INTRODUCTION

This Instructor's Guide to Water Education Activities has been updated and revised by staff of the Department of Environmental Protection (DEP). The purpose of this guide is to enhance student perception of the importance of our most valuable resource – water. Our society has come to expect that water be provided continuously and in unlimited quantity. The only time that the value of water is recognized is when supplies run short. We must realize, however, that water is not the infinitely abundant resource it was once thought to be. In fact, with ever-increasing population growth and accelerating per capita use requirements, we are rapidly reaching the point when water conservation will not represent a temporary measure, but instead, a way of life.

Educators are afforded a unique opportunity in sensitizing the perceptions and thought processes of today's students and tomorrow's decisions-makers. The information prepared as part of this guide will enable instructors to effectively develop an understanding among students of the complexities of wise stewardship of our finite water resources. Within this guide, lesson concepts and associated activities have been developed for students in grades K-9. Student worksheets have also been prepared to reinforce classroom activities. This guide provides the instructor with detailed learning modules, yet allows for a great deal of instructor flexibility and innovation. With this information, the instructor can develop a specialized program which satisfies the objectives of the class as well as individual student needs.

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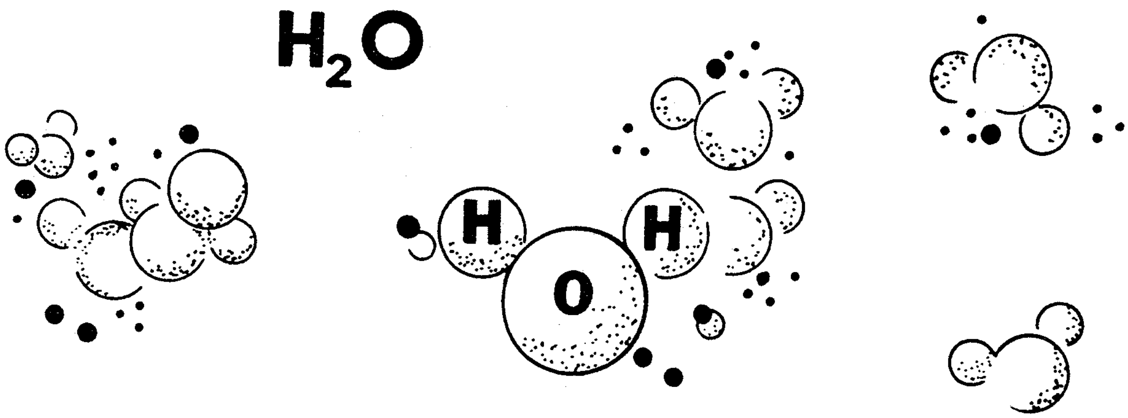
SECTION 1
PHYSICAL AND CHEMICAL PROPERTIES OF WATER

CONCEPT

Water has a unique combination of physical and chemical properties that makes it useful to living things.



TEACHER BACKGROUND

Water is a familiar substance. We know what it looks like, where we can expect to find it, and how it behaves; however, there is much about this compound that we take for granted and only partially understand.

Life on earth is made possible by water. It has a unique set of properties around which living things have developed and which now provide for the continued success of life. Those properties are the result of the structure of the water molecule.

We all know that a molecule of water contains two atoms of hydrogen and one of oxygen. Just as important, however, is the arrangement of those atoms. Each water molecule is arranged so that the two hydrogen atoms form a 105° angle with the oxygen atom. This arrangement gives each water molecule a positive electrical side and a negative electrical side. Positive and negative electrical charges attract one another, so water molecules tend to attract other water molecules and bond with them.

Some of the most important properties of water resulting from its molecular composition and structure are described below:

Boiling point – 100° Celsius (212° Fahrenheit)
Freezing point – 0° Celsius (32° Fahrenheit)
Appearance – colorless and tasteless in any physical state.

SPECIFIC HEAT

The specific heat of a substance is the number of calories needed to raise the temperature of one gram of the substance 1° Celsius. Only a few substances (ammonia, liquid hydrogen, lithium) have a higher specific heat than water.

