Appendix A

Parameter Information and Investigation

To make sense of the data that you collect, it is useful to know a little more about the parameters that you are measuring, and some of the effects that different discharges or land uses may have on these parameters. The following information is provided to assist you in determining whether your data suggests good or poor water quality. It also should help you begin to identify reasons why the water quality may be poor, which in turn should help you identify steps that need to be taken to improve water quality. If you find that Illinois water quality criteria are not met in your stream, contact Prairie Rivers Network.

Temperature

Background

Temperature is an important parameter to measure because it effects the rates of chemical reactions. Biological reactions such as photosynthesis and metabolic rates of aquatic organisms are affected by temperature. Different organisms survive better at different temperatures; every organism's biological reactions are optimal at specific temperatures.

Stream and river temperatures are affected by the air temperature, removal of trees and shade, soil erosion, and also thermal pollution from power plants or storm water runoff (water entering the stream at higher temperatures than the water already present).

Temperature of air and water will be taken in degrees Celsius.

Illinois Water Quality Criteria

At the time of this printing, the Illinois water quality criteria prohibit "abnormal temperature changes that may adversely affect aquatic life," and state that the "rise above natural temperature shall not exceed 2.8º C." The criteria further state that water temperature at representative locations shall not exceed 17.7º C during the months December through March, and shall not exceed 33.7º C during April through November.

A good way to apply the first part of this rule is to test a stream above and below a point of discharge. If the discharge causes the water temperature to rise more than 2.8º C, there may be a violation. If you suspect this, be sure to test above the discharge at a number of places, at the discharge, and below the discharge at varying distances.

If you suspect a problem, monitor more frequently. If your first temperature measurement was taken in the morning, return in the afternoon to determine the temperature at the warmest time of day. Collect additional data for several days to determine if the exceedance is an ongoing problem. Many consistently measured data points are more reliable and valuable than one or two data points.

Dissolved Oxygen (DO)

Background

Nearly all organisms require oxygen for survival. Through the churning action of running water as well as plant photosynthesis, oxygen is transferred from the air into water in its dissolved form. Aquatic organisms can use it for respiration, decomposition, and other biochemical reactions. When oxygen levels in a stream are very low, below 1.0 or 2.0 mg/L, most organisms will not survive. Levels greater than 5.0 or 6.0 mg/L are generally considered supportive of growth and survival.

The oxygen levels in a stream are dependent on other chemicals in the water, temperature, plant and animal respiration and decomposition. Wastewater from sewage treatment plants, industrial wastewater, failing septic systems and storm water runoff from farmland, feedlots, and urban streets often contain organic materials. The decomposition of these materials by microorganisms in the stream requires oxygen, decreasing the amount of oxygen available to fish and macroinvertebrates. Other factors that can cause a change in DO levels are the presence of dams and removal of vegetation. Water released by a dam from the bottom of a lake or reservoir often has very low DO levels, while water released from the top sometimes contains an excess of oxygen. The removal of vegetation reduces shade and decreases the protection from erosion. These together can increase the water temperature and reduce DO levels.

DO levels vary throughout a 24-hour period as well as seasonally. Aquatic plants and algae produce oxygen during daylight hours and take oxygen up during dark hours which causes in-stream concentrations to be highest in the afternoon and lowest just before dawn. Excess nutrients such as phosphorus cause these fluctuations to be very dramatic. The following table shows saturation oxygen concentrations in water with very low salinity at barometric pressure of 760 mm Hg. Use this table to determine if the dissolved oxygen in your sample is greater or less than saturation. If the dissolved oxygen concentration is greater than saturation on a warm day, you should return to the site early in the morning to determine if the concentration falls below the criterion.

Temperature °C	DO mg/L	Temperature °C	DO mg/L	Temperature °C	DO mg/L
0	14.6	11	11.1	22	8.9
1	14.2	12	10.9	23	8.7
2	13.8	13	10.6	24	8.6
3	13.5	14	10.4	25	8.4
4	13.1	15	10.2	26	8.2
5	12.8	16	10.0	27	8.1
6	12.5	17	9.8	28	7.9
7	12.2	18	9.6	29	7.8
8	11.9	19	9.4	30	7.7
9	11.6	20	9.2		
10	11.3	21	9.0		

DO is measured in milligrams per liter, which is equivalent to parts per million (ppm) dissolved oxygen.

