Long Lake 15-0057-00 CLEARWATER COUNTY

Lake Water Quality

Summary

Long Lake is located 17 miles south of Bagley, MN in Clearwater County. It is a long and narrow lake covering 159 acres (Table 1).

Long Lake has no inlets and one outlet, which classify it as a groundwater drainage lake. The outlet is located at the southeast tip of the lake. Water then flows into Sucker Lake and eventually into Sucker Creek. Sucker Creek joins the Mississippi River just north of Highway 200 by Lake Itasca.

Water quality data have been collected on Long Lake since 1985 (Table 3). These data show that the lake is oligotrophic (TSI 35), which is characteristic of clear water throughout the summer and trout fisheries.

Table 1. Long Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	15-0057-00	Surface area (acres):	159
County:	Clearwater	Littoral area (acres):	24
Ecoregion:	Northern Lakes and Forests	% Littoral area:	15%
Major Drainage Basin:	Upper Mississippi River	Max depth (ft):	80
Latitude/Longitude:	47.276416641/-95.29851593	Inlets:	0
Invasive Species:	None as of 2012	Outlets:	1
		Public Accesses:	1

Table 2. Availability of primary data types for Long Lake.

Data Availability		
Transparency data		Couple years of data at many different sites, but not enough to run trend analysis.
Chemical data		Couple years of data, but not enough to run trend analysis.
Inlet/Outlet data		Not available.
Recommendations		**For recommendations refer to page 19.**

Lake Map

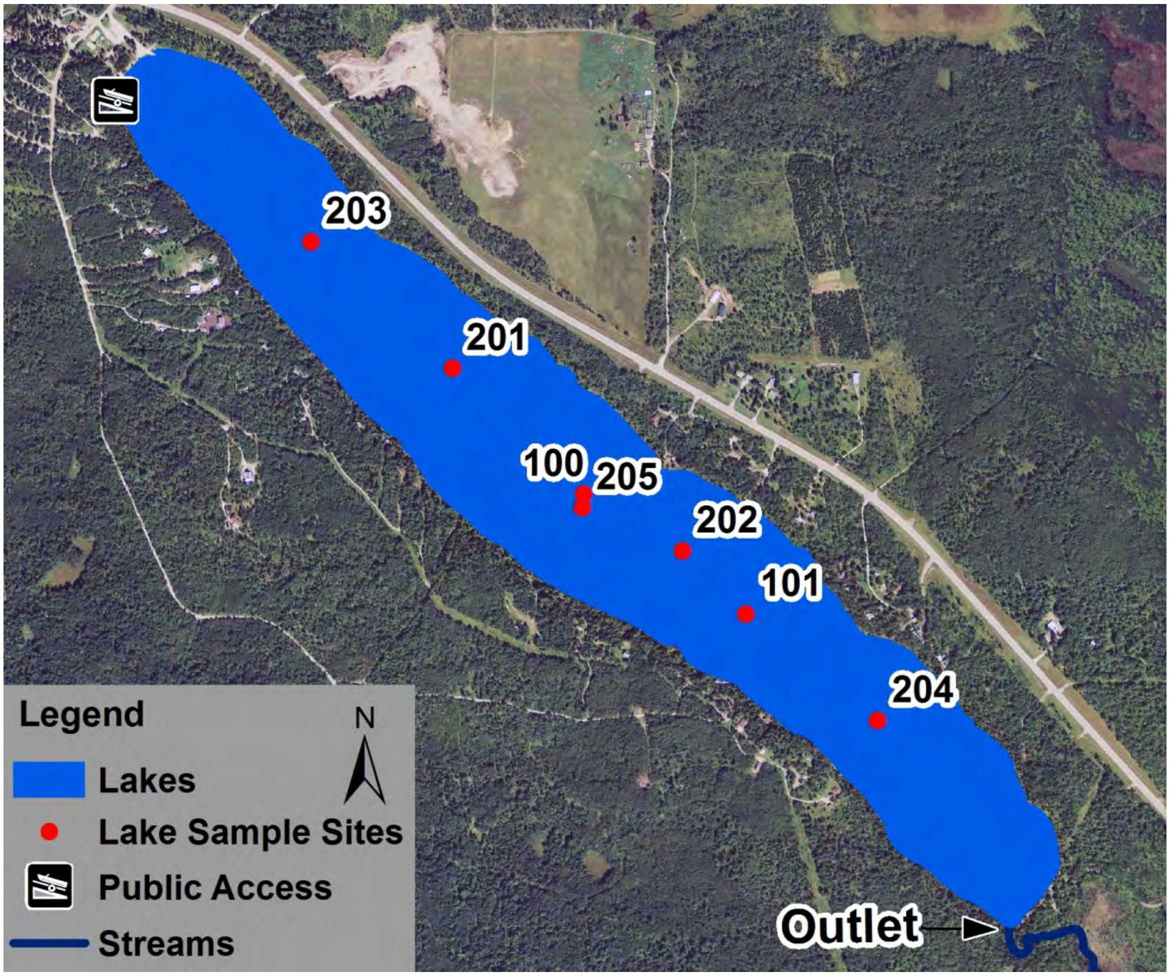


Figure 1. Map of Long Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. There is no digital bathymetry data available for Long Lake.

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Clearwater County 2011 Lake Monitoring Program (CCLMP), Clearwater County Local Water Monitoring (Lakes) (CCLWM), RMB Environmental Laboratories Lakes Program (RMBEL) and MPCA Lake Monitoring Program Project (MPCA).

Lake Site	Depth (ft)	Monitoring Programs
100	75	CLMP: 2007
101*Primary	70	CLMP: 2008-2011; CCLMP: 2008, 2009; CCLWM: 2009; MPCA: 1985, 1986; RMBEL: 2009
201	75	CLMP: 1991; RMBEL: 2002
202	80	CLMP: 1997-2000
203	60	CLMP: 1999, 2000; MPCA: 1985, 1986
204	70	CLMP: 1999, 2000
205	75	CLMP: 2008

Average Water Quality Statistics

The information below describes available chemical data for Long Lake through 2011 (Table 4). Data for total phosphorus, chlorophyll *a* and secchi depth are from the primary site 101 (1985, 1986, 2008 and 2009). All additional chemical data is from the same site, but from only 1985 and 1986.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. For more information on ecoregions and expected water quality ranges, see page 11.

Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.

Parameter	Mean	Ecoregion Range[1]	Impaired Waters Standard[2]	Interpretation
Total phosphorus (ug/L)	8	14 - 27	> 30	Results are better than the expected ecoregion regions.
[3]Chlorophyll *a* (ug/L)	2	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	5	<15		
Secchi depth (ft)	19.4	7.5 - 15	< 6.5	
Dissolved oxygen	*Dimictic* See page 8			Dissolved oxygen depth profiles show that the lake stratifies in the summer.
Total Kjeldahl Nitrogen (mg/L)	0.34	0.4 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	163	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	5	10 - 35		Indicates clear water with little to no tannins (brown stain).
pH	8.5	7.2 - 8.3		Close to the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	4	0.6 - 1.2		Above the expected range for the ecoregion, but still low.
Total Suspended Solids (mg/L)	1.2	<1 - 2		Within the expected range for the ecoregion.
Specific Conductance (umhos/cm)	290	50 - 250		Above the expected range for the ecoregion, but still low.
Total Nitrogen :Total Phosphorus	38:1	25:1 – 35:1		Indicates the lake is phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.

[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 and Ranges

Table 5. Water quality means and ranges for primary sites.

