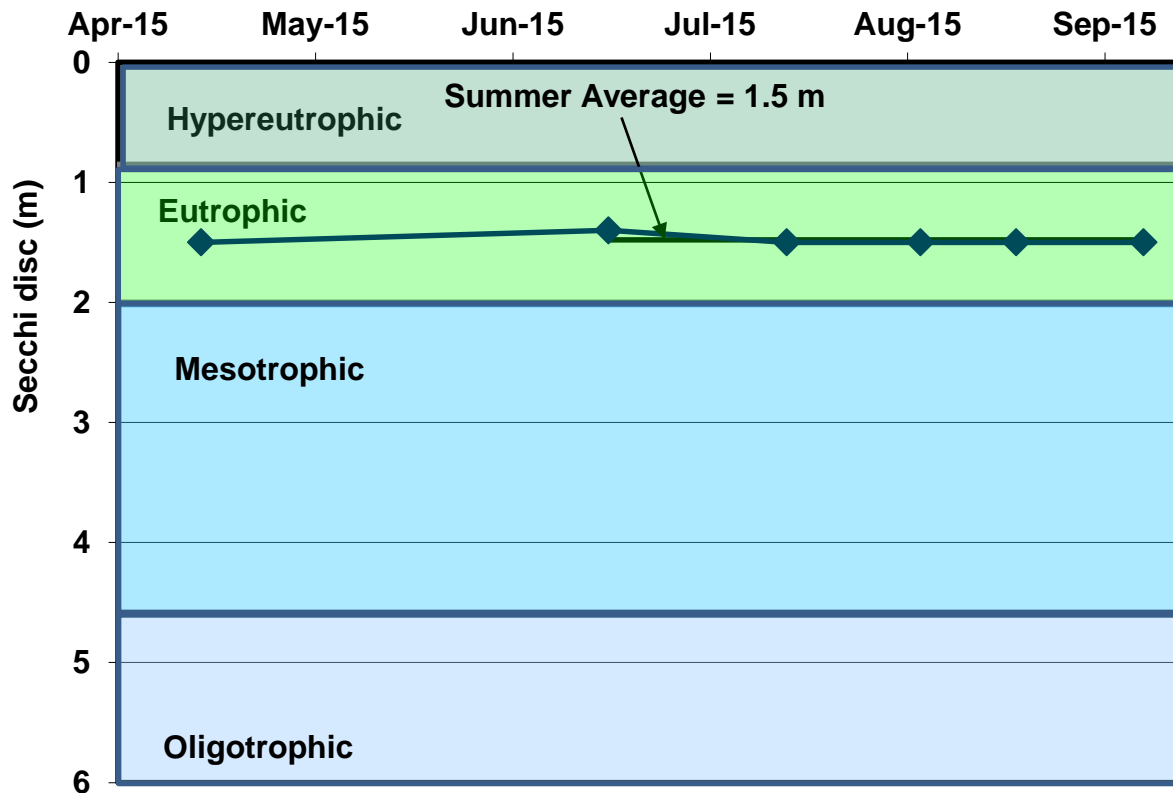


Figure 10 2015 Westwood Lake Secchi Disc Transparency Data

3.4 Historical Trends

Historical water quality trends are shown on Figure 11, Figure 12, and Figure 13. The black squares on the figures show the average summer values from 2006 through 2015 (i.e., summer average total phosphorus

and chlorophyll *a* concentrations and Secchi disc transparency depths). The summer averages include CAMP data collected annually from 2006 through 2014 and BCWMC data collected during 2011 and 2015. The line on each figure shows the long-term trend; the slope of the line shows the rate of change over time.

Significant reductions in total phosphorus and chlorophyll *a* concentrations since 2006 indicate Westwood Lake water quality has greatly improved. These reductions are considered significant because there is less than a 5-percent probability that the changes are due to chance (i.e., 95-percent confidence level). Since 2006, total phosphorus concentrations have declined at an average rate of 2.57 $\mu\text{g/L}$ per year and chlorophyll *a* concentrations have declined at an average rate of 0.85 $\mu\text{g/L}$ per year (Figure 11 and Figure 12). Secchi disc transparency has improved since 2006, increasing at an average rate of 0.02 meters per year. This increase is not considered significant because there is more than a 5-percent probability that the increase is due to chance (Figure 13). However, since the Secchi disc was visible at the lake bottom during all 2015 sample events, additional improvements in water transparency cannot be measured.

