

**Wisconsin  
Citizen  
Lake Monitoring  
Training Manual**  
(Chemistry Procedures)

**3rd Edition**

Written by  
Carolyn Rumery Betz and Patricia J. Howard

Revised by  
Sandy Wickman and Laura Herman



*Front cover: center photos courtesy of Robert Korth,  
background photo from the WI DNR photo archives.*

*Back cover: WI DNR photo archives.*

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## **CITIZEN LAKE MONITORING NETWORK**

[www.dnr.wi.gov/lakes/CLMN](http://www.dnr.wi.gov/lakes/CLMN)

- **Log in to Enter Data**
- **Find Lake Summary Reports**
- **Graphs and Data**
- **Data Sheets**
- **Remote Sensing Schedule**
- **Your Satellite Path**
- **Awards**
- **Quality Assurance Project Plan**



## **CITIZEN LAKE MONITORING NETWORK**

[www.uwsp.edu/uwexplakes](http://www.uwsp.edu/uwexplakes)

- **Manuals**
- **Data Sheets**
- **Training Videos for Water Clarity and Water Chemistry**
- **CLMN Newsletter**
- **Links to Other UWEX-Lakes Resources**
  - \* **Lake Tides**
  - \* **Lake Convention**
  - **Lake Leaders**
  - **Healthy Lakes Wisconsin**

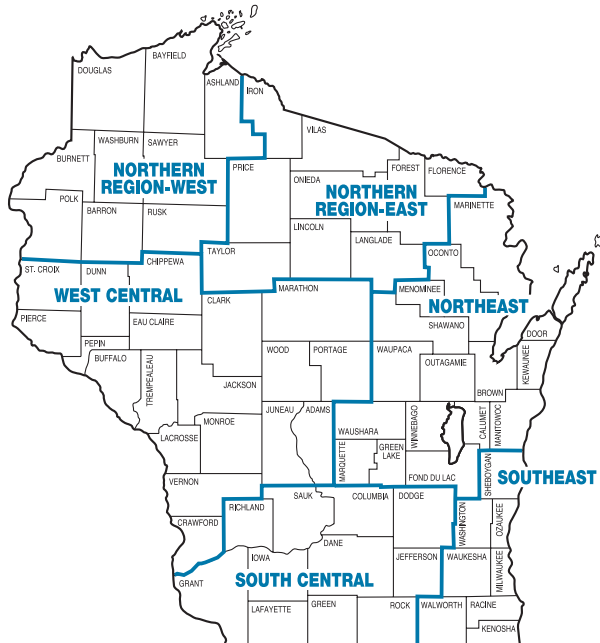


# Need Answers to Your Questions?

Regional CLMN coordinators cover certain counties. The map with areas of coverage is listed below. You may also be able to find answers to your questions on the Wisconsin Department of Natural Resources website at [www.dnr.wi.gov/lakes/CLMN](http://www.dnr.wi.gov/lakes/CLMN) or the UWEX-Lakes CLMN website at [www.uwsp.edu/uwexlakes](http://www.uwsp.edu/uwexlakes).

If you are interested in becoming a citizen lake monitoring volunteer, or have questions about training, refresher courses, or other monitoring opportunities, please contact Paul Skawinski, Citizen Lake Monitoring Network Educator, at (715) 346-4853, or by email [Paul.Skawinski@uwsp.edu](mailto:Paul.Skawinski@uwsp.edu).

For questions about the database, reporting data, or annual reports please contact the WDNR Citizen Lake Monitoring Network support team by email [DNRLakeb@wisconsin.gov](mailto:DNRLakeb@wisconsin.gov).



For questions about equipment, sampling procedures, or interpreting your water quality data, please contact your regional coordinator. You can visit [www.dnr.wi.gov/lakes/CLMN](http://www.dnr.wi.gov/lakes/CLMN) for a current listing of Citizen Lake Monitoring Network coordinators or call 1-888-936-7463 and ask for the citizen monitoring network coordinator number for your county.



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# Introduction

**THANK YOU** for joining the **Citizen Lake Monitoring Network (CLMN or Network)**. You are one of over a thousand citizen volunteers currently monitoring Wisconsin's lakes. Over one million acres of Wisconsin is covered by water. Wisconsin's 15,000 lakes contribute significantly to the economy of individual communities and the state. In addition, these lakes offer diverse recreational opportunities and provide important habitat for fish, waterfowl, and other wildlife. The volunteer monitoring network provides an opportunity for citizens to take an active role in monitoring and helping to maintain water quality. Through this volunteer network, you can learn about your lake and help the Wisconsin Lakes Partnership gain a better understanding of our state's lakes. More importantly, you can share your knowledge and the information you gather with your **lake association** and other lake residents.

The partnering of concerned citizens and the Wisconsin Department of Natural Resources (Wisconsin DNR) was initiated in 1986. In the Network's first year, volunteers throughout the state monitored 129 lakes. Since then, the Network has grown to include over 1,200 volunteers monitoring more than 900 lakes statewide! Some volunteers monitor more than one lake and some larger lakes are monitored at more than one location. Many volunteers share monitoring responsibilities with a friend or a group of friends. That first partnership has grown to include the University of Wisconsin Extension (UWEX) and Wisconsin Lakes. These groups working together with volunteers to form the Wisconsin Lakes Partnership.



*Children of a culture born  
in a water-rich  
environment, we have  
never really learned how  
important water is to us.  
We understand it,  
but we do not respect it.*

*—William Ashworth*



LINDA POHLOD

**A full glossary of highlighted terms is provided on page 93 of this manual.**

**LAKE ASSOCIATION** • *A voluntary organization with a membership generally comprised of those who own land on or near a lake. The goals of lake associations usually include maintaining, protecting, and improving the quality of a lake, its fisheries, and its watershed.*



**SECCHI DISK** • A 20-cm (8-inch) diameter disk painted white and black in alternating quadrants. It is used to measure light transparency in lakes.

**PHOSPHORUS** • The major nutrient influencing plant and algal growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus refers to the amount of phosphorus in solution that is available to plants and algae. Total phosphorus refers to the amount of phosphorus in solution (reactive) and in particulate forms (non-reactive).

**CHLOROPHYLL** • Green pigment present in all plant life and necessary for photosynthesis. The amount of chlorophyll present in lake water depends on the amount of algae and is used as a common indicator of water quality.

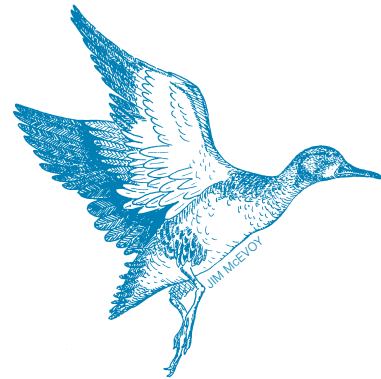
**DISSOLVED OXYGEN** • A measure of the amount of oxygen gas dissolved in water and available for use by microorganisms and fish. Dissolved oxygen is produced by aquatic plants and algae as part of photosynthesis.

**LAKE CLASSIFICATION** • A way of placing lakes into categories with management strategies best suited to the types of lakes found in each category. For example, lakes can be classified to apply varying shoreland development standards.

They can be grouped based on hydrology, average depth, surface area, shoreline configuration, as well as, sensitivity to pollutants and recreational use.

CLMN offers volunteers the opportunity to collect many types of data. The type of data you collect will depend on your concerns and interests, as well as the amount of time you wish to spend monitoring. **Secchi disk** monitoring is the backbone of CLMN and is the most common type of monitoring. Secchi volunteers collect water clarity information on their lakes throughout the open water season. After collecting Secchi data for one or more years, some volunteers choose to get involved in other types of monitoring. Secchi volunteers may be asked by their Lakes Coordinator to collect chemistry data on their lake. Chemistry volunteers collect **phosphorus** and **chlorophyll** samples four times a year *in addition to* collecting Secchi data. This more extensive volunteer monitoring allows Wisconsin DNR lake managers to assess the nutrient enrichment state for their lakes. In addition, some volunteers also collect temperature and **dissolved oxygen** (DO) data for their lakes. Other types of monitoring activities include aquatic invasive species monitoring and native aquatic plant monitoring. Ideally, all volunteers will be able to find a level of involvement that suits their interests and abilities.

The partnership between the volunteer monitors and the Wisconsin DNR has resulted in an extensive volunteer monitoring database. Data collected by volunteers has been published in numerous reports and is frequently used by limnologists (scientists who study lakes) and water resource planners for a variety of purposes. In addition, volunteer data is reported to the U.S. Environmental Protection Agency (EPA) on a regular basis.



## HOW IS CLMN DATA USED?

All citizen volunteers receive an annual data summary report, electronically or by mail, for their lake as well as periodic statewide reports. Most volunteers share this information with other lake residents who are interested in learning more about lake water quality. Lake groups, DNR, and county land conservation offices use CLMN data to support water quality projects such as shoreland restoration, **lake classification**, shoreland zoning, and nutrient diversion projects. All lake data is available to the public at [www.dnr.wi.gov/lakes/CLMN](http://www.dnr.wi.gov/lakes/CLMN).

Every two years, Section 303(d) of the Clean Water Act requires states to publish a list of all waters that do not meet water quality standards. CLMN data is used in the Impaired Waters listing process.

We estimate that citizen collected data has a value of \$4.08 million since 1986!

### **Fish biologists and lake managers use volunteer data to**

- support general lake management decisions,
- support lake planning and protection grants,
- craft aquatic invasive species management decisions,
- determine lake health,
- look at winterkill or summer anoxic conditions,
- supplement statewide long-term trend data to analyze trends and issues and climate change, and
- establish “baseline” data to look at water quality changes and trends through time.

**CLMN data** is used to research water quality trends, to assist with remote sensing research, to investigate climate change and to further wildlife research.

**Volunteer data is provided to other organizations, the state legislature, and federal, tribal, and local agencies** that in turn may use this data to help determine funding for invasive species grants and programs. Every two years, lake data are included in Wisconsin’s Biennial Water Quality Report to Congress.

**Volunteer data is also used by Earth Echo Water Challenge**, an international education and outreach program that builds public awareness and involvement in protecting water resources around the world by engaging citizens to conduct basic monitoring of their local water bodies.

**Volunteer data is incorporated into the Secchi Dip-In.** The Secchi Dip-In is a demonstration of the potential of volunteer monitors to gather environmentally important information on our lakes, rivers, and estuaries. Volunteers have been submitting information during the annual Dip-In since 1994. It is an international effort to track changes in water quality. [nalms.org/secchidipin](http://nalms.org/secchidipin)

# What is Expected of Me?

What we need most from Secchi and water chemistry volunteers is your time and keen observations of your lake. As a **Secchi volunteer**, you will determine how the water clarity of your lake compares to similar lakes statewide and watch for long-term changes. As a water chemistry volunteer, you will continue to collect water clarity (Secchi disk) data every other week throughout the open water season. Chemistry volunteers collect water chemistry data four times a year. Chemistry volunteers collect a phosphorus sample during spring overturn (or turnover) which happens within two weeks after ice out; and phosphorus and chlorophyll samples the last two

weeks of June, July, and August. The Network provides all of the equipment and training needed to collect your water samples and data.

Chemistry monitoring requires minimal expense on your part. Volunteers are responsible for providing distilled water for cleaning water sampling equipment, and ice for shipping the water samples to the State Lab of Hygiene (WSLH). Volunteers also provide the boat and fuel to get to the sampling location (usually the deepest part of your lake). Chemistry monitoring requires a fairly substantial time commitment. Although Secchi disk sampling may only take a few minutes, lake chemistry sampling may take up to several hours to complete. The exact amount of time involved will depend on the size and depth of your lake and your familiarity with the sampling procedures. Like anything else, the more experience

*(continued on page 6)*

## Season Schedule for Chemistry, Temperature and Dissolved Oxygen Monitoring

Parameters	April/May	June	July	August	September	October
<b>Secchi</b>	Every 10 to 14 days check satellite dates	Every 10 to 14 days check satellite dates	Every 10 to 14 days check satellite dates	Every 10 to 14 days check satellite dates	Every 10 to 14 days check satellite dates	1 to 3 times if possible
<b>Phosphorus</b>	Yes within 2 weeks of ice off	Yes last 2 weeks of June	Yes last 2 weeks of July	Yes last 2 weeks of August or early September	No	No
<b>Chlorophyll</b>	No	Yes last 2 weeks of June	Yes last 2 weeks of July	Yes last 2 weeks of August or early September	No	No
<b>Temp. Profile</b>	Yes	Yes	Yes	Yes	Yes	optional
<b>D.O. Profile</b> (if collecting)	Yes	Yes	Yes	Yes	Yes	optional

It is important to collect the April/May phosphorus sample when the lake is still "turning over" – ideally within two weeks of ice out.

If possible, there should be about one month between the summer chemistry (total phosphorus, chlorophyll) dates.

Ice out and ice on dates can be entered into the CLMN database.

**Satellite dates and paths are listed on the CLMN web page.**

## Sample Schedule

A typical year of volunteer monitoring may look something like this:



### February

Check your lake summary report from the CLMN website for accuracy. Volunteers who do not have access to the Internet will receive a paper copy of last year's lake summary report in the mail. Awards for length of service in CLMN or exceptional service will be distributed.

### March

Volunteers should expect to receive their spring monitoring supplies (filters, labels, merchandise return labels, lab slips). Volunteers may be asked to attend a refresher course during March, April, or May and may be asked to pick up sulfuric acid vials and dissolved oxygen chemicals at a local Wisconsin DNR office. Print off your data sheets and remote sensing schedule.

The annual Wisconsin Lakes Convention is held in March or April.

### April

Chemistry volunteers collect a phosphorus sample WITHIN two weeks OF ice off (during spring overturn) – this may occur in April or May. DO NOT collect a chlorophyll sample in April or May.

Continue taking Secchi readings every 10 to 14 days throughout the open water season.

### May

If your first chemistry sample was collected in April, there is no need to collect a phosphorus sample in May.

Continue to take Secchi readings. New volunteers are trained.

### June

Chemistry volunteers collect a chlorophyll and phosphorus sample during the last two weeks of the month.

Invasive Species Awareness Month.

### July

Coordinate Secchi readings with satellite dates.

Secchi Dip-In

Chemistry volunteers take a chlorophyll and phosphorus sample during the last two weeks of July.

### August

Coordinate Secchi readings with satellite dates.

Chemistry volunteers take a chlorophyll and phosphorus sample during the last two weeks of August.

### September

Coordinate Secchi readings with satellite dates.

No chemistry samples collected.

### October

Volunteers wrap up Secchi monitoring for the season.

No chemistry samples collected.

### November

Make sure that all your data has been submitted to Wisconsin DNR. If data has been entered into SWIMS database you do not need to submit a paper copy. If you do not have Internet access, mail copies of your data using the addressed envelopes that are provided to you.

### December

Check your equipment and report broken, lost or damaged equipment to your CLMN regional coordinator. Make sure that all chemicals and your electronic temperature meter are kept in a warm location and do not freeze.

The battery in your electronic temperature meter will last longer if you remove it before winter.

## WHAT IS THE REMOTE SENSING PROGRAM?

The development of capabilities for the remote sensing of water quality in Wisconsin started in 1999 when Citizen Lake Monitoring Network (CLMN) volunteers assisted in a collaborative research effort with the University of Wisconsin-Madison Environmental Remote Sensing Center (ERSC) to develop a model for the retrieval of water clarity data from satellite images. CLMN volunteers collected on-the-ground Secchi depth data when the satellites were overhead to calibrate this model for each satellite image and water clarity data was retrieved for over 8,000 lakes statewide between 1999 and 2001. This research effort provided the foundation for the operational remote sensing of water clarity at the Wisconsin DNR in subsequent years. Today remote sensing data from the NASA/USGS Landsat Program are used by the Wisconsin DNR to provide satellite retrieved Secchi depth data for thousands of lakes annually with the support of CLMN volunteers. Different weather conditions and atmospheric effects on satellite images and challenges in the atmospheric correction of satellite images mean on-the-ground Secchi depth data is still needed to calibrate this model for each satellite image. Your CLMN volunteer coordinator will send you a list of Landsat 7 ETM+ and Landsat 8 OLI-TIRS image acquisition dates for your lake if you are one of our Secchi volunteers and want to support our operational efforts. The satellite image specific algorithms will translate your data to data for hundreds of lakes within the same satellite image if you collect it on a clear satellite image acquisition date for your lake! Find out more about remote sensing at <http://dnr.wi.gov/lakes/CLMN/remotesensing/>.



**LAKE DISTRICT** • *A special purpose unit of government with the cause of maintaining, protecting, and improving the quality of a lake and its watershed for the mutual good of the members and the lake environment*

you have sampling, the smoother it will go. Volunteers who participate in chemistry monitoring will be asked to participate periodically in refresher sessions. These sessions ensure that everyone is familiar with current procedures and that all monitoring equipment is in good condition. Refresher courses also offer the opportunity to meet other volunteers and to ask Wisconsin DNR staff questions about monitoring and lake issues. Volunteers may also be asked to pick up spring sampling equipment at Wisconsin DNR offices or locations chosen throughout the DNR regions.

There are three things that may influence your enjoyment when participating as a citizen volunteer: your overall health, the type of boat you use, and whether or not you have a sampling partner. While the sampling duties are not too physically demanding, you should be in good overall health. A fishing boat or pontoon boat is ideal for sampling work and will be safer and more comfortable than a canoe. A sampling partner will make your job safer, easier, and faster as one person can record data while the other collects samples.

We ask that if you retire from CLMN you contact your CLMN regional coordinator. There is always more demand for water chemistry training and equipment from volunteers than there is available equipment. If you decide that you are unable to collect water chemistry and Secchi samples your equipment will be passed on to someone else on the lake or used on another lake.

**If you pass your equipment on to another volunteer on the lake, please let your CLMN regional coordinator know. New chemistry volunteers should be trained by a CLMN coordinator. Protocols often change and it is important that new volunteers get the most up to date training. And, in some cases, a determination may be made to discontinue chemistry monitoring on certain lakes.**

## THE CITIZEN LAKE MONITORING NETWORK PARTNERSHIP



**Volunteer citizen lake monitoring is a team effort with many players including citizen volunteers, Wisconsin DNR, UWEX and Wisconsin Lakes.**

### **The citizen volunteer is the most important player in the lake monitoring network.**

You know your lake on a day-to-day basis. You know the best spots to fish and what birds visit or nest on the lake. You know when the lake freezes over, when the ice goes out, and you know your neighbors and friends who love and use the lake. You volunteer to participate because of your genuine concern for the lake and your desire to learn more about it. Collecting water quality data is a step in the right direction to gaining a better understanding of your lake.

We depend on volunteers to share the information that they learn about their lakes with their Lake Association, Lake District, or other residents on the lake. You have the best access to your neighbors. Many volunteers share their lake status report every year at annual meetings. Your lake summary report, graphs, and narrative will help you to prepare this report. Your CLMN regional coordinator or Wisconsin DNR lakes coordinator are available to assist you if you need help providing this information to your lake group.

### **Another member of the partnership is the Wisconsin DNR CLMN Regional Coordinator and local staff.**

Local staff is located in several Wisconsin DNR regional offices around the state. As a citizen volunteer, you may already know them or have worked with them in the past. If you have any questions about your lake and your monitoring duties, these are the first people you should contact to help answer your questions.

### **Wisconsin DNR CLMN staff located in Madison.**

Staff help maintain and analyze the volunteer data, keep track of awards, produce reports, and logistically keep the Network running smoothly. .

By the conclusion of the sampling season you will receive an email or postcard reminding you that reports about your lake are available online at the Wisconsin DNR website. The reports summarize previous years' data collected on your lake. These reports include text, graphs, and pictures that help you understand how the data you collected in the past year relates to your lake.

### **The University of Wisconsin – Extension lakes staff.**

The CLMN Statewide Educator is a UWEX-Lakes staff member. UWEX lakes staff ensure that trainers (Wisconsin DNR regional staff, outside agency trainers, and volunteer trainers) follow the Network's protocols when volunteers are trained. This ensures statewide consistency in data collected. UWEX staff write monitoring protocols; help to oversee the Quality Assurance/Quality Control portion of the Network; and order, build, and repair equipment for the Network.

All citizen volunteers receive **Lake Tides**, a quarterly newsletter published by the Wisconsin Lakes Partnership. The newsletter can also be viewed online at the UWEX-Lakes web page. Each issue of Lake Tides has several pages dedicated to topics of interest to CLMN volunteers.

CLMN volunteers receive a copy of **The Monitor**, published by UWEX-Lakes. The Monitor is sent to CLMN volunteers 4 times a year.

## THE CLMN LAKE MONITORING NETWORK HAS TEN PRIMARY GOALS



### 1. Quality and Accessible Data.

Following collection protocols will enable you to collect quality data on your lake. Recording your Secchi disk readings and water chemistry data carefully, regularly and according to procedures, will provide valuable information about your lake. When you report your data to the Network, it is readily available through a database on the Internet. The Wisconsin DNR relies on your data. Without your help, very few lakes would be monitored.

### 2. Document Water Quality Changes Over Time.

The Network's aim is to document water quality changes over time by summarizing the data that you collect and sharing that data with other volunteers and organizations. This is particularly important for those lakes where little or no data exists. You will be collecting baseline data that cannot be captured again in the future; and that will be used for decades to come. You will be able to compare your lake to hundreds of others using the statewide Summary Report. After several years of monitoring, your regional coordinator can work with you or your Lake Association to determine whether or not your lake should receive more intensive monitoring or management attention.

### 3. Educated and Informed Citizen Monitors.

The Network's goal is to help you learn more about basic **limnology**. By collecting, summarizing, and reviewing your data, you will increase your understanding of your lake's overall water quality and will be able to share this information with your Lake Association or other lake residents. The information you collect can be used to help make decisions about your lake (e.g., use restrictions, **watershed** management decisions, aquatic plant management, etc.).

### 4. Greater Number and Frequency of Lakes Monitored.

The Wisconsin DNR relies on citizen volunteers for most of its data. In a given year, Wisconsin DNR staff can only get out to a limited number of lakes, and often only get to these lakes once a year or once every five years. Your help allows many more lakes to be monitored on a much more frequent basis.

### 5. Enhanced Participation in Statewide Network of Volunteer Monitors.

The Network is a partner in a statewide network with other Wisconsin monitoring groups, such as, LoonWatch, Water Action Volunteer Stream Monitoring, and others.

### 6. Quality Support.

Support staff, located in Madison and Stevens Point, are available to help you with database or data reporting questions and awards. Each region of the state has a regional coordinator who trains volunteers and answers questions about equipment, sampling procedures, and annual reports.





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**7. Reduced Administrative Overhead (state, community, and citizen).**

Volunteer help reduces the Wisconsin DNR's operating costs and helps streamline workflow. By having volunteers sample lakes that need to be monitored, the Wisconsin DNR saves time and money involved in having staff travel to those lakes in order to collect the data. Those staff can in turn concentrate their efforts on other lakes. It is the Network's goal to keep monitoring and data reporting as simple and efficient as possible for the citizen volunteer.

**8. Engage Others in Support of the Network.**

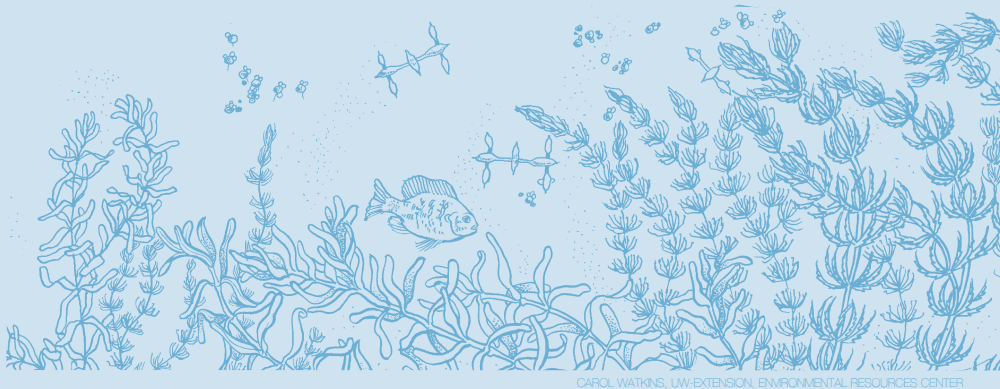
The Network is supported through a partnership, not just the Wisconsin DNR. The University of Wisconsin-Extension, Wisconsin Lakes, and private entities are engaged in providing support and services to the statewide network. Volunteers often serve as mentors or trainers for other volunteers.

**9. Tie-in to National Lake Research and Monitoring.**

Data is often used for lake research. For example, volunteer data has been used to successfully derive water clarity data on thousands of lakes from satellite imagery. You can see the results of this effort and learn more about satellite imagery and water clarity at [www.lakesat.org](http://www.lakesat.org). Volunteers are also annual participants in the "Secchi Dip-In," an international effort to monitor lakes. Visit [www.secchidipin@nalms.org](http://www.secchidipin@nalms.org).

**10. Recognize and Appreciate Citizen Involvement.**

At the end of each monitoring season, the Network provides length of service awards. Volunteers who have taken 100 or 500 Secchi readings on their lake receive recognition as well!



.....

**LIMNOLOGY** • *The study of inland lakes and waters. The study of the interactions of the biological, chemical, and physical parameters of lakes and rivers.*

**WATERSHED** • *The area of land draining into a specific stream, river, lake or other body of water.*

## What Types of Monitoring Can I Participate In?

**If you have an interest in any of the following monitoring activities, please contact your regional coordinator.**

### Secchi

Father Pietro Angelo Secchi was an Italian astrophysicist and the scientific advisor to the Pope. In 1865, he was asked by the head of the Papal Navy to develop a way to measure transparency in the Mediterranean Sea. Secchi used white disks to measure the clarity of water. The Secchi disk was adopted for use by limnologists as a way to measure water clarity and to set a numerical value to water quality. Secchi disks come in various sizes and colors.

A Secchi depth reading is intended to give a general picture of your lake's water clarity. The sampling is easy to do and does not require sophisticated, high-maintenance equipment nor demand a background in science, chemistry, or engineering. One Secchi reading will not tell you a great deal about your lake but Secchi disk readings taken over a period of time will tell a story about your lake – is your water clarity improving, declining, or remaining the same?

Wisconsin CLMN uses a Secchi disk that is 8 inches in diameter. It is black and white and weighted with a stainless steel plate. CLMN protocols must be followed closely so that the data that you collect can be compared to other lakes. The Secchi disk is lowered into the water on a marked rope until it just disappears from view, that point is marked with a clothespin at the water's surface. Volunteers then lower the disk a couple of feet further into the water. They then slowly raise the disk until they can see it again. That point is also marked with a clothespin.

The average of these two measurements is recorded. Doing the two measurements using the “clothespin method” allows the volunteer's eyes to acclimate to looking in the water and gives a more accurate reading. Measuring the water clarity or transparency of lakes over time provides a “pulse” on the health of these lakes, and is a crucial record for long-range planning.

### Water Chemistry

After one year of water clarity monitoring, you may be eligible to participate in water chemistry monitoring. Chemistry volunteers, in addition to measuring water clarity and temperature, collect water samples for analysis for phosphorus and chlorophyll levels four times a year. Volunteer collected samples are sent to the **State Laboratory of Hygiene (WSLH)** for analysis. The information volunteers collect when monitoring both Secchi and water chemistry is used to determine the **trophic state** of the lake. Training and equipment for chemistry monitoring are provided by the Wisconsin DNR. Secchi volunteers who have participated in the Network for at least one sampling season and are interested in becoming a chemistry volunteer should contact their CLMN regional coordinator. The number of chemistry lakes that are added each year is limited due to the cost of equipment and the cost of sample analysis by WSLH. Because of budget limitations lakes are prioritized according to the need for information.

### Temperature and Dissolved Oxygen

Water temperature impacts many organisms living in the lake. Reproduction, metabolic rate, and survival of fish and other aquatic animals; plant and algal growth and biomass; and nutrient cycling are all driven by water temperature. Long term data is needed to understand temperature trends.

DNR Fisheries Biologists and Lake Coordinators may ask you to collect a dissolved oxygen profile. Temperature and dissolved oxygen

profiles are collected at three-foot intervals at the deep hole.

A Van Dorn water sample bottle is used to collect the water sample from the various depths for dissolved oxygen testing. The collection profile will be determined by your regional coordinator. Winkler titration kits are available through CLMN.

Dissolved oxygen meters are not available through CLMN but your CLMN Coordinator may know of meters that are available to the public.

## **N**ative Aquatic Plant Monitoring

Aquatic plants are a good indicator of lake health. Over time, the type of vegetation and size of plant beds may change and/or move in response to changes in water quality, invasives, and human activity. Aquatic plant monitoring is tailored each volunteer's ability, interest, and time commitment and can vary from lake to lake. Some volunteers choose to identify and map plant beds on the lake, keeping track of beds based on whether the plants are submergent, emergent, or floating.

Other volunteers wish to have a more comprehensive list of the aquatic plants that are present on their lake. They identify, collect, and press their lake's aquatic plants and map the plants' location. All plants collected by volunteers are verified.

## **A**quatic Invasive Species (AIS) Monitoring

Citizen volunteer monitoring protocols for AIS can be found at the UWEX-Lakes website. Information on invasive species can be found on the DNR website.

If you think you have found an invasive, please contact your local CLMN coordinator so they can verify the specimen. The DNR website lists the lakes that are known to contain invasive species.



**AQUATIC INVASIVE SPECIES (AIS)** • Refers to species of plant or animal that are not native to a particular region into which they have moved or invaded. Wisconsin law prohibits launching or transporting a boat if aquatic plants or animals are attached to the boat.

## **PUBLIC PERCEPTION OF WATER QUALITY**

As part of your Secchi data collection, the Network is interested in your opinion of the lake's water quality when you are sampling. Using these observations, a public opinion assessment of water clarity can be made. This information will help determine water quality standards for lakes. There is no right or wrong answer to these questions and your answer can change throughout the summer or in subsequent years. Specifically, citizen volunteers will be asked to note the algal content of the water. Is there so much algae that you want to shower after swimming? Do you not want to go swimming? In addition to the Secchi disk readings that you measure, the Network is concerned with your opinion of what constitutes good or poor water quality.

The Network predicts that the public opinion question will reveal that people living in one area of the state will have similar perceptions of what they consider to be acceptable water clarity. The Network hopes to share this information with other states in anticipation of creating a regional map of public perceptions of water clarity.



**STATE LABORATORY OF HYGIENE (WSLH)** • The state of Wisconsin's public health and environmental laboratory.

**TROPHIC STATE** • The extent to which the process of eutrophication has occurred is reflected in a lake's trophic classification or state. The three major trophic states are oligotrophic, mesotrophic, and eutrophic.

**pH** • The measure of acidity or alkalinity of a solution. Neutral solutions are defined as having a pH of 7.0. Solutions which are known as acidic have a pH lower than 7. Solutions which are known as basic have a pH greater than 7.



**Eurasian Water-milfoil**

DNR PHOTO

**Eurasian Water-milfoil (EWM) Watch**

All volunteers are encouraged to monitor their lake for Eurasian water-milfoil (*Myriophyllum spicatum*). EWM is an aquatic plant that is not native to the United States and continues to populate many lakes throughout Wisconsin.

**Curly-leaf Pondweed Watch**

In Wisconsin, curly-leaf pondweed (*Potamogeton crispus*) usually completes its life cycle by June or July. Volunteers are asked to check plant beds on calm, clear days from ice off until mid-July.



**Curly-leaf Pondweed**

SUSAN WRIGHT

**Zebra and Quagga Mussel Watch**

The zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena rostriformis bugensis*) are two non-native mussel species that can spread rapidly and change food webs.

**Spiny Waterflea Watch**

Spiny waterfleas (*Bythotrephes spp.*) and fish hook waterfleas (*Cercopagis pengoi*) are small crustaceans distantly related to shrimp. Both species of waterflea entered the Great Lakes in ship ballast water from Europe. One or both of the species are now found in all of the Great Lakes. Spiny waterfleas are found in some inland lakes in Wisconsin.

Both species tend to gather in masses on fishing lines so anglers may be the first to discover a new infestation.



**Zebra Mussel**

**Chinese and Banded Mystery Snail Monitoring**

There are three species of mystery snails in Wisconsin. Only one of these species, the brown mystery snail (*Campeloma decisum*) is native to Wisconsin. The Chinese mystery snail (*Bellamya chinensis*) is native to Asia. The banded mystery snail (*Viviparus georgianus*) is native to southeastern United States.



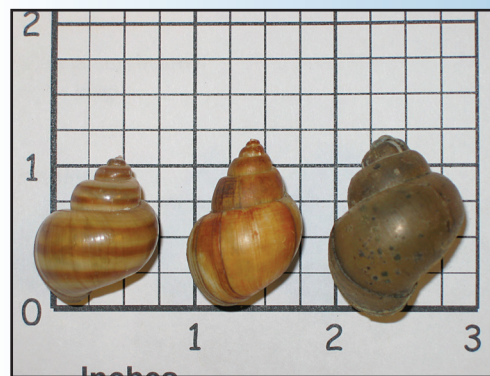
**Quagga Mussel**

EGB PHOTO



**Spiny Waterflea**

DOUGLAS A. JENSEN



LAURA HERMAN

**Banded Mystery Snail (left), Brown Mystery Snail which is native to Wisconsin (center), and Chinese Mystery Snail (right).**

# Volunteer Monitoring in and Around Wisconsin Waters



Welcome to the Citizen Lake Monitoring Network — a volunteer network with over 1,000 citizens collecting water quality data on Wisconsin's lakes! **We welcome you to check out these additional volunteer monitoring opportunities in and around Wisconsin waters!**



## Clean Boats, Clean Waters Watercraft Inspectors

Volunteers can also help stop the spread of invasive species by organizing and conducting watercraft inspections at boat landings in their communities. Trained volunteers then educate boaters on how and where invasive species are most likely to hitch a ride into water bodies. For more information, contact Erin McFarlane, Aquatic Invasive Species Volunteer Coordinator, [erin.mcfarlane@uwsp.edu](mailto:erin.mcfarlane@uwsp.edu).



## Water Action Volunteers

Water Action Volunteers (WAV) has three levels of stream monitoring to accommodate citizens' time availability and interests; volunteers begin by learning to monitor six aspects of water quality their first year. After a monitoring season, citizens can move to the next level to monitor stream health using the same methods as DNR biologists or can conduct intensive monitoring that addresses a specific issue about local stream quality. Contact [wav@extension.wisc.edu](mailto:wav@extension.wisc.edu)



## Project RED

Project RED (Riverine Early Detectors) allows volunteers to identify, report, and control invasive species in and along Wisconsin's rivers and streams. Volunteers are trained to monitor rivers and streams by canoe, kayak, or on foot for 16 species of concern. Contact [info@wisconsinrivers.org](mailto:info@wisconsinrivers.org)



## Mussel Monitoring Program of Wisconsin

Over half of Wisconsin's 51 native mussel species (also known as clams) are listed as species of greatest "conservation need"; we need information on where they currently occur. The Mussel Monitoring Program of Wisconsin would like your help in finding out what mussels occur in your area. [watri.net/inventory/mussels](http://watri.net/inventory/mussels).



