**Water Quality Testing**

Adapted from: *AP Environmental Science Investigations,* "Water Quality Index,"

**Note** You must take 2 pictures: 1 of the water source and a "selfie" at the exact site that you are taking the sample.
Go to (http://people.hws.edu/halfman/FL-Lim/FL-Limnology.htm) for information on water quality of the finger lakes.

Water Quality Index

The Water Quality Index (WQI) was developed in the early 1970s in an effort to compare the quality of water from all parts of the country. Over one hundred water-quality experts were called together to create this standard means of using one number to represent **nine** criteria for calculating the degree of water quality for a given body of water. The results are used to decide whether the water may be considered healthy, to monitor it over time, and to assess it relative to any other body of water on Earth.

This investigation prepares you to perform ***most of the nine tests*** to determine the WQI for our own Eco-Studies Pond. (Due to the fact that we are not equipped to perform all nine tests, we will approximate the WQI for some tests.) Usually these tests are repeated several times to get a full picture of how an ecosystem may change over a period of time.

Below are outlined the bases for these tests and what the tests measure.

**Dissolved Oxygen (DO):** Oxygen is not very soluble in water. What little gets into solution is vital to aquatic life and water quality. Most oxygen dissolved in streams, rivers, and lakes gets there by contact with the atmosphere. In streams and rivers, water splashing over rocks and waterfalls (as in our Eco-Studies Pond) traps oxygen in the water. Waves on rivers and lakes also increase the oxygen level in solution. Photosynthetic plants in the water also contribute a significant amount of oxygen to the water column.

This test determines the amount of oxygen that is dissolved in the water and is available to the aquatic life that lives there. If the DO levels are too low, fish can drown. A DO that is too low is often an indicator of possible water pollution. It also shows a potential for further pollution downstream because the ability of the stream to self-cleanse will be reduced.

**pH:** Pure water contains an equal amount of $H^+$ and $OH^-$ ions. Hydrogen ions are acidic and hydroxide ions are basic, or alkaline. pH measures the –log of the $H^+$ concentration. A pH of 7 is neutral; it is equally acidic and alkaline. pH values below 7 become more acidic and they approach zero as the $H^+$ ions increasingly outnumber the $OH^-$ ions. As the values climb above 7, the water is said to be basic. The water becomes more alkaline as the values approach 14 and the $OH^-$ ions outnumber the $H^+$ ions.

Many aquatic life forms are very sensitive to acid levels in the water. Pollution tends to make water acidic. Most bodies of water have the highest biological diversity when the pH is near 7.

**Temperature:** Water temperature is a very important parameter for a body of water. Most physical and biological processes are affected by the temperature. Most aquatic life requires an optimum temperature range to thrive and, like terrestrial life, finds survival difficult at extreme temperatures. Higher water temperatures lower the amount of dissolved oxygen for two reasons.

First, all gases are less soluble in warmer water. Second, warmer water increases the metabolic rate of aquatic organisms, which increases the consumption of food and dissolved oxygen.

The increase of water temperature is called *thermal pollution*, and it is a significant problem on some bodies of water. Most thermal pollution comes from the industrialization of rivers and waterways. Industries, especially large power plants, use large amounts of water to cool their machinery and equipment. Along smaller bodies of water, cutting trees takes away the shade and allows water temperatures to rise along riparian habitat. Another cause, large-scale logging, increases soil erosion and water turbidity (cloudiness), which, in turn, raises the water temperature to the detriment of aquatic life.

**Fecal Coliform:** Coliforms are a form of bacteria that are found in the intestines of warm-blooded animals; their presence in lakes, streams, and rivers is a sign of untreated sewage in the water. Fecal coliforms can get into the water from untreated human sewage or from farms and runoff from animal feed lots. While fecal coliforms themselves are not harmful to humans, their measures indicate the presence of harmful pathogens.

**Biological Oxygen Demand (BOD):** Aerobic bacteria in water eat organic matter and at the same time remove oxygen. When the organic material in dead aquatic plants is decomposed, it releases the nutrients nitrogen and phosphorous. These nutrients trigger more plant growth and more nutrients, which further lower oxygen levels. If there is too large an amount of organic material in the water, the oxygen levels can drop below what is necessary for other aquatic life forms.