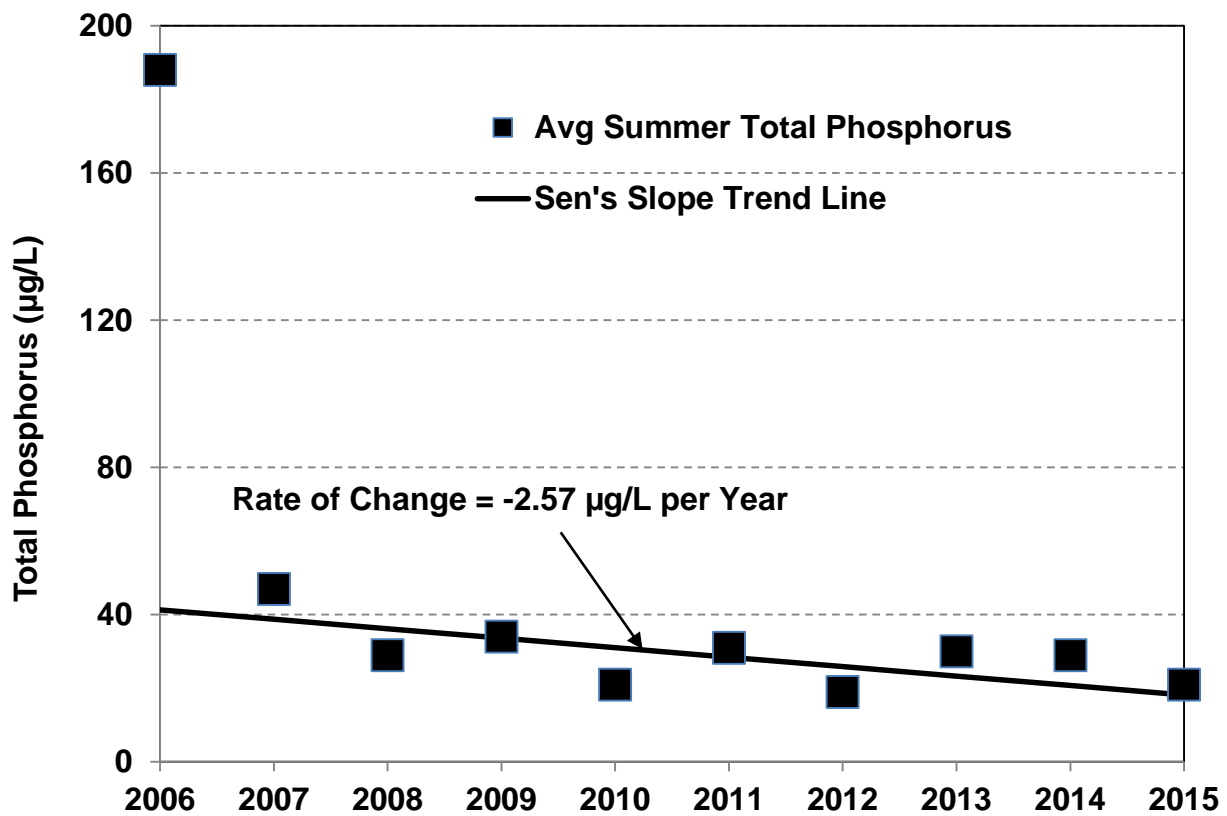


Figure 11 Westwood Lake Total Phosphorus Trend Analysis: 2006–2015

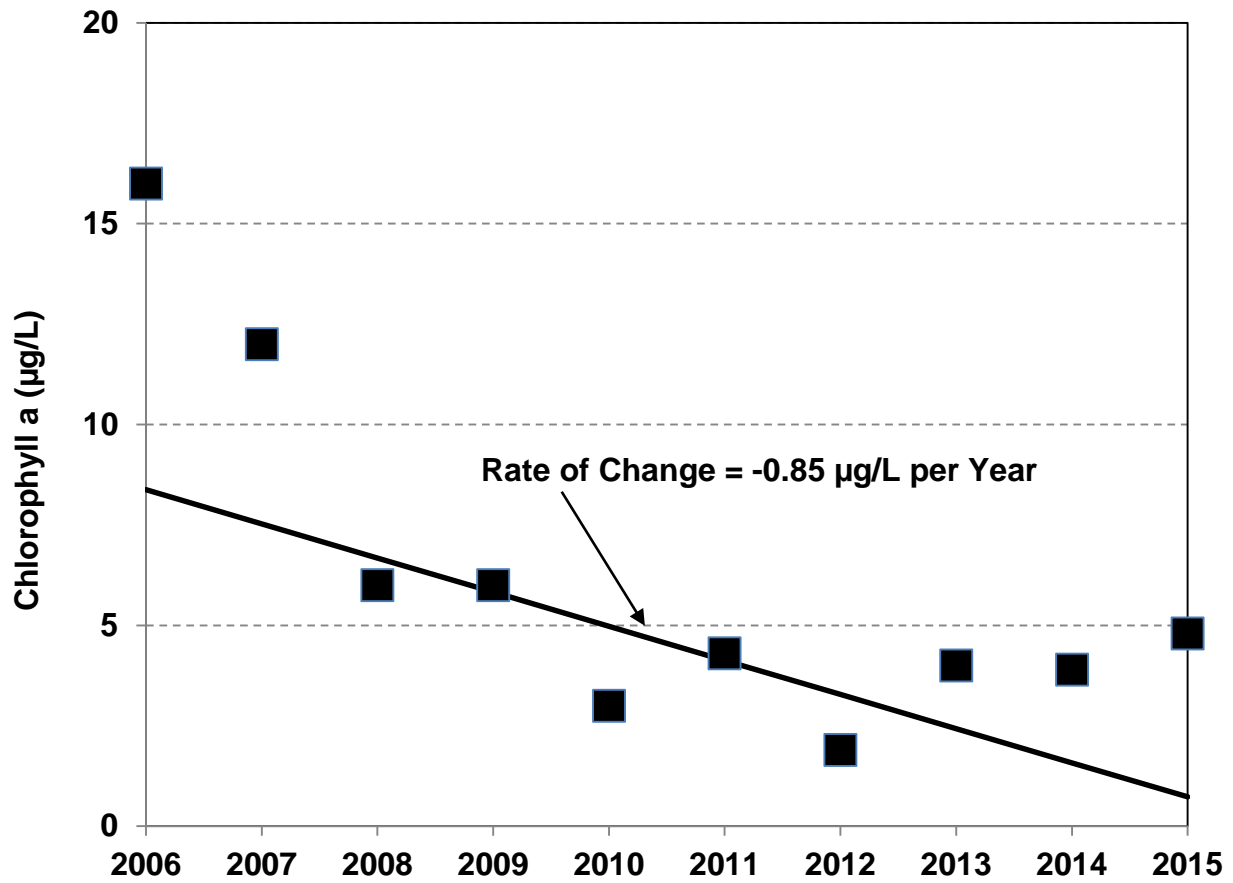


Figure 12 Westwood Lake Chlorophyll a Trend Analysis: 2006–2015

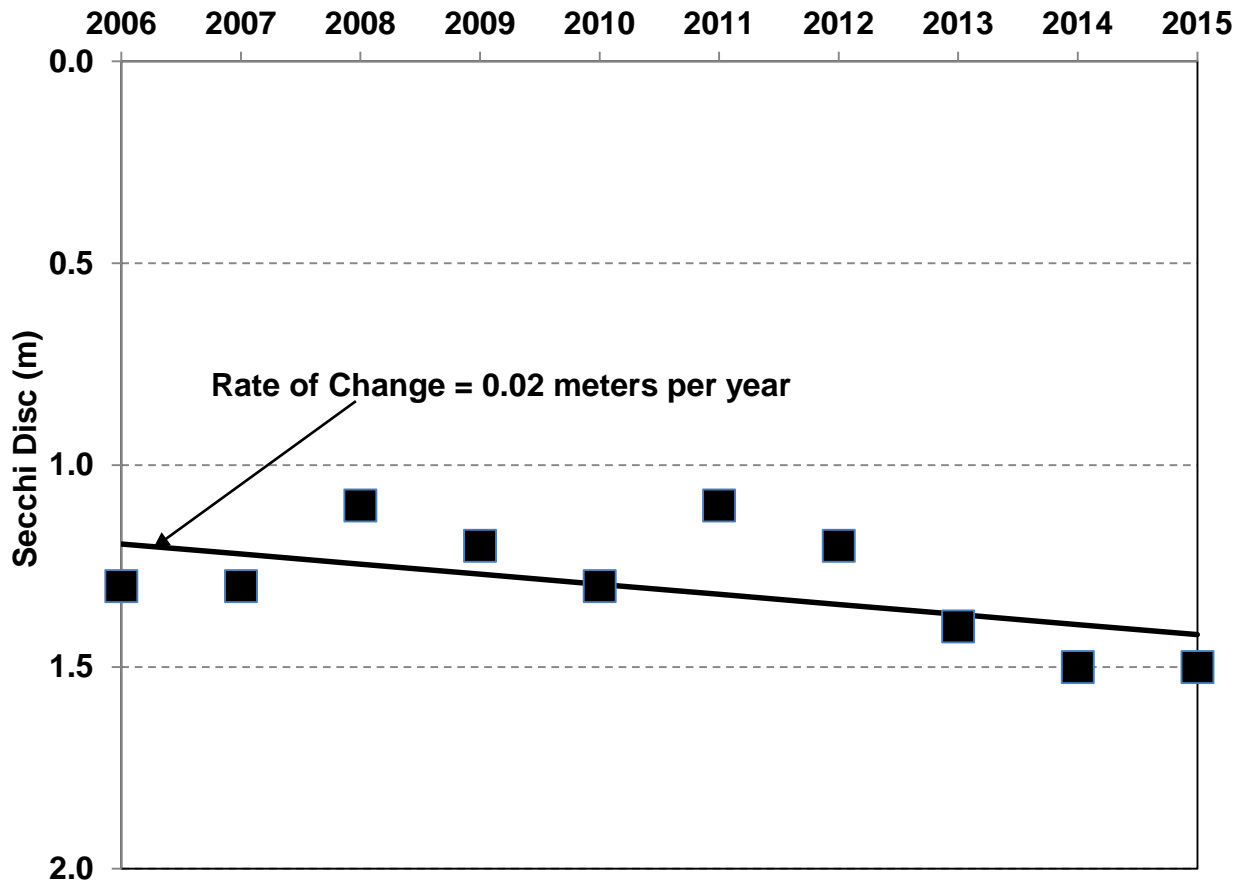


Figure 13 Westwood Lake Secchi Disc Trend Analysis: 2006–2015

3.5 Historical Attainment of BCWMC/MPCA Standards

Figure 14, Figure 15, and Figure 16 compare historical water quality data from Westwood Lake with BCWMC/MPCA standards for the period of record (1977 through 2015). Both CAMP and BCWMC data are included. During the period of record, 80 percent of the summer averages for total phosphorus and 95 percent for chlorophyll *a* and Secchi disc met the BCWMC/MPCA standard (Figure 14, Figure 15, and Figure 16). In 2015, BCWMC/MPCA standards for total phosphorus, chlorophyll *a*, and Secchi disc were all met.

