Illinois Volunteer Lake Monitoring Program
2011

By
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A special "*Thank You*" to ALL 334 volunteers who participated in the 2011 VLMP!!

Lake/County	Volunteer
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Lake Co.	
Zurich	Dick Schick
Lake Co.	Anne Schick
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Program coordination was provided by Teri Holland and Greg Ratliff (IEPA); Holly Hudson (CMAP); Rob Clodi, Cary Minnis and Travis Taylor (GERPDC); and Mike Adam and Kelly Deem (LCHD).

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This report was written by Greg Ratliff and edited by Gregg Good, Teri Holland, Tara Lambert and Steve Kolsto.

Acronyms and Abbreviations

AIS	Aquatic Invasive Species
ALC	Aquatic Life Conditions
AQC	Aesthetic Quality Conditions
CHL-*a*	Chlorophyll-*a*
CMAP	Chicago Metropolitan Agency for Planning
DO	Dissolved Oxygen
GERPDC	Greater Egypt Regional Planning & Development Commission
GPS	Global Positioning System
ICLP	Illinois Clean Lakes Program
IEPA	Illinois Environmental Protection Agency
LCHD	Lake County Health Department
IPCB	Illinois Pollution Control Board
mg/L	milligrams per Liter
NPS	Non-point Source
NVSS	Non-volatile Suspended Solid
SD	Secchi Depth
SPU	Standard Platinum-Cobalt Units
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TN:TP	Total Nitrogen to Total Phosphorus ratio
TP	Total Phosphorus
TSI	Trophic State Index
TSI^{CHL}	TSI for Chlorophyll-A
TSI^{SD}	TSI for Secchi Depth
TSI^{TP}	TSI for Total Phosphorus
TSS	Total Suspended Solid
ug/L	microgram per Liter
VLMP	Volunteer Lake Monitoring Program
VSS	Volatile Suspended Solid

Objectives

1. *Increase citizen knowledge of the factors that affect lake quality in order to provide a better understanding of lake/watershed ecosystems and promote informed decision making;*
2. *Encourage development and implementation of sound lake protection and management plans;*
3. *Encourage local involvement in problem solving by promoting self-reliance;*
4. *Enlist and develop local "grass roots" support and foster cooperation among citizen, organizations, and various units of government;*
5. *Gather fundamental information on Illinois lakes: with this information, current water quality can be determined as well as (with historical data) long term trends;*
6. *Provide an historic data baseline to document water quality impacts and support lake management decision-making; and*
7. *Provide an initial screening tool for guiding the implementation of lake protection/restoration techniques and framework for a technical assistance program.*

Background

There are 3,041 lakes with surface areas of six acres or more in Illinois. Approximately 75 percent of these lakes are artificially constructed, 23 percent are river backwaters, and the remaining 2 percent are of glacial origin. In addition to being valuable recreational and ecological resources, these lakes serve as potable, industrial, and agricultural water supplies; as cooling water sources; and as flood control structures.

Physical Characteristics

The physical characteristics of lakes are mainly established during formation. G.E. Hutchinson, in his *A Treatise on Limnology* (1957), described 76 different ways to form lakes. In this report, we will limit our look to four generalized types; glacial lakes, riverine lakes, impoundments, and quarry lakes. Each of these categories can be broken down into many subcategories (not within the scope of this report); however, this report will present data using these categories.

Glacial Lakes

Glaciers formed lake basins by gouging holes in loose soil or soft bedrock, depositing material across stream beds, or leaving buried chunks of ice that later melted to leave lake basins; scour lakes (Lake Michigan), chain of lakes on an outwash plain divided by moraines (Bluff, Catherine, Channel, Fox, Grass, Marie, Nippersink, Pistakee, Petite, and Redhead lakes along the Fox River) and kettle lakes (Grays Lake in Grayslake, Lake County), respectively.

Riverine Lakes

Erosion and deposition of rivers can form lakes, such as meandering rivers forming oxbow lakes. Rivers never follow the same path over extended periods of time and oxbow lakes are formed by the isolated sections created when rivers change direction and cut new channels. Horseshoe Lake near Granite City is a good example of an oxbow lake. Lakes can be formed from river side channels, convergence of several side channels, or connected backwater off-shoots fed by river or streams. These backwaters may be continually fed or intermittently flooded throughout the yearly cycle. For purposes of this report, we will use riverine to group these river associated lakes.

Impoundment Lakes

Humans have created reservoirs (artificial lakes) by damming rivers and streams. Carlyle of Fayette County (26,000 acres), Rend of Franklin County (18,000 acres), Springfield of Sangamon County (4,260 acres), Mattoon of Coles, Cumberland and Shelby Counties (1,050 acres), Apple Canyon (450 acres) and Galena (225 acres) of Jo Daviess County are all examples of impoundment lakes.

Quarry Lakes

Quarries and abandoned excavation sites may fill with water and become lakes, as well. Examples include: Sunset of Champaign County (89 acres, Sand & Gravel Quarry), Johnson of Peoria County (170 acres, Coal Strip Mine), and Independence Grove of Lake County (119 acres, Borrow Pit).

Lakes constantly undergo evolutionary change, reflected in changes occurring in their watersheds. Most lakes will eventually fill in with the remains of lake organisms as well as silt and soil washed in by floods and streams. These gradual changes in the physical and chemical components of a lake affect the development and succession of plant and animal communities. This natural process takes thousands of years. Human activities, however, can dramatically change lakes, for better or worse, in just a few years.

Lakes serve as traps for materials generated within their watershed (drainage basin). The trapped material generally impairs water quality and may severely impact beneficial uses and significantly shorten the life of the lake. Suspended and deposited sediments can cause serious use impairment problems. Excessive macrophyte (aquatic plant) growth and/or algal blooms often result from the addition of nutrients such as nitrogen and phosphorus. An overabundance of plant life may tend to limit recreational and public water supply usage. Lakes may also collect heavy metal and organic contamination from urban, industrial, and agricultural sources. Dissolved oxygen deficiencies may limit desirable biological habitat, or result in taste and odor problems for public water supplies.

Water Characteristics and Lakes

Water is an invaluable substance with unique characteristics. It is less dense as a solid than as a liquid. While most substances contract when they solidify, water expands. When water is above 39^{o} Fahrenheit (4^{o} Celsius) it behaves like other liquids; it expands as it warms and contracts when it cools. Water starts to freeze when the temperature approaches 32^{o} Fahrenheit (0° Celsius). As the temperature reaches 32^{o} Fahrenheit the water molecules spread apart to lock into a crystalline lattice.

Ice forms and floats on top of a lake when the surface temperature in the lake reaches 32^{o} Fahrenheit. The ice becomes an insulating layer on the surface of the lake; it reduces heat loss from the water below and enables life to continue in the lake. When ice absorbs enough heat for its temperature to increase above 32^{o} Fahrenheit, crystalline lattice of ice is broken and water molecules slip closer together. If ice sank, lakes would be packed from the bottom up with ice, and many of them would not be able to thaw out in spring and summer, since the energy from the air and the sunlight does not penetrate very far.

Water's density increases to a maximum at 39.16^{o} Fahrenheit (3.98° Celsius). Therefore, in lakes, warmer waters are always found on top of cooler waters producing layers of water called strata. This is typical of a lake that is stratified during the summer. In winter, however, the density differences in water cause a reverse stratification where ice floats on top of warmer waters.

The thermal properties of lakes and the annual circulation event that results is the most influential factor on lake biology and chemistry. As surface water warms up in the spring, it becomes lighter than the cooler, denser water at the bottom. The lake becomes stratified as the surface water continues to warm and the density difference between the surface and bottom waters becomes too great for the wind energy to mix.

As the surface waters cool in the late summer and fall, the temperature difference between the layers are reduced, and mixing becomes easier. With the cooling of the surface, the mixing layer gradually extends downward until the entire water column is again mixed and homogeneous. The destratification process is referred to as fall turnover.

During winter, the lake may undergo stratification once again, this time with the colder, less dense water on the surface (or under the ice) with the warmer and denser water of 39^{o} Fahrenheit on the bottom. When the ice melts and the surface water begins to warm up, the density differences between depths are minimal and the lake again circulates creating spring turnover.

The development of summer stratification varies depending on several factors, including lake depth, wind exposure, and spring temperatures. The lakes in Illinois typically finish with spring turnover by early to mid May; however, to make sure spring turnover is complete in a specific lake, a temperature profile of the water column should be taken. (Marencik et al, 2010).

Eutrophication

Lakes are temporary features of a landscape. Over tens to many thousands of years, lake basins change in size and depth as a result of climate, movements in the earth's crust, shoreline erosion, and the accumulation of sediment. Eutrophication is the term used to describe this process.

Classical lake succession takes a lake through a series of trophic states. Oligotrophic lakes exhibit low plant nutrients keeping productivity low. The lake water contains oxygen at all depths and deep lakes can support cold water fish, like trout. The water in Oligotrophic lakes is clear. Mesotrophic lakes exhibit moderate plant productivity. The hypolimnion may lack oxygen in summer and only warm water fisheries are supported. Eutrophic lakes exhibit excess nutrients. Blue-green algae dominate during summer and algae scums are probable at times. The hypolimnion also lacks oxygen in summer and poor transparency is normal. Rooted macrophyte problems may be evident. These states normally progress in a linear fashion from oligotrophy to eutrophy. This progression corresponds to a gradual increase in lake productivity. Where this is not the case, it usually stems from cultural eutrophication. Finally, hypoeutrophic lakes exhibit algal scums during the summer, few macrophytes, and no oxygen in the hypolimnion. Fish kills are also possible in summer and under winter ice.

Some lakes are naturally eutrophic. They lie in naturally fertile watersheds and therefore have little chance of being anything other than eutrophic. Unless other factors, such as higher turbidity or an increase in the hydraulic flushing rate intervenes, these lakes will have naturally high rates of primary production.

It should be noted that the term "eutrophic" covers a wide variety of lake water quality and usability conditions. Eutrophic lakes can range from very desirable recreational and water supply lakes with excellent warm water fisheries, to lakes with undesirable aesthetics and water use limitations (generally considered hypereutrophic). The goal of Illinois Environmental Protection Agency's Lake Program is to protect, enhance, and restore the quality and usability of Illinois' lake ecosystems. This means preventing conditions where the water quality is degraded to the extent of producing nuisance algal blooms, an overabundance of aquatic plants, deteriorated fish populations, excessive sedimentation, and other problems which limit the lake's intended uses.

Tropic State Index

A lake's ability to support plant and animal life defines its level of productivity, or trophic state. The large amount of water quality data collected by the Volunteer Lake Monitoring Program can be complicated to evaluate. In order to analyze all of the data, it is helpful to use a trophic state index (TSI). A TSI condenses large amounts of water quality data into a single, numerical index. Different values of the index are assigned to different concentrations or values of water quality parameters.

The most widely used and accepted trophic state index was developed by Bob Carlson (1977) and is known as the Carlson TSI. Carlson found statistically significant relationships between summertime total phosphorus, chlorophyll a, and Secchi disk transparency for numerous lakes. He then developed a mathematical model to describe the relationships between these three parameters, the basis for the Carlson TSI. Using this, a TSI score can be generated by just one of the three measurements. Carlson TSI values range from 0 to 100. Each increase of 10 TSI points (10, 20, 30, etc.) represents a doubling in algal biomass. Data for one parameter can also be used to predict the value of another.

The Carlson TSI is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive), eutrophic (very productive), and hypereutrophic (extremely productive). The productivity of a lake can therefore be assessed with ease using the TSI score for one or more parameters (Figure 13). Mesotrophic lakes, for example, generally have a good balance between water quality and algae/fish production. Eutrophic lakes have less desirable water quality and an overabundance of algae or fish.

Some lakes are exceptions to the Carlson TSI model. The relationship between transparency, chlorophyll a, and total phosphorus can vary based on factors not observed in Carlson's study lakes. For instance, high concentrations of suspended sediments will cause a decrease in transparency from the predicted value based on total phosphorus and chlorophyll a concentrations. Heavy predation of algae by zooplankton will cause chlorophyll *a* values to decrease from the expected levels based on total phosphorus concentrations.

Carlson's TSI Equations	Where,
$TSI_{SD} = 60 - (4.15)(LN(SD))$	SD = Secchi depth transparency (m)
$TSI_{TP} = 4.15 + (14.42)(LN(TP))$	TP = total phosphorus concentration (ug/L)
$TSI_{CHL} = 30.6 + (9.81)(LN(CHL))$	CHL = chlorophyll a concentration (ug/L)

Trophic State	TSI	Secchi Depth (inches)	Total Phosphorus (mg/L)	Chlorophyll-*a* (mg/L)
Oligotrophic	Less than 40	Greater than 145	Less than 0.012	Less than 2.5
Mesotrophic	40 to 50	79 to 145	0.012 to 0.025	2.5 to 7.5
Eutrophic	50 to 70	18 to 79	0.025 to 0.100	7.5 to 55
Hypereutrophic	Greater than 70	Less than 18	Greater than 0.100	Greater than 55

A TSI based on average Secchi transparency for each lake is calculated to classify lakes according to their degree of eutrophication as evidenced by their ability to support plant growth. As originally derived by Carlson, each major division of the index (10, 20, 30, etc…) represents a theoretical doubling of plant productivity (algae biomass). However, for Illinois lakes, the TSI value also reflects sediment-related turbidity; therefore, the higher the TSI value, the greater impairment the lake likely exhibits from sediment-related turbidity and/or algal growth. Lakes with an average Secchi transparency less than 79 inches (a TSI greater than 50) are classified as eutrophic.

Volunteer Lake Monitoring Program History

Lakes are important resources that will continue to provide beneficial uses if protective measures are taken. In recognition of this need, the Illinois Environmental Protection Agency (IEPA) initiated the Volunteer Lake Monitoring Program (VLMP) in 1981. This program provides effective public education on lake ecology and management and facilitates local lake and watershed management activities. It also serves to supplement IEPA lake data collection efforts. The VLMP provides for a direct transfer of technical expertise from the state level to the local level and provides a valuable service from the local level back to the state.

Annually, 150 to 200 lakes are sampled by approximately 250 citizen volunteers. The volunteers are primarily lake shore residents, lake owners/managers, members of environmental groups, public water supply personnel, and citizens with interest in a particular lake.

The VLMP has been expanded may times since its inception in 1981. A first expansion included the addition of Water Quality Component in 1985. To participate in this component, selected volunteers are trained to collect water samples. These samples are shipped to the IEPA laboratory for analysis of total and volatile suspended solids (TSS and VSS), total phosphorus, nitrate-nitrite nitrogen and ammonia nitrogen. These water quality parameters are routinely measured by lake scientists to help determine the general health of a lake ecosystem.

In the spring of 1992, the VLMP expanded to include two new components, Zebra mussel (*Dreissina polymorpha*) sampling and dissolved oxygen and temperature measurements. Zebra mussel sample sites were located near public boat ramps or areas where invasion was likely to occur. Volunteers attached samplers to either an in-place buoy or dock allowing it to hang one foot below the water surface. Volunteers monitored the samplers once a month throughout the sampling season. In 1997 because of cost-effectiveness and potential knowledge derived from a VLMP monitoring effort on Zebra mussels, the program expanded to encompass all lakes participating in the VLMP. A second program expansion was established in 1992 to measure dissolve oxygen (DO) and water temperature.

In June 1995, the Illinois General Assembly passed Conservation 2000, a major natural resources protection bill. This bill provided funding to the IEPA to expand its lake management program activities. In 1996, a portion of the funding was used to initiate a Chlorophyll Monitoring Component for 50 VLMP lakes. Due to its success, the VLMP Chlorophyll Monitoring Component was expanded from 50 to 100 lakes the following year.

Components of the VLMP

Basic Monitoring "Secchi Transparency"

Citizens select a lake to monitor and are then trained to measure water clarity (transparency) using a Secchi disk. The Secchi disk was developed in 1865 by Professor P.A. Secchi for a Vatican-Financed Mediterranean oceanographic expedition. At the time, it was used to determine if a ship could safely pass over a reef without damaging its hull. It has since become a standard piece of equipment for lake scientists.

The modern Secchi disk consists of an eight-inch diameter weighted metal plate painted black and white in alternate quadrants attached to a calibrated rope or tape measure. The disk is lowered into the lake water and the depth at which it is no longer visible is noted. This measurement, call the Secchi disk transparency or Secchi depth, is used to document changes in the transparency of lake water. Typically, three sites are monitored in each lake two times per month from May through October.

Measurements taken with a Secchi disk indicate light penetration into a body of water. Certain factors such as, Microscopic plants and animals (algae and zooplankton), water color, and sediment (silt, clay, and organic matter) can interfere with light penetration and lessen the Secchi disk transparency. Generally, the euphotic (light) zone of the lake is from the surface to two and three times the Secchi depth. In this region of the lake there is enough light penetration to allow plants to survive and produce oxygen by photosynthesis. Lake water below the euphotic zone can be expected to have little or no dissolved oxygen during the summer if the lake is thermally stratified.

Analysis of Secchi disk transparencies provide an indication of the general water quality conditions of the lake, as well as the amount of usable habitat available for fish and other aquatic life. Secchi disk transparency is a quick and easy measurement which integrates many important features of a lake system.

