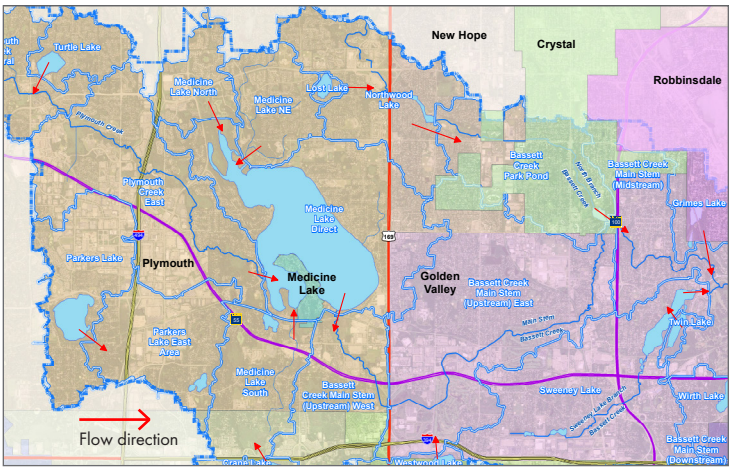
Medicine Lake 2016 water quality monitoring

Item 6B.
BCWMC 2-16-17



About Medicine Lake

BCWMC classification	Priority-1 deep lake
Watershed area	11,014 acres
Lake size	902 acres
Average depth	17.5 feet
Maximum depth	49 feet
Ordinary high water level	889.1 feet
Normal water level	887.7 feet
Downstream receiving waterbody	Bassett Creek
Location (city)	Medicine Lake, Plymouth
MPCA impairments	Mercury in fish tissue, nutrients
Aquatic invasive species	Eurasian watermilfoil, curly-leaf pondweed
Public access	Yes (boat launch)

Monitoring water quality in Medicine Lake

The Bassett Creek Watershed Management Commission (BCWMC) has monitored water quality conditions in the watershed's 10 priority lakes and six ponds since 1972. This monitoring is done to detect changes or trends in water quality and evaluate the effectiveness of efforts to preserve or improve water quality. A summary of 2016 monitoring efforts on Medicine Lake is provided below; more comprehensive information can be found on pages 2–7.

At a glance: 2016 monitoring results

In 2016, the BCWMC monitored Medicine Lake for:

- Water chemistry (nutrients, chlorophyll *a*, chloride)
- Water measurements (e.g., clarity, dissolved oxygen)
- Phytoplankton and zooplankton (microscopic aquatic plants and animals)
- Macrophytes (aquatic plants)

Results indicate that Medicine Lake does not meet applicable Minnesota Pollution Control Agency (MPCA) and BCWMC water quality standards for lakes. Trend analyses indicate chlorophyll *a* concentrations have increased significantly over the past 20 years.

Recommendations

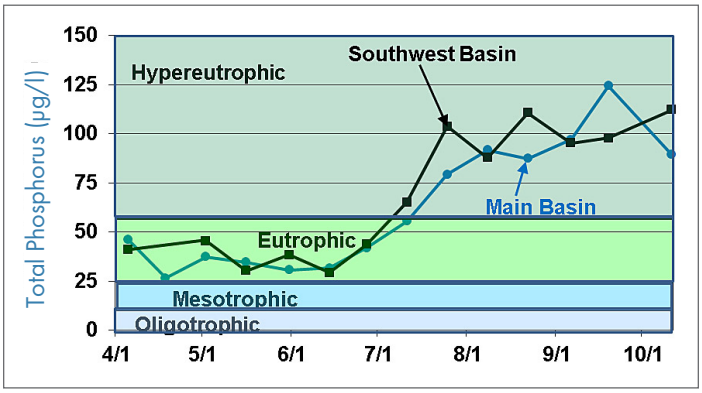
- Implement management measures to reduce the internal phosphorus load from sediment (about one-third of the lake's annual phosphorus load). Alum treatment would reduce internal phosphorus load from sediment and improve water quality.
- Continue water quality and biological monitoring.

Water chemistry monitoring: 2016

Total phosphorus levels

While phosphorus is necessary for plant and algae growth, excessive levels lead to excessive growth, decreased water clarity, and water quality impairment.