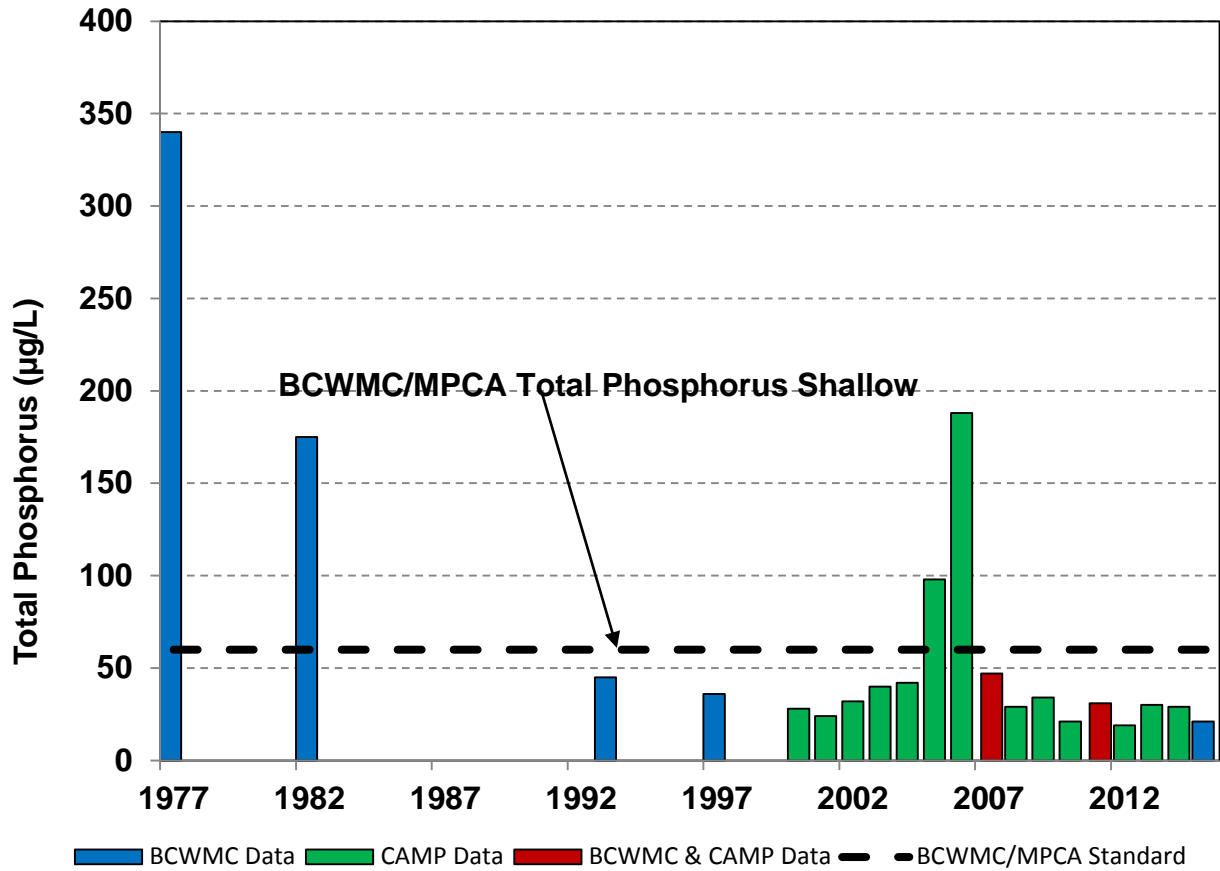


Figure 14 Westwood Lake Historical Total Phosphorus Concentrations Compared with BCWMC/MPCA Total Phosphorus Standard

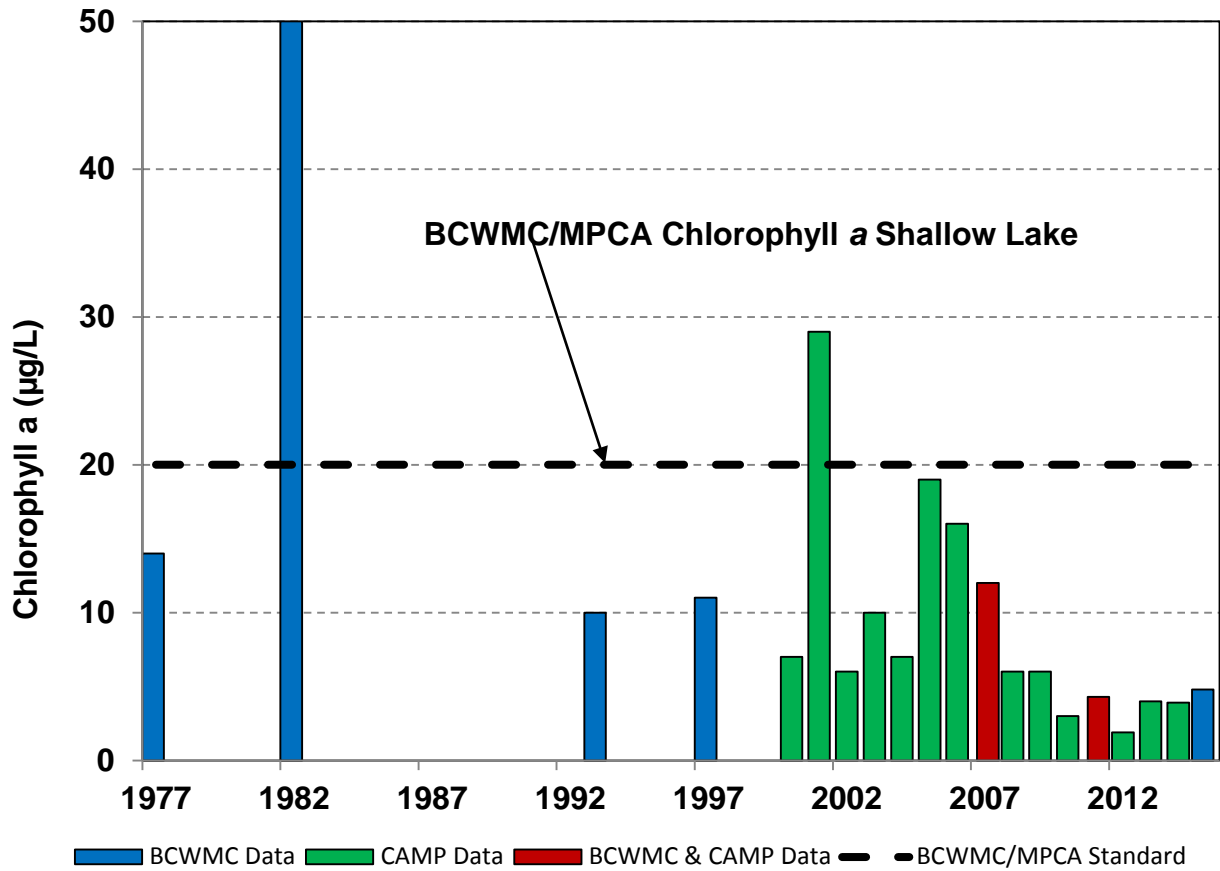


Figure 15 Westwood Lake Historical Chlorophyll a Concentrations Compared with BCWMC/MPCA Chlorophyll a Standard

