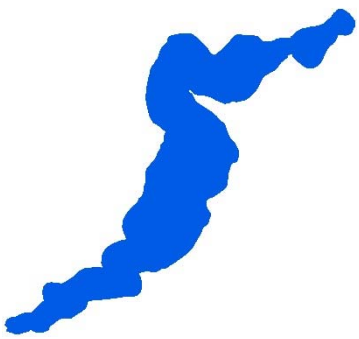
Little Sand Lake 29-0150-00 HUBBARD COUNTY

Lake Water Quality

Summary



Little Sand Lake is located six miles northeast of Park Rapids, Minnesota. It covers 386 acres and has a long, narrow shape.

Little Sand Lake has two inlets and one outlet. The main inlet enters from Ida Lake under County Road 7. The second inlet flows in from Gilmore Lake. The outlet is located near the middle of the east shoreline. The Sand River flows out of the lake and heads south into Round Lake. From Round Lake, the water flows into Clausens Lake and Shallow Lake, and eventually into Lake Belle Taine.

Water quality data have been collected on Little Sand Lake since 1988 (Table 3). These data show that the lake is at the oligotrophic, which is characterized by clear water throughout the summer and excellent recreational opportunities.

The Little Sand Lake Association is involved in many activities, including water quality monitoring. They are also a member of the Hubbard County Coalition of Lake Associations (COLA).

Table 1. Little Sand Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	29-0150-00	Surface area (acres):	386
County:	Hubbard	Littoral area (acres):	149
Ecoregion:	Northern Lakes & Forests	% Littoral area:	38%
Major Drainage Basin:	Upper Mississippi River	Max depth (ft), (m):	80, 24.4
Latitude/Longitude:	46.99055556 / -94.93166667	Inlets:	2
Invasive Species:	None	Outlets:	1
		Public Accesses:	1

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	---	Not necessary.

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

Lake Map

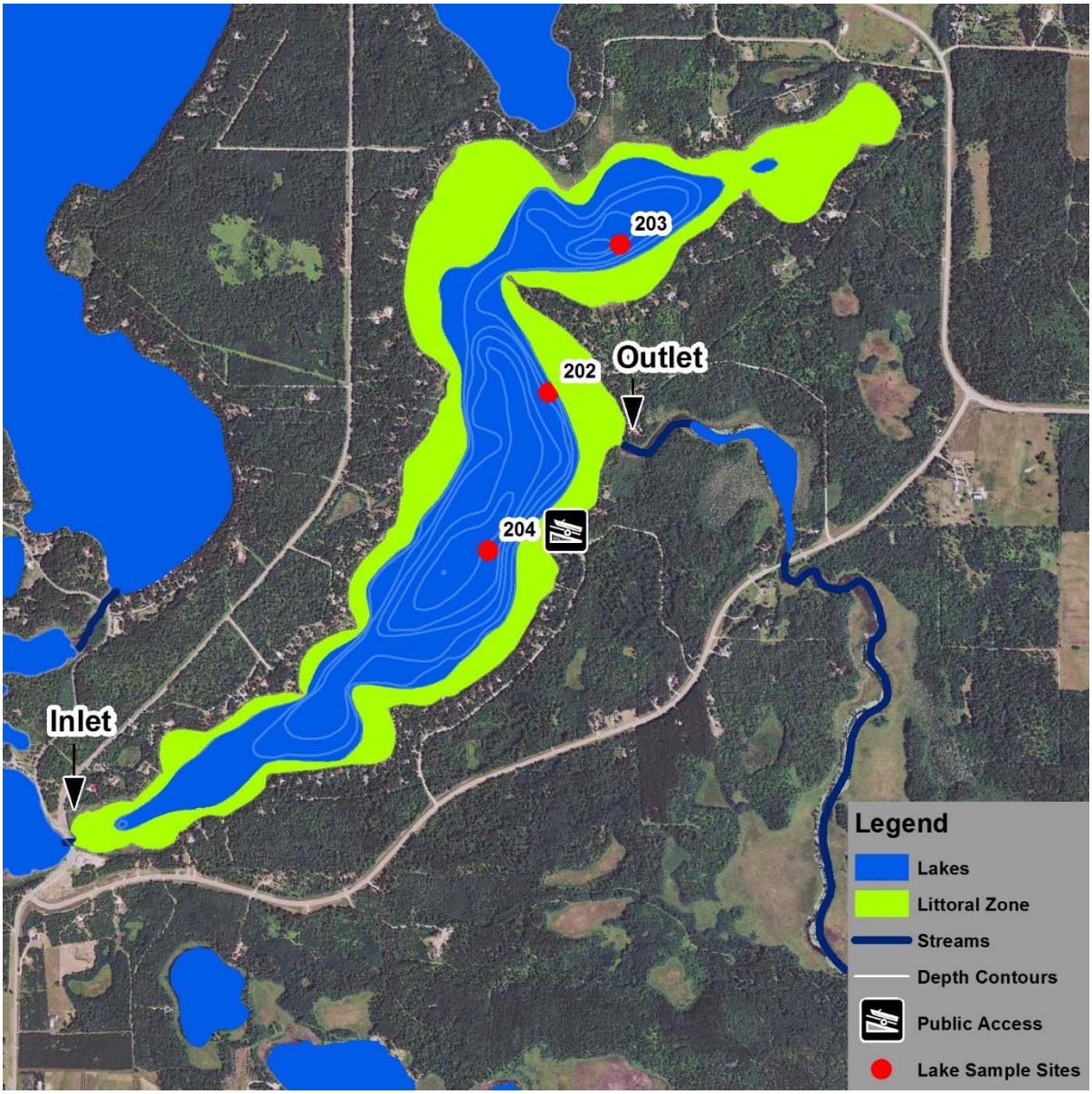


Figure 1. Map of Little Sand Lake with 2010 aerial imagery and illustrations of sample site locations, inlets and outlets, and public access points. The pink areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

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
202	35	MPCA: 1989; CLMP: 1988
203	55	MPCA: 1989; CLMP: 1989-1992, 1994-2006
204	65	MPCA: 1989, 1991; CLMP: 1987-2016; RMBEL: 1997-2016

Average Water Quality Statistics

The information below describes available chemical data for Little Sand Lake through 2016 (site 204). The data set is limited, and all parameters, with the exception of total phosphorus, chlorophyll *a* and secchi depth, are means for just 1989 and 1991 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)	9.3	14 - 27	> 30	Results are better than the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	1.9	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	6.0	<15		
Secchi depth (ft)	21.7	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)	147	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	7.8	10 - 35		Indicates very clear water with little to no tannins (brown stain).
pH	8.6	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)	1.7	0.6 - 1.2		Slightly above the ecoregion average but still considered low level.
Total Suspended Solids (mg/L)	1.8	<1 - 2		Within the ecoregion average range.
Specific Conductance (umhos/cm)	218	50 - 250		Within the ecoregion average range.
Total Nitrogen :Total Phosphorus	31:1	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, 1997-2016.

Parameters	Primary Site 204	Site 203
Total Phosphorus Mean (ug/L):	**9.3**	
Total Phosphorus Min:	<5	
Total Phosphorus Max:	28.0	
Number of Observations:	102	
Chlorophyll *a* Mean (ug/L):	**1.9**	
Chlorophyll-a Min:	<1	
Chlorophyll-a Max:	6.0	
Number of Observations:	101	
Secchi Depth Mean (ft):	**21.7**	**19.0**
Secchi Depth Min:	15.5	10.5
Secchi Depth Max:	40.0	33.0
Number of Observations:	100	189

