Introduction to Water Quality Values

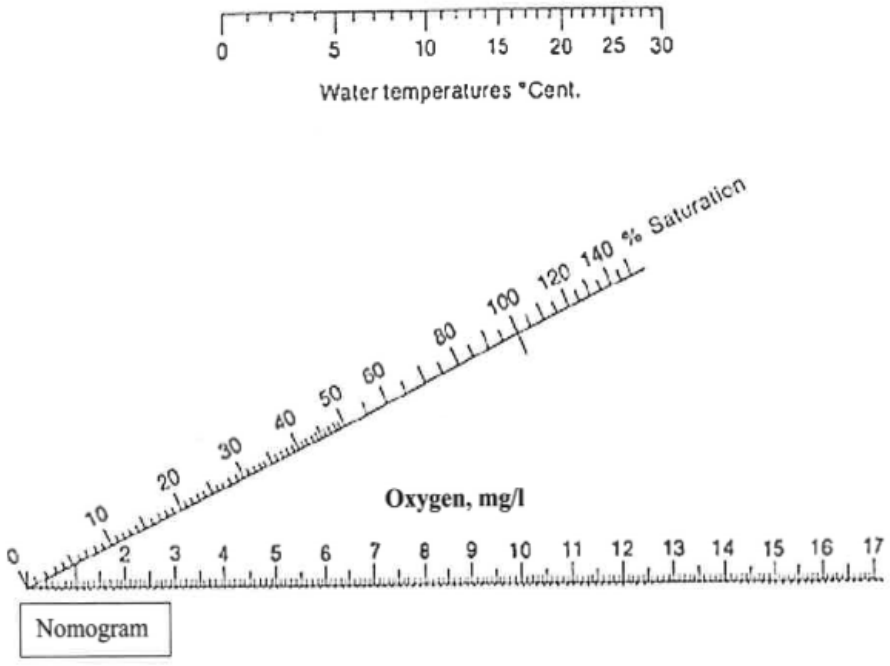
Dissolved Oxygen

Just like people need oxygen to live, aquatic animals (fish, aquatic insects, etc.) and aquatic plants need dissolved oxygen in their environment in order to survive. Dissolved oxygen (DO) is simply oxygen that is dissolved in water. Sources of oxygen for water include the adsorption by water at the air-water interface and the byproduct of aquatic plant photosynthesis (the method of how plants make food).

Optimal levels for salmon are 9.0 mg/L; 7.0 – 8.0 mg/L is acceptable, 3.5 – 6.0 mg/L poor; anything below 3.5 mg/L is fatal to salmon. DO levels below 3.0 mg/L are stressful to most forms of aquatic life.

Measuring DO in water tells you how much dissolved oxygen is present but not how much oxygen the water is *capable* of dissolving. When water dissolves all of the oxygen it is capable of holding at a given temperature, the water is said to be 100% saturated.

For a quick and easy determination of the percent saturation value for dissolved oxygen at a given temperature, use the nomogram below. Pair up the mg/l of dissolved oxygen you measured and the temperature of the water in degrees C. Draw a straight line between the water temperature and the mg/l of dissolved oxygen. The percent saturation is the value where the line intercepts the saturation scale.



Nomogram

Biological or Biochemical Oxygen Demand – BOD

BOD is the amount of oxygen consumed during the decomposition of plant and animal material. This is important to know because if there is high BOD it means that oxygen levels can become very low and cause problems for aquatic life in the stream. The optimal level for BOD is <6mg/L. BOD=DO day 1 – DO day 5

Temperature

Stream temperature controls the metabolic function of animals and plants and also the reproductive timing and duration; in other words the life cycle of aquatic organisms. Temperature can also affect other water quality parameters like dissolved oxygen. Remember, warmer water contains less dissolved oxygen; water can be 100% saturated at higher temperatures but still contain levels of dissolved oxygen that stress fish and other aquatic organisms.

