Descriptions of Water Quality Parameters for lakes in the Ambient Lake Monitoring Program

This document is to be used a reference for water quality parameters collected in Iowa lakes.

Phosphorus – Total Phosphorus and Orthophosphate

Phosphorus occurs naturally in the earth's crust and is an essential nutrient that plants use during photosynthesis. It is generally regarded as the limiting nutrient in fresh waters, but even in low concentrations, phosphorus can cause algae blooms in lakes and rivers. Phosphorus is transported to lakes through plant and animal decay, manure, sewage, agricultural fertilizers, soil erosion, and industrial effluents. Concentrations of Total Phosphorus as low as 30µg/L (ppb) can cause visible algae blooms in lakes. Orthophosphate, often referred to a Soluble Reactive Phosphorus, is readily taken up by algae and can contribute to harmful algal blooms. Additionally, Phosphorus frequently attaches to sediment and will sinks to the bottom of lakes, where it is relatively unavailable to algae under stable lake conditions. Spring and fall turnovers, wind mixing, and bottom-feeding fish, such as carp, can stir up sediments, releasing phosphorus back into the water column. Several chemical and biological processes can unlock phosphorus from the sediment, releasing it back into the water where it can be utilized by the algae. In excess, these events can cause more frequent harmful algal blooms.

Nitrogen – Nitrate + Nitrite as N, Ammonium Nitrogen, and Total Kjeldahl Nitrogen

Nitrogen is an essential nutrient for all plant and animal life; however, too much nitrogen can create problems in our lakes, rivers, streams, and oceans. Nitrogen is an especially potent pollutant in marine environments. In its various forms (Nitrite, Nitrate, Ammonia, and Unionized Ammonia), nitrogen can lead to the formation of harmful algal blooms, toxic environmental conditions for our fish and other aquatic life, and conditions in our drinking water that can cause severe illness or death in very young infants (blue baby syndrome) In addition to the local effects excess nitrogen, it can also contribute to global pollution. One example of nitrogen pollution is the hypoxic zone in the northern Gulf of Mexico, a dead zone, where oxygen levels (depleted by the decomposition of algal blooms created by excess nitrogen) are too low for many animals to live. Nitrogen enters our lakes through natural plant decay, fertilizer runoff, manure, industrial waste waters, landfills, and atmospheric gas. Nitrate nitrogen is the most common form found in Iowa's lakes. Relative to other parts of the country, Iowa lakes have very high nitrate concentrations (especially in regions where tile-drained agriculture is the prominent land use, such as the Des Moines Lobe).

Suspended Solids – Total, Fixed, and Volatile Solids

Soils eroded from the land frequently pollute our lakes by reducing water clarity and negatively impacting aquatic life. Suspended solids in water limit how far light can penetrate in a lake and thus, can limit growth of submerged aquatic plants. Aquatic plants provide excellent structure and shelter for fish and invertebrates in Iowa's lakes. Soil erosion, algae blooms, and re-suspension of lake sediments are the leading causes of high Totals Suspended Solid values in Iowa lakes. Fixed Suspended Solids refer to the portion of the Total Suspended Solids that are inorganic matter (sands, silts and clays). Volatile Suspended Solids are organic and generally are comprised of algae, aquatic and terrestrial detritus, and other soil organic matter.

Secchi Depth

Secchi depth, or Secchi transparency, is measurement taken using a Secchi disk. Secchi disks are a round, flat disk, typically 7 7/8" in size, and painted black and white (See images in Table 2). Secchi disks are lowered into the water on a metered tape or calibrated line to determine the waters clarity (how clear the water is). These values are then used to determine the Carlson's Trophic State Index for Secchi. This value is described below and ranges can be found in Table 1.

Chlorophyll a

Chlorophyll a is a pigment found in most plants and algal cells used for photosynthesis, and it is one of the things that make many plants and algal cells appear green. The measurement of chlorophyll a concentrations in water is done to get an estimate of the amount of algae (phytoplankton) living in the water, and is often used as a surrogate for measuring direct algal biomass. These values are then used to determine the Carlson's Trophic State Index for Chlorophyll a. This value is described below and ranges can be found in Table 1.

Table 1. Table describes value ranges of chlorophyll a, total phosphorus and Secchi transparency for various trophic states.

