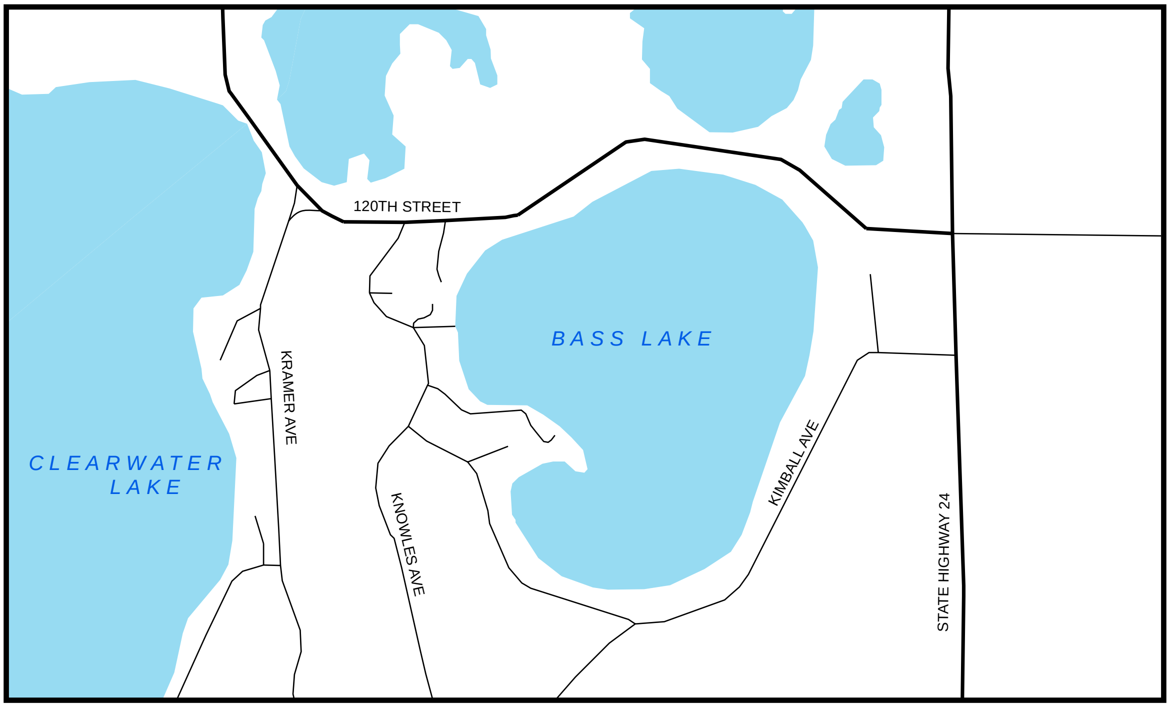
Bass Lake Status and Trend Update Through the Citizen Lake-Monitoring Program (CLMP+):

Advanced Volunteer Lake Monitoring
Wright County



Minnesota Pollution Control Agency

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Bass Lake Status and Trend Update Through the Citizen Lake-Monitoring Program (CLMP+):
Advanced Volunteer Lake Monitoring
Wright County

Bass Lake (86-0234)

Minnesota Pollution Control Agency

Environmental Analysis and Outcomes Division
Water Assessment and Environmental Information Section
Jennifer L.K. Klang
Pam Anderson

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Bass Lake Status and Trend Update Through the Citizen Lake-Monitoring Program (CLMP+): Advanced Volunteer Lake Monitoring Wright County

Part 1: Program History and Background Information on Minnesota Lakes

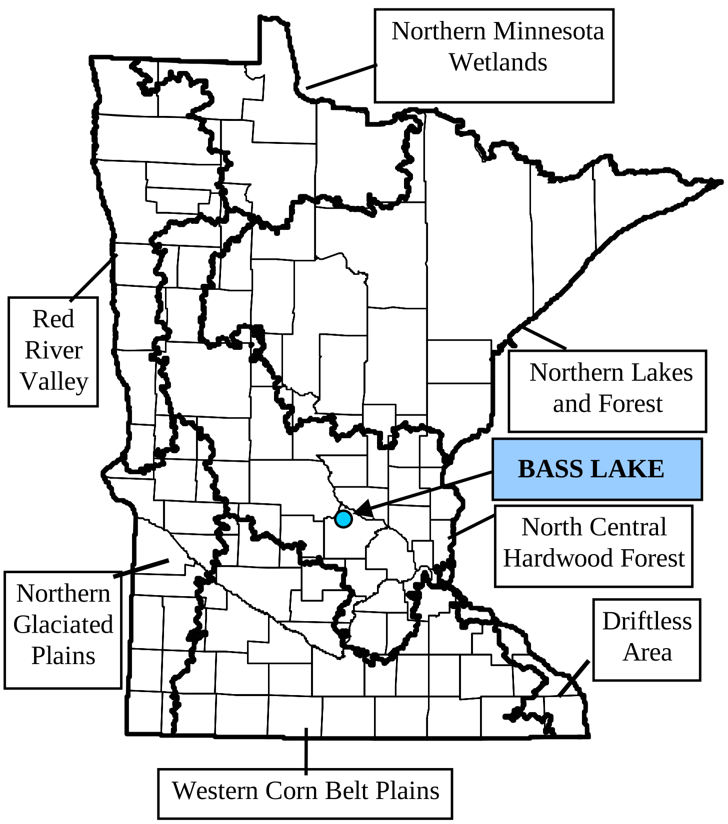
Minnesota's Citizen Lake-Monitoring Program (CLMP) is the largest and oldest volunteer lake-monitoring program in the country. Volunteers in the CLMP currently use a Secchi disk to measure the clarity on hundreds of Minnesota's lakes. The expanded program, including the collection of water chemistry samples for analysis along with Secchi transparency collection, was conducted in several counties. A total of sixteen lakes were selected for monitoring in 2005 by volunteer lake monitors. These lakes were: Latoka, Lobster and Mary Lakes (Douglas County); Big Kandiyohi, Diamond, Long, and Wakanda Lakes (Kandiyohi County); Blueberry, Duck, Jim-Cook, Lower Twin, Morgan, Upper Twin Lakes (Hubbard/Wadena Counties); Bass, Howard, and Pleasant Lakes (Wright County). Spirit and Stocking Lakes (Wadena County) were also sampled by volunteer lake monitors through the County. The data from these two additional lakes was incorporated in the 2005 Wadena County CLMP+ report. All equipment and analytical costs for the samples were provided for and paid by the Minnesota Pollution Control Agency (MPCA). *Note: Only data from Bass Lake will be discussed in this update report.*

Volunteers on these lakes collected water chemistry samples and temperature profiles twice per month along with their weekly Secchi transparency readings. After sampling, the volunteers dropped off their samples at a predetermined location within their county. Andy Dahlgren and Joe Jacobs with the Wright County Soil and Water Conservation District (SWCD), helped plan and coordinate the sample drop-off/pick up schedule for the samples in Wright County. Special thanks to the volunteer on Bass Lake who helped make this project a success: Dan Ross. MPCA staff and volunteer monitors collected quality assurance and quality control (QA/QC) samples for this project. Donna Perleberg, from the MN Department of Natural Resources (MN DNR), provided the plant survey information.

The MPCA core lake-monitoring programs include the CLMP, the Lake Assessment Program (LAP), and the Clean Water Partnership (CWP) Program. 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, and characterize lake conditions in different regions of the state. MPCA also examines year-to-year variability in ecoregion reference lakes and provides additional trophic status data for lakes exhibiting trends in Secchi transparency. Bass Lake was included in the MPCA's LAP program in 1999 with the help of Gerry Stuhr and Dan Ross from the lake association.

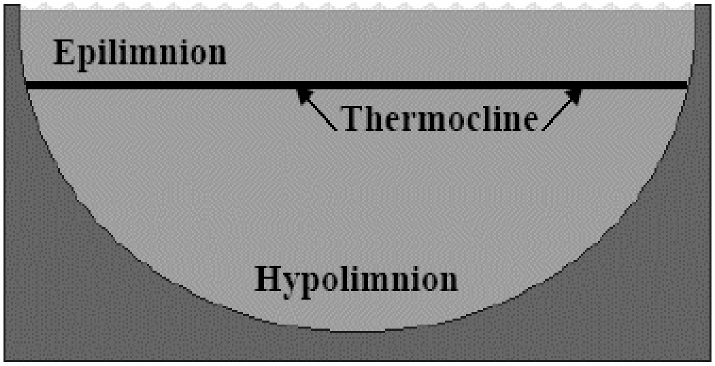
The state of Minnesota is divided into seven ecoregions (Figure 1), based on soils, landform, potential natural vegetation, and land use. Bass Lake is located within the North Central Hardwood Forest (NCHF) ecoregion. Comparing a lake's water quality to that of reference lakes in the same ecoregion provided one basis for characterizing the condition of the lake.