Because water absorbs so much heat with little temperature change, it heats and cools slowly. This prevents radical differences in air temperature from season to season. It also moderates the rate at which air temperatures change from one season to the next.

This ability of water to absorb heat with little change in temperature also makes water an ideal coolant for a variety of industrial uses. In an automobile, for example, the water in the cooling system absorbs engine heat and carries it to a radiator where the heat can be dissipated to the air. Most other liquids would reach very high temperatures after they absorbed this amount of heat.

LATENT HEAT

Water exists in all three physical states at normal earth temperatures. It freezes as ice, melts to liquid water and evaporates to water vapor all within the same temperature range common to the earth's surface.

This change from one state to another involves an exchange of heat energy. Each gram of ice must absorb 80 calories of heat energy to melt and become liquid water at the same temperature. When water freezes and becomes ice, that same amount of heat is released. When liquid water evaporates, 536 calories of heat energy must be absorbed by each gram of water to form water vapor at the same temperature. Again, when water vapor condenses back to liquid water, this amount of heat is released. Heat energy which must be absorbed or released when water changes states is called "latent heat energy."

Latent heat is an important factor in powering the water cycle and plays a very important role in influencing weather on the earth's surface.

SURFACE TENSION

Because of the strong attraction of water molecules for each other, they form very strong bonds which are responsible for many of the properties of water.

Water has a very high surface tension which is evidenced as a sort of elastic skin on the surface of the water. If you slowly place water in a spoon, you will notice that you will be able to raise the level of water above the rim of the spoon. This is due to the elasticity of the surface skin which holds the water in place even though it is above the rim of the spoon. Because of this property of water, some objects which are actually heavier than water are able to float because they are not heavy enough to break the strong molecular bond which causes the high surface tension.

Another phenomenon resulting from this strong bond is the ability of plants to transport water through the tiny tubes in their bodies. Water is constantly moving from the root system up through the plant where it is used for growth and eventually transpired to the atmosphere. As one molecule moves through these tubes it pulls other molecules with it in a chain-like fashion.

SOLVENT

Water dissolves many substances. The electrical charges that hold water molecules together also attract other molecules with electrical charges. Since many substances have charged molecules, water will dissolve most of them. For this reason, water is known as the "universal solvent."

This characteristic is important to the living things that depend on water to transport substances like sugar, oxygen, and carbon dioxide through their cells. However, it also means that undesirable substances can pollute water and make it unfit for use until they are removed.

DENSITY

Water has an unusual density characteristic. Most substances become more dense as they cool and are more dense as a solid than as a liquid. Water is different. It is less dense as a solid than it is as a liquid. Lighter ice, therefore, floats on more dense liquid water. Water is most dense at 4°C (39°F).

As water in a lake cools, it becomes more dense until it reaches 4°C; then it becomes less dense again. Heavier water, around 4°C, sinks while lighter weight water near the freezing point rises to the surface. Lakes, therefore, freeze from the top down, locking a layer of warmer water underneath in which aquatic animals and plants can live.

When water freezes, molecules are locked into a crystal structure that takes more space than the molecules actually occupy. An analogy might be made with a set of tinker toys. The assortment of wheels and sticks can be crowded into a compact package but, when they are assembled to form a bridge or a house, the structure they form occupies more space than the individual pieces. In ice, the crystal structure occupies more space than the molecules themselves. Ice, therefore, expands as it forms and is lighter in weight than an equal volume of liquid water.

The activities that follow will help your students to understand several of the peculiar characteristics of water.

ACTIVITY 1.1
DEMONSTRATING SURFACE TENSION

The strong attraction of water molecules to each other produces a high surface tension on the surface of water, evidenced as an elastic "skin."

