Upper South Long Lake 18-0096-00 CROW WING COUNTY

Lake Water Quality

Summary

Upper South Long Lake is located 6 miles southeast of Brainerd, MN in Crow Wing County. It has an oblong shape, orientated southwest to northeast that covers 795 acres.

Upper South Long Lake has four inlets and one outlet, which classifies it as a drainage lake (Figure 1). Water flows into the lake on the northeast shore through the Nokasippi River. This inlet receives water from Lookout, Clearwater, Eagle, Heron, and Nokay Lakes. The two additional inlets along the west shore drain relatively small acreage. The fourth inlet is located along the south shore, which drains from a small catchment area southeast of the lake. The outlet is located at the southernmost tip of the lake, where the Nokasippi River flows into South Long Lake, eventually joining the Mississippi River near Fort Ripley.

Water quality data have been collected on Upper South Long Lake in 1973, 1976-1980, 1986-2011. These data show that the lake is on the mesotrophic/eutrophic border, which characteristically has moderately clear water most of the summer (page 9).

The Upper South Long Lake Improvement Association was formed in 1980 by concerned lake residents who felt the need, "to work together with others to use, enjoy, and maintain our lake wisely while protecting it for our children, grandchildren and generations to come." The association works closely with the MN DNR to control Curlyleaf Pondweed. In 2010, the lakeshore owners successfully petitioned for the creation of a Lake Improvement District (LID).

Table 1. Upper South Long Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	18-0096-00	Surface area (acres):	795 acres
County:	Crow Wing	Littoral area (acres):	243 acres
Ecoregion:	Northern Lakes and Forests	% Littoral area:	30%
Major Drainage Basin:	Upper Mississippi River	Max depth (ft), (m):	47, 14
Latitude/Longitude:	46.307921, -94.035072	Inlets:	4
Invasive Species:	None as of 2011	Outlets:	1
		Public Accesses:	1

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

Data Availability

Transparency data		Good data set from 1989-2010 through the CLMP.
Chemical data		Good amount of phosphorus and chlorophyll a data, but it is too fragmented to do a trend analysis.
Inlet/Outlet data		Data set from 2007-2008.

Recommendations **For recommendations refer to page 19.**

Lake Map

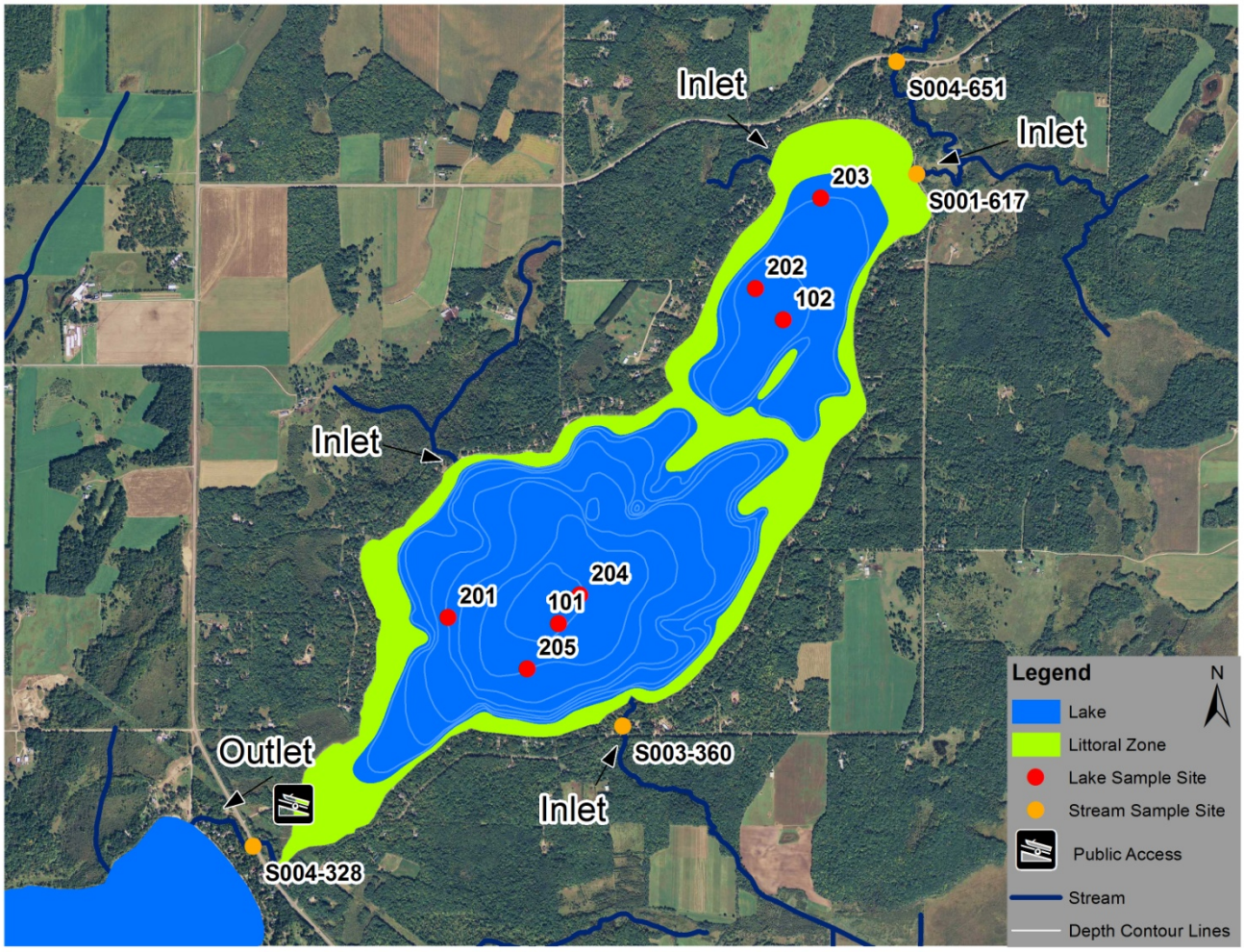


Figure 1. Map of Upper South Long Lake illustrating bathymetry, lake sample site locations, stream inlets and outlets and aerial land use. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

Table 3. Monitoring programs and associated monitoring sites.
Minnesota Pollution Control Agency (MPCA), Upper South Long Lake Association (USLLA), Citizen Lake Monitoring Program (CLMP), Outdoor Corps Lake Monitoring (OCLM)

Lake Site	Depth (ft)	Monitoring Programs
101*primary site	47	MPCA: 1990, 1998; USLLA: 2009-2011
102	20	MPCA: 1990, 1998
201	30	CLMP: 1973
202	25	CLMP: 1976, 1977, 1998-2005
203	15	CLMP: 1977, 1978, 1980; MPCA: 1979, 1980
204	45	CLMP: 1977-1980, 1998-2005; MPCA: 1979, 1980
205	40	CLMP: 1986-2010; OCLM: 2001-2005

Average Water Quality Statistics

The information below describes available chemical data for the primary site (101) of Upper South Long Lake through 2011.

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)	21	14 - 27	> 30	Results are within to slightly above the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	13	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	32	<15		
Secchi depth (ft)	8	7.5 - 15	< 6.5	
Dissolved oxygen	Dimictic *See page 8*			Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kieldahl Nitrogen (mg/L)	0.71	0.4 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	113	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	18	10 - 35		Indicates clear water with little to no tannins (brown stain).
pH	8.9	7.2 - 8.3		Indicates a hardwater lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	3.3	0.6 - 1.2		Slightly higher than the expected range for the ecoregion, but still considered low level.
Total Suspended Solids (mg/L)	4.1	<1 - 2		Slightly higher than the expected range for the ecoregion, but still considered low level.
Conductivity (umhos/cm)	201	50 - 250		Within the expected range for the ecoregion.
Total Nitrogen :Total Phosphorus	33:1	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	Site 102	Site 202	Site 204	Site 205
Total Phosphorus Mean (ug/L):	**21**	**29**		**41**	**28**
Total Phosphorus Min:	10	20		24	14
Total Phosphorus Max:	49	41		60	66
Number of Observations:	24	9		7	24
Chlorophyll *a* Mean (ug/L):	**13**	**15**			**13**
Chlorophyll-a Min:	5	6			3
Chlorophyll-a Max:	32	24			23
Number of Observations:	24	9			24
Secchi Depth Mean (ft):	**8.1**	**7.7**	**6.9**	**7.0**	**7.3**
Secchi Depth Min:	3.6	3.0	3.5	3.5	3.9
Secchi Depth Max:	24.6	20.3	14.0	14.0	14.0
Number of Observations:	24	9	122	141	301

