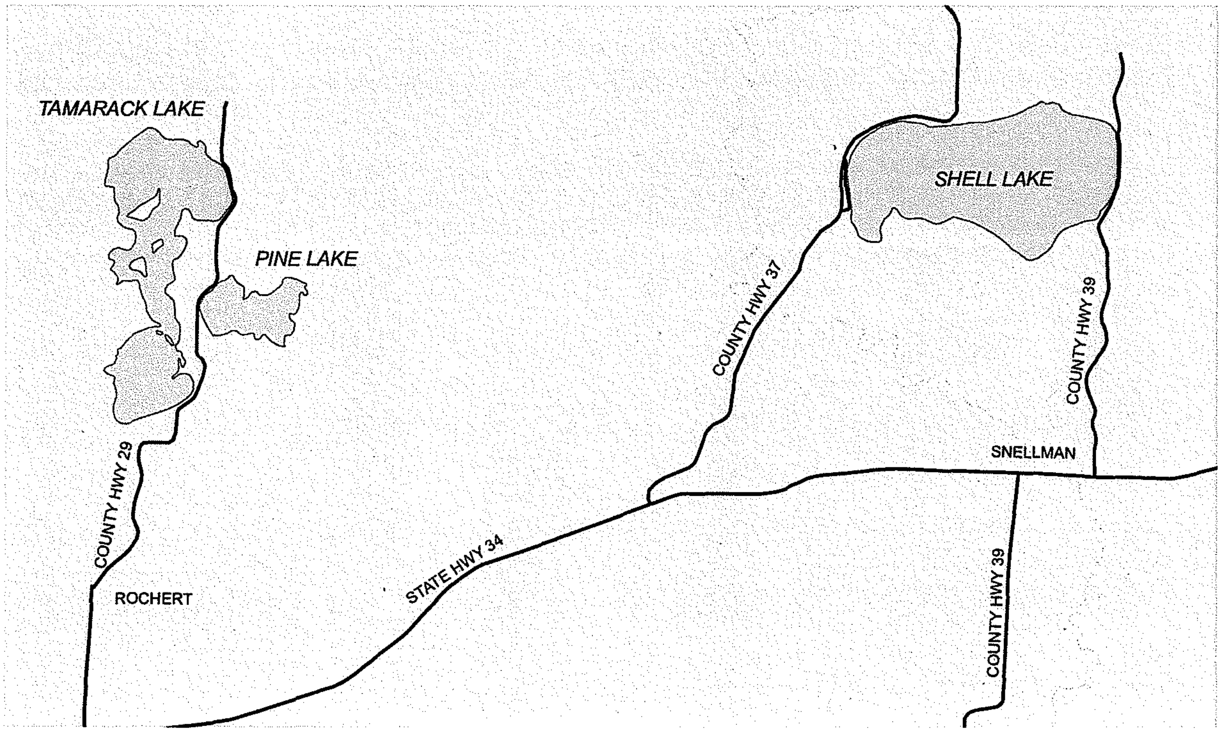
Status and Trend Monitoring of Selected Lakes in Becker County

07 - 0007

2005



Environmental Analysis and Outcomes Division
Water Assessment and Environmental Information Section
November 2006

Minnesota Pollution Control Agency

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Lake Assessment Program
2005

Lake Status and Trends for Selected Lakes in Becker County

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Pam Anderson

Lake Name	Lake DOW# ID
North Tamarack	03-0241-02
South Tamarack	03-0241-01
Pine	03-0200
Shell	03-0102

November 2006

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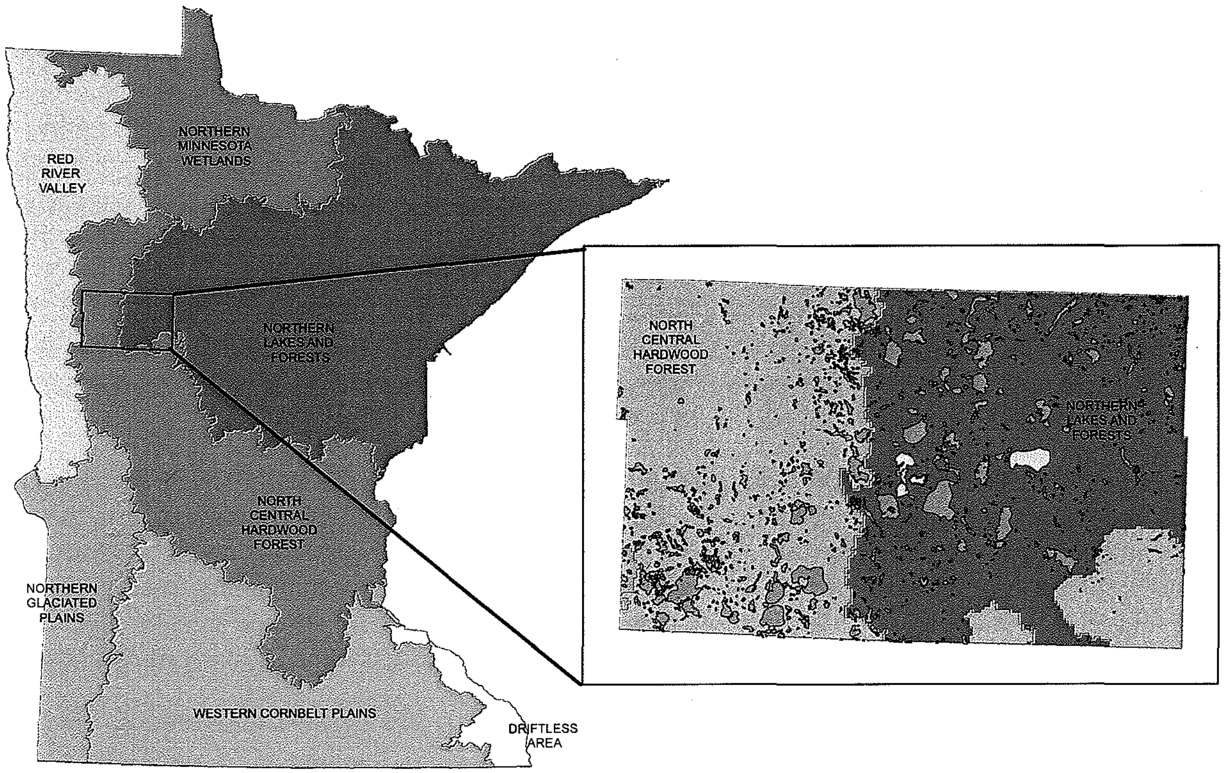
The Minnesota Pollution Control Agency's (MPCA) core lake-monitoring programs include the Citizen Lake Monitoring Program (CLMP) and Lake Assessment Program (LAP). In addition to these programs, the MPCA annually monitors numerous lakes to provide baseline water quality data, provide data for potential LAP and CWP lakes, characterize lake condition in different regions of the state, examine year-to-year variability in ecoregion-reference lakes, and provide additional trophic status data for lakes exhibiting trends in Secchi transparency. In the latter case, sampling is conducted to attempt to determine if the trends in Secchi transparency are "real," i.e., do supporting trophic status data substantiate whether a change in trophic status has occurred. This effort also provides a means to respond to citizen concerns about protecting or improving the lake, and in cases where no data exists, to evaluate the quality of the lake. To make for efficient sampling, geographic clusters of lakes are selected (e.g., focus on a specific county) whenever possible.

This report details efforts on lakes sampled in Becker County during the 2005 season (Figure 1). This general area was selected for study as it is very lake-rich and extensive monitoring in the area had not been conducted in recent years. The actual lakes selected for monitoring all had little to no historical data. For data-poor lakes, the focus of the monitoring is on establishing baseline data. In the selection of lakes, a focus was placed on large lakes, typically with surface areas of 500 acres or more, as one of the program priorities is to ensure that data is collected on as many of Minnesota's larger lakes as possible.

Water quality samples were collected monthly from June through September. A summary of data from 2005 follows. This summary will include data from 2005, as well as any data available in STORET, the U.S. Environmental Protection Agency's (EPA) national water quality data bank (Appendix D). Summer-mean epilimnetic (upper well-mixed layer) concentrations for each lake are compared to the "typical" range for ecoregion-reference lakes in the Northern Lakes and Forests (NLF) and North Central Hardwood Forest (NCHF) ecoregions (Figure 1 and Table 2). These lakes are all on the edge of the NLF ecoregion. For this reason, both NLF and the neighboring NCHF ecoregion values will be used for comparison in the land use (Table 4b) and lake summer-mean water quality (Table 5) tables. This provides a basis for placing data from these lakes in perspective relative to one another, as well as other lakes in the same ecoregion. Additional bases for comparison and evaluation are provided with Tables 1 and 2.

Figure 1. Minnesota's Seven Ecoregions as Mapped by U.S. EPA



Ecoregion Based Lake Water Quality

Table 1 provides the draft ecoregion-based nutrient criteria. These criteria were developed by MPCA in response to an EPA requirement that states develop nutrient criteria for lakes, rivers, wetlands and estuaries. Our approach to developing these criteria are consistent with our previous phosphorus criteria (Heiskary and Wilson, 1989) that have been used extensively for goal setting and evaluating the condition of Minnesota's lakes for our 305(b) report to Congress and have provided a basis for evaluating lakes for the 303(d) "impaired waters" list. Details on the development of the criteria may be found in Heiskary and Wilson (2005). In general, lakes that are at or below the criteria levels will have adequately high transparency and sufficiently low amounts of algae to support swimmable use throughout most of the summer. Whenever possible, these lakes should be protected from increases in nutrient concentrations, which would tend to stimulate algal and plant growth and reduce transparency. For lakes above the criteria level, the criteria may serve as a restoration goal for the lake and may lead to the lake being included on the 303(d) list that is submitted to EPA biennially.

Table 1. Proposed eutrophication criteria by ecoregion and lake type
(Heiskary and Wilson, 2005)

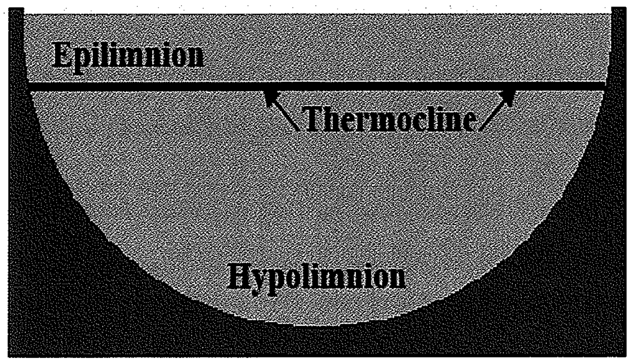
Ecoregion	TP	Chl-a	Secchi
	ppb	ppb	meters
NLF – Lake trout (Class 2A)	< 12	< 3	> 4.8
NLF – Stream trout (Class 2A)	< 20	< 6	> 2.5
NLF – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
CHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
CHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
CHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
WCP & NGP – Aquatic Rec. Use (Class 2B)	< 65	< 22	> 0.9
WCP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	< 90	< 30	> 0.7

Table 2 represents the typical summer-mean water quality for lakes in ecoregion. This data is derived from extensive sampling (1985-1988) of several reference lakes in each of the ecoregions. These "reference" lakes are not necessarily the most pristine lakes in each ecoregion; rather these lakes are "representative" of the ecoregion and are minimally impacted by humans. As is evident, the relative impact by human activities does vary among ecoregions. Further details may be found in Heiskary and Wilson (2005). These data provide an objective basis for comparing data from other lakes. In this study, data from the NLF and NCHF ecoregions will be used as a basis for comparing the water quality of lakes sampled in 2005, as the lakes are near the boundary between the two different ecoregions.

