Big Mantrap Lake 29-0151-00 HUBBARD COUNTY

Lake Water Quality

Summary

Big Mantrap Lake is located about 15 miles northeast of Park Rapids, Minnesota. It covers 1,618 acres and has an undulating shoreline with many bays.

Big Mantrap Lake has three inlets and one outlet, which classifies it as a drainage lake. All the inlets just drain from adjacent lakes (Mud, Bad Axe and Petit), not a large watershed. The outlet is located at the south end of the lake and flows into Upper Bottle, Lower Bottle, Big Sand, Little Sand, Belle Taine and eventually the Crow Wing Lakes Chain.

Water quality data have been collected on Big Mantrap Lake since 1989 (Table 3). These data show that the lake is mesotrophic, which is characterized by clear water throughout most of the summer and excellent recreational opportunities.

The Big Mantrap Lake Association was formed in 1956, and its purpose is “maintaining and improving the natural resources of Big Mantrap Lake, Hubbard County, Minnesota, a public lake.” The association is involved in many activities, including water quality monitoring, a loon nesting program, shoreland restoration, and education. They are also a member of the Hubbard County Coalition of Lake Associations (COLA).

Table 1. Big Mantrap Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	29-0151-01	Surface area (acres):	1618
County:	Hubbard	Littoral area (acres):	752
Ecoregion:	Northern Lakes & Forests	% Littoral area:	46%
Major Drainage Basin:	Upper Mississippi River	Max depth (ft), (m):	68, 20.7
Latitude/Longitude:	47.06805556 / -94.89416667	Inlets:	3
Invasive Species:	None	Outlets:	1
		Public Accesses:	2

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 or outlet data exist for this lake.

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

Lake Map

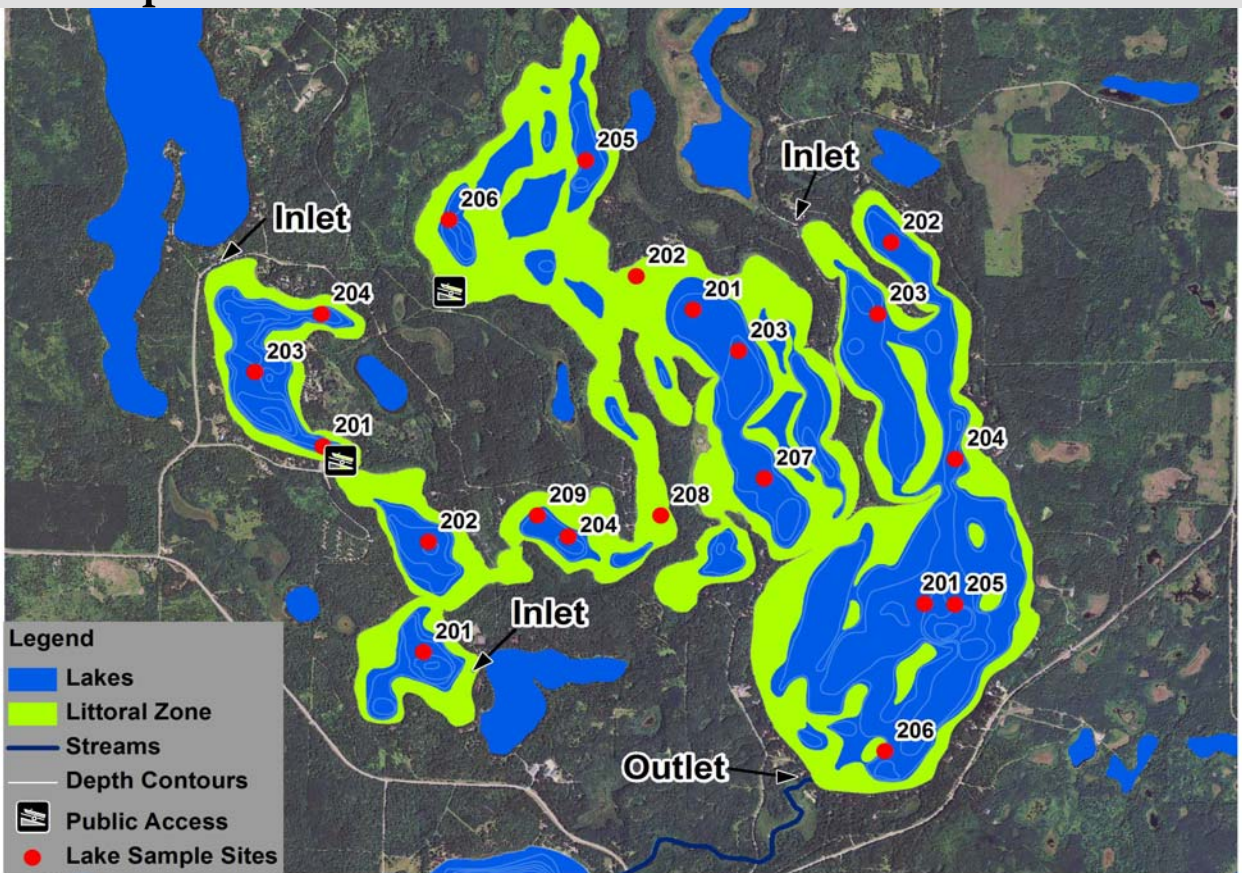


Figure 1. Map of Big Mantrap Lake with 2010 aerial imagery and illustrations lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic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

Table 3. Monitoring programs and associated monitoring sites. Sites with only one year of data were not included in the table. Monitoring programs include the Citizens Lake Monitoring Program (CLMP), Clean Water Legacy Surface Water Monitoring (MPCA) and RMB Environmental Laboratories Lakes Program (RMBEL).

Basin	Lake Site	Depth (ft)	Monitoring Programs
East Bay -01	201* Primary site	40	CLMP: 1980, 1994-2012; RMBEL: 1997-2012
	202	20	CLMP: 1990-1992, 1998, RMBEL: 2007
	203	30	CLMP: 1990-1992, 1994-2010
	204	20	CLMP: 1990-1992
	205	40	CLMP: 1990-1992; RMBEL: 2007, 2010
	206	20	CLMP: 1990-1992
Middle Bay -02	201	30	CLMP: 1973-1974, 1990-1992
	203* Secondary site	30	CLMP: 1980, 1994-2010; MPCA: 2008-2009
	204	20	CLMP: 1980, 1990-1991
	205	25	CLMP: 1990-2010
	206	20	CLMP: 1990-1992
	207	25	CLMP: 1990-2010
	208	10	CLMP: 1990-1992
West Arm -04	202	40	CLMP: 1990-2010
	203	40	CLMP: 1990-2010
	204	30	CLMP: 1990-1992
Home Bay -05	201	45	CLMP: 1980, 1990-2010

