9-12 THE HYDROLOGIC (WATER) CYCLE

OBJECTIVES

The student will do the following:

1. Construct a model of the hydrologic cycle.

2. Observe that water is an element of a cycle in the natural environment.

3. Explain how the hydrologic cycle works and why it is important.

4. Compare the hydrologic cycle to other cycles in nature such as nitrogen cycle, carbon cycle.

SUBJECTS:
Science (Chemistry, Biology, Earth Science)

TIME:
1 class period

MATERIALS:
three 1- or 2- liter bottles, two bottle caps
60 cm heavy cotton string (wick)
one clear 35mm film can
soil, water, ice, moss and plant seedstools to convert bottles: wax pencil, clear tape, scissors, box top, paper punch, tapered reamer, poke, awl, silicone sealant, razor in a safety holder
Plexiglas ™ sheet

BACKGROUND INFORMATION

Because the Earth is essentially a closed system containing all the water we will ever have, all of this water moves in a pattern called the Hydrologic or Water Cycle. This activity will demonstrate some of the ways water moves through natural systems, how water and the atmosphere are polluted and purified, how the water cycle purifies polluted water, and what role plants and soil have in the processes.

The form of water is always changing. Water moves from sky to Earth and back to the sky again. This is called the water cycle. Water falls to Earth as rain, snow, sleet, or hail. Some of the water soaks into the ground and is stored as groundwater. The rest flows into streams, lakes, rivers, and oceans. The sun warms surface water and changes some of it into water vapor. This process is called evaporation. Plants give off water vapor in a process called transpiration. The heated water vapor rises into the sky and forms clouds. When the vapor in the clouds condenses, it falls back to the Earth as rain or snow. The water cycle has then come full circle and begins again.

The water cycle can be demonstrated using two-liter soft drink bottles and other materials. Through capillary action, water moves up the wick from the bottom bottle unit into the soil. From there it evaporates and becomes water vapor in the central bottle unit. Water vapor exits from plants growing in the bottle through transpiration caused by the evaporation of water from the leaves of the plants. This water vapor is cooled by the ice above that causes it to condense onto the cold surface of the inverted bottle, just as water vapor condenses around particles in the atmosphere and forms clouds. These drops of condensation eventually run down the bottle and flow down the string -- precipitation. Precipitating water then collects in the film can, just as falling rain or snow collects in ponds, lakes, springs, seas, and oceans.

Terms

capillary action: the action by which the surface of a liquid where it is in contact with a solid (as in a capillary tube) is elevated or depressed depending on the relative attraction of the molecules of the liquid for each other and for those of the solid

condensation: (1) the process of changing from a vapor to a liquid; (2) a liquid obtained by the coming together of a gas or vapor

evaporate: to pass off in vapor or in invisible minute particles (to cause evaporation)

precipitation: water droplets or ice particles condensed from atmospheric water vapor and sufficiently massive to fall to the Earth's surface, such as rain or snow

transpiration: process in which water absorbed by the root systems of plants, moves up through the plants, passes through pores (stomata) in their leaves or other parts, and then evaporates into the atmosphere as water vapor; the passage of water vapor from a living body through a membrane or pores

water vapor: water in a gaseous (vapor) form and diffused as in the atmosphere

ADVANCE PREPARATION

A. Gather the materials and have them laid out for students to use at stations.

B. Caution students on use of scissors.

PROCEDURE

I. Setting the stage

A. Remove labels from three bottles by using a hair dryer set on low. Hold it about 15cm away from blowing nozzle and move it rapidly up and down so that the air warms the seam of the label.

B. Cut bottle A just below the shoulder or below the curve at the top of the bottle so a straight edge remains on the bottle.

C. Cut B and C bottles just above the hips or above the black bases so bottles have straight sides.

D. Poke a hole in one cap on B. Insert a loop of string (about 40cm) so about 5cm hangs down from the cap.

E. Place a cap with no hole on C. Tie about 20 cm of string around the bottle neck so one end hangs down about 7cm.

II. Activity

A. Introduce and explain the new terms using the chalkboard. Give everyday examples of each term.

B. Build a model that will demonstrate the water cycle.

1. Assemble bottles by placing C upside down in bottle B and B upside down in bottle A. (See diagram.)

2. Thoroughly wet both wicks. This will bring a constant source of water from a reservoir to plant roots. Wicking works by capillary action, the way water moves along fibers of paper towels and cotton string. Add about 150ml of water to A. This is the water source for the cycle. Fill B with enough premoistened soil to cover the loop of the string (200cc or 1 cup). String wick should run up into the soil and not be pressed against side of bottle.

3. Plant two or three seeds of a fast growing plant, such as Chinese cabbage or turnip, in the soil around the perimeter of bottle B. When bottle C isn't being used, leave it off bottle B so that air circulates and seeds can sprout and grow.

4. Place clear film can on top of the soil in center of bottle B so that the wick from bottle C hangs into it. Trim the film can or use a bottle cap if a full-sized can will not fit between bottle C and the soil in bottle B.

5 Fill bottle C with ice water or fill it with water and freeze it. Observe the film can after a few hours.

III. Follow-up

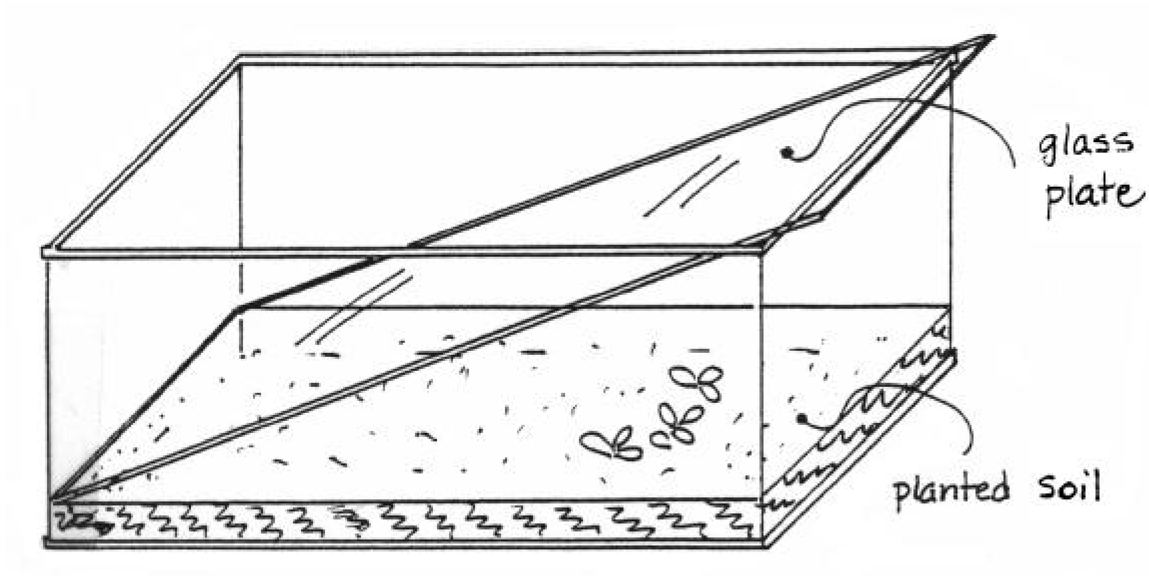
A. Have the students test the water quality in the film can. Test for pH, turbidity, and minerals.

B. Another way to set up a hydrologic cycle would be in an aquarium. One group of students may choose to set up a model this way.

1. In a clean, dry, large aquarium, place a soil mixture in one end so it slopes down towards the other end of the aquarium.

2. Tilt the aquarium so the soil is elevated about 10 cm. Place something under the high end to maintain this position for the entire time (the soil should stay put).

3. Pour the two liters of H_2O into the other end so that a pool is formed.



4. Plant the moss and/or liverworts in the soil end and mist well with a sprayer to dampen the plants and the soil but not enough to form mud.

5. Place the Plexiglas™ sheet so that it rests on the soil and flush against one end of the aquarium. The other end will rest against the top of the aquarium.

6. Set this near a window that receives indirect (north) light or use a small 2- tube grow light placed over the top of the aquarium.

7. Allow this aquarium, which is now a terrarium, to operate for a day or two. Mark the level of water in the pool.

8. As evaporation occurs from the pool, observe condensation on the diagonal Plexiglas™ sheet. This will represent clouds. As the condensation becomes heavy, drops will collect and run down to the lower end and into the soil. Mosses/liverworts will represent plants of the Earth. If there are indentations in the soil, small pools may form that may fill up, overflow, and form streams to the pool (ocean). Some of the water will penetrate the soil and descend to a certain level. This represents groundwater. This water will also eventually go into the pool (ocean). Preparation of the soil could artificially stimulate the cycling to occur. It is suggested that the system be allowed to operate for several days or weeks without artificial manipulation to see if streams will naturally occur.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

THE HYDROLOGIC (WATER) CYCLE

1. What part of this experiment demonstrated capillary action?

2. How could you tell that evaporation and transpiration were taking place?

3. What is the difference between evaporation and transpiration?

4. Another name for rain is_____________________________.

5. What does the ice do in this experiment?

6. Do you think the water in the film can will contain impurities? Explain your answer.

7. What does the water in the bottom bottle represent?

THE HYDROLOGIC (WATER) CYCLE

ANSWER KEY

1. What part of this experiment demonstrated capillary action?
   (String)

2. How could you tell that evaporation and transpiration were taking place?
   (condensation on bottle C and possibly bottle B)

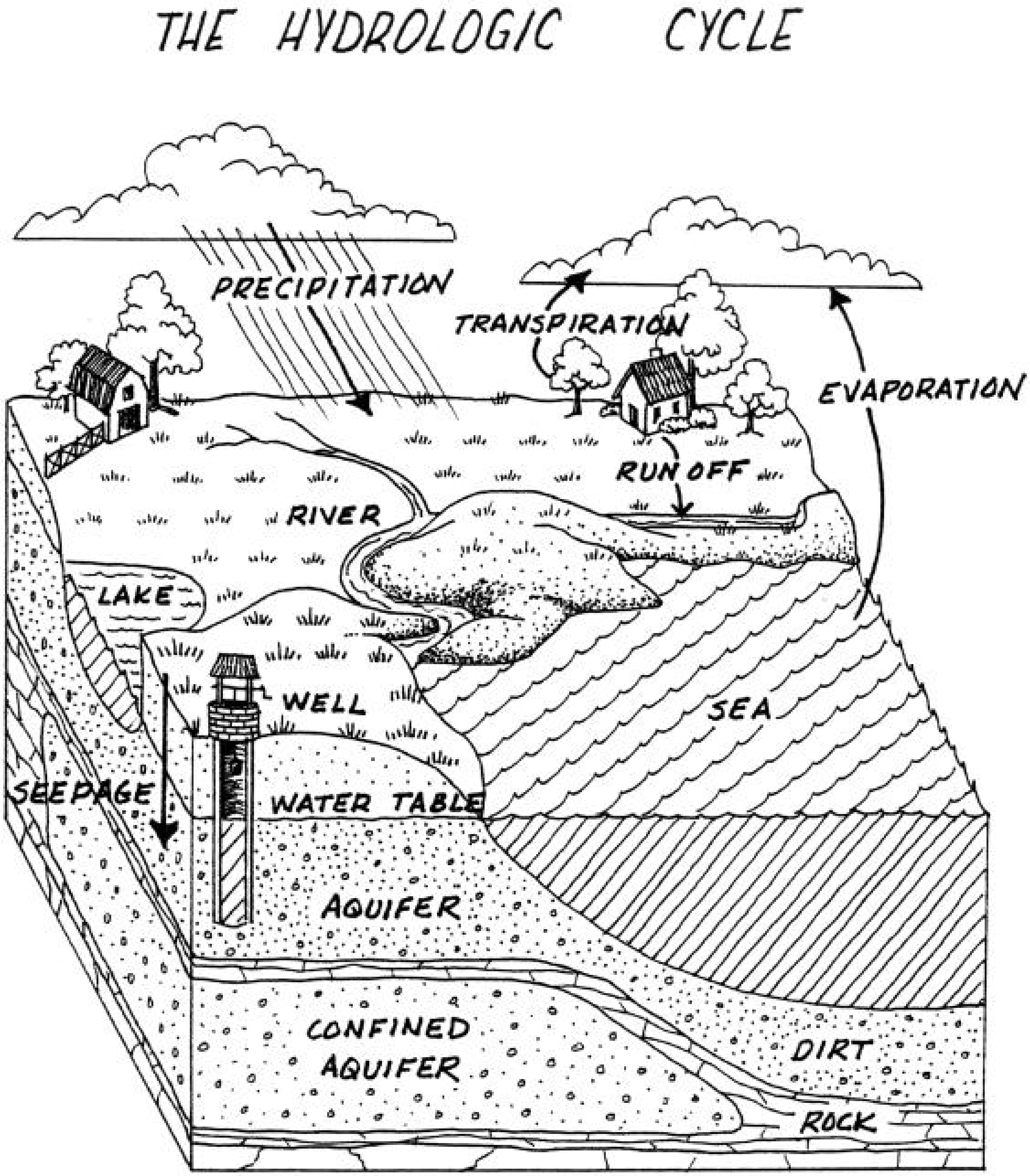
3. What is the difference between evaporation and transpiration?
   (Transpiration is the production of water vapor from a living organism. Evaporation is the formation of a vapor, in this case, water, from any source.)

4. Another name for rain is <u>precipitation.</u>

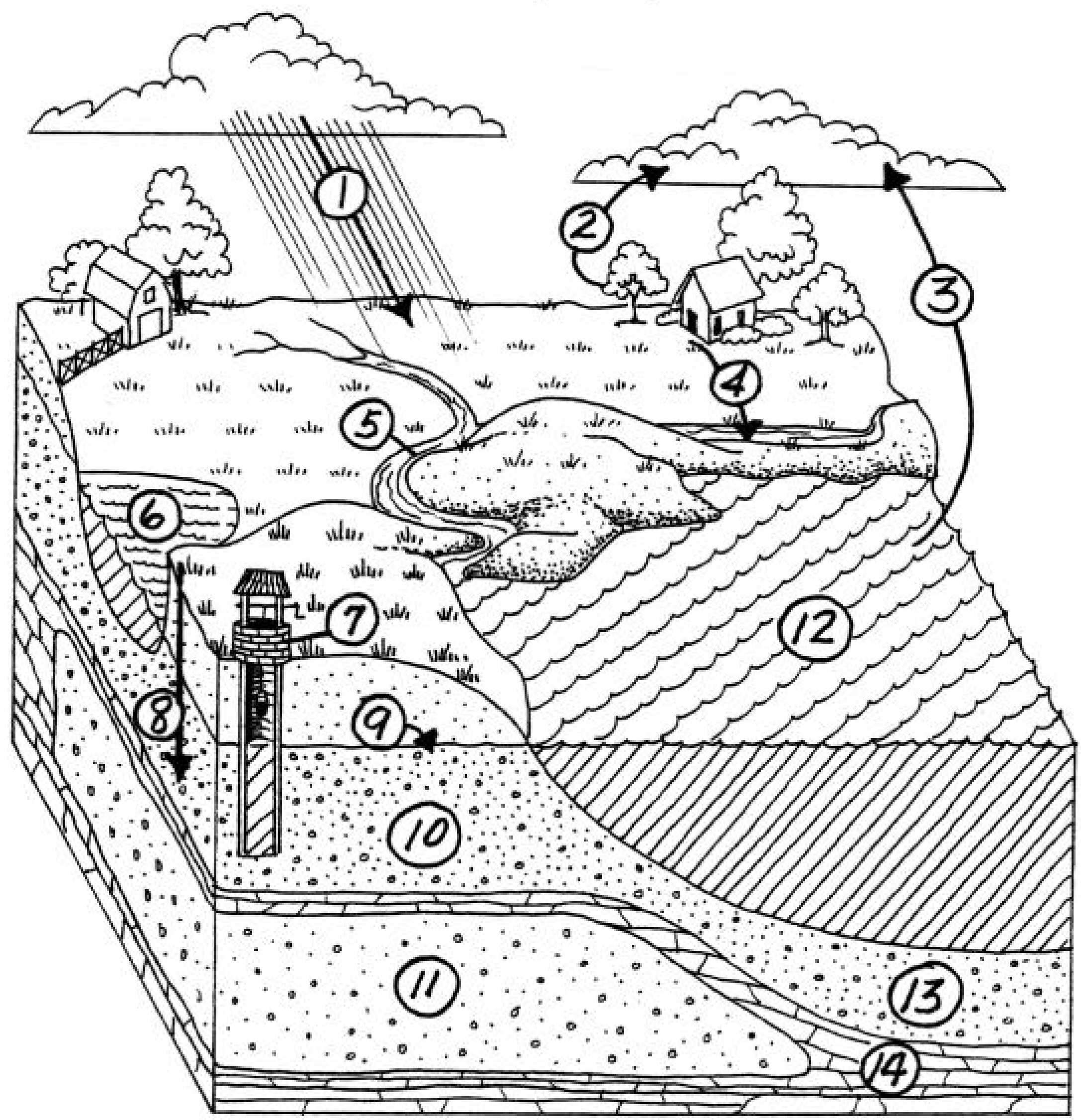
5. What does the ice do in this experiment?
   (causes condensation due to a change in temperature)

6. Do you think the water in the film can will contain impurities? Explain your answer.
   (Not really. When the water evaporates, it does not carry impurities with it. However, it may pick up impurities from the string.)

7. What does the water in the bottom bottle represent?
   (Groundwater)


THE HYDROLOGIC CYCLE
PRECIPITATION
TRANSPIRATION
EVAPORATION
RUN OFF
RIVER
LAKE
WELL
SEA
SEEPAGE
WATER TABLE
AQUIFER
CONFINED AQUIFER
DIRT
ROCK

THE HYDROLOGIC (WATER) CYCLE

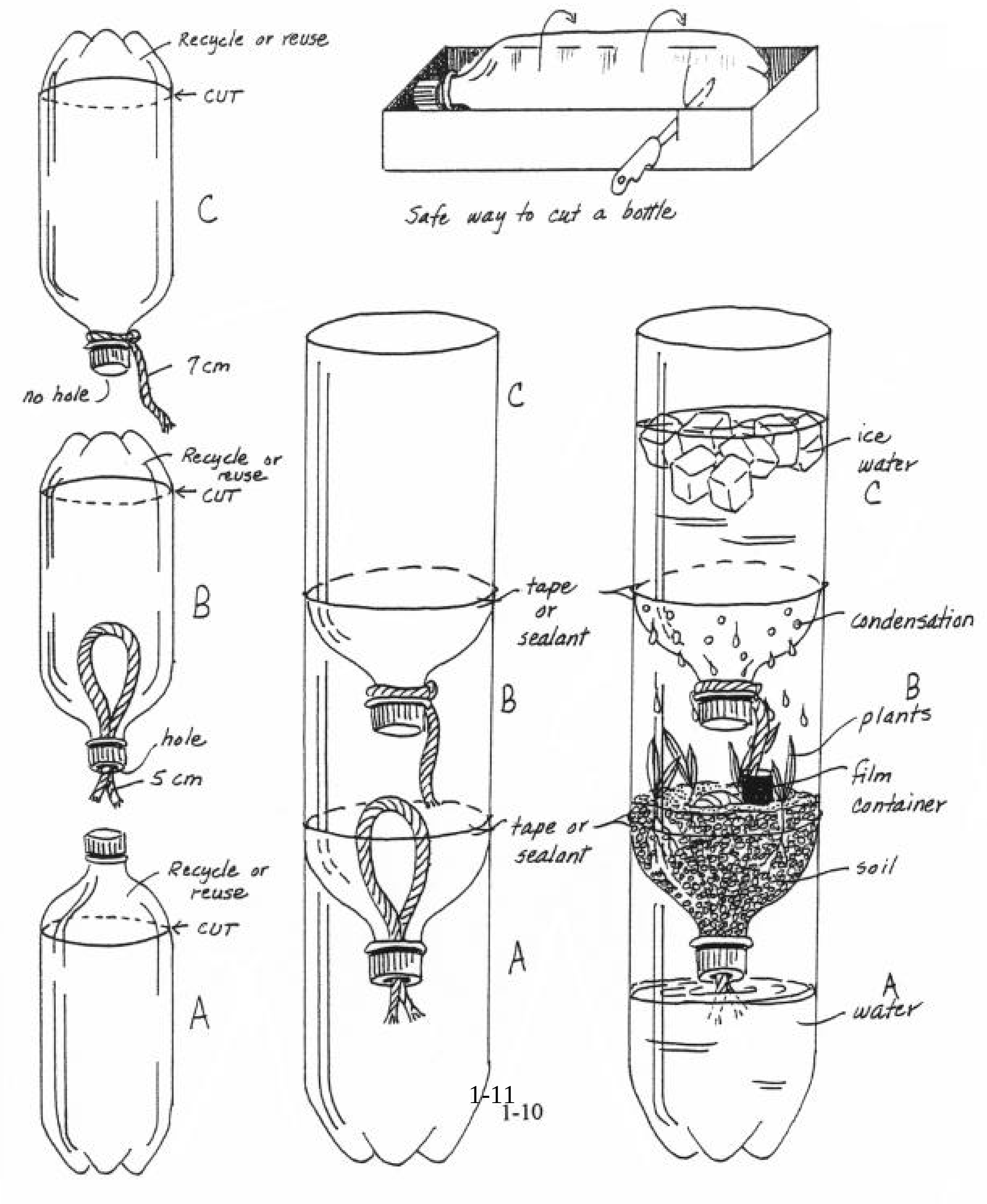


1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________
11. ______________________
12. ______________________
13. ______________________
14. ______________________

1-9

This is the 15. ______________________ cycle.

MODEL ASSEMBLY DIRECTIONS



SURVEYING THE PROPERTIES OF WATER

9-12

OBJECTIVES

The student will do the following:

1. Demonstrate the varied properties that make water unique.

2. List and define new terms.

SUBJECTS:
Science (Physical and Biology)
TIME:
1-2 class periods

MATERIALS:
plastic produce baskets
bowl
beaker
sand
vegetable oil
flashlight
3 x 5 index cards
thermometer
capillary tubes or straws (assorted diameters)
Bunsen burner or hot plate
salt
balance
paper cup
hydrometer (or graduated cylinder and balance)

BACKGROUND INFORMATION

The majority of the United States is blessed with an abundance of water. Seldom do the citizens of the U.S. experience a water shortage. These labs are designed to demonstrate to the student the unique properties of a natural resource that is often taken lightly because of its abundance.

Terms

colloid: a solid, liquid, or gaseous substance made up of very small, insoluble, nondiffusible particles that remain in suspension in a surrounding solid, liquid, or gaseous medium of different matter

density: the ratio of mass of an object to its volume

solution: a homogenous mixture of two substances, usually a gas or solid in a liquid

specific heat: the number of calories needed to raise the temperature of 1 gram of a given substance 1°C, relative to the number of calories (one calorie) needed to raise the temperature of 1 gram of water 1°C

surface tension: a property of liquids in which the exposed surface tends to contract to the smallest possible area, as in the formation of a meniscus. It is caused by unequal molecular cohesive forces near the surface.

suspension: a mixture whose particles are temporarily dispersed through a fluid but not dissolved in it

Tyndall effect: the scattering and polarization of a light beam caused when light is reflected from colloidal particles in a system

universal solvent: water; a material that can dissolve almost any other substance

PROCEDURE

I. Setting the stage

A. Review each of the characteristics to be demonstrated with the class.

B. Provide materials as needed.

II. Activity

A. The Universal Solvent: Water is said to be the "universal solvent" because a great many things can be dissolved in water. In this activity, we will investigate the mixtures formed with water.

1. Make predictions as to what will happen when small amounts of each of the following substances are added to water.

a. salt: ______________________________

b. sand: ______________________________

c. vegetable oil: ______________________________

2. Add small amounts of these materials to three beakers of water and record the results.

3. Determine the type of mixture (solution, suspension, colloid) that was made when these materials were added to water. Record the data in Table 1.

B. Specific Heat:

In this activity, the teacher conducts a demonstration to illustrate the high specific heat of water. A quantity of water will be placed in a paper cup, and the cup will be held directly in an open flame. Make a prediction as to what you think will happen.

Prediction____

Observations_______________________________________

C. Surface Tension: The molecules of water are capable of maintaining a bond between each other. This bond can be quite strong and allows the water molecules to stay close together.

1. Determine the mass of a plastic produce basket and record the value in Table

2. Make a ball of modeling clay so that its mass is equal to that of the plastic basket.

3. Predict what will happen when each is placed on the surface of the water in a bowl.

   a. clay ball____

   b. produce basket____________________________________

4. Place each on the surface of the water and record your observations.

   a. clay ball____

   b. produce basket____________________________________

5. Determine the average mass of a 3 x 5 index card. Record the value in the Data Table.

6. Position the plastic basket so that it is resting on the surface of the water.

7. Carefully place one index card across the top of the basket.

8. Repeat this step by laying one card at a time on the basket. Observe what is happening to the water surface in between the holes on the bottom of the basket.

9. Stop when the basket sinks below the water surface.

10 Remove one card from the pile and count the total number of cards remaining. Calculate the total mass of cards and basket that was supported by the water

and record the information in the Data Table.

11 Repeat this experiment using cold water and warm water.

Prediction: ______________________________

Why do you think this will happen? ______________________________

12 Additional experiments could include testing a sugar solution, a water solution, and a salt water solution.

Predictions: ______________________________

Why? ______________________________

D. Capillary action: a phenomenon related to surface tension is called capillary action. This characteristic causes water to "climb" in a narrow tube.

1. Use food coloring to make a colored water solution for this experiment.

2. Pour a small quantity of the colored water into a beaker or shallow bowl so that it is a few millimeters deep.

3. Make a prediction as to what will happen if one end of a straw is placed into the solution.

Prediction______________________________

4. Place one end of the straw into the water and record your observations.
____

5. Obtain an assortment of straws or capillary tubes. Measure the diameter of each tube or straw and record it on a label as well as on Table 3.

6. Record the temperature of the water in the Data Table.

7. Place each tube or straw into the water and record the height of the water in the column.

8. Repeat this experiment for water at higher and lower temperatures.

E. Density: Water is unique in the way that its density changes with temperature.

Continued cooling will increase density to a certain point. Then water does something odd compared to other liquids.

1. Using a hydrometer, measure the density of a tap water sample.

2. Measure the water temperature and record both in Table 4.

3. If possible, continue to chill the cold water sample to 4°C. You may need to use a freezer.

4. Measure the density at 4°C and record.

5. Chill the sample further and record the density.

Guess what is happening? In a demonstration to the class, two beakers have been set up, each containing a clear liquid. Make predictions as to what will happen when an ice cube is placed in each beaker. (One is water and one is alcohol.)

a. beaker 1 ______________________________

b. beaker 2 ______________________________

III. Extensions

A. Try the experiments using other kinds of liquids or solutions.

B. Discuss or review how these characteristics of water help to:

1. Support life.
2. Create weather phenomena.
3. Maintain ecosystems.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Organizing Data: **DATA**

Table 1: Mixtures

				Type of Mixture (check one)		
sample	color	setting	Tyndall effect?	solution	suspension	colloid

Table 2: Surface Tension

Mass of plastic produce basket ____________________ g

Mass of one 3x5 card ____________________________ g

Solution	Total mass supported (g)
Water (°C)	____________________ g
Water (°C)	____________________ g
Water (°C)	____________________ g
Salt solution	____________________ g
Sugar solution	____________________ g

Table 3: Capillary Action

	height of water columns		
tube diameter	(°C)	(°C)	(°C)

Table 4: Density of Water

water temperature (°C)	density of water (g/cm^3)

Analyzing Data:

1. Explain why the paper cup filled with water did not burn in terms of the specific heat of water.

2. Explain what your data tell you about the effect of temperature on surface tension.

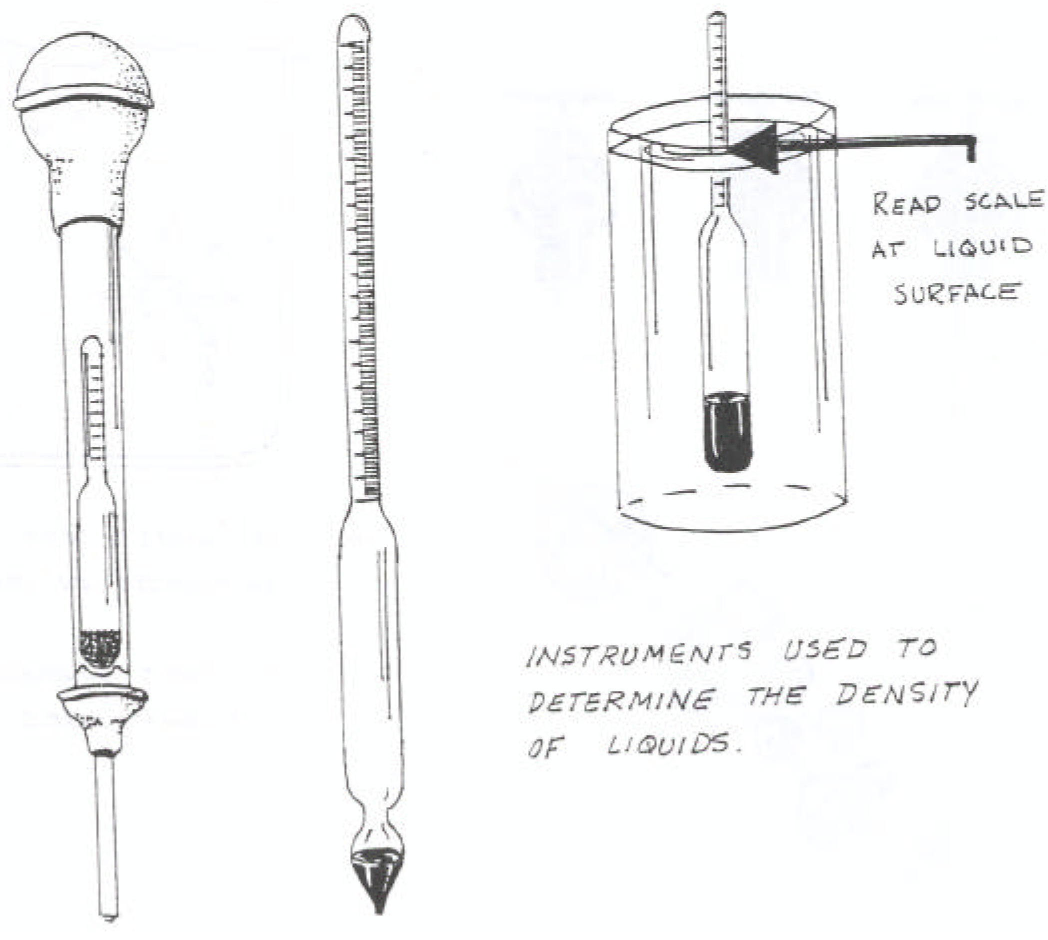
3. How did the presence of solutes affect the surface tension of the water?

4. Explain what the capillary tube activity demonstrated about surface tension.

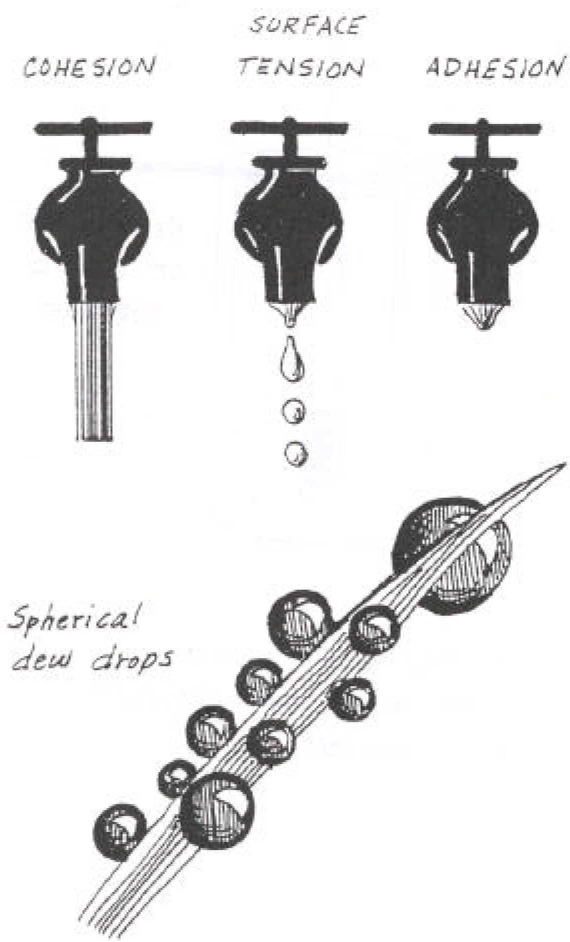
5. Explain what your data tell you about the effect of temperature on the density of water.

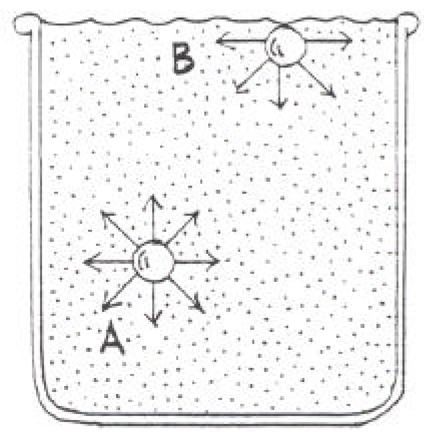
6. Explain why the ice cubes reacted the way they did in terms of density of the clear liquids in the beaker.

HYDROMETERS



SURFACE TENSION





A - net forces = zero
surrounded by molecules

B - net force downward
not surrounded

s

CLEARLY H_2O

9-12

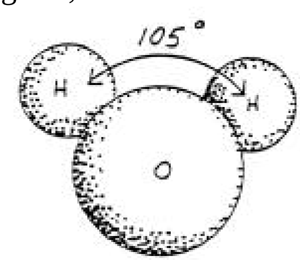
OBJECTIVES

The student will do the following:

1. Perform and read pH tests.
2. Observe with olfactory senses.
3. Determine boiling and freezing points.
4. Make a data chart to graph data.
5. Analyze the characteristics of water.

BACKGROUND INFORMATION

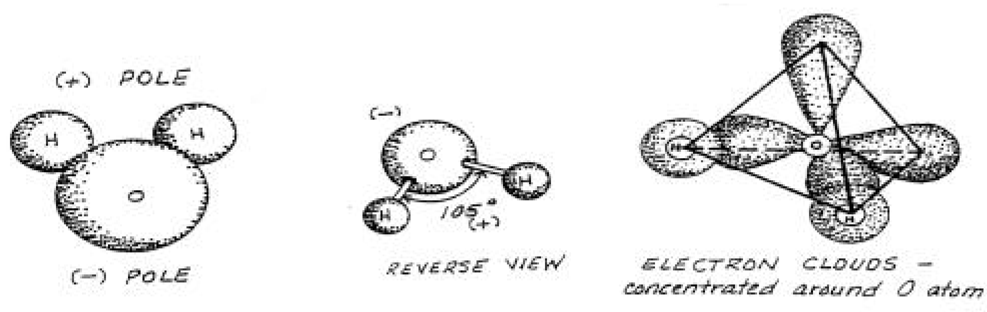
Water is abundant on, in, and around the Earth in liquid, gas (vapor), or solid (ice, snow) form. It has many unique properties that generally are the result of its unusual shape. Water molecules consist of two hydrogen atoms and one oxygen atom. Hydrogen and oxygen are gases; but when combined, they form a liquid chemical compound: water. The two hydrogen atoms form an angle of 105 degrees with oxygen atom. (It looks like Mickey Mouse!)