The BOD test gives an approximation of the level of biodegradable waste there is in the water. This biodegradable waste can be leaves and grass clippings from human activities, animal waste and manure from food production, wood pulp from paper mills, or many other carbon-based wastes. Water with a high BOD usually has a high bacteria count as well.

**Nitrates ($NO_3^-$):** Nitrates are a crucial nutrient in aquatic environments for synthesis of amino acids and proteins, but serious problems can result from *eutrophication*, or excessive nutrient levels. Excess nitrates get into waterways as non-point source fertilizers and from defective septic and sewage treatment systems. Nitrates can also get into the water from natural processes related to the *nitrogen cycle.* Most excessive amounts of nitrates come from human-based activities such as runoff from fertilized land, animal wastes from feedlots, and treated municipal waste effluent. Nitrate pollution effects both surface and ground water. It has been implicated as the primary cause of the dead zones in the Gulf of Mexico, the Chesapeake Bay and Long Island Sound. Nitrates also get reduced to nitrites, which can be harmful to humans and fish.

**Total Phosphates ($PO_4^{3-}$):** Phosphates are another essential nutrient for aquatic plants, but only in very low concentrations. Excessive amounts of phosphorous build up easily, and small amounts can contaminate large volumes of water. Phosphorous gets into water from many sources, such as fertilizers, sewage and detergents. Phosphorous exists in water in both organic and inorganic forms.

**Total Dissolved Solids (TDS):** Solids can be found in water in two forms, dissolved or suspended. Dissolved substances will pass through any filter commonly used in a lab. Suspended solids will be stopped by a filter because they are larger than individual atoms, ions, and molecules. This test measures the many solids found dissolved in water, usually in the form of such ions as sodium ($Na^+$), magnesium ($Mg^{2+}$), calcium ($Ca^{2+}$), chloride ($Cl^-$), hydrogen carbonate ($HCO_3^-$), and sulfate ($SO_4^{2-}$).

Solids soluble in water can also be organic, though they are usually salts. A steady concentration of dissolved minerals is necessary for aquatic life—both as essential nutrients and to maintain the osmotic balance with the cells of organisms. Changes in concentration can lead to a weakening of the organism or even death. High levels of TDS can affect water clarity and photosynthesis and lead to a decline in the quality and taste of drinking water. Some sources of dissolved solids are road salts in winter, urban runoff through storm sewers, farm chemicals, sewage treatment effluent, and factors that increase soil erosion such as road building and clear-cut logging.

**Turbidity or Total Suspended Solids (TSS):** This is a measure of how light is scattered in the water column due to solids that do not dissolve but are small enough to be suspended in the water. The higher the turbidity, the murkier (cloudy) the water. Turbidity keeps light from penetrating into the water and interferes with plant photosynthetic oxygen production and primary productivity. Darkened water holds more heat, increasing the water temperature which in turn lowers the DO. Suspended solids can clog fish gills and, in the case of silt and clay settling to the bottom, also smother larvae and fill in nesting sites. These solids may come from soil erosion or channelization from dredging. Increased water flow rates erode stream banks and allow the water to carry a heavier load of particles, storm and sanitary sewage effluent, and increased algae growth.

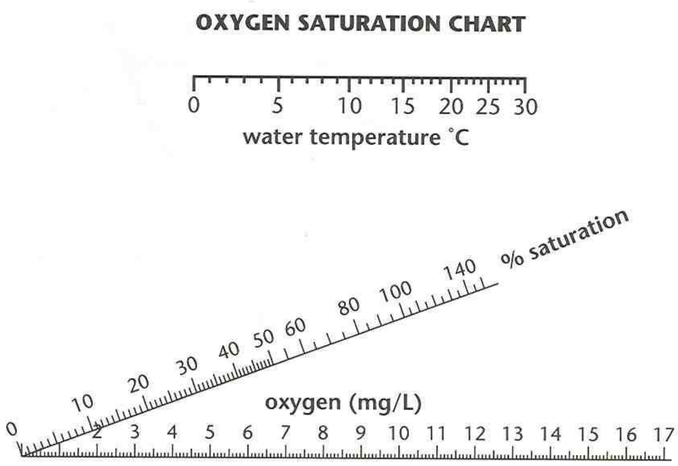
OBJECTIVE: Perform tests to determine the water quality of a local body of water