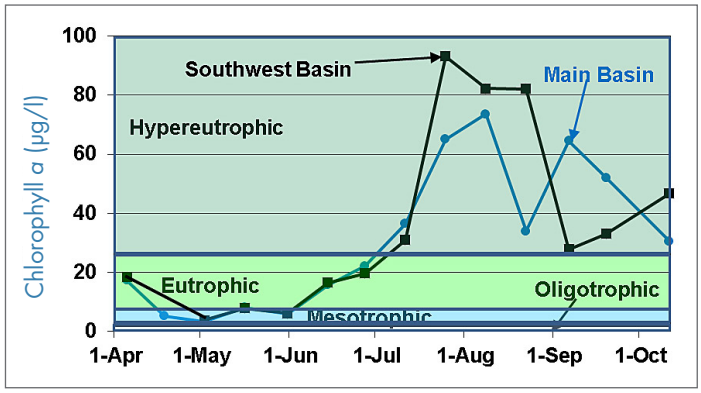
- BCWMC/MPCA standard: 40 micrograms per liter (µg/L) or less.
- Range: Total phosphorus concentrations for Medicine Lake were in the eutrophic category from April to mid-June and increased through September. The low was 27 µg/L in April, and the high was 124 µg/L in September.
- Summer average: 76 µg/L in the Main Basin and 79 µg/L in the Southwest Basin; did not meet BCWMC/MPCA standard.



Chlorophyll *a* levels

Chlorophyll *a* is a pigment in algae and generally reflects the amount of algae growth in a lake. Lakes which appear clear generally have chlorophyll *a* levels less than 15 µg/L.

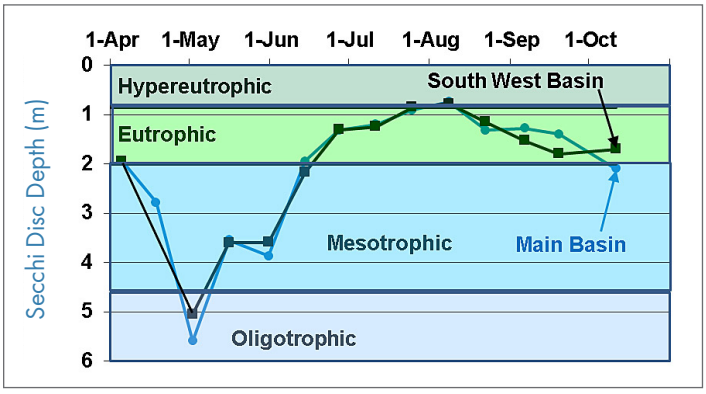
- BCWMC/MPCA standard: 14 micrograms per liter (µg/L) or less.
- Range: Chlorophyll *a* concentrations ranged from a low of 3 µg/L in May to a high of 93 µg/L in July. From July through October, concentrations were in the hypereutrophic range.
- Summer average: 46 µg/L in the Main Basin and 48 µg/L in the Southwest Basin; did not meet BCWMC/MPCA standard.



Water clarity

Water clarity is often affected by the abundance of algae or other photosynthetic organisms in a lake. It is usually measured by lowering an 8-inch "Secchi" disc into the lake; the depth at which the disc's alternating black-and-white pattern is no longer visible is considered a measure of the water's transparency.

- BCWMC/MPCA standard: 1.4 meters or more.
- Range: Secchi disc depth declined from 5.6 meters in early May to 0.7 meters in early August.
- Summer average: 1.4 meters in the Southwest Basin (met BCWMC/MPCA standard) and 1.3 meters in the Main Basin (did not meet standard).