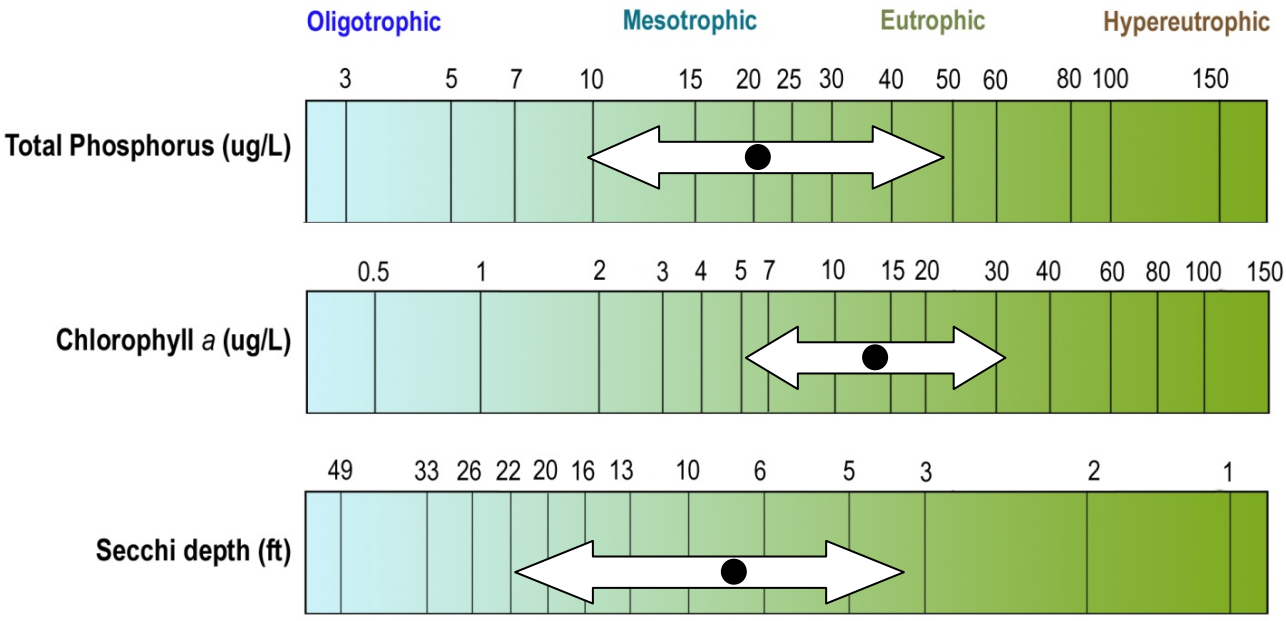


Figure 2. Upper South Long Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 101).
Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (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.

For all the sites that had more than 20 transparency data points, the mean transparency ranges from 5.8 to 7.3 feet (Figure 3). The transparency throughout the lake appears to be relatively uniform, though the southern half consistently had higher secchi readings than the northern half. The northern basin is shallower and where the main inlet drains water into the lake, which could explain why the transparency is less.

The transparency at site 205 remained near the long-term mean. Site 101 means have more variability. This may be due to the low number of readings, compared to site 205 (24 versus 301 data points). Transparency monitoring should be continued annually at sites 101, 202, and 205 in order to track water quality changes.

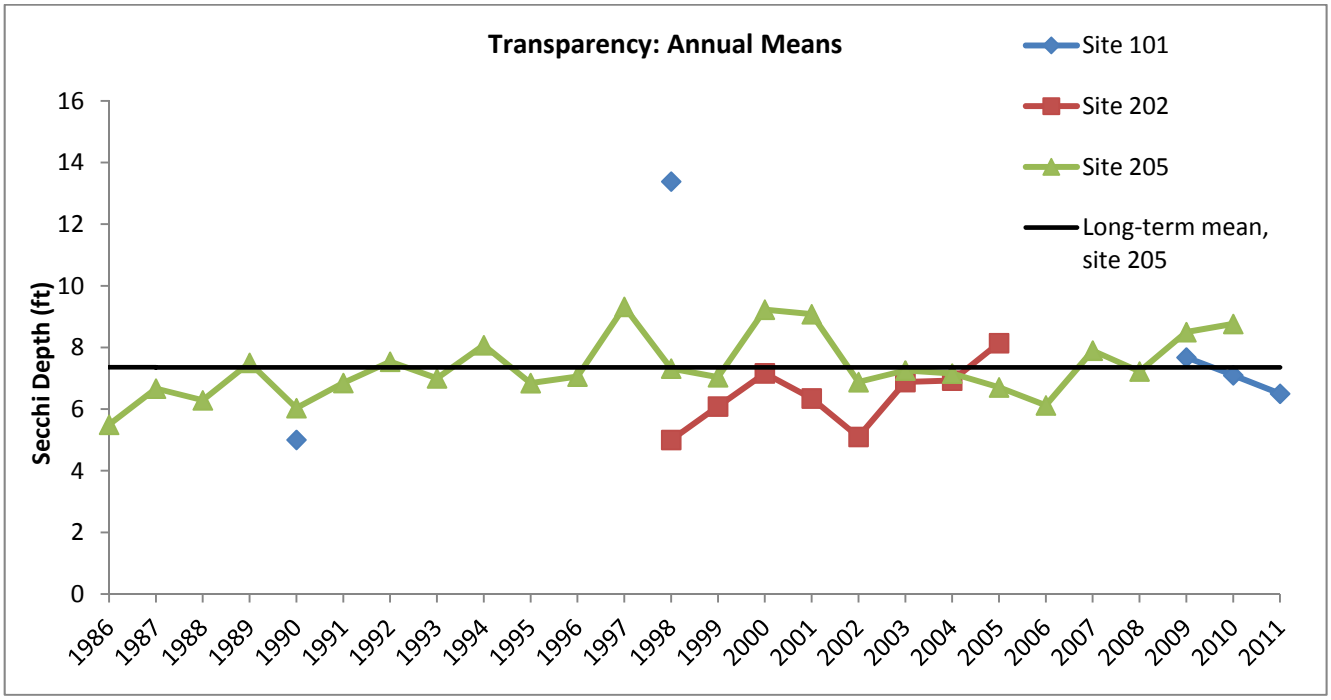


Figure 3. Annual mean transparency compared to long-term mean transparency, sites 101, 202, and 205.

Upper South Long Lake transparency ranges from 3.9 to 14.0 ft at the site 205. Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Upper South 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 northern 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.