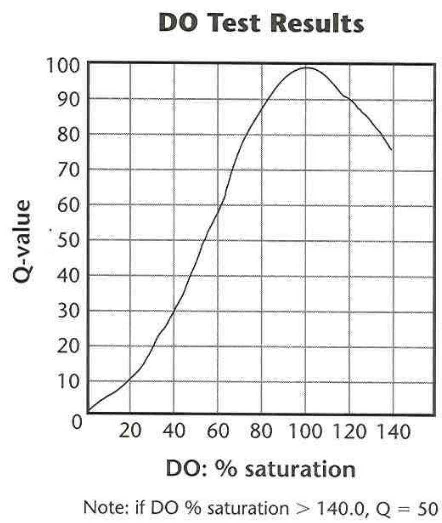
MATERIALS: LaMotte N•P•K Soil Kit ($NO_3^-$ and $PO_4^{3-}$ only) Latex gloves
SAFETY GOGGLES

PROCEDURES:

DISSOLVED OXYGEN (DO)

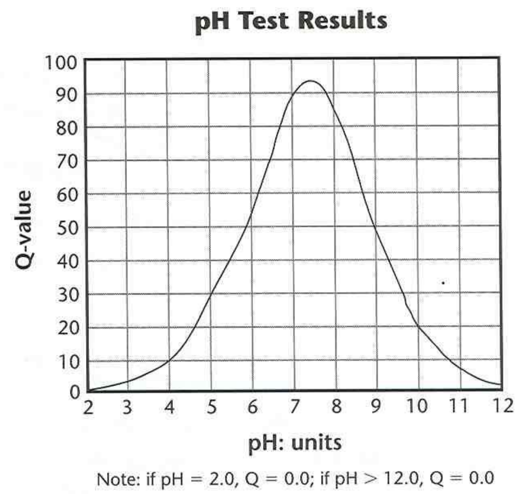
1. Follow the directions in the DO kit (titration)
2. Record the DO value on the DATA TABLE.
3. Determine the % saturation from the nomograph on the left below.
4. Record the % saturation on the DATA TABLE.
5. Determine the Q-value for DO % saturation using the graph on the right below.
6. Record the Q-value for DO % saturation on the DATA TABLE.



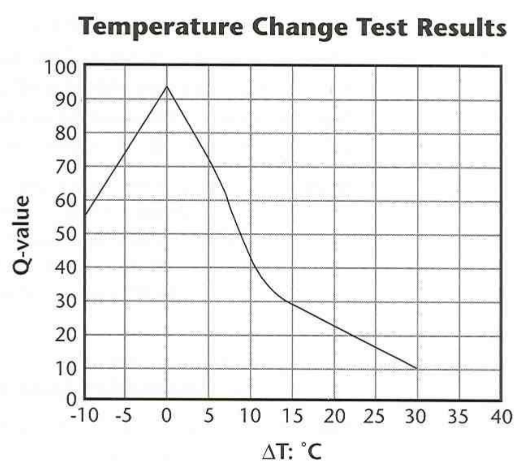

pH

7. Use a pH test strip to determine the pH of your sample.
8. Record your pH on the DATA TABLE.
9. Determine the Q-value for pH using the graph below.
10. Record the Q-value for pH on the DATA TABLE.




TEMPERATURE CHANGE, Δ°C

11. We will assume a 0°C temperature change for this lab.
12. Determine the Q-value for Δ°C using the graph below.
13. Record the Q-value for Δ°C on the DATA TABLE.




BIOLOGICAL OXYGEN DEMAND (BOD)

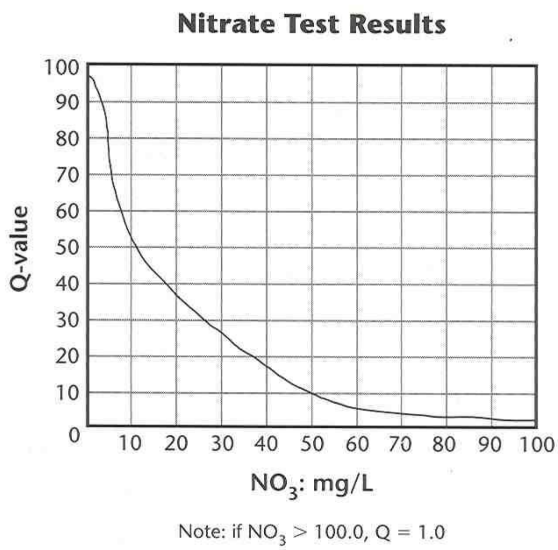
14. You will need a separate sample for BOD. You must immediately wrap the bottle in aluminum foil and test 5 days later.
15. Use the DO results from previous test.
16. Record your DO on the DATA TABLE.
17. Determine the BOD by subtracting the DO of the dark bottle from the DO in Step 2.
18. Record the BOD on the DATA TABLE.