Parameters	Primary Site 101	201	202	203
Total Phosphorus Mean (ug/L):	**8.2**	**7.6**		**10.3**
Total Phosphorus Min:	5	7		10
Total Phosphorus Max:	19	10		11
Number of Observations:	18	4		3
Chlorophyll *a* Mean (ug/L):	**1.8**	**2**		**1.2**
Chlorophyll-a Min:	1	1		0.3
Chlorophyll-a Max:	5	3		2
Number of Observations:	18	4		3
Secchi Depth Mean (ft):	**19.4**	**24.6**	**17.4**	**18.5**
Secchi Depth Min:	11.5	21.5	13.0	14.0
Secchi Depth Max:	36.1	31.5	26.0	25.0
Number of Observations:	85	9	31	14

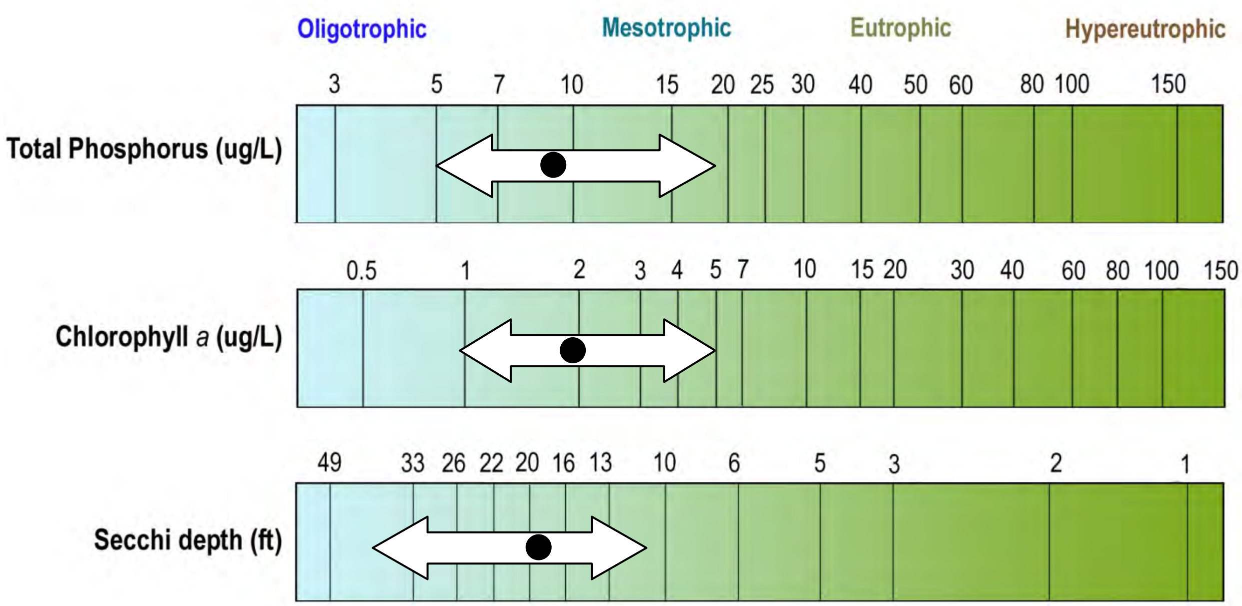


Figure 2. Long Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 101). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the amount of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

The mean transparency in Long Lake ranges from 14.8 to 22.7 feet (Table 5). The transparency throughout the lake appears to be relatively uniform. Transparency monitoring should be continued annually at site 101 to track water quality changes over time.

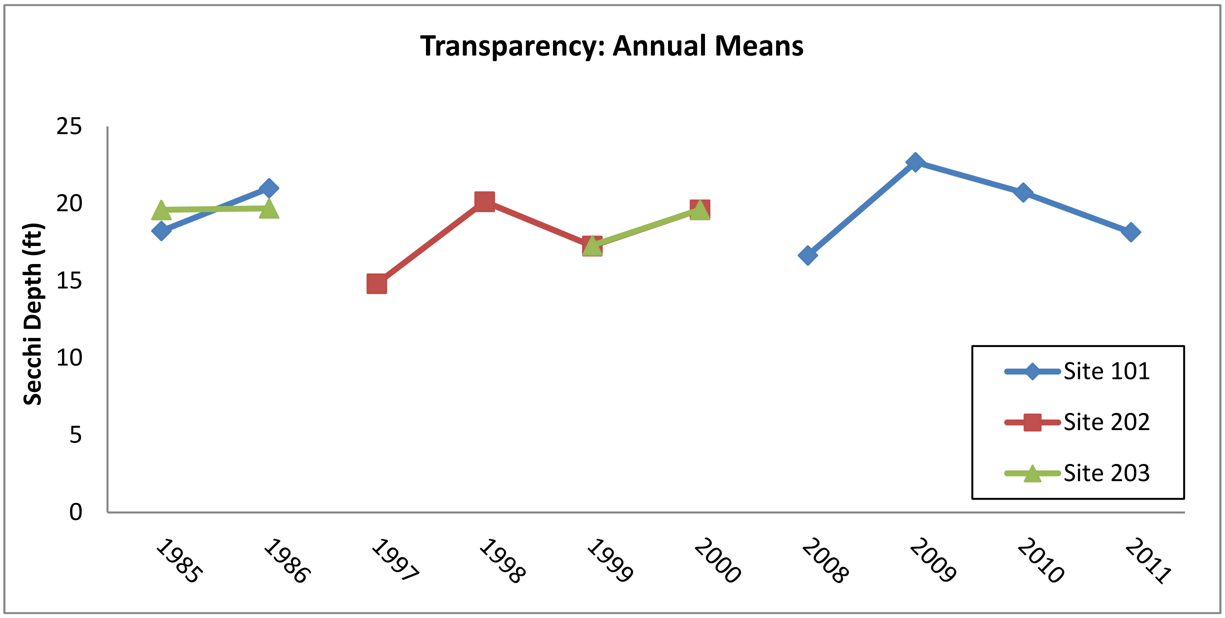


Figure 3. Annual mean transparency compared to long-term mean transparency, sites 101, 202, and 203.

Long Lake transparency ranges from 11.5 to 36.1 feet at the primary site (101). Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Long Lake transparency is high in May and June, and then declines through August. The transparency then rebounds in October after fall turnover. This transparency dynamic is typical of a Minnesota lake. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

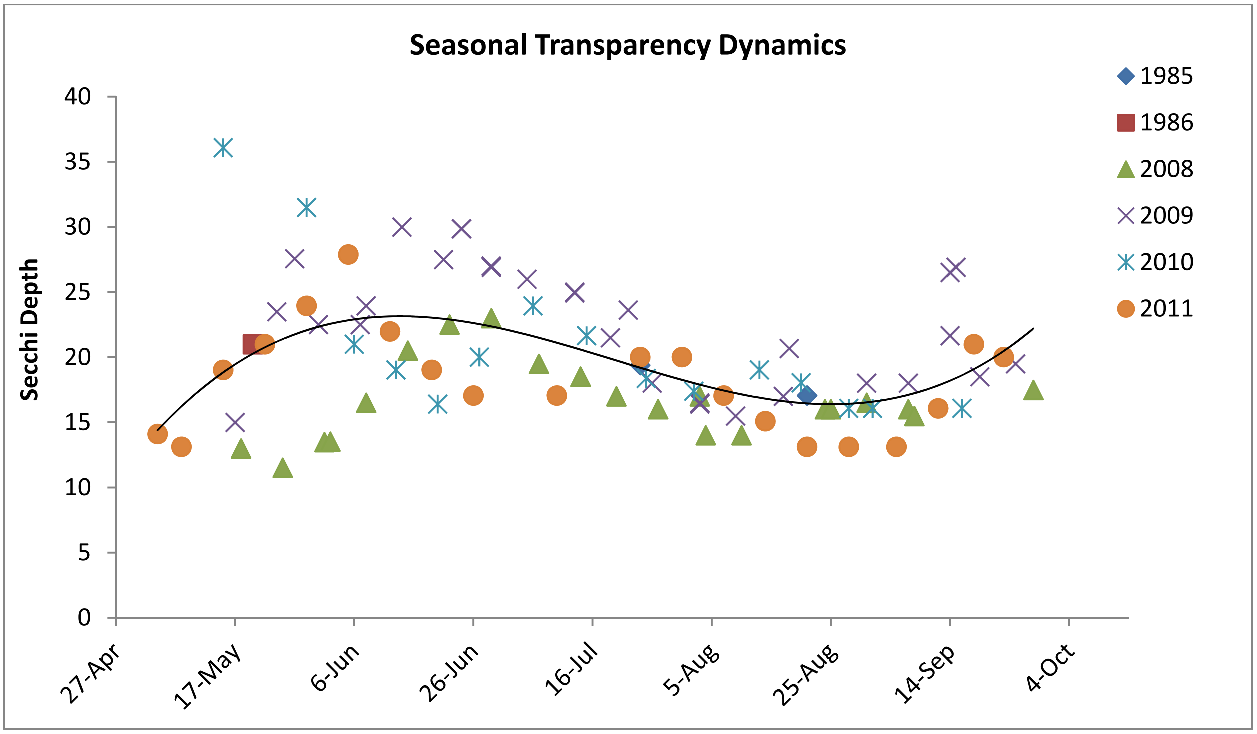


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 101). The black line represents the pattern in the data.