Average Water Quality Statistics

The information below describes available chemical data for Big Mantrap 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 2008 and 2009 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)	17	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)	20	<15		
Secchi depth (ft)	14.0	7.5 – 15.0	< 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)	0.56	0.40 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	163	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	6	10 - 35		Indicates very clear water with little to no tannins (brown stain).
pH	8.2	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)	1.6	0.6 - 1.2		Slightly above the ecoregion average but still considered low level.
Total Suspended Solids (mg/L)	2.8	<1 - 2		Slightly above the ecoregion average but still considered low level. Indicates clear water.
Specific Conductance (umhos/cm)	295	50 - 250		Slightly above the ecoregion average.
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	East Bay 201	Middle Bay 203	Middle Bay 205	West Bay 202	West Bay 203	Home Bay 201
Total Phosphorus Mean (ug/L):	**17**	**24**				
Total Phosphorus Min:	5	15				
Total Phosphorus Max:	44	47				
Number of Observations:	81	13				
Chlorophyll *a* Mean (ug/L):	**6**	**5**				
Chlorophyll-a Min:	<1	1				
Chlorophyll-a Max:	20	8				
Number of Observations:	81	13				
Secchi Depth Mean (ft):	**14.0**	**11.7**	**10.0**	**13.8**	**13.8**	**15.2**
Secchi Depth Min:	6.0	4.5	3.5	7.5	7.0	8.5
Secchi Depth Max:	31.5	30.0	23.0	25.5	25.5	23.0
Number of Observations:	395	352	345	345	345	420

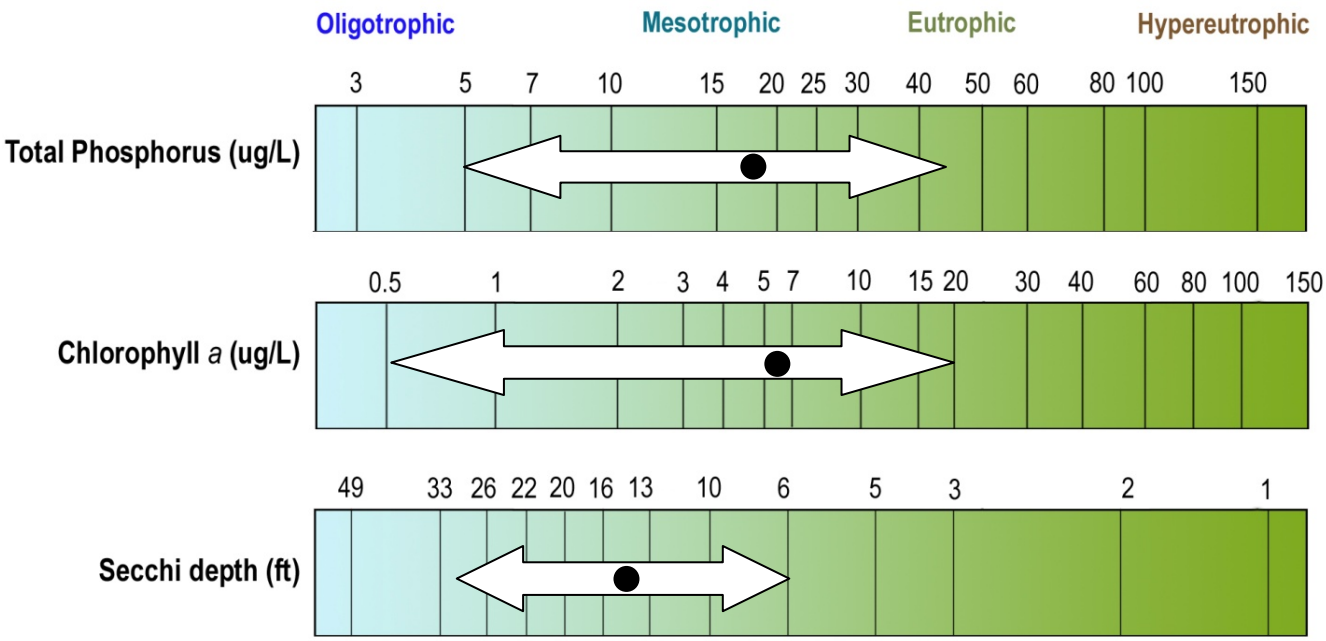


Figure 2. Big Mantrap Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site, East Bay, 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance 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 Big Mantrap Lake ranged from 8.7 - 17.7 feet (Figure 3). Transparency is consistently highest at site 201 in Home Bay and site 201 in East Bay. This could be because these are the deepest monitoring sites (Table 3). Middle Bay has the lowest transparency of all the bays, which could be because it's the shallowest. Transparency monitoring should be continued at all sites to track water quality in Big Mantrap Lake.

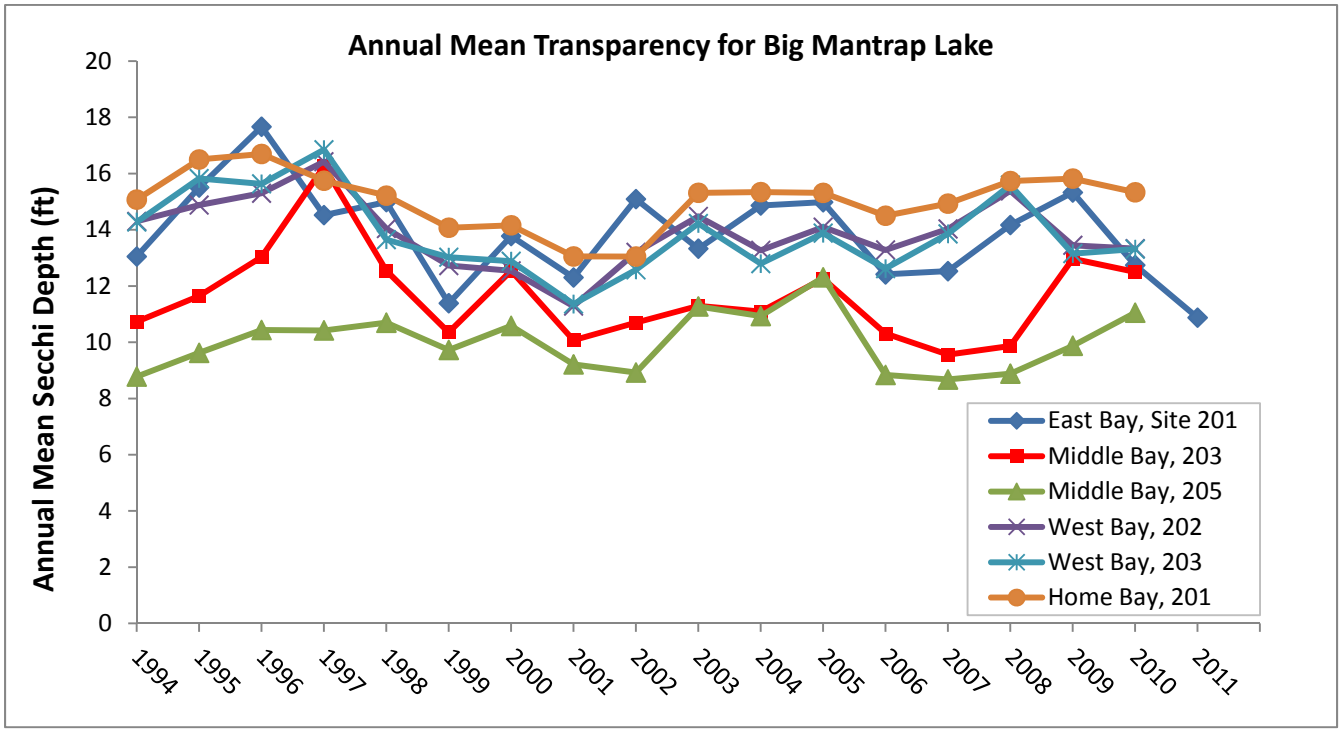


Figure 3. Annual mean transparency for sites 201.