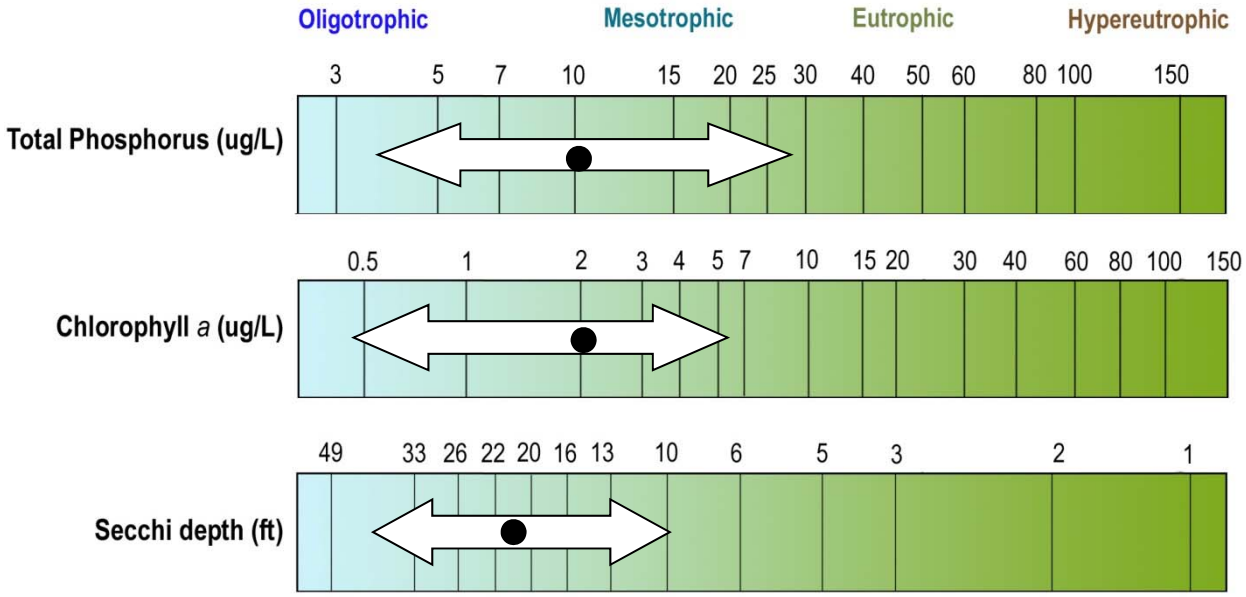


Figure 2. Little Sand Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 204). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. 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 Little Sand Lake range from 14.0 - 26.8 feet and hovers fairly closely around the long-term mean (Figure 3). Transparency monitoring should be continued at both sites to track water quality in Little Sand Lake.

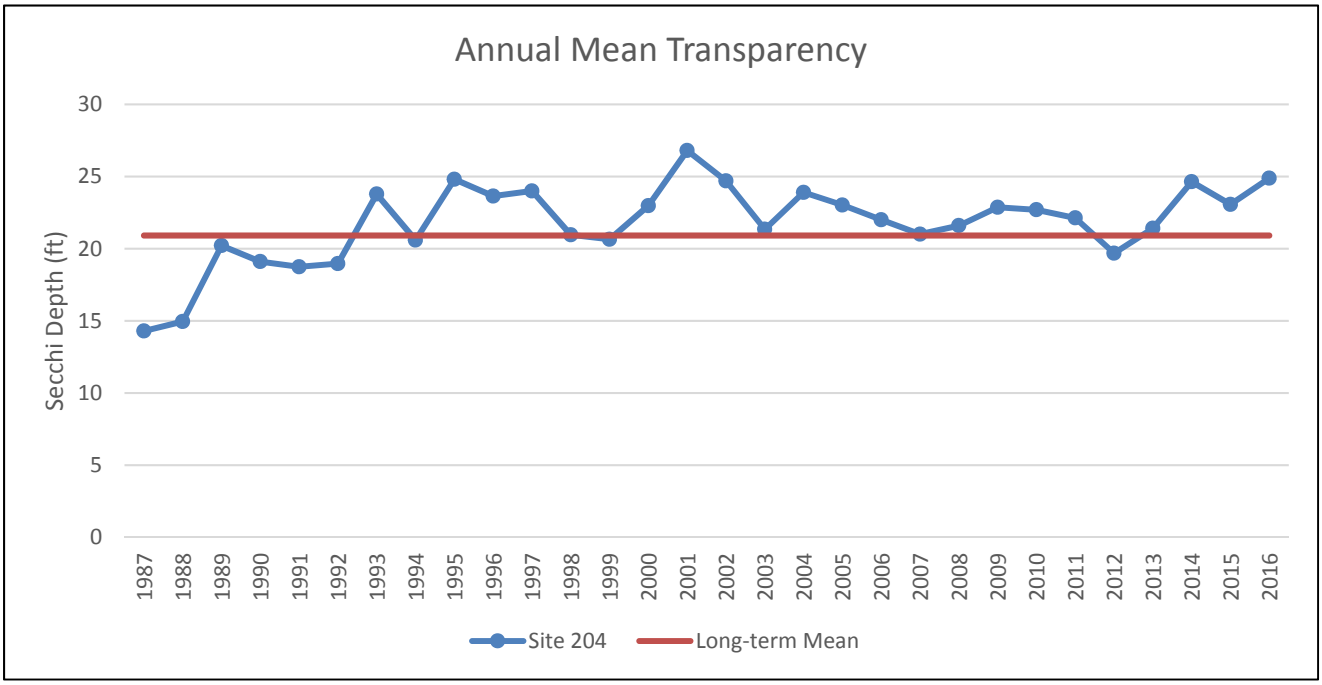


Figure 3. Annual mean transparency for site 204.

Little Sand Lake transparency ranges from 10 to 40 feet throughout the summer. Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Little Sand Lake transparency is high in May and June and declines slightly through August. 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.

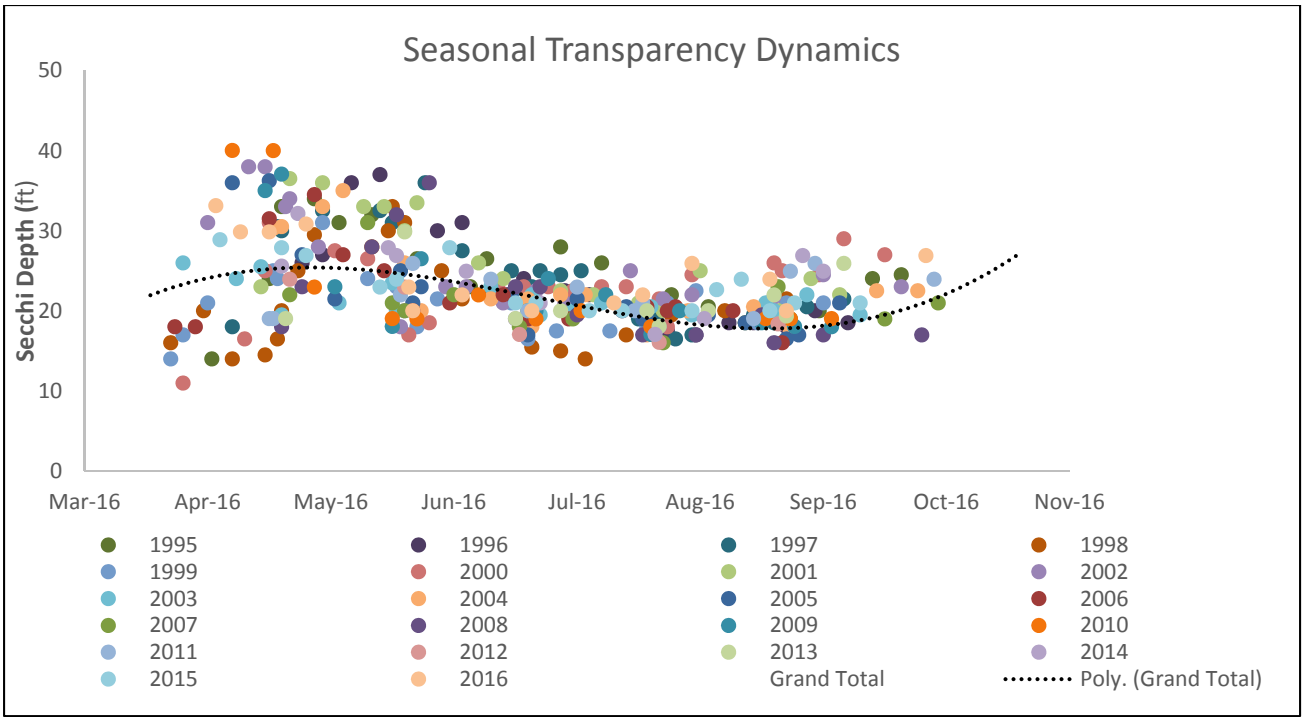


Figure 4. Seasonal transparency dynamics and year-to-year comparison (site 204). The black line represents the pattern in the data.

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. Little Sand Lake was rated as being "crystal clear" 76% of the time between 1989-2016 (Figure 5).

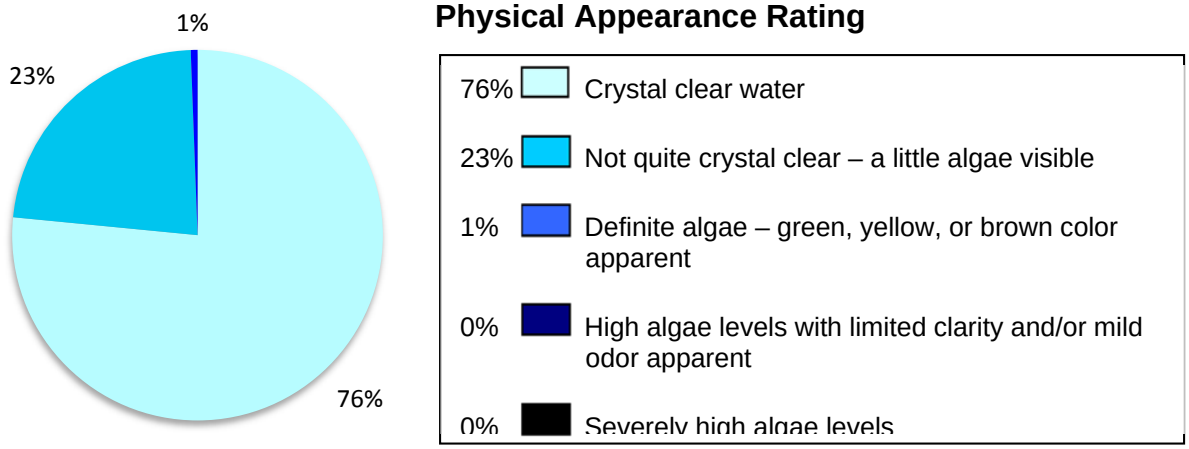


Figure 5. Physical appearance rating, as rated by the volunteer monitor.