## Odonata Survey

The goal of the Wisconsin Odonata Survey is to gain more knowledge about the distribution and habitat requirements of our 160+ species of dragonflies and damselflies (Order Odonata). The Odonata Survey uses volunteers to document populations of dragonflies and damselflies by identifying adults, larvae, and exuviae (cast skins left behind near shore when the larva transforms into the adult).

For more information, [watri.net/inventory/odonata](http://watri.net/inventory/odonata).



## LoonWatch

*LoonWatch* promotes the preservation, understanding, and enjoyment of common loons and their aquatic habitats in the Lake Superior region. Volunteers record when loons arrive, if they nested, how many chicks were produced, and any potential threats to the nest site. For more information, contact the *LoonWatch* Coordinator at (715) 682-1220 or email [loonwatch@northland.edu](mailto:loonwatch@northland.edu).





**Wisconsin Bat Program**

In general, bat populations are susceptible to decline because of low reproductive rates, and many species congregate at a limited number of locations during critical stages of their natural history cycle (i.e., hibernacula and maternity colonies). Volunteers can conduct acoustic surveys or can participate in bat house monitoring. For more information, contact the Wisconsin Bat Program [wiatri.net/inventory/bats](http://wiatri.net/inventory/bats).



**Wisconsin Turtle Conservation Program**

The Wisconsin Turtle Conservation Program (WTCP) records turtle species' distributions using the help of Wisconsin citizens. The program is looking for volunteers to document high turtle mortality locations along roads in order to promote effective management and conservation of Wisconsin's 11 turtle species. For more information, contact [wiatri.net/inventory/WI/turtles](http://wiatri.net/inventory/WI/turtles).



**Wisconsin Frog and Toad Survey**

The Wisconsin Frog and Toad Survey (WFTS) is a citizen-based monitoring program intended to determine the status, distribution, and long-term population trends of Wisconsin's frog and toad species. WFTS includes approximately 150 permanent roadside routes throughout the state where volunteers monitor frog populations through calling surveys. [wiatri.net/inventory/frogtoadsurvey](http://wiatri.net/inventory/frogtoadsurvey).



**Wisconsin Marshbird Survey**

Secretive marshbirds such as rails, bitterns, coots, and grebes are among the most poorly monitored bird groups in North America. Volunteers are needed to conduct surveys of a predetermined route during in May and June to help experts learn more about species' abundance, population trends, and habitat associations. For more information on marshbird surveys or additional bird monitoring opportunities, contact [wiatri.net/projects/birdroutes](http://wiatri.net/projects/birdroutes).



**Purple Loosestrife Biocontrol Project**

There are a number of methods to control purple loosestrife; however, biocontrol may be the most viable long-term control method. The Purple Loosestrife Biocontrol Program offers cooperative support, including free equipment and starter beetles, to all Wisconsin citizens who wish to use these insects to reduce their local purple loosestrife. For more information, contact program coordinator [jeannes.scherer@wisconsin.gov](mailto:jeannes.scherer@wisconsin.gov).

For more information, please visit the Wisconsin Department of Natural Resources at:

[www.dnr.wi.gov/volunteer/](http://www.dnr.wi.gov/volunteer/)

or the Wisconsin Citizen-based Monitoring Network at:

[www.wiatri.net/cbm/](http://www.wiatri.net/cbm/)



# Factors that Affect Water Clarity

Water clarity is a measure of the amount of particles in the water, or the extent to which light can travel through the water. There are many ways to express water clarity, including Secchi disk depth, turbidity, color, suspended solids, or light extinction. Chlorophyll-a, collected by water chemistry volunteers, is a measurement of the amount of **algae** that is in the water.

Water clarity is important for a number of reasons. It affects the depth to which aquatic plants can grow, dissolved oxygen content, and water temperature. Fish and loons and other wildlife depend on good water clarity to find food. Water clarity is often used as a measure of trophic status, or an indicator of ecosystem health. Water clarity is important aesthetically and can affect property values and recreational use of a water body (Tim Asplund, March 2000).

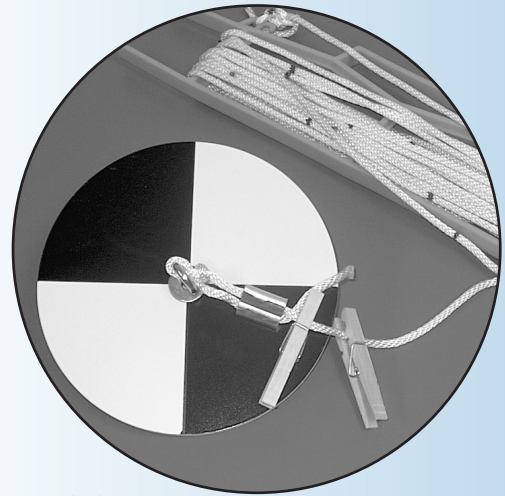
Suspended sediments, algal growth, runoff, shoreline erosion, wind mixing of the lake bottom, and tannic and humic acids from wetlands can all affect water clarity. Water clarity often fluctuates seasonally and can be affected by storms, wind, normal cycles in food webs, and rough fish such as carp, suckers, and bullheads.

## Suspended Sediments

Sediment may enter the lake from a river or stream. Sediment may also come from land use activities in the **watershed** including erosion from cropland and **runoff** from barnyards, construction sites, and city streets. In a shallow lake, sediment from the lake bottom can be suspended throughout the water column during heavy winds. Additionally, certain fish species (e.g., carp) may stir up bottom sediments and make the lake appear muddy. A lake with a lot of suspended sediment will appear cloudy, muddy, or brown. As a result, the Secchi disk may disappear from view within a few feet of the water's surface.

## Algae

**Phytoplankton** (a type of free-floating algae) is a vital part of the food chain in aquatic systems. They provide the food base for **zooplankton** (microscopic animals)



**Secchi disk**



**ALGAE** • Small aquatic plants containing chlorophyll and without roots that occur as single cell or multi-celled colonies. Algae form the base of the food chain in an aquatic environment.

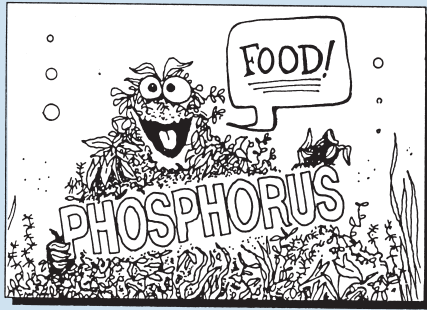
**WATERSHED** • The area of land draining into a specific stream, river, lake, or other body of water.

**RUNOFF** • Water from rain, snow melt, or irrigation that flows over the ground surface and into streams or lakes.

**PHYTOPLANKTON** • Very small free-floating aquatic plants, such as one-celled algae. Their abundance, as measured by the amount of chlorophyll a in a water sample, is commonly used to classify the trophic status of a lake.

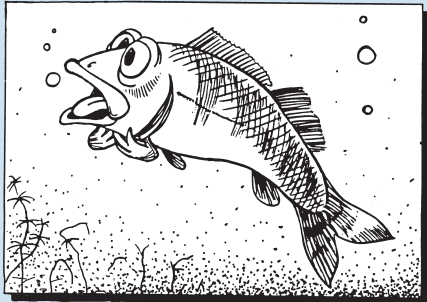
**ZOOPLANKTON** • Plankton that is made up of microscopic animals, for example, protozoa, that eat algae. These suspended plankton are an important component of the lake food chain and ecosystem. For many fish and crustaceans, they are the

## FAMILIAR SIGNS OF RUNOFF POLLUTION

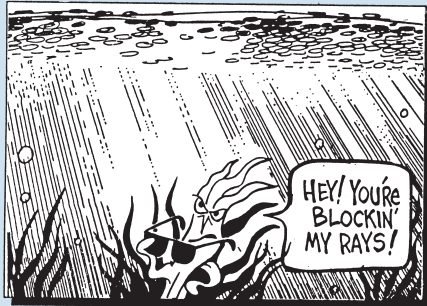


### ALGAE

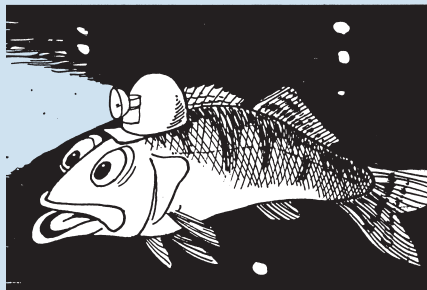
Nutrients, such as phosphorus and **nitrogen**, come from sediments, manure, pet wastes, improperly maintained septic systems, and misapplication of fertilizers on lawns or farm fields. Phosphorus contributes to the **eutrophication** (over-fertilization) of lakes. This leads to an increase in aquatic macrophyte and algae growth. Excess aquatic macrophytes and algae are harmful to fish and make a lake less attractive for swimming, boating, and other activities (UW Extension 2001).



**When algae and aquatic weeds die they are broken down by bacteria.** Bacteria consume oxygen during decomposition and make it difficult for fish and other aquatic life to survive. Excess aquatic macrophytes also contribute to winter fish kills in shallow lakes (UW Extension 2001).



**Excess algae can reduce populations of bottom-rooted plants by blocking sunlight.** Bottom-rooted plants provide food and habitat for fish and waterfowl (UW Extension 2001).



### SEDIMENT

**Sediments can cause water to become cloudy, or "turbid", making it difficult for fish to see and feed properly.** Sediments can also damage fish gills and impair the feeding and breathing processes in aquatic insects (UW Extension 2001).

**Sediments cloud the water and cover plant leaves, reducing sunlight penetration and inhibiting photosynthesis.** Without photosynthesis, desirable plant populations are reduced, leaving fewer habitats for fish and small organisms (UW Extension 2001).

**EUTROPHICATION** • The process by which lakes and streams are enriched by nutrients causing an increase in plant and algae growth. This process includes physical, chemical, and biological changes that take place after a lake receives inputs for plant nutrients (mostly nitrates and phosphates) from natural erosion and runoff from the surrounding land basin. The extent this process occurs is reflected in a lake's trophic classification. Lakes can be classified as being oligotrophic (nutrient poor), mesotrophic (moderately productive), or eutrophic (very productive and fertile).

**NITROGEN** • One of the major nutrients required for the growth of aquatic plants and algae. Various forms of nitrogen can be found in water: organic nitrogen, most of which eventually decomposes to ammonia; ammonia, produced from organic decay by bacteria and fungi; nitrite, produced from ammonia by nitrite bacteria; and nitrate, the form which is most readily available for use by plants. Nitrate is produced from nitrous



that eventually are eaten by fish, ducks, and other animals. Too much phytoplankton can disrupt the natural balance of a lake ecosystem, make the lake unsightly, and make swimming and other activities less enjoyable.

Blue-green algae, also known as Cyanobacteria can grow very quickly in number if conditions are just right. Concerns associated with blue-green algae include discolored water, reduced light penetration, taste and odor problems, dissolved oxygen depletions during die-off, and toxin production. If your lake has little turbidity due to sediment, the Secchi disk data you provide will give a relative estimate of how much algae is present in your lake. It will not reveal what types of algae are present.

## Water Color

Some lakes, especially those near acidic wetlands such as bogs, may be stained brown like tea. This is an indication that the water contains tannic acid that leached from the surrounding vegetation. Since light does not penetrate as well through dark-colored water, Secchi depth may be low although algae may be less abundant. Plant densities may be lower in stained lakes since sunlight is not able to penetrate very deep into the water column. You may also notice a change in water color over the sampling season. Seasonal color changes most likely reflect changes in algae productivity. If your lake turns unusually green, brown, or orange for a few weeks during the summer months, the change is probably the result of an algal bloom. To fully understand variations in Secchi depth, water color observations over time must be recorded.

## Mixing and Stratification

A lake's water quality and ability to support fish are affected by the extent to which the water mixes. Mixing will also impact your Secchi disk reading. The depth, size, and shape of a lake are the most important factors influencing mixing; although climate, lakeshore topography, inflow from streams, and vegetation also play a role (Shaw et al. 2000).

Water density is greatest at 39°F. It is lighter at both warmer and colder temperatures. Variations in water density caused by different temperatures can prevent warm and cold water from mixing (Shaw et al. 2000). When lake ice melts in early spring, the temperature and density of lake water will be similar from top to bottom.



**STRATIFICATION** • The layering of water due to differences in temperature and density.

**EPILIMNION** • The uppermost circulating layer of warm water that occurs in stratified lakes in summer because of the differences in water density. Water's greatest density occurs at 39°F. In lakes that stratify, as water warms during the summer, it remains near the surface while the colder water remains near the bottom. The depth of the epilimnion is determined by wind and usually extends about 20 feet below the surface.

**THERMOCLINE** • Sometimes referred to as the metalimnion. The narrow transition zone between the epilimnion and the hypolimnion that occurs in stratified lakes.

**METALIMNION** • Sometimes referred to as the thermocline. The narrow transition zone between the epilimnion and the hypolimnion that occurs in stratified lakes.

**HYPOLIMNION** • The cold, deepest layer of a lake that is removed from surface influences.



This uniform water density allows the lake to mix completely, recharging the bottom water with oxygen and bringing nutrients to the surface (Shaw et al. 2000). This mixing process is called spring overturn. As surface water warms in the spring, it loses density. Due to physics, wind and waves can only circulate the warmed water 20 to 30 feet deep, so deeper areas are not mixed. If the lake is shallow (less than 20 feet), however, the water may stay completely mixed all summer (Shaw et al. 2000).

During the summer, lakes more than 20 feet deep usually experience a layering called **stratification**. Depending on their shape, small lakes can stratify even if they are less than 20 feet deep. In larger lakes, the wind may continuously mix the water to a depth of 30 feet or more. Lake shallows do not form layers, though deeper areas may stratify. Summer stratification, as pictured in Figure 1, divides a lake into three zones: **epilimnion** (warm surface layer), **thermocline** or **metalimnion**

(transition zone between warm and cold water), and **hypolimnion** (cold bottom water). Stratification traps nutrients released from the bottom sediments in the hypolimnion (Shaw et al. 2000).

In the fall, the surface cools until the water temperature evens out from top to bottom, which again allows mixing (fall overturn). A fall algae bloom often appears when nutrients mix and rise to the surface. Winter stratification, with a temperature difference of only 7°F (39°F on the lake bottom versus 32°F right below the ice), remains stable because the ice cover prevents wind and waves from mixing the water (Shaw et al. 2000).

The lake's orientation to prevailing winds can affect the amount of mixing that occurs. Some small, deep lakes may not undergo complete mixing in the spring or fall if there is not enough wind action. The mixing that takes place in the bays of a large lake will more closely resemble that of a small lake because the irregular shoreline blocks the wind (Shaw et

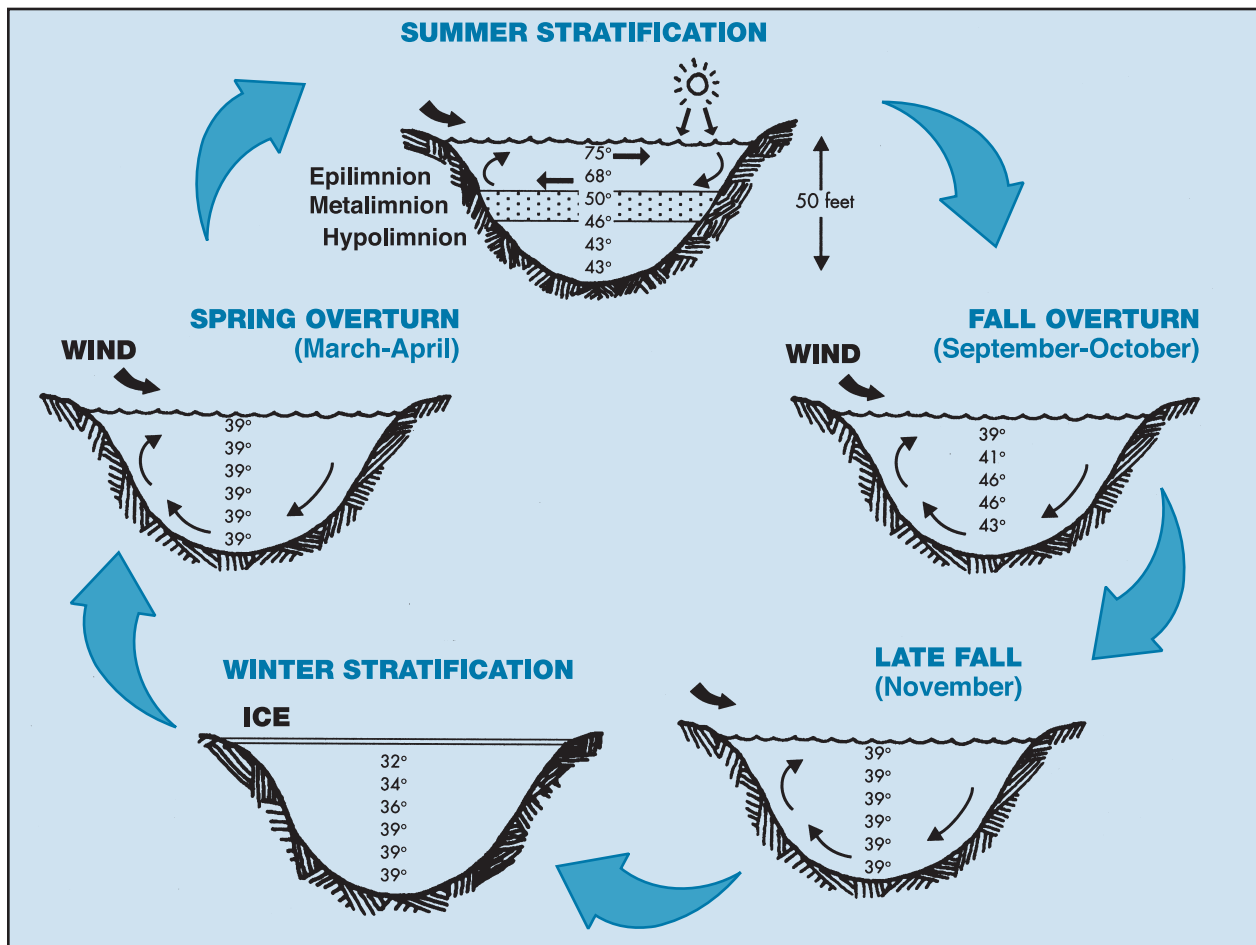


Figure 1. Seasonal Stratification of Lakes. (Taken from Shaw et al. 2000 "Understanding Lake Data")

al. 2000). Because mixing distributes oxygen throughout a lake, lakes that don't mix may have low oxygen levels in the hypolimnion, which can harm fish. Some fish species require lake stratification. The cold water in the hypolimnion can hold more oxygen than the warmer water in the epilimnion and thus provide a summer refuge for cold water fish (e.g., trout). If the lake produces too much algae that falls onto the lake bottom to decay, oxygen in this part of the lake will become depleted since the steep temperature gradient in the metalimnion will prevent any surface water with dissolved oxygen from reaching the bottom (Shaw et al. 2000).

## Water Levels

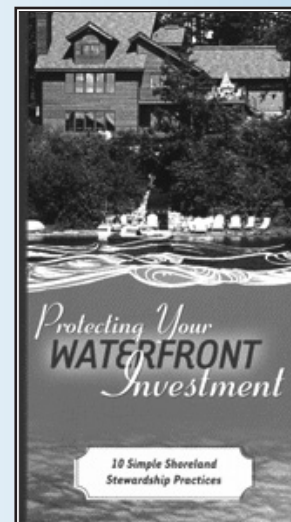
Lake water levels naturally fluctuate over time on approximately a 13 year cycle. Many factors influence water levels on lakes:

- Natural variability due to weather
- Decadal climate cycles (dry and wet periods)
- Climate change
- Dams
- Human use (water withdrawals)
- Lake morphology and hydrology.
  - o Lakes with gradual sloping shorelines will have more lake bed exposed during drought than lakes with steep shorelines
  - o Seepage lakes respond more dramatically to drought than drainage lakes

Natural lake level fluctuations can be important for maintaining healthy riparian plants and provide habitat for rare species of plants or wildlife. At extreme low and high lake levels, there can be negative impacts to both lake health and recreation. As water levels decline, critical littoral habitat for fish and aquatic life is stranded above water in lakes. The loss of this habitat can lower diversity and decrease productivity, particularly for slow-growing aquatic plants that may not be able to retreat as quickly as the water retreats. In some lakes, low water levels have left piers hundreds of feet from shore and rendered boat landings unusable.

Conversely, high water levels can lead to shoreline erosion, increased nutrient inputs, and flooding of piers, homes, and boat landings. Slow no wake boating ordinances may be introduced to protect lake shorelines during the high-water period.

Water level monitoring has been added to CLMN to monitor statewide lake-levels over time to address growing concern for health of aquatic life due to drought, changing



### **Protecting Your Waterfront Investment**

**Protecting Your Waterfront Investment is a handy booklet designed to provide you with 10 simple shoreland stewardship practices you can do to protect your watershed and lake.**

**Free with a small handling fee from UWEX-Lakes**



**SEEPAGE LAKES • Lakes without a significant inlet or outlet, fed by rainfall and groundwater.**

**ALGAL BLOOM • A heavy growth of algae in and on a body of water as a result of high nutrient concentrations.**

climate, and groundwater withdrawals. Although long-term water level records exist, current monitoring efforts are disjointed and do not cover all areas of the state.

Professionals (e.g., county surveyors) survey and install staff gages to lakes shortly after ice-out in spring and then survey and remove staff gages in late fall. Citizen volunteers record and report lake levels preferably weekly, but at least monthly. Seventeen lakes began monitoring water levels in summer 2015 as a pilot and WDNR plans to expand the program. All staff gages are surveyed to at least three reference marks and tied to a datum. This ensures that the data record may continue long into the future even if all reference marks are lost.

## Wind-generated Waves, Sun Position, and Cloud Cover

Wind-generated waves and boat wakes stir up sediments in shallow water areas. Unprotected shorelines can erode and contribute suspended particles to the water. These shoreline and shallow water impacts contribute to turbidity and can block out sunlight and affect photosynthesis.

A 1998 study conducted by Larson and Buktenica found that when the lake surface was calm and skies were clear or had high haze, differences between descending and ascending Secchi observations decreased slightly with increased disk depth. Waves from tour boats, drops of water from the research vessel, and wind generated ripples and chop decreased disk readings as much as 5 meters relative to readings recorded when the lake surface was calm. Furthermore, documenting the variation caused by slightly disturbed lake surface conditions relative to calm surface conditions and among trained observers ensures consistent interpretation of the long-term data (Larson and Buktenica 1998).

The distance of the observer from the water surface, weather conditions, waves, the height of the sun on the horizon, and glare at the water's surface all affect your Secchi disk reading. CLMN monitoring protocols are set up to make sure that lake data is comparable and to eliminate as many extenuating circumstances as possible.

## Motor Boat Activity

Propellers of boats may disturb the lake or river bottom directly, or indirectly through the wash or turbulence they produce, especially in shallow water. This may affect water clarity by increasing the amount of sediment particles in the water or may cause nutrients, such as phosphorus, that are stored in the sediments, such as phosphorus, to become available for algal growth. Waves created by watercraft may contribute to shoreline erosion, which can cloud the water. Boats have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems. Shallow lakes, shallow parts of lakes and rivers, and channels connecting lakes are the most susceptible to impacts. Depth of impact varies depending upon many factors including boat size, engine size, speed, and substrate type. Few impacts have been noted at depths greater than 10 feet (Asplund 2000).



# About the Chemistry Data You Will be Collecting

## Phosphorus and Chlorophyll

Phosphorus is a nutrient that is important for the growth of plant life in freshwater lakes. Under certain conditions, excess phosphorus can cause algae to grow out of control or “bloom”, making a lake look like pea soup. An analysis of phosphorus often includes both soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorus is the form that is biologically available and is used by phytoplankton and **macrophytes** (rooted plants) for growth. Its concentration varies widely in most lakes over short periods of time as plants take it up and release it. Total phosphorus is considered a better indicator of a lake’s nutrient status because its levels remain more stable than soluble reactive phosphorus. Total phosphorus includes soluble phosphorus and the phosphorus in plant and animal fragments (particulate phosphorus) suspended in the lake water.

A concentration of total phosphorus below 20 micrograms per liter for lakes and 30 micrograms per liter for impoundments should be maintained to prevent nuisance algal blooms (Shaw et. al. 2000).

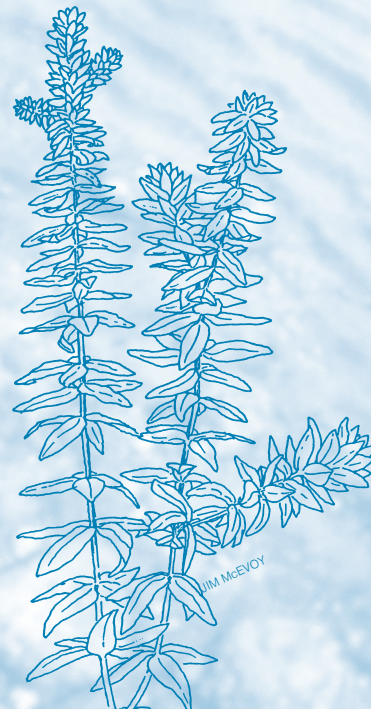
Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems, and runoff from farmland or lawns (Shaw et. al. 2000).

Upon entering a lake, phosphorus may be immediately taken up by algae or bacteria and become part of the food chain. If the water is well oxygenated, it may form an insoluble compound with iron and sink to the bottom. Even if algae take up the phosphorus, it will eventually fall to the bottom of the lake as part of a dead critter higher in the food chain. Whatever the vehicle, most of the phosphorus that comes into the lake, eventually ends up on the bottom of the lake (Knight 2005).

Once phosphorus has settled out into the deeper parts of the lake, it is generally unavailable for plant growth. Particulate phosphorus that settles into the littoral zone or particulate phosphorus in shallow lakes may



**MACROPHYTE** • *Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is usually related to shallow water depth and high nutrient levels.*



## Phosphorus: Around the Lake in 180 Days

by Susan Knight, PhD, University of Wisconsin Trout Lake Station

**T**oo much of a good thing almost always leads to problems. This is especially true when it come to nutrients and lakes. Lakes need some nutrients, such as nitrogen and phosphorus, or they would be as bare as water-filled bathtubs. Nutrients are necessary for algae and plants, which in turn fuel the entire lake food web from tiny zooplankton to feisty crayfish and from fish fry to trophy muskies. But with too many nutrients, and especially too much phosphorus, the algae multiply so fast that the lake's tiny herbivores, the zooplankton, cannot keep up and the lake turns a not so tempting green. Where do the algae get the phosphorus that allows them to multiply so dramatically? Most people know that lots of phosphorus comes from outside the lake every year, but in many lakes, much of the phosphorus stimulating algal growth is recycled from within the lake.

When phosphorus enters a lake from outside it is called external loading and it is easy to see or understand the sources. The phosphorus may come from a readily identifiable source, called a point source, such as a pipe from an upstream wastewater treatment plant. It may come from less conspicuous, or non-point sources, such as runoff from fertilized lawns or as leachate from ineffective septic systems. Both point and non-point sources of phosphorus increase the total amount of phosphorus in the lake.

Upon entering a lake, phosphorus may be immediately taken up by algae or bacteria and become part of the food chain. Or, if the water is well oxygenated, it may form an insoluble compound with iron and sink to the bottom. It may also attach to organic particles, again sinking to the bottom. Even if algae take up the phosphorus, it will eventually fall to the bottom of the lake as part of a dead algal cell, in excreted fecal material or as part of a dead critter higher in the food chain. Whatever the vehicle, most of the phosphorus that comes into the lake, eventually ends up on the bottom of the lake. If the phosphorus stayed at the bottom, and we could control the external loading, we could more successfully control runaway algal growth. But, it doesn't stay put and that leads to trouble.

As summer or winter progresses, bacteria are busy decomposing all the dead organic stuff that has

been raining down to the bottom of the lake. Decomposition consumes oxygen and the bottom of the lake becomes anoxic, meaning there is no dissolved oxygen in the water. (This can also lead to winter and summer fish kills but that is a story for another day). Phosphorus bound to the iron in oxygen-rich waters is released as free phosphate (the most biologically valuable form of phosphorus) under these anoxic conditions. By the end of summer, the bottom layer of water is anoxic but rich in phosphate. This phosphate might stay entrenched at the bottom forever if not for the change of seasons. As summer turns to fall, the surface waters begin to cool. This cool water sinks because cool water is more dense than warm water (until the temperature approaches the freezing point). As the cooler, denser water sinks, the lake "turns over" or mixes from the bottom to the top. Like the 'lava' in a lava lamp, the phosphate-rich bottom water is boosted back up to the surface and becomes available for uptake by algae. This also happens in the spring, but it is the slightly warmer-than-ice water that sinks, initiating spring turnover and the upwelling of the phosphate-rich bottom waters. This lava lamp-like circulation is called internal loading and creates an almost never-ending, though seasonal, source of phosphorus and may cause fall and spring algal blooms.

This scenario is mostly played out in deeper lakes that stratify into layers of different temperature and oxygen levels in the summer. Shallow lakes may never stratify in the summer, and may mix continuously throughout the ice-free season. In these lakes, phosphorus is even more available and is part of the reason that high algal levels often plague shallow lakes. Carp and other organisms that root around in and stir up sediments are also responsible for phosphorus circulation year round.

Cutting off the external load of phosphorus from point and non-point sources may not lead to an immediate decrease in algae levels. There will always be some phosphorus resuspension, at least seasonally. However, the lake's phosphorus "memory" will slowly fade if the phosphorus inputs decline. If this external load is diminished, a lake over-endowed with nutrients may eventually see a return to a more natural phosphorus cycling regime.

still be available for plants to take up via their root system. Phosphorus may also become resuspended in the water by wind or boats and become available for plankton or plants again. What makes the reaction of phosphorus so complex is that there are many forms of phosphorus and this phosphorus binds to other materials with varying degrees of “bioavailability”, depending on the calcium content of the water and the pH of the lake. Lower pH, soft water systems tend to have less tightly bound phosphorus than hard water, high pH systems so the phosphorus may be more available to plants in those soft water systems. Phosphorus does not dissolve easily in water. It forms insoluble precipitates (particles) with calcium, iron, and aluminum. In hard water areas of Wisconsin, where limestone is dissolved in the water, marl (calcium carbonate) precipitates and falls to the bottom. Marl formations absorb phosphorus, reducing its overall concentration as well as algae growth. Aquatic plants with roots in the marl bottom still get phosphorus from sediments. Hard water lakes often have clear water, but may be filled with aquatic plants (Shaw et. al. 2000).

Iron also forms sediment particles that store phosphorus - but only if oxygen is present. When lakes lose oxygen in winter or when the hypolimnion loses oxygen in summer, iron and phosphorus again dissolve in water. Strong summer winds or spring and fall turnover may mix iron and phosphorus with surface water. For this reason, algal blooms may still appear in lakes for many years even if phosphorus inputs are controlled (Shaw et. al. 2000).

Lakes with low iron and insufficient calcium to form marl are most likely to retain phosphorus in solution once it is released from sediments or brought in from external sources. These lakes are the most vulnerable to naturally occurring phosphorus or to phosphorus loading from human activities because the phosphorus remains dissolved in the water - not pulled down into the sediments. Such lakes often respond with greater algae problems (Shaw et. al. 2000).

The water samples that you collect will help answer important questions like, “How phosphorus enriched is my lake (or what is the trophic

state of my lake)?” The results will help predict if your lake is susceptible to nuisance algal blooms.

Chlorophyll is the pigment found in all green plants, including phytoplankton. Phytoplankton are very small free-floating aquatic plants such as algae. Their abundance, as measured by the amount of chlorophyll *a* in a water sample is commonly used to classify the trophic status of a lake.

## **T**emperature and Dissolved Oxygen

A temperature profile will help to explain the physical, biological, and chemical aspects of your lake. Lake temperature affects the rate of decomposition, nutrient recycling, lake stratification, and dissolved oxygen concentrations near the lake bottom. Changes in water temperature can also affect the distribution of fish in a lake. Some fish (e.g., trout and Cisco) prefer colder water. It is important to these fish species that the deeper water stays cold to ensure their survival. Water temperature can also influence the mixing and stratification patterns in your lake. When a lake becomes stratified (forms distinct temperature layers), circulation of nutrients and other chemicals is restricted within those layers. When a lake mixes, the cold bottom water is brought to the surface and the warm surface water is mixed downward. Nutrients that were at one time restricted to the bottom of the lake are brought upward into the water column. During mixing there is very little temperature variation between the top and bottom waters. Shallow lakes can be mixed all year round from top to bottom due to wind and wave action. Deep lakes (generally greater than 20 feet deep) usually mix in the spring and fall. You will be able to determine whether your lake mixes or stratifies when you perform a temperature profile of your lake.

Those volunteers who use an integrated sampler to collect water samples, will collect water temperature using an electronic digital meter. A cable with a stainless steel probe is attached to the meter. The cable is marked in one foot increments and is dropped into the water. Those volunteers who use a Van Dorn sample bottle to collect water samples, will use the thermometer inside the Van Dorn to record water temperature.



**RESPIRATION** • *The complex process that occurs in the cells of plants and animals in which nutrient organic molecules, such as glucose, combine with oxygen to produce carbon dioxide, water, and energy. It is the reverse reaction of photosynthesis, as respiration consumes oxygen and releases carbon dioxide. This process also takes place during decomposition as bacterial respiration increases.*

Oxygen is needed by most aquatic organisms to survive. The solubility of oxygen depends on water temperature (the colder the water, the more oxygen it can hold). Dissolved oxygen levels range from 0 to 18 parts per million (ppm). A chart showing the minimum oxygen requirements for some common fish species can be found on page 84.

Oxygen enters the water by direct absorption from the atmosphere or by plant photosynthesis. Oxygen is produced whenever green plants grow. Plants, using sunlight as the energy source, use carbon dioxide and water to produce simple sugars and oxygen. Photosynthesis occurs only during daylight hours and only to the depths where sunlight penetrates. The amount of photosynthesis depends on the quantity of plants, nutrient availability, and water temperature. Higher temperatures speed up the process.

Plants and animals constantly use oxygen to break down sugar to obtain energy by a process called **respiration**. Respiration is basically the reverse of photosynthesis. The combination of these two reactions largely determines the amount of oxygen and carbon dioxide present in lakes at different times of the day and at different depths. It is common to find high daytime surface water oxygen values. These levels may be much lower at night or in the early morning hours. At lake depths below the reach of sunlight, the only reaction that occurs is oxygen-consuming respiration. The deep hypolimnetic waters of productive lakes often experience oxygen depletion. Lakes with high biological activity undergo greater fluctuations than lakes with few plants and animals.

Winter oxygen depletion (winterkill) is a common problem in many shallow Wisconsin lakes. It happens in years when at least four inches of snow covers the lake, preventing sunlight from reaching the water. All photosynthesis stops and plants begin to die and decompose. The extent of oxygen loss depends on the total amount of plant, algae, and animal matter that decays. Drought increases the chance of winterkill by reducing the volume of water in the lake (Shaw et al. 2000).