Big Mantrap Lake transparency ranges from 6.0 to 31.5 feet throughout the summer. Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Big Mantrap Lake transparency is high in May and June and declines slightly through August. The transparency then rebounds in October after fall turnover. 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

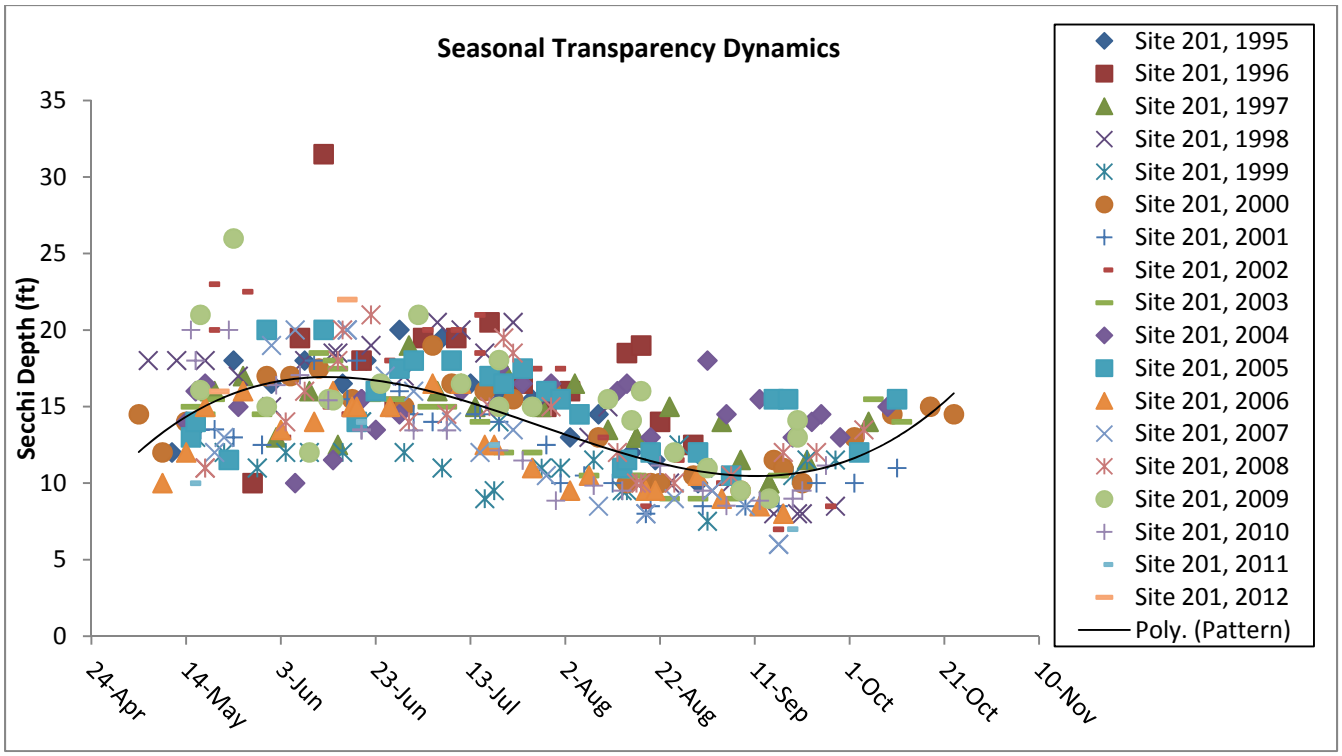


Figure 4. Seasonal transparency dynamics and year-to-year comparison (East Bay, site 201). The black line represents the pattern in the data.

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. At site 201 in the East Bay, Big Mantrap Lake was rated as being "not quite crystal clear" 87% of the time between 1994-2011 (Figure 5).

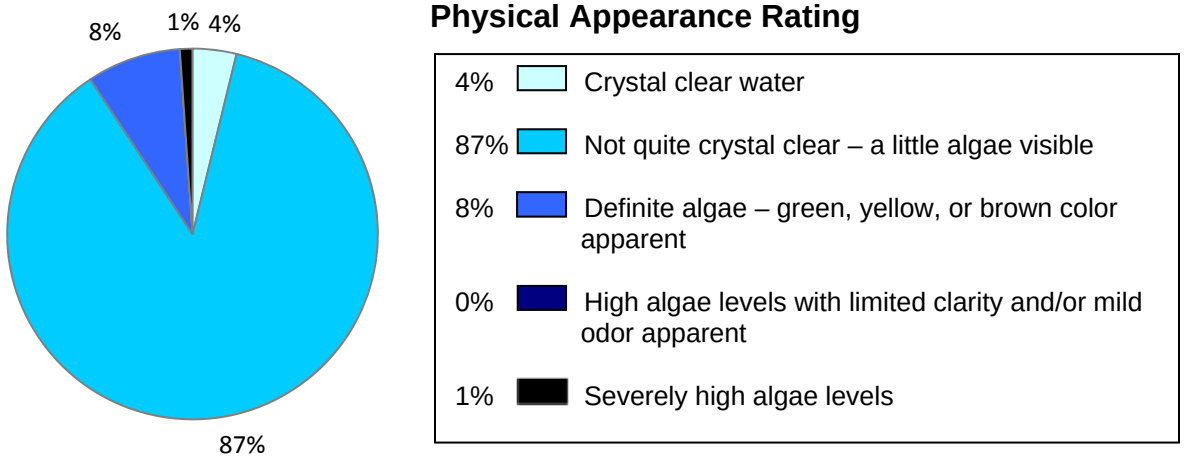


Figure 5. Physical appearance rating, as rated by the volunteer monitor (site 201 in East Bay).

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Big Mantrap Lake was rated as being "beautiful" 46% of the time from 1994-2011 at site 201 in East Bay.

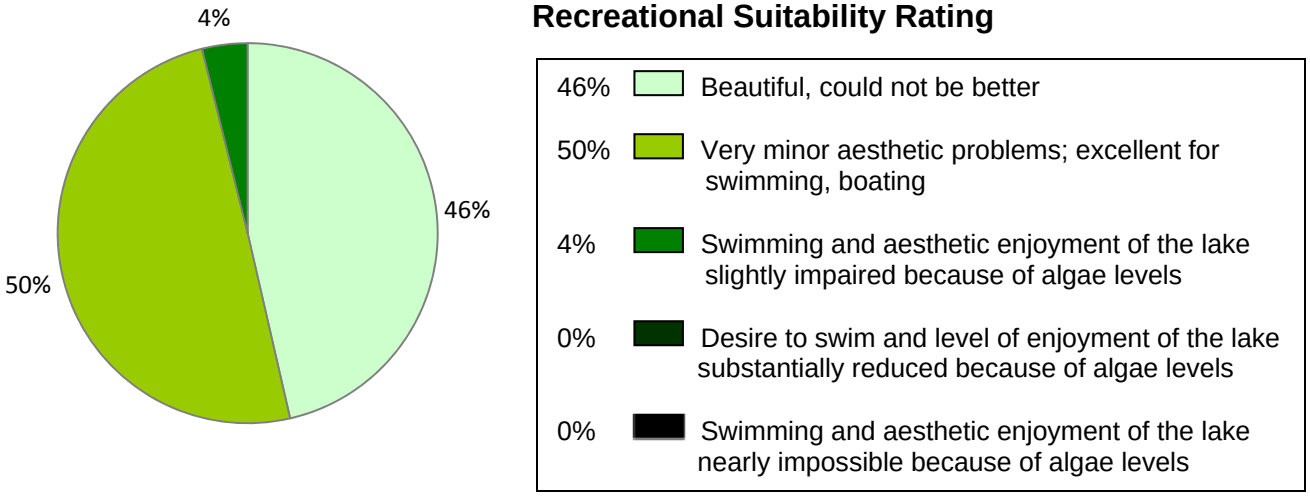


Figure 6. Recreational suitability rating, as rated by the volunteer monitor from 1994-2011 (site 201 in East Bay).