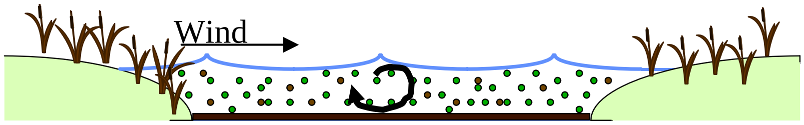
Figure 1. Minnesota's Ecoregions and Counties



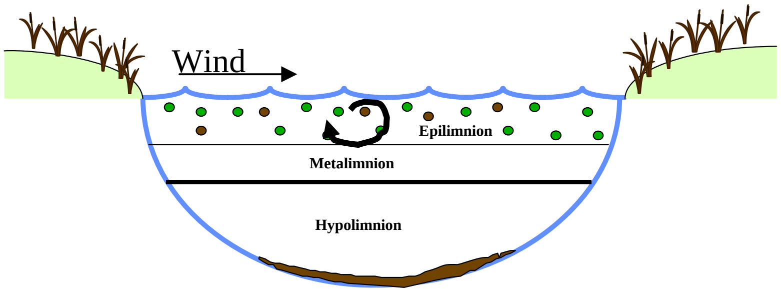
Lake depth can have a significant influence on lake processes and water quality. One such process is *thermal stratification* (formation of distinct temperature layers), in which deep lakes (maximum depths of 30 - 40 feet or more) often stratify (form layers) during the summer months and are referred to as *dimictic*. These lakes full-mix or turn-over twice per year; typically in spring and fall. Shallow lakes (maximum depths of 20 feet or less) in contrast, typically do not stratify and are often referred to as *polymictic*. 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.

Diagram of Lake Layers for Deep and Shallow Lakes

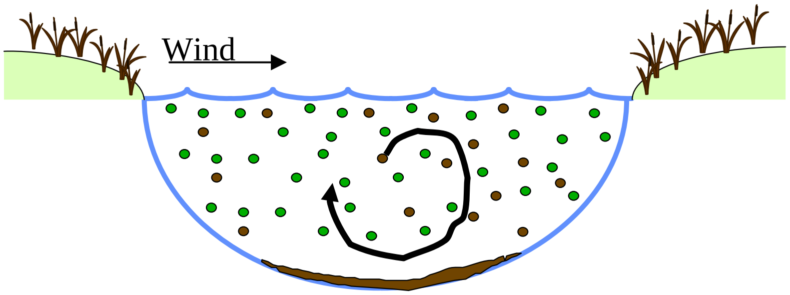




Polymictic Lake
Shallow, No Layers,
Mixes Continuously
Spring, Summer & Fall



Dimictic Lake
Deep, Form Layers,
Mixes Few Times
Summer



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

Part 2: 2005 Lake Surveys

Methods

This report includes data from 2005 as well as previously collected data available in STORET, U.S. Environmental Protection Agency's (EPA) national water quality data bank (Appendix). The following discussion assumes familiarity with basic limnology terms as used in a "Citizens Guide to Lake Protection" and as commonly used in LAP reports. A glossary of terms is included in the appendix and can also be accessed at http://www.pca.state.mn.us/water/lakeacro.html.

One site in the lake was monitored twice per month, from June through September. Lake surface samples were collected with an integrated sampler, constructed from a PVC tube 6.6 feet (2 meters) in length with an inside diameter of 1.24 inches (3.2 centimeters). Lake-bottom samples were collected 1 meter off the bottom of the lake by MPCA staff using a Kemmerer sampler. Seasonal averages were calculated using June – September data. Sampling procedures were employed as described in the MPCA Quality Control Manual and Citizen Lake-Monitoring Program "Plus" Manual. Laboratory analyses were performed at the Minnesota Department of Health using EPA-approved methods. Surface samples from volunteers were analyzed for: total phosphorus (TP), chlorophyll-*a*, and pheophytin. Secchi disk transparency and user perception information was recorded at all sites. Volunteers also collected temperature profiles for each site using a FishHawk Model 520 digital depth and temperature meter. Algae samples were collected from the chlorophyll-*a* sample bottles and preserved with Lugol's solution.

MPCA staff collected surface samples and bottom samples for each site on three occasions. These data serve to augment the volunteer collection and provide an opportunity for comparison of results. MPCA collected surface samples were analyzed for the following parameters: TP, chlorophyll-*a*, pheophytin, total Kjeldahl nitrogen (TKN), total suspended solids (TSS), suspended volatile solids (SVS), total chloride, alkalinity and color. Conductivity, pH, and dissolved oxygen and temperature profiles were collected using a Hydrolab multi-probe unit. Lake-bottom samples were analyzed for TP. Secchi disk transparency and user perception information was recorded for each site. Qualitative analysis of zooplankton collected using a zooplankton net was also recorded.

Additional information, such as bathymetric (contour) and location maps, was obtained from the DNR's lakefinder Web site (http://www.dnr.state.mn.us/lakefind/index.html) and the MPCA Web site (http://www.pca.state.mn.us) and from U.S. Geological Survey quad maps. Watershed area information for the lake was provided from the 1999 LAP report.

Data Analysis

A series of graphs are presented for each parameter including: TP, chlorophyll-*a*, Secchi disk transparency, and temperature profiles. Sample dates with a single asterisk indicate data collected by the MPCA. Dates with no asterisk were collected by CLMP volunteer lake monitors. All raw data for each lake and site are available in the appendix.

The Quality Assurance/Quality Control (QA/QC) samples were taken routinely throughout the sampling season. Thirteen field duplicate TP samples were taken. A field duplicate is a second sample taken right after an initial sample in the exact same location. Field duplicates assess sampler and laboratory precision (reproducibility). Duplicate samples are collected in the exact same manner as the first sample, including the normal sampling equipment cleaning procedures. Of these 13 samples, the percent difference ranged from 0 – 33 percent of the original sample, with the majority (77 %) falling within the 0 – 15 percent range. Of the 12 paired chlorophyll-*a* samples, the percent difference range was 2 – 16 percent, with the majority (83 %) falling within the 0 – 15 percent range. These results are very good considering the difference in quality of the participating lakes and varying concentration levels of these parameters. Four TP sample results from the following lakes were omitted due to sample contamination from adding Lugol's solution instead of sulfuric acid preservative: Duck Lake (Hubbard County), Upper Twin Lake (Hubbard County), Lower Twin Lake (Wadena County), and Pleasant Lake (Wright County). One chlorophyll-*a* sample from Duck Lake (Hubbard County) was also omitted due to sample contamination from Lugol's.

Several TP samples from early June, for the CLMP+ lakes, were held for one week longer than the recommended holding time due to the 2005 government shutdown. However, given that the samples were properly preserved with acid, kept cool and in a dark place, we do not feel these samples were compromised. Several color results were also held over the recommended holding time by one day. As with the TP samples, the integrity of these samples should also still be acceptable.

The Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) computer model was used to predict the TP concentration, chlorophyll-*a* concentration, and Secchi disk transparency of the lake based on the lake area, lake depth, and the area of the lake's watershed. Additional information about this model can be found in the modeling section of this report or a complete explanation of this model may be found in Wilson and Walker (1989).

