Practicing Your Protocols

Purpose

To have students learn to use the hydrology instruments and collect the hydrology data accurately.

Overview

Students will rotate among measurement stations for each of the hydrology protocols that will be done by the class. They will practice using the field guide with the instrument or kit for that particular measurement, exploring sources of variation and error.

Student Outcomes

Students should perform each of the chemistry measurements correctly, relate the units for each measurement, identify approximate ranges for each protocol, understand the importance of quality control, and identify anomalous data

Earth and Space Science

- Water is a solvent.
- Each element moves among different reservoirs (biosphere, lithosphere, atmosphere, hydrosphere).

Life Science

- Organisms can only survive in environments where their needs are met.
- Earth has many different environments that support different combinations of organisms.
- Organisms change the environment in which they live.
- Humans can change natural environments.
- All organisms must be able to obtain and use resources while living in a constantly changing environment.

Scientific Inquiry Abilities

- Develop explanations using observations.
- Recognize and analyze alternative explanations.
- Communicate procedures and explanations.
- Use instruments to gather data accurately.

Time

One to four class periods, depending on how many protocols are done

Level

Varies with the protocol

Materials and Tools

- *Practicing Your Protocols Activity Sheets*
- *Protocol Field Guides*
- Equipment is listed on *Activity Sheets* for specific protocols to be done.

Preparation

Ask students to bring in water samples to be tested.

Prerequisites

It would be helpful for the class to have seen the measurements demonstrated. Teachers can use the GLOBE Hydrology video to demonstrate key points.

Background

A quality assurance and quality control (QA/QC) plan is necessary to ensure test results are as accurate and precise as possible. Accuracy refers to how close a measurement is to true value. Precision means the ability to obtain consistent results. Desired accuracy, precision and reliability are ensured by: careful calibration, use, and maintenance of testing equipment, following the specific directions of a protocol exactly as described, repeating measurements to ensure that they are within acceptable limits, minimizing contamination of samples, stock chemicals and testing equipment, keeping track of samples. Together these steps help make the data you collect valid, valuable and meaningful.

To be able to analyze data, students need some baseline knowledge of what data are being collected and expectations of parameters and sources of error. These labs provide students with a baseline knowledge of the data collected in the GLOBE *Hydrology Protocols* by encouraging them to introduce variables into the data collection procedure to determine the data error recorded when the variables are not controlled.

Preparation

Safety: Consult Material Science Data (MSDS) sheets that come with the kits and buffers. Also consult your local school district's safety procedure guidelines. Discuss lab safety with students.

Set up measurement stations for each of the protocols your students will be performing. The materials for each station are listed on the *Activity Sheets.*

What to Do and How to Do It

Divide the students into small groups, optimally three or four per group. Checking each other's work, students should take turns reading directions, making measurements, and recording the data.

Students rotate through each station learning the instruments and protocols and filling in the *Activity Sheets*. The time it takes to do all of the stations will depend on whether your students are familiar with the equipment and how many stations are set up.

After the station rotations are done

Collect all of the *Activity Sheets*. Ask each student group to compile the data from all the student groups for a particular protocol and prepare a report. They should:

- Plot all the data points as a way of demonstrating the concept of precision. When measurements are precise, points are close together. Discuss the range of measurements found and variations among the measurements;
- Lead discussions on the issues of why there are discrepancies;
- Connect explanations with reasons for specific steps in the protocols; and
- If samples were tested from various places (see *Extensions of the Basic Learning Activity*), help the class make sense of their results by placing data on a map of the water sources and considering the history of each sample.

Extensions of the Basic Learning Activity

Have students bring in water samples from near their own homes for testing.

Have students design explorations for testing other variables that may affect the water quality testing.

Student Assessment

Provide students with the following table of hydrology data. (Note that these data are NOT all from the same water body). In Column 3 ask students to decide whether the data are reasonable (yes or no). In Column 4, ask students to provide a comment on how they might interpret the data or potential sources of error for any data they found questionable in Column 3.

