COOPERATIVE LAKES MONITORING PROGRAM

Michigan's Citizen Volunteer Partnership for Lakes

"MI Lakes - Ours to Protect"

ANNUAL SUMMARY REPORT

2005

Michigan's Citizen Volunteers
Michigan Lake & Stream Associations, Inc.
Michigan Department of Environmental Quality
Fisheries and Wildlife Department – Michigan State University
Great Lakes Commission

Michigan Clean Water Corps

Michigan's Lakes and the Tragedy of the Commons

In 1968, Garrett Hardin published his classic environmental essay *The Tragedy of the Commons* in the journal of *Science*. In it he succinctly depicted the degradation and exploitation of the environment to be expected whenever many individuals share a common resource, such as federal rangeland, state and national parks, the atmosphere, streams and lakes. Using a community pasture as an example, he explained how each herder added more and more animals to his herd until the pasture was destroyed by overgrazing. Each herder benefited monetarily by adding animals to his herd, but bore no responsibility for the pasture and its sustainability.

While Hardin popularized the tragedy of the commons, others before him identified the characteristic fate of common property. In fact, two thousand years ago, Aristotle in his book *Politics* stated, "what is common to the greatest number has the least care bestowed upon it. Everyone thinks chiefly of his own, hardly at all of the common interest". Lakes and streams are clearly a common property, shared by the riparian property owners and the community of citizens who use and enjoy the water, fish, wildlife and aesthetic appeal.

True to the tragedy of the commons, most lakes provide countless hours of recreational enjoyment for numerous users. Some receive waste discharges from municipal and industrial sources. Nearly all are impacted by urban and agricultural development and stormwater runoff, septic systems and lawn fertilizers, increasing weed growth, algae blooms and muck accumulation. Very few are managed to sustain their quality for future generations. With over 11,000 lakes in Michigan, limited state agency staff can provide only partial oversight and must concentrate on the most serious problems. Local government although possessing management tools like Lake Improvement Boards and Watershed Councils address police and fire protection, schools, infrastructure development, and waste management as higher priorities. Riparian property owners who should be the leading advocates for lake protection and promoting collaborative management partnerships are more interested in recreational activities such as swimming, fishing and boating.

Unfortunately most lakes are fulfilling Hardin's principle of the tragedy of the commons. Only a few exceptional communities are proof that the principle is not an irrefutable law of human society. When communities accept ownership in their natural resources, lakes and streams can be sustainable commons not only in quantity but quality. The more each lake owner and user invests in this responsibility the more certain our children will be, that they will “inherit our water resources in the same quality that we the present generation borrowed it from them”. Working together we can protect Michigan’s lakes.

Cooperative Lakes Monitoring Program

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DATA CORRECTIONS FROM PREVIOUS REPORTS

In the 2004 Annual Report the following posting errors were identified and the following corrections made:

- **In Appendix 3, page 1 of 5, Baldwin Lake is in Montcalm County not Montmorency County**
- **In Appendix 3, page 2 of 5, Derby Lake is in Montcalm County not Montmorency County**
- **In Appendix 3, page 3 of 5, the May, June and July chlorophyll results listed under Long Lake, Gr. Traverse County should have been listed under Long Lake, Montmorency County. With the four sampling events the data for Long Lake, Montmorency County becomes <1.0 ug/l for the mean and median with a standard deviation of 0.0 and a Carlson TSI-CHL of <31.**
- **Long Lake, Gr. Traverse County should have a May reading of 3.6 ug/l, a June reading of 1.9 ug/l and a July reading of 2.4 ug/l to go with the two readings of <1.0 for August and 1.7 for September as reported in the 2004 Report. With all five samples the data for Long Lake, Gr. Traverse County becomes mean 2.0 ug/l, median 1.9 ug/l, standard deviation 1.1 and Carlson TSI-CHL 37.**

In the 2004 Annual Report a text error was identified and the following correction made:

- **In Appendix 4, page 7 of 7, Hess Lake in Newaygo County is identified as a "mesotrophic" lake. The sentence should state that Hess Lake is a "eutrophic" lake.**

If you believe that the tabulated data for your lake in this Report are in error please contact Ralph Bednarz, CLMP program coordinator by telephone at 517-335-4211 or email at bednarzr@michigan.gov. It is important for the credibility of the CLMP that all data be accurately reported. When tabulation and reporting errors are found they need to be identified and a correction statement issued. We appreciate your support in the review of CLMP data and maintaining a high level of quality for the Program.

INTRODUCTION

Michigan's unique geographical location provides its citizens with a wealth of freshwater resources including over 11,000 inland lakes. In addition to being valuable ecological resources, lakes provide aesthetic and recreational value for the people of Michigan and neighboring states. An ideal Michigan summer pastime is going to a cottage on an inland lake to fish, water-ski, swim, and relax.

As more and more people use the lakes and surrounding watersheds, the potential for pollution problems and use impairment increases dramatically. Although many of Michigan's inland lakes have a capacity to accommodate the burden of human activities in the short term, continuing stress on the lakes and lake watersheds over time will ultimately lead to adverse water quality and recreational impacts.

Reliable information including water quality data, levels of use, and use impairment are essential for determining the health of a lake and for developing a management plan to protect the lake. As the users and primary beneficiaries of Michigan's lake resources, citizens must take an active role in obtaining this information and managing their lakes.

Michigan's abundant water resources...

...include over 11,000 inland lakes.

To meet this need, the Department of Environmental Quality's (DEQ) Water Bureau and Michigan Lake and Stream Associations, Inc. (ML&SA) have partnered to implement the Cooperative Lakes Monitoring Program (CLMP). The purpose of this effort is to help citizen volunteers monitor indicators of water quality in their lake and document changes in lake quality. The CLMP provides sampling methods, training, workshops, technical support, quality control, and laboratory assistance to the volunteer monitors. Michigan State University's Department of Fisheries and Wildlife supports the partnership with technical assistance.

THE SELF-HELP LEGACY

Originally known as the Self-Help Program, the CLMP continues a long tradition of citizen volunteer monitoring. Michigan has maintained a volunteer lake monitoring program since 1974, making it the second oldest volunteer monitoring program for lakes in the nation. The original program monitored water quality by measuring water clarity with a Secchi disk.

In 1992, the DEQ (then the Department of Natural Resources) and the ML&SA entered into a cooperative agreement to expand the program. An advanced Self-Help program was initiated that included a monitoring component for the plant nutrient phosphorus. In 1994, a side-by-side sampling component was added to the program to assure the quality of the data being collected.

The CLMP continues the "self-help" legacy by providing citizens an opportunity to learn and participate in lake management. Currently, the CLMP supports monitoring components for Secchi disk transparency, total phosphorus, chlorophyll *a*, dissolved oxygen/temperature and aquatic plants.

The CLMP is a cost-effective process for the DEQ to increase the baseline data available for Michigan's lakes as well as establish a continuous data record for determining water quality trends. Therefore the DEQ/citizen volunteer partnership is critical to lake management in Michigan.

CLMP Contacts

- Michigan Lake and Stream Associations, Inc.
  P.O. Box 249
  Three Rivers, MI 49093
  Telephone: 269-273-8200
  http://www.mlswa.org

- Michigan Department of Environmental Quality
  Water Bureau
  P.O. Box 30273
  Lansing, MI 48909-7773
  Telephone: 517-335-4211
  http://www.michigan.gov/deq

- Michigan Clean Water Corps
  c/o Great Lakes Commission
  2805 South Industrial Hwy.
  Suite 100
  Ann Arbor, MI 48104-6791
  Telephone: 734-971-9135
  http:// www.micorps.net

CLMP and MiCorps

The CLMP is also a principal program within the Michigan Clean Water Corps (MiCorps), a network of volunteer monitoring programs in Michigan. It was created through an executive order by Governor Granholm to assist the DEQ in collecting and sharing water quality data for use in management programs and to foster water resource stewardship. MiCorps provides volunteer monitoring programs with many services including:

- Training programs,
- A web site-*www.micorps.net,*
- A data exchange network,
- A listserv,
- An annual conference, and
- A monitor's newsletter.

The mission of MiCorps is to network with and to support and expand volunteer water quality monitoring organizations across the state. To learn more about MiCorps visit their web site (www.micorps.net).

Michigan Clean Water Corps

LAKE QUALITY

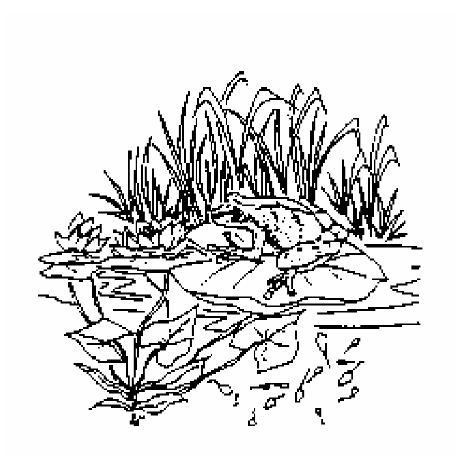
A lake's condition is influenced by many factors, such as the amount of recreational use it receives, shoreline development, and water quality. Lake *water quality* is a general term covering many aspects of chemistry and biology. The health of a lake is determined by its water quality.

CLMP Goals

- Provide baseline information and document trends in water quality for individual lakes.
- Educate lake residents, users, and interested citizens in the collection of water quality data, lake ecology, and lake management practices.
- Build a constituency of citizens to practice sound lake management at the local level and to build public support for lake quality protection.
- Provide a cost-effective process for the DEQ to increase baseline data for lakes state-wide.

CLMP Measurements

- Secchi disk transparency
- spring total phosphorus
- summer total phosphorus
- chlorophyll *a*
- dissolved oxygen and temperature



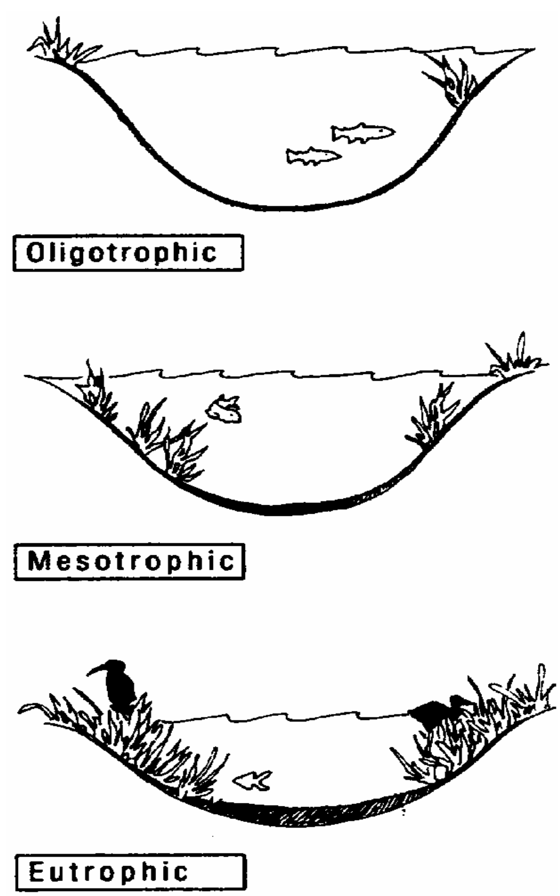
Increasing lake productivity can impact water quality and result in problems such as excessive weed growth, algal blooms, and mucky bottom sediments. *Productivity* refers to the amount of plant and animal life that can be produced within the lake.

Plant *nutrients* are a major factor that cause increased productivity in lakes. In Michigan, *phosphorus* is the nutrient most responsible for increasing lake productivity.

The CLMP is designed to specifically monitor changes in lake productivity. The current program enlists citizen volunteers to monitor water clarity, the algal plant pigment chlorophyll *a* and dissolved oxygen throughout the summer months and total phosphorus is measured during the spring and late summer. These parameters are indicators of primary productivity and, if measured over many years, may document changes in the lake.

CLASSIFYING LAKES

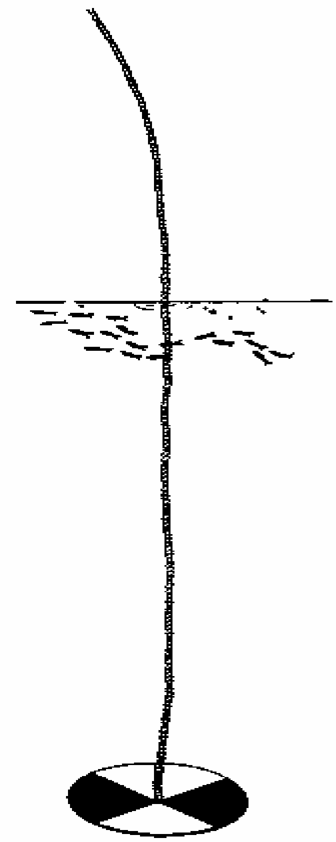
A lake's ability to support plant and animal life defines its level of productivity, or *trophic state*. Lakes are commonly classified based on their productivity. Low productive *oligotrophic* lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient *dissolved oxygen* in the cool, deep-bottom waters during late summer to support cold water fish, such as trout and whitefish. By contrast, high productive *eutrophic* lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish, such as bass and pike. Lakes that fall between these two classifications are called *mesotrophic* lakes. Lakes that exhibit extremely high productivity, such as nuisance algae and weed growth are called *hypereutrophic* lakes.



(Source: Hamlin Lake Improvement Board)

EUTROPHICATION

The gradual increase of lake productivity from oligotrophy to eutrophy is called lake aging or *eutrophication*. Lake eutrophication is a natural process resulting from the gradual accumulation of nutrients, increased productivity, and a slow filling in of the lake basin with accumulated sediments, silt, and muck. Human activities can greatly speed up this process by dramatically increasing nutrient, soil, or organic matter input to the lake. This human influenced, accelerated lake aging process is known as *cultural eutrophication*. A primary objective of most lake management plans is to slow down cultural eutrophication by reducing the input of nutrients and sediments to the lake from the surrounding land.



MEASURING EUTROPHICATION

Measuring a lake's water quality and eutrophication is not an easy task. Lakes are a complex ecosystem made up of physical, chemical, and biological components in a constant state of action and interaction.

As on land, plant growth in lakes is not constant throughout the summer. Some species mature early in the season, die back, and are replaced by other species in a regular succession.

While overall population levels often reach a maximum in mid-summer, this pattern is influenced or altered by numerous factors, such as temperature, rainfall, and aquatic animals. For the same reasons lakes are different from week to week, lake water quality can fluctuate from year to year.

Given these factors, observers of lake water quality must train themselves to recognize the difference between short-term, normal fluctuations and long-term changes in lake productivity (eutrophication). Many years of reliable data collected on a consistent and regular basis are required to separate true long-term changes in lake productivity from seasonal and annual fluctuations.

Important Measures of Eutrophication

Nutrients are the leading cause of eutrophication. Nitrogen and *phosphorus* both stimulate plant growth. Both are measured from samples of water and reported in units of ug/l (micrograms per liter), or ppb (parts per billion). *Phosphorus* is the most important nutrient, and is often used directly as a measure of eutrophication.

Plants are the primary users of nutrients. *Chlorophyll a* is a component of the cells of most plants, and can be used to measure the concentration of small plants in the water, such as algae. *Chlorophyll a* is measured from samples of water and reported in units of ug/l. Macrophytes are aquatic plants with stems and leaves. The location of different species of plants can be mapped, and the density can be measured in pounds of plants per acre of lake.

Transparency or the clarity of water is measured using a device known as a *Secchi disk*. This is an eight inch diameter target painted black and white in alternate quadrants. The disk is attached to a marked line, or measuring tape, and lowered from a boat into the lake. The distance into the water column the disk can be seen is the transparency, measured in feet or meters. A short distance of visibility means that there are suspended particles or algae cells in the water, an indication of nutrient enrichment.