Total Phosphorus

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

Total phosphorus was evaluated in Big Mantrap Lake in the east bay in 1997-2011. Most of the data points fall into the mesotrophic range (Figure 7). The phosphorus concentrations increase somewhat as the summer progresses. This could be due to internal loading if the lake is turning over multiple times during the summer.

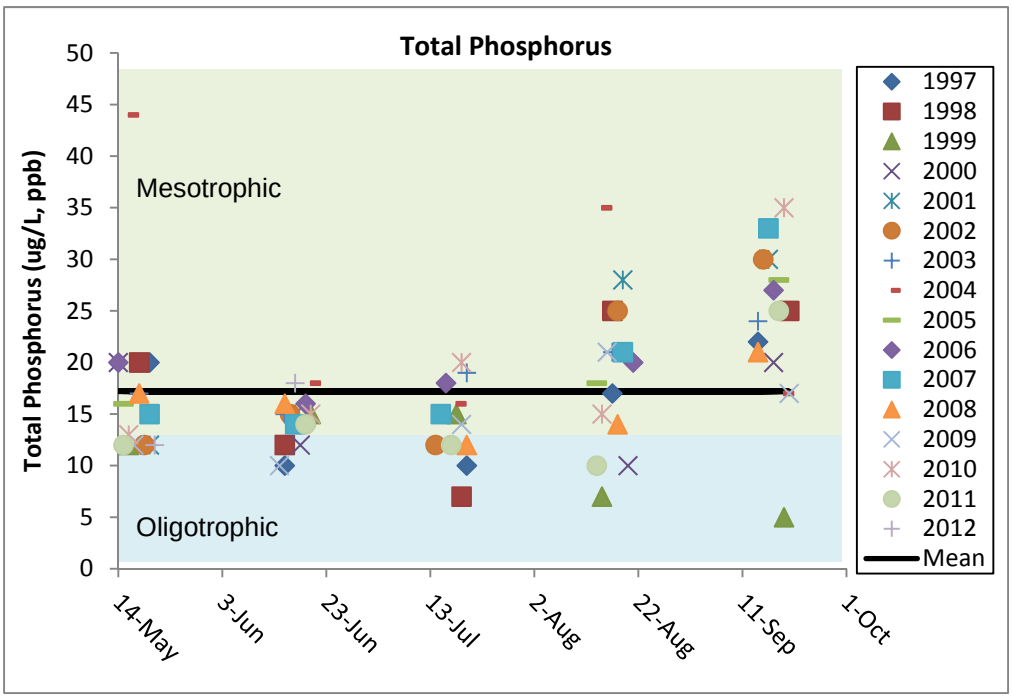


Figure 7. Historical total phosphorus concentrations (ug/L) at site 201 (East Bay) for Big Mantrap Lake.

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.

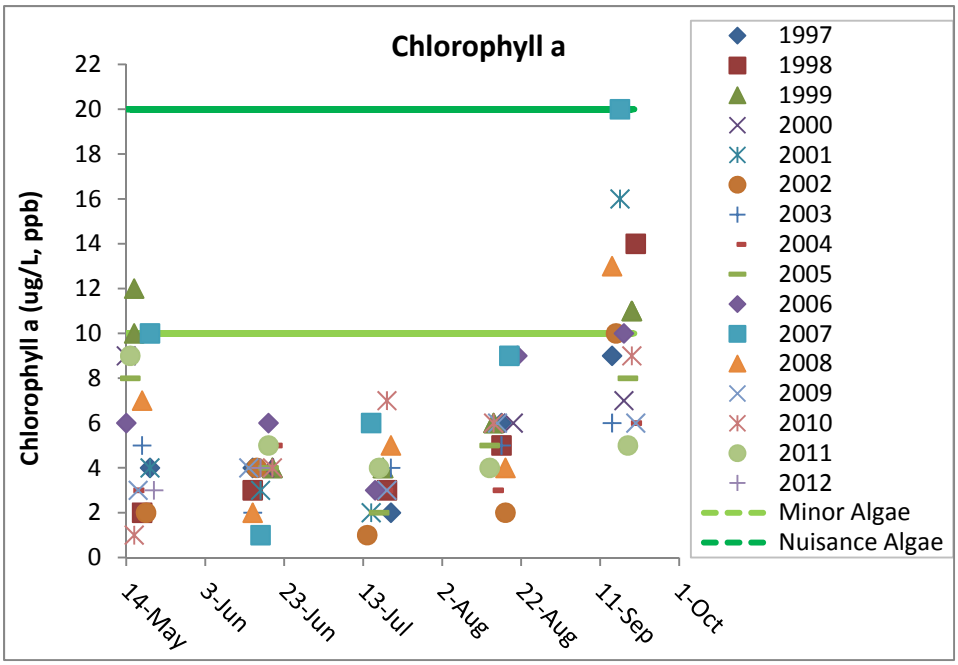
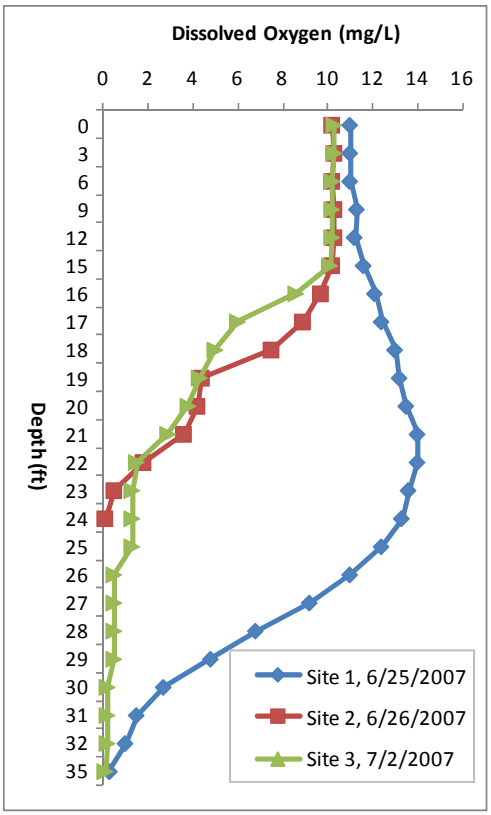


Figure 8. Chlorophyll *a* concentrations (ug/L) for Big Mantrap Lake at site 201 (East Bay).

Chlorophyll *a* was evaluated in Big Mantrap Lake in 1997-2011 (Figure 8). Chlorophyll *a* concentrations reached 10 ug/L most years, indicating minor 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.

Big Mantrap Lake is a moderately deep lake, with a maximum depth of 68 ft. Dissolved oxygen profiles from 2007 indicate that Big Mantrap Lake stratifies in the summer at the deeper sites (Figure 9). The thermocline occurs at different depths at each of the three different sites (Figure 9). This is because all three sites have different water depths. The shallow basins of Mantrap Lake most likely turn over more often in the summer, such as site 2 (Figure 9).

Figure 9. Dissolved oxygen profiles for Big Mantrap Lake at three different sites in 2007, 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 Big Mantrap Lake falls into the mesotrophic range (Figure 10). There is good agreement between the TSI for phosphorus and chlorophyll *a*, indicating that these variables are strongly related (Table 6). The TSI for transparency is lower. This could be due to the fact that there is a lot more extensive data for transparency, or that large algae dominate, or zooplankton are selectively eliminating the smaller algae.