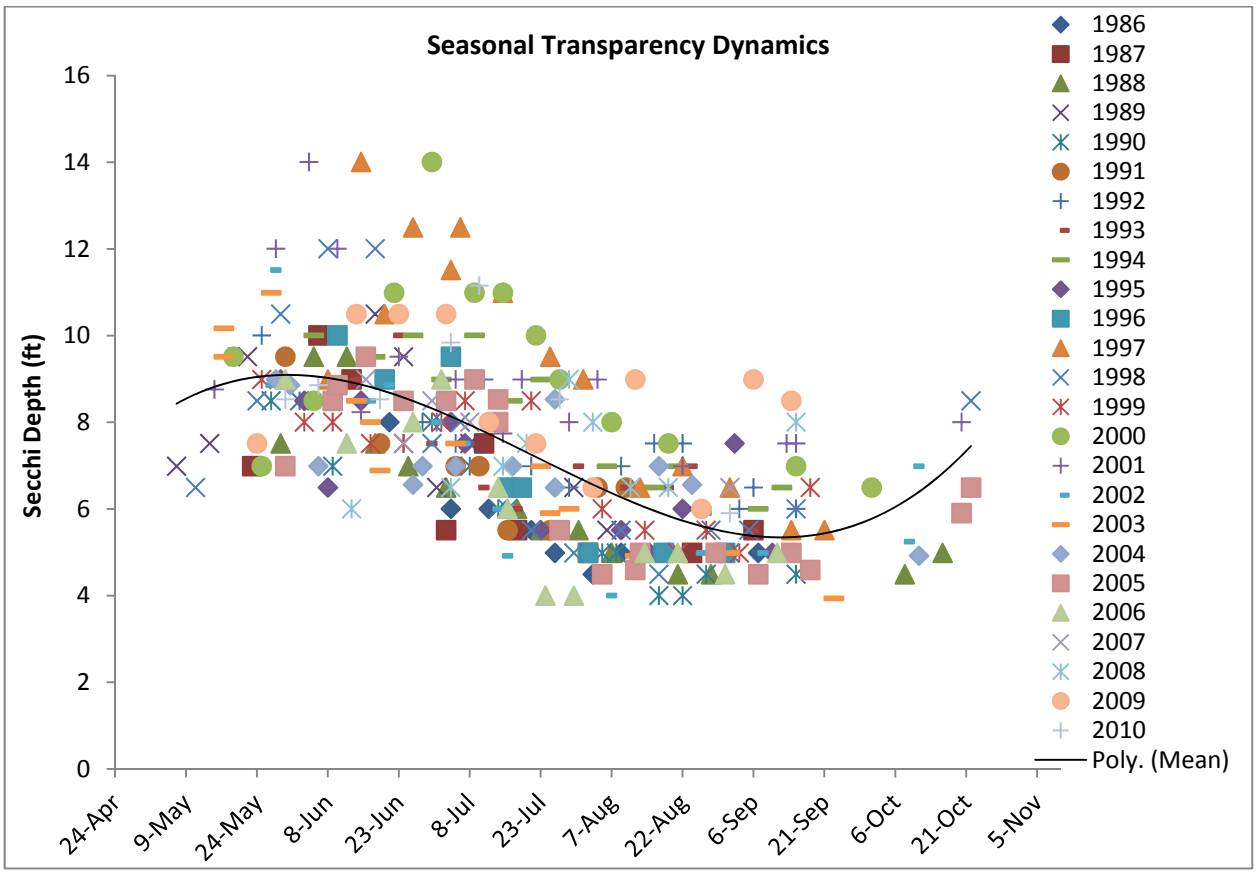


Figure 4. Seasonal transparency dynamics and year to year comparison (Site 205). The black line represents the seasonal pattern of the data.

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. Upper South Long Lake (site 205) was rated as being "not quite crystal clear" 79% of the time between 1987-2010.

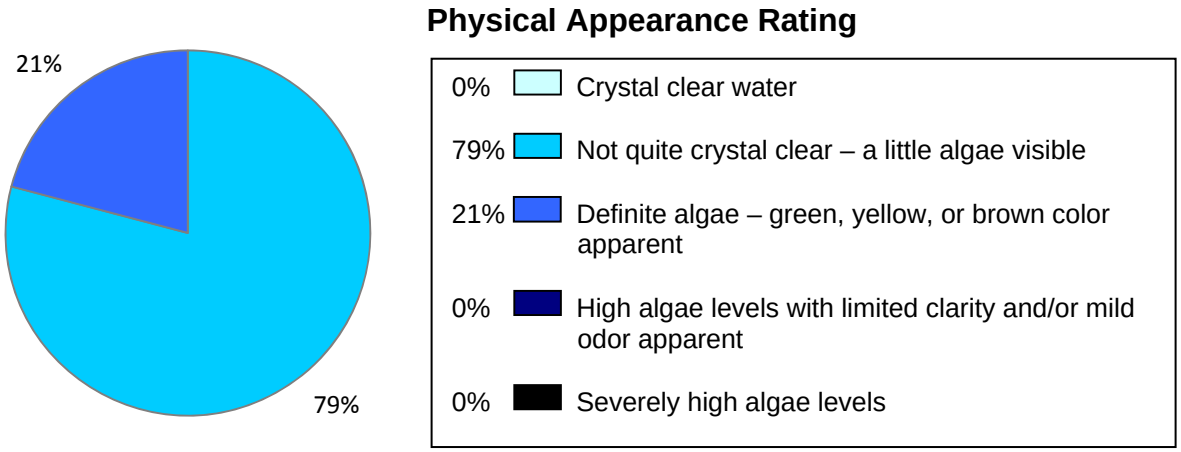


Figure 5. Physical appearance rating, as rated by the volunteer monitor (site 205 from 1987-2010).

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Upper South Long Lake was rated as having "very minor aesthetic problems" 77% of the time from 1987-2010 at site 205 (Figure 6).

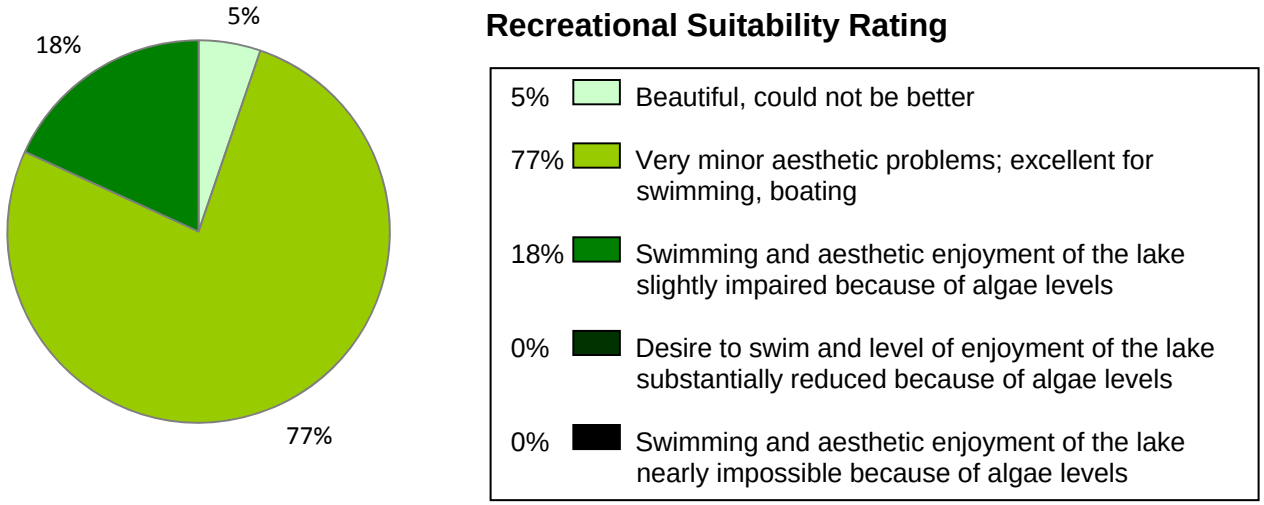


Figure 6. Recreational suitability rating, as rated by the volunteer monitor (site 205 from 1987-2010).

Total Phosphorus

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

Total phosphorus was evaluated in Upper South Long Lake in 1979, 1980, 1990, 1999, 2001-2005, and 2009-2011. The data do not indicate much seasonal variability. Both sites have similar concentrations in each year of monitoring (Figure 7). There were 4 results greater than 40 ug/L, because these samples were taken in the spring and fall, they could be related to lake turnover.

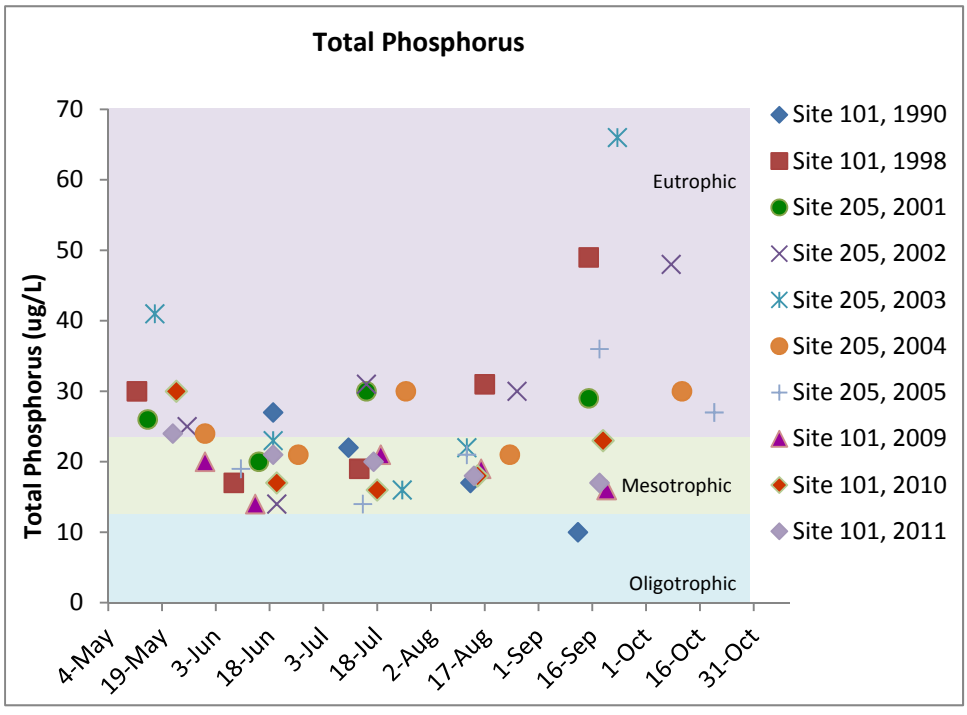


Figure 7. Historical total phosphorus concentrations (ug/L) for Upper South Long Lake for sites 101 and 205.