Analysis Table

Data type	Measurement	Reasonable? (Yes or No)	Comments: interpretation or suspected sources of error
Turbidity Tube	4 cm		
Water Temperature	67 degrees		
Dissolved oxygen	2 ppm		
pH	7.5		
Conductivity	140 mS/cm		
Salinity	35 ppm		
Alkalinity	350 ppm		
Nitrate	>10 ppm		

Analysis Table (Sample responses)

Data type	Measurement	Reasonable?	Comments
Transparency Tube	4 cm	yes	Water must contain many suspended particles. Maybe soil has washed in recently or there is an algae bloom.
Water Temperature	67 degrees	no	Too high! Maybe read the wrong scale (ºF instead of ºC)
Dissolved oxygen	2 ppm (or 2 mg/L)	yes	This is very low. We should try the measurement again, then try to determine why the oxygen levels are low if it still measures 2.
pH	7.5	yes	This is optimal for many animals. We should monitor for change over time.
Conductivity	140 µS/cm	yes	This is fairly low conductivity - not very many dissolved solids in this water.
Salinity	35 ppm	no	Should be ppt
Alkalinity	280 ppm	yes	This is a well-buffered system.
Nitrate	>10 ppm	no	It is possible, but I would check to see if correct since this is above safe levels. Check to see if directions for low or high range tests were used.

Transparency Station

Activity Sheet

Transparency is the measurement of water clarity. The clarity of your water determines how much light can penetrate. The transparency of water at your site will depend on the amount of particles suspended in the water. Typical suspended particle are clays (eroded from soils) and algae. Transparency may change seasonally with changes in growth rates, in response to precipitation runoff, or for other reasons. Since plants require light, transparency is an important measurement in determining productivity of your water site.

Materials

- ❏ GLOBE Science Log
- ❏ Pen or pencil
- ❏ *Transparency Field Guide*
- ❏ Turbidity tube
- ❏ Plastic cup
- ❏ Water sample in bucket
- ❏ Extra clean bucket
- ❏ Stirring spoon
- ❏ Silt or clay (three 2-g piles)
- ❏ Green food coloring
- ❏ Pipette
- ❏ Graph paper

What to Do

1. Review the *Transparency Field Guide*. Follow the steps as they are outlined to determine the transparency of your water sample.
2. Move to a part of the room with bright light. Repeat the measurement.
3. Pour half of the water into the clean bucket. Add 2 grams of silt or clay to the water and stir. Repeat the measurement with this water. Add 2 more grams and repeat the measurement. Add 2 more grams and repeat the measurement.
4. Discard the dirty water. Into the remaining fresh water add 2 drops of green food coloring. Repeat the measurement. Try adding 4 drops, then 6 drops.
5. Make a graph with Transparency (cm) on the Y-axis and grams of soil on the X-axis.
6. Make a graph with Transparency (cm) on the Y-axis and drops of food coloring on the X-axis.

Sample	Student #1	Student #2	Student #3
Water in bucket			
Tube placed in bright light			
Water with soil (2 grams)			
Water with soil (4 grams)			
Water with soil (6 grams)			
Green water (2 drops)			
Green water (6 drops)			

Temperature Station

Activity Sheet

Water temperature measures the surface temperature of your water body. Water bodies have different temperatures depending on latitude, altitude, time of day, season, depth of water, and many other variables. Water temperature is important to chemical, biological and physical processes. It can help us understand what may be happening in the water body without directly measuring hundreds of variables.

Materials

- ❏ GLOBE Science Log
- ❏ Pen or pencil
- ❏ *Thermometer Calibration Lab Guide*
- ❏ *Water Temperature Field Guide*
- ❏ Water sample in bucket
- ❏ Distilled water
- ❏ Thermometer(s)
- ❏ Crushed ice
- ❏ Watch or clock for timing
- ❏ Salt
- ❏ 500-mL beaker

What to Do

1. Calibrate your thermometer(s) using the *Calibration Lab Guide*.
2. Follow the steps on the *Water Temperature Field Guide* to measure the temperature of your water sample.
3. Pour 500 mL of crushed ice into the water sample. Stir until the ice has melted.
4. Place the thermometer into the cooled water for 5 seconds. Record the temperature.
5. Wait 10 more seconds. Record the temperature.
6. Record the temperature after 3 minutes.
7. Remove the thermometer from the water. Read the temperature. Record the number of seconds it takes before you observe a change in the temperature reading.
8. Place the thermometer into the water for 30 seconds. Remove the thermometer from the water. Read the temperature. Hold the thermometer in front of a fan or blow on it. Record the number of seconds it takes before you observe a change in the temperature reading.
9. Prepare an ice bath with 250 mL water, 250 mL crushed ice and a spoonful of salt. Measure the temperature of the saltwater bath.

