Factors that Affect Water Clarity

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

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

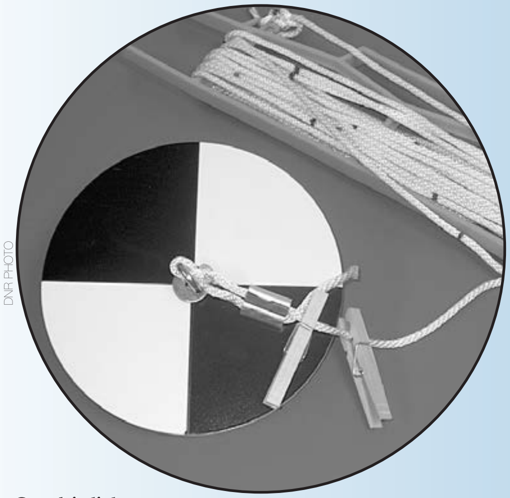
Suspended sediments, algal growth, runoff, shoreline erosion, wind mixing of the lake bottom, and tannic and humic acids from wetlands can all affect water clarity. Water clarity often fluctuates seasonally and can be affected by storms, wind, normal cycles in food webs, and rough fish such as carp,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

Suspended Sediments

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

Algae

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



DNR PHOTO

Secchi disk

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

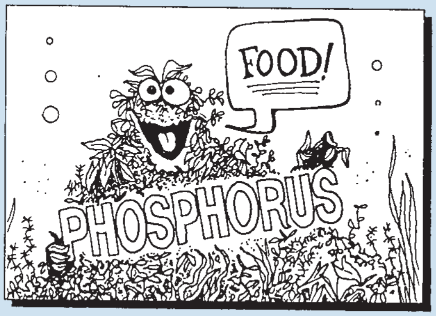
WATERSHED • *The area of land draining into a specific stream, river, lake, or other body of water.*

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

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

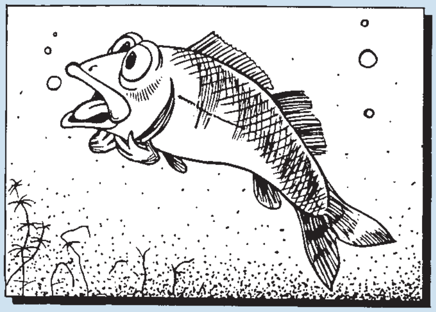
ZOOPLANKTON • *Plankton that is made up of microscopic animals, for example, protozoa, that eat algae. These suspended plankton are an important component of the lake food chain and ecosystem. For many fish and crustaceans, they are the primary source of food.*

FAMILIAR SIGNS OF RUNOFF POLLUTION

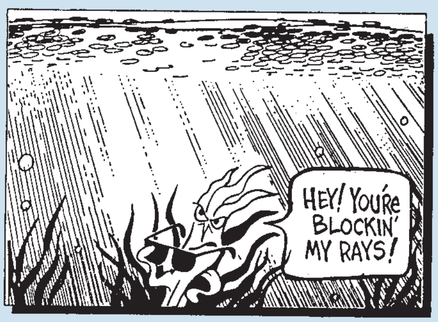


ALGAE

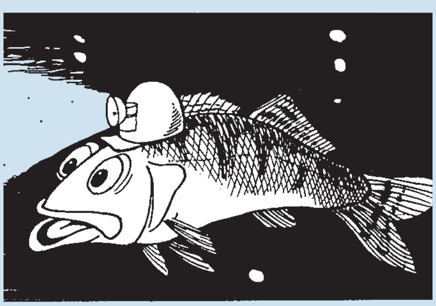
Nutrients, such as phosphorus and nitrogen, come from sediments, manure, pet wastes, improperly maintained septic systems, and misapplication of fertilizers on lawns or farm fields. Phosphorus contributes to the **eutrophication** (over-fertilization) of lakes. This leads to an increase in aquatic macrophyte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