Dissolved Oxygen (DO) which is oxygen dissolved in the water, is necessary to sustain fish populations. Fish, such as trout, require more DO than warm water species. Eutrophic lakes occasionally have levels of DO below the minimum for fish to survive, and fish kills can result.

Sediments can be measured to determine how fast material is depositing on the bottom. This may indicate watershed erosion, or a large die-off of aquatic plants.

Fish can be sampled using nets. In an oligotrophic lake there are likely to be cold water species, such as trout. A sample of warm water fish, such as sunfish, bass, bullheads, and carp is more typical of a eutrophic lake.

Temperature affects the growth of plants, the release of nutrients, and the mixing of layers of water in the lake. Temperature measurements can determine if mixing occurs, moving nutrients from the lake bottom up into the surface waters promoting algae blooms.

LAKE PRODUCTIVITY INDEX

The general lake classification scheme described is convenient, but somewhat misleading in that it places all lakes into a few distinct trophic categories. In reality, lake water quality is a continuum pro gressing from very good to very poor conditions. A more precise method of describing the productivity of a lake is to use a numerical index which can be calculated directly from water quality data. A variety of indexes are available with Carlson's (1977) *Trophic State Index*, or TSI, being the most widely used.

Carlson's TSI was developed to compare lake data on water clarity, as measured by a Secchi disk, chlorophyll *a,* and total phosphorus. These parameters are good indirect measures of a lake's productivity. The TSI expresses lake productivity on a continuous numerical scale from 0 to 100, with increasing numbers indicating more eutrophic conditions. The zero point on the TSI scale was set to correlate with a Secchi transparency of 64 meters (210 feet).

Carlson developed mathematical relationships for calculating the TSI from measurements of Secchi depth transparency, chlorophyll *a*, and total phosphorus in lakes during the summer season. The computed TSI values for an individual lake can be used to compare with other lakes, to

Carlson's TSI Equations

$$TSI_{SD} = 60 - 33.2 \log_{10} SD$$

$$TSI_{TP} = 4.2 + 33.2 \log_{10} TP$$

$$TSI_{CHL} = 30.6 + 22.6 \log_{10} CHL$$

where,
SD = Secchi depth transparency (m)
TP = total phosphorus concentration (ug/l)
CHL = chlorophyll *a* concentration (ug/l)

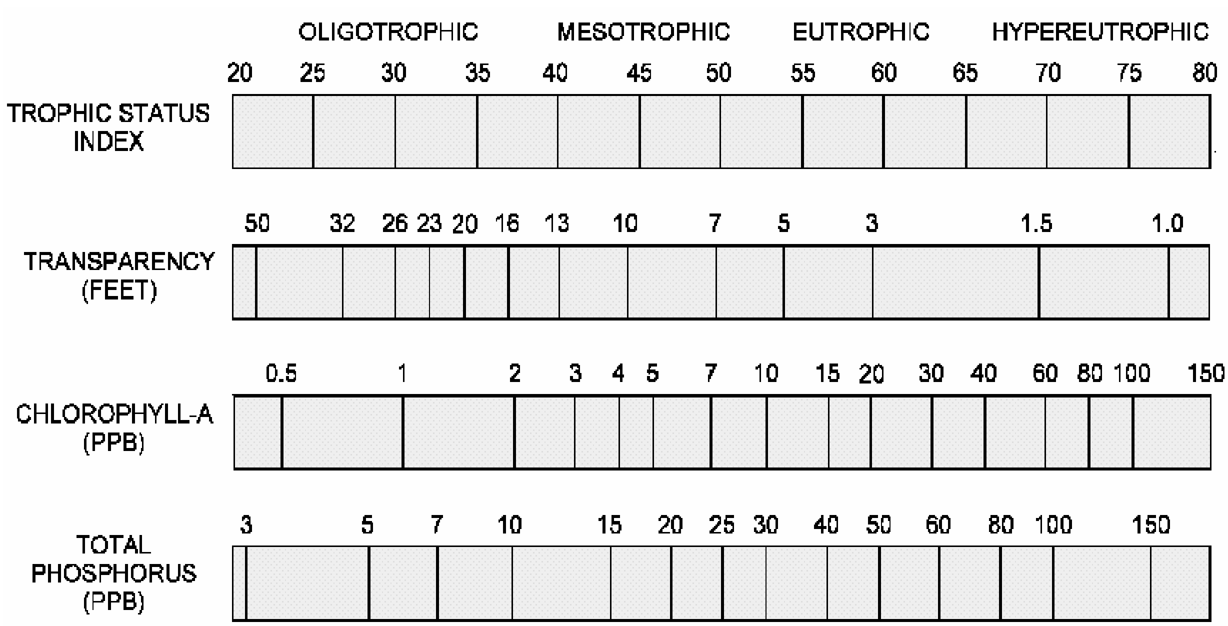
evaluate changes within the lake over time, and to estimate other water quality parameters within the lake.

For those preferring to use the general lake classification scheme, the TSI values which correspond approximately with the trophic state terms are illustrated in the figure below. However, the dividing lines between these categories are somewhat arbitrary since lake water quality is a continuum and there is no broad agreement among lake scientists as to the precise point of change between each of these classifications. For many lakes in Michigan, Carlson's TSI equations can be used to roughly predict values of one variable from measurements of another in the surface water of the lake during the summer season as shown in the figure below.

Lake scientists have also developed relationships to predict summer productivity indicators from water quality variables measured during lake turnover in the spring. One such relationship was developed by Dillon and Rigler (1974) which predicts mean (average) summer chlorophyll *a* from spring phosphorus measurements.

These relationships must be used carefully when predicting water quality variables and productivity.

CARLSON'S TROPHIC STATE INDEX



(Source: Minnesota Pollution Control Agency)

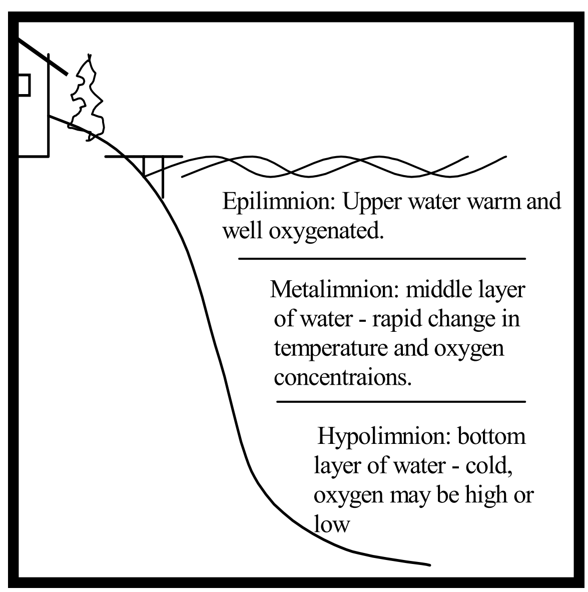
OTHER MEASURES OF LAKE PRODUCTIVITY

Dissolved Oxygen (DO) and Temperature

Dissolved oxygen and temperature are two fundamental measurements of lake productivity. The amount of dissolved oxygen in the water is an important indicator of overall lake health.

For approximately two weeks in the spring and fall, the typical lake is entirely mixed from top to bottom, with all the water in the lake being 4 degrees Celsius. In the winter there is only a few degrees difference between the water under the ice (0 degrees Celsius) and the water on the bottom (4 degrees Celcius). However, in the summer most lakes with sufficient depth (greater than 30 feet) are stratified into three distinct layers of different temperatures. These layers are referred to as the epilimnion (warm surface waters) and hypolimnion (cold bottom waters) which are separated by the metalimnion, or thermocline layer, a stratum of rapidly changing temperature. The physical and chemical changes within these layers influence the cycling of nutrients and other elements within the lake.

During summer stratification the thermocline prevents dissolved oxygen produced by plant photosynthesis in the warm waters of the well-lit epilimnion from reaching the cold dark hypolimnion waters. The hypolimnion only has the dissolved oxygen it acquired during the short two-week spring overturn. This finite oxygen supply is gradually used by the bacteria in the water to decompose the dead plant and animal organic matter that rains down into the hypolimnion from the epilimnion, where it is produced. With no opportunity for re-supply the dissolved oxygen in the hypolimnion waters is gradually exhausted. The greater the supply of organic matter from the epilimnion and the smaller the volume of water in the hypolimnion the more rapid the oxygen depletion in the hypolimnion. Highly productive eutrophic lakes with small hypolimnetic volumes can lose their dissolved oxygen in a mater of a few weeks after spring overturn ends and summer stratification begins. Conversely, low productive oligotrophic lakes with large hypolimnetic volumes can retain high oxygen levels all summer.



This figure shows how lakes over 25 feet deep are divided into three layers during the summer.

When a lake's hypolimnion dissolved oxygen supply is depleted, significant changes occur in the lake. Fish species like trout and whitefish that require cold water and high dissolved oxygen levels are not able to survive. With no dissolved oxygen in the water the chemistry of the bottom sediments are changed resulting in the release of the plant nutrient phosphorus into the water from the sediments. As a result the phosphorus concentrations in the hypolimnion of productive eutrophic and hypereutrophic lakes can reach extremely high levels. During major summer storms or at fall overturn, this phosphorus can be mixed into the surface waters to produce nuisance algae blooms.

Some eutrophic lakes of moderate depth (25 to 45 feet deep) can stratify, lose its hypolimnion dissolved oxygen and then destratify with each summer storm. So much phosphorus can be brought to the surface water from these temporary stratifications and destratifications that the primary source of phosphorus for the lake is not the watershed but the lake itself in the form of internal loading or recycling.

Besides the typical lake stratification pattern just described, it is now known that some Michigan lakes may not follow this pattern. Small lakes with significant depth, and situated in hilly terrain or protected from strong wind forces, may not completely circulate during spring overturn every year. Additionally, some lakes deep enough to stratify will not, if they have a long fetch oriented to the prevailing wind or are influenced by major incoming river currents. Finally, lakes with significant groundwater inflow may have low dissolved oxygen concentrations due to the influence of the groundwater instead of the lake's productivity and biological decomposition.

The dissolved oxygen and temperature regime of a lake is important to know in order to develop appropriate management plans. A lake's oxygen and temperature patterns not only influence the physical and chemical qualities of a lake but the sources and quantities of phosphorus, as well as the types of fish and animal populations.

Aquatic Plant Mapping

A major component of the plant kingdom in lakes are the large, leafy, rooted plants. Compared to the microscopic algae the rooted plants are large. Sometimes they are collectively called the "macrophytes". "Macro" meaning large and "phyte" meaning plant. It is these macrophytes that some people sometimes complain about and refer to as lake weeds.

Far from being weeds macrophytes or rooted aquatic plants are a natural and essential part of the lake, just as grasses, shrubs and trees are a natural part of the land. Their roots are a fabric for holding sediments in place, reducing erosion and maintaining bottom stability. They provide habitat for fish, including structure for food organisms, nursery areas, foraging and predator avoidance. Waterfowl, shore birds and aquatic mammals use plants to forage on and within, and as nesting materials and cover.

Though plants are important to the lake, overabundant plants can negatively affect fish populations, fishing and the recreational activities of property owners. Rooted plant populations increase in abundance as nutrient concentrations increase in the lake. As lakes become more eutrophic rooted plant populations increase. They are rarely a problem in oligotrophic lakes, only occasionally a problem in mesotrophic lakes, sometimes a problem in eutrophic lakes and often a problem in hypereutrophic lakes.

In certain eutrophic and hypereutrophic lakes with abundant rooted plants it may be advantageous to manage the lake and its aquatic plants for the maximum benefit of all users. To be able to do this effectively it is necessary to know the plant species present in the lake and their relative abundance and location. A map of the lake showing the plant population locations and densities greatly aids management projects.

CLMP PROJECT RESULTS

Secchi Disk Transparency

Citizen volunteers measure Secchi disk transparency from late spring to the end of the summer. Ideally, 18 weekly measurements are made from mid-May through mid-September. As a minimum, eight equally spaced measurements from the end of May to the beginning of September are accepted to provide a good summer transparency mean (average) for the lake. Frequent transparency measurements are necessary throughout the growing season since algal species composition in lakes can change significantly during the spring and summer months, which can dramatically affect overall water clarity.

A summary of the transparency data collected by the lake volunteers during 2005 is included in Appendix 1. The number of measurements, or readings, made between mid-May and mid-September and the minimum and maximum Secchi disk transparency values are included for each lake that participated in the program. For those lakes with eight or more evenly spaced readings over this time period, the mean, median, standard deviation, and Carlson TSI_{SD} values were calculated and listed.

The mean, or average, is simply the sum of the measurements divided by the number of measurements. The median is the middle value when the set of measurements is ordered from lowest to highest value. The standard deviation is a common statistical determination of the dispersion, or variability, in a set of data.

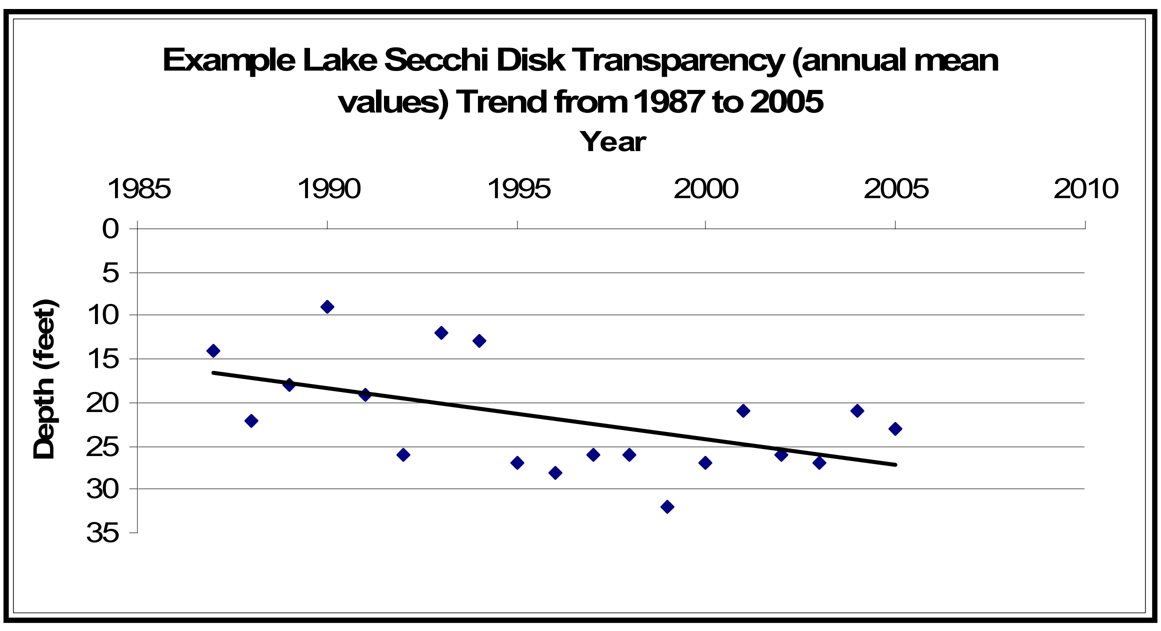
The data range and standard deviation gives an indication of seasonal variability in transparency in the lake. Lakes with highly variable Secchi disk readings need to be sampled frequently to provide a representative mean summer transparency value. Few measurements and inconsistent sampling periods for these lakes will result in unreliable data for annual comparisons.

The TSI_{SD} values were calculated using Carlson's equations (see page 7) and the mean summer transparency values. (Note: the mean transparency value is converted from feet to meters for the TSI_{SD} calculation) The graphical relationship (see page 8) can be used to relate the TSI_{SD} value to the general trophic status classification for the lake (i.e., oligotrophic, mesotrophic, eutrophic) as well as to provide a rough estimate of summer chlorophyll *a* and total phosphorus levels in the lake. If the transparency measurements are made properly and consistently year after year, the Secchi disk transparency annual means or TSI_{SD} values can be compared to evaluate changes, or trends, in trophic status of the lake over time, see the figure below.