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Little Sand Lake was rated as being "beautiful" 90% of the time from 1989-2016.

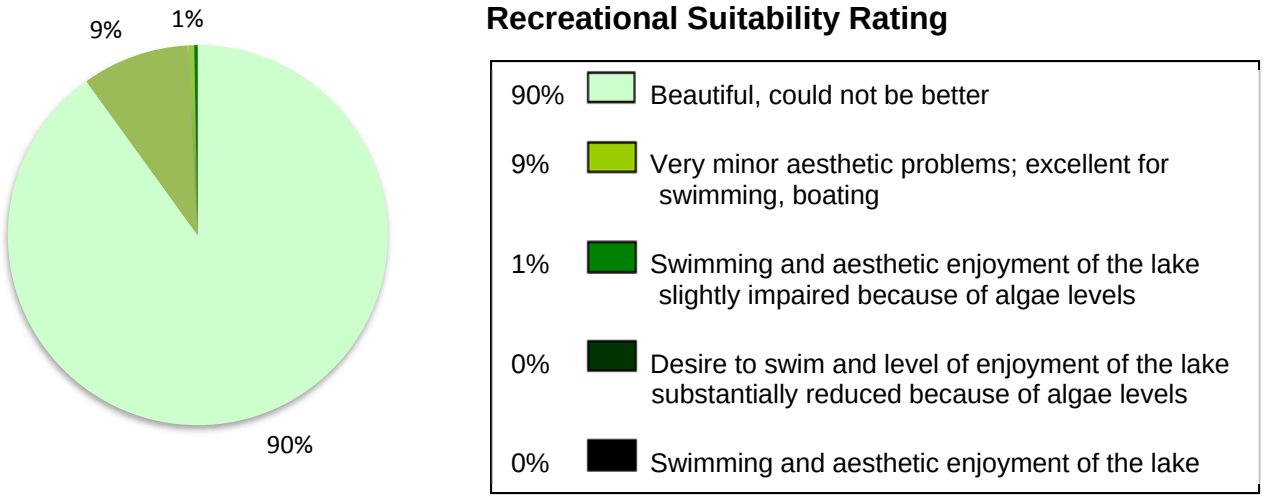


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Little Sand Lake in 1997-2016. Most of the data points fall into the oligotrophic range (Figure 7). There is not much seasonal variation in phosphorus concentration for Little Sand Lake. The highest phosphorus has occurred in May, which could be due to spring thaw runoff and rains.

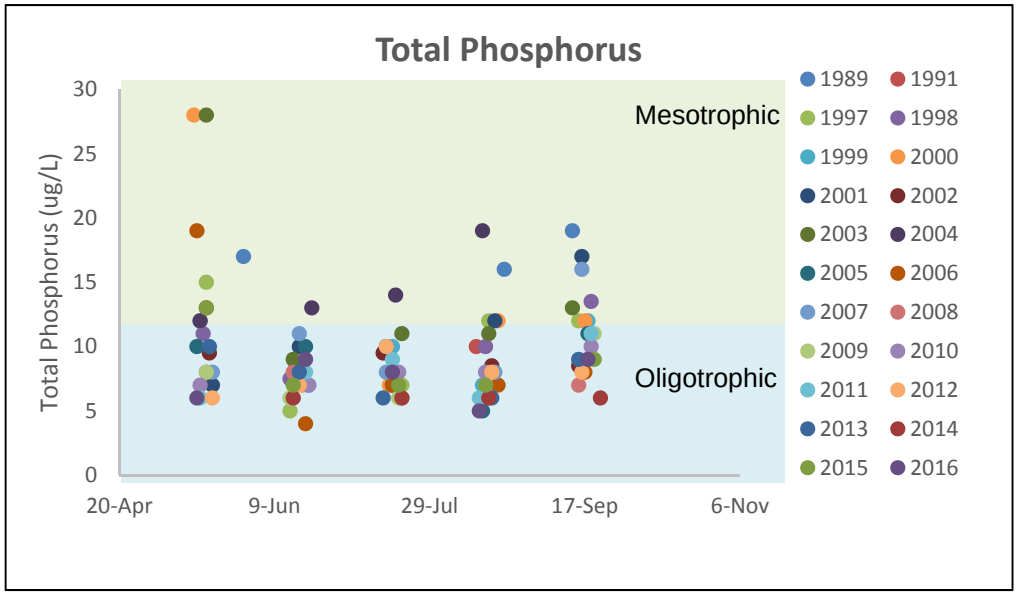


Figure 7. Historical total phosphorus concentrations (ug/L) at site 204 for Little Sand Lake.

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.

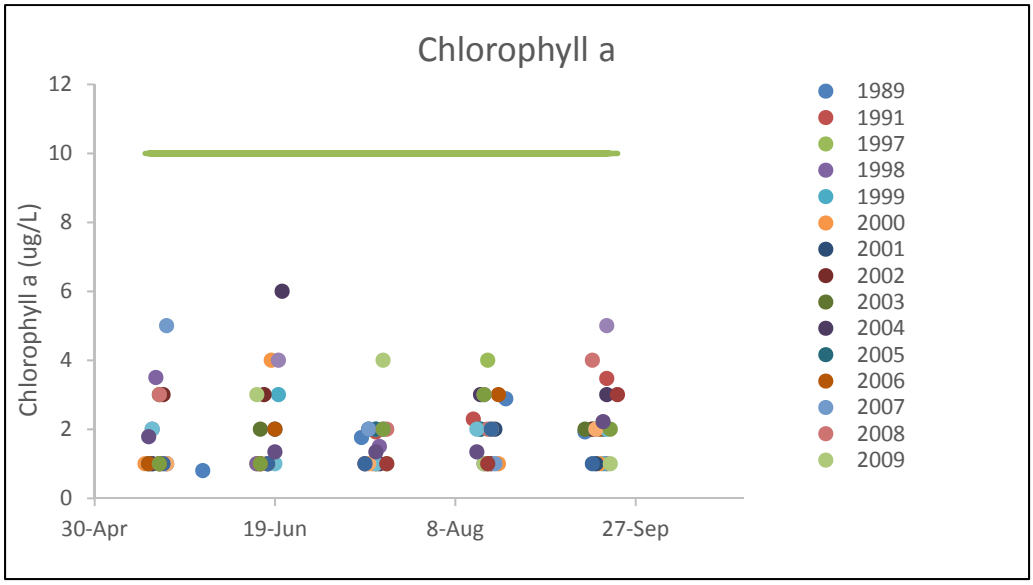
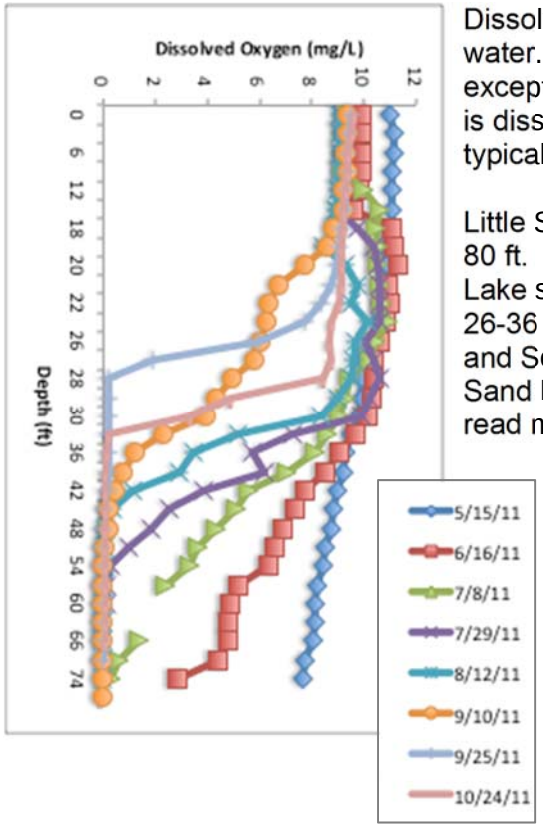


Figure 8. Chlorophyll *a* concentrations (ug/L) for Little Sand Lake.

