Science and a Sense of Place: Watershed Education

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Vital Signs: Assessing the health of the ponds and streams in your watershed (late morning, early afternoon)

In the same way that doctors and nurses use vital signs like temperature and blood pressure to determine whether their patients are healthy, scientists use a variety of physical, chemical, and biological indicators to determine the environmental condition of a watershed. To “diagnose” this condition, there are three big questions we can ask:

(1) How do the vital signs change over time and space?
(2) How do our measurements compare with what we would expect to find?
(3) What could be causing these changes and/or deviations from our expectations?

Elementary to high school-level example exercise: Monitoring water temperature
Objective: Students will use water temperature measurements to create graphical representations of their data and draw conclusions about environmental conditions in the drainage basin.

Increases in water temperature can be caused by a variety of “thermal pollution” sources, including suspended solids, industrial discharge, organic waste, lack of shade, runoff from a warm urban surface, or if the flow of water is impeded somehow (by a dam). Just like humans become uncomfortable when the air is too hot, plants and creatures living in the water cannot survive above certain temperatures. The optimal temperature range for fish is 20 to 25 ºC.

Activity:
Select points around the pond or stream that vary in terms of depth, shade, or other factors that you think might affect water temperature. Using a thermometer (a standard pool/spa thermometer is fine), measure temperature in degrees Celsius until you get a constant reading. Record your data in a table or as points on a map.

Questions:
1. What trends do you notice in your data? With enough data points, more advanced students might be able to make a contour map of temperature in the pond or stream. How would you go about doing this?

2. List some possible explanations for the trends you observe.

3. Using your data and the following table, construct a graph relating temperature to time. Are these trends the ones you'd expect to find? Why or why not?

Date	**Location**	**Temperature °C**
6/28/2006	Inlet	18.5
6/28/2006	Forebay	28.5
6/28/2006	Main Basin	33.9
7/3/2006	Inlet	17.4
7/3/2006	Forebay	23.1
7/3/2006	Main Basin	27.3
7/10/2006	Inlet	17.6
7/10/2006	Forebay	19.8
7/10/2006	Main Basin	25.6
7/17/2006	Inlet	18.1
7/17/2006	Forebay	21.9
7/17/2006	Main Basin	28

Elementary to high school-level example exercise: Measuring volumetric discharge in a stream or into a pond

Objective: Students will use simple tools and methods to determine how much water is flowing past a given point in a body of water at a given time. This exercise will improve their conceptual understanding of velocity, area, volume, unit conversions, and orders of magnitude.

Imagine digging a hole or channel and filling it with one gallon of water over a minute. What would happen to that basin if you filled it with one gallon every five seconds? Volumetric discharge measurements are useful in estimating rates of stream bank erosion, basin flooding/recession rates, or how long harmful concentrations of chemicals will remain in the water. As the questions above suggest, discharge is defined as the volume of water that passes through a given point over a certain amount of time. In this exercise, we determine discharge by measuring water velocity in distance per unit time and estimating the cross-sectional area that it passes through.

Activity:

Velocity

Using a leaf, plastic egg, or other floating object, find a current that follows a fairly direct path. Align a meter stick in that direction of flow. Position your float upstream from the meter stick, and prepare your stopwatch. Release the float and begin timing when it first passes the yardstick. Stop the watch when it has floated for one meter. Record data and repeat several times. Calculate your average velocity. (Note: your results will be in 1 meter per x seconds. You will need to convert this to x meters per second)

Cross-sectional area

Halfway between your start and finish points for the velocity measurement, stretch a string or measuring stick across the width of the channel, perpendicular to flow. Beginning at one side of the channel, measure and record water depth at 10 cm increments until you reach the other side. Use graph paper and the scale of your choice (I like 1 square= 10 cm, in each direction) to sketch a profile of the area of the stream. Determine the area of each square on the paper. Count the squares to estimate the cross-sectional area at this point. Multiple measurements can be used to calculate an average area.

Volumetric discharge

Multiply average velocity by average cross-sectional area to determine the volume of water flowing past a point in a given amount of time. Convert units as necessary.

Questions:

1. Are your measurements consistent or do they vary? What causes any variations, especially if there are big differences?

2. Do you think the volumetric discharge of your bath or shower at home is faster or slower than the rate you measured? What about the rain gutters at your home? How could you figure this out for sure?

3. Suppose there is a pipe of the same diameter 1 km upstream, but it is positioned at a steeper angle so water flows twice as fast. If you poured 1 L of water into that pipe, how long would it take for it to enter our pond?

Middle to high school-level example exercise: Water chemistry (pH and dissolved oxygen measurements)
Objective: Students will become familiar with real-world applications of theoretical equilibrium expressions and logarithmic scales. They will also gain a conceptual understanding of feedback relationships in environmental systems.

pH background:

$$H_2O \Leftrightarrow H^+ + OH^- \qquad K_w = 10^{-14}$$

$$K_w = \frac{[H^+][OH^-]}{[H_2O]} \qquad pH = -\log_{10} [H^+]$$

As the expressions above show, pH is defined as the negative logarithm (in base 10) of the concentration of hydrogen in a solution. On a pH scale of 1 to 14, values greater than 7 are considered basic and values less than 7 are acidic. The closer to 7 your reading is, the more neutral the solution. Environmental factors that affect pH include industrial waste, runoff, acid rain, and the rock types underlying the stream or pond. A related variable that can allow us to tell a more complete water chemistry story is alkalinity, or how well a solution can maintain a stable pH as acid is added. Just as some people might have normal body temperatures that are a degree higher or lower than 98.6 ºF, some perfectly healthy streams and ponds have pH levels that deviate from neutral. In general, we are more concerned with changes over time (or differences between two locations that seem identical) than we are with pH readings slightly lower or higher than 7.

pH activity:
Select points around the pond or stream that vary in terms of depth, shade, or other factors that you think might affect pH. At each site, use a pH meter or pool test strips to measure pH. Record your data in a table or as points on a map.

pH questions:
1. What is your range of pH values? Using the expressions provided above, determine the range of H^+ and/or OH^- concentrations. How do these ranges differ?

2. How would you use pH to determine whether this water is actually healthy?

Dissolved oxygen (DO) background:
As with temperature, plants and animals in streams or ponds can be very sensitive to changes in the amount of available oxygen in the water; as dissolved oxygen (DO) decreases, plants and animals that require lots of oxygen die out and are replaced by plants and animals that favor anoxic conditions. Decreases in DO can be caused by temperature increases, organic waste, chemical runoff, trash, low water levels, lack of algae and other aquatic plants.

DO activity:
Select points around the pond or stream that vary in terms of depth, shade, or other factors that you think might affect DO. At each site, fill a sample container with 5 mL of water. Snap a CHEMetrics VacuuVial ampoule in the container and invert it to activate the reagent. “Blank” the photometer, then wipe the surface of the ampoule and insert it into the meter. Record the reading of DO concentration parts per million (ppm), in a table or as points on a map. (Note: You can use information provided with the meter to understand the chemical reactions and physics concepts that the machine uses to calculate concentration. We won’t do this today).

DO questions:
1. What trends do you notice in your data? With enough data points, more advanced students might be able to make a contour map of DO in the pond or stream. How would you go about doing this?

2. List some possible explanations for the trends you observe.

3. Compare your DO data with temperature measurements from today. Come up with a story for how one of these variables could affect the other. What sort of feedback relationships might be in play here?