During 2005, Secchi disk transparency data were reported for 199 lakes (240 basins). Over 3400 transparency measurements were reported, ranging from 0.5 to 58 feet. For the lakes with eight or more equally spaced readings between mid-May and mid-September, the overall mean, or average, Secchi disk transparency was 13.5 feet. the median value was 11.5 feet. The Carlson TSISD values ranged from 23 to 65 for these lakes with a mean value of 41. A Carlson TSI value of 41 is generally indicative of a good quality mesotrophic lake (see page 8).

Total Phosphorus

Phosphorus is one of several essential nutrients that algae need to grow and reproduce. For most lakes in Michigan, phosphorus is the most important nutrient, the limiting factor, for algae growth. The total amount of phosphorus in the water is typically used to predict the level of pro-



ductivity in a lake. An increase in phosphorus over time is a measure of nutrient enrichment in a lake.

The CLMP volunteers monitor for total phosphorus during spring overturn, when the lake is generally well mixed from top to bottom, and during late summer, when the lake is at maximum temperature stratification from the surface to the bottom. Spring overturn is an opportune time of the year to sample just the surface of a lake to obtain a representative sample for estimating the total amount of phosphorus in the lake. A surface sample collected during late summer represents only the upper water layer of the lake, the epilimnion, where most algal productivity occurs. The late summer total phosphorus results, along with the Secchi disk transparency and chlorophyll measurements, are used to determine the trophic status of the lake. The spring overturn total phosphorus data, collected year after year, are useful for evaluating nutrient enrichment in the lake.

Total phosphorus results for the 2005 CLMP are included in Appendix 2. The spring total phosphorus data are listed first, followed by the late summer data. The TSI_{TP} values were calculated using Carlson's equations (see page 7) and the late summer total phosphorus data. Results from replicate and side-by-side sampling are also provided. Approximately 10 percent of the replicate samples collected by the volunteers were analyzed as part of the data quality control process for the CLMP. Also, the DEQ participated in side-by-side sampling on approximately 10 percent of the enrolled lakes.

During 2005, samples for total phosphorus measurements were collected on 199 lakes. The spring overturn total phosphorus results ranged from <5 to 97 ug/l with a mean (average) of 14 ug/l and a median value of 11 ug/l. The late summer total phosphorus results ranged from <5 to 470 ug/l with 15 ug/l as the mean (13 ug/l mean without 470 ug/l outlier) and 11 ug/l as the median. The Carlson TSI_{TP} values ranged from <27 to 93 (61 without 470 ug/l outlier) for these lakes with a mean value of 40 (39 without 470 ug/l outlier) . A Carlson TSI value of 40 is generally indicative of a good quality mesotrophic lake (see page 8).

For the spring overturn sampling, 170 total phosphorus samples were turned in from 198 lakes registered in the program, for a participation rate of 86 percent. For the late summer sampling period 190 samples were received from 206 lakes for a participation rate of 92 percent. Only one sample turned in was not processed because of quality control issues.

Chlorophyll *a*

Chlorophyll is the green photosynthetic pigment in the cells of plants. The amount of algae in a lake can be estimated by measuring the chlorophyll *a* concentration in the water. As an algal productivity indicator, chlorophyll *a* is often used to determine the trophic status of a lake.

Chlorophyll monitoring was added to the CLMP in 1998. Volunteers were asked to collect and process five sets of chlorophyll *a* samples, one set per month from May through September. For purposes of calculating TSI values only those lakes that had data for at least four of the five sampling events were used. During 2005 volunteers collected a minimum of four samples on 99 lakes.

Results from the chlorophyll monitoring for 2005 are included in Appendix 3. Results for each monthly sampling event are listed as well as the mean, median, and standard deviation of the monthly data for each lake. The TSI_{CHL} values were calculated using Carlson's equations (see page 7) and the median summer chlorophyll values. Results from the replicate and side-by-side sampling are also provided. Side-by-side and replicate samples were collected and analyzed for about one-third of the lakes. About 560 chlorophyll samples were collected and processed in 2005. The chlorophyll *a* levels ranged from <1 to 61 ug/l over the five-month sampling period. The overall mean (average) was 5.3 ug/l and the median was 3.7 ug/l. The Carlson TSI_{CHL} values ranged from <31 to 58 with a mean value of 43. A Carlson TSI value of 43 is generally indicative of a mesotrophic lake (see page 8).

During 2005, a total of 121 lakes registered for chlorophyll sampling. A total of 114 lakes participated minimally by turning in at least one sample, for a minimum participation rate of 94 percent. A total of 99 lakes turning in at least four samples for a complete participation rate of 82 percent. Twenty-two samples were turned in, but not processed because of quality control issues for a 4 percent quality control rejection rate.

TSI Comparisons

The TSI_{CHL}, TSI_{SD}, and TSI_{TP} values for the individual lakes can be compared to provide useful information about the factors controlling the overall trophic status in these lakes (Carlson and Simpson, 1996). For lakes where phosphorus is the limiting factor for algae growth, all three TSI values should be nearly equal. However, this may not always be the case. For example, the TSI_{SD} may be significantly larger than the TSI_{TP} and TSI_{CHL} values for lakes that precipitate calcium carbonate, or marl, during the summer. The marl particles in the water column would scatter light and reduce transparency in these lakes, which would increase the TSI_{SD}. Also, phosphorus may adsorb to the marl and become unavailable for algae growth, which would reduce the TSI_{CHL}. For lakes where zooplankton grazing or some factor other than phosphorus limits algal biomass, the TSI_{TP} may be significantly larger than the TSI_{SD} and TSI_{CHL}.

Dissolved Oxygen and Temperature

Temperature and dissolved oxygen are typically measured as surface-to-bottom profiles over the deep part of the lake. Temperature is usually measured with a thermometer or an electronic meter called a themistor. Dissolved oxygen is either measured with an electronic meter or by a chemical test. The CLMP uses an electronic meter (YSI 95D) designed to measure both temperature, with a themistor, and dissolved oxygen. The meter is calibrated by the volunteer monitor before each sampling event. Dissolved oxygen and temperature are measured from the surface to within 3 feet of the bottom, as a profile, in the deepest basin of the lake. Measurements are taken at 5-foot intervals in the upper part of the water column. Through the mid-depth region or thermocline (15 to 45 feet), measurements are taken at 2½ foot intervals. Below the thermocline, measurements are usually made every 5 feet. Measurements are made every two weeks from mid-May to mid-September in the same deep basin location.

During 2005, CLMP participants in the dissolved oxygen/temperature project sampled 41 lakes. A total of 355 dissolved oxygen/temperature profiles were recorded. The lakes involved in the project are identified in Appendix 4. The results of the sampling are highly varied depending upon the size, depth, volume and productivity of the lake sampled. Because of these highly varied results and the amount of individual data collected, each lake's results are not included in this report. Each participating lake community will receive individual data graphs for their lake. Instead of individual results, representative oxygen and temperature patterns are illustrated in Appendix 4. For the most part, data collected on lakes participating in the 2005 project are used to present these representative patterns. Volunteer monitors may compare the results from their lake with the patterns illustrated in Appendix 4.

While it is not possible to illustrate every conceivable temperature and dissolved oxygen scheme that may develop in a lake, five common summer patters are presented in Appendix 4. These five patterns include: an oligotrophic lake with a very large volume hypolimnion, an oligotrophic/mesotrophic lake with a large volume hypolimnion, an oligotrophic/mesotrophic lake with a small hypolimnion, a eutrophic lake with a small hypolimnion, and a eutrophic lake which weakly stratifies during the summer. A sixth pattern not represented is the very shallow lake, with a maximum depth of less than 15 feet. These lakes usually have the same temperature and dissolved oxygen concentrations from surface-to-bottom as a result of frequent mixing.

Aquatic Plant Mapping

To create the volunteer's aquatic plant map and data sheets, sampling transects are identified on each lake.

AQUATIC PLANT SAMPLING RAKE

Cut the handles off of two garden rakes and bolt the rakes back to back with two "C" bolts. Use a small hose clamp between the rake tines to prevent side to side slipping. Drill a hole in the remaining wooden handle core and twist into the hole a moderately large eye bolt. The rope should be about 20 feet long. File off any sharp edges. Wear gloves when using the rake to protect the hands from cuts.

Along each transect, plant samples are collected at the one, four and eight foot depths with a constructed sampling rake. The rake is tossed out into the lake and retrieved from the four compass directions. The density of each plant species is determined by its presence on one, two, three or all four of the rake tosses. The data from all the transects are calculated to create the plant distribution map and data sheet. A complete description of sampling procedures is provided in Wandell and Wolfson, 2000.

During 2003, an evaluation of the aquatic plant monitoring project was made and presented in the CLMP 2003 Report, Appendix 5. The results of this study of volunteer aquatic plant survey methods suggested that:

- Citizen volunteers are capable of conducting good qualitative aquatic plant surveys, if properly trained and provided limited professional assistance, and
- Volunteer survey methods compare reasonably well with DEQ methods to qualify aquatic plant species, densities and distributions in a lake.

The results warranted continuing aquatic plant monitoring as a component of the CLMP.

During 2005, CLMP participants in the aquatic plant project sampled two lakes for aquatic plants. The community at Glen Lake employed their modified plant sampling program to address the specific concern for exotic species introduction to the lake. Their monitoring would allow for early detection and rapid response to any introduced exotic aquatic plant. The community at Wells Lake, Osceola County did the standard plant survey.

In 2005, Wells Lake had TSI values of 35 for Secchi disk, 41 for Total Phosphorus and 40 for Chlorophyll. These values would suggest that the lake is oligotrophic/mesotrophic. Given this trophic state or productive level the lake should have a limited aquatic plant population. Indeed except for fern pondweed all plant species had limited distribution and low densities. (See the results of the Wells Lake survey in Appendix 5)

The volunteer monitors for Wells Lake believe that fern pondweed may be new to the lake. No one at the lake remembers seeing the plant until a few years ago. It appeared near a boat launching ramp and quickly spread throughout the lake.

If this observation is true and if this native plant follows a typical new colonization pattern, it should fairly quickly become a normal part of the plant community and its populations may decline.

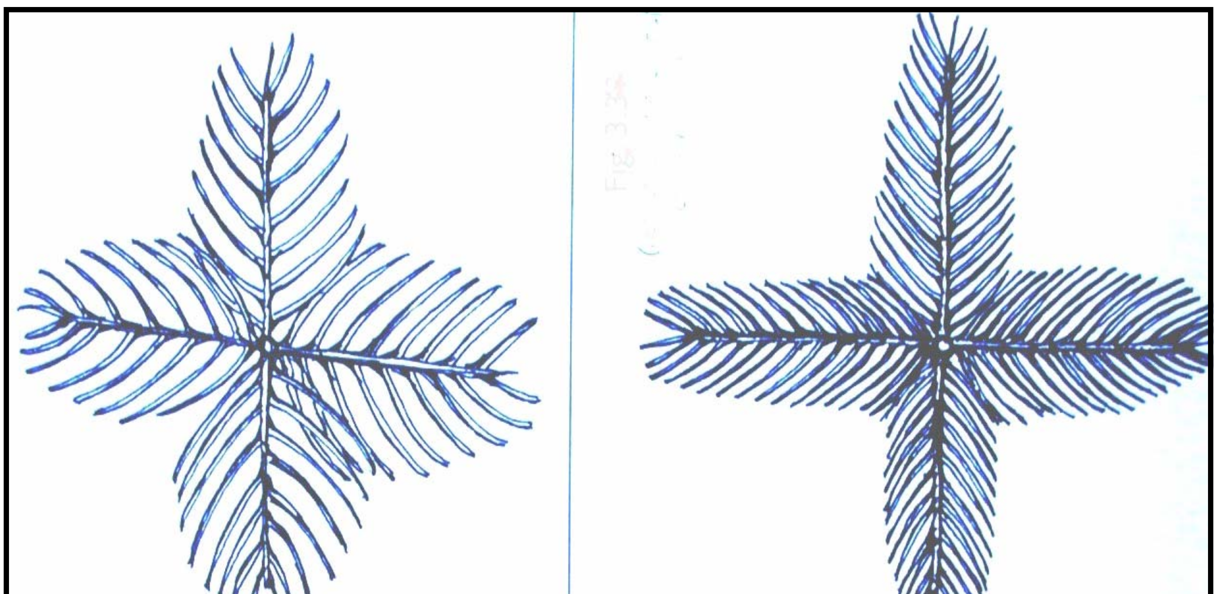
The Wells Lake survey found no exotic plant species. The lake does have an access site and the west end of the lake does have extensive shallow areas with water less than 15 feet deep. These conditions could make the lake susceptible to infestation and nuisance populations of aggressive exotic species.

CONCLUSION

Data from the CLMP provide citizens with basic information on their lakes that can be used as indicators of the lake's productivity. If measured over many years, these data may be useful in documenting changes and trends in water quality. More importantly these data will assist the local community with the management of their lake. Michigan's lakes are high quality resources that should be protected from nutrient and sediment inputs to keep them as the special places we use and enjoy. To do this, each lake should have its own management plan.

Although CLMP data provide very useful water quality information, for certain management programs it may be necessary to assemble more specific data or information on a lake's condition. The DEQ and the ML&SA may be able to help you obtain additional information on your lake.

The figures below represent stem cross sections at a leaf node for both native and Eurasian milfoils. Note that Eurasian milfoil has more leaflets on each leaf than native milfoils. Eurasian milfoil generally has more than twelve leaflets on one side of the leaf's central axis, while native milfoils have less than twelve.



Native milfoil | Eurasian milfoil

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A PROFILE OF HOW
A COMMUNITY HAS USED CLMP DATA TO PROTECT THEIR LAKE

Glen Lake/Crystal River Watershed, Leelanau County
Glen Lake Association's Protection Efforts to Preserve Our High Quality Waters

A principal focus of the Glen Lake Association over the past years has been to work to preserve our precious resource. Periodic water quality monitoring by professional, governmental, and conservancy testers, while very helpful, has not been sustained and does not closely track trends over time. Therefore, the Glen Lake area landowners, have assumed responsibility for protection of our lakes. The Association has been monitoring water transparency in Big and Little Glen Lakes since 1979. Phosphorus and chlorophyll have been monitored since 2001, and since 2002 we have been performing aquatic plant surveys, all as part of the CLMP program. In 2001 and 2002 we participated in the Dissolved Oxygen/Temperature profile measurement program, which led us to acquire a Hydrolab™ to enable us to expand our water quality testing into other lakes and streams in our watershed. Monitoring, performed by volunteer Glen Lake Association members, has an added advantage of educating landowners how they can be better stewards of their valued resource.

Our close attention to water transparency, phosphorus, and chlorophyll values, is a powerful tool for us to communicate with landowners about the tropic state of the lakes. A recent jump in the late summer phosphorus levels in Glen Lake has us concerned and motivated us to relate to watershed landowners, especially riparians, the need to employ best practices for control of nutrient inflow into our waters. We have employed a lake biologist to work with homeowners where our cladophora shoreline survey indicates high level nutrient inflow. Armed with CLMP phosphorus data and results of our shoreline survey, he helps identify causes and suggests changes where warranted.

Aquatic Plant Mapping under the CLMP program is used in a variety of ways to protect Big and Little Glen Lakes. In 2002, the first year of the study, we established a baseline of plant data. Once collected, each species was identified, quantified, given a GPS location, press dried, mounted, and photographed. In subsequent years we have only collected new species found. We have increased the number of sampling sites, and concentrated on the search for exotic plants. We want to make sure Eurasian watermilfoil, hydrilla, and other exotics have not invaded our waters. We use our mounted samples and digital photographs of the plants for riparian and watershed landowner education in many ways. Our aquatic plant studies are a focus at our annual meeting presentations, Glen Lake Association newsletter articles, and PowerPoint talks at local clubs and associations.

