Six Mile Lake 11-0146-00 CASS COUNTY

Summary

Six Mile Lake is located two and a half miles southeast of Bena, MN in Cass County. It covers 1,323 acres, which places it in the upper 10% of lakes in Minnesota in terms of size.

Six Mile Lake is located in the Leech Lake River Watershed. Its inlet is a ditch that drains from Lake Winnibigoshish. The outlet, Six Mile Brook, joins the Leech Lake River and eventually the Mississippi River.

Water quality data for Six Mile Lake is extremely limited and outdated. Six Mile Lake is within the Chippewa National Forest, Bowstring State Forest, and the Leech Lake Indian Reservation. Due to the lack of development along its shoreline, it is not considered high priority for a monitoring program.

Vitals

MN Lake ID:	11-0146-00
County:	Cass
Ecoregion:	Northern Lakes and Forest
Major Drainage Basin:	Upper Mississippi River
Latitude/Longitude:	47.31566 / -94.14751
Water Body Type:	Public
Monitored Sites (Primary):	None
Monitored Sites (Secondary):	None

Invasive species present: none documented

Physical Characteristics

Surface area (acres):	1,323	
Littoral area (acres):	606	
% Littoral area:	47%	
Max depth (ft):	68	(m): 20.7
Mean depth (ft):	NA	
Lakeshed: size (acres):	5,323	
Lakeshed:lake area ratio	4:1	
Inlets	3	
Outlets	1	
Accesses	1 public	

Data Availability

Transparency data		Limited transparency data exist from the US Forest Service in 1970-1976.
Chemical data		Limited chemical data exist from the US Forest Service in 1970-1976, and a 1987 DNR Fisheries Survey.
Inlet/Outlet data		No inlet or outlet data exist for Six Mile Lake.
Recommendations		For recommendations refer to page 6.