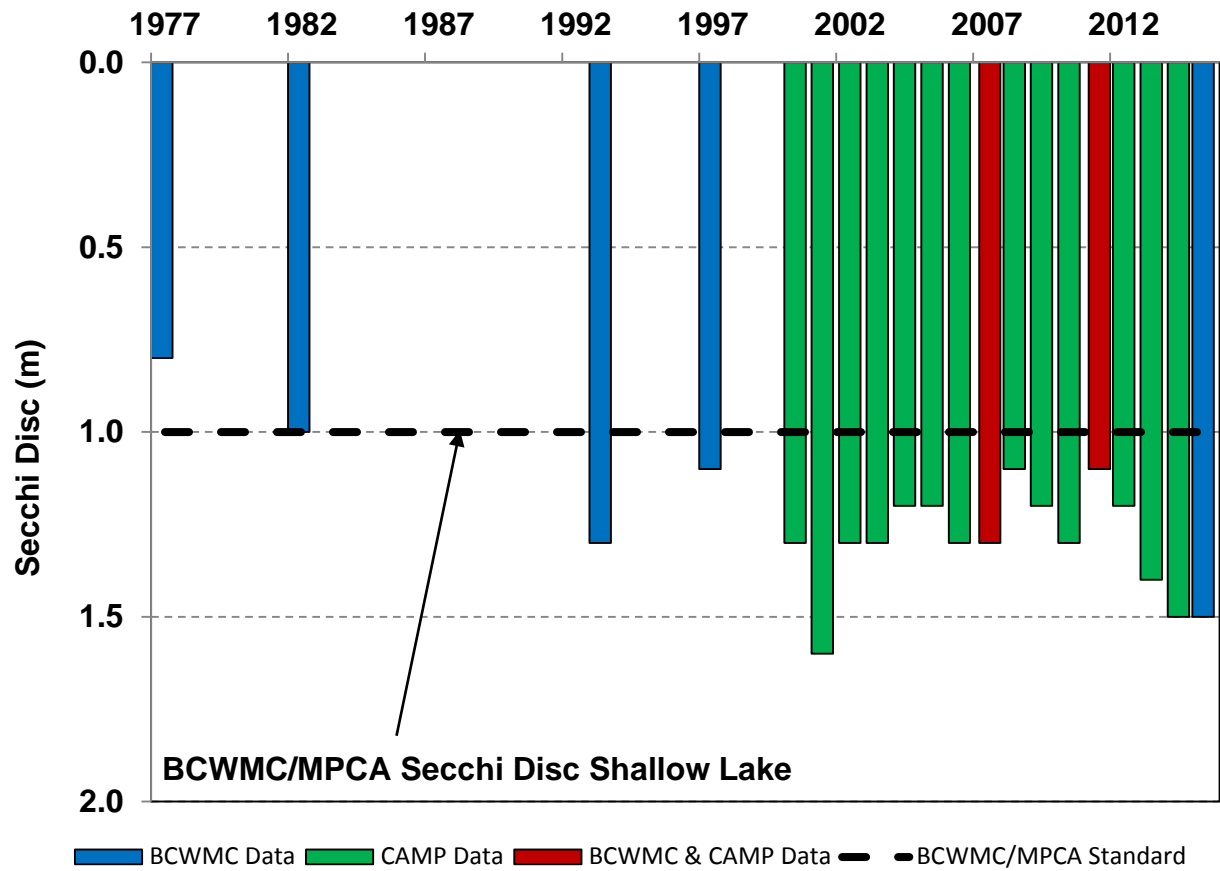


Figure 16 Westwood Lake Historical Secchi Disc Depths Compared with BCWMC/MPCA Secchi Disc Standard

3.6 Biota

Three components of lake biota are presented in this section: macrophytes, phytoplankton, and zooplankton. Fisheries status is managed by the Minnesota Department of Natural Resources and is not addressed in this report.

3.6.1 Macrophytes

Macrophytes are aquatic plants that are large enough to be visible to the naked eye. They are divided into three groups:

- **Submerged**—grow beneath the water surface
- **Floating leaf**—leaves float on the water surface
- **Emergent**—stem and leaves are above the water surface

Plants from all three groups were present in Westwood Lake during 2015. Plant survey statistics are presented in Table 3-3. A comparison of plant survey statistics from 1993 through 2015 is presented in Table 3-4. The 2015 frequency of occurrence of individual species is shown in Figure 17.

Table 3-3 2015 Westwood Lake Aquatic Plant Survey Statistics

Parameters	6/24/2015	8/24/2015
Total number of sites visited	125	125
Total number of sites with vegetation	125	125
Total number of sites shallower than maximum depth of plants	125	125
Frequency of occurrence of plants at sites shallower than maximum depth of plants	100	100
Simpson Diversity Index (0–1, higher number, higher diversity)	0.79	0.77
Maximum depth of plants (ft)	5.0	5.0
Average number of all species per site (shallower than maximum depth of plants)	2.69	2.60
Average number of all species per site (vegetated sites only)	2.69	2.60
Average number of native species per site (shallower than maximum depth of plants)	2.54	2.58
Average number of native species per site (vegetated sites only)	2.54	2.58
Number of species	11	14
Number of species (including visuals)	14	17
Number of species (including visuals and boat survey)	15	17
Average rake fullness (1–4)	2.62	3.23
Mean C (0–10, increasing values, decreased tolerance to disturbance, higher quality)	5.4	5.1
FQI (3–49 observed in Wisconsin, median value in Wisconsin is 22; higher number, more diverse, higher quality)	16.3	17.6

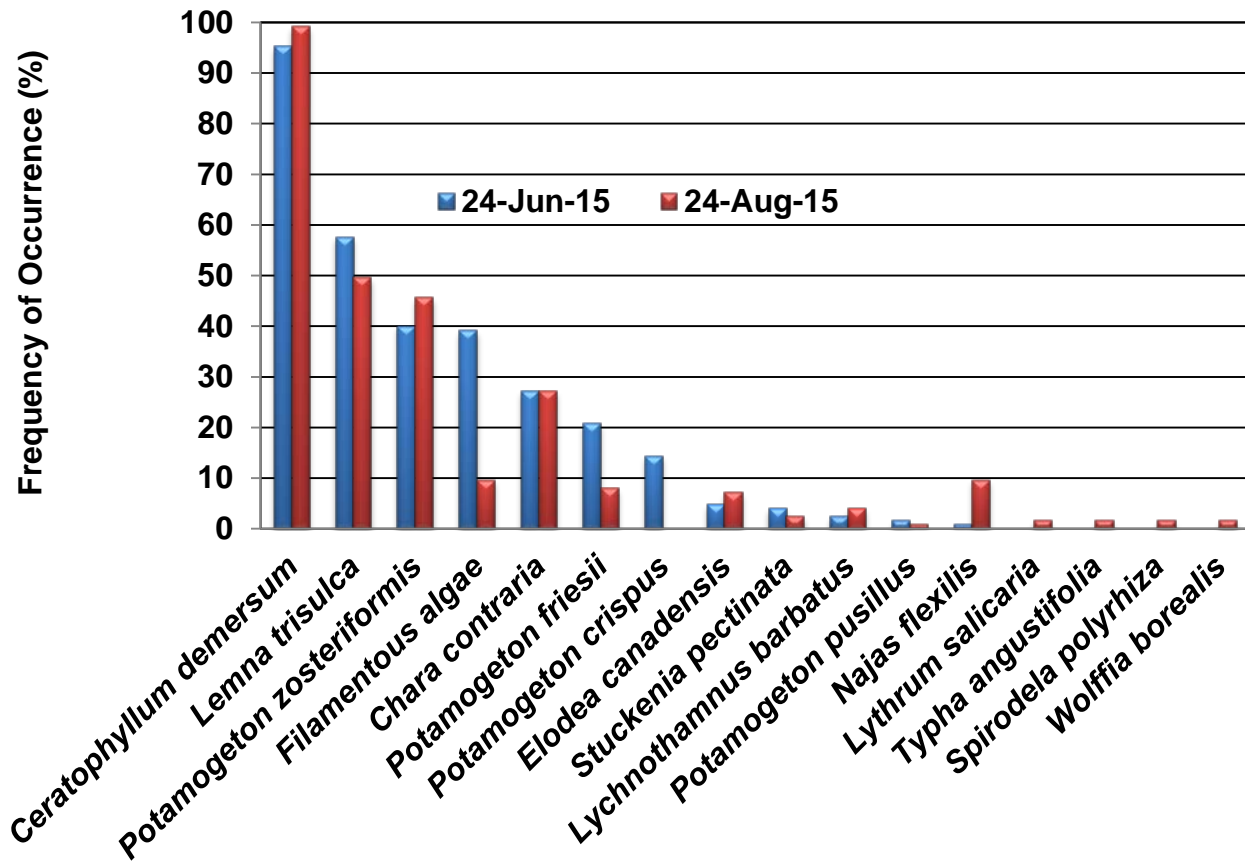


Figure 17 2015 Westwood Lake Frequency of Occurrence of Plant Species: June and August

**Table 3-4 1993–2015 Westwood Lake Aquatic Plant Survey Statistics:
Number of Species, Average C, and FQI**

Year	# of Species: June	# of Species: August	June Average C*	August Average C *	June FQI**	August FQI**
1993	–	10	–	4.2	–	12.7
1997	9	9	4.8	4.3	11.8	11.3
2007	10	7	4.6	3.8	13.1	9.4
2011	8	10	4.3	4.8	11.3	14.3
2015	15	17	4.9	4.7	14.7	16.2

*C indicates the average tolerance to disturbance by the plant community. Values are on a scale of 1 to 10 with increasing values indicating decreasing tolerance to disturbance.

**FQI or floristic quality index indicates the quality of the plant community; increasing values indicate increasing quality. Although Minnesota has not kept a record of FQI values, the median value in Wisconsin is 22.

A healthy and diverse plant community was observed in Westwood Lake in 2015, with vegetation observed throughout the lake. Plant density, measured by the quantity of vegetation collected on the sampling rake, ranged from less than one-third of the rake covered by vegetation (a rake fullness rating of 1) to vegetation completely covering and overtopping the rake head (a rake fullness rating of 4). The lake’s average vegetation density, number of native species per sample location, and number of species increased during the growing season:

- Average density increased from a rake fullness rating of 2.62 in June (from one-third to two-thirds of the rake head covered by vegetation) to a rake fullness rating of 3.23 in August (more than two-thirds of the rake head covered by vegetation, Table 3-3).
- Average number of native plant species per sample location increased from 2.54 in June to 2.58 in August (Table 3-3).
- Number of plant species observed in the lake increased from 15 in June to 17 in August (Table 3-3 and Table 3-4).

