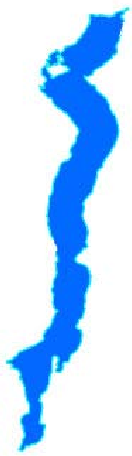
Long Lake 29-0161-00 HUBBARD COUNTY

Lake Water Quality

Summary



Long Lake is located a couple miles east of Park Rapids, Minnesota. It covers 1,926 acres and has a long, narrow shape.

Long Lake has two minor inlets and one outlet, which classifies it as a drainage lake. The inlets enter from Peysenske Lake to the east and from Sweitzer Lake to the north. The outlet is located at the south end of the lake, and flows into the Fishhook River, which joins the Shell River and eventually joins the Crow Wing River.

Water quality data have been collected on Long Lake since 1984 (Table 3). These data show that the lake is at the mesotrophic, which is characterized by moderately clear water throughout the summer and excellent recreational opportunities.

The Long Lake Area Association was formed in 1975, and its mission is “to be an advocate for the quality of life within our lake community through education and communication”. The Association is involved in many activities, including water quality monitoring, invasive species monitoring and education. They are also a member of the Hubbard County Coalition of Lake Associations (COLA).

Table 1. Long Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	29-0161-00	Surface area (acres):	1,926
County:	Hubbard	Littoral area (acres):	468
Ecoregion:	Northern Lakes & Forests	% Littoral area:	23%
Major Drainage Basin:	Upper Mississippi River	Max depth (ft), (m):	129, 41.1
Latitude/Longitude:	46.90444444 / -94.99250000	Inlets:	2
Invasive Species:	None as of 2011	Outlets:	1
		Public Accesses:	4

Table 2: Availability of data and an observation of the quantity of sample points.

Data Availability		
Transparency data		Excellent data set through the Citizens Lake Monitoring Program.
Chemical data		Excellent data set through the RMB Lab Lakes Program.
Inlet/Outlet data		No inlet data exist for this lake. There are data available for the outlet from 2007-2008.
Recommendations		**For recommendations refer to page 18.**

Lake Map

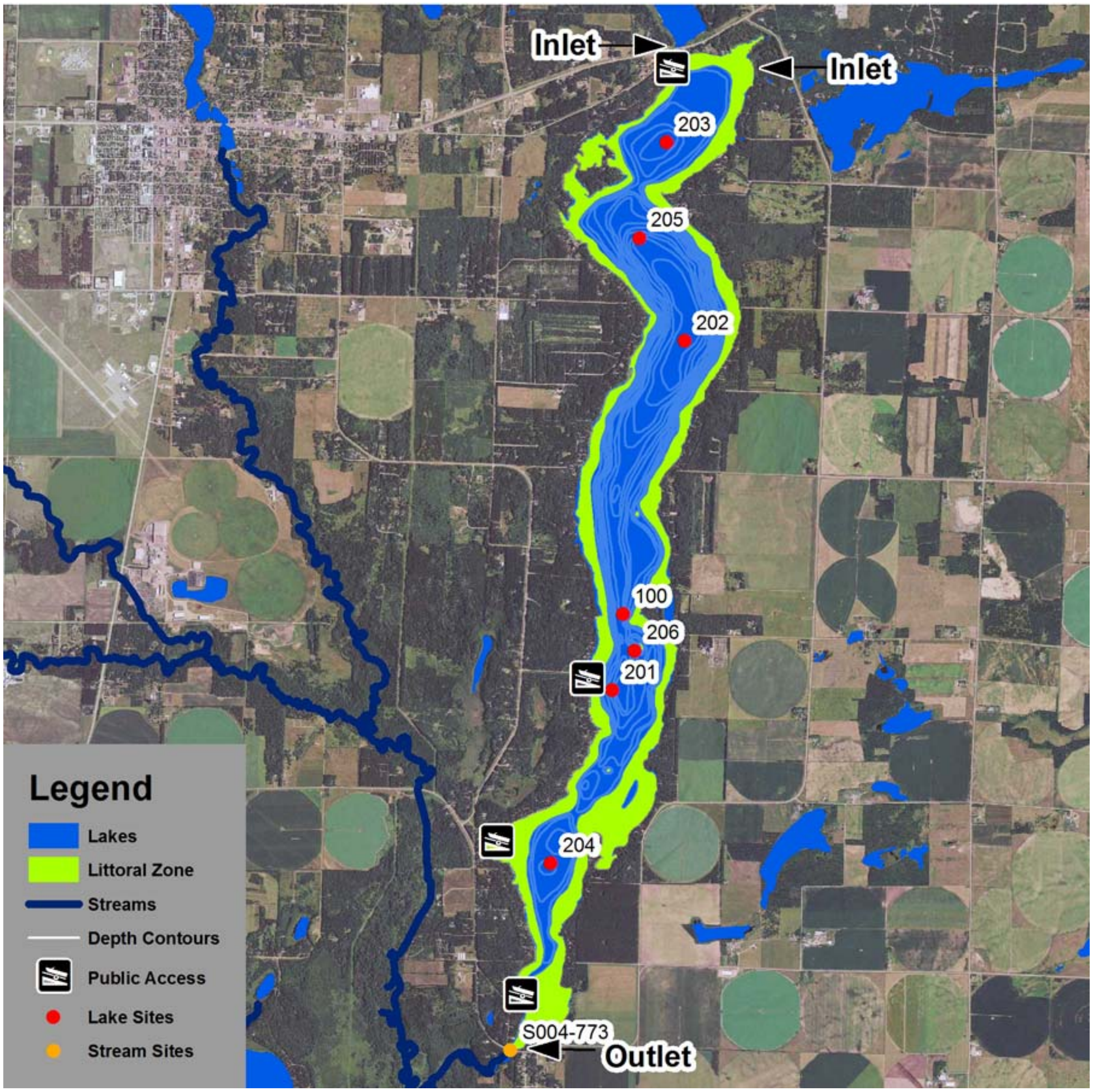


Figure 1. Map of Long Lake with 2010 aerial imagery and illustrations of sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Minnesota Pollution Control Agency (MPCA), Citizens Lake Monitoring Program (CLMP) and RMB Environmental Laboratories Lakes Program (RMBEL).

Lake Site	Depth (ft)	Monitoring Programs
201	70	CLMP: 1984-2007; MPCA: 1990, 1995, 2007
202* primary site	120	CLMP: 1990, 1994-2011; MPCA: 1990, 1995; RMBEL: 1997-2011
203	50	CLMP: 1990, 1994-2006; MPCA: 1990, 1995
204	40	CLMP: 1990, 1994-2003; MPCA: 1990
205	110	CLMP: 2004
206	50	CLMP: 2008-2010

Average Water Quality Statistics

The information below describes available chemical data for Long Lake through 2011. The data set is limited, and all parameters, with the exception of total phosphorus, chlorophyll *a* and secchi depth, are means for just 1990 and 1995 MPCA data.