User Perceptions

When volunteers collect secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the secchi depth decreases the perception of the lake's physical appearance rating decreases. Long Lake was rated as being "crystal clear" 54% of the time by samplers at site 101 in 2008, 2009 and 2011 (Figure 5).

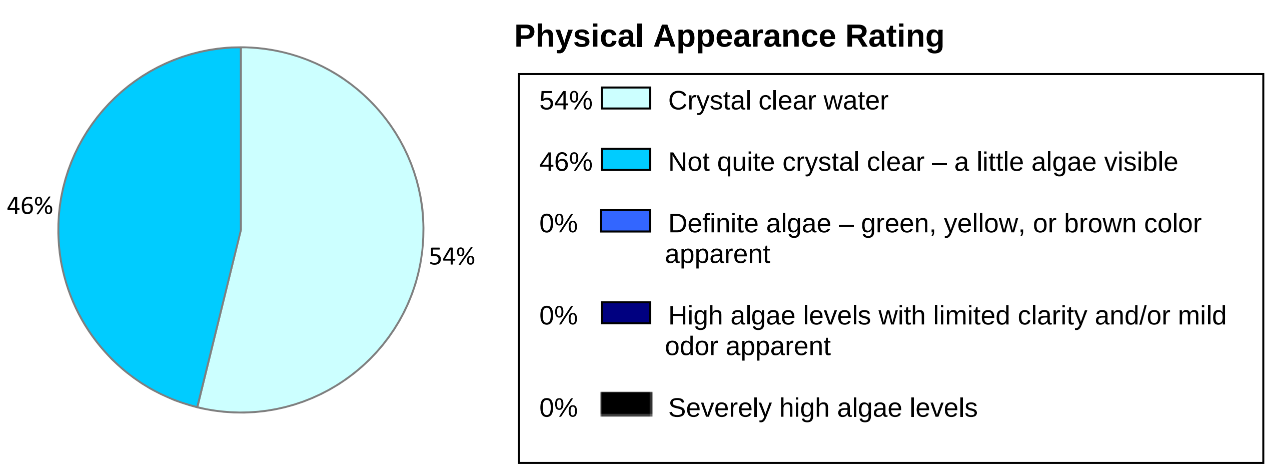


Figure 5. Long Lake physical appearance ratings by samplers at site 101.

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Long Lake was rated as being "beautiful" 46% of the time in 2008 and 2009 (Figure 6).

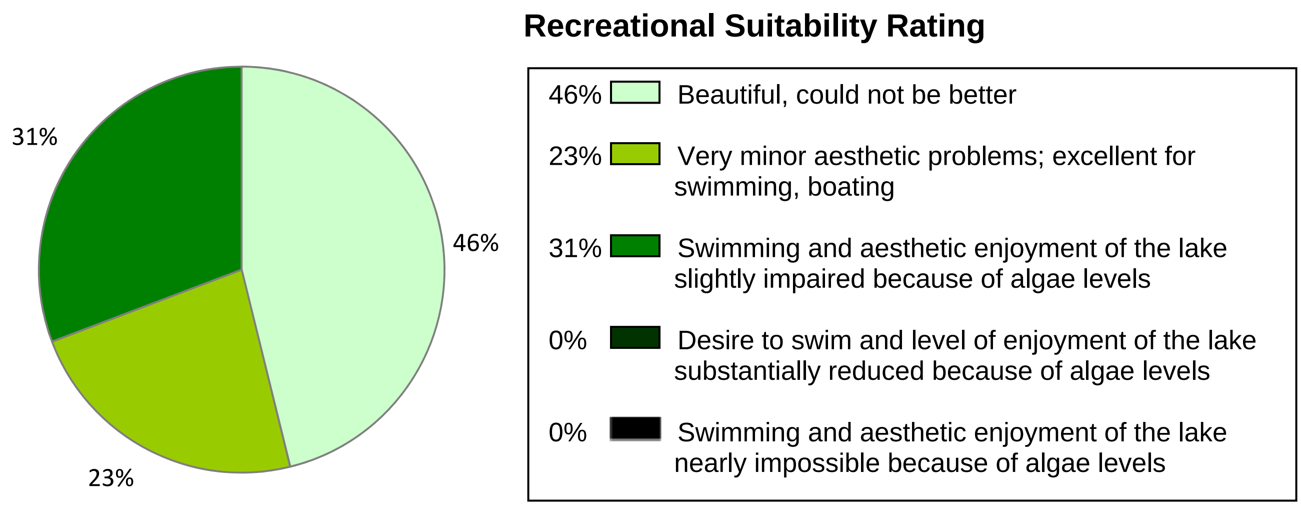


Figure 6. Recreational suitability rating, as rated by the volunteer monitor at site 101.

Total Phosphorus

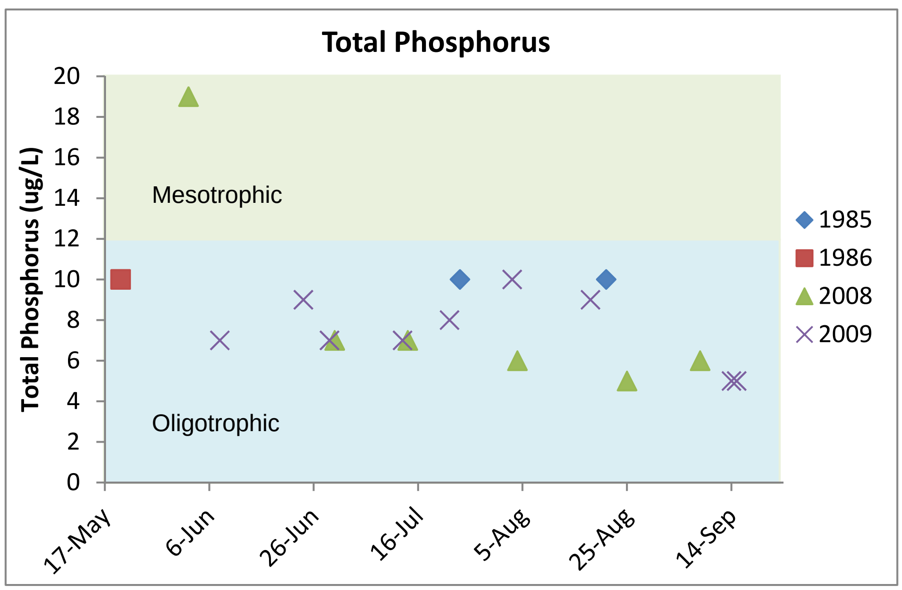


Figure 7. Historical total phosphorus concentrations (ug/L) for Long Lake site 101.

Long Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Long Lake in 1985, 1986, 2008 and 2009. The data do not indicate much seasonal variability. The majority of the data points fall in the oligotrophic range (Figure 7). The spike in early 2008 could have been collected during turnover. A few water sample collections near the bottom of the lake (benthic samples) do have slightly elevated phosphorus levels (21 ug/L), compared to surface sample collection. Phosphorus should continue to be monitored to track any future changes in water quality.