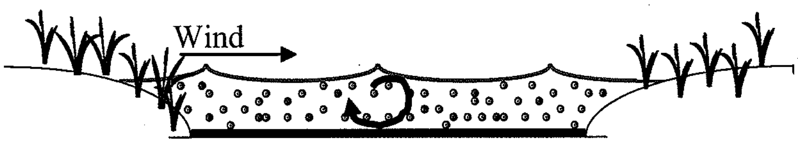
Lake depth can have a significant influence on lake processes and water quality. One such process is *thermal stratification* (formation of distinct temperature layers, see Figure 2a), in which deep lakes (maximum depths of 30 - 40 feet or more) often stratify (form layers) during the summer months and are referred to as *dimictic* (Figure 2c). These lakes full-mix or turn-over twice per year; typically in spring and fall (Figure 2d). Shallow lakes (maximum depths of 20 feet or less) in contrast, typically do not stratify and are often referred to as *polymictic* (Figure 2b). Some lakes, intermediate between these two, may stratify intermittently during calm periods. Measurement of temperature throughout the water column (surface to bottom) at selected intervals (e.g. every meter) can be used to determine whether the lake is well-mixed or stratified. It can also identify the depth of the thermocline (zone of maximum change in temperature over the depth interval). In general, the upper, well-mixed layer (epilimnion) is warm and has high oxygen concentrations. In contrast, the lower layer (hypolimnion) is much cooler and often has little or no oxygen. Most of the fish in the lake will be found in the epilimnion or near the thermocline. The combined effect of depth and stratification can influence overall water quality.

Figure 2. Thermal Stratification and Lake Mixing

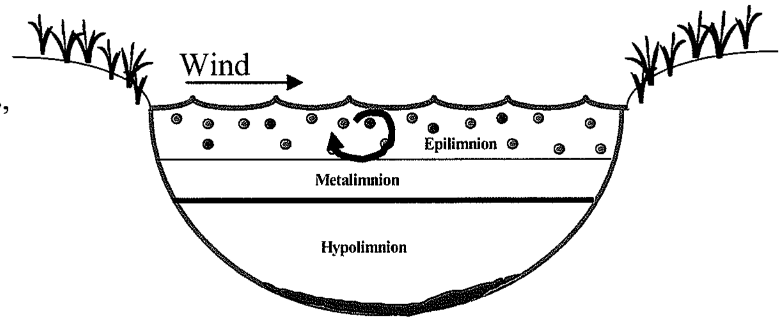
2a



2b **Polymictic Lake**
Shallow, No Layers,
Mixes Continuously
Spring, Summer & Fall



2c **Dimictic Lake**
Deep, Form Layers,
Mixes Few Times
Summer



2d **Dimictic Lake**
Deep, Form Layers,
Mixes Few Times
Spring/Fall

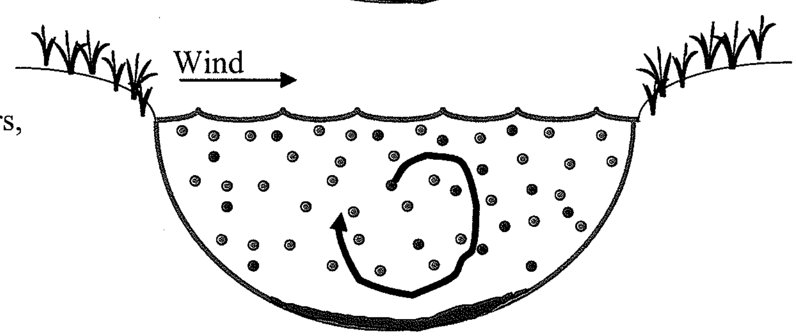


Table 2. Reference Lake Data Base Water Quality Summary
(Summer Average Water Quality Characteristics for Lakes by Ecoregion)*

Parameter	NLF	CHF	WCP	NGP
# of lakes	**32**	**43**	**16**	**13**
Total Phosphorus (ug/l)	**14 - 27**	**23 - 50**	**65 - 150**	**122 - 160**
Chlorophyll mean (ug/l)	**4 - 10**	**5 - 22**	**30 - 80**	**36 - 61**
Chlorophyll maximum (ug/l)	**< 15**	**7 - 37**	**60 - 140**	**66 - 88**
Secchi Disk (feet) (meters)	**8 - 15 (2.4 - 4.6)**	**4.9 - 10.5 (1.5 - 3.2)**	**1.6 - 3.3 (0.5 - 1.0)**	**1.3 – 2..6 (0.4 – 0.8)**
Total Kjeldahl Nitrogen (mg/l)	**0.4 – 0.75**	**< 0.60 - 1.2**	**1.3 - 2.7**	**1.8 - 2.3**
Nitrite + Nitrate-N (mg/l)	**<0.01**	**<0.01**	**0.01 - 0.02**	**0.01 - 0.1**
Alkalinity (mg/l)	**40 – 140**	**75 - 150**	**125 - 165**	**160 - 260**
Color (Pt-Co Units)	**10 – 35**	**10 - 20**	**15 - 25**	**20 - 30**
pH (SU)	**7.2 - 8.3**	**8.6 - 8.8**	**8.2 - 9.0**	**8.3 - 8.6**
Chloride (mg/l)	**0.6 – 1.2**	**4 - 10**	**13 - 22**	**11 - 18**
Total Suspended Solids (mg/l)	**< 1 – 2**	**2 - 6**	**7 - 18**	**10 - 30**
Total Suspended Inorganic Solids (mg/l)	**< 1 – 2**	**1 - 2**	**3 - 9**	**5 - 15**
Turbidity (NTU)	**< 2**	**1 - 2**	**3 - 8**	**6 - 17**
Conductivity (umhos/cm)	**50 – 250**	**300 - 400**	**300 - 650**	**640 - 900**
TN:TP ratio	**25:1 - 35:1**	**25:1 - 35:1**	**17:1 - 27:1**	**13:1 - 17:1**

*Based on Interquartile range (25th - 75th percentile) for ecoregion reference lakes.
Derived in part from Heiskary, S. A. and C. B. Wilson (1990).

Table 3 represents the percentile distribution of summer-mean in-lake TP concentrations for each ecoregion based on the mixing (temperature stratification) status of the lake as follows:

dimictic — Deep lake, fully mixes in spring and fall but remains stratified in summer.

polymictic — Shallow lake, remains well mixed from spring through fall.

intermittent — Lake with moderate depths, may stratify temporarily during summer, but may mix with strong wind action. Sorting TP concentrations within each mixing type creates this distribution (by ecoregion) from low to high. These percentiles can provide an additional basis for comparing observed summer-mean TP and may further serve as a guide for deriving an appropriate TP goal for the lake.

Table 3. Distribution of Total Phosphorus (μg/L) Concentrations by Mixing Status and Ecoregion. Based on all assessed lakes for each ecoregion.
D = Dimictic, **I** = Intermittent, **P** = Polymictic

	Northern Lakes and Forests			North Central Hardwood Forest			Western Corn Belt Plains		
Mixing Status:	**D**	**I**	**P**	**D**	**I**	**P**	**D**	**I**	**P**
Percentile value for [TP]									
90 %	37	53	57	104	263	344	--	--	284
75 %	29	35	39	58	100	161	101	195	211
50 %	20	26	29	39	62	89	69	135	141
25 %	13	19	19	25	38	50	39	58	97
10 %	9	13	12	19	21	32	25	--	69
# of obs.	257	87	199	152	71	145	4	3	38

Background

Watersheds

The lakes in the study are located in the Red River of the North and Upper Mississippi Basins. Within these basins, lakes were located in the following watersheds: Buffalo River (North Tamarack and Pine Lakes), Otter Tail River (South Tamarack), and Crow Wing River (Shell Lake). For this report we will group lakes by these watersheds, which should provide a basis for comparison among lakes in the same watershed or lake chain.

Lake Level Trends

Lake level is measured in several of the lakes based on volunteers through MDNR's Lake Level Monitoring Program. Lake level has historically been recorded on North Tamarack, South Tamarack, Pine, and Shell Lakes. These records showed some fluctuation in level over time, especially between different lakes. North Tamarack and South Tamarack, both monitored from 1975 to 1993 had ranges of 3.7 feet and 5.1 feet, respectively. Pine Lake was monitored from 1977 to 1993 with a variation of 3.15 feet. Shell Lake, with the shortest and most recent record, 1992 to 2004, exhibited a range of 1.4 feet. Data for specific lakes and years can be found at www.dnr.state.mn.us.

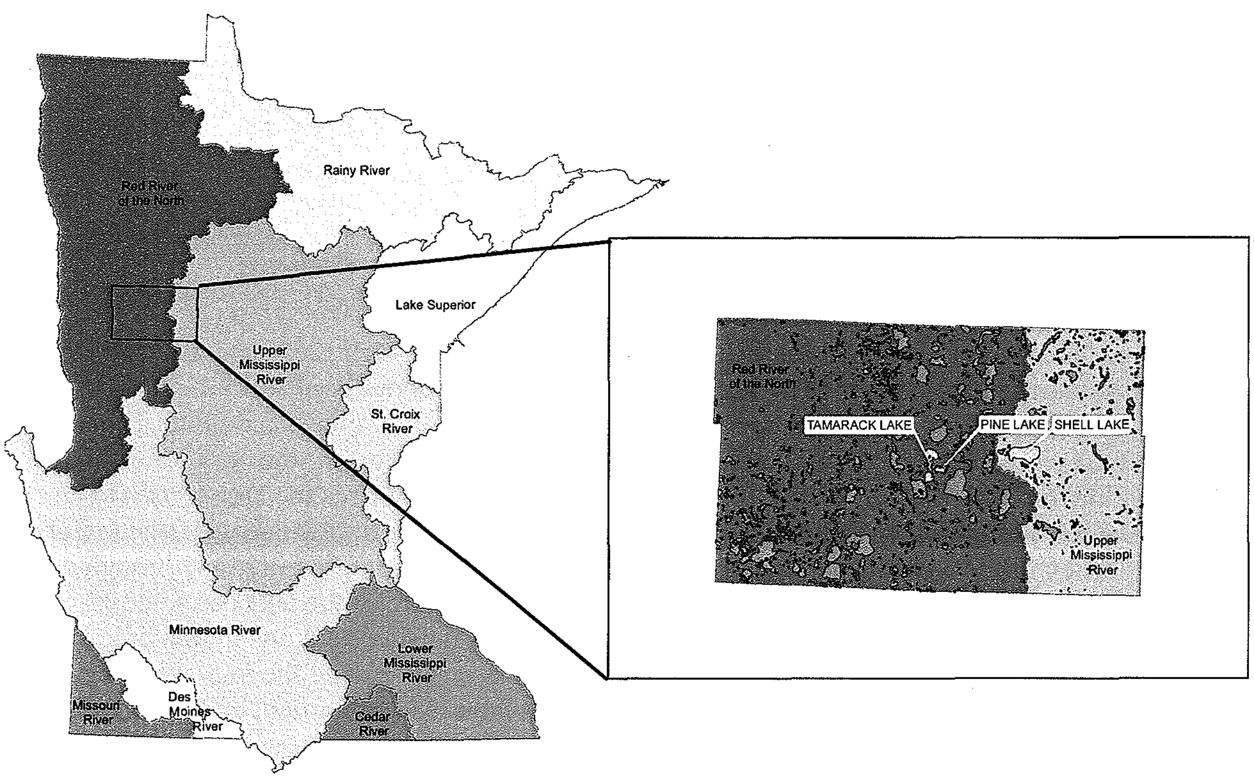
Fisheries

Both North Tamarack (2003) and Shell (2005) lakes have been surveyed by the MDNR Fisheries Section. More detailed reports are available at www.dnr.state.mn.us.

North Tamarack Lake is recovering from a severe fish kill which occurred in 1997. The only species which survived the winterkill were northern, yellow perch, white sucker, and bullhead. Walleye, bluegill, largemouth bass, and black crappie have since been reintroduced. Walleye have been stocked several times since then, while bluegills and largemouth bass have been successfully reproducing in the lake.