Plant studies and our water quality data are used very effectively to communicate to our membership a rationale for keeping phosphorus, nitrogen, and chlorophyll levels in control. These CLMP data are also very useful for preparation of grant requests, our shoreline restoration efforts, and the operation of the Glen Lake Association annual invasive species boat inspection/power spray/ education operation at our DNR watercraft launch site.

Through our CLMP training and lake testing activities Glen Lake Association volunteers have gained the experience, direction, and confidence to put our data to work. CLMP has been an effective enabler in the development of our protection/prevention programs for maintaining the high water quality we all love and enjoy.

By Mike and Sarah Litch, Co-chairs
Water Quality Committee
Glen Lake Association

Do you have a success story of how your community has used the CLMP data to implement a protection program for your lake? We would like to hear from you. Mr. Ralph Bednarz Telephone: 517-335-4211 or bednarzr@michigan.gov

ACKNOWLEDGMENTS

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Thank you to the dedicated volunteers who have made the CLMP one of the nations most successful citizen volunteer lakes monitoring programs. Also a special thank you to Ralph Vogel for constructing the Secchi disks for the CLMP, to Jean Roth for handling numerous administrative tasks, and to Brian Carley, Bruce Bonnell and volunteer samplers who compiled data.

APPENDIXES

Appendix 1

2005 Secchi Disk Transparency Results

Appendix 2

2005 Total Phosphorus Results

Appendix 3

2005 Chlorophyll Results

Appendix 4

2005 Dissolved Oxygen and Temperature Participating Lakes and Example Results

Appendix 5

2005 Aquatic Plant Mapping Participating Lakes and Example Results

APPENDIX 1
2005 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	TSI_{SD} (transparency)
Ann	Benzie	16	12.0	29.0	19.1	16.0	6.04	35
Arbutus 1	Gr. Traverse	18	8.0	13.0	10.8	11.5	1.73	43
Arbutus 2	Gr. Traverse	18	11.0	32.0	17.2	14.0	6.87	36
Arbutus 3	Gr. Traverse	18	10.0	29.0	15.7	12.5	6.05	37
Arbutus 4	Gr. Traverse	18	9.0	27.0	14.5	11.0	5.87	39
Arbutus 5	Gr. Traverse	18	9.0	20.0	12.2	10.5	3.52	41
Arnold	Clare	15	13.0	30.0	19.7	17.0	4.97	34
Avalon	Montmorency	18	18.0	47.0	31.3	30.0	10.20	27
Baldwin	Montcalm	18	7.0	13.5	11.2	11.7	1.74	42
Baldwin 1	Cass	8	8.3	12.5	9.8	9.4	1.60	44
Baldwin 2	Cass	8	8.0	14.0	10.2	9.3	2.13	44
Baldwin 3	Cass	8	6.8	13.0	10.5	10.4	2.20	43
Baldwin 4	Cass	8	7.0	12.3	10.0	9.9	1.94	44
Barlow	Barry	15	7.5	18.0	12.3	12.5	3.07	41
Bass	Kalkaska	3	13.5	21.2				
Bear	Manistee	17	8.0	10.5	9.4	9.5	0.76	45
Bear 1	Kalkaska	18	31.0	50.0	42.1	46.0	7.38	23
Bear 2	Kalkaska	18	31.0	50.0	42.2	46.5	7.52	23
Beatons 1	Gogebic	8	12.0	18.0	15.0	15.8	2.09	38
Beatons 2	Gogebic	8	15.5	20.3	17.8	17.8	1.74	36
Beatons 3	Gogebic	8	14.3	19.5	16.6	16.3	1.49	37
Beatons 4	Gogebic	8	15.5	19.5	17.3	17.0	1.25	36
Beaver	Alpena	18	11.7	23.0	16.2	16.7	3.09	37
Bellaire	Antrim	18	9.0	21.0	14.2	12.0	4.05	39
Big	Osceola	16	21.0	32.0	24.3	24.0	2.62	31
Big Blue	Kalkaska	16	18.0	31.0	24.3	24.4	3.43	31
Big Bradford	Otsego	10	13.5	22.0	16.9	15.5	3.23	36
Big Platte	Benzie	18	8.0	21.0	12.6	12.0	3.75	41
Big Star	Lake	15	9.5	12.5	10.8	10.3	1.01	43
Big Twin	Kalkaska	18	15.0	29.0	21.9	22.5	4.92	33
Big Twin North	Cass	16	7.5	25.0	14.1	12.0	5.69	39
Bills 1	Newaygo	13	4.0	22.0	10.9	8.0	6.09	43
Bills 2	Newaygo	18	4.0	16.5	8.6	6.5	4.61	46

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSISD
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
Birch	Cass	18	13.0	32.0	20.3	19.0	6.83	34
Blue	Mason	12	17.5	34.0	22.6	19.5	5.53	32
Blue 1	Mecosta	18	8.0	24.0	12.8	11.5	4.80	40
Blue 2	Mecosta	18	8.0	22.0	13.1	11.5	4.46	40
Bostwick	Kent	11	4.9	12.2	8.2	9.5	2.76	47
Brighton	Livingston	4	2.7	4.4				
Brooks	Newaygo	9	1.8	3.0	2.3	2.3	0.41	65
Buck	Livingston	16	7.0	14.3	9.2	9.1	1.79	45
Byram 1	Genesee	18	11.0	19.0	15.2	15.0	1.93	38
Byram 2	Genesee	18	11.0	18.0	15.1	15.0	1.66	38
Byram 3	Genesee	18	11.0	17.0	14.9	15.0	1.47	38
Canadian (Main)	Mecosta	9	6.0	13.5	8.2	7.5	2.59	47
Canadian (West)	Mecosta	9	6.5	16.5	9.0	7.5	3.56	45
Cedar	Van Buren	18	9.0	26.0	12.9	11.5	4.52	40
Cedar(BriarwoodBay)	Alcona\Iosco	13	8.0	12.0	10.5	11.0	1.20	43
Cedar(Schmidt's Pt.)	Alcona\Iosco	12	5.0	10.0	7.3	8.0	1.67	48
Center	Osceola	9	13.0	24.0	16.7	16.0	3.47	37
Chain	Iosco	14	10.0	13.0	11.2	11.0	0.89	42
Chemung	Livingston	7	14.3	19.6				
Christiana	Cass	16	4.5	15.0	8.9	8.0	3.30	46
Clam	Antrim	15	16.0	23.0	18.7	18.0	2.28	35
Clark 1	Jackson	17	6.5	26.4	12.2	11.4	5.72	41
Clark 2	Jackson	14	5.4	28.0	11.8	10.6	6.29	42
Clear	Jackson	17	8.3	14.0	11.1	10.8	1.62	42
Clear 1	St. Joseph	4	15.0	18.0				
Clear 2	St. Joseph	4	14.0	17.0				
Clifford 1	Montcalm	18	11.6	24.0	15.4	14.0	3.89	38
Cobb	Barry	2	12.8	14.3				
Corey	St. Joseph	18	7.5	23.0	12.4	9.5	5.23	41
Cowan	Kent	18	2.5	10.0	5.6	5.7	1.86	52
Crockery	Ottawa	5	2.7	8.3				
Crooked (Big)	Van Buren	15	11.5	17.3	13.2	13.0	1.46	40
Crystal	Hillsdale	18	12.5	18.0	14.7	14.8	1.83	38
Crystal	Newaygo	11	11.0	23.0	16.4	16.0	4.61	37

APPENDIX 1
2005 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet)						Carlson
		Number of	Range				Standard	TSI$_{SD}$
		Readings	Min	Max	Mean	Median	Deviation	(transparency)
Crystal	Oceana	13	3.0	18.0	11.2	12.0	4.64	42
Cub	Kalkaska	16	16.5	25.0	21.3	21.0	3.08	33
Deer	Alger	11	7.2	10.5	8.7	9.1	1.05	46
Deer	Oakland	18	8.0	21.0	12.5	11.7	2.79	41
Derby	Montcalm	17	10.0	25.0	16.0	15.0	4.42	37
Diamond	Cass	18	6.0	21.0	12.3	11.0	5.46	41
Dinner	Gogebic	18	10.0	13.0	11.4	11.0	0.70	42
Eagle	All./Van Buren	18	12.0	21.0	15.1	15.0	2.35	38
Earl	Livingston	18	5.1	10.8	7.5	7.1	1.79	48
East Twin	Montmorency	9	7.0	21.0	10.8	8.2	5.20	43
Emerald	Newaygo	14	8.0	22.0	14.5	14.5	4.53	39
Evans	Lenawee	18	11.0	27.0	17.6	16.8	4.73	36
Fair	Barry	13	7.7	17.1	11.3	10.2	2.91	42
Farwell	Jackson	18	7.0	21.0	11.8	10.0	4.49	41
Fenton	Genesee	9	15.0	20.5	17.9	18.0	1.96	35
Fish	Van Buren	18	7.0	15.5	10.9	11.0	2.39	43
Fisher	St. Joseph	18	4.8	31.0	12.8	8.3	9.08	40
Ford	Mason	13	15.1	21.8	18.0	17.6	1.83	35
Freska	Kent	15	5.0	13.1	10.2	10.6	2.18	44
George	Clare	18	6.0	16.0	8.6	7.8	2.83	46
Gill/Gut	Livingston	14	8.0	13.2	10.9	11.2	1.46	43
Gilletts	Jackson	18	6.2	10.3	8.3	8.5	0.93	47
Glen (Big)	Leelanau	15	12.0	22.0	18.1	19.0	2.64	35
Goshorn	Allegan	15	4.0	7.5	6.2	6.2	1.11	51
Gourdneck	Kalamazoo	14	9.0	15.0	11.2	11.5	1.73	42
Gratiot	Keweenaw	17	14.8	22.8	18.8	18.7	2.39	35
Gunn	Mason	9	9.5	18.0	13.7	14.0	2.64	39
Hamburg	Livingston	18	10.0	30.0	15.2	14.0	5.32	38
Harper	Lake	16	10.0	25.0	16.0	15.0	4.00	37
Hawk	Oakland	16	5.8	12.1	9.0	9.2	1.98	45
Hess	Newaygo	7	2.0	4.0				
Hicks	Osceola	16	3.0	8.0	5.9	6.1	1.38	52
Higgins (North)	Roscommon	8	25.5	49.0	36.3	36.5	7.01	25
Higgins (South)	Roscommon	8	18.0	51.0	36.5	37.8	9.09	25

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
High	Kent	7	11.8	19.7				
Horsehead	Mecosta	15	9.0	17.5	12.5	11.0	2.94	41
Houghton 1	Roscommon	12	6.3	9.9	8.0	8.1	1.12	47
Hubbard 1	Alcona	12	10.5	28.5	18.6	18.0	6.02	35
Hubbard 2	Alcona	13	12.0	30.0	19.4	18.0	6.16	34
Hubbard 3	Alcona	15	11.5	29.0	18.5	17.0	6.17	35
Hubbard 4	Alcona	16	10.0	32.0	18.4	16.5	6.35	35
Hubbard 5	Alcona	15	10.0	30.0	18.9	17.0	6.82	35
Hubbard 6	Alcona	17	10.0	27.0	18.3	17.0	5.73	35
Hubbard 7	Alcona	13	10.0	30.0	18.8	18.0	6.26	35
Hunter 1	Gladwin	14	6.7	15.3	10.6	9.3	3.39	43
Hutchins	Allegan	18	7.0	14.5	9.4	8.9	2.22	45
Indian	Kalamazoo	13	5.0	15.0	10.4	12.0	3.33	43
Indian	Kalkaska	7	8.0	15.0				
Indian	Osceola	16	15.0	28.0	19.8	19.3	2.94	34
Island	Grand Traverse	13	15.0	34.0	22.0	20.0	6.79	33
Island 1	Ogemaw	17	10.8	17.7	14.6	14.6	1.95	38
Island 2	Ogemaw	17	11.6	17.8	14.4	14.6	1.90	39
Jewell	Alcona	15	7.5	10.5	9.0	9.0	0.91	45
Juno	Cass	16	5.0	12.5	7.3	7.0	1.88	48
Kimball	Newaygo	13	5.0	16.0	10.0	10.5	3.44	44
Kirkwood	Oakland	17	3.2	9.0	6.6	6.5	1.94	50
Klinger	St. Joseph	18	5.5	29.0	13.1	10.0	7.35	40
Knob Loch	Oakland	11	9.0	9.0	9.0	9.0	0.00	45
Lake Margrethe 1	Crawford	18	10.0	29.0	17.1	12.0	7.47	36
Lake Nepessing	Lapeer	18	9.0	19.0	14.1	14.0	2.34	39
Lakeville	Oakland	17	11.0	25.0	17.4	17.0	5.01	36
Lancelot 1	Gladwin	11	6.0	11.0	7.5	7.0	1.42	48
Lancelot 2	Gladwin	11	6.0	10.0	7.7	7.5	1.19	48
Lancelot 3	Gladwin	11	5.5	10.5	8.3	9.0	1.57	47
Lancer 1	Gladwin	9	7.0	9.0	8.0	8.0	0.87	47
Lancer 2	Gladwin	9	8.0	14.0	10.6	11.0	2.01	43
Lancer 3	Gladwin	9	7.0	10.0	8.6	9.0	1.13	46
Lancer 4	Gladwin	9	5.0	7.0	5.3	5.0	0.71	53

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSISD (transparency)
Lancer 5	Gladwin	9	4.0	6.0	5.3	5.0	0.71	53
Lansing	Ingham	15	3.0	11.1	5.9	4.1	3.25	52
Lily	Clare	11	8.0	10.3	8.9	9.0	0.77	46
Lime	Kent	9	5.5	17.0	11.2	11.0	3.96	42
Little	Marquette	14	10.0	19.0	14.6	14.8	2.74	38
Little Crooked	Cass	11	13.6	24.3	16.9	17.0	3.64	36
Little Fisher	St. Joseph	18	6.8	15.0	9.7	8.3	2.94	44
Little Glen	Leelanau	17	4.0	7.5	5.1	5.0	1.04	54
Little Paw Paw	Berrien	12	4.0	9.0	6.5	6.3	1.52	50
Little Platte	Benzie	13	5.0	8.0	6.2	6.0	1.14	51
Little Twin	Cass	18	6.0	16.0	10.4	9.5	3.14	43
Little Twin	Kalkaska	9	12.4	19.3	15.1	14.0	2.55	38
Long	Branch	12	3.5	9.5	5.3	4.8	2.01	53
Long	Grand Traverse	18	19.0	58.0	29.4	25.0	11.57	28
Long	Iosco	9	9.5	17.0	13.4	13.0	2.38	40
Long (North)	Montmorency	14	9.0	26.0	15.2	15.0	4.30	38
Long (South)	Montmorency	14	10.0	20.0	14.5	13.5	3.35	39
Long(Sylvania)	Gogebic	13	12.0	22.0	17.2	17.0	3.35	36
Long(West)	Gogebic	13	13.0	22.0	17.0	16.0	3.34	36
Louise	Dickinson	17	14.5	21.0	17.5	17.5	2.07	36
Lower Brace	Calhoun	18	7.0	12.0	8.3	8.0	1.18	47
Lower Hamlin	Mason	17	9.0	18.5	13.6	13.0	2.54	39
Magician	Cass	15	4.0	18.0	11.1	8.0	5.35	42
Mary	Dickinson	17	14.5	21.0	16.8	16.5	1.84	36
Mecosta	Mecosta	15	8.5	18.0	11.4	10.0	2.86	42
Mehl	Marquette	14	9.0	13.0	10.9	11.0	1.14	43
Mill	Van Buren	11	11.0	19.0	13.2	13.0	2.16	40
Miner	Allegan	12	7.3	17.2	11.5	10.8	2.87	42
Moon	Gogebic	18	16.0	27.0	21.4	21.0	3.24	33
Mullet	Cheboygan	12	10.0	22.0	17.1	18.0	3.94	36
Murray	Kent	15	5.1	12.1	8.3	8.2	1.71	47
Muskellunge 1	Montcalm	18	3.2	17.2	8.3	7.9	3.64	47
North Blue Lake	Kalkaska	17	16.0	20.0	18.8	19.0	1.30	35
North Buckhorn	Oakland	17	10.0	16.0	13.4	14.0	1.33	40