The volunteer also records a series of field observations relating to other important environmental characteristics of the lake, such as water color, suspended algae and sediment, aquatic plants, and odor. Weather conditions on the day of sampling, as well as during the prior 48 hours, are recorded. Recent lake management activities or other factors which could impact the lake are also documented. Field observation data can reveal a great deal of information about a lake.

Combined with field observations, Secchi transparency readings provide an indication of the amount of usable habitat available for fish and other aquatic life, as well as general water quality conditions of the lake. Consistent monitoring and observations throughout the sampling season and over a period of years can help identify lake problems and causes, document water quality trends, and evaluate lake and watershed management strategies.

Aquatic Invasive Species

Aquatic invasive species (AIS) tracking has expanded over the years. AIS are freshwater organisms that spread or are introduced outside their native habitats and cause negative environmental and/or economic impacts. You also may hear AIS called aquatic "exotic," "nuisance," or "non-indigenous" species. Unfortunately, more than 85 AIS have been introduced into Illinois. The zebra mussel, Eurasian water milfoil, and silver carp are all examples of invaders that have impacted our state.

Aquatic invaders such as these have been introduced and spread through a variety of activities including those associated with recreational water users, backyard water gardeners, aquarium hobbyists, natural resource professionals, the baitfish industry, and commercial shipping. The Illinois VLMP is partnering with Illinois-Indiana Sea Grant, the Illinois Natural History Survey, and the Midwest Invasive Plant Network to monitor for and help prevent the spread of aquatic invasive species to Illinois lakes.

Some of the AIS on the IEPA's watch list include:

- **Mollusks:** Zebra mussel, Quagga mussel, New Zealand mudsnail, Asian clam
- **Crustaceans:** Rusty crayfish, Spiny water flea, Fishhook water flea, Bloody red shrimp
- **Fish:** Round goby, Bighead & Silver carp (Asian carps), Ruffe, White perch
- **Aquatic Plants:**
    - **Submersed (underwater) plants:** Eurasian water milfoil, Curlyleaf pondweed, Brazilian elodea (Brazilian waterweed), Hydrilla, Indian swampweed, Brittle waternymph (Brittle naiad)
    - **Free-floating plants:** European frogbit, Water hyacinth, Water lettuce
    - **Rooted, floating-leaved plants:** Pond water-starwort, Swamp stone crop, European waterclover, Yellow floating heart, Water chestnut
    - **Emergent (above water) plants:** Purple loosestrife, Flowering rush, Reed manna grass, Parrot feather

Identifying Pollutants

Major pollutants, like sediment, (which turns the water shades of brown or tan) and nutrients that act like fertilizers and promote the growth of aquatic plants and algae (which turn the water green, greenish-brown, blue-green or yellowish) can be detected via volunteer monitoring .

Seasonal differences in transparency are often apparent and can indicate the types and causes of problems in a lake. In the spring, the combination of heavy rainfall and lack of plant cover results in increased soil erosion; the suspended sediment may turn the lake a shade of brown. The more suspended sediment, the browner the water and the shallower the Secchi disk reading will be. Illinois lakes are often brown in the spring and green in the summer. However, the brown pattern may repeat itself with rainfall events throughout the year.

Deep lakes that have small amounts of incoming sediment from rainfall are generally clearer in the spring than shallow lakes. They may remain relatively clear throughout the year or they may exhibit algal blooms. Lakes with suspended sediment problems may show some improvement during the summer, when fewer storm events and the development of crop cover in agricultural watersheds generally results in less soil erosion. These lakes, as well as those that were relatively clear in the spring, may develop nuisance algal blooms during the summer if excessive nutrients are present.

Suspended Solids: TSS in the water column is composed of volatile and non-volatile fractions. VSS are organic in nature (plant and animal material), while non-volatile solids are generally inorganic (mineral, soil material) or organics resistant to volatilization at 500°C. Computing the percentages of TSS that are volatile or nonvolatile indicates whether turbidity is caused primarily by sediment or algae.

Suspended solids in many Illinois lakes result largely from nonpoint sources such as soil erosion from within a lake's watershed and shoreline areas, as well as algal blooms. In shallow lakes, significant suspended solids and turbidity may result from the resuspension of bottom materials from wind action, power boating, and activity of bottom-feeding fish, such as carp. Suspended solids reduce the transparency of water and the depth to which sunlight penetrates. Thus, they reduce the extent of the eutrophic zone and limit photosynthetic production of oxygen, and can thereby restrict the usable fish habitat in the lake.

Nutrients: Nitrogen and phosphorus are the primary nutrients that affect aquatic plant growth. Inorganic forms of nitrogen (nitrate+nitrite and ammonia) are used as nutrients by algae and other aquatic plants. Levels of inorganic compounds above 0.3 mg/L at spring turnover are known to contribute to nuisance algal blooms in summer (Sawyer, 1952).

Nitrate and Nitrite Nitrogen: Higher nitrate+nitrite values are often found in lakes in the Illinois, Sangamon, Kaskaskia and Wabash River basins (see river basin map, Figure 2) because of their typically large, highly agricultural watersheds. This is characteristic of central Illinois artificial impoundments with ditched and tiled agricultural watersheds. High nitrate concentrations are often detected in surface water following fertilizer application and after spring rains. Nitrates can also leach through the soil and into groundwater where they are discharged into spring-fed lakes.

High nitrate and nitrite concentrations are major public health considerations. The Illinois Pollution Control Board (IPCB) Public and Food Processing Water Supply standards require that nitrate concentrations not exceed 10 mg/L and nitrite not exceed 1 mg/L. Higher values are especially dangerous to infants less than six months old because of their susceptibility to methemoglobinemia, "*blue baby syndrome*."

Total Ammonia Nitrogen: Ammonia in fresh water can be extremely toxic to aquatic organisms, while at the same time it is a source of nutrients that promote plant growth. For “General Use” waters, the IPCB specifies that total ammonia nitrogen shall not exceed 15 mg/L, and un-ionized ammonia shall not exceed 0.04 mg/L. Ammonia nitrogen in aquatic systems usually occurs in high(er) concentrations only when dissolved oxygen is low or depleted.

Phosphorus: Phosphorus is an essential nutrient for plant and animal growth. It is a constituent of fertile soils, plants, and protoplasm. It also plays a vital role in energy transfer during cell metabolism. To restrict noxious growth of algae and other aquatic plants, the IPCB established a General Use standard of 0.05 mg/L for total phosphorus (TP) in any lake, or in any stream at the point where it enters a lake. Allum et al (1977) classified oligotrophic lakes as those with TP values below 0.01 mg/L and mesotrophic as those lakes with TP values between 0.01 and 0.02 mg/L. Eutrophic lakes have TP values greater than 0.02 mg/L.

Chlorophyll Monitoring

Chlorophyll: Chlorophyll is a pigment found in all green plants and is responsible for giving them their hue. It is also the chemical which allows plants to carry out photosynthesis (the process plants use to convert sunlight,

water and carbon dioxide to oxygen and energy or food). There are many different forms of chlorophyll. Algal chlorophyll is found as three different types. Chlorophyll a (found in algae), chlorophyll b (found in green algae and eulgenoids), and chlorophyll c (found in diatoms and golden brown algae). By taking a measured sample of lake water and extracting the chlorophyll from the algae cells contained in that sample, monitors can get a good indication of the density of the algal population. The density of the algae population will tell lake scientists if an algal bloom is likely to occur.

When blooms occur, deoxygenating of the water column can occur due to increased respiration of the algae during the night and on cloudy days. Additionally, when a bloom dies off, the decay process can increase the potential for deoxygenating of the lake in addition to causing taste and odor problems for public water supplies.

The chlorophyll sample is taken at twice the Secchi depth and is filtered by the volunteer. The water quality sample and the chlorophyll samples are then mailed to the IEPA's Springfield laboratory for analysis. All training, equipment, and analysis are free of charge to the volunteers.

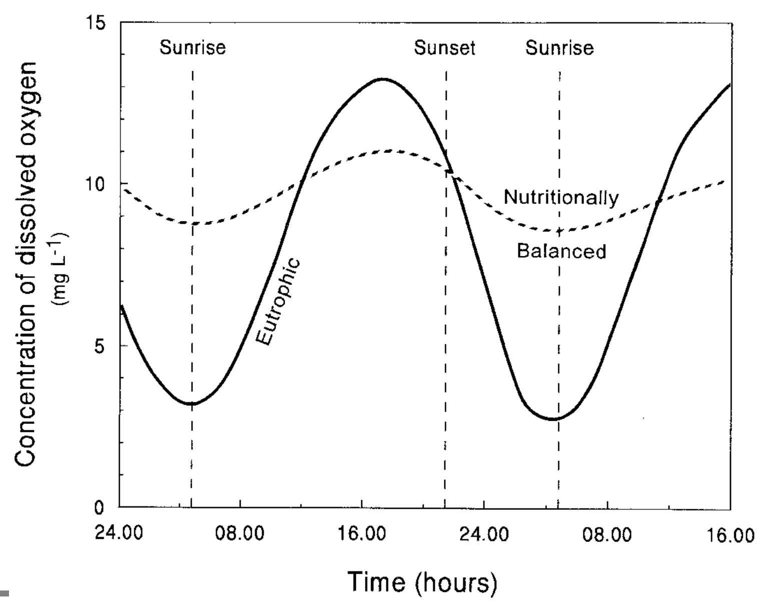
Dissolved Oxygen/Temperature

These two water quality measurements play important roles in the overall health of lakes. Most living organisms need oxygen to survive. So it is important to know how much and at what depth dissolved oxygen is available to these organisms. Low oxygen levels often occur during summer and winter stratification. During the summer in Illinois' stratified mesotrophic lakes, the top layer is warm, highly oxygenated water (epilimnion), while the bottom waters are very low in oxygen and much cooler (hypolimnion).

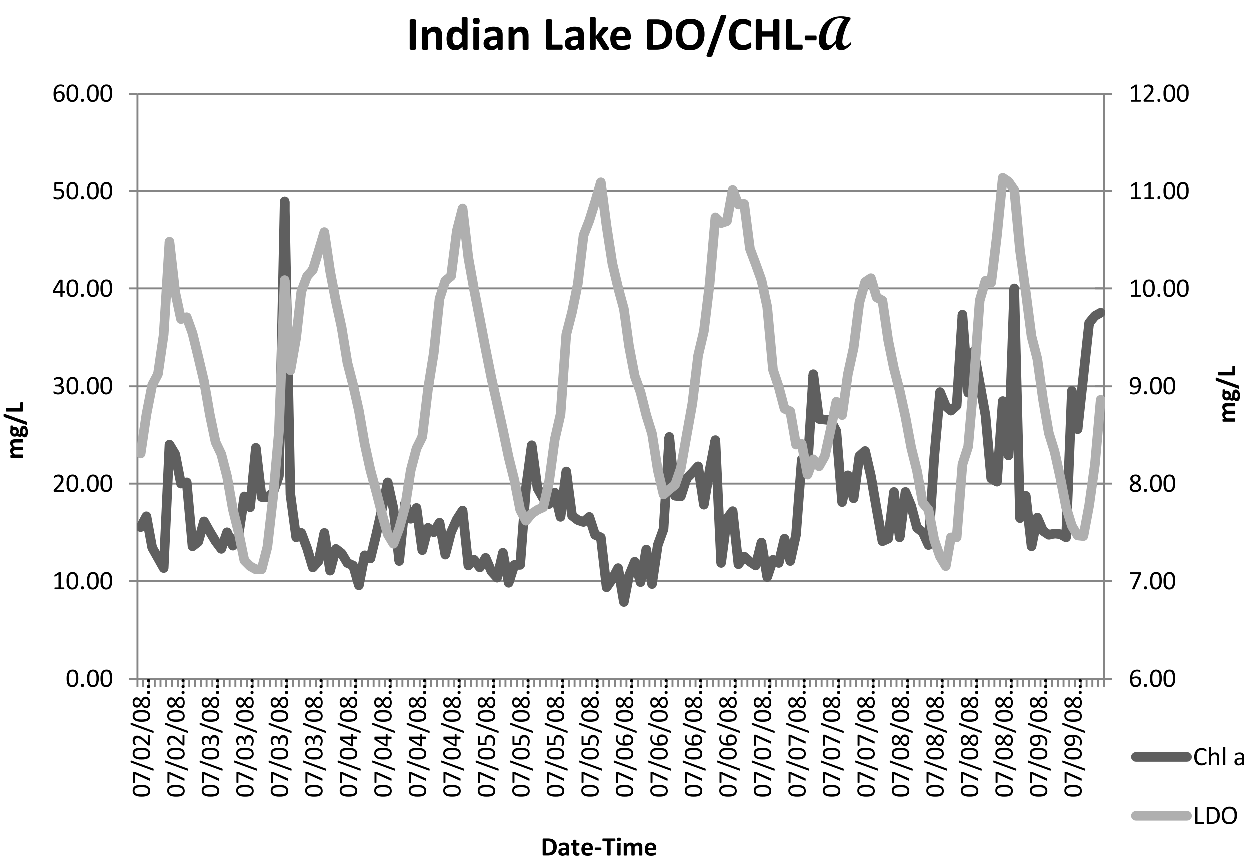
Oxygen can enter the water column in several ways. The most common are through photosynthesis of aquatic plants and algae, as well as through diffusion of oxygen entering the lake from the atmosphere. Oxygen can also enter the lake via water from inflowing tributaries.

The amount of oxygen that can be dissolved in water is determined by the water's temperature. Cooler water can hold more oxygen than warmer water. Often, the amount of oxygen in water is reported as percent saturation. During an algal bloom, the algae can put more oxygen into the water than the water can normally hold; this is called super-saturation. The percent saturation is calculated as a ratio of the lake's actual DO concentration and the maximum concentration possible under saturated conditions. During an algal bloom, the percent saturation may exceed 200 percent. Conversely, the mass dying of algae and/or macrophytes can cause a depletion of DO as organisms that use oxygen feed on dead material.

SUPER-SATURATION AND DEPLETION GRAPH (Wetzel 2001)
The graph depicts the dramatic difference between a nutritionally balanced lake and a eutrophic lake. Depending on fish species, dissolved oxygen dropping below a certain threshold may cause a "fish kill."



A study by John Kanzia, Environmental Quality Manager of the Chicago Zoological Society and Brookfield Zoo, plots the concentrations of dissolved oxygen and chlorophyll a over a period of eight (8) days in early July of 2008. This data was collected at Indian Lake of Cook County with a Hydrolab DS5X 44813.



DIURNAL CYLCE OF DISSOLVED OXYGEN AND CHLOROPHYLL a ON INDIAN LAKE, ILLINOIS (Kanzia 2008)

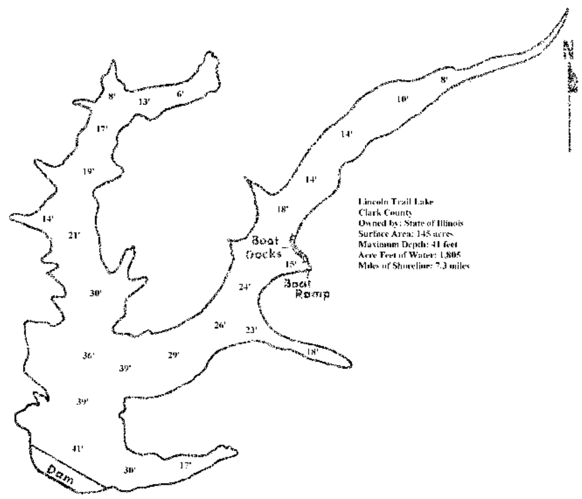
Temperature is indicative of water density and therefore drives the stratification process. By knowing the temperatures of the water at different depths, potential oxygen depletions can be predicted. During summer stratification, warm water is the least dense and is found near the surface. Cold water is denser (unless frozen) and is on the bottom. Between these two layers is the thermocline, an area of rapid temperature change. The thermocline acts as a barrier that does not allow mixing of oxygen from the epilimnion to the hypolimnion.

Methods and Procedures

Volunteer Recognition and Education

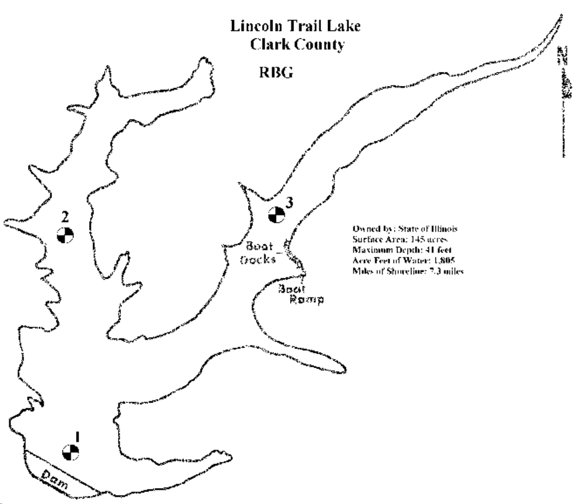
At the beginning of the season, new volunteers were presented cloth emblems to display on clothing highlighting their involvement in the VLMP. At the end of the sampling season, all volunteers who monitored four or more sampling periods were sent a Certificate of Appreciation.