Sample	**Student #1**	**Student #2**	**Student #3**
Temperature of water sample			
Temperature of ice water after 5 seconds			
Temperature of ice water after 15 seconds			
Temperature of ice water after 3 minutes			
Time for temperature change to occur			
Time for temperature change to occur (with fan)			
Temperature of ice water with salt			

Dissolved Oxygen Station

Activity Sheet

Most living things depend on molecular oxygen to survive. Molecules of oxygen dissolve in the water. Aquatic animals can use this dissolved oxygen (DO) for respiration. In air, about 20 out of every 100 molecules are oxygen. In water, less than 20 out of every 1,000,000 molecules are oxygen. This is why dissolved oxygen is measured in parts per million (ppm). Different kinds of organisms need different amounts of oxygen, but generally aquatic organisms require at least 6 ppm for normal growth and development.

Water temperature and pressure affect how much oxygen is in the water. Water that has as much oxygen as it can hold for its temperature and pressure (a function of altitude) is said to be in 'equilibrium'. Warm water cannot hold as much oxygen as cold water. At high altitudes, where there is less pressure, water cannot hold as much oxygen as at low altitudes. Look for these patterns in the Temperature and Elevation Tables in the DO quality control sheet.

The actual amount of DO in water may be higher or lower than the equilibrium value. Bacteria in the water use oxygen as they digest decaying plants or animals This can lower the DO levels of the water. Plants in the water produce oxygen during photosynthesis. This sometimes results in higher DO levels.

Materials

- ❏ GLOBE Science Log
- ❏ Pen or Pencil
- ❏ *Dissolved Oxygen Quality Control Lab Guide*
- ❏ *Dissolved Oxygen Field Guide*
- ❏ Fresh bucket of tap water
- ❏ Fixed sample of water (fixed sample should be made immediately after the bucket of sample water is collected)
- ❏ Bucket of tap water left setting several hours
- ❏ Dissolved Oxygen kit(s)
- ❏ Distilled water
- ❏ 250-mL sample bottle with lid
- ❏ Thermometer

What To Do

1. Do the quality control procedure for the DO kit as described in the *Dissolved Oxygen Quality Control Lab Guide*
2. Once you are sure that your procedure and kit are accurate, test a fresh water sample from the tap.
3. Test the water sample that has been standing for several hours.
4. Titrate the fixed sample that was prepared from a similar fresh water sample earlier in the day. Record the DO level.

Sample	Student #1	Student #2	Student #3
Fresh water sample			
Standing water sample			
Fixed water sample			

pH Station
Activity Sheet

pH indicates the acid content of water. The pH scale ranges from 1.0 (acidic) to 14.0 (basic) Neutral is 7.0. The scale is logarithmic. A change of one pH unit means 10 times the acid or base concentration. For instance, a change from 7.0 to 6.0 indicates water 10 times more acidic; a change from 7.0 to 5.0 indicates water 100 times more acidic.

The pH of a water body helps determine what can live in it. Many amphibians, insect larvae and other types of aquatic life are very sensitive to low or high pH.

Materials

- ❑ GLOBE Science Log
- ❑ Pen or pencil
- ❑ *pH Protocol Field Guide*
- ❑ Water sample
- ❑ Box of pH paper
- ❑ Cups or 100 mL beakers for buffers and water samples
- ❑ pH meter(s)
- ❑ Distilled water
- ❑ Buffers for pH calibration
- ❑ Paper towels
- ❑ Ice
- ❑ Salt

What To Do

1. Test the water sample for pH using the *pH Protocol Field Guide (pH paper)*.
2. Do not calibrate the pH meter. Follow the steps in the *pH Protocol Field Guide (pH meter)* to measure the pH of the water sample.
3. Calibrate your pH meter according to the instructions that come with your instrument.
4. Follow the steps in the *pH Protocol Field Guide (pH meter)* and measure the pH of the water sample.
5. Pour 50 mL of sample water into a cup. Place the cup in an ice water bath to cool the sample water. Test the pH of the cooled sample using both pH paper and the meter.
6. Pour 50 mL of distilled water in a clean cup and test the pH using both the paper and the meter.
7. Add a few grams of salt to the distilled water, and test the sample again.
8. Add a few grams of salt to the tap water sample, and test the sample again