SUBJECTS:
Science (Physical, Chemistry, Ecology)

TIME:
1-2 class periods

MATERIALS:
10 - 100 ml beakers
10 thermometers
10 packs of pH paper
hot plate
10 trays
freezer
10 clear liquids
tap water
7-up®
vinegar
alcohol
distilled water
hydrogen peroxide
salt water
sugar water
dilute HC1
bottled water



This configuration produces an asymmetry of the water molecule with the oxygen atom dominating one end of the molecule and the hydrogen atoms dominating the other end. Because the oxygen atom has a larger positive nucleus than hydrogen, the electrons shared through covalent bonding between the oxygen and hydrogen atoms remain closer to the oxygen atom. This asymmetry causes the oxygen atom in a water molecule to have a slight negative charge and the hydrogen atoms to have a slight positive charge. A molecule that has (+) and (-) poles like this is called a polar molecule and it can act like a small magnet. Each (+) end of the water molecule repels a (+) end of another molecule or attracts another (-) molecule's end.

This weak attraction between the separate water molecules by way of the oxygen atom of one molecule and the hydrogen atom of an adjacent molecule is termed "hydrogen bonding" (each O-H bond is known as a hydrogen bond). Hydrogen bonds constantly form and break among the multitude of water molecules in liquid water; they hold water molecules together at normal temperatures and make it fluid. Evaporation of water occurs when individual water molecules at the air-water interface break free of all hydrogen bonds and enter the vapor phase.

Water can exist in any of three states: solid (crystal form), liquid, or vapor, depending primarily on temperature. Water molecules can be in constant, agitated motion, moving so fast that they are not connected to each other (vapor); or they can be slowed down so that each water molecule is touching other water molecules and the motion is not as fast (liquid); or the water molecules can be locked together in a crystal form (ice). As the temperature of liquid water is decreased below the freezing point or raised above the boiling point, its state changes. Imagine a pot of boiling water on the stove, where millions of water molecules are moving, actually "jumping" up into the air (evaporation) because of their kinetic movement when close to the surface.

Just because a substance appears to be water doesn't prove it is. Water, like any other substance, has its own specific properties: pH, boiling point, melting point, color, and odor. By using a few tests, students can determine if a substance is "clearly H_2O."

<u>Terms</u>

acidity: (1) a characteristic of substances with a pH less than 7; (2) tending to form an acid

adhere: to stick fast; stay attached to another substance

alkalinity: (1) a characteristic of substances with a pH greater than 7; (2) the capacity of water to neutralize acids, imparted primarily by the water's content of carbonates, bicarbonates, and hydroxides (expressed in mg/l of $CaCO_3$)

atom: any of the smallest particles of an element that combine with similar atomic particles of other elements to produce molecules; made up of electrons, neutrons, and protons

boiling point (BP): the temperature at which a liquid starts to bubble up and vaporize by being heated

cohere: to be united by molecular cohesion; to stick to the same substance

compound: a substance formed by the bonding of two or more atoms or ions that share electrons (covalent compounds) or transfer electrons (ionic compounds)

electron: any of the negatively charged particles that form a part of all atoms; exists outside the nucleus; involved in bond formation

element: natural substances that cannot be broken into anything simpler by ordinary chemical means

freezing point (FP): the temperature at which a liquid begins to precipitate crystals

kinetic movement: movement of electrons, atoms, and molecules as a result of their energy state

molecule: the smallest particle of a compound that can exist in the free state and still retain the characteristics of the compound

pH: a measure of the concentration of hydrogen ions (H^+) in a solution; the pH scale ranges from 0 to 14, where 7 is neutral, values less than 7 are acidic, and values greater than 7 are basic or alkaline. It is measured by an inverted logarithmic scale so that every unit decrease in pH means a 10-fold increase in hydrogen ion concentration. Thus, a pH of 3 is 10 times as acidic as a pH of 4 and 100 times as acidic as a pH of 5.

polar molecule: covalent molecule that has a partial (+) and partial (-) end

valence: a number representing the capacity of an atom or radical to combine with other atoms or radicals, as measured by the number of hydrogen or chlorine atoms which one radical or one atom of an element will combine with or replace (oxygen has a valence of two: one atom of oxygen combines with two hydrogen atoms to form the water molecule H_2O); the electric charge of an element or radical resulting from a change in oxidation state (that is, in the transfer or sharing of electrons)

ADVANCE PREPARATION

1. Ask students how they would determine that a glass of clear liquid was water.

2. Write down different ideas they have and discuss with class if these ideas would be accurate safe ways to determine whether or not the clear liquid was water.

3. Have students research to determine the pH boiling point and freezing point of water, or have them conduct experiments with one known sample being water.

PROCEDURE

I. Setting the stage

   A. Place 50 ml of 10 different clear substances in a 100 ml beaker. Number each beaker and keep a written record of each for a key. (For the teacher: see materials list.)

   B. Place each beaker in a tray with a thermometer and a pack of pH paper.

   C. Give each student a Data Sheet.

   D. Students may work individually or in groups and exchange trays when data are obtained from each one.

II. Activity

Data collection: Complete the Data Sheet from each of the following.

A. Remove a strip of pH paper carefully from the container without touching the end used for testing. Dip the end of the strip in each substance and match the colorimeter for a numerical value. Record the value on the Data Sheet.

B. To observe the odor, waft the top of the beaker with a hand towards the nose. Record if there is or is not a perceptible odor on the Data Sheet. If yes, record the odor (if you recognize it). If you do not recognize the odor, enter a ?(question mark).

C. Have students place the beakers on hot plates with a thermometer in each beaker. Bring each to a boil while watching the thermometer. As soon as boiling begins, read temperature and record on the Data Sheet. Repeat this procedure for all remaining substances. (Wear goggles.)

D. After boiling, let cool to room temperature. Then place all 10 substances in one tray in a freezer compartment. Keep thermometers in each of the beakers. Check every 30 minutes for signs of crystal formation. Remove substance from freezer as temperature

WARNING - DILUTE ACIDS USED

Use safety goggles.

DO NOT TASTE ANY SAMPLES!

Check for odors by gently wafting fumes from the liquids toward your face. (See illustration.)

Wash hands if they come in contact with the samples.

Carefully clean any spills.

is recorded on the Data Sheet when crystallization starts. Make temperature data available to all students.

III. Follow-up

A. Have students make three graphs of all 10 substances: one graph for pH, one for boiling point, and one for freezing point. (options: line or bar graph)

B. Students should determine which sample(s) is(are) water using the known information on H_2O.

IV. Extensions

Ask students:

1. What would be the next step in determining if the water is potable? Design an experiment to determine if the water is potable.

2. How could it be guaranteed that the water is potable?

3. Which of the liquid unknowns is water? How do you know?

4. Do all clear liquids have the same BP? FP?

5. How can you use what you learned to find out if an unknown clear liquid is water?

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Data Sheet

1. Complete the data analysis:

Known information on H_2O: odor ______

pH _______

BP _______ºC

FP _______ºC

Give recorded data for each:

#______ pH ______ odor _____ BP ______ FP ______	# ______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______
#______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______	#______ pH ______ odor _____ BP ______ FP ______

A. Substances with recordings closest to known data for H_2O, #_______.

B. Which sample(s) is(are) water?

C. Does this test determine if the water is potable?

WATER, WATER EVERYWHERE

9-12

OBJECTIVES

The student will do the following:

1. Determine how much water there is on the Earth.
2. Identify ways of conserving water.
3. Evaluate the future demand for water.
4. Reproduce the hydrologic cycle.
5. Determine what state or territorial agencies investigate, monitor, or regulate water resources in the state or territory.

SUBJECT:
Science (Physical)

TIME:
3 class periods
optional 1 field trip

MATERIALS:
The World's Water article
optional field trip and /or water analysis kit

BACKGROUND INFORMATION

With many rivers, lakes, and streams in the United States, you would think that there would never be a water shortage. Because we share our borders with Canada and Mexico, we also share water resources. Water from lakes and rivers, as well as groundwater, is shared. This creates a need for cooperation and planning between the United States and our bordering countries. With the increasing demand for fresh water, we can no longer take our water supply for granted. We now realize that our present water resources are limited. Today's students will be challenged to find technical and social solutions to meet future U.S. water demands.

<u>Terms</u>

atmospheric water: water found in vapor form in the atmosphere

condensation: (1) the process of changing from a vapor to a liquid; (2) a liquid obtained by the coming together of a gas or vapor

evaporation: the process of changing from a liquid to a vapor

groundwater: water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation

hydrologic cycle: the cyclical process of water's movement from the atmosphere, its inflow an temporary storage on and in land, and its outflow to the oceans; cycle of water from the atmosphere, by condensation and precipitation, then its return to the atmosphere by evaporation and transpiration

salinity: the amount of salt dissolved in water

transpiration: process in which water absorbed by the root systems of plants, moves up through the plants, passes through pores (stomata) in their leaves or other parts, and then evaporates into the atmosphere as water vapor; the passage of water vapor from a living body through membrane or pores

vadose zone: the zone of aeration between the Earth's surface and the water table; area of th soil that contains both air and water; same as unsaturated zone--zones between land surface and the water table

water analysis: series of tests to determine various chemical or physical characteristics of a sample of water

zone of saturation: that region below the surface in which all voids are filled with liquid

ADVANCE PREPARATION

A. Make copies and have students read "*The World's Water.*"

B. The article is provided to explain the world water supply and nature's methods of replenishing fresh water. This inventory of the world's water and description of the water cycle provides the initial information for discussion.

C. Class exercises may then expand on this information to learn what technology can do to provide sufficient water for the future.

PROCEDURE

I. Activity

A. Fill out Student Sheet on Hydrologic Cycle. (See activity on Hydrologic Cycle.)

B. Determine the source of water for your school and visit a local treatment plant.

C. From the total annual rainfall given in the article, calculate the average annual rainfall over the Earth.

D. Can glaciers and icecaps be used for fresh water? Are they limited, or are they being replenished?

E. Study past droughts in this century.

F. Evaluate the future demand for water in your city based on the patterns of population and industrial growth.

G. List short term and long term methods of conserving water.

H. If people in your city decided on a very austere use of water, how would it affect the community?

I. Discuss possible conflicts that could arise from the increased demand for water between countries and states.

II. Follow-up

A. Have students develop a water trivia sheet from "The World's Water" article. Use these to develop quiz questions.

B. Name one state or territorial agency which regulates, monitors, or investigates water resources in your state or territory. (Contact state/territorial environmental management agency or geological survey.)

C. Write to research companies, such as Phillips Petroleum, who advertise that they can purify sea water for drinking water. Learn the way this is done and the potential for doing it in your area.

D. Investigate water's role in providing the world's energy (HINT: Hydropower - hydroelectric and tidal power).

III. Extensions

A. In 1986, the Great Salt Lake in Utah was at its highest level in recorded history. The Great Lakes were also considered high and were eroding their shores. Can you determine why this occurred?

B. Discuss this question: Do city officials encourage expanded use of water because it brings in revenue?

C. Build a small, low-cost solar still. (This may require a little research.)

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Forrester, F. H., An Inventory for the World's Water, (ESO2), Weatherwise, Helen Dwight Reid Education Foundation, Heldref Publications, 1319 18th St. N.W., Washington, D. C. 20036-1802, April 1985.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

THE WORLD'S WATER

By Frank H. Forrester

Nobody really knows exactly how much water exists around the world. The sheer volume of our planet's water -- locked in glaciers, stored in lakes, detained in underground rocks, or moving in the atmosphere, river and seas -- almost defies the imagination. Even the hottest and driest parcels of air overlying the world's most arid regions contain at least traces of water vapor as part of the Earth's aerial canopy of gases. In the same arid regions, dry though the surfaces may be, abundant water often can be found in deep subsurface rock formations.

The waters of the world have been inventoried, roughly of course, but within generally accepted limits of hydrologic research. Like oil or gas inventories, estimates of water might be broken down into two major categories: known or identified reserves and unknown or inferred resources. Water contained in large glaciers, many rivers, lakes, and seas can be identified or estimated with reasonably high percentages of accuracy. Estimates of groundwater resources, however, often based on indirect evidence and measurements, are compiled with varying degrees of uncertainty. Even today, the United States is far from completing the task of probing suspected sources of groundwater and determining the amounts the hydrated rocks might yield.

Some research hydrologists of the U.S. Geological Survey have estimated that the world's water supply-- liquid, frozen, and vapor- - totals 326 million cubic miles (a cubic mile is equal to about 1. 1 trillion gallons of water). If this total supply were in liquid form and poured upon the 50 United States, the land surface would be submerged to a depth of about 90 miles.

With "water, water everywhere," why are there shortages? To answer this question and others related to a variety of water problems, it is instructive --perhaps imperative -- to consider water on a planetary scale.

Most people are aware that water is unevenly distributed on the Earth's surface in oceans, rivers, and lakes, but few realize the disproportion of the distribution. Further, few realize the manner in which "hidden" water is distributed - underground, in glacial ice, and in the atmosphere. Finally, one of the most important concepts of hydrology, known as the hydrologic cycle, is often poorly perceived by the public. This endless cycle, a global natural distillation and pumping system, has been going on since the first clouds formed and the first rains fell, transferring water time and again from the surface of the land and water to the sky and back again, keeping our planet fed with the liquid of life. The waters of long geologic history are the waters of today; little has been added or lost.

An Inventory of the World's Water

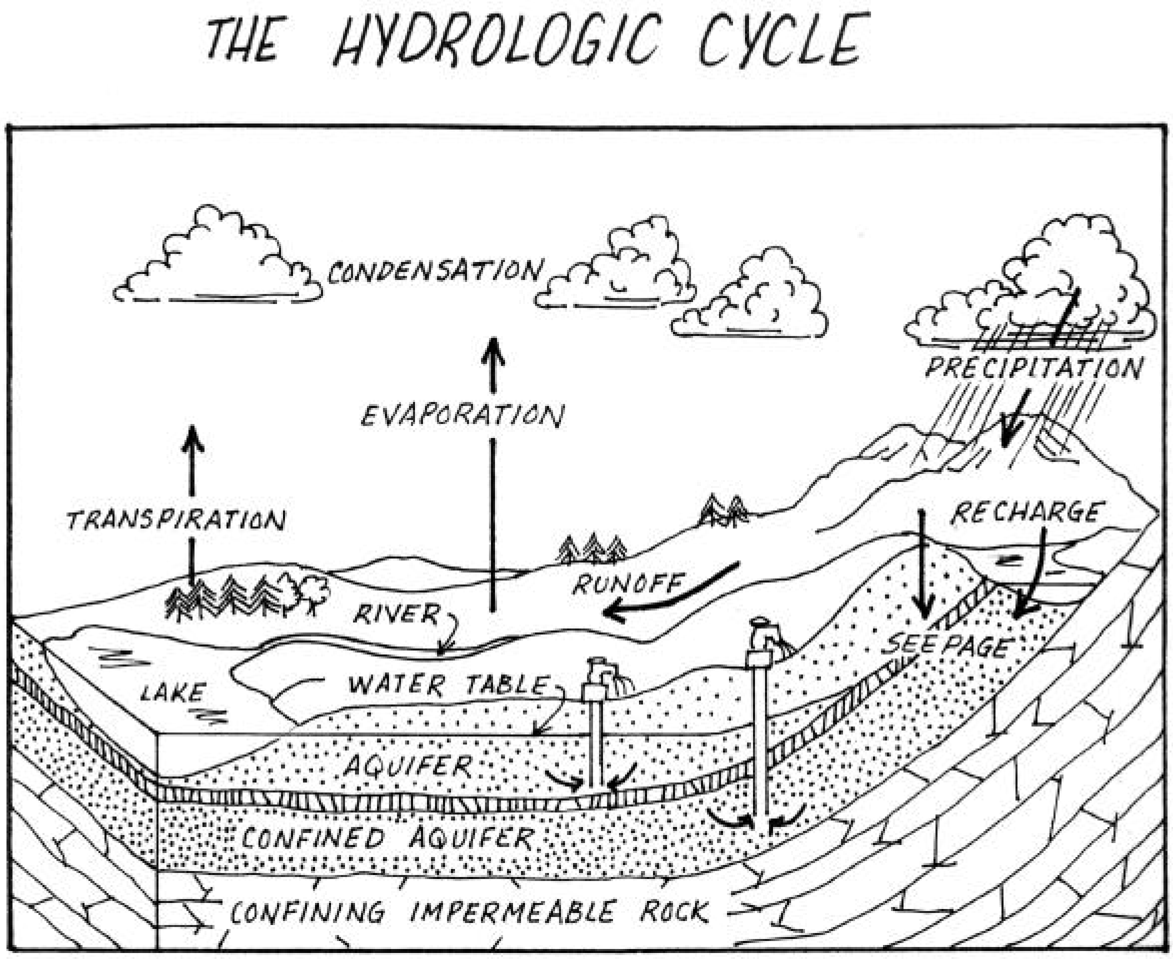
Views of the Earth from space confirm one of the first lessons of geography in elementary schools--water covers about 70 percent of the Earth's surface. But this one-dimensional view, suggestive as it is, provides only a beginning hint in preparing a world water inventory. There are a host of surprises to be found in such an inventory; one is the realization that man gets by on an incredibly small amount of the total supply of 326 million cubic miles. Usable fresh water amounts to less that 1 percent of the total!

It should come as no surprise to find that the world's oceans -- covering 139.5 million square miles of the Earth's surface, with their basins averaging about 12,500 feet in depth -- comprise the bulk of the world's water. It may be an eye-opener, however, to learn that the approximately 320 million cubic miles of sea water constitute about 97.2 percent of the planet's total water supply. Every other source of water pales in statistical comparison to the oceans, but the importance to mankind of other, lesser sources is not revealed by sheer statistics.

The next items on the world water balance sheet are the planet's icecaps and glaciers. The amount of water stored in frozen form, though a far second to the oceans, nonetheless totals an impressive 7 million cubic miles, representing 2.15 percent of the world's water. Of the frozen water, mountain glaciers, such as those of the Alps in Europe, the Himalayas of Asia, the Cascades of North America, and small icecaps in the world, have a total volume of only about 50,000 cubic miles - an insignificant fraction of the world's water. But the Greenland and Antarctic icecaps are entirely different matters.

About 667,000 square miles in area, and averaging more than 5,000 feet in thickness, the Greenland icecap represents about 630,000 cubic miles of water. If melted, the Greenland icecap would yield enough water to maintain the flow of the Mississippi River for more than 4,700 years. Even so, this is less than 10 percent of the total volume of icecaps and glaciers.

The greatest single item in the water budget of the world, aside from the oceans, is the Antarctic ice sheet. The huge southern hemisphere icecap, 1000 feet thick in some places, and covering an area of about 6 million square miles, has a total volume of between 6 and 7 million cubic miles or about 85 percent of all existing ice and about 64 percent of all water outside the oceans. If the Antarctic icecap were to melt at a suitable uniform rate, it could feed the Mississippi River for more than 50,000 years; all rivers in the United States for about 17,000 years; the Amazon River for about 5,000 years; or all the rivers of the world for about 750 years.



THE HYDROLOGIC CYCLE of the world's water budget. Water that has evaporated from the Earth's surface may fall as precipitation many thousands of miles from where it entered the atmosphere. (Adapted from Spiegel and Graber, From Weather Vanes to Satellites.)

Thus far, we have inventoried slightly over 99 percent of the world's water: that contained in the oceans, icecaps, and glaciers. Statistically, the next ranking source of water consists of subsurface water or groundwater. Estimates of such water are broken down into three categories: vadose water (which includes surface moisture); groundwater to a depth of a half mile; and deep-lying groundwater.

Vadose Water

The average amount of soil moisture at any given time is on the order of 6,000 cubic miles for the world as a whole, an extremely small percentage of the Earth's total water but profoundly important because of the key role played by plants in the food chain. On a global scale, relatively little vegetation receives artificial irrigation; most of it depends upon soil moisture. The world volume of vadose water -- water just below the belt of soil moisture -- probably is somewhat more than that of soil moisture, say 10,000 cubic miles. Again, this is not a significant amount on a world scale; and even though not extractable by man, it is important because it is potential groundwater recharge and groundwater is extractable.

Groundwater

Below the vadose water, our planet contains a water reservoir, groundwater, known to man for thousands of years. Scripture on the Noacniari Deluge states, "The fountains of the great deep (were) broken up ." Exodus, among its many references to water and to wells, refers to "water under the Earth." Many other chronicles show that man has known from ancient times that there is much water underground. Only recently, however, have we begun to appreciate how much groundwater exists and how important it is in meeting current and future water needs.

Beneath most land areas of the world, even under deserts, mountain peaks, and some sub-sea floors, there is a zone where the pores of rocks and sediment are saturated with water. The upper limit of the saturated zone is called the water table. It may be right at the land surface as in a marsh, or it may lie hundreds of thousands of feet below the land surface as in some arid regions.

Sometimes there are surprises in groundwater discoveries. In 1965 during a geologic probe of the Atlantic sea floor about 30 miles off northern Florida by an international team of scientists aboard a research vessel, drilling struck some sub-sea rocks that contained fresh water. Pumped to the ship's deck, the water was found to be potable -- a spinoff dividend from the expedition.

In 1975, U.S. Earth scientists tapped other water-bearing rock formations under the ocean about 30 to 60 miles off the Mid-Atlantic coast. When tested, the water was found to be of surprisingly low salinity, some of it directly potable and some requiring slight treatment to reach drinking water standards. These and other potential sub-ocean deposits of fresh water are not likely to be used in the reasonably near future. They do, however, reflect the watery nature of our planet, and they are of great research value. The findings off the Atlantic coast, for example, may yield insight into such problems as salt water invasion of aquifers (subsurface, water-bearing rock formations) that are tapped by many Atlantic coast communities.

Below the water table to a depth of about a half mile in land areas of the Earth's crust, there is an estimated 1 million cubic miles of groundwater. This is probably 3,000 times greater than the volume of water in all rivers at any one time. An equal, if not greater, amount of groundwater is present at a greater depth down to some 10,000 to 15,000 feet. This deeper water, however, circulates sluggishly because its rocks are only slightly permeable. Much of the deep-lying water is not economically recoverable for human use at the present time, and a good deal of it is strongly mineralized.

Tallying all the subsurface waters of the planet, the total is a little over 2 million cubic miles or about two-thirds of one percent of the world's water. The balance is to be found in surface water (freshwater lakes, saline lakes, inland seas, and rivers) and in the atmosphere.

The Earth's land areas are dotted with hundreds of thousands of lakes. Wisconsin, Minnesota, and Finland each contain some tens of thousands. But these lakes, important though they may be locally, hold only a minor amount of the world supply of fresh water, most of which is contained in a relatively few large lakes on three continents - Africa, Asia, and North America.

Whether water is fresh or salty makes a considerable difference in its usefulness to man, and the Earth's greatest lakes fall in both categories, fresh and salt.

Lakes, Both Fresh and Salt

The volume of all the large freshwater lakes in the world aggregates nearly 30,000 cubic miles (their combined surface area is about 330,000 square miles). "Large" is a relative term for our inventory purposes. A lake is called large if its contents are 5 cubic miles or more. Thus, the listing includes the Dubawnt Lake, Canada (about 6 cubic miles), but excludes the Zurich Sea of Switzerland (about 1 cubic mile). The range of volume among the large lakes is enormous, from a lower limit of 5 cubic miles to an upper one of 6,300 cubic miles in Lake Baikal, Siberia. An appreciation of this volume may be gained from the realization that Lake Baikal alone contains nearly 300 cubic miles more water than the combined contents of the five North American Great Lakes. These Great Lakes loom large on a map, but their average depth is considerably less than that of Baikal.

For comparison purposes, here are some of the world's large freshwater lakes (in terms of water volume): Dubawnt, Canada; and Tutigting, China (about 6 cubic miles each); Leman, Switzerland (about 12 cubic miles); Vanern, Sweden (about 35 cubic miles); Nipigan, Canada (about 150 cubic miles); Great Bear, Canada (about 670 cubic miles); Superior, U.S. and Canada (about 3,000 cubic miles); Nyasa, Africa (about, 3,200 cubic miles); Tanganyika, Africa (about 5,000 cubic miles); and Baikal, Siberia (about 6,300 cubic miles).

Saline lakes are roughly equivalent in magnitude to freshwater lakes. Their total area is about 270,000 square miles, and their total volume is about 25,000 cubic miles. The distribution, however, is quite different. About 19,240 cubic miles (75 percent of the total saline volume) is in the Caspian Sea, and most of the remainder is in Asia. North America's shallow Great Salt Lake is comparatively insignificant with about 7 cubic miles.

Rivers and Streams

Rivers and streams are next in the water budget calculations, and here we need to differentiate between the actual amount of water present at any given time in river channels and the amounts that are discharged by the rivers. It has been estimated that the total amount of water physically present in stream channels throughout the world at a given moment is about 500 cubic miles, a small fraction of the world's fresh surface water supply and only a little more than one thousandth of the world's total supply.

To get a better perspective of the relative importance of large and small rivers in maintaining continental water balance, consider some statistics on the amounts of water that flow or discharge out of rivers. The Mississippi, North America's largest river, has a drainage area of 1,243,000 square miles (about 40 percent of the total area of the 48 conterminous states) and discharges at an average rate of 620,000 cubic feet per second. This amounts to some 133 cubic miles per year and about 34 percent of the total discharge from all rivers of the United States. The Columbia, nearest competitor of the Mississippi, discharges less than 75 cubic miles per year. Relatively speaking, the great Colorado River is a watery dwarf, discharging only about 5 cubic miles annually.

On the other hand, the Amazon, the largest river in the world, is nearly 10 times the size of the Mississippi, discharging about 4 cubic miles each day or some 1,300 cubic miles per year -- about 3 times the flow of all U.S. rivers.

Africa's great Congo River, with a discharge of about 340 cubic miles per year, is the world's second largest. The estimated annual discharge of all African rivers is about 510 cubic miles.

Measurements of only the few principal streams on a continent afford a basis for reasonably accurate estimates of the total runoff item in a continental water balance. The small streams are important locally, but they contribute only minor amounts of the total water discharged. Thus, it is possible to estimate the total runoff of all the rivers of the world even though many of them have not been measured accurately. It is calculated that 97 principal rivers of the world discharge about 4,980 cubic miles of water yearly. The estimated total from all rivers, large and small, measured and unmeasured, is about 8,430 cubic miles yearly (about 23 cubic miles daily).

The figure of about 500 cubic miles --the amount estimated to be present in river channels throughout the world at any given moment--is, however, suitable for entry in the world water inventory.

The Atmosphere

The final item in the world's water budget is the atmosphere, the gaseous ocean that clings to the Earth's surface by gravity. In view of the total precipitation that falls on the surface of our planet in the course of a year, one of the most astonishing world water facts is the extremely small amount of water in the

atmosphere at any given time. Consider, for example, that the volume of the lower 7 miles or so of the atmosphere--the realm of weather phenomena--is roughly 4 times the volume of the world's oceans. But the atmosphere contains only about 3,100 cubic miles of water (about one-
one hundredth of a percent of the world's total supply), chiefly in the form of invisible vapor. If all this vapor were suddenly condensed and then precipitated from the air onto the Earth's surface, it would form a layer only about 1 inch thick.

Powered by the sun's heat and energy, together with the force of gravity, the hydrologic cycle keeps the world's water moving; essentially there results a key balance--what goes up comes down. In the natural cycle, there occurs a three-way action that allows the total replenishment of water to the sky, sea, and Earth. It starts with a process whereby water vapor rises into the air from oceans, lakes, forests, fields, plants, and animals the world over (evaporation). This water vapor then develops, by cooling, into visible moisture in the form of clouds or fog (condensation). Finally, the cycle of replenishing is completed by the return of the water to the land and sea in liquid or solid form (precipitation).

As a cycle, the global water system has neither beginning nor end; but from man's point of view, the oceans are the major source, the atmosphere is the deliverer, and the land is the user. In the cycle, there is no water lost or gained; but the amount of water available to the user may fluctuate widely because of variations at the source or, more usually, in the delivering agent. In the geologic past, large alterations in the cycle roles of the atmosphere and the oceans have produced deserts and ice ages across entire continents. Even now, small fluctuations of the local patterns of the hydrologic cycle produce floods and droughts.

On the average--about once every 12 days or so--the water in the air falls and then is replaced. Once fallen, water may move swiftly to the sea in rivers or may be held in glaciers for several decades, in a lake for 100 years, or in the ground from a few years to thousands of years depending upon how deep the water goes. Or, the water may evaporate almost immediately. Regardless of how long the water is delayed, it is eventually released to enter the cycle once more.

About 102,000 cubic miles of water rise into the air annually. Of this amount, about 78,000 cubic miles fall directly back into the oceans. Streams and rivers collect and return to the oceans some 9,000 cubic miles of water including a large quantity that has percolated down into the ground and that, as groundwater, moves slowly to natural outlets in the banks and channels of rivers. This movement of groundwater into a river "feeds" the river, maintaining its flow even when precipitation is scarce throughout the basin drained by the river. The remaining 15,000 cubic miles of water soaked into the ground and, principally as soil moisture, maintain plant and animal life. The water ingested by living organisms ultimately is returned to the air again through evaporation, excreta, or perspiration. Once more there is a balance of water intake and outgo.

In the conterminous (48) United States, it has been estimated that about 1,420 cubic miles (about 1,560 trillion gallons of water or equivalent to about 30 inches of rain) fall annually as rain, sleet, and snow. Of this, about 995 cubic miles (about 1,100 trillion gallons) evaporate into the atmosphere. Another 380 cubic miles (420 trillion gallons) flow to the seas as surface runoff, and about 45 cubic miles (about 50 trillion gallons) of groundwater are discharged directly to the seas. Recent rough estimates by federal hydrologists indicate that there is a total of about 53,400 cubic miles (58,740 trillion gallons) of groundwater in storage in the United States.

A Drumful of Water . . .

If we let a 55-gallon drum, filled to the brim, represent the world's total water supply, then . . .

' the oceans of the world would total 53 gallons, 1 quart, 1 pint, and 12 ounces;

' the icecaps and glaciers would total 1 gallon and 12 ounces;

' groundwater would add up to 1 quart and 11.4 ounces;

' the atmosphere would contribute 1 pint and 4.5 ounces;

' freshwater lakes would add up to half an ounce;

' saline lakes and inland seas would total slightly more than a third of an ounce;

' soil moisture and vadose water would total about one-fourth of an ounce;

' and the rivers of the world would measure only one one-hundredth of an ounce, less than one one-millionth of the waters on the planet.

Global Water: The Challenge

Water everywhere indeed! But while the water cycle balances what goes up with what comes down on a worldwide basis, no such reciprocity exists for individual areas -- a blessed circumstance for some regions and often a disastrous occurrence for others. Simply stated, nature does not always provide the amount of water needed everywhere, when needed, nor with the desired quality. And adding to the fickle ways by which water is distributed through the natural cycle are the complications posed by the spread of human population and activities. With about 97 percent of all water stored in the oceans, and with most of the remainder frozen on Antarctica and Greenland, man must get along with the less than 1 percent of the world's water that is directly available for freshwater use.

Thus, water is a global concern; the water cycle recognizes no national boundaries. Man's future success on this planet may well hinge on the degree to which nations join to cooperate effectively in the conservation and wise development and use of water.

A GLOBAL VIEW OF THE WET EARTH

9-12

OBJECTIVES

The student will do the following:

1. Locate and label the major bodies of water and the major rivers of Earth.

2 Locate and label the major centers of population in the world.

3. Locate and label countries that are "water scarce" at the present time and those projected to be in future years.

4. Differentiate among various types of water resources.

5. Know the impacts and stresses large centers of population exert on water resources.

SUBJECTS:
Science (Physical), Math, Art, Social Studies (Geography, Economics)

TIME: varies
several activities included, each requiring 1-2 class periods

MATERIALS:
outline maps
lists of water sources, population centers
pencils (or colored pencils)
globe(s)
almanac(s)
world map(s)
worksheets

BACKGROUND INFORMATION

Earth is the water planet with 71% of its surface covered by water. Water features define continental, national, and state boundaries and influence climate, productivity, and accessibility for the land. Too often our knowledge of geography is hazy or limited and in need of expansion or review.

U.S. citizens use about 150 gallons of water per day per person for ordinary household use. Europeans use a third of this and citizens of other nations much less. It takes about one gallon per day per person just to sustain life.

Renewable water resources, such as groundwater or lakes, are becoming scarce for many countries experiencing population growth. World Resources Institute has identified 26 countries with less than 1000 cubic meters (m^3) of water available per person annually. The United States has about 10,000 m^3/person annually. Most of the water-scarce places are located in Africa, the Middle East, or islands. (Note: 1 m^3 = 265 gal.)

Most citizens of developed countries consider water quality as a local environmental problem and have focused efforts on local waterways. Many Americans do not understand the growing world-wide water crisis. Water, made unsafe by human waste, industrial wastewater, pesticides, and fertilizers, represents a major global health problem as well as contributes to water scarcity. If sources become too polluted, they are often abandoned rather than cleaned.

Over 12 million children die each year because of unsafe drinking water. The United Nations set a goal ensuring that all people would have safe drinking water by 1990. This goal has not yet been attained. Despite progress, many countries still lack sanitation facilities that would prevent organic wastes from polluting drinking water. In addition, affluent nations, such as the United States as well as these developing countries, need stronger measures to preserve groundwater from contamination. Many people rely on groundwater; and groundwater, once contaminated, cannot be decontaminated in the same ways that polluted lakes and rivers can.

Students should have a global conception of water resources and know where the resources lie. We, therefore, face the serious educational challenge of getting water quality and water scarcity to be perceived as central global environmental issues. These activities are steps toward that direction.

Terms

bay: a body of water partly enclosed by land but with a wide outlet to the sea

equator: a great circle of the Earth that is everywhere equally distant from the two poles and divides the Earth's surface into the northern and southern hemispheres

glacier: a large mass of ice formed on land by compacted snow

gulf: large area of a sea or ocean partially enclosed by land

harbor: a waterbody where wave action is reduced or dampened

lagoon: a shallow body of water, especially one separated from the sea by sandbars or coral reefs

lake: a standing body of water which undergoes thermal stratification and turnover by mixing

ocean: the entire body of salt water that covers about 71 percent of the Earth's surface

pond: a still body of water smaller than a lake where mixing of nutrients and water occurs primarily through the action of wind (as opposed to turnover)

river: a large body of flowing water that receives water from other streams and/or rivers

river mouth: where the river empties into a larger body of water

river source: where the river begins

sound: long, broad inlet of the ocean larger than a strait or channel, connecting larger bodies of water

strait: a narrow passage of water that connects two larger bodies of water

tributary: a stream that flows into a larger stream, river, or another waterbody

waterfall: a cascade of water, as over a dam

ADVANCE PREPARATION

A. Prepare copies of world maps and lists for each student or group of students who will work together.

B. Gather sufficient atlases, reference materials, maps, globes.

C. Copy lists of waterways and population centers from an almanac.

PROCEDURE

I. Setting the stage

A. Give Background Information and invite discussion about water uses and misuses, types of bodies of water, and problems from water shortages.

B. Distribute copies of maps and lists to students.

C. Explain the use of globes, almanacs, and other resources that have been provided.

II Activity

A. Identify types of surface water sources in the vocabulary and locate examples on the maps provided.

B. Locate water-scarce countries and countries with large population centers on the maps provided.

C. Relate water scarcity to:

1. topography (runoff).

2. climate (little natural precipitation).

3. economic development (the cost of wells, water treatment).

4. population size or population growth rate (amount available per person).