As another way to honor volunteers each year, a session at the Illinois Lake Management Association's Annual Conference is designated as the Volunteer Lake Monitoring Program Session. Outstanding VLMP volunteers are presented with plaques and lapel pins to commemorate years of service. Session participants also receive information about other volunteer programs and an update on the VLMP for the upcoming sampling season. Volunteers also receive a VLMP newsletter. These newsletters contain reminders for the volunteers regarding VLMP, as well as educational information on lake conditions, management, and monitoring.



Training Volunteers

Training of new volunteers, "refresher" training for returning volunteers and expanded monitoring training was conducted by staff coordinators from IEPA's Lake Program, as well as from Regional Coordinators. In all cases, this training took place at the volunteer's lake. During the training sessions, the coordinator used the volunteer's boat to visit each sampling site, whereupon the volunteer was instructed in the proper sampling procedures.



Basic Monitoring Program

Volunteers typically take lake water transparency readings with a Secchi disk at three designated sites, generally twice a month from May 1 through October 31. The sites are chosen after a review of the lake's physical statistics including a bathymetric map, location and size of inlets and outlets, and any structures or features affecting the lake, such as, farms, residential properties, commercial or industrial properties and old dam or infrastructure with the confines of the lake bed. Site one is typically the deepest part of the lake. In impoundment lakes, that is most often near the dam.

Two or more additional sites are identified in the inlets (fingers) for the lake, in channels deep enough for volunteers to reach by boat. A site map is generated by the program personnel that includes the general site locations, Global Positioning System (GPS) coordinates (if available), and a unique site code identifying the lake.

Basic Monitoring Procedures

The volunteer proceeds to a site using a lake map. The order for monitoring the lake sites is not specific. Locations are located specifically by either using "sight lines" (aligning 2 sets of landmarks on shore) or by GPS coordinates. After reaching the monitoring site, the volunteer carefully lowers the anchor over the side of the boat until it reaches the lake bottom, letting out plenty of anchor line so that the boat drifts away from any sediment disturbed by the anchor.

The volunteer must remove any sunglasses, hat or object which may obstruct a clear view of the Secchi disk. The Secchi disk is then slowly lowered into the water until it can no longer be seen. At the point where the volunteer lose sight of the disk, the rope or survey tape is marked at the water level with a clothespin. The Secchi disk is then lowered about 1 to 2 more feet into the water, before slowly being raised towards the water surface. When the disk reappears, the line is again marked by pinching the rope or survey tape at the water level with the fingers. The rope/survey tape and Secchi disk are brought back into the boat, being careful not to release your "pinching" fingers. A loop is formed between the clothespin and the pinching fingers, sliding the clothespin to the center (the top) of the loop. This marks the average of the two transparency readings. The number of inches between the disk and the clothespin, to the closest inch, is recorded on the Secchi Monitoring Form, along with the time (in 24-hour format) that the measurement was taken.

Sometimes, the "true" Secchi disk transparency can't be measured because either: the disk reached the lake bottom and could still be seen or the disk was lost from view because it "disappeared" into dense growth of rooted aquatic plants. Sometimes moving a few feet will permit the Secchi disk to be observed through the aquatic plants, however, this situation cannot always be avoided. The Secchi Monitoring Form is annotated to reflect these two potential situations. Secchi disk transparency reading is recorded regardless of these situations.

Volunteer also record water color at each location. Determine the water color by lowering the Secchi disk (on the shaded side of the boat) to one-half (½) the Secchi transparency. Holding the Color Chart just above the surface of the water near one of the disk's white quadrants, compare the color of the white quadrant with the various colors on the standardized Color Chart, and record the corresponding number on the Secchi Monitoring Form. If no exact match exists, record the color number that is the closest match or a 20 to represent "other." If choosing other, please provide your observations in "Additional Observations." If the Secchi transparency was limited by either reaching the lake bed or plant growth, do not take a color reading (just place a dash or "n/a" for color on the Secchi Monitoring Form).

- *If collecting water samples, chlorophyll samples, and/or recording dissolved oxygen/temperature measurements at this site as part of the expanded program, stop here and proceed to the expanded program methods. When completed with the expanded program, return to finish the basic monitoring.*

To complete basic monitoring measure the site's total water depth by lowering the Secchi disk all the way to the bottom of the lake. Make sure the rope or survey tape is vertical before placing the clothespin on the rope/survey tape at the water level. Bring the Secchi disk back up into the boat. Determine the site's total depth and record this depth to the nearest half-foot. Alternately, a depth sounder may be used. Pull up your anchor line.

Before proceeding to the next site, indicate the relative amount of aquatic plants growing in the immediate vicinity of the monitoring site by circling the appropriate number (0-4) on the Secchi Monitoring Form. The scale is as follows:

0 = None: no floating-leaved aquatic plants (e.g., lily pads) or submersed (underwater) plants visible or pulled up with the Secchi disk or anchor.

1 = Minimal: only a very few floating-leaved plants or submersed plants visible (or if not visible, a couple/few plant strands might be pulled up with the anchor). Submersed plant growth may be well below the water surface and may or may not be visible as you look into the water.

2 = Slight: a small amount of floating-leaved plants and/or submerged plants visible (or if not visible, a clump of plants might be pulled up with the anchor). Submersed plant growth may be well below the water surface and may or may not be visible as you look into the water.

3 = Moderate: extensive but not complete coverage by floating-leaved and/or submersed plants. Submersed plants would be visible, growing close to the water surface. Boaters and/or swimmers could probably still use the area.

4 = Substantial: complete coverage of the water surface by floating-leaved plants and/or submersed plants that have grown to the water surface. Boaters and/or swimmers would have a difficult time using this area.

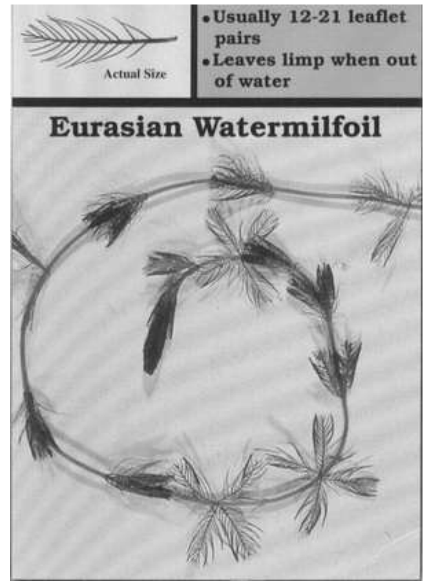
Repeat these sampling procedures for each monitoring site. If a search for AIS is conducted, it should be noted in the "Lake/Watershed Management" section of the Secchi Monitoring Form. More details about AIS monitoring are provided on the following pages. Indicate on the Secchi Monitoring Form that a AIS search is conducted; what areas of the lake are checked; what objects are inspected, if applicable, in those areas (e.g., multi-plate or concrete block sampler, dock posts, buoys, riprap, etc.); and whether or not any AIS at each of those locations were found.

Aquatic Invasive Species Tracking

All VLMP volunteers are requested to participate in the AIS monitoring effort. Provided in the Training Manual is a set of AIS "WATCH" cards that provide a photo, sketch, description, and identification tips for several invasive fish, mollusk, crustacean, and aquatic plant species. Also provided is a "New Aquatic Invasive Plants" identification sheet with photos and descriptions of several aquatic invasive plants, which have been documented in the Midwest. The participating volunteer reviews each WATCH card and the New Aquatic Invasive Plants sheet, and keeps an eye out for these and any aquatic invaders.

Eurasian Ruffe

If a volunteer finds—or suspects they have found—any aquatic invasive species, they make note of exactly where it was found, take photos and collect and preserve some specimens if possible, according to the tips provided for the various species in their manual. They then contact their Regional VLMP Coordinator or the Statewide VLMP Coordinator for further instructions about sending specimens for identification.



In addition, some volunteers set out and inspect zebra mussel samplers once a month, May through October. The samplers are hung from a float or dock one foot below the surface in an area of the lake most susceptible to zebra mussel attachment. Determine the presence of zebra mussel attachment by visual means as well as by lightly running fingers over the sampler surface, feeling for "crusty bumps" (an indication of very young mussels). Other known or observed exotic species can be checked off on the AIS section of the Secchi monitoring form or written into the appropriate section.

Expanded Monitoring Program

In addition to collecting the information for the Basic Program, volunteers involved in Tier II or III, special projects or involved in the Illinois Clean Lakes Program, collect water samples analyzed by the IEPA laboratory. These samples (consisting of a 1 L preserved bottle and a 1 L or 500 mL bottle) are collected once each month from May through October and analyzed for nutrients, suspended solids and chlorophyll. A nutrient and suspended solid sample is collected at one foot and (if selected) at two feet from the bottom. A chlorophyll sample is collected from the lake surface to twice the Secchi depth. Due to light penetration, this is the region of the lake where plant life is expected to be present. The volunteer then filters the cholorophyll sample and the filter is sent to the laboratory.

Preserved Sample: The preserved sample is analyzed for Ammonia, total Kjeldahl Nitrogen and total Phosphorus.

Sample (without preservative): The other sample is analyzed for TSS, VSS, total nitrite + nitrate Nitrogen, Chloride and alkalinity.

Chlorophyll Filter Sample: The chlorophyll filter samples are analyzed for chlorophyll-*a*, chlorophyll-*B*, chlorophyll-*c* and pheophytin.

General Sample Handling

As mentioned, the expanded monitoring program collects water samples once each month from May through October. During the same trip, a basic "secchi transparency monitoring" is also conducted. However, water chemistry and chlorophyll samples need to be collected on a Sunday, Monday, Tuesday, or Wednesday because there is a short holding time on the samples. Therefore, it is important to plan ahead so that the samples are properly chilled and shipped in a timely manner. Ship the samples the same day they are collected (if that is not possible, ship them no later than the next day). Wednesday is the last day during the week samples can be shipped to ensure the samples will arrive and are checked in at the laboratory before the following weekend.

To ensure that water samples arrive at the lab within the acceptable temperature range, it is critical that all sample bottles are kept in a cooler and surrounded by ice until it is time to pack and ship the samples. Add more ice to the cooler if needed after returning from a sampling trip. If not shipping the samples until the following day, keep the bottles upright and surrounded by ice in a cooler. The following day, pack with blue ice packs and ship. Ice packs must be fully frozen (in a freezer for at least 24 hours) and sample bottles remain surrounded by ice in a cooler for at least 1 hour in order to be fully chilled prior to packing and shipping.

If filtering water for chlorophyll analysis, freeze the foil-wrapped filter(s) in the provided plastic reclosing bag immediately after filtering. After securing each baggie containing a foil packet to a frozen ice pack using rubber bands, place the ice pack(s) with the attached baggie(s) into a freezer until you are ready to pack and ship them to the lab. If you do not have access to a freezer, sandwich the baggie(s) between two ice packs and keep the ice packs in a cooler and out of the sun.

Water Quality Sampling Procedures

Establish a “rinse” side and a “sample collection” side of the boat and do not collect samples near the anchor line. Rinse your hands and forearms briskly in the water on the “rinse” side of the boat opposite from where you will sample. Rinse the half-gallon water collection bottle on the “rinse” side of the boat by immersing the half-gallon bottle, with the cap on, into the water. Remove the cap while the bottle is under water using your other hand. While keeping this hand away from the bottle opening, allow the bottle to fill about half way. Replace the cap while the bottle is still under water. Bring the bottle out of the water, shake the contents, remove the cap, discard the water on the “rinse” side of the boat, and replace the cap.

Next, proceed to collect the water sample by moving to the “sample collection” side of the boat. Immerse the half-gallon bottle, with the cap on, down into the lake about 1 foot deep (up to your elbow) and remove the cap under water with your other hand, while keeping this hand away from the bottle opening and allow the bottle to fill completely. Replace the cap while the collection bottle is still under water before bringing the collection bottle up into the boat. Gently invert the half-gallon collection bottle a few times so that the water is well mixed. Remove the cap from the half gallon bottle and set it aside with its inside portion facing up.

Take the two sample bottles (1 preserved, 1 unpreserved) out of the cooler and keep the bottles upright. Taking the preserved bottle first, unscrew its cap and set the cap aside with its inside portion facing up. Be careful to keep the inside of the cap from getting contaminated. If the cap does get soiled, you can rinse the cap in the lake on the "rinse" side of the boat.

Slowly pour the water from the half-gallon collection bottle into the preserved sample bottle. Fill the sample bottle to just under its shoulder. Be careful not to overfill the preserved bottle, since it contains an acid preservative. Recap the preserved sample bottle tightly and gently rotate and invert the sample bottle to ensure the preservative is well-mixed with the sample water. Then follow the same procedure to fill the unpreserved sample bottle. Both the preserved and unpreserved sample bottles must be filled from the same half-gallon water collection.

If you overfill the preserved bottle, mark a big "X" across its label and set it aside for later disposal. Write the appropriate SAMPLE ID on a new preserved bottle. Pour out the lake water that's still in the half-gallon collection bottle on the "rinse" side of the boat, then resample as described above.

Immediately place the two sample bottles into a cooler with ice. Push the bottles into the ice so they are upright and surrounded by ice. Remember to close the lid, so sunlight cannot reach the samples. Discard any remaining water in the half-gallon collection bottle on the "rinse" side of the boat.

<u>Chlorophyll Sampling Procedures</u>

Check the water depth again using the handheld depth sounder. The chlorophyll sampling depth is twice the Secchi transparency, to the nearest foot, unless the lake is not deep enough at the monitoring site or if aquatic plants might interfere with sample collection. In these cases, the depth is reduced to 2 feet from the bottom of the lake or to a depth that does not touch plant growth. In all cases, collect the chlorophyll sample to the nearest foot. Also make sure to record the chlorophyll sample collection depth on the Secchi Monitoring Form and chlorophyll lab sheet.

To collect a chlorophyll water sample, take a close-pin and place it at the predetermined depth on the weighted bottle sampler. Place the half-gallon chlorophyll collection bottle into the weighted bottle sampler. Remove the bottle cap. Rinse the chlorophyll collection bottle by lowering the bottle and sampler a foot or two into the lake on the "rinse" side of the boat. If there is a surface scum, break it up by "bouncing" the weighted bottle sampler on the water surface a few times. Allow the bottle to fill about half way, pull the bottle back up, shake the contents, and discard the rinse water into the lake on the rinse side.

If your chlorophyll sampling depth is 12 feet or more, a special cap with a hole in the center is used. This special cap slows down the rate at which the bottle fills, allowing for a more precise sample. Move to the "sample collection" side of the boat. If there is a surface scum, break it up by "bouncing" the weighted bottle sampler on the water surface a few times. In one continuous motion, lower the bottle at a steady pace to the depth marked by the clothespin, then raise the bottle back up at a similar steady rate. Do not pause or stop during the process. It may be necessary to lower and raise the bottle more than once. Continue at a steady lowering/raising pace until the bottle is one-half (1/2) to two-thirds (2/3) full. If the collection bottle is completely (or even nearly completely) full after you pull it up, you must discard the water on the "rinse" side of the boat and start over. As you lower and raise the weighted bottle sampler, never let it touch the lake bottom or rub against aquatic plants. Bring the weighted bottle sampler into the boat. Place the solid cap on the half-gallon bottle and tighten, then remove the bottle from the sampler. Gently invert the half-gallon bottle several times to ensure the water is well mixed.

Take the foil-covered bottle out of the cooler, remove its cap, and set the cap aside with its inside facing up. Remove the half-gallon bottle's cap in the same manner. Slowly pour the water from the half-gallon bottle into the foil-covered bottle. Fill the foil-covered bottle to or near its shoulder. Be careful not to overfill the foil-covered sample bottle because it contains a powdered preservative (magnesium carbonate, $MgCO_3$) that can be washed out if the bottle is overfilled. If you overfill the foil-covered bottle, mark a big "X" on its side and set it aside for later disposal. Get out a new foil-covered bottle. Pour out any lake water still in the half-gallon collection bottle on the "rinse" side of the boat, then repeat collection procedures as mentioned above to refill the half-gallon collection bottle on the "sample collection" side of the boat. Recap the foil-covered bottle tightly and pull the extra foil up, around, and over the cap completely so that no sunlight can reach the bottle. Gently rotate and invert the foil-covered bottle several times to ensure the preservative is well mixed. Immediately place the foil-covered bottle into a cooler on ice. Close the lid of the cooler to ensure sunlight does not reach the sample. Discard any remaining water in the half-gallon collection bottle on the "rinse" side of the boat.

Chlorophyll Filtering Procedures

After you get back to shore you need to immediately filter your chlorophyll sample(s), preferably in your home, office, or a nearby building. If this is not feasible, pick a comfortable location that is in the shade and out of the wind. Make sure you have all your chlorophyll filtering equipment and supplies handy.