NITRATE ($NO_3^-$) – LaMotte N•P•K Soil Kit

19. Follow all instructions included in the Nitrate Kit.
20. Compare the pink color of the solution to the Nitrogen Color Chart.
21. Determine the quantitative mg/L value for $NO_3^-$ as follows:

**L**ow $NO_3^-$: 17.5 mg/L **M**edium $NO_3^-$: 50.5 mg/L **H**igh $NO_3^-$: 83.0 mg/L

22. Record this value on the DATA TABLE.
23. Using the graph below, determine the Q-value for $NO_3^-$.
24. Record the Q-value for $NO_3^-$ on the DATA TABLE.

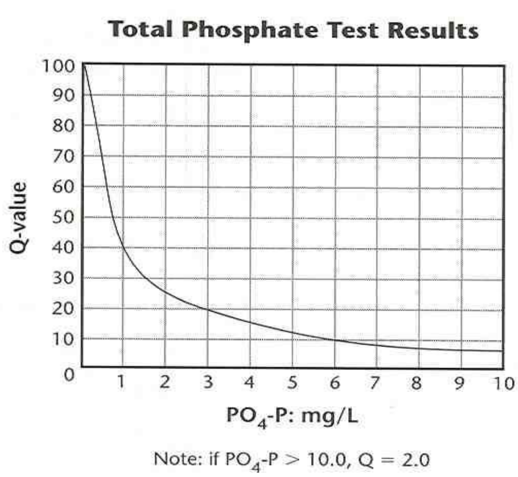



PHOSPHATE ($PO_4^{3-}$) – LaMotte N•P•K Soil Kit

25. Follow all instructions included in the Phosphate Kit
26. Compare the blue color of the solution to the Phosphorous Color Chart.
27. Determine the quantitative mg/L value for $PO_4^{3-}$ as follows:

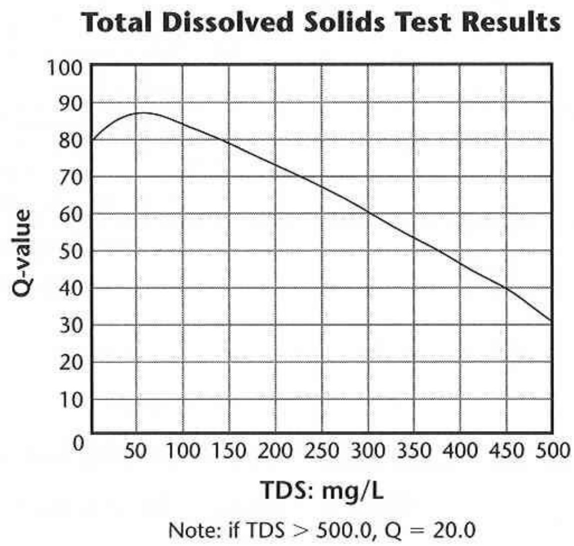
**L**ow $PO_4^{3-}$: 1.8 mg/L **M**edium $PO_4^{3-}$: 5.1 mg/L **H**igh $PO_4^{3-}$: 8.3 mg/L

28. Record this value on the DATA TABLE.
29. Using the graph below, determine the Q-value for $PO_4^{3-}$.
30. Record the Q-value for $PO_4^{3-}$ on the DATA TABLE.