IV. Follow-up

A. Watch for current events stories about world water supplies. Keep a current bulletin board of these items.

B. Have a geography bee to reinforce knowledge of <u>types</u> of surface waters and/or <u>names</u> of surface waters.

C. Discuss the relationship between population centers and fresh water sources.

IV. Extensions

A. Convert the amounts of water shown to gallons per person. Compare your own usage to that of an African nation.

B. Locate large industries, agricultural areas, economic centers, deserts. Note areas that have had recent water shortages.

C. Do a current events search for these bodies of water.

D. Assign each student a current event on which to do further research.

E. Add your state map with its rivers, lakes, bays, and dams to the assignment.

F. List some possible environmental and cultural factors leading to water scarcity.

G. Present and defend some possible solutions in terms of expense, time delay, cultural acceptability.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

State or Locally Adapted World History Book; World Almanac

Name________________________________ Date__________

FOR EACH TERM LISTED BELOW, DEFINE THE TERM AND LOCATE ONE OF THE EXAMPLES GIVEN ON A WORLD MAP. MARK THE LOCATION ON THE MAP WITH THE CORRESPONDING LETTER OF THE ALPHABET FOR EACH TERM.

A. Canal (Erie Canal, Panama Canal, Suez Canal)
Defined:____

B. Gulf (Gulf of Mexico, Persian Gulf, Gulf of Carpentauria)
Defined:____

C. River (Mississippi, Rio Grande, Nile, Amazon)
Defined:____

D. Reservoir (Lake Mead, AZ or Lake Martin, AL)
Defined:____

E. Port (New York, Los Angeles, Mobile)
Defined:____

F. Harbor (San Diego, New Orleans, Hong Kong)
Defined:____

G. Lake (Superior, Erie, Victoria)
Defined:____

H. Coast (Gulf Coast, Pacific Coast, Atlantic Coast)
Defined:____

I. Ocean (Atlantic, Pacific, Indian)
Defined:____

J. Bay (Chesapeake Bay, Hudson Bay, Bay of Biscay)
Defined:____

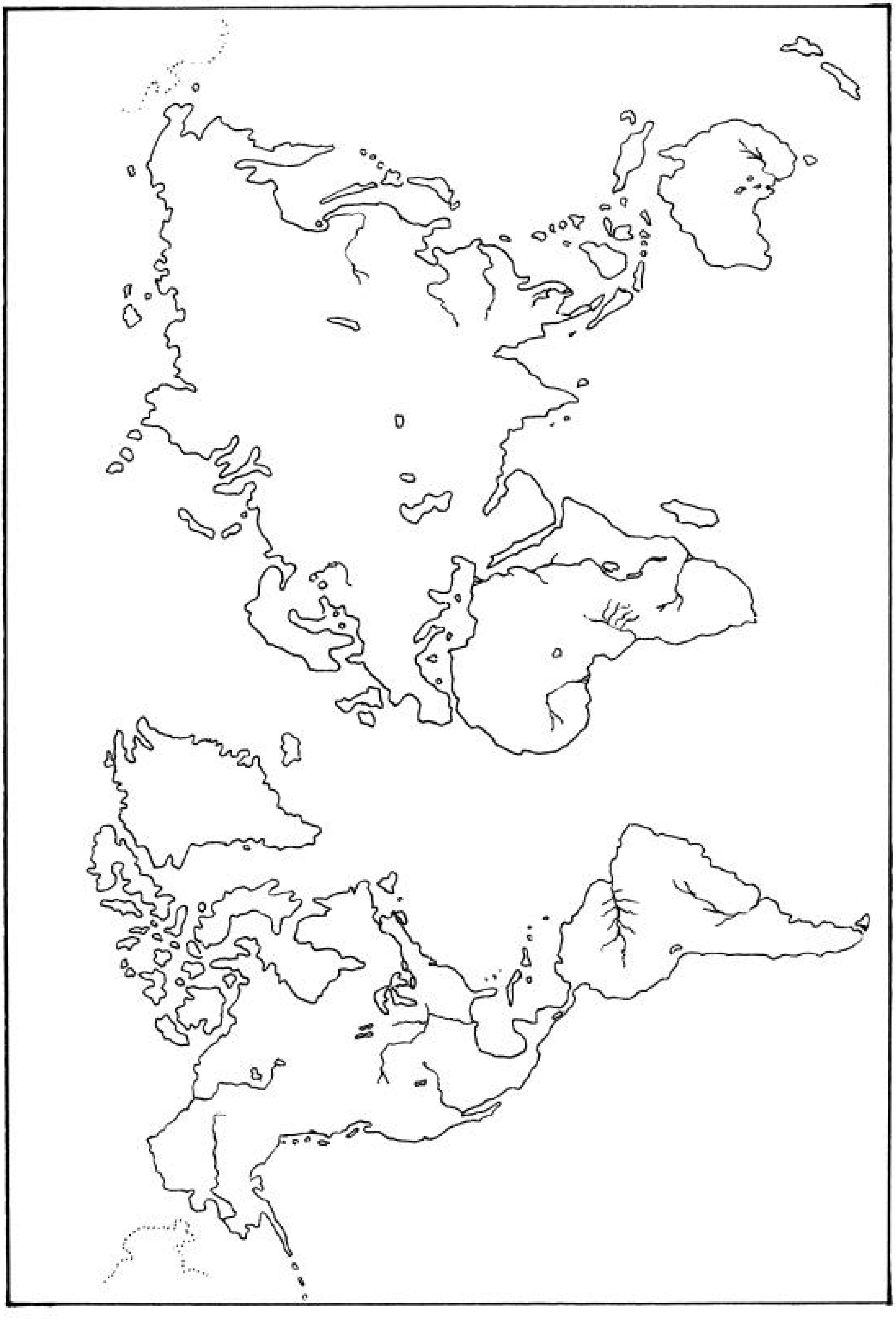
K. Strait (Bering Strait, Strait of Gibraltar, Magellan)
Defined:____

L. Reef (Great Barrier Reef, Great Bahama Bank, Great Sand Barrier)
Defined:____

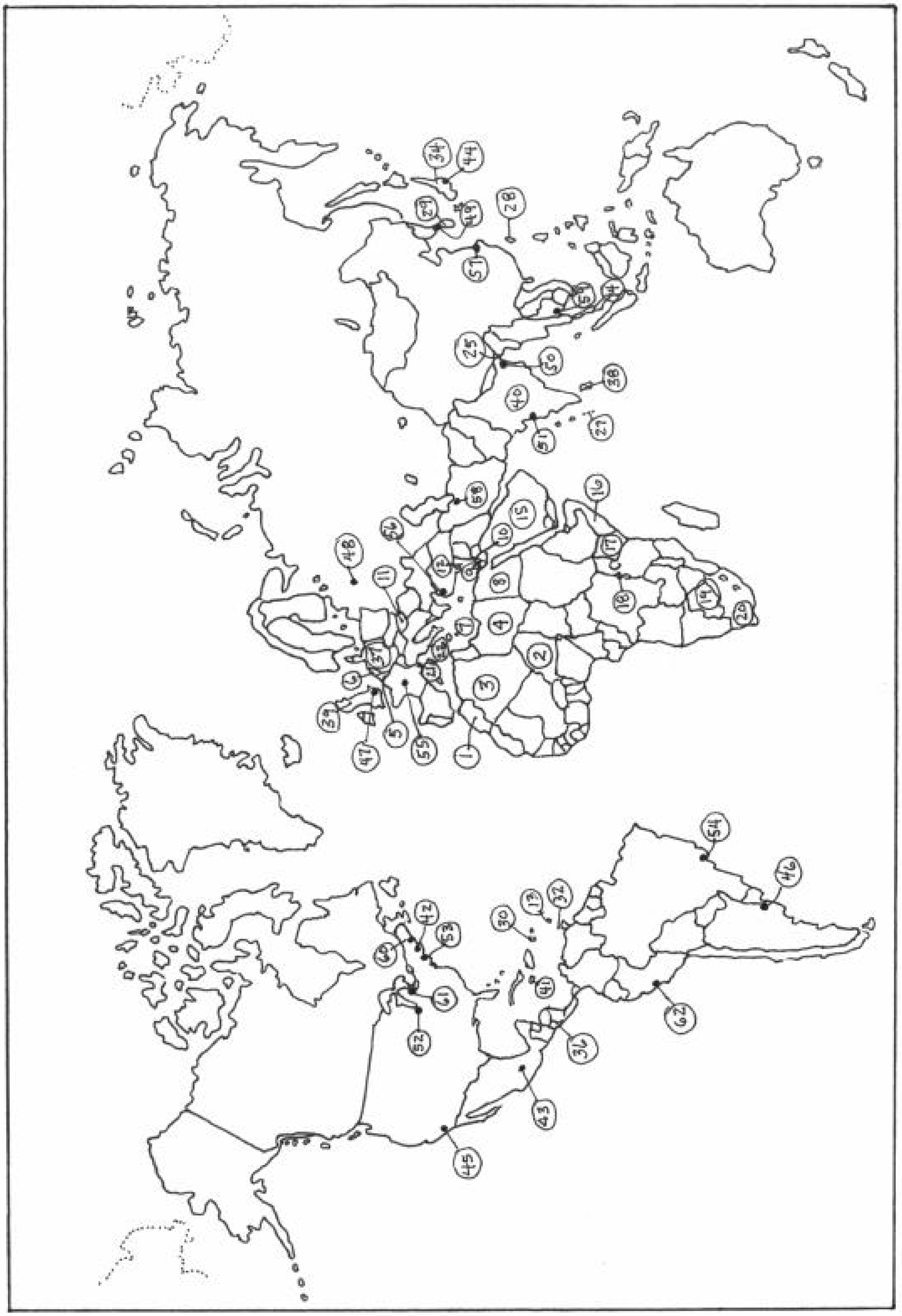
M. Sound (Puget Sound)
Defined:____

N. Swamp (Okefenokee)
Defined:____

SURFACE WATERS OF THE WORLD



WORLD MAP - KEY



COUNTRIES OF THE WORLD

SOME WATER-SCARCE COUNTRIES
Cubic meters of water/person/year

	Country	1992	2010
1.	Morocco	1150	830
2.	Niger	1690	930
3.	Algeria	730	500
4.	Libya	160	100
5.	Belgium	840	870*
6.	Netherlands	660	600
7.	Malta	80	80
8.	Egypt	30	20
9.	Israel	330	250
10	Lebanon	1410	980
11.	Hungary	580	570
12.	Syria	550	300
13.	Barbados	170	170
14.	Singapore	210	190
15.	Saudi Arabia	140	70
16.	Somalia	1390	830
17.	Kenya	560	330
18.	Rwanda	820	440
19.	Botswana	710	420
20.	South Africa	1200	600

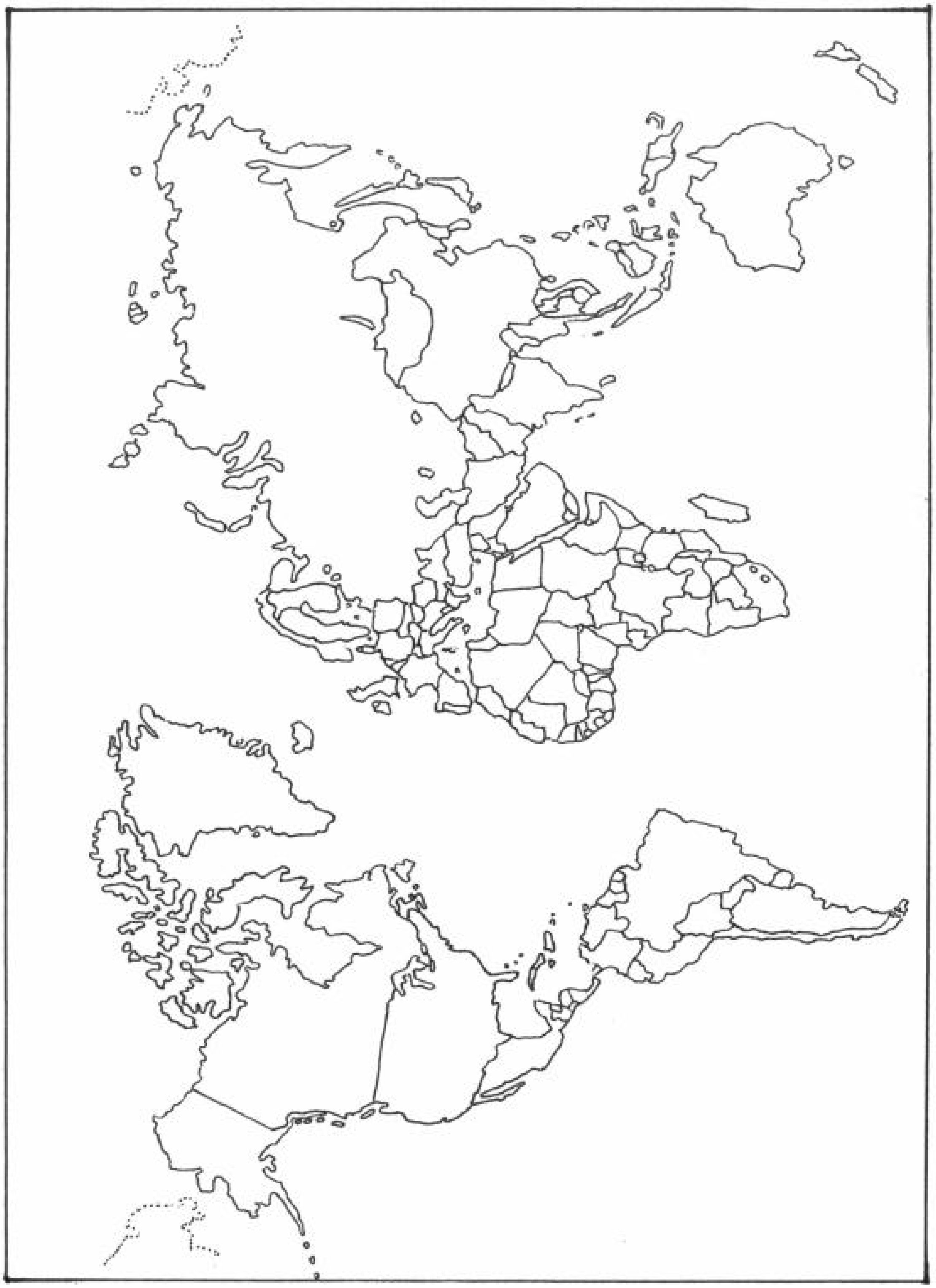
* population decreasing

HIGH POPULATION DENSITIES

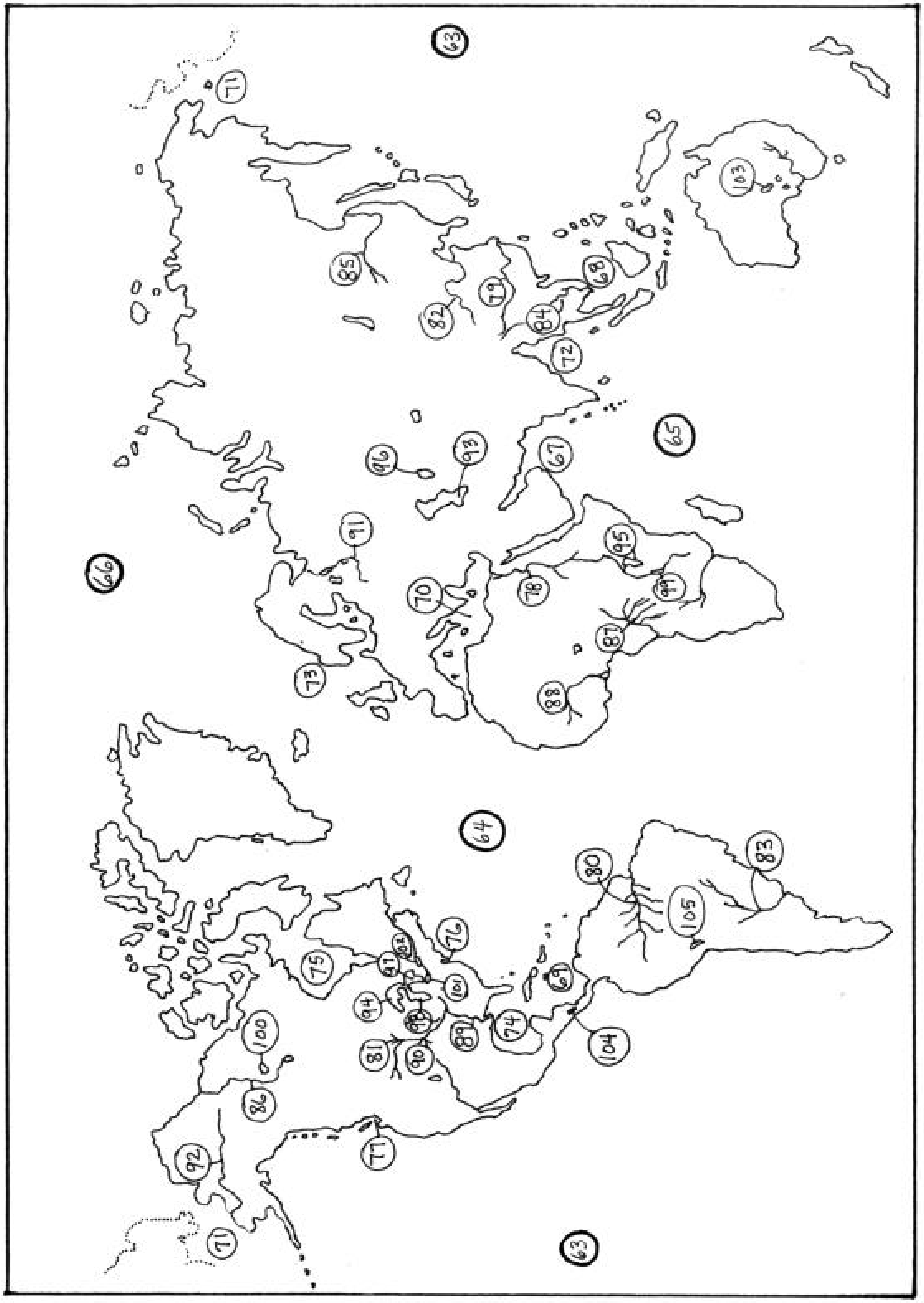
In descending order:

COUNTRIES/TERRITORIES		**CITIES**	
21	Monaco	42.	New York, USA
22.	Singapore (14)	43.	Mexico City, Mex.
23.	Vatican City	44.	Tokyo, Japan
24.	Malta (7)	45.	Los Angeles, USA
25.	Bangladesh (13)	46.	Buenos Aires, Arg.
26.	Barbados (13)	47.	London, Eng.
27.	Maldive Islands	48.	Moscow, Russia
28.	Taiwan	49	Seoul, Kor.
29.	South Korea	50.	Calcutta, India
30.	Puerto Rico	51.	Bombay, India
31.	Netherlands	52.	Chicago, USA
32.	Grenada	53.	Philadelphia, USA
33.	Belgium (5)	54.	Rio de Janeiro, Brz.
34.	Japan	55	Paris, France
35.	Lebanon (10)	56.	Istanbul, Tur.
36.	El Salvador	57.	Shanghai, China
37.	Germany	58.	Tehran, Iran
38.	Sri Lanka	59.	Bangkok, Thai.
39.	England	60.	Boston, USA
40.	India	61.	Detroit, USA
41.	Jamaica	62.	Lima, Peru

WORLD MAP



SURFACE WATERS - KEY



SURFACE WATERS OF THE WORLD

PRINCIPAL OCEANS, SEAS, GULFS

63. Pacific Ocean
64. Atlantic Ocean
65. Indian Ocean
66. Arctic Ocean
67. Arabian Sea
68. South China Sea
69. Caribbean Sea
70. Mediterranean Sea
71. Bering Sea
72. Bay of Bengal
73. Norwegian Sea
74. Gulf of Mexico
75. Hudson Bay
76. Chesapeake Bay
77. Puget Sound

PRINCIPAL RIVERS

78. Nile, Africa
79. Yangtze, China
80. Amazon, Brazil
81. MS-Missouri-Red Rock, USA
82. Yellow, China
83. Rio de la Plata-Parana, S. Amer.
84. Mekong, Asia
85. Amur, China
86. Mackenzie, Canada
87. Congo, Zaire
88. Niger, Africa
89. Mississippi, USA
90. Missouri, USA
91. Volga, Russia
92. Yukon, Canada-Alaska

PRINCIPAL LAKES

93. Caspian Sea, Iran
94. Lake Superior, USA-Canada
95. Lake Victoria, Africa
96. Aral Sea, Uzbekistan and Kazakhstan
97. Lake Huron, USA-Canada
98. Lake Michigan, USA-Canada
99. Lake Tanganyika, Africa
100. Great Bear Lake, Canada
101. Lake Erie, USA-Canada
102. Lake Ontario, USA-Canada
103. Lake Eyre, Australia
104. Lago de Nicaragua, Nic.
105. Lago de Titicaca, Bolivia

WATER WHIZ - A BOARD GAME

9-12

OBJECTIVES

The student will do the following:

1. Play a board game with three to five other students.

2. Compute the price of water that will be on the monthly water bill.

3. Identify the different activities in the game that affect the price of water.

4. Describe two ways that water usage is affected by each of the different aspects of community life.

SUBJECTS:
Science (Physical and Biology), Social Studies) Economics

TIME:
1-2 class periods

MATERIALS:
Water Whiz game board
game cards
dice
"water bills" for each student

BACKGROUND INFORMATION

Everyone of us in our daily lives is involved in activities that directly or indirectly affect the quality and price of the water made available to us by our water utility. This game can be used as an introductory activity for a water quality unit to be taught in any course. Its objective is to make students aware that the activities they engage in affect the quality of the water they will have for bathing and drinking.

ADVANCE PREPARATION

A. Be certain that there are enough board games, game cards, blank water bills, and dice for the students.

B. Suggestions:

1. Print the game board on ledger paper. Color each "card" space a different color and

laminate the boards.

2. Print the cards for each category on colored paper to coordinate with the board. Laminate each sheet; then cut out the cards. (Hint: Cut bulletin board paper to 11"x17" and feed it into your copier!)

3. Print water bills with game summaries on back. Use half sheets.

C. Teach the students the rules of the game.

1. Each student will obtain a blank water bill and place $1.00 as the initial price for each 1000 gallons of water used by him/her during the month.

2. Predetermined by the roll of a die, the first player will roll a die and draw a card from the spot on the board as is indicated by the number on the die.

1 is the agricultural space.
2 is the business space.
3 is the development space.
4 is the industry space.
5 is the recreation space.
6 is the residential space.

3. Pick up the card from the appropriate stack. Read this card so that everyone in the group may hear what affects the water and its price.

4. Change the price of the water as you are instructed to do by the card. Then return the card to the bottom of the stack.

5. The winner is the student who pays the least for water.

D. Cut out the six different pages of station cards.

PROCEDURE

I. Setting the stage

A. After dividing the class into groups of four, tell the students to open up the game board and look at the community drawn on the board. The community reservoir provides roughly one-half of the community's drinking water; an artesian well and a river provide water for the other half. Have them study the game board to observe what activities they see occurring in the community that might affect the quality and quantity of the water.

B. Tell the students to notice the six stations that are placed on the board. Each of these stations has a rectangular empty space next to it. Have the students place the shuffled and appropriately labeled cards upside down in these areas. The first station will have the agricultural cards, the second the business cards, and so on.

C. Have the students in each group select a person who will start the game, with the play moving to the right, until all persons in the group have had a chance to represent some sector of the community and have changed their water bill one time.

D. Remind the students that they must listen to the activity on the card because they will participate later in a summary activity from the information gained from the game.

E. The first player will roll the die, pick up the top card, and read it aloud. He/she will then alter the price of water on the bill as the card so instructs.

F. Each player in the group will follow the same procedure until all the students have taken part in a round. As many rounds will be completed as time permits (approximately 10).

G. Remember that the winner of the game is the person who pays the lowest rate for each 1000 gallons of water used.

II. Activity

A. Students will participate in the game.

B. Summary activity - The students will write down two activities carried out by each sector of the community that affect the quantity and quality of water, one activity that increases and one that decreases the bill. The information for this written activity will come from what they remember from playing the game.

III. Follow-up

Ask the students to discuss at home some ways their family can improve their community's water supply.

IV. Extensions

Ask students the following day to discuss, in their same groups, the reaction of their families. Have each group make a short report to the class.

RESOURCES

The data for the amount of water lost in leaky faucets, garden watering with different size hoses, the shower, etc., came from a book entitled Water in Crisis by Peter H. Gleick, published by the Oxford University Press in 1993.

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Agricultural A sod farmer uses simazine as a herbicide on his land. A weather front with severe thundershowers blows in very rapidly and the simazine is washed into the streams. INCREASE: $.10/1000 gallons	Agricultural A farmer harvests his spring grain and then plows his soil to plant his corn. Harsh spring rains come and erode thousands of pounds of his topsoil into the streams and lakes. INCREASE: $.10/1000 gallons
Agricultural Farmers allow cattle to graze too close to the streams and their banks. Fecal material winds up in the water. There is an increase in bacterial and viral contamination. More testing and treatment are required of the public water supply. INCREASE: $.10/1000 gallons	Agricultural A farmer is extremely conscientious and gets support from the state to fence his cattle away from the streams and to build ponds to provide water for his livestock. The public water supply is freer of microbial infection. DECREASE: $.10/1000 gallons
Agricultural A farmer carefully uses no-till farming practices as he plants his spring corn crop. Heavy rains come, and the Milo stalks on the ground from his previous crop cut down on erosion. DECREASE: $.10/1000 gallons	Agricultural A fisherman has been harvesting fish in lakes for 20 years to support his family. The insecticide chlordane is now building up in the sediment of the lake, and he has been prohibited from selling his catfish to the restaurants. INCREASE: $.05/1000 gallons
Agricultural Straight row plowing practices have caused much topsoil to wash into the rivers and lakes. Deeper pool areas in the stream are filling. Recreational fishing and swimming have almost ceased. INCREASE: $.05/1000 gallons	Agricultural Sunlight penetration into the river is decreased because of the turbidity caused by topsoil runoff. The natural inhabitants are moving out because the habitat is changing. INCREASE: $.05/1000 gallons

<u>Residential</u> You neglect to fix a leaky faucet and lose 25 gallons of water each day. <u>INCREASE</u>: $.10/1000 gallons	<u>Residential</u> You decide to replace your toilets with the new 1.6 gallon models. You will save approximately 60 gallons of water/day. <u>DECREASE</u>: $.10/1000 gallons
<u>Residential</u> You change the size of the water hose you use in your yard from a ¾ inch to a ½ inch diameter. You water your yard 5 hrs./wk. and save 1250 gallons in a week. <u>DECREASE</u>: $.05/1000 gallons	<u>Residential</u> In summer months, you water your grass 2 hours each day. You use 100,000 gallons in a month. <u>INCREASE</u>: $.10/1000 gallons
<u>Residential</u> Your cousins come to visit, and an additional 120 gallons of water are used each day in your home. <u>INCREASE</u>: $.05/1000 gallons	<u>Residential</u> You change the oil in your car and take the old oil and pour it around your home's foundation to reduce pests. The hydrocarbons leach to the groundwater. It costs to clean it up. <u>INCREASE</u>: $.05/1000 gallons
<u>Residential</u> It is spring. You plant your garden and then spray your lawn and garden for weeds. It rains the same day and washes the pesticide into the streams and lakes. <u>INCREASE</u>: $.10/1000 gallons	<u>Residential</u> You change your shower head to a water-saving type and reduce the flow 50%. <u>DECREASE</u>: $.05/1000 GALLONS

<u>Development</u> Your community is opening a new residential development next to the lake. They have graded new roads. This development created a turbidity problem in the lake. The fish are leaving the area because the food chain is being destroyed. <u>INCREASE:</u> $.10/1000 gallons	<u>Development</u> The stream flowing into the river has a sediment problem, and the deeper fishing and swimming pools are filling with sediment. The value of the riverfront property has decreased. <u>INCREASE:</u> $.05/1000 gallons
<u>Development</u> New housing development around the lakes and streams has increased the number of septic tanks. More nitrates and phosphates are going into the streams and lakes decreasing the oxygen supply for fish. New sewage pipes must be laid. <u>INCREASE:</u> $.05/1000 gallons	<u>Development</u> You are maintaining your septic tank as you should. You have properly cleaned it of the sludge. <u>DECREASE:</u> $.05/1000 gallons
<u>Development</u> A new golf course has been built around the lake. The caretaker has used simazine on the turf. Rain and stormwater discharge have carried the herbicide to the lake. <u>INCREASE:</u> $.05/1000 gallons	<u>Development</u> The coliform count has increased with the addition of new septic tanks. More chlorination is needed to prepare the municipal drinking water. <u>INCREASE:</u> $.05/1000 gallons
<u>Development</u> A request for permit to fill in a low-lying wetland bog to build more apartments has been denied. <u>DECREASE:</u> $.10/1000 gallons	<u>Development</u> The new highway being built is coming into the north side of town. All the proper erosion protection practices are being used. The lake is not experiencing a sediment problem. <u>DECREASE:</u> $.25/1000 gallons

<u>Business</u> The corner auto service station has a leak in its gasoline storage tank. Hydrocarbons leach down to the groundwater. <u>INCREASE:</u> $.10/1000 gallons	<u>Business</u> Many old car batteries are taken to the old county landfill. There is no polyethylene or clay lining. Seepage of lead and acids occurs through the sandy soil. <u>INCREASE:</u> $.10/1000 gallons
<u>Business</u> The county commissioners have been told that the present landfill is no longer environmentally safe. New monies must be found to construct a new landfill to protect our groundwater. <u>INCREASE:</u> $.10/1000 gallons	<u>Business</u> Your dry cleaning business has permitted some of its chemicals to get into the ground and move toward the groundwater. Your treatment plant must install granular activated carbon to remove them. <u>INCREASE:</u> $.10/1000 gallons
<u>Business</u> A furnace manufacturer improved its manufacturing process and now sells one of its recovered chemicals to claim a profit of over $1000/year. They used to pour this waste chemical down the drain. <u>DECREASE:</u> $.10/1000 gallons	<u>Business</u> The textile factory in town now has the technology to control its trichloroethylene release. <u>DECREASE:</u> $.10/1000 gallons
<u>Business</u> Toluene from a gasoline spill leaks into the groundwater. <u>INCREASE:</u> $.05/1000 gallons	<u>Business</u> A service station carefully recycles all its old oil drained out of cars and pays its "do it yourself" customers to bring in their oil. <u>DECREASE:</u> $.10/1000 gallons

<u>Industry</u> Bad tilling practices in the agricultural and developmental sections of the town have caused the river to fill with sediment. The depth is no longer sufficient for the coal barge to take its load to the power plant. It must be redredged. <u>INCREASE:</u> $.05/1000 gallons	<u>Industry</u> Detergent foaming agents were not completely removed by the industrial wastewater treatment plant. These have been released into the river and are causing concern among homeowners along the water's shorelines <u>INCREASE :</u> $.05/1000 gallons
<u>Industry</u> The industrial sector has built its own wastewater treatment plant, relieving the municipal plant of such a heavy load. <u>DECREASE:</u> $.05/1000 gallons	<u>Industry</u> Corrosive chemicals have been released into the surrounding watershed by older industry. These chemicals were not all removed by the treatment plant and have caused pipe corrosion in the city downstream. New pipes must be installed. <u>INCREASE:</u> $.05/1000 gallons
<u>Industry</u> The town must drill a new well tapping the groundwater because an old hazardous waste underground storage tank has been found located too close to the wellhead. The tank has begun leaking and has contaminated the surrounding soil. <u>INCREASE:</u> $.10/1000 gallons	<u>Industry</u> During the hot summer months, a coal- fired power plant is working at peak performance to provide electricity for air conditioning. SO_2 and NO_2 going into the air cause acid rain, and the pH of the lake is changing slightly. It must be adjusted. <u>INCREASE:</u> $.05/1000 gallons
<u>Industry</u> The pulp and paper mill has a wonderful environmental engineering department. The mill is odorless, the water is returned at ambient temperatures, and the pH and dissolved oxygen (DO) of the river is normal. <u>DECREASE:</u> $.10/1000 gallons	<u>Industry</u> In the hot summer months, the holding ponds of the mill do not cool the water as fast as in the winter months. Production is up, so the released water does not stay in the ponds long enough to cool down. It is causing fish kills in the river. <u>INCREASE:</u> $.10/1000 gallons

Recreation Nutrients from a farm have caused hydrilla to grow around the shore of the lake. This must be removed for recreational activities. INCREASE: $.05/1000 gallons	Recreation Boat fuel is being spilled into the lake because of improperly managed fueling stations at the marina. The water must be cleaned up. INCREASE: $.10/1000 gallons
Recreation The marina has installed a pump-out station to dispose of human waste from the self-contained larger boats. DECREASE: $.10/1000 gallons	Recreation Many boat owners will not take the time to return to the pump-out station at the marina and empty their holding tanks directly into the lake. INCREASE: $.10/1000 gallons
Recreation The drainage ditches in the community have been converted into artificial wetlands that adjoin the lake. The natural wetlands in the low areas around the lake have been preserved. This helps to clean the storm water running into the lake. DECREASE: $.10/1000 gallons	Recreation The creek and lake in town are filling up with sediment, and the community must pay the charge of dredging the lake out to restore its beauty and recreational value. INCREASE: $.05/1000 gallons
Recreation Recreational fishing is at an all time high because the fishermen and volunteer lake quality monitors are preserving the natural habitats of the area. DECREASE: $.05/1000 gallons	Recreation The schools in this community are very progressive and are teaching the students to care for their lakes' quality during their recreation. Their drinking water supply will stay uncontaminated. DECREASE: $.10/1000 gallons

Name:____________________

WATER BILL

Initial Cost: 1000 gallons = $1.00

Round 1 amount change: + or - ________
Altered Price $________

Round 2 amount change: + or - ________
Altered Price $________

Round 3 amount change: + or - ________
Altered Price $________

Round 4 amount change: +or - ________
Altered Price $________

Round 5 amount change: + or - ________
Altered Price $________

Round 6 amount change: + or - ________
Altered Price $________

Round 7 amount change: + or - ________
Altered Price $________

Round 8 amount change: +or - ________
Altered Price $________

Round 9 amount change: + or - ________
Altered Price $________

Round 10 amount change: +or - ________
Final Price $________

GAME SUMMARY

List several of the things you have learned that will affect your water bill.