Definitions

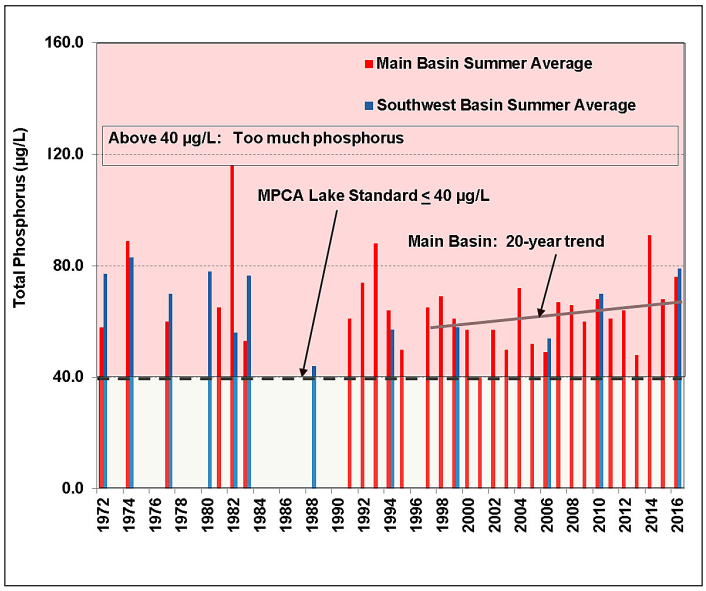
- ***Eutrophic:*** Lake condition characterized by abundant accumulation of nutrients supporting dense growth of algae and other organisms; decay of algae can reduce lake oxygen levels
- ***Hypereutrophic:*** Nutrient-rich lake conditions characterized by frequent and severe algal blooms and low transparency
- ***Mesotrophic:*** Lake condition characterized by medium levels of nutrients and clear water
- ***Oligotrophic:*** Lake condition characterized by a low level of dissolved nutrients, high oxygen content, and sparse algae growth

Water chemistry monitoring from 1972–2016: historical trends

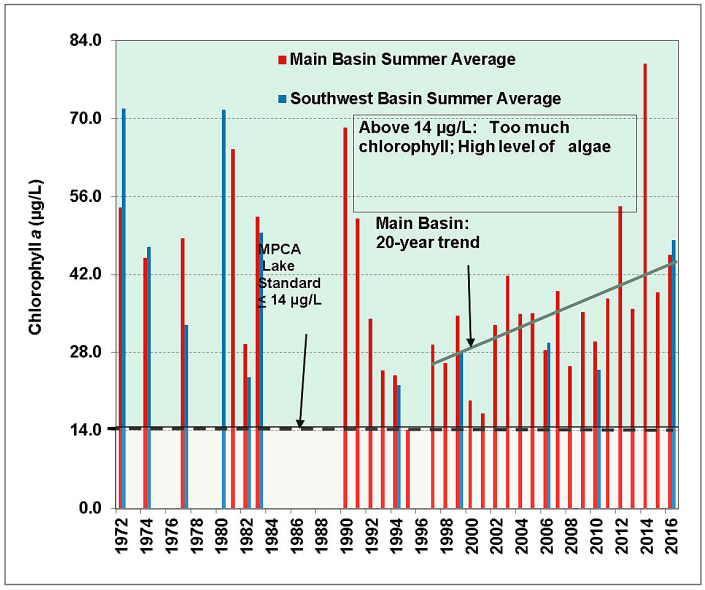
Water quality in Medicine Lake has been monitored since 1972. Summer averages (June through September) of total phosphorus, chlorophyll *a*, and Secchi disc transparency for the Main Basin and Southwest Basin from 1972–2016 are shown in the figures to the right. Summer averages for total phosphorus and chlorophyll *a* have not met the BCWMC/MPCA standard throughout this period. However, Secchi disc summer averages have met the BCWMC/MPCA standard 66 percent of the time in the Main Basin and 73 percent of the time in the Southwest Basin.

Trend analyses of the Main Basin show statistically significant (95 percent confidence level) increases in chlorophyll *a* concentrations during the past 20 years. These increases correspond with significant increases in algal levels. Summer average total phosphorus concentrations and Secchi disc depths have also increased during the past 20 years, but these increases are not statistically significant.