Table 1. Bass Lake Morphometric and Watershed Characteristics

Morphometry	Bass Lake
Area[1]	**220 acres (86 ha) (0.3 mi^2)**
Mean Depth[1]	**17 feet (5.2 meters)**
Maximum Depth[1]	**34 feet (10.4 meters)**
Volume[1]	**3,731 acre-feet (4.6 hm^3)**
Littoral Area[2]	**~ 45 %**
Watershed area[1] ***(excludes the lake)***	**475 acres (192 ha) (0.7 mi^2)**
Watershed:Lake[1]	**2:1**

Table 2: 1999 & 2005 Bass Lake Average Summer Water Quality Parameters

Parameters	Bass – 1999	Bass – 2005	Typical Range (NCHF Ecoregion[3])
Total Phosphorus (µg/L)	19.0	17.4	23 – 50
Chlorophyll-*a* (µg/L)[4] **Mean**	6.0	3.6	5 – 22
Chlorophyll-*a*(µg/L)[4] **Maximum**	10.0	6.5	7 – 37
Secchi disk (m)	4.4	4.2	1.5 – 3.2
Secchi disk (feet)	14.5	13.9	4.9 – 10.5
Total Kjeldahl Nitrogen (mg/L)	0.6	0.6	0.62 – 1.2
Alkalinity (mg/L)	152	160	75 – 150
Color (Pt-Co Units)	5	8.3	10 – 20
pH (SU)	8.6	8.5	8.6 – 8.8
Chloride (mg/L)	19.5	26	4 – 10
Total Suspended Solids (mg/L)	2.9	2.7	2 – 6
Total Suspended Inorganic Solids	1.0	1.9	1 – 2
Conductivity (µmhos/cm)	324	351	300 – 400
TN:TP Ratio	34:1	34:1	25:1 – 35:1

Table 3. Bass Lake Trophic Status Indicators: 1999 and 2005

TSI Parameter	Bass 1999	Bass 2005
TP TSIP =	**46**	**45**
Chl-*a* TSIC =	**48**	**43**
Secchi TSIS =	**39**	**39**
Mean (All) TSI =	**44**	**42**

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[1] MPCA Lake Assessment Report (2000)

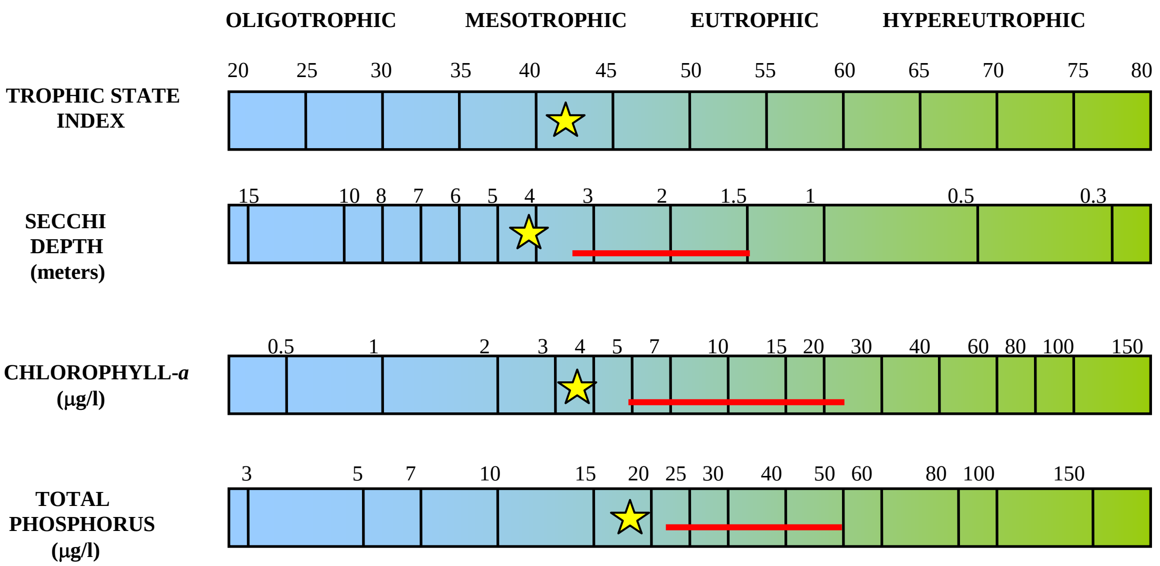
[2] DNR Web Site (www.dnr.state.mn.us)

[3] Based on approximately 700 assessed lakes in the North Central Hardwood Forests Ecoregion

[4] Chlorophyll-*a* measurements have been corrected for pheophytin.

Figure 2. Carlson's Trophic State Index, based on a scale of 0 – 100. (Carlson 1977)

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 bluegreen 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.



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

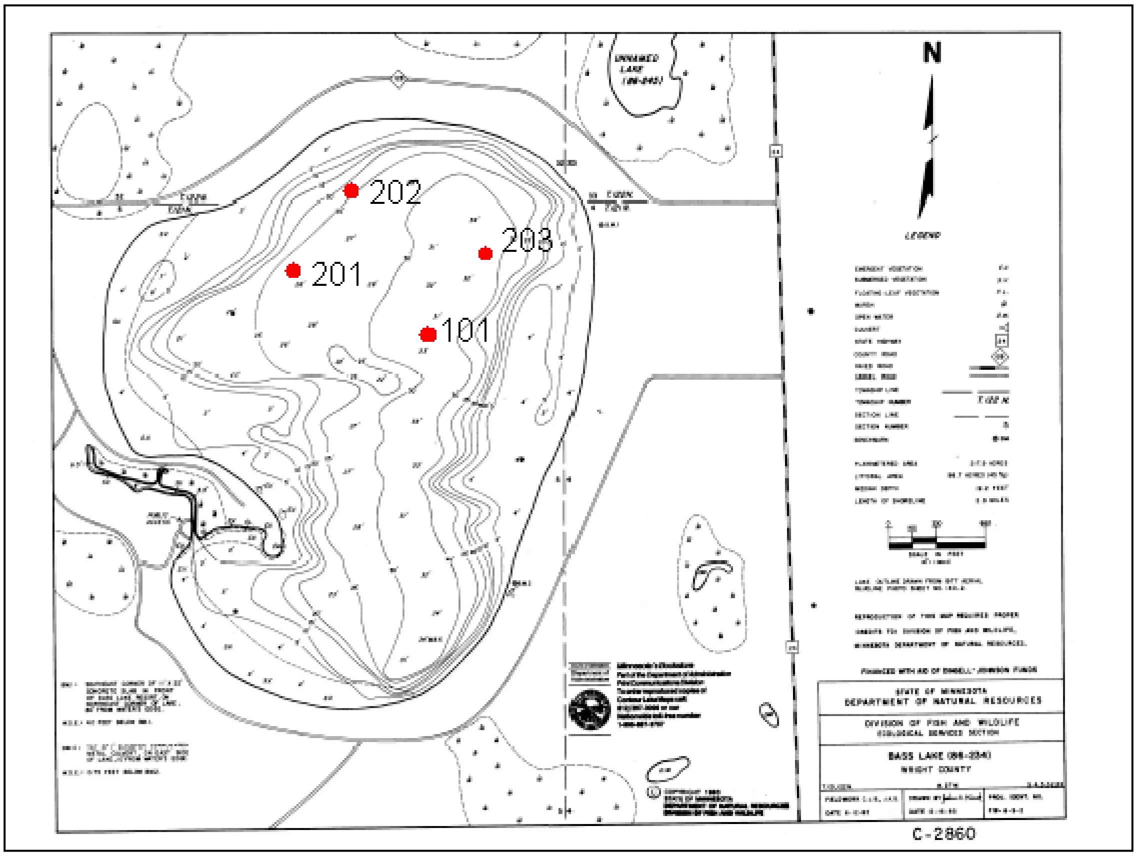
NCHF Ecoregion Range, 25th – 75th percentile: ▬▬▬▬ Bass Lake 2005: ☆

Bass Lake (86-0234)

Bass Lake is located approximately three miles north of Annandale, Minnesota. It is a moderate-sized lake with a surface area of 220 acres, maximum depth of 34 feet and mean depth of 17 feet. It is in the upper ten percent of lakes in terms of its size. Approximately 45 percent of the lake is littoral and there is one public access for the lake. It has a very small watershed, 0.7 mi^2; and as such, the watershed to lake ratio is also small at 2:1 (Table 1). Its water residence time is on the order of sixteen years.