AGRICULTURAL

Increase ____

Decrease ____

BUSINESS

Increase ____

Decrease ____

DEVELOPMENT

Increase ____

Decrease ____

INDUSTRY

Increase ____

Decrease ____

RECREATION

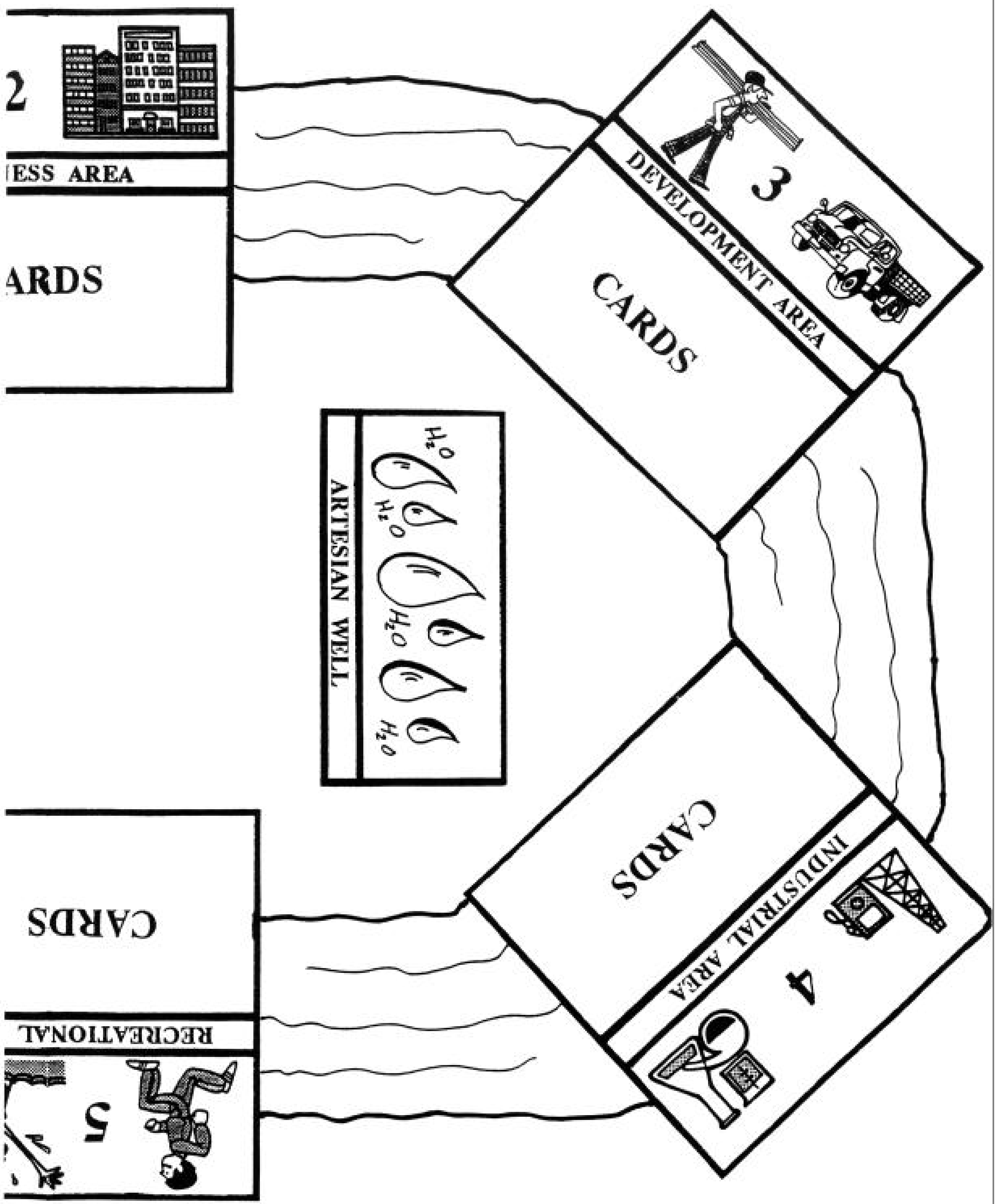
Increase ____

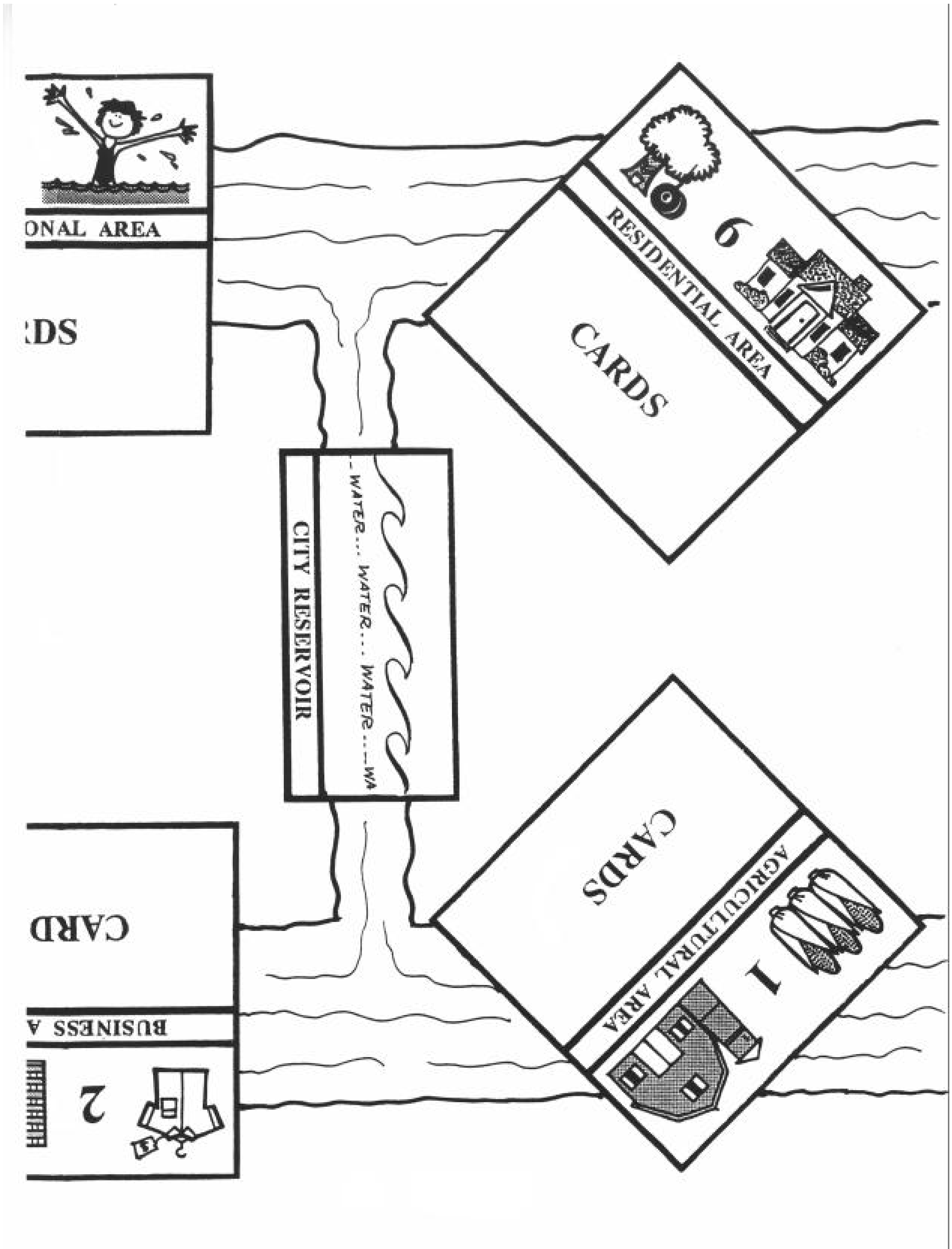
Decrease ____

RESIDENTIAL

Increase ____

Decrease ____


2
ESS AREA
ARDS
3
DEVELOPMENT AREA
CARDS
ARTESIAN WELL
H2O
CARDS
INDUSTRIAL AREA
4
CARDS
RECREATIONAL
5


ONAL AREA
RDS
RESIDENTIAL AREA
CARDS
CITY RESERVOIR
WATER... WATER... WATER...WA
AGRICULTURAL AREA
CARDS
BUSINESS A
CARD

WATER: POETIC, PROSAIC, MOSAIC

9-12

OBJECTIVES

SUBJECT:
Language Arts

TIME:
You will need three class periods if you are introducing metaphors, similes, and alliteration for the first time.

MATERIALS:
film clips
slides or pictures of large bodies of water--lakes, rivers, oceans

The student will do the following:

1. Watch film clips, slides, or look at pictures of water at its most beautiful in oceans, lakes, and rivers or take a field trip to a body of water (river, creek, lake).
2. Compose descriptive sentences of what is seen, using metaphors, similes, and alliteration.
3. Convert the sentences into a paragraph and then into a poem.
4. Explain various words, phrases, adages, and poems that refer to water.
5. Put the author's words into demonstrations.
6. Describe the aesthetic aspect of bodies of water.
7. Describe photographic composition.
8. Compile a photographic essay (8 photographs) of a local body of water.

BACKGROUND INFORMATION

Almost all descriptive language uses metaphors, similes, and alliteration. These literary devices are the building blocks of poetry. Many students balk at a poetry writing assignment. But when they learn to use the building blocks of poetry as they write prose, they gain confidence to compose poetry. Describing such a beautiful natural setting as a lake, a river, or the ocean is a non-threatening assignment; and it also reminds students of the importance of keeping our natural settings beautiful and of the importance of clean water.

Water is not just a natural resource and a necessity for life. Humans always described it, used it in creation stories, allegorized and anthropomorphized it, and put it in verse. Each of these usages <u>says</u> something about water and the way we view it.

Photography is a viable communication tool. The cliche, "A picture is worth a thousand words," is a truism. How do we feel when we see a river, a creek, or a lake that has been littered or polluted? Conversely, how do we feel when we see beautiful, clean bodies of water? When students are forced to look through a lens to compose a photograph, they see things they would not otherwise see. By composing a photographic essay, they will take a close look at the aesthetic quality of a local body of water.

<u>Terms</u>

adage: an old saying; a phrase passed down through the years

allegory: a story in which symbols are used to present moral truths

alliteration: repetition of an initial sound, usually of a consonant or cluster, in two or more words of a phrase or line of poetry

anthropomorphize (personify): to take something inanimate or subhuman and give it human characteristics

haiku: 3-line poem. First line has 5 syllables, second line has 7 syllables, and third line has 5 syllables.

metaphor: a figure of speech containing an implied comparison in which a word or phrase ordinarily and primarily used for one thing is applied to another

model: using simple or familiar objects to explain or demonstrate a new, unfamiliar, or complicated concept

simile: a figure of speech in which one thing is likened to another dissimilar thing by the use of words such as *like* or *as*

ADVANCE PREPARATION

A. Before starting this assignment, be sure students understand what metaphors, similes, and alliteration are. Provide them with examples of these literary devices from both prose and poetry.

B. Gather pictures of beautiful water. Listed below are some possible sources.

1. Film clips

a. ANNE OF GREEN GABLES--film produced by Kevin Sullivan for Wonderworks (available for sale or rent in most video stores): lakes and rivers around Prince Edward Island, Canada.

b. A RIVER RUNS THROUGH IT--film directed by Robert Redford (available for rent in most video stores): river in Montana.

2. Large photographs
Check with travel agencies. They will often let you borrow large posters.

3. Slides
Obtain personal slides of lakes, rivers, oceans or slides in the social studies or science section of many school libraries.

4. Copy the Water Quotes Student Sheet, adding to it as desired.

5. Divide the students and/or phrases into groups.

6. Copy the Hint Sheet (enclosed).

7. Find several photographs in a National Geographic magazine that incorporate the hints given to the students.

8. Collect some photographs that evoke strong feelings.

9. Locate two water sites: one clean, one littered. Make arrangements for trips to both sites.

PROCEDURE

I. Setting the stage

A. Explain to students that they are going to write a descriptive paragraph. They must use a metaphor, a simile, and at least one case of alliteration.

B. Show students a film clip (slide or photo) and have them describe it.

II. Activity

A. The students should first write a straightforward description; then they should create the metaphors, similes, and alliteration, putting their description in paragraph form.

B. Students should read through their prose, looking for natural rhythms and breaking points for line arrangement. They may have to change some words, delete some words, or add words for the sake of rhythm.

C. Students are now ready to make poems out of their descriptive paragraphs. Many of them will need help--or rather approval--to give them confidence to finish what they have started. An example of this process follows.

III. Follow-up

A. Students may want to illustrate their poems and display them in the classroom.

B. If the school has a literary magazine, submit some of these poems for publication.

C. Evaluation - This assignment should be evaluated only on the use of metaphors, similes, and alliteration.

D. Tell the students that water is like the weather -- everyone is always talking about it, but no one does much about it. They are going to see what people have <u>said</u> about water, figure out what they <u>meant</u>, and make a <u>model</u> or demonstration to explain their "water words."

E. Show students the photographs that evoke strong emotion. Ask them to respond orally to these photographs. Emphasize that photography has the power to prompt action.

F. Give students the Hint Sheet. Explain the sheet. Then show students some examples of well-composed photographs.

G. Explain that the upcoming field trip is to give the students ideas about locationsin which to film a photographic essay that makes a statement about the aesthetic quality of water.

EXAMPLE

(photograph of rough surf on beach at sunset)

SIMPLE DESCRIPTION--

The waves are crashing on a deserted beach. The sky is a little cloudy so that the setting sun makes them and, consequently, the water look like they are on fire.

PARAGRAPH--

It is evening, and once again the sea claims the beach for its very own. The sun, like a defeated general, retreats behind the clouds that have become a screen of smoke and fire. Incessantly the waves, soldiers marching in forceful formation, crash upon the shore claiming new territory with salt and foam. Who sends these relentless soldiers? Who gives the orders to march? The sirens of the moon sing the marching tune as Neptune gives the orders.

POEM--

NEPTUNE'S ARMY

Behind a screen of smoke and fire
  The Sun surrenders.
The waves, regimented soldiers,
  March at Neptune's command.
The sirens of the moon sing his orders--
  Rolling, rolling, relentlessly to the shore.

Like a defeated general,
  The Sun retreats.
With salt and spray, the regimented waves
  Claim new territory.
Day gives way to night
  And land bows again to Neptune's sway.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Water Quotes

1. "Sweetwater seas" - refers to the Great Lakes

2. Ben Franklin: "When the well's dry, we know the worth of water."

3. Romantic poet who called water a "sensitive chaos"

4. The cardinal law of California politics: "Water runs uphill to money."

5. "Water seeks its own level."

6. "That's all water under the bridge."

7. Coleridge: "Water, water everywhere and not a drop to drink."

8. Hermann Hesse: "Love this river, stay by it, learn from it." Yes, he wanted to learn from it, he wanted to listen to it. It seemed to him that whoever understood this river and its secrets would understand much more, many secrets, all secrets.

9. Kathleen Raines

"Because I see these mountains
they are brought low,
Because I drink these waters
they are bitter,

Because I tread these black rocks
they are barren,
Because I found these islands
they are lost;
Upon seal and seabird dreaming their
innocent world,
My shadow has fallen."

10. Ruskin Bond: "I never cease to wonder at the tenacity of water -- its ability to make its way through various strata of rock, zigzagging, backtracking, finding space, cunningly discovering faults and fissures in the mountains and sometimes traveling underground for great distances before emerging into the open. Of course, there's no stopping water. For no matter how tiny that little trickle, it has to go somewhere."

11. The 23rd Psalm: "My cup runneth over."

12. "The Big Muddy" - refers to the Mississippi River

13. "Ol' Man River" - refers to the Mississippi River

14. "Still waters run deep."

15. That's just "water off a duck's back."

16. "Oil and water don't mix."

17. "Up a creek without a paddle."

18. "Blood is thicker than water."

19. Don't get "bogged down."

20. He'd rather be a "big frog (fish) in a small pond."

21. "Get your feet wet."

22. "Don't rock the boat."

23. "Just a drop in the bucket."

24. It’s “raining cats and dogs.”

25. He’s a “fish out of water.”

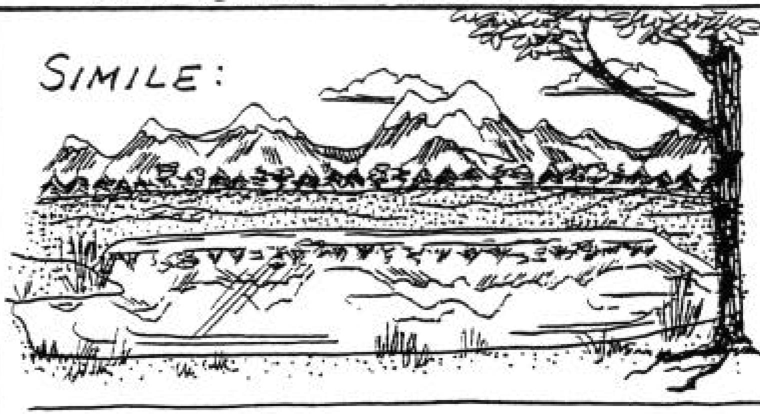
26. That’s just the “tip of the iceberg.”

27. Like the “parting of the waters.”

28. “Everybody’s downstream from someone.”

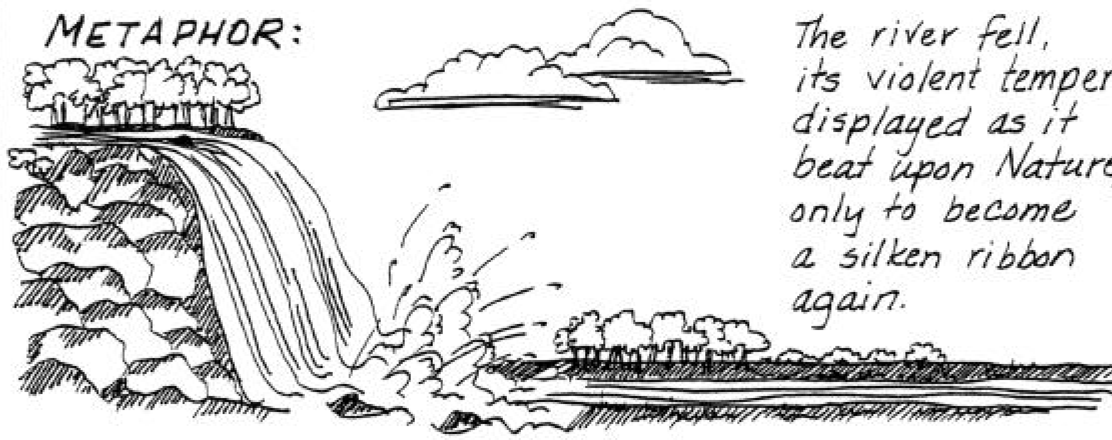
BUILDING BLOCKS OF POETRY

SIMILE:



The lake lay sparkling and quiet, like a huge mirror reflecting the distant fields and mountains.

METAPHOR:



The river fell, its violent temper displayed as it beat upon Nature, only to become a silken ribbon again.

ALLITERATION:

The bubbling brook bounced along across rocky ridges toward the bottomlands.

HOW WOULD WE SAY IT WITHOUT WATER?

9-12

OBJECTIVES

The student will do the following:

1. Participate in class discussion about the importance of water as a symbol in literature.

2. Work in a small group to explore thoroughly the importance of water in one particular work.

3. Prepare a group presentation to demonstrate the importance of water in his/her chosen work of literature.

SUBJECTS:
Language Arts, Social Studies (Geography)

TIME:
3 class periods,
1 week homework time

MATERIALS:
water poems
books
essays

BACKGROUND INFORMATION

As a natural resource and an ever-present force in our natural world, water has always been an important factor in one's imagination. In Homer's Odyssey, Odysseus meets many perils on his return--over water--to Ithaca. Beowulf journeys across the sea to assist Hrothgar and, at his death, embarks in the funeral ship upon the sea of the immortal unknown. Many poets from Matthew Arnold's "Dover Beach" to Alfred Lord Tennyson's "The Lady of Shallot" recognize both the physical and symbolic properties of water in verbal expression. Huckleberry Finn finds safety on the mighty Mississippi; Marlowe journeys into the Heart of Darkness on the Congo River. Great writers have used the aesthetic properties of water to make us think. They have used the familiar to ferry us into the unfamiliar.

ADVANCE PREPARATION

I. Reading Materials

A. Check library for poems, books, essays, and stories whose central symbol is water or a body of water.

B. Check the adopted literature book of your school (on your grade level) for poems and/or stories that use water as a central symbol.

II. Copy Procedure Sheet for group project (one for each group).

III. Copy Student Evaluation Sheets for each group.

IV. Divide the class into groups of three or four (no more than four).

PROCEDURE

I. Setting the stage

A. Secure an audio tape or CD that has sounds of the ocean or of rain (available at local and/or nature company stores). Have tape playing when students enter the room.

B. Have posters of oceans, rivers, or lakes around the room.

C. Have students write a paragraph about images or feelings that the tape and/or CD called to mind.

D. Have a few of the students read their paragraphs aloud. Then talk about what water symbolizes: relaxation, vacation, peace, soothing rainfall, freedom, no normal responsibilities on lake/river. Also discuss that what water symbolizes is dependent on its purity and accessibility.

E. Ask for discussion of the use of water as a significant symbol in works familiar to students. You may have to help them get started: Huckleberry Finn (river is freedom, safety) or "The Lady of Shallot" (river is the border between imagination and reality, ideal and/or real). List their selections on the board.

II. Activity

A. Divide the class into small groups.

1. Have each group select a leader/spokesperson.

2. Have each group draw a number.

B. Each group should decide which work of literature it will research. The groups may announce their choices by the order of the numbers they draw.

C. Hand out Group Report Procedure Sheets and Group Evaluation Sheets. Explain these to students.

1. Students should divide responsibilities among themselves.

2. Students should set up out-of-class meeting times.

D. Have one class day reserved for library work. After library day, give students one week to complete project.

E. Students will give reports orally in the order of the numbers they draw and will hand in a written version. Students may display visual aids in classroom.

F. Take up Student Evaluation Sheets. These should figure in the grading of the project.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

EVALUATION SHEET

NAME:____

LITERARY WORK:____

YOUR RESPONSIBILITY:____________________________________

THREE THINGS YOU LEARNED WHILE WORKING ON THIS PROJECT:

1. ____

2. ____

3. ____

EVALUATE YOUR CONTRIBUTION TO THIS GROUP EFFORT 0-10
Explain:____

EVALUATE OTHER GROUP MEMBERS (0-10)

#1 NAME: ______________________________
SCORE: ______________
WHY? ____

#2 NAME: ______________________________
SCORE: ______________
WHY? ____
#3 NAME: ______________________________
SCORE: ______________

WHY? ____

Student Sheet

PROCEDURE SHEET

GROUP #:__________________________

NAMES OF GROUP MEMBERS, RESPONSIBILITIES

1. ________________________________ , ______________________________

2. ________________________________ , ________________________________

3. ________________________________, ________________________________

4. ________________________________ , ________________________________

LITERARY WORK: ____

AUTHOR:____

BODY OF WATER USED AS A SYMBOL:____________________________________

THE WATER SYMBOLIZES:____

DUTIES OF GROUP MEMBERS:

I. SYMBOLISM DETECTIVE/REPORTER--This student should understand and explain how water is used as a symbol in this work. How is it used in the work, and what does it symbolize? His/her findings should be both written and oral.

II. CONTEXT DETECTIVE/REPORTER--This student researches the author or the time period to show why the author, in this place and time, chose this kind of water for this kind of symbol. His/her findings should be both written and oral.

III. HANDS ON MAN/WOMAN--This student should prepare a visual aid to demonstrate how the symbol is used in the book/poem/story (salt maps of rivers or oceans with significant locations noted; a representation of the Lady of Shallot's mirror showing everything she sees in the poem). This student should be ready to present and explain the visual aid to the class.

IV. GOPHER AND TECHNICAL ASSISTANT--This student should help coordinate the work of the other three and should be available to help each of them.

HINT, HINT-- THE MORE YOU WORK TOGETHER, THE BETTER YOUR PROJECT WILL BE!

PROCEDURE

1. Choose a work of literature that uses water or a body of water in a symbolic way.

2. Each student prepares his/her report in a neatly written (or typed) format to be compiled with the other group members (by TECHNICAL ASSISTANT) and turned in.

3. Each student should be ready to give an oral presentation. The group will be introduced by the TECHNICAL ASSISTANT.

4. Each group should have:

a. Cover sheet (decorative with title and author of chosen work).

b. Table of Contents sheet (you'll have two reports--title both of them).

c. Reports one and two.

d. List of group members.

e. Group report in a plastic folder.

WATER CAREERS

9-12

OBJECTIVES

The student will do the following:

1. Describe the great variety in water-related careers.

2. Compare specific careers regarding education, training, salary, and job description.

SUBJECTS:
Science, Language Arts, Art, Social Studies, Math

TIME:
2 class periods
out -of-class time for research

MATERIALS:
list of careers (teacher sheet)
resource materials and people checklist (student sheet)

BACKGROUND INFORMATION

Water-related careers abound in science, industry, agriculture, recreation, federal, state, and/or local government, research, transportation, engineering, and the military. With an increasing awareness of environmental concerns, these career options can be expected to multiply. Some require no more than a high school diploma and on-the-job training; some require a Ph.D. in a very specialized area. Too often students have no clear career goals. Many of these careers will be unfamiliar to the students; perhaps some will find their niche!

Terms

career: a chosen pursuit or life's work; job or profession one is trained to do

ADVANCE PREPARATION

A. Put each career from Student Sheet on Water-Related Careers on slips of paper (one for each student). Cut them apart. Put them in a container so that students can draw them out.

B. Have students contact any people in the area who are in these careers. If they are willing to be interviewed by the students, list their names and telephone numbers where they can be reached.

PROCEDURE

I. Setting the stage

A. Ask students what their career goals are.

1. Are any water-related?

2. What does "water-related" mean?

3. Ask for examples.

B. Tell students you have an expanded list and they are going to investigate these careers by randomly picking one. Students may exchange their careers as long as each student researches a different one.

II. Activity

A. Research one or more water-related careers including all of the information on checklist (education or technical or on-the-job training, where education/training is available and what duration, degree, certification, or bonding is required, possible employers and geographical location of jobs, salary, job description).

B. Locate and interview a person following this career including all the information on checklist (how long in profession, where trained, advancement or travel, favorite and least favorite aspects of job).

C. Report to class (oral presentation). Turn in completed checklists.

III. Follow-up

A. Invite persons who have the most interesting, in demand, or locally available jobs to speak to class.

B. Send for information to some of the colleges, training institutes, or professional Organizations.

C. Make a bulletin board with information and pictures of water-related careers.

D. Make a file of all reports on the various careers so students can have access for future reference.

IV. Extensions

Have students impersonate a professional and demonstrate some of the activities involved in the job.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Current, Volume 12, Number 4, 1994, pp. 31-32.

Earth: The Water Planet, NSTA.

Grades 3-5 Water Sourcebook, pp. 1-88.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

WATER-RELATED CAREERS

Agricultural Engineer
Aquarium Director
Archaeologist
Aquatic Entomologist
Biologist
Biosolids Specialist
Boat Builder
Boater
Botanist
Bottled Water Company Employee
Builder
Chemist
Chemical Engineer
Civil Engineer
Coast Guard
College/University Professor
Commercial Fisherman
Computer Scientist
Desalination Plant Director
Diver
Docks Master
Ecologist
Environmental Attorney
Environmental Chemist
Environmental Engineer
Environmental Scientist
Farmer
Fire Fighter
Fisheries Biologist
Forester
Geographer
Geologist
Groundwater Contractor
Health Dept./Environmental Inspector
Hydraulic Engineer
Hydrologist
Ice Skater
Landscape Artist
Landscape Architect
Limnologist
Malacologist
Marine Salvage Engineer
Marine Geophysicist
Marine Geologist
Marine Conservationist
Marine Explorer
Marine Technician
Merchant Marine
Meteorologist
Motor Sailboater
Navy
Oceanographer
Olympic/Professional Swimmer
Photographer
Physical Scientist
Plant Physiologist
Plumber
Potter
Professional Tournament Fisherman
Professional Skier (Water or Snow)
Rafting Guide
Ranger
Recreation Instructor
Science Teacher
Scuba Instructor
Scuba Diver
Ship Builder
Seaman
Snow Hydrologist
Soil Scientist
Structural Engineer
Submariner
Sunken Treasure Hunter
Tugboat Biologist
Underwater Photographer
Wastewater Treatment Engineer
Water Meter Reader
Water Level Controller
Water Resources Engineer
Water Quality Control Officer
Well Driller
Yachtsman

Checklist

1. Job title:

2. Education required:

3. Where is this type of education available and how long does it take?

4. What kind of a degree, certification, or bonding is required?

5. Who employs this type of worker?

6. What is the most common geographical location for this type of job?

7. What is the average annual salary range?

8. What are the job prospects/stability of employment?

9. Describe the work that is done on this job.

10. If there is anything else you learned in your research of this job, include it below.

11. Would you be interested in this type of job? Why or why not?

WATER: MORE PRICELESS THAN GOLD

9-12

OBJECTIVES

The student will do the following:

1. Identify the source of the community's water that is used for residential housing.

2. Describe an actual case study of a water-rights issue in the western part of the United States.

3. Write water rights laws that are free of ambiguities.

4. Demonstrate skill of solving water-rights issues.

5. Outline the water rights laws of his/her state.

6. Compute the monetary value of the water being piped into homes in the community.

7. Demonstrate an appreciation for the importance of water.

SUBJECTS:
Science (Physical), Social Studies (History, Economics), Math

TIME:
2 class periods

MATERIALS:
a copy of the background material for each student

BACKGROUND INFORMATION

Water is indispensable! The possession of water rights with the ownership of real estate in the western half of the United States is prized as gold. Following this introductory paragraph is a summary of an actual water-rights dispute in a western state. Help settle the dispute as a class. In actuality, this has not yet been done. Role play the end of the story to get an understanding of the emotions of the people who are battling for their water.

For 75 years, Jack Wilson and his family have owned hundreds of acres of land backing up to a national forest. In 1955 the Wilson family formed a real estate agency and began the development of several canyons in the area. Gravel roads were graded and dug out of the side of the canyon hills to provide access to one-acre lots. Triple Canyon Real Estate then began the sale of these individual lots. The agency even provided the construction of a cabin shell on each purchased lot if the buyer did not want to construct his or her own. Triple Canyon Real Estate continued to sell lots and cabins in this area until 1991.

Water pipelines were laid connecting the cabins to a storage tank that was supplied with water from three different springs. Water usage and its misuse have been a problem there in dry years when less water flowed into the springs. Sometimes cabin owners had undetected leaks in their pipes when they were away from the area for long periods of time. These leaks often nearly drained the storage tank, thereby depleting the available water and also decreasing the water pressure. This pressure was necessary to carry the water to all the homes, especially during holidays when the area became alive with people on vacations.

Mountain winter freezes and thaws are destructive to underground pipelines laid close to the surface. Extreme water pressure during times that the storage tank was full also caused a fast deterioration of the water system's pipes. Jack Wilson was inundated with complaints about the system. The State Engineer's office sent a letter to Triple Canyon Real Estate advising them of the improvements that had to be made to the water system.

Concerned citizens of the area decided to form a water board and did so with the encouragement of Jack Wilson. Dues were charged, and the monies collected helped to pay for some of the improvements. Because all of the improvements suggested by the State Engineer's office were not carried out, this office sent another letter to Triple Canyon Real Estate. This time the recommendations were more stringent, and a deadline was given for their completion.

Jack Wilson was also advised to draw up a deed that would establish the springs of the area to be for residential usage, not agricultural. Wilson neglected to do so. One of the water laws of this state said that if the water from a spring had not been used as designated in a deed for the previous four consecutive years, the water may be used in another way. The water from the Meandering Slough Spring, which was the one in contention, had been used only for residential use since 1921.

In 1982 the newly formed water board elected a president (Harry Harrison) and a secretary (Nelda Ball). Their services were voluntary as were the services of the men who worked on the pipelines of Triple Canyon Estates. These men were retired petroleum engineers, oil-field workers, and plumbers.

In 1988 Nelda Ball and her husband Drew contracted to buy 15 acres of the Wilson Ranch to farm trees. The designated 15 acres were not part of the Triple Canyon Estates development but did contain one of the springs that was used to supply water to the residential area. Jack Wilson's lawyer, in drawing up the bill-of-sale, failed to include a retention of the water-rights for the area. This meant that Triple Canyon Real Estate's usage of water from Meandering Slough Spring was no longer legal.

Nelda and Drew Ball rerouted Meandering Slough Spring's water from the storage tank to another storage tank on their property. The property owners had approximately 1/3 less water to use for their subsistence. Jack Wilson convinced residential property owners that there was ample time for an appeal on the ruling. The board members, in their naivety and trust of Jack Wilson, let time pass without bringing suit against the Ball family.

The board from Triple Canyon Estates Water Association finally filed suit against Nelda and Drew Ball in 1989. The judge in the case, Martha Gregory, ruled in favor of Nelda and Drew Ball because of the water board's silence for a year after the legal decision. The Ball family did offer to sell water to the residents' Water Association at $99/acre foot per annum. They would only agree to sell 15 acre feet, however. The association turned this down, feeling that the law was on their side because of the state's water laws. Six years later, the homeowners had not regained the rights for usage of Meandering Slough Spring. There are 400+ homes and cabins using the water. They have had three lawyers at this time and have been to court twice. All the lawyers had told the homeowners' Water Association that it was certain to win its case.

The homeowners have been trying to find another source of water for their residential area. They have received permission from the Forest Service to drill on the land in the National Forest or to pipe in water from a nearby spring. They have not, however, been able to find a suitable source.

Terms

water rights: rights, sometimes limited, to use water from a stream, canal, etc. for general or specific purposes, such as irrigation

ADVANCE PREPARATION

A. Answer the following by researching each topic.

1. Determine how many gallons a family of four typically requires for subsistence each day.

2. How many gallons of water must your water utility be able to supply daily in order to meet your community's demand? Yearly?

B. Call your community's water supplier and investigate the source of your water supply. Ask them the price of your water when it comes into your treatment plant. Compare this to the amount that the Ball family was going to charge Triple Canyon Estates owners.

C. Carefully read the Background Information and become familiar with the main players in the drama.

D. Prepare copies of the Background Information for your students to read. Begin with the second paragraph.

E. Obtain the name and address of your district's state congressperson.

PROCEDURE

I. Setting the stage

A. Ask the students these questions.

1. How would you feel if every time you wanted to flush your commode, you would have to pour two gallons of water into the tank before it would flush? This water would have to be water that you

had hauled into your home from an outside water source or would be “graywater” from other uses in your home.

2.How would you feel if you were limited to two 15-gallon baths a week? You dare not use any more water than this because if you did, you might not be able to take any baths the following week.

3.How would you feel if you turned on the tap, only a few drops of water flowed, and you were expecting company the following day?

B. Tell the students that these situations truly do happen in some parts of the United States. Water is a commodity to be grateful for and to conserve in all ways possible.

II. Activity

A. Have the students read and study the Background Information. While they are reading:

1.Have students think of themselves as the judge who will have to rule in this.

2.Have students write down reasons why the judge might rule in favor of the Ball family and reasons the judge might rule for the homeowners' association.

B. Divide the class into two groups.

1. One group is in favor of the Ball family retaining the water rights.

2. The second group is in favor of the homeowners regaining their lost usage for Meandering Slough Spring.

3.Collectively have each group prepare a list of arguments favoring its side.

C. Ask a willing teacher or an outside resource person to listen to the arguments presented in class and choose the group which best presents its arguments. Two students, perhaps absent the day before, can help the resource person make the decision.

D. Have each group choose a person to present its arguments and then let him/her do so. Have the Ball family presentation first. After both sides have had a turn, let each side ask questions of the other, or let any student speak who feels he or she has something extra to say.

III. Follow-up

As a homework assignment:

A. Have the students summarize the two class-period activities by having them write what they believe to be the two best arguments, both pro and con, and the judge's decision.

B. Have the students write state water-rights laws that may have prevented this situation from occurring.

IV. Extensions

A. Have student(s) write the state congressperson from their district requesting to send the class the water-rights laws of their state.

B. Review these laws and see if you can find any gray areas that might be sources of future conflict.

C. Review federal water laws in fact sheet to see if the current laws can solve the problem.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

WATER YOU DOING ABOUT THIS?