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Range Max	Mean	Median	Standard Deviation	Carlson TSI$_{SD}$ (transparency)
North Crooked	Kalkaska	5	10.8	12.5				
Oneida	Livingston	10	8.0	12.9	10.2	9.3	1.87	44
Orion	Oakland	8	12.0	21.0	15.7	15.5	2.96	37
Osterhout	Allegan	9	4.0	8.0	5.8	6.0	1.41	52
Otsego	Otsego	17	7.0	18.0	11.3	9.8	3.35	42
Oxbow	Oakland	10	10.0	18.0	14.2	14.0	2.69	39
Painter	Cass	16	4.0	7.0	5.8	6.0	1.00	52
Papoose	Kalkaska	9	24.0	27.0	25.6	25.0	1.24	30
Parke	Oakland	15	12.5	19.0	15.8	17.0	2.38	37
Payne	Barry	9	5.0	17.0	9.5	9.0	3.48	45
Pentwater 2	Oceana	7	4.6	8.2				
Pentwater 4	Oceana	7	4.7	8.4				
Perch	Hillsdale	18	5.0	8.5	7.1	7.3	0.95	49
Perch	Otsego	8	8.0	12.5	9.9	10.0	1.50	44
Pickerel	Kalkaska	18	19.0	35.0	25.4	24.0	5.75	30
Pickerel	Newaygo	13	12.0	20.0	15.5	16.0	2.36	38
Pickerel	Washtenaw	9	6.2	7.5	6.8	6.8	0.44	49
Pinic	Montcalm	10	3.0	13.0	8.1	8.5	3.14	47
Pleasant	St. Joseph	17	6.0	24.0	13.6	12.0	6.06	39
Pleasant 1	Wexford	13	5.6	7.2	6.3	6.4	0.45	51
Portage	Livingston	10	6.5	22.0	10.2	9.2	4.41	44
Randall	Branch	14	4.0	16.5	8.0	6.5	4.25	47
Ranger	Otsego	7	7.5	19.5				
Reeds	Kent	13	3.9	12.1	5.5	4.9	2.15	53
Robinson	Newaygo	8	7.5	10.0	8.8	9.0	0.85	46
Round	Clinton	18	6.5	14.0	8.9	8.5	1.92	46
Round 1	Mecosta	15	5.0	17.0	10.5	10.0	3.71	43
Sage	Ogemaw	12	12.0	18.0	15.4	16.0	1.83	38
Sanford	Benzie	18	7.0	12.0	9.1	9.0	1.43	45
Sapphire	Missaukee	16	7.0	8.2	7.5	7.5	0.44	48
School Section	Van Buren	18	4.6	14.3	9.7	9.3	3.11	44
School Section 1	Mecosta	17	11.8	16.0	14.5	15.0	1.45	39
School Section 2	Mecosta	17	12.3	16.8	15.0	15.8	1.64	38
Shingle	Clare	18	9.0	16.0	12.4	12.5	2.20	41

APPENDIX 1
2005 COOPERATIVE LAKES MONITORING PROGRAM
SECCHI DISK TRANSPARENCY RESULTS

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Silver	Grand Traverse	18	16.0	46.0	26.1	23.0	9.77	30
Silver	Livingston	15	10.0	20.0	13.0	12.0	3.00	40
Silver	Van Buren	18	10.1	14.5	11.7	11.6	1.24	42
Silver 1	Genesee	16	6.0	20.5	11.6	9.5	5.30	42
Silver 2	Genesee	16	6.5	19.5	11.8	10.0	4.85	42
Silver 3	Genesee	16	6.0	20.0	11.8	9.8	5.02	42
Smallwood	Gladwin	8	5.3	9.0	7.1	7.3	1.18	49
Spider 1	Grand Traverse	15	13.0	24.0	16.6	16.0	3.36	37
Spider 2	Grand Traverse	15	12.0	22.0	15.7	16.0	2.81	37
Spider 3	Grand Traverse	15	11.0	22.0	14.6	13.0	3.04	38
Starvation	Kalkaska	14	17.1	23.5	19.0	18.4	1.97	35
Stone Ledge	Wexford	18	6.0	11.5	8.7	9.0	1.76	46
Stoney	Oceana	18	4.2	19.1	10.0	9.4	4.24	44
Strawberry	Livingston	17	7.7	10.2	9.0	9.2	0.56	45
Sweezy	Jackson	18	6.0	14.0	9.4	9.8	2.01	45
Sylvan	Newaygo	14	9.0	23.0	16.2	16.0	4.76	37
Taylor	Oakland	18	16.0	20.0	17.8	18.0	1.10	36
Thurston Pond	Washtenaw	6	0.5	0.7				
Torch North	Antrim	14	14.0	41.0	26.1	30.5	8.52	30
Torch South	Antrim	14	28.0	35.0	32.2	32.0	1.48	27
Upper Brace	Calhoun	18	6.0	17.0	9.7	8.5	3.20	44
Upper Crooked 1	Barry	18	8.0	16.2	12.4	12.8	2.43	41
Upper Crooked 2	Barry	18	7.0	16.0	11.5	12.0	2.30	42
Upper Hamlin	Mason	17	4.5	14.5	10.6	11.0	2.64	43
Van Etten	Iosco	17	3.3	9.3	5.4	5.3	1.78	53
Vaughn	Alcona	18	9.2	15.8	14.0	14.6	1.94	39
Viking	Otsego	18	7.0	15.0	10.6	10.5	2.73	43
Vineyard	Jackson	18	7.5	22.0	14.2	12.5	5.54	39
Wahbememe	St. Joseph	18	12.0	31.0	20.2	21.5	5.15	34
Wamplers	Lenawee	15	5.0	11.0	6.9	6.0	1.98	49
Webinguaw	Newaygo	18	4.5	7.5	5.8	5.8	0.84	52
Wells	Osceola	18	15.0	24.0	18.6	18.0	2.73	35
West Twin	Montmorency	10	8.1	17.5	11.3	10.9	2.95	42
White	Oakland	8	14.5	22.5	19.9	20.0	2.45	34

Lake	County	Secchi Disk Transparency (feet) Number of Readings	Range Min	Max	Mean	Median	Standard Deviation	Carlson TSI_{SD} (transparency)
Wildwood	Cheboygan	18	10.3	12.7	11.6	11.6	0.54	42
Windover	Clare	10	8.0	30.0	15.5	14.3	6.83	38
Woods	Kalamazoo	17	6.5	18.0	11.5	11.5	2.38	42

APPENDIX 2
2005 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l)								Carlson
		Spring Overturn				Late Summer				TSITP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
ANN	BENZIE	6				9				36
ARBUTUS	GR. TRAVERSE	9				8				34
ARNOLD	CLARE	10				7				32
AVALON	MONTMORENCY	4 T,c				7				32
BALDWIN	MONTCALM	23				20				47
BARLOW	BARRY	8		10		8				34
BASS	KALKASKA	*				9	9			36
BEAR	KALKASKA	9				5				27
BEAVER	ALPENA	7	7			12				40
BELLAIRE	ANTRIM	4 T				9				36
BIG	OSCEOLA	11				9				36
BIG BRADFORD	OTSEGO	*				9				36
BIG STAR	LAKE	11				10				37
BILLS	NEWAYGO	6				8				34
BIRCH	CASS	6				6				30
BLUE	KALKASKA	*				*				
BLUE	MASON	12				10				37
BLUE	MECOSTA	*				7				32
BLUE (BIG)	KALKASKA	9	5			9	6	2 <		36
BLUE, NORTH	KALKASKA	9		8		3 <				<27
BOSTWICK	KENT	16				31				54
BRACE, LOWER	CALHOUN	11				19				47
BRACE, UPPER	CALHOUN	19				11				39
BRIGHTON	LIVINGSTON	28				52				61
BUCKHORN	OAKLAND	23				11				39
CANADIAN, MAIN	MECOSTA	12				17				45
CANADIAN, WEST	MECOSTA	13				17				45
CEDAR	ALCONA/IOSCO	7				13				41
CEDAR	VAN BUREN	6				9				36
CENTER	OSCEOLA	12				7				32
CHAIN	IOSCO	10				11				39
CHEMUNG	LIVINGSTON	19				14				42
CHRISTIANA	CASS	*				15				43

APPENDIX 2
2005 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring Overturn				Late Summer				Carlson TSI$_{TP}$
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
CLAM	ANTRIM	4 T				12	10			40
CLARK	JACKSON					8				34
CLEAR	JACKSON	11	7	12		12				40
CLIFFORD	MONTCALM	14				13	13			41
COBB	BARRY	6		8		11				39
COREY	ST. JOSEPH	8	8			9				36
COWAN	KENT	33				22		24		49
CROCKERY	OTTAWA	72				21				48
CROOKED	KALAMAZOO	*								
CROOKED, LOWER	BARRY					9				36
CROOKED, SOUTH	KALKASKA	13				13				41
CROOKED, NORTH	KALKASKA	13				8				34
CROOKED	LIVINGSTON	15 b				19				47
CROOKED, BIG	VAN BUREN	9				9				36
CROOKED, LITTLE	VAN BUREN	12				14				42
CRYSTAL	BENZIE	6				*				
CRYSTAL	HILLSDALE	11				11				39
CRYSTAL	NEWAYGO	9				12				40
CRYSTAL	OCEANA	15	12			16	15			44
CUB	KALKASKA	6				7				32
DAVIS	CASS	24	23			20				47
DEER	ALGER	8				6				30
DEER	OAKLAND	9				8	10			34
DERBY	MONTCALM	7	4 T			8	7			34
DEVILS	LENAWEE	9				*				
DIAMOND	CASS	4 T				8	8			34
DINNER	GOGEBIC	12	13			14	12			42
EAGLE	ALLEGAN	8				17				45
EAGLE	CASS	*				*				
EAGLE	KALKASKA	10				7				32
EARL	LIVINGSTON	45		50		26	27			51
EMERALD	NEWAYGO	8				12				40
EVANS	LENAWEE	7				13				41

APPENDIX 2
2005 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
FAIR	BARRY	9				13	15			41
FARWELL	JACKSON	3 <				5	8			27
FENTON	GENESEE	11				11				39
FISH	LIVINGSTON	15				7				32
FISH	VAN BUREN	12				19				47
FISHER	ST. JOSEPH	11				9				36
FISHER, LITTLE	ST. JOSEPH	13				13				41
FRESKA	KENT	15				18				46
GEORGE	CLARE	9				12				40
GILL	LIVINGSTON	18				10				37
GILLETTS	JACKSON	11				14				42
GLEN, BIG	LEELANAU	4 T				5				27
GLEN, LITTLE	LEELANAU	4 T				10				37
GOSHORN	ALLEGAN	*				28				52
GOURDNECK	KALAMAZOO	15				13				41
GRATIOT	KEWEENAW					7				32
GUNN	MASON	5				8				34
HAMBURG	LIVINGSTON	16	14	19		6				30
HAMLIN, LOWER	MASON	22				18				46
HAMLIN, UPPER	MASON	18				19				47
HARPER	LAKE	10				6				30
HESS	NEWAYGO	32				32				54
HICKS	OSCEOLA	25				23				49
HIGGINS, N1	ROSCOMMON	5				7	9	9	4 T	32
HIGGINS, S1	ROSCOMMON	4 T				9		3 <		36
HIGH	KENT	14				15				43
HORSEHEAD	MECOSTA	8	8			14				42
HOUGHTON	ROSCOMMON	21				22				49
HUBBARD	ALCONA	6				14				42
HUTCHINS	ALLEGAN	16	17	14	15	13				41
INCHWAGH	LIVINGSTON	*				*				
INDIAN	KALAMAZOO	*				8				34
INDIAN	KALKASKA	5		9		22				49

APPENDIX 2
2005 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
INDIAN	MONTCALM	16		25		*				
INDIAN	OSCEOLA	9				9				36
ISLAND	GR. TRAVERSE	2 <				8				34
ISLAND	OGE/OSCODA	10				13				41
JEWELL	ALCONA	14	11			11				39
JORDAN	IONIA/BARRY	*				*				
JUNO	CASS	*				21				48
KIMBALL	NEWAYGO	97		103		19				47
KLINGER	ST. JOSEPH	12				7				32
KNOB LOCK	OAKLAND	*				19		17		47
LAKEVILLE	OAKLAND	7				15		12		43
LANCELOT	GLADWIN	17				19				47
LANCER	GLADWIN	*				13				41
LANSING	INGHAM					17				45
LILY	CLARE	15				18				46
LIME	KENT	31								
LIMEKILN	LIVINGSTON	41 b				34	35			55
LITTLE	MARQUETTE	10	9			11	12			39
LONG	GOGEBIC	7				7				32
LONG	GR. TRAVERSE	15				6				30
LONG	IOSCO	7				8				34
LONG	MONTMORENCY	*				7				32
LOUISE	DICKINSON	40				7				32
MAGICIAN	CASS	*				9				36
MANISTEE	KALKASKA	*				10				37
MARGRETHE	CRAWFORD	5				5				27
MARL	GENESEE	5				5				27
MARY	DICKINSON	22				9				36
MECOSTA	MECOSTA	*				13				41
MEHL	MARQUETTE					8				34
MOON	GOGEBIC	7				4 T				<27
MULLETT	CHEBOYGAN	4 T				8				34
MURRAY	KENT	36				13		11		41

APPENDIX 2
2005 COOPERATIVE LAKES MONITORING PROGRAM
TOTAL PHOSPHORUS RESULTS

Lake	County	Total Phosphorus (ug/l)								Carlson
		Spring Overturn				Late Summer				TSITP
		Vol	Rep.	DEQ	Rep.	Vol	Rep	DEQ	Rep	(summer TP)
MUSKELLUNGE	MONTCALM	39				17				45
NEPESSING	LAPEER	10				24	22			50
ONEIDA	LIVINGSTON	13				8				34
ORE	LIVINGSTON	13 a				14				42
ORION	OAKLAND	6				22				49
OSTERHOUT	ALLEGAN	*				14				42
OTSEGO	OTSEGO	7	9	10		14				42
OXBOW	OAKLAND	8				12				40
PAINTER	CASS	*				37				56
PAPOOSE	KALKASKA	*				12				40
PARKE	OAKLAND	21	22			12		9	9	40
PAYNE	BARRY	11 h		20		11				39
PENTWATER	OCEANA	*				35				55
PERCH	HILLSDALE	10				19				47
PERCH	OTSEGO	12				12	16			40
PICKERAL	KALKASKA	8				4 T		6		<27
PICKERAL	WASHTENAW	17		18		*				
PICKEREL	NEWAYGO	59	55	70		14				42
PICNIC	MONTCALM	59				20				47
PINE ISLAND, BIG	KENT	*				15				43
PLATTE, LITTLE	BENZIE	*				*				
PLEASANT	JACKSON					*				
PLEASANT	WEXFORD	13				15	15			43
PLEASANT, BIG	ST. JOSEPH	13				9				36
PORTAGE	LIVING/WASH	14				10				37
PRETTY	MECOSTA	17				22				49
RANDALL	BRANCH	*				27				52
RANGER	OTSEGO	8				*				
ROBINSON	NEWAYGO	29				17		16		45
ROUND	CLINTON	27				18				46
ROUND	LENAWEE	7				*				
ROUND	MECOSTA	*				14				42
SAGE	OGEMAW	7				9				36