Attach the plastic tubing to the hand pump and to the spout on the plastic flask. Make sure to push the tubing over the two raised rings on the spout to make a tight seal. Using the wash bottle or under a faucet, rinse the lower portion of the magnetic filter funnel. Push the stopper end into the top of the plastic flask. Wetting the stopper first helps to make a tight seal. Do not touch the filter screen with your fingers. When inserting the stopper into the filter flask, push down on the stopper itself. Do not push down on top of the filter base because it could break. Using the tweezers, carefully remove one filter from the reclosing bag of filters. Place the filter exactly in the center of the black filter screen. Do not touch the filter or the filter screen with your fingers. You might need to squirt a small amount of fresh tap water onto the filter to ensure that the entire filter becomes moistened. If you need to move the filter slightly to center it on the screen, do so by gently and carefully using the tweezers to grip the edge of the filter and reposition it. If the filter tears, punctures, or creases, use a new filter. Rinse the tinted plastic funnel cup with fresh tap water. Carefully align the funnel cup on top of the filter base. Be sure that the filter does not move, and that the funnel cup doesn't come in contact with the middle area of the filter. Rinse the graduated cone with fresh tap water. Then take the chlorophyll sample bottle out of your cooler and mix the sample gently by turning it upside down several times. Fill the graduated cone with sample water exactly to the 500 ml mark.

To begin filtering, pour some of the water from the graduated cone into the funnel cup. Squeeze the hand pump to create a vacuum suction. Do not apply more than "15 inches" of vacuum pressure as measured on the outer scale of the pump's gauge. When the vacuum pressure reaches “10 inches” as read on the gauge’s outer scale, do not add too much more sample water to filter, if any. As the filtering slows, add smaller amounts of water. Filter all of the sample water that you pour into the funnel cup. If filtering really slows down, be patient and let the water drip through slowly, being careful not to exceed 15 inches of vacuum pressure. If the filter becomes fully clogged and any water left in the funnel cup cannot pass through, you will have to start the entire process over.

When you're done filtering the sample, use your squirt bottle and "wash down" the sides of the funnel cup with small amounts of water to wash down any algal cells adhering to the side of the vessel. Apply additional vacuum suction as needed to completely pull the "wash water" through the filter. Make note of volume filtered. When the vacuum suction has pulled all the wash water through and the filter looks relatively "dry," release the vacuum pressure by pulling on the hand pump’s trigger. Then carefully push the rubber stopper slightly off the flask to release any remaining vacuum seal. While holding onto the filter base with one hand, carefully lift the funnel cup off, up, and away from the filter base with the other hand.

Without removing the filter from the screen, use the tweezers to fold the filter in half so that the algae are on the inside. Use the "modified" paper clip to help hold the filter in place while you gently fold it. Again, do not touch the filter with your fingers and the tweezers and paper clip should never touch the algae covered portion of the filter. Using the tweezers, fold the filter in half again. Remove the filter from the filter screen with the tweezers. Place the filter on a piece of aluminum foil. Fold each edge of the aluminum foil around the filter to form a closed packet. Place in a labeled small sample bag and rubber-band the packet to an ice pack and place in the freezer or a cooler until shipping. The label is marked with sample identification and volume of filtered chlorophyll sample in milliliters.

Dissolved Oxygen/Temperature Profiles Procedures

Calibrate the dissolved oxygen/temperature meter. At each site location, turn on the DO/temperature meter. Ensure the cable is securely attached to the meter. Check the water depth again using the handheld depth sounder. Write in the required information at the top of the "Dissolved Oxygen/Temperature Profile" data form: unique station code, lake name and county, volunteer name(s), date (mm/dd/yyyy), time (hh:mm), meter brand/model (e.g., Hach HQ30d, Hydrolab Quanta, YSI 550A), IEPA case/meter #, barometer reading, and comments. Fill in each depth (in whole numbers) in the left column of the data form, down to 2 feet above the lake bottom The "0" and "1" foot depths have been pre-printed on the form.

Place the probe into the lake. Make sure the tip of the probe is under the water surface by immersing the probe to the top of the protective shroud's locking ring. (This is the "0" depth.) Press the "Read" button. When the display indicates a stabilized reading when the meter beeps and a padlock icon appears in the upper left corner of the screen. Record the displayed DO and temperature readings on the data form, rounding to the nearest tenth. The DO is displayed in mg/L (milligrams per liter), and the temperature is in °C (degrees Celsius).

Repeat reading and stabilizing after lowering the probe to the 1 foot depth, and then to every other foot thereafter, down to 2 feet above the lake bottom. After recording the final DO/temperature measurement at each monitoring site, turn off the meter to conserve battery power.

Data Handling

After collecting the Secchi depth and other information and entering that data into an Online Lakes Database, volunteers return the completed monitoring forms to the appropriate coordinator after each sampling trip, and the data is validated for accuracy in the database or entered into the data management system (if the volunteer does not have web access). This system serves to check in monitoring forms, enter Secchi and other qualitative data, track volunteer participation, produce graphical and tabular outputs and provide volunteers and the public with immediate access to current water quality information and historical trends on all volunteer monitored lakes.

Online Lakes Database address:

http://dataservices.epa.illinois.gov/waBowSurfaceWater

Data Evaluation

This section explains how the data collected by monitors is used to evaluate aquatic life conditions (ALC) and aesthetic quality conditions (AQC) in their lakes. Evaluations of these uses are based on water-body specific monitoring data believed to accurately represent existing conditions. The confidence level of the data is dependent on how well the monitors adhere to the VLMP training manual which is the Quality Assurance Project Plan (QAPP) for this program. Tier III equivalent monitors were audited by the coordinators in August or October to further raise the confidence level of their data. Monitoring data are used to assign an evaluation to the entire lake acreage as a single unit. The methodology for the evaluation of ALC and AQC is explained below.

This report determines a potential level of support of ALC and AQC for each lake which concludes one of three possible outcomes: Good, Fair or Poor. These outcomes are not pass-fail, but a mechanism for lake managers to focus potential resources towards balancing current and future activities towards attaining and setting goals. For Fair and Poor outcomes, examples of potential causes and sources for these lower classifications are given.

In general, evaluations that are based on data meeting IEPA's QA/QC requirements are considered having "Good" evaluation confidence and may be used by the Agency in the bi-annual report for lake assessments. The QA/QC difference between Tier II and Tier III is an audit conducted in August or October to ensure that field sampling is consistent with the field manual (VLMP Training Manual).

	Evaluation Use	Evaluation Type	Evaluation Confidence
Tier I	None	Physical	
Tier II	Aquatic Life Aesthetic Quality	Physical/Chemical	
Tier III	Aquatic Life Aesthetic Quality	Physical/Chemical	Good

Aquatic Life Conditions

ALC is the tool used for evaluating aquatic life conditions in lakes using:

- The TSI for Secchi depth (TSI^{SD}), Total Phosphorus (TSI^{TP}), and/or *Chlorophyll-a* (TSI^{CHL}),
- The average recorded percent macrophyte coverage during peak growing season of June, July and August, and
- The median concentration of nonvolatile suspended solids (NVSS); calculated by the subtraction of VSS values from the TSS values.

These three components are used to calculate ALC scores for each TSI. Higher ALC scores indicate potential increases in unfavorable conditions.

Evaluations of ALC are based on physical and chemical water quality data collected from the current year only. The physical and chemical data used include:

- Secchi disk transparency (meters),

- Total Phosphorus (ug/L) (epilimnetic samples only),
- *Chlorophyll-a* (ug/L),
- NVSS (mg/L) (epilimnetic samples only), and
- Percent surface area of macrophyte coverage.

Chemical data are collected five times, May, June, July, August and October, at site 1 for Tier II monitors and three sites for Tier III equivalent monitors. Physical data are collected 12 times, twice a month from May through October. Data goals for evaluations are:

- The three chemical data points over the summer months (June thru August) (NVSS and TP are not restricted to summer months) and
- The six physical data points over the summer months for physical data (June thru August).

Whole-lake TSI values are calculated for:

- Median Secchi disk transparency (SD) values using "=60-LN(meters SD)*14.4",
- Median TP values (epilemnetic sample only) using "=LN(ug/L TP)*14.4+4.15", and
- Median *chlorophyll-a* values using "=LN(ug/L *CHL-a*)*9.81+30.6"

Note: LN is the natural logarithm.

A minimum of two parameter-specific TSI values are needed for comparison to effectively evaluate ALC. Only Tier II and Tier III equivalent lakes collect chemical data making a complete evaluation possible. However, Tier I lakes can still compare their physical TSI^{SD} and percent macrophyte coverage to similar lakes to help develop potential goals.

Evaluation Factor	Weighting Criteria for ALC	Points
Trophic State Index	Less than 60	40
	60 to (but not equal to) 85	50
	85 to (but not equal to) 90	60
	90 or greater	70
Macrophyte Coverage	Less than 5	15
	5% to 25%	0
	26% to 50%	5
	51% to 70%	10
	Greater than 70%	15
NVSS Concentration	Less than 12	0
	12 to (but not equal to) 15	5
	15 to (but not equal to) 20	10
	20 or greater	15

Aquatic Life Conditions	Guidelines
Good	Total ALC points are less than 75
Fair	Total ALC points are greater than or equal to 75, but less than 95
Poor	Total ALC points are equal to 95 or greater

When an ALC is found to be less than "Good" in a particular lake, potential causes should be identified.

Potential Causes for Impaired Aquatic Life Conditions
Chemical
Chloride: Acute - 500 mg/L
Ammonia
Phosphorus (Total): Acute - 0.05 mg/L in lakes with 20 acres or greater
Oxygen, dissolved
pH: Acute - Less than 6.5 or greater than 9.0
Non-Chemical Causes
Alteration in stream-side or littoral vegetative covers
Alteration in wetland habitats
Fish kills
Non-native aquatic plants
Non-native fish, shellfish, or zooplankton

Aesthetic Quality Conditions

AQC is the tool used for evaluating aesthetic quality conditions in lakes. This measures the extent to which pleasure boating, canoeing, swimming and aesthetic enjoyment are attained using:

- The TSI for Secchi depth (TSI^{SD}), Total Phosphorus (TSI^{TP}), and/or *Chlorophyll-a* (TSI^{CHL}),
- The average recorded percent macrophyte coverage during peak growing season of June, July and August, and
- The median concentration of NVSS; calculated by the subtraction of VSS values from the TSS values.

These three components are used to calculate AQC scores for each TSI. Higher AQC scores indicate potential increases in unfavorable conditions.

Evaluations of AQC are based on physical and chemical water quality data collected from the current year only. The physical and chemical data used include:

- Secchi disk transparency (meters),
- Total Phosphorus (ug/L) (epilimnetic samples only),
- *Chlorophyll-a* (ug/L),
- NVSS (mg/L) (epilimnetic samples only), and
- Percent surface area of macrophyte coverage.

Chemical data are collected five times, May, June, July, August and October, at site 1 for Tier II monitors and three sites for Tier III equivalent monitors. Physical data are collected 12 times, twice a month from May through October. Data goals for evaluations are:

- The three chemical data points over the summer months (June thru August) (NVSS and TP are not restricted to summer months) and
- The six physical data points over the summer months for physical data (June thru August).

Whole-lake TSI values are calculated for:

- Median Secchi disk transparency (SD) values using "=60-LN(meters SD)*14.4",

- Median TP values (epilemnetic sample only) using "=LN(ug/L TP)*14.4+4.15", and
- Median *chlorophyll-a* values using "=LN(ug/L *CHL-a*)*9.81+30.6"

Note: LN is the natural logarithm.

A minimum of two parameter-specific TSI values are needed for comparison to effectively evaluate AQC. Only Tier II and Tier III equivalent lakes collect chemical data making a complete evaluation possible. However, Tier I lakes can still compare their physical TSI (TSI^{SD}) and percent macrophyte coverage to similar lakes to help develop potential goals.

Evaluation Factor	Weighting Criteria for AQC	Points
Trophic State Index	Actual TSI Value	Actual TSI Value
Macrophyte Coverage	Less than 5	0
	5% to 25%	7.5
	Greater than 25%	15
NVSS Concentration	Less than 3	0
	3 to (but not equal to) 7	5
	7 to (but not equal to) 15	10
	15 or greater	15

Aesthetic Quality Conditions	Guidelines
Good	Total AQC points are less than 60
Fair	Total AQC points are greater than or equal to 60, but less than 90
Poor	Total AQC points are equal to 90 or greater

When an ALC is found to be less than "Good" in a particular lake, potential causes should be identified.

Potential Causes for Impaired Aesthetic Quality Causes
Potential Cause
Sludge, Bottom Deposits, Floating Debris, Visible Oil, Odor,
Aquatic Algae, Aquatic Plants (Macrophytes), Color, Turbidity
Total Phosphorus: In lakes greater than 20 acres where macrophytes and algae growth are the cause, nutrients are considered a contributing cause.
Phosphorus (Total): Acute: 0.05 mg/L in lakes with 20 acres or greater

Identifying Potential Sources of Lake Use Reduction

Identifying potential sources related to the reduction in aquatic life conditions and aesthetic quality is essential in setting effective goals for lake managers. Information used to identify potential sources include Facility-Related Stream Survey data, ambient-monitoring data, effluent-monitoring data, facility discharge monitoring reports, review of National Pollutant Discharge Elimination System permits and compliance records, land use data, personal observations, and documented site-specific knowledge. The last two are what lake managers primarily rely. The table below is an excerpt from the IEPA's bi-annual report used to help identify sources. See Table 14 for a list of potential sources.

Other Data

Nitrogen

Nitrogen, like phosphorus, is an important nutrient for macrophyte and algae growth in lakes. The amount of nitrogen in lake water depends on the local land use and may enter a lake from surface runoff or groundwater sources. It should be noted that nitrogen compounds often exceed 0.5 mg/L in rainfall (Shaw, Mechenich & Klessig 2004).

Lake water nitrogen exists primarily in three categories analyzed through this program; nitrate (NO_3^-) plus nitrite (NO_2^-), ammonium (NH_4^+), and Kjeldahl nitrogen (TKN). Total nitrogen (TN) is calculated by adding nitrate and nitrite to TKN. Organic nitrogen is often referred to as biomass nitrogen and can be back calculated by subtracting ammonium from TKN.

All inorganic forms of nitrogen (NO_3^-, NO_2^- and NH_4^+) can be used by aquatic plants and algae. If these inorganic forms of nitrogen exceed 0.3 mg/L (as N) in spring, there is sufficient nitrogen to support summer algae blooms. (Shaw, Mechenich & Klessig 2004). In the absence or low levels of inorganic forms of nitrogen, nuisance blue-green algae blooms can occur. The blue-green algae can use the atmospheric nitrogen gas (N_2).

Nitrogen:Phosphorus (N:P) Ratio	Algae Growth Limiting Factor	Descriptions
Less than 10:1	Nitrogen limited	Nitrogen limits most algae growth; blue-green algae more likely present
10:1 to 15:1	Transitional	A variety of situations may arise depending on actual nitrogen and phosphorus concentrations. Other factors may be predominant in limiting algae growth; such as available sunlight.
Greater than 15:1	Phosphorus limited	Phosphorus limits algae growth

Chlorides

The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution. Sources of chloride include septic systems, animal waste, potash fertilizer (potassium chloride), and drainage from road-salting chemicals. Since lakes vary in their natural chloride content, it is important to have background data or a long term database to document changes.

Alkalinity

Alkalinity is used to determine how resistant a lake is to any change in pH. For example, making the lake less sensitive to acid rain, as the bicarbonate$^-$ and carbonate$^=$ ions neutralize the acid's hydronium$^+$ ions. This buffering capacity is described by Taylor 1984 using four categories of sensitivity. The Agency reports Alkalinity values in mg/L.

Sensitivity to Acid Rain	Alkalinity Value (mg/L $CaCO_3$)
High	0-0.002
Moderate	0.002-0.010
Low	0.010-0.025
Non-sensitive (well buffered)	Greater than 0.025

Color

The concentration of natural, dissolved, humic acids in lake water directly affects the Secchi transparency depth because of the color produced. Natural dissolved organic acids such as tannins and lignin's give the water a tea color. These acids leach from vegetation in the lake watershed.

Color is measured in Standard Platinum Units (SPU). Lakes with color levels greater than 25-30 SPU are considered to be colored. Increased color may indicate elevated levels of phosphorus, or the source of the color may also be contributing to the levels of phosphorus. This does not mean the lakes are more productive, the color simply interferes with the test so better transparency results cannot be achieved. Color varies from 1 to 630. When lakes are highly colored, the best indicator of algal growth is chlorophyll-*a*.

Excerpt from Wetsell 2001; Limnology: Lake and River Ecosystems, 3rd edition.