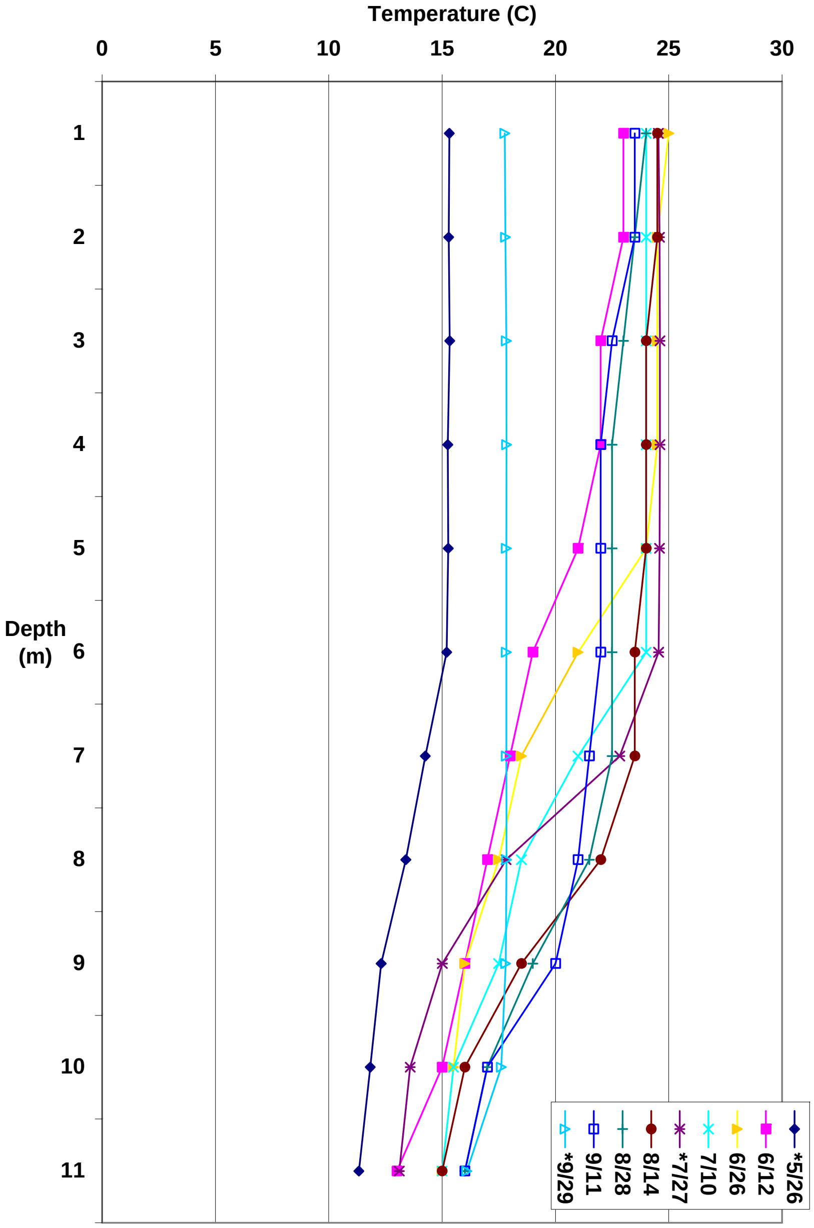
Water quality data was collected in June, July, August, and September, 2005 by volunteer lake monitor: Dan Ross. One site was used on Bass Lake: Site 101– located in the middle of the lake over the point of maximum depth (Figure 3).

Figure 3. Bass Lake Bathymetric Map and Monitoring Location



Temperature data indicated that the lake was well-mixed on the September sampling events and thermally stratified the other sampling events. The thermocline formed between 7 – 9 meters over most of the summer (Figure 4).

Figure 4. Bass Lake Temperature Profile at Site 101



Total phosphorus (TP) concentrations averaged 17.4 µg/L (micrograms per liter or parts per billion) in Bass Lake during the summer of 2005. This value is better than the range of concentrations for reference lakes in this ecoregion (Table 2). TP concentrations in 2005 ranged from 15 – 25 µg/L (Figure 5a) with increasing concentrations in late August and September, which were most likely due to the wind-mixing and lake turnover. This mixing would bring more nutrient-rich water into the upper layer of the lake. In general, TP concentrations were higher in 1999 as compared to 2005 (Figure 5b), with the exceptions of June and September. Both years followed a similar pattern of a slight increase in concentrations over the summer.

Chlorophyll-*a* concentrations for Bass Lake averaged 3.6 µg/L and were well below the ecoregion range (Table 2) in 2005. Concentrations on Bass Lake ranged from 2.1 – 6.5 µg/L with no mild (chl-*a* > 10 µg/L) or nuisance (chl-*a* > 20 µg/L) algae blooms (Figure 5a) during the summer of 2005. Chlorophyll-*a* concentrations, like the TP concentrations, increased slightly in late August and September as a result of wind-mixing and lake turnover. With the exception of May-2005, chlorophyll-*a* concentrations were higher in 1999 as compared to 2005 (Figure 5b). As with the TP concentrations, both years showed a slight increase in chlorophyll-*a* concentrations over the summer.

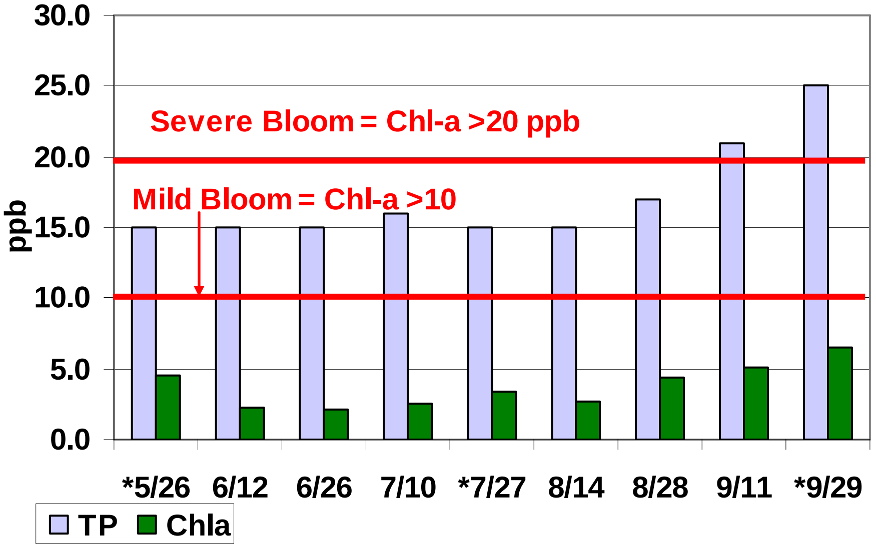


Figure 5a. Bass Lake Total Phosphorus & Chlorophyll-*a* Results for 2005

Figure 5b. Bass Lake Total Phosphorus & Chlorophyll-*a* Results for 1999 and 2005

