LESSON 2: APPENDIX A
CONSTITUENTS OF WATER AND THEIR IMPORTANCE

What is Ammonia?

Ammonia (NH_3), a form of nitrogen, is commonly found in terrestrial and aquatic ecosystems. Other forms of nitrogen include ammonium (NH_4^+), nitrates (NO_3^-), and nitrites (NO_{2-}). Ammonia is a colorless gas at standard temperature and pressure and is very soluble in low-pH (acidic) water.

Ammonia levels in zero-salinity surface water increase with increasing pH and temperature. Under low pH and temperature conditions, ammonia combines with water (H_2O) to produce an ammonium ion (NH_4^+) and a hydroxide ion (OH^-). The ammonium ion is nontoxic and not of concern to organisms. Above a pH of 9, however, ammonia is of major concern. Excess ammonia ((NH_3) may accumulate in an organism and cause changes in its metabolism or increases in its body pH. Fish may be subject to poorer hatching success, reductions in growth rate and morphological development, and injuries to gill, liver, and kidney tissues.

What is Dissolved Oxygen?

Oxygen in its dissolved form in water is measured as dissolved oxygen (DO). A stream system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis. Because running water churns, it dissolves more oxygen than still water. Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen in the water. DO levels fluctuate both seasonally and over a 24-hour period. Levels also vary with changes in water temperature and altitude.

Oxygen is as important to life in water as it is to life on land. Most aquatic plants and animals require oxygen for survival and the availability of oxygen affects their growth and development. When excessive organic materials such as animal waste enter a stream, microorganisms in the water feed on this organic material and consume DO in the process. With warm temperatures, these microorganisms can proliferate to such a degree that their consumption of DO will suffocate fish and other aquatic life.

What are Nitrates?

Nitrates (NO_3^-) are another form of nitrogen. Nitrates from land sources end up in water bodies more quickly than other nutrients such as phosphorous. This is because they

dissolve in water more readily than phosphates, which have a stronger affinity for soil particles. Together with phosphorous, nitrates in excessive amounts can cause dramatic increase in aquatic plant growth, which in turn reduces dissolved oxygen (DO) concentrations. Elevated levels of nitrates can be toxic to humans, especially children because the nitrates prevent hemoglobin from binding oxygen and transporting it to vital tissues.

What is pH?

The alkalinity or acidity of a solution is described in terms of the solutions pH level. Water (H_2O) contains both hydrogen ions (H^+) and hydroxide ions (OH^-). The relative concentrations of these ions determine whether a solution is acidic or basic (alkaline). The pH scale ranges from 1 (most acidic) to 14 (most basic), with 7 (pure water) being neutral. It is important to remember that pH is measured on a logarithmic scale: A change of 1 pH means a ten-fold change in the ion concentrations.

The pH value affects many chemical and biological processes in the water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefers a pH range of 6.5 to 8.5. When the pH value falls outside of this range, the stream's biological diversity suffers because of stresses to the physiological systems of most organisms that can, among other things, reduce reproduction. Low pH conditions can also allow toxic elements and compounds to become available for uptake by plants and animals.

What is Phosphorus?

Phosphorus is the eleventh-most abundant mineral in the earth's crust and commonly occurs in water in the form of phosphate ions (HPO_4^{2-}) and $H_2PO_4^-$). Phosphorus is in short supply in most water bodies, but even a modest increase in phosphorus can, under the right conditions, set off a chain of undesirable events in a stream including accelerated plant growth, algae blooms, decreased dissolved oxygen, and the death of certain fish and invertebrates. Unlike nitrogen and other nutrients, phosphorus does not have a gaseous phase; it adsorbs to soil particles or is incorporated into organic matter. Once phosphorus enters an aquatic system, it tends to remain there unless physically removed.

What are Salinity and Conductivity?