Illinois Water Quality Criteria

At the time of this printing, dissolved oxygen water quality criteria state that concentration should not be less than 6.0 mg/L during 16 hours each day, and it should never fall below 5.0 mg/L during any part of the day.

Between the hours of 9 AM and 9 PM, dissolved oxygen levels will probably be at their highest. Be aware that values under 6.0 mg/L during these hours may be problematic. Because dissolved oxygen can vary substantially during a 24 hour period, if you suspect a problem, return to the site as early in the morning as you can (before dawn if possible), to determine the oxygen concentrations at their lowest point in the day.   Also continue to monitor the site for several days at similar times.

pH

Background

pH is a measurement of logarithmic concentration of hydrogen (H^+) and hydroxide (OH^-) ions in a sample of water. At pH=7.0, hydrogen and hydroxide ions are at equal concentrations and the water is deemed neutral. At pH values of less than 7, more hydrogen ions are in solution and the water is acidic. Likewise, at pH values of 7 to 14, the water is alkaline with more hydroxide ions. Because the scale is logarithmic, a difference of 1.0 unit in pH represents a 10-fold change in acidity or alkalinity. For example, a pH of 5 is 10 times more acidic than a pH of 6, and a pH of 4 is 100 times more acidic than a pH of 6.

Most aquatic organisms prefer a range of 6.5-8.0, but some organisms prefer more acidic or alkaline environments. Often in water with a low pH, toxic elements, such as metals, are more soluble and therefore more toxic to aquatic organisms. On the other hand, ammonia is more toxic to aquatic organisms at a high pH. Most organisms do not respond well to sudden or drastic changes in pH.

Acid rain, rocks and soils, wastewater discharges, and algae and plant growth can affect pH. Emissions of nitrogen oxides and sulfur dioxides, often from automobiles and coal-fired power plants, can result in acid rain or snow. The geology of the watershed determines how well the water can deal with acidic elements and thus the pH of the water. Presence of algae and plants in the water cause pH to fluctuate slightly during the day because carbon dioxide, which is taken up during photosynthesis and released during night time respiration, forms some acid when dissolved in water.

Illinois Water Quality Criteria

At the time of this printing, Illinois State water quality criteria require that pH should be between 6.5 and 9.0 except for natural causes.

If your waters have a pH of less than 6.5 or greater than 9.0, examine and research the geology of the area before assuming the causes are unnatural.

Alkalinity

Background

Alkalinity measures the water's ability to neutralize, or buffer, acids. Ions enter the water and neutralizing compounds (alkaline compounds such as bicarbonates) remove the ions and lower the water's acidity. Without these neutralizing compounds, acid entering the stream would cause drastic changes in pH, to which most organisms do not respond well.

A stream's alkalinity is highly influenced by rocks and soils. Limestone deposits cause a high amount of alkaline compounds to enter the water, and streams that pass through them are able to neutralize acids very well because of this. Rainfall, snow-fall, and some industrial wastewater discharges also influence alkalinity.

Alkalinity is measured in milligrams per liter (mg/L) $CaCO_3$.

Illinois Water Quality Criteria

There is no criterion for alkalinity.

Alkalinity can be used to help understand the geology of your stream. According to BASIN, Boulder, Colorado's environmental information outreach program, for freshwaters, measurements of 20-200 mg/L are generally normal. Higher measure-ments are not problematic. When alkalinity falls below 10 mg/L, that can indicate that a stream has poor capability to buffer acids entering it. Acidic discharges in these waters would be more dangerous than in streams with high alkalinity.

Nitrate-Nitrogen

Background

Nitrogen is an essential component of life. Organic nitrogen is found in proteins and cells of all living things. Inorganic nitrogen exists as gas, nitrates, nitrites, or ammonia. Nitrates are essential plant nutrients and are commonly found in water. In excess they can contribute to an overabundance of aquatic plant growth and algal blooms, leading to dramatic fluctuations and low levels of dissolved oxygen. Under certain conditions, high concentrations of nitrates can become toxic to warm-blooded animals. Infants are particularly susceptible and should not drink water that is high in nitrate.