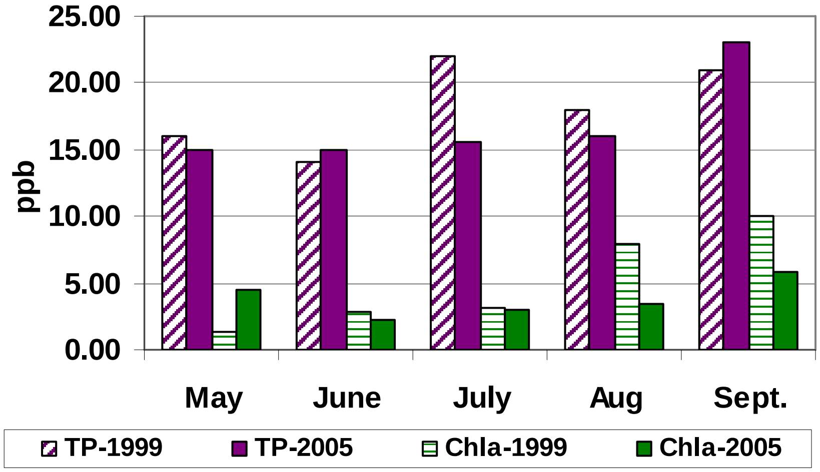
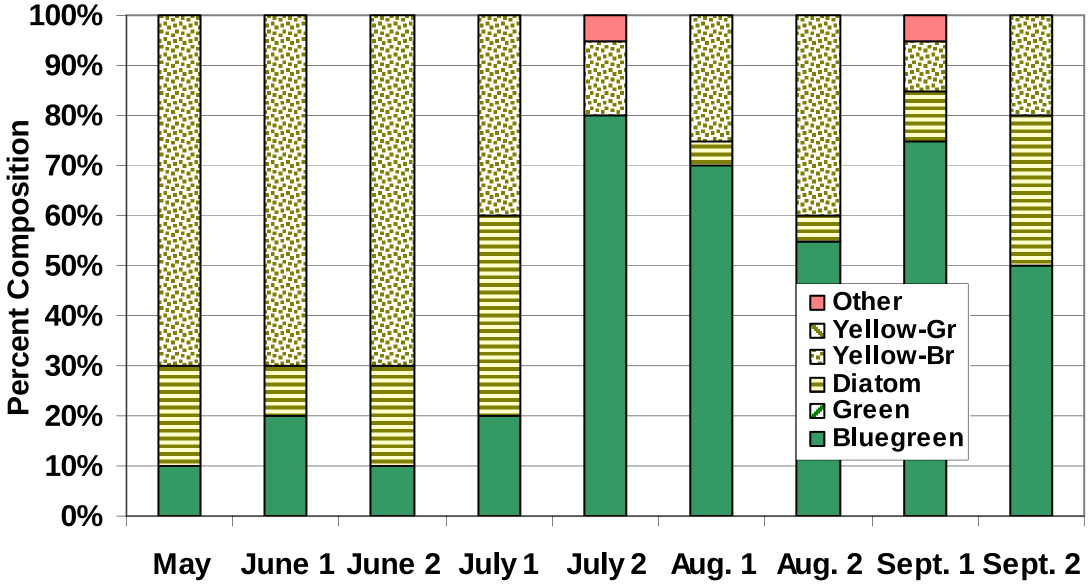
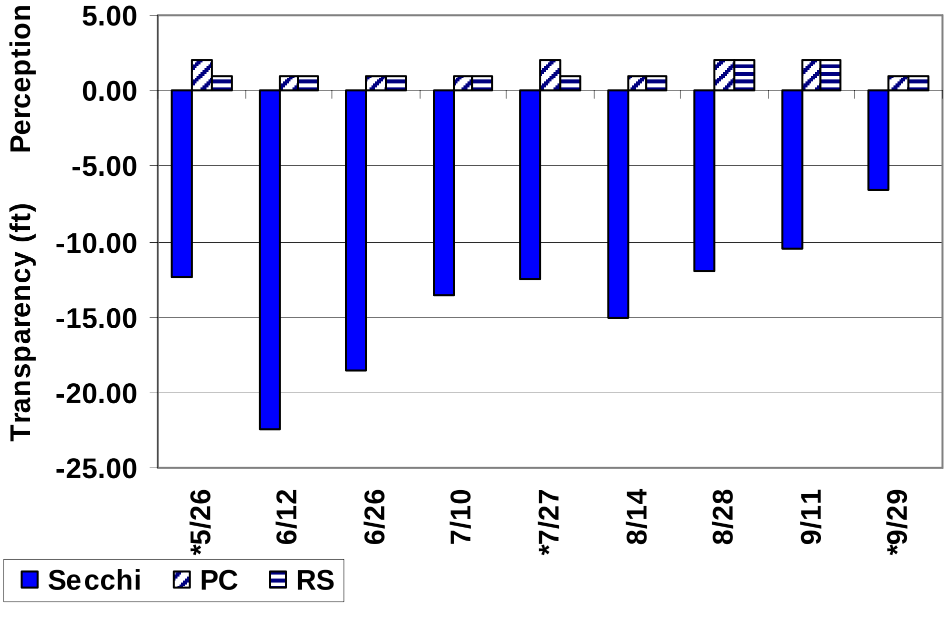


Figure 6. Bass Lake Algal Populations for 2005



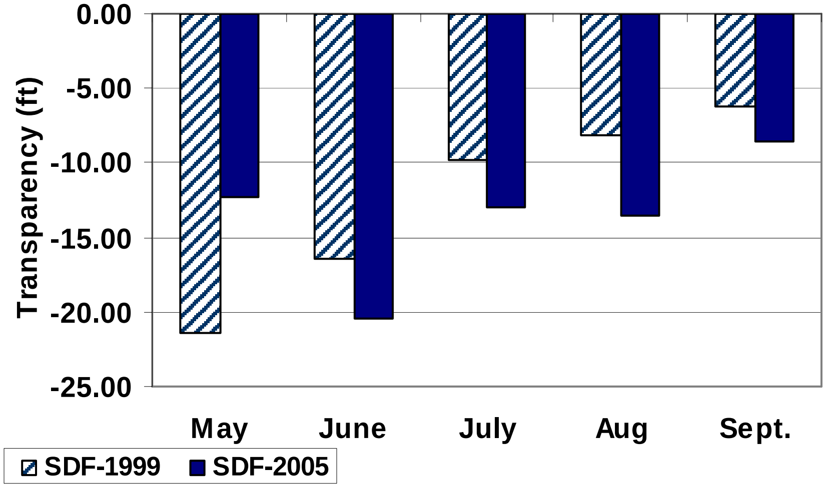
The composition of the phytoplankton (algae) population of Bass Lake is presented in Figure 6. Data are presented in terms of algal type. Samples were collected at Site 101. The yellow-browns and bluegreens were well represented throughout the summer, with bluegreen algae dominating the algae population from late-July through September. The forms *Dinobryon* (yellow-brown) and *Anacystis* (bluegreen) were the most common algae types found in 2005. A seasonal transition in algal types from diatoms to greens to bluegreen is more typical for mesotrophic and eutrophic lakes in Minnesota.

Figure 7a. Bass Lake Secchi Transparency for 2005



Secchi disk transparency on Bass Lake ranged from 6.6 feet (2.0 meters) in late September to 22.5 feet (6.9 meters) in early June (Figure 7) and averaged 13.9 feet (4.2 meters) in 2005. These transparency measures are better than the typical range for ecoregion reference lakes (Table 2). Transparency values generally decreased over the summer as concentrations for TP and chl-*a* increased. Along with transparency measurements, subjective measures of Bass Lake's "physical appearance" and "recreational suitability" were made. Lake conditions were characterized as "crystal clear" and "not quite crystal clear" (Classes 1 and 2) and "beautiful" and "minor aesthetic problems" (Classes 1 and 2) throughout the summer for Bass Lake. With the exception of May-2005, transparency values were higher (i.e. better) in 2005 as compared to 1999.

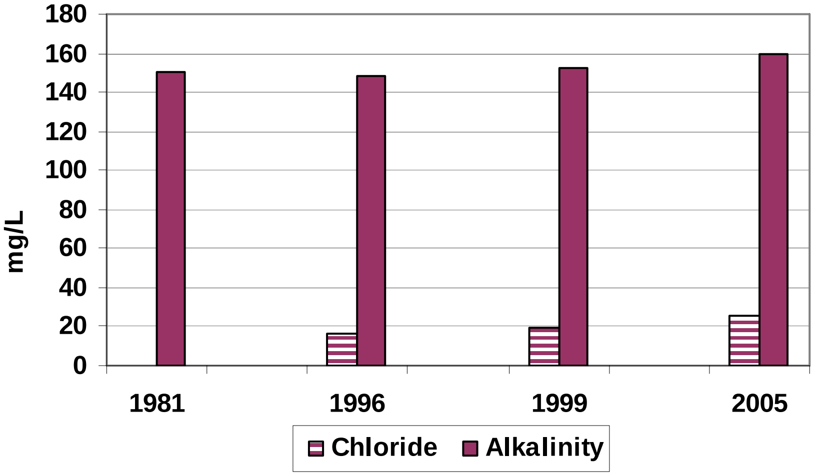
Figure 7b. Bass Lake Secchi Transparency for 1999 and 2005



Other parameters, such as total suspended solids and conductivity, analyzed for Bass Lake were all near or well within or better than the typical range of values for ecoregion reference lakes and results from 1999 (Table 1). The only exception was the parameter, chloride; which was significantly higher than the expected range and the 1999 average. This is likely due to road salt usage and stormwater runoff that enters the lake (Figure 8). The increase in chloride between 1999 and 2005 may be a reflection of increased salt usage and/or an increase in impervious surfaces around the lake.

Trophic State Index (TSI) values for Bass Lake compare very favorably to each other (Table 3); indicating *mesotrophic* conditions. As such, Secchi transparency should continue to be a good estimator for TP and chlorophyll-*a* values as well as an indicator of overall water quality for Bass Lake.