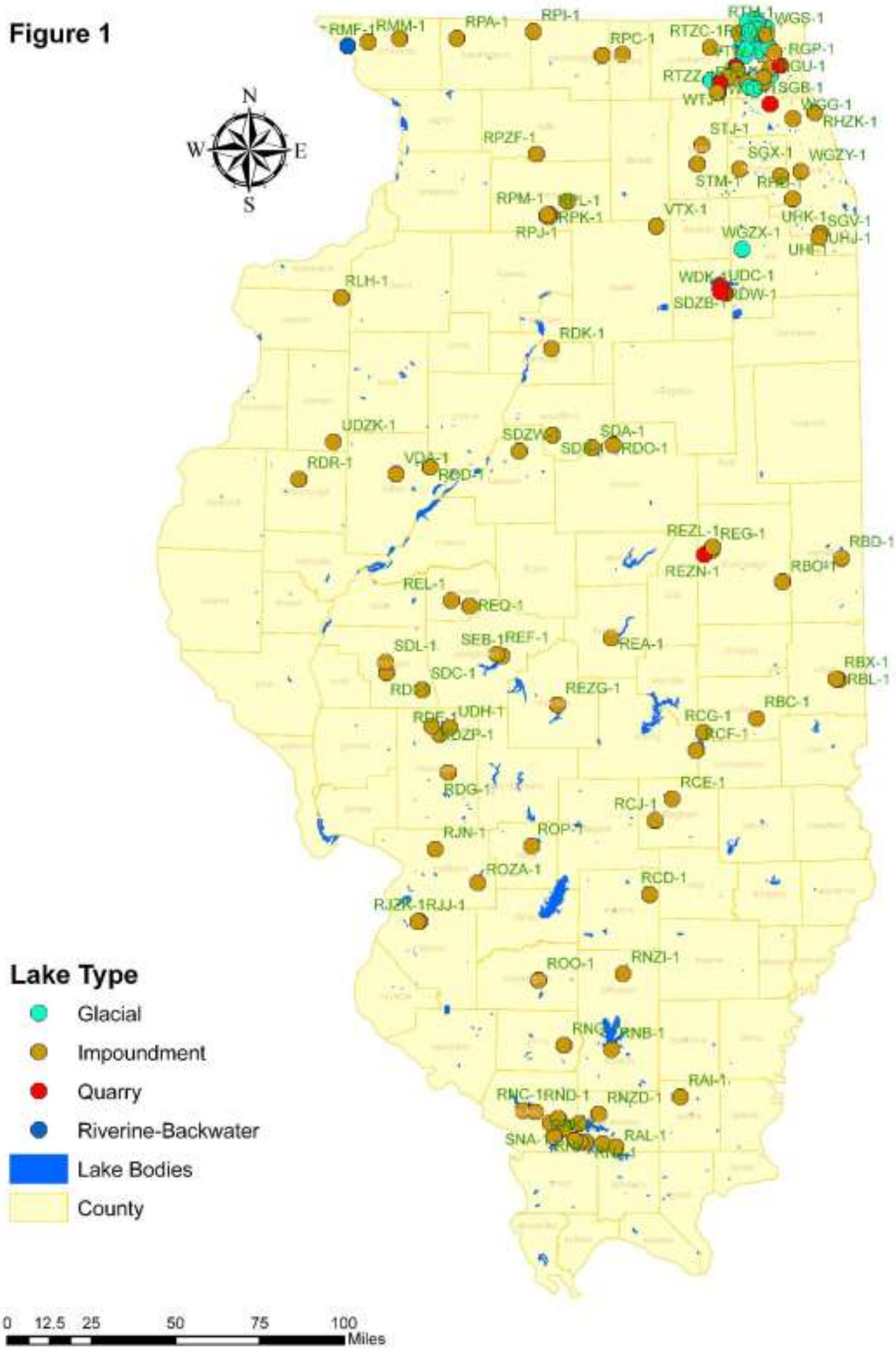
Any color always has two decisive characteristics: color intensity and light intensity. This duality in color intervals results in an extremely subjective ability to discriminate colors. Moreover, visual memory is very poor in comparison with auditory memory. Therefore, the psychophysical nature of reactions of visual organs to light and color has led to several attempts to standardize observations by means of various color scales.

Several color scales have been devised to empirically compare the true color of lake water, after filtration to remove suspensoids, to various combinations of inorganic compounds in serial dilutions. Platinum units* is the most widely used comparative scale in the United States. Very clear water would yield a value of 0 Pt units, and heavily stained bog water about 300. In Europe, the Forel-Ule color scale, involving comparisons to alkaline solutions of cupric sulfate, potassium chromate, and cobaltus sulfate, is commonly used. A strong correlation exists between the brown organic color, which is derived chiefly from decomposing plant detritus, and the amount of dissolved organic carbon in the surface waters. Frequently, color units increase with depth in strongly stratified lakes; this is most likely related to increased concentrations of dissolved organic matter and ferric compounds near the sediments. The subjectivity of color evaluations can be reduced greatly by optical analyses and comparisons with standardized chromaticity coordinates.

*1000 Pt units equal the color from 2.492 g potassium hexachloroplatinate, 2 g cobaltic chloride hexahydrate, 200 ml concentrated hydrochloric acid and 800 ml water. The color units of filtered water are best examined spectrophotometrically at 410 nm, calibrated against Pt-Co reference solutions.

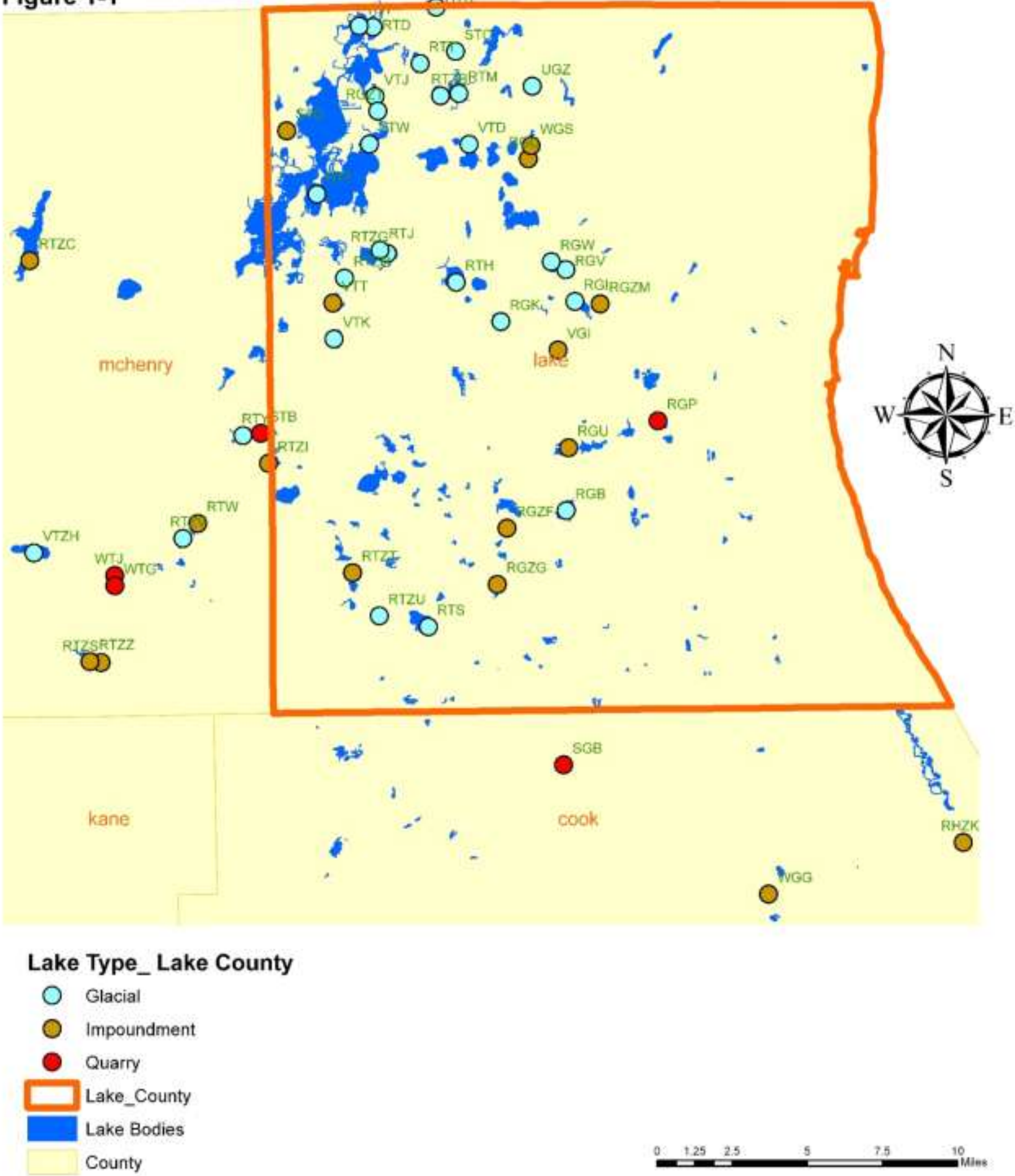
2011 VLMP Lakes

Figure 1



2011 VLMP Lakes. Lake County. LCHD

Figure 1-1



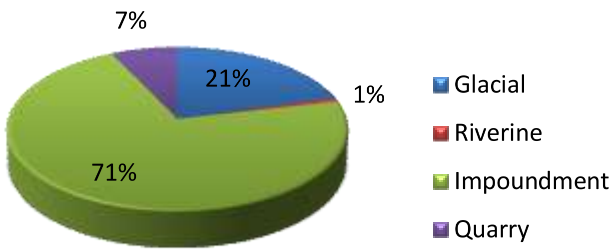
Results and Discussion

Basic Monitoring Program

Lakes

168 lakes were registered with 140 sampled at least once in 2011. These lakes are distributed across the state with clusters occurring in several areas (See Figure 1). Types of lakes in the program included glacial, riverine (backwater, oxbow), impoundment (dammed, dug), and old quarries (coal, sand, gravel, burrow). The size of the lakes in the program varied greatly, from the 18,000 acre Rend Lake of Franklin County to the 3 acre Pine Lake of Lee County. Volunteers covered 63,620 acres of lake surface water. The public's access to these lakes turned out to be around 58%. The private access ranged from single owner to multiple homeowner housing developments, even forest preserve lakes with limited access. The maximum depth of these lakes ranged from 5 feet at Black Oak in Lee County to 90 feet at Devil's Kitchen in Williamson County.

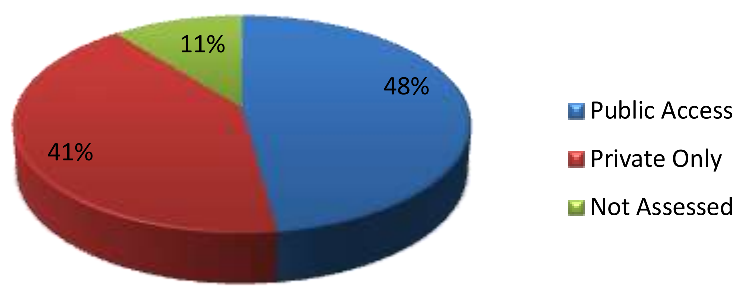
Figure 2: Lake Types



Volunteers

334 volunteers participated in the monitoring of 140 of the 168 registered lakes during 2011. These 334 monitors donated over 2,100 volunteer-hours of their time for 1,264 monitoring events. Volunteers are primarily lakeshore residents, lake owner/managers, sportspersons, members of environmental groups, public water supply personnel, and interested citizens.

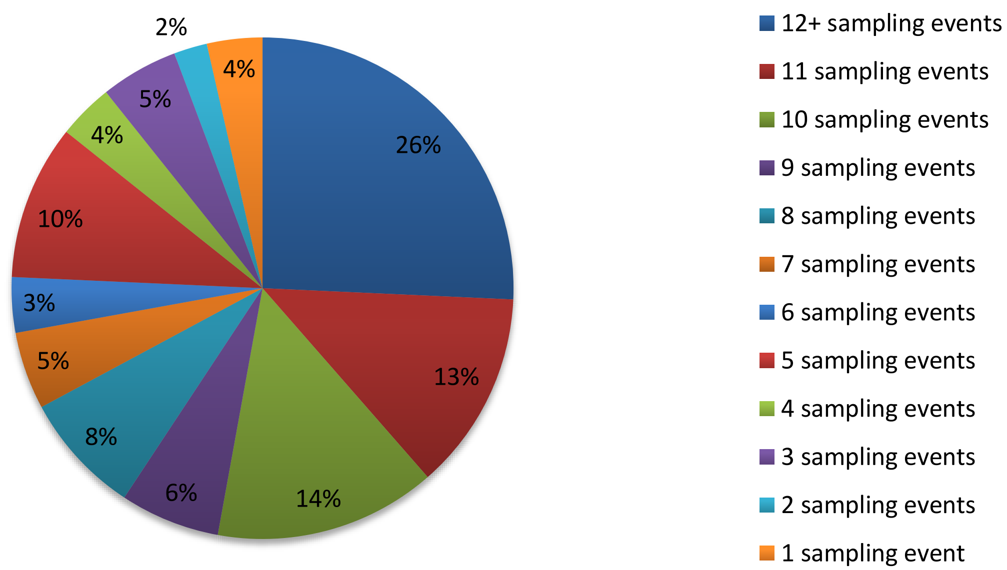
Figure 3: Lake Access



Data Returns

36 lakes had a 100% data return (sampled during all 12 monitoring periods). 46 lakes had 9 to 11 data returns, 22 had 6 to 8 data returns and 27 had 3 to 5 data returns (See Table 1: Volunteer Participation).

Figure 4: 2011 Volunteer Participation



The following 36 lakes were sampled all 12 periods:

Lake Name/County Name	Lake Name/County Name	Lake Name/County Name
Antioch/Lake	Fischer/Lake	Sanctuary Pond/Dupage
Barrington/Lake	Indian/Cook	Sara/Effingham
Bass/Lee	Island/Lake	Silver/McHenry
Bertinetti/Christian	Kincaid/Jackson	Spring/Lake
Catherine/Lake	La Fox Pond/Kane	Spring Arbor/Jackson
Cedar/Jackson	Little Grassy/Williamson	Sunset/Lee
Charles/DuPage	Little Silver/Lake	Sylvan/Lake
Channel/Lake	Loch Lomond/Lake	Third/Lake
Civic/Grundy	Miller/Jefferson	Valley/Lake
Crab Orchard/Williamson	Murphysboro/Jackson	Vermilion/Vermilion
Crystal/McHenry	Petersburg/Menard	Virginia/Cook
Deep/Lake	Richardson Wildlife/Lee	Woodhaven/Lee

Transparency Ranking

Each lake was assigned a trophic class based on a "whole-lake" median from the Secchi transparencies during the summer months of June, July and August, 2011 (Figure 5 and Table 2). Deep Lake in Lake County had the greatest transparency with a median value of 182 inches among glacial lakes. Civic Lake in Gundy County had the greatest average transparency with a median value of 425 inches among quarry lakes. Leopold in Lake County had the greatest median transparency with a value of 109 inches among impoundment lakes. The lowest median transparency goes to the only riverine backwater lake, Fish Trap of Jo Daviess County. Civic Lake also had the highest single transparency reading of 528 inches (44 ft). 137 TSI^{SD}'s were calculated from the median Secchi depths and are summarized in Table 4: Trophic State Indexes.

Figure 5: 2011 Transparency Comparison

Oligotrophic (145+), Mesotrophic (79-145), Eutrophic (18-79), Hypereutrophic (<18)

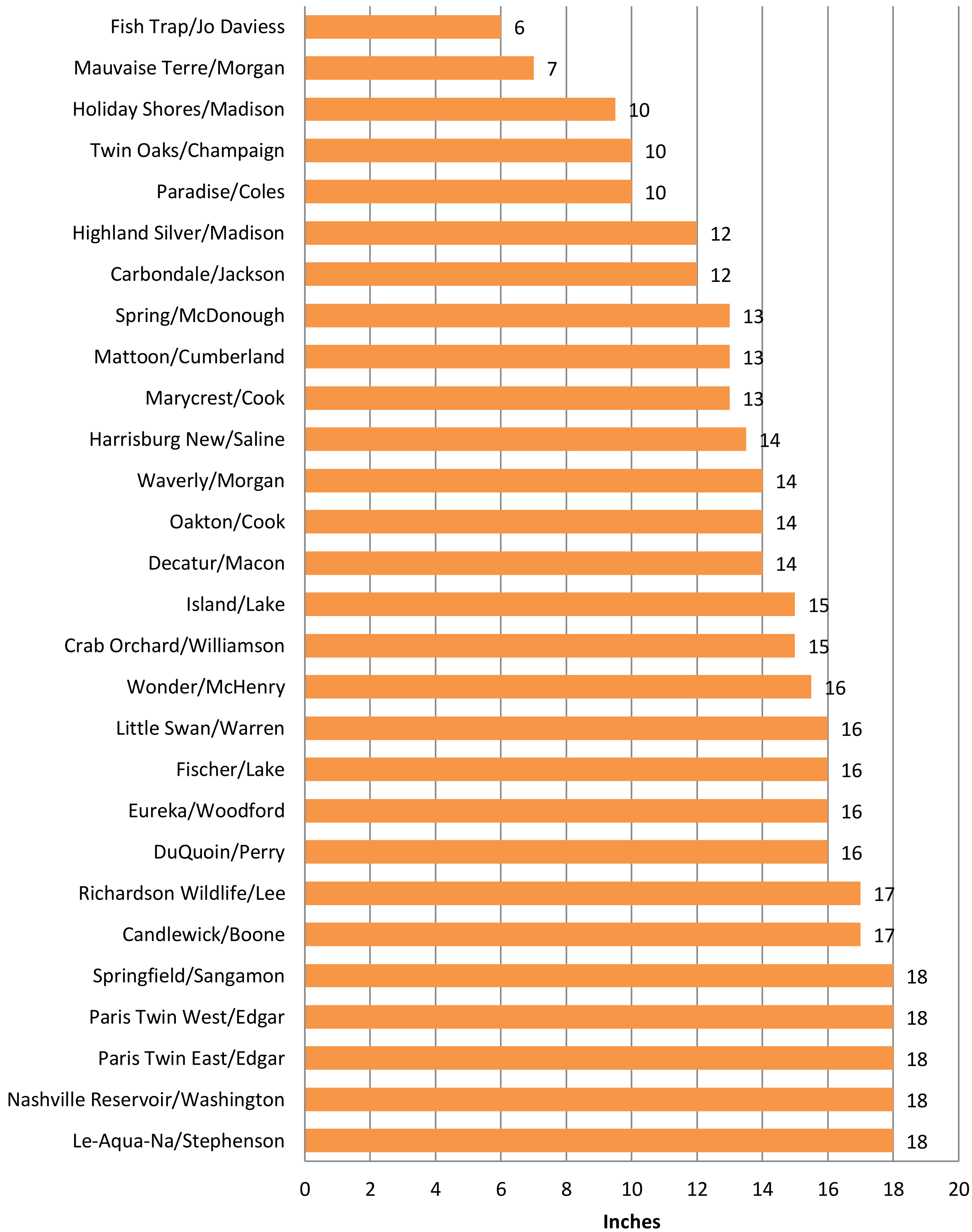


Figure 5: 2011 Transparency Comparison, Cont'