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.

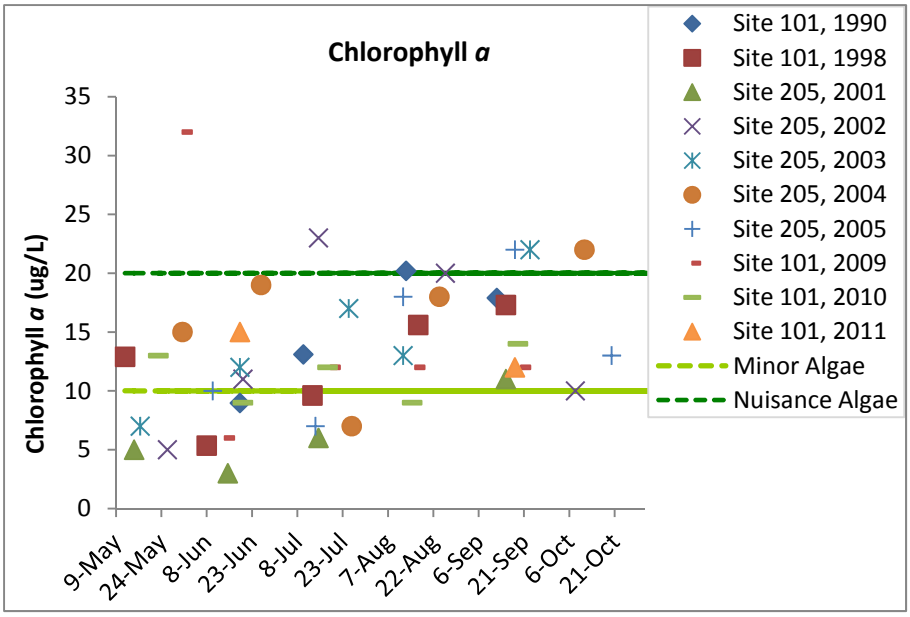
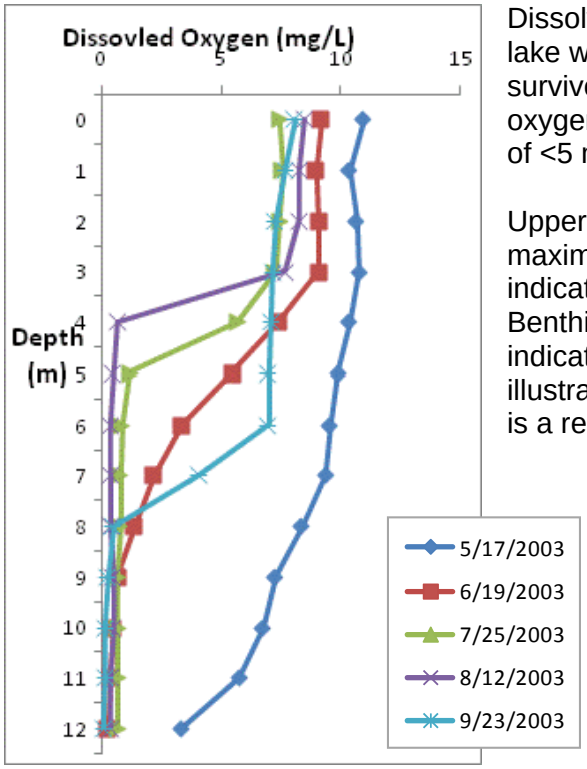


Figure 8. Chlorophyll *a* concentrations (ug/L) for Upper South Long Lake.

Chlorophyll *a* was evaluated in Upper South Long Lake in 1990, 1998, 2000-2005, and 2009-2011. Chlorophyll *a* concentrations reached 10 ug/L most years and 20 ug/L occasionally, signaling algae bloom frequency and severity (Figure 8). Upper South Long Lake has somewhat green water most of the summer. These results follow the phosphorus results (Figure 7).

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.

Upper South Long Lake is a relatively deep lake, with a maximum depth of 47 ft. Dissolved oxygen profiles from 2003 indicate that both sites 101 and 205 stratify in the summer. Benthic phosphorus samples taken in 1998 at site 101 indicate internal loading (TP=227-573 ug/L). Figure 9 illustrates stratification in the summer of 2003 at site 205. This is a representative DO profile for Upper South Long Lake.

Figure 9. Dissolved oxygen and temperature profile for Upper South Long Lake in 2002 at site 205.

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 site 101 falls on the border between mesotrophic and eutrophic (49-51) (Figure 10). There is fairly good agreement between the TSI for phosphorus, chlorophyll *a* and transparency. The chlorophyll *a* TSI is slighty higher than the phosphorus and transparency TSI (Table 6). This could be due to a present of larger algae particulates in the water or possibly a decrease in rooted vegetation.

Eutrophic lakes (TSI 50-70) are characteristic of "green" water most of the summer. "Eu" means true and the root "trophy" means nutrients therefore, eutrophic literally means true nutrients or truly nutrient rich (phosphorus). Eutrophic lakes are usually shallow, and are found where the soils are fertile. Eutrophic lakes usually have abundant aquatic plants and algae.

Table 6. Trophic state index for site 101.

Trophic State Index	Site 101
TSI Total Phosphorus	47
TSI Chlorophyll-a	55
TSI Secchi	49
TSI Mean	50
Trophic State:	Mesotropic/ Eutrophic

Numbers represent the mean TSI for each parameter.

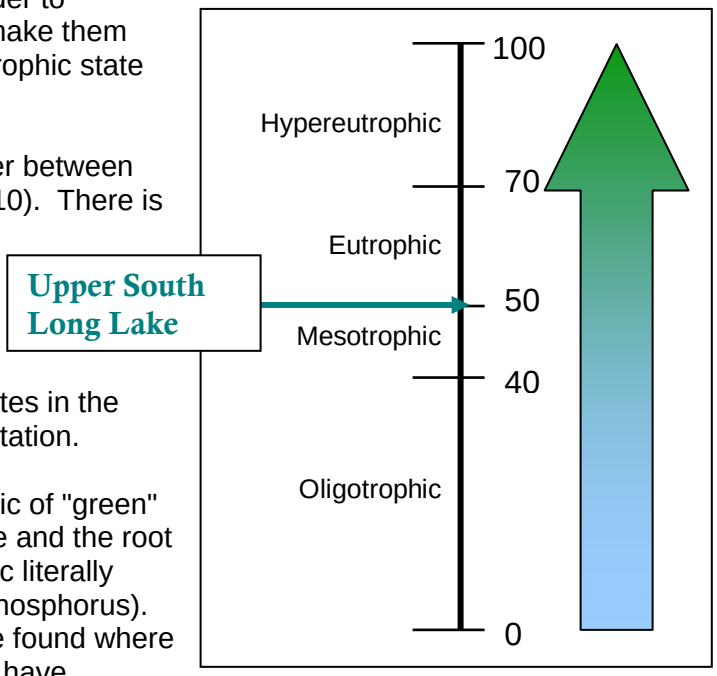


Figure 10.Trophic State Index chart with corresponding trophic status.

Table 7. Trophic State Index categories and corresponding lake 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 not enough historical data to perform trend analysis for total phosphorus or chlorophyll *a* on Upper South Long Lake. Site 205 had over 8 years of transparency data, which was enough data to perform a long-term trend analysis. The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Upper South Long Lake.