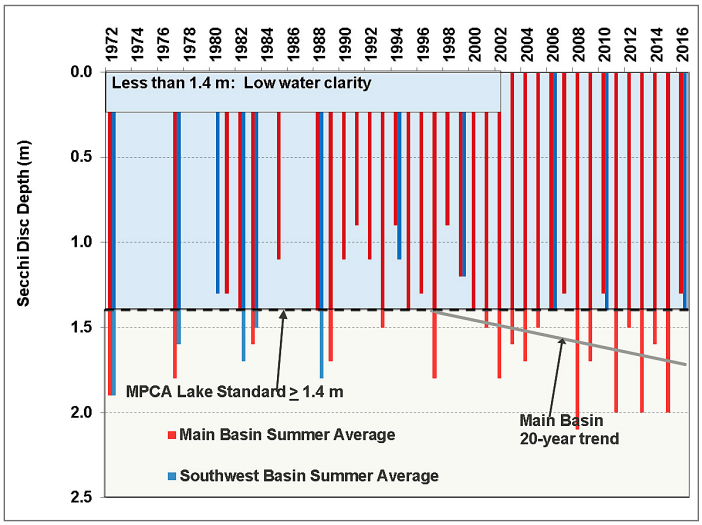
Total phosphorus trends

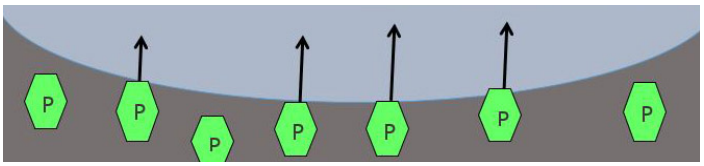


Chlorophyll *a* trends



Water clarity trends





Phosphorus loading from sediment (2016)

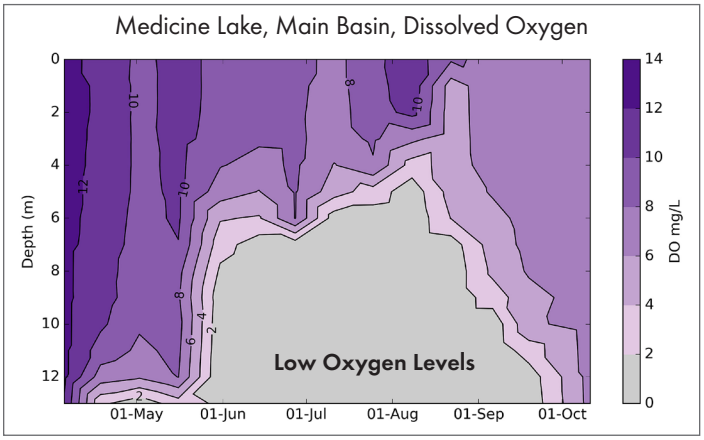
The release of phosphorus stored in lake-bottom sediments when oxygen levels are low is described as "internal phosphorus loading from sediment." The Medicine Lake total maximum daily load (TMDL) study (LimnoTech 2010) found internal phosphorus loading from sediment to be a significant source of lake phosphorus—about one-third of the lake's total annual phosphorus load. According to the study, phosphorus from Medicine Lake's sediment is conveyed to the surface either by diffusion or wind mixing. Wind-mixing events completely mix the water column several times each year, typically in July, August, and September.

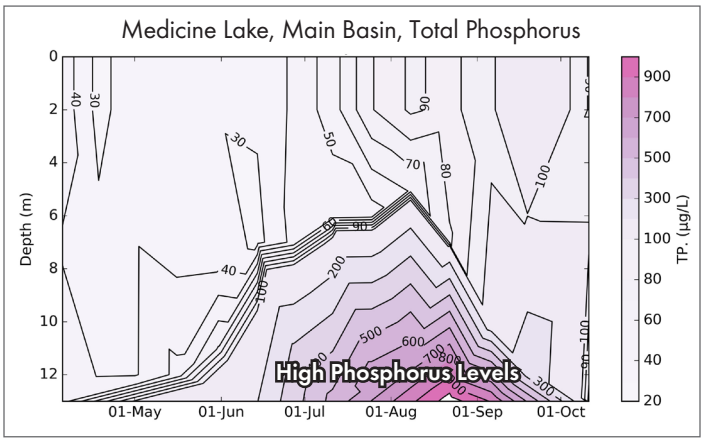
The 2016 data are consistent with the TMDL findings. Near-bottom oxygen levels in Medicine Lake were low in both the Main and Southwest Basins from June through September. Internal phosphorus loading from sediment during this period caused near-bottom phosphorus concentrations to increase consistently; this was correlated with increasing phosphorus concentrations in surface water. Temperature and dissolved oxygen data indicate that wind-mixing events occurred in late June, August, and September of 2016, resulting in increased surface water phosphorus concentrations.