Chlorophyll *a* was evaluated in Little Sand Lake in 1997-2016 (Figure 8). Chlorophyll *a* concentrations remained well below 10 ug/L, indicating clear water all summer and no nuisance algae blooms.

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.

Little Sand Lake is a relatively deep lake, with a maximum depth of 80 ft. Dissolved oxygen profiles from 2011 indicate that Little Sand Lake stratifies in the summer (Figure 9). The thermocline occurs at 26-36 feet, although the oxygen only drops below 5 mg/L in August and September. This is good habitat for Cisco (Tullibee) fish. Little Sand Lake is designated by the DNR as a Cisco refuge lake. To read more about this designation, see pages 16-17.

Little Sand Lake has been monitoring dissolved oxygen and temperature for many years with the DNR. Those data are available from the DNR in Park Rapids.

Figure 9. Dissolved oxygen profiles for Little Sand Lake in 2011.

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 Little Sand 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 are characteristic of clear water throughout the summer and are excellent for recreation (Table 7). They have very low nutrient levels and sandy/rocky shores. If there is enough hypolimnetic oxygen, trout can survive.

Table 6. Trophic State Index.

Trophic State Index	Site 204
TSI Total Phosphorus	36
TSI Chlorophyll-a	35
TSI Secchi	33
TSI Mean	35
Trophic State:	Oligotrophic

Numbers represent the mean TSI for each parameter.

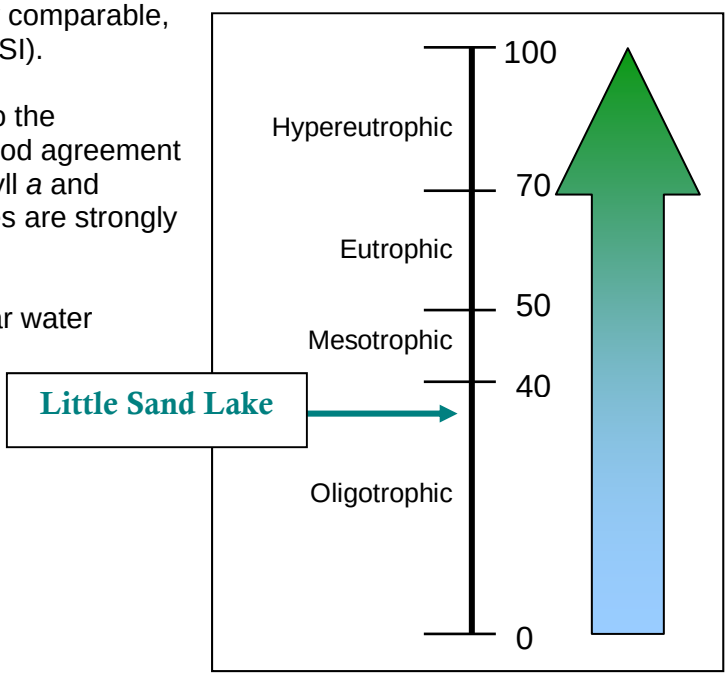


Figure 10. Trophic state index chart with corresponding trophic status.

Table 7. Trophic 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 Little Sand Lake (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Little Sand Lake.

Lake Site	Parameter	Date Range	Trend	Probability
204	Transparency	1987-2016	Improving	99.9%
204	Total Phosphorus	1997-2016	Improving	99%
204	Chlorophyll a	1997-2016	No trend	-

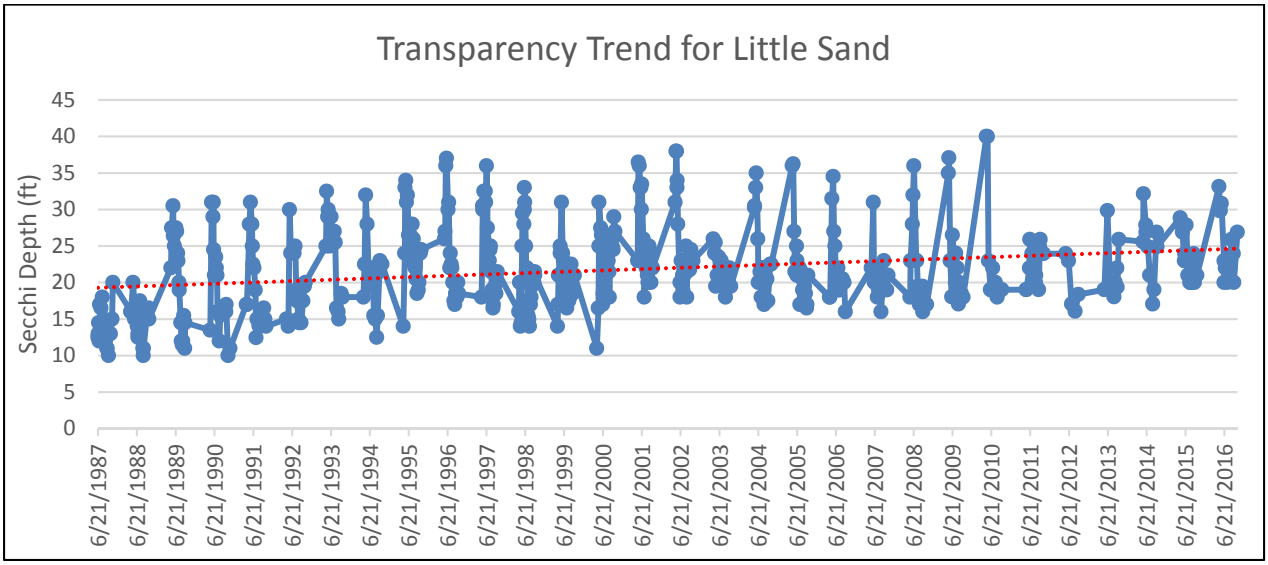


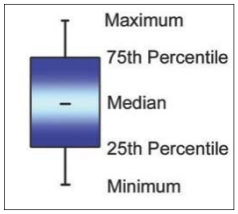
Figure 11. Long-term transparency trend for site 204 in Little Sand Lake.

Site 204 shows a statistically significant improving trend in transparency from 1987-2016 (Figure 11). There is also an improving trend in phosphorus, which means that phosphorus concentrations are getting lower. Monitoring should continue at site 204 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.