Lake Site	Parameter	Date Range	Trend
205	Transparency	1986-2010	No Trend
205	Total Phosphorus	2001-2005	Insufficient Data
205	Chlorophyll *a*	2001-2005	Insufficient Data

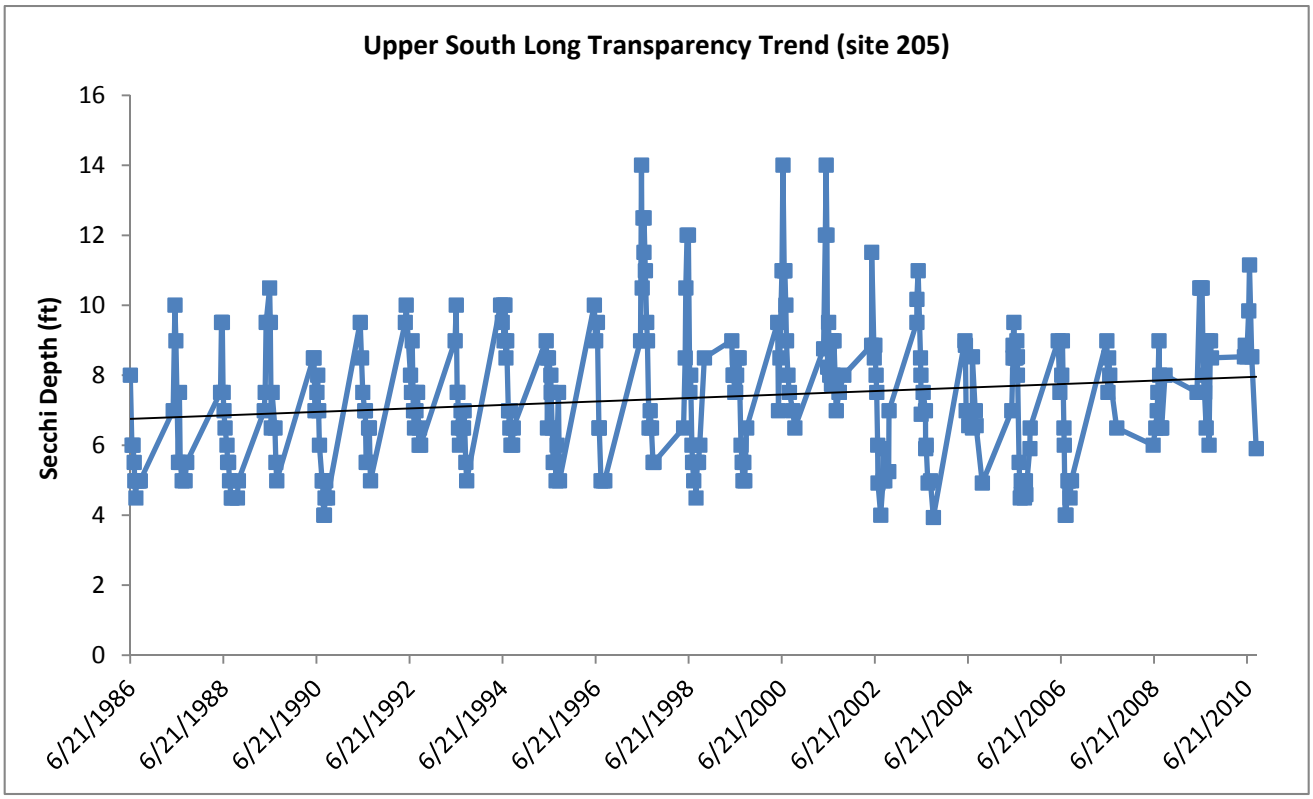
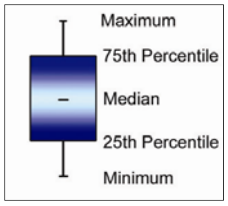


Figure 11. Transparency (ft) trend for site 205 from 1986-2010.

Upper South Long Lake transparency shows no significant evidence of a trend in water quality (Figure 11). This means the water quality is stable. Transparency monitoring should continue so that this trend can be tracked in future years.

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.



Upper South Long Lake is in the Northern Lakes and Forests Ecoregion. The mean total phosphorus, chlorophyll a and transparency (secchi depth) for Upper South Long are all within to slightly above the expected ecoregion ranges (Fig. 13).

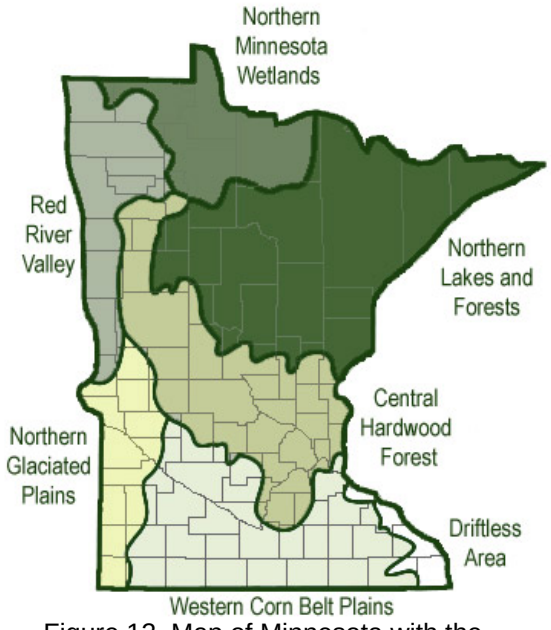
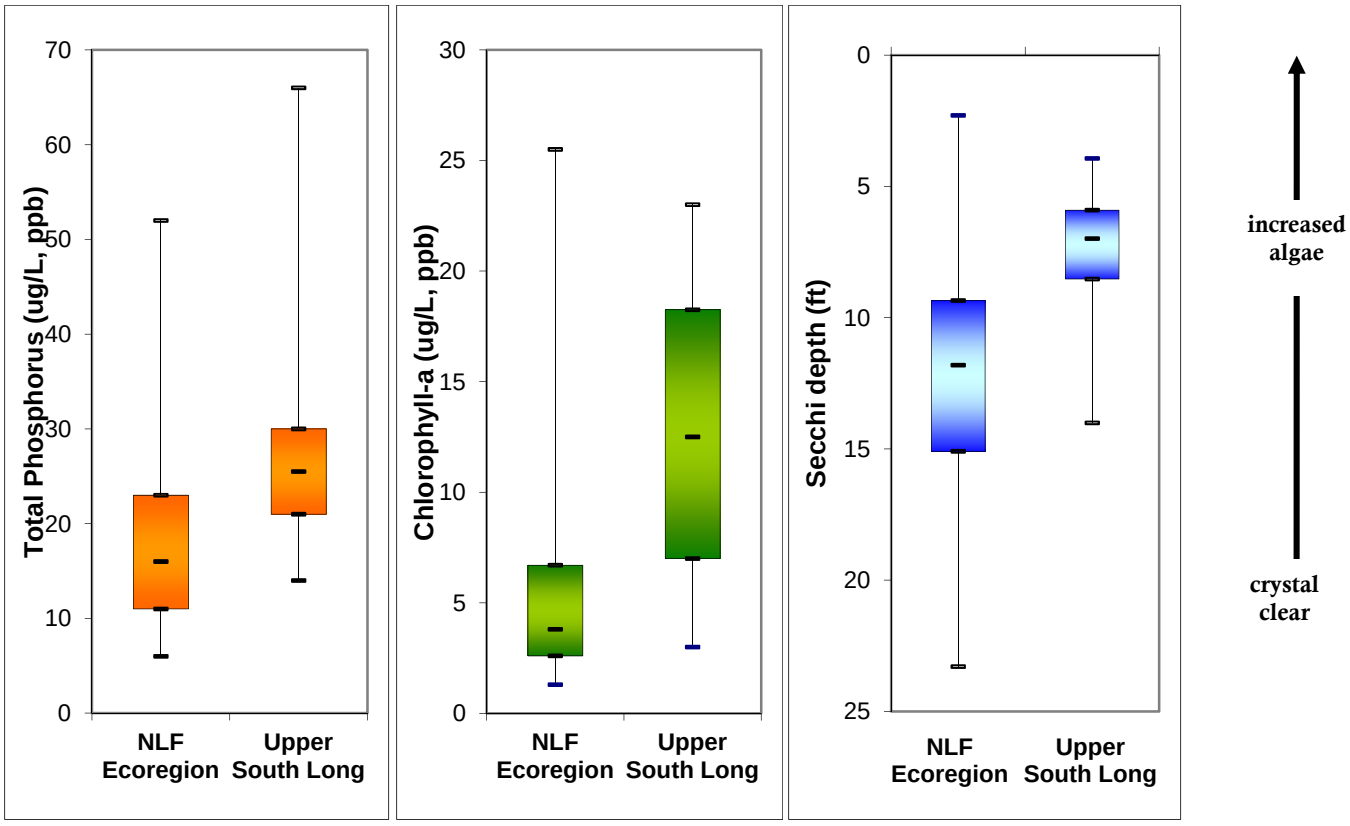


Figure 12. Map of Minnesota with the seven ecoregions.