Oligotrophic (145+), Mesotrophic (79-145), Eutrophic (18-79), Hypereutrophic (<18)

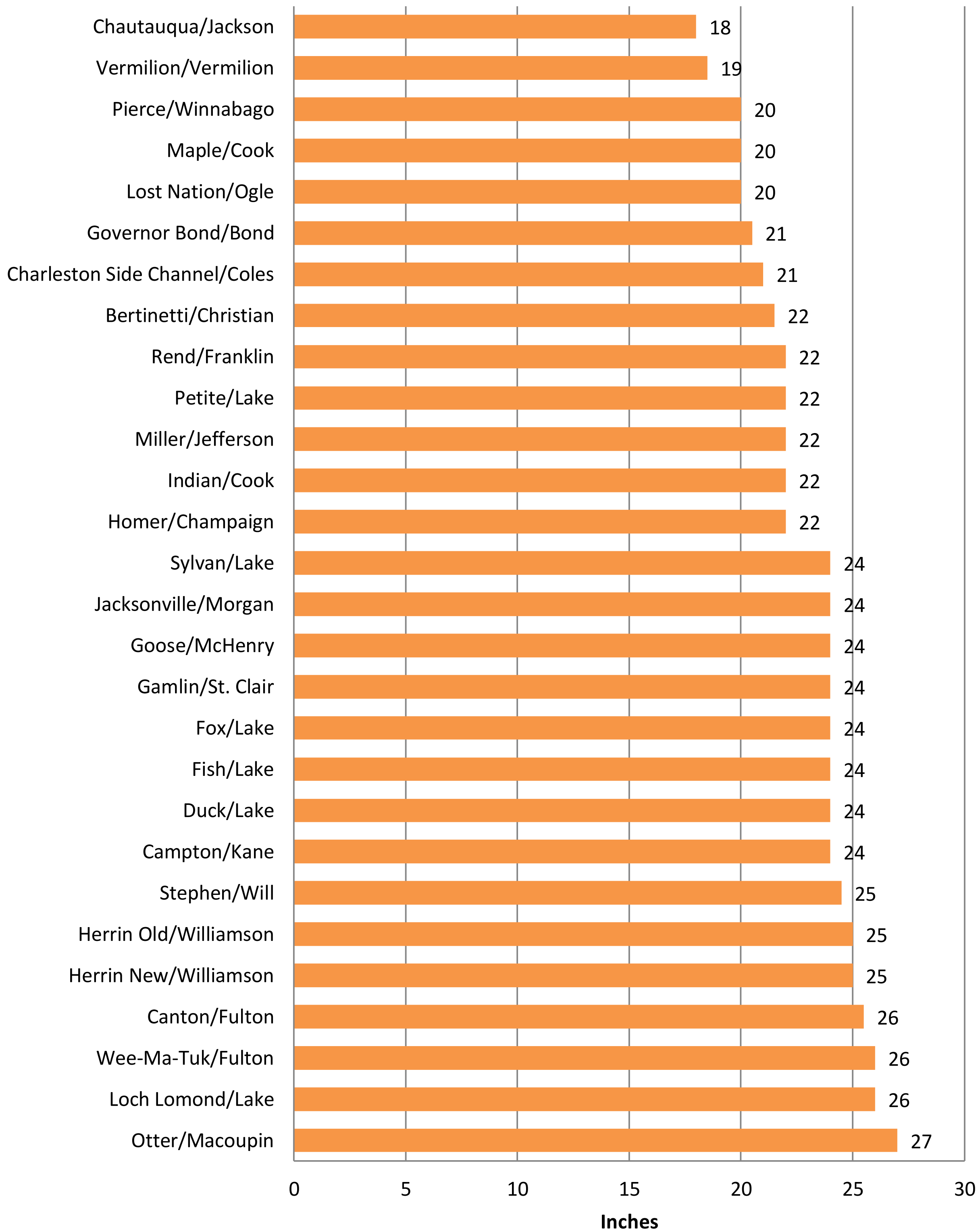
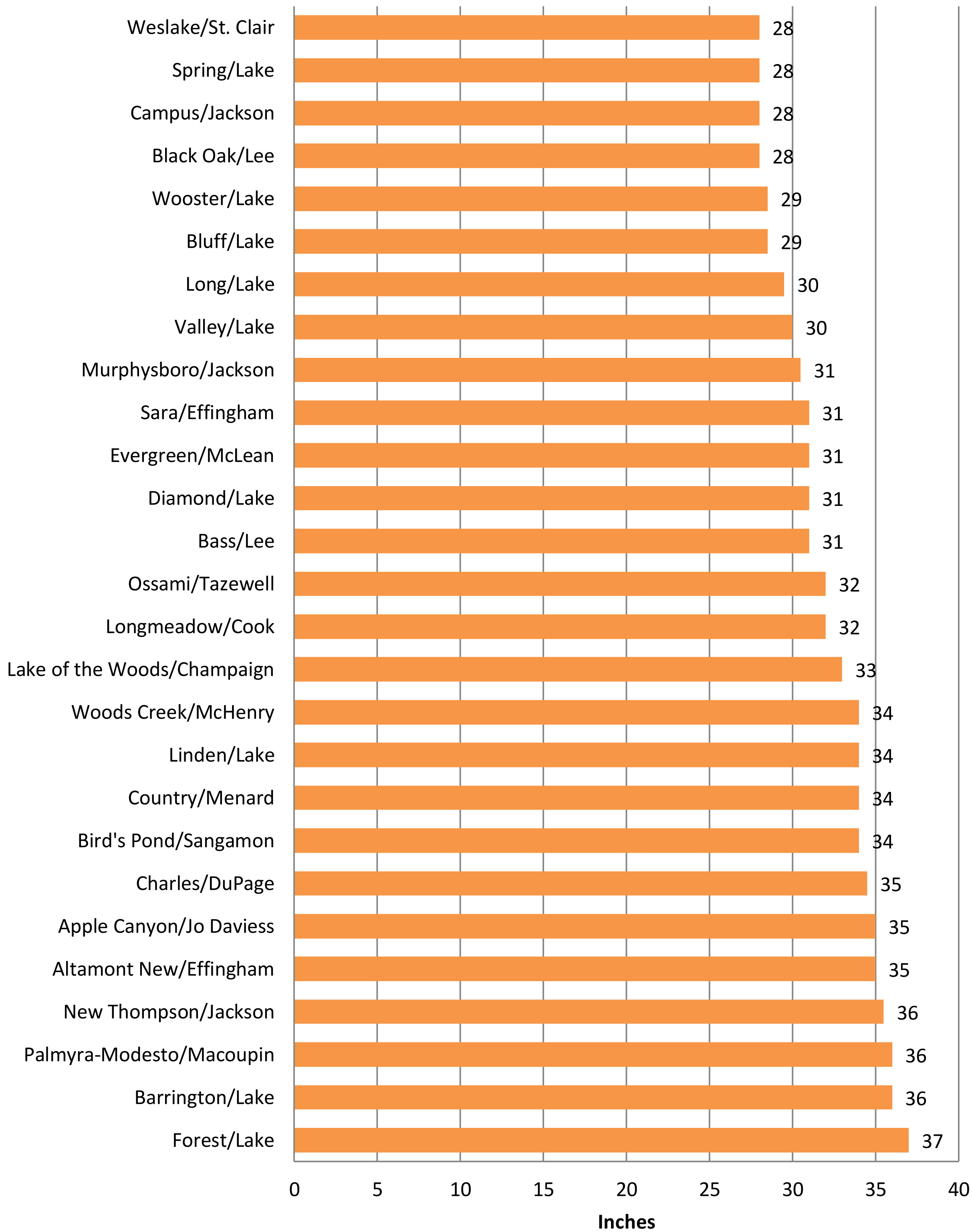


Figure 5: 2011 Transparency Comparison, Cont'

Oligotrophic (145+), Mesotrophic (79-145), Eutrophic (18-79), Hypereutrophic (<18)



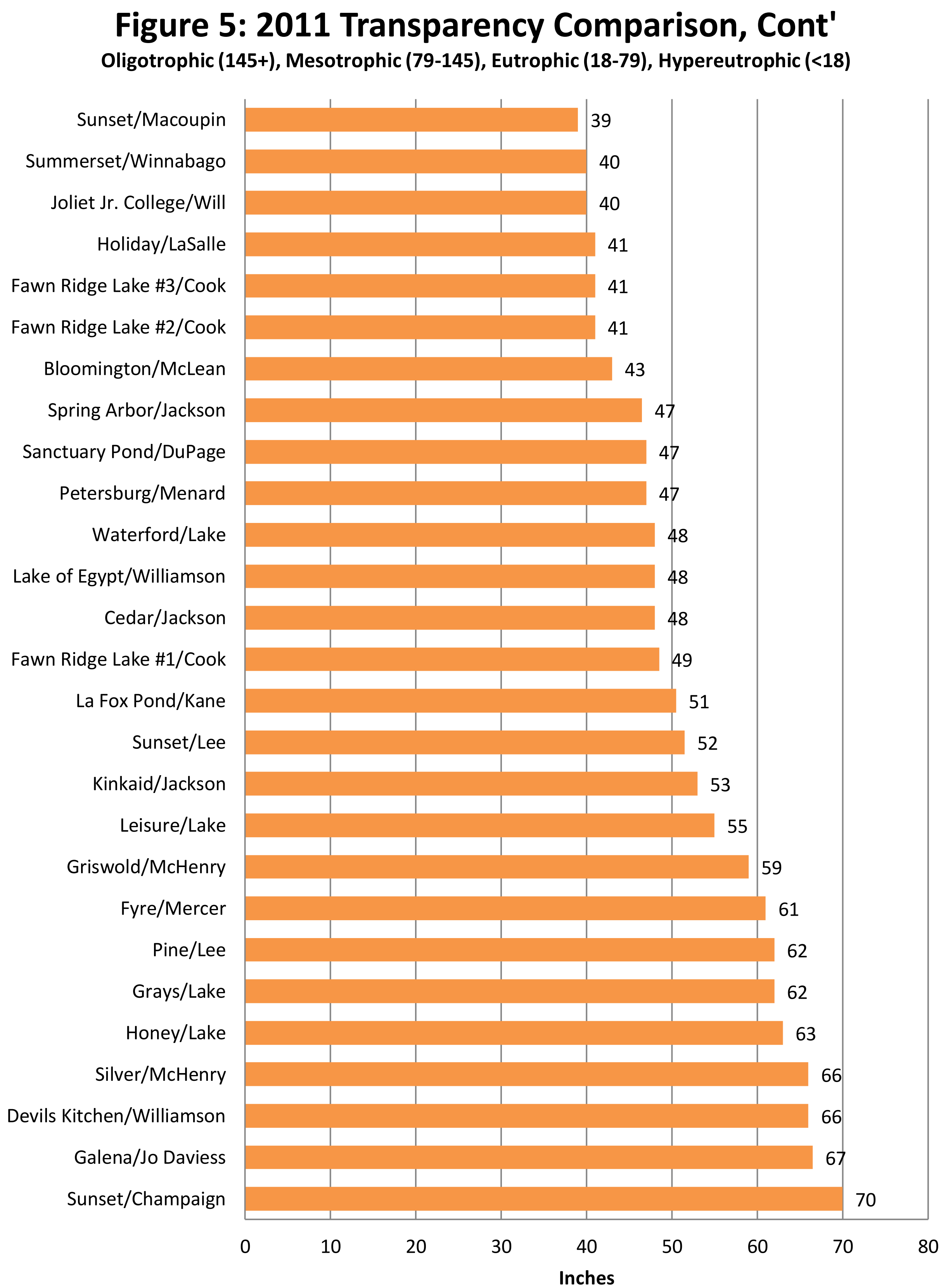
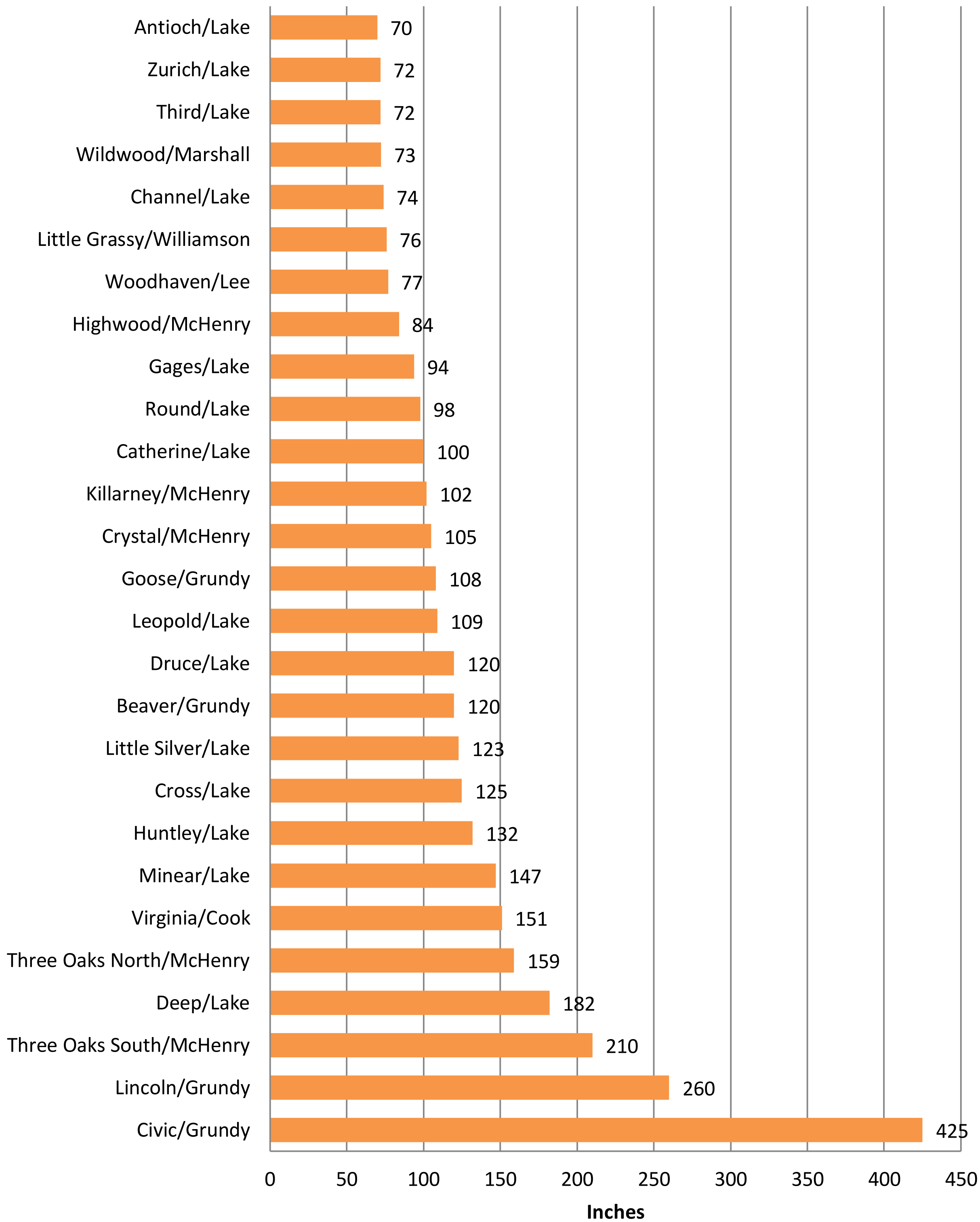


Figure 5: 2011 Transparency Comparison, Cont'
Oligotrophic (145+), Mesotrophic (79-145), Eutrophic (18-79), Hypereutrophic (<18)
Sunset/Macoupin
39
Summerset/Winnabago
40
Joliet Jr. College/Will
40
Holiday/LaSalle
41
Fawn Ridge Lake #3/Cook
41
Fawn Ridge Lake #2/Cook
41
Bloomington/McLean
43
Spring Arbor/Jackson
47
Sanctuary Pond/DuPage
47
Petersburg/Menard
47
Waterford/Lake
48
Lake of Egypt/Williamson
48
Cedar/Jackson
48
Fawn Ridge Lake #1/Cook
49
La Fox Pond/Kane
51
Sunset/Lee
52
Kinkaid/Jackson
53
Leisure/Lake
55
Griswold/McHenry
59
Fyre/Mercer
61
Pine/Lee
62
Grays/Lake
62
Honey/Lake
63
Silver/McHenry
66
Devils Kitchen/Williamson
66
Galena/Jo Daviess
67
Sunset/Champaign
70
0
10
20
30
40
50
60
70
80
Inches

Figure 5: 2011 Transparency Comparison, Cont'

Oligotrophic (145+), Mesotrophic (79-145), Eutrophic (18-79), Hypereutrophic (<18)



Transparency Variability

Average transparency data for all the years a lake has been monitored is available online at http://dataservices.epa.illinois.gov/waBowSurfaceWater. The collection of annual average Secchi transparencies helps establish a "trend" for that lake. A trend is a way to describe the pattern of data over a certain time period. Increasing, decreasing and fluctuating are all terms used to describe the Secchi transparency trend for a particular lake.