The oxygen concentration at representative lake depths can be measured using a chemical test (Winkler titration) or an electronic meter. CLMN uses the Winkler titration test due to the relatively low cost and high accuracy of the test. Note on your data sheet which method, titration or meter, you used to determine dissolved oxygen levels.



# PROCEDURES

## HELP STOP THE SPREAD OF INVASIVE SPECIES

### Wisconsin law requires that you:

- Inspect your boat, trailer and equipment.
- Remove any attached aquatic plants or animals (before launching, after loading and before transporting on a public highway).
- Drain all water from boats, motors and all equipment
- Don't move live fish away from a waterbody.
- Buy minnows from a Wisconsin bait dealer and **USE** leftover minnows only under certain conditions\* (See [fishingwisconsin.org](http://fishingwisconsin.org) for more information).

### In addition you can:

- Rinse boat and equipment with hot or high pressure water and dry for at least five days.
- Learn to easily recognize Eurasian water-milfoil. Monitor boat landings, marinas, and inlets on a regular basis for the first sign of an invasion. Report new sightings to your nearest Wisconsin DNR office.
- Work with your local lake association to develop an aquatic plant management program for your lake including contingency plans in case Eurasian water-milfoil is found in the lake.
- Dispose of unwanted live bait in the trash.

*A lake  
is the landscape's  
most beautiful and  
expressive feature.  
It is earth's eye;  
looking into which  
the beholder  
measures the depth  
of his own nature.*

*—Henry David Thoreau*



**Want to know what water clarity monitoring entails? Haven't used your Secchi disc in awhile and want to refresh your memory? Visit the Extension Lakes web page!**

The Secchi disk visibility world record of 262 feet was set in the eastern Weddell Sea, Antarctica in 1986. Even the clearest of lakes in Wisconsin have a maximum water clarity of 25 to 55 feet. These include the aptly named Crystal Lake in Sheboygan County with a water clarity of 32.5 feet in March 2012, Maiden Lake in Oconto County with a water clarity reading of 47.5 feet in May 2009 and Black Oak Lake in Vilas County with a water clarity reading of 53.5 feet in June 2012

These lakes stand in stark contrast to some of the more turbid lakes we find in Wisconsin. Lake Wissota in Chippewa County had a Secchi reading of 0.25 feet in June 2012 and Lake Winnebago with a clarity reading of 0 to 0.25 feet in July 2012.

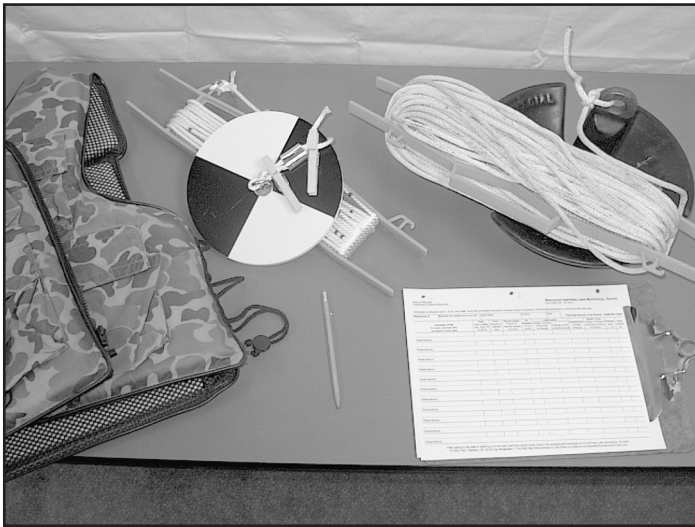


**Want to know more about water chemistry monitoring? Want a little refresher after the winter months to make sure you collect and report accurate data?**

**Visit the Extension Lakes web page or visit the "Extension Lakes" YouTube Channel!**

# 1. SECCHI (Water Clarity)

**B**efore you start sampling, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using.



*After sampling, it is very important to rinse and air dry thoroughly all of the equipment that you used. Keep paperwork separate from equipment.*

## What Equipment Will You Need?

- At your training session, your CLMN regional coordinator will outline and provide all of the equipment that you will need to successfully monitor your lake.
- Secchi disk (with rope and holder)
- Two clothespins
- Lake map with sampling site marked
- Life jackets (you provide)
- Anchor and rope (you provide)
- Boat (you provide)
- Field data sheets
- Pencil

## SHOULD I COLLECT SECCHI DATA IN THE WINTER?

Secchi measurements taken through the ice are highly variable depending on the amount of snow on the ice and ice clarity (i.e. did it freeze fast or was there slush on the lake that froze and created “cloudy” ice). These are the main factors that determine the amount of light that can get through the ice which allows you to take accurate measurements.

Since algae production is at a minimum under the ice, this data has no real value for Network use.



**Waterbody # or WBIC (Waterbody Identification Code)** • A unique identification number the Wisconsin DNR uses to identify each waterbody in the state. Every one of the 15,000 lakes in Wisconsin has a unique WBIC.

**Station #** • A number assigned to sampling locations on a waterbody. The station identification number makes it easy to track secchi and chemistry data. Each sampling site on a lake will have a separate station identification number.

## How Do You Prepare to Sample?

### The Day You Sample

On the day you plan to sample, complete the top portion of your field data sheet by filling in the **waterbody # (or WBIC)** and “**Station #**”. Enter the name of each volunteer who will be sampling. If you do not know these numbers, contact your CLMN regional coordinator. Before you launch your boat, make sure you have your Secchi disk, an anchor, and personal flotation devices (life jackets) in your boat before proceeding to your sampling site.

## Sampling Overview

### When to Take Your Secchi Readings

The weather can affect the depth at which you can no longer see the Secchi disk. Wind-generated waves, sun position, and cloud cover are major weather factors that can affect the accuracy of your readings.

- Secchi readings should be taken every 10 to 14 days.
- Secchi readings should be taken on clear, calm days between 10 am and 4 pm.
- Anchor the boat.
- Secchi disk readings are taken on the shady side of the boat.
- Kneel or sit so you are close to the surface of the water.
- Remove your sun glasses – sun glasses can increase the depth that you can see your Secchi disk. For consistency and so we can compare data from one lake to another, please remove your sun glasses.
- Use clothespin method to determine accurate reading.
- For color and clear/murky determination, hold Secchi disk one foot below the surface of the water.

To make sampling regular and convenient, try to make it a part of your weekly routine. You can include it as part of your weekend fishing trip or family outing on the lake. The most important time to collect your Secchi data is in July and August. These are the prime months for lake recreation and the time when algae is the most prevalent. Secchi analysis statewide relies on information for these months and will appear in your statewide summary. Averages of Secchi data recorded during July and August will appear in your statewide summary report. Due to seasonal variation, the entire years’ Secchi disk data cannot be averaged.

The Secchi readings you take in the spring and fall will tell a story about your lake. These readings can tell you when spring runoff occurs in your lake or when there are algal blooms. For this reason, many Secchi volunteers may start collecting data in April and continue through

If you are unable to sample during your normally scheduled sampling time, do not worry about it! Just try to sample as soon as possible after that time. However, if you think that you will not be able to continue monitoring your lake due to illness, schedule conflicts, or other problems, please contact your CLMN regional coordinator as soon as you can.

### **Remote Sensing Project**

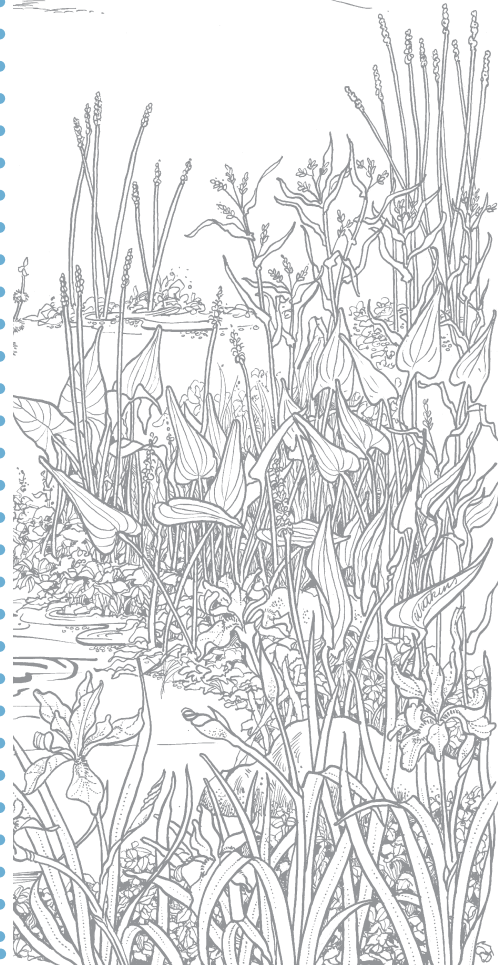
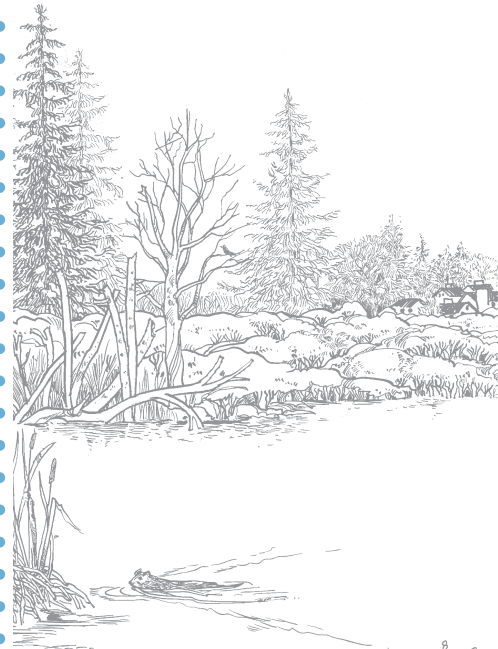
Today remote sensing data from the NASA/USGS Landsat Program are used by the Wisconsin DNR to provide satellite retrieved Secchi depth data for thousands of lakes annually with the support of CLMN volunteers. Different weather conditions and atmospheric effects on satellite images and challenges in the atmospheric correction of satellite images mean on-the-ground Secchi depth data is still needed to calibrate this model for each satellite image. Your CLMN volunteer coordinator will send you a list of Landsat 7 ETM+ and Landsat 8 OLI-TIRS image acquisition dates for your lake if you are one of our Secchi volunteers and want to support our operational efforts. The satellite image specific algorithms will translate your data to data for hundreds of lakes within the same satellite image if you collect it on a clear satellite image acquisition date for your lake! Find out more about remote sensing at <http://dnr.wi.gov/lakes/CLMN/remotesensing/>.

### **WHAT IS THE SATELLITE RETRIEVED WATER CLARITY DATA USED FOR?**

The operational annual satellite retrieval of the water clarity for thousands of lakes across Wisconsin from Landsat 7 ETM+ and Landsat 8 OLI-TIRS data assists the Wisconsin DNR in trophic state assessments for the State of Wisconsin. The results are shared within the Wisconsin DNR for the Wisconsin Water Quality Reports to Congress in compliance with Section 305(b) of the Clean Water Act and with state and local water quality managers, lake organizations, and the public. Summer water clarity maps are shared through the Wisconsin Lakes & Aquatic Invasive Species Mapping Tool and GIS data portal. Check out the latest summer water clarity maps at <https://dnr.wi.gov/lakes/viewer/>.

### **WHAT ARE CURRENT AND FUTURE REMOTE SENSING ACTIVITIES?**

Current and future remote sensing activities at the Wisconsin DNR include the transition of image processing efforts from a desktop to cloud environment, the collection of field and satellite match-up data for waterbodies across Wisconsin to support algorithm development and validation efforts by external partners, and the development of strategies for the integration of satellite data products into our water quality monitoring program. Recently started algorithm development and validation efforts include a comparison of several state of the art algorithms for the satellite retrieval of total suspended solid (TSS) and chlorophyll-a (Chla) concentrations in partnership with NASA. This study presents the first step towards the operational annual satellite retrieval of TSS and Chla for thousands of lakes across Wisconsin from Landsat 8 OLI-TIRS, Sentinel-2 MSI, and Sentinel-3 OLCI data.



CAROL WATKINS, UNIVERSITY ENVIRONMENTAL RESOURCES CENTER

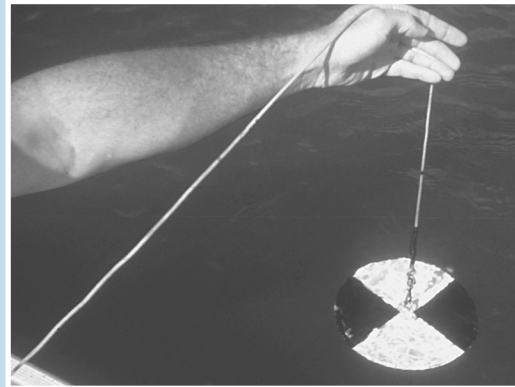
## ON LAKE PROCEDURES

**STEP 1.** Before going out to take your Secchi disk readings, be sure the conditions are right for sampling. Ideal weather conditions include sunny or partly sunny/cloudy skies; wind-calm to breezy (there should be no whitecaps on the lake). Collect Secchi measurements between 10 am and 4 pm. If possible, try to collect Secchi readings when the satellite is overhead.

**STEP 2.** Your CLMN regional coordinator will provide you with a lake map with the sampling site marked. Be sure you have a station id number for each site you are monitoring.

**STEP 3.** Anchor your boat at your sampling site to prevent drifting. Be careful not to disturb the sediments on the lake bottom when anchoring since this could cloud the water. **Remove your sun glasses. Wearing sun glasses will give you an unnatural reading.** Unwind the Secchi disk rope from the holder.

**STEP 4.** Lean over the shady side of the boat and slowly lower the Secchi disk into the water until you can no longer see it. If you are sampling in a pontoon boat, be sure to kneel down on the floor of the boat when you take your readings so you are closer to the surface of the water. Be as close to the surface of the water as you can safely be. **Secchi disk readings are taken on the shady side of the boat to reduce glare.**



**STEP 5.** When the Secchi disk barely disappears from your view, mark the rope at the surface of the water with a clothespin.

- Secchi values vary by about 6% due to change in sun's angle in midsummer.
- 5" waves can decrease Secchi reading by 10%.



DNR PHOTOS

## ON LAKE PROCEDURES

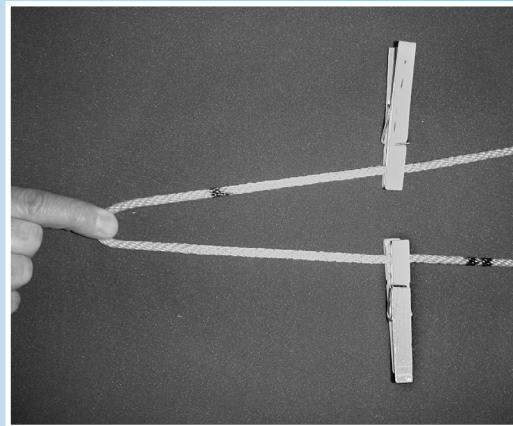
**STEP 6.** After you have marked this spot with the clothespin, lower the disk a few more feet into the water. Slowly raise the disk. When the Secchi disk reappears, mark the rope at the surface of the water with the second clothespin. The clothespin marks may be at the same spot, several inches or even several feet apart. The purpose of lowering the Secchi disk and raising it back into view is so your eyes become accustomed to looking into the water. The average of the two readings will be a more accurate result.



DNR PHOTO

**STEP 7.** Bring the Secchi disk back into the boat.

**STEP 8.** Average your two Secchi disk readings by forming a loop between the two clothespins. Slide one clothespin into the center of the loop to mark it. Remove the other clothespin. The remaining clothespin mark will be your Secchi reading.



JIM KLOSIEVSKI

**STEP 9.** Your rope is marked in foot increments. The red lines indicate five, fifteen, and twenty-five feet. The double black lines indicate ten, twenty, and thirty feet. Carefully measure the number of feet from the disk until you reach your clothespin mark. Round off to the nearest quarter foot.

**STEP 10.** Record this measurement on your data sheet and then fill out the rest of your data sheet.

*(continued on next page)*

## ON LAKE PROCEDURES

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**STEP 11.** Record your perception of water color and water appearance. Hold the Secchi disk **one foot** under the surface of the water to determine color and appearance. Record perception. This is your perception of the amount of algae that is in the water at the deep hole.

### Perception Numbers

- 1 - Beautiful, could not be any nicer.
- 2 - Very minor aesthetic problems, excellent for swimming and boating.
- 3 - Swimming and aesthetic enjoyment of lake slightly impaired.
- 4 - Desire to swim and level of enjoyment of lake substantially reduced because of algae (would not swim, but boating is okay).
- 5 - Swimming and aesthetic enjoyment of the lake substantially reduced because of algal level.

**STEP 12.** If you are taking Secchi readings at more than one site or lake, proceed to your next location and repeat steps 1 through 10 above (step 11, perception, is recorded at the deep hole only.)

**STEP 13.** Report your data. Data can be submitted electronically at the CLMN web site. Instructions for entering data are in Appendix 2 of this manual. If you enter data online, you do not need to submit data sheets by mail.

For those without Internet access – data sheets can be mailed to your CLMN regional coordinator to be entered into the database.



# 2. TEMPERATURE MONITORING:

## Using a Digital Meter

**B**efore you start sampling, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using. It is very important that you follow the sampling procedures exactly as they are laid out in the following pages to ensure good, consistent, high quality data.



Digital Temperature Meter

*After sampling, it is very important to rinse and thoroughly air dry all of the equipment that you used. Be sure to unplug your meter and store out of direct sunlight.*

### What Equipment Will You Need?

At your training session, your CLMN regional coordinator will outline and provide all of the equipment that you will need to successfully monitor your lake.

- Manual
- Lake map with sampling site marked
- Digital temperature meter and probe (there are two models in use)
- Lifejackets (you provide)
- Anchor and rope (you provide)
- Field data sheets
- Pencil



Digital Temperature Meter

## How Do You Prepare to Sample?

### The Day You Sample

On the day you plan to sample, complete the top portion of your field data sheet by filling in the Waterbody # (or WBIC) and Station #. If you do not know these numbers, contact your regional coordinator. Check your monitoring equipment to make sure it is good working condition. If you have an electronic temperature meter, make sure the 9-volt battery is working. Before you launch your boat, make sure you have an anchor, sufficient gas, and personal flotation devices in your boat.

## Sampling Overview

### Temperature Readings

Some limnologists believe that lake temperature profile data are very important to document the effects of climate change. Keep this in mind, as the accuracy of the data you collect is critical. Temperature readings are easy to take. When using a digital temperature meter, a measured cable with a probe is lowered into the water and a hand-held digital meter records the temperature. The cable is marked in one foot increments. Your regional coordinator will give you the depths at which the temperature should be recorded for your particular lake.

Your temperature profile will also tell you if your lake stratifies. You will be able to determine the depth of the epilimnion and where the thermocline is. Temperature profiles will also help determine if a fish kill is a possibility on your lake.

## ON LAKE PROCEDURES

### Temperature Monitoring

#### Temperature Probe Method

**STEP 1.** Your regional coordinator will assign the depths at which you should sample the temperature of your lake. List these pre-determined depths on your field data sheet.

**STEP 2.** Plug cable into unit.



**STEP 3.** Lower the probe to your assigned depths and note the corresponding temperatures from the meter onto your data sheet.



**STEP 4.** Once you are finished, raise probe and unplug the cable from unit to conserve the battery. Be sure to store the digital meter out of direct sunlight.

# 3. TEMPERATURE MONITORING:

## Using a Van Dorn Sampling

**B**efore you start sampling, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using.

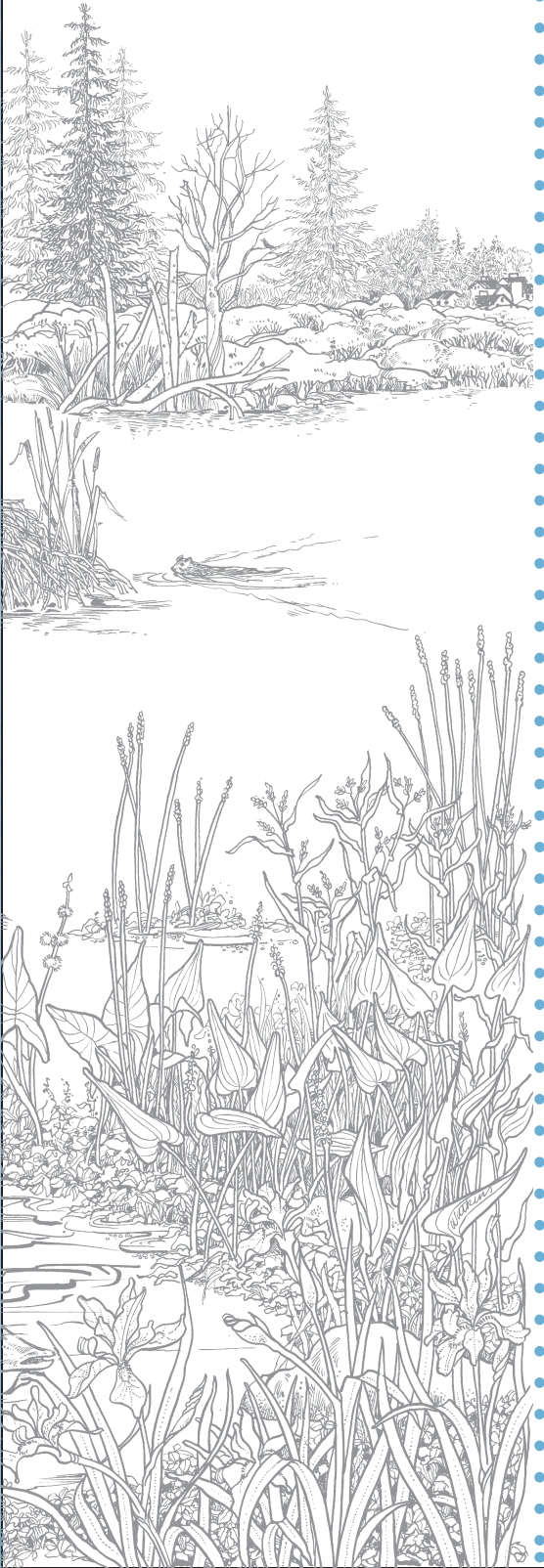


*After sampling, it is very important to rinse and thoroughly air dry all of the equipment that you used.*

### What Equipment Will You Need?

At your training session, your CLMN regional coordinator will outline and provide all of the equipment that you will need to successfully monitor your lake.

- Manual
- Lake map with sampling site marked
- Van Dorn sampling bottle with thermometer
- Lifejackets (you provide)
- Anchor and rope (you provide)
- Field data sheets
- Pencil



CAROL WATKINS, UW-EXTENSION, ENVIRONMENTAL RESOURCES CENTER

## How Do You Prepare to Sample?

### The Day You Sample

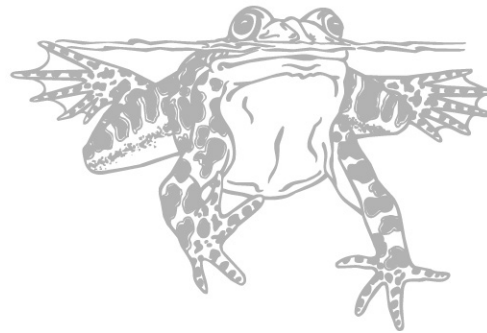
On the day you plan to sample, complete the top portion of your field data sheet by filling in the Waterbody # (or WBIC) and Station #. Before you launch your boat, make sure you have an anchor, sufficient gas, and personal flotation devices in your boat.

Measure the rope on your Van Dorn sampling bottle before the season starts to make sure it is accurate. Check your Van Dorn sampling bottle before each sample period to make sure it is working. If it is not working properly return it to your CLMN coordinator for repair or replacement.

## Sampling Overview

### Temperature Readings

Some limnologists believe that lake temperature profile data are very important to document the effects of climate change. Keep this in mind, as the accuracy of the data you collect is critical. Temperature readings are easy to take. Your regional coordinator will give you the depths at which the temperature should be recorded for your particular lake. When using this method you will use a regular thermometer in the Van Dorn sampling bottle to record the temperature of the water.



# ON LAKE PROCEDURES

*The following instructions are for the vertical messenger release sampler. Please contact your regional coordinator if you need instruction on using other models or if your sampler fails to work properly.*

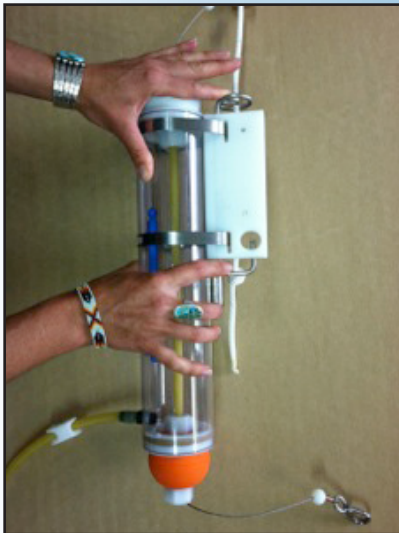
- *Anchor your boat before collecting water sample(s). If the boat is drifting, the release mechanism may not work properly.*
- *Always secure the end of the sampler to a floating object to avoid accidental loss of sampler.*
- *Try to keep sampler out of direct sunlight for extended periods of*



astics,

- *Store your sampler dry.*
- *The latex internal closure can be adjusted to increase tension between sealing caps. If there is too little tension, the unit will not seal properly.*
- *The “how to” video on the UWEX Lakes*

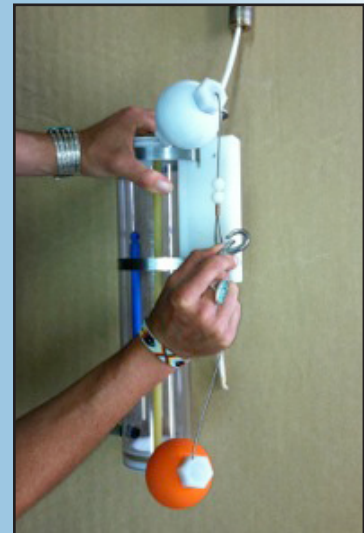
**STEP 1.** Lay sampler on its side with the rope side of the cable clamp positioned downward (figure 1 ▼).



**STEP 2.** Start with the top seal (the rubber ball with the lanyard coming out of the top). Use your index finger to pull the arming rod of the release mechanism downward. Pull the top ball seal out of the sampler cylinder using the lanyard loop (figure 2 ▼).



**STEP 3.** Insert the lanyard “loop” inside the hole in the closing mechanism. Release the arming pin to hook the loop (figures 3 ▼).



**STEP 4.** Release the arming pin to hook the loop (figure 4▶).



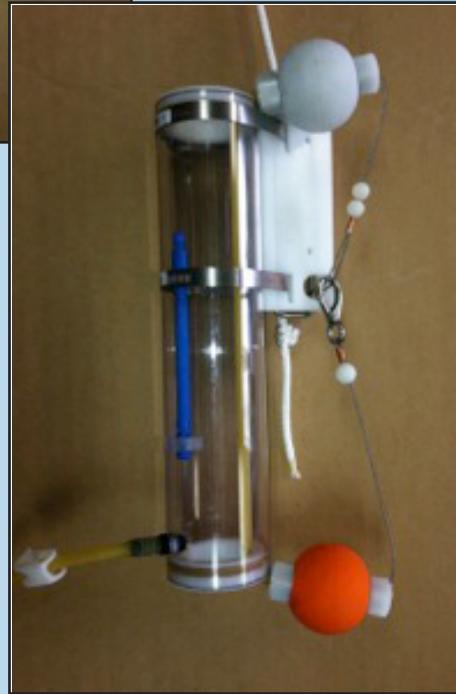
**STEP 5.** Arm the bottom seal (the rubber ball) using the same procedure as above and clip the stainless steel clip around both strands of the loop lanyard (figure 5▶).

The sampler is now ready for deployment.

**STEP 6.** Lower the sampler to the desired depth. Release the messenger to activate the closing mechanism. You can generally feel the sampler close at depth through the line.

**STEP 7.** Bring the now closed sampler to the surface. Open the clamp to release a small amount of water through the drain tube. You can cock the rubber ball seal to increase the flow out of the drain tube.

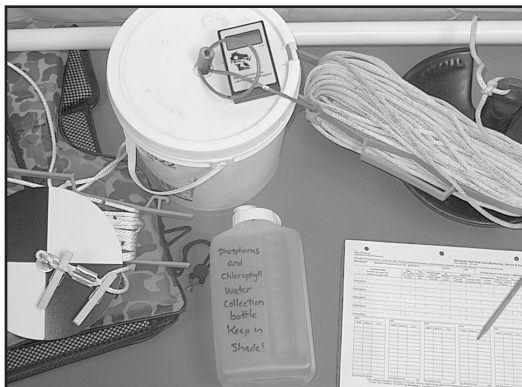
**STEP 8.** After sampling, thoroughly rinse your sampler with distilled water. Place pencils in either end so the sampler will dry out. Open up or remove the hose clamp so the hose will air dry as well. When the sampler is dry, remove pencils so the rubber tubing does not stretch and wear out.



# 4. CHEMISTRY MONITORING:

## Phosphorus and Chlorophyll

**B**efore you start sampling, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using.



Please remember to keep all sampling equipment and chemicals out of the reach of children. Many of the chemicals you will be using are hazardous (see Appendix 1). After sampling, it is very important to rinse and thoroughly air dry all of the equipment that you used.

### What Equipment Will You Need?

At your training session, your CLMN regional coordinator will outline and provide the equipment that you will need to successfully monitor your lake. [This list includes everything that you will need while you are on and off the lake.]

- Secchi disk
- Manual
- Lake map with sampling site marked
- Integrated water sampler
- A large plastic tub containing: 1000 ml flask, filter cup, pump and tube, squirt bottle (to be filled with distilled water that **you** provide), water collection bottle, filter membrane, 250 ml graduated cylinder, sulfuric acid vial, "acid added" stickers, safety goggles and gloves, and mailing tape.
- Life jacket (you provide)
- Anchor and rope (you provide)
- Field data sheets
- Pencil
- As much ice as you can fit into the cooler (you provide)

The following supplies will be provided to you by the CLMN to send your collected water samples to the State Laboratory of Hygiene for analysis:

- Styrofoam® mailer
- 250 ml bottle for the phosphorus sample
- Zip-lock bag for phosphorus bottles
- Chlorophyll tube and baggies for ice cubes
- Data forms
- Chlorophyll sample stickers
- Phosphorus sample stickers
- State Laboratory of Hygiene lab slip
- Merchandise return labels for mailers
- Priority mail stickers

## How Do You Prepare to Sample?

### The Day Before You Sample

The day before you are planning to sample your lake, you should always check to see that your equipment is in good condition. Make sure you have plenty of ice cubes available and your squirt bottle is filled with distilled water. Distilled water can be purchased at your local grocery store but be sure it is labeled “*distilled* water” **not** “*drinking* water” or “*pure* water”. **Sampling early in the week (e.g., Monday, Tuesday, or Wednesday) is advised as it allows your samples to arrive at the State Laboratory of Hygiene (WSLH) when someone is at the lab to process them. Samples should arrive with some ice cubes still intact for the most accuracy.**

It is perfectly all right to collect your water sample and process the samples and hold them for a *few* days before mailing them. Keep the total phosphorus sample in the refrigerator (fixed with the sulfuric acid) and the chlorophyll sample (the filter in the tube) in the freezer until you are ready to mail it early in the week.

A quality assurance check in 2017 showed us that chilling the phosphorus sample and placing the chlorophyll filter in the freezer for an hour or two before mailing helped the samples to arrive at the WSLH with some ice still intact.

## Sampling Overview

### Water Sampling

To collect water samples for phosphorus and chlorophyll analysis, you will use one of two types of water samplers—either an integrated water sampler or a Van Dorn sampling bottle. Your lake needs to be at least 10-feet deep in order to use the integrated water sampler. Shallow lakes less than 10 feet in depth will usually be assigned a Van Dorn sampling bottle.

The integrated water sampler is a six and a half-foot PVC pipe that serves as a collection tube. At the bottom of the tube is a PVC ball that acts as a water-locking mechanism. To take your sample, slowly lower the tube vertically into the water to the tape mark (a depth of six feet), using the rope to lower and raise your integrated sample will help to avoid contamination. After lifting the tube, you will have collected an *integrated* sample that is a *mix* of water from the surface to six feet deep in the water column (0-6 feet). The water in the integrated sampler will be released when the integrated

sampler is placed on top of the water collection bottle. The ball will be displaced by the bar on the neck of the water collection bottle, releasing the water. Contamination can occur if you touch the end of the integrated sampler or if it lies in the bottom of your boat and touches oil or gas. Please keep your integrated water sampler clean. The collection end should be rinsed with distilled water prior to storing. The water sample in the water collection bottle will be used to fill your WSLH phosphorus sample bottle. The remainder of the water in the water collection bottle will be used for your chlorophyll analysis. When the sampler is not in use, it is very important to store the sampler upside down to dry; this will prevent the growth of algae and bacteria which could contaminate future samples.

Some volunteers collect the water sample for phosphorus and chlorophyll analysis at a depth of three feet with the Van Dorn sampling bottle. The Van Dorn sampling bottle is different type of sampler than the integrated sampler. The Van Dorn sampling bottle is a plastic collection bottle with rubber stoppers at each end. This type of sampler is able to collect water at a specific depth—not a mix of water from multiple depths like the integrated sampler. When the Van Dorn sampling bottle is lowered into the lake, water will enter the plastic bottle. Once the sampler is at the appropriate depth, a brass “messenger” is dropped down the line to snap the sampler closed with the water sample inside.

### Phosphorus Sampling

The water you collect for your phosphorus sample will be analyzed by WSLH. Since phosphorus can be measured in very small amounts, it is important that “clean” sampling techniques be used. ***Be careful not to touch the inside of the WSLH sample bottles or caps or the water as it is being drained from the sampler into the bottle as your fingers may have phosphorus residue on them.*** Phosphorus contamination can come from a variety of sources, including soap, dishwashing detergents, or lawn fertilizers. To further reduce possible contamination, make sure the sample bottle caps rest upside down as you fill the bottles.

Before mailing your phosphorus sample to WSLH for analysis, it must be preserved (or “fixed”) by adding sulfuric acid. Once the acid is added, the sample is stabilized. Remember to always wear your safety goggles and gloves when handling sulfuric acid to prevent injury to your hands or eyes. Long pants and shoes will protect your legs and feet.



## Chlorophyll Sampling

Your chlorophyll samples should be collected once during the last two weeks of June, July, and August. Since there is little algal growth in early spring, there is no need to sample chlorophyll until June. The integrated water sampler will collect a sample from 0-6 feet of the water column. This depth contains algae that are representative of species that live in the upper layers of the water column. After collecting your sample, transfer the water to your water collection bottle. Algae will continue to grow in sunlight so be sure to place the water collection bottle in a cool, shady spot after collection. Process your samples on shore and out of direct sunlight.

The amount of water that you will filter is dependent on your Secchi reading the day you collect the water samples. The Secchi depth is one way to estimate the concentration of algae in the water. The deeper you can see the Secchi disk, the greater the likelihood of fewer algae in the water. The shallower the Secchi disk reading, the more algae is present. An exception are lakes with turbid or naturally stained water. Since there is a proportional relationship between Secchi depth and the amount of chlorophyll present, the deeper the Secchi reading, the more water you will have to filter to collect enough algae to measure (see table on page 46). Once you have determined the volume of water that you will need to filter, pour that volume from the water collection bottle into your graduated cylinder for a precise measurement.