Figures 13a-c. Upper South Long Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Upper South Long Lake total phosphorus and chlorophyll *a* ranges are from 24 data points collected in May-September of 2001-2005. The Upper South Long Lake secchi depth range is from 301 data points collected in May-September from 1986-2010.

Stream Inlet Assessment

Upper South Long has one major inlet (4 inlets total) and one outlet (Figure 14). The Nokasippi River Inlet and Outlet was monitored in 2007-2008 by the Nokasippi Watershed Group.

When compared to the ecoregion ranges for streams, the data are within the expected range (Table 9). None of the results show impairments in the Nokasippi River.

The total phosphorus in the Nokasippi River inlet was higher than the in-lake phosphorus concentrations (Figure 15). This is typical for lakes. The phosphorus gets diluted once it flows into the lake. The outlet's phosphorus concentrations are nearly identical to the in-lake phosphorus, because the outlet is the lake water flowing out.

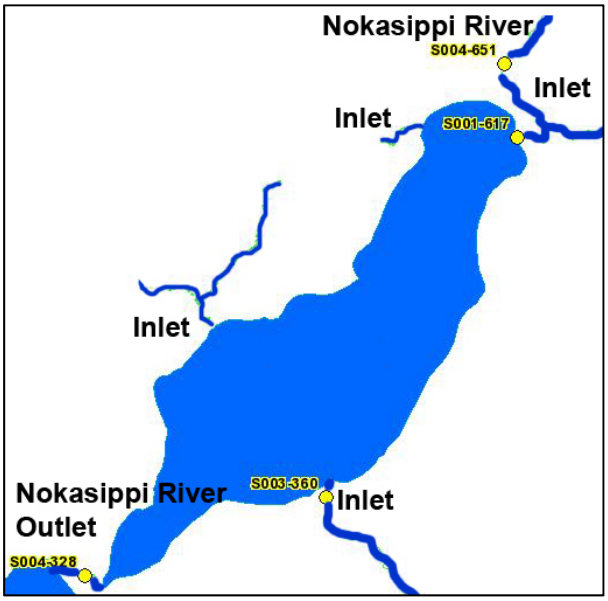


Figure 14. Map of Upper South Long Lake and its inlets and outlets.

Table. 9. Average values for the Upper South Long Lake Inlet and Outlet from 2007-2008 compared to the Northern Lakes and Forest Ecoregion.

Site Description	TP (ug/L)	TSS (mg/L)
Inlet (S004-651)	50	3.7
Outlet (S004-328)	24	2
Ecoregion Range	20 - 50	1.8 - 6

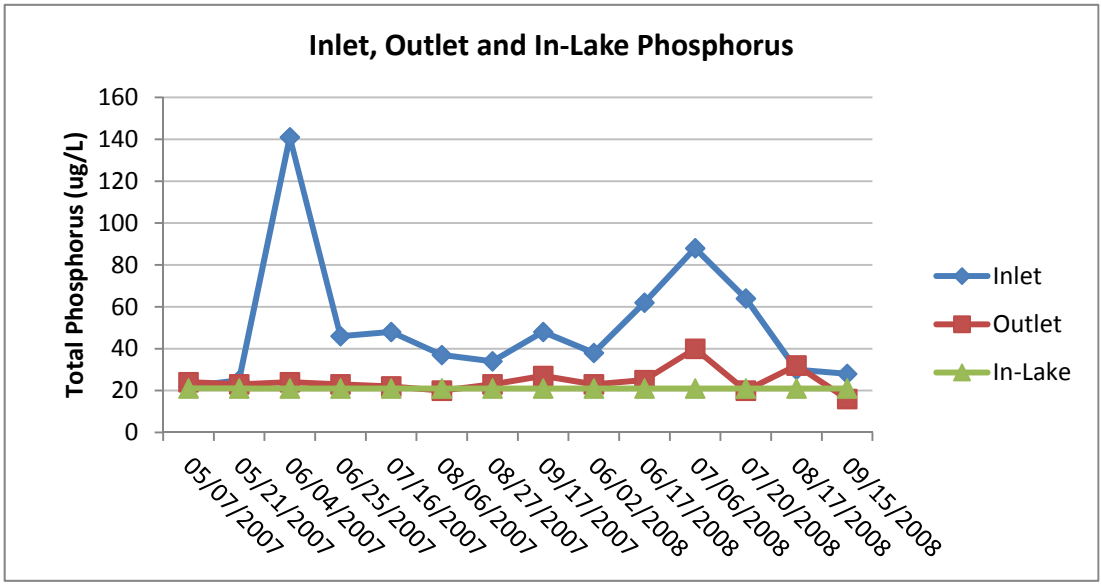


Figure 15. Phosphorus concentration in the inlet and outlet compared to the in-lake average for 2007-2008.

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 – Brainerd Major Watershed** is one of the watersheds that make up the Upper Mississippi River Basin, which drains south to the Gulf of Mexico (Figure 16). This major watershed is made up of 128 minor watersheds. Upper South Long Lake is located in **minor watershed 10106** (Figure 17).

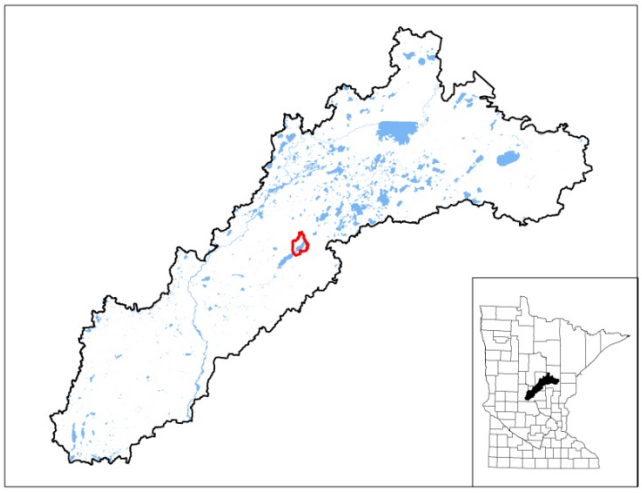


Figure 16. Mississippi River – Brainerd Watershed

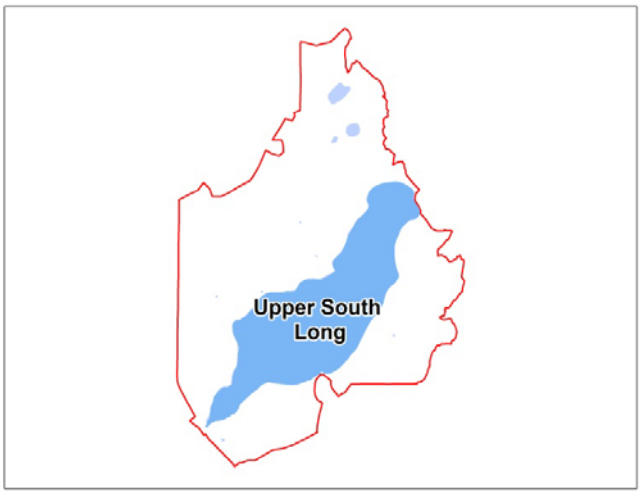


Figure 17. Minor Watershed 10106 contributes water to Upper South Long Lake.