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



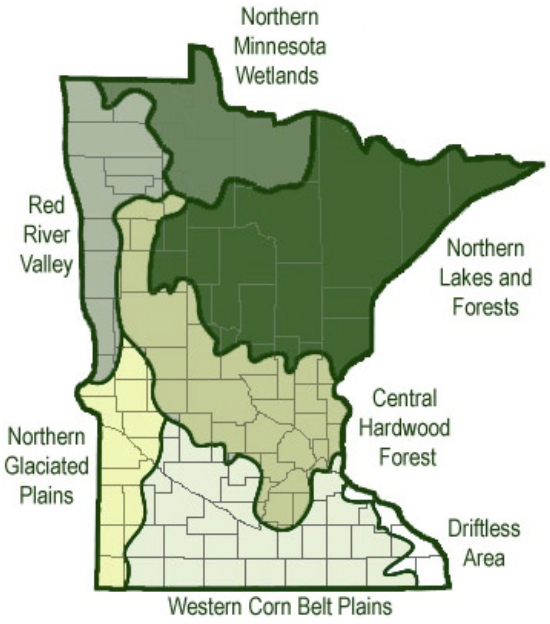
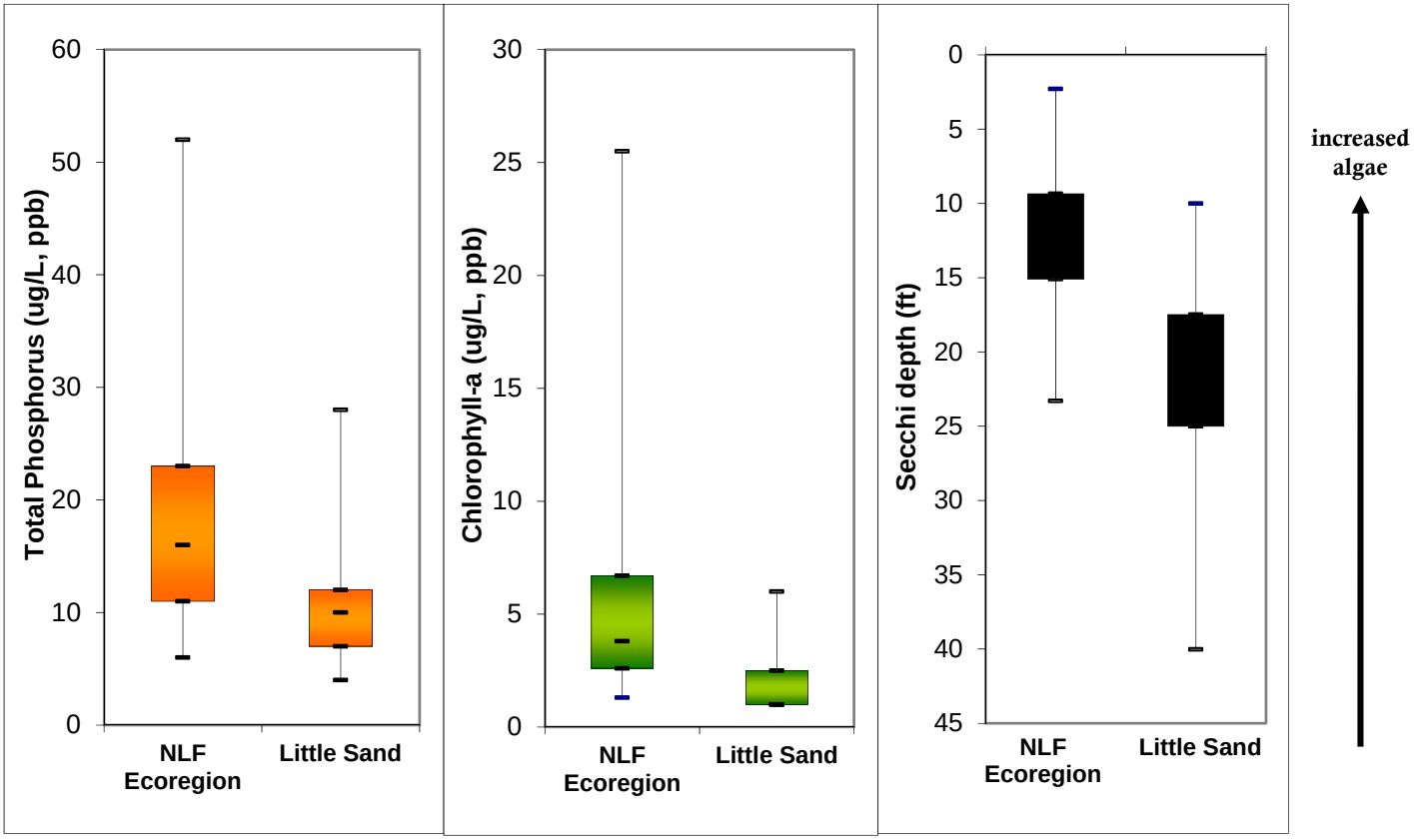


Figure 12. Map of Minnesota with the seven ecoregions.



Figures 13a-c. Little Sand Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Little Sand Lake total phosphorus and chlorophyll *a* ranges are from 80 data points collected in May-September of 1997-2011. The Little Sand Lake Secchi depth range is from 434 data points collected in May-September from 1987-2011.

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. Little Sand Lake is located in **minor watershed 12007** (Figure 15).

Figure 14. Crow Wing River Watershed.

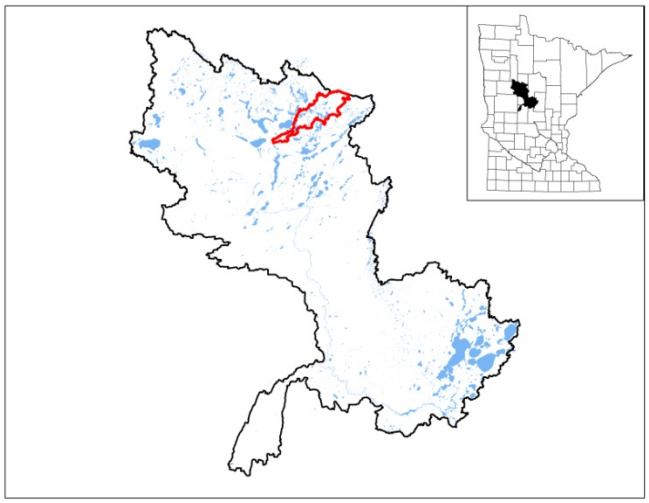
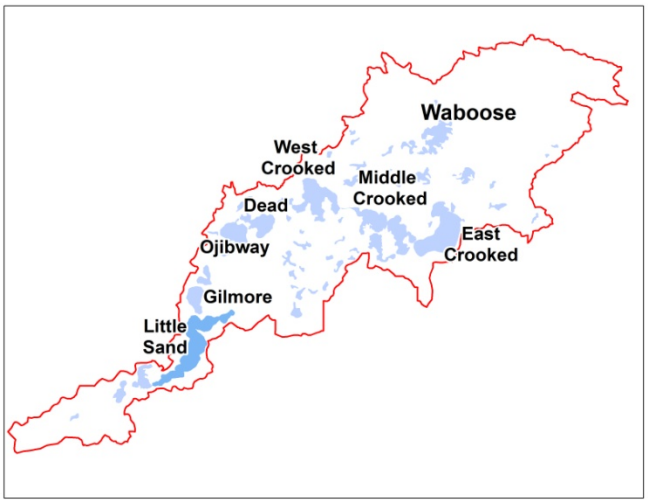


Figure 15. Minor Watershed 12007



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. Little Sand Lake falls within **lakeshed number 1200700** (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

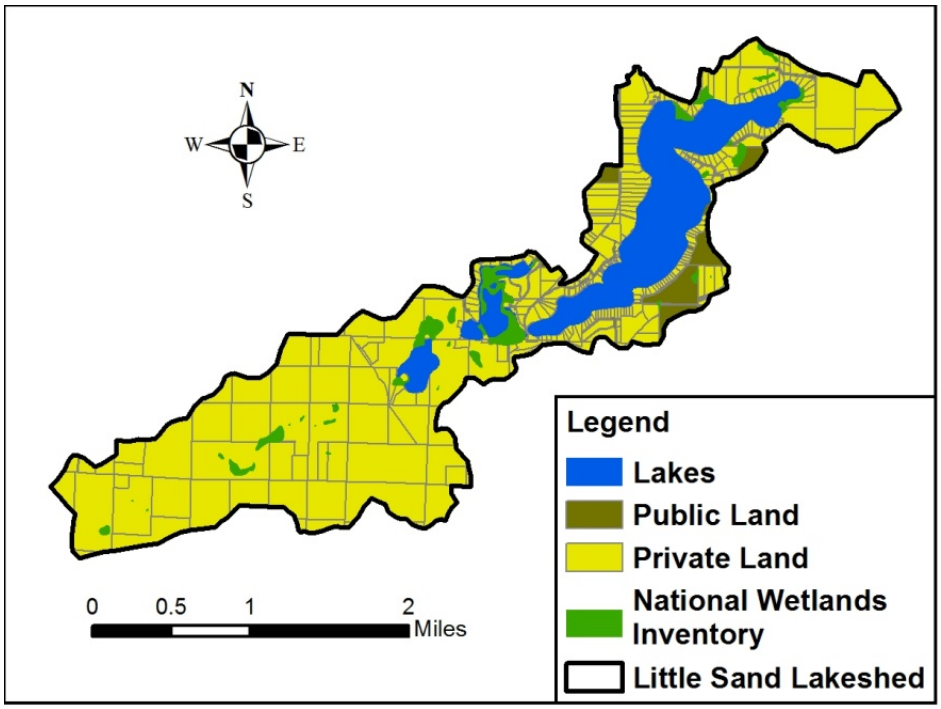


Figure 16. The Little Sand Lake lakeshed with land ownership, lakes, wetlands, and rivers illustrated.

larger drainage area via stream or river networks. For further discussion of Little Sand Lake's full watershed, containing all the lakesheds upstream of Little Sand Lake lakeshed, see page 17. The data interpretation of the Little Sand Lake lakeshed includes only the immediate lakeshed, as this area is the land surface that flows directly into Little Sand 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

Possibly detrimental to the lake
Warrants attention
Beneficial to the lake

Table 9. Lakeshed vitals for Little Sand Lake.

Lakeshed Vitals		Rating
Lake Area	410 acres	descriptive
Littoral Zone Area	149 acres	descriptive
Lake Max Depth	80 ft.	descriptive
Lake Mean Depth	24.8 ft.	
Water Residence Time	0.9	
Miles of Stream	0.17	descriptive
Inlets	2	
Outlets	1 – Little Sand River	
Major Watershed	Crow Wing River	descriptive
Minor Watershed	12007	descriptive
Lakeshed	1200700	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	7:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	137:1	
Wetland Coverage	3.7%	
Aquatic Invasive Species	None	
Public Drainage Ditches	None	
Public Lake Accesses	1	
Miles of Shoreline	6.4	descriptive
Shoreline Development Index	2.3	
Public Land : Private Land (excludes water)	0.05:1	
Development Classification	Recreational Development	
Miles of Road	15.5	descriptive
Municipalities in lakeshed	None	
Forestry Practices	2002 Hubbard County Forest Resources Management Plan	
Feedlots	None	
Sewage Management	Individual waste treatment systems (last lake-wide county inspection - 1994)	
Lake Management Plan	Healthy Lakes & Rivers Partnership program, 2003	
Lake Vegetation Survey/Plan	Completed 2005	

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.