Trends based on lake median should be interpreted with caution. A lake's median transparency for a particular year can be affected by a number of factors, such as:

1. Variations in meteorological conditions and precipitation patterns,
2. Water depths,
3. Variations in the timing and frequency of monitoring,
4. Variations in monitoring techniques and perceptions by different volunteers,
5. Exact location of sampling sites, and
6. Growth of aquatic plants that can inhibit the depth to which the Secchi disk can physically be lowered.

A technical analysis of lake trends should always consider these types of potential sampling errors and variability. Factors such as the minimum and maximum transparencies for each year, seasonal patterns in transparency, effects of a particular storm event or management practice on transparency, and many other factors also should be examined when interpreting Secchi transparency trends. Hence, it is apparent that the most reliable data means are those derived from consistent and frequent monitoring throughout the season and over a period of years.

<u>% Macrophyte Results</u>

Volunteers make an estimate of the % coverage of macrophytes (aquatic plants) on a lake. Each range is given a weighted point value in regards to whether that coverage range is good (0 points) to poor (15 points) for "Aquatic Life conditions" and "Aesthetic Quality conditions." See Table 3: Macrophyte Coverage Totals.

Aquatic Life conditions Weighting Criteria	Points	Aesthetic Quality conditions Weighting Criteria	Points
Less than 5%	15	Less Than 5%	0
5% to 25%	0	5% to 25%	7.5
26% to 50%	5	26% to 50%	15
51% to 70%	10	51% to 70%	15
Greater Than 70%	15	Greater Than 70%	15

Expanded Monitoring Programs

Water Quality Monitoring

In 2011, volunteers at 61 lakes collected water samples from one foot below the lake water surface that were analyzed by IEPA laboratories for alkalinity, chlorides, TSS, VSS, ammonia, nitrate+nitrite, TKN and TP. Water quality data are summarized in tables, see Appendix D.

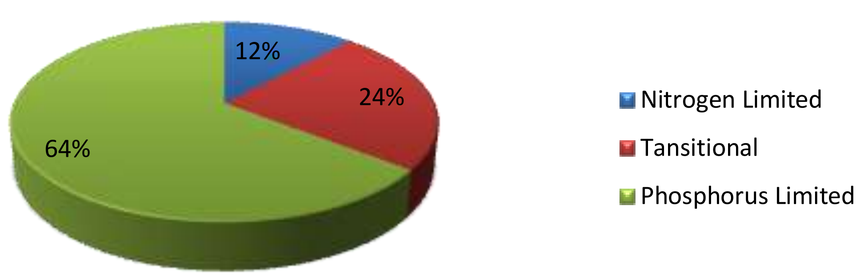
Total Phosphorus: 61 lake TSI^{TP}'s were calculated and are summarized in Table 4: Trophic State Indexes. 35 of the 61 lakes had median values of TP over the 0.05 mg/L which means they are at risk of summer algae blooms. It should be noted that many of the lakes with medians under the 0.05 mg/L TP had one or more sampling events with TP levels over that benchmark.

Chlorophyll-*a*: 12 lake TSI^{CHL}'s were calculated and are summarized in Table 4: Trophic State Indexes.

Non-volatile Suspended Solids: 61 lake NVSS median values were calculated from TSS & VSS. Table 5 summarizes these median values and assigns weighted points for evaluating its effects on aquatic life and aesthetic quality. 36 lakes showed no significant amounts of NVSS.

Nitrogen: Total Nitrogen to Total Phosphorus (TN:TP) ratios were calculated for 61 lakes. These ratios indicate that 7 lakes are nitrogen limited, 14 are transitional, and 38 are phosphorus limited. Whether these nutrients truly are the main factor in limiting algae growth depends on the third factor, light, which is effected by suspended solids and/or water color. TN:TP ratios ranged from 5:1 at Altamont New in Effingham County to 108:1 at Canton in Fulton County. As mentioned earlier, when inorganic nitrogen is available over 0.3 mg/L in a lake, summer algae blooms should be expected. In lakes were inorganic nitrogen is low, but phosphorus is readily available, the lake's nutrient factors favor blue-green algae growth. Table 6: Total Nitrogen to Total Phosphorus Ratios summarizes the median inorganic nitrogen, total nitrogen, total phosphorus, TN:TP ratios and are assigned a nutrient category of nitrogen limited, phosphorus limited or transitional. Also, lakes highlighted with a blue-green background have nutrients at levels favorable for blue-green algae growth to out-compete green algae growth.

Figure 7: Algae Growth Limiting Nutrient



Chloride: None of the 61 lakes sampled have chloride values over the Agency's water quality standard for surface water. The values ranged from 1 mg/L at Devil's Kitchen and Little Grassy in Williamson County to 341 mg/L at Three Oaks South in McHenry County. Table 7 summarizes the chloride median values.

Alkalinity: All of the 61 lakes sampled appear to be well buffered, with a range of 24 mg/L at Devil's Kitchen and Little Grassy in Williamson County to 318 mg/L at Sanctuary Pond in DuPage County. Table 7 summarizes the alkalinity median values.

Dissolved Oxygen/Temperature Profiles

In 2011, volunteers at 41 lakes collected dissolved oxygen and temperature profiles. Dissolved oxygen and temperature profiles are not included in this report.

Trophic State Index

Figure 6: Trophic State

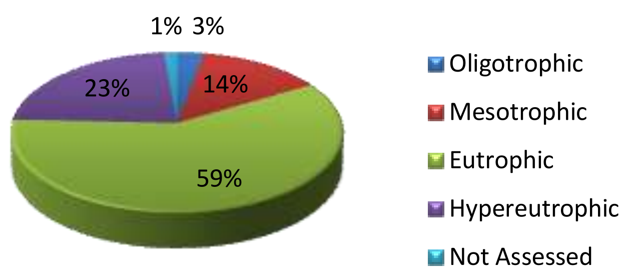


Table 4 presents the volunteer lakes with their trophic state designation based on the Trophic State Indexes (TSI^{SD}, TSI^{TP}, and/or TSI^{CHL}). When all three TSIs are available, the trophic state is determined by a simple two out of three. When only two TSIs are available, the trophic state is weighted in the order of TP, CHL then SD. There are 4 lakes classified as oligotrophic, 19 lakes classified as mesotrophic, and the remaining 115 lakes as eutrophic (32 of which fall into the hypereutrophic classification). 3 lakes did not submit Secchi depth readings in the summer months, so a TSI is not relevant for this report period. It should be noted that all four oligotrophic lakes are old quarries or strip mines.

It should be noted that Carlson considers the amount of plant biomass in the lake using CHL-*a* as the surrogate as a more accurate means of measure than Secchi Depth; however, the IEPA regards volunteer CHL-*a* sampling as providing a greater margin for error. In Illinois, it has been observed that the higher the amount of total Phosphorus, the higher the trend towards a hypereutrophic state.

Using the Indices Beyond Classification (excerpt from Carlson, R.E. and J. Simpson. 1996.)

A major strength of TSI is that the interrelationships between variables can be used to identify certain conditions in the lake or reservoir that are related to the factors that limit algal biomass or affect the measured variables. When more than one of the three variables is measured, it is possible that different index values will be obtained. Because the relationships between the variables were originally derived from regression relationships and the correlations were not perfect, some variability between the index values is to be expected. However, in some situations the variation is not random and factors interfering with the empirical relationship can be identified. These deviations of the total phosphorus or the Secchi depth index from the chlorophyll index can be used to identify errors in collection or analysis or real deviations from the "standard" expected values. Some possible interpretations of deviations of the index values are given in the table below.

The simplest way to use the index for comparison of variables is to plot the seasonal trends of each of the individual indices. If every TSI value for each variable is similar and tracks each other, then you know that the lake is probably phosphorus limited and that most of the attenuation of light is by algae.
In some lakes, the indices do not correspond throughout the season. In these cases, something very basic must be affecting the relationships between the variables. The problem may be as simple as the data were calculated incorrectly or that a measurement was done in a manner that produced different values. For example, if an extractant other than acetone is used for chlorophyll analysis, a greater amount of chlorophyll might be extracted from each cell, affecting the chlorophyll relationship with the other variables. If a volunteer incorrectly measures Secchi depth, a systematic deviation might also occur.

Relationship Between TSI Variables	Conditions
$TSI^{CHL} = TSI^{TP} = TSI^{SD}$	Algae dominate light attenuation; TN/TP ~ 33:1
$TSI^{CHL} > TSI^{SD}$	Large particulates, such as Aphanizomenon flakes, dominate
$TSI^{TP} = TSI^{SD} > TSI^{CHL}$	Non-algal particulates or color dominate light attenuation
$TSI^{SD} = TSI^{CHL} > TSI^{TP}$	Phosphorus limits algal biomass (TN/TP >33:1)
$TSI^{TP} > TSI^{CHL} = TSI^{SD}$	Algae dominate light attenuation but some factors such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.

After methodological errors can be ruled out, remaining systematic seasonal deviations may be caused by interfering factors or non-measured limiting factors. Chlorophyll and Secchi depth indices might rise above the phosphorus index, suggesting that the algae are becoming increasingly phosphorus limited. In other lakes or during the season, the chlorophyll and transparency indices may be close together, but both will fall below the phosphorus curve. This might suggest that the algae are nitrogen-limited or at least limited by some other factor than phosphorus. Intense zooplankton grazing, for example, may cause the chlorophyll and Secchi depth indices to fall below the phosphorus index as the zooplankton remove algal cells from the water or Secchi depth may fall below chlorophyll if the grazers selectively eliminate the smaller cells.

In turbid lakes, it is common to see a close relationship between the total phosphorus TSI and the Secchi depth TSI, while the chlorophyll index falls 10 or 20 units below the others. Clay particles contain phosphorus, and therefore lakes with heavy clay turbidity will have the phosphorus correlated with the clay turbidity, while the algae are neither able to utilize all the phosphorus nor contribute significantly to the light attenuation. This relationship of the variables does not necessarily mean that the algae are limited by light, only that not all the measured phosphorus is being utilized by the algae.

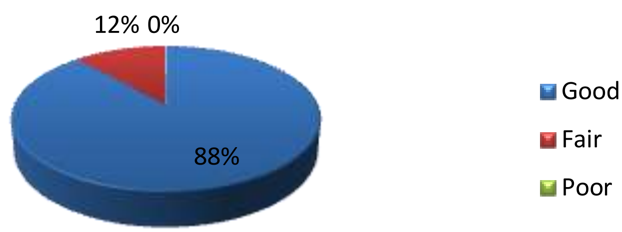
Evaluation of Aquatic Life Conditions

Twelve lakes were sampled for the Secchi depth, macrophyte coverage, nutrient list and chlorophyll. 49 lakes were sampled for the Secchi depth, macrophyte coverage, and nutrient list. The sample results were used to calculate TSI values for Secchi depth, TP and on 12 lakes, chlorophyll-a (CHL) as seen in Table 4: Trophic State Indexes. The TSIs are assigned point values as shown on page 30 under Weighting Criteria for ALC. The summer

ALC macrophyte points are determined using the average percentage against the weighting criteria category and the category's potential points. The macrophyte points are summarized in Table 3: Macrophyte Coverage Totals. Finally, the NVSS median is calculated using all surface samples and compared to the weighing criteria for NVSS, See Table 5: Non-volatile Suspended Solids Calculations. All ALC components are summarized in Table 8: Aquatic Life Condition Components and totaled by TSI type in Table 9: Aquatic Life Ratings.

As with TSI values, the ratings are weighted by using the two out of three rule when all three values are available, then by ALC^{TP} first and ALC^{CHL} second when only two TSI values. The ALC^{SD} alone cannot be used, unless NVSS was calculated in the absence of usable total Phosphorus data. Therefore, lakes only collecting Secchi information cannot be used to directly determine aquatic life conditions in a lake, but they can be compared with similar lakes of their type using TSI^{SD} and macrophyte coverage.

Figure 8: Aquatic Life Conditions

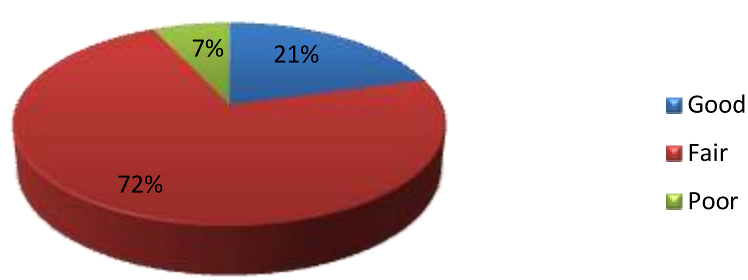


Out of the 61 lakes with chemical data available, 53 were rated with "Good" aquatic life conditions and 7 were rate with "Fair" aquatic life conditions. None were rated poor. One lake did not have enough data to evaluate aquatic life conditions.

Evaluation of Aesthetic Quality Conditions

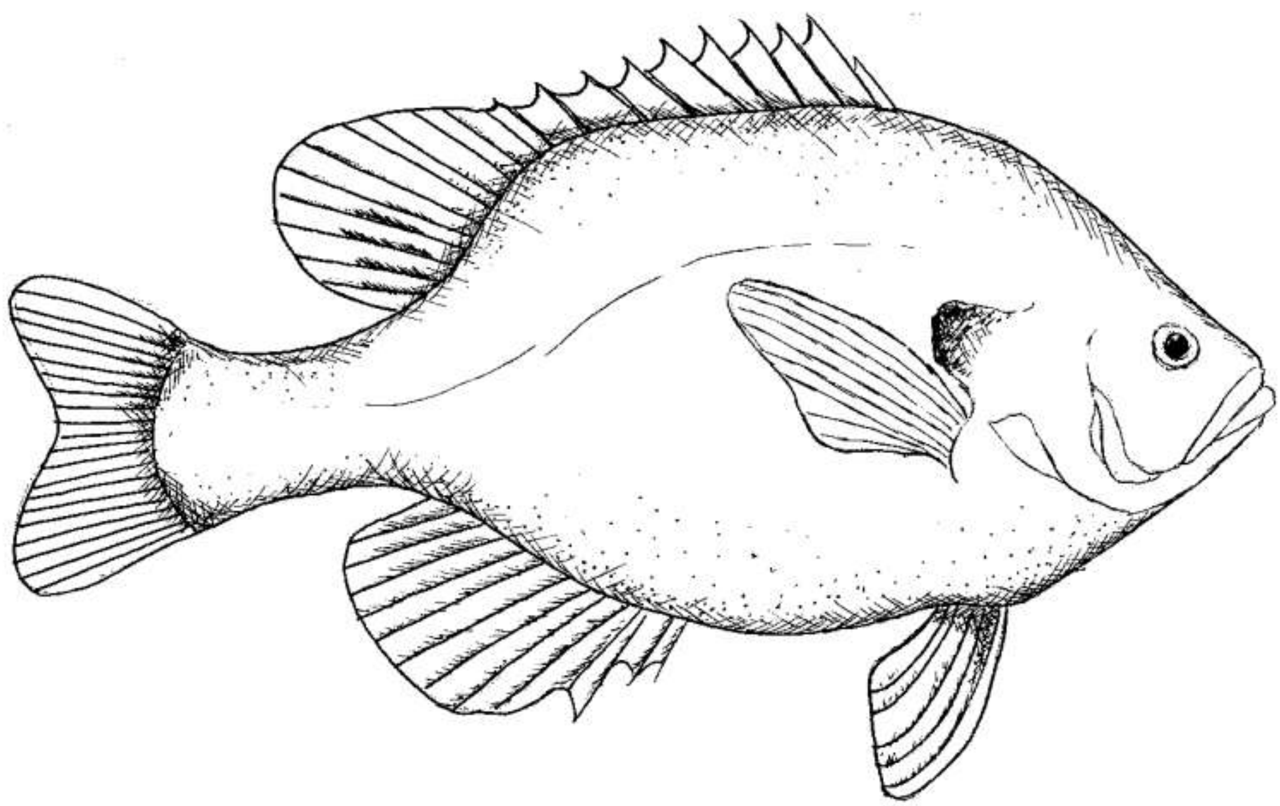
Twelve lakes were sampled for the Secchi depth, macrophyte coverage, nutrient list and chlorophyll. 49 lakes were sampled for the Secchi depth, macrophyte coverage, and nutrient list. The sample results were used to calculate TSI values for Secchi depth, TP and on 12 lakes, chlorophyll-A (CHL) as seen in Table 4: Trophic State Indexes. The TSIs are assigned point values as shown on page 32 under Weighting Criteria for AQC. The summer AQC macrophyte points are calculated by multiplying the percentage of each weighting criteria category with the categories potential points. The macrophyte points are summarized in Table 3: Macrophyte Coverage Totals. Finally, the NVSS median is calculated using all surface samples and compared to the weighing criteria for NVSS, See Table 5: Non-volatile Suspended Solids Calculations. All AQC components are summarized in Table 10: Aesthetic Quality Condition Components and totaled by TSI type in Table 11: Aesthetic Quality Ratings.