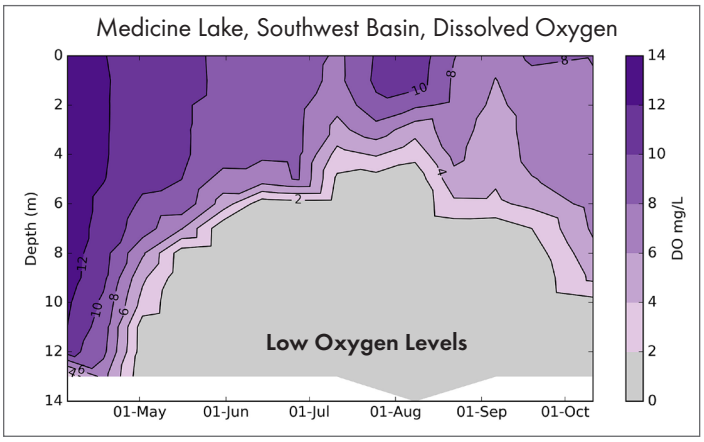
Chloride levels in 2016

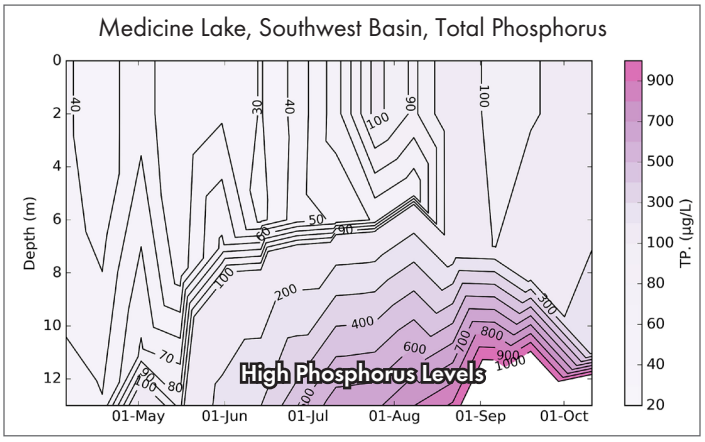
Chloride present in deicing chemicals applied to streets and parking lots in the Medicine Lake watershed is conveyed to the lake by snowmelt and rainfall runoff. Excessive chloride concentrations have been linked to decreased biodiversity in water bodies.

- **MPCA chronic exposure standard:** 230 mg/l or less.
- **Range:** Concentrations in the Main Basin ranged from 116 mg/L to 148 mg/L; concentrations in the Southwest Basin ranged from 108 mg/L to 150 mg/L.
- **Average:** 140 mg/L in the Main Basin, 148 mg/L in the Southwest Basin; both met MPCA standards.







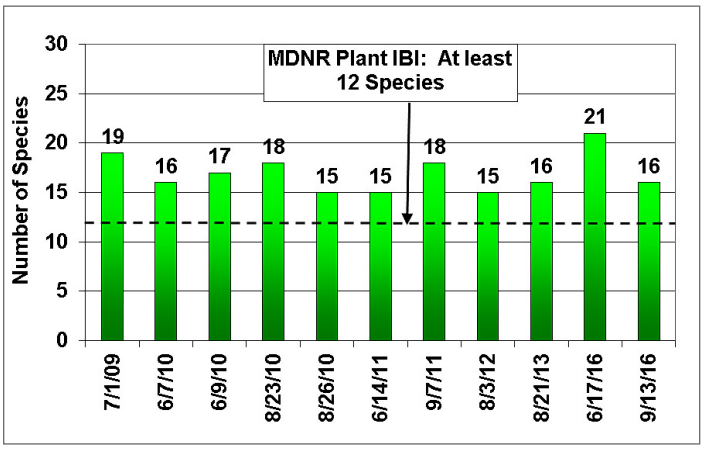


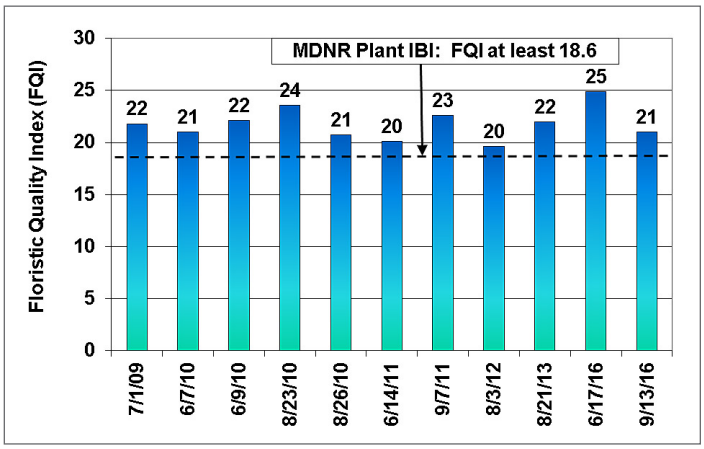
Macrophytes (aquatic plants)