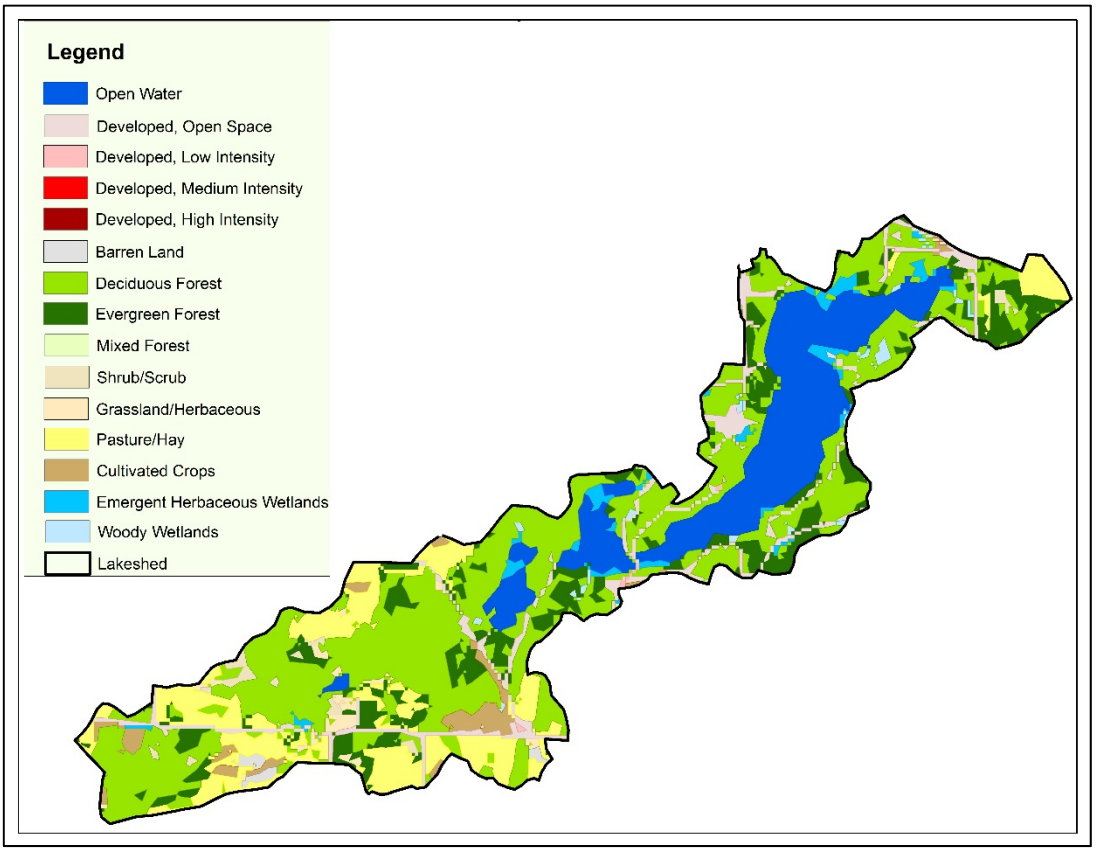


Figure 17. Little Sand (1200700) lakeshed land cover (http://land.umn.edu).

Changes in land use, and ultimately land cover, impact the hydrology of a lakeshed. Land cover is also directly related to the 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.

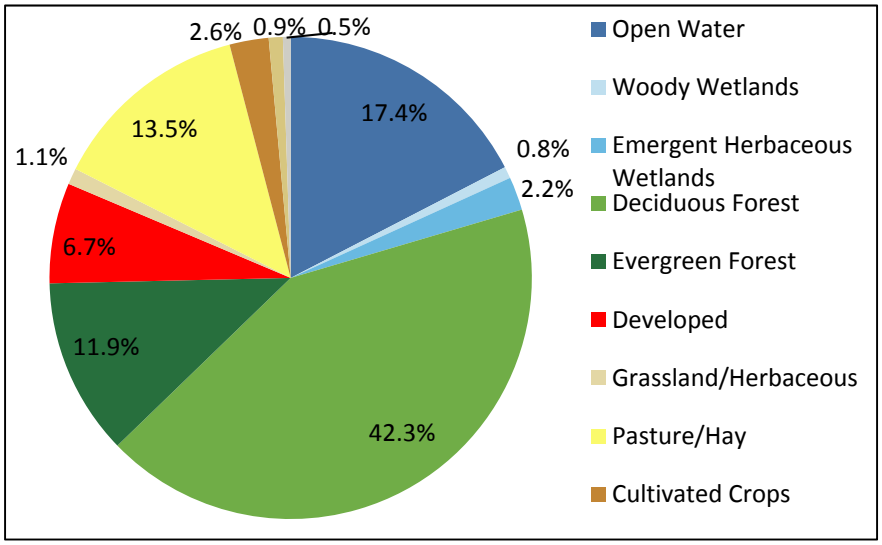


Figure 18. Percentage of each land cover in the Little Sand Lake lakeshed.

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 Little Sand Lake's lakeshed and Figure 18 shows the percentage of each land cover.

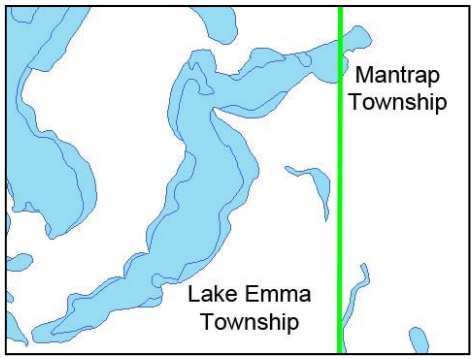
The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). This data is somewhat outdated, but it shows increases in development in the 1990s when the economy was booming. The impervious intensity in the lakeshed has increased, which has implications for storm water runoff into the lake (Table 10).

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

	1990		2000		% Change
	Acres	Percent	Acres	Percent	1990 to 2000
Total Impervious Area (Percent Impervious Area Excludes Water Area)	29	1.2	57	2.32	96.6% Increase

Demographics

Little Sand 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 Hubbard County as a whole, Mantrap and Lake Emma Township have a higher extrapolated growth projection (Figure 19).

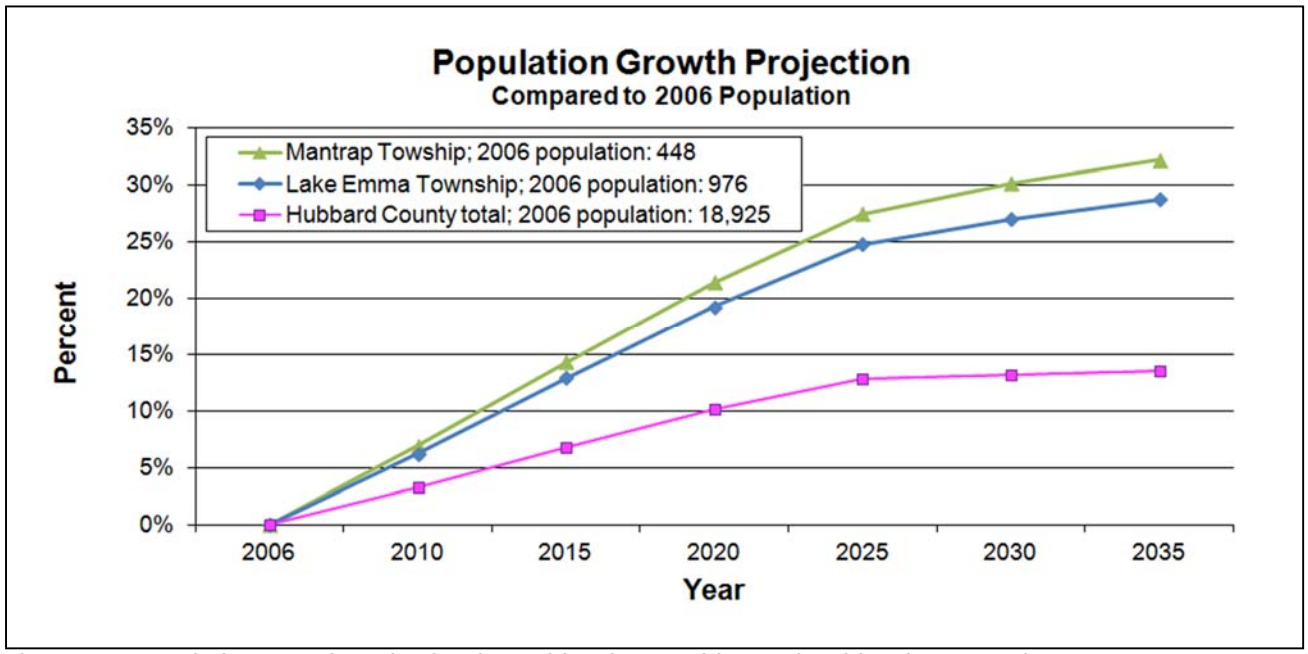


Figure 19. Population growth projection for Hubbard Townships and Hubbard County. (source: http://www.demography.state.mn.us/resource.html?Id=19332)

Little Sand 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 Little Sand Lake's lakeshed is made up of private forested uplands (Table 11). This land can be the focus of development and protection efforts in the lakeshed.