The upper cup of the filtering apparatus should not be used to measure the volume of water you need to filter. Do not touch the filter paper with your fingers. The oil on your skin may degrade the chlorophyll in the samples. Use the tweezers provided to place the filter on and to remove the filter paper from the filtering device. After the water has been filtered to extract the algae, the filtered water may be discarded. Only the residue on the filter paper will be analyzed. After you are done filtering, the filter paper sample must be kept in the freezer until you send it to the WSLH to be analyzed.

Phosphorus sample collected with 2 weeks of ice off. Phosphorus and chlorophyll sample collected the last 2 weeks of June, last 2 weeks of July and the last 2 weeks of August.



## ON LAKE PROCEDURES

### How to Collect Water Samples

#### *Integrated Water Sampler*

*The integrated water sampler is used to collect the water sample for phosphorus and chlorophyll analysis on lakes that are deeper than ten feet. Chemistry volunteers collecting water samples on lakes less than ten feet in depth will use a Van Dorn sampling bottle.*

**STEP 1.** Before using the integrated sampler rinse with lake water three times. Fill the sampler with lake water and empty the water out of the top of the sampler. This will clean out any dirt or dust that may have gotten in the sampler.



**STEP 2.** Rinse the water collection bottle and cap with lake water three times. Always place the cap top side down to prevent contamination of the inside of the cap.

**STEP 3.** While holding onto the rope, lower the collection end (bottom) of the sampler tube vertically into the water column until the water level reaches the six-foot mark on the sampler. Raise the sampler out of the water.



**STEP 4.** Drain the integrated water sampler by touching the collection end of the sampler to the rod in the neck of the water collection bottle. Water will drain from the integrated water

**STEP 5.** Keep your water sample in a cool place and out of direct sunlight until you return to shore. A cooler is an ideal place to keep it. Algae in the lake water will continue to grow if the bottle remains in the sun.

**STEP 6.** Rinse your integrated sampler with distilled water after use and stored topside down. This will prevent algal growth between the ball and the collection end of the sampler.

***Do not handle any food, drink, sunscreen or insect repellent until after samples have been collected!***



DNR PHOTOS

**B**efore you start processing the sample(s), be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using.

**Sulfuric acid vials MUST be replaced every year.**

## ON SHORE PROCEDURES

Before you begin processing your water samples and preparing them for the State Laboratory of Hygiene, here is a quick checklist to make sure that you have everything you will need.

- Manual
- Field Data Sheets
- State Laboratory of Hygiene slip for your phosphorus and chlorophyll samples
- Pencil
- Safety gloves
- Safety goggles
- Phosphorus sample sticker
- Chlorophyll sample sticker
- "Acid added" stickers (optional)
- Plenty of ice cubes (you provide)
- Styrofoam<sup>®</sup> mailer kit
- Ziploc<sup>®</sup> bags
- Packaging tape
- Merchandise return label and priority mail stickers
- Magnetic Filter Funnel (2 pieces)
- Chlorophyll tube
- Hand pump with plastic tubing
- 500 or 1000 ml plastic flask
- 250 or 500 ml graduated cylinder
- Membrane filters
- Tube for chlorophyll filter
- 1 Filter forceps and 1 regular forceps
- Paper towels (you provide)
- Squeeze bottle filled with distilled water (you provide distilled water)
- Acid vial with sticker on it
- Phosphorus sample
- Water sample in the 2-quart water collection bottle



## ON SHORE PROCEDURES

### Phosphorus Sample Preparation

Be sure to wear long pants and shoes while processing samples to avoid getting acid on yourself and be sure to put on your gloves and safety goggles before beginning your phosphorus sample preparation!

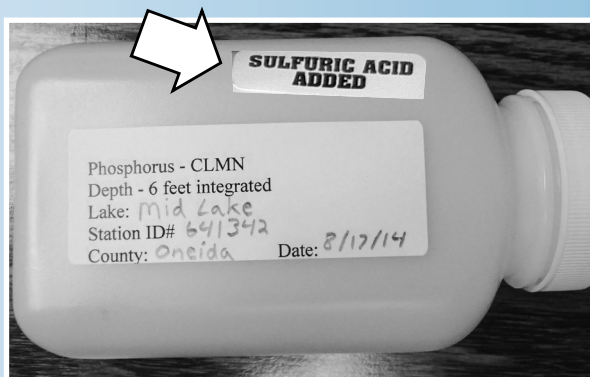
**STEP 1.** To prepare your phosphorus sample, remove the cap from your 250 ml State Laboratory of Hygiene bottle. Place cap topside down to prevent contamination. Gently mix the water in the water collection bottle and pour the water from the water collection bottle into the 250 ml bottle. Fill to the neck. Avoid touching the mouth of the water collection bottle and the phosphorus bottle lip to prevent contamination.

**STEP 2.** Remove the sulfuric acid vial from your kit.

**STEP 3.** Uncap your phosphorus bottle and empty contents of one acid vial into your phosphorus sample. Preservation by acid inhibits bacterial growth for a limited period of time. Always place the cap topside down to prevent contamination.

**STEP 4.** Replace lid on acid vial and the cap on your phosphorus sample. Mix your sample by inverting the bottle several times.

Attach a completed label with the name of your lake, station id number, county, and date. Don't forget to mark on your bottle that it is preserved with H<sub>2</sub>SO<sub>4</sub> (sulfuric acid), or as an option, attach the acid-added sticker to your bottle.



DNR PHOTOS

**STEP 5.** Remove label from sulfuric acid vial and place it on your lab form where it says, "Place sulfuric acid vial sticker over this box." If you aren't able to peel off the sticker, just make sure you get the lot # and expiration date.

**STEP 6.** When you are done adding the sulfuric acid, rinse and dispose of the used vials in the garbage. Store unused vials out of the reach of children!

**STEP 7.** Refrigerate phosphorus sample until ready to mail.

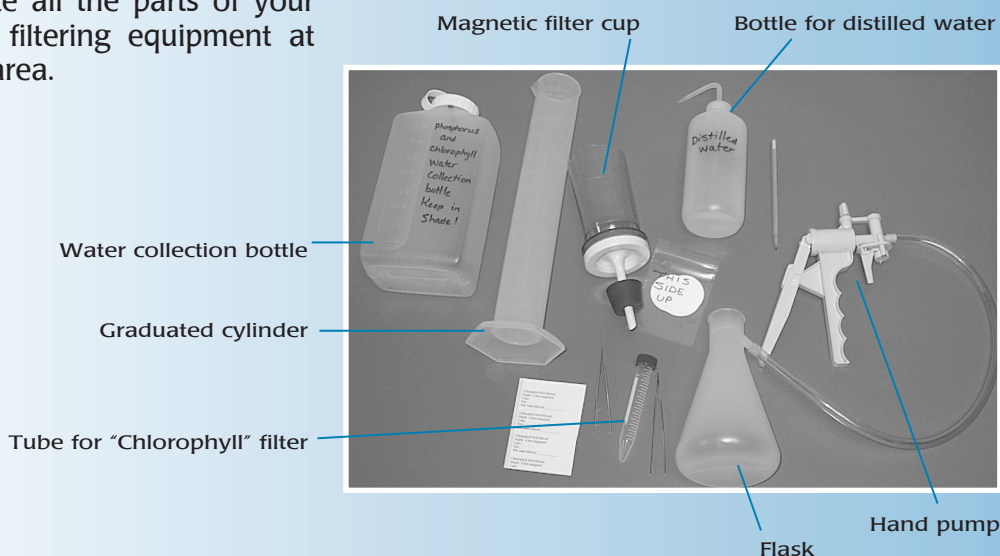


# ON SHORE PROCEDURES

## Chlorophyll Sample Preparation

Since light can cause the algae to grow and alter your sample, this on shore procedure for preparing your chlorophyll sample

**STEP 1.** Place all the parts of your chlorophyll filtering equipment at your work area.



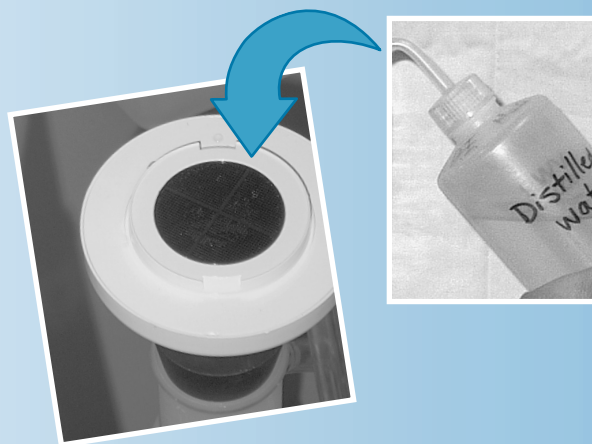
**STEP 2.** Attach the plastic tubing of the hand pump to the spout of the 500 or 1000 ml plastic flask.

**STEP 3.** Insert the stopper of the filtering cup into the flask. You may want to moisten the stopper first to ensure a good seal.

### STEP 4.

Squirt a small amount of distilled water on the black filter base **before** placing the membrane filter on it (see Step 5). This will help to hold the membrane filter in place until you can place the magnetic cup on top of it (see Step 6).

*Distilled water in squeeze bottle should be replaced every year.*

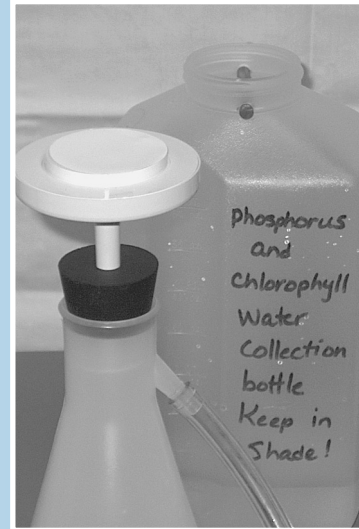


# ON SHORE PROCEDURES

## Chlorophyll Sample Preparation (continued)

**STEP 5.** Use the tweezers to pick up one membrane filter and place it on the center of the filter cup base (i.e. the black screen). Note that filters are white and the divider sheets are blue. Make sure you use a white filter and not a blue divider sheet!

**Note:** Never touch the filter with your fingers! Always use tweezers when removing it from the Ziploc® bag or when placing it on the black screen.



DNR PHOTOS

**STEP 6.** Carefully place the magnetic cup on top of the filter base. Be sure that the filter does not move! If the filter moves, wrinkles, or tears, remove the filter cup and discard the torn/wrinkled filter. Repeat steps 4 and 5 with a new filter.



DNR PHOTO

**STEP 7.** Using the table on the right, look up the Secchi depth you measured earlier in the day. Use this to determine the volume of water that you need to filter to obtain your chlorophyll sample. Please be aware that this amount may change each time you sample. In general, the better the water clarity (i.e. deep Secchi depth), the fewer algae there are in the water, and the more water you need to filter in order to collect enough algae for analysis.

**Volume of water to filter as determined by Secchi depth.**

Secchi Depth (ft)	Volume of Water to Filter (ml)
Less than 1	50
1 to 1.5	100
Greater than 1.5	200

# ON SHORE PROCEDURES

## Chlorophyll Sample Preparation (continued)

**STEP 8.** Gently mix the water that you collected in your water collection bottle. Fill your 250 ml graduated cylinder with the appropriate volume of water needed to filter your sample (Refer to step 7). **Note that although the upper cup of the filtering apparatus can be used to measure water volume, it is not an accurate measuring device and should not be used to measure the volume of water you need to filter.**

**STEP 9.** To begin filtering, pour some of the measured water from the graduated cylinder into the filter apparatus. You don't want to pour the full amount into the filter cup all at once. If your lake contains lots of algae or sediment, the filter will become clogged and you will not be able to empty the filter cup easily.

If the filter becomes clogged, try to filter the remaining water from the filter cup. You should remove the used filter using the filter forceps and place it in the chlorophyll tube provided by the WSLH. Put a new filter on the magnetic filter cup apparatus, replace the cup and continue to filter. You can send more than one filter successfully. **OR:** Try to filter as much water from the cup as possible and record only the amount of water you were able to filter.

**STEP 10.** Squeeze the hand pump to move the water through the filter. Once all the water has been filtered, wash down the sides of the graduated cylinder and filter cup with distilled water to ensure that all of the algae are washed onto the filter paper.



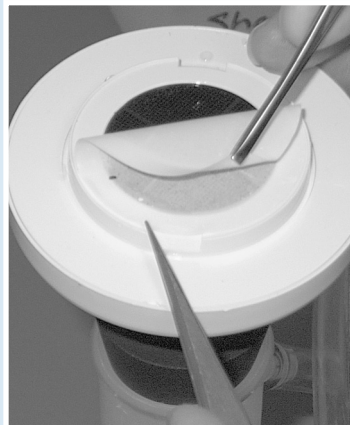
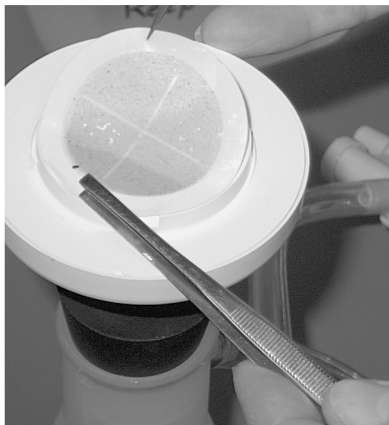
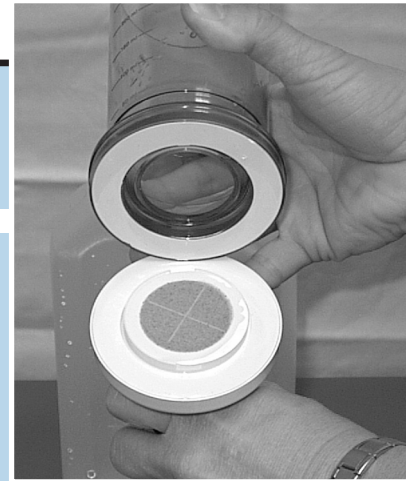
DNR PHOTOS

## ON SHORE PROCEDURES

### Chlorophyll Sample Preparation (continued)

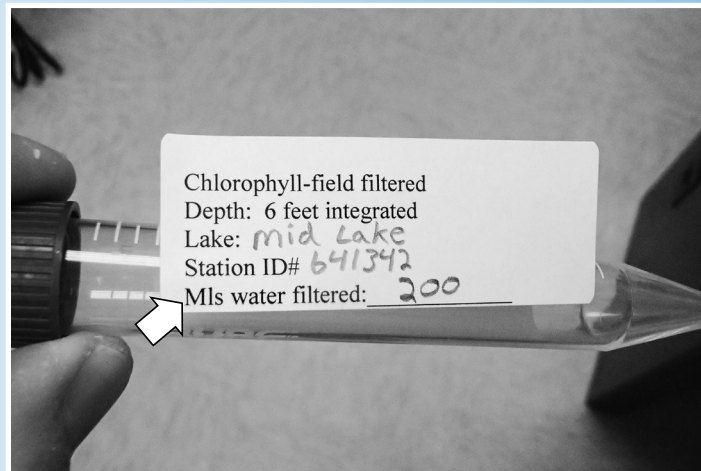
**STEP 11.** After you have filtered the appropriate volume of water, separate the filter apparatus by removing the top cup from the filter base.

**STEP 12.** Using tweezers, place the filter into the chlorophyll tube that came in the mailer from the WSLH. If the filter tears while you are removing it, it is okay to place it in the tube. Make sure that the algae that is on the filter does not get lost during transfer to the tube.



**STEP 13.** Fill out the chlorophyll label and place it on the tube containing your chlorophyll sample. Be sure to include the volume filtered (mls) on the label. Your station id number should be written on the label.

**STEP 14.** Don't forget to write the volume of water that you filtered for your chlorophyll sample on your lab slip.



**IT IS BEST TO MAIL YOUR SAMPLE ON THE DAY YOU COLLECT IT. But, put your chlorophyll sample in the freezer for a few minutes before you mail it. You can keep the chlorophyll sample in the freezer overnight and mail it the next day.**



## How to Fill Out Your Lab Sheet

When filling out your lab sheet, please make sure the following information listed is completed.

- Date**
- Time**
- Collected By Name**
- Telephone**
- Email Address**
- Depth of Sample**  
(3 feet or 0-6 feet)
- Chlorophyll - a mls of water filtered**

## Mailing Your Samples

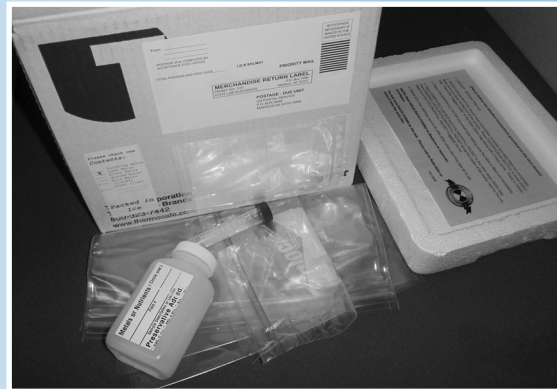
For the lab to get an accurate analysis of the phosphorus and chlorophyll in your lake, your

samples must be handled and shipped properly. Try to collect your samples early in the week so that you are able to put them in the mail on a Monday, Tuesday, or Wednesday. You want your samples to reach the WSLH by Friday so they do not sit in the post office over the weekend. If you collect your samples on a Friday, Saturday, or Sunday put your chlorophyll sample in the freezer and keep your phosphorus sample in the refrigerator until you are able to mail them on Monday. **Do not put your phosphorus sample in the freezer!** Keep in mind that the sooner the lab is able to analyze your samples, the more accurate your results will be. The following steps are an efficient way to make sure that your samples are packaged properly and prepared to ship to the State Laboratory of Hygiene safely.

## MAILING YOUR SAMPLES

**STEP 1.** Complete the laboratory data sheet for your phosphorus and chlorophyll samples. All information must be complete for the lab to analyze the samples. Make sure you have placed the sticker from the acid vial on your laboratory data sheet.

**STEP 2.** Gather all the materials you will need to mail your samples: Styrofoam® mailer, completed lab sheet, merchandise return label (mailing label), plenty of ice cubes, two sandwich-size Ziploc® bags, 2 one-gallon Ziploc® bags, and Priority Mail® stickers.

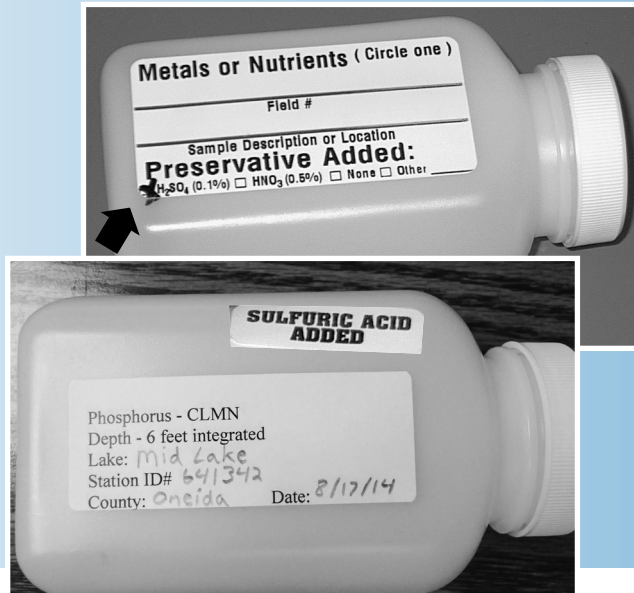


DNR PHOTOS

**STEP 3.** Prepare to mail your chlorophyll sample by making sure that the chlorophyll sticker is filled out completely and attached to the tube. Don't forget to include the volume of water that you filtered! Put your chlorophyll filter tube in a sandwich-size Ziploc® bag.

## MAILING YOUR SAMPLES (continued)

**STEP 4.** Prepare to mail your phosphorus sample by making sure that your sample was preserved with sulfuric acid. Attach the completed label with the name of your lake, station id#, county, and date. Don't forget to mark on your bottle that it is preserved with H<sub>2</sub>SO<sub>4</sub> (sulfuric acid), or as an option, attach the acid-added sticker to your bottle.



**STEP 5.** Place your phosphorus sample in the sandwich-size Ziploc® bag, seal the bag, and then put it in a one-gallon Ziploc® bag with as much ice as possible. Make sure this bag is sealed tightly or it will leak. If this bag leaks during mailing, the Post Office will not deliver it to the lab and your sample will be ruined.



### STEP 6.

- Place your bagged phosphorus sample containing the ice in the styrofoam mailer.
- Place the tube with the chlorophyll filter in the small Ziploc® bag and put it in the cooler next to the bag of ice.



**NOTE:** Always mail the lab slip with your samples!

DNR PHOTOS

## MAILING YOUR SAMPLES (continued)

**STEP 7.** Place your folded lab form in the large Ziploc® bag and lay it on top of the closed lid of the styrofoam cooler.



**NOTE:** Always mail the lab slip with your samples!

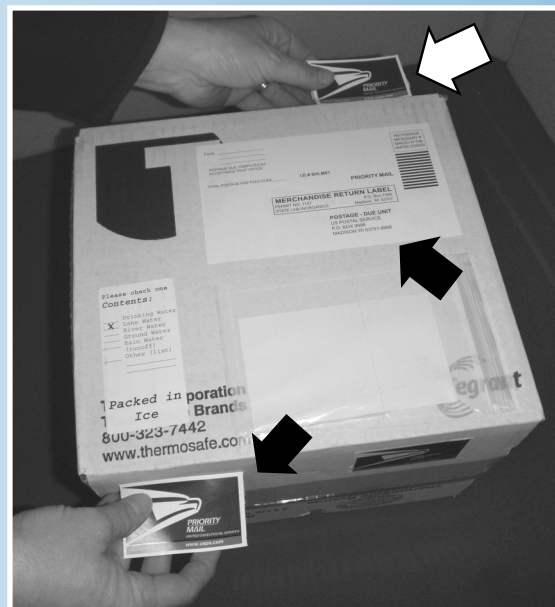
**STEP 8.** Tape the cardboard mailing box shut.



**STEP 9.** Tape once around the cardboard sleeve. Attach the 4 inch x 6 inch white merchandise return label to the top of the mailer. Attach **one** priority mail sticker to the top of the package and **one** to the bottom. The mailer card should have your postal address on one side. The other side should be **BLANK**. You want the blank side facing out when the sample is sent to the WSLH.

**STEP 10.** Put your samples in the mail with your regular outgoing mail or at the post office. The mailing label is postage paid, so you will not need any stamps.

**STEP 11.** Once the WSLH has received your samples, they will send you a new mailer to use for your next collection of samples.



DNR PHOTOS

## Quality Assurance Sampling Protocol

In 2007, the Citizen Lake Monitoring Network implemented procedures to document the accuracy and precision of the field data collected by volunteers. These procedures are a way to look at natural variability and sampling error. The protocol that was designed mimicked the Quality Assurance/Quality Control (QA/QC) methods used by the Wisconsin Department of Natural Resources (Wisconsin DNR) water quality staff.

Approximately ten percent of the total phosphorus (TP) and chlorophyll stations are randomly selected each year to participate in collection of QA/QC samples. The Wisconsin DNR asks volunteers who are chosen to participate to collect two additional phosphorus samples – a field blank and a duplicate (also called a replicate) sample. Volunteers also collect a duplicate chlorophyll sample.

The phosphorus field blank is prepared using deionized water – this water is provided to the volunteer and comes from the State Lab of Hygiene (WSLH). Deionized water is ultra pure. The blank phosphorus sample that the volunteer submits should be a “clean” sample – there should be no nutrients in it (which means your equipment is clean and does not have residual phosphorus). The blank sample is processed the same way that you process your regular phosphorus sample except that you are using deionized water instead of lake water. The QA/QC procedures are meant to “mimic” the collection procedures that are used in phosphorus collection and processing.

Before going out in the field, you will prepare your blank sample by rinsing your Van Dorn or integrated sample with deionized water, and then placing deionized water in your integrated sampler or Van Dorn sampling bottle. This water will then be placed in the water collection bottle that you normally use. From the water collection bottle the water sample goes to a “phosphorus bottle” – the same kind you use to mail your water sample to the WSLH. This water sample is preserved with sulfuric acid. Ideally, when analyzed by WSLH, the sample will have no detectible phosphorus. If the blank sample does contain phosphorus it could be that your equipment contains residual amounts of phosphorus or that the sampling technique is faulty – for instance, phosphorus could show up in a blank sample if you used your finger to release the ball of your integrated sampler to release water. The field blank also tests laboratory processing once the sample arrives at the WSLH.

The duplicate phosphorus sample is taken from the same site, at the same time, using the same method as your normal phosphorus sample. The only difference is that you will use a separate water collection bottle for each sample collected using your integrated sampler. Your CLMN regional coordinator provides an extra water collection bottle for you to use. The original and duplicate samples are independently analyzed in the same manner. The duplicate sample can be used to detect both the natural variability in the environment and that caused by your collection method in the field.

*(continued on next page)*

## Quality Assurance Sampling Protocol *(continued)*

The duplicate chlorophyll sample is taken from the same site, at the same time, using the same method as your normal chlorophyll sample. The original and duplicate samples are independently analyzed in the same manner. The duplicate sample can be used to detect both the natural variability in the environment and that caused by your collection method in the field.

If you are asked to participate in the QA/QC project you will be contacted by your CLMN regional coordinator who will explain the procedures and will provide you with the following:

### Field Blank Sample – Total Phosphorus

#### Materials Provided by Your CLMN Regional Coordinator

- A container of deionized water. There will be enough water to rinse your integrated sampler or Van Dorn sampling bottle and fill it once and enough to rinse your collection bottle.
- An additional phosphorus bottle (250 ml).
- A phosphorus label for the bottle that says BLANK. You will fill out the rest of the label.
- A lab slip for the BLANK sample. Please fill out the lab slip.
- A vial of sulfuric acid to preserve the BLANK sample.
- An extra Styrofoam mailer.

### How to Collect Your BLANK phosphorus sample

Please prepare this sample on land or on the boat prior to collection of your regular samples.

- Use the deionized water provided to rinse your integrated sampler or Van Dorn sampling bottle (which ever you normally use to collect your water samples).
- Dump the rinse water out the top of the integrated sampler or drain the Van Dorn sampling bottle like you normally do.
- Rinse the water collection bottle with deionized water and dump the rinse water out. Do not rinse the water collection bottle with lake water like you normally do.
- Fill the integrated sampler or Van Dorn sampling bottle with the deionized water provided to you by pouring it in through the top of the sampler to approximately the 6-foot tape mark.
- Drain the water from the integrated sampler or Van Dorn sampling bottle into the water collection bottle (like you normally do).
- Fill a 250-ml “phosphorus” bottle with the water from the water collection bottle.
- Add a vial of sulfuric acid to the sample to preserve it.
- Fill out and attach the label that reads BLANK.
- Refrigerate sample until ready to mail.

*(continued on next page)*

**Quality Assurance Sampling Protocol** *(continued)*

**Field Duplicate Sample – Total Phosphorus only**  
**Materials Provided by Your CLMN Regional Coordinator**

- One additional phosphorus bottle (250 ml).
- Extra Ziploc® bag for phosphorus bottle.
- Extra label for bottle that says DUPLICATE (be sure to fill out the rest of the label).
- Extra lab slip, this will be for the DUPLICATE phosphorus **and** chlorophyll sample. (Please fill out the lab slip).
- Extra sulfuric acid vial for DUPLICATE phosphorus sample.
- An extra Styrofoam mailer.

**Field Duplicate Sample – Chlorophyll –**  
**Materials Provided by Your CLMN Regional Coordinator**

- An additional chlorophyll mailing tube.
- Additional chlorophyll filter.
- Extra Ziploc® bag for the DUPLICATE chlorophyll tube and DUPLICATE and BLANK lab slip.

**How to Collect Your DUPLICATE**  
**Phosphorus and Chlorophyll Samples**

These will be collected while you are out on the lake doing your normal water collection.

- Rinse integrated sampler or Van Dorn sampling bottle and water collection bottle as you normally do.
- Collect lake water with your integrated sampler or Van Dorn sampling bottle as you normally do.
- Empty water into the normal 2-quart water collection bottle to use for the phosphorus and chlorophyll sample.
- Collect a second water sample with your integrated sampler or Van Dorn sampling bottle and empty into the new water collection bottle that was provided to you.
- Process the samples from the first water collection bottle on shore.
- Refrigerate the phosphorus sample and freeze the chlorophyll sample until you are ready to mail them.
- Rinse all equipment with distilled water before processing the second set of samples.
- On shore, fill a second 250-ml bottle (phosphorus bottle) and preserve as you normally would. Place the completed DUPLICATE phosphorus label on the bottle. Refrigerate sample until ready to mail.
- On shore, filter the appropriate amount of water from the second sample and process the second chlorophyll sample. Place in a separate tube and place the completed DUPLICATE chlorophyll label on the tube. Freeze the sample until you are ready to mail.

*(continued on next page)*

## Quality Assurance Sampling Protocol *(continued)*

### How to Ship Your Regular, BLANK, and DUPLICATE Phosphorus and Regular and DUPLICATE Chlorophyll Samples

- ✓ You will have 3 lab slips (one for the BLANK phosphorus sample, one for your regular phosphorus and chlorophyll samples, and one for the DUPLICATE phosphorus and chlorophyll samples).
- ✓ Put your regular chlorophyll tube in the small plastic zip lock bag and seal.
- ✓ Place your regular phosphorus in a small Ziploc® bag and seal.
- ✓ Add ice to a large ice bag and put the regular phosphorus sample in the ice bag. Place the Ziploc® bag with the chlorophyll tube in the cooler next to the ice.
- ✓ Place the lab form in the large Ziploc® bag and place on top of the closed styrofoam lid of the mailer—Seal the box.
- ✓ Do the same with the duplicate phosphorus bottle, duplicate chlorophyll tube and blank phosphorus—Place in second mailer. Place the lab form for the duplicate samples and blank sample in the Ziploc® bag on top of the styrofoam lid. Seal the box.

You will be mailing a total of three phosphorus samples and two chlorophyll samples.

After the samples are analyzed by the WSLH the results of the QA/QC study will be published on the CLMN website. If there are specific problems with a volunteer sample, they will be contacted by the CLMN regional coordinator and together they will work to resolve the problem.

### A Training Video For Quality Assurance

A training video showing how to collect a blank and duplicate sample and how to mail it is available with at <https://youtu.be/Rzqi29Hc6DU> or you can go to the “Extension Lakes” YouTube channel and search for “quality assurance”.

# NOTES





# 5. DISSOLVED OXYGEN MONITORING:

## Using a Digital Meter

**B**efore you start sampling, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using.

- **NOTE:** If you are using a dissolved oxygen meter you must read the manufacturers manual before use. Dissolved Oxygen meters require regular calibration and/or regular membrane changes.



- After sampling, it is very important to rinse and thoroughly air dry all of the equipment that you used.
- As always keep paperwork and envelopes separate from equipment. Be sure to turn off your meter and store out of direct sunlight.

## How Do You Prepare to Sample?

### The Day You Sample

On the day you plan to sample, complete the top portion of your field data sheet by filling in the Waterbody # (or WBIC) and Station #. Before you launch your boat, make sure you have an anchor, sufficient gas, and personal flotation devices in your boat.

Before using your dissolved oxygen meter, be sure to read the owner's manual. In order to get accurate data from your meter, you must learn how to calibrate your meter and use your meter properly. You should keep a Calibration Log.

## Sampling Overview

### Dissolved Oxygen Meter

The CLMN allows volunteers to use their own dissolved oxygen meter to take your readings. If you choose to collect your dissolved oxygen data using this method, it is important to calibrate your meter each time it is used. Please follow all instructions for care and maintenance found in the operation manual for your particular model as maintenance of the meter is imperative to get good data. If you choose this method you should inform your CLMN coordinator so they can flag the database with this information.

## ON LAKE PROCEDURES

### Dissolved Oxygen Monitoring

#### *Dissolved Oxygen Meter*

**STEP 1.** Your regional coordinator will assign 5 to 10 depths to sample for dissolved oxygen. Your meter will also record temperature. You will collect dissolved oxygen and temperature data at the same depths.

**STEP 2.** Follow manufacturer's instruction for calibration and use.

**STEP 3.** Lower the probe to the assigned depth. Record temperature and dissolved oxygen reading from the meter onto your data sheet.

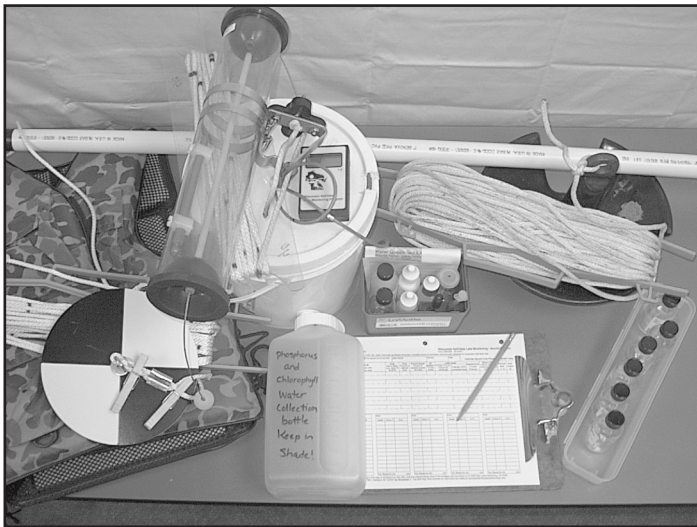


**NOTE:** Dissolved oxygen should be collected in the "mg/L" mode only. Some meters are calibrated in percent saturation, so be sure to use the mg/L mode while gathering data.

Record the type of meter you are using under "observations" on your data sheet.