Shell Lake has also recovering from a severe winterkill, this one in 1996. Again, bullheads, white suckers, and northern pike were the only surviving species. Since then walleye, bluegills, largemouth bass, and black crappie have been reintroduced. All but walleye have maintained their populations through reproduction, and walleye continue to be stocked in the lake. By the 2005 survey, the catch rates for most species were at or above historical averages for the lake. In addition to angling, waterfowl hunting is another important recreational use of the lake. Shell Lake also contains extensive wild rice beds in the shallow areas of the lake.

Figure 3. Location of 2005 study lakes.



Lake Characteristics

Lake morphometric characteristics including surface area, mean and maximum depth and percent littoral are summarized in Tables 4a and 4b. With 3,140 acres, Shell Lake was the largest in the study, while Pine Lake (533 acres) was the smallest. Maximum depths ranged from 7.5 feet in South Tamarack Lake to 18 feet in Pine Lake. Mean depths ranged from 5 feet in South Tamarack to 9 feet in Pine. Lake volume, which is the product of mean depth times surface area ranged from 3,060 acre-feet in South Tamarack to 22,608 acre-feet in Shell.

Percent littoral refers to that portion of the lake that is 15 feet or less in depth, which often represents the depth to which rooted plants may grow in the lake. Lakes with a high percentage of littoral area often have extensive rooted plant (macrophyte) beds. These plant beds are a natural part of the ecology of these lakes and are important to protect. The definition for "shallow" lakes applies to those with maximum depths of 15 feet or less or where the littoral area comprises 80% or more of the basin (Heiskary and Wilson, 2005). Based on this definition all the lakes in this study would be considered "shallow" lakes (Table 4a). Shallow lakes will often remained well-mixed from top to bottom during the summer, in contrast to deep lakes that will typically form distinct thermal layers.

Watershed areas were estimated for the lakes based on DNR Data Deli Lakeshed data and USGS watershed data that may be found at: http://deli.dnr.state.mn.us/about.html and http://gisdmnspl.cr.usgs.gov/watershed/index.htm, respectively. For North and South Tamarack and Pine Lakes, all located within the Tamarac National Wildlife Refuge, the only watershed information available was for the DNR Minor Watershed that comprises the lakes. Individual lakesheds were estimated by MPCA staff using topographic maps. Immediate watershed refers to that portion of the watershed that drains directly to the lake without flowing first through other lakes; while total watershed refers to the entire watershed upstream of the lake. In some cases, such as South Tamarack and Pine, the immediate and total watersheds are one in the same. In others such as Shell, the immediate watershed represents less than half of the total watershed to the lake. Differentiating between immediate and total is important as nutrient and water budgets are determined for the lake (typically requires total watershed as an input); whereas when focusing best management practices and protection efforts the immediate watershed is the first target. Total watershed: lake area ratio also provides an important perspective on the size of the watershed relative to the lake. In this study Pine and South Tamarack have the smallest watershed to lake ratios, which generally means that water (and often nutrient) loading to the lakes is rather small and water residence time is long. In contrast Shell Lake, with a ratio of 9:1, has the highest ratio of any lake in the study. This implies that large volumes of water flow through the lake and residence time is short by comparison. This will be explained in greater detail in a section on modeling results.

The soils found around lakes in the study are defined as medium textured forest soils and coarse to medium textured prairie soils from the Nebish Rockwood and Estherville-Wadena-Hubbard series. These tend to be light colored, well drained soils in hilly areas, formed from loam calcareous glacial till and in level areas dark, well to excessively drained soils formed from calcareous outwash gravel (Arneman 1963). Tamarack, Pine, and Shell lakes were likely formed by irregular deposition of glacial till (Zumberge, 1952).

Precipitation

Approximately 33 inches of water evaporates annually in the part of the state. This typically exceeds precipitation, which averages 24 to 26 inches (0.61 to 0.66 m). Runoff averages about 4 inches with 1-in-10 year low and high values (may occur with a frequency of once in ten years) of 0.8 inches and 6 inches, respectively for this area (Gunard, 1985).

Rain gage records from the Tamarac National Wildlife Refuge near Snellman, MN, show two one-inch and one two-inch rain events during summer 2005 (Figure 4a). In particular, large rain events were noted for June 29, July 11, and August 17. These rain events will increase runoff into the lakes and may influence in-lake water quality and lake levels. This will be considered in the individual discussions of lake water quality for 2005. Precipitation records for the 2005 water year (October 2004 through September 2005) showed average rainfall (0 -2 inches above normal) for the Becker study area (Figure 4b).

Figure 4a. Rainfall based on records from Snellman, MN. Lat: 46.90428 Lon: -95.51577

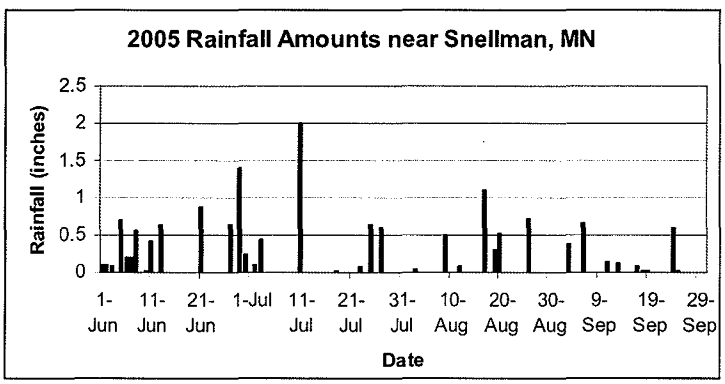
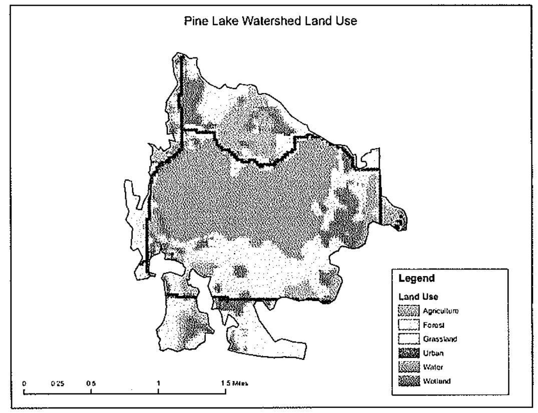


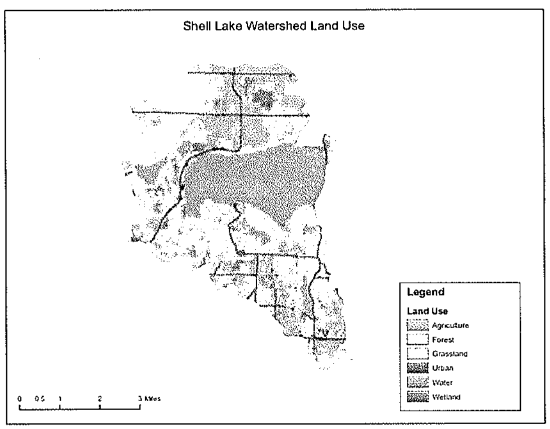
Table 4a. Lake morphometry and watershed characteristics.

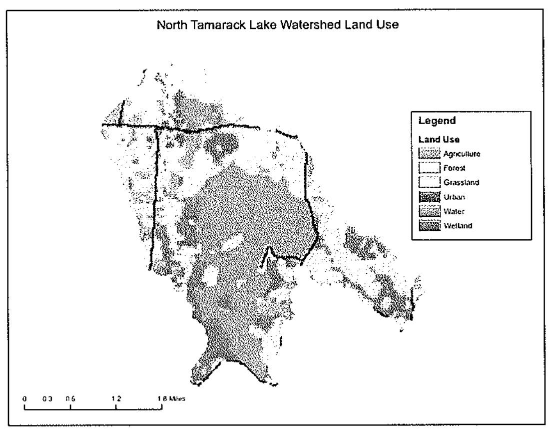
Lake Name	Lake	Lake Basin	Littoral Area		Immediate Watershed	Total Watershed Area	Total Watershed To Lake	Max. Depth	Average Depth	Lake Volume
Name	ID	Acres	Acres	% Littoral	Acres	Acres	Ratio	Ft.	Ft.	Acre-Ft.
N Tamarack	03-0241-02	1,431	1,389	97	5,456	7,103	5:1	17	8	11,448
Pine	03-0200	533	477	89	1,647	1,647	3:1	18	9	4,797
S Tamarack	03-0241-01	612	612	100	1,752	1,752	3:1	7.5	5	3,060
Shell	03-0102	3,140	3,070	98	12,626	28,941	9:1	16	7.2	22,608

4b. Watershed land use as compared to Ecoregion Interquartile Ranges

Land Use (%)	N Tamarack	Pine	S Tamarack	Shell	NLF Ecoregion	NCHF Ecoregion
Forest	44	36	40	45	54 – 81	6 – 25
Water/wetlands	48	47	52	34	14 – 31	14 – 30
Pasture/grasslands	0	0	0	0	0 – 6	11 – 25
Cultivated	6	13	7	18	< 1	22 – 50
Urban	2	4	3	3	0 - 7	2 - 9







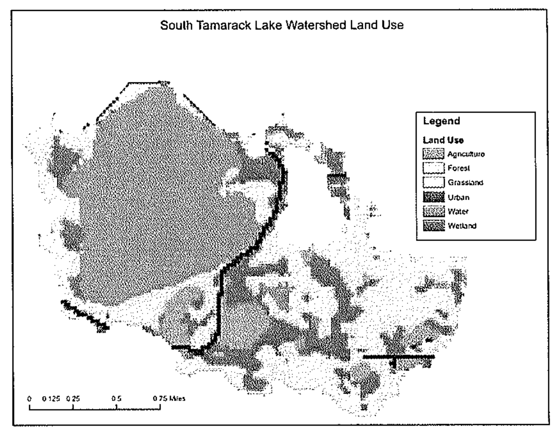
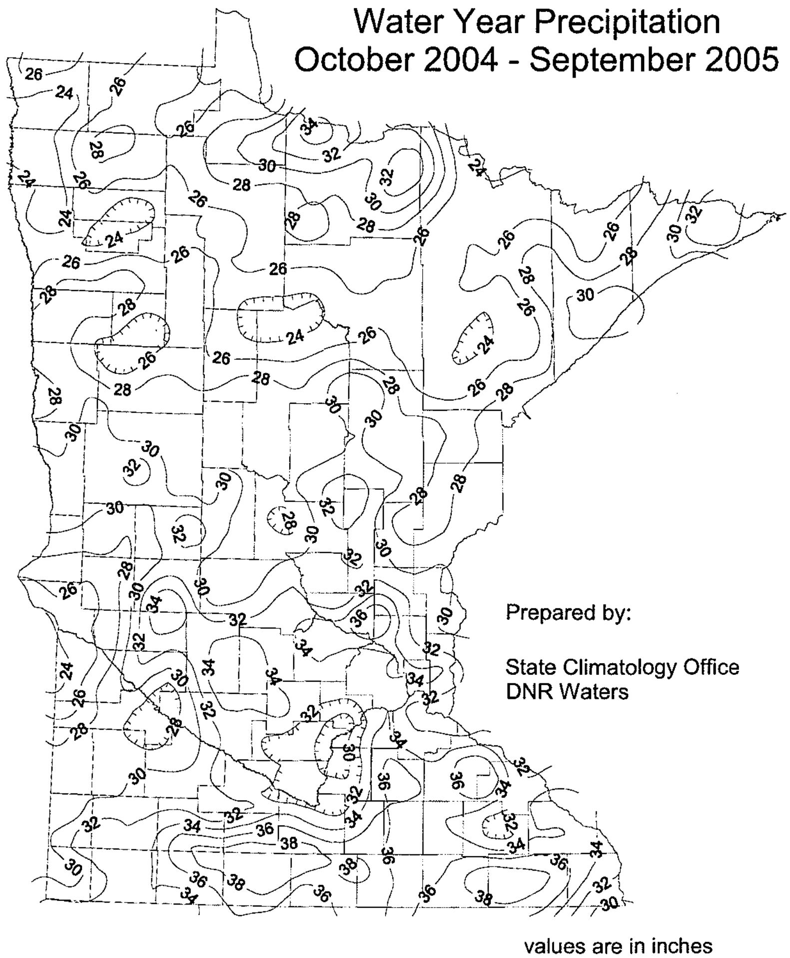


Figure 4b. Water year precipitation for 2005.