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 and the 2011 National Land Cover Dataset).

	Private (78.0%)					**18.8%**	**Public (3.2%)**		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	5.7%	15.8%	51.7%	2.4%	2.4%	18.8%	2.8%	1.2%	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	77 – 255	122 – 422	138		6.5		5.2	3.4	
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.

Little Sand Lake was classified with having 22.8% of the watershed protected and 22.1% of the watershed disturbed (Figure 20). Therefore, Little Sand Lake should have a protection focus. This lake is almost at the 25% disturbed threshold, so it is almost ranked in the yellow (full restoration) category. Goals for the lake should be to limit any increase in disturbed land use.

Figure 21 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 Little Sand Lake, whether through direct overland flow or through a creek or river. The majority of the watershed has a protection focus.

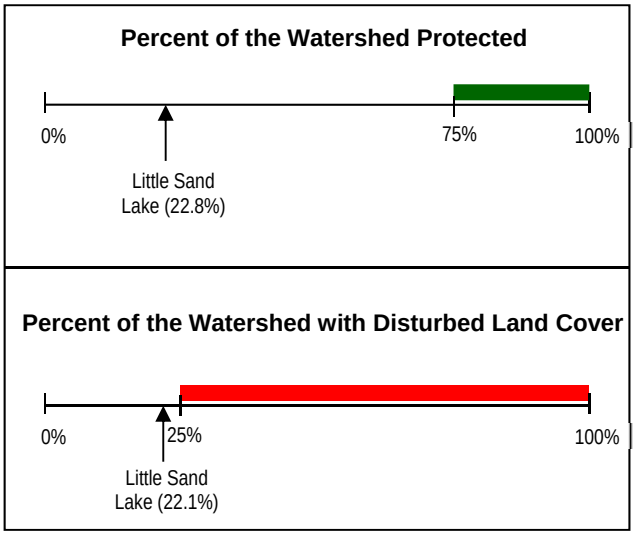


Figure 20. Little Sand Lake lakeshed's percentage of watershed protected and disturbed.

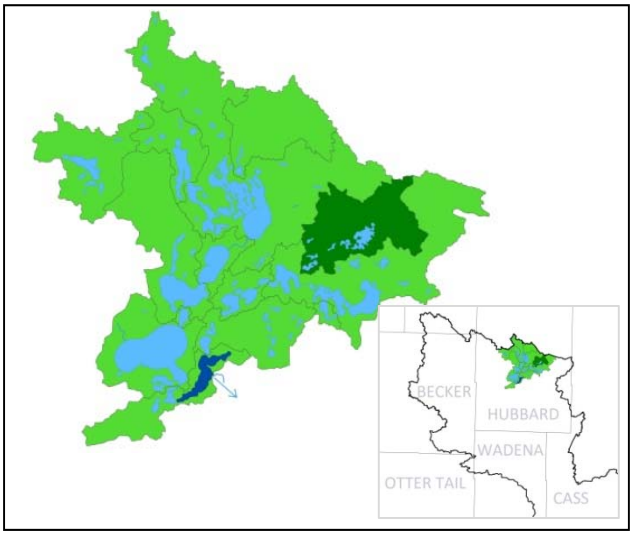


Figure 21. Upstream lakesheds that contribute water to the Little Sand lakeshed. Color-coded based on management focus (Table 12).

Little Sand, Status of the Fishery (as of 06/19/2012)

Little Sand Lake is located in southern Hubbard County, 2 miles north of Dorset. Little Sand has a surface area of 409 acres and a maximum depth of 80 feet. A public access is located on the south shore of the lake. Boating access with a small craft is also available from the inlet channel connecting to Ida Lake. Little Sand provides multi species opportunities to the angler, with good populations of walleye, northern pike, panfish, and bass.

The Minnesota Department of Natural Resources (DNR) has classified Minnesota's lakes into 43 different types based on physical, chemical, and other characteristics. Little Sand is in lake class 25. Class 25 lakes are generally deep, clear, hard water lakes, with irregularly shaped shoreline. Other class 25 lakes in the Park Rapids area include: Bad Axe, Belle Taine, Eagle, West Crooked, Third Crow Wing, Island, Big Mantrap, Little Mantrap, Ojibway, Straight, and Two Inlets.

Walleye abundance was up from previous surveys and within the range for similar type lakes, but short of management goals. Multiple year classes of walleye were sampled with good numbers of walleye in the 16 to 18 inch range. Little Sand is currently stocked with walleye fingerlings during even numbered years. Present and past surveys have shown low and sporadic contribution from walleye natural reproduction. Yellow perch, an important forage species for walleye were sampled in low to moderate numbers for this lake class. Yellow perch were small in size, with few perch of an acceptable size for angling. Tullibee (cisco) are present in Little Sand and have been sampled in low numbers in past surveys.

Anglers can expect to find an abundant population of small, "hammer handle" northern pike in Little Sand. Sampled northern pike had an average length and weight of 20 inches and 1.8 pounds, with pike measured up to 31 inches. Northern pike abundance was low in historical surveys, and then started to explode in the late 1990's. Silver pike (a genetic color phase of northern pike) are present in low numbers in Little Sand.

While not known as a panfish lake, Little Sand does provide angling opportunities for bluegill, pumpkinseed, and black crappie. Anglers can expect to find low to moderate numbers of black crappie with fish in the 9-10 inch size range. Bluegill abundance was within the range for similar type lakes. Anglers will find good numbers of bluegill in the 6-8 inch size range.

Little Sand has both a largemouth bass and smallmouth bass population with good numbers and sizes for both species. Little Sand has good water quality, bottom substrate, and aquatic vegetation that will help insure a healthy largemouth and smallmouth bass population.

Other species sampled in moderate numbers included rock bass, yellow bullhead, and white sucker.

Currently no aquatic invasive species (AIS) have been identified in Little Sand. To avoid spreading AIS, lake users are required to remove all aquatic plants or animals from their watercraft and drain all water from their boat before leaving the access.

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=29015000

Key Findings / Recommendations

Emergent and Floating Leaf Plant Survey
In 2005, Little Sand Lake was surveyed by members of the Little Sand Lake Association - Vern Thompson, Jim Thomsen, & Dan Kittilson. The survey was conducted over 4 days - August 28 & 29, and September 3 & 4 in cooperation with the DNR in Park Rapids. During the survey, 177 points were sampled and 20 different plants were identified. The most common plant found was Chara, which is found in clear sandy lakes and indicates good water quality. For the full report from this survey, see the Little Sand Lake website: http://littlesandlakemn.com.

Monitoring Recommendations
Transparency monitoring at site 204 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.

Although zebra mussels have not been discovered in Little Sand Lake to date, lake residents should be vigilant to make sure that their boats, docks, and hoists are zebra mussel-free prior to entering the lake. Zebra mussels, and other aquatic invasive species, can dramatically change the lake ecosystem if they establish populations in Little Sand Lake. Water quality (e.g Secchi depth, chlorophyll *a*, and total phosphorus) can change significantly when zebra mussels become established in a lake, altering the fisheries and creating problems near shore (e.g. sharp shells can hurt when stepped on).

Overall Conclusions
Little Sand Lake is an outstanding water resource. It is an oligotrophic lake (TSI=35) with an improving water quality trend in both transparency and phosphorus. Four percent (4%) of the lakeshed is in public ownership (Table 11), and 22.8% of the watershed is protected, while 22.1% of the watershed disturbed (Figure 19). Half of the private land area is covered in forest (Table 11).

It is unclear why Little Sand Lake is improving in transparency and phosphorus. Sometimes these trends are due to the natural environment. Little Sand Lake has a high watershed to lake area ratio (137:1), which means there is a lot of area draining into the lake. If the Little Sand Lake area is very sandy, as the name suggests, it could be that the nutrients from the watershed are just draining through the sand and not affecting the lake.

Big Sand Lake is improving in clarity and phosphorus as well, and Big Sand drains into Little Sand, so the trends on these two lakes could be linked. Lakewide septic system upgrades were completed on both lakes in the mid-1990s, so this could be another possible explanation for the water quality improvement.