Minnesota is divided into seven 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)	14	14 - 27	> 30	Results are within the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	6	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	17	<15		
Secchi depth (ft)	10.8	7.5 - 15	< 6.5	
Dissolved oxygen	Dimitic *see page 8*			Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kjeldahl Nitrogen (mg/L)	0.38	0.40 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	155	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	7	10 - 35		Indicates very clear water with little to no tannins (brown stain).
pH	8.5	7.2 - 8.3		Characteristic of a hard water lake. Lake water with 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		Slightly above the ecoregion average but still considered low level.
Total Suspended Solids (mg/L)	2	<1 - 2		Within the ecoregion average range.
Specific Conductance (umhos/cm)	281	50 - 250		Slightly above the ecoregion average.
Total Nitrogen :Total Phosphorus	27:1	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 202	Site 201	Site 203
Total Phosphorus Mean (ug/L):	**14**	**12**	**11**
Total Phosphorus Min:	<5	2	2
Total Phosphorus Max:	36	17	14
Number of Observations:	73	7	9
Chlorophyll *a* Mean (ug/L):	**6**	**6**	**4**
Chlorophyll-a Min:	<1	2	2
Chlorophyll-a Max:	17	15	9
Number of Observations:	77	7	9
Secchi Depth Mean (ft):	**10.8**	**11.5**	**10.7**
Secchi Depth Min:	6.5	6.5	6.5
Secchi Depth Max:	17.0	17.0	14.8
Number of Observations:	200	242	136

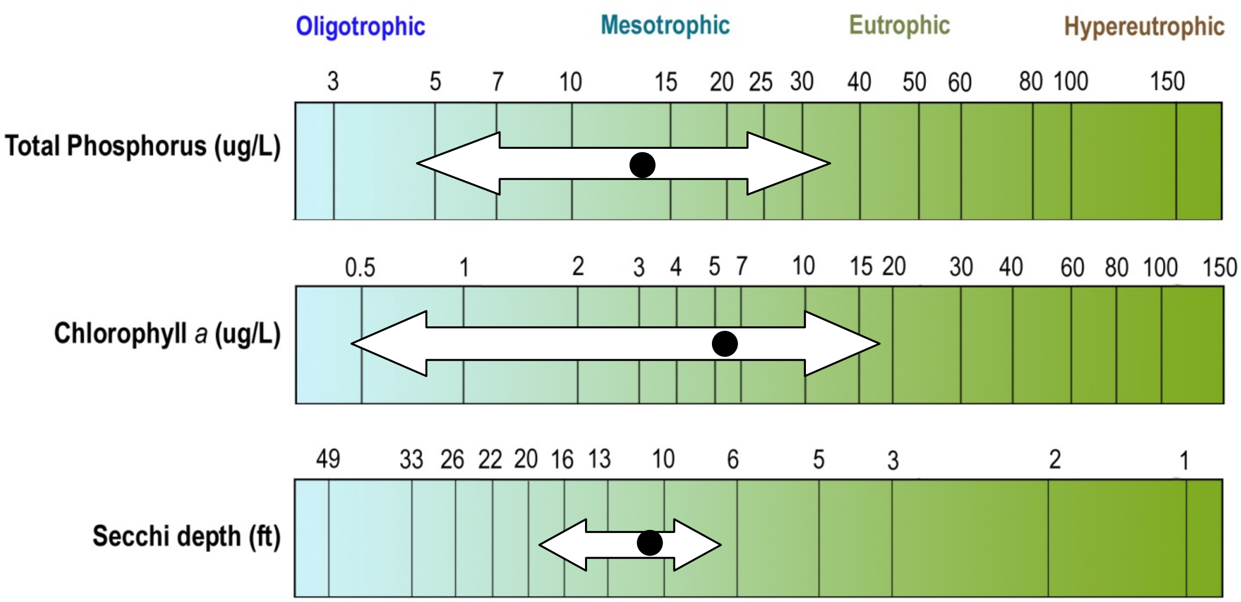


Figure 2. Long Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 202). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. 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 annual mean transparency for Long Lake ranges from 9.0-13.8 ft (Figure 3). Transparency is very uniform across all three sites. Transparency monitoring should be continued at all sites to track water quality in Long Lake.

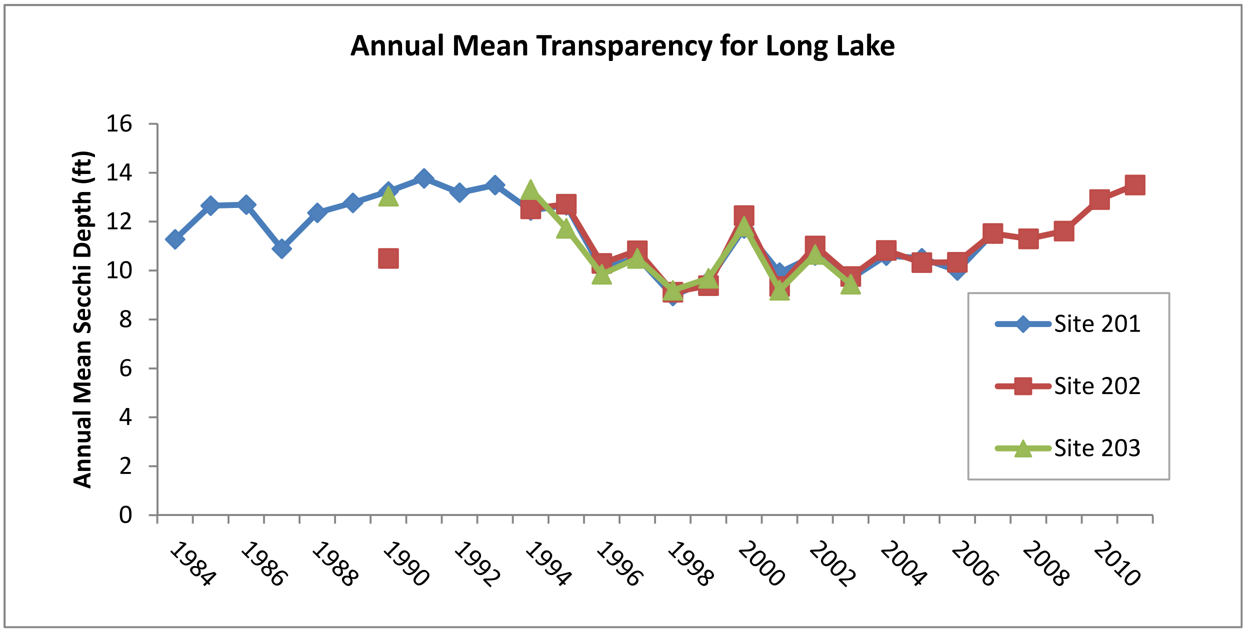


Figure 3. Annual mean transparency for Long Lake.

Long Lake transparency ranges from 6.5 to 17 feet throughout the summer. Figure 4 shows the seasonal transparency dynamics. The Long Lake transparency remains somewhat steady most of the year. Some lakes change a lot during the year and some stay the same. 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 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.