9-12

OBJECTIVES

The student will do the following:

1. Demonstrate quantities of water that an average family uses on a daily basis.

2. Explain how water resources can be managed to meet human needs.

3. Explain how water can be conserved.

SUBJECTS:
Science (Physical, Earth Science), Related Arts, Math, Social Studies (Economics) Health

TIME:
1 class period and after-school time

MATERIALS:
data sheet
tables
writing materials
calculator

BACKGROUND INFORMATION

Water is too important to take for granted: without it, life would not exist on Earth. Our bodies need water to function properly. Tremendous amounts of water have been used all over the world. Water use in the United States is as follows:

8% for domestic use (washing, drinking, toilet)
10% for business/industry
33% for irrigation
49% for electric power plants

Although the world's total water supply is enormous, over 97% of it is salty ocean water. Salt water cannot be used for drinking, irrigating crops, power plants, or other industries. All of these uses require fresh water supplies that only make up three percent of the world's total water; and 2/3 of that is frozen in Antarctica, Greenland, and alpine glaciers. Only 0.6% of the Earth's water supply is usable as liquid and fresh water. This water is unevenly distributed in lakes, rivers, and underground.

Since the water supply on Earth is fixed, the total amount stays the same. As the world's population grows, the demand for water also increases. We cannot increase the water supply; however, we can manage it more effectively. Scientists estimate that 30-50 percent of the water in the United States is wasted. One part of water management in which everyone can take part is water conservation--using only what is needed.

Since most of the water used in the United States is not used in our homes, it may seem we can do nothing about its use. We must keep in mind that industries use water to produce the products we purchase. If we do not demand a new car every two years, recycle as much as possible, and do not waste food and other materials, water will be saved!

We can also encourage conservation of water through industries by legislative action. Laws can be passed to require water conservation equipment and methods. Federal and state subsidies that encourage waste of water can be eliminated or reduced.

Reducing the amount of water used in flushing the toilet by only 10% would save enough water for doing the laundry and almost enough for drinking. Using a water-saving toilet can cut water usage almost 75 percent. Water pollution is a problem even in communities that have adequate water supplies. This makes clean fresh water more expensive. Our concern about water shortages should not just be for human consumption but also for the impact on the environment. When reservoirs are built, valleys are flooded and downstream rivers are changed. Channelizing of streams destroys riparian communities along their banks. Diverting water from one area to another using canals or pipes damages the environment from where the water was taken as well as from where the canals and pipes were laid. Conserving water just makes sense - environmentally, financially, and ETHICALLY!

Terms

conservation: act of using the resources only when needed for the purpose of protecting from waste or loss of resources

riparian communities: living organisms adjacent to or living on the bank of a river, lake, or pond

ADVANCE PREPARATION

Copy Data Chart and Water Use Student Sheets for each student.

PROCEDURE

I. Setting the stage

A. Have the students list various ways that water is used in the home. Before students record how much water they use in a day and a week, have students record on their Data Sheet how much they THINK they use.

B. Remind students that they will need to time showers and check for low flow equipment in their homes.

II. Activity

A. Ask students to keep a Data Sheet of water use in their homes for two/three days. Students should record results on data table. They can add any appropriate activities that are not listed.

B. Ask students to review the Student Sheet of average water volumes required for typical activities and then answer the following using the data from their two/three days.

1.Estimate the total amount of water your family uses in a week. Give your answer in gallons and liters. (approximately 4.2 liters in a gallon)

2.On average how much water did each family member use in a week? Give your answer in gallons and liters per person per week.

3.On average how much water was used per family member each day? Give your answer in gallons and liters per person per day.

4.Compare the daily volume of water used per person in your family to the average daily water volume used per person in the United States (100 gallons).

5.What reasons can you offer to explain any differences?

6.Compare daily volume of water used per person in your family to the average daily volume used per person in several other countries. (Show a variety of water uses.)

III. Follow-up

A. Have students list some other ways they could conserve water at home (turning off the hose when not in use, taking shorter showers, fixing leaky faucets, installing water conservative toilets and shower heads).

B. Landscape with plants and grasses that are native to the area and thus require less watering.

C. Have students find out what is done locally with wastewater. Is it discharged to a surface waterbody, injected underground, or sprayed onto land surfaces (e.g., dedicated sprayfields, agricultural areas, or public access areas, such as golf courses)? Have students determine additional "uses" for treated wastewater (e.g., aquifer recharge, etc.) and determine the level of treatment needed for each use and associated costs.

D. Present any viable options as determined in C. above as recommendations to the community.

IV. Extensions

A. Have students find out the cost of installing different water saving devices in the home.

B. Have students estimate how long it would take for each item to pay for itself.

RESOURCE

"Water Quality and Pollution Control Handbook,"Alabama Cooperative Extension Service, Auburn University, Alabama, 36849.

WATER USE

TABLE A			
Gallons of water typically used to produce various products in the United States			
1 automobile	10,000	1 pound of grain fed beef	800
1 ton of brown paper bags	82,000	1 pound of rice	560
1 pound of cotton	2,000	1 pound of steel	25
1 pound of aluminum	1,000	1 gallon of gasoline	70

*Producing aluminum from raw materials "costs" much more in terms of water than it does when producing aluminum from recycled aluminum.

TABLE B			
Percentage of water consumed by various uses in the United States			
irrigation	60%	industry	13%
rural domestic use	59%	power plant cooling	2%
urban domestic and business	29%		

TABLE C			
Domestic use of water in the United States			
toilet flushing	40%	drinking	5%
washing and bathing	37%	household cleaning	3%
kitchen usage	7%	garden usage	3%
laundry	4%	cleaning car	1%

Student Sheet

DATA SHEET

I THINK I USE APPROXIMATELY ___________ GALLONS PER DAY;
I THINK I USE APPROXIMATELY ____________ GALLONS PER WEEK

WATER USE	**TIMES PER DAY**	**AMOUNT USED**		**TOTAL USED**			
		average *estimated gallons	your estimated gallons	per day			per week
				1	2	3	
1. bathing		30					
2. showering		6 gals per min.					
3. flushing toilet		6					
4. washing face & hands		5					
5. getting a drink		.25					

6. brushing teeth		2						
7. cooking		10						
8. washing clothes		60						
9. washing dishes		30						
10 other								
			TOTALS					
TOTALS (should include things that don't happen every week)								

***estimates on Data Sheet are based on the following:**

1. This could vary depending on how full tub is for bathing.
2. 3 gallons/min with low-flow head
3. 1.5 gallons with water saver toilet
4. 2 gallons if water is turned off
5. Includes running water to reduce lead quantities from piping solder
6. 0.25 gallons if water is turned off
7. Per meal, includes rinsing
8. Large load
9. 10 gallons with dishwasher or using two 5-gallon pans

ENVIRONMENTAL CONTROVERSY: CLASS PROJECT

OBJECTIVES

The student will do the following:

1. Research one of two sides of an environmental issue dealing with industrial impacts on water.
2 Conduct a debate over that issue.
3. Summarize that debate and present, in written form, the strongest arguments on both sides.
4. Conclude with a decision over the debate.

SUBJECTS:
Any high school class

TIME:
1 hour in class
1 week homework preparation

MATERIALS:
none

BACKGROUND INFORMATION

Sometimes protecting the environment is not as straightforward as it seems. There are some hard choices that have to be made and different groups that have different ideas about what is best. It usually boils down to a debate about jobs versus the environment and the trade-offs needed to reach solutions.

In this exercise, students will learn and demonstrate negotiation. This is a role playing exercise.

SITUATION:
There is a medium-size town somewhere in the U.S. It has come upon hard economic times because several manufacturing operations have closed and the unemployment rate is up to 12 percent.

One of the positive things about this community is that it is a scenic part of the state and tourism business also comes in due to the pristine nature of a small, but scenic, river that flows close by. There is even a canoeing and fishing guide service that uses part of the river.

Because of the available work force, a new industry is interested in locating in the town. There are no other major industries in the town, and there is a regulated amount of wastewater that can be released into the local creek (Pretty Creek). The industry manufactures widgets. It will have a large discharge into Pretty Creek. It will create several hundred new jobs.

There is to be a public hearing on the proposed industry. Everyone will get to present his/her side, and the town people (class) must vote on whether or not they think the industry should be allowed to locate in the community.

PLAYERS:
Mayor Harried knows that the location of the industry will be controversial. The people need jobs, and the business owners need a transfusion of new customers. He is in favor of the new industry. But there are several groups opposed to the location of the industry.

Ms. Nature is a housewife who is involved in environmental issues and has started an environmental group called "Save Pretty Creek." She is adamantly opposed to the industry locating in the town. She is aware of a similar industry (but not the same company) that is located in a town close by that has a bad record with the environmental agency and a history of noncompliance.

Mr. Councilman represents the homeowners who will be primarily influenced by the discharge since they will be close to the industry. He is opposed because his constituents are opposed.

Mr. Consulting Engineer represents the industry. He knows that the Widget Company has a good environmental record. He also has designed a good treatment system that he is confident will treat the water to such an extent that it will not be harmful to Pretty Creek, but he also knows that the wastewater discharge is a large one for the size of the creek. Proper operation of the treatment system is going to be critical.

Mr. Company Owner wants to locate in the community because it is a nice area, and he knows that his core group of executives will not mind moving here. Also, there is a pool of well-trained labor available.

Mr. Retired Environmental Engineer now lives in the community. He has a home on the river. He is opposed because he knows that the system Mr. Consulting Engineer has designed will treat the wastewater to a point, but it will be critical as to how well the treatment system is run.

Ms. Business runs the canoeing and fishing guide service down the river from where the discharge is located. She has spent years and a lot of money building up her business and sees this discharge as a direct threat to its profitability. She is opposed to the project, and she wants a large area of the creek zoned so that no business can go in any area that will affect her business.

Mr. Unemployed Worker has lost his job. He is having to get by on his wife's salary as a secretary for a lawyer in town. He very much wants the industry to locate in the town because he has the exact skills for which the industry is looking.

Terms

The terms below relate to the industry's impact or potential impact to a creek:

biochemical oxygen demand (BOD): a parameter used to measure the amount of oxygen that will be consumed by microorganisms during the biological reaction of oxygen with organic material

eutrophication: the process in which a body of water becomes oxygen deficient, nutrient-rich and supports an abundant growth of surface aquatic plants and algae; natural aging cycle of lakes, normally taking centuries, but it can be rapidly accelerated when outside sources of nutrients are added, such as wastewater, fertilizer, or feed lot runoff.

phosphorus: an element considered the key nutrient in controlling eutrophication in lakes and ponds

total suspended solids (TSS): amount of solids in suspension in water or wastewater

ADVANCE PREPARATION

A. Have some of the students in favor of the facility do some research on the effect of employment on other communities so that they can argue their side.

B. Have the opposing students do research on the effect of BOD, TSS, phosphorus, and other pollutants from wastewater on streams.

PROCEDURE

I. Setting the stage

The debate will be a town meeting with the mayor presiding.

II. Activity

A. Students not involved will get to vote on whether they think that the industry will be allowed to come.

B. After hearing all cases, students not playing a part other than town citizen will vote on whether they think that the industry should be allowed to come.

III. Follow-up

The teacher will direct a discussion on the outcome and make the point that environmental debate is not always black and white and the decisions made have long-term consequences.

IV. Extensions

Students could interview different citizens in the community to get their opinions on allowing new industry with potential pollution problems into their community.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

"pH - THE FIRST CLUE TO WATER QUALITY"

9-12

OBJECTIVES

The student will do the following:

1. Define acidity and alkalinity.
2. Explain pH.
3. Perform pH tests to determine initial water quality.

SUBJECTS:
Science (Chemistry, Ecology, Earth Science)

TIME:
1-2 class periods

MATERIALS:
pH testing strips or pH meter
sand
salt
lime
vinegar
filter paper
funnels
200 ml beaker
jars for water samples

BACKGROUND INFORMATION

Water is not simply water. The water around us is typically water and something else. (Renn) Water dissolves many of the materials that it touches and absorbs gases in the air. This ability of water to dissolve and hold so many other substances makes it important for us to know about water quality. The purest water is produced when water is vaporized into the atmosphere. This conversion of water from a liquid to a gas produces the purest form of water found in nature. Although this atmospheric water represents 3000 cubic meters of water, it constitutes less than 1/100 of one percent of the total water in the hydrologic cycle. Most water on Earth is not pure. When water vapor in the atmosphere condenses into rain or snow, it typically condenses around fine particles and absorbs some atmospheric gases and other impurities. These particles and impurities may be from the ocean or dust from prairies, forest fires, volcanoes, or smoke stacks. The newly formed droplets of water may contain nitrogen compounds, sulfur compounds, ammonia, salts, dust, argon, carbon dioxide, ozone, and other atmospheric gases. Rain is water and "something else." The amount of materials that combine with water and the nature and types of these materials are of great importance to humankind.

When it comes to water quality, the compound carbon dioxide (CO_2) is the most important material that dissolves into water. CO_2 has a large effect on water. It causes water to be a weak acid. This increases water's ability to dissolve materials, especially those which are slightly alkaline. This increased dissolving ability of water is responsible for most of the physical and chemical changes that have occurred on Earth (erosion, soil deposition, soil depletion, leaching, etc.). When weakly acidic rain falls on the Earth's surface, it reacts with minerals and other materials in soils and rocks that dissolve in the weak acid. For instance, the mineral calcite ($CaCO_3$) that comprises most of limestone or marble, is readily dissolved in a weak acid. This results in water having a "mineral content." The chemical process of water dissolving and carrying away elements and salts in the soil is called leaching. Water can also pick up CO_2 produced by biological processes such as respiration of plants and animals in the water and soil, and by the microbiological decomposition of dead organic materials. No matter what the source of CO_2 in water, it makes water behave like a weak acid and increases water's ability to pick up other materials. The weak acid properties can cause corrosion, rusting, clogging, nutrient leaching, soil depletion, "smelly water," off-colored water and a contamination of water resources. pH also affects soil quality. Shortage of rainfall in a desert makes the soil alkaline because very few minerals are washed away. Areas of high rainfall usually have acidic soil because many of the alkaline minerals are washed away. Different types of plants grow best in different pH soils.

Pure water is a very weak electrolyte and ionizes according to the equation:

$$H_2O \;] \; H^+ + OH^-$$

The expression for the ionization constant is derived from this simplified equation:

$$K = [H^+][OH^-]/[H_2O]$$

Since the concentration of water is constant, we may combine $[H_2O]$ with K:

$$K[H_2O] = [H^+][OH^-]$$

The resulting constant $K[H_2O]$ is called the ion product of water, or the water dissociation constant, and is given the symbol, K_w . At 25^o C,

$$K_w = 1.0 \text{ x } 10^{-14} = [H^+][OH^-]$$

The concentration of $[H^+]$ in a solution can be expressed more simply in terms of the pH scale. The pH of any solution is the negative logarithm of the hydrogen ion concentration or

$$pH = \log 1/[H^+] = -\log[H^+].$$

Rules for the common logarithm of a number: $a = 10^n$ then, $\log a = n$

The following table represents the pH scale.

pH	$[H^+]$	$[OH^-]$
14	10^{-14}	10^{0}
13	10^{-13}	10^{-1}
12	10^{-12}	10^{-2}
11	10^{-11}	10^{-3}
10	10^{-10}	10^{-4}
9	10^{-9}	10^{-5}
8	10^{-8}	10^{-6}
7	10^{-7}	10^{-7}
6	10^{-6}	10^{-8}
5	10^{-5}	10^{-9}
4	10^{-4}	10^{-10}
3	10^{-3}	10^{-11}
2	10^{-2}	10^{-12}
1	10^{-1}	10^{-13}
0	10^{0}	10^{-14}

By examining the table above, it can be determined that when the pH is 2, the (H^+) concentration is much higher than the (OH^-) concentration. This is just the opposite of the pH of 12; more so, note a difference of 1 pH unit is equivalent to a ten-fold difference in concentration of H^+ and of OH^-.

Why would it be important in an aqueous environment to maintain a balance of ionic species? (osmosis)

Terms

acidic: having a pH value of less than 7; acidic liquids are corrosive and sour. (DO NOT TASTE!)

alkaline: having a pH greater than 7; alkaline liquids are caustic and bitter. (DO NOT TASTE!)

condensation: (1) the process of changing from a vapor to a liquid; (2) a liquid obtained by the coming together of a gas or vapor

conversion: a physical transformation from one material state to another

corrosion: a substance formed or an action of wearing away by chemicals; formed by deterioration

decomposition: the process of breaking down into constituent parts or elements

evaporation: the process of changing from a liquid to a vapor

fluid: a substance, as a liquid or gas, that is capable of flowing and that changes its shape at a steady rate when acted upon by a force

hard water: water high in mineral content; water containing an abundance of Ca^{+2} and Mg^{+2} ions

hydrologic cycle: the cyclical process of water's movement from the atmosphere, its inflow and temporary storage on and in land, and its outflow to the oceans; cycle of water from the atmosphere, by condensation and precipitation, then its return to the atmosphere by evaporation and transpiration.

ionization constant: a comparison of the strengths of acids or bases in a given solvent, such as water, expressed by the amount of H^+ ions compared to the OH^- ions

leaching: the removal of chemical constituents from rocks and soil by water;
(Leach = to leak)

liquid: fluid composed of molecules that move freely among themselves but do not tend to separate like those of gases; state of matter that has a definite volume but not a definite shape

microbiological: referring to microscopic or ultramicroscopic organisms such as algae, bacteria, or protozoa

organic: of, pertaining to, or derived from living organisms

percolate: to drain or seep through a porous and permeable substance; to filter such as a liquid passing through a porous body (water through soil to the aquifer)

pH: a measure of the concentration of hydrogen ions (H^+) in a solution; the pH scale ranges from 0 to 14, where 7 is neutral, values less than 7 are acidic, and values greater than 7 are basic or alkaline. It is measured by an inverted logarithmic scale so that every unit decrease in pH means a 10-fold increase in hydrogen ion concentration. Thus, a pH of 3 is 10 tim as acidic as a pH of 4 and 100 times as acidic as a pH of 5.

precipitation: water droplets or ice particles condensed from atmospheric water vapor and sufficiently massive to fall to the Earth's surface, such as rain or snow

respiration: the sum total of the process of oxygen being conveyed to the cells and tissues of living organisms and the process by which the products of this oxidation process, CO_2 and H_2O, are given off

soft water: water that is low in mineral content because it has flowed through soils and rocks containing minerals that react poorly. Soaps are very "sudsy" in soft waters.

solvent: a substance that dissolves another to form a solution

vapor: a substance in gaseous form

ADVANCE PREPARATION

A. Obtain water samples from four different sites around the community or school.

1. Be sure to collect enough water in each sample to give each student group/station samples.
2. Use closeable jars or containers for the samples to ensure the integrity of the samples.

B. Decide if you will use an electronic pH meter or pH paper.

PROCEDURE

I. Setting the stage

A. Have four unidentified water samples prepared ahead for each group.

B. Have pH tests available for each group. You may use the simple pH test strips (papers) from a pH test kit or a pH meter. Show students how to use pH test strips or meter.

II. Activity

A. Each group will test the pH of each of its water samples and record the results on the Data Sheet.

B. Each group will then filter, strain, or add one of the available chemicals to the water sample to see the effect on the water sample. They will describe the process on the Data Sheet. One group should not duplicate another group's work.

C. A new pH reading should be taken after the student process. Record on Data Sheet.

III. Follow-up

A. Compare results and discuss implications to drinking water, to industry (corrosion, clogging), to soil quality.

B. Discuss effects on water treatment and additives to water.

C. Try to determine if each sample is surface water or groundwater. (Teacher will identify before end of activity.)

D. Have groups explain how water acquired its properties through the hydrologic cycle.

E. Graph the different results for different samples.

IV. Extensions

A. Have students bring water samples from a location of their choice. Let groups determine the pH of the water, the source of the water, and the way it acquired observed properties.

B. Test the "hardness" and "softness" of the water by ways, such as soap tests, and compare with your pH findings.

C. Create graphs and/or charts of the results of tests before and after the student treatment" processes.

D. Create a bulletin board to post the results and increase the awareness among students/teachers of water sources.

E. Create a map of the locations of the samples and try to determine the causes of the pH of the different samples.

RESOURCES

Compton's Encyclopedia, Water, Compton's Learning Library, 1990.

EPA, Water Quality Management Bulletin, Water Planning Division, Washington D.C., March 1980.

Renn, Dr. Charles E, A Study Of Water Quality, Johns Hopkins University, Chestertown, MD, 1968.

Sumich, James L., Biology Of Marine Life, Wm. C. Brown Company, Dubuque, Iowa, 1982.

DATA SHEET

Group Number _________

Group Names ____
Water Sample Number ________

pH of Original Sample __________

Describe procedure done on water. (Include amounts.)

____

____

____

____

pH of altered sample _______

Try to determine where this original water sample was collected by reviewing the background information and discussing the characteristics of your local area.

WHERE COLLECTED ____
____

REASON(S) FOR DECISIONS ____

____

____

____

Did this sample get any of its pH properties from the Hydrologic Cycle? Explain.

WHAT'S IN A BOTTLE OF WATER?

9-12

OBJECTIVES

The student will do the following:

1. Examine the bottled water industry.

2. Distinguish between different kinds of bottled water.

3. Become more aware of the differences between bottled water and tap water.

4. Develop an individual perspective on bottled water controversy through a project.

SUBJECTS:
Social Science (Economics), Language Arts, Science (Physical, Ecology)

TIME:
1 class period for discussion.
homework/presentation

MATERIALS:
handout Bottled Water: "Quality or Hype"

BACKGROUND INFORMATION

Bottled water is big business in the United States. It is a business that may anticipate considerable growth in the coming years, for consumers are often turning to bottled water as a replacement for tap water and as an alternative to alcoholic beverages and sodas.

Terms:

artesian well: a well that produces water without the need for pumping due to pressure exerted by confining layers of soil

bottled water: water that is sealed in food grade bottles and is intended for human consumption

club soda: same as soda water; water charged under pressure with carbon dioxide gas

mineral waters: sparkling (carbonated) waters generally used as an alternative to soft drinks or cocktails

natural water: water that comes from springs or streams and does not have any chemicals added to it

potable water: water suitable for drinking without harmful effects

seltzer water: natural mineral water that is effervescent

soda water: water charged under pressure with carbon dioxide gas

sparkling water: carbonated drinking water

spring: a surface flow of water originating from subsurface sources (groundwater); often a source of a stream or pond

well: a bored, drilled, or driven shaft or dug hole. Wells range from a few feet to more than 6 miles in depth but most water wells are between 100 and 2,000 feet in depth.

ADVANCE PREPARATION

A. Have vocabulary words/definitions on board for discussion at beginning of class period.

B. Copy Student Sheet "Bottled Water: Quality or Hype."

C. Copy Student Sheets for Word Find and Cryptogram (cover solution when copying) if teacher wants to include these.

PROCEDURE

I. Setting the stage

A. Discuss the current popularity of bottled water.

B. Give copies of handouts.

C. Have individual students or groups research and read at least three articles dealing with bottled water.

II. Activity

A. Write an article for the school newspaper in which you discuss the growth of the bottled water industry. Include information from the handout.

B. Construct poster/collage to show different labels of bottled water. Include name, source, distributor's name, source of supply, and any other information unique to each label. Use U.S. or regional map to show point of origin of the water.

C. Phone or visit a local supermarket. Talk to the manager about bottled water sales. Write a four-paragraph essay to report your findings. Be sure to develop a strong thesis in the introduction. Write two detailed body paragraphs to report your findings. Summarize and draw conclusions in the fourth paragraph.

D. Develop your own questionnaire to poll opinions of ten students or adults about bottled water. Report your findings to the class using graphs and/or charts.

E. Have a taste test of different kinds of bottled water.

III. Extensions

A. Cryptogram

B. Word Find

C. Research the purity of your local tap water and compare it to state and federal contamination limits and guidelines. Check with the local water system for information.

RESOURCE

Marguardt, Sandra, “Bottled Water: Sparkling Hype at a Premium Price”, Environmental Policy Institute. January, 1989.

Bottled Water Fact Sheet, EPA, May 1990. Call the Safe Drinking Water Hotline at 1-800-426-4791.

BOTTLED WATER: QUALITY OR HYPE

In this time of growing public concern over how safe is drinking water, Americans are buying bottled water to satisfy their needs and tastes. The bottled water industry has sales of $1.9 billion a year. Concerns over the purity of bottled water are now stimulating research into the benefits/disadvantages of this water.

Americans are paying premium prices for bottled water with little assurance that the product is "purer" than their tap water. However, bottled water is tested for contaminants similarly to drinking water (or tap water) provided by a public water system. Sales of bottled water increased by almost 500 percent between 1977 and 1987. Bottled water costs 700 times the average cost of tap water and three times the cost of oil.

People have different reasons for buying bottled water products. Some buy it because of advertising that promotes the idea that bottled water is important to a fit lifestyle. For others, water in a bottle just tastes better. Then there are the people who are forced to buy bottled water because their private wells or public water supplies have become contaminated by pesticides, fertilizers, chemicals, or bacteria. Government reliance on bottled water as a response to water supply contamination, combined with advertising, appears to have encouraged the misconception that bottled water guarantees a product substantially safer and healthier than tap water.

The following is a quote from Sandra Marquardt who works for The Environmental Policy Institute (EPI). "After reviewing government documents, independent and government studies, as well as state and federal regulations governing bottled water, the Environmental Policy Institute has concluded that, despite the attractive packaging of bottled water, this product, in general, is not necessarily any safer or more healthful than the water which comes out of most faucets. In fact, the public water utilities supplying these same faucets are the source for more than one-third of all the bottled water in the U.S."

EPI has found that numerous independent studies of bottled water have cast doubt on claims of bottled water purity. In reviewing these studies and assessing other available evidence, the Environmental Policy Institute has found that bottled water frequently contains low levels of contaminants such as heavy metals and solvents.

Activities for: DRINKING BOTTLED WATER

WORD FIND: DRINKING BOTTLED WATER

DRINKING WATER	D	W	P	O	T	A	B	L	E	A	S	H	L
MINERAL	E	R	E	M	U	S	N	O	C	P	H	T	L
NATURAL	S	T	I	L	L	W	A	T	E	R	E	S	E
STILL WATER	N	R	D	N	A	T	U	R	A	L	C	U	W
SPARKLING	O	G	E	O	K	R	M	G	E	S	I	S	N
PUBLICI	H	A	W	B	I	E	P	L	H	L	A	A	
FILTRATION	T	S	E	S	N	R	N	D	L	H	B	N	I
POTABLE	A	O	U	E	N	T	R	G	E	S	U	S	S
SODA	R	D	R	V	E	E	I	T	W	L	P	P	E
CLUB SODA	T	A	L	E	Z	A	S	L	A	A	R	B	T
SELTZER	L	P	A	T	A	E	M	A	R	I	T	E	R
WELL	I	X	L	Y	P	Z	X	K	N	R	Y	E	A
SPRING	F	E	M	A	R	L	L	G	Z	R	U	T	R
ARTESIAN WELL	S	T	N	A	N	I	I	M	A	T	N	O	C
TAP	X	Y	Z	N	N	C	L	U	B	S	O	D	A
CONSUMER	E	P	A	G	C	O	N	T	A	E	N	E	R
I B W A													
EPA													
PEST													

Activities for: DRINKING BOTTLED WATER

WORD FIND: DRINKING BOTTLED WATER

DRINKING WATER	D	W	P	O	T	A	B	L	E	A	S	H	L
MINERAL	E	R	E	M	U	S	N	O	C	P	H	T	L
NATURAL	S	T	I	L	L	W	A	T	E	R	E	S	E
STILL WATER	N	R	D	N	A	T	U	R	A	L	C	U	W
SPARKLING	O	G	E	O	K	R	M	G	E	S	I	S	N
PUBLIC	I	H	A	W	B	I	E	P	L	H	L	A	A
FILTRATION	T	S	E	S	N	R	N	D	L	H	B	N	I
POTABLE	A	O	U	E	N	T	R	G	E	S	U	S	S
SODA	R	D	R	V	E	E	I	T	W	L	P	P	E
CLUB SODA	T	A	L	E	Z	A	S	L	A	A	R	B	T
SELTZER	L	P	A	T	A	E	M	A	R	I	T	E	R
WELL	I	X	L	Y	P	Z	X	K	N	R	Y	E	A
SPRING	F	E	M	A	R	L	L	G	Z	R	U	T	R
ARTESIAN WELL	S	T	N	A	N	I	I	M	A	T	N	O	C
TAP	X	Y	Z	N	N	C	L	U	B	S	O	D	A
CONSUMER	E	P	A	G	C	O	N	T	A	E	N	E	R
I B W A													
EPA													
PEST													

CRYPTOQUOTE: Here's how it works: One letter stands for another letter. Single letters, double letters, word formations, and punctuation are all clues. E is the most frequently used letter of the alphabet; THE is the most frequently used three-letter word. Have fun!!

J S Q Q M B V O I Q B D K C J K H

J Z C K R B C C K R Q U B

Z R K Q B V C Q I Q B C.

SOLUTION:

Bottled water is big business in the United States.

KEEP OUR COMMUNITY BEAUTIFUL!

9-12

OBJECTIVES

The students will do the following:

1. Describe the severe trash dumping problem and its effects on surface water .

2. Organize a problem solving process.

3. Relate the pressure and confusion people often face when making decisions that affect the environment and health.

SUBJECTS:
Science (Ecology, Physical), Social Studies (Economics), Language Arts, Math

TIME:
2 hours or 2 class periods

MATERIALS:
calculators (1 per group)
paper
pencils/pens
markers
staplers

BACKGROUND INFORMATION

No discussion concerning water pollution is complete without the mention of trash dumping in and around our waterways. The magnitudeof this problem continues to grow, and yet it is very simple to prevent. Despite millions of dollars spent by the federal government and private environmental groups to educate the public, trash dumping continues to plague both our land and water resources.

As students will discover through this activity, environmental professionals face difficult decisions when trying to affect change. Even at the community level, there are many factors to consider.

ADVANCE PREPARATION

Make copies of student sheets - Situation and Joe’s Agenda.

PROCEDURE

I. Setting the stage

A. Divide class into small groups of 3 or 4.

B. Have students read student sheet - Situation.

II .Activity

A. Tell student to follow the instructions in the student sheet and to reread carefully the "points to consider" in the reading.

B. Allow time for group discussion of the possible solutions.

C .Students may use student sheet "Joe's Agenda" as a guide to producing their group report.

III. Follow-up

A. Have groups present their report to the class. Tell them to do the presentation as if they were trying to "sell" their idea to a board of directors.

B. Students should discuss each group's proposal and choose one or a combination of ideas to solve the probl

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

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Hodge, Karen & Younger, Lids. K., 1991 International Coastal Cleanup Overview, Washington, DC, 1992.

Kuyendahl, Jim, Ph.D., personal interviews, Alpha Environmental Press Release, The Center for Marine Conservation, June 1995.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

“Salvaging our Seashores,” Environment, September 1995, v.37 p.22.

Student Sheet

Situation

You are a high school student who has been working weekends and summers at Lake Meramec. Your responsibilities include renting canoes, and water sports equipment, and heading the cleanup committee. You love working at the lake because you can utilize the facilities whenever you aren't working. You don't mind helping clean up the banks and sand bars because you like knowing that you can swim without the danger of stepping on broken glass or trash floating around in the water. Over the past two summers, you have befriended Mr. Smith, a boater who frequents the lake. This gentleman has discussed the cleanliness of the area with you and is impressed with your attitude and ideas.

It is May and after final exams, you will start your third summer at the lake. You have finally received a long deserved raise, so now you are making $5.50 per hour. Mr. Smith approaches you and offers you a temporary job at twice what you are making - $11.00 per hour. He says he needs some fresh ideas to complete an ongoing project. You decide not to quit the lake but try juggling both jobs and school. You are very excited as you ponder all the items that will now be affordable with your expanded budget.

For the first two weeks, you only have to spend a few hours on Mr. Smith’s project. It turns out that he works for the Parks and Recreation Department in your state. He is in charge of an effort to rid the surface water of refuse in your area. He takes you on a tour of several streams, ponds, and lakes in the area. You are appalled at the severity of the problem. Part of the task will be to educate the community. The intention is to attack the source of the problem.

During the second week, you meet with Mr. Smith, and John and Joe who are also working on the project. One specific portion of the project is being finalized. This portion includes the plan for long- term community education and beautification for a 50-acre area surrounding the lake. At this meeting, Joe produces an Agenda (see Joe's Agenda).

At this meeting you begin to understand why Mr. Smith hired you. Although both John and Joe are qualified, they are both very negative toward the project and are not committed to its success. Mr. Smith knows that beyond your natural enthusiasm, you have a personal investment in the situation. While John and Joe live across the state, you live in the same region.

Under the heading WHAT DOESN'T WORK, Joe and John have filled the space allotted. They have only one idea under FRESH IDEAS. Together the four of you have a brainstorming session. Mr. Smith is very impressed with your ideas. Later, he informs you that with the completion of this project, he has other similar opportunities for you. You can't believe your good fortune.

At your next meeting, only you and John show up. Mr. Smith is overseeing another project, and Joe's wife had a baby prematurely. He will be gone for at least two weeks. The deadline to submit the final report is eight days away. John has brought a copy of the preliminary report for your perusal. John and Joe have amassed loads of information. However, on looking it over, you discover that it is unorganized and badly written. It even contains some erroneous statistics. John announces proudly that the cost sheet is correct but that his background is actually in accounting, and he has never had to submit a report of this nature. Even though you are just a high school student, you know that Mr. Smith will not be impressed. You convince John to scrap the report and start over.

The report must describe the problem, explain a plan of action, and justify a submitted budget. Joe and John have provided all the information you need. You suddenly wish you had paid more attention when writing term papers, but know that you can go to the library and check out a book on technical reports. It is Thursday afternoon, and the report is due next Friday. Unfortunately, you have final exams next week, Sunday is your grandmother’s ninetieth birthday celebration, and Saturday afternoon you have to work at the lake. You decide to spend Friday evening at the library. John agrees to meet you on Saturday morning for an intense two hours in which the two of you will piece together the final report.

The following pages are examples of the information presented by Joe and John. Working in small groups of four or five, try to eliminate erroneous information and write a report that Mr. Smith will *be able* to pass on to the Parks and Recreation Department. Remember, the budget comes from taxes, and any use of those funds must be justified. As a bare skeleton your report should include these items:

Title Page	Table of Contents
Plan of Action	Outline of Community Campaign
Cost Sheet/Budget	Justification of Budget

Important points to consider:

- Some of the points will simply be mentioned. Remember the aim is quality, not quantity. Those reading this report are busy; they want relevant information only. Utilize Joe's agenda to do some brainstorming of your own. Budget constraints and media resources can be changed if methods can be justified.

- Allow at least an hour and a half to organize and write your report. Wise use of time can best be achieved when one person is named Project Coordinator or PC. The "PC" can then delegate specific tasks.

- In the immediate area, there are nine schools, two libraries, and two community centers.

This budget is for 36 months.

- The acreage is five miles out of town, and the refuse pickup company wants to charge $10 extra per pickup to cover time and fuel expenses.

JOE'S AGENDA

CAMPAIGNS

Enforcing through stakeouts and fines
Beautification - planting wildflowers
Education of community through pamphlets and videos

FRESH CAMPAIGN IDEAS

Adopt an Acre (publicity needed)

PLAN OF ACTION

ALTERNATE MEDIA RESOURCES

Mobilizing university, high-school, or local environmental groups (publicity needed)
Local newspaper reporter

BUDGET CONSTRAINTS

$5,000

Fund raising activities possible but must be volunteered by civic-minded group

COST ESTIMATES

Community Awareness

Brochures/Pamphlets	
Black and White on colored paper 5,000	
Both sides Initial Setup (Text Only)	$ 72.00
5,000 copies @13 cents each	$ 650.00
Add additional cost per copy for Clip Art	

Color text including color photos	
Both sides Initial Setup	$ 92.00
5,000 copies @79 cents per side	$ 7,900.00
Distribution of pamphlets labor and gas	$ 100.00
Video for presentations at schools (10 min.)	$11,000.00
Labor for presentations - $17.00 per hour/ per person. (Estimated need: 2 people)	

Circumventing Trash Dumping

Signs - law enforcement warning and/
or Keep This Area Beautiful

2 signs @ $115.00 each	$ 230.00

Beautification - wildflowers

LONG TERM CONTRACT FOR WASTE DISPOSAL

Trash containers and refuse pickup (per month)

No picking up of grounds	$ 60.00

Labor for area pick-up twice a month

16 hours at $5.00 per hour	$ 80.00

Mileage?