# 6. DISSOLVED OXYGEN MONITORING:

**B**efore you start sampling, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using.

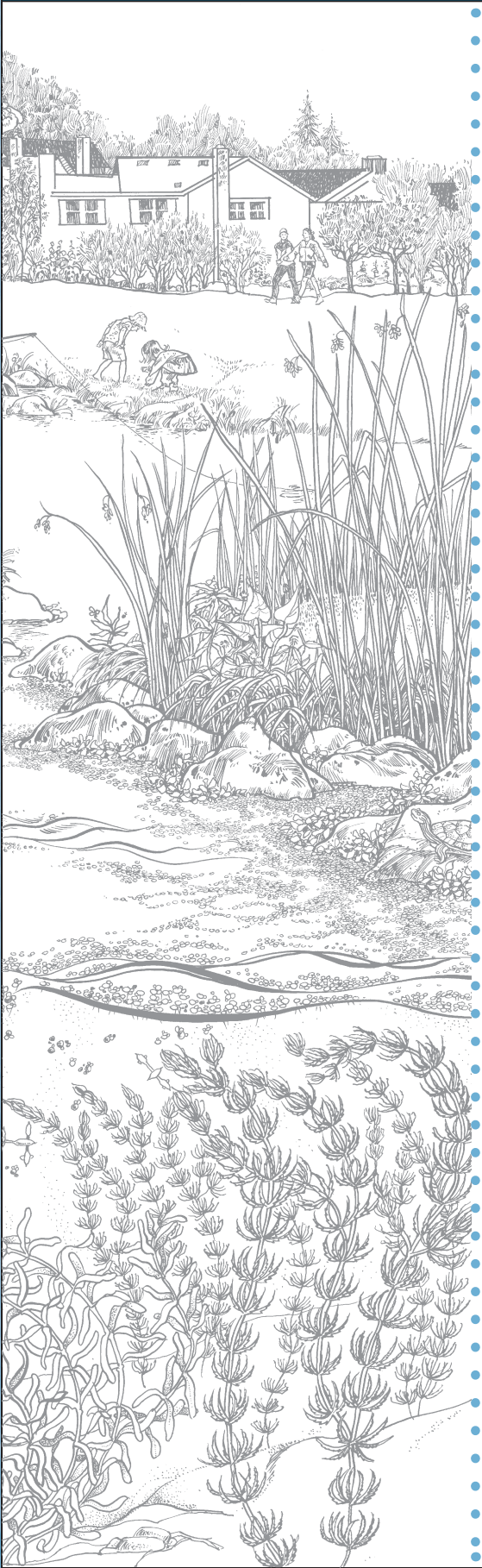


*Please remember to keep all sampling equipment and chemicals out of the reach of children. Many of the chemicals you will be using are hazardous (see Appendix 1). After sampling, it is very important to rinse and thoroughly air dry all of the equipment that you used. As always keep paperwork and envelopes separate from equipment.*

## What Equipment Will You Need?

At your training session, your CLMN regional coordinator will outline and provide all of the equipment that you will need to successfully monitor your lake.

- Manual
- Lake map with sampling sites marked
- Life jackets (you provide)
- Anchor and rope (you provide)
- Field data sheets
- Van Dorn sampling bottle
- Safety gloves
- Safety goggles
- Chemicals and equipment in the LaMotte® titration kit (**note:** all chemicals should be replaced every year): manganous sulfate, alkaline potassium iodide azide, sulfuric acid, sodium thiosulfate, starch indicator solution, syringe, 25-ml graduated cylinder, eye dropper, dissolved oxygen sample bottles (labeled with appropriate depths) and rack, glass vial with plastic lid.



## How Do You Prepare to Sample?

### The Day You Sample

On the day you plan to sample, complete the top portion of your field data sheet by filling in the Waterbody # (or WBIC) and Station #. If you do not know what these numbers are contact your CLMN regional coordinator. If you are using the LaMotte® titration kit to measure dissolved oxygen, mark the bottles with appropriate pre-determined depths. Check to make sure all of your chemicals are fresh (they need to be replaced every year). Check your Van Dorn sampling bottle to make sure it is working properly. Once this is done, you can begin to load all of your sampling equipment into the boat. Before you launch, make sure you have an anchor, sufficient gas, and personal flotation devices in your boat.

### Sampling Overview

#### Winkler Titration Method (LaMotte® Dissolved Oxygen Kit)

Sampling the dissolved oxygen in your lake can be tricky since oxygen in the air can easily contaminate your water sample. To create your dissolved oxygen profile, you will collect water samples at specified depths and measure the oxygen content of the water. Since you have no alternative but to bring your samples to the surface to measure the oxygen, you must take precautions to ensure that your samples do not get contaminated. When filling your collection bottles with your water samples, make sure that you allow the bottle to overflow at least 2 seconds before quickly capping the bottle. This will make certain that no air will get trapped in the bottle and contaminate your sample.

The LaMotte® kit uses the Winkler titration method for determining dissolved oxygen. With this method, reagents react with chemicals in your water sample causing a color change. The amount of reagent needed to create this color change helps you determine what your dissolved oxygen reading is. Use of the Van Dorn sampling bottle is necessary for determining your dissolved oxygen profile since it retrieves water samples from the desired depth to be tested.

**NOTE: If you are collecting water samples using a Van Dorn sampling bottle, see page 39. You must use a Van Dorn sampling bottle to collect samples for dissolved oxygen analysis.**

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## ON LAKE PROCEDURES

**STEP 1.** Your regional coordinator will assign to you 5 to 10 depths at which you should sample for dissolved oxygen and will help you mark your sample bottles accordingly. These depths will be the same as the ones you measure for water temperature.

**STEP 2.** Use the Van Dorn sampling bottle to collect samples at your pre-determined depths.

**STEP 3.** Remove the cap of the appropriate dissolved oxygen sample bottle. Place cap topside down to avoid contamination.

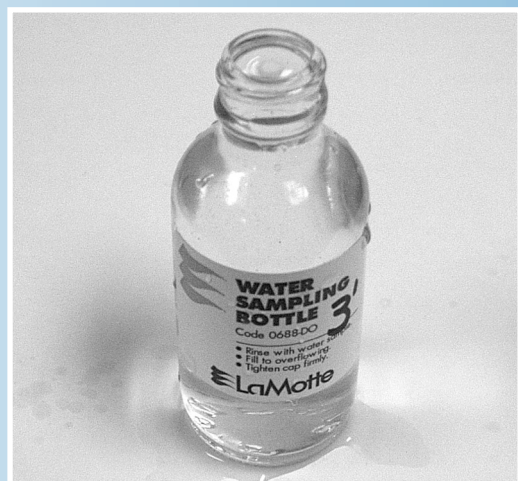
**STEP 4.** If you did not already record a temperature profile of your lake using a digital probe, now is the time to record the water temperature using the thermometer in the Van Dorn sampling bottle. After recording the water temperature of your first sample, let out a small amount of water from the sampler to rinse out the rubber tube. Then insert the rubber tube all the way to the bottom of your sample bottle. Open the hose clamp, release the vacuum and allow the water you collected to flow into your sample bottle overfilling the bottle for at least 2 seconds.



**STEP 5.** While the water is still flowing, slowly remove the tube allowing your sample bottle to overfill. Water will actually appear above the top of the bottle.

**STEP 6.** Quickly cap your sample bottle. There is a nipple in the cap. This nipple will displace water in the bottle making room for you to add chemicals for your analysis.

**STEP 7.** Put on your gloves and safety goggles.



DNR PHOTOS

## ON LAKE PROCEDURES

**STEP 8.** Remove the cap from the sample bottle you just filled with lake water and add eight drops of the manganous sulfate solution from the squeeze bottle. Make sure to hold the squeeze bottle completely vertical (i.e. not at an angle) for consistent drop size and to avoid splatter.

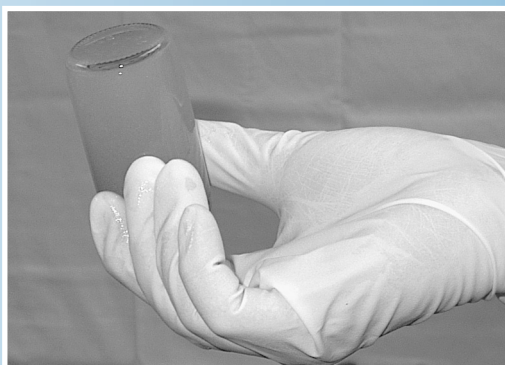
**Note:** Place cap topside down to avoid contamination.



**STEP 9.** Then add eight drops of the alkaline potassium iodide azide solution. Once again, make sure to hold the squeeze bottle completely vertical (i.e. not at an angle) for consistent drop size and to avoid splattering.



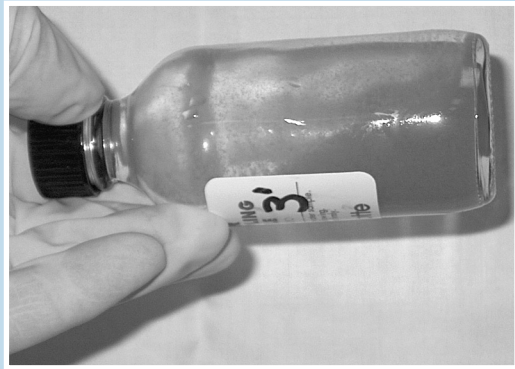
**STEP 10.** Cap your dissolved oxygen bottle and mix your sample by inverting the bottle 10 to 20 times. Put the bottle in the sample tray and allow the precipitate (e.g. the solid substance that is forming in your bottle due to a chemical reaction) to settle. This process may take a few minutes.



DNR PHOTOS

## ON LAKE PROCEDURES

**STEP 11.** Once the precipitate has settled, re-mix your sample by inverting the sample bottle another 10 to 20 times. Put the bottle in the sample tray and allow the precipitate to settle again.



**STEP 12.** Once the precipitate has settled for a second time, add eight drops of sulfuric acid ( $H_2SO_4$ ) from the squeeze bottle. Cap your sample bottle and invert to mix. Continue mixing the bottle for several minutes until all the precipitate has dissolved. The sample is now “fixed”, meaning that the dissolved oxygen concentration cannot change.



DNR PHOTOS

**STEP 13.** Repeat steps 1-12 for each pre-determined depth that you are collecting a water sample.



**NOTE:** Your fixed D.O. sample will retain its dissolved oxygen level for up to 8 hours if the sample is refrigerated and kept in the dark. However, for best results, the sample should be titrated as soon as you return to shore.

**B**efore you continue processing your dissolved oxygen samples, be sure to read the following pages to familiarize yourself with the equipment and the procedures that you will be using. All of the procedures that you will follow in sampling your lake are done for specific reasons. It is very important that you follow the sampling procedures exactly as they are laid out in the following pages to ensure good, consistent, high quality data. The following pages will provide you with sufficient background on the design of the equipment and proper procedures to use.



**MENISCUS** • The curved upper surface of a still liquid in a tube caused by surface tension; concave if the liquid wets the walls of the container, convex if it does not.

## ON SHORE PROCEDURES

### Winkler Titration Analysis (LaMotte® Dissolved Oxygen Kit)

Before you begin analyzing your samples on shore, here is a quick checklist to make sure that you have everything you will need.

- Manual
- Field Data Sheets
- Pencil
- Safety gloves
- Safety goggles
- LaMotte® titration kit

**Note:** All chemicals should be replaced every year.

Set up your LaMotte® dissolved oxygen kit in a place that has plenty of room and is convenient place to work. You should have already added eight drops of the manganous sulfate solution and eight drops of the alkaline potassium iodide azide solution to each of you samples in the field.



**NOTE:** If you did not “fix” your samples in the field (as outlined in step 12 on page 65), **make sure that you do it now** by adding the eight drops of sulfuric acid ( $H_2SO_4$ ) to each of the dissolved oxygen samples you took. Invert the bottles enough to mix the acid and dissolve the precipitate.



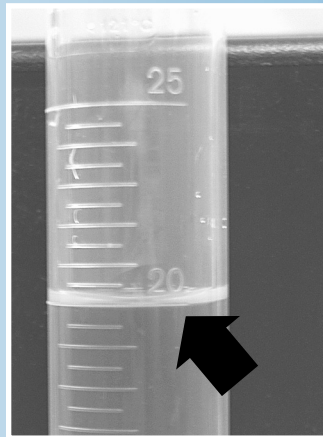
# ON SHORE PROCEDURES

## Winkler Titration Analysis (LaMotte® Dissolved

**STEP 1.** Rinse the 25 ml graduated cylinder and the small glass vial with the center-hole plastic lid with distilled water.

**STEP 2.** Take out your first “fixed” dissolved oxygen sample. Uncap your sample bottle and fill the graduated cylinder with 20 ml of your “fixed” sample.

*Due to the adhesive nature of water molecules, when you look at the water level from the side, the liquid in the graduated cylinder will not be flat. Instead the liquid will sag downward. This curved surface is called the meniscus. Always read from the bottom of the **meniscus** when measuring the volume of liquid that you want. In this case you want the bottom of the meniscus to line up with the 20 ml mark on the graduated cylinder.*



**STEP 3.** Pour the 20 ml sample that you just measured from the graduated cylinder into the small glass vial. Cap the glass vial with the center-hole plastic lid. Please note that even though the glass vial may have volume measurement markings on it, the graduated cylinder is a more accurate measure of volume than pouring your “fixed” sample directly into the small glass vial.



**STEP 4.** Insert the tip of the syringe into the sodium thiosulfate solution. Turn the bottle and syringe upside down and slowly draw the solution into the syringe past the line marked “0”. Remove any air trapped in the syringe by pushing liquid back into the bottle until the bubbles are expelled. You may need to tap the syringe while it is upside down to move the bubbles towards the tip. Remove the syringe. Store the sodium thiosulfate solution in a cool, dry place.

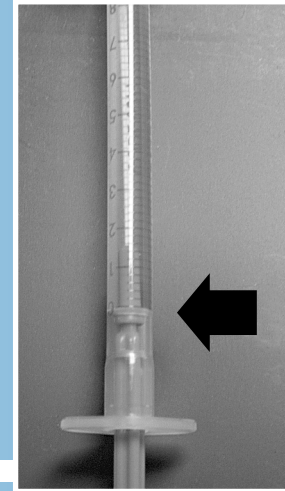


DNR PHOTOS

## ON SHORE PROCEDURES

### Winkler Titration Analysis (LaMotte® Dissolved Oxygen Kit) (continued)

**STEP 5.** Pushing the plunger of the syringe and expelling any extra solution onto the ground, match up the top of the plunger with the line on the syringe marked "0" (see "Reading the Syringe" on page 71).



**STEP 6.** Insert the syringe into the hole in the cap of your glass vial containing your "fixed" sample. Very slowly, add the sodium thiosulfate solution drop by drop by pushing on the plunger of the syringe. Gently swirl your sample after each drop. It is possible to add as little as 0.1 units (half the distance between the lines on the syringe) with each addition.



**STEP 7.** Add the sodium thiosulfate solution until the color of your water sample has changed to a very faint straw yellow. To clearly see the color, it may be helpful to hold a sheet of white paper behind your sample vial after each addition. The exact color is not that important. The object is to add drops to lighten the color, but to stop before the sample becomes clear. The amount of sodium thiosulfate that you add will vary between your samples depending on the amount of dissolved oxygen that is in each sample.

**Note:** *If the dissolved oxygen content of your sample is very high, it may not become a faint yellow color even after you have added the entire contents of the syringe! In this case, you will need to refill the syringe with the sodium thiosulfate solution by repeating steps 4 and 5. Make sure you note this on your data*

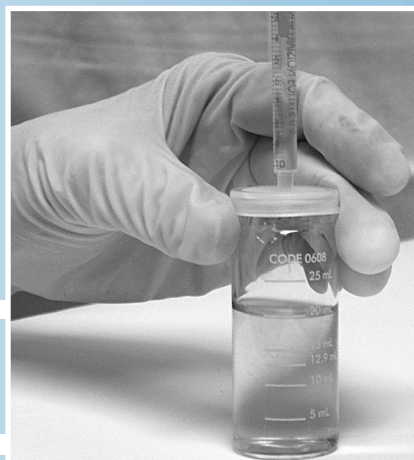


DNR PHOTOS

## ON SHORE PROCEDURES

### Winkler Titration Analysis (LaMotte® Dissolved Oxygen Kit) (continued)

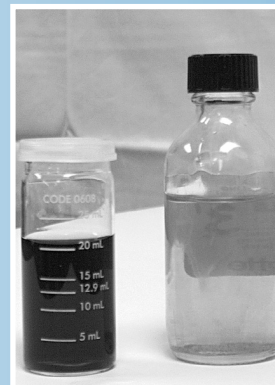
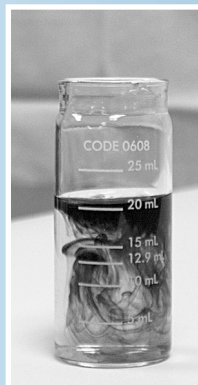
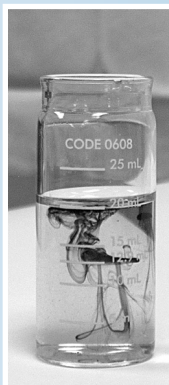
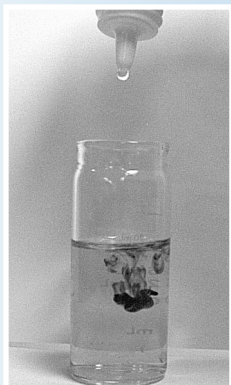
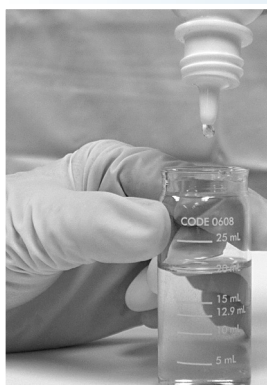
**STEP 8.** When you have achieved the straw yellow color, carefully remove the syringe from the vial and set the syringe aside. Do not empty the contents of the syringe as you will need it for step 11.



**STEP 9.** Remove the center-hole plastic lid from the glass vial.

**STEP 10.** Add eight drops of the starch indicator solution to your 20 ml sample in the glass vial.

Put the lid back on. Gently mix your sample by swirling the vial. Your sample will turn dark blue or black.



**STEP 11.** Reinsert the syringe that you set aside in step 8 into your sample vial. The syringe should still contain the sodium thiosulfate from steps 4 through 8.

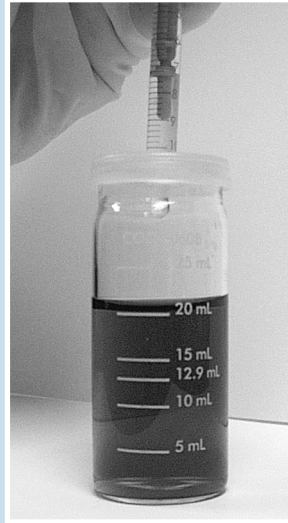


DNR PHOTOS

## ON SHORE PROCEDURES

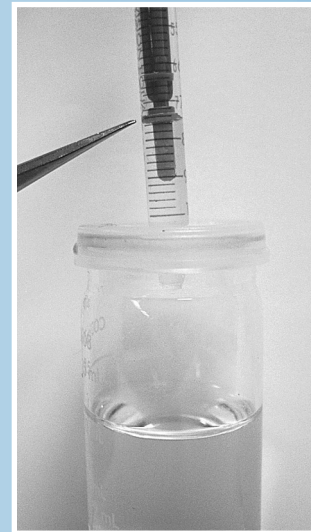
### Winkler Titration Analysis (LaMotte® Dissolved Oxygen Kit) (continued)

**STEP 12.** Very slowly, add the sodium thiosulfate solution to your sample one drop at a time. Take care to swirl the contents of the glass vial between drops. Add the sodium thiosulfate solution drop by drop until the blue or black color of your sample disappears when you swirl it. Swirling the contents of your sample vial allows time for the color to change between drops! Every drop counts so proceed slowly.



**STEP 13.** When your sample has turned clear, remove the syringe. Before expelling the remainder of the sodium thiosulfate solution in the syringe, read and record the volume of solution that you used (see “Reading the Syringe” on the next page).

This step is very important, as it is the “answer” to the dissolved oxygen content of your water sample! Once you have recorded the volume of solution that you used, you can discard the remaining solution by flushing it down a drain with lots of water. Do not return it to the sodium thiosulfate bottle!



DNR PHOTOS

**STEP 14.** Rinse the syringe with distilled water and wipe it off before repeating steps 1 through 13 for your next sample. Remember, since this analysis only uses 20 ml of your “fixed” sample, if at any time you feel that you made a mistake, you should have enough “fixed” sample water remaining to repeat the analysis.

**Note:** *all chemicals should be stored out of the reach of children. Chemicals should be replaced every year.*

**STEP 15.** Be sure to rinse all of your equipment with distilled water when you are finished.

## READING THE SYRINGE

Once your sample in the glass vial has changed from blue to clear (steps 12 to 13), the dissolved oxygen titration is complete. To determine the amount of dissolved oxygen in your sample, record the position of the plunger in your syringe. The syringe is marked in 0.2 (two-tenths) intervals.

**Example 1:** The tip of the plunger is flush with the number 6.0 after step 12 (page 70). Since you started adding the solution when the plunger was flush with the number 0, your sample contains 6 **parts per million (ppm)** of dissolved oxygen.

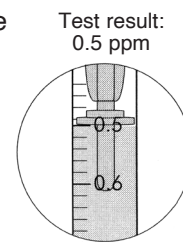
**Example 2:** Suppose you had to refill the syringe once with the sodium thiosulfate solution before your sample changed color to a faint straw yellow. After adding the sodium thiosulfate solution for a second time, the color of your sample changes from blue to clear. At this point the plunger is flush with the number 3.2. Therefore, the dissolved oxygen content of your sample is 13.2 ppm (10 ppm from the first syringe of sodium thiosulfate solution when the entire contents were added, plus 3.2 ppm from the second syringe of sodium thiosulfate solution).



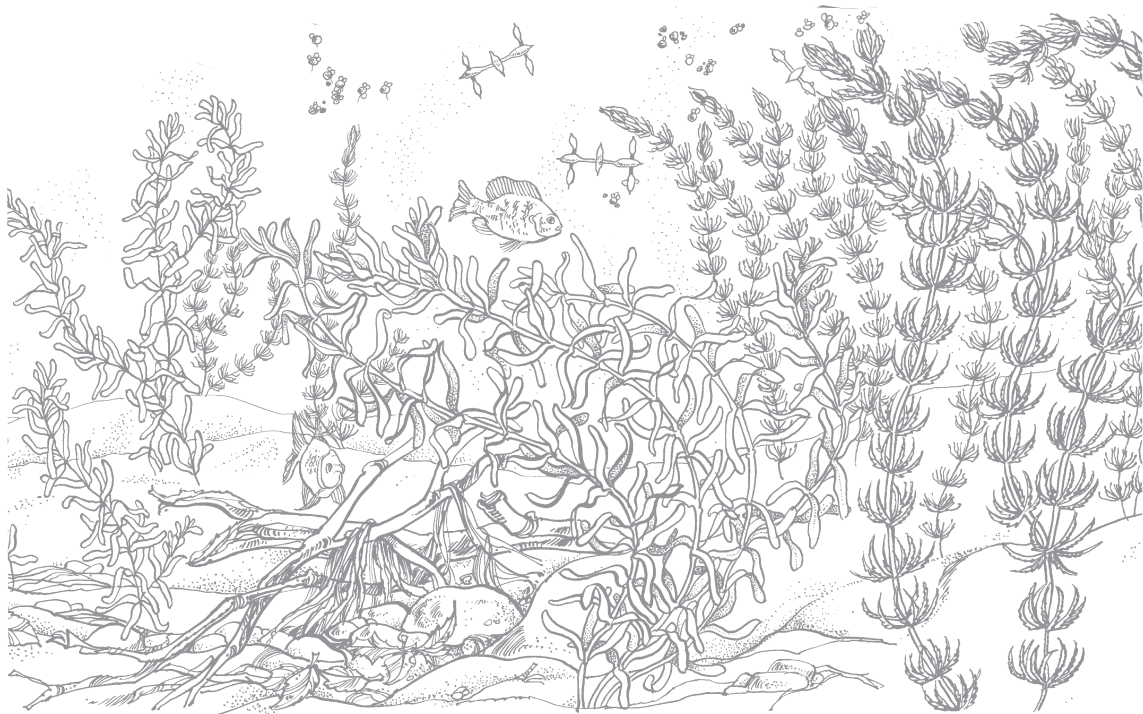
**PARTS PER MILLION (ppm)** • An expression of concentration indicating weight of a substance in a volume of one liter. Milligrams per liter (mg/l) is an equivalent unit.

### Reading the syringe.

Read the test result directly from the scale where the large ring on the Titrator meets the Titrator barrel. If the Titrator was refilled to reach the final color change, add the total amounts of titrant used to determine the final test result.



USED WITH PERMISSION FROM THE LAMOTTE COMPANY



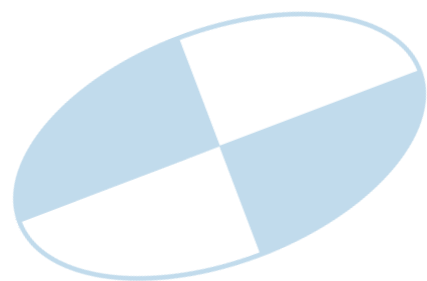
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## Clean-up

There are only a few things left for you to do after you have prepared your samples for mailing to the State Laboratory of Hygiene. Rinse out your water sampler, graduated cylinder, water collection bottle, and filtering apparatus with distilled water. If you analyzed dissolved oxygen, you should thoroughly rinse all your dissolved oxygen bottles and the glass vial and syringe with distilled water. It is okay for the contents of these items to be rinsed down the sink with a continuous flush of water. Do not use soap when cleaning your sampling supplies! Be sure to let all of your equipment air dry before storing them. Once everything has air dried, store your sampling equipment in the plastic tub where it can stay dry and be out of the reach of children! Make sure the lid to the plastic tub is tight to keep dust and rodents out.

Before storing the integrated water sampler, rinse the inside with distilled water. Store your integrated sampler in a vertical position with the rope end down. This will allow for the water to drain from the tube and prevent potential algae and bacterial growth on the ball mechanism.

Rinse your Van Dorn sampling bottle with distilled water. Place pencils or popsicle sticks in both ends so the sampler will dry out. Remove the popsicle sticks or pencils from the Van Dorn sampling bottle as soon as the sampler is dry so that the rubber tubing inside the sampler does not stretch causing the sampler to leak. Open up or remove the hose clamp from the rubber tubing on the outside of the sampler so the hose can dry out – otherwise mold or mildew will grow inside of the tubing.



# Taking Care of Data

Once you are back on shore, transfer all your data to the data form. This form will make it easier for you to enter your data online or submit by mail. After entering your data into the DNR database, fill in the column labeled “Date Entered” on your data form. This will allow you to keep track of what data you have already entered.

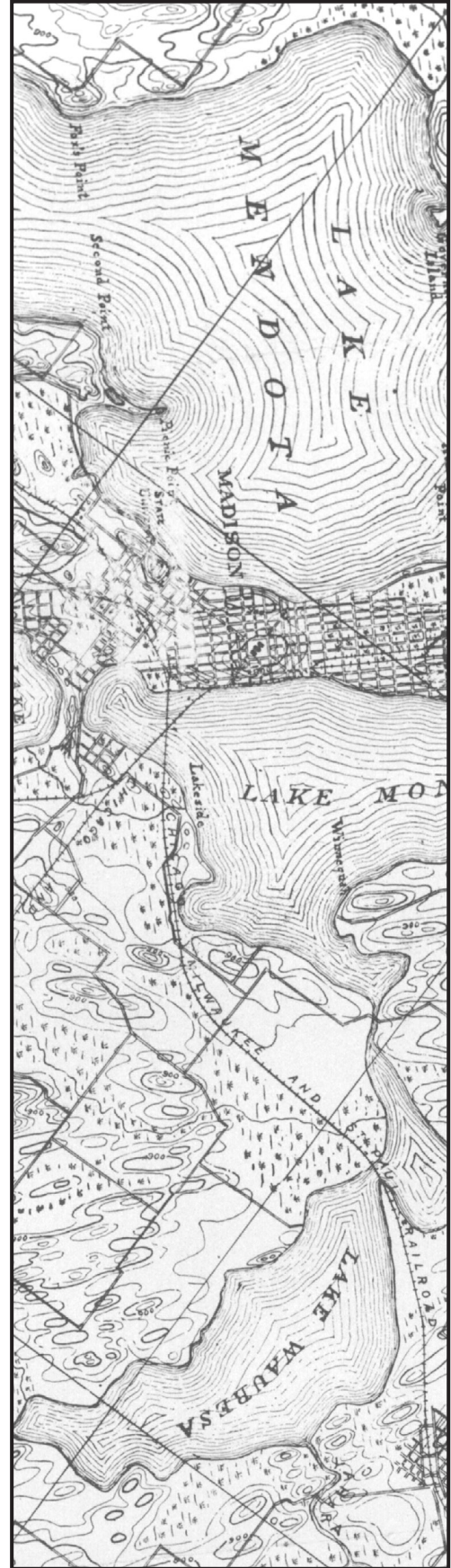
## Online

The address to enter your data online is [on.wisconsin.gov/WAMS/home](http://on.wisconsin.gov/WAMS/home). You will need a user name and password to enter data. If you are entering a temperature profile and/or dissolved oxygen profile choose the option “Save and Enter Temp D.O. Profile”. If you make mistakes while entering data, edits can be made. Instructions for online data entry can be found in Appendix 4.

If you enter your data online, there is no need to mail in a paper copy.

All data for the year should be entered by November 1st to guarantee that it will be included in reports and analyses done in the winter and spring. If you find data that has not been entered after this date you can still enter your data online or you can mail your data sheets to your CLMN Coordinator.

Your reports will show the dates you sampled, and your Secchi disk readings measured in feet and meters. Always compare your annual report to a copy of your original data sheet to verify your data.



## HOW TO FILL OUT YOUR FIELD DATA SHEET

During your training session, you should have received:

- A waterbody identification code (WBIC)
- Station #

The WBIC is a number assigned to your lake and allows the Citizen Lake Monitoring Network to know exactly which lake you are monitoring. The Station # is assigned to the specific monitoring site on your lake and the data that you collect is tied to that specific number. If you decide to change your sampling site, it is very important that you contact your regional coordinator right away so a new Station # can be assigned for that site. While you are sampling on your lake, record all of your data on the white "Field Data Form". You can use this same form for repeated sampling days until it is filled up, or too wrinkled from wind and water to use anymore. However, if you change sampling site locations within a lake or change lakes, you must use a new form!

**Wisconsin Citizen Lake Monitoring Network – Secchi & Chem**  
Form 3200-099 (R 10/19)  
Notice: Information is collected under s. 33.02, Wis. Stats. Personally identifiable information, including names of volunteers, will be broadly distributed in conjunction with lakes data.

State of Wisconsin  
Department of Natural Resources

Names of each volunteer who sampled on each date

Date Use 4 digits. May 19 is 0519

Time Round to nearest hour

Secchi Depth Round to nearest quarter of a foot

Hit Bottom Yes No

Lake Level High Low Normal

Appearance Clear Murky

Water Color Blue, Green, Brown, Red, Yellow

Perception 1-5

Date Entered to SWIMS

Observations:

Observations:

Observations:

Observations:

Did you calibrate DO meter? Y/N

Depth Temp. F D.O. mg/L

Did you calibrate DO meter? Y/N

Depth Temp. F D.O. mg/L

Did you calibrate DO meter? Y/N

Depth Temp. F D.O. mg/L

Did you calibrate DO meter? Y/N

Depth Temp. F D.O. mg/L

\*Perception = Perception of the amount of algae in the water at your sample location:  
1=Beautiful, could not be any nicer.  
2=Very minor aesthetic problems; excellent for swimming and boating enjoyment.  
3=Swimming and aesthetic enjoyment of lake slightly impaired because of high algae levels.  
4=Desire to swim & level of enjoyment of lake substantially reduced because of algae; would not swim, but boating is OK.  
5=Swimming and aesthetic enjoyment of lake substantially reduced because of algae levels.

If you enter the data on the web, keep a copy for your records. There is no need to mail a paper copy. Otherwise mail copy to Citizen Lake Monitoring Network, WI DNR, PO Box 7921, Madison WI 53703; or to your local coordinator, by November 1. The Citizen Lake Monitoring web site is: <https://dnr.wi.gov/lakes/cimn/>

The following descriptions represent the portions of your data sheet that can be filled out while you are on the shoreline or before you get into your boat. Data sheets can be found online.

### Date

When recording the date it is only necessary to use 4 digits. For example, if you sampled on May 19<sup>th</sup>, you would record this on your data form as "0519"; July 6<sup>th</sup> would be "0706", etc. You do not need to include the year since your data is submitted annually.

### Time

Record the time you started your sampling.

### Lake Level

Record the water level on your lake. It helps to use the shoreline or your pier as a guide to indicate whether your lake level is high, low, or normal. If you are able to determine the water level using a staff gauge on the lake, indicate this on the data sheet and record the numerical value in the space provided.



The following descriptions should be filled out while you are on the water at your sampling site so the observations are fresh in your mind.

#### Secchi Depth

When recording your Secchi disk reading, round off to the nearest quarter foot. Record fractions of a foot as a decimal since this is how it will be entered online. For example, 12 1/4 feet is 12.25 feet. It is possible that the Secchi disk will be visible even when it is resting on the bottom of the lake. If this is the case, record the depth as you always would, but make sure you record a "yes" for the "Hit Bottom" field of your data sheet.

#### Appearance

To determine if the water appearance is clear or murky, hold your Secchi disk one foot under the surface of the water and observe how the white part of the disk appears.

#### Water Color

The water color is determined at your site using the Secchi disk as a guide. After lowering the disk about a foot into the water, ask yourself the question, "Does the white part of the Secchi disk look white, or does it appear green or brown?" If it appears white, then the water color is "blue." If it appears green, then the water color is "green" and so on. If you are using color cards to determine the color of your lake water, then the white part of the disk would be compared to the colors on the card and a numeric value assigned to the color. Be aware that the online data entry form and Secchi Line only accept one color, for instance, if the water appears "bluish-green," you will have to select the one color (blue or green) that best describes your water color.

#### Perceptions

Indicate your perception of the water quality for your lake at the deep hole. **Refer only to the condition of the water itself.** You can record information on aquatic plants around the shoreline or other problems you perceive in the observation section of the data sheet. On a scale of 1 to 5 (1 being the best and 5 being the worst), your perception of the water should reflect how much algae is in the water.

- 1 - Beautiful, could not be any nicer
- 2 - Very minor aesthetic problems; excellent for swimming and boating enjoyment
- 3 - Swimming and aesthetic enjoyment of lake slightly impaired because of high algae levels
- 4 - Desire to swim and level of enjoyment of lake substantially reduced because of algae (would not swim, but boating is OK)
- 5 - Swimming and aesthetic enjoyment of lake substantially reduced because of algae levels

#### Observations

In the observation section of the data sheet, you can include any comments about the weather, water conditions, wildlife sightings, plant densities, or other information you want to include that you think will help to better understand your lake. If you need more data sheets, have questions or problems, you may also include those comments in this section. Feel free to attach additional observations on a separate sheet of paper. You can enter as much information as you'd like. The database can hold long entries.