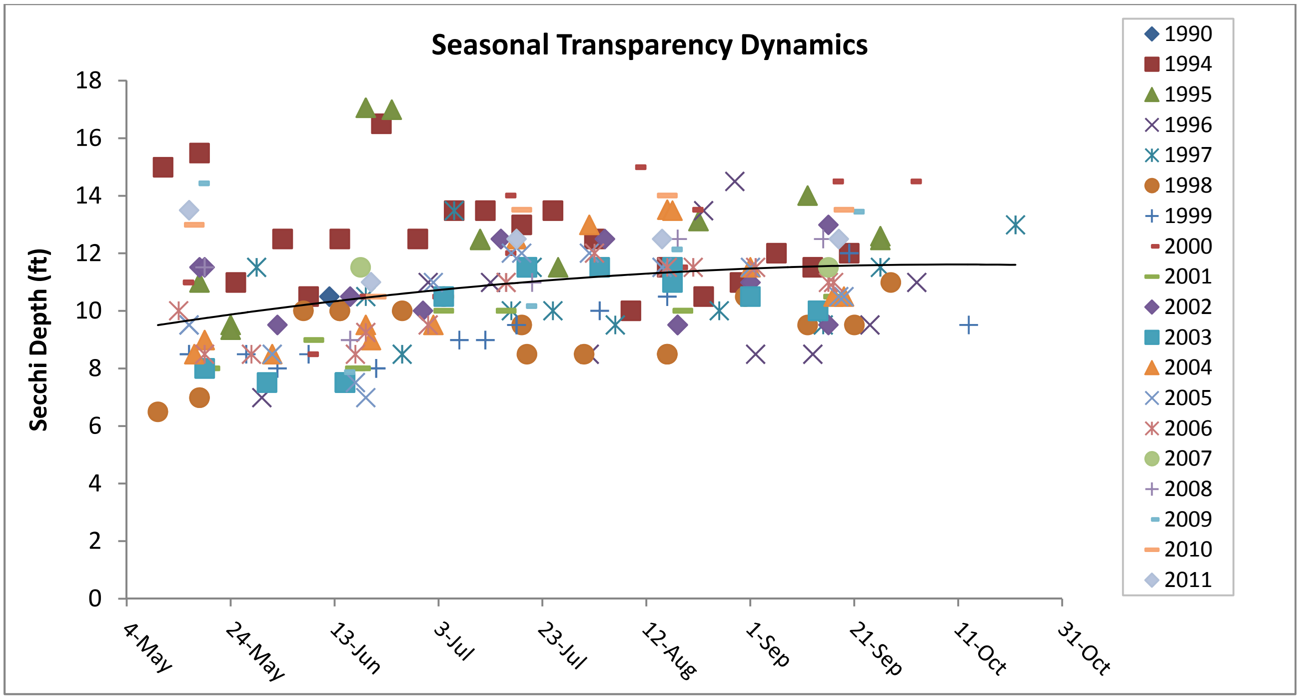


Figure 4. Seasonal transparency dynamics and year-to-year comparison (site 202). The black line represents the pattern in the data.

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" 69% of the time between 1994-2010 (Figure 5).

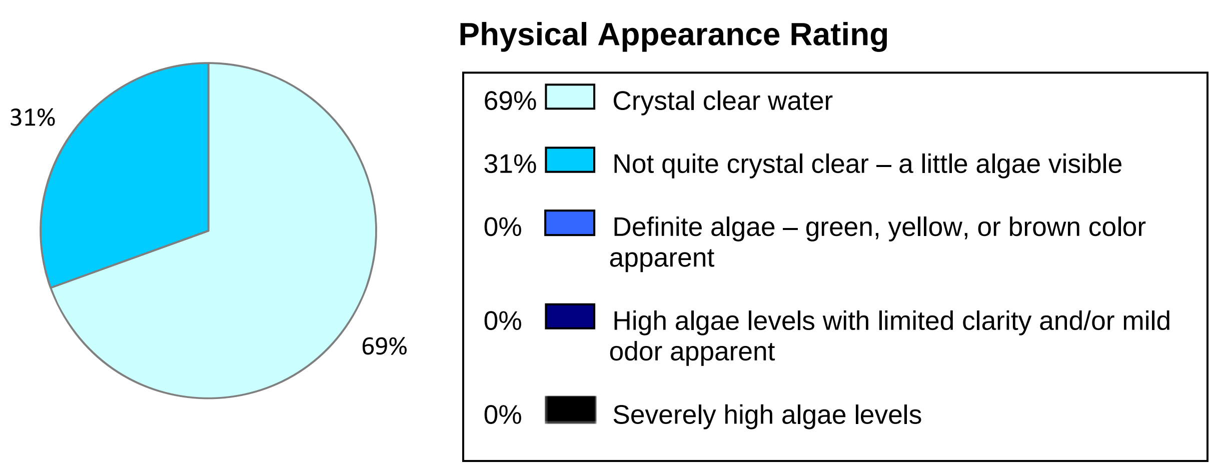


Figure 5. Physical appearance rating, as rated by the volunteer monitor.

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Long Lake was rated as being "beautiful" 75% of the time from 1994-2010.

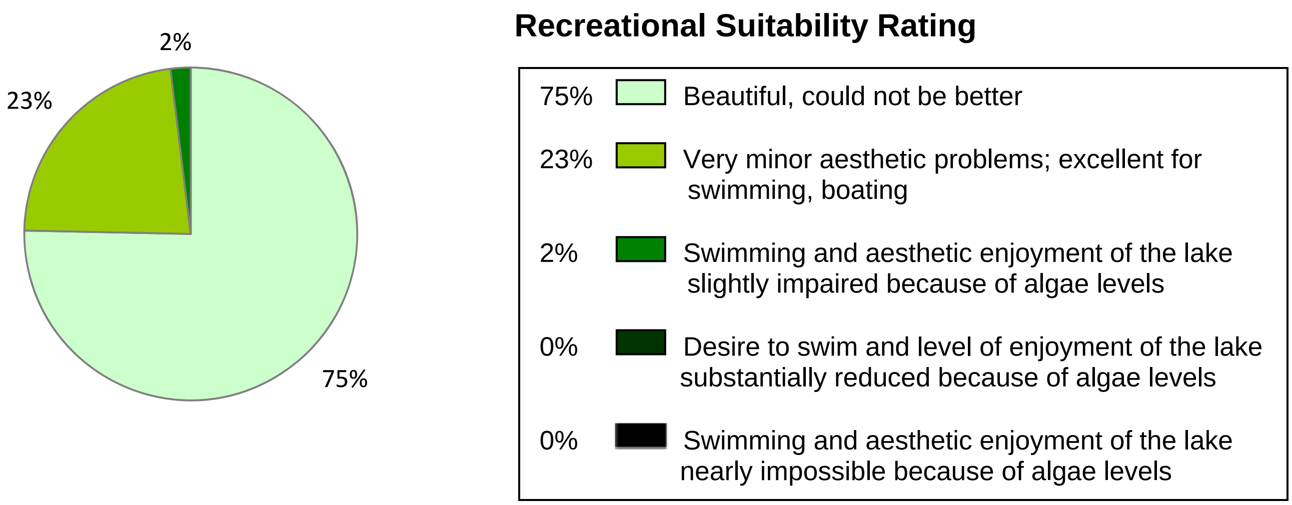


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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 1997-2011. Most of the data points fall into the mesotrophic range (Figure 7). There is not much seasonal variation in phosphorus concentration for Long Lake.

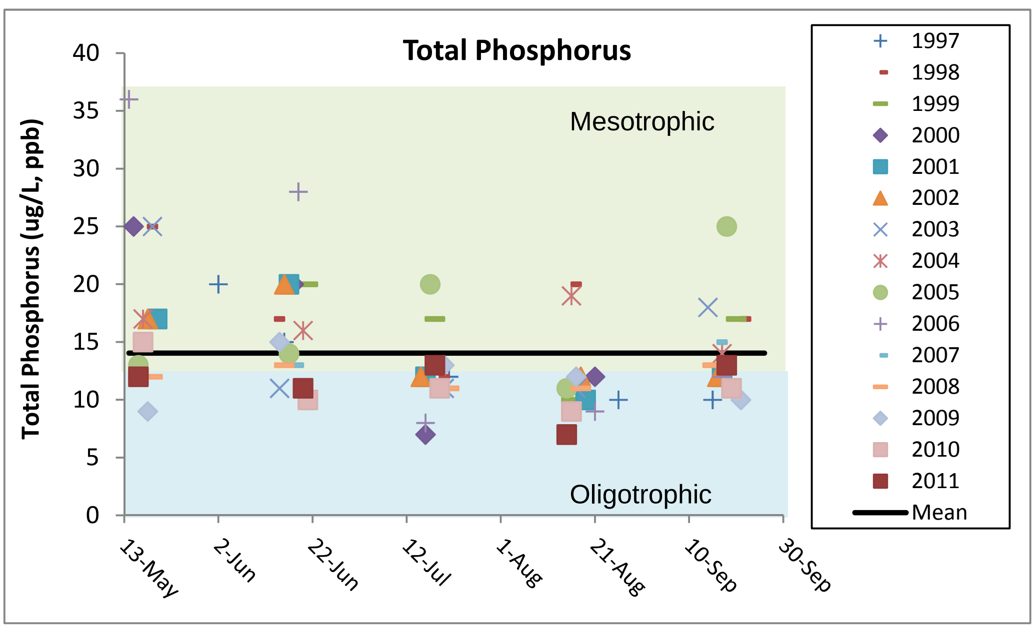


Figure 7. Historical total phosphorus concentrations (ug/L) at site 202 for Long Lake.