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



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



SEDIMENT

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

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

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

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

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

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

Water Color

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

Mixing and Stratification

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

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

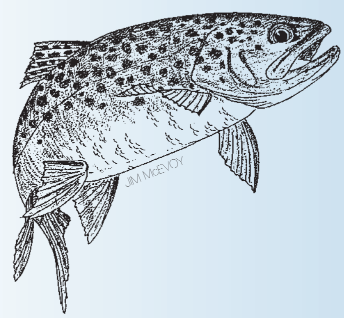
STRATIFICATION • *The layering of water due to differences in temperature and density.*

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

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

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

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



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

During the summer, lakes more than 20 feet deep usually experience a layering called **stratification**. Depending on their shape, small lakes can stratify even if they are less than 20 feet deep. In larger lakes, the wind may continuously mix the water to a depth of 30 feet or more. Lake shallows do not form layers, though deeper areas may stratify. Summer stratification, as pictured in Figure 1, divides a lake into three zones: **epilimnion** (warm surface layer), **thermocline** or **metalimnion** (transition zone between warm and cold water), and **hypolimnion** (cold bottom water). Stratification traps nutrients released from the bottom sediments in the hypolimnion (Shaw et al. 2000).

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

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

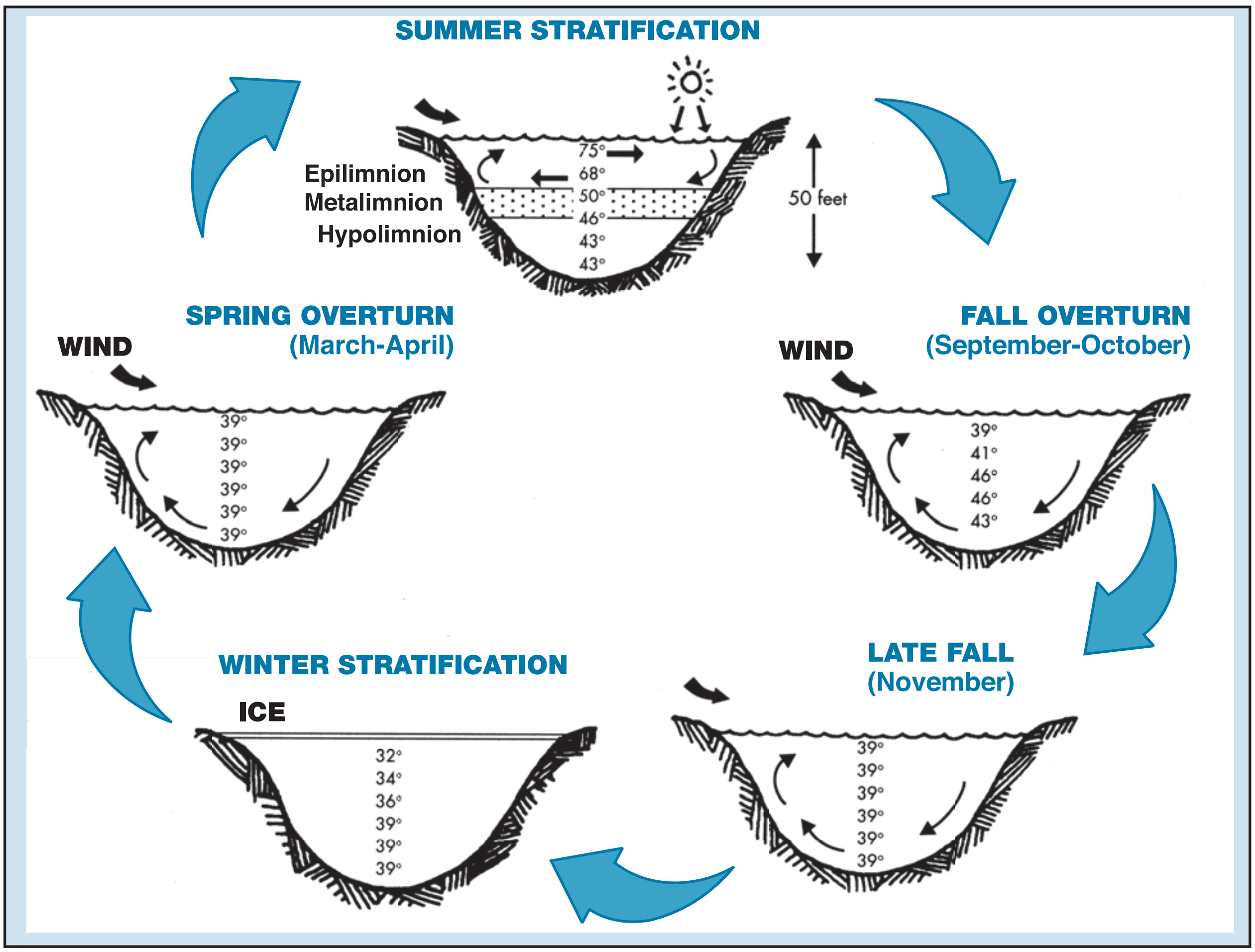


Figure 1. *Seasonal Stratification of Lakes. (Taken from Shaw et al. 2000 "Understanding Lake Data")*

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

Water Levels

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

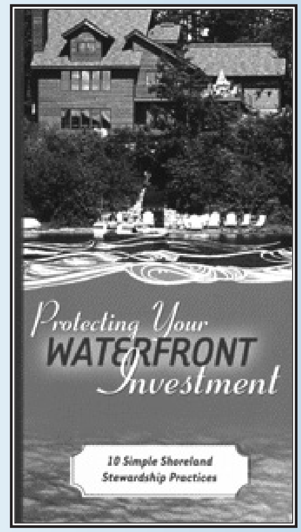
- Natural variability due to weather
- Decadal climate cycles (dry and wet periods)
- Climate change
- Dams
- Human use (water withdrawals)
- Lake morphology and hydrology.
    - o Lakes with gradual sloping shorelines will have more lake bed exposed during drought than lakes with steep shorelines
 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