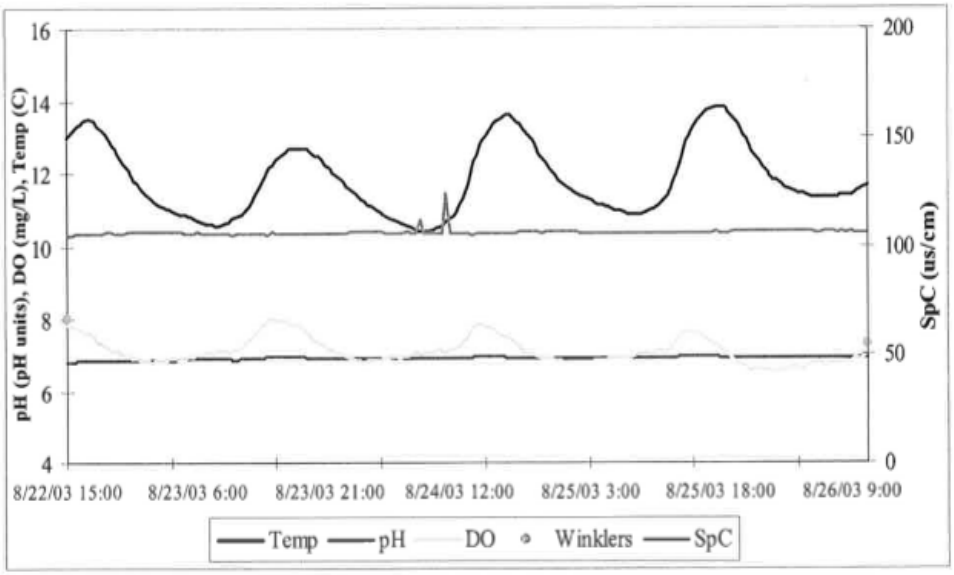
Temperature is one of the most important parameters for fish, especially salmon. Young salmon need temperatures of around 9°Celsius; adult salmon need 12°Celsius. Stream temperatures should not exceed 18°Celsius and anything over 21°Celsius is unacceptable.

Easy way to roughly convert Celsius to Fahrenheit and vice versa:

Celsius = Fahrenheit – 30 then divide by 2

Fahrenheit = Celsius * 2 then add 30

Key Point: Lowest DO levels occur just before dawn and are highest in the mid-afternoon (see graph below).



Woodland Creek at River Mile 3.1

pH

pH is a measurement of the hydrogen ion concentration of a solution. This tells us whether a solution is acidic or alkaline (also known as basic). pH is actually an acronym for the French words "puissance d'Hydrogene", which translates to English as "strength of Hydrogen".

pH values range from 0 to 14; values with a pH less than 7 are considered acidic, 7 is neutral and above 7 is considered alkaline or basic. The units of measure are called "Standard Units" sometimes shown as "SU". The pH scale is logarithmic not linear. This means a pH value of "6" is 10 times more acidic than a pH value of "7".

The determination of the pH of a waterbody is dependent on:

- The natural geology of the area (some rocks have minerals that, when dissolved in water are acidic or alkaline).
- The type of vegetation in and near a waterbody (bogs and swampy areas typically have much more acidic water).
- Human influences. Some of the human influences on a waterbody's pH include acid rain (when fossil fuels are refined or burned and the resulting chemicals mix with rain), stormwater and sewage effluent.

Also, when aquatic plants and algae are photosynthesizing (making food) during daylight hours, pH values can rise because carbonic acid (dissolved carbon dioxide gas in water) is removed as part of the photosynthetic process, thereby making the water more alkaline or basic. The opposite occurs at night when the plants are respiring (producing energy from carbohydrates). Carbon dioxide is given off (making carbonic acid) and the water becomes more acidic.

In Western Washington, the geology of the area is a lot of granite and other rocks that make the pH of streams more on the acidic side – 6.5 to 7.5. On the east side of the mountains the geology is much different and the pH's tend to be more alkaline or basic.

The table to the right gives the pH values of some commonly recognized substances:

Representative pH values

Substance	pH
Battery Acid	0.5
Stomach Acid	1.5 – 2.0
Lemon Juice	2.4
Cola	2.5
Vinegar	2.9
Orange Juice	3.5
Tomato Juice	4.0
Acid Rain	5.0 or less
Coffee	5.0
Healthy Skin	5.0
Urine	6.0
Milk	6.5
Pure Water	7.0
Health Human Saliva	6.5 - 7.4
Blood	7.3 – 7.5
Seawater	7.7 – 8.3
Baking Soda	8.4
Hand Soap	9.0 – 10.0
Household Ammonia	11.5
Bleach	12.5
Household Lye	13.5

Nitrates

Nitrate is the form of nitrogen which is used as food by plants and animals – both aquatic and terrestrial. The concentration and supply of nitrates to a waterbody is intimately connected with the land use practices of the surrounding watershed. Nitrates can come from animal waste (including human sewage), fertilizers and stormwater run-off.