OTHER EXPENSES

Phone calls	$ 43.00
Newspaper Want Ad (Labor Pickup) ($56 weekly or $21 weekend only)	$ 21.00

STATISTICS

Debris included in the 2,878,913 pounds of refuse collected by volunteers during the 1991 annual cleanup of U
lakes. rivers, streams, beaches, and underwater sites:

8,487 syringes   22,440 tampon applicators

7,143 condoms   13,162 diapers

967,873 cigarette butts

Information for subsequent years may be obtained by contacting the Center for Marine Conservation and requesting a copy of the latest edition of "International Coastal Cleanup Overview."

Last year, approximately 800 lbs. of litter were collected from Meramec park. This debris was collected by tw volunteer groups: Boy Scout Troop 527 and Central High School's Green Group.

RISK ASSESSMENT: HOW MUCH RISK ARE YOU WILLING TO TAKE?

9-12

OBJECTIVES

The student will do the following:

1.Understand several ways of analyzing, prioritizing, and regulating risk.

2.Understand the concept of cost/benefit analysis as applied to regulating risk.

3.Examine his/her own attitudes about risk priorities.

4.Develop a personal rationale for assessing risk.

SUBJECTS:
Social Studies (Economics), Language Arts, Math

TIME:
90 minutes, about 50 minutes in class

MATERIALS:
handouts of reading materials
handouts of attitude survey

BACKGROUND INFORMATION

Risk assessment is a term used for the process of describing or characterizing the nature and magnitude (that is, the effects and the size of those effects) of the potential hazard. Four activities are generally involved. The first is identifying the risk (such as benzene in relation to cancer). The second is drawing a dose/response curve (how much does it take to cause a reaction of some kind). This is usually done with animal testing. Next is estimating the amount of human exposure (how much and for how long might be probable). Finally, the result or effect must be categorized as high or low using all available data. An assessment should be both descriptive and mathematical. Even when the best available evidence is used, this is not an exact science. Once risks have been technically assessed, a more policy-oriented decision process, commonly called risk management is employed. This process involves weighing risk estimates with or against other key elements of public policy, such as equity, quality of life, individual preferences, cost effectiveness, and distribution of risks and benefits. Studies show a wide divergence between "expert" and public perceptions of risk. The public often makes a distinction between voluntary and involuntary risks and feels less fear of risks that provide personal enjoyment, benefit, or those over which they have a sense of personal control.

Over 50 federal agencies are responsible for various types of environmental regulation. In a given year, economists have estimated that environmental regulation costs the U.S. economy $580 billion a year or $6,000 per household. Comparisons of performance of risk protection agencies show that allocation of risk protection expenditures could be improved, even in environmental policy, if cost effectiveness were taken into account. One study estimated that shifting resources from less to more cost-effective programs could increase the number of life years saved in the U.S. by 600,000 per year at no increased cost to citizens. In a 1987 report titled Unfinished Business, little correlation was found between risks EPA judged most threatening and its program priorities. The report concluded that priorities appear more closely aligned with public opinion than with estimated risks.

Risk management is often hotly debated. For example, should the government spend more for AIDS research? Someone with AIDS would definitely say yes. Someone with cancer would argue against this because more people have cancer and cancer research would lose funding. Where is the greater risk? How would the money bring about the greatest benefits? Such questions are no easier to answer when they pertain to government spending and the environment.

Terms

assessment: a fact-based evaluation or judgement

benefit: help or reward; positive factors to consider

cost: price; practical factors to consider

management: to effect a plan of action; to solve a problem by direction, guidance, administration, or control

perception: one’s belief, comprehension, or knowledge; may not be based on facts

risk: exposure to danger; negative factors to consider

ADVANCE PREPARATION

A. Run off Student Sheets.

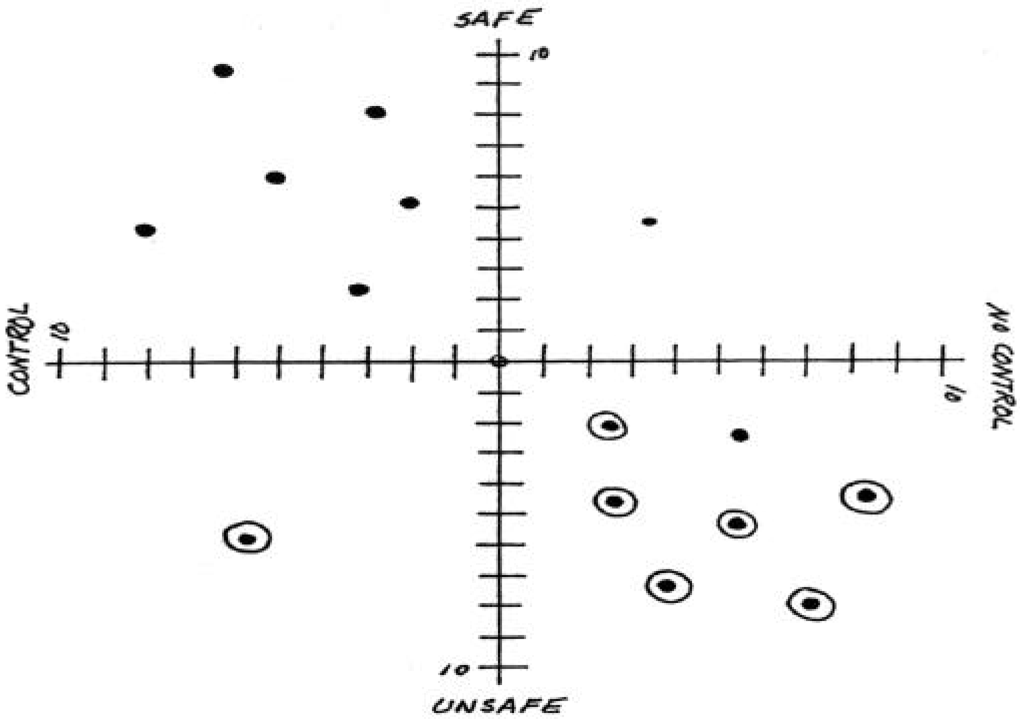
B. Put Teacher Sheet on the overhead.

PROCEDURE

I. Setting the stage

A. Give each student a copy of the Risk Perception Survey Student Sheet. Allow about 10 minutes to complete. Ask students to identify quadrants in which most points plotted.

NOTE: MOST STUDENT RESPONSES WILL FOLLOW THIS PATTERN:



STUDENTS FEAR AND WANT CONTROL ON ITEMS OVER WHICH THEY FEEL THEY HAVE NO CONTROL!

B. After completing A, explain that experts rate the risk in reverse order. Show transparency and discuss the EPA's assessment of public concerns.

II. Activity

A .Divide class into four groups and choose two issues these materials or others that involve controversy over risk assessment or risk management. Two groups will work on each issue, identifying themselves with distinctly different interests or opinions on the given issue.

B. Allow the two groups to work together for about 15-20 minutes, utilizing the first set of questions below to develop their group identification. Then separate them, and use the second set of questions to establish what priorities or points of compromise exist for their interest groups. Be sure that each group has a recorder to write down the ideas that emerge.

1.State the issue.

a .Identify two "sides" to this issue.

b. Make a clear statement of the perceived risks related to this issue.

c .List at least four consumer groups, public interest groups, business groups, government agencies, or others that would identify themselves with each side.

2.For each group identified with your side in "a" above, write down a reason w it has a stake in the outcome of the issue.

a. List the outcomes you as a group of stakeholders most desire from a public hearing.

b. Write down any compromises you would be willing to make.

c. Think about what the other side is going to say and be prepared to counter their assertions.

C. Hold a mock public hearing on each issue with the teacher as facilitator. After each group is allowed 6-8 minutes to present its side, allow class discussion.

III. Follow-up

A. Ask students to discuss the survey of risk perception. The list is in inverse order of the rankings made by experts.

B. Over which of the listed risks do they have some control?

C. From what kinds of risks do they feel the government should be most involved in protecting them? What sorts of risks should be left to individual choice: bike helmets, seat belts, personal health choices?

D. Over what kinds of risks do they feel they have the least control? Why?

IV. Extensions

A. Have students choose a specific risky activity .

1.Do a report on how many deaths are associated with this risk each year.

2.Explain how many might have been prevented and the cost associated with prevention.

B. Have students do research for statistics used to estimate risk.

1.Tell them to look for different estimates of the same risk.

2.Have students do research looking for statistics on the numbers of cancers caused by different agents. Again, tell them to find several sources and estimates that are different.

RESOURCES

Graham, John D., "Risk Analysis," Environmental Engineer, Vol. 31, Apr. 1995, p. 22.

"Risk Based Decision Making at EPA ," hearings before Congress, Feb. 1994.

Unfinished Business, EPA report, 1987.

“Use of Risk Analysis and Cost Benefit Analysis in Setting Environmental Priorities,” hearings before Congress, Nov. 1993.

SURVEY OF RISK PERCEPTION

Plot the numbers for each item on the graph, depending on how safe or dangerous you think it is to you and depending on how much personal control you have over it. Circle the numbers of the items that you feel shou be regulated by the government. (See sample on graph.)

1. Skiing
2. Mountain climbing
3. Power mowers
4. Football
5. Spray cans
6. Vaccinations
7. Antibiotics
8. Hunting
9. Home appliances
10. Food coloring
11. Nuclear power
12. Railroads
13. Fire fighting
14. Police work
15. Commercial aviation
16. Bicycles
17. Food preservatives
18. Large construction
19. Private aviation
20. Contraceptives
21. Swimming
22. Electric power (non-nuclear)
23. Pesticides
24. X-rays
25. Motorcycles
26. Surgery
27. Handguns
28. Alcoholic beverages
29. Smoking
30. Motor vehicles

RISK ASSESSMENT

Comparison of public's perceived risk vs. non-cancer health risk. (1987)

Perceived Risk:	Non-Cancer Health Risk:
High	High
Chemical Waste Disposal	Air Pollution (hazardous/criteria pollutants)
Water Pollution	Indoor Air Pollution (except Radon)
Chemical Plant Accidents	Drinking Water
Air Pollution	Accidental Releases (toxics)
	Pesticides (application & food residue)
	@Consumer Product Exposure
	Worker Exposure to Chemicals
Medium	Medium
Oil Spills	Radon
Worker Exposure to Chemicals	Radiation (not radon)
Pesticides	UV Radiation/Ozone Depletion
Drinking Water	Water Pollution (most point source & NPS)
	Non-hazardous Waste Sites
	Other Pesticide Risks
Low	Low
Indoor Air Pollution	Hazardous Waste Sites (active & inactive)
Consumer Products	Industrial Discharges to Surface Water
Genetic Radiation (except nuclear power)	Mining Waste
Global Warming	Storage Tank Releases
	Contaminated Sludge

Not Ranked
Global Warming
Oil Spills

KEY:

@ Responsibility shared with other Federal Agencies

Unfinished Business: A Comparative Assessment of Environmental Problems, EPA 230/2-87-025, February 1987, Overview Report, pp. xix-xx & Appendix II, p. 2-2.

The frequency of dramatic and sensational lethal events tends to be overestimated; the frequency of unspectacular events tends to be underestimated.

Most Overestimated	Most Underestimated
All accidents	Smallpox vaccinations
Motor vehicle accidents	Diabetes
Pregnancy, childbirth, abortion	Stomach cancer
Tornadoes	Lightning
Flood	Stroke
Botulism	Tuberculosis
All cancer	Asthma
Fire and flames	Emphysema
Venomous bite or sting	
Homicide	

Source: Fischoff, Issues in Science and Technology, 1988, p. 8

The Big Cleanup - costs for several categories of polluted sites

Category	**# of sites**	**Estimated cost (Billions of $)**
Superfund abandoned sites	4,000	$ 80-120
Federally owned sites	5,000-10,000	$ 75-250
Active private sites	2,000-5,000	$ 12-100
Underground storage tanks	400,000	$ 32
State law cleanups	6,000-12,000	$ 3-120
Inactive uranium tailings	24	$ 1.3
Abandoned mine lands	2,300	$ 55

Source: New York Times, Sept. 1, 1991, p.28.

Cause	**Annual rate (deaths per 1 million)**
Asbestos	**0.005-0.093**
Whooping cough vaccinations (1970-80)	**1-6**
Aircraft accidents (1979)	**10**
High school football	**27**
Drowning	**32**
Motor vehicle accidents, pedestrian (ages 5-14)	**60**
Home accidents (ages 1-14)	**120**
Long-term smoking	**<1**

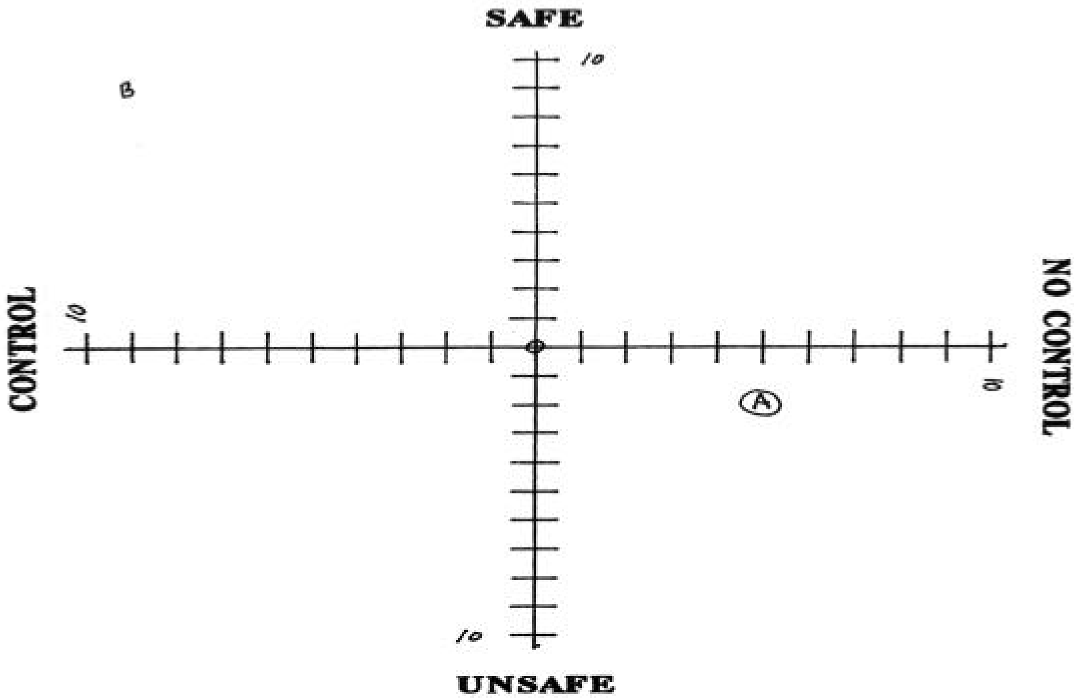
Source: Mossman, et. al., "Asbestos: Scientific Developments and Implication for Public Policy, 247 Science 297 (1990).

Percent of all cancer deaths attributed to various factors

Factor	Best estimate %	Acceptable range%
Tobacco	30	25-40
Alcohol	3	2-4
Diet	35	10-70
Food additives	<1	0.5-2
Reproductive & sexual behavior	7	1-13
Occupation	4	2-8
Pollution	2	<1-5
Industrial products	<1	<1-2
Medicines and medical procedures	1	.05-3
Geophysical factors	3	2-4
Infection	10	1-?

Source: R. Doll and R. Peto, The Causes of Cancer, 1256, (1989).

**Studen
t Sheet**



**SURV
EY OF
RISK PERCEPTION**

Plot each item on your survey list as directed, using your own personal perceptions.

See examples below. (Your personal perceptions may differ from the author's.)

EXAMPLE A - Drive-by shooting
Author's rationale: This is dangerous, but unlikely, thus it gets a "2" on the UNSAFE scale. I have no control over what others do, but I can avoid dangerous parts of town, thus it gets a "5" on the NO CONTROL scale. Laws are needed, thus the "A" is circled.

EXAMPLE B - Drag racing
Author's rationale: This is fun and safer than driving on highways. I've been doing it all of my life, thus it get on the SAFE scale. I'm a good racer, so it gets a "9" on the CONTROL scale. There are many associations th set rules, so the government is not need or wanted, thus the "B" is not circled

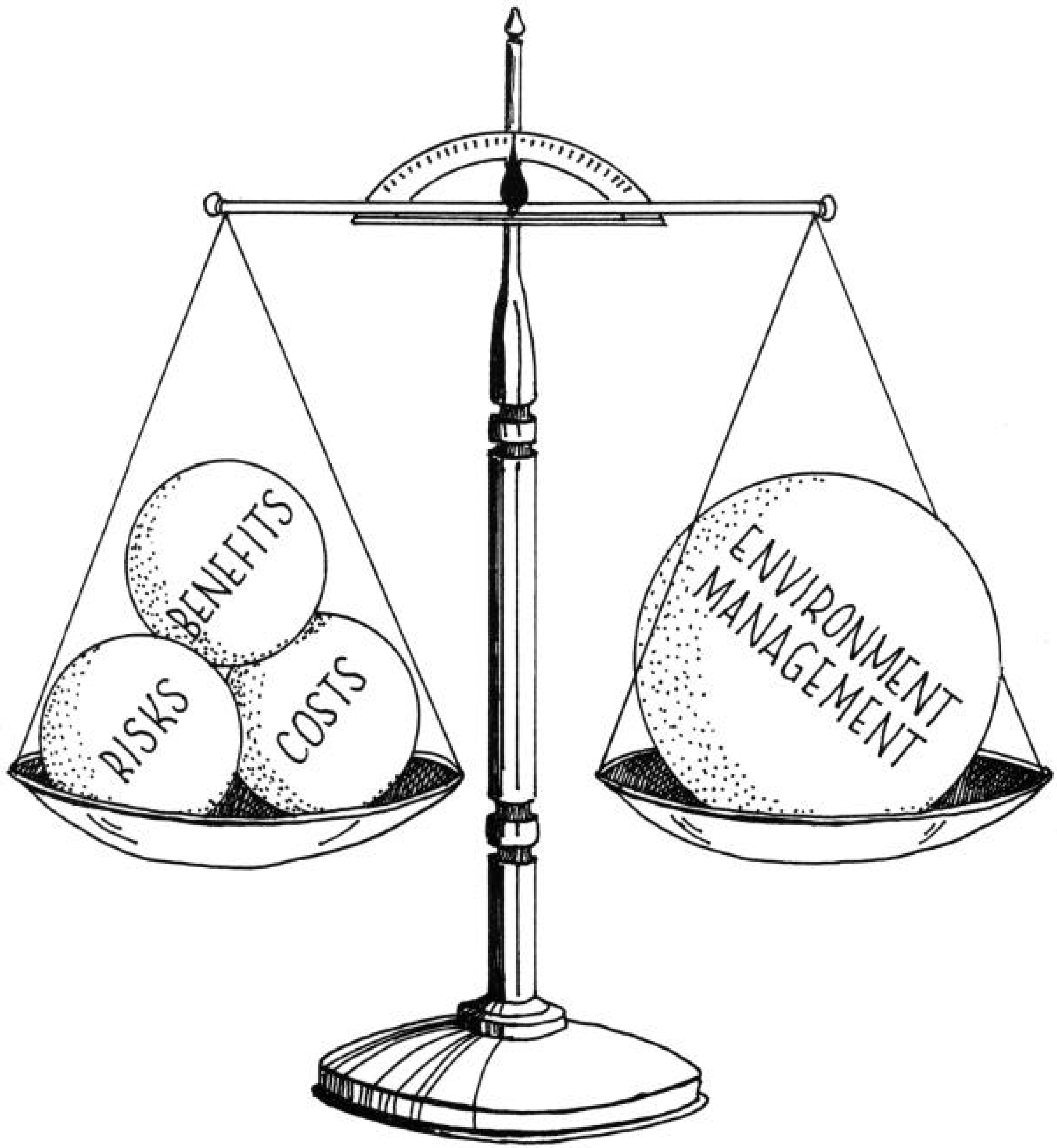
.

Teacher Sheet

RISKS - exposure to danger; negative factors to consider.

BENEFITS - help or reward; positive factors to consider.

COSTS - price; practical factors to consider.



INTERNATIONAL WATER DISPUTES: YOU BE THE NEGOTIATOR!

9-12

OBJECTIVES

The student will do the following:

1.Demonstrate researching skills.

2.Participate in a mock international water conflict.

3.Develop problem solving and negotiating skills.

SUBJECTS:
Science (Physical), Language Arts, Social Studies (Geography)

TIME:
2 weeks

MATERIALS:
student sheets

BACKGROUND INFORMATION

Many locations in the world experience ongoing disputes regarding plans in an upstream country or state to divert water for its use when that body of water travels through other countries or states downstream. In addition to limiting the amount of water to countries or states downstream, this can also seriously impact the quality of the remaining water. Conflicts between countries and states have been caused by problems related to both quantity and quality. Water rights issues have caused some very emotional and violent disputes.

Because water is essential to life, humans should learn to solve problems related to water. Water rights issues may be the major cause of wars between countries in the future. An understanding of the terms will be needed to complete the activity.

Terms

arid: lacking enough water for adequate growth; dry and barren

headwaters: the streams that are the sources of a river

hydrology: the study of water, its properties, distribution on Earth, and effects on the Earth's environment

negotiations: a conferring, discussing, or bargaining to reach an agreement riparian: of, adjacent to, or living on the bank of a river or stream, or sometimes, of a lake or pond

riparian rights: water rights enjoyed by owners of land adjacent to a body of water

water rights: rights, sometimes limited, to use water from a stream, canal, etc., for general or specific purposes, such as irrigation

watershed: land area from which water drains to a particular surface waterbody

ADVANCE PREPARATION

1.Check library resources to see that articles about water disputes are available.

2.Photocopy Watershed Map, Helsinki Rules, and Assignment Sheet for each student.

3.Photocopy Article Summary Forms (two per student).

4.Prepare overhead transparency on which the watershed has been drawn. Prepare opening comments to "set the stage" for student research and negotiations.

5.Prepare cards for individual assignments within each group. (See list under vocabulary. Modify the list for the number of students in class.)

PROCEDURE

I. Setting the stage

A. Show students the local watershed so they have a clear understanding of what a watershed is.

B. Show overhead transparency and describe the situation to the class. Country A contains the headwaters of the river. The western part of the country has experienced drought for several years. Country B is very arid. The river is their main water source. Country C is arid expect to the west of the river. Country C has the largest population and has more military power than countries A and B.

C. Explain the type of articles that students are to research. Have students study vocabulary terms. (Have students look for articles over water rights disputes between countries and states.)

D. Divide class into three groups--one group for each country. Have each student draw a card for his/her particular role in the negotiation.

II. Activity

A .Have groups decide when they will meet outside of class or set up class time for meeting after they have finished their article research.

B. Make a pre-negotiation assignment. It will be due the day of the negotiations. This is assignment #3 on the Student Assignment Sheet.

C. Take students to the library to find pertinent articles.

D. Give students the following instructions:

1. Assign research articles. Make sure members of each team read about several different conflicts so they will have a broad base of information. As a group, discuss the articles.

2. Based on individual rules, write a proposal using guidelines from Assignment Sheet #3 telling what they have learned from articles.

3. Prepare a proposal for your country with all members having input. Again see guidelines, Assignment Sheet #3. Select a spokesperson.

4. Present your country's proposal. Follow "on negotiation day" steps.

5. Assign pact negotiation assignment.

E. On negotiation day:

1. Have each country's members present their opening positions.

2. Have open discussion time.

3. Facilitate discussion. Assist students in moving toward a consensus, if possible.

4. Make post-negotiation assignment. (See Student Assignment Sheet.)

5. Assign due date for the total project to include:

a. Article summaries. (See Student Sheet.)

b Pre-negotiation opening position.

c. Post-negotiation work.

III. Follow-up

A. Discuss how students felt about the issues.

B. Ask if they felt they came to the best solution for all three countries.

IV. Extensions

A. Allow students who have developed an interest in a particular situation in the world to do further research and present a more extensive paper for extra credit.

B. Research local water dispute issues and find out how water rights are determined in your state.

C. Have a local water hydrologist or water-rights expert make a presentation to the class or send information.

D. Conduct an Internet search on water disputes, if possible.

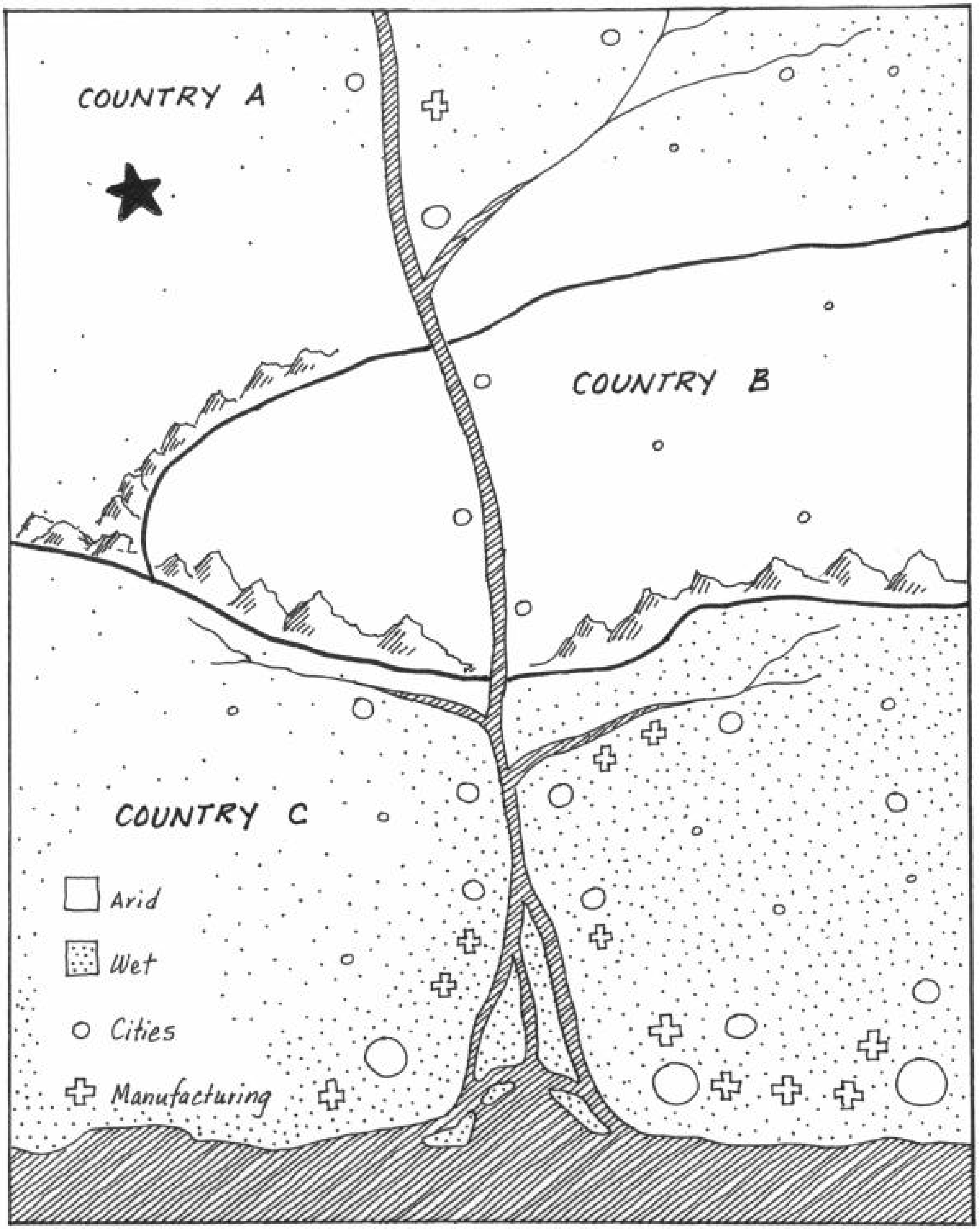
RESOURCES

High school government book.

High school political science book.

Wolf, Aaron, Ph. D., University of Alabama, Lecture and handout, Water Sourcebook Workshop, Camp McDowell, Alabama, June l995.

WATER BASIN AREA



Vocabulary:

Define and learn the following terms:

1. watershed
2. hydrology
3. riparian rights
4. negotiations

INDIVIDUAL ASSIGNMENTS

FOR ALL THREE COUNTRIES:

1. minister of agriculture
2. president of local fishing association
3. farmer association representative
4. homeowner association representative
5. mayor of main city
6. group moderator

COUNTRY B ONLY

director of water management

COUNTRY C ONLY

coastline (salt water) fishing association representative

ASSIGNMENT SHEET

Water basin dispute situation:

An important river has its headwaters in Country A. It flows through Country B and flows into the ocean Country C. Country A has experienced a drought in the starred location on the map and wants to build a dam on the river to create a reservoir. Countries B and C are violently opposed to Country A's damming their main source of wat

RESEARCH:

This type of problem has occurred in the Middle East, the area of Egypt/Ethiopia, the southeastern United States in the Apalachicola-Chattahoochee-Flint River basin (as a conflict here between states in the United States), the Colorado River basin, and in other areas.

1Find two articles about the same water conflict. Look for information in the articles on the cause of the conflict and the possible resolution to the problem. Fill in the Article Summary Form.

2.Look at the map, read and think about the Helsinki Rules (which are suggestions and have been passed as international law), and consider the role you drew for the negotiations.

3.Pre-negotiations: Prepare a written opening position based on your research and your role. Describe what your position coming into the negotiations will be: what issues are important to you and to the people or group you are representing, what issues are negotiable, on what issues you are unwilling to compromise. Try to think of what you may be able to trade from your country to get the water you need. Be ready to turn in a typed pre-negotiation paper on the day of negotiations (two-page limit).

4.Take notes on the day of negotiations.

5.Post-negotiations: Add two pages to #4. What did you learn on negotiation day? Were the conclusions what you anticipated? Why or why not? What circumstances did you fail to consider in your pre-negotiation paper? How did you modify your opening position?

TURN IN THE COMPLETED PROJECT ON THE DAY ASSIGNED.

Student Sheet

NAME: ______________________ PERIOD: ___________ DATE: ________________

TOPIC: ____

ARTICLE SUMMARY FORM

1.Article Name: ____
2.Author: ____
3.Publication: _______________________________ Date: _________
4.Page number(s): ________________

5.What problem does this article address? ____
____
____
____

6.What groups are or were involved? ____
____
____
____

7.How is/was the resolution handled? ____
____
____
____

8.Remark on other important issues in the article. ____
____
____
____

I read the above named article. Date: ______________________

Signature: ____________________________

HELSINKI RULES (1966)

ARTICLE IV:

Each basin state is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an international drainage basin.

ARTICLE V (REASONABLE AND EQUITABLE USE):
(considerations during negotiations)

A) The basin's geography and the extent of the drainage area in the territory of each basin state

B) The basin's hydrology, including the contribution of water by each basin state

C) The climate affecting the basin

D) Past and existing utilizations of basin waters

E) Economic and social needs of the basin states

F) Population dependent on the waters of the basin within each basin state

G) Comparative costs of alternative means of satisfying (E)

H) Availability of other resources

I) The avoidance of unnecessary waste in the use of the waters

J) The practicability of compensation as a means of adjusting conflicts among users

K) The degree to which a state’s needs may be satisfied, without causing substantial injury to a co-basin state

ENVIRONMENTAL INFRASTRUCTURE FINANCING

9-12

OBJECTIVES

The student will do the following:

1. Determine some of the economic considerations faced by communities in complying with the Clean Water Act.

2. Describe the value of two water treatment options.

3. Calculate the cost of financing two water treatment options.

SUBJECTS:
Science (Ecology), Math, Social Studies (Economics)

TIME:
1 hour

MATERIALS:
calculator
paper
pencil

BACKGROUND INFORMATION

All environmental concerns involve costs: either the cost of losing clean air, clean water, natural habitat, or living species, or the cost of retaining them through environmental management, education, and infrastructure expenses. By far, the most expensive are infrastructure costs that include construction or modification of buildings, equipment, roads, or waterways. These expenses are normally beyond what any individual can afford and are initially shouldered by business enterprises or government institutions. But eventually, through consumer purchases or taxation, the individual pays a portion of the overall cost. Therefore, each of us will benefit if infrastructure financing is accomplished using the best decision-making processes available.

Our federal government has decided that the cost of maintaining clean water is less expensive in the long run than the medical disasters that can result from unclean public water and the natural disasters from polluted rivers and streams. The Clean Water Act requires the establishment of water quality standards to protect existing or designated uses of state waters (e.g., navigation, irrigation, propagation of fish and aquatic life, recreation, drinking water supply, etc.) Municipalities with wastewater treatment plant discharges are issued NPDES permits, with some permit limitations based on water quality standards. Meeting permit limitations can involve changing outdated methods of water treatment with all that entails in associated costs. Decisions made by city and county governments across the country can affect both your health and your pocketbook. Individual citizens can influence these decisions if they understand the various costs involved and what options are possible to achieve the best results at the least expense over the long run. Cost and benefits must be analyzed to determine the best financial and environmental decisions for the community. This lesson is designed to help students learn methods used to arrive at the most cost-effective decisions.

Terms

advanced treatment: any level of treatment beyond secondary treatment that includes secondary treatment plus nutrient removal. Advanced treatment generally removes greater than 85% of BOD and TSS; typically required when the waters receiving effluent from a treatment plant do not provide adequate dilution. It is generally very expensive to construct and maintain advanced treatment facilities.

biochemical oxygen demand (BOD): a parameter used to measure the amount of oxygen that will be consumed by microorganisms during the biological reaction of oxygen with organic material

Clean Water Act (CWA): water pollution control law passed to restore and maintain the nation's waters; the nation's primary source of federal legislation that specifies the methods to be used in determining how much treatment is required for discharges (effluents)
from publicly owned treatment works (POTWs)

effluent: treated wastewater flowing from a lagoon, tank, treatment process, or treatment plant

NPDES (National Pollutant Discharge Elimination System): a program created by the Clean Water Act to ensure that water quality is maintained by dischargers of wastewater. NPDES permits require the operator of wastewater treatment plants to test and report the quality of the effluent discharged to streams. The NPDES permit specifies pollutant limitations on the effluent that prevent damage to receiving waters.

primary treatment: the first stage of wastewater treatment that removes settleable or floating solids only; generally removes 40% of the suspended solids and 30-40% of the BOD in the wastewater.

secondary treatment: a type of wastewater treatment used to convert dissolved and suspended pollutants into a form that can be removed, producing a relatively highly treated effluent. Secondary treatment normally utilizes biological treatment processes (activated sludge, trickling filters, etc.) followed by settling tanks and will remove approximately 85% of the BOD and TSS in wastewater. Secondary treatment for municipal wastewater is the minimum level of treatment required by the Clean Water Act.

total suspended solids (TSS): amount of solids in suspension in water or wastewater

ADVANCE PREPARATION

A. Go to the library and find articles about the cost of complying with various environmental regulations. See if the articles state the impact on the town/company due to the cost. Learn what the term "cost-benefit" means.