Periodic low water conditions consolidate sediments, allow new plants to colonize the lake bed and provide habitats for rare plants and shorebirds. One of Wisconsin's rarest shoreline plants, Fassett's locoweed, is dependent upon periodic fluctuations of water levels to grow.

When water levels return, this expansion of plants becomes habitat for fish and wildlife, removes nutrients from the water and can increase water clarity. Human actions that cause water levels to drop farther than this natural variation, or prevent the lake from returning to normal conditions, may harm the lake and its inhabitants over the long term.

There are fish species that benefit from flooding (e.g., vegetation spawners like pike and muskies), and there may be some riverine fishes that are dependent on flooding.

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



Protecting Your Waterfront Investment

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

Free with a small handling fee from UWEX-Lakes

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

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

Prolonged drought can leave spawning substrate such as rock and cobble high and dry. Natural littoral structures such as coarse woody habitat can be critical to fishes for prey production, refuge, and spawning. Drought-driven lake level declines may strand these structures above the waterline and thereby remove them from littoral zones. A research project in northern Wisconsin equates the loss of coarse woody habitat with a reduction in yellow perch numbers and reduced growth of largemouth bass.

At extreme low and high lake levels, there can be negative impacts to both lake health and recreation. . The loss of this habitat can lower diversity and decrease productivity, particularly for slow-growing aquatic plants that may not be able to retreat as quickly as the water retreats. In some lakes, low water levels have left piers hundreds of feet from shore and rendered boat landings unusable.

Water level monitoring has been added to CLMN to monitor statewide lake-levels over time to address growing concern for health of aquatic life due to drought, changing climate, and groundwater withdrawals. Although long-term water level records exist, current monitoring efforts are disjointed and do not cover all areas of the state.

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

Wind-generated Waves, Sun Position, and Cloud Cover

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

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

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

Motor Boat Activity

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