Mesotrophic lakes (TSI 40-50) are characterized by moderately clear water most of the summer. "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 204
TSI Total Phosphorus	45
TSI Chlorophyll-a	48
TSI Secchi	39
TSI Mean	44
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

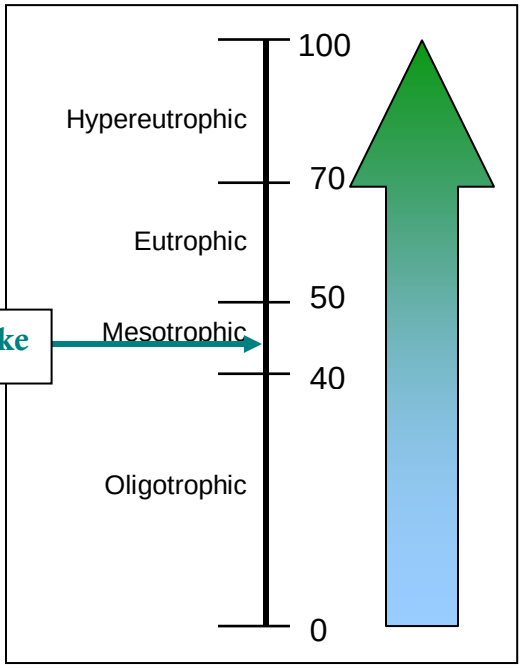


Figure 10. Trophic state index chart with corresponding trophic status.

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 Big Mantrap Lake (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Big Mantrap Lake.

Lake Site	Parameter	Date Range	Trend
All bays	Transparency	1997-2011	No trend
All bays	Total Phosphorus	1997-2011	No trend
All bays	Chlorophyll a	1997-2011	No trend

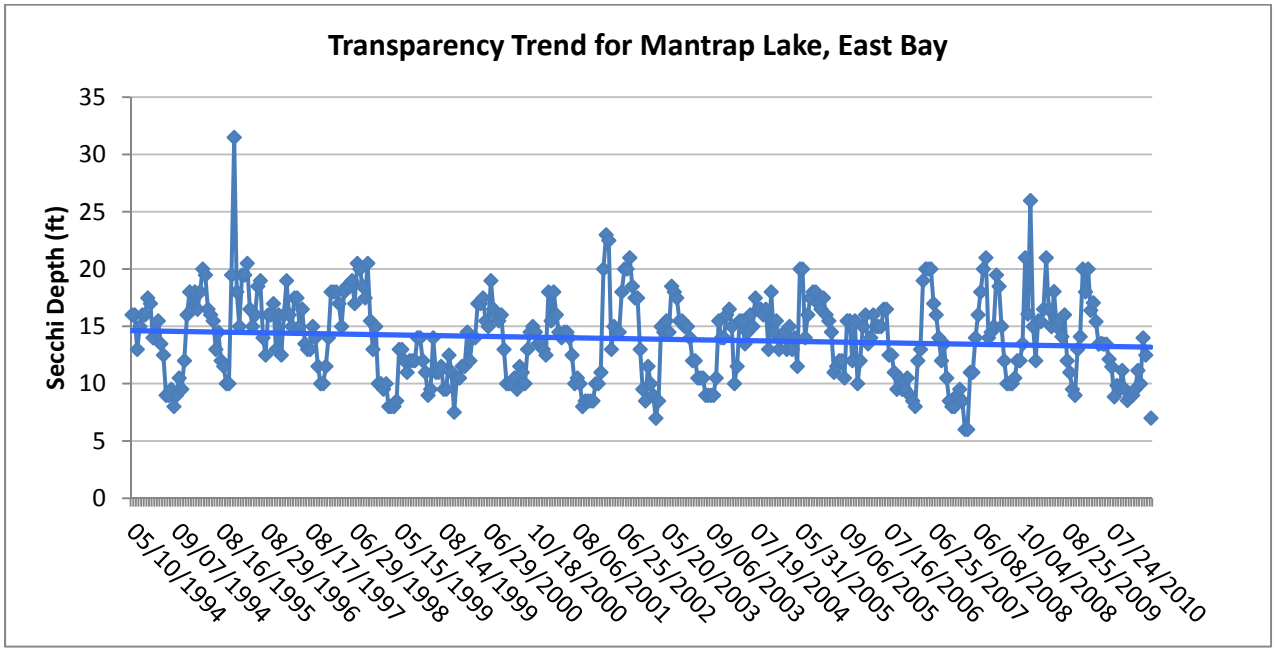


Figure 11. Long-term transparency trend for site 201 in the east bay of Big Mantrap Lake.

There is an extensive transparency data set for all the different bays of Mantrap Lake. All sites show no trends in water quality, which means the water quality is stable. Monitoring should continue at all sites 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.

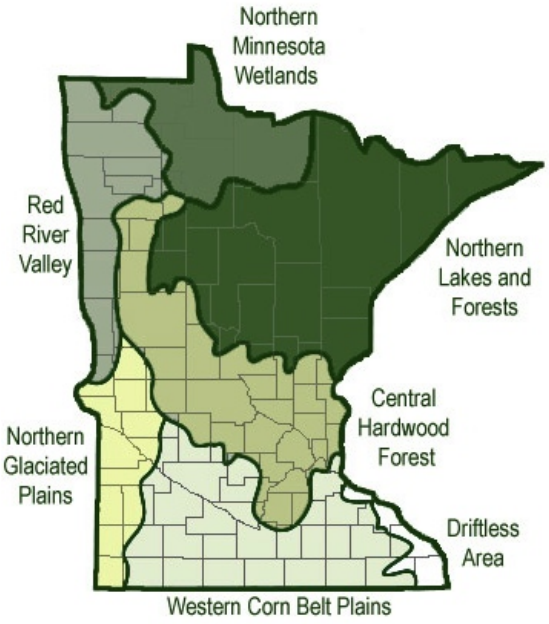
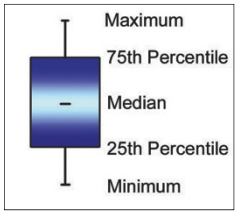
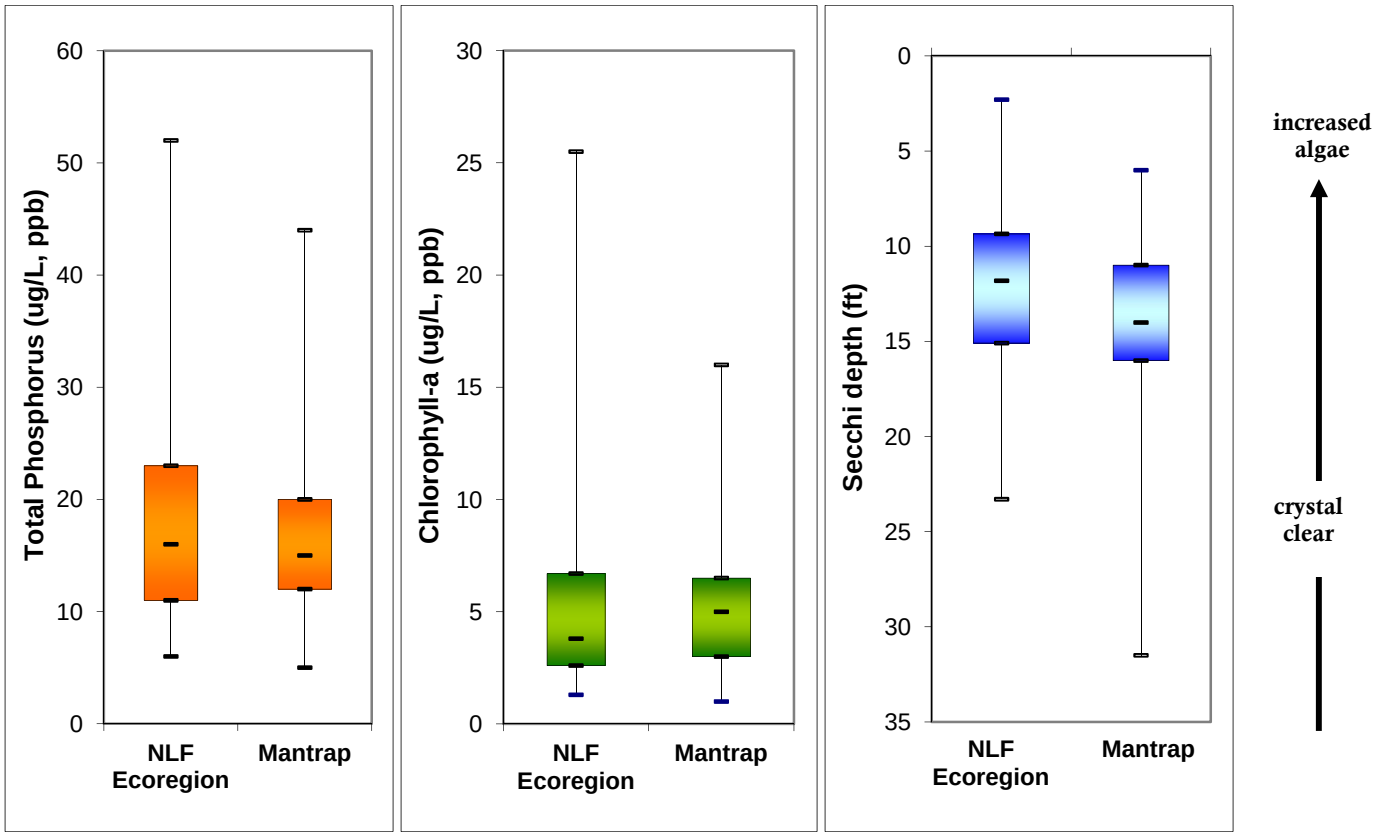