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 determine 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.

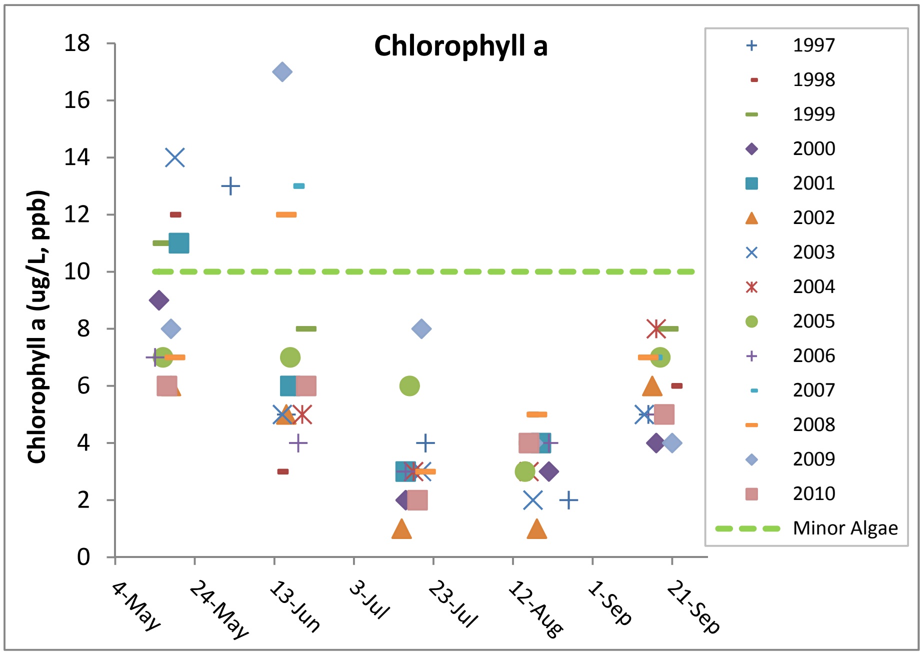
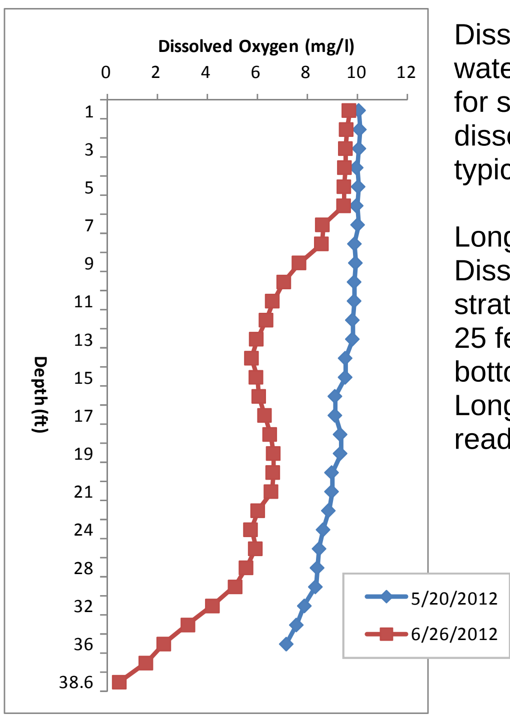


Figure 8. Chlorophyll *a* concentrations (ug/L) for Long Lake.

Chlorophyll *a* was evaluated in Long Lake in 1997-2011 (Figure 8). Chlorophyll *a* concentrations were above 10 ug/L in the spring, indicating nuisance algae blooms. These algae blooms could be from phosphorus runoff in the watershed in the spring.

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 fisheries.

Long Lake is a deep lake, with a maximum depth of 129 ft. Dissolved oxygen profiles from 2012 indicate that Long Lake stratifies in the summer (Figure 9). The thermocline occurs around 25 feet, although the oxygen only drops below 5 mg/L at the very bottom of the lake. This is excellent habitat for Cisco (Tullibee) fish. Long Lake is designated by the DNR as a Cisco refuge lake. To read more about this designation, see page 17.

Figure 9. Dissolved oxygen profiles for Long Lake in 2012, MN DNR.

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 mesotrophic 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). The TSI for chlorophyll a is slightly higher than the other two parameters. This could be due to the higher chlorophyll a concentrations in the spring (Figure 8).

Mesotrophic lakes (TSI 40-50) are characterized by moderately clear water most of the summer (Table 7). "Meso" means middle or mid; therefore, mesotrophic means a medium amount of productivity. Mesotrophic lakes are commonly found in central Minnesota and have clear water with algal blooms in late summer. They are also good for walleye fishing.

Table 6. Trophic State Index.

Trophic State Index	Site 202
TSI Total Phosphorus	42
TSI Chlorophyll-a	48
TSI Secchi	43
TSI Mean	44
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

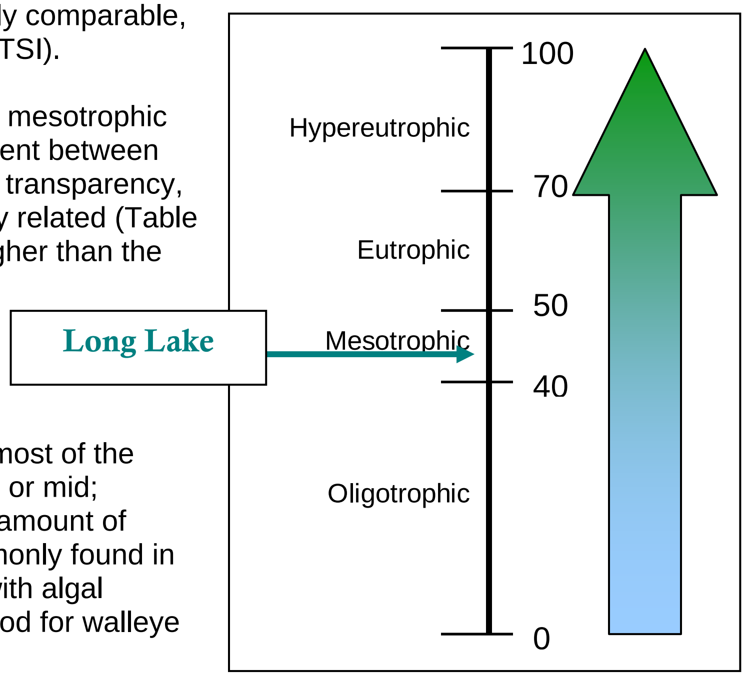


Figure 10. Trophic state index chart with corresponding trophic status.

Table 7. Trophic states and corresponding lake and fishery conditions.

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.

There is enough historical data to perform trend analysis for total phosphorus, chlorophyll *a,* and transparency on Long Lake (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Long Lake.