Sample	**Student #1**	**Student # 2**	**Student #3**
Sample water - pH paper			
Sample water – without calibration			
Sample water – after calibration			
Cooled sample water - pH paper			
Cooled sample water - pH meter			
Distilled water - pH paper			
Distilled water - pH meter			
Saltwater (was distilled - pH paper)			
Saltwater (was distilled - pH meter)			
Saltwater (was tap – pH paper)			
Saltwater (was tap – pH meter)			

Electrical Conductivity Station
Activity Sheet

Electrical conductivity measures the ability of a water sample to carry an electrical current. Pure water is a poor conductor of electricity. It is the impurities in water, such as dissolved salts, that allows water to conduct electricity. Conductivity is used to estimate the amount of dissolved solids in the water.

Conductivity is measured in a unit called microSiemens/cm (µS/cm). Sensitive plants can be damaged if they are watered with water that has electrical conductivity levels above about 2200-2600 µS/cm. For household use, we prefer water with conductivity below 1100 µS/cm.

Materials

- ❑ GLOBE Science Log
- ❑ Pen or pencil
- ❑ Conductivity meter(s)
- ❑ *Conductivity Protocol Field Guide*
- ❑ Water sample
- ❑ Cups or 100-mL beakers for buffers and water samples (vinegar, milk, soda, coffee, sugar water, artificial sweetener, ice water, salt water
- ❑ Distilled water
- ❑ Paper towels
- ❑ Graph paper
- ❑ Salt (two piles of 1 g)
- ❑ 100-mL graduated cylinder
- ❑ Calibration standard

What To Do

1. Do not calibrate the meter. Test the conductivity of the water sample using the *Electrical Conductivity Protocol Field Guide*
2. Calibrate the meter.
3. Test the conductivity of the water sample using the *Electrical Conductivity Protocol Field Guide*
4. Add a gram of salt to 100 mL of distilled water. Measure the conductivity.
5. Add two grams of salt to 100 mL of distilled water. Measure the conductivity.
6. Measure the conductivity of the other samples: vinegar, milk, soda, sugar water, water with artificial sweetener, ice water, coffee

Sample	Student #1	Student #2	Student #3
Fresh water sample – no calibration			
Fresh water sample - calibration			
1 g salt			
2 g salt			
Vinegar			
Milk			
Soda			
Sugar water			
Artificial sweetener			
Ice water			
coffee			

Salinity Protocol
Activity Sheet

Salinity is the measurement of dissolved salts in salty or brackish water. It is measured in parts per thousand (ppt). Salinity may vary with precipitation, snow melt, or proximity to a freshwater source such as a river mouth.

The hydrometer is an instrument which measures the specific gravity or density of a fluid. Its design is based on the principle that the weight loss of a body floating or immersed in a liquid equals the weight of the liquid displaced. The denser your liquid, therefore, the less the weighted bulb must sink to displace its own weight.

Why do you need to take a temperature reading with your hydrometer reading? Water becomes more dense as it approaches freezing. Since we want to measure the effect of dissolved salts on density, we must control the temperature variable.

Materials

- ❑ GLOBE Science Log
- ❑ Pen or pencil
- ❑ *Salinity Conversion Table*
- ❑ 500-mL graduated cylinder
- ❑ Distilled water
- ❑ Hydrometer
- ❑ Thermometer
- ❑ 20 g salt (in two 10-g units)
- ❑ Ice

What To Do

1. Fill the 500 mL graduated cylinder to the 500-mL line with distilled water.
2. Gently place the hydrometer into the cylinder of distilled water and read the scale.
3. Remove the hydrometer and add 10 g salt. Mix.
4. Take the water temperature.
5. Replace the hydrometer and read the scale.
6. Find the salinity of the water sample using the *Salinity Conversion Table*
7. Discard the water in the cylinder, rinse with distilled water, then fill the cylinder _ full of ice. Fill to the 500-mL line with distilled water.
8. Place the hydrometer gently into the cylinder and read.
9. Remove the hydrometer and add 10 g salt to the cylinder. Mix.
10. Find the water temperature.
11. Place the hydrometer gently into the cylinder and read.
12. Find the salinity of the water sample using the *Salinity Conversion Table*.