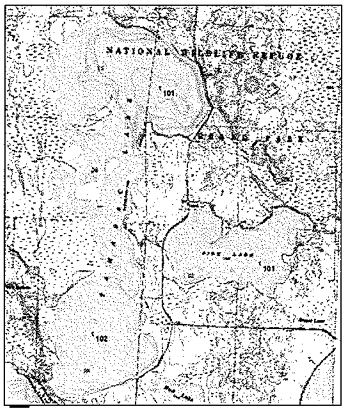
Methods

Water quality data was collected in June, July, August, and September 2005 on most of the Becker County lakes. Lake surface samples were collected with an integrated sampler, which is a PVC tube 6.6 feet (2 meters) in length with an inside diameter of 1.24 inches (3.2 centimeters). Depth samples were collected with a Kemmerer depth sampler. Zooplankton samples were collected with a Wisconsin plankton net. Phytoplankton (algae) samples were taken at a primary site with an integrated sampler. Summer-means were calculated using June - September data.

Sampling procedures were employed as described in the MPCA Quality Control Manual. Laboratory analyses were performed by the laboratory of the Minnesota Department of Health using U.S. Environmental Protection Agency (EPA)-approved methods. Samples were analyzed for nutrients, color, solids, pH, alkalinity, conductivity, chloride and chlorophyll. Temperature and dissolved oxygen profiles and Secchi disk transparency measurements were also taken. Phytoplankton samples were analyzed at the MPCA by Dr. Howard Markus.

Figure 5. 2005 Site Locations for Tamarack, Pine, and Shell Lakes

Tamarack and Pine Lake Sites



Shell Lake Sites

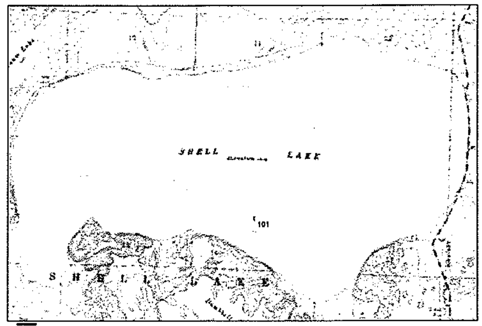


Table 5. Lake Summer Mean Water Quality

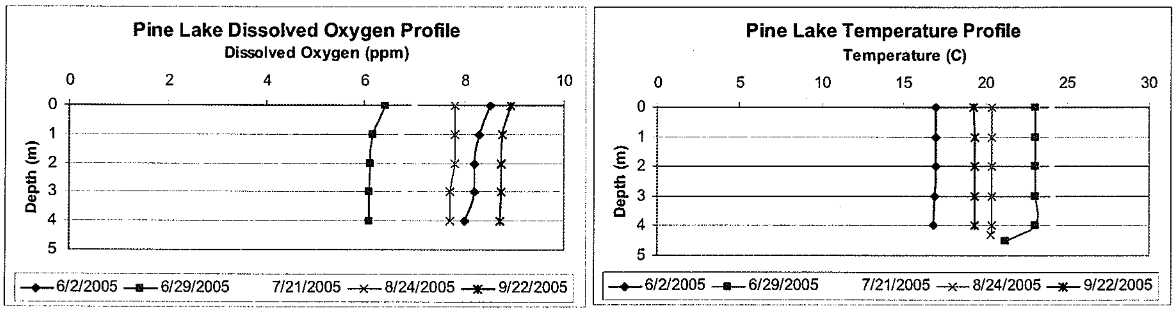
Parameter	N Tamarack 101	S Tamarack 102	Pine 101	Shell 101	Typical Range for NLF Ecoregion	Typical Range for NCHF Ecoregion
Total Phosphorus (µg/l)	44	29	27	36	14 - 27	23 – 50
Chlorophyll-a (µg/l) mean	12.4	4.2	7.3	10.9	4 - 10	5 – 22
Chlorophyll-a (µg/l) max	19	5.9	11.7	13.4	< 15	7 – 37
Secchi disk (feet)	4.1	6.2	6.6	4.3	8 - 15	4.9 – 10.5
Secchi disk (m)	1.25	1.9	2.0	1.3	2.4 – 4.6	1.5 – 3.2
Total Kjeldahl Nitrogen (mg/l)	1.1	1.2	1.0	0.9	0.4 – 0.75	< 0.6 – 1.2
Alkalinity (mg/l)	182	187	188	166	40 - 140	75 – 150
Color (Pt-Co Units)	14	17	9	8	10 - 35	10 – 20
Chloride (mg/l)	1.6	1.4	1.7	4.2	0.6 – 1.2	4 – 10
Total Suspended Solids (mg/l)	9.2	4.9	5.7	5.8	< 1 - 2	2 – 6
Total Suspended Inorganic Solids (mg/l)	5.5	2.7	2.8	4.4	< 1 - 2	1 – 2
Conductivity (µmhos/cm)	296	314	301	279	50 - 250	300 – 400
TN:TP Ratio	40:1	24:1	27:1	40:1	25:1 – 35:1	25:1 – 35:1

Due to the limited historical dataset, there is not enough data to determine water quality trends. All data was stored in STORET, the EPA's national water quality data bank. The following discussion assumes that the reader is familiar with basic water quality terminology as used in the Citizens' Guide to Lake Protection, which may be obtained from http://www.pca.state.mn.us/water/lakeprotection.html.

Results: Pine Lake

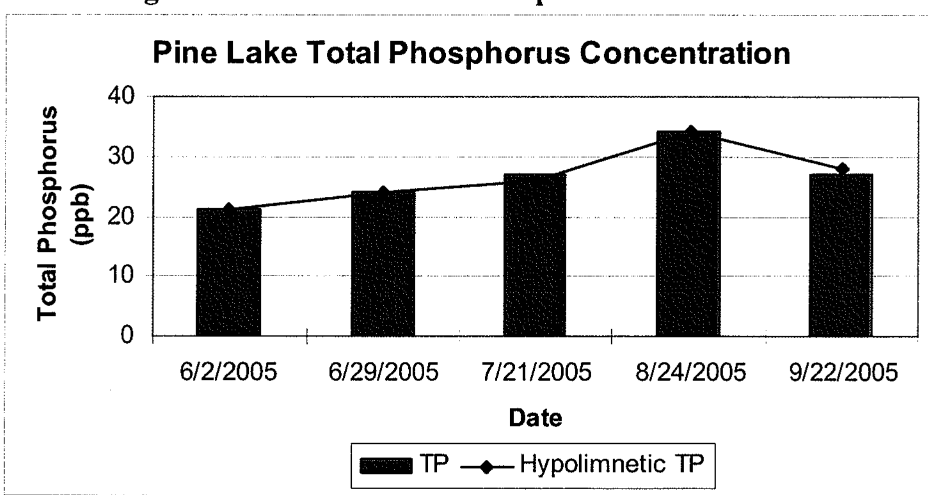
Dissolved Oxygen and Temperature profiles were taken monthly at site 101. The lake was well mixed on all dates, with DO levels remaining above 5 mg/l to the bottom of the lake (4 m) (Figure 6). The temperature profile also indicates a well mixed lake, with temperatures remaining constant throughout the water column. These profiles indicate that Pine Lake is polymictic (continuously mixing).

Figure 6. Pine Lake Dissolved Oxygen and Temperature Profiles



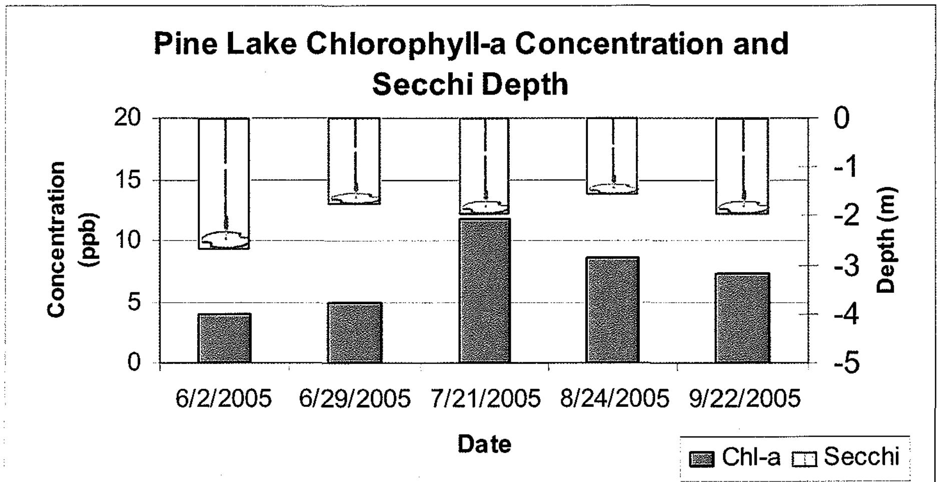
Total Phosphorus (TP) concentrations averaged 27 µg/l in the epilimnion during the summer of 2005, with a minimum of 21 µg/l in early June and a maximum of 34 µg/l in August (Figure 7). The average total phosphorus for Pine Lake is the lowest of the 3 lakes in the study, and the only lake with an average TP that falls in the range of expected values for the NLF ecoregion (Table 5). The hypolimnetic total phosphorus very similar to that of the surface samples, and this would be expected, considering the depth and continuous mixing of the lake.

Figure 7. Pine Lake Total Phosphorus Concentration



Chlorophyll-*a* concentrations for 2005 on Pine Lake averaged 7.3 µg/l, with a low of 4.0 µg/l in early June and a high of 11.7 µg/l in July (Figure 8). Concentrations from 10-20 µg/l are frequently perceived as a mild algal bloom. Considering this, mild algae blooms were evident only during the July sampling trip. Both the average and maximum chlorophyll-*a* values were within the typical range for NLF ecoregion lakes (Table 5). Chlorophyll-*a* followed a similar pattern as total phosphorus; concentrations peaked in mid summer and then declined in concentration for the remainder of the season.

Figure 8. Pine Lake Chlorophyll-*a* Concentration and Secchi Transparency

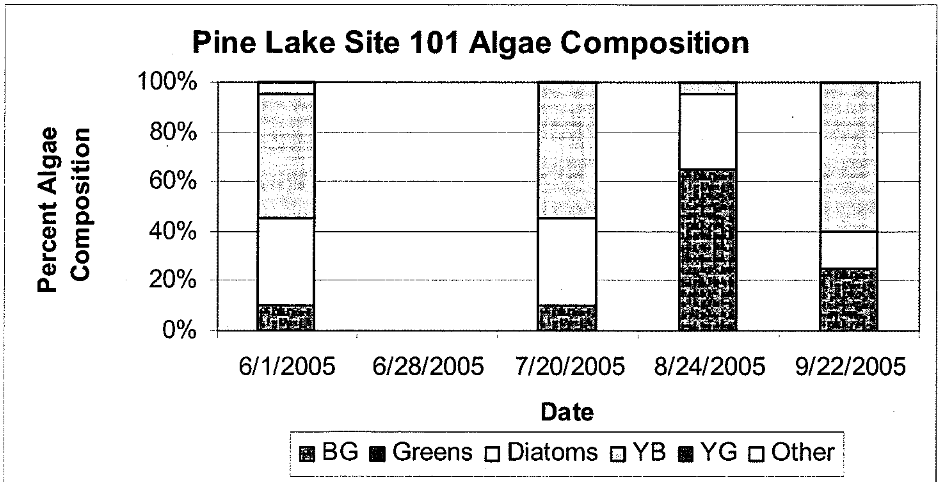


Secchi disk transparency on Pine Lake averaged 2.0 meters (6.6 feet) with a range of 1.6 – 2.7 m during the summer of 2005 (Figure 8). Color averaged 9 Pt-Co Units and total suspended solids averaged 5.7 mg/l. Color is just below the typical range of NLF ecoregion values and TSS is considerably above the range of values (Table 5). These levels should not appreciably reduce the clarity of the water. The average Secchi depth is just below the typical NLF ecoregion values.