Lake Plant Eutrophication Index of Biological Integrity (IBI)

The Minnesota Department of Natural Resources (MDNR) recently developed metrics to determine the overall health of a lake's aquatic plant community. The *Lake Plant Eutrophication Index of Biological Integrity (IBI)* is used by the MPCA to determine whether a lake is meeting the federal Clean Water Act standards intended to protect aquatic life. The plant IBI includes two metrics: (1) the number of species in a lake and (2) the "quality" of the species, as measured by the floristic quality index (FQI).

Medicine Lake plant survey data from 2009 through 2016 were assessed to determine plant IBI. The figures below show the number of species and FQI for that period compared to the MDNR plant IBI impairment threshold. During the period examined, the number of species in Medicine Lake has ranged from 15 to 21, exceeding the impairment threshold of at least 12 species. FQI values ranged from 20 to 25, which also exceeds the impairment threshold (18.6 minimum). This means that Medicine Lake is not considered impaired in terms of its ability to support aquatic plant life.





Aquatic invasive species

In 2016, two aquatic invasive species were known to be present in Medicine Lake:

- Eurasian watermilfoil (*Myriophyllum spicatum*)
- Curly-leaf pondweed (*Potamogeton crispus*)

Eurasian watermilfoil was not problematic in 2016, ranging in frequency from 10 to 14 percent of the lake's vegetation. From 2004 through 2012, Eurasian watermilfoil frequency has ranged from 3 to 70 percent.

Curly-leaf pondweed has been a consistent problem in Medicine Lake; from 2004 through 2012 it has comprised between 15 and 87 percent of the lake's vegetation. With the exception of 2007, the herbicide endothall has been used to control the plant each year since 2004. The 2010 TMDL implementation plan for Medicine Lake specified that curly-leaf pondweed should continue to be managed annually to prevent it from exceeding 2006 levels (22 percent).

In 2016, 37 acres of curly-leaf pondweed were treated with herbicide; in June, the plant's frequency was 22 percent, near the low end of the historical range and equal to the TMDL threshold. Because die-off of curly-leaf pondweed is an internal source of nutrients for Medicine Lake, control of the plant helps reduce the lake's internal phosphorus loading.


Eurasian watermilfoil


Curly-leaf pondweed

Microscopic plants and animals

Phytoplankton in 2016

Samples of phytoplankton, microscopic aquatic plants, were collected from Medicine Lake in 2016 to evaluate water quality, determine the quality of food available to the lake's zooplankton (microscopic animals), and estimate the public health risk posed by blue-green algae, which produce toxins.

Phytoplankton numbers followed a pattern similar to chlorophyll *a*, increasing from June through early August and decreasing in late August and September. As shown in the figures on page 7, green algae, a good food source for the lake's zooplankton, dominated the spring community while blue-green algae, a poor food source for zooplankton, were dominant during the summer.

Medicine Lake is subject to significant "internal phosphorus loading" during the summer, meaning that phosphorus from the lake's sediment is released to the surface water. This increase in phosphorus encourages phytoplankton growth, particularly blue-green algae.

Blue-green algae can produce natural toxins; in high concentrations, these toxins can be harmful to pet and human health. The World Health Organization (WHO) has established the following guidelines for assessing the risk posed to lake users by exposure to blue-green algae.

- Lakes with blue-green algae densities less than 20,000 cells per milliliter pose no risk to the health of humans or pets.
- Exposure to lakes with blue-green algae density levels between 20,000 and 100,000 cells per milliliter poses a low risk of adverse health impacts (i.e., skin irritation or allergenic effects such as watery eyes).
- Exposure to lakes with blue-green algae densities greater than 100,000 cells per milliliter poses a moderate health risk (i.e., long-term illness from algal toxins is possible).

In 2016, blue-green algae numbers were generally within the no-risk category. However, on August 8, densities in both the Main Basin (35,036 cells per milliliter) and Southwest Basin (23,893 cells per milliliter) were both in the low-risk category. As noted, this change was correlated with increasing surface water phosphorus concentrations.