Excessive amounts of nitrates can cause too much aquatic plant and algal growth which in turn can lower the dissolved oxygen levels when the plants die and decompose. In marine waterbodies, nitrogen (in the form of nitrate) is typically the nutrient which is in the shortest supply; therefore the nutrient which is the most limiting with regard to plant and algal growth. In a freshwater system, phosphorus is typically the nutrient which limits plant and algal growth. However nitrates are still important in freshwater systems and typically should be below 1.0 mg/L.

Another problem associated with high nitrate levels is when the nitrates enter our drinking water systems. This can lead to a medical condition called methemoglobinemia which affects the bloods ability to carry oxygen. It was historically referred to as "blue-baby syndrome" because the lack of oxygen caused the veins and skin to appear blue. However pregnant women and the elderly can also be affected. The EPA has determined levels of nitrates in drinking water should be no more than 10 mg/L.

Turbidity/ Total Suspended Solids

Turbidity and total suspended solids (TSS) measure the amount of solid material suspended in the water. This solid material can be a combination of sediment, algae, aquatic animals - anything that can be suspended in the water.

Turbidity measures the scattered light from a sample (the light that bounces off of suspended solids in the water sample). The more suspended solids, the more scattering of light. The turbidity units are called Jackson Turbidity Units (JTU).

Total suspended solids (TSS) are not addressed in Washington's water quality standards, except indirectly by way of the turbidity standard. The National Academy of Sciences considers the following TSS values to be levels of protection to aquatic life:

- < 25 mg/L – high level of protection to aquatic life
- 25 to 80 mg/L – moderate level of protection to aquatic life
- 80 to 400 mg/L – low level of protection to aquatic life
- > 400 mg/L – very low level of protection to aquatic life

To measure total suspended solids, the water sample is filtered and the filter is put in a drying oven for a set period of time. The filter is then weighed and the total suspended solid result is shown as the weight of the material per volume of water sampled – typically milligrams/ Liter.

Erosion in the watershed, excessive plant and algae growth (caused by too much nitrogen and phosphorus in the water) and stormwater can all contribute to higher levels of turbidity and total suspended solids. Problems which occur include:

- The sediment can settle into the streambed reducing good fish spawning habitat.
- Waters that are high in turbidity and total suspended solids can also reduce the amount of light coming into the water and affect the ability of aquatic plants to photosynthesize (make food).
- Sediment particles provide an attachment for bacteria and metals.
- Turbid waters can impede a fish's ability to see and catch prey or escape predators.
- Sediment absorbs more sunlight, increasing water temperature.

Bacteria

There are thousands of different kinds of bacteria. The group of bacteria called "total coliforms" includes a sub-group called fecal coliforms. They are found in the intestinal tract of warm-blooded animals (humans, cows, ducks, etc.). Fecal coliforms are transmitted to water and soil by human and animal feces.

Not all bacteria are harmful to humans, even some of the fecal coliform bacteria. Bacteria live in our digestive tract and help in digestion; other bacteria help keep the world clean by decomposing plant and animal remains. Some bacteria produce the important vitamins, vitamin K and the B-complex vitamins.

However, some bacteria are harmful and do produce toxins. One strain of the bacteria *Escherichia coli* (commonly referred to as *E. coli*) is well known to most people as causing serious symptoms ranging from diarrhea to kidney failure.

It is important to protect humans from these harmful bacteria which could occur both in our drinking water as well as in the lakes and rivers where people recreate. Because it would be impossible to test for every kind of bacteria that is harmful to people, we limit our testing to the fecal coliform group since they serve as an "indicator" of those bacteria which are harmful to people. And sometimes we test specifically for the *E. coli* bacteria, depending on our resources.

Credit: Maggie Bell McKinnon, biologist, Washington State Department of Ecology