The change in the transparency of Pine Lake over the course of the summer closely mirrored the changes in nutrient availability (TP) and algal production (chl-a). Transparency was the greatest in the spring when the waters were cool and algal production was relatively low. As the chlorophyll-*a* concentrations increased, the Secchi depth generally decreased. In the fall as the waters cooled, the transparency improved.

Algal composition for Pine Lake was dominated in June, July, and September by yellow-brown algae, with blue-greens dominating the system for August. A seasonal transition from diatoms to greens to blue-greens is rather typical for mesotrophic and eutrophic lakes in Minnesota. During 2005, the green algae were never present, and diatoms were present throughout the summer, but never dominated the population (Figure 9).

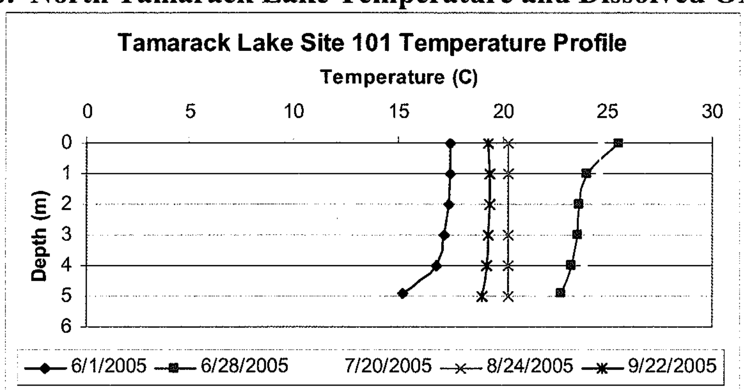
Figure 9. Pine Lake Algae Composition

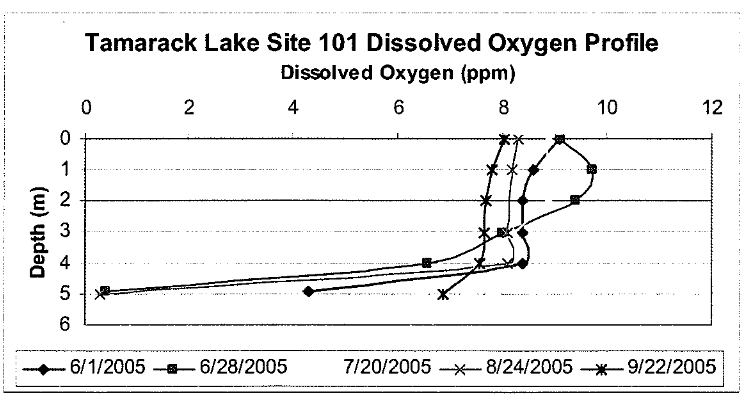


Results: North Tamarack Lake

Dissolved oxygen and temperature profiles were taken at a point near maximum depth at site 101 monthly from June to September (Figure 10). Dissolved oxygen concentrations declined slightly with depth, but remained above 5 mg/l (DO levels of 5 mg/l or greater preferred for game fish) down to a depth of 4 meters. The temperature profile indicated a well mixed (polymictic) lake on all sampling dates.

Figure 10. North Tamarack Lake Temperature and Dissolved Oxygen Profiles





Total Phosphorus (TP) is typically the limiting nutrient in algae growth in Minnesota's lakes. Summer-mean TP was 44 µg/l (micrograms per liter or parts per billion) in the epilimnion during the summer of 2005 for site 101. This is higher than the expected range for the NLF ecoregion (Table 5). Surface TP levels increased from early June to late July, where the TP at site 101 peaked at 54 µg/l, and then declined through September (Figure 11). Hypolimnetic (depth) samples mirrored surface TP concentrations, which suggests that the lake remains mixed during the summer (does not stratify).

Chlorophyll-*a* concentrations provide an estimate of the amount of algal production in a lake. During the summer of 2005, chlorophyll-*a* concentrations ranged from a low of 7.8 µg/l in September to a high of 19 µg/l in July with an average of 12.4 µg/l at site 101 (Figure 12). Chlorophyll-*a* concentrations are well above typical NLF ecoregion values at site 101, and mild algae blooms were observed on the late June, July, and August sampling trips (concentrations from 10-20 µg/l are frequently perceived as a mild algal bloom).

Figure 11. North Tamarack Lake Total Phosphorus Concentration

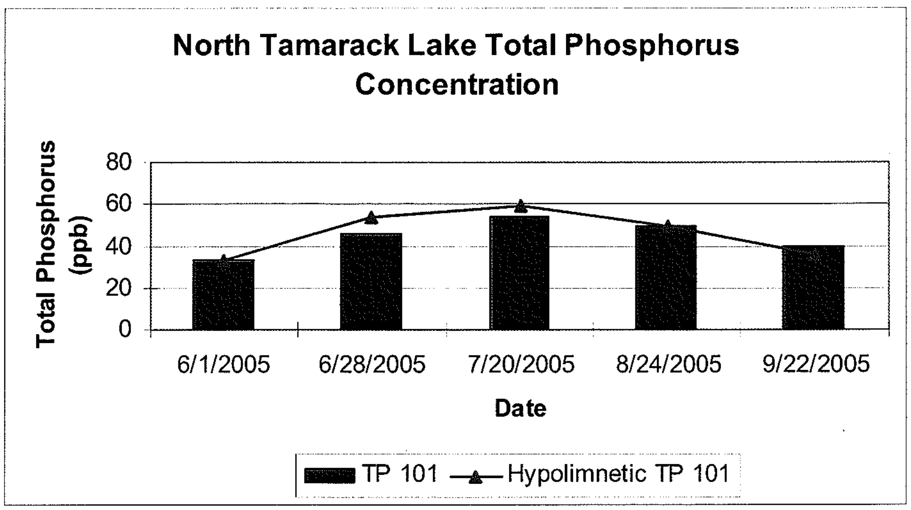
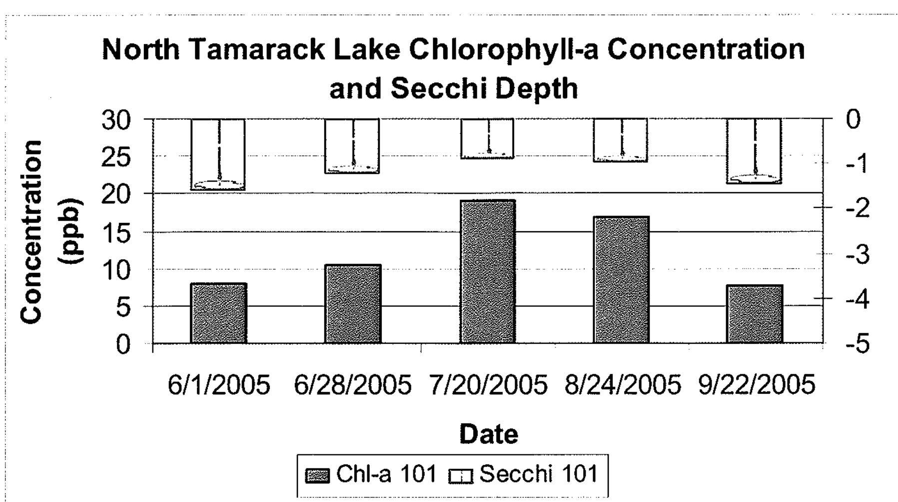


Figure 12. North Tamarack Lake Chlorophyll-*a* Concentration and Secchi Transparency

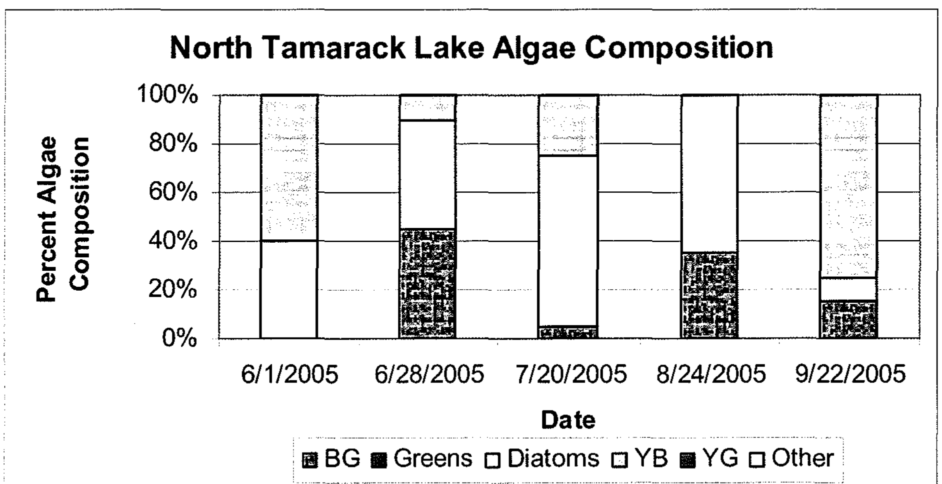


Secchi disk transparency is generally a function of the amount of algae in the water. Suspended sediments or color due to dissolved organics may also reduce water transparency. Color averaged 14 Pt-Co Units at site 101 and total suspended solids (TSS) averaged 9.2 mg/l. TSS values are above the expected range of values for the NLF ecoregion, while the color fell within the range of expected values for the ecoregion, and likely did not appreciably limit water transparency. Secchi transparency at site 101 ranged from a low of 0.9 m in July to a high of 1.6 m in early June, with an average of 1.3 m. This average is well below the typical range of Secchi disk transparencies for the NLF ecoregion (Table 5).

For typical mesotrophic-eutrophic lakes in Minnesota, transparency varies across the season. High readings are normally found in the spring when the water is cool and algae populations are low. Zooplankton (small crustaceans which feed on algae) populations are high at the time of year also, but decline later in the summer due to predation by young fish. As the summer goes on and the waters warm, the algae make use of available nutrients. As algae become more abundant, the transparency declines (Figure 12). The decrease in the abundance of zooplankton may allow for further increase in the amount of algae. Later in the summer, surface blooms of algae may also appear. In late summer, as the waters cool, the transparency typically improves.

Algal composition on North Tamarack Lake at site 101 was dominated in early June and September by yellow-brown algae and switched to a diatom-dominated system for the remainder of the summer. Diatoms made up a considerable portion of the algal composition on all dates except for the September trip (Figure 13). Green algae were never present in these samples, and blue-greens were never dominant.