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. Upper South Long Lake falls within the **Upper South Long (1010600) lakeshed** (Figure 18). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not true watersheds because they do 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 Upper South Long Lake's full watershed, containing all the lakesheds upstream of Upper South Long Lake lakeshed, see page 17. The data interpretation of the Upper South Long Lake lakeshed is only the

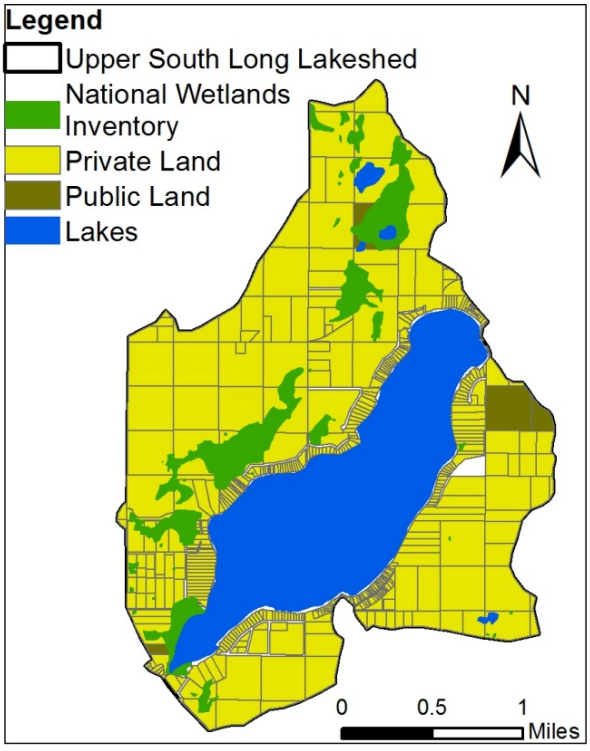


Figure 18. The Upper South Long (1010600) Lakeshed. This area is the land and water surface that flow directly into Upper South Long Lake.

immediate lakeshed, not including the upstream lakesheds, as this area is the land surface that flows directly into Upper South Long Lake.

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). 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 10. Lakeshed vitals table.

Lakeshed Vitals		Rating
Lake Area	795 acres	descriptive
Littoral Zone Area	243 acres	descriptive
Lake Max Depth	47 ft.	descriptive
Lake Mean Depth	20 ft	
Water Residence Time	0.5 years	
Miles of Stream	1.6	descriptive
Inlets	4	
Outlets	1 – Nokasippi River	
Major Watershed	10 – Mississippi River-Brainerd	descriptive
Minor Watershed	10106	descriptive
Lakeshed	1010600	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	4:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	50:1	
Wetland Coverage	8.2%	
Aquatic Invasive Species	None	
Public Drainage Ditches	None	
Public Lake Accesses	1	
Miles of Shoreline	6.3	descriptive
Shoreline Development Index	1.6	
Public Land to Private Land Ratio	0.04:1	
Development Classification	General Development	
Miles of Road	14.7	descriptive
Municipalities in lakeshed	None	
Forestry Practices	County Forest Management: http://www.co.crow-wing.mn.us/index.aspx?NID=261	
Feedlots	2	
Sewage Management	Individual Subsurface Sewage Treatment Systems (Inspection and assessment required for all permits and property transfers within the Shoreland Protection Zone)	
Lake Management Plan	Healthy Lakes & Rivers Partnership program, 2001	
Lake Vegetation Survey/Plan	Minnesota DNR, 2009	

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.

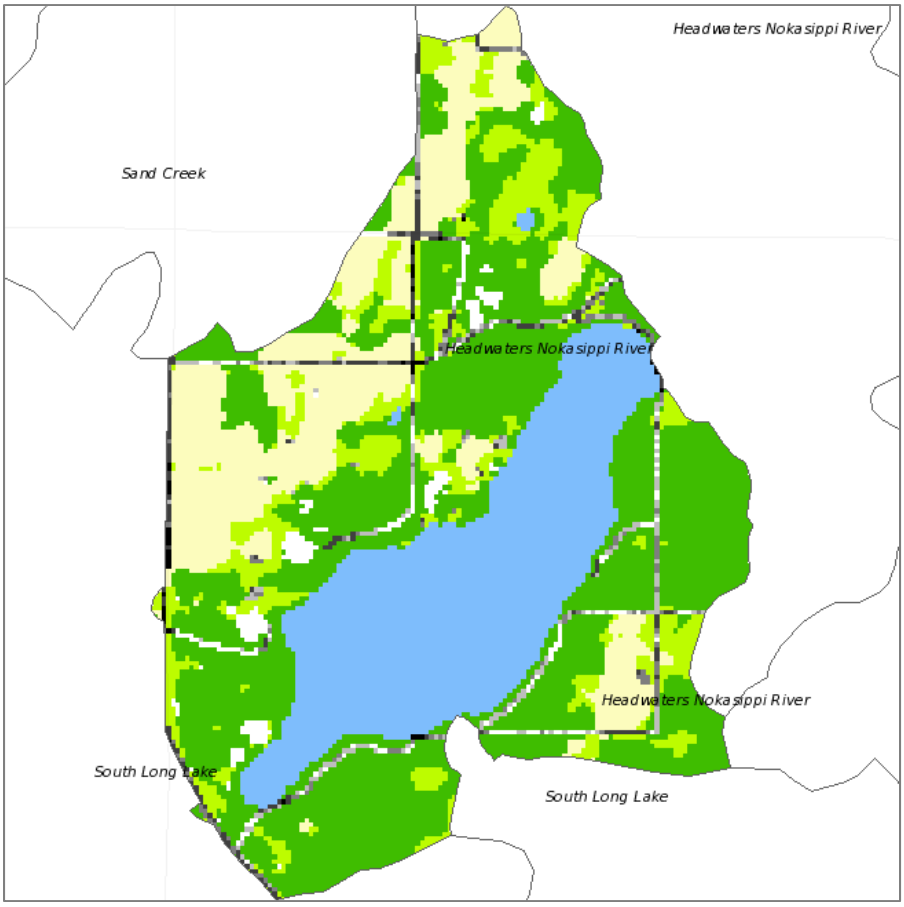


Figure 19. The Upper South Long (1010600) lakeshed land cover (http://land.umn.edu).

Changes in land use, and ultimately land cover, impact the hydrology of a lakeshed. Land cover is also directly related to the lands 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 lands 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 19 depicts the land cover in Upper South 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 available to compare over a decade of time. Table 11 describes Upper South 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 decrease in agriculture cover (30%); however, in acreage, forest cover has increased the most (221 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 11. Upper South 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	795	23.71	552	16.46	30.6% Decrease
Grass/Shrub/Wetland	356	10.62	423	12.62	18.8% Increase
Forest	1223	36.47	1444	43.07	18.1% Increase
Water	822	24.52	768	22.9	6.6% Decrease
Urban	156	4.65	165	4.92	5.8% Increase
Impervious Intensity %					
0	3243	96.69	3229	96.27	0.4% Decrease
1-10	35	1.04	46	1.37	31.4% Increase
11-25	38	1.13	37	1.1	2.6% Decrease
26-40	23	0.69	24	0.72	4.3% Increase
41-60	10	0.3	12	0.36	20% Increase
61-80	4	0.12	6	0.18	50% Increase
81-100	1	0.03	0	0	100% Decrease
Total Area	3353		3353		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	24	0.95	27	1.04	12.5% Increase

Demographics

Upper South Long Lake is classified as a general development lake. General Development Lakes usually have more than 225 acres of water per mile of shoreline 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 Crow Wing County as a whole, Maple Grove Township has a slightly lower extrapolated growth projection (Figure 20).

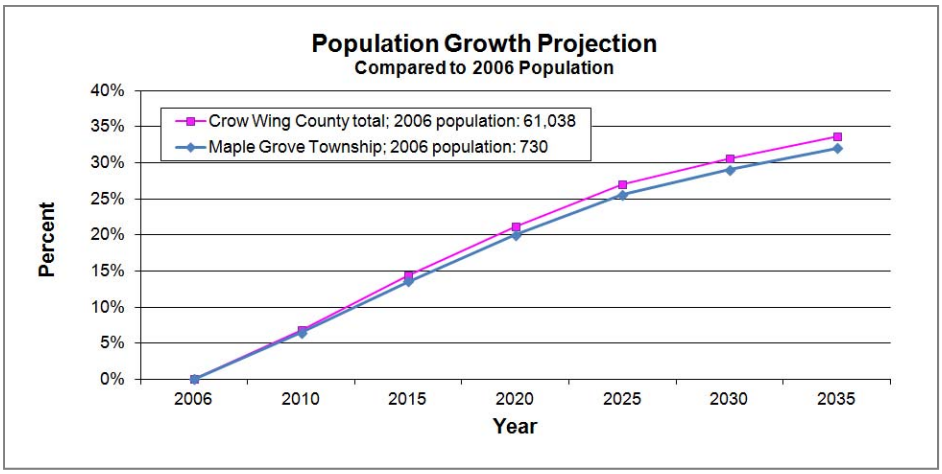


Figure 20. Population growth projection for Maple Grove Township and Crow Wing County. (source: http://www.demography.state.mn.us/resource.html?Id=19332)

Upper South 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 Upper South Long Lake's lakeshed is made up of private forested uplands and agricultural land uses (Table 12). This land can be the focus of development and protection efforts in the lakeshed.