Figure 12. Map of Minnesota with the seven ecoregions.

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





Figures 13a-c. Big Mantrap Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Big Mantrap Lake total phosphorus and chlorophyll *a* ranges are from 80 data points collected in May-September of 1997-2011. The Big Mantrap Lake Secchi depth range is from 395 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 drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 136 minor watersheds. Big Mantrap Lake is located in **minor watershed** 12008 (Figure 15).

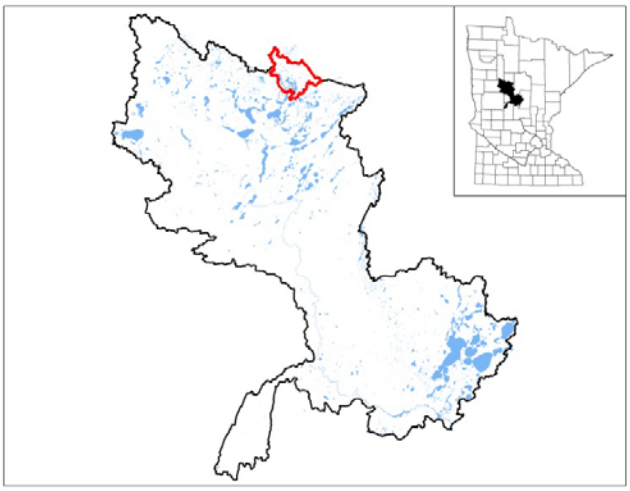


Figure 14. Crow Wing River Major

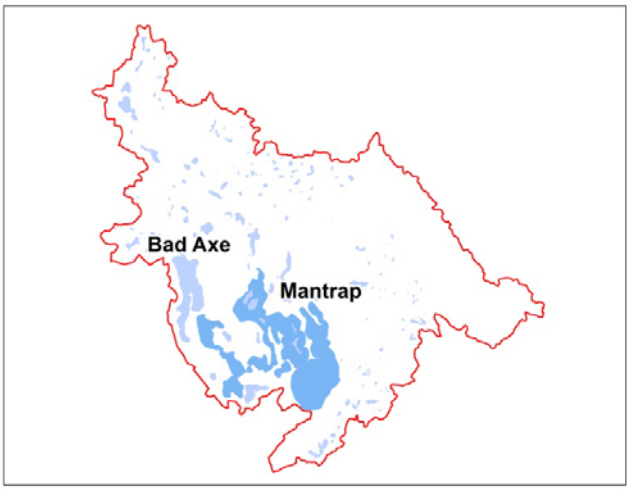


Figure 15. Minor Watershed 12008.

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. Big Mantrap Lake falls within the **Mantrap (1200800) lakeshed** (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 Big Mantrap Lake's full watershed, containing all the lakesheds upstream of Big Mantrap Lake lakeshed, see page 17. The data interpretation of the Big Mantrap Lake lakeshed includes only the immediate lakeshed, as this area is the land

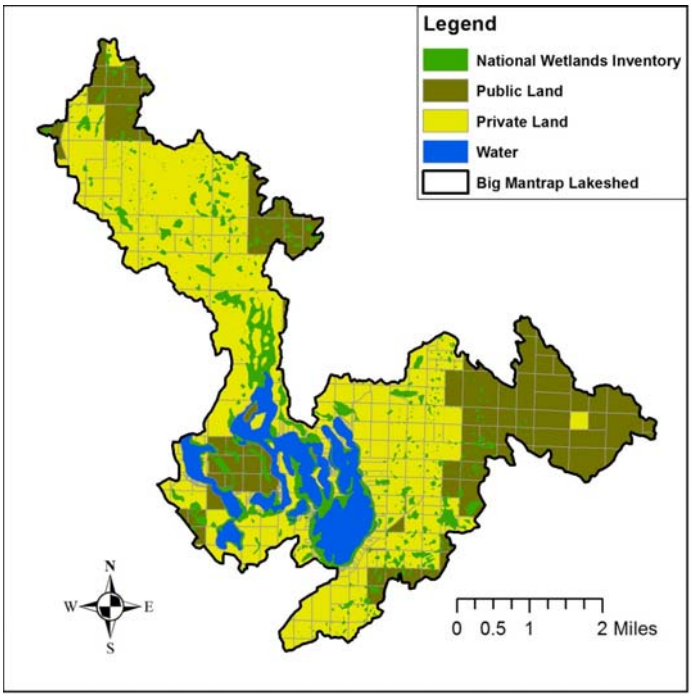


Figure 16. The Mantrap (1200800) lakeshed with land ownership, lakes, wetlands, and rivers illustrated.

surface that flows directly into Big Mantrap 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 Big Mantrap Lake.