Figure 13. North Tamarack Lake Algae Composition



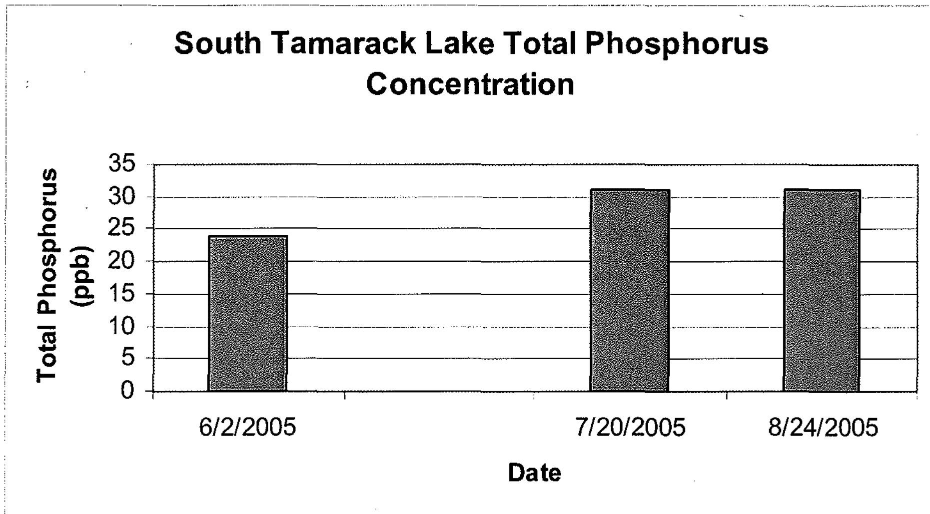
Results: South Tamarack Lake

Dissolved Oxygen and Temperature profiles were taken at site 102 during the June, July, and August sampling trips. With a depth of less than 2 meters, the site was well mixed on all dates, with temperature between 17 and 25 degrees Celsius and dissolved oxygen between 7.7 and 8.9

mg/l. It should be noted that sampling was limited on South Tamarack due to difficulty accessing the lake via boat and inclement weather.

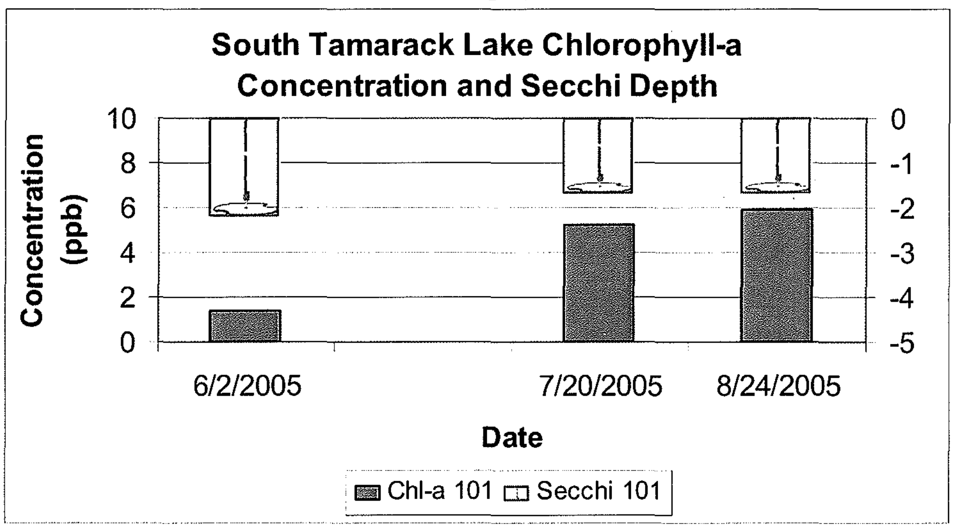
Total Phosphorus concentrations on South Tamarack Lake averaged 29 µg/l, with a low of 24 µg/l in early June and a high of 31 µg/l in both July and August (Figure 14). This is slightly above the typical range for lakes in the NLF ecoregion. With a small, protected watershed and the shallow nature of the lake, increases in total phosphorus across the season are likely due to the continuous mixing of the phosphorus laden bottom sediments into the water column.

Figure 14. South Tamarack Lake Total Phosphorus Concentration



Chlorophyll-*a* concentrations on South Tamarack ranged from a low of 1.4 µg/l in early June to a high of 5.9 µg/l in August, with an average of 4.2 µg/l (Figure 15). This is well within the typical range of values for the NLF ecoregion. As expected, the chlorophyll-a concentration increases with a corresponding increase to total phosphorus concentration.

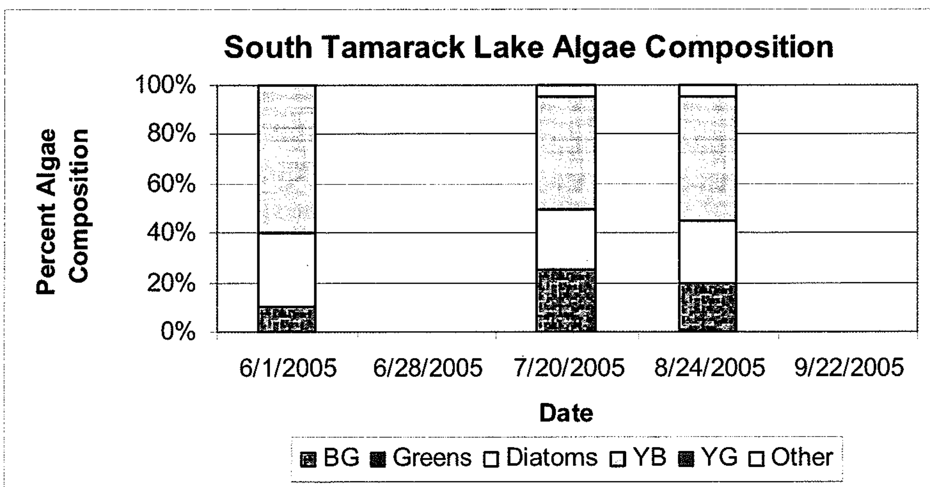
Figure 15. South Tamarack Lake Chlorophyll-a Concentration and Secchi Depth



Secchi disk transparency is generally a function of the amount of algae in the water. Suspended sediments or color due to dissolved organics may also reduce water transparency. Color averaged 17 Pt-Co Units on South Tamarack Lake, and total suspended solids averaged 4.9 mg/l. TSS values are above the expected range of values for the NLF ecoregion, while color was within the range. These likely did not appreciably limit transparency. Transparency ranged from a low transparency of 1.7 m in July and August trip to with a high of 2.2 m in early June (Figure 15). The seasonal average transparency on South Tamarack Lake was 1.9 m. This is just below the typical range for the NLF ecoregion. Again, these changes in transparency (decrease in clarity) follow the increase of chlorophyll-*a* concentrations (algal growth) and total phosphorus concentration.

Algal Composition on South Tamarack Lake was dominated by yellow-brown algae on all three dates (Figure 16). For most mesotrophic to eutrophic lakes in Minnesota, the algae composition shifts from diatoms to greens to blue-greens. Greens were never present on South Tamarack, and bluegreens were never a dominant algal type.

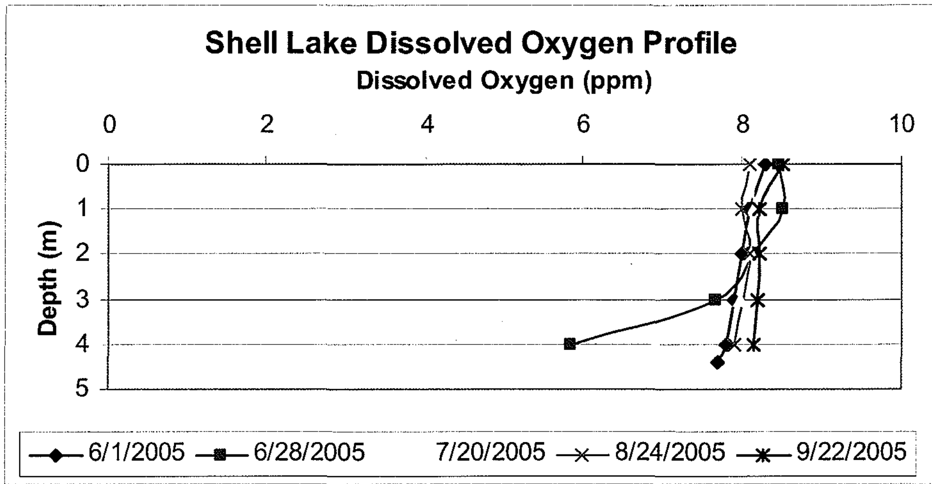
Figure 16. South Tamarack Lake Algal Composition

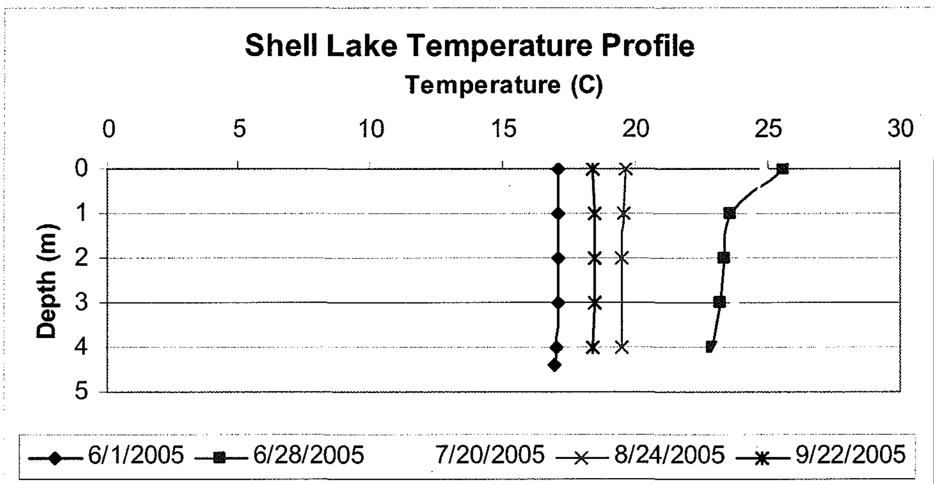


Results: Shell Lake

Dissolved oxygen and temperature profiles were taken at site 101 June, July, August, and September 2005. Dissolved oxygen remained above 5 mg/l on all sampling dates above a depth 4 meters (Figure 17). Temperature profiles indicated that the lake was well mixed (polymictic) on all dates.

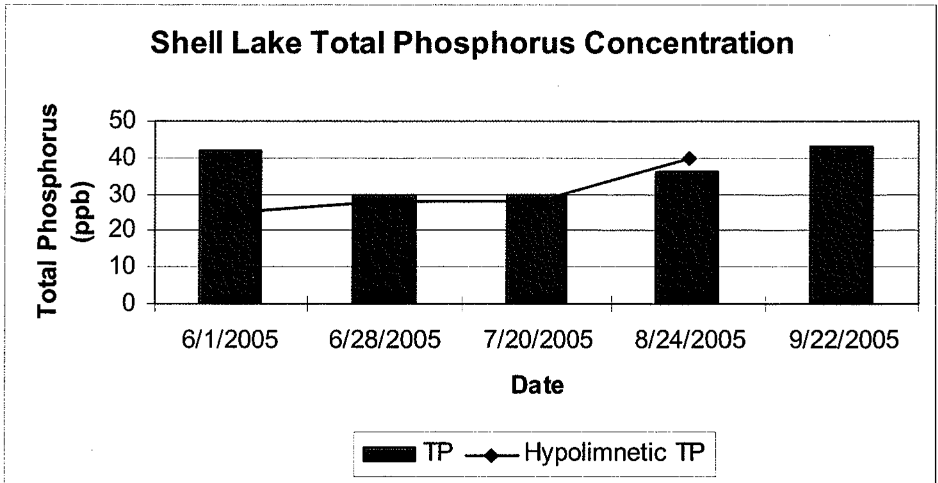
Figure 17. Shell Lake Dissolved Oxygen and Temperature Profiles





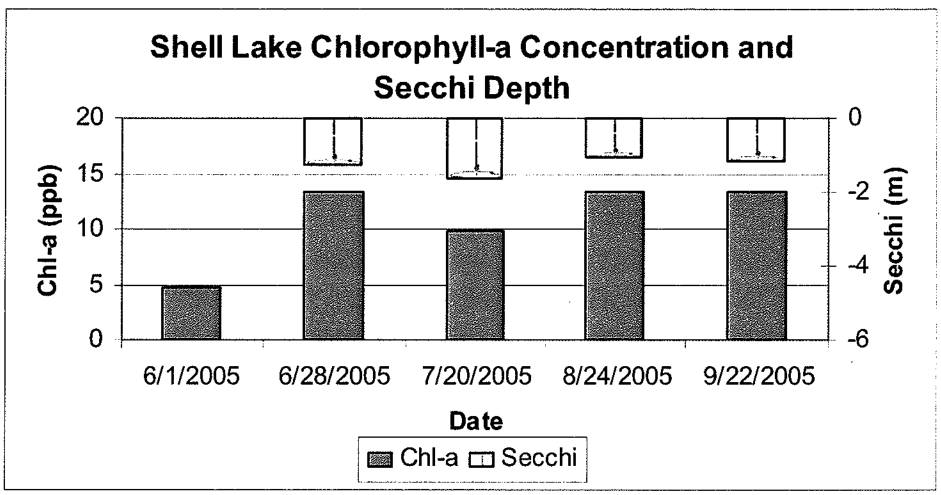
Total Phosphorus concentrations on Shell Lake averaged 36 μg/l at site 101 in 2005 (Figure 18). This is well above the typical range for lakes in the NLF ecoregion (Table 5). Hypolimnetic total phosphorus concentrations were not as consistently measured, but averaged 30 μg/l at site 101. This would be expected with the polymictic nature of the lake. Typically total phosphorus concentrations decline across the summer as watershed loading to the lake diminishes. However, in 2005, total phosphorus was elevated in early June, than declined and slowly increased across the summer, reaching a peak in September of 43 μg/l.