Excess nitrates found in water come from poorly functioning septic systems, wastewater from sewage treatment plants, runoff from fertilized yards and agricultural land, and livestock manure.

Nitrates are measured in milligrams per liter (mg/L), which is equivalent to parts per million (ppm).

Illinois Water Quality Criteria

Illinois water quality criteria require that for waters used for public water supply, nitrate-nitrogen shall not exceed 10 mg/L. There is no criterion for waters that are not used for public water supply. However, IEPA uses a threshold of 7.8 mg/L of nitrate-N as an indicator of excessive nitrate, and the statewide average concentration is approximately 3.9 mg/L nitrate-N.

Orthophosphate

Background

Phosphorus is typically the limiting nutrient for plant growth in Illinois. Because it is limiting, even small increases can have a dramatic impact on streams and rivers, causing excessive plant and algal growth, lowered dissolved oxygen levels, and sometimes death of some aquatic animals. The most easily used, and therefore most problematic, form of phosphorus is *orthophosphate*.

An increase in phosphorus can be caused by wastewater from sewage treatment plants, runoff from fertilized lands (farmland, parks, lawns, and golf courses), runoff from land treated with animal manure, drained wetlands, or failing septic systems.

The Stream Team kit can be used to determine the amount of orthophosphate (PO_4) and the amount of phosphorus (P) that is in the form of orthophosphate, referred to as orthophosphate-P or PO_4-P. These are measured in parts per million (ppm), or mg/L. Note that orthophosphate-P is only one form of phosphorus. Therefore, the concentration of total phosphorus would be higher than the concentration of orthophosphate-P.

Illinois Water Quality Criteria

At the time of this printing, Illinois water quality criteria require that total phosphorus shall not exceed 0.05 mg/L in lakes and reservoirs, or in a stream at the point where it enters a lake or reservoir.

IEPA does not currently have phosphorus criteria for flowing waters, but it anticipates adopting criteria by 2008. The IEPA does use 0.61 mg/L of total phosphorus as a threshold for excessive phosphorus concentrations. The statewide average total phosphorus concentration is approximately 0.38 mg/L. Since orthophosphate-P is only a portion of the total P, a typical concentration of orthophosphate-P is less than 0.3 mg/L.

Total Suspended Solids

Background

Total suspended solids (TSS) is a measure of the amount of suspended particles in a water sample. Most often TSS measurements are taken using a filter that is dried in an oven and weighed, giving an exact measurement. The use of the Ohio Sediment Stick provides an estimate of TSS with a reasonable degree of accuracy without a filter and drying oven. High TSS prevents light from reaching submerged vegetation, in turn slowing photosynthesis and the release of oxygen into water from plants. This can cause plants to die, and these together can result in low dissolved oxygen levels. Also, particles making up TSS absorb sunlight, increasing the water temperature. High TSS can also limit visibility for fish catching food, interfere with fish gills, smother fish and insect eggs, and destroy habitat.

The substances contributing to TSS include soil, algae, microorganisms, and decaying matter. In faster flowing streams, the amount of total suspended solids are sometimes greater, while in slower moving streams solids can settle to the bottom faster and TSS measurements are lower.

An increase in TSS is often caused by soil erosion from development, construction, quarries, gravel mining, or agricultural areas that have not adopted good management practices to prevent soil erosion.

Illinois Water Quality Criteria

Illinois currently has no water quality criteria for total suspended solids, but the State considers measurements greater than 116 mg/L to be potential cause for stream impairment.

Using the Ohio Sediment Stick, this corresponds to less than 4.0 inches.

Stream Flow

Background

Stream flow is a measurement of the volume of water that moves over a designated point over a certain period of time. Flow affects water quality because during high flows, rivers receiving continuous pollution discharges have a greater capacity to dilute the wastes compared to small, slower streams. Velocity is closely related to flow and increases as the volume of water in the stream increases. Different organisms prefer living in streams with different velocities; some organisms need fast-flowing habitats while others prefer quiet pools. The amount of silt and sediment carried by the stream is also determined by stream velocity. In slower streams, sediment will settle quickly at the bottom while in faster streams sediment will be kept suspended longer. Also, because of the greater churning action in faster moving streams, dissolved oxygen levels are often higher than in slow moving streams.