Lake Site	Parameter	Date Range	Trend	Probability
201	Transparency	1984-2006	Declining	95%
202	Transparency	1994-2011	No trend	-
202	Transparency	2000-2011	Improving	80%
202	Total Phosphorus	1997-2011	No trend	-
202	Chlorophyll a	1997-2011	No trend	-

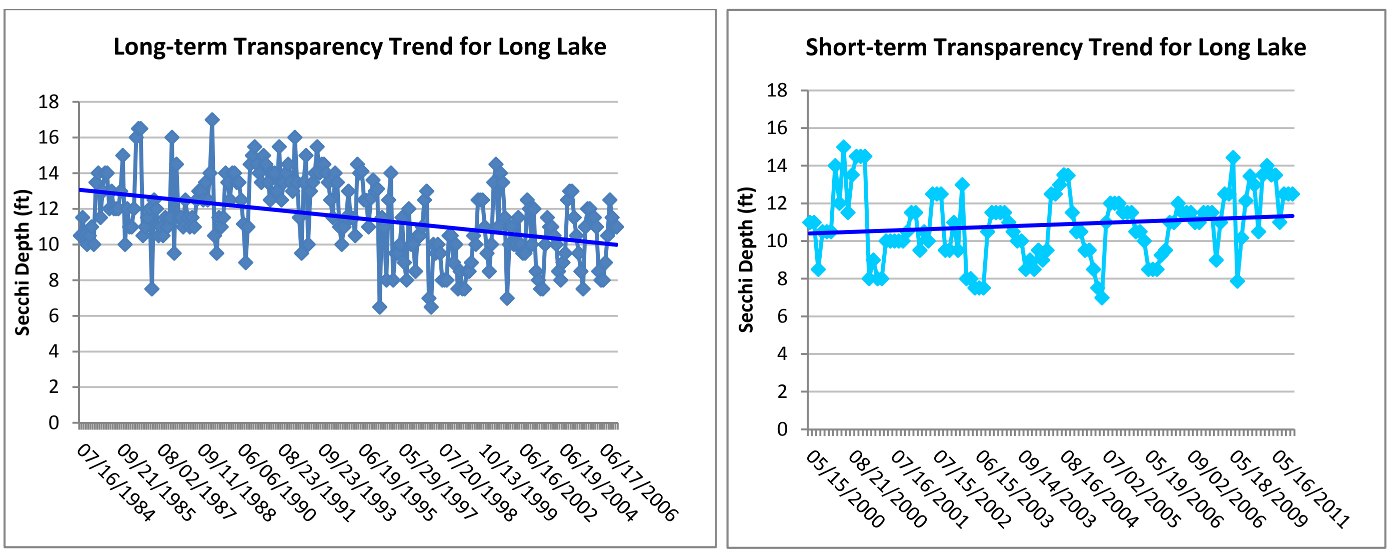


Figure 11. Long-term and short-term transparency trends for Long Lake.

Long Lake has a declining long-term water quality trend in transparency from 1984-2007, but an improving short-term trend in transparency from 2000-2011 (Figure 11). Annual transparency means declined in the mid 1990s, reaching their lowest in 1998 at 9 feet. Since the early 2000s, the transparency has been increasing, with 2010-2011 reaching pre 1990s averages again (12.5 feet). Monitoring should continue at site 201 and 202 so that this trend can be tracked in future years. If the short-term improving trend continues, the lake could return to its original clarity in the late 1980s.

Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology (Figure 12). 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.

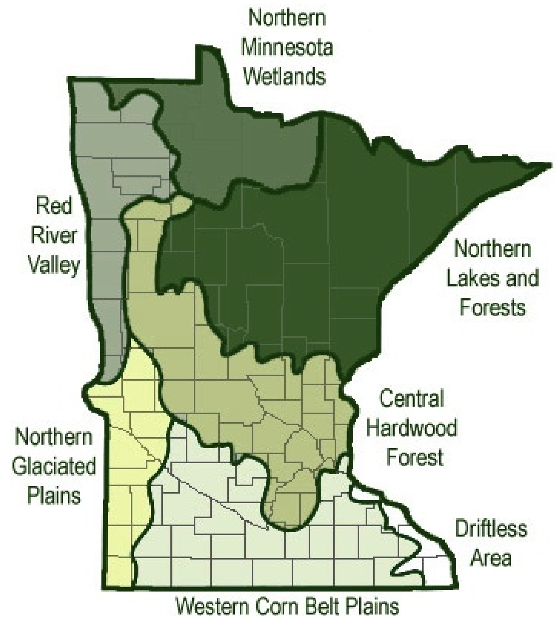
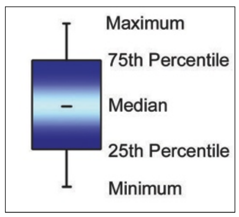
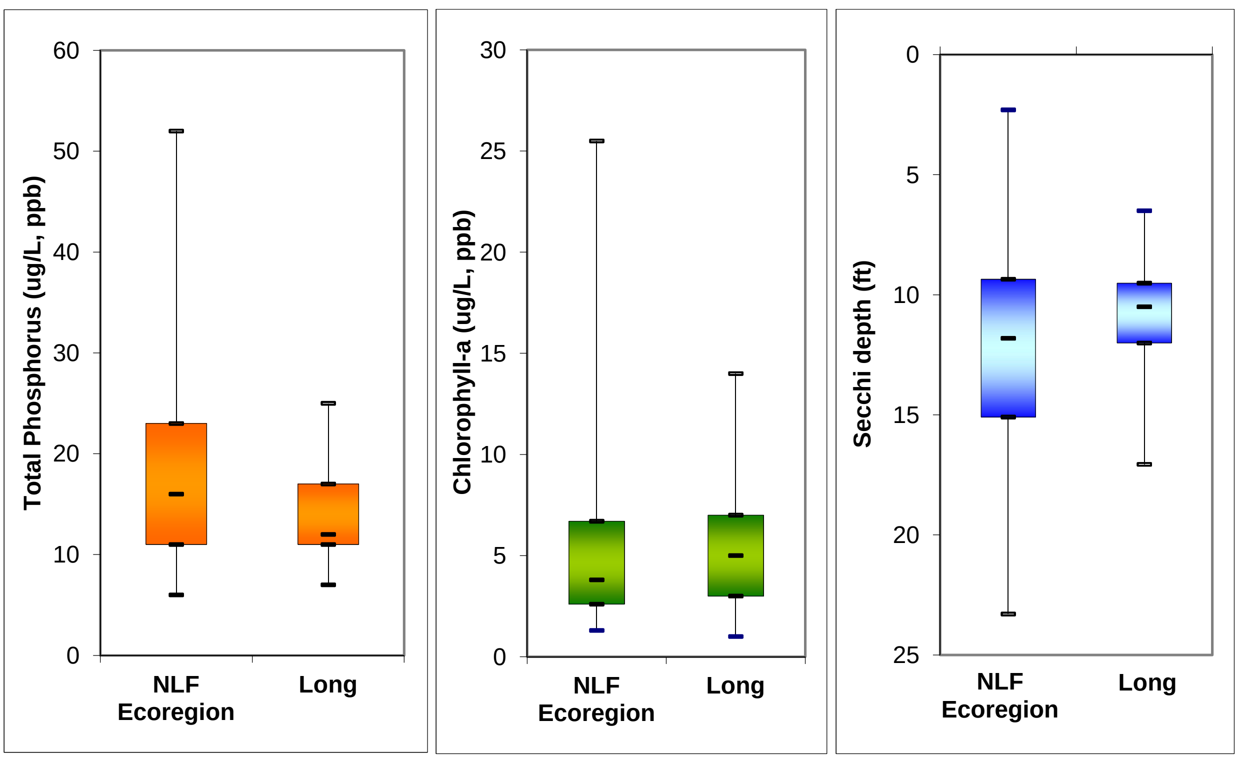


Figure 12. Map of Minnesota with the seven ecoregions.

Long Lake is in the Northern Lakes and Forests Ecoregion. The means for phosphorus, chlorophyll a and transparency are within the ecoregion ranges (Fig 13).





Figures 13a-c. Long Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Long Lake total phosphorus and chlorophyll *a* ranges are from 77 data points collected in May-September of 1997-2011. The Long Lake Secchi depth range is from 200 data points collected in May-September from 1994-2011.