Figure 18. Shell Lake Total Phosphorus Concentration



Chlorophyll-*a* concentrations in Shell Lake averaged 10.9 µg/l in 2005 (Figure 19). Both the average and the maximum (101 = 13.4 µg/l) were within the range of expected values for the NLF ecoregion (Table 5). Mild algae blooms (Chl-a between 10 µg/l and 20 µg/l) occurred during the late June, August, and September sampling dates.

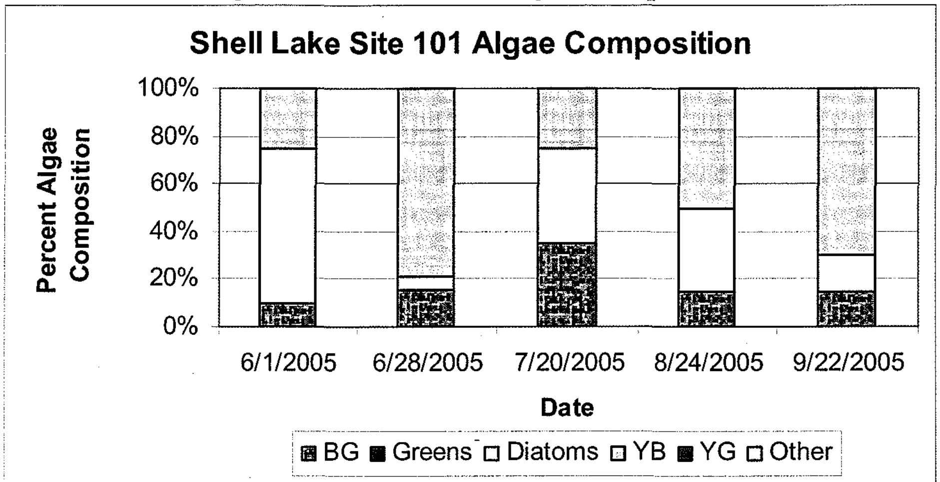
Figure 19. Shell Lake Chlorophyll-*a* Concentration and Secchi Transparency



Secchi disk transparency averaged 1.3 m (4.3 feet) at site 101 (Figure 19). This average is considerably below the typical range of expected values for the NLF ecoregion (Table 5). Color averaged 8 Pt-Co Units and TSS averaged 5.8 mg/l. While color is below the typical ecoregion values, TSS is above the expected range; however, they should not appreciably limit transparency. Transparency followed a similar pattern to chlorophyll-*a* (algae) concentrations in 2005 (Figure 16). When the chlorophyll-a levels were elevated, a corresponding drop in transparency was observed.

Algal composition on Shell Lake was dominated by diatoms in early June and July 2005. In the late June, August, and September samples, yellow-brown algae shifted to the dominant form (Figure 20). As with Tamarack and Pine Lakes, Shell did not follow the typical progression from diatoms to greens to blue-greens.

Figure 20. Shell Lake Algae Composition



Modeling

Numerous complex mathematical models are available for estimating nutrient and water budgets for lakes. These models can be used to relate the flow of water and nutrients from a lake's watershed to observed conditions in the lake. Alternatively, they may be used for estimating changes in the quality of the lake as a result of altering nutrient inputs to the lake (e.g., changing land uses in the watershed) or altering the flow or amount of water that enters the lake. To analyze the 2005 water quality of Becker County lakes, MINLEAP (Wilson and Walker, 1989) was used.

MINLEAP which refers to "Minnesota Lake Eutrophication Analysis Procedures" was developed by MPCA staff based on an analysis of data collected from the ecoregion reference lakes. It is intended to be used as a screening tool for estimating lake conditions with minimal input data and is described in greater detail in Wilson and Walker (1989). In this instance we applied it as a basis for comparing the observed (2005) TP, chlorophyll-*a* and Secchi values with that predicted based on the size, depth and size of the watershed for each lake.

The lakes in this study are all located on the edge of the NLF ecoregion. The watersheds are all forest and wetland land use dominated, and did not drain any watersheds in the NCHF ecoregions. For this reason, the model was run using NLF ecoregion-based inputs for precipitation, runoff, evaporation and average stream TP remain constant for all cases. It should be noted that the model predicts in-lake TP from these inputs and subsequently predicts chlorophyll-*a* based on a regression equation with TP and Secchi based on a regression equation based on chlorophyll-*a*. A comparison of MINLEAP predicted vs. observed values is presented in Table 6.

There was not a significant difference between observed and MINLEAP predicted TP for most of the lakes in this report. In simple terms this means that the observed TP is consistent with that expected for a lake of that size and depth and size watershed in the NLF ecoregion. However, in North Tamarack Lake, the model predicted significantly lower total phosphorus concentrations that were observed. Since North Tamarack Lake has a small watershed, with only Pine Lake as an upstream contributor, it is likely that the lake experiences periodic internal loading of phosphorus from the bottom sediments. With a maximum depth of only 16 feet, the lake is mixes routinely (polymictic) and this combined with periodic low dissolved oxygen, high temperatures near the sediment-water interface, and potential re-suspension of phosphorus laden sediments from the bottom may account for the higher than expected total phosphorus concentration. Of the 4 lakes, North Tamarack and Shell both exceeded the 30 µg/l draft nutrient criteria for lakes in the NLF ecoregion (Table 1). South Tamarack and Pine lakes were also quite close to the criteria, with average total phosphorus concentrations of 29 µg/l and 27 µg/l, respectively. This suggests the possibility that these lakes could be included on a future impaired waters listing; however further data would be needed to complete an aquatic use recreation assessment of the lakes.

MINLEAP predicts chlorophyll-*a* as a function of TP and hence lakes with predicted TP lower than observed will tend to have lower than observed predicted chlorophyll-*a* – as is the case for Pine, Shell, and North Tamarack Lakes. The inverse is the case for South Tamarack, where observed chlorophyll-*a* is lower than predicted (Table 6). Shell Lake and North Tamarack both had chlorophyll-*a* values were in excess of the 9 µg/L draft chlorophyll-*a* criteria, and all the lakes failed to meet the minimum draft Secchi criteria of greater than 2 meters (Table 1).

Trophic State Index

TSI Comparison

Comparisons of the individual TSI measures provides a bases for assessing the relationship among TP, Chl-*a* and Secchi for the lakes (Figure 21). In general, the TSI values are in fairly close correspondence with each other. Pine and Shell lakes both are mesotrophic-eutrophic, while North and South Tamarack are eutrophic.

Pine Lake had a Chl-*a* TSI value slightly low relative to TP. This suggests that Pine Lake has the potential for higher Chl-a based on TP, but some factors such as light exclusion, rooted plant growth, and/or grazing zooplankton may limit algal production.

Secchi TSI's closely corresponded to TP TSI for the lakes in this study. North and South Tamarack had lower than anticipated Secchi transparency based on TP (Figure 21).

Lastly Chl-*a* and Secchi TSI were in good correspondences for most lakes (Figure 21). South Tamarack and Shell Lakes had lower transparency (higher TSI) than anticipated. This may be in part due to the elevated total suspended solids in the lakes. All were above the ecoregion range for total suspended solids and total inorganic suspended solids. This may have interfered with light penetration into the water column and therefore reduced the transparency.

Goal Setting

The phosphorus criteria value for lakes in the Northern Lakes and Forests ecoregion is less than 30 μg/l for support of aquatic recreation use. At or below 30 μg/l, "nuisance algal blooms" (chlorophyll-a > 20 μg/l) should occur less than 10 percent of the summer and transparency should remain at or above 3 meters over 85 percent of the summer.

For North and South Tamarack, Pine, and Shell lakes, it would be desirable to reduce in-lake TP concentrations from levels observed in 2005. Should in-lake TP concentrations increase, it is likely that the frequency of nuisance algal blooms would increase and transparency would decrease. All the lakes were near or exceeding the 30 μg/l total phosphorus criteria, and exceeded (below) the Secchi criteria of greater than 2.0 meters transparency. It would be important to reduce as much external phosphorus loading to the lake as possible to maintain or reduce the current concentrations. Considering the depth of the lakes, it appears that internal loading of phosphorus will continue to be a considerable source of nutrients to the lake.

Important considerations include land use practices in the shoreland and watershed area of the lake. A more comprehensive review of land use practices in the watershed may reveal opportunities for implementing BMPs in the watershed and reducing phosphorus loading to the lake. The US Fish and Wildlife Service will be an important partner in the improvement efforts in the Tamarack and Pine Lake watersheds.

Table 6. MINLEAP Model Results

Parameter	2005 N Tamarack Observed	Total Watershed MINLEAP
TP (µg/l)	44 ± 3.6	22 ± 7
chl-a (µg/l)	12.4 ± 2.3	6.2 ± 3.6
% chl-a > 20 µg/l	0	0
% chl-a > 30 µg/l	0	0
Secchi (m)	1.3 ± 0.1	2.7 ± 1.1
P-loading rate (kg/yr)	--	351
% P retention	--	63
P inflow conc. (µg/l)	--	60
water load (m/yr)	--	1.01
outflow volume (hm3/yr)	--	5.83
"background P"	--	31.6
residence time (years)	--	2.4

Parameter	2005 Pine Observed	Total Watershed MINLEAP
TP (µg/l)	26.6 ± 2.2	20 ± 7
chl-a (µg/l)	7.3 ± 1.4	5.4 ± 3.3
% chl-a > 20 µg/l	0	1
% chl-a > 30 µg/l	0	0
Secchi (m)	2.0 ± 0.2	2.9 ± 1.2
P-loading rate (kg/yr)	--	112
% P retention	--	67
P inflow conc. (µg/l)	--	62
water load (m/yr)	--	0.84
outflow volume (hm3/yr)	--	1.81
"background P"	--	30.7
residence time (years)	--	3.2

Parameter	2005 S Tamarack Observed	Total Watershed MINLEAP
TP (µg/l)	29 ± 2.3	25 ± 8
chl-a (µg/l)	4.2 ± 1.4	7.1 ± 4.1
% chl-a > 20 µg/l	0	0
% chl-a > 30 µg/l	0	0
Secchi (m)	1.9 ± 0.2	2.4 ± 0.9
P-loading rate (kg/yr)	--	122
% P retention	--	60
P inflow conc. (µg/l)	--	62
water load (m/yr)	--	0.79
outflow volume (hm3/yr)	--	1.95
"background P"	--	37.2
residence time (years)	--	1.9

Parameter	2005 Shell Observed	Total Watershed MINLEAP
TP (µg/l)	36 ± 2.8	28 ± 8
chl-a (µg/l)	10.9 ± 1.7	8.4 ± 4.5
% chl-a > 20 µg/l	0	0
% chl-a > 30 µg/l	0	0
Secchi (m)	1.3 ± 0.1	2.2 ± 0.8
P-loading rate (kg/yr)	--	1,591
% P retention	--	50
P inflow conc. (µg/l)	--	56
water load (m/yr)	--	2.25
outflow volume (hm3/yr)	--	28.59
"background P"	--	31.5
residence time (years)	--	1.0

FIGURE 21. Carlson's Trophic State Index for Becker County Lakes
R.E. Carlson

TSI < 30 Classical Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.