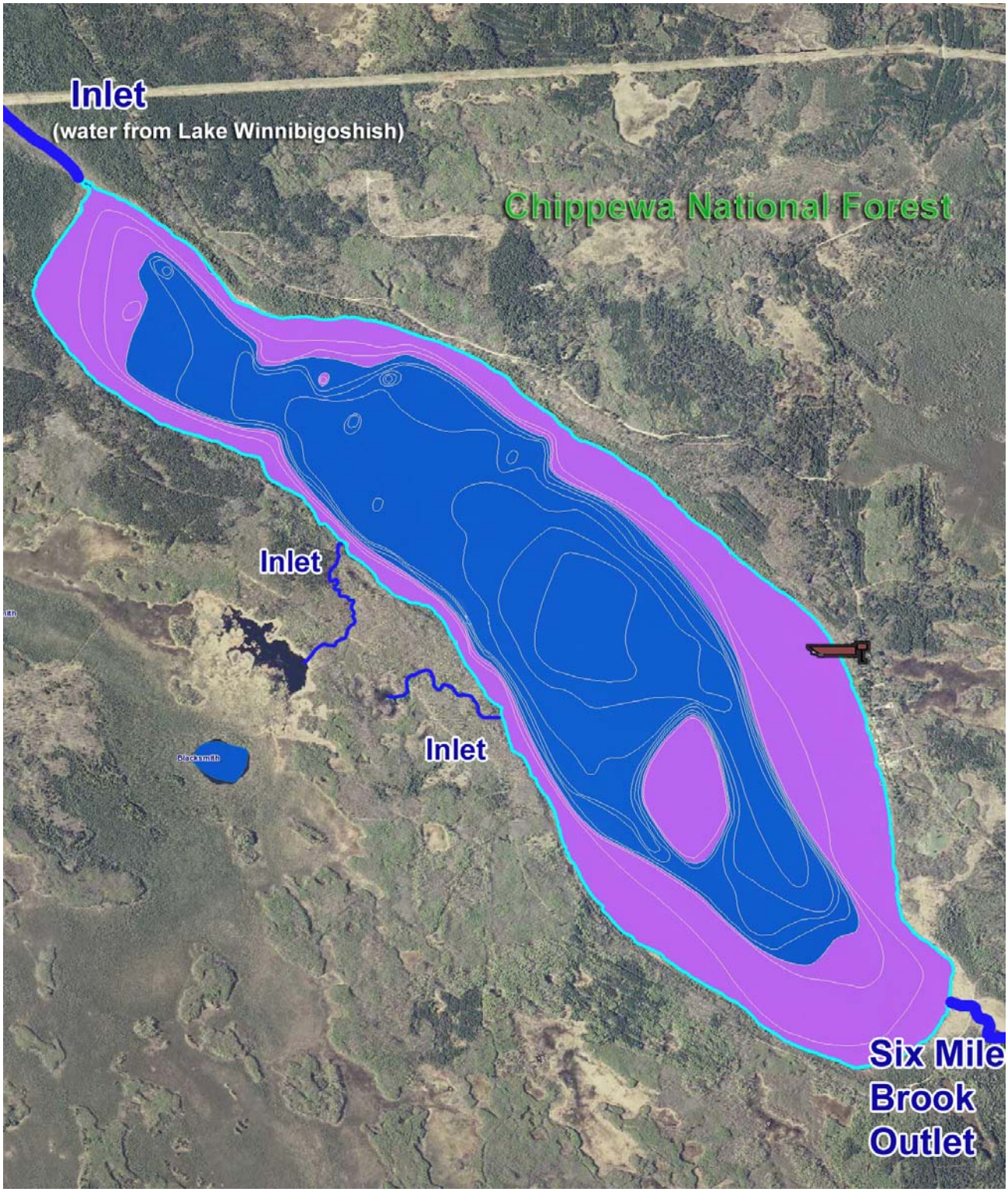


Figure 1. Map of Six Mile Lake illustrating bathymetry, stream inlets and outlets and aerial land use. The pink shaded areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

The information below describes available chemical data for Six Mile Lake through 2008. The data set is extremely limited, and only consists of one data point from a DNR Fisheries survey on 07/13/87 and 3-5 data points from the US Forest Service in1970-1976.

Parameter	Mean	Ecoregion Range[1]	Impaired Waters Standard[2]	Interpretation
Total phosphorus (ug/L)	42	14 - 27	> 35	The data is limited, so it is not representative of the lake's full growing season. In addition, it is not enough data to draw any conclusions about impaired waters (see page 6).
Chlorophyll *a* (ug/L)[3]	8.5	4 - 10	> 12	
Chlorophyll *a* max (ug/L)	--	<15		
Secchi depth (ft)	10.5	7.5 - 15	< 4.5	
Dissolved oxygen	See page 4			The dissolved oxygen data indicate that Six Mile Lake does not stratify.
Total Kieldahl Nitrogen (mg/L)	--	0.4 - 0.75		Data non-existent.
Alkalinity (mg/L)	120	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	17.5	10 - 35		Indicates semi-clear water with some tannins (brown stain), which are common in wetlands.
pH	8.1	7.2 - 8.3		Characteristic of a hard water lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	1.3	0.6 - 1.2		Slightly higher than the ecoregion average, but still considered low level.
Total Suspended Solids (mg/L)	--	<1 - 2		Data non-existent.
Conductivity (umhos/cm)	226	50 - 250		Conductivity is within the expected range for the ecoregion.
Total Nitrogen :Total Phosphorus	--	25:1 – 35:1		Six Mile Lake is most likely phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.

Data Source: 1987 DNR Fisheries Survey; 1970-1976 US Forest Service

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

Water Quality Characteristics - Historical Means

Years monitored: 1970-1976, 1987

Parameters

Total Phosphorus (ug/L):	**42**
Total Phosphorus Min:	15
Total Phosphorus Max:	71
Number of Observations:	6
Chlorophyll *a* Mean (ug/L):	**8.5**
Chlorophyll *a* Min:	
Chlorophyll *a* Max:	
Number of Observations:	1
Secchi Depth Mean (ft):	**10.5**
Secchi Depth Min:	4
Secchi Depth Max:	14.6
Number of Observations:	8