Sample	**Student #1**	**Student #2**	**Student #3**
(2) Hydrometer reading – distilled water			
(4) Water temperature – 10 g salt			
(5) Hydrometer reading – 10 g salt			
(6) Salinity (from table) – 10 g salt			
(8) Hydrometer reading – distilled water, ice			
(10) Temperature – 10 g salt, ice			
(11) Hydrometer reading – 10 g salt, ice			
(12) Salinity of sample – 10 g salt, ice			

Alkalinity Station
Activity Sheet

Alkalinity, measured as ppm calcium carbonate, is a measure of the ability of a body of water to resist changes in pH when acids are added. Acid additions generally come from rain or snow, although soil sources may also be important in some areas. Alkalinity is added to water when water dissolves rocks such as calcite and limestone. The alkalinity of natural waters protects fish and other aquatic organisms from sudden changes in pH.

Materials

- ❑ GLOBE Science Log
- ❑ Pen or pencil
- ❑ Alkalinity Test Kit(s)
- ❑ *Alkalinity Quality Control Procedure Lab Guide*
- ❑ Alkalinity standard
- ❑ *Alkalinity Protocol Field Guide*
- ❑ 100-mL graduated cylinder
- ❑ Distilled water
- ❑ Baking soda (3 1-g units)
- ❑ Vinegar
- ❑ Pipette

What To Do

1. Use the *Alkalinity Quality Control Procedure Lab Guide* to check your kit and procedure.
2. Use the *Alkalinity Protocol Field Guide* to measure the alkalinity of the water sample.
3. Add 1 g of baking soda to a 100-ml fresh water sample. Mix well. Test the alkalinity.
4. Repeat step (3) using 2 g of baking soda, then 3 g baking soda.
5. Add a drop of vinegar to fresh 100-ml water sample. Mix well. Test the alkalinity.
6. Repeat step (5) using 2 drops vinegar, then repeat using 3 drops.

Sample	Student #1	Student #2	Student #3
Alkalinity of water sample			
Alkalinity – 1 g baking soda			
Alkalinity – 2 g baking soda			
Alkalinity – 3 g baking soda			
Alkalinity – 1 drop vinegar			
Alkalinity – 2 drops vinegar			
Alkalinity – 3 drops vinegar			

Nitrate Station
Activity Sheet

Nitrogen is one of the three major nutrients needed by plants. Most plants cannot use nitrogen in its molecular form (N_2). In aquatic ecosystems blue-green algae are able to convert N_2 into ammonia (NH_3) and nitrate (NO_3^-), which can then be used by plants. Animals eat these plants to obtain nitrogen that they need to form proteins. When the plants and animals die, protein molecules are broken down by bacteria into ammonia. Other bacteria then oxidize the ammonia into nitrites (NO_2^-) and nitrates (NO_3^-). Under suboxic conditions nitrates can then be transformed by other bacteria into ammonia (NH_3), beginning the nitrogen cycle again.

Typically nitrogen levels in natural waters are low (below 1 ppm nitrate nitrogen). Nitrogen released by decomposing animal excretions, dead plants, and animals is rapidly consumed by plants. In water bodies with high nitrogen levels, eutrophication can occur. Nitrogen levels can become elevated from natural or human-related activities. Ducks and geese contribute heavily to nitrogen in the water where they are found. Man-made sources of nitrogen include sewage dumped into rivers, fertilizer washed into streams or leached into groundwater, and runoff from feedlots and barnyards.

Nitrate levels are measured in parts per million (ppm) nitrate nitrogen.

Remember that nitrate levels can change over time. So it is best to test fresh samples (less than 2 hours old) or refrigerated samples.

Materials

- ❑ GLOBE Science Log
- ❑ Pen or pencil
- ❑ Nitrate Test Kit(s)
- ❑ Nitrate standard
- ❑ *Nitrate Quality Control Procedure Lab Guide*
- ❑ *Nitrate Protocol Field Guide*
- ❑ Fertilizer
- ❑ Water sample from an aquarium

What To Do

1. Use the *Nitrate Quality Control Procedure Lab Guide* to check your kit and procedure.
2. Measure the nitrate of your water sample using the *Nitrate Protocol Field Guide*
3. Dissolve a few grams of nitrogen rich fertilizer in your water sample. Test the nitrate level.
4. Test water from an aquarium.

Sample	Student #1	Student #2	Student #3
Nitrate of water sample			
Nitrate with fertilizer			
Nitrate in aquarium			