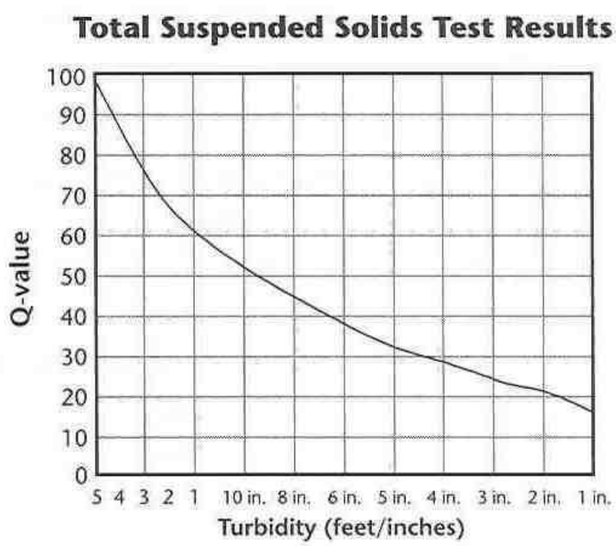
TOTAL DISSOLVED SOLIDS (TDS) – **INSTRUCTOR WILL PROVIDE**

31. Your Instructor will provide you with the mass of the dissolved solids.
32. Record the mass of the dissolved solids on the DATA TABLE.
33. Multiply the mass of the dissolved solids by 5 to calculate the Total Dissolved Solids in mg/L.
34. Record the Total Dissolved Solids value on the DATA TABLE.
35. Using the graph below, determine the Q-value for TDS.
36. Record the Q-value for TDS on the DATA TABLE.

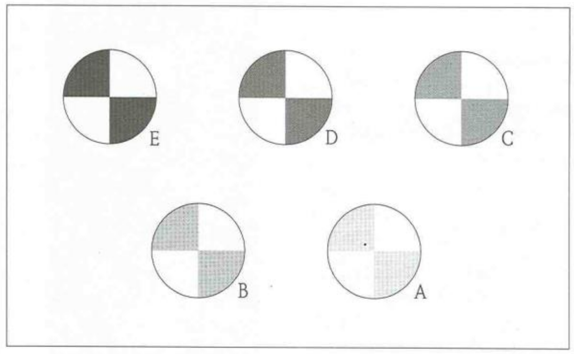



TURBIDITY or TOTAL SUSPENDED SOLIDS (TSS) – **INSTRUCTOR WILL PROVIDE**

37. Your Instructor will provide you with the depth of turbidity.
38. Record the depth of turbidity on the DATA TABLE.
39. Using the graph on the left below, determine the Q-value for TSS.
40. Record the Q-value for TSS on the DATA TABLE.



Turbidity Test




A–Little effect on aquatic plants and animals
B–Less light reaches plants, photosynthesis slows
C–Algae and zooplankton production drops
D–Aquatic insect production slows
E–Stressful for some fish due to lack of food production

Note: if Turbidity > 100.0, Q = 5.0

CALCULATE THE WATER QUALITY INDEX (WQI)

41. For each test, multiply the Q-value by the weighing factor and place the product in the TOTAL column on the DATA TABLE.

42. Add the TOTALs of all the tests then multiply this value by 1.19. (The 1.19 value takes into account the factor of **fecal coliform bacteria)**.

43. Record this value as the Water Quality Index (WQI) on the DATA TABLE.

**Water Quality Testing**

DATA TABLE:

| TEST: | TEST RESULTS: | Q-VALUE: | WEIGHING FACTOR: | |
|---|---|---|---|---|
| D.O. | ______mg/L | | | |
| | ______% Saturation | ______ | 0.17 | ______ |
| pH | ______ | ______ | 0.11 | ______ |
| Δ°C | ______°C Pond | | | |
| | ______°C Stream | | | |
| | ______Δ°C | ______ | 0.10 | ______ |
| BOD | ______mg/L | | | |
| | ______Δ mg/L D.O. | ______ | 0.11 | ______ |
| $NO_3^-$ | ______mg/L | ______ | 0.10 | ______ |
| $PO_4^{3-}$ | ______mg/L | ______ | 0.10 | ______ |
| TDS | ______mg | | | |
| | ______mg/L | ______ | 0.07 | ______ |
| TSS | ______ ft in | ______ | 0.08 | ______ |

WQI = ______

| WQI Value | Water Quality Rating |
|---|---|
| 91–100 | Excellent Water Quality |
| 71–90 | Good Water Quality |
| 51–70 | Average Water Quality |
| 26–50 | Fair Water Quality |
| 0–25 | Poor Water Quality |

**Water Quality Testing**

Report

A 1-2 page, typed, write up of your results.

Format

Title Page: include a Title and the 2 pictures required in lab procedure

Report:
Introduction: what is WQI, how is it determined, and why is it important.

Method: Similar to a procedure but more general

Results: A summary of your testing.

Conclusion:  A discussion of the final WQI and implications for safety.