Lakeshed Vitals		Rating
Lake Area	1618 acres	descriptive
Littoral Zone Area	752 acres	descriptive
Lake Max Depth	68 ft. (East Basin); 35 ft. (Middle Basin); 6ft. (Mirror Bay); 58 ft. (West Arm); 53 ft. (Home Bay)	descriptive
Lake Mean Depth	18.7 ft. (East Basin); 11.1 ft. (Middle Basin); 3.0 ft. (Mirror Bay); 18.3 ft. (West Arm); 15.1 ft. (Home Bay)	
Water Residence Time	NA	NA
Miles of Stream	0.2	descriptive
Inlets	3	
Outlets	1	
Major Watershed	12 - Crow Wing River	descriptive
Minor Watershed	12008	descriptive
Lakeshed	1200800	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	8:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	12:1	
Wetland Coverage	11%	
Aquatic Invasive Species	None	
Public Drainage Ditches	None	
Public Lake Accesses	2	
Miles of Shoreline	76.6	descriptive
Shoreline Development Index	1.85 (East Bay); 2.83 (Middle Bay); 1.15 (Mirror Bay); 2.05 (West Arm); 1.26 (Home Bay)	
Public Land : Private Land (excludes water)	0.5:1	
Development Classification	Recreational Development	
Miles of Road	43.1	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 - 1995)	
Lake Management Plan	Healthy Lakes & Rivers Partnership program, 2005	
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 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.

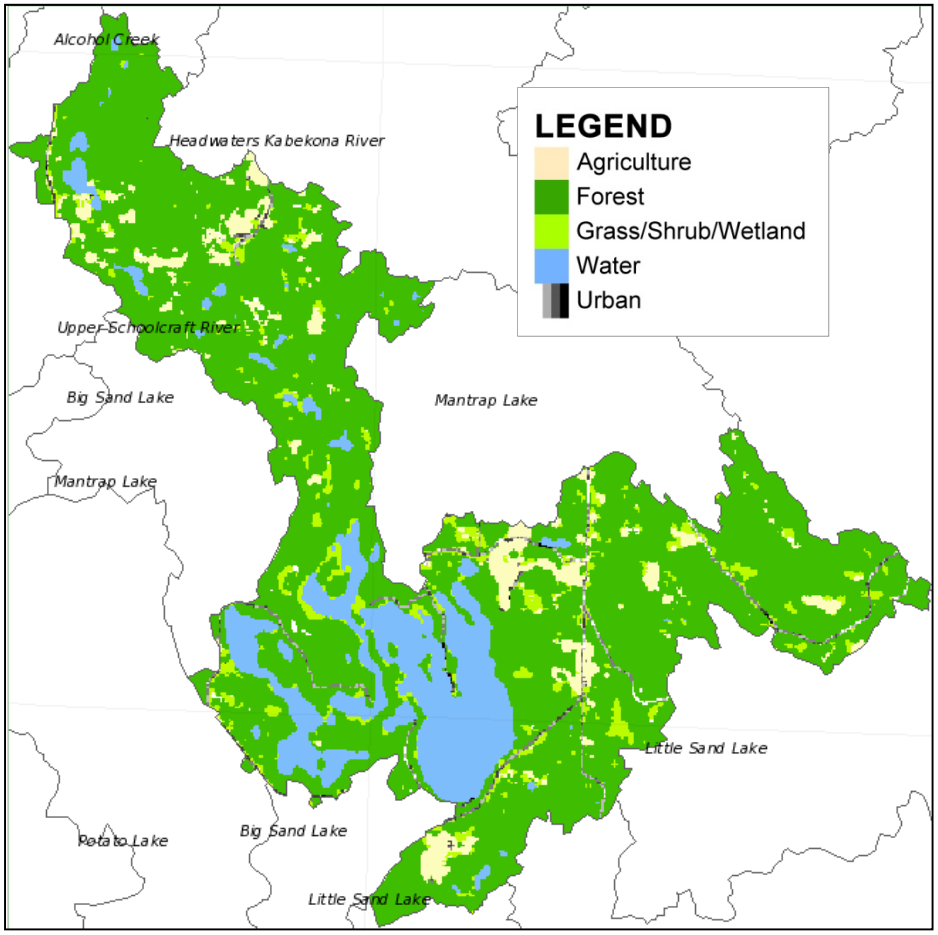


Figure 17. Mantrap (1200800) lakeshed land cover (http://land.umn.edu).

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.

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 Big Mantrap Lake's lakeshed.

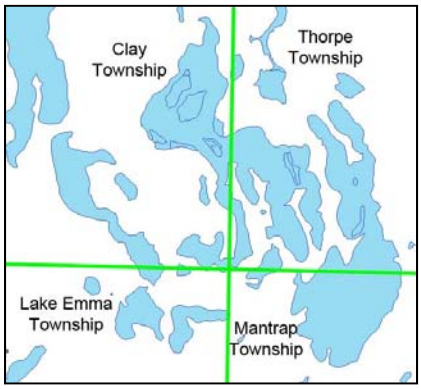
The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). This data is somewhat outdated, but it is the most recent comparable data available. Table 10 describes Big Mantrap Lake's lakeshed land cover statistics and percent change from 1990 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 Grass/Shrub/Wetland cover (35.1%). In addition, the impervious intensity has increased 66.7% (20 acres), 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. Big Mantrap 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	953	7.1	726	5.41	23.8% Decrease
Grass/Shrub/Wetland	1055	7.86	685	5.11	35.1% Decrease
Forest	9099	67.83	9950	74.17	9.4% Increase
Water	2022	15.07	1753	13.07	13.3% Decrease
Urban	287	2.14	301	2.24	4.9% Increase
Impervious Intensity %					
0	13196	98.37	13142	97.97	0.4% Decrease
1-10	97	0.72	95	0.71	2.1% Decrease
11-25	92	0.69	112	0.83	21.7% Increase
26-40	23	0.17	43	0.32	87% Increase
41-60	6	0.04	17	0.13	183.3% Increase
61-80	1	0.01	6	0.04	500% Increase
81-100	0	0	0	0	No Change
Total Area	13415		13415		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	30	0.26	50	0.43	66.7% Increase

Demographics

Big Mantrap 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. On the other hand, Thorpe and Clay Township have a similar or lower extrapolated growth projection (Figure 18).

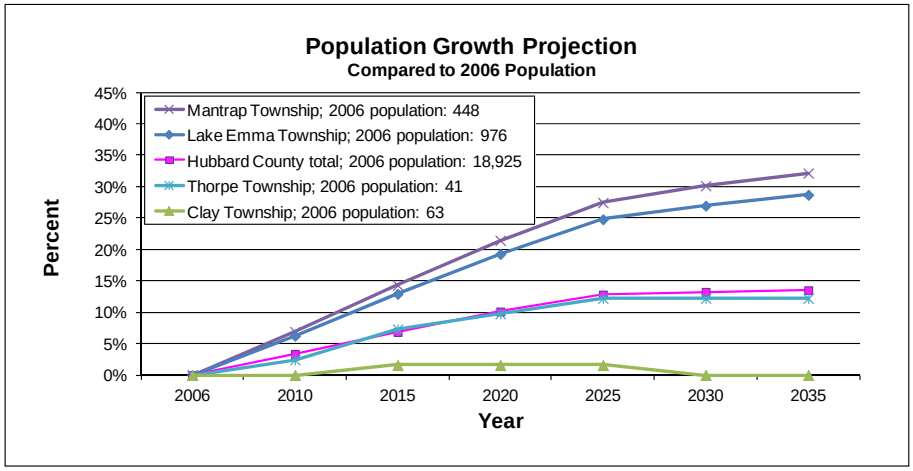


Figure 18. Population growth projection for Hubbard Townships and Hubbard County.

Big Mantrap 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 land within Big Mantrap 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, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (59%)					12%	Public (29%)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	1.4%	1.4%	43.9%	5.8%	6.5%	11%	8%	21%	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	85 – 283	47 – 163	530		77		94	257	
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.