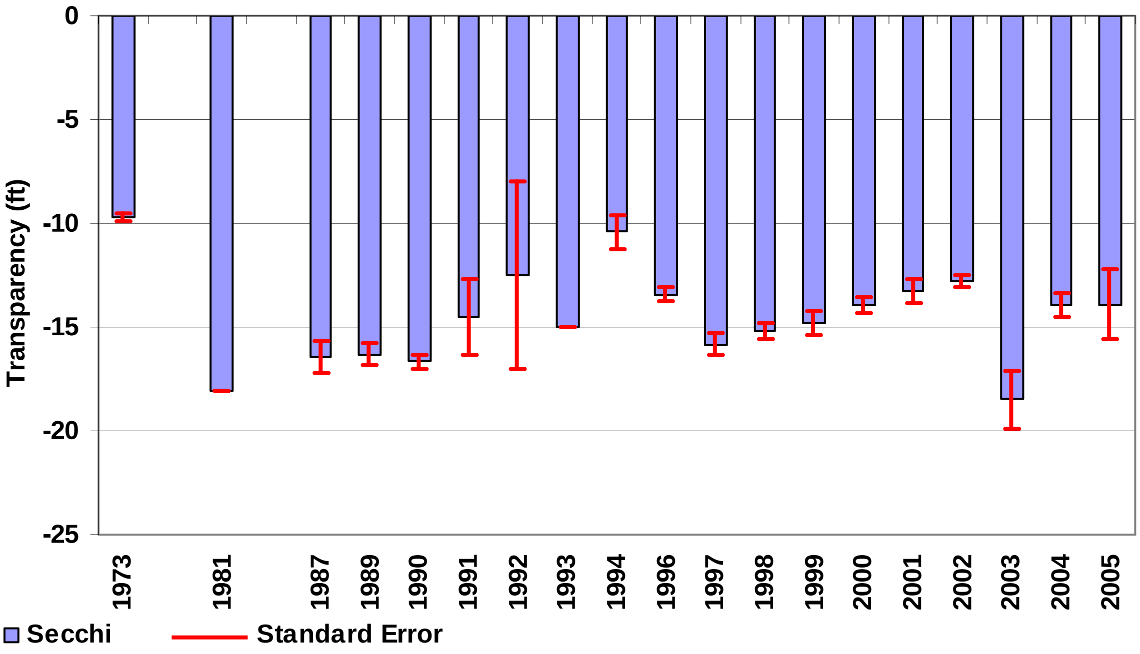
Figure 8. Bass Lake Chloride & Alkalinity for 1999 & 2005



Part 3. Water Quality Trends

All available Secchi transparency data from STORET (U.S. EPA's national water quality database) were used for this assessment. The majority of the data collected is from volunteer lake monitors in the MPCA's Citizen Lake-Monitoring Program. For our trend analysis, we ran Kendall statistical test using WQ Stat Plus^{TM} software. We used a probability (p) level of $p \leq 0.1$ as the basis for identifying a significant trend. At this p-level, there is a 10 percent chance of identifying a trend when it does not exist. Simply stated, the smaller the p-value, the stronger the trend (i.e. more likely a trend occurred). Summer-mean transparency in a lake varies from year to year due to climatic changes (precipitation, runoff, and temperature), nutrient and sediment loading, and biological factors. Understanding and quantifying the relative magnitude of this variability is essential to assessing trends. Based on a previous study (Heiskary and Lindbloom 1993), typical year-to-year Secchi transparency variability was found to be on the order of 1 – 2 feet. In general, annual transparency in Minnesota lakes fluctuates within about 20 percent of the long-term mean. Lakes with larger fluctuations or non-random fluctuations, relative to the long-term mean, often exhibit a trend. Figure 9 in this section contains a factor called standard error (Std. Error). Standard error is defined as the standard deviation of a dataset divided by the square root of the number of samples from that dataset. Standard error is a measure of variability within a dataset and provides a simple basis for comparing means. Simply stated, small standard error means minimal variability in Secchi measurements during a given summer, whereas a large standard error implies a high degree of variability.

Figure 9. Bass Lake Secchi Transparency



Bass Lake (86-0234)

A good historical data base is available for assessing trends in the transparency of Bass Lake. These data include 19 years of Secchi data but very limited water chemistry data. Individual summer-mean data and related statistics for each year may be found in Appendix I. The majority of the data was collected by citizen volunteers through the CLMP and monitoring conducted by the MPCA. Secchi transparency data date back to 1973. Based on 19 years of record, the long-term mean Secchi is 14.5 feet; however, four of these years have less than 4 readings, so they were not included in the trend analysis. Based on 15 years of Secchi data, no *statistically significant* change in Secchi transparency over time was noted; however, a fairly distinct decline in transparency was noted for the period from 1997 – 2002 (Figure 9). It is important to note that there is a significant break in the record between the years: 1973 – 1981 and 1981 – 1987. Data for these periods would help us improve our assessment of trends in Bass Lake. When data from 1973 was omitted from the trend analysis (because of the large record break), an overall decline in transparency was noted, but it was not *statistically significant*. Continued monitoring will allow us to discern whether this is a trend or simply a reflection of year-to-year variation. There is not enough TP or chlorophyll-*a* data at this time to perform trend analysis for Bass Lake.

Aquatic Vegetation Study – Contributed by Donna Perleberg, MN DNR

The aquatic plant community of Bass Lake (86-0234-00), Wright County, MN was surveyed in September 1999 and June 2005. The 2005 survey included more survey points and was GIS-based. Since the survey methods differed in each year, the results will not be compared directly.

In both years, rooted plants were common from shore to a depth of 20 feet and at least 90 percent of the samples sites in this zone contained vegetation. In 2005, plants were occasionally found to a depth of 22 feet.

A total of 22 aquatic plant species were located in Bass Lake during these surveys including three emergent, one floating-leaf and 18 submerged species. Bushy pondweed (*Najas* sp.) was the most common submerged plant species in both years. Muskgrass (*Chara* sp.), broadleaf and narrowleaf pondweeds (*Potamogeton* spp.), northern watermilfoil (*Myriophyllum sibiricum*) and coontail (*Ceratophyllum demersum*) were also common. Native submerged species were most often found in depths less than 16 feet.

The non-native submerged species, curly-leaf pondweed (*Potamogeton crispus*) was present in the lake during the September 1999 survey but since this species naturally dies back in early summer, it was difficult to estimate its actual occurrence in the lake. The June 2005 survey was conducted near the peak of curly-leaf pondweed’s growth. In 2005, curly-leaf occurred to a depth of 20 feet and was found in 16 percent of all sites sampled in the shore to 20 feet zone. It was most common in depths of 16 to 20 feet, where few native species occurred.

Part 4. Water Quality Modeling

The Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) computer model was used to predict the TP concentration of Bass Lake. These predictions are based on: lake area, mean depth, watershed area, and ecoregion in which the lake is located. Known information such as lake and watershed areas, and mean depth are inputs to the model; which in turn, computes a “predicted” TP value. The predicted TP value is used to predict a chlorophyll value, which in turn, is used to predict a Secchi value. The predicted values can then compared to the observed values (summer means) for each lake to determine if the lake’s condition is what would be expected – based on its size, depth and watershed area. The model has some limitations in that it cannot take into account groundwater influence and cannot account for TP-trapping or settling in large lakes that may be upstream of the lake being modeled.

A subroutine in the MINLEAP model provides an estimate of background TP concentration for each lake based on its mean depth and alkalinity. This estimate was derived from an equation developed by Vighi and Chiaudani (1985) and is based on the morphoedaphic index commonly used in fisheries science. This equation assumes that most of the phosphorus entering the lake arises from soil erosion in the watershed, and that phosphorus and other minerals, which contribute to alkalinity, are delivered in relatively constant proportions. In turn, the mean depth of the lake will moderate the in-lake phosphorus concentration (e.g. deep lakes settle material readily, which contributes to low phosphorus concentrations). This estimated "background" concentration helps place modern-day results and goal setting in perspective. Mean depth, volume and watershed area information was taken from the 1999 MPCA LAP report. A watershed map for the lake is included in the appendix.

Bass Lake

MINLEAP predicted a slightly higher, but not significantly different TP concentration than the 1999 and 2005 observed values for the lake (Table 4). As such, the MINLEAP predicted chlorophyll-*a* and Secchi transparency is slightly poorer than the 1999 and 2005 observed values. The Vighi-Chiaudani model predicted slightly, but not significantly, higher TP concentrations for the lake as compared to the 1999 and 2005 observed values (Table 4). TP-loading for Bass Lake is estimated to be on the order of 63 kg P/yr. *(Note: there are 2.2 pounds of phosphorus per kilogram.)* The TP-retention coefficient was estimated to be 0.90. This means that roughly 90 percent of the TP that enters Bass Lake stays in the lake. Overall, model predictions do compare favorably with observed results and suggest that based on the available data, the lake is near or better than background conditions and has not changed significantly since 1999.