B. Learn about compound interest and how the interest on a loan is calculated. If you have a scientific or financial calculator, learn its features related to calculating loan payments.

PROCEDURE

I. Setting the stage:

A rural town of 2000 people (500 households) owns and operates a small wastewater treatment plant that was constructed about 30 years ago. Under the standards in place at that time, it was designed to produce primary effluent. The plant consists of a pump station and a concrete settling basin with an effluent discharge pipe to a small stream nearby. The town has been issued an NPDES permit by the state environmental agency that requires advanced treatment. According to monthly reports submitted to the state by the town, the POTW is not meeting the NPDES permit requirements. In particular, the town's plant is producing effluent with BOD=100 mg/l and TSS=115 mg/l. This effluent has a very cloudy appearance and a definite odor of sewage. The state has determined that effluent of this quality has a negative effect on the small stream to which the plant discharges, causing fish to die. The stream also exhibits a high level of bacteria due to the POTW discharge and cannot support fish and wildlife. However, a study by the state suggests that the large river into which the stream flows is not affected negatively by the discharge because of its larger size (greater dilution).

Because the town violates its NPDES permit, the state environmental agency is required by federal law (Clean Water Act) to take action against the town. The agency issues an administrative order that fines the town $5000 for polluting (noncompliance with its NPDES permit) and sets a schedule for the town to construct upgraded wastewater treatment facilities within three years. The town hires an environmental engineering firm to determine the most cost-effective way to comply with the requirements of the Clean Water Act.

The engineers prepare an engineering report that outlines two alternatives for the town.

1.Build a new advanced treatment plant on the site of the existing plant at a cost of $600,000. It will take $80,000/year to operate this plant including electricity, labor, and chemicals.

2.Build a new secondary treatment lagoon system downstream from the existing treatmentfacility that will discharge into a larger stream. This alternative will cost $700,000 to build and $50,000/year to operate.

Both treatment facilities will be designed to have a useful life of 20 years. In order to evaluate alternatives on the basis of cost, it is necessary to calculate the "present worth (PW) cost of each alternative. The present worth takes into consideration <u>both</u> the capital cost and the operations and maintenance cost (O&M). The capital cost (CC) is the cost of construction, engineering, and administration and occurs only once at the beginning of the project. However, the cost of operating and maintaining occurs <u>every year</u> that the plant is in operation and must be taken into consideration. Use the following formula to calculate the present worth (PW) cost of each alternative.

$$PW = CC + (P/A,i,n) \times O\&M$$

The factor (P/A,i,n) is a <u>compound interest rate factor</u> that may be found in accounting, finance, and engineering economics textbooks. The following table was generated for use in this exercise.

Present Worth Factors (P/A,i,n), given annual cost, interest rate, and # of periods

(P/A,i,n) Factors

Mathematically this factor can be calculated from the following formula.

$$(P/A,i,n) = \frac{(l + I)^n - l}{I * (l + I)}$$

n (years)	Interest Rate 4.00%	Interest Rate 6.00%
5	4.451 822	4.212 364
10	8.110 896	7.360 087
15	11.118 387	9.712 249
20	13.590 326	11.469 921

In order to use this table, read across the columns to the interest rate and then down the rows to the term of the loan (in years). The (P/A,i,n) factor is the number where these intersect. To determine the present worth of an annual cost, such as a loan payment, multiply by this factor. If you know the amount being borrowed and want to know the annual payment amount, divide by the (P/A,i,n) factor.

II. Activity

A .Determine which course of action is most cost effective for the town. Calculate the Present Worth" cost of the two alternatives.

B. After determining the best alternative, calculate the cost of financing the work with municipal bonds at 6% interest.

C. How much will the most cost-effective alternative cost each family? Discuss this cost relative to other household costs such as telephone and cable TV. Is the cost for providing advanced sewage treatment reasonable?

D. Recalculate the estimated household costs if the town is able to obtain a $400,000 grant and financing for the remaining cost at 4%. Compare to the cost if no financial assistance is available from state/federal sources.

III. Follow-up

A. Present Worth Calculations:

1.For the Advanced Treatment alternative with CC= $600,000 and O&M= $80,000/yr:

PW = CC + (P/A,i,n) x O&M

From the interest rate tables for I=6% and n=20 years:
(P/A,i,n)= 11.469921

Present Worth (PW)= $600,000 + ($80,000) x (11.469 921)

Present Worth (PW)= $1,517,594

2. For the Secondary Treatment alternative with CC= $700,000 and O&M= $50,000/yr:

PW = CC + (P/A,i,n) x O&M

from the interest rate tables for I=6% and n=20 years:

(P/A,i,n)= 11.469921

Present Worth (PW) = $700,000 + ($50,000) x (11.469 921)

Present Worth (PW) = $1,273,496

Conclusion: The present worth cost difference between the two alternatives is $244,098. Although moving the treatment system will cost more initially, the cost savings in O&M cost will, over time, more than make up for the difference.

B.Financing cost for the Selected Alternative:

Assuming that the town will be able to obtain financing at 6% interest, we can calculate the cost of borrowing $700,000 (the project's capital cost; CC) for 20 years:

Annual Loan Payment = CC / (P/A,i,n)

Annual Loan Payment = $700,000 / 11.469 921

Annual Loan Payment = $61,029/year for 20 years

Total Annual Cost = $61,029 (debt service) + $50,000 (O&M)

Total Annual Cost = $111,029 / year

C. Expressed in terms of the monthly cost for each of the 500 families in the town:

Average Monthly Household Cost = $111,029 / (12)(500)

Average Monthly Household Cost = $18.50

D. If the town were able to obtain a $400,000 grant and 4% financing:

From the interest rate tables for I=4% and n=20 years: (P/A,i,n) = 13.590 326

Annual Loan Payment = CC / (P/A,i,n)

CC = $700,000 - $400,000 (grant)

Annual Loan Payment = $300,000 / 13.590 326

Annual Loan Payment = $22,075 / year for 20 years

Total Annual Cost = $22,075 (debt service) + $50,000 (O&M)

Total Annual Cost = $72,075 / year

Expressed in terms of the monthly cost for each of the 500 families in the town:

Average Monthly Household Cost = $72, 075 / (12)(500)

Average Monthly Household Cost = $12.01

If no financial assistance were available from the state/federal government, the cost of the most cost-effective wastewater treatment system would be $18.50 per month, which is $6.49 per month more.

RESOURCES

For more information regarding wastewater treatment, consult the following sources:

National Small Flows Clearinghouse, West Virginia State University, Morgantown, WV 26506-6064. 1-800-624-8301.

Knopman, Debra S. and Richard A. Smith, "20 Years of the Clean Water Act," Environment, January/February 1993.

THERE "OUGHTA" BE A LAW

9-12

OBJECTIVES

The student will do the following:

1.Learn or understand existing law as it applies to water rights.

2.Apply various doctrines to case studies.

3.Evaluate different legal claims and remedies that apply to water rights.

SUBJECTS:
Science (Physical Science, Ecology), Social Studies (Geography, Government, Political Science)

TIME:
1 or several class periods for preparation and presentation of simulations

MATERIALS:
optional props or visual displays of major rivers
literature on applicable water-rights disputes
information on rates of water use, per facility, for various purposes

BACKGROUND INFORMATION

U.S. citizens use more water than the citizens of any other country--about 150 gallons a day per person. In the U.S., irrigation consumes 33 percent of the available freshwater, power plants 49 percent, factories 10 percent, and households 8 percent a day. When water is plentiful and the usage is not polluting, there isn't a problem. But when water is scarce or the water quality is affected, questions of rights and priorities arise. We have no federal doctrine of water rights in our country.

Many of the basic rules of water use in the United States evolved as part of the *common law* of England during the period between the Norman Conquest and the American Revolution. Common law developed bit by bit as judges made decisions that were logical extensions from previous decisions. The common law was mainly concerned with private rights because a large proportion of the cases coming before judges in feudal England involved conflicts between private litigants over land rights. Generally, water came to be considered a part of the land. With ownership of the land went certain rights, riparian rights. Riparian rights address issues dealing with streams flowing across the land's known and defined channels. Under common law, the riparian land owner had absolute right to use a stream for domestic purposes or livestock defined as ordinary or primary use. For extraordinary or secondary use like irrigation or power, so long as these were incidental to the use of the land, the land owner also had rights; but they were more limited. Owners had no right to export the water or to use it for purposes unconnected with the land. The riparian owner, under common law, had the right to the water of the stream in its natural state. An owner could bring action against those responsible for changing its quality even though he sustained no actual damages.

Most of the 26 states east of the Mississippi River follow Riparian Water Policy that has the shortcoming of not recognizing the interrelationship of surface water and groundwater. Under this policy, state legislatures must define virtually all the parameters of water use management.

Although riparian rights are not recognized in some western states, they remain an important part of the law relating to water in most parts of the United States. They are often modified in various ways to better meet local or regional needs. Riparian doctrine cannot be successfully applied, however, in arid western states where large quantities of water are needed for mining and irrigation. From the few streams having adequate flow, it is sometimes necessary to transfer water great distances for use at other locations.

The Prior Appropriations Water Rights Doctrine is embraced by the western states due to the perennial shortage of water in these states. Simply stated, this doctrine says that one who "is first in time is first in right," or whoever was there first receives water that he/she wants or needs before the next user receives any allocation. Under appropriative doctrine, the traditional concepts of priority have generally been applied when applications have competed for appropriation from a limited supply: domestic and municipal uses have been given first priority and irrigation second. Appropriative rights have typically not been given for the use of water for waste disposal. The administration of appropriative rights is pursuant to state laws. Administration of these principles, therefore, is under state law rather than federal law. Modern courts have ruled, however, that under neither principle can a state totally prohibit export or diversion of water to another state without a conflict with interstate commerce provisions. Today in water-scarce areas, low flow equipment and water-saving toilets may be required in new construction, and high rates may discourage water waste. Various types of water conservation may reduce some of the problems involving water disputes.

Terms

common law: the law of a country or state based on custom, usage, and the decisions and opinions of law courts

NIMBY: NOT IN MY BACK YARD

nonpoint source pollution (NPS): pollution that cannot be traced to a single point (e.g., outlet or pipe) because it comes from many individual sources or a widespread area (typically, urban, rural, and agricultural runoff)

point source pollution: pollution that can be traced to a single point source such as a pipe or culvert (e.g., industrial, wastewater treatment plant, and certain storm water discharges)

Prior Appropriations Water Rights: doctrine of western states that says that "one who is first in time is first in right," or whoever occupies a location first receives the water that he/she wants or needs

riparian rights: water rights enjoyed by owners of land adjacent to a body of water

ADVANCE PREPARATION

A. Depending on your geographical location, research current water right conflicts. (Suggestions: 1. Colorado River usage in the SW for irrigation and water shortages in California and Arizona, 2. the Chattahoochee River diversion in Georgia/
Alabama/Florida, or 3. pollution cases like the Perdido River in Alabama/Florida.) Discuss the situation with your students.

B. Prepare or have students research information concerning recent court decisions about water rights and the roles of federal and state governments in managing water rights questions.

C. Have vocabulary words on board at the beginning of the class period. Guide students to discover their meanings as they read Background Information and discuss dilemmas.

PROCEDURE

I. Setting the stage

Discuss current law or policy regarding water rights in the U.S. Divide the class into groups and have several water dilemma scenarios, one for each group. Give each member of the group a different perspective or role. Let groups meet to discuss their problems in terms of law, need, morality, expense, and technical feasibility. Stress to students that solutions are workable compromises. Discuss that the goal is not identifying the bad guy or the right/wrong "side." Real life is often found in shades of gray!

II. Activity

Each group will make an oral presentation to the class. The group may choose to have a presenter or to allow each student to present his/her own viewpoint in the form of an organized debate.

<u>Dilemmas:</u>

1.<u>Strict water rationing must occur in the community because of the drought year</u>. Consider those with water usage roles: municipal "water police," "water court" judge, swimming pool owner, plant nursery owner, farmer with Best Management Practices (BMPs), a farmer who uses no till farming and drip irrigation, mayor, hotel owner, hydroponics farmer, school principal, hospital employee, landscape architect, and steam plant manager.

2.The border of your state is a river, and the neighboring state has decided to construct a nuclear power plant on the river. Roles: power company officials, state officials, environmentalists, NIMBY anti-nuclear activists, local fish hatchery owner, and/or recreational area employees.

3.You're in a state near the mouth of a river that runs through several states. Not only has the volume of water been reduced but point and nonpoint source pollution have severely impacted upon water quality. Roles: politicians of affected states, environmental activists.

4.Your family has owned a large parcel of land since before World War II. The land is no longer used for timber; but you've managed to keep the land holdings by making it an environmental camp available for schools, scouts, church groups. Beavers have dammed up a creek providing a terrific scenic and educational highlight for the camp. Property owners below you are complaining that their boats are high and dry, the mud stinks, and the fishing is not good. Roles: family members, camp owners, camp attendees, and property owners below camp.

5.You're a biology teacher whose Environmental Club has been monitoring a stream. You are finding lower dissolved oxygen values and some fish kills. Upstream is a rendering plant that employs about 10 of your students' fathers and mothers. Roles: teachers, students, parents, plant officials and/or state environmental officials.

6.You're part of an aquaculture co-op that is involved in growing oysters on racks. Last week two customers became ill, and E. coli and vibrios were detected in the water. The Health Department wants to shut you down. Roles: health department workers, customers, co-op workers.

III. Follow-up

A .Offer extra credit or some incentive to keep this issue simmering. Follow a continuing real-life conflict, looking for current events relating to this subject.

B. Each student's written assignment is to design a win/win compromise and an agreement that will avoid similar future conflicts.

IV. Extensions

A. Create a game with "choices" for several communities along a waterway. Offer "incentives" of money, market profit, cleaner environment, cheaper energy and "penalties" of fines, legal hassles, shutdowns, and bad publici

B. Write a bill for your state legislature defining water rights for your state.

C. Invite different sides of a legal dispute on water to sit on a panel for the class with student moderation, interviewers, timers.

RESOURCES

Parfit, Michael, "Water," National Geographic: Special Edition, November, 1993.

UNCLE SAM SAYS, "KEEP IT CLEAN!"

9-12

OBJECTIVES

The student will do the following:

1.Describe the Clean Water Act.

2.Explain the legalities of the Clean Water Act.

3 Infer the local benefits and responsibilities of the Act.

SUBJECTS:
Social Studies (Economics, Government, Political Science), Language Arts

TIME:
2 class periods, longer if necessary

MATERIALS:
student sheets

BACKGROUND INFORMATION

The Federal Water Pollution Control Act (Clean Water Act), passed in 1972 with major amendments in 1977, 1981, and 1987, provides the basis for water quality standards today.

In 1992, President George Bush, the U.S. Congress, and 35 governors proclaimed 1992 as the "Year of Clean Water" and October as "Clean Water Month." The Clean Water Act was originally created in response to public demands that the government do something to clean up and protect the nation's waterways.

Today there are more than 18 federal laws and regulations governing water quality. In 1994, approximately 63 percent of the nation’s surveyed waters fully supported their water quality designated uses. This number has steadily increased over the years due to the efforts of state and federal regulators, local governments, industries, citizens, and environmental organizations.

Terms

biodegradable: capable of being decomposed (broken down) by natural biological processes

nonpoint source pollution (NPS): pollution that cannot be traced to a single point (e.g., outlet or pipe) because it comes from many individual sources or a widespread area (typically, urban, rural, and agricultural runoff) point source pollution: pollution that can be traced to a single point source such as a pipe or culvert (e.g., industrial, wastewater treatment plant, and certain storm water discharges)

toxic chemical: a chemical with the potential of causing death or damage to humans, animals, plants, or protists; poison

water quality criteria: levels of water quality needed to support a designated use for a body of water, usually expressed as concentration values for specific chemicals

ADVANCE PREPARATION

Have vocabulary words on board at the beginning of class period. Have students enter vocabulary words and definitions in class journals; allow time for brainstorming.

PROCEDURE

I. Setting the stage

A .After using vocabulary words as introduction, allow time for independent reading of "America's Clean Water Act."

B. Discuss the article according to the 5 W's of a newspaper article: Who, What, When, Where, and Why.

C. Discuss political comic on handout page. Discuss the pun and its effect on readers. Discuss trivia statements on handout page.

D. Ask for student opinion to the idea of federal laws controlling water pollution.

II. Activity

As a homework assignment, ask students to select one of the following activities:

A. Write a letter to the editor of your local newspaper in which you cite an obvious infraction of some requirement of the "Clean Water Act" as you understand the Act.

B. Draw a political cartoon in which you stress one of the principles of the "Clean Water Act."

C. Create on paper a conversation between two people who have owned lakefront property for several years. In the dialogue, both are concerned about federal regulations of lake water.

D. Work with one other student to create a skit involving a federal compliance officer and a person who has violated one requirement of the "Clean Water Act." Have the officer explain the violation; have the other person accept responsibility for the violation and agreee to "clean up his/her act."

E. As each presentation is made to the class, a copy of the "America's Clean Water Foundation Personal Proclamation" may be presented to students (year may be changed from 1992 to the present).

III.Follow-up

Have each student write up one good question concerning the "Clean Water Act." Compile the best questions into a quiz for students.

IV. Extensions

A. Have students present activities to entire class on assigned day. Assignments may be further developed according to student interests and response

B. Have students solve Cryptoquote and Word Find. (See Student Sheets.)

C. Have students do research on water quality criteria and learn why they are set at certain levels for different parameters.

RESOURCES

1992: THE YEAR OF THE CLEAN WATER CALENDAR; America's Clean Water Foundation; 750 First Street NE, Suite 911, Washington, D.C. 20002.

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Student Sheet

Extensions:

Cryptoquote: Here's how it works: One letter stands for another letter. Single letters, punctuation, and the length and formation of the words are all hints. E is the most frequently used letter, and THE is the most frequently used word. Have fun!

M H M L O T V M L M T P Q M L N B P Q V N G R X A

C M P S Q O ; E M M J N Q Z Y M P G, J Y M P B M !

O X S L S G Z Y M B P U

Solution: Everywhere water is a thing of beauty; keep it clean, please! - Your Uncle Sam

WORD FIND

CLEAN WATER ACT

CLEAN WATER
POLLUTION
QUALITY
STANDARD
PRES BUSH
CONGRESS
WATERWAYS
TOXIC
POINT
NONPOINT
POISON
CULVERT
CRITERIA
INTERSTATE
ENVIRONMENT
ILLEGAL
ECOSYSTEM
SEWAGE
RUNOFF

P	S	E	W	A	G	E	H	U	N
E	O	H	U	N	T	S	V	T	R
N	I	L	L	E	G	A	L	N	U
V	*N*	I	L	Q	L	L	E	I	N
I	T	A	L	U	S	A	C	O	O
R	E	B	A	A	T	M	I	P	F
O	R	A	G	L	A	I	X	N	F
N	S	P	O	I	N	T	O	O	E
M	T	O	O	T	D	R	T	N	G
E	*A*	I	S	Y	A	E	C	T	P
N	T	S	Y	S	R	H	R	R	R
T	E	O	A	E	D	P	I	E	E
S	H	N	W	E	R	D	T	V	S
S	M	A	R	R	I	A	E	L	B
E	L	Y	E	N	W	E	R	U	U
R	J	A	T	N	E	G	I	C	S
G	N	E	A	S	P	A	A	U	H
N	S	E	W	A	A	W	N	M	A
O	L	R	W	A	T	E	R	G	A
C	M	E	T	S	Y	S	O	C	E

WORD FIND   CLEAN WATER ACT

CLEAN WATER
POLLUTION
QUALITY
STANDARD
PRES BUSH
CONGRESS
WATERWAYS
TOXIC
POINT
NONPOINT
POISON
CULVERT
CRITERIA
INTERSTATE
ENVIRONMENT
ILLEGAL
ECOSYSTEM
SEWAGE
RUNOFF

P	S	E	W	A	G	E	H	U	N
E	O	H	U	N	T	S	V	T	R
N	I	L	L	E	G	A	L	N	U
V	N	I	L	Q	L	L	E	I	N
I	T	A	L	U	S	A	C	O	O
R	E	B	A	A	T	M	I	P	F
O	R	A	G	L	A	I	X	N	F
N	S	P	O	I	N	T	O	O	E
M	T	O	O	T	D	R	T	N	G
E	A	I	S	Y	A	E	C	T	P
N	T	S	Y	S	R	H	R	R	R
T	E	O	A	E	D	P	I	E	E
S	H	N	W	E	R	D	T	V	S
S	M	A	R	R	I	A	E	L	B
E	L	Y	E	N	W	E	R	U	U
R	J	A	T	N	E	G	I	C	S
G	N	E	A	S	P	A	A	U	H
N	S	E	W	A	A	W	N	M	A
O	L	R	W	A	T	E	R	G	A
C	M	E	T	S	Y	S	O	C	E

WATER QUALITY LEGISLATION

Laws involving water quality date back as far as 1914. The first Federal law dealing exclusively with water quality was the Water Pollution Control Act, passed in 1948. Under this law, the states retained primary responsibility for water quality standards and maintenance. The Federal government supplied money primarily for research. There were no water quality standards established, and the law provided only weak punishments for offenders. During the 1960s, amendments provided for water quality standards for interstate waterways, Federally approved state standards, and increased funding for research. However, as water pollution increased in many areas of the country, public concern resulted in passage of two more very important environmental laws.

The National Environmental Policy Act of 1969 (NEPA) required federal agencies to consider the environmental impacts of their actions. All federal agencies must prepare environmental impact statements to assess the impacts of major federal actions, such as large building or industrial projects. Because of NEPA, federal undertakings have been conducted in a manner to ensure protection of all natural resources, including water.

The Federal Water Pollution Control Act (Clean Water Act) which was passed in 1972 and amended in 1977, 1981, and 1987, provides the basis for water quality standards today. The Clean Water Act allowed the Federal government to assume a lead role in cleaning up the nation's waterways. National goals for pollution elimination were set, and the National Pollutant Discharge Elimination System (NPDES) was established. The NPDES permitting system made pollution discharge without a permit illegal. Generators of pollution to surface waters (sources) must apply for NPDES permits, which are issued by EPA or EPA - approved state agencies. The limits on what the generators may release vary from small amounts (for suspended biodegradable organic material and solids) to none allowed (for some toxics). The stringency of the requirement is greatest for the most dangerous water pollutants. The public is invited to participate in the permit issuance process through public notice of proposed permits, and opportunity to comment or request a public hearing.

The Clean Water Act also established four national policies for water quality:

1. Prohibit the discharge of toxic pollutants in toxic amounts

2. Assist publicly owned treatment works with Federal grants and loans

3. Support area-wide waste treatment planning at Federal expense

4. Create a major research and development program for treatment technology.

In 1994, 63 percent of surveyed surface waters met water quality standards. In 1973, only 36 percent of streams were of high enough quality to meet standards. Future amendments to the Clean Water Act are likely to make ecosystem protection as important as providing potable water for human use. Amendments are also likely to establish water quality standards for lakes and to focus more specifically on preventing storm water nonpoint source pollution.

Other federal laws that deal with water quality are the Safe Drinking Water Act and Amendments of 1986 and 1996, the Toxic Substances Control Act of 1976, the Resource Conservation and Recovery Act of 1976, the Surface Mining Control and Reclamation Act of 1977, and the Rivers and Harbors Act of 1899.

America's Clean Water Act

In response to citizens' demands that the government do something to clean up and protect our water resources, Congress passed the Federal Water Pollution Control Act amendments of 1972, known as the Clean Water Act. Its message was simple - there shall be no unlawful discharge of pollution to U. S. waters. The goals of the law called for water to be clean enough for swimming, fishing, and other recreational uses.

In the first decade after the Clean Water Act was passed, when the nation's population grew by 11 percent and water use by industry and recreation increased, significant progress was made. It is estimated that:

, 47,000 stream miles improved in quality. That's a distance of about twice around the world.

, 390,000 acres of lakes (an area twice the size of New York City) improved in quality.

, 142 million people received secondary or more advanced levels of sewage treatment - a 67 percent increase.

Congress revised and expanded the Clean Water Act in 1977, 1981, and 1987. Today the Clean Water Act addresses:

C Point-source pollution (direct pollution from pipes or other conveyances)

C nonpoint-source pollution (diffuse pollution from sources such as urban, rural, and agricultural runoff)

C Marine ecology, including oceans, estuaries, and wetlands

C Toxic pollutant controls

C Groundwater protection.

America's water quality continues to improve. Federal, state, and local laws have been strengthened; and public and private institutions have invested many billions of dollars to restore the physical, chemical, and biological quality of water.

While advances in technology have helped clean up our waters, societal demands continually increase pollution. To ensure clean water for ourselves and for future generations, we must strengthen our clean water programs and provide the necessary funds to protect our precious water resources.

Water:

The Source of Life

America's Clean Water Foundation

©1992

President George Bush, the United States Congress, and 35 Governors have proclaimed 1992 as the Year of Clean Water and October as Clean Water Month to commemorate the Twentieth Anniversary of the passage of the Clean Water Act.

In 1972 Congress passed the Federal Water Pollution Amendments (Public Law 92-500) (The Clean Water Act). The Clean Water Act as designed to respond to public demands that the government do something to clean up and protect our nation's waterways. The Act stated that there shall be no unlawful discharge of pollution to U. S. waters. The goals called for waters to be "fishable" and swimmable" by 1983 and the elimination of pollution discharges to navigable waters by 1985.

With the passage of time, the public attention to these goals has waned, even though Americans consistently cite clean water as among their highest priorities. In an effort to rekindle support for the mission of the Clean Water Act, America's Clean Water foundation was created to coordinate the Twentieth Anniversary of the Clean Water Act. The goals of this nonprofit foundation are to:

1. Increase public awareness.
2. Educate our nation's youth.
3. Promote personal stewardship.
4. Generate national support for protecting our precious water resources.

To accomplish these goals, the Foundation has enlisted the support and involvement of a host of public and political figures, known throughout the world as active supporters of environmental protection. For example, Senator Edmund Muskie, Senator Howard Baker, and Representative William Harsha (the original authors of the Clean Water Act) jointly chair the Foundation's Board of Governors. The Board is comprised of such leaders as President Jimmy Carter, 16 members of Congress, 5 state governors, and a host of prominent environmental leaders. Some 70 national organizations serve on America's Clean Water Foundation Steering Committee and a Celebrity Advisory Council assists the Foundation with public outreach.

> For ideas on how you can get involved and help us make a difference, call or write:
> America's Clean Water Foundation
> Roberta Haley Savage, President

This booklet was adapted from the 1992 The Year of Clean Water Calendar. A special thanks to Kathryn Sevebeck, George Wills, and T. W. Johnson of the Virginia Water Research Center, and to Charles Evans of America's Clean Water Foundation for their dedication to citizen awareness of clean water.

Backyard mechanics that change their own oil generate over 324 million gallons of used oil and dispose of more than 90 percent of it improperly.

CCCCCCCCCCCCCCCCCCCCCCCCC

Nearly 1.3 billion gallons of used oil are produced each year, but only about 770 million gallons are reprocessed by recyclers.

CCCCCCCCCCCCCCCCCCCCCCCCC

Since 1950 fertilizer use has increased from 20 million tons annually to 50 million tons. Nearly 1.1 billion pounds of pesticides are applied each year in the United States.

CCCCCCCCCCCCCCCCCCCCCCCCC

The average household generates 20 pounds of hazardous waste each year from household cleaners and chemicals.

CCCCCCCCCCCCCCCCCCCCCCCCC

An estimated 60 percent of the 23 million septic systems in the United States are not operating properly.

CCCCCCCCCCCCCCCCCCCCCCCCC

About 10 percent of the 1.4 million underground storage tanks for gasoline and other hazardous substances are leaking.

CCCCCCCCCCCCCCCCCCCCCCCCC

KEEPING IT CLEAN

President George Bush and the Congress have proclaimed October as Clean Water Month. During the month there will be many opportunities to participate in activities that will broaden your understanding of today's critical water quality issues.

< Organize a stream cleanup program and monitor the stream on a regular basis for evidence of pollution incidents. Report the results to your state water control agency.

< Participate in comprehensive plan development and zoning for your city or county and take a position on how your community can best protest its water.

< Encourage civic associations and other community groups to get involved in programs and efforts to maintain clean water.

< Tell your elected representatives about your concern for the quality of life and the need for protection of our natural environment for drinking water, wildlife habitat, and human activities.

< Become a steward of our natural resources.

AMERICA'S CLEAN WATER FOUNDATION
PERSONAL PROCLAMATION

WHEREAS: clean water is a natural resource of tremendous value and importance to every American citizen;

WHEREAS: there is resounding public support for protecting and enhancing the quality of this Nation's rivers, lakes, wetlands, coastal waters and groundwater;

WHEREAS: maintaining and improving water quality is essential to protect public health, to protect fisheries and wildlife, and to assure abundant opportunities for public recreation;

WHEREAS: substantial progress has been made to improve water quality since the passage of the Clean Water Act in 1972 due to the concerted efforts by Federal, State and Local governments, the private sector and the American public;

WHEREAS: further development of water pollution control programs, advancement of water pollution control research, technology and education are necessary and desirable;

WHEREAS: 1992 is the 20th anniversary of the enactment into law of the Clean Water Act;

NOW THEREFORE, be it resolved that I, the undersigned, do hereby proclaim, in support of America's Clean water Foundation to make the calendar year 1992 my personal YEAR OF CLEAN WATER, and be it further resolved that I will do all I can to assure the integrity of our vital water resources for my generation and for the generations to follow.

____
Signatory of Proclamation

____
Roberta Haley Savage

ONE HUNDRED FIRST CONGRESS OF THE UNITED STATES OF AMERICA

AT THE SECOND SESSION

Begun and held at the City of Washington on Tuesday, the twenty-third day of January
one thousand nine hundred and ninety

JOINT RESOLUTION

To establish calendar year 1992 as the AYear of Clean Water@.

Where as, clean water is a natural resource of tremendous value and importance to the Nation;
Where as, thee is resounding public support for protection and enhancing the quality of the Nation'a rivers, streams, wetlands, and marine waters;
Where as, maintaining and improving water quality is essential to protect public health, to protect fisheries and wildlife, and to assure abundant opportunities for public recreation;
Where as, it is a national responsibility to provide clean water as a legacy for future generations;
Where as, substantial progress has been made in protecting and enhancing water quality since passage of the 1972 Federal Water Pollution Control Act (Clean Water Act) due to concerted efforts by Federal, State, and local governments, the private sector, and the public;
Where as, serious water pollution problems persist throughout the Nation and significant challenges lie ahead in the effort to protect water resources from point and nonpoint sources of conventional and toxic pollution;
Where as, further development of water pollution control programs and advancement of water polltion control research, technology, and education are necessary and desirable; and
Where as, October of 1992 is the 20th annicersary of the enactment into law of the Clean Water Act:
Now, therefore, be it

Resolved by the Senate and House of Representatives of the United States of America in comgress assembled, That, the Congress of the United States hereby designates calendar year 1992 as the AYear of Clean Water@ and the month of October 1992 as AClean Water Month: in celebration of the Nation's accomplishments under the Clean Water Act, and the firm commitment of the Nation to the goals of that Act.

APPROVED
October 12, 1990

Speaker of the House of Representatives

President of the Senate

WATER CHEMISTRY CHECKUP

9-12

OBJECTIVES

The student will do the following:

1 Conduct a number of water quality tests.

2.Determine the quality of a sample of water.

SUBJECTS:
Science (Chemistry, Physical)

TIME:
one 50-minute class period
field trip (optional)

MATERIALS:
a fresh sample of water for testing
water analysis kit
student sheet
thermometers

BACKGROUND INFORMATION

Water quality standards are often based on seven criteria - pH, temperature, dissolved oxygen, toxic pollutants, bacteria, radioactivity, and turbidity.

To profile a healthy stream, pH must be within an acceptable range (6.0-8.5). Temperature must not exceed 90° F (86° F in certain rivers) nor have rapid increases or decreases in temperature. Dissolved oxygen must not go below 5.0 mg/l except due to natural conditions. Toxic pollutants and radionuclides must not be present at harmful levels or levels which may cause bioaccumulation or biomagnification throughout the food chain. Bacteria must not be present at levels harmful to human health when stream water is ingested or absorbed. Turbidity (cloudiness) must not be at such levels that sunlight penetration is significantly diminished and sedimentation damages benthic habitat.

Terms

acidic: having a pH value of less than 7; acidic liquids are corrosive and sour (DO NOT TASTE!)

alkalinity: (1) a characteristic of substances with a pH greater than 7; (2) the capacity of water to neutralize acids, imparted primarily by the water's content of carbonates, bicarbonates, and hydroxides (expressed in mg/l of $CaCO_3$).

benthic: living on the bottom of a lake or sea; pertaining to the ocean bottom

bioaccumulate: to accumulate larger and larger amounts of a toxin within the tissues of organisms at each successive trophic level biological magnification (biomagnification): bioaccumulation occurring through severallevels of a food chain; process by which certain substances (such as pesticides or heavy metals) aredeposited into waterway, eaten by aquatic organisms which are in turn eaten by large birds, animals, or humans, and become concentrated in tissues or internal organs as they move up the food chain.

dissolved oxygen (DO): oxygen gas (O_2) dissolved in water

hardness: a measure of all the multivalent (primarily calcium and magnesium) ions expressed in mg/l of calcium carbonate ($CaCO_3$)

hydrogen sulfide: gas emitted during organic decomposition by anaerobic bacteria which smells like rotten eggs and can cause illness in heavy concentrations (chemical formula, H_2S)

ingestion: the process of taking into the body, as by swallowing

pH: a measure of the concentration of hydrogen ions (H^+) in a solution; the pH scale rangesfrom 0 to 14, where 7 is neutral, values less than 7 are acidic, and values greater than 7 are basic or alkaline. It is measured by an inverted logarithmic scale so that every unit decrease in pH means a 10-fold increase in hydrogen ion concentration. Thus, a pH of 3 is 10 times as acidic as a pH of 4 and 100 times as acidic as a pH of 5.

plankton: microscopic plants and animals in water which are influenced in mobility by the movement of water (i.e., as opposed to nekton (fish) which can swim)

radionuclides: types of atoms which spontaneously undergo radioactive decay; usually naturally occurring and can contaminate water or indoor air (e.g., radon)

toxic: harmful to living organisms

turbidity: the cloudy or muddy appearance of a naturally clear liquid caused by the suspension of particulate matter

ADVANCE PREPARATION

A. Obtain water testing kits from one of the companies listed on page F-69, Water Testing Fact Sheet.

B. Copy and distribute Student Sheets.

C. Have students collect water samples. Explain that bottles should be filled to the top and sealed.

PROCEDURE

I. Setting the stage

A. Have students carefully read and go over each of the water tests that they will be doing.

B. Answer any questions about these tests before beginning the experiment.

C. Explain to students that they will only be testing for the presence of a few of the many contaminants that may occur in water.

II. Activity

A. Students will use an assortment of test kits to determine the quality of water from a local stream. If a field trip is possible, take students to a local stream to collect water samples.

B. If a field trip is possible, take students to a local stream to collect water samples. If a field trip is not possible, samples can be brought to the classroom and tested for some parameters. The samples must be fresh and sealed tightly, or the DO will be incorrect. Temperature needs to be taken at time of collection, and no air bubbles should be present in the top of the jars. Jars should be capped while they are completely submerged.

Parameter		Limitations on Sample Storage
1. Temperature	ÿ	Must be recorded in the field at the time of sample collection.
2. Dissolved Oxygen	ÿ	First two steps of reaction must be done in field to yield iodide solution that will be titrated. Treated solution must be kept cool in sealed sample container. This can be kept up to six hours before titration.