Chlorophyll *a*

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to deter mine the algae concentration or how "green" the water is. Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

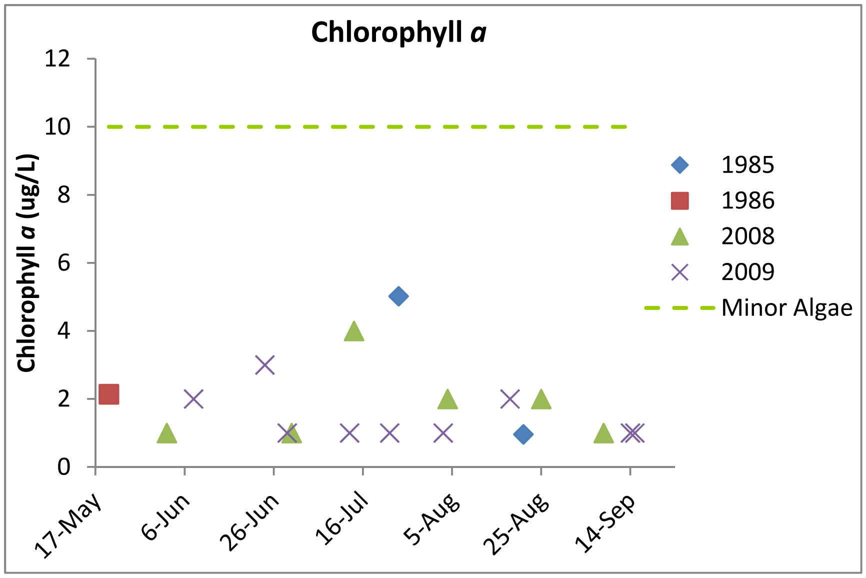


Figure 8. Chlorophyll *a* concentrations (ug/L) for Long Lake at site 101.

Chlorophyll *a* was evaluated in Long Lake at site 101 in 1985, 1986, 2008 and 2009 (Figure 8). Chlorophyll *a* concentrations remained below 10 ug/L on all sample dates, indicating clear water throughout of the summer. There was not much variation over the years monitored and chlorophyll *a* concentrations remained steady over each summer.

Dissolved Oxygen

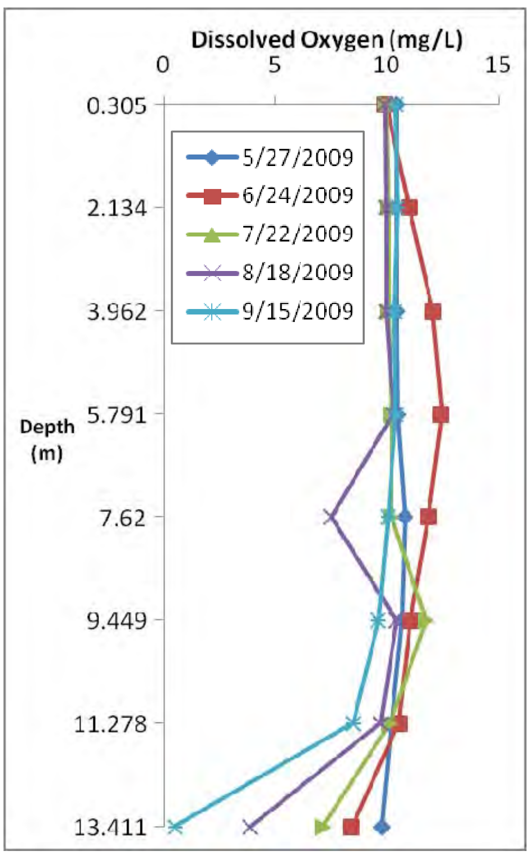


Figure 9. Dissolved oxygen profile for Long Lake in 2009 at site 101.

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 fisheries.

Long Lake is a relatively deep lake, with a maximum depth of 80 ft. Dissolved oxygen profiles from data collected in 2009 at site 101 shows that the lake does stratify, but the hypolimnion remains oxygenated. The thermocline occurs at approximately 12.5 meters (41 feet), which means that gamefish will be scarce below this depth. Figure 9 is a representative DO profile for Long Lake and it illustrates stratification in the summer of 2009 at site 101.

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.

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 mean TSI for Long Lake falls into the oligotrophic range (Figure 10). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are strongly related (Table 6).

Oligotrophic lakes (TSI 0-39) are characteristic of extremely clear water throughout the summer and sandy or rocky shores. They are excellent for recreation. Some very deep oligotrophic lakes are able to support a trout fishery. Long Lake is stocked with rainbow trout annually.

Table 6. Trophic State Index for sites 101 and 203.

Trophic State Index	Site 101	Site 203
TSI Total Phosphorus	34	38
TSI Chlorophyll-a	36	32
TSI Secchi	34	35
TSI Mean	35	35
Trophic State:	Oligotrophic	

Numbers represent the mean TSI for each parameter.

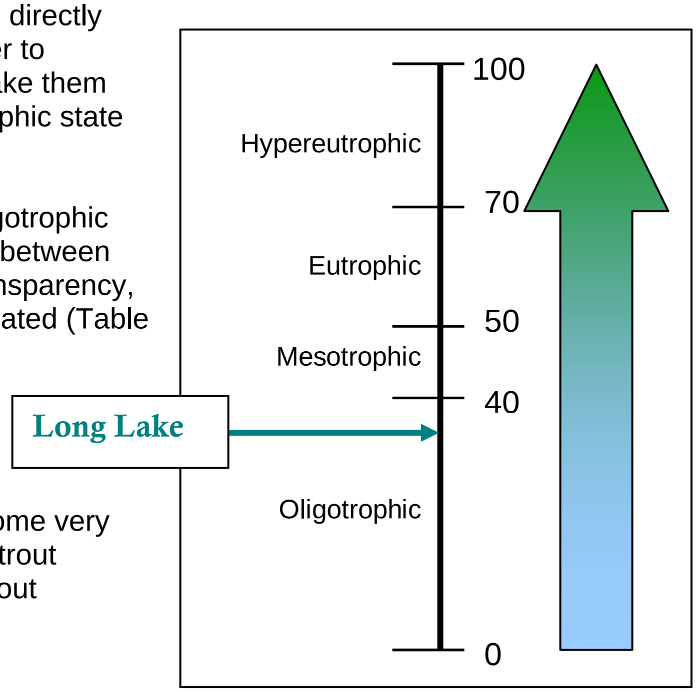


Figure 10. Trophic state index chart with corresponding trophic status.

Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics.

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, Cisco 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.

Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Long Lake did not have enough data to perform a trend analysis on any of the parameters (Table 8). Without at least 8 years of data a statistical significant trend cannot be analyzed. Though from the pattern of the data it appears to be relatively stable (Figure 11). Transparency monitoring should continue so that this trend can be tracked in future years.

Table 8. Trend analysis for site 101.

Lake Site	Parameter	Date Range	Trend
101	Total Phosphorus	1985, 1986, 2008, 2009	Insufficient Data
101	Chlorophyll a	1985, 1986, 2008, 2009	Insufficient Data
101	Transparency	1985, 1986, 2008-2011	Insufficient Data

