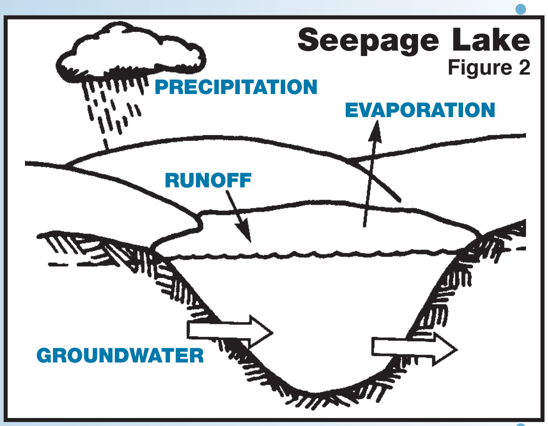
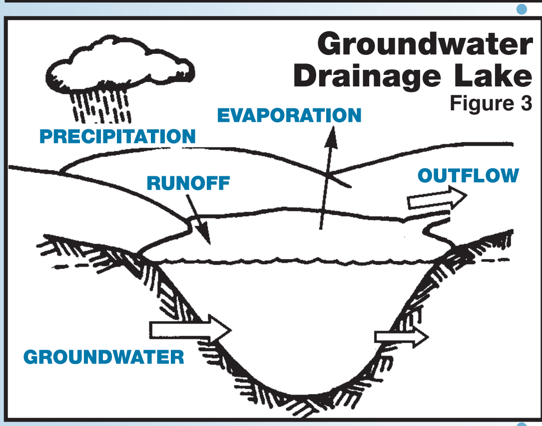
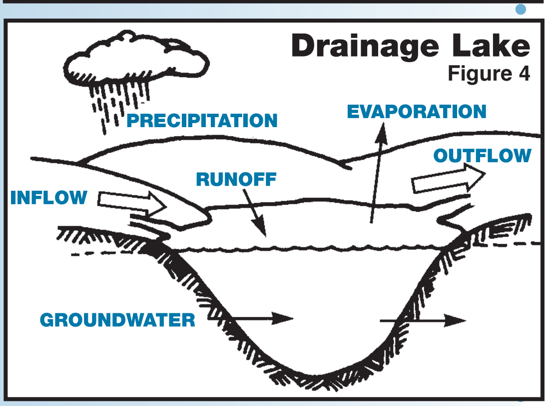
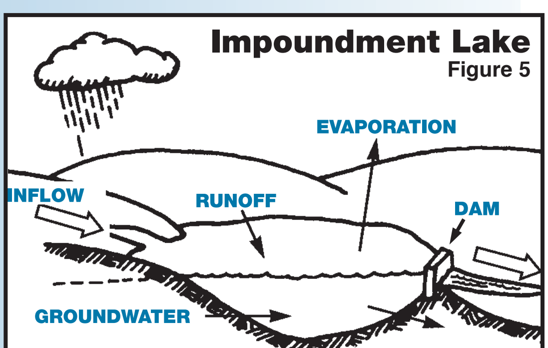
Figures 2-5. ***Lake Types.*** *Major water inputs and outflows of different lake types. Large arrows indicate heavy water flow. (Taken from Shaw et al 2000 "Understanding Lake Data")*