Table 12. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in the lakeshed (Sources: Crow Wing County parcel data, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (72%)					24%	Public (4%)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	4.3%	20.2%	29.2%	11.5%	6.8%	24%	3.8%	0.2%	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 Acerage x runoff coefficient	65–217	176–611	88		21		8	<1	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 13). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 13. 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.

Upper South Long Lake is classified with having 26.9% of the watershed protected and 25.9% of the watershed disturbed (Figure 21). Therefore, Upper South Long Lake should have a full restoration focus. Goals for the lake should be to limit any increase in disturbed land use and implement best management practices.

Figure 22 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 Upper South Long Lake, whether through direct overland flow or through a creek or river. Three of the 13 upstream lakesheds have the same management focus (full restoration).

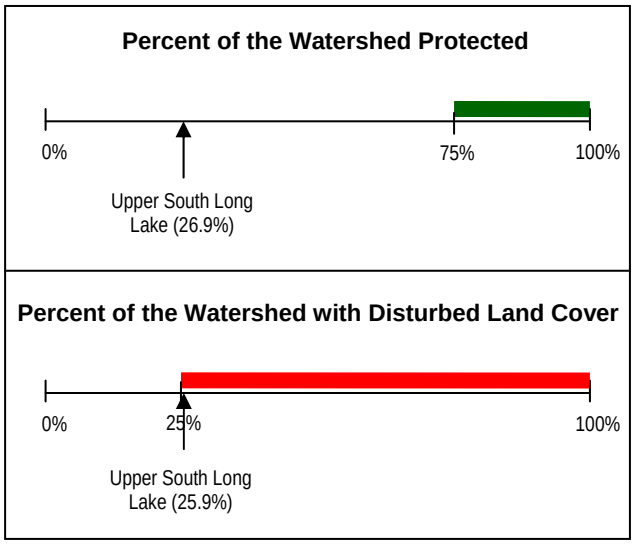


Figure 21. Upper South Long Lake lakeshed's percentage of watershed protected and disturbed.

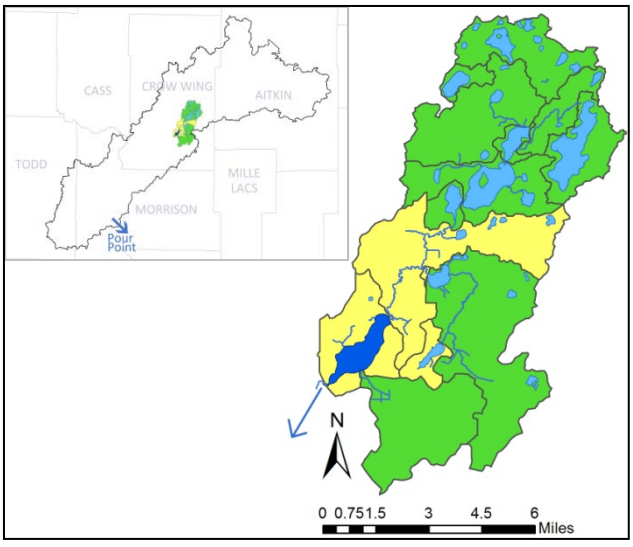


Figure 22. Upstream lakesheds that contribute water to the Upper South Long lakeshed. Color-coded based on management focus (Table 13).

Upper South Long, Status of the Fishery (as of 07/23/2007)

Upper South Long Lake is an 802 acre lake located about 8 miles southeast of Brainerd in Crow Wing County. A public access is located on the southwest shore. The lake is heavily developed with 31 homes/cabins per shoreline mile based on 1999 data. Many of these are small seasonal cabins and conversion of these may be an issue in the future. The maximum depth is 47' and about 35% of the lake is 15' deep or less. Shallow water substrates consist primarily of sand and gravel, although areas of rubble, marl, and muck are also present. The aquatic plant community is quite diverse with 43 species present and is critical to maintaining healthy fish populations. Emergent plants such as bulrush and water lillies are still relatively common along much of the shoreline, although the overall area has diminished in recent years. It is essential to protect and maintain these plants as they are important for shoreline protection, maintaining water quality, and provide critical spawning habitat for bass and panfish species. Submerged plants provide food and cover needed by fish and other aquatic species.

The 2007 walleye catch of 1.8/gill net was below average and the lowest catch since 1979. Five different year classes were represented with the 2005 year class (age 2) accounting for 62% of the current population. Average length and weight were 13.9" and 1.1 lbs in 2007. Northern pike were caught in average numbers in 2007 at 3.5/gill net. Average length and weight were 25.0" and 3.4 lbs in 2007. Growth was relatively good with 60% of these fish measuring at least 24".

The largemouth bass abundance of 0.6/trap net is average when compared to similar lakes. Spring electrofishing resulted in a largemouth bass catch rate of 97/hr with an average length of 10.8" and 38% measuring at least 12".

The 2007 bluegill catch of 21.4/trap net is typical of past catches on this and similar lakes. Black crappies were present in good numbers when compared to similar lakes, however size was small. Tullibee and yellow perch are important forage species for the lake's game fish and were caught in low numbers in 2007.

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=18009600

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at sites 202 and 205 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 at site 101, as the budget allows, to track future water quality trends.

Site 101 should be the primary site for Upper South Long Lake. All future phosphorus and chlorophyll a data should be collected at site 101. Transparency data has been collected at site 205, which is relatively close to site 101. Transparency monitoring should continue at site 205 to continue to track the transparency trend.

Overall Conclusions
Overall, Upper South Long Lake has fair water quality, and is in fair shape for lakeshed protection. It is a mesotrophic/eutrophic lake (TSI=50) with no trend in transparency over the past decade. Four percent (4%) of the lakeshed is in public ownership, and 26% of the watershed is protected, while 26% of the watershed is disturbed (Figure 21).

Priority Impacts to the lake
There are two priority impacts to Upper South Long Lake. The first is the surrounding development and any future development. The first tier around the lake is fully developed, and the second tier is developed in some small areas. Maple Grove Township is expected to grow 10% in population in the next 10 years (Figure 20).

The second potential impact, and the reason the lakeshed is rated as "full restoration" (Figure 22) is the agriculture north of the lake in the lakeshed (Figure 19). It looks like there is some forest buffer between the agriculture and the lake, so it is unclear how much the agriculture is actually impacting the lake. On the ground inspection would help determine areas where the buffer is not wide enough.

Best Management Practices Recommendations
The management focus for Upper South Long Lake should be to restore the water quality and the lakeshed. Restoration efforts should be focused on managing and/or decreasing the impact caused by additional 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.

Partnering with farmers in the lakeshed to implement conservation farming practices, increase shoreline buffers, restore wetlands, or place priority parcels into land retirement programs can decrease the impacts of agriculture in the lakeshed.

Future Studies
Future studies that would better pinpoint the impacts on the lake include a shoreline inventory and a watershed flow analysis. The shoreline inventory would consist of boating around the lake and rating each parcel as to how much of the frontage has a vegetative buffer.

A watershed flow analysis would be done using GIS software and LiDAR data to see the areas of heaviest runoff into the lake. This analysis would also help pinpoint whether the agriculture in the lakeshed is impacting the lake or not.

County-wide Recommendation
In order to better manage the impact of septic systems on lake water quality, it is recommended that the county implement a lake-wide septic inspection program. In a program such as this, the county would focus on one to three lakes a year, pull septic system records on those lakes, and require old systems to be inspected. This program can rotate through the county doing a few lakes each year.

Organizational contacts and reference sites

Upper South Long Lake Improvement Association	http://www.usllia.org/
DNR Fisheries Office	1601 Minnesota Drive, Brainerd, MN 56401 218-828-2550 brainerd.fisheries@state.mn.us
Regional Minnesota Pollution Control Agency Office	7678 College Road, Suite 105, Baxter, MN 56425 218-828-2492, 800-657-3864 http://www.pca.state.mn.us/pyri3df
Crow Wing Soil and Water Conservation District	Crow Wing County Land Services Building 322 Laurel St. Suite 13, Brainerd, MN 56401 218-828-6197 http://www.co.crow-wing.mn.us/swcd/
Crow Wing County Environmental Services Department	Crow Wing County Land Services Building 322 Laurel St. Suite 14, Brainerd, MN 56401 218-824-1125 http://www.co.crow-wing.mn.us/index.aspx?nid=211

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