The quality of the Westwood Lake plant community was measured by the Floristic Quality Index (FQI), which considers the quality of the individual species found in the lake and the number of species. To compute FQI, each individual plant species in a lake is assigned a number (termed a coefficient of conservatism, or C value), depicting its quality (see Section 2.2). Increases in average C value show a plant community that is less tolerant of degraded conditions (i.e., higher quality). In 2015, the Westwood Lake mean C value was 4.9 in June and 4.7 in August. The mean C was approximately midway in the 0 to 10 range and indicates, on average, plants in Westwood Lake are tolerant of moderate disturbance.

The change from a qualitative survey method to a quantitative (point-intercept) plant survey method in 2015 provided a more detailed analysis of the plant community. The methodology change likely explains why the number of native species increased (from 7–10 in previous years to 15–17 in 2015). Consequently, the quality of the plant community, as measured by FQI, improved accordingly—from scores of 11.3–14.3 in previous years to 14.7–16.2 in 2015 (Table 3-4).

In 2015, *Lychnothamnus barbatus* (bearded stonewort), a good plant, was observed in Westwood Lake (and Minnesota) for the first time. This species was not seen in North America until 2012 and few populations have been documented in the world. Paul Skawinski of the University of Wisconsin—Extension Lakes Program first found this species in Wisconsin. In Wisconsin, which now has 14 known populations of *Lychnothamnus barbatus*, the plant has been found in seepage lakes and impoundments from a few inches to about 6 meters deep. It occurs sparsely in some lakes and is dominant in others. Some of these lakes have public access and some do not. Thus, its habitat appears to be highly variable. Several of the lakes are man-made, so there is evidence that *Lychnothamnus barbatus* is moving. We do not know whether this movement is via humans, animals, or other mechanisms (Skawinski 2015).



Lychnothamnus barbatus, pictured above and below, is a plant species observed for the first time in Westwood Lake and Minnesota in 2015.

Lychnothamnus barbatus is in the family Characeae, an algae that resembles rooted aquatic plants. *Lychnothamnus barbatus* was found in 4 to 5 feet of water in Westwood Lake, either growing with *Chara contraria* (fetid stonewort) or monotypically (i.e., only species). As shown in Figures 18 and 19, its frequency of occurrence during 2015 was 2.4 percent in June and 4.0 percent in August. Plant samples were sent to the New York Botanical Garden for DNA testing to determine whether the plants in Westwood Lake are genetically similar to the Wisconsin populations and/or other known populations in the world. The results of the genetic testing are not yet available.



Three of the species present in Westwood Lake in 2015—bearded stonewort (*Lychnothamnus barbatus*) fetid stonewort (*Chara contraria*), and coontail (*Ceratophyllum demersum*)—are strong nutrient absorbers. Coontail was found at 95 to 99 percent of sample locations, fetid stonewort at 27 percent of sample locations, and bearded stonewort at 2 to 4 percent of sample locations (Figure 18 and Figure 19). The presence of these species was favorable for the water quality of the lake. The absorption of nutrients by the plants likely reduced the concentrations of nutrients in the water column, subsequently improving water quality.

Only two non-native species were present in Westwood Lake: purple loosestrife (*Lythrum salicaria*) and curly-leaf pondweed (*Potamogeton crispus*).

Sporadic growths of purple loosestrife were found along the north edge of the lake in June (Figure 20) and along the north and west edges of the lake in August (Figure 21). Purple loosestrife is undesirable because it displaces native species and provides a poorer quality habitat. *Galerucella* beetles were found on the plants and causing heavy damage. Because the beetles appear to be managing the plants, no further management is presently needed.

Although the undesirable curly-leaf pondweed (*Potamogeton crispus*) was present throughout Westwood Lake in June of 2015, it was a minor part of the overall plant community (Figure 22) and not problematic. This species dies off in late June or early July and begins a new growing season in August or September. Curly-leaf pondweed was found at only one Westwood Lake location in August of 2015 (Figure 23). Because it has been present intermittently since 1997 and has not been problematic, management is not necessary at this time.









Purple loosestrife, pictured above, was present in Westwood Lake, but *Galerucella* beetles were doing heavy damage to the plants.



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Rake Fullness Rating

-  Visual
-  1
-  2
-  3
-  4
-  None Found

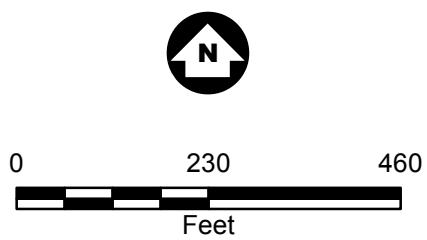
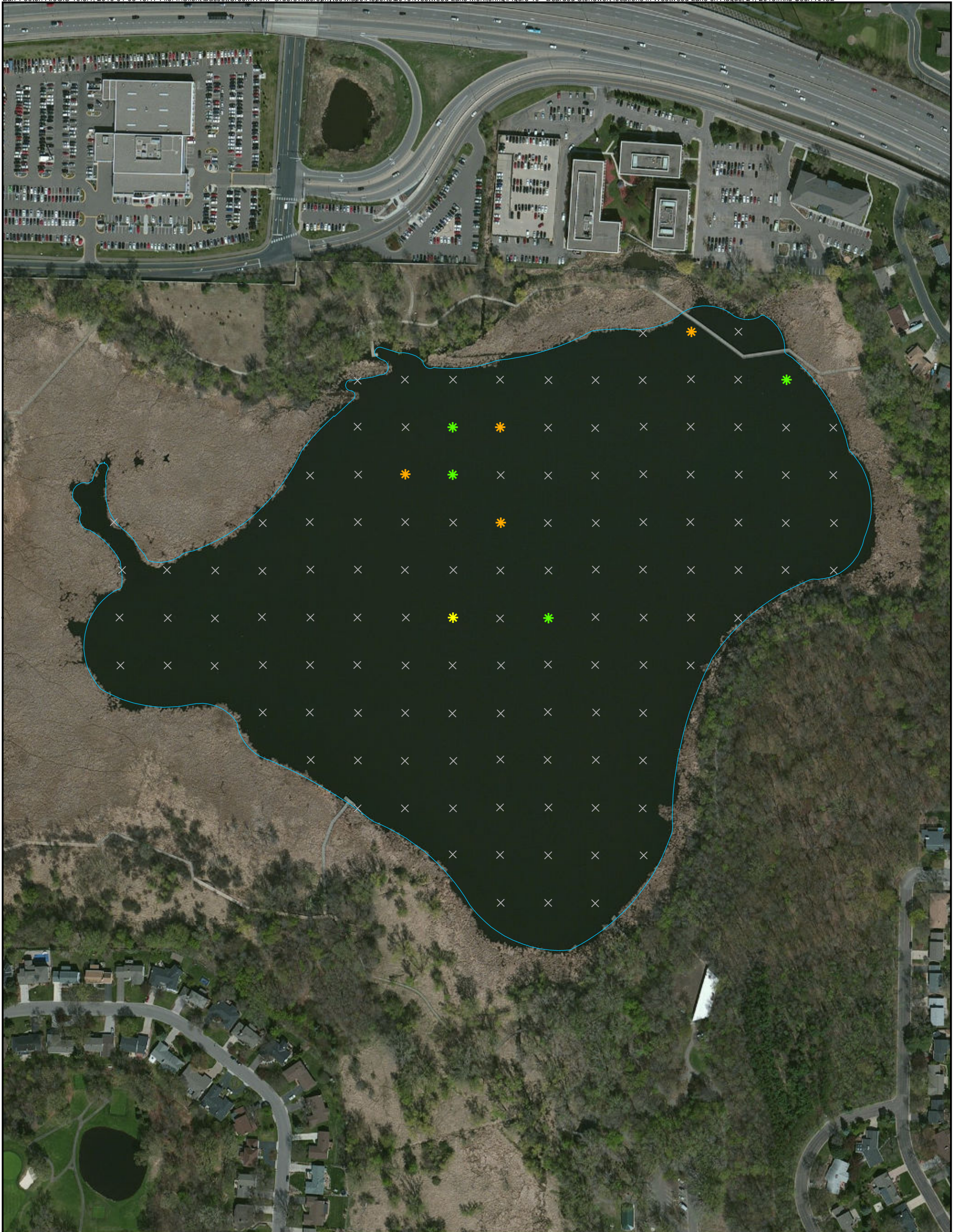