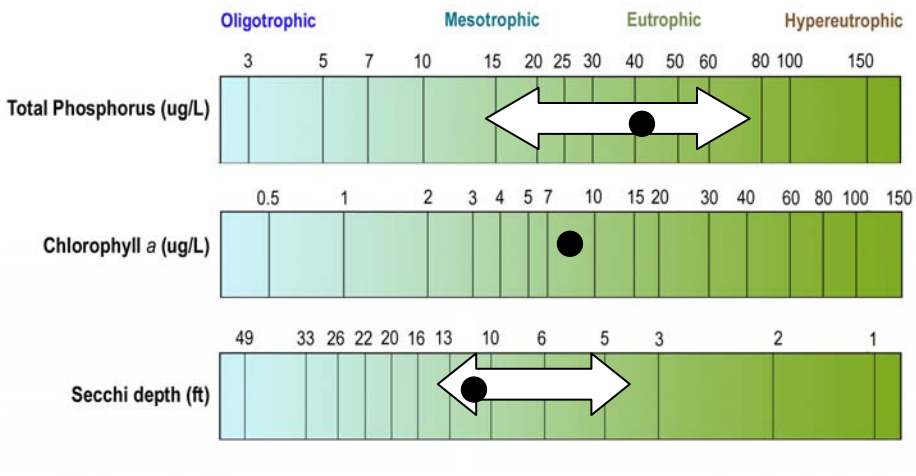
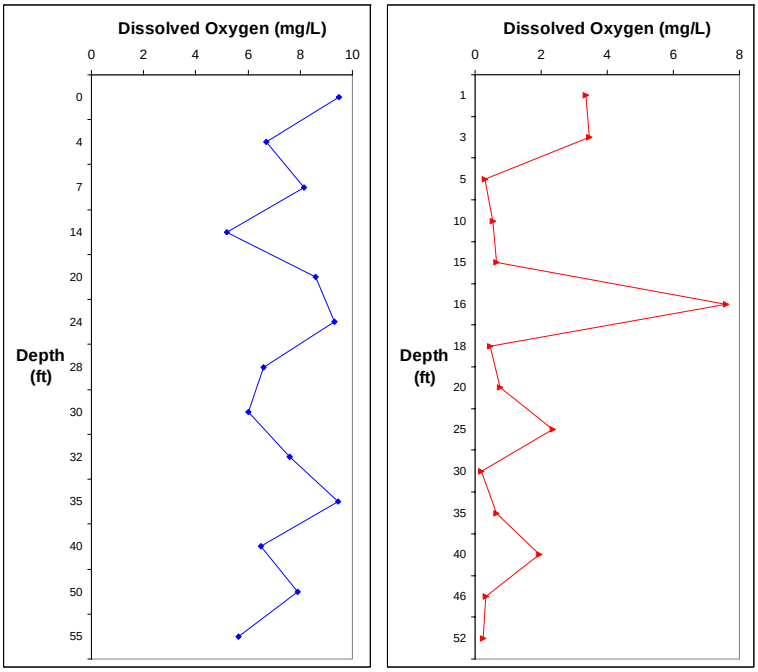


Figure 2. Six Mile Lake total phosphorus and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean. Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Dissolved Oxygen



Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive, except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fish.

The dissolved oxygen data collected by the US Forest Service in 1971 and 1975 is inconclusive as far as determining the oxygen dynamics in Six Mile Lake. It appears that the lake does not stratify during the summer (Figure 3).

This data should be updated with more recent dissolved oxygen profiles.

Figure 3. Dissolved oxygen profiles for July 21, 1971 and July 16, 1975.

Trophic State Index

Phosphorus (nutrients), chlorophyll *a* (algae concentration) and Secchi depth (transparency) are related. As phosphorus increases, there is more food available for algae, resulting in increased algal concentrations. When algal concentrations increase, the water becomes less transparent and the Secchi depth decreases.

Trophic State Index	
TSI Total Phosphorus	58
TSI Chlorophyll-a	52
TSI Secchi	43
TSI Mean	NA*

*Numbers represent the mean TSI for each parameter. *Because the TSI for phosphorus, chlorophyll a, and transparency are not within 5 points of the TSI for secchi, it is not scientifically accurate to average them to determine an overall TSI mean.*

The results from these three measurements cover different units and ranges and thus cannot be directly compared to each other or averaged. In order to standardize these three measurements to make them directly comparable, we convert them to a trophic state index (TSI).