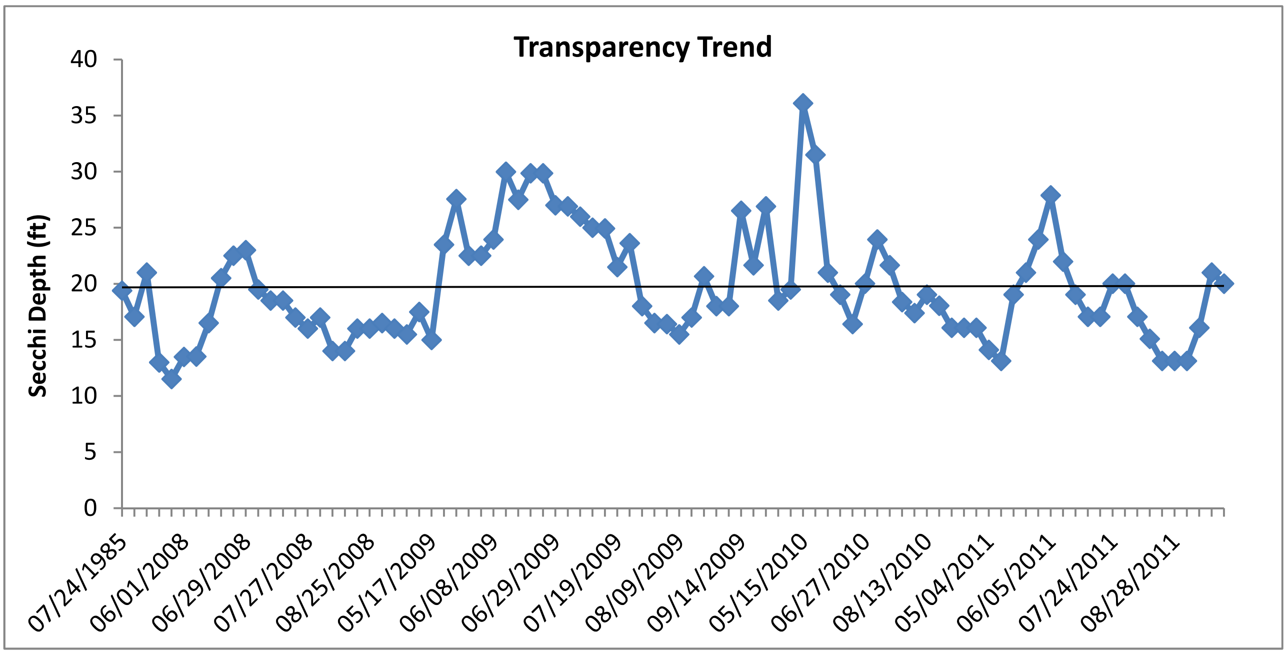


Figure 11. Transparency (ft) trend for site 101 from 1985, 1986, and 2008-2011.

Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. From 1985-1988, the MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine, but are considered to have little human impact and therefore are representative of the typical lakes within the ecoregion. The "average range" refers to the 25th - 75th percentile range for data within each ecoregion. For the purpose of this graphical representation, the means of the reference lake data sets were used.

Long Lake is in the Northern Lakes and Forests Ecoregion (Figure 12). The mean total phosphorus, chlorophyll a and transparency (secchi depth) for Long Lake are better than the ecoregion ranges (Figure 13).

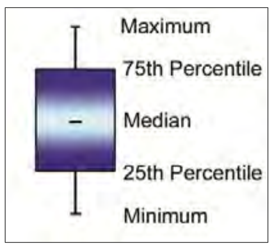
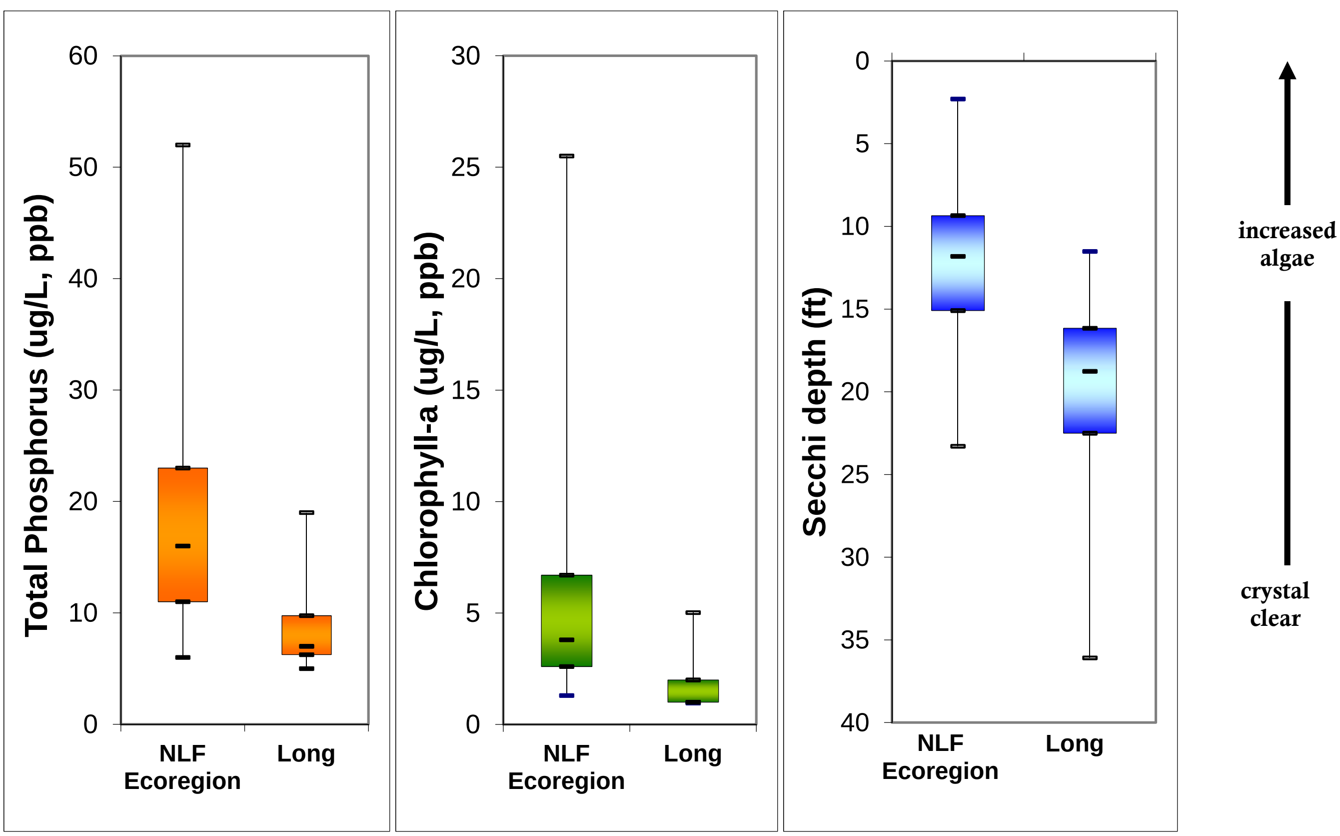


Figure 12. Minnesota Ecoregions.



Figures 13a-c. Long Lake ranges compared to Northern Lakes and Forests Ecoregion ranges. Long Lake total phosphorus and chlorophyll *a* ranges are from 18 data points collected in May-September from 1985, 1986, 2008 and 2009. The Long Lake secchi depth range is from 90 data points collected in May-September from 1985, 1986 and 2008-2011.

Lakeshed Data and Interpretations

Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The **Mississippi River (Headwaters) Major Watershed** is one of the watersheds that make up the Upper Mississippi River Basin, which drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 121 minor watersheds. Long Lake is located in **minor watershed** 7051 (Figure 15).

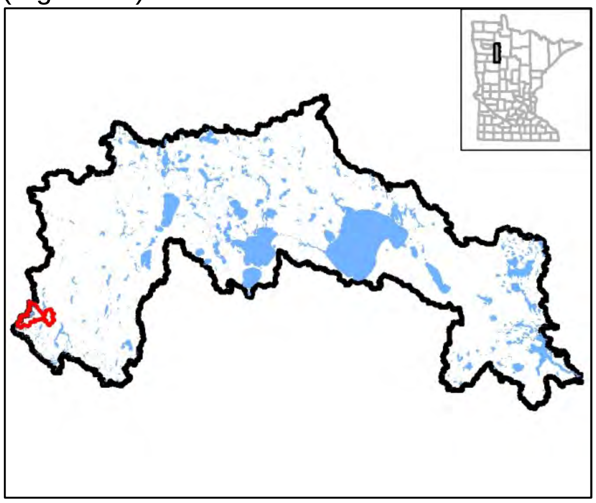


Figure 14. Mississippi River (Headwaters) Major Watershed.