Figure 18

Bearded Stonewort Locations
in Westwood Lake on
June 24, 2015



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Rake Fullness Rating

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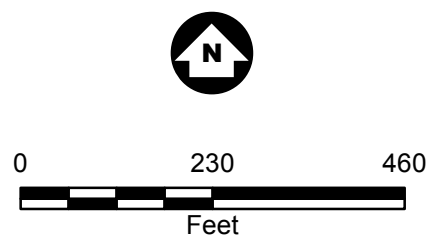








Figure 19
Bearded Stonewort Locations
in Westwood Lake on
August 24, 2015



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Rake Fullness Rating

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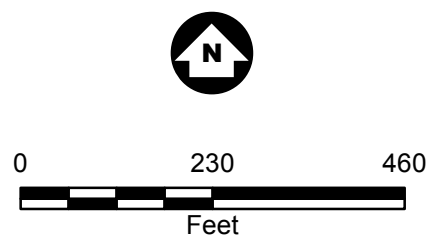








Figure 20
Purple Loosestrife Locations
in Westwood Lake on
June 24, 2015



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Rake Fullness Rating

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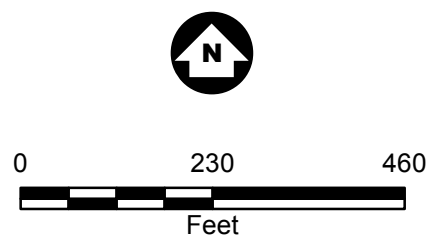
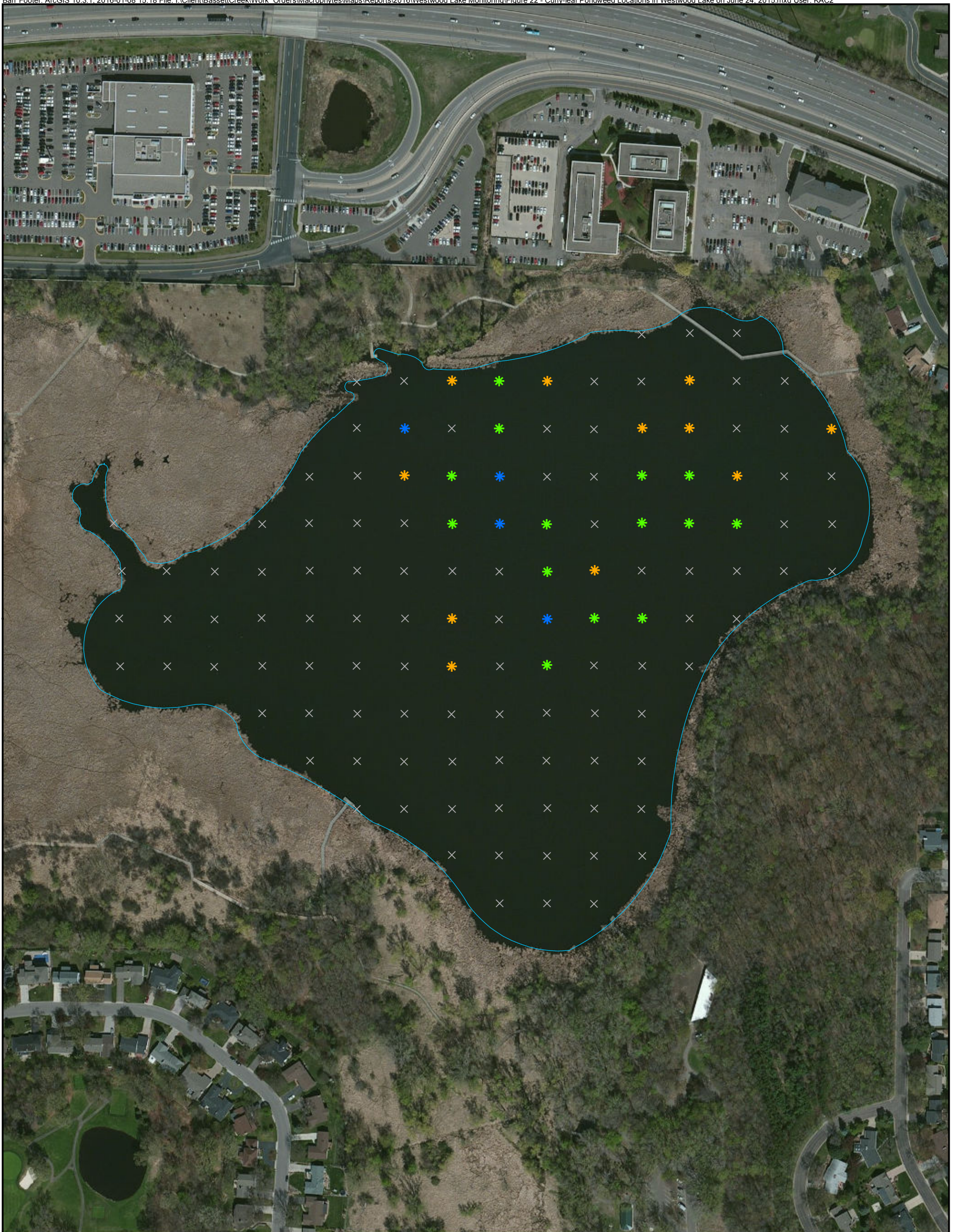








Figure 21
Purple Loosestrife Locations
in Westwood Lake on
August 24, 2015



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Rake Fullness Rating

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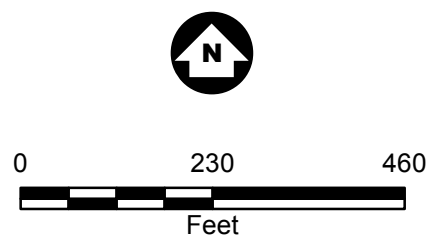








Figure 22
Curly-leaf Pondweed Locations
in Westwood Lake on
June 24, 2015



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Rake Fullness Rating

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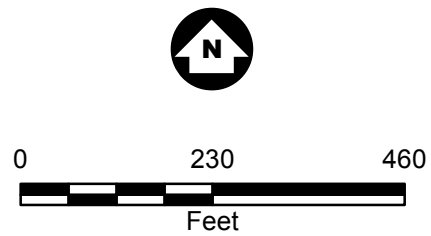


Figure 23
Curly-leaf Pondweed Locations
in Westwood Lake on
August 24, 2015

3.6.2 Phytoplankton

Algae are microscopic plants that convert sunlight and nutrients into biomass. They can live on the bottom sediments and substrates (filamentous algae), on plants and leaves (periphyton), or in the water column (phytoplankton).

Phytoplankton samples have been collected periodically from Westwood Lake since 1993 to evaluate water quality and determine the quality of food available to the lake's small animals (zooplankton). Algae have short life cycles. As a result, changes in water quality are often reflected by changes in the algal community within a few days or weeks. The types of algae in a lake vary over the course of a year. Typically, there are fewer algae in winter and spring because of ice cover and cold temperatures. As a lake warms up and sunlight increases, algae communities begin to increase. Their short life span quickly cycles the nutrients in a lake and affects nutrient dynamics.

There are seven divisions of algae found in typical lakes of Minnesota (Table 3-5); all seven have been observed in Westwood Lake during the period of record (Figure 24 and Figure 25).