Table 4. MINLEAP Model Outputs & Predictions

LAKE	TP (µg/L) Observed[1]	TP (µg/L) Predicted[2]	TP (µg/L) Vighi-Chiaudani	Chl-a (µg/L) Observed[1]	Chl-a (µg/L) Predicted[2]	Secchi (m) Observed[1]	Secchi (m) Predicted[2]
BASS 2005	**17.4 ± 1.3**	**23 ± 10**	**23**	**3.6 ± 0.6**	**6.5 ± 4.6**	**4.2 ± 0.5**	**2.6 ± 1.2**
BASS 1999	**19 ± 1.8**	**23 ± 10**	**23**	**6 ± 1.8**	**6.4 ± 4.6**	**3.1 ± 0.7**	**2.6 ± 1.2**

[1] **Observed Values reported as summer-mean ± standard error.**
[2] **Predicted Values based on the Total watershed.**

Part 5. Goal Setting

For Bass Lake, it would be desirable to maintain the currently low in-lake TP concentrations. The summer-mean P-concentration for Bass Lake was slightly below the predicted P-value and Vighi and Chiaudani "background" estimate. Based on Tables 5 and 6, the lake should be fully supporting for all designated uses. Continued efforts to protect this water body from any degradation are strongly recommended. Some important considerations for improving and protecting the water quality of the lake include implementation of BMP's in the shoreland area and ultimately through the watershed with a particular emphasis on the direct drainage area. A more comprehensive review of land use practices in the watershed may reveal opportunities for implementing BMPs in the watershed and reducing P-loading to the lake. Proper maintenance of buffers areas between lawns and the lakeshore, minimizing use of fertilizers, and minimizing the introduction of new significant sources of P-loading (e.g., stormwater from near-shore development activities in the watershed), will serve to minimize loading to the lake. Protection of the aquatic plant community in this lake is important for fish and wildlife habitat as well as the overall ecology of the lake. These and other considerations will be important if the water quality of this Wright County lake is to be maintained over the long term.

Table 5. Nutrient & Trophic Status Thresholds for Determination of Use Support for Lakes.

Ecoregion (TSI)	TP (ppb)	Chl (ppb)	Secchi (m)	TP Range (ppb)	TP (ppb)	Chl (ppb)	Secchi (m)
305(b):	**Full Support**			**Partial Support**	**Non-Support**		
303(d):	**Not Listed**			**Review**	**Listed**		
NCHF	**< 40**	**< 15**	**≥ 1.2**	**40 - 45**	**> 45**	**> 18**	**< 1.1**
(TSI)	(< 57)	(< 57)	(< 57)	(57 – 59)	(> 59)	(> 59)	(> 59)

Derived from MPCA Guidance Manual for Assessing Minnesota Surface Waters for Determination of Impairment (MPCA 2003). *TSI* = Carlson's Trophic State Index; *Chl-a* = Chlorophyll-*a*, includes both pheophytin-corrected and non-pheophytin-corrected values; *ppb* = parts per billion or µg/L; *m* = meters

Table 6. Draft Eutrophication Criteria by Ecoregion & Lake Type with 2005 Observed (Heiskary and Wilson, 2005)

Ecoregion	TP (ppb)	Chl-*a* (ppb)	Secchi (meters)
NCHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0

Lake: 2005 Observed (Ecoregion)	TP (ppb)	Chl-*a* (ppb)	Secchi (meters)
Bass (NCHF)	17.4	3.6	4.2

Part 6. Summary & Recommendations

During the summer of 2005, Bass Lake was sampled by CLMP volunteers as a part of a monitoring program, CLMP "Plus". This lake was selected because it is a priority in the county and had been exhibiting a trend in Secchi transparency in past years.

Following are a few general observations and recommendations based on our monitoring and data analysis:

A. Secchi transparency monitoring: Monitoring Secchi transparency provides a good basis for estimating trophic status and detecting trends. Routine participation is essential to allow for trend analysis. Continued CLMP monitoring of the lake will contribute to the database, which already exists and allow for future trend assessments.

B. Water quality and tropic status: Based on data collected in 2005, the lake exhibited TP and chlorophyll-*a* concentrations that were better than the typical range for minimally-impacted lakes in the NCHF ecoregion. Bass Lake would be considered *mesotrophic* in condition.

C. Water quality trends: No statistical improvement in transparency was found for Bass Lake; however, a slight decline from 1997 – 2002 was noted. There was not enough TP or chlorophyll-*a* data to allow trend analysis on these two parameters at this time. Continued monitoring of all of these lakes will enhance our ability to assess trends.

D. Model predictions: In general, observed TP was slightly but not significantly better than the predicted (MINLEAP) TP. As such, predicted chlorophyll-*a* and Secchi, were also slightly poorer than the 2005 observed values. Based on the model, Bass Lake is near or better than background conditions.

E. This lake has very good water quality and every effort to protect it from degradation should be taken. Further development or land use change in the watershed should occur in a manner that minimizes water quality impacts on the lake. In the shoreland areas, setback provisions should be strictly followed. MDNR and County shoreland regulations will be important in this regard.

- Stormwater regulations should be adhered to during and following any major construction/development activities in the watershed. Limiting the amount of impervious surfaces can have beneficial affects as well, in terms of reduced runoff and P-loading. Properly designed sedimentation ponds should be included in any development to minimize P-loading to the lakes. A "no-net-increase" in TP is recommended.
- Activities in the watershed that change drainage patterns, such as wetland removal or major alterations in lake use, should be discouraged unless they are carefully planned and adequately controlled. Restoring or improving wetlands in the watershed may also be beneficial for reducing the amount of nutrients or sediments that reach the lake. The U.S.

Fish and Wildlife Service at Fort Snelling may be able to provide technical and financial assistance for these activities.

- The lake association should continue to seek representation on boards or commissions that address land management activities so that their impact can be minimized. The booklet, Protecting Minnesota's Waters: The Land-Use Connection, may be a useful educational tool in this area.

F. Lakeshore property owners should be encouraged to maintain emergent and submergent vegetation in the near-shore areas and restore a percentage of their shoreline to “natural conditions”. The aquatic plant community of Bass Lake provides critical fish and wildlife habitat. Emergent plants such as bulrush and cattail serve to stabilize shorelines and, along with submersed plants, are essential to the ecology of the lake. Some specific recommendations for the Association include:

- Minimize the amount of aquatic plant control on Bass Lake.
- Implement a slow-no-wake motor use near shore, in the channel and other areas where plants grow on or near the water surface.
- Many shoreline areas of Bass Lake lack vegetation buffer zones and would benefit from vegetation re-establishment. Refraining from mowing a one or two foot strip next to the lake would help to accomplish this goal.

G. Curly-leaf pondweed (an exotic species) has been present in the lake since at least 1999. A 2005 plant survey found it present at 16 percent of all sites sampled, and was most common n depths of 16 – 20 feet; where few native species are found. Maintaining good water quality and a diverse population of native submerged plants should help keep curly-leaf from attaining nuisance levels. In contrast, removal of native species could allow for an increase in curly-leaf population.

H. On-site septic systems are a *potential* source of nutrients to lakes that are not sewered. While their influence may not be express in terms of dramatic increases in algae in the lake, they may be expressed by increased near-shore weed growth or excessive attached algae on docks and plants. A house-to-house septic system survey may help the individual lake associations and Wright County determine if homeowners are somewhat familiar with the age and maintenance (pumping) of their systems and if further education is needed on proper maintenance of their systems. This may also help them encourage all homeowners with non-code systems to bring their systems up to code. The lake associations may want to facilitate a lake-wide schedule for pumping systems.

I. An examination of land use practices in the watershed and identification of possible nutrient sources such as lawn fertilizer, the effects of ditching and draining of wetlands, and development practices etc., may aid the lake association in determining areas where best management practices may be needed. For example, recent studies indicated that a majority of lawns in the Twin Cities metro area do not need additional phosphorus – this may be true for lawns in Wright County as well. In April 2004, a new law came into effect restricting the use of phosphorus fertilizers in Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington Counties and set a three percent (by weight) limit outside the metro area. In

2005 this law was extended statewide. The lake associations, together with Wright County, should encourage the use of P-free fertilizers on lawns in the watershed. There may be other opportunities to implement/promote Best Management Practices (BMP's) that may reduce nutrient loading from other sources in the watershed as well.