The TSI for transparency indicates that Six Mile Lake is mesotrophic (Figure 4). The TSI for total phosphorus and chlorophyll *a* indicate that Six Mile Lake is eutrophic. All of the available data is limited and outdated, so if should be updated if necessary for any future planning efforts.

Mesotrophic lakes (TSI 40-50) are characterized by moderately clear water most of the summer, while eutrophic lakes become increasingly "green" in late summer.

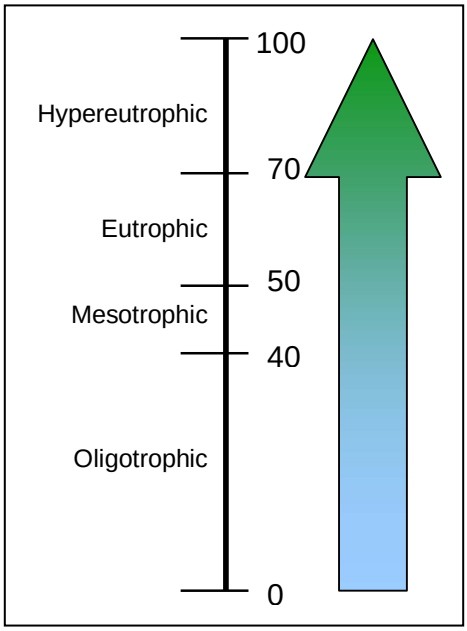


Figure 4. Trophic state index chart with corresponding trophic status.

TSI	Attributes	Fisheries & Recreation
<30	**Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water.	Trout fisheries dominate.
30-40	Bottom of shallower lakes may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Tullibee present.
40-50	**Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50-60	**Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60-70	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70-80	**Hypereutrophy:** Dense algae and aquatic plants.	Water is not suitable for recreation.
>80	Algal scums, few aquatic plants.	Rough fish (carp) dominate; summer fish kills possible.

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

Inlet/Outlet Data Assessment

No inlet or outlet data exist for Six Mile Lake.

Assessment/Findings Recommendations

Transparency
Transparency monitoring should be implemented at the deepest spot in the lake. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses.

Impaired Waters Assessment 303(d) List
There are two main types of Impaired Waters Assessment for lakes: eutrophication (excess phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption. Six Mile Lake was listed as impaired for mercury in fish tissue in the 2006 Impaired Waters List; however it is part of the statewide mercury TMDL, so it was removed from the 2008 Impaired Waters List. Six Mile Lake is not considered impaired for eutrophication; however it does not have sufficient data for assessment. Ten data points of each total phosphorus, chlorophyll *a* and secchi depth over a two-year period are required for assessment.

Aquatic Recreational Use Assessment 305(b)
In the 2008 MPCA Aquatic Use Assessment (305(b)) Six Mile Lake was classified as having insufficient data. The data requirements for this assessment are the same as above.

Inlet/Outlet Assessment
Because of the limited inlet/outlet data, a mass balance project should be considered. This study answers questions about nutrient loading into the lake and nutrient budget within the lake.

Organizational contacts and reference sites

Chippewa National Forest	200 Ash Avenue NW, Cass Lake, MN 56633 (218) 335-8600 http://www.fs.fed.us/r9/forests/chippewa/
Leech Lake Band of Ojibwe Division of Resource Management	15756 State 371 NW, Cass Lake, MN 56633 (218) 335-7400 http://www.lldrm.org/index.html
Cass County Environmental Services Department	303 Minnesota Avenue W, P.O. Box 3000, Walker, MN 56484-3000 (218) 547-7241 http://www.co.cass.mn.us/esd/home_esd.html
DNR Fisheries Office	7316 State Hwy 371 NW, Walker, MN 56484 (218) 547-1683 http://www.dnr.state.mn.us/lakefind/index.html
Regional Minnesota Pollution Control Agency Office	7678 College Road, Suite 105, Baxter, MN 56425 (218) 828-2492 http://www.pca.state.mn.us
Regional Board of Soil and Water Resources Office	1601 Minnesota Drive, Brainerd, MN 56401 (218) 828-2383 http://www.bwsr.state.mn.us