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 **Crow Wing River Major Watershed** is one of the watersheds that make up the Upper Mississippi River Basin, which begins at Itasca State Park and drains south towards the Gulf of Mexico (Figure 14). This major watershed is made up of 136 minor watersheds. Long Lake is located in **minor watershed 12023** (Figure 15).

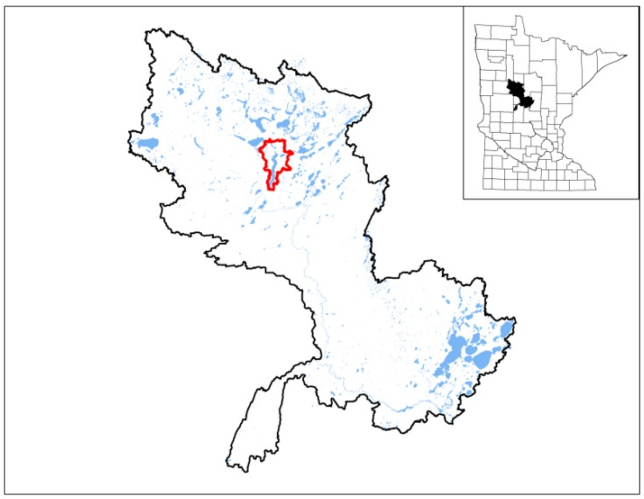


Figure 14. Crow Wing River Major Watershed.

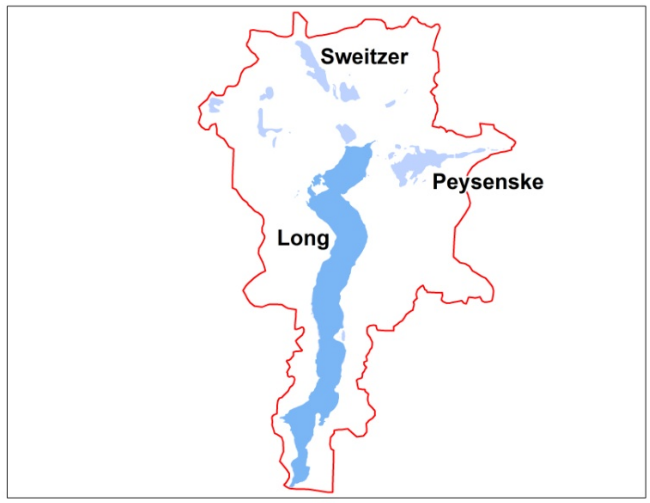


Figure 15. Minor Watershed 12023

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 number **1202300** (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 draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks. For further discussion of Long Lake's full watershed, containing all the lakesheds upstream of Long Lake lakeshed, see page 5. The data interpretation of the Long Lake lakeshed includes only the immediate lakeshed, as this area is the land surface that flows directly into Long Lake.

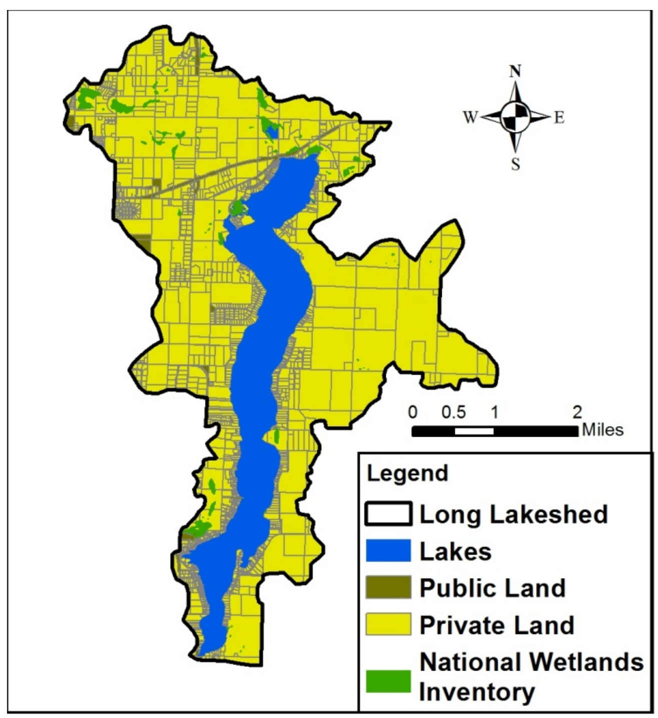


Figure 16. Long Lake Lakeshed (1202300) with land ownership, lakes, and wetlands illustrated.

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

● Possibly detrimental to the lake
◉ Warrants attention
○ Beneficial to the lake

Table 9. Lakeshed vitals for Long Lake.

Lakeshed Vitals		**Rating**
Lake Area	1926 acres	descriptive
Littoral Zone Area	468 acres	descriptive
Lake Max Depth	129 ft.	descriptive
Lake Mean Depth	36.9 ft.	○
Water Residence Time	4 years	○
Miles of Stream	0	descriptive
Inlets	2	◉
Outlets	1	◉
Major Watershed	12 - Crow Wing River	descriptive
Minor Watershed	12023	descriptive
Lakeshed	1202300	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	6:1	◉
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	8:1	○
Wetland Coverage	2%	○
Aquatic Invasive Species	None	○
Public Drainage Ditches	None	○
Public Lake Accesses	4	◉
Miles of Shoreline	18.9	descriptive
Shoreline Development Index	3.1	●
Public Land : Private Land (excludes water)	0.04:1	◉
Development Classification	Recreational Development	◉
Miles of Road	53.3	descriptive
Municipalities in lakeshed	Park Rapids	●
Forestry Practices	2002 Hubbard County Forest Resources Management Plan	○
Feedlots	3	●
Sewage Management	Individual waste treatment systems (last lake-wide county inspection - 1993)	○
Lake Management Plan	Healthy Lakes & Rivers Partnership program, 2005, 2010	○
Lake Vegetation Survey/Plan	None	◉

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.

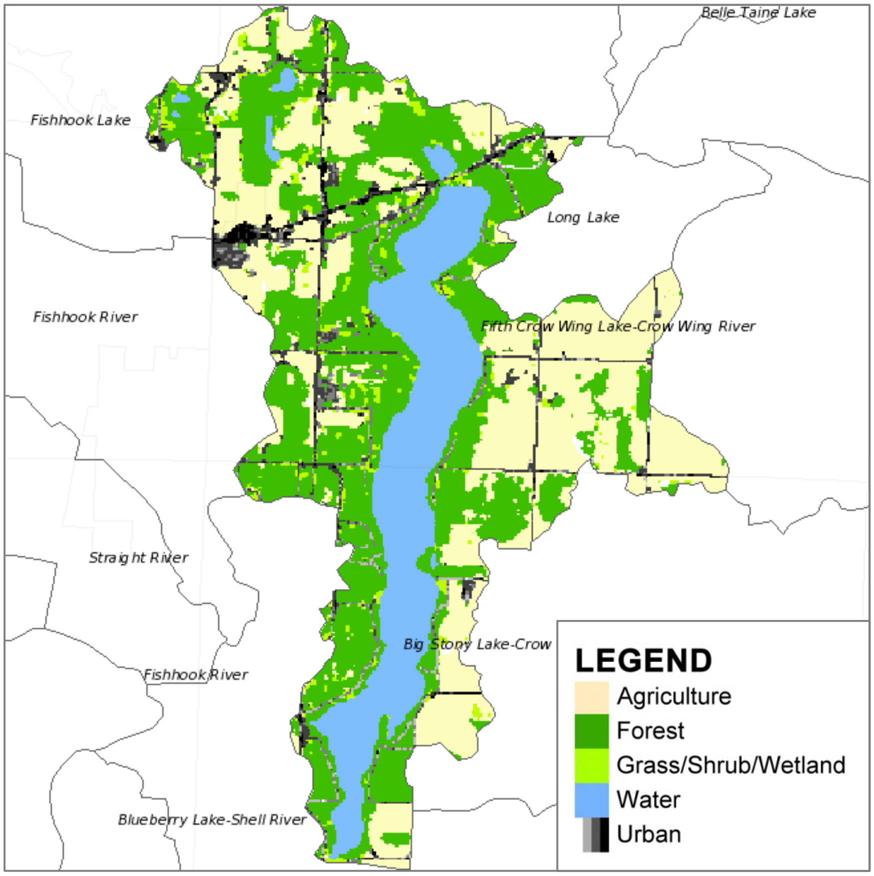


Figure 17. Land use/land cover for Long Lake lakeshed (1202300) (http://land.umn.edu).