Zooplankton in 2016

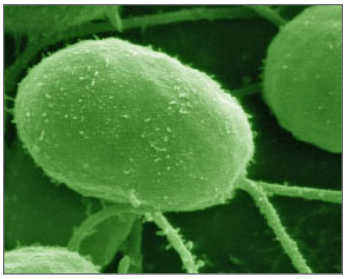
The size and composition of the lake's zooplankton community, as illustrated by the figures on page 7, was consistent with previous years. All three groups of zooplankton (rotifers, copepods, and cladocerans) were represented; however, small rotifers and copepods (which have limited impact on the lake's water quality) generally dominated.

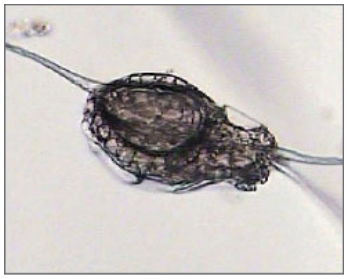
The zooplankton data illustrate the interconnectedness of a lake's food web and its water quality. Of particular interest in 2016 were the large-bodied cladoceran. The numbers of these zooplankton increased from April through mid-June, then declined rapidly and remained at low levels until late summer/early fall when numbers again began to rise. In general, periods with increased cladoceran presence correlated with decreases in chlorophyll *a* concentrations and increases in Secchi disc depth (i.e., better water quality). In the early summer period, chlorophyll *a* was reduced by two-thirds and Secchi disc transparency more than doubled. This is because the large-bodied zooplankton graze on algae.

While large-bodied cladoceran can improve lake water quality, fish predation limits their impact much of the summer. Another limiting factor is the predominance of blue-green algae, a poor food source for zooplankton.

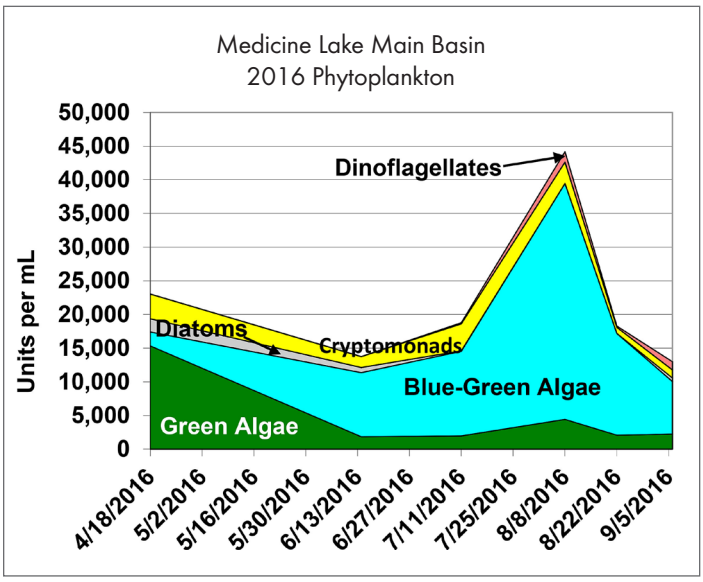
The importance of monitoring

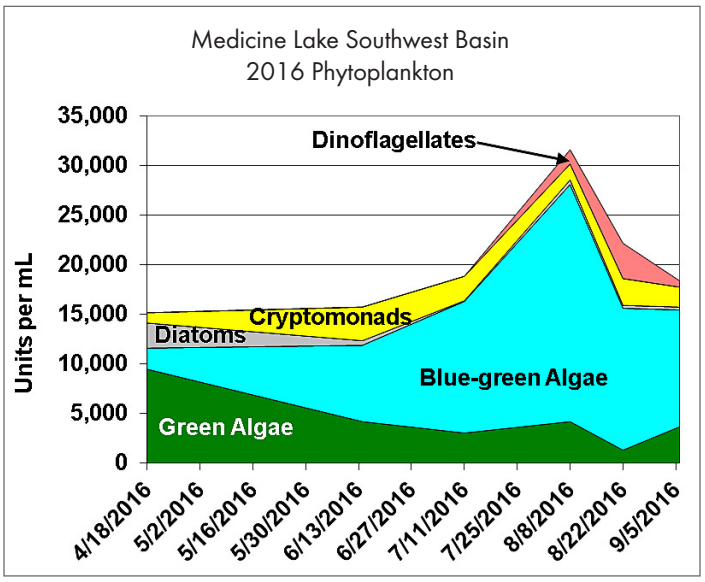
Both the phytoplankton and zooplankton data affirm the importance of reducing phosphorus loading to the lake to prevent increases in blue-green algae. The data also highlights the importance of monitoring the phytoplankton community to ensure that blue-green algae density levels do not threatened the health of lake users.