Figure 9: Aesthetic Quality Conditions



As with TSI values, the ratings are weighted by using the two out of three rule when all three values are available, then by AQC^{TP} first and AQC^{CHL} second when only two TSI values. The AQC^{SD} alone cannot be used, unless NVSS was calculated in the absence of usable total Phosphorus data. Therefore, lakes only collecting Secchi information cannot be used to directly determine aesthetic quality conditions in a lake, but they can be compared with similar lakes of their type using TSI^{SD} and macrophyte coverage.

Out of the 61 lakes with chemical data available, 13 were rated with "Good," 43 were rate with "Fair," and 4 were rated with "Poor" aesthetic quality conditions. One lake did not have enough data to evaluate aquatic life conditions.



Summary

For many decades, lakes have been classified according to their trophic state. A eutrophic lake has high nutrients and high plant growth. An oligotrophic lake has low nutrient concentrations and low plant growth. Mesotrophic lakes fall between eutrophic and oligotrophic lakes. While lakes may be lumped into a few trophic classes, each lake has a unique set of attributes that create its trophic state.

Three main factors contribute to the trophic state of a lake; rate of nutrient supply, climate, and shape of the lake basin. The rate of nutrient supply is directly affected by the soils, vegetation and human land uses and management practices in a lake’s watershed. The climate factors include the amount of sunlight a lake receives, temperature and precipitation. Another important climate related factor is a lake’s turnover time and water retention time. Finally, the shape of a lake basin affects how the other two factors interact. Basin morphology factors include lake volume, depth, surface area and sized of its watershed.

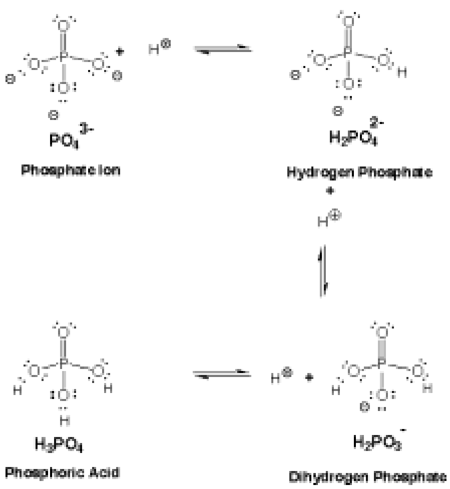
Trophic status is a useful means of classifying lakes and describing lake processes in terms of the productivity of the system. Basins with infertile soils release relatively little nitrogen and phosphorus leading to less productive lakes, classified as oligotrophic or mesotrophic. Watersheds with rich organic soils, or agricultural regions enriched with fertilizers, yield much higher nutrient loads, resulting in more productive, eutrophic (even hyper-eutrophic) lakes.

The concept of lake aging has been interpreted by some as an inevitable and irreversible process whereby a lake eventually "dies." In fact, many oligotrophic lakes have persisted as such since the last glaciation. Changes in climate and watershed vegetation seem to have both increased and decreased lake productivity over this period. Some lakes probably experienced high rates of photosynthesis fairly soon after glacial retreat and then became less productive until recent times. It is also possible that water sources for some lakes have changed over the past thousands of years through diversions of stream flow, for example. In such cases water supplies to a lake (and therefore nutrient supplies) could have changed, leading to changes in the lake's productivity.

Lakes may undergo cultural eutrophication by accelerating their natural rate of nutrient inflow. This occurs through poor management of the watershed and introduction of human wastes through failing septic systems. Such changes may occur over periods of only decades and are reversible if anthropogenic nutrient loading can be controlled.

In Illinois, most of the problems associated with the direct discharge of domestic wastewater have been successfully mitigated. Now the focus is on the much more difficult problem of controlling non-point sources (NPS) of nutrient pollution such as agricultural drainage, storm water runoff, and inadequate on-site septic systems. NPS pollution is particularly difficult to address because it is diffuse, not attributable to a small number of polluters, and associated with fundamental changes in the landscape, such as agriculture, urbanization and shoreline development.

Data from the Volunteer Lake Monitoring Program continues to show heavy loading of nutrients such as Phosphorus, into Illinois lakes. Data for the sixty-one lakes with total Phosphorus values had a median range of 0.004 mg/L to 0.274 mg/L. The lowest single value for total phosphorus was 0.004 mg/L and the highest was 0.538 mg/L. The water quality standard for Illinois surface water is 0.05 mg/L. **Twenty-six** of the sixty-one lakes were under the surface water standard for their median total phosphorus values, but that number falls to **thirteen** without at least one value over 0.05 mg/L.



Twenty-five of the sixty-one lakes had some level of concern for suspended solids, though only **three** had high levels and **six** others were of moderate concern.

Besides high nutrient loads in Illinois lakes, balancing macrophyte coverage appears to be the number one factor between keeping aquatic life conditions favorable while maintaining aesthetic quality conditions for recreation. **Twenty-seven** of the one-hundred forty lakes studied had good macrophyte coverage for supporting aquatic life while maintaining good recreational use conditions as well.

There are a number of options for improving the water quality of a lake – from picking up litter to implementing best management practices in the watershed. Best management practices have been developed for construction, cropland, and forestry, as well as other similar land-use activities. Managers of lakes and streams can focus their best management practices to control water runoff, erosion, nutrient loading and contaminant loading. Table 13 contains a long list of best management practices with a set of priorities assigned from low to high for agriculture, construction, urban runoff, hydrologic modification, resource extraction, groundwater, and wetlands.

Grants Available to Control Nonpoint Source Pollution in Illinois

Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address water quality issues relating directly to nonpoint source pollution. Funds can be used for the implementation of watershed management plans including the development of information and/or education programs and for the installation of best management practices.

IEPA receives these funds through Section 319(h) of the Clean Water Act and administers the program within Illinois. The maximum federal funding available is 60 percent. The program period is two years unless otherwise approved. This is a reimbursement program.

Applications are accepted June 1 through August 1. If August 1 is a Saturday or Sunday, the deadline becomes the prior Friday before 5 p.m. At this time, electronic submittals are not accepted. Please mail applications to:

Illinois Environmental Protection Agency
Bureau of Water
Watershed Management Section
Nonpoint Source Unit
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

(217)782-3362

Applications due by close of business on: August 1, 2012

Links for 319 Grants

- Section 319 Request for Proposals
- Section 319 Application
- Section 319 Application Instructions
- Section 319 Certifications and Grant Conditions

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Glossary of Terms

Algae: a group of photosynthetic eucaryotes that are single celled, colonial, or filamentous aquatic plants, often microscopic.

Algal bloom: A condition which occurs when excessive nutrient levels and other physical and chemical conditions facilitate rapid growth of algae. Algal blooms may cause changes in water color. The decay of the algal bloom may reduce dissolved oxygen levels in the water.

Alkalinity: A measure of the capacity of water to neutralize acids. It is a measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. (Expressed as milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$), or as microequivalents per liter (μeq/l). 20 μeq/l = 1 mg/L of $CaCO_3$.)

Ammonia: A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient. It converts rapidly to nitrate (NO_3^-) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for indigenous aquatic life is 0.1 mg/L of unionized ammonia. At a pH of 7 and a temperature of 68^o Fahrenheit (20^o Celsius), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1.

Anaerobic: Any process that can occur without molecular oxygen; also applicable to organisms that can survive without free oxygen.

Aquatic Invasive Species (AIS): AIS is a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Aquatic invertebrates: Aquatic animals without an internal skeletal structure such as insects, mollusks, and crayfish.

Beneficial use: The uses of a water resource that are protected by state laws called water quality standards. Uses include aquatic life, recreation, human consumption, and fish or wildlife habitat.

Benthic: Living in or on the bottom of a body of water.

Benthos: Collectively, all organisms living in, on, or near the bottom substrate in aquatic habitats (examples are oysters, clams, burrowing worms).

Best management practices (BMPs): Management practices (such as nutrient management) or structural practices (such as terraces) designed to reduce the quantities of pollutants — such as sediment, nitrogen, phosphorus, and animal wastes — that are washed by rain and snow melt from lands into nearby receiving waters, such as lakes, creeks, streams, rivers, estuaries, and ground water.

Biomass: 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.

Blue-green algae: Algae which are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N_2) from the air to provide their own nutrient.

Chlorophyll: Green pigments essential to photosynthesis.

Chlorophyll *a*: A green photosynthetic pigment found in the cells of all algae and other plants. The chlorophyll-*a* level in lake water is used to estimate the concentration of planktonic algae in the lake.

Chlorophyll *b*: A type of chlorophyll found in green algae and euglenoids. Both of these are good food for zooplankton which is good fish food.

Chlorophyll *c*: A type of chlorophyll found in diatoms and golden brown algae. Both of these are good food for zooplankton which is good fish food.

Conductivity: The ability of water or other substance to carry an electric current.

Color: Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. Color also affects light penetration and therefore the depth at which plants can grow.

Cultural Eutrophication: The enrichment of lakes with nutrients (especially phosphorus) as a result of human activity, resulting in an acceleration of the natural ageing process of the lake.

Detritus: Fragments of plant material.

Diatoms: Any number of microscopic algae whose cell walls consist of two box-like parts or valves and contain silica.

Dinoflagellates: Unicellular biflagellate algae with thick cellulose plates.

Dissolved Oxygen: Dissolved oxygen is the amount of oxygen dissolved in the water. The DO concentration in water is affected by the water temperature, water quality, and other factors.

Epilmnion: the upper (usually warmer) circulated zone of water in a temperature stratified lake.

Erosion: Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

Euphotic: the zone of vertical light penetration in a lake.

Eutrohic: water which are rich in plant nutrients and capable of supporting high amounts of plant and animal growth (Secchi transparency less than 6.6 feet and TSI 50 to 70).

Eutrophication: the lake aging process via nutrient enrichment and sedimentation; both a natural and human induced process.

Hypereutrophic: a lake with extreme level of nutrients and nuisance plant growth, often as a result of human activities (a TSI greater than 70).

Hypolimnion: the lower (usually cooler) non-circulated zone of water in a temperature stratified lake.

Invasive Species: An alien species whose introduction does, or is likely to, cause economic or environmental harm to human health.

Lake: A man-made impoundment or natural body of fresh water of considerable size, whose open-water and deep-bottom zones (no light penetration to bottom) are large compared to the shallow-water (shoreline) zone, which has light penetration to its bottom.

Limnology: The scientific study of the life and phenomena of lakes, ponds and streams.

Littoral Zone: The near shore shallow water zone of a lake, where light penetrates to the bottom and aquatic plants grow. Some shallow ponds are entirely littoral.

Macroinvertebrate: Any nonvertebrate organism that is large enough to be seen without the aid of a microscope.

Macrophyte: water plants that are visable to the unaided eye.

Mesotrophic: waters intermediate in eutrophy between oligotrophic and eutrophic (Secchi transparency 6.6 to 12.1 feet and TSI 40 to 50).

Metabolism: the sum of the physical and chemical processes ongoing in all living things.

Methemoglobinemia: a condition brought on by drinking water high in nitrates, that reduces the ability of blood to carry oxygen and may also cause respiratory problems. Infants are particularly at risk.

Native Species: A species naturally occurring of originating in a geographical region or in a specific ecosystem.

Nonpoint source (NPS) pollution: Unlike pollution from industrial and sewage treatment plants, NPS pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands and even our underground sources of drinking water. It has been determined that over 60 percent of the (national) documented water pollution problem can be traced to nonpoint sources.

Nutrients: Chemicals that are needed by plants and animals for growth (e.g., nitrogen, phosphorus). In water resources, if other physical and chemical conditions are optimal, excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae. Some nutrients can be toxic to animals at high concentrations.

Oligotrophic: water with low concentrations of plant nutrients and hence relatively low amounts of plant and animal growth (Secchi transparency greater than 12.1 feet and TSI less than 40).

Online Lakes Database: An online interface for volunteer lake monitors to input their data into the IEPA Lake's Data Management System. It also provides a means for all citizens to view current and historical water quality information on monitored lakes. Database currently contains only those lakes sampled since 1999. Previous to 1999, all data may be accessed through USEPA's **STORET**.

pH: A measure of the acidic or basic (alkaline) nature of water, relating to the number of hydrogen ions. A pH of 7 is neutral. Acid waters are below 7; alkaline waters are above 7.

Pheophytin: The dead chlorophyll of algal cells. Can indicate when an algal bloom dies off.

Phosphorus: One of the major nutrients needed for plant growth. Phosphorus is the critical nutrient for algae growth in lake and ponds.

Photosynthesis: the process by which green plants use sunlight, water, and carbon dioxide to produce oxygen.

Plankton: Small organisms that float passively (or swim weakly) in open water. The two groups of plankton are: phytoplankton, also called algae; and planktonic animals, also called zooplankton.

Pollutant: A contaminant that adversely alters the physical, chemical, or biological properties of the environment. The term includes nutrients, sediment, pathogens, toxic metals, carcinogens, oxygen-demanding materials, and all other harmful substances. With reference to nonpoint sources, the term is sometimes used to apply to contaminants released in low concentrations from many activities which collectively degrade water quality. As defined in the federal Clean Water Act, pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Protoplasm: the living substance of in a cell (includes the cytoplasm and nucleus).

Representative Site: generally is the deepest area of the lake and is called Site 1.

Saturation: the maximum concentration that water can hold (of any substance, in this case oxygen). This is a function of temperature and pressure.

Secchi Disk Transparency: the depth in the water column that an eight inch, black and white disk disappears from view. Two or three time the Secchi depth is the depth that sunlight can reach into the water column and thereby support plant growth. A healthy plant community is needed for animal (fish) habitat within the lake.

Sediment: Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water.

STORET: USEPA's old national data storage database; it is housed in a computer mainframe system.

Stratification: The layering of water due to differences in density. Water's greatest density occurs at 39^o Fahrenheit (4^o Celsius). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer **(epilimnion),** which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water **(hypolimnion)** is called the **thermocline**.

Super-Saturation: a concentration of a substance (in this case oxygen) above the maximum concentration that water can hold at a given temperature and pressure. This can happen when temperature or pressure changes, or as a result of biological activity.

Suspended solids: Suspended solids refer to small solid particles which remain in suspension in water as a colloid or due to the motion of the water. It is used as one indicator of water quality

Thermal Stratification: As lake water is warmed in the summer, the water in the deep pond or lake is layered into three levels: 1) warmer (less dense) epilimnion layer at the surface; 2) the thin thermocline or transition layer; and 3) the cold and deep hypolimnion layer.

Thermally Stratified: lake water often separates into zones or layers by temperature difference.

Thermocline: the zone in a temperature-stratified lake between the epilimnion and the hypolimnion, also referred to as the "metalimnion."

Total Phosphorus: A measure of all forms of phosphorus (organic and inorganic) in water.

Total Suspended Solid (TSS): The weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles. Total suspended solids are differentiated from total dissolved solids by a standardized filtration process, the dissolved portion passing through the filter.

Transparency: A measure of water clarity that, in lakes and ponds, indirectly measures algal productivity. Transparency is determined by the depth at which a Secchi disk lowered into the water column is no longer visible.

Trophic: A level of nutrition, nutrient enrichment within a lake.

Trophic State Index (TSI): A simplified index of biological productivity in lakes.

Turbidity: A measure of the amount of light intercepted by a given volume of water due to the presence of suspended and dissolved matter and microscopic biota. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

Volatile suspended solids (VSS): That fraction of suspended solids, including organic matter and volatile inorganic salts, which will ignite and burn when placed in an electric muffle furnace at 550 °C for 15 minutes.

Watershed: A region or area divided by points of high land that drains into a lake, stream, or river.

Watershed Based Plan: A watershed based plan is a document designed to protect and improve water quality by controlling nonpoint source pollution and related water quality problems. Such plans provide an integrated, holistic process to effectively and efficiently protect, enhance and restore the physical, chemical and biological integrity of water resources within a defined hydrologic area (watershed). Watershed based plans present assessment and management information for a geographically defined watershed, including the analyses, actions, participants, and resources related to development and implementation of the plan. Watershed based plans should be consistent with the nine minimum elements of watershed based plan as defined by USEPA watershed based plan guidance, the Chicago Metropolitan Agency for Planning's Guidance for Developing Watershed Action Plans in Illinois, total maximum daily load (TMDL) implementation plan requirements, and current watershed planning principles.

Water quality standards: Established limits of certain chemical, physical, and biological parameters in a water body; water quality standards are established for the different designated uses of a water body.

Wetlands: Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Zooplankton: microscopic animals found in the water of lakes and rivers.