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). This data is somewhat outdated, but it is the most recent comparable data available. 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 percentage is the increase in urban cover (44.2%, 299 acres); however, in acreage, forest cover has increased the most (563 acres). In addition, the impervious intensity has increased, which has implications for storm water runoff into the lake. The increase in impervious intensity is consistent with the increase in urban acreage.

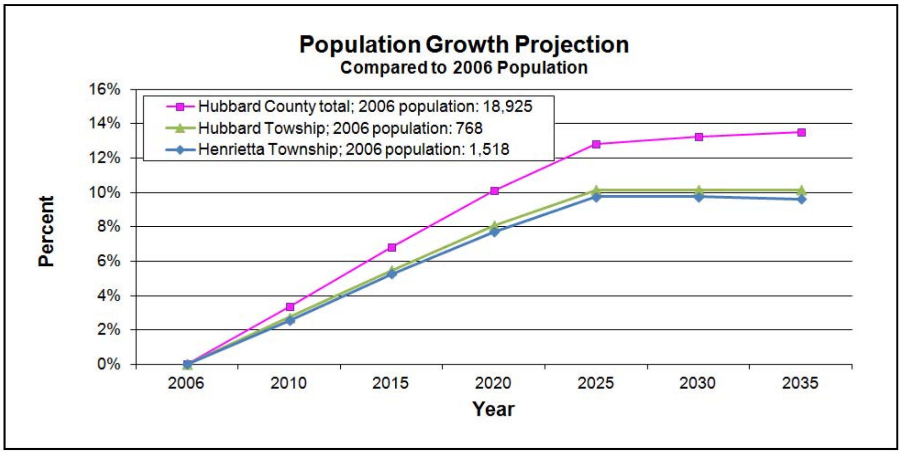
Table 10. Long Lake's lakeshed land cover statistics and % change from 1990 to 2000 (http://land.umn.edu).

	1990		2000		% Change
Land Cover	**Acres**	**Percent**	**Acres**	**Percent**	**1990 to 2000**
Agriculture	4217	38.15	3542	32.04	16% Decrease
Forest	3637	32.9	4200	37.99	15.5% Increase
Grass/Shrub/Wetland	431	3.9	358	3.24	16.9% Decrease
Water	2093	18.93	1978	17.89	5.5% Decrease
Urban	676	6.11	975	8.82	44.2% Increase
Impervious Intensity %					
0	10393	94.04	10091	91.3	2.9% Decrease
1-10	109	0.99	128	1.16	17.4% Increase
11-25	173	1.57	235	2.13	35.8% Increase
26-40	141	1.28	238	2.15	68.8% Increase
41-60	146	1.32	235	2.13	61% Increase
61-80	82	0.74	98	0.89	19.5% Increase
81-100	7	0.06	26	0.24	271.4% Increase
Total Area	11055		11055		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	219	2.44	334	3.68	52.5% Increase

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. These projections are shown in Figure 18 below. Compared to Hubbard County as a whole, Hubbard and Henrietta Township have a lower extrapolated growth projection.



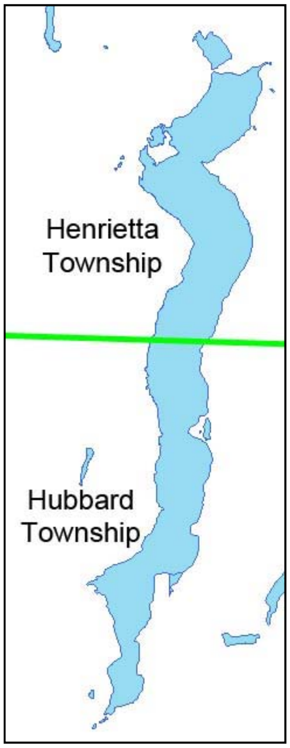


Figure 18. Population growth projection for Hubbard Township, Henrietta Township and Hubbard County. (source: http://www.demography.state.mn.us/resource.html?Id=19332)

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 made up of private forested uplands and agriculture (Table 11). This land can be the focus of development and protection efforts in the lakeshed. Almost all county land consists of roads, which would have a runoff coefficient similar to developed lands.

Table 11. Percent land use in private versus publicly owned land with corresponding phosphorus loading and protection/restoration ideas (Sources: Minnesota DNR GAP Stewardship data, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (79%)					18%	Public (3%)		
	Developed	Agriculture	Forested Uplands	Other	Wetlands	Open Water	County	State	Federal
Land Use (%)	4.7%	28.7%	39%	5%	1.6%	18%	2.96%	.04%	.006%
Runoff Coefficient Lbs of phosphorus/acre/year	0.45 – 1.5	0.26 – 0.9	0.09		0.09		0.45 – 1.5	0.09	0.09
Estimated Phosphorus Loading Acreage x runoff coefficient	232 – 772	825 – 2857	388		16		147 – 492	0.4	0.06
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.

The Long Lake lakeshed is classified with having 22.3% of the watershed protected and 36.3% of the watershed disturbed (Figure 19). Therefore, Long Lake should have a full restoration focus (yellow). By reducing the disturbed land percentage and implementing BMPs, this lake has a realistic chance for full restoration of water quality and improving the quality of fish communities. In addition, Long Lake was designated by DNR Fisheries as a high valued fishery lake because of its cisco population.

Figure 20 displays the upstream lakesheds that contribute water to the lakeshed of interest. All of the land and water area in this figure has the potential to contribute water to Long Lake, whether through direct overland flow or through a creek or river. The entire watershed of Long Lake should have a restoration focus.

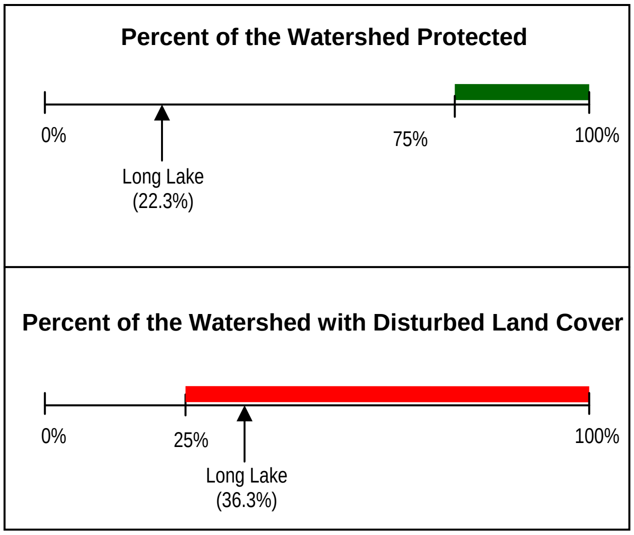


Figure 19. Long Lake lakeshed's percentage of watershed protected and disturbed.