Understanding Your Data

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

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

Lake Types

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

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

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

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

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

Lake Georegions

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

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

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

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

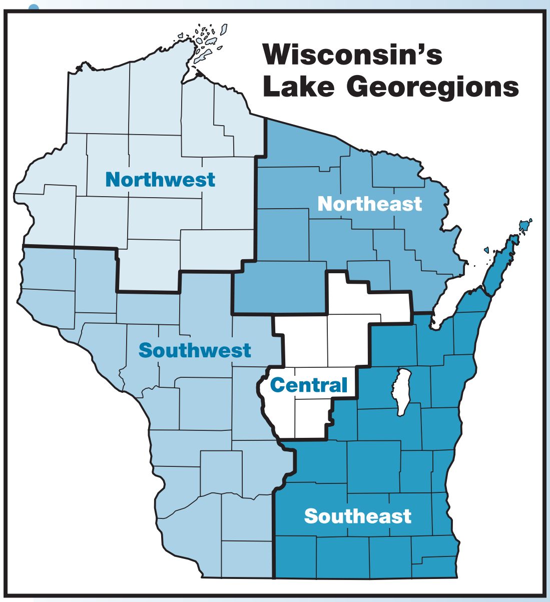


Figure 6. *Wisconsin's lake georegions.*

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

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

WATER SOURCE

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

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

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

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

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

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

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

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

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

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

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

What Do My Secchi Readings Mean?

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

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

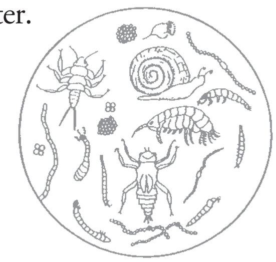
Georegion	Average Secchi depth (ft.) for mixed lakes	Average Secchi depth (ft.) for stratified lakes
Northwest	6.5	10.7
Northeast	7.4	12.8
Central	8.1	10.8
Southwest	3.4	4.7
Southeast	3.6	4.7

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

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

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

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



What Do My Total Phosphorus and Chlorophyll Readings Mean?

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

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

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

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

Lake Georegion	Average Chlorophyll Value (µg/L)
Northwest	13
Northeast	7
Central	9
Southwest	45
Southeast	14

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

TSI less than 30
Classic oligotrophic lake characterized by clear water, many algal species, oxygen throughout the year in bottom water, and cold water oxygen-sensitive fish species in deep lakes. Excellent water quality.

TSI 30-40
Deeper lakes will still be oligotrophic, but the bottom waters of some shallower lakes may become oxygen-depleted during the summer.

TSI 40-50
Classic mesotrophic lake. characterized by moderately clear water, but increasing chance of low dissolved oxygen in deep water during the summer.

TSI 50-60
Lake becoming eutrophic characterized by decreased clarity, fewer algal species, and oxygen-depleted bottom waters during the summer. Plant overgrowth evident, supporting only warm-water fisheries.

TSI 60-70
Becoming very eutrophic. Blue-green algae may become dominant with possible algal scums. Extensive plant overgrowth problems likely.

TSI 70-80
Lake becoming hypereutrophic characterized by heavy algal blooms throughout summer, dense plant beds limited by light penetration.

TSI > 80
Hypereutrophic lake with very poor water quality, algal scums, summer fish kills, and few plants.

What is Trophic State?

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

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

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

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

THE NATURAL AGING OF LAKES

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

In contrast, a less productive lake is referred to as oligotrophic. In oligotrophic lakes, the Secchi disk may be visible to great depths, indicating high water clarity. Oligotrophic lakes generally contain little algae, fewer plants, and often have low fish densities. Mesotrophic lakes categorize the state between the oligotrophic and eutrophic stages. Mesotrophic lakes often have low dissolved oxygen levels in late summer. The hypolimnion (cold, bottom water) in these lakes limits coldwater fish populations and causes phosphorus cycling from the sediments.

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

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

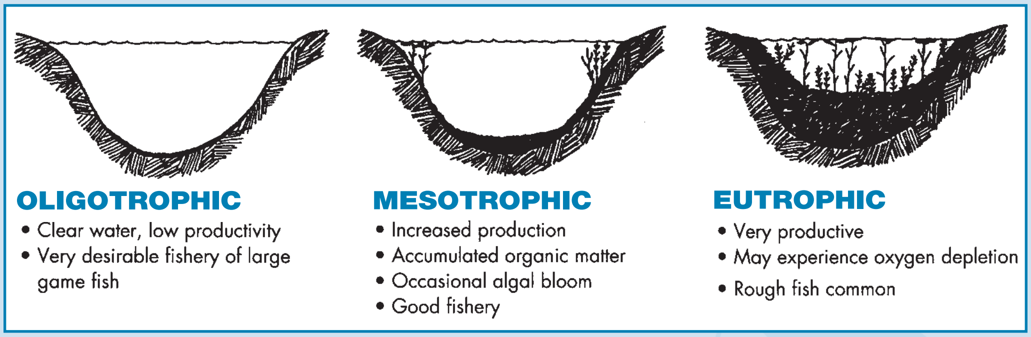


Figure 7. *(Taken from Shaw et al. 2000 "Understanding Lake Data")*

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

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

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

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

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

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

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

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

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

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

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

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

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

How Do My TSI Values Relate to One Another?