Lake type:	Chlorophyll a (µg/L):	Total Phosphorus (µg/L):	Secchi Transparency (meters):	Trophic State Index value:
Mesotrophic	2.6 – 20	12 - 24	2 - 4	40 - 50
Eutrophic	21 - 56	25 - 96	0.5 - 2	51 - 70
Hypereutrophic	57 +	97 +	< 0.5	71 +

Carlson's Trophic State Index

The Carlson's Trophic State Index (TSI) is an index that was developed to compare different lake water quality values against one another on the same scale. The index uses raw numbers from analyses and converts them on a scale from <30 – 100+. Ranges of index numbers inform the reader about the overall nutrient status and productivity of the lake. While nutrients are important for aquatic life, an overabundance of nutrients can lead to nuisance algae blooms, limit water clarity, and have other negative impacts on the lake. There are 4 classes of lakes that are described within this index. These classes are oligotrophy (nutrient poor), mesotrophy (intermediate nutrient levels), eutrophy (nutrient rich), and hypereutrophy (extremely nutrient rich). In Iowa, we usually see 3 of these classes (mesotrophy through hypereutrophy). Classes are described in the Table 2. DNR uses index values for both chlorophyll a and Secchi Depth to assess water quality in our public lakes under the Clean Water Act.

Table 2. Photos show water clarity with Secchi disk (black and white disk pictured) at 0.2 meters deep. Photos are courtesy of the Iowa State University Limnology Laboratory.

Lake type:	Description:
Oligotrophic (Nutrient Poor) 	Oligotrophic lakes have low algae production, or primary productivity, due to low nutrient content. They are often characterized by clear waters with some submerged/rooted vegetation. They typically have ample dissolved oxygen and support diverse fisheries and communities of aquatic organisms. These types of lakes are most often found in colder regions of the world with igneous bedrock.
Mesotrophic (Intermediate Nutrient Levels) 	This group of lakes has as intermediate level of algal productivity. Lakes are characterized by relatively clear water and an abundance of submerged plants. These lakes typically support large fish populations, although they may not support very oxygen sensitive fish.
Eutrophic (Nutrient Rich) 	The majority of Iowa lakes fall into this category. This group is characterized by high levels of nutrients (especially phosphorus and nitrogen) that cause frequent algae blooms and an abundance of aquatic plants (when light penetrates to the bottom of the lake). Oxygen concentrations in these lake vary with algae production and decomposition, thus, large fisheries can be sustained under the right conditions but are frequently subjected to oxygen stress.
Hypereutrophic (Extremely Nutrient Rich) 	This class of lakes is characterized by extremely high levels of nutrients that cause frequent algae blooms, usually dominated by blue-green algal species, and very low water clarity (typically less than 3 feet of transparency). These lakes often are pea-soup colored and filled with thick algal scums. They also can have very low oxygen concentrations as algae decompose and sink to the bottom of the lake. As a result, they may not be able to support thriving fisheries or other aquatic life.

Phytoplankton and Zooplankton

Phytoplankton (green algae, diatoms, cyanobacteria (blue green algae), dinoflagellates, etc.) are microscopic plants and animals that photosynthesize in lakes (aka primary producers). These organisms form the base for many aquatic food webs. In low densities, certain groups and types of algae serve as excellent food sources for other organisms. When lakes are polluted with high levels of nutrients, such as nitrogen and phosphorus, however; phytoplankton become over-abundant, turning the surface of lakes green, forming dense algal scums and mats, and causing water taste and odor problems. The types of phytoplankton found also shifts with increased pollution, moving from a healthy community that serves as the base of food webs, to blue-green, or cyanobacterial forms. Many species of these blue-green algae produce toxins that can cause skin irritation and illnesses. At high levels, these toxins can also cause tissue damage and death in humans and animals. High phytoplankton biomasses can also contribute to low oxygen and high pH levels in lakes, putting stress on fish and other plants and animals.

Zooplankton are microscopic animals, mainly crustaceans, that feed on phytoplankton in lakes and serve as important sources of food for fish and other aquatic life. Identifying and measuring the diversity and abundance of these organisms in our lakes can help us better understand the overall health of the aquatic ecosystem. Reduced diversity of zooplankton is frequently observed in very nutrient rich, or hypereutrophic, lakes. Some species of zooplankton have also been used as an indicator for good water quality.

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