Conductivity is a measure of the ability of water to pass an electric current. It is used to determine the salinity of water. The natural concentration of salts in a waterway is largely influenced by the geology of the area through which the water flows. Streams that run through areas with clay soils (e.g. ancient marine sediments) tend to have

higher conductivity because of the presence of materials that ionize when washed into water.

High salinity may interfere with the growth of aquatic vegetation. Salt may decrease the osmotic pressure, causing water to flow out of the plant in order to achieve equilibrium, and this in turn causes stunted growth, leaf tip burn and marginal leaf burn, bleaching or defoliation. Some freshwater organisms are salt tolerant and may invade or replace native species.

Inadequate drainage or excessive evaporation from agricultural fields may lead to an accumulation of salts in the soil. High salt concentrations in the soil around plant roots may cause plant dehydration by reversing osmotic conditions. In some cases, rather than destroying a crop, elevated salt levels may simply reduce crop yields and leave the plants prone to disease.

Why is Temperature Important?

The rates of biological and chemical processes depend on temperature. Temperature affects

1. ***dissolved oxygen levels*** – Colder water can hold more dissolved oxygen than warmer water, so colder water generally has a higher diversity of macro invertebrates. Warmer water has less dissolved oxygen. Lower oxygen levels weaken fish and aquatic insects, making them susceptible to illness and disease.
2. ***rate of photosynthesis*** – Photosynthesis by algae and aquatic plants increases with increasing temperature. Increased plant/algae growth leads to increased death and decomposition, resulting in decreased oxygen consumption by bacteria.
3. ***metabolic rates of aquatic organisms*** – Many animals require specific temperatures for survival. Water temperature controls their metabolic rates, and most organisms operate efficiently within a limited temperature range. Aquatic organisms die when temperatures become too high or too low. Fish species are particularly sensitive to temperature changes, which can affect reproduction and the growth of juveniles.

What is Turbidity?

Turbidity is the measure of water clarity, the degree to which suspended material in the water decreases the passage of light through the water. Higher turbidity increases water temperatures because the suspended particles in water absorb heat. This reduces the water's concentration of dissolved oxygen (DO), since warm water holds less DO than cold water. Higher turbidity also reduces the amount of light that can penetrate the water, which reduces photosynthesis and the production of DO. Suspended particles

can clog the gills of fish. If the particles settle out of the water, they can smother spawning beds (gravel), fish eggs, and benthic organisms. Sediment can also carry pathogens, nutrients, and pesticides downstream.

Note that turbidity is not a measurement of the *amount* of suspended solids present or the rate of sedimentation in a stream; it measures only the scattering of light by suspended particles. Measurement of total solids is a more direct means for measuring the amount of material suspended and dissolved in the water.

Table 1. Water quality tests and what they measure

TEST FOR:	WHY MEASURE IT?	MEASURING TOOLS:
Ammonia	**Toxic levels of ammonia can kill fish and other aquatic organisms. Water temperatures strongly influence the toxicity of ammonia.**	**Ammonia test kit or ammonia meter**
Dissolve O_2 (DO)	Low levels of dissolved oxygen affect the growth and development of plants and animals.	Dissolved oxygen test kit or meter
Nitrate	If enough phosphorus is available, a high concentration of nitrates will result in an increase in algae growth	Nitrate test kit, meter, or test strips
pH	pH affects many chemical and biological processes in the water.	Meter or litmus test strips
Phosphorus	If too much phosphate is present, algae blooms may develop that could later lead to the depletion of dissolved oxygen.	Phosphate test kit, meter or test strips
Salinity/Conductivity	The level of salinity in water is often critical to the survival of many aquatic plants and animals	Alkalinity (chloride test kit or TDS/conductivity meter
Temperature	Every aquatic organism has upper and lower temperature limits; temperatures outside these limits will affect the health of the organism.	Alcohol-filled thermometer, if available
Turbidity/sediment	Sediments can carry pollutants that bind to soil particles. They can also have a negative effect on fish health and spawning habitat.	Imhoff cone or turbidity meter

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