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

LAKE SUMMARY REPORT SAMPLE

Lake Water Quality 2008 Annual Report

Franklin Lake
Forest County
Waterbody Number: 692900

Lake Type:
DNR Region: NO
GEO Region:NE

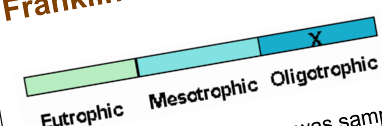
Site Name	Storet #
Franklin Lake - Deep Hole	213138

Date	SD (ft)	SD (m)	Hit Bottom	CHL	TP	TSI (SD)	TSI (CHL)	TSI (TP)	Lake Level	Clarity	Color	Perception
05/20/2008	12	3.7	NO		14	41		49	LOW	CLEAR	BROWN	3-Enjoyment somewhat impaired (algae)
06/02/2008	21	6.4	NO								REEN	2-Very minor aesthetic problems
06/10/2008	27	8.2	NO								REEN	1-Beautiful, could not be nicer
06/14/2008	25	7.6	NO	.58	9	31	31	4			REEN	1-Beautiful, could not be nicer
06/24/2008	18	5.5	NO			35			NORMAL	CLEAR	GREEN	1-Beautiful, could not be nicer
07/13/2008				2.39	9		41	45				
07/14/2008	15	4.6	NO			38			NORMAL	CLEAR	GREEN	1-Beautiful, could
07/21/2008	18	5.5	NO			35			LOW			uld
07/28/2008	22	6.7	NO									ld

Actual chlorophyll analysis yields .58 µg/l – converted to trophic state = 31.

Total Phosphorus 14 µg/l – converted to trophic state = 49. Actual secchi reading = 12 feet - converted to trophic state = 41 (see Table 1)

Franklin Lake - Deep Hole 2008 Results



Franklin Lake - Deep Hole was sampled **12** different days during the 2008 season. Parameters sampled included:

- water clarity
- temperature
- dissolved oxygen
- total phosphorus
- chlorophyll

The average summer (July-Aug) secchi disk reading for Franklin Lake - Deep Hole (Forest County, WBIC: 692900) was 19.4 feet. The average for the Northeast Georegion was 10.2 feet. Typically the summer (July-Aug) water was reported as **CLEAR** and **GREEN**.

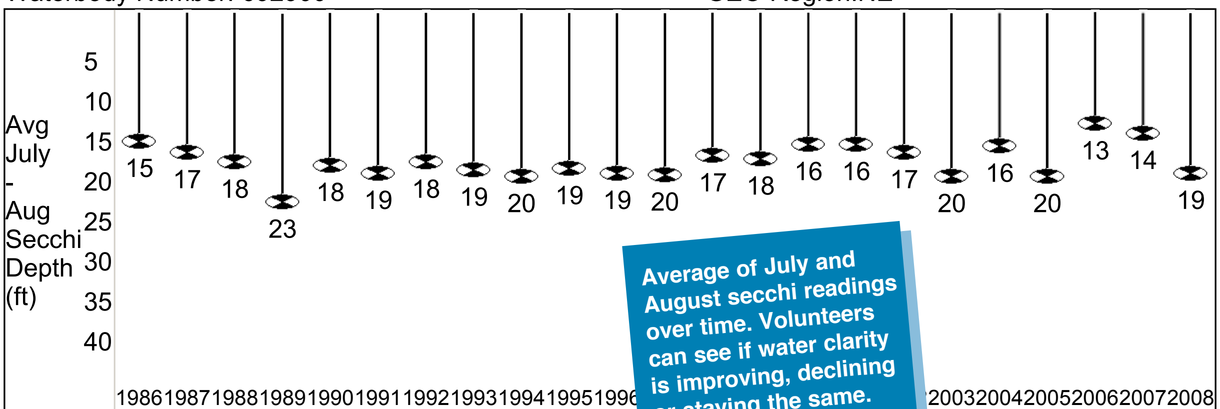
Chemistry data was collected on Franklin Lake - Deep Hole. The average summer Chlorophyll was 2.1 µg/l (compared to a Northeast Georegion summer average of 9.6 µg/l). The summer Total Phosphorus average was 10 µg/l. Lakes that have more than 20 µg/l and impoundments that have more than 30 µg/l of total phosphorus may experience noticable algae blooms.