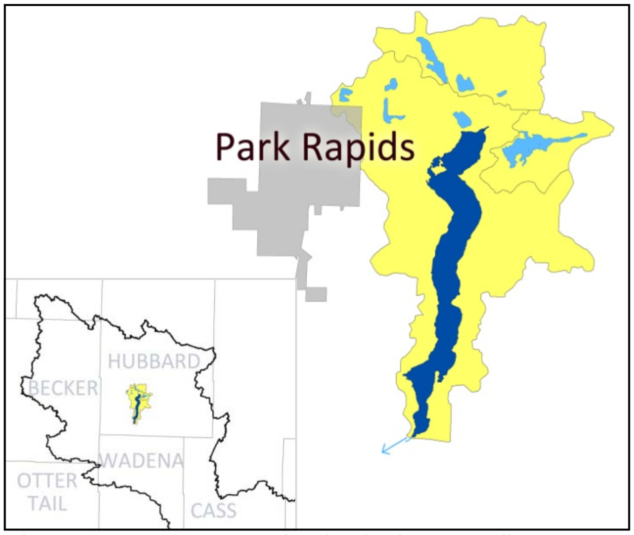


Figure 20. Upstream lakesheds that contribute water to the Long lakeshed. Color-coded based on management focus (Table 3).

Long, Status of the Fishery (as of 07/09/2009)

Long Lake is located two miles east of Park Rapids in Hubbard County. Long Lake has a surface area of 1,974 acres and a maximum depth of 135 feet. Long Lake is eight miles long from north to south end. Long Lake has heavy home/cabin development for this area and is a very popular lake for fishing and other water recreation. The Minnesota Department of Natural Resources (DNR) has classified Minnesota's lakes into 43 different types based on physical, chemical, and other characteristics. Long Lake is in lake class 22. Other Park Rapids area lakes in this same classification include: Big Sand, Lower Bottle, Kabekona, and Potato.

Long Lake is a popular walleye lake and is known for producing some large fish. Walleye abundance (5.8 walleye/gillnet) was near the current management goal of 6.0 walleye/gillnet, similar to recent surveys. Sampled walleye had an average length and weight of 17.0 inches and 2.1 pounds, with fish measured up to 28.5 inches. Important walleye forage species such as yellow perch and tullibee (cisco) were sampled in good numbers. Long Lake is currently stocked with walleye fingerlings during even numbered years.

Northern pike were sampled in moderate numbers (5.9 pike/gillnet), within the range "typical" for this lake class. Sampled northern pike had an average length and weight of 22.7 inches and 3.0 pounds, with pike measured up to 35.0 inches. A good tullibee (cisco) forage base provides the conditions to produce large pike.

Black crappie fishing is popular right after ice-out on the north end of the lake in an area known as "the fill". Black crappie abundance in Long Lake has remained fairly stable, generally at low to moderate levels. Anglers will find good numbers of bluegill and pumpkinseed in Long, however, average size is poor (5.2 inches). Larger bluegill are present in Long, however, the size of bluegill is limited by slow growth rates.

Long Lake supports a healthy largemouth bass population, especially in the north and south bays where there is shallower water and good beds of submerged aquatic vegetation which provides excellent habitat. Anglers will find good numbers of bass in the 12-14 inch size range as well as larger fish.

Other species sampled included high numbers of rock bass, yellow bullhead, and white sucker and low numbers of brown bullhead, bowfin (dogfish), and hybrid sunfish.

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=29016100

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at site 202 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. Phosphorus and chlorophyll a monitoring should continue, as the budget allows, to track future water quality trends.

Overall Conclusions
Long Lake is a mesotrophic lake (TSI=44). The DNR has designated Long Lake as a Cisco refuge lake, which requires cold deep water with high dissolved oxygen levels. Three percent (3%) of the lakeshed is in public ownership, and 22% of the watershed is protected, while 36.3% of the watershed is disturbed (Figure 6).

Long Lake has a declining long-term water quality trend in transparency from 1984-2007, but an improving short-term trend in transparency from 2000-2011 (Figure 21). Annual transparency means declined in the mid 1990s, reaching their lowest in 1998 at 9 feet. Since the early 2000s, the transparency has been increasing, with 2010-2011 reaching pre 1990s averages again (12.5 feet).

In the mid-1990s, Hubbard County conducted septic system upgrades around the lake, which could have contributed to the improving trend in transparency since then.

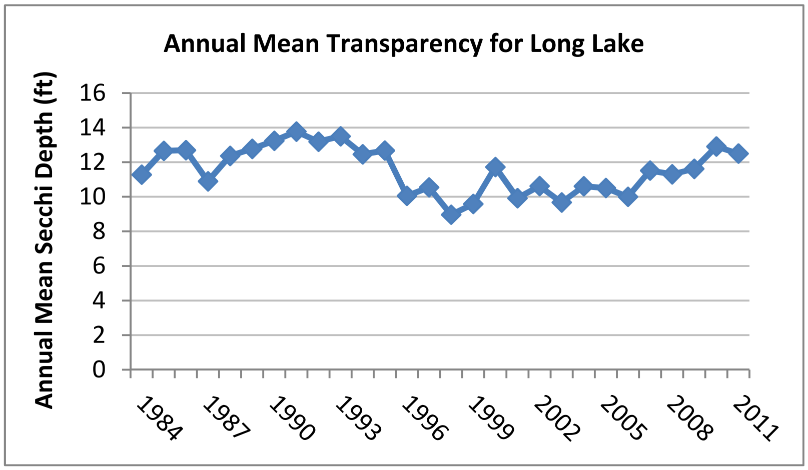


Figure 21. Long Lake annual mean transparencies from 1984-2011.

Long Lake is at an advantage that it has a small watershed (8:1 watershed to lake area ratio), and only minor inlets. This means that improvements made in the lakeshed should have a direct improvement on the lake's water quality.

Priority Impacts to the lake

There is a high degree of agriculture in the lakeshed (28.7%) that extends very close to the lake's eastern shoreline. In addition, both the first and second tiers around the lake are highly developed. Additional land parcel subdivision is occurring for development in forested sections. There are 53 miles of road in the lakeshed, which is high relative to the lakeshed land area. The lake needs to be better protected from runoff from these land uses.

Chloride levels and specific conductivity in the lake are slightly higher than other area lakes, which could be due to all the road runoff and impervious surfaces around the lake.

Thirty-nine percent (39%) of the lakeshed is forested uplands. Large tracts of land, near the shoreline, appear to be forested plots for silviculture. When these tracts of land are logged, best management techniques should be used to minimize the effect on Long Lake's water quality.

Best Management Practices Recommendations

The management focus for Long Lake should be to restore the lakeshed by decreasing the impact of the impervious surface in the lakeshed. Although it may not be possible to decrease the impervious area in the lakeshed, it is possible to reduce the impact of the impervious surface by retaining stormwater instead of allowing it to runoff into the lake. Project ideas include shoreline restorations on lakeshore property, rain gardens in the city and around the lake, and enforcement of county shoreline ordinances that limit impervious surface.

In addition, efforts can go into improving lake protection from agriculture runoff through wetland restoration, shoreline buffers (especially on the eastern side from agriculture) and additional forest cover.

Targeted placement of best management practices can increase their cost effectiveness. Individual parcel assessment of percent impervious cover and proximity to a river or the shoreline is one way to rank priority. Flow analysis using GIS software could also pinpoint locations where water accumulates into a swale or depression.

Future Studies
A GIS flow analysis of the lakeshed could better pinpoint the areas where restoration will have the greatest positive impact.

Organizational contacts and reference sites

Long Lake Area Association	http://www.longlakeliving.org/
DNR Fisheries Office	301 South Grove Avenue, Park Rapids, MN 56470 218-732-4153 parkrapids.fisheries@state.mn.us http://www.dnr.state.mn.us/areas/fisheries/parkrapids/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
Hubbard County Soil and Water Conservation District	212 1/2 2nd St W, Park Rapids MN 56470 218-732-0121 http://www.hubbardswcd.org/