Priority Impacts to the lake
Overall, the lake's water quality has been maintained and improving. However, this does not mean the lake is resistant to future changes in water quality. Because Little Sand Lake is such an outstanding water resource and fishery, there is a high degree of development pressure. From 1990-2000, the impervious surface increased by 96% (28 acres) (Table 10). Most suitable first tier land parcels have been developed (Figures 16, 22). This could mean that future development would occur in the second tier, which can have impacts to the drainage around the lake. The population in the Lake Emma Township is projected to grow another 25% in the next 10 years.

As discussed on page 16, 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%. The Little Sand lakeshed is currently at 22.1% disturbed land uses (urban and agriculture categories). Conversion of land to one of these uses should be

carefully planned and its effect should be mitigated through the implementation of best management practices.

In addition, 16% of the lakeshed is in agricultural land use; however, the agricultural cover is mainly pasture, which has much less runoff potential than row crops (Figure 18). The agriculture is mainly in the southwest end of the lakeshed and at least 0.5 miles from the shoreline.

There are two stormceptors at County Highway 7 at the south end of Little Long Lake (Figure 23). When the stormceptors overflow during a storm event, they have the potential to contribute nutrient and sediment loading to Lake Ida, which flows into Little Sand Lake (Figures 24-25). For more details, see Appendix I on page 22 of this report.

Best Management Practices Recommendations

The management focus for Little Sand Lake should be to protect the current water quality. Protection efforts should be focused on managing and/or decreasing the impact caused by additional development, including second tier development, and impervious surface area. Deliberate planning should focus on the placement of development infrastructure and its resulting drainage patterns. Project ideas include protecting land with conservation easements (forest stewardship enrollment), enforcing county shoreline ordinances, smart development, shoreline restoration, rain gardens, and septic system maintenance.

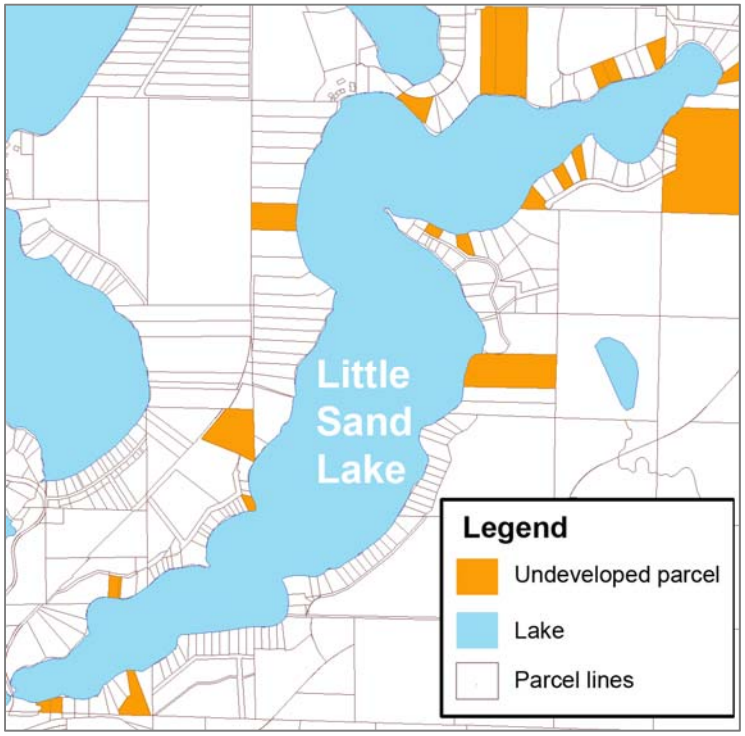


Figure 22. Parcels around Little Sand Lake without houses on them are highlighted in orange.

Some of the lakeshed is privately owned forested uplands (Table 11). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has some of the shoreline in large undeveloped parcels (Figure 22). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

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)
- Conservation easements

Lake Associations
- Lake condition monitoring
- Ground truthing – visual inspection upstream on stream inlets
- Watershed runoff mapping by a consultant
- Shoreline inventory study by a consultant
- Conservation easements

Soil and Water Conservation District (SWCD) and Natural Resources Conservation Service (NRCS)
- Shoreline restoration
- Stream buffers
- Wetland restoration
- Forest stewardship planning
- Work with farmers to
    - Restore wetlands
    - Implement conservation farming practices
    - Land retirement programs such as Conservation Reserve Program

Organizational contacts and reference sites

Little Sand Lake Association	http://littlesandlakemn.com
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/

Appendix I

Stormceptor Testing

When County Highway 7 was replaced, stormceptors were installed on the west side of the highway at the southern end of Lake Ida (Figure 23). Lake Ida flows into Little Sand Lake. The stormceptors are large boxes underground that are meant to capture runoff water and sediment from the highway during storms so that it doesn't flow directly into the lake. Stormceptors do need to be cleaned out every so often when they fill up with sediment so they can function properly.

On a few dates in 2009-2014, the stormceptors overflowed and spilled into Lake Ida. The Little Sand Lake Association collected water samples of the overflow for lab analysis (Figures 24-25). Results show some sediment and nutrient loading during major storm events.

Figure 23. Stormceptor location near Lake Ida and Little Sand Lake.

Recommendations

The stormceptors should be checked every few months and emptied of sediment when they are over half way full or if an overflow event occurs. This ensures they will continue to properly capture stormwater and settle out sediment. Overflow events should be documented and can be monitored to determine any local impacts. Conditions to look for that would indicate an impact from the overflow loading include cloudy water, a localized algae bloom and/or increased localized aquatic plant growth.

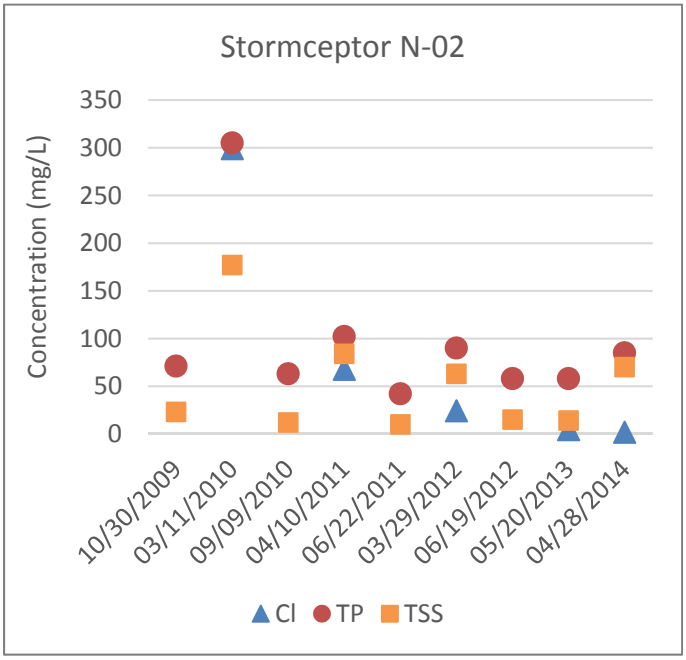


Figure 24. Stormceptor testing results for site N-02 from 2009-2014 for chloride (CL), total phosphorus (TP), and total suspended solids (TSS).

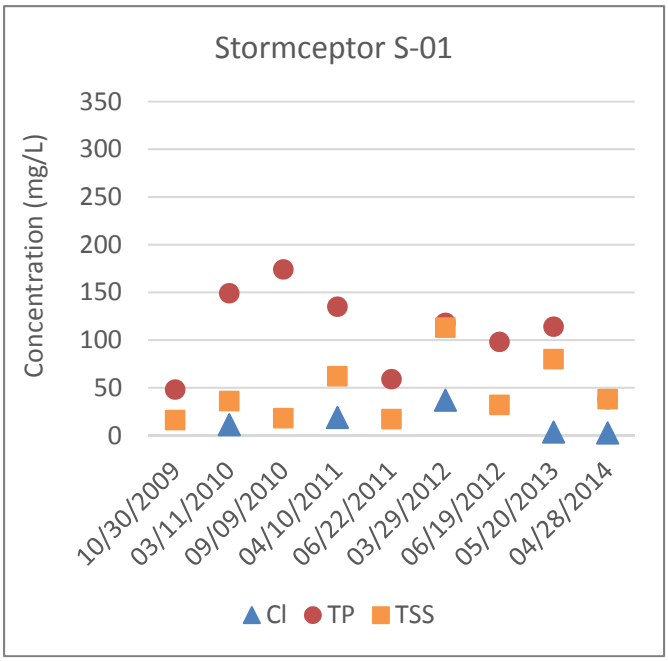


Figure 25. Stormceptor testing results for site S-01 from 2009-2014 for chloride (CL), total phosphorus (TP), and total suspended solids (TSS).