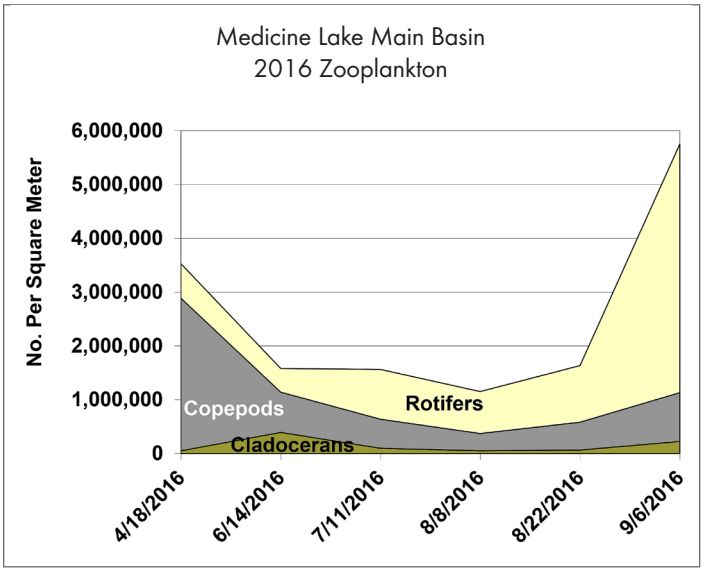


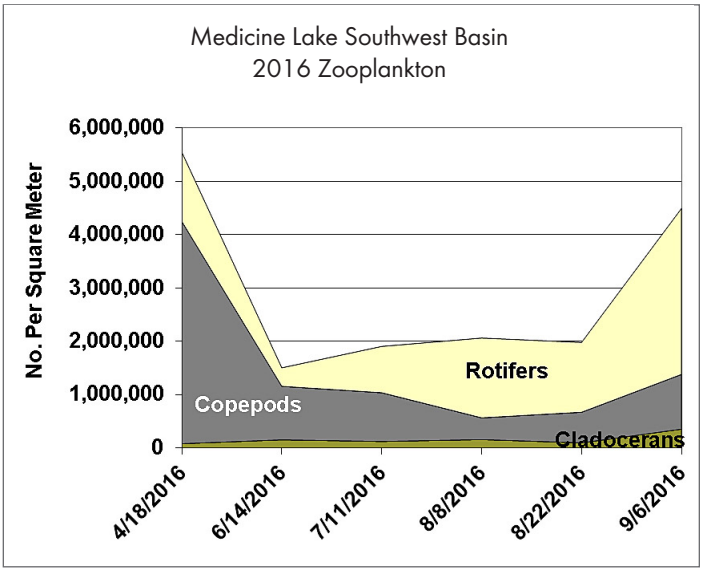


Above: Left—Chlamydomonas, a type of green algae found in Medicine Lake. Right—Filinia longiseta, a rotifer found in Medicine Lake; the phytoplankton and zooplankton communities in Medicine Lake are represented in the figures on page 7.









Medicine Lake fish

According to MDNR surveys, Medicine Lake is home to walleye, yellow perch, and northern pike (as shown). Lake species also include black bullhead, black crappie, bluegill, brown bullhead, channel catfish, green sunfish, hybrid sunfish, largemouth bass, pumpkinseed, white crappie, yellow bullhead, bowfin (dogfish), common carp, goldeye, white sucker, banded killifish, blacknose shiner, bluntnose minnow, brook silverside, golden shiner, spottail shiner.

Fish Index of Biotic Integrity

Similar to aquatic plants, the MDNR recently developed a method to evaluate environmental conditions in a lake based on assessments of fish populations. The resulting index of biotic integrity (IBI) score is used to determine whether the lake is meeting the standard value of 45 (i.e., the impairment threshold). The MPCA is likely to begin using fish IBI scores to determine impairments for fish during its 2020 watershed assessment process. Using the most recent fish survey data from 2012, Medicine Lake's current fish IBI score is 25; thus, the lake would be considered impaired for fish.

Bassett Creek Watershed Management Commission
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