3. pH ÿ Fill containers to top and keep sample cool. Measure within two hours.

4. Alkalinity ÿ Should be done in field to get valid data.

5. CO_2 ÿ Must be done in field to get valid data.

C. Students will work in teams to complete tests on alkalinity, hardness, DO, ammonia, phosphate, turbidity, silica, pH, carbon dioxide (CO_2), nitrate, and hydrogen sulfide (H2 S).

III. Follow-up

A. Teams should compare results to those found in standards.

B. Alkalinity, hardness, and carbon dioxide are not regulated parameters but are important to water quality.

IV. Extensions

A. Ask students to try to identify the source of their sample, if unknown, by looking at data (groundwater or surface water: lake, river, pond). Discuss how this might be done. (e.g., groundwater would have comparatively low turbidity).

B. Discuss what students think could be done to improve water quality in the body of water from which this sample was taken.

RESOURCES

Water Analysis Kit, page F-69, Water Testing Fact Sheet

Team Member Names ____________________
____
____
____

WATER TEST KITS
DATA SHEET

We have all heard reports about water being contaminated by many different types of substances. You are aware that water can be crystal clear and still have substances dissolved in it. How does anyone determine if water contains dissolved materials and whether they are harmless or dangerous? In this activity, you will have the opportunity to conduct a number of tests to determine if a sample of water contains certain substances.

Materials:

sample of water to be tested assortment of test kits

Gathering Data:

1. When you have been assigned a series of tests to perform, read the instructions completely before actually going through the procedures.

2. When you have completed a test, record the value in Table 1.

3. When all groups have finished, combine all the data on the master data sheet.

Organizing Data: Table 1: Water Chemistry Data

Source:
Your Name:
Date:
Water Temperature:

Parameter	Results (mg/l)	Typical Discharge Limitations
* Alkalinity		
* Hardness		
Dissolved Oxygen		not below 5.0 mg/l
Ammonia		
Phosphate		
Turbidity		
pH		6.0 - 8.5
* Carbon dioxide		
Nitrate		

~~pH~~		~~6.0 - 8.5~~
Sulfide		

* not regulated parameters but important to note

Student Sheet

Testing will be done on five basic water quality parameters.

1. Temperature
2. Turbidity
3. pH
4. Dissolved oxygen
5. Total alkalinity

Most tests are colorimetric; that is, they are based on adding chemical reagent to the water sample until a color change is produced. The amount of reagent used to produce the color change is then directly related to a quantitative measure of the parameter being tested.

Temperature

Temperature affects the physical and chemical properties of water and greatly influences aquatic organisms by affecting feeding, reproduction, and metabolic rate. Most species have optimal temperatures for normal growth with corresponding upper and lower lethal limits. Temperature determines the density of water, the amount of oxygen it can hold, and how quickly nutrients will be recycled through the process of decomposition.

Turbidity

Turbidity, exhibited as cloudiness in water, is caused by suspended matter that scatters light passing through the water. The suspended particles range in size from colloidal (small) to coarse (large) dispersion.

There are many sources of turbidity. Although sediment from disturbed or eroded soil is often thought of as the source of cloudy water, turbidity can also be caused by dissolved organic matter from an abundance of microscopic plankton. Apparent water color, microscopic examination, and streamwalk observations can help determine the sources of turbidity.

Measuring Turbidity

Turbidity can be measured by using the clear plastic tubes in a water analysis kit. This method involves a clear plastic tube with a turbidity "target" at the bottom. The sample turbidity causes a "fuzziness" of the target that can be matched in a second tube containing clear water by adding a standard turbidity reagent [calibrated in Nephelometric Turbidity Units (NTUs)] dropwise until the fuzziness of both targets are equal.

Assuring Accuracy

Turbidity is best measured in the field. The turbidity of a bottled sample will change due to biological activity, settling, clumping, and absorption of particles onto surfaces of the sample container. If time elapses between sampling and measurement, be sure to shake the sample well to suspend particles before measuring turbidity.

pH

Water is an effective ionizing solvent. Water ionizes into hydrogen (H^+) and hydroxyl (OH^-) ions as demonstrated by the equation below:

$$H_2O <=> H^+ + OH^-$$

Even perfectly pure water contains some hydrogen and hydroxyl ions. The equilibrium condition for the two ions depends upon temperature.

The pH, a term coined in 1909 meaning the power of hydrogen, is a quantitative indicator of concentration of hydrogen ions. The pH is defined as the negative logarithm of the hydrogen ion activity [$pH = -\log (H^+)$].

If the hydrogen ion concentration is greater than that of the hydroxyl ions, the solution is said to be acidic. When the reverse situation exists and there are more hydroxyl ions, the solution is said to basic. When the concentrations of the two ions are equal, the solution is neutral.

Values for pH are usually between 0 and 14.0 with the neutral point at (25°C) at 7.0. Solutions with pH values less than 7.0 are considered acidic; those between 7.0 and 14.0 are designated as basic. Most natural waters have pH values between 5.0 and 10.0 with the greatest frequency of values found between 6.5 and 9.0. Since the pH scale is logarithmic, every one-unit change represents a tenfold change in acidity (a pH value of 6.0 indicates 10 times more acidity than a value of 7.0; a value of 5.0 represents 100 times more acidity than the neutral condition). pH is affected by carbon dioxide concentrations (CO_2) because CO_2 in water forms a weak organic acid (carbonic acid). Both plants and animals continuously release carbon dioxide through the process of respiration. During daylight, aquatic plants use carbon dioxide during photosynthesis. Since CO_2 is acidic, and if plants remove more than is being produced through respiration, the pH will increase during periods of high photosynthetic activity, decreasing at night when photosynthesis stops. Daily fluctuations in pH are less when water is buffered (has higher alkalinity).

Measuring pH

The pH is measured using liquid indicator kits or electronic pH meters.

Significant Levels

The following figure and table represent pH values for common substances and natural water supplies, and the effect on the aquatic community of varying pH values, respectively.

What measured levels may indicate

Routine monitoring of a waterbody should provide baseline information about normal pH values. Unanticipated decreases in pH could be indications of acid rain, runoff from acidic soils, or contamination by agricultural or livestock chemicals or by-products. pH values outside the expected range of 5.0 to 10.0 could be considered as an indication of industrial pollution.

Assuring accuracy

When using test kits, accuracy is a function of the sensitivity of the kit. Many groups use kits with a test range of pH 3.0 to 10.0 with a sensitivity of 1.0 units. This can be complemented with a test range of 6.8 to 8.2 with a sensitivity of 0.2 pH units.

When using pH meters, these should be calibrated frequently. Temperature affects the function of the electrode, and the meter must calibrate for temperature to provide correct pH values.

pH should be measured in the field since the pH of bottled samples will rapidly change due to biological and chemical activity in the sample container.

Effects of pH on aquatic life

AT pH	EFFECT ON AQUATIC LIFE
3.0 - 3.5	Unlikely fish can survive for more than a few hours in this range although some plants and invertebrates can be found at pH levels this low.
3.4 - 4.0	Known to be lethal to salmonids.
4.0 -4.5	All fish, most frogs, and insects absent.
5.0 -5.5	Bottom-dwelling bacteria (decomposers) begin to die. Leaf litter and detritus begin to accumulate, locking up essential nutrients and interrupting chemical cycling. Plankton begin to disappear. Snails and clams absent. Mats of fungi begin to replace bacteria in the substrate.
5.5 - 6.0	Metals (aluminum, lead) normally trapped in sediments are released into the acidified water in forms toxic to aquatic life.
6.0 -6.5	Freshwater shrimp absent. Unlikely to be directly harmful to fish unless free carbon dioxide is high (in excess of 100 ppm).
6.5 - 8.2	Optimal for most organisms.
8.2 - 9.0	Unlikely to be directly harmful to fish, but indirect effects occur at this level due to chemical changes in the water.
9.0 - 10.5	Likely to be harmful to salmonids and perch if present for long periods.

10.5 - 11.0	Rapidly lethal to salmonids. Prolonged exposure may be lethal to carp and perch.
11.0 - 11.5	Rapidly lethal to all species of fish.

In addition to direct effects on aquatic systems, pH affects many chemical processes. The toxicity of ammonia increases as the pH increases. Low pH can reduce the amount of dissolved inorganic phosphorus and carbon dioxide available to plankton. Low pH can also increase the risk of hydrogen sulfide toxicity.

9-12

HOW HARD IS HARD WATER?

SUBJECTS:
Science (Chemistry, Physical, Biology, Ecology), Math

TIME:
1-2 class periods

MATERIALS:
bottled drinking water
distilled water
milk
soft drink
Epsom salts
fabric softener
deionized salt
lotion
water analysis kit

OBJECTIVES

The student will do the following:

1.Perform chemical analyses for hardness on water samples.

2.Collect data and prepare Data Sheets.

3.Analyze data using various graphing techniques.

4.Determine the importance of water hardness in natural habitats and for human use.

BACKGROUND INFORMATION

Hard water is the result of the presence of primarily two elements in their ionic form in water. The two elements mainly responsible for hardness are calcium (Ca^{+2}) and magnesium (Mg^{+2}). Iron, aluminum, manganese, and other minerals may also cause hardness, but large amounts of these minerals are not usually found in natural waters. Water hardness is often correlated with the "lathering" capacity of soap in certain water sources by the general public--the harder the water, the less the lather!

The geological makeup of an area usually determines the natural source of hardness. Limestone rock that has been dissolved by slightly acidic water (carbonic acid) is the usual source. Granite isn't easily dissolved by carbonic acid; therefore, areas rich in limestone usually have very hard water whereas those that are mostly granite do not.

Acidic water is formed when water absorbs carbon dioxide. Carbon dioxide (CO_2) makes up 0.03% of air and is a waste product of plant and animal respiration. The decomposition process, in soil and water, also contributes CO_2 to the atmosphere.

When carbon dioxide combines with water, it forms a weak solution of carbonic acid, which is found in carbonated beverages. Carbonic acid reacts with limestone to produce calcium carbonate ($CaCO_3$)--a white compound that leaves a scaly deposit, especially in teakettles.

There's an important relationship between the amount of carbonates in water and the amount of "bicarbonates" that are similar compounds. Bicarbonates function like Alka-Seltzer to buffer water against acids. If a waterway has a high carbonate content (total alkalinity), it also has a good buffering ability and is less likely to be hurt by acid rain and acid wastes. Some common hardness values are shown in the following chart.

TOTAL HARDNESS (mg/L $CaCO_3$)	DESCRIPTION
0 to 60	Soft water
61 to 120	Moderately hard water
121 to 180	Hard water
181 and up	Very hard water

In the baking industry, very soft water produces sticky bread dough and soggy bread. On the other hand, hard water used for cooking toughens many vegetables and slows fermentation----the process by which cheese, yogurt, and beer are made. Recommended hardness values for industrial use are summarized in the table below.

INDUSTRY	TOTAL HARDNESS (mg/L $CaCO_3$)
Brewing beer	200 to 300
Carbonated beverages	200 to 250
Washing clothes	0 to 50
Steel manufacturing	50

Heavy metals, such as mercury, copper, and lead, and nonmetals, such as ammonia, phenols, and certain acids, are much more toxic to fish in soft water than in hard water because soft water has fewer binding sites for the toxic substances. Research studies have appeared to indicate that drinking soft water over long periods of time may increase one's chances of having a heart attack. To avoid the potential problems, faucets providing drinking water can be disconnected from a water softener.

There are two different testing procedures for hardness. The total hardness test is performed frequently in the water industry. It measures the total amount of calcium and magnesium in water, and the results are expressed in metric units as milligrams per liter (mg/l) of calcium carbonate ($CaCO_3$). The second procedure determines calcium content only.

Both hardness tests, total and calcium only, use EDTA, ethylenediaminetetraacetic acid. It chelates, or wraps around, any ions in solutions that have multiple positive (multivalent) charges. Calcium and magnesium are the most common multivalent ions in natural waters that contribute to hardness.

Terms

acid rain: rain with a pH of less than 5.6; results from atmospheric moisture mixing with sulphur and nitrogen oxides emitted from burning fossil fuels or from volcanic activity; may cause damage to buildings, monuments, car finishes, crops, forests, wildlife habitats, and aquatic life.

bicarbonate: an acid salt of carbonic acid containing the radical HCO_3^-

calcium carbonate: one of the most stable, common, and widely dispersed materials on Earth; occurs naturally in oyster shells, calcite, limestone, marble, chalk, and other forms; used to express hardness and alkalinity (mg/l of $CaCO_3$)

carbon dioxide: colorless, odorless gas made of carbon and oxygen (CO_2); exhaled by animals and humans, utilized by plants in photosynthesis and contained in automobile exhaust

carbonic acid: substance formed by combining water (H_2O) and carbon dioxide (CO_2); chemical formula H_2CO_3 .

hard water: water high in mineral content; water containing an abundance of Ca^{+2} and Mg^{+2} ions

hardness: a measure of all the multivalent (primarily calcium and magnesium) ions expressed in mg/l of calcium carbonate ($CaCO_3$)

ion: an atom or molecule that has lost or gained one or more electrons multivalent (ion): ion that has lost or gained more than one electron (also called a “polyvalent” ion)

toxic: harmful to living organisms

ADVANCE PREPARATION

A. Copy Data Sheets.

B. Discuss Background Information and/or copy and hand out to students.

C. Divide students into small groups.

PROCEDURE

I. Setting the stage

Have the students engage in directed discussion, or have them make a list of places they have lived or visited where they have noticed differences in the water when used for certain activities --- drinking, brushing teeth, shampooing, washing clothes, bathing, etc.

II. Activity

A. Have students bring in samples of water from various sources.

1. bottled water from various geographic areas
2. tap water
3. well or spring water
4. river or creek water
5. lake or pond water

B. Other substances can also be used to test for hardness.

1. carbonated beverages

2. milk

3. solution of Epsom salts

4. liquid fabric softeners diluted with distilled water

5. lotions, creams diluted with distilled water

C. Using a water analysis kit, test each item for hardness. (Directions for using each test kit are included in the kit.)

D. Follow the directions for each testing procedure.

E. Record the data on the Data Sheet.

F. Graph the data from each sample using a bar graph.

G. Write an analysis comparing the test results of each.

III. Follow-up

Explain why groundwater is generally harder than surface water.

IV. Extensions

1. Have students research the geologic areas of the world on the bottled water samples to determine the rock formations. Report on how this correlates with the hardness results.

2. Analyze the hardness results of flowing waters (rivers, creeks) compared to that of standing waters (wells, ponds, swamps, rain barrels). Use bar graphing on poster board, perhaps computer generated, to present results.

3. Obtain hardness data from water quality testing in different states and/or countries and compare to your area. Use a computer to locate databases with this information if there is access to the Internet or a commercial communications network. Hardness data may be obtained from the state Geological Survey and from the U.S. Geological Survey. (See fact sheet pages J-1 to J-6 in the back of this book.)

4. Locate other schools or organizations that do water testing and compare the data collected to that of your area.

RESOURCES

Jacobson, Cliff, Water, Water Everywhere (Student Reading Unit About Water Quality), Hack Company, Loveland, CO, Catalog Number 21975-00. 1-800-227-HACH.

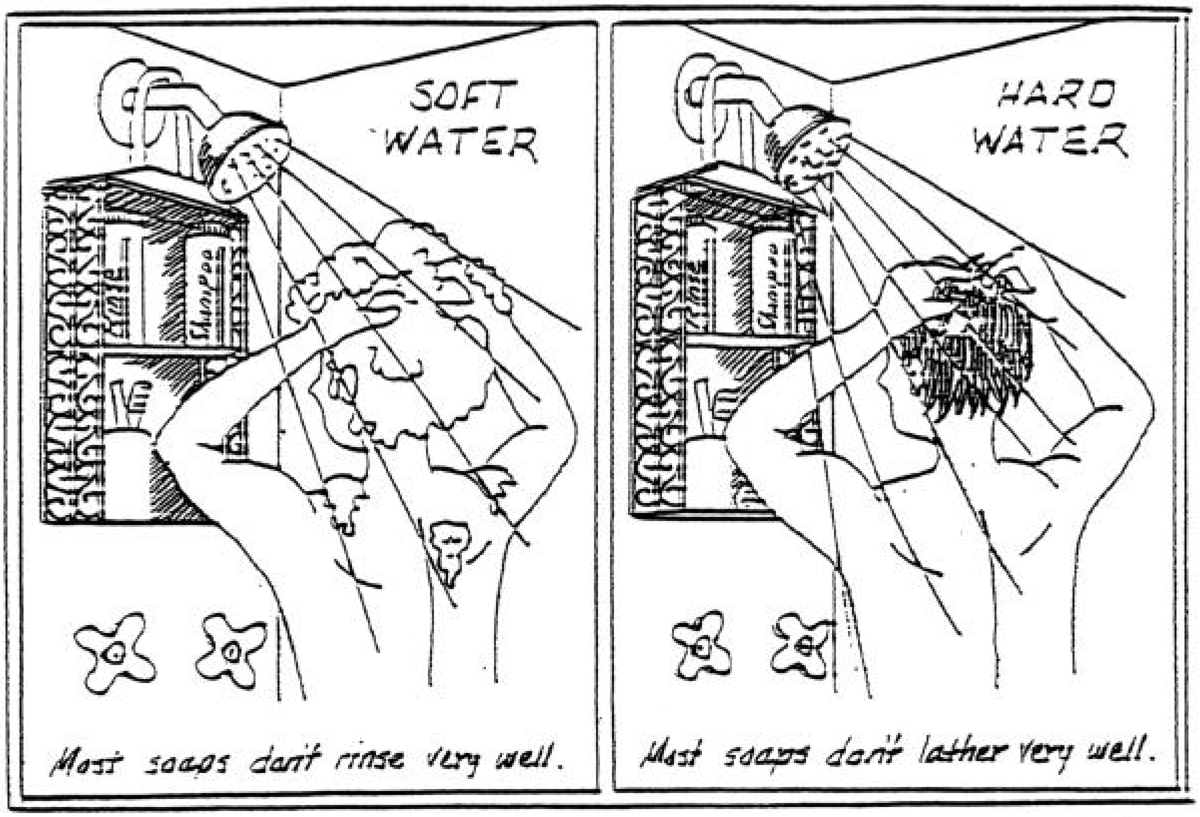
TVA Teacher - Student Water Quality Monitoring Network, March, 1992, Tennessee Valley Authority.

Water Analysis Kit, page F-69, Water Testing Fact Sheet

Water Hardness

Data Sheet

Substance Tested	Hardness ($CaCO_{3,}$ mg/L)
____________________	______________________
____________________	______________________
____________________	______________________
____________________	______________________
____________________	______________________
____________________	______________________


SOFT WATER
Most soaps don't rinse very well.
HARD WATER
Most soaps don't lather very well.

IS YOUR WATER WELL FOR DRINKING?

9-12

OBJECTIVES

The student will do the following:

1.List the types of tests that are done on drinking water.

2.Outline a wellhead protection program.

3.Learn and report on some aspect of water quality and/or water testing.

SUBJECTS:
Science (Chemistry, Ecology, Social Studies, Language Arts

TIME:
1 class period; longer if necessary

MATERIALS:
handouts: "Groundwater Protection and "Home Water Testing"
transparencies: "Possible Drinking Water Contaminants" and "Activities Which Contribute to Well Water Contamination"

BACKGROUND INFORMATION

Americans have traditionally had the safest drinking water supplies in the world. However, in a country as industrialized as ours, there is nothing natural or simple about the need to keep our water supplies safe. It takes a tremendous amount of work to ensure this. At all levels of government and industry, there are people who work full-time to protect our drinking water supplies by passing laws, setting regulatory standards, making improvements in treating water, and delivering it to our homes.

Terms

contaminant: an impurity that causes air, soil, or water to be harmful to human health or the environment; something that makes a substance impure, infected, corrupted, or polluted

drinking water standard: maximum contaminant level or treatment technique requirement

Environmental Protection Agency (EPA): the U.S. agency responsible for efforts to control air, land, and water pollution, radiation, and pesticide hazards, and to promote ecological research, pollution prevention, and proper solid waste disposal

groundwater: water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth’s surface; water within the zone of saturation

maximum contaminant level (MCL): maximum permissible level of a contaminant in water which is delivered to any user of a public water system; drinking water standard.

Safe Drinking Water Act: a law passed by the U.S. Congress in 1974 and amended in 1986 and 1996 to help ensure safe drinking water in the United States. The Act requires that regulations be enacted to set maximum contaminant levels (MCLs) or treatment technique requirements for a variety of chemicals, metals, and pathogens in public water supplies; also requires protection of surface source waters and underground sources of drinking water.

treatment technique: drinking water treatment requirement in lieu of a maximum contaminant level (MCL); typically used when establishing an MCL is too difficult or when compliance with an MCL would be too costly; drinking water standard.

wellhead: the physical structure or device at the land surface from or through which groundwater flows or is pumped

ADVANCE PREPARATION

A .Have vocabulary words on board to be used as a springboard for an introduction to the lesson theme.

B. Have students write terms and definitions in their class journals. These words will later be used in a unit vocabulary study.

C. Prepare copies of "Ground Water Protection: A Citizen's Action Checklist" and "Home Water Testing."

PROCEDURE

I. Setting the stage

A. After a brief discussion of the topic of the lesson, give students copies of handouts and guide students through independent study of handouts. Call special attention to the section titled Should You Have Your Water Tested?.

B. Show the Possible Drinking Water Contaminants transparency. Discuss the sources and effects with the class.

II. Activity

A. Show the Activities Which Contribute to Well Water Contamination transparency. Have the class list five ways to protect the wellhead area for each category shown. Students may reply based on municipal or individual well supplies.

B. Invite an employee of your municipal water works or local water supplier to talk to the class about ongoing water testing and water supply protection in the area. If an employee cannot come to the class, schedule a telephone or personal interview (perhaps, combined with a water treatment plant tour). Ask about the type of contaminants in the water, MCLs typically exceeded, and source water protection activities conducted.

C. Write a newspaper article stressing the importance of testing drinking water using information from the handouts.

D. Write an article for the school paper discussing the current fad of buying bottled drinking water. Survey students to find out why they purchase bottled water and the distrust their local water supply.

E. Create a collage/poster in which you illustrate rules and regulations related to safe drinking water.

F. Have students look up the Public Notification regulations for MCL exceedences and treatment technique requirements. Have them research to see if their water system has ever exceeded an MCL or other requirement which necessitates Public Notification. Have them find the Public Notices in the newspaper and report on their content.

FOR MORE INFORMATION, CALL SAFE DRINKING WATER HOTLINE 1-800-426-4791.

III. Follow-up

On a designated class day, have students present findings/projects to the entire class. Work the cryptoquote for fun or bonus points.

IV. Extensions

Do more intense research of local drinking water treatment plants; possibly take field trips individually or as a class. Have students write individual reports.

RESOURCES

Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Chiras, Daniel D., Environmental Science, High School Edition, Addison-Wesley, Menlo Park, CA, 1989.

Nebel, Bernard J. and Richard T. Wright, Environmental Science: The Way The World Works, 4th Edition, Prentice-Hall, Englewood Cliffs, NJ, 1993.

Public Education Fact Sheets, United States Environmental Protection Agency, Office of Water, "Home Water Testing," June 1991, EPA 570/9-91-500 and "Groundwater Protection," June 1992, EPA 810-F-92-002.

Cryptoquote:

Here's how it works: One letter stands for another letter. Single letters, double letters, one-letter words, and punctuation are all clues. E is the most frequently used letter; THE is the most frequently used word. Have fun!!

N E X C I , N E X C I   C R C I U N A C I C

E B Z   E H H   X A C   Q K E I Z P   Z M Z   P A I M B Y;

NE X C I , N E X C I   C R C I U N A C I C

B K I   E B U   Z I K O   X K   Z I M B Y.

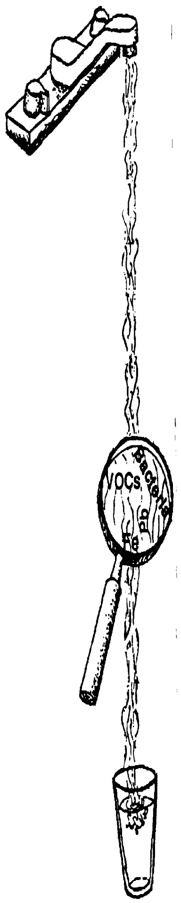
- J K H C I M Z V C : X A C   E B J M C B X

W E I M B C I

solution:

Water, water everywhere
And all the boards did shrink;
Water, water everywhere

Nor any drop to drink.
-Coleridge: The Ancient Mariner



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EPA
Home Water Testing

Should You Have Your Water Tested?

The question of whether or not to have your wastewater tested is a serious one. In addition to illness, a variety of less serious problems, such as taste, color, odor, and staining of clothes or fixtures, are symptoms of water quality problems.

Not everyone needs to test his/her water. This fact sheet provides a few guidelines for deciding whether or not to have your water tested; and, if so, what tests would be appropriate for your situation.

Public Versus Individual Water Supplies

If you obtain drinking water from your own well, you alone are responsible for assuring that it is safe. Routine testing for a few of the most common contaminants is highly recommended, and regular testing can be valuable to establishing a record of water quality.

If your water comes from a public or municipal water system, your water is regularly tested for contaminants regulated by federal and state standards. However, some water supply districts do not have enough money to hire trained specialists or to comply immediately with expanding government requirements. In addition, bacteria may grow in your plumbing, or corrosive water or deteriorating pipes in the house may add contaminants to your drinking water.

Individual Water Supplies

Routine Tests. The testing frequencies in this fact sheet are general guidelines. Test more often if you suspect there is a problem. If any tests give positive results, contact either the state health department or call the Safe Drinking Water Hotline for more information.

< Once each year test for coliform bacteria, nitrate, pH, and total dissolved solids (TDS). Test for these contaminants during the spring or summer following a rainy period or after repairing or replacing pipes and after installing a new well or pump.

Every three years, test for sulfate, chloride, iron, manganese, hardness, and corrosion index.

- If your home plumbing contains lead materials, brass fittings, or lead solder, test your water as soon as possible. Congress has banned the use of lead in new or replacement plumbing materials.

- If a new baby is expected in the household, test for nitrate in the early months of a pregnancy, before bringing an infant home, and again during the first six months of the baby's life.

Special Situations. If someone in your family becomes ill or the taste, odor, or color of your water changes, your water supply may be contaminated. Table 1 lists other situations that deserve attention.

Municipal Water Supplies

Municipal water supply systems perform a variety of tests and will provide water quality reports upon request. You should have your water tested when any of the situations in Table 1 arise.

If you are considering buying a home treatment device for protection against any contaminants, first have your water tested by an independent certified laboratory. Also, if you are buying a home and wish to assess the safety and quality of the existing water supply, test for coliform bacteria, nitrate, lead, radon, iron, hardness, pH, sulfate, total dissolved solids (TDS), corrosion index, and other parameters depending on proximity to potential sources of contamination.

How Should You Collect Test Samples?

Most testing laboratories or services supply their own sample containers. Use the containers provided and carefully follow the instructions given for collecting, preserving, and handling water samples. Laboratories may sometimes send a trained technician to collect the sample or to analyze the sample directly in your home. Keep a record of all your water test results as a reference for future testing. By comparing recent test results with original results, you may discover that a change in treatment is needed or that a treatment device is not working as it should.

Where Can You Have Your Water Tested?

- Private testing laboratories (listed in the telephone book)

- The Safe Drinking Water Hotline(to find state certified labs)

- County and state health laboratories, departments of health, and local hospital and university laboratories

- Water treatment companies and plumbing supply stores may offer certain tests in your home for free.

,   Local engineering firms.

TABLE 1.

Conditions or nearby activities	Recommended Test
Recurrent gastrointestinal illness	coliform bacteria (total, if possible, then fecal)
Household plumbing contains lead	pH, lead, copper
Radon in indoor air or region is radon rich	radon
Scaly residues, soaps don’t lather	hardness
Water softener needed to treat hardness	calcium, magnesium
Stained plumbing fixtures, laundry	iron, copper, manganese
Objectionable taste or smell	hydrogen sulfide, corrosivity, metals, algae
Water appears cloudy, frothy, or colored	color, detergents
Corrosion of pipes, plumbing	corrosivity, pH, lead
Rapid wear of water treatment equipment	pH, corrosivity
Nearby areas of intensive agriculture	nitrate, pesticides, coliform bacteria
Coal or other mining operation nearby	iron, manganese, pH, corrosivity
Gas drilling operation nearby	chloride, sodium, barium, strontium
Odor of gasoline or fuel oil, near gas station or buried fuel tanks	volatile organic compounds (VOCs), oil and grease analysis
Dump, junkyard, landfill, factory, or dry cleaning operation nearby	VOCs, TDS, pH, sulfate, chloride, metals
Salty taste, seawater, or a heavily salted roadway nearby	chloride, TDS, sodium

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Ground Water Protection:

EPA

A Citizen's Action Checklist

What is being done to protect our drinking water

Americans have the safest drinking water supplies in the world. In a country as industrialized as ours, though, there is nothing natural or simple about our safe water. At all levels of government, there are people who work full time to protect our drinking water supplies through passing laws, setting regulatory standards, and making improvements in treating water and delivering it to you.

However, these people make up a relatively small group compared to the size of their task, and there are always limited government resources to protect drinking water.

There is much that individual citizens can do to pitch in and help. This fact sheet describes actions that you can take to help protect your drinking water supply.

What you should know about potential threats to ground water supplies

Until recently ground water was thought to be protected from contamination by the natural filtering action of soil and rock. We now know that chemicals can pass through these soil layers. Some types of activity around your water source can affect your water quality, whether your water comes from a public supply or a private well. The most important of these are listed here.

< Expanding or building new industrial, residential or commercial areas.

< Routine road maintenance such as repaving or deicing during winter months.

< Using pesticides or fertilizers on any commercial or residential areas.

< Disposal of household waste at landfills or in your backyard.

< Use of underground storage tanks or drains such as at gasoline stations or on farms for farm equipment.

What you should do to help protect your water
1. Begin by finding out where your drinking water comes from
If it comes from a private or household well:

! Determine the type of well you have - is it shallow dug or a deep, drilled well? If you are not sure, call your well drilling contractor or the drinking water office in your state department of public health, natural resources or environmental protection.

! Shallow wells or poorly constructed deeper wells tend to be more vulnerable to contamination. If your well is likely to be vulnerable, conduct a survey of the area around your well:

C Is there livestock nearby?

C Are pesticides being used on nearby agricultural croplands or nurseries?

C Do you use lawn fertilizers near the well?

C Is your well "downstream" from your’s or a neighbor's septic system?

C Is your well located near a road that is frequently salted or sprayed with deicers during the winter months?

C Do you or your neighbors dispose of household wastes or used motor oil in the backyard, even in small amounts?

! If any of these items apply, it may be best to have your water tested, and ask your local public health department or agricultural extension agent for preventive measures.

If your water comes from a public supply:

< Look for a phone number on your monthly water bill. Call about the operation of the water system plant.

< Ask a plant operator about the source of your drinking water. Is it surface water or a ground water source?

C If the source is ground water from a well, does the state have a wellhead protection program that manages the land around the well and around the original source of the ground water?

C If the source is surface water from a lake, river, or spring, does the water system have a watershed protection program in place around the supply?

< If there are such programs in your area, ask the supplier to send you any public information he or she may have on the program. A citizen's advisory group may help guide the program.

< If the supplier does not have this information, contact the drinking water office in your state department of public health, natural resources, or environmental

protection.

2. Get involved in long-term protection of your water supply.

< Be aware of your surroundings. Take note of new construction and new development of industry.

< Check the paper or call your local planning or zoning commission for hearings or zoning appeals on development or industrial projects that could possibly affect your water.

< Attend these hearings. Ask questions like, "If you build this landfill, what will you do to ensure that my water will be protected?"

< Support plans to improve your community's water system, sewage system, or waste disposal landfills.

< Enlist in local citizen's advisory groups that serve planning or utility commissions.

3. Learn how to use the right tools for protecting your water supply.

Communities actually have quite a bit of power over land use, construction, and health standards. There are several management tools your community can use to influence these decisions.

< Zoning Ordinances can specify the appropriate regulations that can be used to prevent activities that could affect ground water quality.

< Subdivision Ordinances can set limits on population density, require open space set aside and regulate the timing of development.

< Site Plan Reviews can determine if proposed projects and existing facilities are compatible with planned land use.

< Design Standards can ensure that structures will not affect water quality. Underground tanks may be required to be double-walled.

< Operating Standards can ensure that best management practices are used for some activities. Pesticide applications or feedlot operations may be limited.

< Source Prohibitions may forbid or restrict the use of some materials within a defined area, perhaps around a wellhead.

< Purchase of Property or Development Rights of lands that feed water supplies can guarantee control over activities there.

< Special Programs, such as public education campaigns, volunteer ground water monitors, or household hazardous waste collection programs, can be organized.

For More Information
Call the Safe Drinking Water Hotline at:

POSSIBLE DRINKING WATER CONTAMINANTS

Most of these are only of concern at levels above those set by the EPA.

SUBSTANCE	SOURCES	EFFECTS
SOLIDS/SOILS	Erosion: agriculture, forests,	Reduced light penetration
Sediment	mines, construction	(turbidity), reduced volumes
Sewage	Toilets, drains, sewers; human	Enrichment of surface water
Total dissolved solids (TDS)	wastes, soaps, detergents	(eutrophication), carries germs
ORGANISMS	Variety: industry, agriculture,	Varied, depending on solutes
Cholera bacteria	urban activities	
		Diarrhea, vomiting, dehydration,
Dysentery	Infected person(s)	death
bacteria/amoeba		Colon infection, diarrhea, blood in
	Infected person(s)	stools, abdominal pain
E. coli bacteria		Kidney and pelvic inflammation;
Hepatitis A	Sewage	infantile diarrhea
viruses		Inflammation of liver, jaundice, fever
	Infected person(s); contaminated	
Hookworms	food; hypodermic needles	Severe anemia, diarrhea, abdominal
Typhoid bacteria	Infected person(s)	pain
		Typhoid fever (high fever, fatigue,
INORGANICS	Infected person(s); contaminated	headache, rash, pneumonia,
Copper	food or water	intestinal hemorrhage, death)
Lead	Plumbing, algae control	Stomach and intestinal distress, liver
		and kidney damage, anemia
Mercury	Old ceramics, paints, gasoline,	Neurotoxin, tremors, learning
	plumbing, batteries, pesticides	disabilities
Metals	Batteries, thermometers, gold	Neurotoxin, Minimata Disease in
Nitrates	mines, industry	shellfish, bottom feeders
	Varied: industry, mines	Varied: toxins or carcinogens
Radon	Fertilizers, industry, car exhaust,	Anemia, especially in infants;
Salts	combustion	toxin, carcinogen
	Radioactive gas from the crust	Increased risk of lung cancer
Sulfates	Industry, deicing	Inhibit plants and aquatic life
ORGANICS	Coal combustion, car exhaust,	Toxic, contribute to acid rain
	industry	
Dioxins		Carcinogens, birth defects
Organic pesticides	Industry, white paper mills	Toxins, carcinogens, inhibit wildlife
	Agriculture, industry	Attack liver and kidneys
Polychlorinated biphenyls		Carcinogens
Vinyl chlorides	Industry, electrical transformers	Varied, may be toxins, may be
	Plastics, during manufacturing or	carcinogens
Volatile organic compounds (VOCs)	combustion	
	Fuel gases, phenols, benzene,	
	chloroflurocarbons (CFCs)	

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Teacher/Student Sheet