TSI 30 - 40 Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.

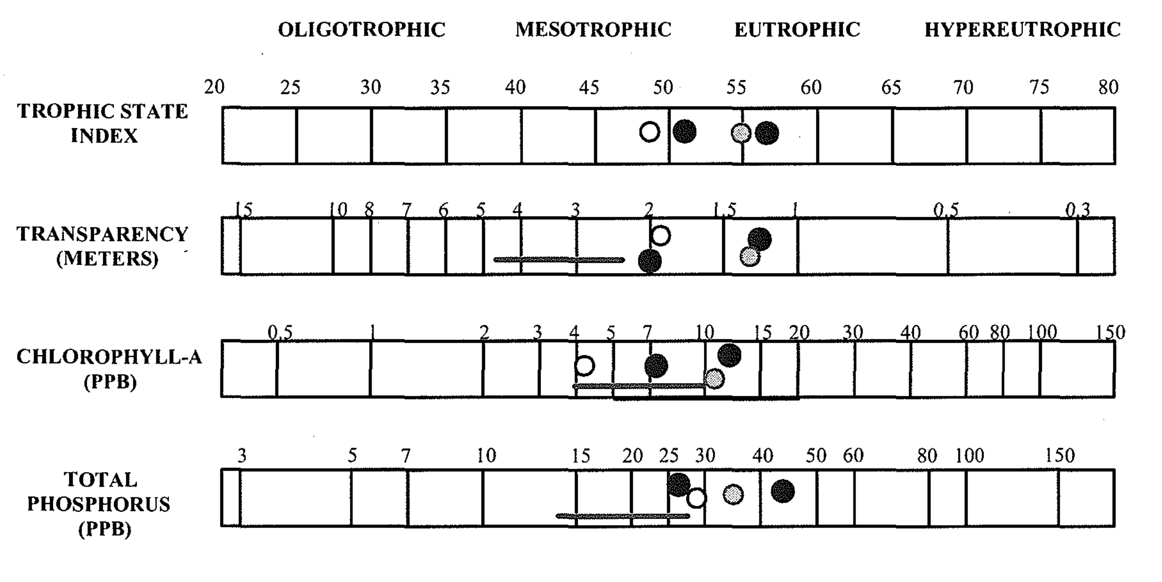
TSI 40 - 50 Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.

TSI 50 - 60 Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only.

TSI 60 - 70 Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.

TSI 70 - 80 Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.

TSI > 80 Algal scums, summer fish kills, few macrophytes, dominance of rough fish.



<u>After</u> Moore, l. and K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

NLF Ecoregion Range: ——— N Tamarack: ● Pine: ●
S Tamarack: ○ Shell: ◎

Appendix A Glossary

Acid Rain: Rain with a higher than normal acid range (low pH). Caused when polluted air mixes with cloud moisture. Can make lakes devoid of fish.

Algal Bloom: An unusual or excessive abundance of algae.

Alkalinity: Capacity of a lake to neutralize acid.

Bioaccumulation: Build-up of toxic substances in fish flesh. Toxic effects may be passed on to humans eating the fish.

Biomanipulation: Adjusting the fish species composition in a lake as a restoration technique.

Dimictic: Lakes which thermally stratify and mix (turnover) once in spring and fall.

Ecoregion: Areas of relative homogeneity. EPA ecoregions have been defined for Minnesota based on land use, soils, landform, and potential natural vegetation.

Ecosystem: A community of interaction among animals, plants, and microorganisms, and the physical and chemical environment in which they live.

Epilimnion: Most lakes form three distinct layers of water during summertime weather. The epilimnion is the upper layer and is characterized by warmer and lighter water.

Eutrophication: The aging process by which lakes are fertilized with nutrients. *Natural eutrophication* will very gradually change the character of a lake. *Cultural eutrophication* is the accelerated aging of a lake as a result of human activities.

Eutrophic Lake: A nutrient-rich lake – usually shallow, "green" and with limited oxygen in the bottom layer of water.

Fall Turnover: Cooling surface waters, activated by wind action, sink to mix with lower levels of water. As in spring turnover, all water is now at the same temperature.

Hypolimnion: The bottom layer of lake water during the summer months. The water in the hypolimnion is denser and much colder than the water in the upper two layers.

Lake Management: A process that involves study, assessment of problems, and decisions on how to maintain a lake as a thriving ecosystem.

Lake Restoration: Actions directed toward improving the quality of a lake.

Lake Stewardship: An attitude that recognizes the vulnerability of lakes and the need for citizens, both individually and collectively, to assume responsibility for their care.

Limnetic Community: The area of open water in a lake providing the habitat for phytoplankton, zooplankton and fish.

Littoral Community: The shallow areas around a lake's shoreline, dominated by aquatic plants. The plants produce oxygen and provide food and shelter for animal life.

Mesotrophic Lake: Midway in nutrient levels between the eutrophic and oligotrophic lakes

Meromictic A lake that does not mix completely

Nonpoint Source: Polluted runoff – nutrients and pollution sources not discharged from a single point: e.g. runoff from agricultural fields or feedlots.

Oligotrophic Lake: A relatively nutrient- poor lake, it is clear and deep with bottom waters high in dissolved oxygen.

pH Scale: A measure of acidity.

Photosynthesis: The process by which green plants produce oxygen from sunlight, water and carbon dioxide.

Phytoplankton: Algae – the base of the lake's food chain, it also produces oxygen.

Point Sources: Specific sources of nutrient or polluted discharge to a lake: e.g. stormwater outlets.

Polymictic: A lake that does not thermally stratify in the summer. Tends to mix periodically throughout summer via wind and wave action.

Profundal Community: The area below the limnetic zone where light does not penetrate. This area roughly corresponds to the hypolimnion layer of water and is home to organisms that break down or consume organic matter.

Respiration: Oxygen consumption

Secchi Disk: A device measuring the depth of light penetration in water.

Sedimentation: The addition of soils to lakes, a part of the natural aging process, makes lakes shallower. The process can be greatly accelerated by human activities.

Spring Turnover: After ice melts in spring, warming surface water sinks to mix with deeper water. At this time of year, all water is the same temperature.

Thermocline: During summertime, the middle layer of lake water. Lying below the epilimnion, this water rapidly loses warmth.

Watershed storage area The percentage of a drainage area labeled lacustrine (lakes) and palustrine (wetlands) on U.S. Fish and Wildlife Service National Wetlands Inventory Data.

Zooplankton: The animal portion of the living particles in water that freely float in open water, eat bacteria, algae, detritus and sometimes other zooplankton and are in turn eaten by planktivorous fish.

Appendix B Water Quality Data: Abbreviations and Units

TP= total phosphorus in mg/l(decimal) or ug/L as whole number
TKN= total Kjeldahl nitrogen in mg/l
TNTP=TN:TP ratio
pH= pH in SU (F=field, or L=lab)
ALK= alkalinity in mg/l (lab)
TSS= total suspended solids in mg/l
TSV= total suspended volatile solids in mg/l
TSIN= total suspended inorganic solids in mg/l
TURB= turbidity in NTU (F=field)
CON= conductivity in umhos/cm (F=field, L=lab)
CL= chloride in mg/l
DO= dissolved oxygen in mg/l
TEMP= temperature in degrees centigrade
SD= Secchi disk in meters (SDF=feet)
Chl-a= chlorophyll-a in ug/l
TSI= Carlson's TSI (P=TP, S=Secchi, C=Chla)
PHEO= pheophytin in ug/l
PHYS= physical appearance rating (classes=1 to 5)
REC= recreational suitability rating (classes=1 to 5)
RTP, RN2N3...= remark code; k=less than, Q=exceeded holding time

Appendix C References

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Appendix D Surface water results

Lake Name	Lake ID	Date	Site	Sample Depth		TP	Chl-a	Secchi	Total Alk	Cl	TKN	Color, Apparent	TSS	VSS
			Site	Up	Lwr	ug/l	ug/l	m	mg/l	mg/l	mg/l	PCU	mg/l	mg/l
N Tamarack	03-0241-02	6/1/2005	101	0	2	33	7.88	1.6	190	1.5	1.16	10	5.2	3.2
		6/1/2005	101	4.5	4.5	33								
		6/28/2005	101	0	2	46	10.5	1.25	190	1.5	1.01	20	9.2	6.4
		6/28/2005	101	4	4	54								
		7/20/2005	101	0	2	54	19	0.9	180	1.3	1.11	20	13	7.2
		7/20/2005	101	4.5	4.5	59								
		8/24/2005	101	0	2	49	16.9	1	170	1.8	1.07	10	13	7
		8/24/2005	101	4	4	49								
		9/22/2005	101	0	2	40	7.77	1.5	180	1.8	0.91	10	5.4	3.6
		9/22/2005	101	5	5	36								
Pine	03-0200	6/2/2005	101	0	2	21	4.04	2.7	190	1.7	0.87	5	2.8	1.2
		6/2/2005	101	4	4	21								
		6/29/2005	101	0	2	24	4.99	1.8	190	1.6	0.97	10	2.4	1.6
		6/29/2005	101	3.5	3.5	24								
		7/21/2005	101	0	2	27	11.7	2	190	1.4	1.06	10	5.2	4.4
		7/21/2005	101	4	4	26								
		8/24/2005	101	0	2	34	8.61	1.6	180	1.8	1.05	10	15	4.4
		8/24/2005	101	3.5	3.5	34								
		9/22/2005	101	0	2	27	7.31	2	190	1.9	1.02	10	3.2	2.4
		9/22/2005	101	4	4	28								

Lake Name	Lake ID	Date	Site	Sample Depth		TP	Chl-a	Secchi	Total Alk	Cl	TKN	Color, Apparent	TSS	VSS
			Site	Up	Lwr	ug/l	ug/l	m	mg/l	mg/l	mg/l	PCU	mg/l	mg/l
S Tamarack	03-0241-01	6/2/2005	102	0	2	24	1.43	2.2	180	1.3	1.01	10	2.8	2
		7/20/2005	102	0	2	31	5.23	1.7	190	1.4	1.26	20	5.2	2
		8/24/2005	102	0	1.8	31	5.88	1.7	190	1.6	1.28	20	6.7	4
Shell	03-0102	6/1/2005	101	0	2	42	4.68		170	4	0.76	5	4.2	2.4
		6/1/2005	101	4	4	25								
		6/28/2005	101	0	2	30	13.4	1.3	170	3.9	0.73	5	6.6	4.8
		6/28/2005	101	4	4	28								
		7/20/2005	101	0	2	30	9.74	1.7	160	3.9	0.8	10	5.2	4
		7/20/2005	101	3.5	3.5	28								
		8/24/2005	101	0	2	36	13.3	1.1	160	4.4	1.03	10	8.4	7.2
		8/24/2005	101	3.5	3.5	40								
		9/22/2005	101	0	2	43	13.4	1.2	170	4.6	0.95	10	4.4	3.6