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
SANDY BOTTOM	LIVINGSTON	25 b				13				41
SANFORD	BENZIE					8				34
SAPPHIRE	MISSAUKEE	9				19	19	14		47
SCHOOL SEC.	MECOSTA	7				8				34
SCHOOL SEC.	VAN BUREN	34				11				39
SHINGLE	CLARE	19				10				37
SILVER	GENESEE	6	5			3 <				<27
SILVER	LIVINGSTON	7				9				36
SILVER	VAN BUREN	9	9			10	10			37
SILVER	GR. TRAVERSE	4 T				7				32
SMALLWOOD	GLADWIN	21				16				44
SPIDER	GR. TRAVERSE	6	6			10				37
SQUAW	KALKASKA	8				10		8		37
STARVATION	KALKASKA	7		10		3 <		5	5	<27
STONE LEDGE	WEXFORD	*				22 p				49
STONY	OCEANA	11				23				49
STRAWBERRY	LIVINGSTON	15				*				
SWEEZEY	JACKSON					10		6		37
SYLVAN	NEWAYGO	6				10				37
TAYLOR	OAKLAND	28				13				41
THURSTON	WASHTENAW					470		480		93
TORCH (N. BASIN)	ANTRIM	6				4 T				<27
TORCH (S. BASIN)	ANTRIM	6				6				30
TWIN, BIG	CASS	9				8				34
TWIN, LITTLE	CASS	12				9				36
TWIN, BIG	KALKASKA	14	13	12		7				32
TWIN, LITTLE	KALKASKA	6		3 <		7				32
TWIN, EAST	MONTMORENCY	7				11				39
TWIN, WEST	MONTMORENCY	5				12				40
VAN ETTAN	IOSCO	23				38	36			57
VAUGHN	ALCONA	33	36			*				
VIKING	OTSEGO	15				53				61
VINEYARD	JACKSON	5				10				37

Lake	County	Total Phosphorus (ug/l) Spring Overturn Vol	Rep.	DEQ	Rep.	Late Summer Vol	Rep	DEQ	Rep	Carlson TSITP (summer TP)
WAHBEMEME	ST. JOSEPH	9				10	12			37
WALLED	OAKLAND	13				*				
WAMPLERS	JACK/LENAWEE	8	8	14		16	14			44
WEBINGUAW	NEWAYGO					17	16	20		45
WELLS	OSCEOLA	11				13				41
WEST	KALAMAZOO	17				39				57
WHITE	OAKLAND	*				12				40
WILDWOOD	CHEBOYGAN					*				
WINDOVER	CLARE	5				13				41
WOLF	LAKE	8	7			9				36
WOODS	KALAMAZOO	36				12				40

* No sample received or received too late to process.

T Value reported is less than limit of quantification (5 ug/l). Result is estimated

< Value is less than method detection limit (3 ug/l)

a No field sheets received

b Sampling date on field sheet does not correspond with date on sample bottle label

c Improper sample collection - no replicate

h Recommended laboratory holding time was exceeded

p Recommended sample collection/preservation technique not used; reported result(s) is an estimate.

APPENDIX 3
2005 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
ANN	BENZIE	1.0	2.8	2.9	2.2	2.9	2.4	2.8	0.8	41
ARBUTUS	GR. TRAVERSE	1.2	3.3	2.7	2.5	4.0	2.7	2.7	1.0	40
ARNOLD	CLARE	1.0	1.2	3.6						
Vol/Rep			1.4							
AVALON	MONTMORENCY	*	1.3a	2.4a	*	2.8				
BALDWIN	MONTCALM	*	2.9	5.6	*	9.5				
BARLOW	BARRY	1.9	2.0	5.0	2.3	2.2	2.7	2.2	1.3	38
BEAVER	ALPENA		2.1	1.2	c	2.3	2.2	2.2	0.8	38
Vol/Rep		1.3								
MDEQ		8.6	2.9							
MDEQ/Rep			3.2							
BELLAIRE	ANTRIM	1.5	2.0	1.6	1.8	1.1	1.6	1.6	0.3	35
BIG	OSCEOLA	1.0<,b	c	1.0	1.5	1.3	1.1	1.2	0.4	32
BIG PINE IS.	KENT									
BIG STAR	LAKE	5.1	3.7	2.8	4.0	3.8	3.9	3.8	0.8	44
MDEQ					3.5					
MDEQ/Rep					3.9					
BILLS	NEWAYGO	1.0<	4.2	2.4	3.6	4.3	3.0	3.6	1.6	43
BIRCH	CASS	2.2	2.2	3.7	2.7	2.6	2.7	2.6	0.6	40
BLUE	MECOSTA	1.4	3.0	4.1	4.1	2.3	3.0	3.0	1.2	41
BOSTWICK	KENT	c	c	6.9	*	12.0				
BRIGHTON	LIVINGSTON	10.0	9.5	15.0	12.0	13.0	11.9	12.0	2.2	55
Vol/Rep			11.0							
CEDAR	ALCONA/IOSCO	2.8	3.0	4.8	5.5	4.8	4.2	4.8	1.2	46
Vol/Rep			3.4							
MDEQ			4.8							
MDEQ/Rep			4.6							
CEDAR	VAN BUREN	1.5	2.6	1.0<	4.1	4.4	2.6	2.6	1.7	40
CHEMUNG	LIVINGSTON	3.2	1.0	3.9	3.9	6.1	3.6	3.9	1.8	44
CHRISTIANA	CASS	2.7	2.5	4.7	10.0	6.7	5.3	4.7	3.1	46
CLAM	ANTRIM	1.0<	1.3	1.9	4.1	2.1	2.0	1.9	1.3	37
Vol/Rep						2.0				
COREY	ST. JOSEPH	3.8	2.4	2.8	3.6	3.9	3.3	3.6	0.7	43

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
COWAN	KENT	1.0	16.0	11.0	12.0	7.1	9.4	11.0	5.7	54
Vol/Rep		1.0<								
MDEQ						14.0				
MDEQ/Rep						15.0				
CROCKERY	OTTAWA	61.0	*	18.0	8.1	7.9	23.8	13.1	25.3	56
Vol/Rep					6.0					
CROOKED	LIVINGSTON	*	*	*	9.8	10.0				
CROOKED (B)	VAN BUREN	8.5	2.8	3.1	2.6	4.9	4.4	3.1	2.5	42
CROOKED (L)	VAN BUREN	*	5.1	4.2	4.7	6.7	5.2	4.9	1.1	46
CRYSTAL	BENZIE	1.0<	1.0<	1.0<	*	*				
CRYSTAL	HILLSDALE	3.6	2.1	3.2	3.8	4.0	3.3	3.6	0.8	43
CRYSTAL	NEWAYGO	3.0	2.5	3.5	4.4	2.8	3.2	3.0	0.7	41
DEER	ALGER	2.9	3.3	4.2	3.9	4.2	3.7	3.9	1.1	44
Vol/Rep			3.4							
DERBY	MONTCALM	1.1	1.7	3.2	2.2	1.8	2.0	1.8	0.8	36
DEVILS	LENAWEE	*	*	*	*	*				
DIAMOND	CASS	1.0	1.0<	3.8	3.1	2.6	2.2	2.6	1.4	40
EAGLE	ALLEGAN	1.0<	2.0	4.0	4.3	5.5	3.3	4.0	2.0	44
MDEQ		1.8								
MDEQ/Rep		1.9								
EVANS	LENAWEE	3.0	1.4	2.9	2.2	9.5	3.8	2.9	3.3	41
FAIR	BARRY	2.1	7.5	6.5	8.8	4.2	5.8	6.5	2.7	49
FARWELL	JACKSON	1.0<	1.1	1.6	1.4	1.6	1.2	1.4	0.5	34
Vol/Rep					1.2					
FISH	LIVINGSTON	*	*	*	1.1	1.8				
FISH	VAN BUREN	16.0	4.8	25.0	26.0	2.1	14.8	16.0	11.1	58
FISHER	ST. JOSEPH	1.8	1.5	3.6	3.9	3.5	2.9	3.5	1.1	43
FISHER (LIT)	ST. JOSEPH	1.4	2.4	3.6	4.4	2.7	2.9	2.7	1.1	40
FRESKA	KENT	7.5	10.0	11.0	7.9	27.0	12.7	10.0	8.1	53
GEORGE	CLARE	2.1	4.0	4.8	8.6	7.7	5.4	4.8	2.7	46
GILLETTS	JACKSON	3.9	3.2	4.0	3.8	3.4	3.7	3.8	0.3	44
Vol/Rep				4.3						
GLEN (LITTLE)	LEELANAU	1.6	1.3	3.1	2.1	2.5	2.1	2.1	0.7	38
Vol/Rep				3.1						

APPENDIX 3
2005 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
GLEN(BIG)	LEELANAU	2.4	1.0<	1.0<	1.0	1.0<	1.0	1.0	0.8	<31
GOSHORN	ALLEGAN	d	d	d	d	d				
GOURDNECK	KALAMAZOO	c	c	c	c	c				
GUNN	MASON	2.7	2.6	3.1	3.0	6.7	3.6	3.0	1.7	41
HAMLIN (L)	MASON	2.3	3.9	3.6	2.5	5.2	3.5	3.6	1.2	43
HAMLIN (U)	MASON	2.8	5.1	4.2	19.0	5.5	7.3	5.1	6.6	47
HESS	NEWAYGO	7.5	6.4	10.0	5.2	6.9	7.2	6.9	1.8	50
MDEQ				18.0						
MDEQ/Rep				18.0						
HICKS	OSCEOLA	61.0	6.9	23.0	12.0	16.0	23.8	16.0	21.6	58
MDEQ				23.0						
MDEQ/Rep				25.0						
HIGGINS (N)	ROSCOMMON	1.0<	1.0	1.0<	1.0<	1.0<	0.6	1.0	0.2	<31
MDEQ						1.3				
MDEQ/Rep						1.2				
HIGGINS (s)	ROSCOMMON	1.0<	1.0<	1.0<	1.0<	1.0<	1.0	1.0	0.0	<31
MDEQ						1.2				
MDEQ/Rep						1.2				
HIGH	KENT	8.2	6.5	4.9	6.7	8.3	6.9	6.7	1.4	49
HOUGHTON	ROSCOMMON	3.7	6.7	3.8	6.7	2.9	4.8	3.8	1.8	44
HUBBARD	ALCONA	1.0<	2.3	2.1	1.8	2.4	1.8	2.1	0.8	38
MDEQ		1.0								
MDEQ/Rep		1.0<								
INCHWAGH	LIVINGSTON	*	*	*	*	*				
INDIAN	KALAMAZOO	1.8	1.7	3.3	1.3	1.6	1.9	1.7	0.8	36
Vol/Rep						1.9				
INDIAN	OSCEOLA	1.3	2.4	6.2	6.4	9.0	5.1	6.2	3.2	48
ISLAND	GR. TRAVERSE	1.3	1.7	1.4	7.2	5.9	3.5	1.7	2.8	36
JEWELL	ALCONA	4.1	2.8	5.9	5.2	4.0	4.4	4.1	1.2	44
JUNO	CASS	6.8	6.0	7.3	14.0	10.0	8.8	7.3	3.3	50
Vol/Rep		6.8								
KIMBALL	NEWAYGO	c	8.0	8.4	8.0	1.0<	6.2	8.0	3.8	51
MDEQ				22.0						
MDEQ/Rep				21.0						

APPENDIX 3
2005 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
KLINGER	ST. JOSEPH	1.0<	1.1	5.2	4.5	3.7	3.0	3.7	2.1	43
LAKEVILLE	OAKLAND	1.0<	1.4	1.9	4.5	3.7	2.4	1.9	1.7	37
MDEQ						3.7				
MDEQ/Rep						3.8				
LANCELOT	GLADWIN	2.5	4.6	3.7	6.5	7.1	4.9	4.6	1.9	46
LANCER	GLADWIN	1.8	2.3	4.8	2.8	1.7	2.7	2.3	1.3	39
LANSING	INGHAM	1.9	6.0	13.0	12.0	7.2	8.0	7.2	4.6	50
LILY	CLARE	1.1	2.6	4.7	3.6	4.1	3.2	3.6	1.4	43
LIMEKILN	LIVINGSTON	*	*	*	52.0	59.0				
LONG	GR. TRAVERSE	1.3	2.4	2.5	*	2.1	2.1	2.3	1.0	39
LONG	IOSCO	4.1	1.7	2.0	2.4	3.4	2.7	2.4	1.0	39
LONG	MONTMORENCY	*	1.3	1.0<	1.1	d				
MAGICIAN	CASS	*	1.0<	6.2	4.3	3.4	3.6	3.9	2.4	44
MARGRETHE	CRAWFORD	1.0<	1.2	2.1	2.1	3.3	1.8	2.1	1.1	38
MECOSTA	MECOSTA	1.0	2.3	3.6	2.9	3.9	2.7	2.9	1.2	41
MOON	GOGEBIC	3.8	2.2	2.3	2.9	4.1	3.1	2.9	0.9	41
Vol/Rep					3.3					
MULLETT	CHEBOYGAN	1.0	1.3	1.0<	1.7	1.0<,a	1.0	1.0	1.0	31
MURRAY	KENT	14.0	2.4	2.7	1.1	2.9	4.6	2.7	5.3	40
MDEQ						3.6				
MDEQ/Rep						3.6				
NEPESSING	LAPEER	6.0	2.6	3.3	3.7	4.1	3.9	3.7	1.3	43
ORE	LIVINGSTON	1.6	1.7	3.0	*	*				
Vol/Rep				3.0						
ORION	OAKLAND	*	*	*	*	*				
OSTERHOUT	ALLEGAN	*	7.8	7.3	4.3	4.4	6.0	5.9	1.9	48
OTSEGO	OTSEGO	4.7	2.7	8.1	4.3	5.4	5.0	4.7	2.0	46
OXBOW	OAKLAND	*	4.3	7.7	*	3.4				
PAINTER	CASS	16.0	5.2	14.0	37.0	39.0	22.2	16.0	15.0	58
PENTWATER	OCEANA	4.8	7.5	9.3	14.0	24.0	11.9	9.3	7.5	52
PERCH	HILLSDALE	7.8	1.4	3.1	5.1	5.5	4.6	5.1	2.4	47

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSICHL
PICKEREL	NEWAYGO	c	3.6	4.7	4.7	4.3	4.3	4.5	1.0	45
MDEQ				8.4						
MDEQ/Rep				9.1						
PICNIC	MONTCALM	8.1	6.5	11.0	21.0	13.0	11.9	11.0	5.7	54
PRETTY	MECOSTA	3.9b	5.4	4.6	4.4	6.1b	4.9	4.6	0.9	46
RANDALL	BRANCH	1.5	12.0	16.0	23.0	13.0	13.1	13.0	7.8	56
ROBINSON	NEWAYGO	19.0	8.3b	6.1	*	9.3	10.7	8.8	5.7	52
MDEQ						4.7				
MDEQ/Rep						4.8				
ROUND	CLINTON	3.2	3.4	14.0	14.0	16.0	10.1	14.0	6.3	56
ROUND	LENAWEE	*	*	*	*	*				
ROUND	MECOSTA	9.8	3.7	7.7	1.0<	6.7	5.7	6.7	3.6	49
SAGE	OGEMAW	d	d	d	3.1	3.0				
SANDY BOTTOM	LIVINGSTON	*	*	*	6.2	6.2				
SAPPHIRE	MISSAUKEE	*	3.2	5.9	4.3	5.4	4.7	4.9	1.2	46
MDEQ						6.9				
MDEQ/Rep						7.2				
SCHOOL SEC.	MECOSTA	*	*	*	*	*				
SHINGLE	CLARE	2.7	5.3	3.2	4.6	25.0	8.2	4.6	9.5	46
SILVER	GR. TRAVERSE	1.0<	1.6	2.2	2.2a	1.8a	1.7	1.8	0.7	36
SMALLWOOD	GLADWIN	4.7e	*	1.1e	4.6b	6.4	4.2	4.7	2.2	46
SPIDER	GR. TRAVERSE	2.2	2.1	6.5	4.2	3.3	3.7	3.3	1.8	42
STONY	OCEANA	5.2	4.0	9.4	23.0	18.0	11.9	9.4	8.3	53
STRAWBERRY	LIVINGSTON	4.7	8.1	8.2	8.7	1.5	6.2	8.1	3.1	51
TORCH (N.)	ANTRIM	c	1.0<	1.0<,b	1.0<	1.0<	1.0	1.0	0.0	<31
TORCH (S.)	ANTRIM	*	1.0<,b	1.0<	1.0<	1.0<	1.0	1.0	0.0	<31
TWIN (E)	MONTMORENCY	1.0	2.0	5.2	4.9	2.8	3.2	2.8	1.8	41
TWIN (W)	MONTMORENCY	2.4	2.3	4.8	6.8	2.4	3.7	2.4	2.0	39
VAN ETTAN	IOSCO	8.5	5.9	7.8	18.0	4.4	8.9	7.8	5.3	51
MDEQ			11.0							
MDEQ/Rep			11.0							
VIKING	OTSEGO	7.2	12.0	22.0	14.0	32.0	17.4	14.0	9.7	56
VINEYARD	JACKSON	1.0<	1.0<	3.8	3.4	2.6	2.2	2.6	1.6	40