Big Mantrap Lake lakeshed is classified with having 43.7% of the watershed protected and 3.7% of the watershed disturbed (Figure 19). Therefore, Big Mantrap Lake should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use.

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 Big Mantrap Lake, whether through direct overland flow or through a creek or river. All of the upstream lakesheds have a protection focus as well. Goals for this watershed should be to limit any increase in disturbed land use.

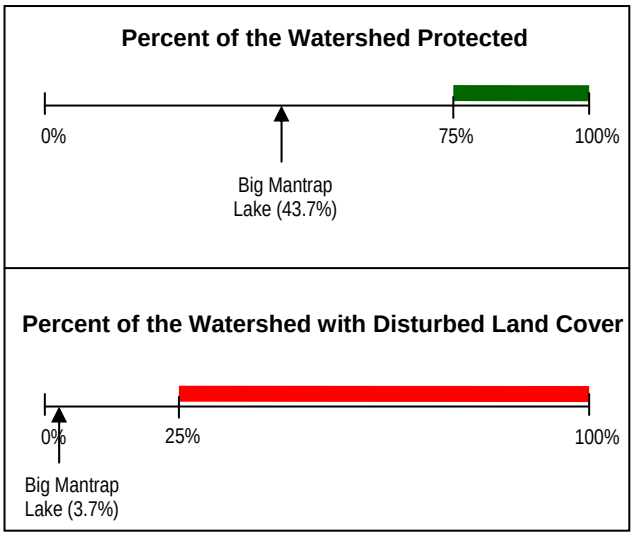


Figure 19. Big Mantrap Lake lakeshed's percentage of watershed protected and disturbed.

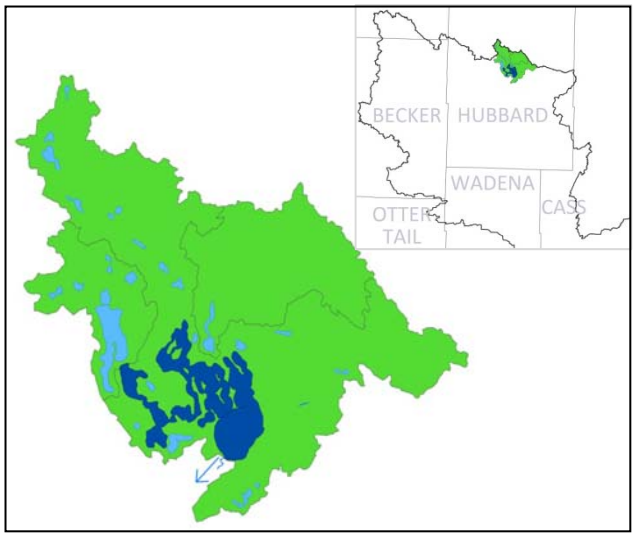


Figure 20. Upstream lakesheds that contribute water to the Big Mantrap lakeshed. Color-coded based on management focus (Table 3).

Big Mantrap, Status of the Fishery (as of 06/25/2007)

Big Mantrap is a diverse lake with numerous bays, island, and channels and has over 22 miles of shoreline. There are two public boat accesses located on the lake. The more popular and developed access is located in the State Forest Campground on the "west arm" of the lake. There are two concrete ramps and spacious parking at this access. The other public access is located on the "north arm" of the lake and has an earthen ramp. Big Mantrap is known for its muskie fishery, but also supports fine fishing opportunities for northern pike and black crappie.

The muskellunge population in Big Mantrap has changed significantly over the past twenty years. Big Mantrap had an abundant muskie population from the 1960's to the early 1980's. While muskie numbers were high, size of fish was small, with many 30-inch fish, but few over 40 inches in length. The reason for the small size is that genetic strains of muskie called “Shoepac” were stocked into Big Mantrap during that period. This strain of muskie survived and did well in Big Mantrap, but were never capable of growing to large sizes (over 40 inches). Starting in 1988, "Leech Lake" strain of muskellunge were stocked into Big Mantrap. The Leech Lake strain has the genetic capability to grow fish to 50 inches or more in length. To adequately assess the muskellunge population in Big Mantrap, special sampling such as spring trap netting is done. After ice-out and when the surface water temperature is near 50 F, muskellunge are moving to shallow water areas looking for suitable spawning areas. This shallow water movement by muskie makes them more susceptible to sampling with trapnets. Since 1988, spring trapnet sampling has shown an increase in the size structure of the muskie population. Average length and the numbers of fish over 40 inches has increased for both male and female muskie. Muskie anglers are reporting seeing and releasing a few 50 inch fish. A 52.7 inch muskie was sampled in the spring of 2007. Big Mantrap is stocked with muskellunge (Leech Lake strain) in even numbered years (750 fish). Natural reproduction is also occurring with sporadic and limited contribution to the muskellunge population in Big Mantrap.

Big Mantrap supports an excellent northern pike fishery. While not known for producing big pike (over 10 pounds), Mantrap has good numbers of northern pike in the 3 to 5 pound range. Starting in 2003, a special length limit regulation that requires the release of all northern pike from 24.0 to 36.0 inches (24-36 inch protected slot) was implemented. The 2007 survey showed good numbers of northern pike within the 24-36 inch protected slot. Sampled northern pike had an average length and weight of 25.7 inches and 4.3 pounds, with pike measured up to 34.4 inches. It will take several more years to see if the regulation has an effect on the northern pike size structure.

Black crappie fishing is popular year around on Big Mantrap. Black crappie were abundant and sampled in high numbers for all gear types. While black crappie numbers were high, the number of larger crappie (over 10 inches) was low when compared to other area lakes. Starting in the spring of 2006, a 10-inch minimum size length limit and a possession limit of 5 crappie was implemented. At this point, it is too early to tell if black crappie abundance or size has changed significantly.

Big Mantrap has an abundant bluegill and pumpkinseed population, however, size tends to run small. The number of bluegill and pumpkinseed over 7 inches is low. Big Mantrap also supports a moderate largemouth bass population. Good largemouth bass habitat is found in the "north arm" around the islands and bays. Smallmouth bass are also present in low numbers and tend to be found in the "main lake" basin.

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=29015100

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring in each bay 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
Overall, Big Mantrap Lake is in good shape. It is a mesotrophic lake (TSI=44) that falls within the expected ecoregion ranges of water quality for the area. It has no detectable trend in water quality. Twenty nine percent (29%) of the lakeshed is public land (Table 3), and 43.7% of the watershed is protected while only 3.7% is disturbed (Figure 6).

The full area that contributes water to Big Mantrap is relatively small with minimal streams (0.2 miles). With very little disturbed land use in the watershed, a high percent of forest cover and a mosaic of wetlands across the landscape, the current watershed condition provides a good setting to maintain the water quality and support healthy fish communities.

Priority Impacts to the lake
Shoreline development pressure is a concern for Big Mantrap Lake. Lakeshed development since 1991 has occurred primarily along shorelines and the last lake-wide septic system inspection was in 1995. The population around Big Mantrap Lake is projected to grow by 25% in the next decade (Figure 5). There will be pressure for further subdivision of remaining large shoreline parcels.

Best Management Practices Recommendations
The management focus for Big Mantrap 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 and impervious surface area. Project ideas include enforcing county shoreline ordinances, smart development, shoreline restoration, rain gardens, septic system maintenance, and forest stewardship enrollment.

Organizational contacts and reference sites

Big Mantrap Lake Association	http://mantraplake.webs.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/