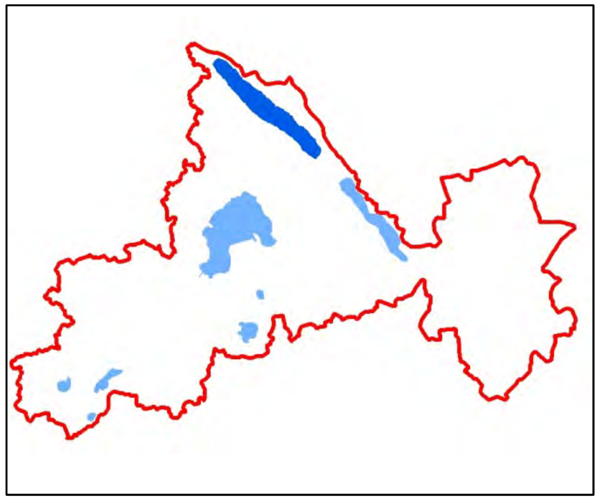


Figure 15. Minor Watershed 7051

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Long Lake falls within **lakeshed 0705101** (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds

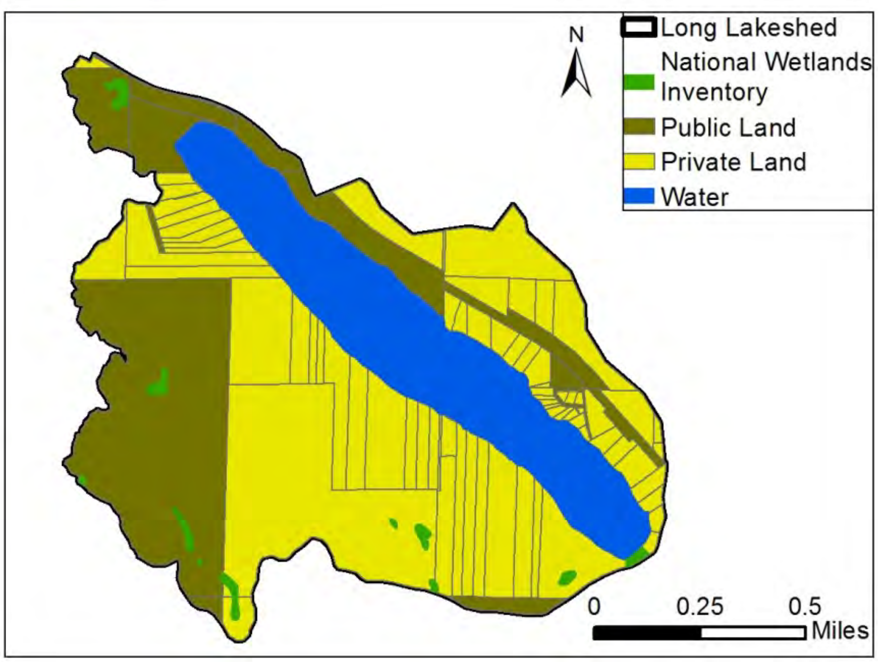


Figure 16. Long Lake lakeshed (0705101) with land ownership, lakes, wetlands, and rivers illustrated.

draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks. However, Long Lake's lakeshed is a headwaters catchment, which means the area displayed in Figure 16 is the only lakeshed that contributes water to the Lake.

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 9). Criteria were developed using limnological concepts to determine the effect to lake water quality.

KEY
- (dark oval) Possibly detrimental to the lake
- (medium oval) Warrants attention
- (light oval) Beneficial to the lake

Table 9. Long Lake lakeshed vitals table.

Lakeshed Vitals		Rating
Lake Area	159 acres	descriptive
Littoral Zone Area	24 acres	descriptive
Lake Max Depth	80 ft.	descriptive
Lake Mean Depth	NA	NA
Water Residence Time	NA	NA
Miles of Stream	0.02	descriptive
Inlets	0	(light oval) Beneficial
Outlets	1	(medium oval) Warrants attention
Major Watershed	7 – Mississippi Headwaters	descriptive
Minor Watershed	7051	descriptive
Lakeshed	705101	descriptive
Ecoregion	Northern Lakes and Forests	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	5:1	(medium oval) Warrants attention
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	5:1	(light oval) Beneficial
Wetland Coverage	1.2%	(medium oval) Warrants attention
Aquatic Invasive Species	None as of 2012	(light oval) Beneficial
Public Drainage Ditches	None	(light oval) Beneficial
Public Lake Accesses	1	(medium oval) Warrants attention
Miles of Shoreline	3.21	descriptive
Shoreline Development Index	1.8:1	(light oval) Beneficial
Public Land to Private Land Ratio	0.6:1	(medium oval) Warrants attention
Development Classification	Recreational Development	(medium oval) Warrants attention
Miles of Road	3.27	descriptive
Municipalities in lakeshed	None	(light oval) Beneficial
Forestry Practices	Yes, managed by the Clearwater County Resource Management Plan	(light oval) Beneficial
Feedlots	None	(light oval) Beneficial
Sewage Management	Individual Waste Treatment Systems	(medium oval) Warrants attention
Lake Management Plan	None	(medium oval) Warrants attention
Lake Vegetation Survey/Plan	None	(medium oval) Warrants attention

Land Cover / Land Use

The activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. The basic purpose of land use planning is to ensure that each area of land will be used in a manner that provides maximum social benefits without degradation of the land resource.

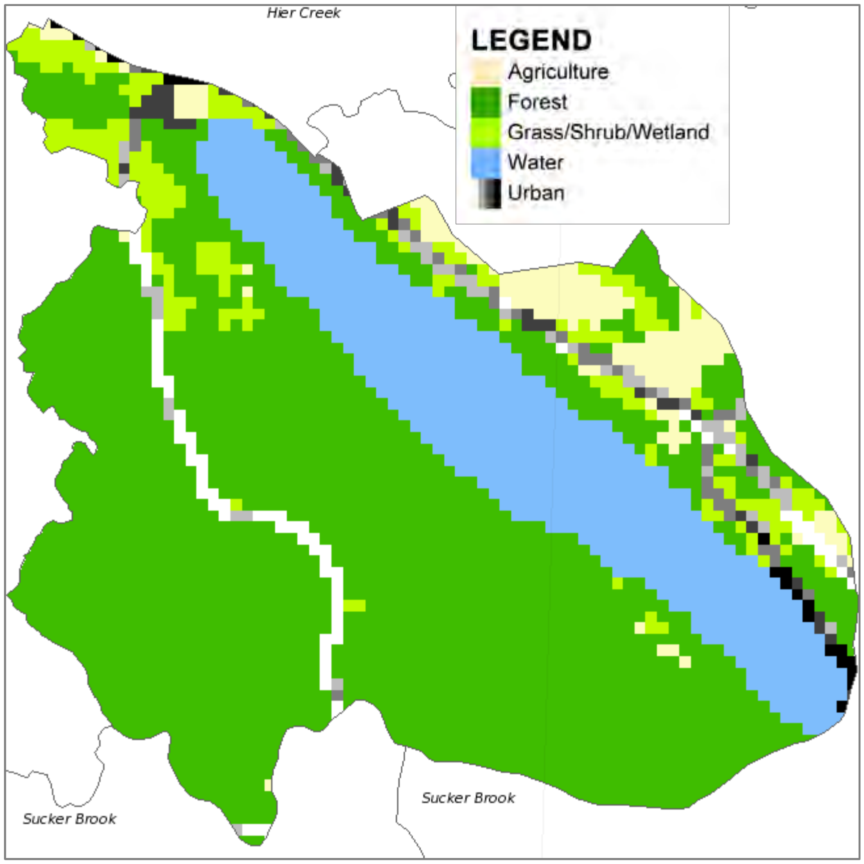


Figure 17. Long Lake lakeshed (0705101) land cover (http://land.umn.edu).

Changes in land use, and ultimately land cover, impact the hydrology of a lakeshed. Land cover is also directly related to the land's ability to absorb and store water rather than cause it to flow overland (gathering nutrients and sediment as it moves) towards the lowest point, typically the lake. Impervious intensity describes the land's inability to absorb water, the higher the % impervious intensity the more area that water cannot penetrate in to the soils. Monitoring the changes in land use can assist in future planning procedures to address the needs of future generations.