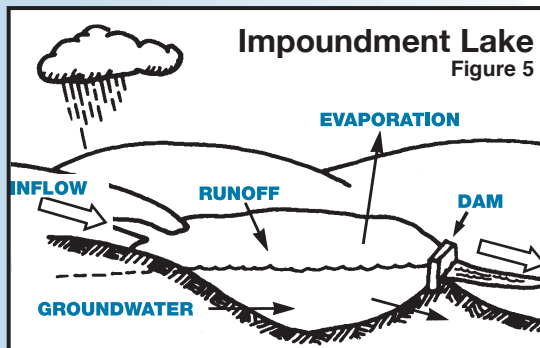
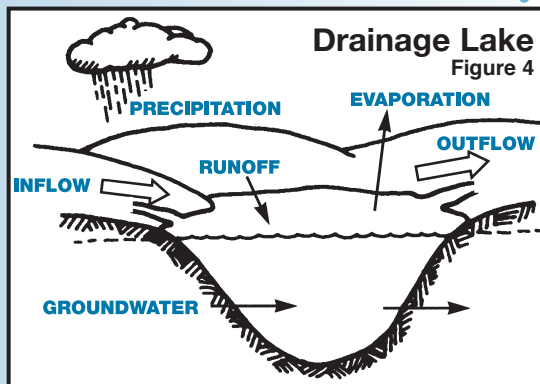
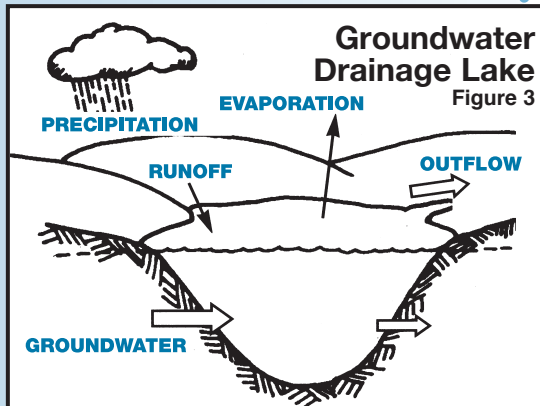
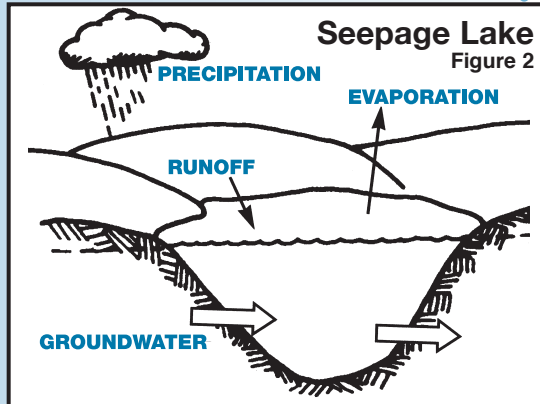
## HOW TO REPORT ICE ON/OFF INFORMATION

You can report your ice observations online in SWIMS. After you log in, choose the Ice Observation project for your lake. If you do not have an Ice Observation project, contact your CLMN Coordinator.



ROBERT QUEEN

Figures 2-5. *Lake Types. Major water inputs and outflows of different lake types. Large arrows indicate heavy water flow.* (Taken from Shaw et al 2000 "Understanding Lake Data")



# Understanding Your Data

When you receive your annual report, the first thing you should do is check for errors. The easiest way to do this is to compare your report to your original records. If you find an error, please let your coordinator know.

Before you review your results there are some basic things you should note about your lake: the lake type and lake **georegion**. This information can be found at the very top of your annual report. Since lakes of the same type located in the same georegion are usually comparable to one another, this information is important when comparing your lake to others.

## Lake Types

The physical characteristics of a lake can greatly influence its water quality. Two factors are especially important: the primary source of the lake's water along with its flushing rate and whether or not the lake is stratified in the summer.

*Seepage lakes* are fed mainly by precipitation and runoff, supplemented by groundwater from the immediate drainage area. These lakes do not have an inlet or permanent outlet. Seepage lakes are the most common lake type in Wisconsin. Many seepage lakes are low in nutrients, acidic, and susceptible to acid rain. These lakes usually have small watersheds (Figure 2).

*Groundwater drainage lakes*, often referred to as spring-fed lakes, are fed by groundwater, precipitation, and limited runoff. Spring-fed lakes have a permanent outlet, but no inlet. The primary source of water for spring-fed lakes is groundwater flowing into the bottom of the lake from inside and outside the immediate surface drainage area. Spring-fed lakes are located at the headwaters of many streams and are a fairly common type of lake in northern Wisconsin. These lakes are usually well buffered against acid rain and contain low to moderate amounts of nutrients. These lakes have small watersheds (Figure 3).

**Drainage lakes** are fed by streams, groundwater, precipitation, and runoff. These lakes have an inlet and an outlet, and the main water source is stream drainage. Most major rivers in Wisconsin have drainage lakes along their course. Water quality in drainage lakes can be highly variable. These lakes often have large watersheds (Figure 4).

**Impoundments** are man-made lakes or reservoirs made by damming a stream or river. An impoundment is drained by a stream or river. Because of nutrient and soil loss from upstream land use practices, impoundments typically have higher nutrient concentrations and faster sedimentation rates than natural lakes (Figure 5).

## Lake Georegions

Wisconsin's lake georegions first originated from a grouping of lakes made in the early 1980s by Wisconsin DNR senior limnologists. These first groupings were based on the best professional judgment of the scientists most familiar with Wisconsin's lake resources. The georegions roughly reflect "hydro-chemical lake regions" which are based on the state's bedrock geology, glacial geology, and soil type; and more recently described ecoregions which are based on geological characteristics and dominant vegetation (Figure 6).

The **northwest georegion** is lake-rich. Most of the lakes found here are relatively small (i.e., less than 100 acres). They are usually natural lakes and many have extensive wetlands. Many "stained" lakes are found in this georegion. In general, the lakes in this georegion have low phosphorus levels and are moderately free of sediment. However, lakes in Polk, St. Croix, and Barron counties tend to be shallow and more eutrophic. For this reason, chlorophyll concentrations and water clarity both vary considerably in northwest georegion lakes.

Thirty seven percent of Wisconsin's lakes are found in the **northeast georegion**. Many are natural "stained" lakes and tend to be clustered with extensive wetlands. Lake size varies considerably. Lakes in the northeast georegion tend to be deeper than lakes in other georegions. As a group, northeastern lakes have low phosphorus and chlorophyll levels and tend to have the greatest water clarity when compared to lakes in the other four georegions.



**GEOREGION** • Wisconsin's lake "georegions" originated from a grouping of lakes made in the early 1980s by Wisconsin DNR senior limnologists. These groupings are based on the best professional judgment of the scientists most familiar with Wisconsin's lake resources. The georegions roughly reflect "hydro-chemical lake regions" which are based on the state's bedrock geology, glacial geology and soil type, and the more recently described "ecoregions" which are based on geological characteristics as well as the dominant vegetation.

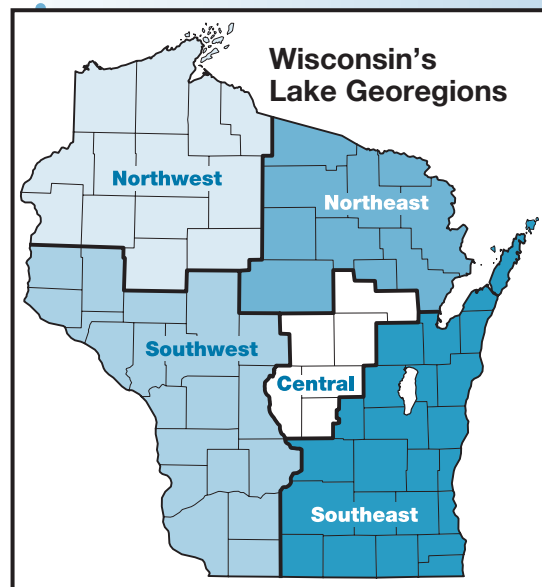


Figure 6. Wisconsin's lake georegions.

**Average summer TSI values for different lake georegions. Averages were calculated from Secchi measurements recorded in June, July, and August 2004.**

Lake Georegion	TSI Value
Northwest	45
Northeast	43
Central	44
Southwest	58
Southeast	49

## WATER SOURCE

**The source of a lake's water supply is very important in determining its water quality and in choosing management practices to protect that quality.** If precipitation is a major water source, (e.g., a seepage lake) the lake will be acidic, low in nutrients, and susceptible to acid rain (Shaw et al. 2000).

**If groundwater is the major water source, the lake is usually well buffered against acid rain and contains low to moderate amounts of nutrients.** Local septic systems or other groundwater contamination could cause problems. Water exchange is fairly slow creating long residence times for nutrients. (Shaw et al. 2000).

**If streams are the major source of lake water, nutrient levels are often high and water exchange takes place more rapidly.** These lakes have the most variable water quality depending on the amount of runoff and human activity in the watershed (Shaw et al. 2000).

**Managing the watershed to control the amount of nutrients and soil that enter a lake is essential to protecting water quality.** Controlling runoff (water that runs from the land's surface into the lake) is important for drainage lakes and impoundments, and some seepage and groundwater lakes. Protecting groundwater quality is particularly important for seepage and groundwater drainage lakes (Shaw et al. 2000).

**Watershed management becomes especially critical in impoundment lakes.** If a stream is dammed the natural movement of water will be restricted, causing soil and nutrients to collect in the impoundment (Shaw et al. 2000).

**Lake managers will measure the inflow and outflow of a lake to determine its water budget.** As shown in the formula below, a water budget consists of several elements. The average precipitation in Wisconsin is 30 inches per year. Evaporation depends on the type of summer weather, but is usually about 21 inches. Groundwater flow is more difficult to measure, but can be estimated (Shaw et al. 2000).

**The water budget can be expressed in percent or volume.** A typical water budget for a drainage lake may look something like this:

**Groundwater inflow (30%)**  
 + **Precipitation (10%)**  
 + **Surface runoff (60%)**  
 = **Groundwater outflow (5%)**  
 + **Evaporation (11%)**  
 + **Stream outlet (84%).**

The *central georegion* forms a distinct lake group in Wisconsin. In a large part of this georegion, lakes are scarce due to the nature of the underlying soil and bedrock. Most central georegion lakes are small (i.e., less than 100 acres) and tend to have small watersheds. Most have low phosphorus, low chlorophyll concentrations, and high water clarity.

Large, shallow, eutrophic lakes and impoundments are found in the *southwest georegion*. Natural lakes are scarce because of the topography and geological history since much of this georegion lies in the driftless area (a highly eroded and unglaciated landscape). Most lakes in this georegion are shallow and do not stratify in the summer. Lakes in the southwestern georegion tend to have high phosphorus and chlorophyll levels, and as a result, low water clarity.

Lakes and bogs are common in the *southeast georegion*. This georegion has more large lakes (i.e., greater than 1000 acres) than the other four georegions and also has many shallow lakes. Lakes in the southeastern georegion tend to exhibit high phosphorus and chlorophyll levels along with low water clarity.

## What Do My Secchi Readings Mean?

On a statewide level, a Secchi reading of greater than 20 feet is considered excellent water clarity. A reading of less than 3 feet is considered very poor. The water clarity that can be expected of a lake varies widely depending on the location, lake type, and historical conditions.

**Average summer Secchi values for different lake georegions. Averages were calculated from Secchi measurements recorded in July and August 2004.**

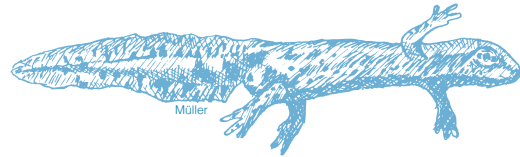
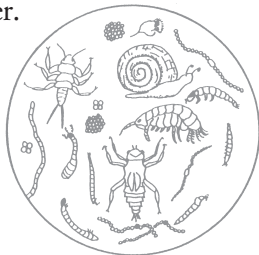
Georegion	Average Secchi depth (ft.) for mixed lakes	Average Secchi depth (ft.) for stratified lakes
Northwest	6.5	10.7
Northeast	7.4	12.8
Central	8.1	10.8
Southwest	3.4	4.7
Southeast	3.6	4.7

**What Can I Learn From the Variation in My Secchi Readings?**

Was your lake clearest in the spring and gradually became murky as the summer progressed? This trend might suggest that the lake is receiving a constant supply of nutrients, either from the watershed or from the lake sediments. This nutrient supply could be what is fueling the algal growth you are seeing throughout the summer.

If your lake water became clearer as the monitoring season went on, nutrients might be coming into the lake mainly in the spring with snowmelt. But as the summer progresses, there is no nutrient supply and algal growth is slowed.

If you see a sharp increase in your lakes water clarity in May or June, it may be that tiny grazing animals, called zooplankton, are eating the algae. When zooplankton are abundant, they can actually be seen as tiny dark dots swimming over the white part of the Secchi disk when it is submerged. These animals help decrease the amount of algae in the water, but are grazed on by minnows and other fish (e.g., bluegills, perch, crappie, etc.). If fish species that eat zooplankton become too abundant, often due to over-fishing of predator fish (i.e. bass), then the zooplankton population can decrease and the algae can become more abundant. The reason why zooplankton are more abundant in the spring is because fish that feed on them are not as active in the cooler water.



**What Do My Total Phosphorus and Chlorophyll Readings Mean?**

The samples that you collected were sent to and analyzed by the State Laboratory of Hygiene (WSLH) in Madison, Wisconsin. The level of phosphorus and chlorophyll in your samples is measured in micrograms per liter ( $\mu\text{g/L}$ ), which is equivalent to parts per billion (ppb).

Phosphorus can be in the water in various forms and may not always be in a form available for biological productivity. Therefore, total phosphorus shows the potential productivity of your lake. The results of your phosphorus analysis will enable you to answer the question, “Is my lake potentially susceptible to algal blooms?” Lakes that have more than 20  $\mu\text{g/L}$  of total phosphorus and impoundments that have more than 30  $\mu\text{g/L}$  of total phosphorus may experience noticeable algal blooms.

Chlorophyll is the pigment that makes algae green. When you filtered water as part of your on-shore sample preparation, you were extracting algae from the water. The filter sent to the WSLH was used to quantify how much algae was in the water. Comparing the chlorophyll analysis with your Secchi readings for the same day, you can determine if your water clarity is due to algae or tannins. If the chlorophyll measurements are low but your Secchi depth indicated poor water clarity, the poor clarity was probably caused either by suspended sediments or tannins. On a statewide level, a chlorophyll reading of less than 5  $\mu\text{g/L}$  is very good or excellent. A chlorophyll reading of greater than 30  $\mu\text{g/L}$  is very poor.

**Average summer chlorophyll values for different lake georegions. Averages were calculated from chlorophyll measurements recorded in July and August 2004.**

Lake Georegion	Average Chlorophyll Value ( $\mu\text{g/L}$ )
Northwest	13
Northeast	7
Central	9
Southwest	45

**TABLE 1. The Trophic State Index (TSI) continuum.**

<p><b>TSI less than 30</b></p> <p>Classic oligotrophic lake characterized by clear water, many algal species, oxygen throughout the year in bottom water, and cold water oxygen-sensitive fish species in deep lakes. Excellent water quality.</p>
<p><b>TSI 30-40</b></p> <p>Deeper lakes will still be oligotrophic, but the bottom waters of some shallower lakes may become oxygen-depleted during the summer.</p>
<p><b>TSI 40-50</b></p> <p>Classic mesotrophic lake. characterized by moderately clear water, but increasing chance of low dissolved oxygen in deep water during the summer.</p>
<p><b>TSI 50-60</b></p> <p>Lake becoming eutrophic characterized by decreased clarity, fewer algal species, and oxygen-depleted bottom waters during the summer. Plant overgrowth evident, supporting only warm-water fisheries.</p>
<p><b>TSI 60-70</b></p> <p>Becoming very eutrophic. Blue-green algae may become dominant with possible algal scums. Extensive plant overgrowth problems likely.</p>
<p><b>TSI 70-80</b></p> <p>Lake becoming hypereutrophic characterized by heavy algal blooms throughout summer, dense plant beds limited by light penetration.</p>
<p><b>TSI &gt; 80</b></p> <p>Hypereutrophic lake with very poor water quality, algal scums, summer fish kills, and few plants.</p>

## What is Trophic State?

Lake enrichment levels for Wisconsin lakes can range from being oligotrophic (i.e., lakes that experience low levels of productivity) to eutrophic (i.e., lakes that are highly productive). A natural aging process occurs in all lakes, causing them to change from oligotrophic to eutrophic over time, and eventually filling in. Human activity can accelerate this aging process. “Cultural eutrophication” is a term coined by ecologists to define human activity impacts on a lake’s trophic state.

Your Secchi depth results, along with phosphorus and chlorophyll data, allow a determination of the level of nutrient enrichment of the lake (i.e., trophic status). The Trophic State Index (TSI) is a continuum scale of 0 to 100, corresponding with the clearest and most nutrient poor lake possible, to the least clear and most nutrient rich lake (Table 1). Lakes can be divided into three main levels of nutrient enrichment categories. **Oligotrophic**, or nutrient poor lakes are characterized by very high Secchi depths, plenty of oxygen in deep water, and may have cold-water fish species living in them. **Mesotrophic** lakes fall in the middle of the continuum from nutrient-poor to nutrient-rich. They have moderately clear water, and may experience low to no oxygen concentrations in bottom waters. Nutrient-rich lakes are called **eutrophic**. They have decreased Secchi disk readings and experience low to no oxygen in the bottom waters during the summer. These lakes would only be habitable for warm water fish. They may also experience blue-green algal blooms. Lakes that are super-enriched fall into an additional fourth category termed hypereutrophic. These lakes experience heavy algal blooms throughout the summer, and may even experience fish kills. Rough fish dominate in hypereutrophic lake systems.

**TABLE 2. Trophic classification of Wisconsin lakes based on chlorophyll a, water clarity measurements, and total phosphorus values. (Adapted from Lille and Mason, 1983.)**

Trophic Class	Total Phosphorus (µg/l)	Chlorophyll a (µg/l)	Secchi Disk (ft)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

## THE NATURAL AGING OF LAKES

Lakes can be divided into three categories based on trophic state: **eutrophic, mesotrophic, and oligotrophic**. Eutrophic lakes (very productive or fertile lakes) contain an overabundance of algae and may appear green in color. The water clarity of a eutrophic lake is low, meaning the Secchi disk disappears when submerged only a few feet. A eutrophic lake is not necessarily an unhealthy lake, but often has abundant plant growth or algae. Eutrophic lakes often support large fish populations but can be susceptible to oxygen depletion.

In contrast, a less productive lake is referred to as oligotrophic. In oligotrophic lakes, the Secchi disk may be visible to great depths, indicating high water clarity. Oligotrophic lakes generally contain little algae, fewer plants, and often have low fish densities. Mesotrophic lakes categorize the state between the oligotrophic and

eutrophic stages. Mesotrophic lakes often have low dissolved oxygen levels in late summer. The hypolimnion (cold, bottom water) in these lakes limits coldwater fish populations and causes phosphorus cycling from the sediments.

A natural aging process occurs in all lakes, causing them to change from oligotrophic to eutrophic over time, and eventually filling in (Figure 7). However, human activity can accelerate this aging process. The term “**cultural eutrophication**,” coined by ecologists, defines the human activity impact on a lake’s trophic state.

**By examining Secchi data over time, general lake productivity can be estimated.** But in order to estimate the trophic state of your lake, you must have enough data collected over several years; particularly in the summer months when algal blooms are most prevalent.

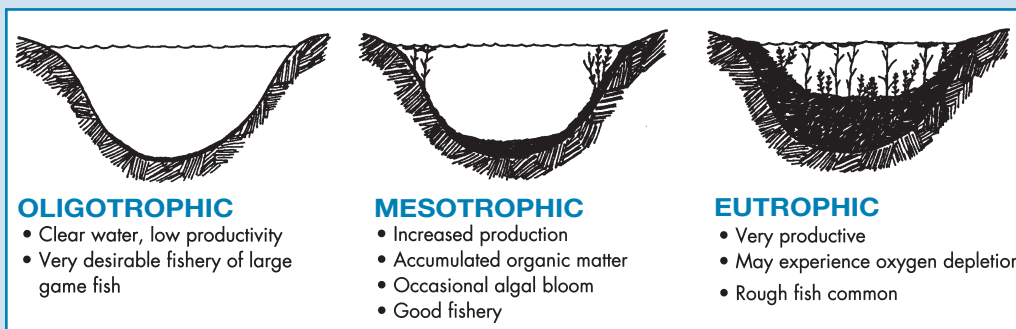


Figure 7. (Taken from Shaw et al. 2000 “Understanding Lake Data”)



**CULTURAL EUTROPHICATION** • Accelerated eutrophication of a lake that occurs as a result of human activities in the watershed. These activities increase nutrient loads in runoff water that drains into lakes.

**OLIGOTROPHIC** • Lakes characterized by low nutrient inputs and low productivity. They are generally deep with high water clarity.

**MESOTROPHIC** • Lakes characterized by their moderately fertile nutrient levels. Falls in between the oligotrophic and eutrophic levels of nutrient enrichment.

**EUTROPHIC** • Lakes characterized by high nutrient inputs, high productivity, often experiencing algal blooms and abundant weed growth. This term can also refer to a nutrient-rich lake, as large amounts of algae and weeds characterize a eutrophic lake.

**Table 3. Relationships between Secchi, chlorophyll, and phosphorus TSI values.**

<b>Relationship</b>	Chlorophyll = Phosphorus = Secchi TSI TSI TSI
<b>Meaning</b>	It is likely that algae dominate <b>light attenuation</b> .
<b>Relationship</b>	Chlorophyll > Secchi TSI TSI
<b>Meaning</b>	Large particulates, such as <b>Aphanizomenon</b> flakes, dominate.
<b>Relationship</b>	Phosphorus = Secchi > Chlorophyll TSI TSI TSI
<b>Meaning</b>	Non-algal particulate or color dominate light attenuation.
<b>Relationship</b>	Chlorophyll = Secchi > Phosphorus TSI TSI TSI
<b>Meaning</b>	The algae <b>biomass</b> in your lake is limited by phosphorus.
<b>Relationship</b>	Phosphorus > Chlorophyll = Secchi TSI TSI TSI
<b>Meaning</b>	If this happens once or twice during the monitoring season, it suggests that a peak of zooplankton might have eaten much of the algae and made the lake clear. However, the nutrients would still be there in the lake. If your total phosphorus was greater than your chlorophyll and Secchi throughout the entire season, it suggests that total phosphorus may have been coming heavily into the lake, but the algae were limited by nitrogen or some other nutrient. This is often due to septic pollution.

**Note:** Chlorophyll TSI (Trophic State Index), Phosphorus TSI, and Secchi TSI values for your lake can be found on your lake summary report.



**BIOMASS** • Total mass of all living organisms present (e.g., the total quantity of plants and animals in a lake). Measured as organisms or dry matter per cubic meter, biomass indicates the degree of a lake system's eutrophication or productivity.

**LIGHT ATTENUATION** • How fast the light intensity decreases with distance from objects.

Although trophic states are labeled for purposes of discussion, keep in mind that in nature, the categories make smooth transitions into each other. Data from one date may show your lake as being eutrophic, and the next date as being mesotrophic.

After a few years of collecting Secchi data, you will be able to answer two major questions about your lake.

1. *What is the trophic state of my lake based on water clarity data alone? (Is my lake generally more eutrophic, mesotrophic, or more oligotrophic?)*
2. *Is the water quality of my lake improving, declining, or remaining the same over time?*

If your lake has many rooted aquatic plants and relatively clear water, the TSI could be a mischaracterization of the true nutrient status of your lake. Lakes dominated by aquatic plants tend to have high amounts of phosphorus in the bottom sediments and relatively low amounts phosphorus in the water column. On the other hand, lakes that grow mostly algae have high amounts of phosphorus in the water column. The TSI only measures the portion of nutrients that are found in the water column, as evidenced by the amount of algae. So if most of the nutrients are held in the sediments and the lake is loaded with aquatic plants, the true total nutrient status would not be accurately measured using the TSI.

**How Do My TSI Values Relate to One Another?**

If you measured Secchi, chlorophyll, and phosphorus, you can learn a lot about your lake by looking at the relationships of these values to each other (Table 3). You will need the graph of your TSI that is provided with your lake summary report. The TSI graph shows summer (July and August) averages over time.



# LAKE SUMMARY REPORT SAMPLE

## Lake Water Quality 2019 Annual Report

Oxbow Lake  
 Vilas County  
 Waterbody Number: 2954800

Lake Type: DRAINAGE  
 DNR Region: NO  
 GEO Region: NE

Site Name	Storet #
Oxbow Lake - Deep Hole	643251

Date	SD (ft)	SD (m)	Hit Bottom	CHL	TP	TSI (SD)	TSI (CHL)	TSI (TP)	Lake Level	Clarity	Color	Perception
05/13/2019					14.4			49				
05/13/2019	6.75	2.1	NO			50			HIGH	CLEAR	YELLOW	2-Very minor aesthetic problems
06/21/2019	8.25	2.5	NO	1.25	11.9	47	36	47	NORMAL	CLEAR	YELLOW	1-Beautiful, could not be nicer
07/30/2019	6.5	2	NO	3.38	18.4	50	44	51	NORMAL	CLEAR	YELLOW	1-Beautiful, could not be nicer
08/19/2019	6.75	2.1	NO	3.08	18.7	50	43	51	NORMAL	CLEAR	YELLOW	1-Beautiful, could not be nicer

05/13/2019		
Depth FEET	Temp. DEGREES F	D.O.
0	57.9	
3	51.6	
6	49.2	
9	48.2	
12	46.5	
15	46.2	
18	45.6	
21	45.3	
24	44.9	
27	44.6	
30	44.4	
33	44	
36	43.8	
39	43.1	
42	42.9	
45	42.8	
46	42.6	

06/21/2019		
Depth FEET	Temp. DEGREES F	D.O.
0	66.9	
3	67.6	
6	67.8	
9	63.6	
12	59.1	
15	56.1	
18	53.6	
21	51.6	
24	50.1	
27	49.4	
30	48.3	
33	47.6	
36	47.1	
39	46.5	
42	46.2	
45	45.8	
46	45.6	

07/30/2019		
Depth FEET	Temp. DEGREES F	D.O.
0	71.6	
3	72.5	
6	72.6	
9	72.6	
12	67.2	
15	60	
18	54.8	
21	52.7	
24	51.2	
27	50.1	
30	49.2	
33	48.7	
36	48.2	
39	47.8	
42	47.6	
45	47.4	
46	47.1	

08/19/2019		
Depth FEET	Temp. DEGREES F	D.O.
0	69.2	
3	69.9	
6	70.1	
9	70.1	
12	70.1	
15	62.4	
18	57	
21	53.2	
24	50.9	
27	49.8	
30	49.2	
33	48.9	
36	48.5	
39	48.2	
42	47.6	
45	47.4	
46	47.3	

Date	Collector Comments
06/21/2019	Beautiful- calm- clear- early morning.
07/30/2019	Partly cloudy day with a cold 8 mph wind from the north. Measureable rainfall + major cold front began to move in 40 hours prior to sampling.
08/19/2019	clear - SW 7 mph winds

### Oxbow Lake - Deep Hole 2019 Results



Oxbow Lake - Deep Hole was sampled 8 different days during the 2019 season. Parameters sampled included:

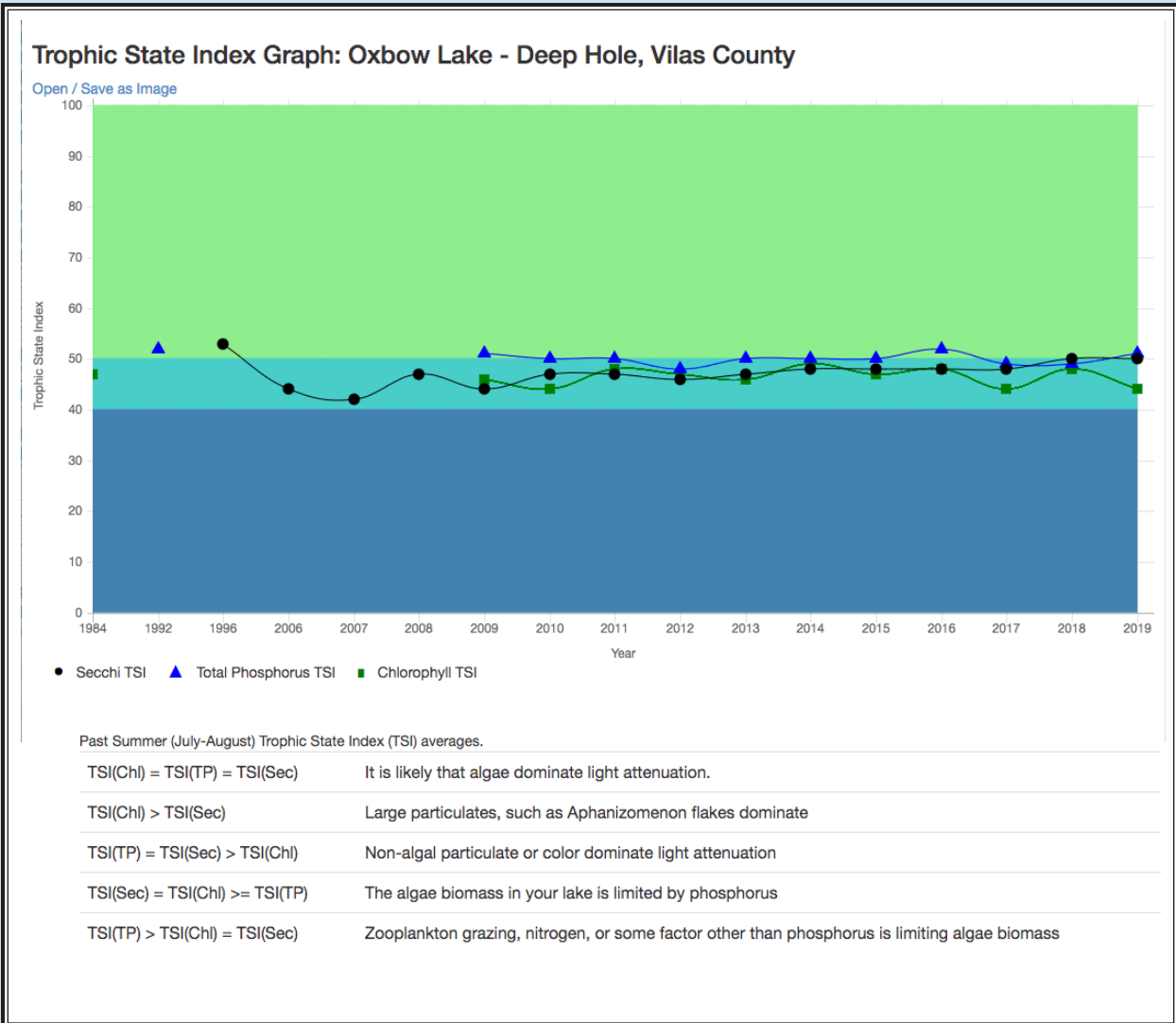
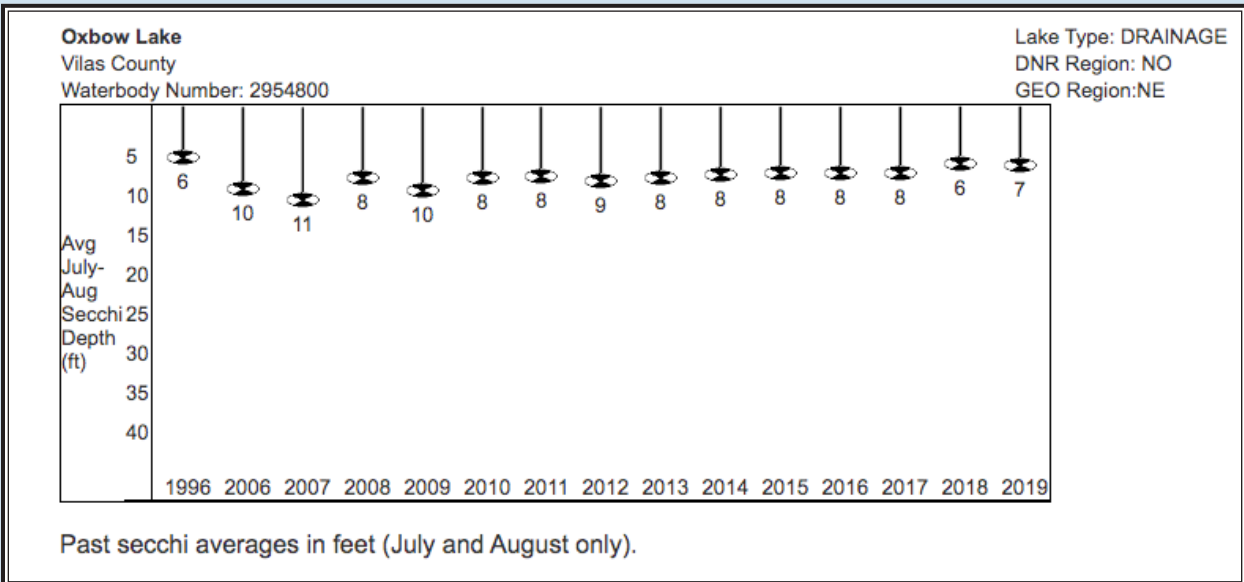
- water clarity
- temperature
- total phosphorus
- chlorophyll

The average summer (July-Aug) secchi disk reading for Oxbow Lake - Deep Hole (Vilas County, WBIC: 2954800) was 6.63 feet. The average for the Northeast Georegion was 10.2 feet. Typically the summer (July-Aug) water was reported as **CLEAR** and **YELLOW**.

Chemistry data was collected on Oxbow Lake - Deep Hole. The average summer Chlorophyll was 3.2 µg/l (compared to a Northeast Georegion summer average of 8.9 µg/l). The summer Total Phosphorus average was 18.6 µg/l. Lakes that have more than 20 µg/l and impoundments that have more than 30 µg/l of total phosphorus may experience noticeable algae blooms.

The overall Trophic State Index (based on chlorophyll) for Oxbow Lake - Deep Hole was 44. The TSI suggests that Oxbow Lake - Deep Hole was **mesotrophic**. Mesotrophic lakes are characterized by moderately clear water, but have a increasing chance of low dissolved oxygen in deep water during the summer.

LAKE SUMMARY REPORT SAMPLE continued



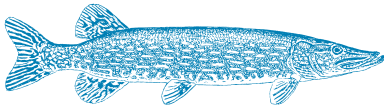
## Dissolved Oxygen

The amount of dissolved oxygen available in a lake, particularly in the deeper parts of the lake, is critical to its overall health. The amount of dissolved oxygen in the water is determined by water temperature (e.g., cold water holds more oxygen than warm water), atmospheric pressure, and biological productivity. Plants and algae are important for producing oxygen in the water, but when they die, the situation is reversed when bacteria associated with decomposition consume oxygen. In general, cold-water fish species (e.g., trout) need at least 5 parts per million of oxygen to survive. In contrast, warm-water fish species need 3 parts per million of oxygen to survive (see next page).

Phosphorus does not dissolve easily in water. It forms insoluble precipitates (particles) with calcium, iron, and aluminum. In hard water areas of Wisconsin, where limestone is dissolved in the water, marl (calcium carbonate) precipitates and falls to the bottom. Marl formations absorb phosphorus, reducing its overall concentration as well as algae growth (Shaw, 2000).

Iron, in the presence of oxygen, also forms sediment particles that store phosphorus. When lakes lose oxygen in winter or when the deep water loses oxygen in summer, iron and phosphorus again dissolve in the water (Shaw, 2000). In extreme cases, low dissolved oxygen can result in the elimination of the cold-water fishery and other bottom-dwelling animals.

## Temperature



Temperature is another critical factor to keep in mind when trying to understand your lake. Just as cold-water fish need lots of oxygen to survive, they also need cold water temperatures, generally less than 72°F. If the water gets too warm, or oxygen is not available, a fish kill may result. Conversely, warm water fish species can tolerate warm water temperatures. Bluegills, for example, can survive in water upwards of 80°F.