Appendix

1. **Bass Lake Data for 2005 and Historic Data**

2. **Watershed Map for Bass Lake**

3. **Lake Level Data for Bass Lake**

4. **Status of the Fishery for Bass Lake**

Appendix 1. Bass Lake Data for 2005 and Historic Data

Bass Lake (86-0234) 2005 Water Quality Data & Temperature and Dissolved Oxygen Data

Date	Time	D	TP	Chl*a*	Pheo	SDF	PC	RS	TSS	TSV	COL	ALK	CL	TKN	pH	Cond
*5/26	9:30	0	15	4.5	< 0.3	12.3	2	1	2.4	1.2	10	170	25	0.6	8.5	448
*5/26	9:30	9	30													
6/12	13:40	0	15 Q	2.3	0.3	22.5	1	1								
6/26	15:15	0	15	2.1	0.4	18.5	1	1								
7/10	14:20	0	16	2.6	0.3	13.5	1	1								
*7/27	10:15	0	15	3.4	0.7	12.5	2	1	2.4	2.4	5	160	27	0.6	8.7	280
*7/27	10:15	9	36													
8/14	14:15	0	15	2.6	0.3	15.0	1	1								
8/28	11:30	0	17	4.4	0.3	12.0	2	2								
9/11	12:30	0	21	5.2	0.7	10.5	2	2								
*9/29	10:15	0	25	6.5	1.8	6.6	1	1	3.2	2.0	10	150	26	0.6	8.1	326
*9/29	10:15	9	27													

D = Depth of Sample in feet
TP = Total Phosphorus in parts per billion
Chl*a* = Chlorophyll-*a* in parts per billion
Pheo = Pheophytin in parts per billion
SDF = Secchi Transparency in feet
RMK = Remark Codes for parameters *(Q = sample held past holding time, K=less than the detection limit)*

PC = Physical condition
RS = Recreational Suitability
TSS = Total Suspended Solids in mg/L
TSV = Total Suspended Volatile Solids in mg/L
COL = Color in Pt-Co units

Alk = Alkalinity in mg/L
CL = Chloride in mg/L
TKN = Total Kjeldahl Nitrogen in mg/L
pH = pH of sample in SU
Cond = Conductivity in umhos/cm

Temperature (°C)

Depth (m)	*5/26	6/12	6/26	7/10	*7/27	8/14	8/28	9/11	*9/29
0	15.32	23	25	24	24.54	24.5	24	23.5	17.77
1	15.29	23	24.5	24	24.59	24.5	23.5	23.5	17.8
2	15.34	22	24.5	24	24.61	24	23	22.5	17.83
3	15.25	22	24.5	24	24.61	24	22.5	22	17.84
4	15.27	21	24	24	24.59	24	22.5	22	17.83
5	15.2	19	21	24	24.55	23.5	22.5	22	17.83
6	14.26	18	18.5	21	22.84	23.5	22.5	21.5	17.83
7	13.4	17	17.5	18.5	17.82	22	21.5	21	17.84
8	12.31	16	16	17.5	15.01	18.5	19	20	17.81
9	11.83	15	15.5	15.5	13.59	16	17	17	17.61

Dissolved Oxygen (mg/L)

Depth (m)	*5/26	*7/27	*9/29
0	12.72	7.82	9.09
1	12.28	7.68	8.15
2	11.74	7.68	7.68
3	11.36	7.61	7.64
4	11.23	7.58	7.53
5	11.31	7.56	7.44
6	11.35	4.43	7.49
7	10.2	0.86	7.42
8	9.1	0.3	7.52
9	7.98	0.25	7.18

10	11.33	13	15	15	13.11	15	16	16	16.09		10	6.84	0.23	3.12

Bass Lake (86-0234) Historic Water Quality Data

Year	TP	SEP	NP	Chl-*a*	SEC	NC	SDF	SES	NS
1973							9.72	0.2	18
1981	48		1	2.4		1	18.04		1
1987							16.42	0.77	6
1989							16.33	0.54	6
1990							16.67	0.33	3
1991							14.5	1.85	4
1992							12.5	4.5	2
1993							15		1
1994							10.43	0.79	4
1996	14	1.08	4	4.22	0.7	4	13.42	0.31	9
1997							15.82	0.53	14
1998							15.19	0.38	13
1999	18.75	1.8	4	6	1.78	4	14.81	0.57	22
2000							13.94	0.38	19
2001							13.25	0.59	12
2002							12.78	0.3	9
2003							18.5	1.37	12
2004							13.94	0.6	10
2005	17.4	1.3	8	3.6	0.6	8	13.9	1.7	8

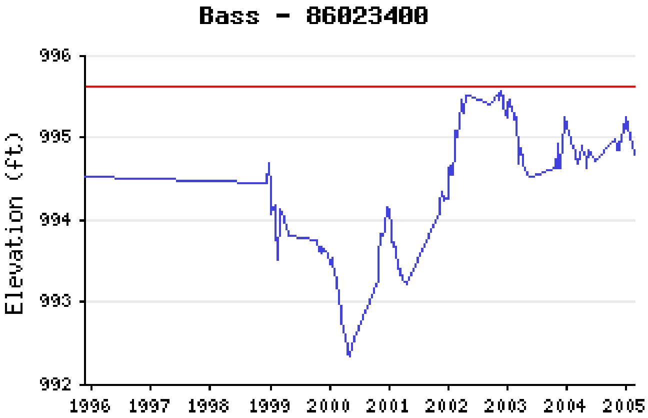
Year = Year Monitored
TP = Total Phosphorus in parts per billion
SEP = Standard Error for TP
NP = # TP samples/yr
Chl-*a* = Chlorophyll-*a* in parts per billion
SEC = Standard Error for Chl-*a*
NC = # Chl-*a* samples/yr
SDF = Secchi Transparency in feet
SES = Standard Error for SDF
NS = # Secchi Readings/yr

Appendix 2. Watershed Map for Bass Lake

Appendix 3. Lake Level Data for Bass Lake
From MN DNR web site: http://www.dnr.state.mn.us/lakefind/index.html

Water Level Data

Period of record: 01/01/1951 to 08/08/2005
# of readings: 216
Highest recorded: 995.6 ft (11/02/1983)
Highest known: 995.7 ft (1983?)
Lowest recorded: 991 ft (01/01/1951)
Recorded range: 4.6 ft
Average water level: 994.34 ft
Last reading: 994.79 ft (08/08/2005)
OHW elevation: 995.6 ft
Datum: 1929 (ft)



Appendix 4. Status of the Fishery for Bass Lake
Excerpts from DNR web site www.dnr.state.mn.us
For a complete report, please visit the MDNR web site

Bass Lake Status of the Fishery (as of 07/10/1995):

The most abundant species in Bass Lake are northern pike, largemouth bass and bluegill. Considerable information exists on these species from test nettings done in 1981, 1987, 1992 and 1995. In addition a great deal has been learned about the fishery from creel surveys conducted in 1994 and 1995. Walleye were not abundant in the netting. In the past seven years walleye fingerlings have been stocked twice (1989 and 1993). With the high number of northern pike and low number of perch walleye fingerling stockings have a lower probability of success.

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GLOSSARY

Alkalinity: Capacity of a lake to neutralize acid.

Chloride: Common anionic form of chlorine which carries one net negative charge. A common anion in many waters.

Chlorophyll a: The main pigment in algae. It is used to measure aquatic productivity.

Ecoregion: Areas of relative homogeneity based on land use, soils, topography and potential natural vegetation.

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.

Eutrophic: Describes a lake of high photosynthetic productivity. Nutrient rich.

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.

Littoral Area: The shallow areas around a lake's shoreline, dominated by aquatic plants.

Mesotrophic: Describes a lake of moderate photosynthetic productivity.

Metalimnion: The middle layer of lake water during the summer months.

Nitrite/Nitrate Nitrogen: The weight of concentration of the nitrogen in the nitrate ion.

Oligotrophic: Describes a lake of low photosynthetic productivity.

Phosphate: An essential nutrient containing phosphorus and oxygen. Phosphate is often a critical nutrient in lake eutrophication management.

Phosphorus: Phosphorus is an element that can be found in commercial products such as foods, detergents, and fertilizers as well as in larger amounts naturally in organic materials, soils, and rocks. Phosphorus is one of many essential plant nutrients. Phosphorus forms are continually recycling throughout the aquatic environment. All forms are measured under the term "Total Phosphorus" in parts per billion (ppb).

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

Secchi Disk: A metal plate used for measuring the depth of light penetration in water.

Suspended Solids: Small particles that hang in the water column and create turbid, or cloudy conditions.

Total Maximum Daily Load (TMDL): This process determines why waters are impaired, the amount by which pollution must be reduced to meet water-quality standards and determines allocations (limits) for all contributing sources plus future growth.

Thermocline: During summertime, the middle layer of lake water. Lying below the epilimnion, this water rapidly loses warmth. Zone of maximum change in temperature over the depth interval.

Trophic Status: The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration.

Turnover (Overturn): Warming or cooling surface waters, activated by wind action, mix with lower, deeper layers of water.

Watershed: Geographical area that supplies water to a stream, lake, or river.

Zooplankton: Microscopic animals.