Table 3-5 Characteristics of Algae Observed in Westwood Lake from 1993 through 2015 (Shaw et al. 2004, Brown 2002, Guedes et al. 2012)

Algal Division	Common Name	Characteristics
Chlorophyta	Green algae	<ul style="list-style-type: none"> • Provide high nutritional value to consumers • Can be single-celled, colonial, or filamentous • Filamentous often intermingle with macrophytes
Bacillariophyta	Diatoms	<ul style="list-style-type: none"> • Provide high nutritional value to consumers • Sensitive to chloride, pH, color, and total phosphorus in water • As total phosphorus increases, diatoms decrease • Generally larger in size; tend to be abundant in spring
Cryptophyta	Cryptomonads	<ul style="list-style-type: none"> • Provide high nutritional value to consumers • Bloom-forming and used to feed small zooplankton
Cyanophyta	Blue-green algae	<ul style="list-style-type: none"> • Provide low nutritional value to consumers • Prevail in nutrient-rich standing waters • Blooms can be toxic to zooplankton, fish, livestock, pets, and humans • Can be unicellular, colonial, planktonic, or filamentous • Can live on almost any substrate; more prevalent in late- to mid-summer • Colonies and filaments often too large to be ingested by zooplankton
Pyrrophyta	Dinoflagellates	<ul style="list-style-type: none"> • Have starch reserves and serve as food for grazers.
Chrysophyta	Golden-brown algae	<ul style="list-style-type: none"> • A genus of single-celled algae with ovoid cells and a distinctive golden color
Euglenophyta	Euglenoids	<ul style="list-style-type: none"> • Commonly found in freshwater that is rich in organic materials; most are unicellular

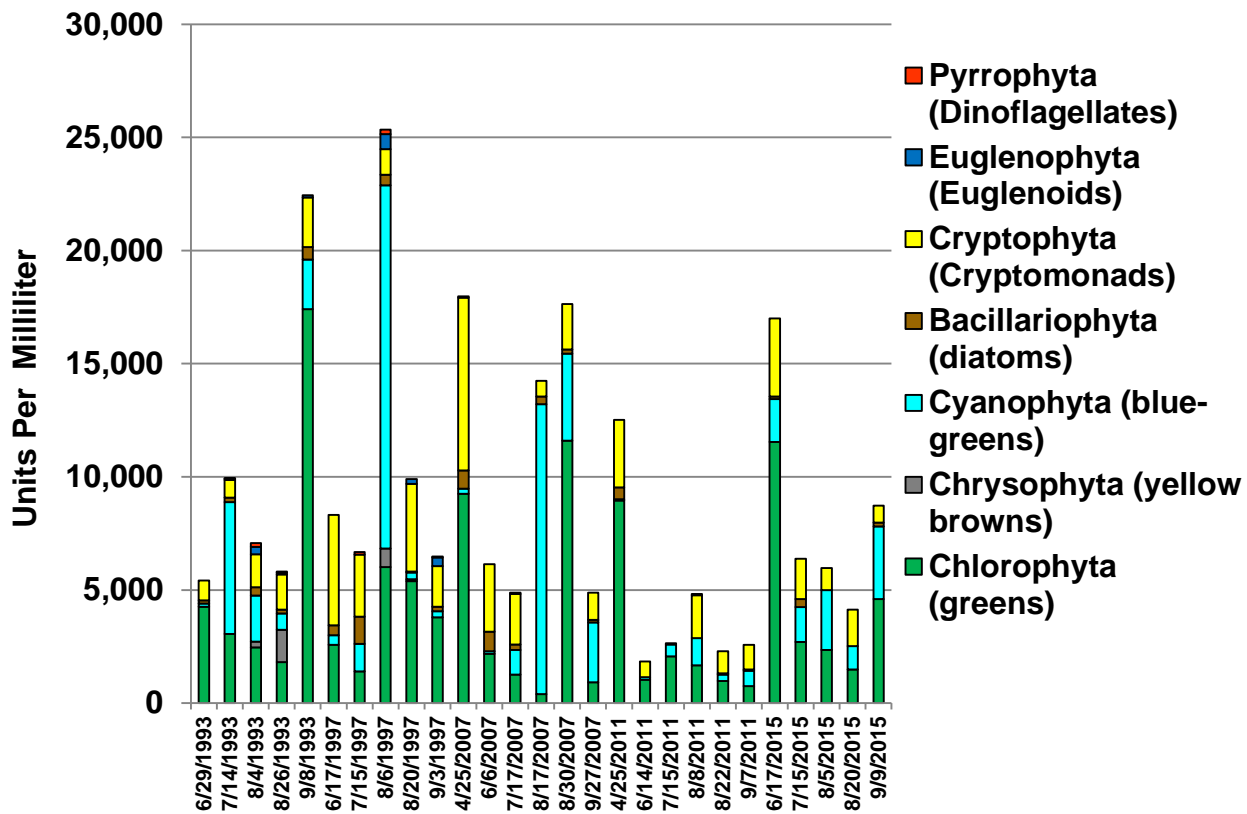


Figure 24 1993–2015 Westwood Lake Phytoplankton Data Summary

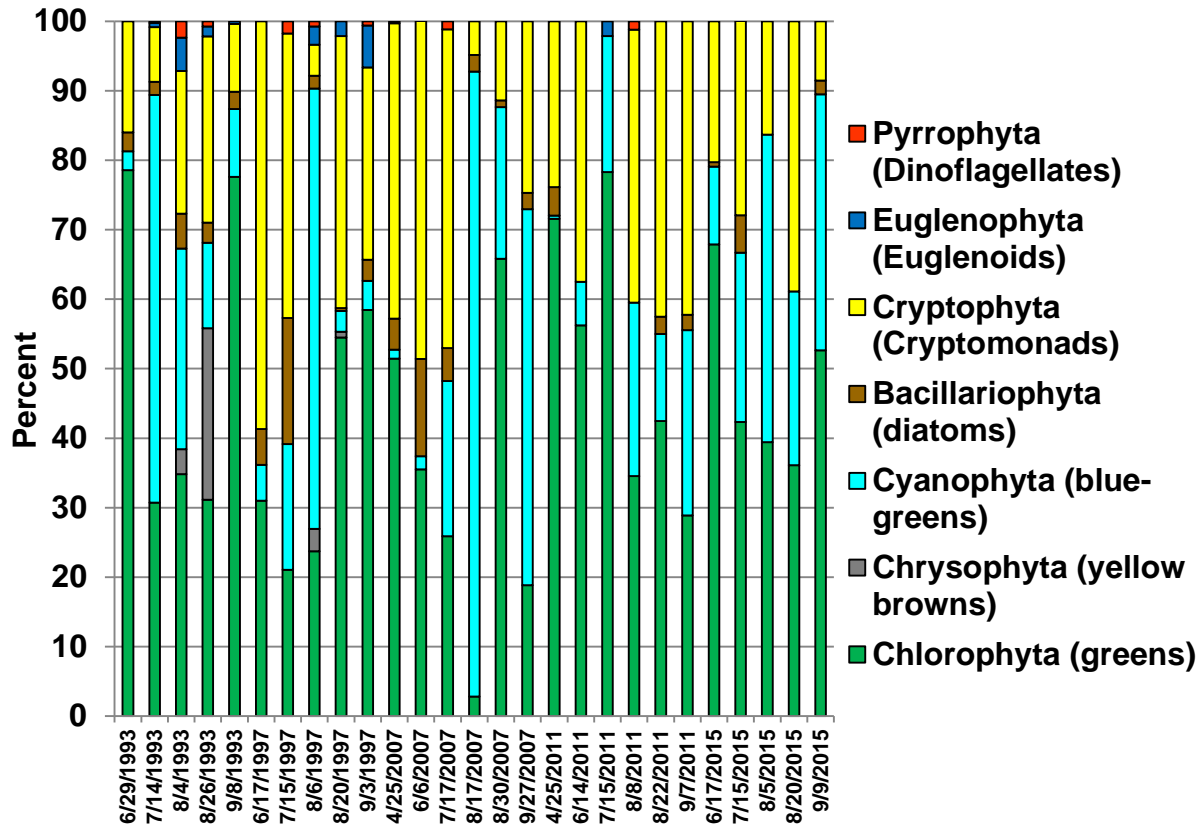


Figure 25 1993–2015 Westwood Lake Phytoplankton Composition by Division

In 2015, phytoplankton numbers followed a pattern similar to chlorophyll *a*, both indicating good lake water quality. Phytoplankton numbers declined from June through August and then increased in September (Figure 24).

In 2015, the Westwood Lake phytoplankton community composition was consistent with previous years (Figure 25) and the numbers of phytoplankton were within the range observed during the period of record (Figure 24). As in previous years, the phytoplankton community was generally dominated by green algae, cryptomonads, and blue-green algae. Green algae and cryptomonads are very desirable food items for zooplankton; blue-green algae is undesirable (Figure 24 and Figure 25).

3.6.3 Zooplankton

Zooplankton are small aquatic animals that feed on algae and are eaten by fish. They are divided into three main groups: rotifers, copepods, and cladocerans.

- **Rotifers** eat algae, other zooplankton, and sometimes each other. Due to their small size, rotifers are not capable of significantly reducing algal biomass, although they are able to shift the algae community to favor larger species (Shaw et al. 2004).
- **Copepods** feed on algae and other plankton. They are eaten by larger plankton and are preyed heavily upon by pan fish, minnows, and the fry of larger fish (Shaw et al. 2004).
- **Cladocerans** are filter feeders that play an important part in the food web. Species of cladocerans (particularly *Daphnia*) are well known for their ability to reduce algal biomass and help maintain clear water in lake ecosystems (Shaw et al. 2004).