Your temperature profile data will tell you whether your lake mixes or stratifies. Typically,

shallow lakes mix constantly through normal wind and wave action, allowing water that had been at the bottom to move to the top and vice versa. Because of this mixing, temperature and dissolved oxygen values remain fairly consistent from surface to bottom. In contrast, deep lakes usually stratify or divide into distinct temperature layers during the summer months. The warm water stays at the top and the cold water stays at the bottom. The zone at which the temperature changes most abruptly is called the thermocline. Water below the thermocline is usually much colder and does not mix with the water above the thermocline. The reason you must take the temperature of the water at different depths is so you can locate the thermocline.

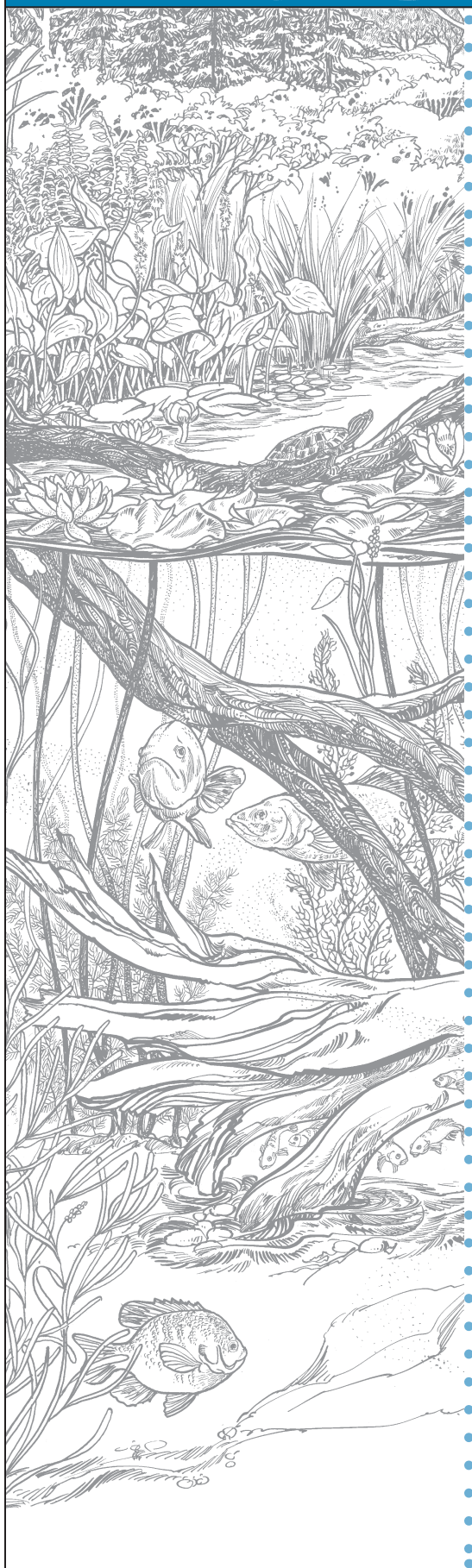
Normally, deep lakes stratify during the summer months and mix during the spring and fall. As the air temperature gets cooler at the end of the summer and early fall, the surface of the water cools. The cooler, denser water begins to sink, destroying the summer stratification and initiating a complete mixing of the water column. Winter stratification, with a temperature difference of only 7°F from bottom to top remains stable because the ice cover prevents wind from mixing the water. Once the ice melts in the spring, the water is once again exposed to wind action, and begins mixing. The spring overturn will continue until the lake stratifies on a calm, warm day in the summer.

The dissolved oxygen and temperature values you collect are related to one another. When looking at your temperature data you see that there is a thermocline, you know that your lake stratifies. Once you determine the depth at where the thermocline is, you can usually predict that the dissolved oxygen concentration will decline at that same depth. This pattern is typical for deep lakes. If the dissolved oxygen concentration declines to the point where it is zero, chemical reactions can take place that would otherwise not occur in an oxygen-rich environment. Specifically, in an anoxic (zero oxygen) environment, phosphorus that had previously been chemically bound to bottom sediments are released into the colder layers of the water column. This may result in algal blooms after your lakes next mixing event.

### Water Quality Parameter Guide for Selected Fish Species

Adapted from Post 1988. Note that the minimum required dissolved oxygen levels may be less in the winter if the aquatic organisms have acclimated to their environment.

Fish Species	Water Temperature Range(°F)	Water Type	Water Clarity	Minimum Oxygen Requirement (ppm)	pH
<b>Bluegill</b>	65 - 80	Eutrophic to Mesotrophic. Warmwater streams, rivers, and ponds.	Less turbid waters.	3.0 - 5.0	5.5 - 9.0
<b>Channel catfish</b>	75 - 85	Eutrophic. Warmwater streams, rivers, and ponds.	Clear to turbid; can adapt to waters most fish can't tolerate.	3.0	4.5 - 9.0
<b>Common carp</b>	55 - 80	Eutrophic. Warmwater streams, rivers, and ponds.	Clear to turbid; can adapt to waters most fish can't tolerate.	0.8	4.0 - 9.5
<b>Freshwater drum</b>	55 - 75	Eutrophic. Warmwater rivers.	Clear to turbid.	3.0 - 5.0	4.5 - 9.0
<b>Northern pike</b>	45 - 75	Mesotrophic to Oligotrophic. Coolwater lakes, large rivers, and reservoirs.	Clear with moderate amounts of aquatic vegetation.	4.0	6.0 - 9.0
<b>Rainbow trout</b>	40 - 60	Mesotrophic to Oligotrophic. Coldwater streams, rivers, and deep lakes.	Clear with some to very little fertility and moderate vegetation.	6.0	6.5 - 8.5
<b>Walleye</b>	35 - 80	Mesotrophic. Large coolwater lakes and streams.	Clear, sometimes turbid waters with good fertility.	5.0	6.0 - 9.0
<b>White bass</b>	55 - 78	Eutrophic to Mesotrophic. Warmwater rivers and lakes.	Clear, sometimes turbid waters.	5	5.5 - 9.0
<b>White sucker</b>	40 - 65	Oligotrophic. Coolwater lakes and streams.	Clear with scant fertility and aquatic vegetation.	4.0	6.5 - 8.5



## GET TO THE ROOT OF THE PROBLEM

Suppose that your lake is not as clear as others in the area, and that there is some indication of clay turbidity in the spring and after rainstorms. However, the color of your lake is green indicating that algae, not clay, is affecting water clarity. What do you do now?



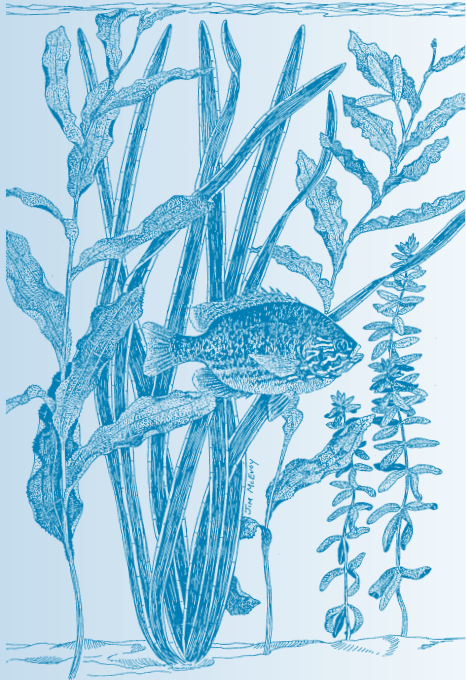
### First, do some detective work.

Your data have given you some clues as to the sources and cycles of nutrients and erosion materials. Drive through the watershed, preferably after a recent rain and observe the condition of the streams entering your lake. Are some more turbid than others? Look upstream and try to track down the sources of turbidity. You may find a point source (e.g., pipes) or a specific location such as a field or housing development that is the source of the problem. You may find that there are numerous contributors to stream turbidity. Are there any sewage treatment plants discharging into the river or are houses in the watershed using septic tanks? Sewage in any form is high in nutrients and septic systems sometimes fail or are deliberately by-passed. By the time you have done several of these surveys you might have a better idea of the sources of your lake's problems. It might even be necessary to obtain a detailed map that includes the watershed and start mapping problem streams and sources.



### Second, take more Secchi measurements in your lake.

Even though the Network requires you to collect data every other week, you can sample more often if you think it is important. Make a point to sample your lake after rainstorms to see if there is any relationship between rainfall and your lake's turbidity. You may also want to sample more sites on your lake, preferably near the mouths of streams that you think may be causing turbidity. To make these new sites "official" contact your regional coordinator. If you think weekend watercraft use may be affecting your water clarity, try sampling the lake during the week and again on the weekend (Don't forget to make a note of this on your data sheet!). Volunteers have even used their Secchi data to detect the consequences of leaking septic systems by monitoring decreases in transparency near houses. Be sure to write down all of your observations and report your data to the Network. We really do want to know more about your lake, too!



### DID YOU KNOW?

Usually, light can penetrate the surface of a lake to about 1.7 times the recorded Secchi depth. This light penetrating zone is called the photic zone. In this zone, plants and algae produce oxygen. Aquatic plants provide good habitat for fish and invertebrates. This zone also provides good habitat for fish and other vertebrates, because the light enables them to see better under water when searching for prey.



**PHOTIC ZONE** • The surface and under-water lighted zone in a lake that usually has a depth around 1.7 times the Secchi reading.

**PHOTOSYNTHESIS** • Process by which green plants convert carbon dioxide (CO<sub>2</sub>) dissolved in water to sugar and oxygen using sunlight for energy.

**DECOMPOSITION** • The act of breaking down organic matter from a complex form to a simpler form, mainly through

In shallow lakes, there is usually no thermocline, and dissolved oxygen concentrations stay fairly high. However, shallow lakes that are constantly mixing may be more sensitive to nutrient loading from the watershed. These nutrient inputs can come from various non-point sources of pollution (e.g., agricultural or urban runoff). When nutrients are added to a shallow lake, they may be constantly available to feed weeds or algae. In a deep lake, the nutrients may become isolated in the deep, cold water (the hypolimnion), where they are unavailable to be used until the lake mixes.

## Secchi Reading and Light Penetration

Secchi disk measurements can indicate the depth at which your lake contains enough oxygen to support fish and other aquatic life. In general, sunlight can penetrate to a depth 1.7 times greater than your recorded Secchi depth. For example, if your Secchi disk reading is 12 feet deep, that means the sunlight can actually penetrate 20 feet deep (1.7 times 12). The depth at which sunlight can penetrate is called the **photic zone**. It is within this zone that **photosynthesis** occurs and oxygen is produced by algae and other aquatic plants. Plant life is important to provide necessary habitat for fish and invertebrates. In deep, productive lakes, oxygen may become depleted below the photic zone as a result of bacterial **decomposition** of dead plants and animals. Without oxygen, phosphorus and other nutrients may be released from the lake sediments and during the lake's mixing periods be circulated to the surface water. This internal cycling of nutrients can trigger algae blooms, aquatic plant growth, and odor problems.

## How Does My Lake Compare to Others?

To examine how your lake quality compares to others around the state, use the summary reports generated by CLMN. These reports contain graphs that chart the Secchi, phosphorus and chlorophyll TSIs for each lake type in each georegion.

## What if Your Data is Better Than Average

If your Secchi, chlorophyll, and phosphorus readings are better than average for your lake type and georegion,

you will want to work to protect your lake and keep it the way it is. One way to help protect your lake is through a Lake Protection Grant. Qualified lake associations, lake districts, as well as, counties, towns, cities, or villages are eligible to receive lake planning and protection grant funding. Through these grants, money is available for lake and watershed data collection, development of local lake management plans, land acquisition, and other lake protection activities. For more information on lake grants, contact your CLMN regional coordinator or a UWEX lake specialist. The Wisconsin DNR also has excellent information on lake grants online.

## **W**hat if Your Data is Worse Than Average

If your Secchi readings are lower than average for your lake type and georegion, take a look at your chlorophyll readings. If your lake has low chlorophyll levels and your lake water appears clear and brown, chances are your lake is a “stained” lake. This staining is natural and not an indication of a water quality problem.

If your chlorophyll reading is low and your water appears murky and brown, the problem may be sediment. In this case, you will want to investigate where the problem is coming from. Sediment in the water can be due to erosion along the lake shore, or erosion coming from streams that flow into lakes. Sediment in your lake could also be a result of carp or boat traffic stirring up the bottom.

If your chlorophyll levels are high and you have high phosphorus readings working with people that live and work around your lake to reduce nutrient inputs is one thing you can do.

A recent study of over 1,000 waterfront properties in Minnesota found that when all other factors were equal, properties on lakes with clearer water commanded significantly higher property prices (Krysel, 2003).

What you and your neighbors do to maintain or improve water quality will improve resale potential.

Here are some things that you can do to improve water quality.

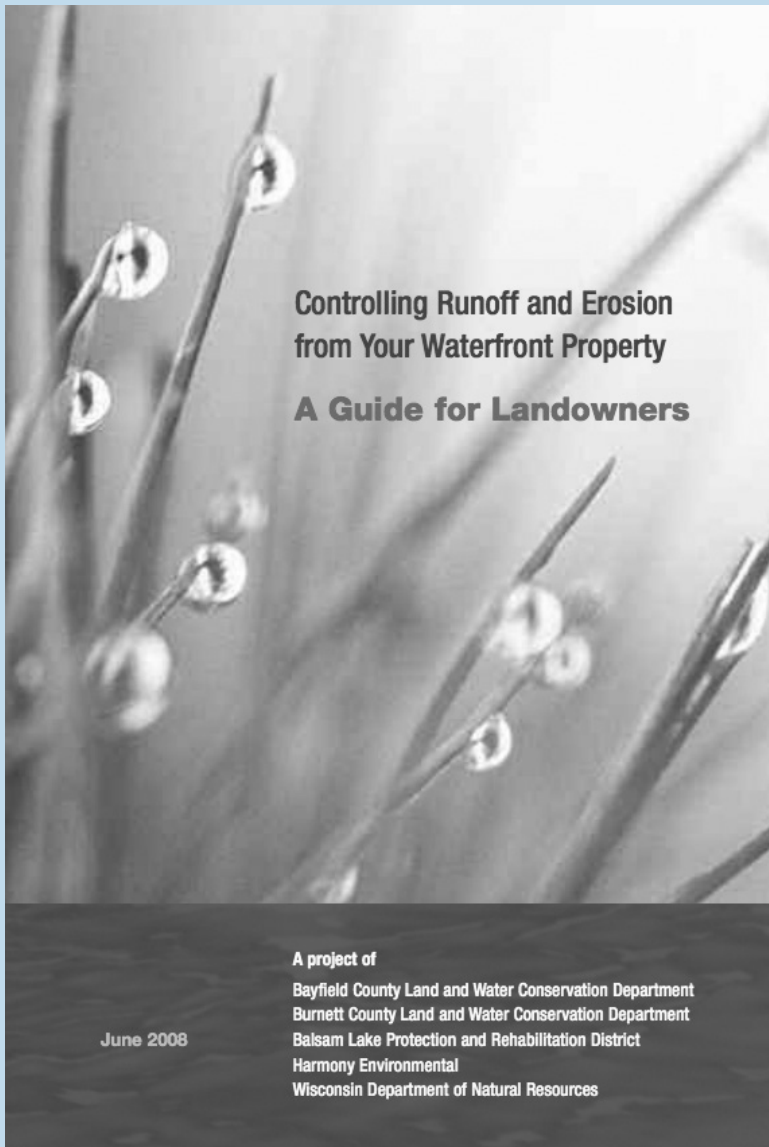
- Agricultural producers should apply best management practices to reduce the amount of nutrient runoff to lakes. Your local Land Conservation Office can offer assistance.
- A healthy, diverse aquatic plant community stabilizes a shoreline and reduces erosion and provides habitat for fish and wildlife.
- Protect or restore your shoreland buffer.
- Plant native trees and shrubs or protect your wooded areas.
- Capture and cleanse pollutant and sediment-carrying runoff before it reaches the waterway – with shoreland buffers, rain barrels or rain gardens.
- Try to maintain as much woody habitat as possible. Fish use submerged trees to spawn on and they provide cover to young and old alike.
- Declines in submerged tree habitats have been linked to reduced abundance of young smallmouth bass and yellow perch.
- Inspect and maintain your septic system and well regularly
- Reduce the hard surfaces and driveways on your property. Pervious pavers are an option for areas that do not have heavy traffic. To reduce runoff, diversion practices such as rock infiltration can be installed.
- Monitor your lake for aquatic invasive species
- Assess your property and participate in Healthy Lakes Wisconsin. The goal is to protect and improve the health of our lakes by increasing lakeshore property owner participation in habitat restoration and runoff and erosion control projects. Check out the Healthy Lakes Wisconsin web site or contact Pat Goggin at 715-365-8943.
- If your lake does not have a lake

association or lake district, consider forming one. Dealing with a broad range of issues (aquatic invasive species, water quality) can be overwhelming for one person. Working as an organized group that shares a common goal can make even the most difficult problems easier to tackle.

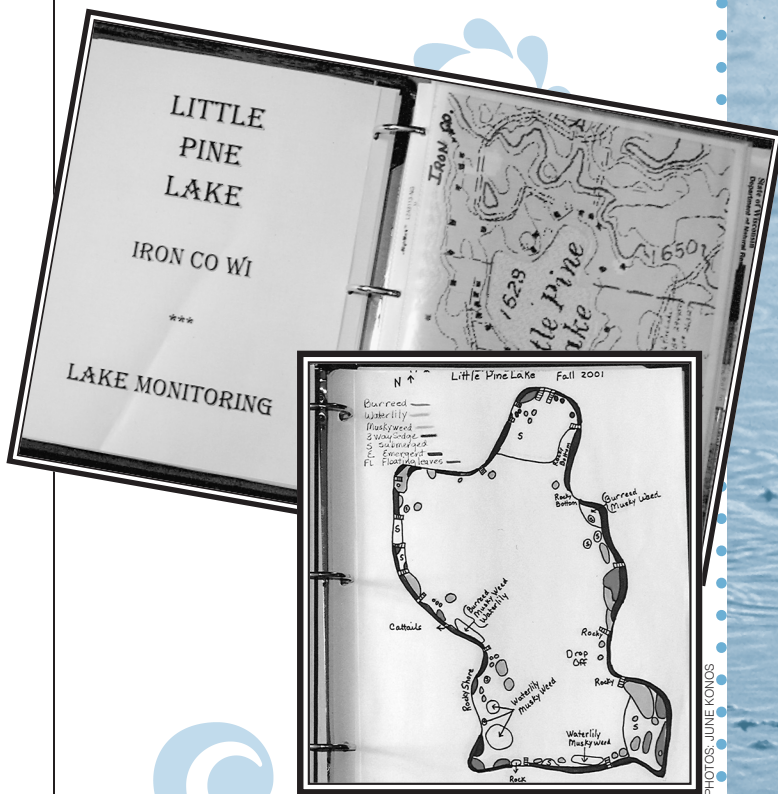
- Plan a lake fair or event. A lake fair is an educational and social event that blends a sense of discovery and entertainment. These events provide an opportunity for participants to get hands-on experience,

talk with lakes experts in an informal setting, meet lake neighbors and build relationships.

- Become a Lake Leader. Lake Leaders is designed to stretch the mind by exploring new ideas about lake management and the human use of lakes. Graduates of this program develop a network to share experiences and learn from each other.
- The Lakes Convention is an annual event that gives educators, lake lovers, and professionals a chance to get together and discuss lake issues.







## Record-Keeping

### Keeping a "Lake Log"

As a CLMN volunteer, you are a record-keeper of your lake's overall health. The Secchi data, water chemistry information, and observations that you supply help with current management activities and also provide a basis for future management. The information that you collect in the field, as well as, the summary results presented in CLMN reports, can be used to create a "lake log" (i.e. a long-term record of your lake's overall history and health).

The field data sheet copies of your water clarity and chemistry information can be used as basic information for starting your lake log. Eventually you can add graphs, news clippings, lake history, maps, wildlife sightings, land use records, etc., to make your log complete. The sky's the limit! But don't take on this responsibility alone. You can share record-keeping responsibilities by enlisting the help of lakeshore residents, lake association members, and youth or school groups to help collect and compile information. For a *basic*

PHOTOS: SUJINE KONOS

ROBERT QUEEN

lake log, the following items are recommended: a lake map, copies of your field data sheets and notes, and your annual data summary sheets. In addition to the items listed above, if you would like to compile a more comprehensive lake log the following items are recommended.

- Graphs of your results
- General lake ecology information (e.g., CLMN reports, *Understanding Lake Data*, etc.)
- Planning and protection grant information
- Precipitation and other weather information
- Ice-on and ice-off dates
- Wildlife sightings
- Illustrations and photographs
- Aquatic plant information
- Lake history notes from interviews with long-time residents
- Historical maps showing watershed development
- Video or photos of shoreline development runoff, plants, algal blooms, etc.
- Any other data or information collected about your lake

#### **Assembling the Basics**

You will receive a lake map showing your sampling site from your CLMN regional coordinator. Lake maps can also be found online.

When you sample, make careful observations. Your initial observations are important since they can help you remember (and others understand) what is happening in and around your lake. In addition, taking careful field notes can provide a better understanding of the water quality and ecosystem conditions on your lake.



# What if?...

## Frequently Asked Questions

**Q:** What if I get to the post office too late on Thursday afternoon and they are closed. What should I do with my samples?

**A:** *It's okay! Just unpack your box, put the chlorophyll sample in the freezer and phosphorus sample in the refrigerator until Monday. Dispose of the ice and re-package again on Monday.*

**Q:** What if I get to the post office and I have not put the pre-paid merchandise return label on the package?

**A:** *The best option is to return home and get the label for the package. Very few WDNR offices have petty cash available to refund the cost of shipping. If you pay for the cost of shipping yourself, it may be difficult to be reimbursed.*

**Q:** What if my Van Dorn sampling bottle breaks while I am collecting water samples.

**A:** *Unfortunately, these types of water samplers seem to break when it is the most inconvenient. If you are unable to make a repair on the spot, you will need to contact your regional coordinator and make arrangements for a new sampler. If you are unable to complete that sampling session, just record the information that you have and make a note of what happened.*

**Q:** What if I don't receive a Styrofoam<sup>®</sup> mailer back from the State Laboratory of Hygiene before I am ready to collect my next sample?

**A:** *If you need a mailer, call (608) 224-6202 at least one week before you plan to take your next sample. Ask them to transfer you to the shipping department to request a new mailer.*

**Q:** What if the water in the magnetic filter cup isn't filtering through the filter? It seems like I have been using the hand pump for a long time and nothing is happening.

**A:** *First, check to make certain that you are using a **white** filter and not a blue filter liner. Next, check to make sure that you have a good seal between the rubber stopper and the flask. Sometimes it helps to press down on the rubber stopper to make sure that it is in the flask as far as it will go. Check the clear tubing; is there a good connection between the flask and the hand pump? If your equipment is not the problem, you may have a lot of algae, sediment, or other material in your water that is making it hard to filter. If you are able, filter the remaining water in the filter cup, remove the filter and record just the amount that you were able to filter. Another option is to transfer the remaining water to your empty graduated cylinder, remove the first filter and place it in the mailing tube. Put another filter on the base and filter the remaining water in the cylinder. Both filters can be placed in the tube and mailed to the State Laboratory of Hygiene.*



**Q:** What if I forget to place my lab slip in my mailer with my samples before I send them to the State Laboratory of Hygiene?

**A:** Contact your CLMN regional coordinator by email or by phone and as soon as you can. Tell the coordinator your name, WBIC number, Station ID#, the name of your lake, and the amount of water you filtered for your chlorophyll sample. Your regional coordinator will contact the State Laboratory of Hygiene directly with your information.

**Q:** What if I just took my Secchi reading closer to my house instead of the deepest part of the lake (the location assigned to me by my Coordinator)?

**A:** All of the data collected at a specific site is tied back to that site through the Station ID #. Usually, Secchi disk readings are taken at the deepest part of the lake to get data that best represents the lake as a whole. Large lakes or lakes with distinct lobes may have more than one area sampled. If you think a new sampling spot will yield good data, talk to your regional coordinator to have a new Station ID # assigned to that location.

**Q:** What if I use the Winkler titration method to determine my dissolved oxygen? Is there any way for me to know what's going on with all these color changes?

**A:** The first step in a dissolved oxygen titration is the addition of 8 drops of manganous sulfate

solution and 8 drops of alkaline potassium iodide azide solution. These reagents react to form a precipitate of manganous hydroxide. Immediately upon formation of the precipitate, the oxygen in the water oxidizes an equivalent amount of the manganous hydroxide to brown-colored manganic hydroxide. For every molecule of oxygen in the water, four molecules of manganous hydroxide is converted to manganic hydroxide.

To "fix" the sample, 8 drops of sulfuric acid is added to the sample. The acid converts the manganic hydroxide to manganic sulfate. At this point the sample is considered "fixed" and any concern for additional oxygen being introduced into the sample is reduced. Simultaneously, iodine (from the potassium iodide in the alkaline potassium iodide azide solution) is oxidized by manganic sulfate, releasing free iodine into the water. Since the manganic sulfate for this reaction is a result of the reaction between the manganous hydroxide and oxygen, the amount of iodine released is directly proportional to the amount of oxygen present in your original sample. The release of free iodine is indicated by your sample turning a yellow-brown color.

The final stage in the Winkler titration is the addition of sodium thiosulfate. The sodium thiosulfate reacts with the free iodine to produce sodium iodide. When all the iodine has been converted, your sample changes from yellow-brown to colorless. Since the yellow-to-clear color change is very hard to see, it is necessary to add the starch indicator solution. Starch turns blue in the presence of iodine. Once all the iodine has been titrated out, the starch turns clear.



# Glossary

**Algae.** Small aquatic plants containing chlorophyll and without roots that occur as a single cell or multi-celled colonies. Algae form the base of the food chain in an aquatic environment.

**Algal bloom.** A heavy growth of algae in and on a body of water as a result of high nutrient concentrations.

**Aquatic Invasive Species (AIS).** Refers to species of plant or animal that are not native to a particular region into which they have moved or invaded. Zebra mussels and Eurasian water-milfoil are examples of AIS. Wisconsin has laws preventing the spread on boats and trailers.

**Bathymetric map.** A map showing depth contours in a water body. Bottom contours are usually presented as lines of equal depth, in meters or feet. Often called a hydrographic map.

**Chlorophyll.** Green pigment present in all plant life and necessary for photosynthesis. The amount of chlorophyll present in lake water depends on the amount of algae and is used as a common indicator of water quality.

**Cultural eutrophication.** Accelerated eutrophication of a lake that occurs as a result of human activities in the watershed. These activities increase nutrient loads in runoff water that drains into lakes.

**Decomposition.** The act of breaking down organic matter from a complex form to a simpler form, mainly through the action of fungi and bacteria.

**Deionized water.** Water that has been passed through a column or membrane to remove ions present.

**Distilled water.** Water that is boiled in a still and the condensate collected and distributed. Distillation removes both ionic and nonionic organic contaminants.

**Dissolved oxygen.** A measure of the amount of oxygen gas dissolved in water and available for use by microorganisms and fish. Dissolved oxygen is produced by aquatic plants and algae as part of photosynthesis.

**Drainage lake.** Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter residence times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

**Epilimnion.** The uppermost circulating layer of warm water that occurs in stratified lakes in summer because of the differences in water density.

**Euphotic zone.** That part of a water body where light penetration is sufficient to maintain photosynthesis.

**Eutrophic.** Lakes characterized by high nutrient inputs, high productivity, often experiencing algal blooms and abundant weed growth. This term can also refer to a nutrient-rich lake, as large amounts of algae and weeds characterize a eutrophic lake.

**Eutrophication.** The process by which lakes and streams are enriched by nutrients causing an increase in plant and algae growth.

**Georegion.** Wisconsin's lake "georegions" originated from a grouping of lakes made in the early 1980s by Wisconsin DNR senior limnologists. These groupings are based on the best professional judgment of the scientists most familiar with Wisconsin's lake resources. The georegions roughly reflect "hydro-chemical lake regions" which are based on the state's bedrock geology, glacial geology and soil type, and the more recently described "ecoregions" which are based on geological characteristics as well as the dominant vegetation.

**Hypolimnion.** The cold, deepest layer of a lake that is removed from surface influences.

*(Glossary continued on next page)*

**Lake association.** A voluntary organization with a membership generally comprised of those who own land on or near a lake. The goals of lake associations usually include maintaining, protecting, and improving the quality of a lake, its fisheries, and its watershed.

**Lake classification.** A way of placing lakes into categories with management strategies best suited to the types of lakes found in each category. For example, lakes can be classified to apply varying shoreland development standards. They can be grouped based on hydrology, average depth, surface area, shoreline configuration, as well as, sensitivity to pollutants and recreational use.

**Lake district.** A special purpose unit of government with the cause of maintaining, protecting, and improving the quality of a lake and its watershed for the mutual good of the members and the lake environment.

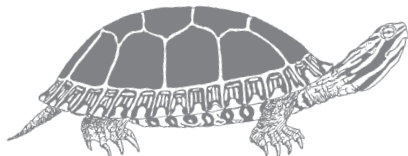
**Limnology.** The study of inland lakes and waters. The study of the interactions of the biological, chemical, and physical parameters of lakes and rivers.

**Macrophyte.** Large, rooted or floating aquatic plants that may bear flowers and seeds.

**Meniscus.** The curved upper surface of a still liquid in a tube caused by surface tension.

**Mesotrophic.** Lakes characterized by their moderately fertile nutrient levels. Falls in between the oligotrophic and eutrophic levels of nutrient enrichment.

**Metalimnion.** Sometimes referred to as the thermocline. The narrow transition zone between the epilimnion and the hypolimnion that occurs in stratified lakes.



**Nitrogen.** One of the major nutrients required for the growth of aquatic plants and algae.

**Oligotrophic.** Lakes characterized by low nutrient inputs and low productivity. They are generally deep with high water clarity.

**Parts per million (ppm).** An expression of concentration indicating weight of a substance in a volume of one liter. Milligrams per liter (mg/l) is an equivalent unit.

**pH.** The measure of the acidity or alkalinity of a solution. Neutral solutions are defined as having a pH of 7.0. Solutions which are known as acidic have a pH lower than 7. Solutions which are known as basic have a pH greater than 7.

**Phosphorus.** The major nutrient influencing plant and algal growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus refers to the amount of phosphorus in solution that is available to plants and algae. Total phosphorus refers to the amount of phosphorus in solution (reactive) and in particulate forms (non-reactive.)

**Photic zone.** The surface and underwater lighted zone in a lake that usually has a depth around 1.7 times the Secchi reading.

**Photosynthesis.** Process by which green plants convert carbon dioxide (CO<sub>2</sub>) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base and is an important source of oxygen for many lakes.

**Phytoplankton.** Very small free-floating aquatic plants, such as one-celled algae. Their abundance, as measured by the amount of chlorophyll a in a water sample, is commonly used to classify the trophic status of a lake.

**Qualified Lake Association.** To be eligible for state lake planning, protection and recreational boating facilities grants, a lake association must meet certain standards set out in section 281.68 of the Wisconsin statutes.

*(Glossary continued on next page)*

**Respiration.** The reverse reaction of photosynthesis. The complex process that occurs in the cells of plants and animals in which nutrient organic molecules, such as glucose, combine with oxygen to produce carbon dioxide, water, and energy. Respiration consumes oxygen and releases carbon dioxide. This process also takes place during decomposition as bacterial respiration increases.

**Runoff.** Water from rain, snow melt, or irrigation that flows over the ground surface and into streams or lakes.

**Secchi disk.** A 20-cm (8-inch) diameter disk painted white and black in alternating quadrants. It is used to measure light transparency in lakes.

**Seepage lakes.** Lakes without a significant inlet or outlet, fed by rainfall and groundwater.

**Spring lakes.** Lakes that have no inlet, but have an outlet. The primary source of water for spring lakes is groundwater flowing into the bottom of the lake from inside and outside the immediate surface drainage area. Spring lakes are found at the headwaters of many streams and are a fairly common type of lake in northern Wisconsin.

**State Laboratory of Hygiene.** The state of Wisconsin's public health and environmental laboratory.

**Station #.** A number assigned to sampling locations on a waterbody. The Station # makes it easy to track secchi and chemistry data. Each sampling site on a lake will have a separate Station #.

**Stratification.** The layering of water due to differences in temperature and density.

**SWIMS.** Surface Water Integrated Monitoring System. The database where all CLMN data and other water quality data is stored.

**Tannins.** Natural pigments found in organic matter such as leaves and bark.

**Thermocline.** Sometimes referred to as the metalimnion. The narrow transition zone between the epilimnion and the hypolimnion that occurs in stratified lakes.

**Trophic state.** The extent to which the process of eutrophication has occurred is reflected in a lake's trophic classification or state. The three major trophic states are oligotrophic, mesotrophic, and eutrophic.

**µg/L.** micrograms per liter is an expression of concentration indicating weight of a substance in a volume of one liter. Parts per billion (ppb) is an equivalent unit.

**Waterbody # or WBIC (Waterbody Identification Code).**

A unique identification number the Wisconsin DNR uses to identify each waterbody in the state. Every one of the 15,000 lakes in Wisconsin has a unique WBIC.

**Watershed.** The area of land draining into a specific stream, river, lake, or other body of water.

**Zebra mussel.** A tiny bottom dwelling mollusk native to Europe.

**Zooplankton.** Plankton that is made up of microscopic animals, for example, protozoa, that eat algae. These suspended plankton are an important component of the lake food chain and ecosystem. For many fish and crustaceans, they are the primary source of food.





## Appendix 1: Secchi Collection Summary Sheet

1. Contact your Citizen Lake Monitoring Network coordinator for waterbody # or WBIC (Waterbody Identification Code) and Station #. The Station # identifies the sample site on the lake, usually the deepest part of the lake (the deep hole).
2. Before going out to collect Secchi reading, be sure that conditions are right and safe for sampling.
  - Sunny to partly sunny/cloudy skies
  - Wind calm to breezy – there should be no white caps on the lake
  - Between 10:00 am and 4:00 pm
3. Gather your reporting form, lake map with the sample site marked, PFD and Secchi disk. Motor to the deep hole or other designated sampling site. Anchor boat.
4. Mark time and date on your data sheet.
5. Remove sunglasses. Secchi reading is taken from the shady side of the boat.
6. Unwind the Secchi disk rope from the holder. Lean over the shady side of the boat and slowly lower the Secchi disk into the water until you can no longer see it. You should be as close to the surface of the water as is safe. If you are sampling from a pontoon boat, kneel down on the floor of the boat.
7. When the Secchi disk barely disappears from view, mark the rope at the water level with a clothes pin.
8. Lower the Secchi disk a few more feet into the water. Slowly raise the disk. When the Secchi disk reappears, mark the rope at the water level with the second clothespin. The clothespin may be at the same spot or there may be several inches to several feet difference.
9. Bring the Secchi disk back into the boat. Average the two Secchi readings by forming a loop between the two clothespins. Slide one clothespin into the center of the loop to mark it. Remove the other clothespin. The remaining clothespin will be your Secchi reading.
10. Count the number of feet from the disk until you reach your clothespin. Round off to the nearest quarter foot and record that number on your data sheet.
11. Complete water aesthetics survey on your worksheet. Water level should be recorded using the ordinary high water mark as the norm.
12. To determine if the water appearance is clear or murky, hold your Secchi disk **one foot** under the surface of the water and observe how the white part of the disk appears.
13. To determine water color, hold your Secchi disk **one foot** under the surface of the water and observe the water against the white of the disk. Clear water should be recorded as “blue.”
14. Indicate your perception of the water quality **at the deep hole**. On a scale of 1 to 5 (1 being the best and 5 being the worst) record your perception of the amount of algae in the water.
15. Record weather and other observations.