APPENDIX 3
2005 COOPERATIVE LAKES MONITORING PROGRAM
CHLOROPHYLL RESULTS

Lake	County	Chlorophyll *a* (ug/l) May	June	July	Aug	Sept	Mean	Median	Std. Devia-tion	Carlson TSI_{CHL}
WALLED	OAKLAND	*	*	*	*	*				
WELLS	OSCEOLA	2.0	2.2	2.7	3.5	4.4	3.0	2.7	1.0	40
WHITE	OAKLAND	4.2	1.7	2.7	1.9	2.4	2.6	2.4	1.0	39
Vol/Rep		7.8								
WINDOVER	CLARE	3.5	3.3	5.0	3.6	2.6	3.6	3.5	0.9	43
WOODS	KALAMAZOO	*	7.0	7.4	18.0	23.0	13.9	12.7	7.9	56

< Sample value is less than limit of quantification (1 ug/l)

* No sample received

a No data sheet submitted with sample

b Sample not collected within the designated sampling window

c Sample not collected at proper time - sample not processed

d Sample poorly or not covered by aluminum foil

e Dates on field sheet and vile labels do not match

APPENDIX 4
2005 COOPERATIVE LAKES MONITORING PROGRAM
DISSOLVED OXYGEN AND TEMPERATURE RESULTS

County	Participating Lake
Alcona	Hubbard Lake
	Jewell Lake
Antrim	Lake Bellaire
	Clam Lake
Alpena	Beaver Lake
Benzie	Lake Ann
Cass	Magician Lake
Cheboygan	Mullet Lake
Clare	Lake George
	Shingle Lake
Gladwin	Smallwood Lake
Grand Traverse	Arbutus Lake
	Silver Lake
Kalamazoo	Gourdneck Lake
	Indian Lake
Kent	Bostwick Lake
	Cowan Lake
	Freska Lake
	Murray Lake
Lake	Harper Lake
Livingston	Lake Chemung
	Strawberry Lake
Mason	Hamlin Lake
	Gunn Lake
Mecosta	Blue Lake
	Mecosta Lake
	Round Lake
Montcalm	Derby Lake

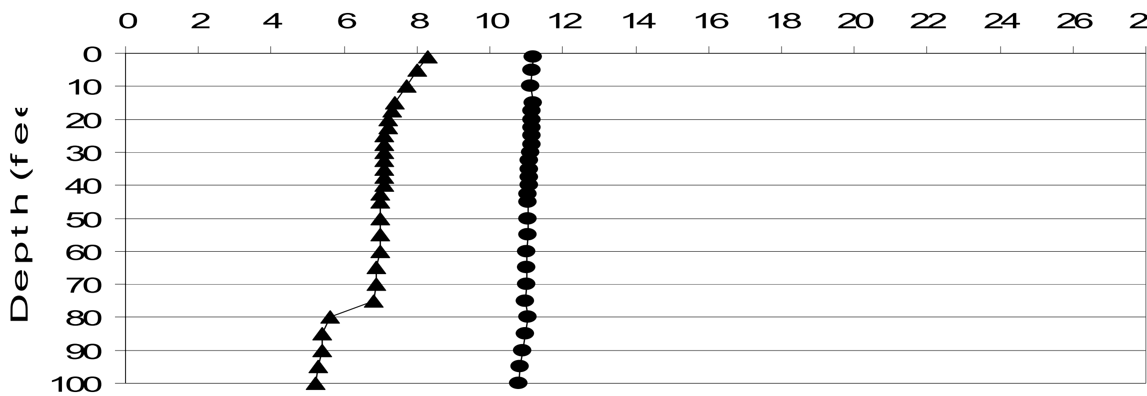
County	Participating Lake
Newaygo	Crystal Lake Hess Lake Robinson Lake Pickerel Lake Kimball Lake
Oakland	Lake Orion Oxbow Lake
Osceola	Indian Lake Wells Lake
Ottawa	Crockery Lake
Roscommon	Higgins Lake
St. Joseph	Fisher Lake Little Fisher Lake

On the following pages five representative dissolved oxygen/temperature patterns are illustrated. The first is of a high quality oligotrophic lake, which has a very large hypolimnion volume. The lake maintains high oxygen levels in the hypolimnion all summer. The second pattern represents a good quality oligotrophic/mesotrophic lake with a large hypolimnion volume. It retains some oxygen in the hypolimnion all summer, but the deepest parts of the lake do drop to zero dissolved oxygen. The third pattern is of a good quality oligotrophic/ mesotrophic lake with a small hypolimnion volume. This lake keeps some dissolved oxygen in the hypolimnion into mid-summer, but by late summer the entire hypolimnion is devoid of oxygen. The fourth pattern is a productive eutrophic lake with a small hypolimnion. Within a few weeks of spring overturn the hypolimnion has lost all oxygen. This anaerobic condition persists all summer. The final pattern is a eutrophic lake, which is too shallow to maintain stratification. It loses oxygen in the deeper water, but summer storms drive wave energy into the deepest parts of the lake renewing the oxygen supply to these waters.

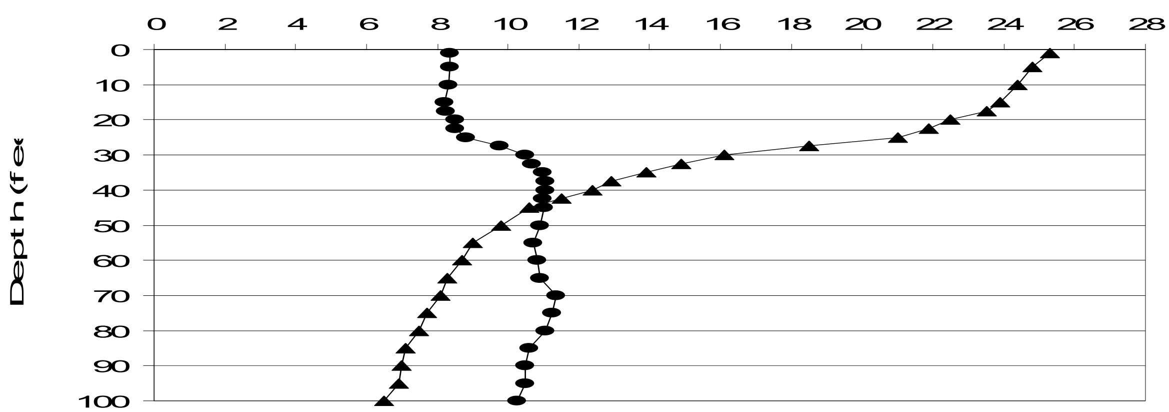
Oligotrophic Lake with a Very Large Volume Hypolimnion

Higgins Lake in Roscommon County is an oligotrophic lake with a large volume hypolimnion. As an oligotrophic lake, it produces less organic material that must be decomposed. Its large volume hypolimnion has a substantial oxygen supply that is not reduced significantly by the decomposition of the limited organic material, which falls into the hypolimnion during the summer. Consequently, dissolved oxygen levels remain high in the hypolimnion all summer long. In fact, dissolved oxygen levels are actually higher in the upper hypolimnion than at the water surface. The colder hypolimnion water is able to hold more oxygen than the warmer epilimnion (surface) waters.

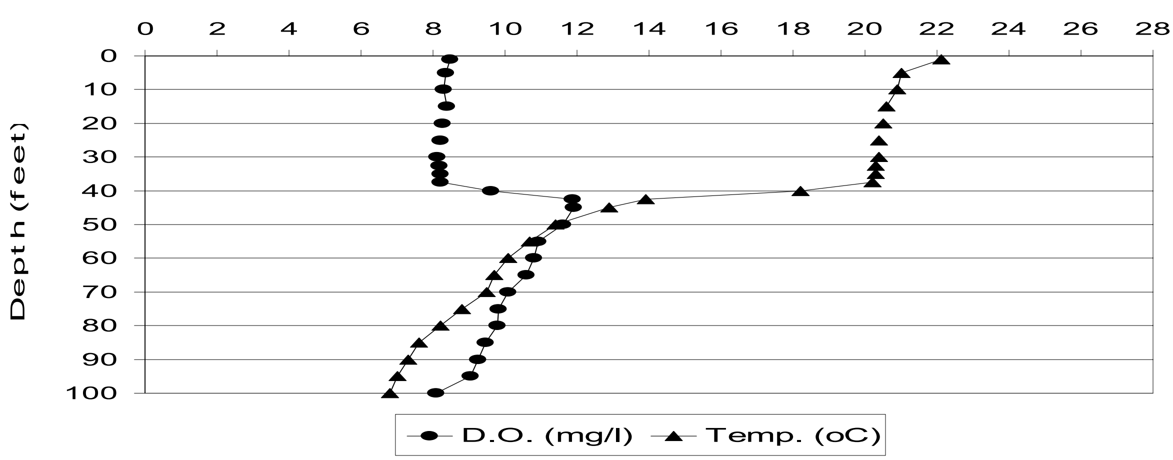
May 17, 2005



July 15, 2005



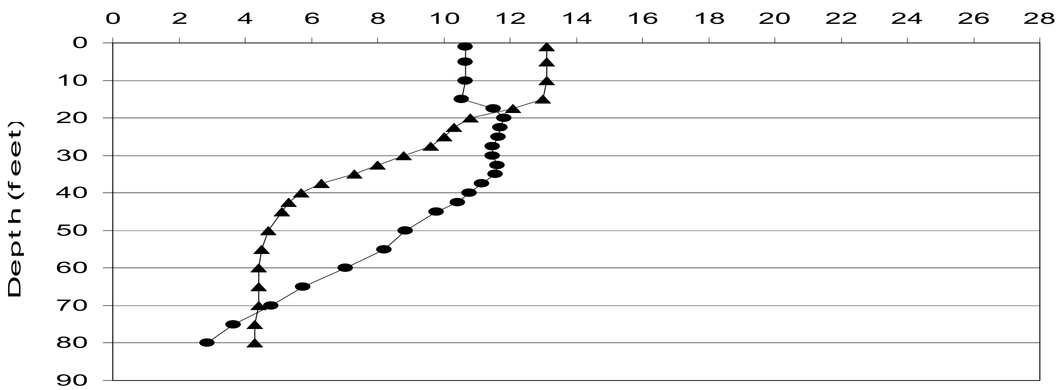
September 7, 2005



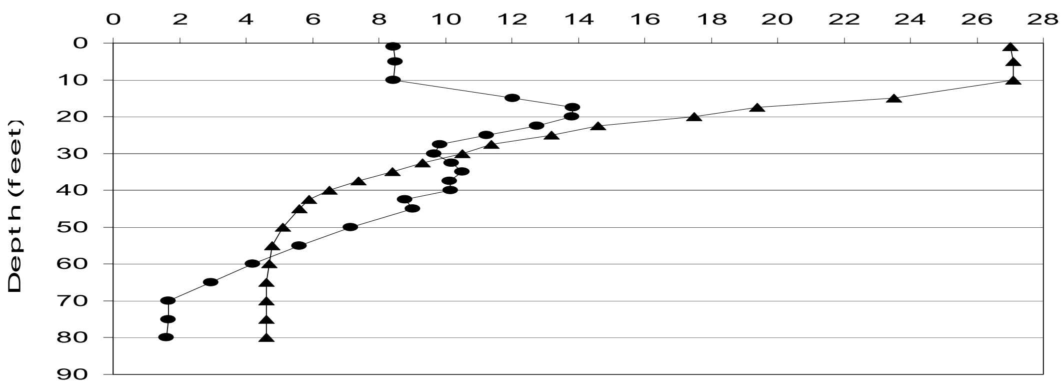
Oligotrophic/Mesotrophic Lake with a Large Volume Hypolimnion

Derby Lake in Montcalm County is an oligotrophic/mesotrophic lake with a large hypolimnion. It produces minor amounts of organic material that must be decomposed. Its hypolimnion has a substantial oxygen supply that is gradually depleted by the decomposition of the organic material. Dissolved oxygen levels remain high in the hypolimnion into mid-summer. By August oxygen is gone in the deepest waters, but the upper hypolimnion retains some oxygen even into late summer (September). Also, note that oxygen concentrations at mid-depth (20 to 40 feet) are higher than at the surface. This is due to a layer of deep algae producing oxygen in the colder water, which can hold more dissolved oxygen.