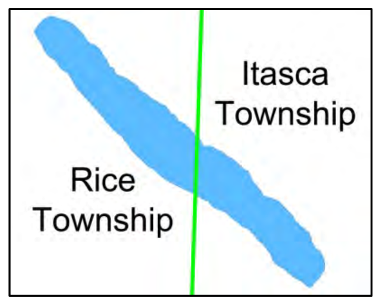
Phosphorus export, which is the main cause of lake eutrophication, depends on the type of land cover occurring in the lakeshed. Figure 17 depicts the land cover in Long Lake's lakeshed.

The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). Although this data is 12 years old, it is the only data set that is comparable over a decade's time. Table 10 describes Long Lake's lakeshed land cover statistics and percent change from 1990 to 2000. Due to the many factors that influence demographics, one cannot determine with certainty the projected statistics over the next 10, 20, 30+ years, but one can see the transition within the lakeshed from agriculture, grass/shrub/wetland, and water acreages to forest and urban acreages. The largest change in land use from 1990 to 2000 was an increase in grassland/wetland coverage (23 to 46 acres). The other categories did not change much.

Table 10. Long Lake's lakeshed land cover statistics and % change from 1990 to 2000 (http://land.umn.edu).

	1990		2000		% Change
Land Cover	**Acres**	**Percent**	**Acres**	**Percent**	**1990 to 2000**
Agriculture	42	5.46	34	4.42	19.0% Decrease
Forest	498	64.76	487	63.33	2.2% Decrease
Grass/Shrub/Wetland	23	2.99	46	5.98	100% Increase
Water	153	19.9	148	19.25	3.3% Decrease
Urban	49	6.37	51	6.63	4.1% Increase
Impervious Intensity %					
0	730	95.5	731	95.18	0.1% Increase
1-10	10	1.3	13	1.69	30% Increase
11-25	16	2.08	10	1.3	37.5% Decrease
26-40	9	1.17	6	0.78	33.3% Decrease
41-60	2	0.26	3	0.39	50% Increase
61-80	1	0.13	3	0.39	200% Increase
81-100	0	0	4	0.52	400% Increase
Total Area	769		769		
Total Impervious Area	8	1.3	11	1.77	37.5% Increase
(Percent Impervious Area Excludes Water Area)					

Demographics



Long Lake is classified as a recreational development lake. Recreational development lakes usually have between 60 and 225 acres of water per mile of shoreline, between 3 and 25 dwellings per mile of shoreline, and are more than 15 feet deep.

The Minnesota Department of Administration Geographic and Demographic Analysis Division extrapolated future population in 5-year increments out to 2035. Compared to Clearwater County as a whole, Rice and Itasca Townships have a lower extrapolated growth projection (Figure 18). Itasca's extrapolated growth is actually declining. (source:http://www.demography.state.mn.us/resource.html?Id=19332)

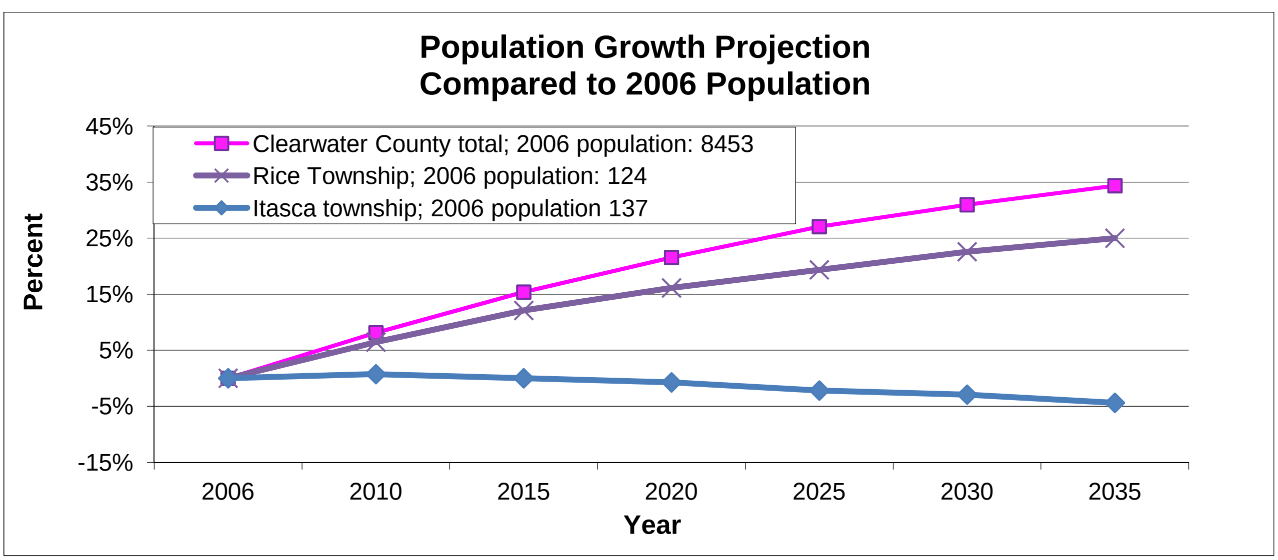


Figure 18. Population growth projection for Rice and Itasca Townships and Clearwater County.

Long Lake Lakeshed Water Quality Protection Strategy

Each lakeshed has a different makeup of public and private lands. Looking in more detail at the makeup of these lands can give insight on where to focus protection efforts. The protected lands (easements, wetlands, public land) are the future water quality infrastructure for the lake. Developed land and agriculture have the highest phosphorus runoff coefficients, so this land should be minimized for water quality protection.

The majority of the land within Long Lake's lakeshed is privately owned and forested uplands (Table 11). This land can be the focus of development and protection efforts in the lakeshed. This particular lakeshed also has very high county ownership (22.8%). A portion of the public ownership could be misleading as "protected" because it is a county park that is developed for camping and other recreational uses (i.e. swimming and fishing).

Table 11. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in Long lakeshed (Sources: Clearwater County parcel data, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (52%)					20%	Public (28%)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	4.2	1.5	43.1	2.6	0.6	20	22.8	5.2	0
Runoff Coefficient Lbs of phosphorus/acre/year	0.45 – 1.5	0.26 – 0.9	0.09		0.09		0.09	0.09	0.09
Estimated Phosphorus Loading Acreage x runoff coefficient	15 – 49	3 – 11	30		0		16	4	0
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Phase 3 Discussion Items	Shoreline restoration	Restore wetlands; CRP	Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives		Protected by Wetland Conservation Act		County Tax Forfeit Lands	State Forest	National Forest

DNR Fisheries approach for lake protection and restoration

Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 12). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 12. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.

Watershed Disturbance (%)	Watershed Protected (%)	Management Type	Comments
< 25%	> 75%	Vigilance	Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected.
	< 75%	Protection	Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%.
25-60%	n/a	Full Restoration	Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented.
> 60%	n/a	Partial Restoration	Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes.

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Long Lake's lakeshed is classified with having 50.6% of the watershed protected and 9.8% of the watershed disturbed (Figure 19). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use. Figure 20 displays all the land area that contributes water to Long Lake, whether through direct overland flow or through a creek or river. This particular lakeshed is a headwaters catchment, which means no additional lakesheds upstream contribute water to this area.

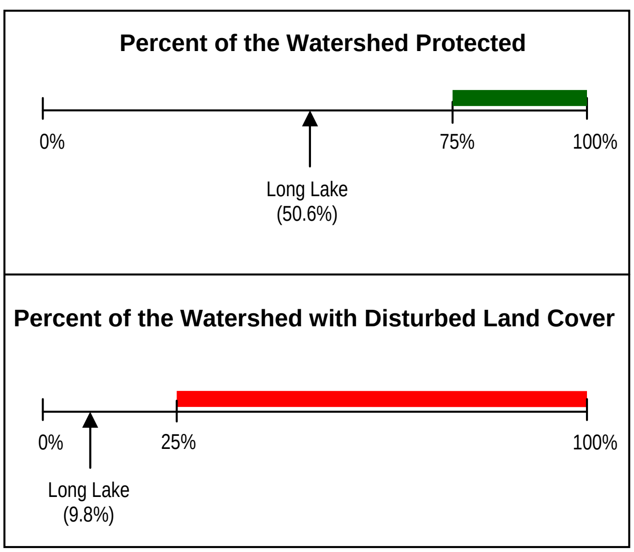


Figure 19. Long Lake's lakeshed percentage of watershed protected and disturbed.