## Appendix 2: Sample Collection Summary Sheet

### 6-Foot Integrated Sampler on Lake

1. Gather your reporting form, lake map, PFD, chemistry equipment, and Secchi disk. Motor to the deep hole or other designated sampling site. Anchor boat.
2. Remove sunglasses. Go to shady side of boat. Using clothespin method, take Secchi reading and record on datasheet. Complete water aesthetics survey.
3. Record weather and other observations.
4. Rinse integrated sampler and water collection bottle three times with lake water. Collect a 6-foot integrated water column sample. Empty water into the water collection bottle. Store sample in a cool, shady spot until you return to shore.
5. Collect and record temperature readings for your pre-selected depths.
6. If you are monitoring oxygen levels, use Van Dorn to collect water samples (depths selected by CLMN coordinator) and run the analysis for titration (summary attached).

**NOTE: If you monitor more than one site, you should have a separate water collection bottle to collect water from each site.**

### On Shore Procedure

1. In a shady spot, gently mix the water sample in water collection bottle and fill the phosphorus bottle. Put on safety goggles and gloves. Add vial of sulfuric acid to phosphorus bottle.  
Label phosphorus bottle. Place sample in refrigerator until ready to mail. Triple rinse the used acid vial(s) and dispose in garbage.
2. For chlorophyll analysis determine amount of water to filter based on your Secchi disk reading from that day. Gently shake remaining water in water collection bottle. Using the graduated cylinder, measure water to be filtered. Using forceps, place filter over the support screen on the funnel base of magnetic filter cup. Pour water from graduated cylinder a little at a time into filter cup. If filter clogs and water does not filter, refer to your manual.
3. Pump water through filter. Use distilled water to rinse inside of filter cup so all lake water has been rinsed from filter cup and has gone through the filter.
4. Using forceps, place chlorophyll filter in plastic tube from WSLH mailer.
5. Label tube and keep tube in freezer until ready to mail.

**Amount of water to filter for chlorophyll sample is based on your Secchi reading for that day.**

Secchi Depth	Volume of Water to Filter
1 Foot	50 mls
1 - 1.5 Feet	100 mls
Greater than >1.5 Feet	200 mls



## Appendix 3: Dissolved Oxygen On-Lake Procedure Summary LaMotte Titration Kit

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1. Using Van Dorn sampling bottle, collect water sample from the first depth assigned by CLMN coordinator.
2. Select the D.O. bottle with the depth written on it that corresponds to the sample depth you are collecting. Remove cap. Run a small amount of water through the rubber tube of the Van Dorn sampling bottle to clean it.
3. Insert sampler hose to bottom of bottle. Overfill bottle at least two seconds.
4. Remove hose while water is still flowing to overflow the bottle.
5. Quickly cap the bottle.
6. Put on safety gloves and goggles.
7. Remove cap; add 8 drops of Manganous Sulfate solution from the squeeze bottle.
8. Add 8 drops of Alkaline Potassium Iodide Azide solution from the squeeze bottle.
9. Cap and invert 10-20 times to mix (more oxygen will make it darker brown).
10. Allow precipitate (the solid substance forming in the bottle) to settle halfway down the bottle.
11. Mix and invert another 10-20 times. Let the precipitate settle halfway down the bottle again.
12. Add 8 drops of Sulfuric Acid.
13. Cap the bottle and invert to mix. Continue inverting the bottle for several minutes until all of the precipitate has dissolved. Your sample is now “fixed.” Place bottles in holder for on shore procedure (see on-shore procedures of your manual).
14. Repeat steps 1 through 13 for each successive pre-selected depth.
15. Complete remaining analysis for all samples on shore.
16. Record data on Secchi & Chem form.

# Appendix 4: How to Report Data Online

## Citizen Lake Monitoring How to Report Data

### User ID and Password: How to Get One

If you entered data online last year, you can use your existing WAMS Account (User ID and Password).

If you do not have a User ID and Password:

- Go to <http://on.wisconsin.gov>,
- Click **Self Registration**. Scroll down and click ,
- Then, fill in your information. Only fields with “\*” are required. If you have a problem with it not accepting your mailing address, just leave the whole address blank. Before hitting , print the page and jot down your password. Save it in a safe place,
- Open your email account and look for an e-mail from Wisconsin.gov. Click on the e-mail and log in,
- Now, there is only one more step: **E-mail your User ID** to the Lakes Inbox at [DNRLakeb@Wisconsin.gov](mailto:DNRLakeb@Wisconsin.gov).
  - If you are a first time volunteer, include the lake(s) and counties in which you are volunteering and what activities you are doing (Citizen Lake Monitoring, Clean Boats/Clean Waters, Loon Watch, etc.). We need to set you up in the SWIMS database so it will know what lake you monitor.,
- You will get a reply within a couple of business days saying you are all set up to enter CLMN data.

### User ID and Password: What if I Forgot?


- Go to <http://on.wisconsin.gov>,
- Click on **Account Recovery** to go to the account recovery page,
- Scroll down and enter either your e-mail address or User ID. Click on ,
- You will receive an automated email from Wisconsin.gov (if no email after 20 minutes, check your Junk Mail folder).
- Click on the link in the email, and follow the steps to reset your password,
- If you have trouble still, contact Jake Dickmann at [Jacob.Dickmann@Wisconsin.gov](mailto:Jacob.Dickmann@Wisconsin.gov). While we at the DNR don't have access to your password, we can help make sure you're able to log in again soon.

### How to Enter Data

- Go to the Citizen Lake Monitoring page at: <http://dnrx.wisconsin.gov/swims>,
- Click on  at the top of the page,
- Login by entering your User ID and password. Click ,
- Find the correct project you have data for and click on [Enter Data](#),
- If more than one station, select the correct monitoring station and data collectors,
- Enter the date and time,
- Down below, enter your written observations in the comment box (i.e. weather, wildlife),
- Click ,
- Fill in your results. To enter a temperature or D.O. profile, click  at the bottom right,
- To enter another date: click , then click ,
- If you are finished: click , then click .

### How to Edit Existing Data

You can only edit data you have entered during the current monitoring season. Here's how:

- Within SWIMS, click the [My Recent Data](#) link at the top right ,
- Click the pencil icon  for the date you want to edit,
- You can edit comments, etc. on the first page if necessary, then click . You can now edit your results,
- If you hit click  then , your changes will be saved.

# Appendix 5: Sample Lab Slip

State of Wisconsin  
Department of Natural Resources  
and Laboratory of Hygiene

**Test Request - Citizen Lake Monitoring Network**

**\*\* DO NOT PHOTOCOPY \*\***

June-013159

**Billing and Reporting**

Account Number SH022	Field Number (Bottle Label ID) June-013159
DNR User ID WIESED	Report To Name Dennis Wiese

**Date and Time of Sample Collection**

Date (mm/dd/yyyy)	Time (24-hr clock)
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**Sample Type**

Sample Type:  SU Surface Water

**Who collected the sample**

Collected By Name	Telephone	Email
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**Where the sample was collected**

Station ID (STORET #) 013159	Sample Address or Location Description Arkdale Lake (Millpond) - Deep Hole	
County 1-Adams	Waterbody ID (WBIC) 1374300	Point / Outfall (or SWIMS Fieldwork Seq No) 155575999

**Sample Details**

Sample Description/ Device Description

Grant or Project Number CLMN-013159	If Field QC Sample (select one): <input type="radio"/> Duplicate <input type="radio"/> Blank <input type="radio"/> _____	Depth of Sample (grab/Van Dorn): _____ <input checked="" type="radio"/> F <input type="radio"/> M <input type="radio"/> In <input type="radio"/> Cm
		Or Top and Bottom of Sample Interval (integrated sampler): 0-6 <input checked="" type="radio"/> F <input type="radio"/> M <input type="radio"/> In <input type="radio"/> Cm

**Analyses Requested**

Be sure to indicate if you are using a grab/vandorn sample (3 feet) or an integrated sampler (0-6 feet) to collect your water sample.

**Do not sample for chl until after May 31st.**

Chlorophyll A (if Field Filtered, give ml \_\_\_\_\_ filtered)

Place Sulfuric Acid Vial Sticker Over This Box

**250 ml Nutrients Bottle (Acidify w/ Sulfuric Acid)**

Tot.- Phosphorus

Please enclose this form in the mailer along with the sample and send to the State Lab of Hygiene.

For lab use: Sample Temp \_\_\_\_\_ C  Iced

## Appendix 6: CHEMICAL SAFETY INFORMATION

### General Precautions for Using the LaMotte® Dissolved Oxygen Test Kit

1. Read all instructions to familiarize yourself with the test procedures before you begin.
2. Read the label on each LaMotte® reagent container prior to use. Some containers include precautionary notices and first-aid information.
3. Keep all equipment and reagent chemicals out of the reach of children!
4. In the event of an accident or suspected poisoning, immediately call the Poison Center phone number located in the front of your local telephone directory or call your physician. Be prepared to give the name of the reagent in question and its LaMotte® code number. All LaMotte® reagents are registered with POISINDEX®, a computerized poison control information system available to all local poison control centers.

#### ***To protect yourself and your equipment, use proper analytical techniques:***

1. Avoid contact between reagent chemicals and your skin, eyes, nose, and mouth.
2. Always wear safety goggles or glasses when handling the reagent chemicals.
3. Use the bottle caps, not your fingers, to cover bottles during shaking or mixing.
4. When dispensing a reagent from a plastic squeeze bottle, always hold the bottle vertically upside-down (i.e. not at an angle) and gently squeeze it. If a gentle squeeze does not produce the reagent then the dispensing cap or plug may be clogged.
5. Immediately wipe up any reagent chemical spills, liquid or powder. Rinse the area with a wet sponge and then dry it.
6. Tightly close all reagent containers immediately after use. Do not interchange caps from different reagent containers.

## Appendix 6: continued

**Chemical Safety Procedures*****Manganous Sulfate Solution- POISINDEX® Code #4167***

**Health Hazard Data:** May irritate skin and eyes.

**Eye Contact:** Immediately flush eyes with water for at least 15 minutes.  
Consult a physician.

**Skin Contact:** Flush with water, remove affected clothing and flush and flush skin for 15 minutes.

**Ingestion:** Induce vomiting immediately, consult a physician.

**Spills and Cleanup:** Mop up carefully and flush down drain with excess water.

***Alkaline Potassium Iodide Azide- POISINDEX® Code #7166***

**Health Hazard Data:** Severe burns, may be fatal if swallowed.

**Eye Contact:** Immediately flush eyes with water for at least 15 minutes.  
Consult a physician.

**Skin Contact:** Immediately flush with water, remove affected clothing and flush skin for 15 minutes. Consult a physician.

**Ingestion:** Do not induce vomiting! Rinse mouth, drink a glass of water, and consult a physician.

**Spills and Cleanup:** Neutralize with 6-MHCL, if available, and flush down drain with excess water.

***Sulfuric Acid- POISINDEX® Code #6141***

**Health Hazard Data:** Severe burns, may be fatal if swallowed

**Eye Contact:** Immediately flush eyes with water for at least 15 minutes.  
Consult a physician.

**Skin Contact:** Immediately flush with water for 15 minutes. Consult a physician.

**Ingestion:** Do not induce vomiting! Rinse mouth, drink a glass of water, and consult a physician

**Spills and Cleanup:** Cover with sodium bicarbonate (baking soda) or soda ash-calcium hydroxide mixture. Scoop up and wash down drain with excess water.

***Sodium Thiosulfate- POISINDEX® Code #4169***

**Health Hazard Data:** Large doses orally can cause purging. Human toxicity is low.

**Eye Contact:** Immediately flush eyes with water.

**Skin Contact:** Flush thoroughly with water.

**Ingestion:** Drink water and consult a physician.

**Spills and Cleanup:** Mop up and wash down the drain.

***Starch Indicator Solution- POISINDEX® Code #4170***

**Eye Contact:** Immediately flush eyes with water.

**Skin Contact:** Flush thoroughly with water.

**Ingestion:** Drink water and consult a physician.

**Spills and Cleanup:** Mop up and wash down the drain with excess water.



## Appendix 7: Forms

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- **Secchi and Chemistry Datasheet**
- **Ice Observation Report**
- **Aquatic Invasives Presence/Absence Report**
- **Schedule for Chemistry, Temperature and Dissolved Oxygen Monitoring**
- **Calibration Log for Dissolved Oxygen Meter**
- **Dissolved Oxygen Solubility Chart  
uncorrected barometric pressure**
- **Uncorrecting Barometric Pressure Based on Altitude**







Personally identifiable information collected on this form will be incorporated into the DNR lakes database. It is not intended to be used for any other purposes, but may be made available to requesters under Wisconsin's Open Records laws, s. 19.32 - 19.39, Wis. Stats.

**Primary Data Collector**

Name	Phone Number	Email
------	--------------	-------

Additional Data Collector Names

**Monitoring Location**

Waterbody Name	Township Name	County
----------------	---------------	--------

Describe your observation point

Describe portion of waterbody you can see from your observation point

**Date and Time of Monitoring**

Start Date	Start Time	End Date	End Time
------------	------------	----------	----------

*Start Date = Date you began making ice observations for the winter season. End Date = Date you finished making ice observations in the spring*

**Monitoring Results**

"Ice On" = A lake is considered ice covered when the deepest part of the lake is ice covered.

"Ice Off" = The lake is considered thawed when it is possible to boat from any shore to the deepest part of the lake without encountering ice.

If you or past observers on your lake have always used another method to judge ice-on and ice-off, please describe the method

Date of First "Ice On" (When lake was first observed to be closed in the fall)

Date First "Ice Off" (When lake was first observed to be open in the spring)

Ice Duration (Total number of days frozen) [provide only if lake was observed daily]

Comments

This monitoring is designed to help detect new invasive species on your lake, so DNR can be alerted and lake residents and/or professionals can respond appropriately. The purpose of the DNR collecting this data is to let us know what methods trained citizens and professionals use when actively looking for aquatic invasive species. You are often the ones to alert us of new invasives in our waters. Remember for surveillance monitoring, a report of "no invasive" at a location is just as important as finding an invasive. One cannot confidently state that the invasive is not present in an area if no one has looked and reported their findings. Knowing where invasives are not, as well as where they are, is extremely important in being able to track and understand their spread. Knowing how often monitors are looking for species and what they are finding is very important information.

**Notice:** Information on this voluntary form is collected under ss. 33.02 and 281.11, Wis. Stats. Personally identifiable information collected on this form will be incorporated into the DNR Surface Water Integrated Monitoring System (SWIMS) Database. It is not intended to be used for any other purposes, but may be made available to requesters under Wisconsin's Open Records laws, ss. 19.32 - 19.39, Wis. Stats.

Data Collectors			
Primary Data Collector Name		Phone Number	Email
Additional Data Collector Names			
Total Paid Hours Spent (# people x # hours each)		Total Volunteer Hours Spent (# people x # hours each)	
Monitoring Location			
Waterbody Name	Township Name	County	Boat Landing (if you only monitor at a boat landing)
Dates Monitored			
Start Date (when you first monitored this season)		End Date (when you last monitored this season)	
Did at least some data collectors monitor in... May? June? July? August? (circle all that apply)			
Did you monitor...		Did you...	
All Beaches and Boat Landings? Frequently    Some of the Time    Not Often/Never		Walk along the shoreline? Frequently    Some of the Time    Not Often/Never	
Perimeter of whole lake? Frequently    Some of the Time    Not Often/Never		Observe entire shallow water area (up to 3 feet deep)? Frequently    Some of the Time    Not Often/Never	
Docks or piers? Frequently    Some of the Time    Not Often/Never		Use rake to extract plant samples? Frequently    Some of the Time    Not Often/Never	
Other: _____		Check underwater solid surfaces (boat hulls, dock legs, rocks)? Frequently    Some of the Time    Not Often/Never	
		Other: _____	
Did you find...(even if not a new finding for the lake or stream)			
Banded Mystery Snail?	Yes	No	Did not look for
Hydrilla?	Yes	No	Did not look for
Chinese Mystery Snail?	Yes	No	Did not look for
Purple Loosestrife?	Yes	No	Did not look for
Curly-Leaf Pondweed?	Yes	No	Did not look for
Rusty Crayfish?	Yes	No	Did not look for
Eurasian Water Milfoil?	Yes	No	Did not look for
Spiny Waterfleas?	Yes	No	Did not look for
Fishhook Waterfleas?	Yes	No	Did not look for
Zebra Mussels?	Yes	No	Did not look for
Freshwater Jellyfish?	Yes	No	Did not look for
		Other?: _____	

***If you find an aquatic invasive***  
 If you find an aquatic invasive and it is not listed at <http://dnr.wi.gov/lakes/AIS> fill out an incident report for the species. Then bring the form, a voucher specimen if possible, and a map showing where you found it to your regional DNR Citizen Lake Monitoring or AIS Coordinator as soon as possible (to facilitate control if control is an option).

***If you don't find an aquatic invasive***  
 If you submit your data online, that is all you need to do. Otherwise, please mail a copy to your regional DNR Citizen Lake Monitoring Coordinator. <http://dnr.wi.gov/lakes/contacts>



## Dissolved Oxygen Solubility Chart

Uncorrected Barometric Pressure													
Temp. (deg F)	Barometric Pressure (in Hg)												
	27.4	27.6	27.8	28	28.2	28.4	28.6	28.8	29	29.2	29.4	29.6	29.8
40	11.9	11.9	12	12.1	12.2	12.3	12.4	12.5	12.6	12.6	12.7	12.8	12.9
40.5	11.8	11.9	11.9	12	12.1	12.2	12.3	12.4	12.5	12.6	12.6	12.7	12.8
41	11.7	11.8	11.9	11.9	12	12.1	12.2	12.3	12.4	12.5	12.5	12.6	12.7
41.5	11.6	11.7	11.8	11.9	11.9	12	12.1	12.2	12.3	12.4	12.5	12.5	12.6
42	11.5	11.6	11.7	11.8	11.9	11.9	12	12.1	12.2	12.3	12.4	12.5	12.5
42.5	11.4	11.5	11.6	11.7	11.8	11.9	11.9	12	12.1	12.2	12.3	12.4	12.4
43	11.4	11.4	11.5	11.6	11.7	11.8	11.9	11.9	12	12.1	12.2	12.3	12.4
43.5	11.3	11.4	11.4	11.5	11.6	11.7	11.8	11.9	11.9	12	12.1	12.2	12.3
44	11.2	11.3	11.4	11.4	11.5	11.6	11.7	11.8	11.9	11.9	12	12.1	12.2
44.5	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9	11.9	12	12.1
45	11	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9	11.9	12
45.5	11	11.1	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9	11.9
46	10.9	11	11.1	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8	11.9
46.5	10.8	10.9	11	11.1	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7	11.8
47	10.7	10.8	10.9	11	11.1	11.1	11.2	11.3	11.4	11.5	11.5	11.6	11.7
47.5	10.7	10.8	10.8	10.9	11	11.1	11.1	11.2	11.3	11.4	11.5	11.5	11.6
48	10.6	10.7	10.8	10.8	10.9	11	11.1	11.2	11.2	11.3	11.4	11.5	11.5
48.5	10.5	10.6	10.7	10.8	10.8	10.9	11	11.1	11.2	11.2	11.3	11.4	11.5
49	10.5	10.5	10.6	10.7	10.8	10.8	10.9	11	11.1	11.2	11.2	11.3	11.4
49.5	10.4	10.5	10.5	10.6	10.7	10.8	10.9	10.9	11	11.1	11.2	11.2	11.3
50	10.3	10.4	10.5	10.6	10.6	10.7	10.8	10.9	10.9	11	11.1	11.2	11.2
50.5	10.3	10.3	10.4	10.5	10.6	10.6	10.7	10.8	10.9	10.9	11	11.1	11.2
51	10.2	10.3	10.3	10.4	10.5	10.6	10.6	10.7	10.8	10.9	10.9	11	11.1
51.5	10.1	10.2	10.3	10.4	10.4	10.5	10.6	10.7	10.7	10.8	10.9	10.9	11
52	10.1	10.1	10.2	10.3	10.4	10.4	10.5	10.6	10.7	10.7	10.8	10.9	11
52.5	10	10.1	10.1	10.2	10.3	10.4	10.4	10.5	10.6	10.7	10.7	10.8	10.9
53	9.9	10	10.1	10.2	10.2	10.3	10.4	10.4	10.5	10.6	10.7	10.7	10.8
53.5	9.9	9.9	10	10.1	10.2	10.2	10.3	10.4	10.5	10.5	10.6	10.7	10.7
54	9.8	9.9	10	10	10.1	10.2	10.2	10.3	10.4	10.5	10.5	10.6	10.7
54.5	9.7	9.8	9.9	10	10	10.1	10.2	10.3	10.3	10.4	10.5	10.5	10.6
55	9.7	9.8	9.8	9.9	10	10	10.1	10.2	10.3	10.3	10.4	10.5	10.5
55.5	9.6	9.7	9.8	9.8	9.9	10	10.1	10.1	10.2	10.3	10.3	10.4	10.5
56	9.6	9.6	9.7	9.8	9.8	9.9	10	10.1	10.1	10.2	10.3	10.3	10.4
56.5	9.5	9.6	9.6	9.7	9.8	9.9	9.9	10	10.1	10.1	10.2	10.3	10.4
57	9.4	9.5	9.6	9.7	9.7	9.8	9.9	9.9	10	10.1	10.1	10.2	10.3
57.5	9.4	9.5	9.5	9.6	9.7	9.7	9.8	9.9	9.9	10	10.1	10.2	10.2
58	9.3	9.4	9.5	9.5	9.6	9.7	9.7	9.8	9.9	10	10	10.1	10.2
58.5	9.3	9.3	9.4	9.5	9.6	9.6	9.7	9.8	9.8	9.9	10	10	10.1
59	9.2	9.3	9.4	9.4	9.5	9.6	9.6	9.7	9.8	9.8	9.9	10	10
59.5	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.6	9.7	9.8	9.8	9.9	10
60	9.1	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.7	9.7	9.8	9.9	9.9
60.5	9.1	9.1	9.2	9.3	9.3	9.4	9.5	9.5	9.6	9.7	9.7	9.8	9.9
61	9	9.1	9.1	9.2	9.3	9.3	9.4	9.5	9.5	9.6	9.7	9.7	9.8
61.5	8.9	9	9.1	9.1	9.2	9.3	9.3	9.4	9.5	9.5	9.6	9.7	9.7
62	8.9	9	9	9.1	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.6	9.7
62.5	8.8	8.9	9	9	9.1	9.2	9.2	9.3	9.4	9.4	9.5	9.6	9.6
63	8.8	8.9	8.9	9	9.1	9.1	9.2	9.3	9.3	9.4	9.4	9.5	9.6

## Dissolved Oxygen Solubility Chart

Uncorrected Barometric Pressure													
Temp. (deg F)	Barometric Pressure (in Hg)												
	27.4	27.6	27.8	28	28.2	28.4	28.6	28.8	29	29.2	29.4	29.6	29.8
63.5	8.7	8.8	8.9	8.9	9	9.1	9.1	9.2	9.3	9.3	9.4	9.5	9.5
64	8.7	8.8	8.8	8.9	9	9	9.1	9.1	9.2	9.3	9.3	9.4	9.5
64.5	8.6	8.7	8.8	8.8	8.9	9	9	9.1	9.2	9.2	9.3	9.4	9.4
65	8.6	8.7	8.7	8.8	8.9	8.9	9	9	9.1	9.2	9.2	9.3	9.4
65.5	8.5	8.6	8.7	8.7	8.8	8.9	8.9	9	9.1	9.1	9.2	9.2	9.3
66	8.5	8.6	8.6	8.7	8.8	8.8	8.9	8.9	9	9.1	9.1	9.2	9.3
66.5	8.4	8.5	8.6	8.6	8.7	8.8	8.8	8.9	9	9	9.1	9.1	9.2
67	8.4	8.5	8.5	8.6	8.7	8.7	8.8	8.8	8.9	9	9	9.1	9.2
67.5	8.4	8.4	8.5	8.5	8.6	8.7	8.7	8.8	8.9	8.9	9	9	9.1
68	8.3	8.4	8.4	8.5	8.6	8.6	8.7	8.7	8.8	8.9	8.9	9	9.1
68.5	8.3	8.3	8.4	8.4	8.5	8.6	8.6	8.7	8.8	8.8	8.9	8.9	9
69	8.2	8.3	8.3	8.4	8.5	8.5	8.6	8.6	8.7	8.8	8.8	8.9	9
69.5	8.2	8.2	8.3	8.4	8.4	8.5	8.5	8.6	8.7	8.7	8.8	8.8	8.9
70	8.1	8.2	8.2	8.3	8.4	8.4	8.5	8.6	8.6	8.7	8.7	8.8	8.9
70.5	8.1	8.1	8.2	8.3	8.3	8.4	8.4	8.5	8.6	8.6	8.7	8.8	8.8
71	8	8.1	8.2	8.2	8.3	8.3	8.4	8.5	8.5	8.6	8.6	8.7	8.8
71.5	8	8.1	8.1	8.2	8.2	8.3	8.4	8.4	8.5	8.5	8.6	8.7	8.7
72	8	8	8.1	8.1	8.2	8.3	8.3	8.4	8.4	8.5	8.6	8.6	8.7
72.5	7.9	8	8	8.1	8.1	8.2	8.3	8.3	8.4	8.4	8.5	8.6	8.6
73	7.9	7.9	8	8	8.1	8.2	8.2	8.3	8.3	8.4	8.5	8.5	8.6
73.5	7.8	7.9	7.9	8	8.1	8.1	8.2	8.2	8.3	8.4	8.4	8.5	8.5
74	7.8	7.8	7.9	8	8	8.1	8.1	8.2	8.3	8.3	8.4	8.4	8.5
74.5	7.7	7.8	7.9	7.9	8	8	8.1	8.2	8.2	8.3	8.3	8.4	8.4
75	7.7	7.8	7.8	7.9	7.9	8	8.1	8.1	8.2	8.2	8.3	8.3	8.4
75.5	7.7	7.7	7.8	7.8	7.9	8	8	8.1	8.1	8.2	8.2	8.3	8.4
76	7.6	7.7	7.7	7.8	7.9	7.9	8	8	8.1	8.1	8.2	8.3	8.3
76.5	7.6	7.6	7.7	7.8	7.8	7.9	7.9	8	8	8.1	8.2	8.2	8.3
77	7.5	7.6	7.7	7.7	7.8	7.8	7.9	7.9	8	8.1	8.1	8.2	8.2
77.5	7.5	7.6	7.6	7.7	7.7	7.8	7.8	7.9	8	8	8.1	8.1	8.2
78	7.5	7.5	7.6	7.6	7.7	7.8	7.8	7.9	7.9	8	8	8.1	8.1
78.5	7.4	7.5	7.5	7.6	7.7	7.7	7.8	7.8	7.9	7.9	8	8	8.1
79	7.4	7.4	7.5	7.6	7.6	7.7	7.7	7.8	7.8	7.9	8	8	8.1
79.5	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.7	7.8	7.9	7.9	8	8
80	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.8	7.8	7.9	7.9	8
80.5	7.3	7.3	7.4	7.4	7.5	7.6	7.6	7.7	7.7	7.8	7.8	7.9	7.9
81	7.2	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.7	7.8	7.8	7.9
81.5	7.2	7.3	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.8	7.8	7.9
82	7.2	7.2	7.3	7.3	7.4	7.4	7.5	7.6	7.6	7.7	7.7	7.8	7.8
82.5	7.1	7.2	7.2	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.7	7.8
83	7.1	7.2	7.2	7.3	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7	7.7
83.5	7.1	7.1	7.2	7.2	7.3	7.3	7.4	7.4	7.5	7.5	7.6	7.7	7.7
84	7	7.1	7.1	7.2	7.2	7.3	7.4	7.4	7.5	7.5	7.6	7.6	7.7
84.5	7	7	7.1	7.2	7.2	7.3	7.3	7.4	7.4	7.5	7.5	7.6	7.6
85	7	7	7.1	7.1	7.2	7.2	7.3	7.3	7.4	7.4	7.5	7.5	7.6

Solubility of oxygen in fresh water at various temperatures and pressures

[Solubility shown in milligrams per liter. Values based on published equations by Benson and Krause (1980 and 1984).

deg F - degrees Fahrenheit; in Hg - inches of mercury]

Results from DOTABLES program at <https://water.usgs.gov/software/DOTABLES/>.

Table generated Tuesday 05-Feb-2019 14:23 EST



## Uncorrecting Barometric Pressure Based on Altitude

Barometric pressure (BP) retrieved from online weather sites and most airports has been corrected to sea level. To properly calibrate meters for dissolved oxygen, this value must first be **uncorrected**. To uncorrect BP, find your local altitude or closest corresponding altitude and apply one of the two following correction factors to the retrieved BP. **Example: Rhinelander is app. 1550 ft in altitude. If the online BP is 762 mm, uncorrect this value by subtracting 41.7 mm or multiplying by 0.947. (762 - 41.7 = 720.3)** This is the value your meter should be displaying. If it isn't, the meter barometer should be calibrated. *For meters without built-in barometers, hand enter the uncorrected BP or on older instruments, enter the closest altitude value for your location during instrument calibration.*

Altitude (feet)	Multiplication Factor*	Subtraction Factor**	
		(mm)	(in)
550	0.981	15.0	0.6
600	0.979	16.3	0.6
650	0.978	17.8	0.7
700	0.976	19.1	0.8
750	0.974	20.3	0.8
800	0.973	21.8	0.9
850	0.971	23.1	0.9
900	0.969	24.4	1.0
950	0.968	25.7	1.0
1000	0.966	27.2	1.1
1050	0.964	28.4	1.1
1100	0.962	29.7	1.2
1150	0.961	31.0	1.2
1200	0.959	32.5	1.3
1250	0.957	33.8	1.3
1300	0.956	35.1	1.4
1350	0.954	36.3	1.4
1400	0.952	37.6	1.5
1450	0.950	39.1	1.5
1500	0.949	40.4	1.6
1550	0.947	41.7	1.6
1600	0.945	42.9	1.7
1650	0.944	44.2	1.7
1700	0.942	45.5	1.8
1750	0.940	47.0	1.9
1800	0.938	48.3	1.9
1850	0.937	49.5	2.0
1900	0.935	50.8	2.0
1950	0.933	52.1	2.1
2000	0.932	53.3	2.1

\*Multiply against sea level barometric pressure to get station pressure (most precise method)

\*\*Subtract from sea level barometric pressure to get station pressure (simplest method)

## Additional Resources

CLMN Web Site: [www.dnr.wi.gov/lakes/CLMN](http://www.dnr.wi.gov/lakes/CLMN) and [www.uwsp.edu/uwexplakes](http://www.uwsp.edu/uwexplakes)

CBCW Web Site: [www.uwsp.edu/uwexplakes](http://www.uwsp.edu/uwexplakes)

UWEX Web Site: [www.uwsp.edu/uwexplakes](http://www.uwsp.edu/uwexplakes)

The following resources and many other limnology related books can be found on the web or at your local or University library.

### *Understanding Lake Data*

This booklet will help you understand how lakes work and what your data means for your lake. The CLMN web site can also provide links to other lake information.

### *Through the Looking Glass...*

#### *A Field Guide to Aquatic Plants*

This book was written by Susan Borman, Robert Korth and Jo Temte and published in 1997 by the University of Wisconsin, and Second Edition published in 2014. It is available from University of Wisconsin Extension Lakes Partnership, College of Natural Resources, University of Wisconsin Stevens Point.

## Literature Cited

Asplund, T.R. 2000.

The Effects of Motorized Watercraft on Aquatic Ecosystems. *Miscellaneous Publication* SS-948. Wisconsin Department of Natural Resources, Bureau of Science Services and University of Wisconsin, Water Chemistry Program.

Gaeta, J.W. and S.R. Carpenter. 2013

Drought-driven lake level decline: effects on coarse woody habitat and fishes. Center for Limnology, UW-Madison.

Krysel, Charles et al. June 2003.

Lakeshore property values and water quality: Evidence from property sales in the Mississippi headwaters region. [www.friendscvsf.org/bsu\\_study.pdf](http://www.friendscvsf.org/bsu_study.pdf)

Larson, G.L. and Buktenica, M.W., 1998.

Variability of secchi reading in an exceptionally clear and deep caldera lake. *Archiv fuer Hydrobiologie*. Vol. 141. No. 4

Lillie, R.A. and J.W. Mason. 1983.

Limnological characteristics of Wisconsin lakes. *Technical Bulletin* (138):1-116. Wisconsin Department of Natural Resources, Madison.

Lisi, Peter J. and Katherine L. Hein, 2010.

Eutrophication drives divergent water clarity responses to decadal variation in lake level. *Limnol. Oceanogr.* 00.2018, 1-11.

Lundquist, J.B. 1975.

A Primer on Limnology. University of Minnesota Limnological Research Center, St. Paul, MN. 28 pp.

Markham, Lynn and Kate Demorest. 2012.

Protecting Your Waterfront Investment. Ten Simple Shoreland Stewardship Practices. Center for Land Use Education, UW-Extension.

Shaw, B.H., C. Mechenich and L. Klessig. 2000.

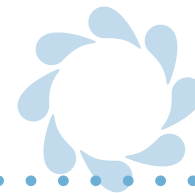
Understanding Lake Data. University of Wisconsin Extension, Madison, WI. 20 pp.

University of Wisconsin Sea Grant Institute. 1992.

Zebra Mussel Boater's Guide. University of Wisconsin Sea Grant Institute, Madison, WI.

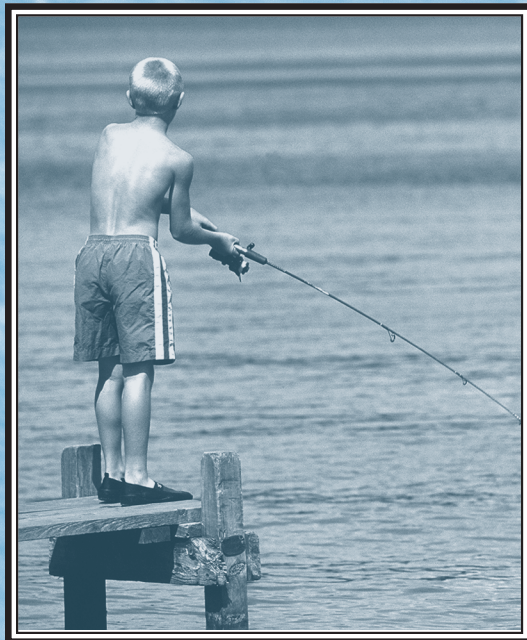
University of Wisconsin-Extension. 2001.

Brown Water, Green Weeds. University of Wisconsin-Extension, Madison, WI. Publication number GWQ003. Wisconsin Department of Natural Resources, Madison, WI. Publication









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