Zooplankton avoid predation by taking refuge within the aquatic plant community (Shaw et al. 2004). Hence, the Westwood Lake plant community provides a refuge for the lake's zooplankton.

In 2015, the composition of the zooplankton community in Westwood Lake was consistent with previous years and the numbers of zooplankton were within the range observed during the period of record. All three groups of zooplankton have consistently been represented in Westwood Lake during the period of record; however, small rotifers and copepods have generally dominated the community (Figure 26). The rotifers graze primarily on extremely small particles of plant matter and do not significantly affect the lake's water quality. The copepods also have limited impact on the lake's water quality and are less effective predators than cladocerans. The presence of larger numbers of rotifers and copepods relative to cladocerans is an indication of fish predation. Cladocerans are more easily seen and more desirable as food than small-bodied groups of zooplankton. They are also slow swimmers and easily preyed upon by fish, which "sight feed," selecting and depleting the number of large-bodied zooplankters in the water body.

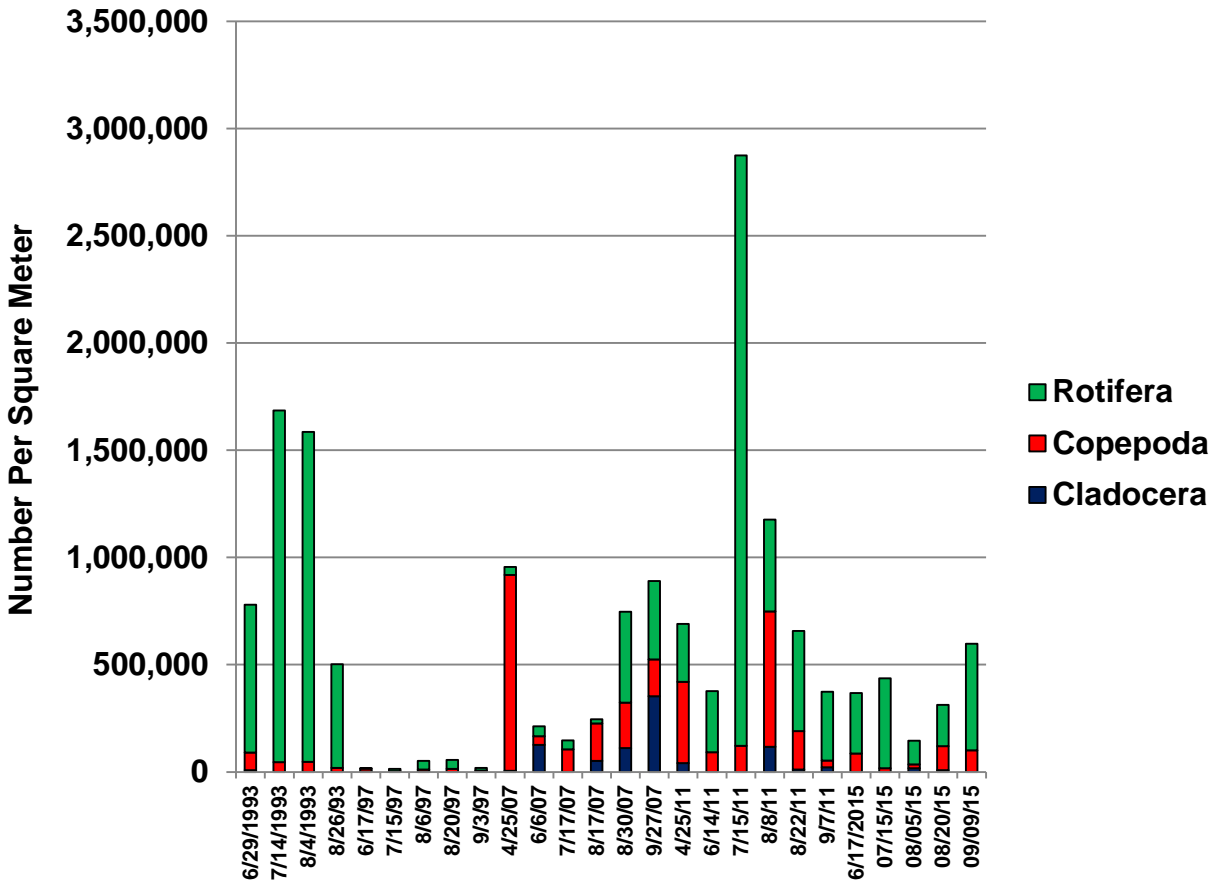


Figure 26 1993–2015 Westwood Lake Zooplankton Data Summary by Division

4.0 Conclusions and Recommendations

4.1 Conclusions

The following conclusions summarize the 2015 study of Westwood Lake:

- Summer average total phosphorus and chlorophyll *a* concentrations and Secchi disc transparency met the BCWMC/MPCA standards.
- Trend analyses indicate reductions in summer average total phosphorus and chlorophyll *a* concentrations were statistically significant over the past 10 years. Though Secchi disc transparency depths have increased over this same period of time, the increases are not statistically significant. However, during 2015, the Secchi disc was visible to the lake bottom during all sampling events—meaning that transparency cannot be further improved. Overall, the lake’s water quality has significantly improved over the past 10 years.
- From 1977 through 2015, 80 percent of the summer averages for total phosphorus and 95 percent for chlorophyll *a* and Secchi disc transparency met the BCWMC/MPCA standards. During the past 9 years, summer averages for these parameters have all met the BCWMC/MPCA standards.
- Specific conductance in Westwood Lake has remained relatively stable over time, ranging from about 400 to 500 $\mu\text{mhos/cm}$ @ 25°C during 2011 and 2015, well below the MPCA standard of 1,000 $\mu\text{mhos/cm}$ @ 25°C. Although chlorides have not been measured in Westwood Lake, chloride concentrations can be estimated by using a relationship between specific conductance and chlorides documented for Nine Mile Creek. Using that relationship, the estimated chloride concentrations in Westwood Lake during 2011 and 2015 ranged from about 40 to 50 mg/L, well below the MPCA chronic standard of 230 mg/L.
- The 2015 phytoplankton and zooplankton community compositions were consistent with previous years and the numbers of phytoplankton and zooplankton were within the range observed during the period of record.
- The change from a qualitative to a quantitative (point-intercept plant) survey method in 2015 provided a more detailed analysis of the plant community. The methodology change likely explains the increase in native species (from 7–10 in previous years to 15–17 in 2015). The quality of the plant community, as measured by floristic quality index (FQI), improved accordingly (from 11.3–14.3 in previous years to 14.7–16.2 in 2015).
- In 2015, *Lychnothamnus barbaratus* (bearded stonewort) was observed in Westwood Lake and Minnesota for the first time. Plant samples were sent to the New York Botanical Garden for DNA testing to determine whether the plants in Westwood Lake are genetically similar to the Wisconsin populations and/or other known populations in the world. The results of the genetic testing are not, yet, available.

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- Three of the species present in Westwood Lake in 2015, bearded stonewort (*Lychnothamnus barbatus*) fetid stonewort (*Chara contraria.*), and coontail (*Ceratophyllum demersum*), are strong nutrient absorbers. The absorption of nutrients by the plants likely reduced the concentrations of nutrients in the water column, subsequently improving water quality.
 - Only two non-native species were present in Westwood Lake: purple loosestrife (*Lythrum salicaria*) and curly-leaf pondweed (*Potamogeton crispus*). These plants are not problematic and do not require management at this time. In 2015, *Galerucella* beetles were present, causing heavy damage to the purple loosestrife plants and managing the infestation. Curly-leaf pondweed has been present in the lake since 1997, but has never been problematic.

4.2 Recommendations

Because current watershed management practices are adequately protecting Westwood Lake water quality from degradation and have improved lake water quality over time, the recommendation is to make no changes.

Continuation of the current water quality and biological monitoring program at a three year frequency (consistent with the monitoring recommendations in the BCWMC 2015-2025 Watershed Management Plan) is recommended to periodically assess the condition of the lake's water quality and biological community. The assessment will determine whether the lake is stable or is changing over time. If changes are detected, the assessment will determine whether the changes are favorable or unfavorable for the lake.

Addition of chloride monitoring to future programs is recommended to verify that the lake is currently meeting MPCA chloride standards and to determine impacts of deicing practices within the lake's watershed on lake water quality over time.

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