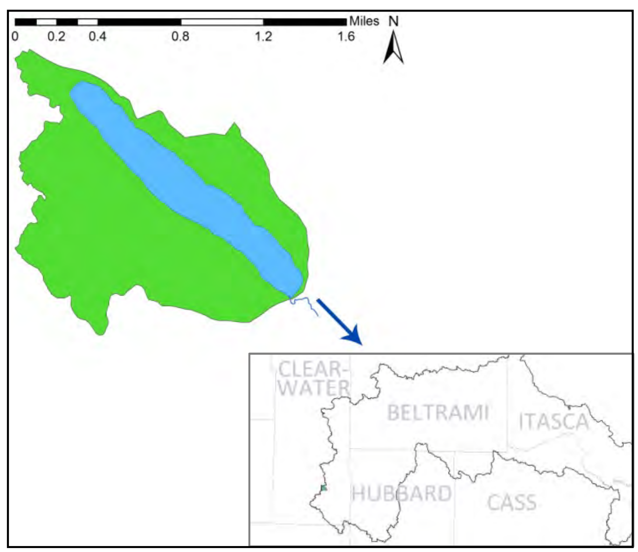


Figure 20. Upstream lakesheds that contribute water to the Long lakeshed. Color-coded based on management focus (table 12).

Status of the Fishery (DNR, as of 06/05/2006)

Long Lake is referred locally as South Long Lake. It is a 145-acre lake with a maximum depth of 80 feet located in Clearwater County. The lake is located 3 miles northwest of the town of Lake Itasca at the north entrance of Itasca State Park. There is a public access on the northwest end of the lake off of state hwy. 200. The access is located within Clearwater County Park that includes camping and a fishing pier adjacent to the access.

South Long Lake is managed as a two-story stream trout lake. Many stream trout lakes have been reclaimed (chemically treated to remove other species). Two-story management means it is managed for trout in addition to the resident warm-water species. South Long Lake is suitable for trout because of its characteristics of being deep, cool and having well oxygenated waters. Rainbow trout have been stocked since 1961.

Historically, northern pike abundance has been quite low in South Long Lake. This was an important consideration in selecting South Long Lake for trout management since pike can be a significant predator on trout. There is limited pike spawning habitat present within the lake due to its steep shoreline contours. A fish barrier exists between South Long Lake and Sucker Lake to the southeast. This barrier is intended to limit migration of pike between lakes since Sucker Lake has ample pike spawning habitat. An assessment in 1996 documented a dramatic increase in pike abundance resulting in a decline in trout abundance to the lowest level ever recorded. It is speculated that failure of the barrier allowed substantial migration of pike from Sucker Lake. Steps were taken to repair the fish barrier and five consecutive years of pike removal were conducted. By the 2001 assessment, pike abundance had been reduced substantially and has remained relatively low through this 2006 assessment.

Even after aggressive removal, it is recognized that some pike will always be present, so additional steps were implemented to reduce predation on trout. In 1998 the annual trout stocking program was switched from using smaller fingerling to larger yearling sized trout. The results of these management activities have been impressive. In the 2006 assessment, trout were sampled at a record high while pike numbers remain low. Trout sampled ranged in length from 10.5 to 19 inches with an average length and weight of 12.8 inches and 0.9 pound. Trout anglers have reported noticeable improvement in fishing success. In addition the remaining low-density pike population has exceptional growth rates, providing a limited but high quality pike fishery.

South Long Lake also maintains abundant populations of various species of sunfish including bluegill, pumpkinseed, green sunfish, rock bass, largemouth bass and black crappie. These species are not the main attraction but do provide some additional angling opportunity. See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=15005700

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at site 101 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Total Phosphorus and chlorophyll a monitoring should continue (site 101), as the budget allows, to track trends in water quality.

Overall Summary
Long Lake has excellent water quality. It is an oligotrophic lake (TSI = 35) with excellent lake user perceptions. Long Lake was rated as “crystal clear” or not quite crystal clear” 100% of the time during secchi depth readings in 2008 , 2009 and 2011. Long Lake is known for its scuba recreational opportunities. Long Lake does not currently have enough data to run trend analysis on transparency, chlorophyll *a* or total phosphorus data. This mirrors the chlorophyll *a* data, with the majority of results at or below 2 ug/L.

About half of the lakeshed is in private ownership (52%). The other area is open water (20%) and public ownership (28%). The majority of the private ownership is forested uplands (43.1%). The majority of public land is categorized under Clearwater County ownership (22.8%). The large area of public land south of the lake is a County Memorial Forest. The public land north of the lake is a mix of county land (Long Lake County Park) and state-owned land. The county land may be misleading as “protected” because this area is developed as a campground and park.

Long Lake is at an advantage in that it is a headwaters lakeshed and also does not have any inlets. This means that the main sources of phosphorus to the lake come from the surrounding shoreline.

Long Lake is unique in that it supports a stream trout fishery. The dissolved oxygen profile (Figure 9) shows that the hypolimnion is well-oxygenated. If these oxygen levels were to decline in the future, loss of trout could indicate eutrophication and/or climate change.

Priority Impacts to the lake
The priority impact to Long Lake is the existing lakeshore development and the potential for future developments. Long Lake is fortunate to have very low levels of phosphorus. When land transitions from forested uplands to developed land use, the runoff coefficient of estimated pounds of phosphorus/acre/year increases dramatically (Table 11). Without proper ordinances in place and best management practices installed to mitigate the effect of development, it could have a dramatic negative effect on Long Lake’s water quality.

Fortunately, it appears that the current parcel subdivisions are quite large, limiting the number of driveways and buildings, which are one of the reasons for the higher runoff coefficients. In addition, Highway 200 runs fairly close to the lake along the north side. Ideally, this land between the road and the lake should stay forested as it provides a buffer to containments from the road. Much of the land between Long Lake and Highway 200 is owned by the State of MN Departmant of Transportation. If this narrow strip of land is ever plotted for development, strict ordinances need to be in place to minimize the effect it would have on water quality.

Current lakeshore homeowners can minimize their impact on water quality by maintaining the existing tree canopies on their properties and installing buffers and native vegetation. Septic systems should be pumped regularly and maintained to ensure they are working properly.

Best Management Practices Recommendations
The management focus for Long Lake should be to protect the current water quality and maintain the low level of disturbed land use in the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, smart development, shoreline restoration, rain gardens, and septic system maintenance. In addition, Long Lake would benefit from the development of a lake management plan.

Project Implementation
The best management practices above can be implemented by a variety of entities. Some possibilities are listed below.

Individual property owners

- Shoreline restoration
- Rain gardens
- Aquatic plant bed protection (only remove a small area for swimming)

Lake Associations

- Lake condition monitoring
- Internal loading monitoring
- Ground truthing – visual inspection upstream on stream inlets
- Watershed mapping by a consultant
- Shoreline inventory study by a consultant

Soil and Water Conservation District (SWCD) and Natural Resources Conservation Service (NRCS)

- Shoreline restoration
- Stream buffers
- Work with farmers to
    - Restore wetlands
    - Implement conservation farming practices
    - Land retirement programs such as Conservation Reserve Program

Organizational contacts and reference sites

Lake Association	Mike Miller, President E-mail: mdm@mccollumlaw.com
DNR Fisheries Office	2114 Bemidji Avenue, Bemidji, MN 56601 218-308-2339 bemidji.fisheries@state.mn.us http://www.dnr.state.mn.us/areas/fisheries/bemidji/index.html
Regional Minnesota Pollution Control Agency Office	714 Lake Ave., Suite 220, Detroit Lakes, MN 56501 218-847-1519, 1-800-657-3864 http://www.pca.state.mn.us/yhiz3e0
Clearwater Soil and Water Conservation District	312 Main Avenue North, Suite 3, Bagley, Minnesota 56621 218.694.6845 http://www.clearwaterswcd.org/