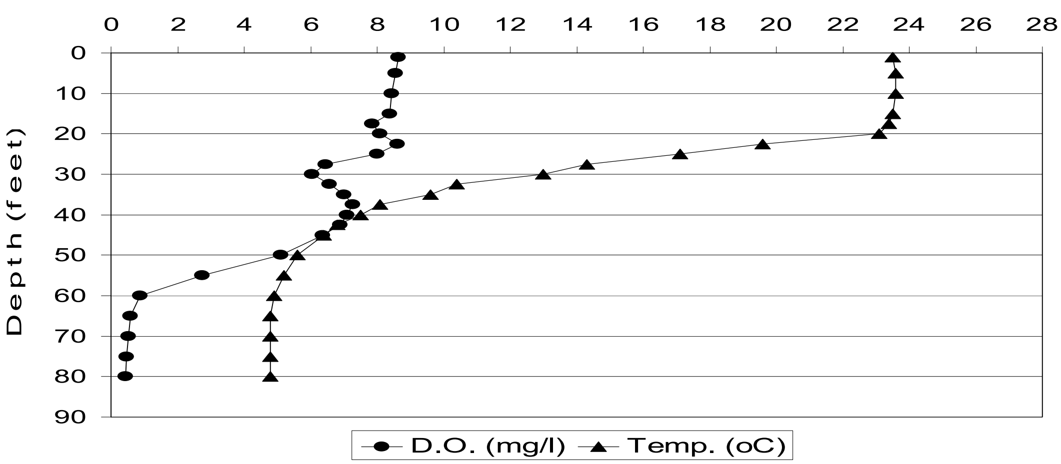
May 16, 2005



July 15, 2005

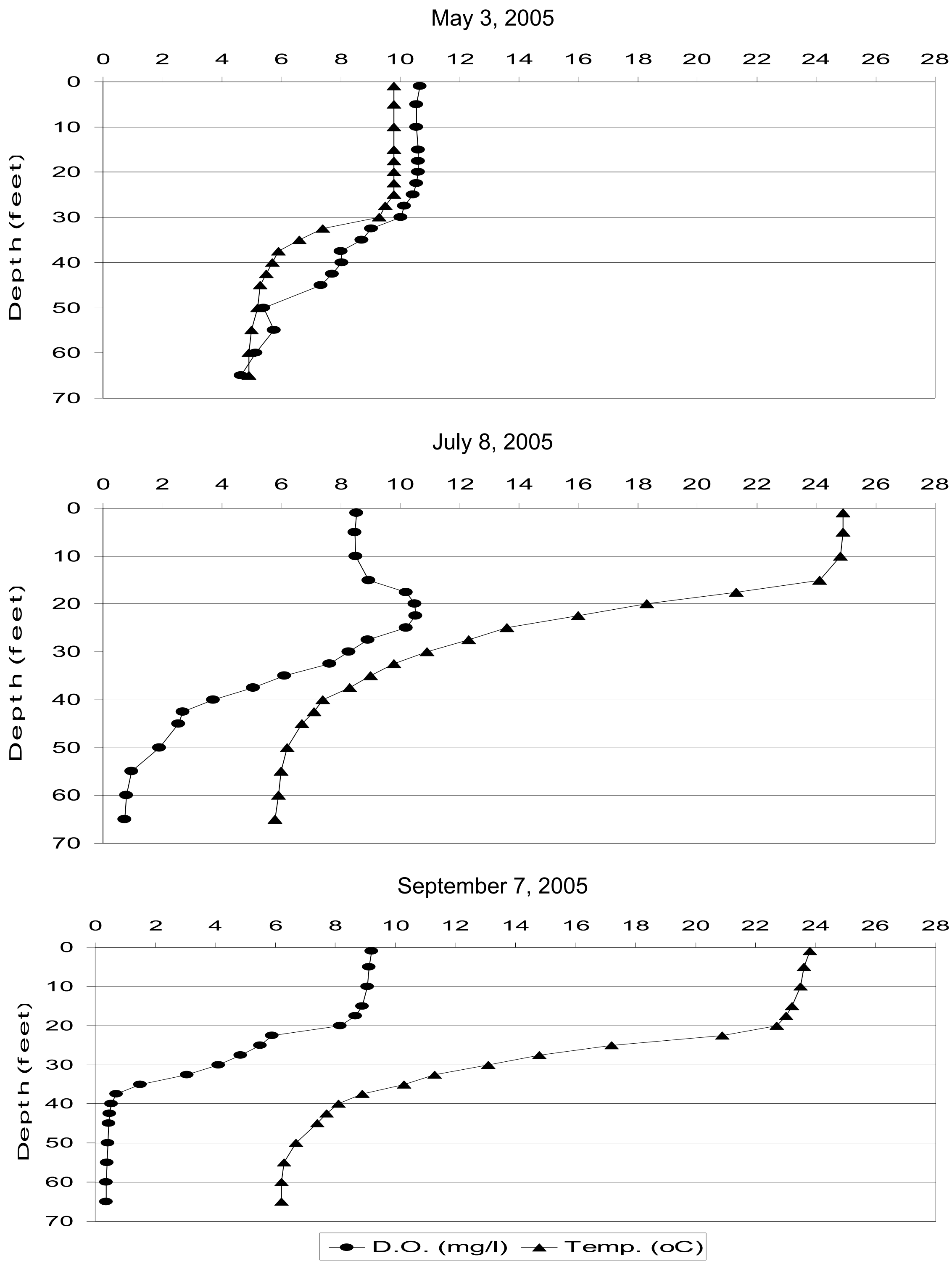


September 15, 2005



Oligotrophic/Mesotrophic Lake with a Small Volume Hypolimnion

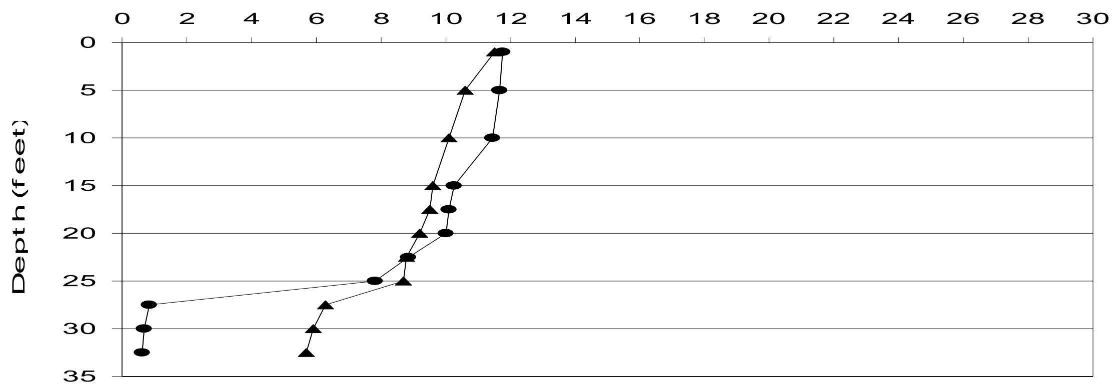
Crystal Lake in Newaygo County is an oligotrophic/mesotrophic lake with a small volume hypolimnion. As an oligotrophic/mesotrophic lake it produces minor amounts of organic material that must be decomposed. Its hypolimnion has a limited oxygen supply that is gradually depleted by the decomposition of the organic material, which falls into the hypolimnion during the summer. Dissolved oxygen levels remain in the hypolimnion into mid-summer, but by August oxygen is gone in the deepest waters, and by late-summer (September) the entire hypolimnion is without oxygen.



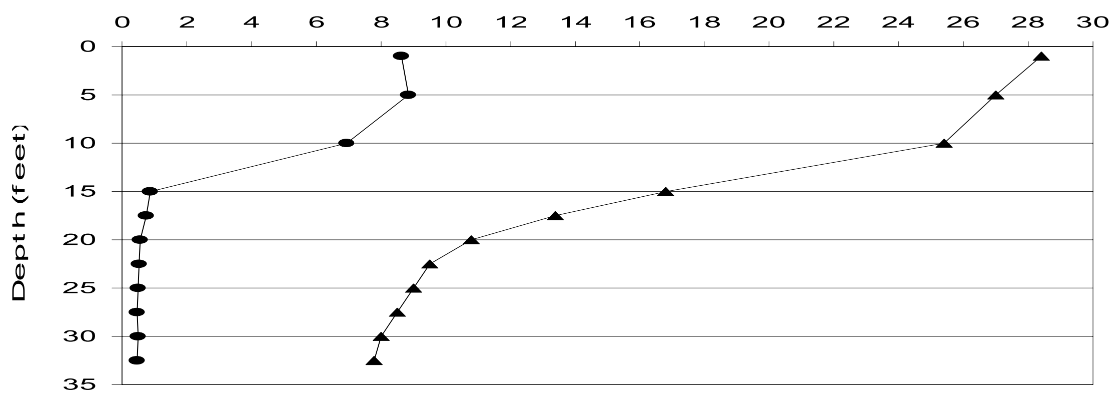
Eutrophic Lake with a Small Volume Hypolimnion

Robinson Lake in Newaygo County is a eutrophic lake with a small volume hypolimnion. As a productive lake it produces abundant amounts of organic material that must be decomposed. Its hypolimnion has a small oxygen supply that is rapidly depleted by the decomposition of the organic material, which falls into the hypolimnion during the summer. Dissolved oxygen levels in the hypolimnion drop to near zero within a few weeks of spring overturn. With no oxygen re-supply from the upper waters and atmosphere, the hypolimnion is devoid of oxygen all summer.

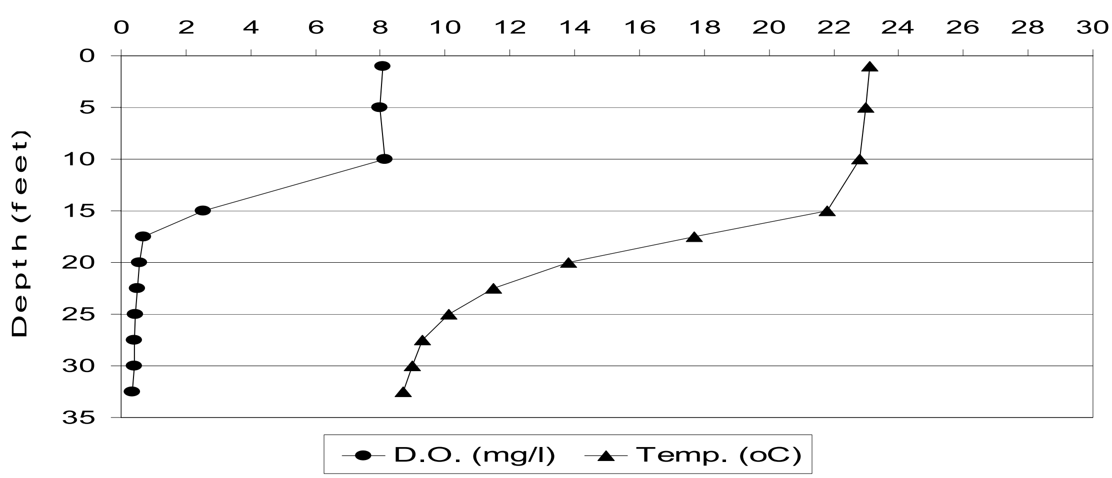
May 5, 2005



July 21, 2005



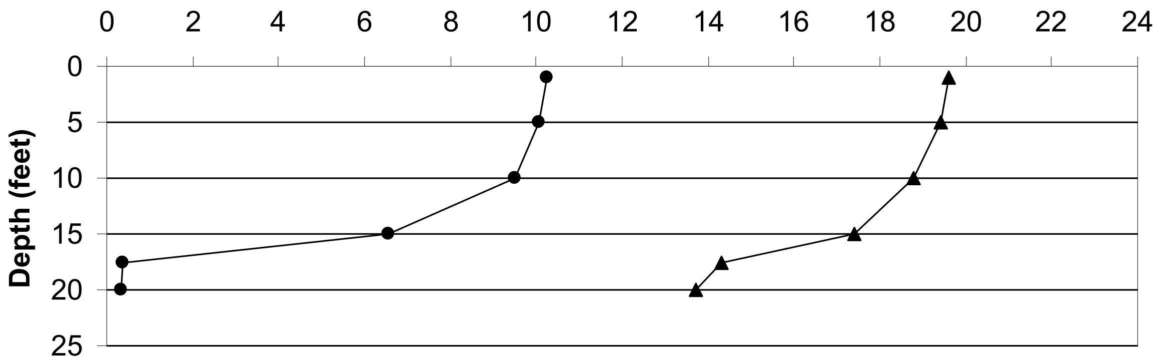
September 15, 2005



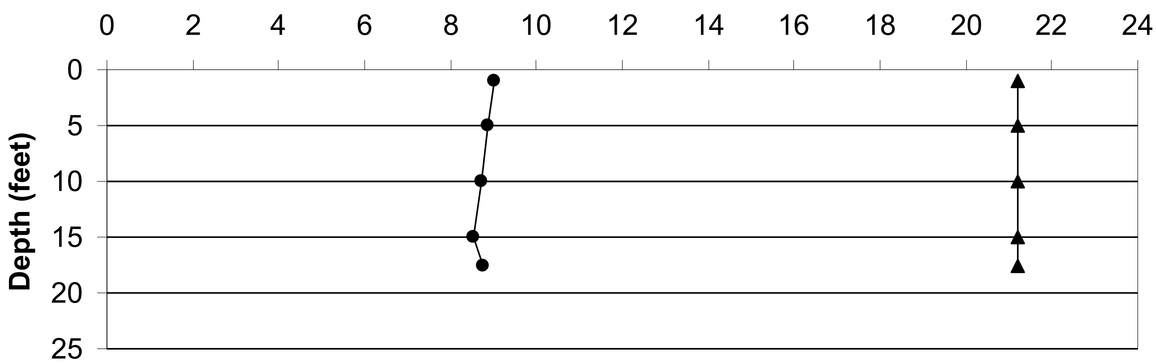
Shallow Eutrophic Lake that does not Maintain Summer Stratification

Hess Lake in Newaygo County is a shallow eutrophic lake with insufficient depth to maintain stratification all summer. As a eutrophic lake it produces abundant amounts of organic material that must be decomposed. Its hypolimnion, if present, has a very small oxygen supply that is rapidly depleted by the decomposition of the organic material, which falls into the deeper parts of the lake during the summer. Dissolved oxygen levels in the deeper water can drop to zero within a few weeks of spring overturn. Because the lake is shallow, summer storms can drive wave energy into the deepest parts of the lake breaking up any stratification present and re-supplying the deep water with oxygen. In the calm periods between storms, dissolved oxygen is again quickly lost.

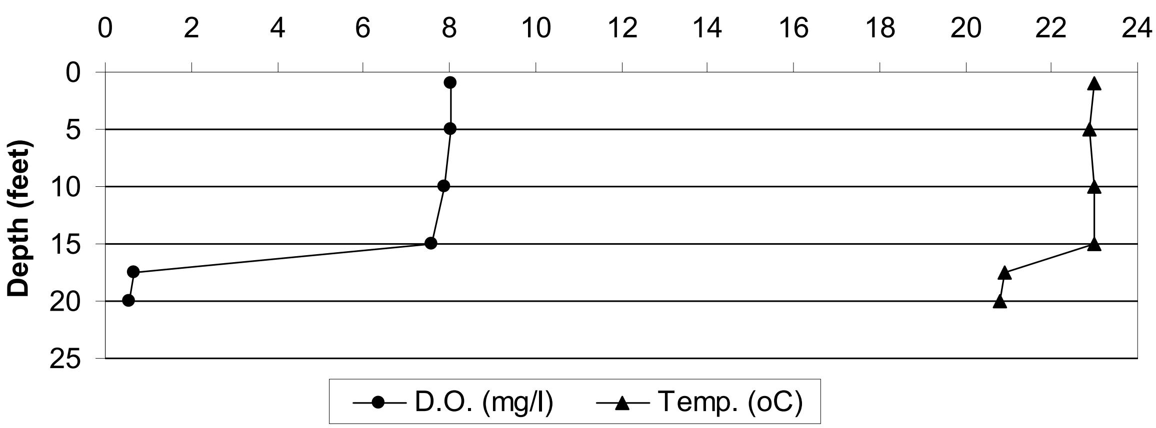
May 18, 2004



June 22, 2004



September 16, 2004



APPENDIX 5
2005 COOPERATIVE LAKES MONITORING PROGRAM
AQUATIC PLANT MAPPING RESULTS

Two lakes participated in the 2005 CLMP aquatic plant mapping project. They were Glen Lake in Leelanau County and Wells Lake in Osceola County. Both Lakes have similar productivity, with TSI values generally in the 30's and low 40's. The CLMP plant mapping project revealed that both lakes had limited plant populations consisting of a good diversity of species, none of which dominated except fern pondweed in Wells Lake, which the volunteer monitors believe may be a new introduction. Neither of the lakes had populations of exotic species. Both lakes have extensive shallow areas of water less than ten feet deep, which if conditions are appropriate could make the lakes susceptible to significant exotic species infestations.

As an example of the work completed in the CLMP aquatic plant mapping project the whole lake reporting data sheet for Wells Lake is presented below. These data are from a survey done on the lake in June. In addition to the data sheet each lake monitoring team produced aquatic plant maps for their lake.

Plant Number	Plant Name	Distribution (# of sites where observed)	Average Density
3	Duckweed	1	0.03
6	Cattail	2	0.07
10	Pickerelweed	3	0.17
12	White water lily	1	0.13
13	Yellow water lily	9	0.90
14	Watershield	4	0.33
20	Stonewort (Chara)	14	1.17
21	Bushy pondweed (najas)	8	0.37
22	Fern pondweed	30	3.56
30	Large-leaf pondweed	16	1.17
32	Thin-leaf pondweed	8	0.37
33	Flat-stemmed pondweed	2	0.10
36	Waterweed	11	0.67
40	Native milfoil	5	0.37
41	Coontail	2	0.10
	Unknown	3	0.17