Irrigation and industrial activities that withdraw water from streams can dramatically decrease stream flow. Dams used for electric power often block stream flow and then release it in a surge.

The float method is the most common way for volunteers to measure stream flow.

Stream flow is measured in cubic feet per second (ft^3/sec)

Water Observations

The appearance and odor of the stream also can help you identify potential sources of pollution. The following interpretations of water observations are adapted from the Delaware Stream Watch *Technical Monitoring Volunteer Manual*.

Water Color

Clear – Colorless and transparent, clear water may indicate good water quality.
Milky – Cloudy white or gray and not transparent, a milky appearance may be indicative of excess bacteria and/or total suspended solids.
Green/Blue-green – Green to blue-green, the water may appear nearly black. This may be the result of algal blooms, which are caused by an increase of nutrients released into the stream.
Reddish – Ranging from orange to red, this color may indicate acids draining into the water or the presence of synthetic dyes.
Brown/Tea – This color ranges from yellow brown to dark brown. Water that is a dark tea color is commonly called "black water" and indicates tannic acids released from decaying plants. This occurs naturally each fall when trees drop leaves.
Muddy – Light brown and cloudy, this is often caused by the sediment depositing during erosion or entering the stream from construction sites or other disturbed areas.

Water Odor

Rotten Egg – A sulfurous smell can indicate sewage pollution, since hydrogen sulfide gas is a product of sewage decomposition, though it can also be due to plant or algae

decomposition.
Sewage – This can indicate the release of human waste material, untreated domestic sewage or livestock waste, though it can also be due to plant or algae decomposition.
Chlorine – This may indicate that a sewage treatment system effluent is over-chlorinated or is not properly de-chlorinated.
Fishy – This may indicate the presence of excessive algal growth or dead fish
Musky – This may indicate the presence of untreated sewage, livestock waste, algae, or other conditions.
Petroleum – This may indicate an oil spill from marine or terrestrial sources.

Surface coating

Scum – Usually resulting from algal blooms, a scum coating may indicate a high nutrient input from fertilizer or other organic matter.
Foam – Usually white or brownish-white, a small amount of foam will often occur naturally below an area of turbulence. However, iridescent bubbles can indicate the presence of detergent.
Oily – A multicolored reflection on the water surface can occur naturally as a result of decay or deposition of iron oxide, but it can also indicate oil floating in the stream.

Streambed coating

Orange-red – If in suspension, an orange-red streambed coating often occurs with an oily surface coating. This indicates that iron in groundwater is being oxidized as the groundwater seeps to the surface, resulting in naturally occurring iron oxide. Iron is also associated with mining operations.
Green – This will probably be caused by algae growing on the stream bottom.
Black – This is common in brackish waters, indicating low availability of oxygen and often resulting from decaying organic matter.
Brown – Some algae may be brown or yellowish brown. Excessive algae growth can be caused by a high amount of nutrients.
Grayish-white – This is often observed as cottony masses that could be sewage fungus.
Yellow – This may indicate sulfur entering the stream.

Quick Reference Safe Levels Chart

Parameter	Concern Range	Safe Range
Water Temperature	Above 17.7 °C (Dec - Mar), above 33.7 °C (Apr - Nov)	Below 17.7 °C (Dec - Mar), below 33.7 °C (Apr - Nov)
Dissolved Oxygen	0-5.0 mg/L	Above 6.0 mg/L
pH	0-6.4, 9.1-14.0	6.5-9.0
Alkalinity	0-10 mg/L	Above 20 mg/L
Nitrate-Nitrogen	Above 7.8 mg/L	unknown; 0 - 3.8 mg/L is less than average
Orthophosphate	Above 0.6 mg/L for streams; above 0.05 for lakes	unknown; 0 – 0.3 is probably less than average
Total Suspended Solids	Above 116.0 mg/L	unknown