The overall Trophic State Index (based on chlorophyll) for Franklin Lake - Deep Hole was 40. The TSI suggests that Franklin Lake - Deep Hole was **oligotrophic**. This TSI suggests deeper lakes still

LAKE SUMMARY REPORT SAMPLE continued

Franklin Lake
Forest County
Waterbody Number: 692900

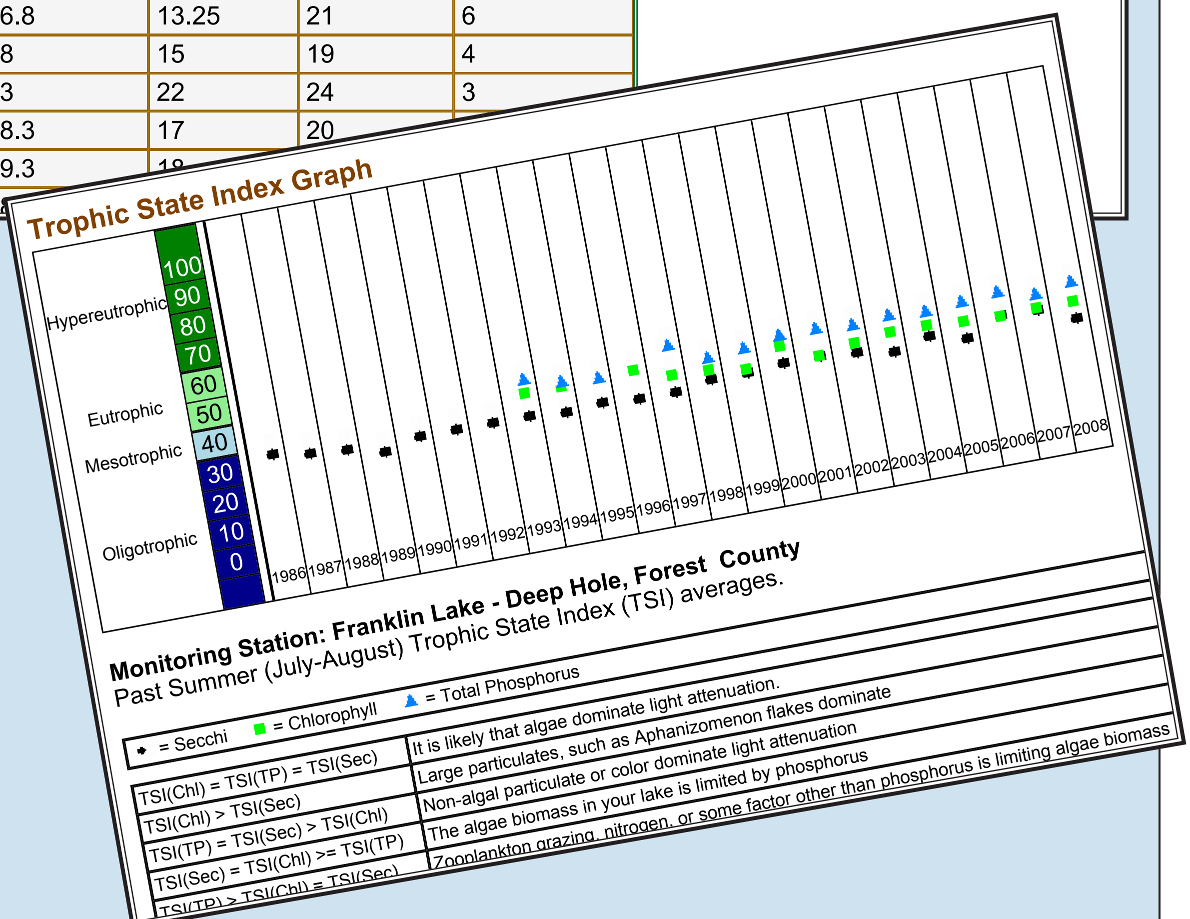
Lake Type:
DNR Region: NO
GEO Region:NE



Average of July and August secchi readings over time. Volunteers can see if water clarity is improving, declining or staying the same.

Past secchi averages in feet (July and August only).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1986	15.3	13.25	18.5	3
1987	16.8	13.25	21	6
1988	18	15	19	4
1989	23	22	24	3
1990	18.3	17	20	
1991	19.3	1[illegible]		
1992	1[illegible]			



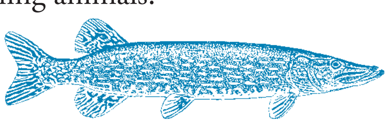
Dissolved Oxygen

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

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

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

Temperature



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

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

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

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

Water Quality Parameter Guide for Selected Fish Species

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

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

CAROL WATKINS, UW-EXTENSION, ENVIRONMENTAL RESOURCES CENTER

GET TO THE ROOT OF THE PROBLEM

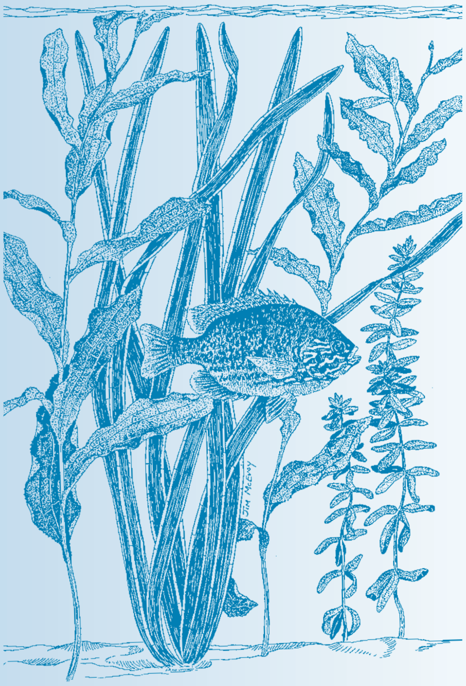
Suppose that your lake is not as clear as others in the area, and that there is some indication of clay turbidity in the spring and after rainstorms. However, the color of your lake is green indicating that algae, not clay, is affecting water clarity. What do you do now?

First, do some detective work.

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

Second, take more Secchi measurements in your lake.

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



DID YOU KNOW?

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

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

***PHOTOSYNTHESIS** • Process by which green plants convert carbon dioxide (CO_2) dissolved in water to sugar and oxygen using sunlight for energy.*

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

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

Secchi Reading and Light Penetration

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

How Does My Lake Compare to Others?

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

What if Your Data is Better Than Average

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

What if Your Data is Worse Than Average

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

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

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

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

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

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

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

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

- Plan a lake fair or event. A lake fair is an educational and social event that blends a sense of discovery and entertainment. These evens provide an opportunity for participants to get hands-on experience, talk with lakes experts in an informal setting, meet lake neighbors and build relationships.
- Become a Lake Leader. Lake Leaders is designed to stretch the mind by exploring new ideas about lake management and the human use of lakes. Graduates of this program develop a network to share experiences and learn from each other.
- The Lakes Convention is an annual event that gives educators, lake lovers, and professionals a chance to get together and discuss lake issues.