GRADE LEVEL

4-6 (Appropriate for other levels with modifications)

MATERIALS

Dinner fork	Window screen
Sewing needle	Wide-mouth container
Razor blade	Water
Paper clip	Detergent

PROCEDURE

1. Fill a wide-mouth container with water.

2. Use a fork to slowly lower a sewing needle onto the surface of the water.

3. Discuss why the needle floats even though it is heavier than water.

4. Try to float other small objects: a doubled-edge razor blade, a small paper clip, a wire boat made from window screen (Hint: If you have trouble getting the objects to float, rub them between your fingers to deposit a thin layer of oil which will make the objects float more easily.)

5. Add a small amount of soap or detergent to the floating object and observe what happens.

DISCUSSION

Although these objects are heavier than water, they are not heavy enough to break the surface tension; therefore, they float. However, detergents will weaken surface tension because they readily break the electrical bonds holding water molecules together.

APPLICATION

The strong molecular bond between water molecules is an important factor in the movement of water. Water molecules moves through soils much as it does through a towel whose corner hangs in a bowl of water. Water molecules are attracted to the towel fibers and move to new fibers pulling other molecules along. Water movement in plants is similar except it is facilitated by tiny tubes in plant bodies called capillaries. Water moves through these tubes from the roots to the leaves in a chain-like fashion-each molecule pulling the next.

ACTIVITY 1.2
EXPANSION OF ICE

An unusual property of water is that it expands when it freezes.

GRADE LEVEL

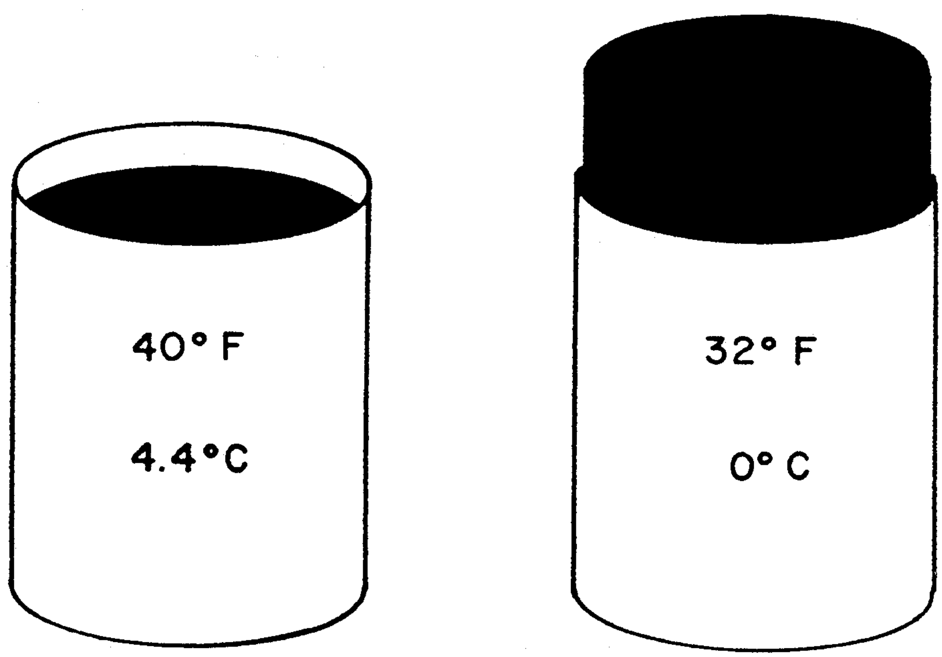
4-6 (Appropriate for other levels with modifications)

MATERIALS

Two juice cans
Access to refrigerator/freezer

PROCEDURE

1. Completely fill two juice cans with tap water.
2. Record the temperature of the water in each can.
3. Place one can in the freezer, the other in the refrigerator.
4. Discuss with your class what might happen to each can and why.
5. After 24 hours, remove the cans and compare the height of the water or ice in each.
6. Record the temperature of the water.



DISCUSSION

The water in the freezer will expand and project above the rim of the can as it freezes. Older students can measure the height of the ice column and calculate the percentage of expansion. The volume of ice above the rim should be approximately 1/9 of the volume of water in the can.

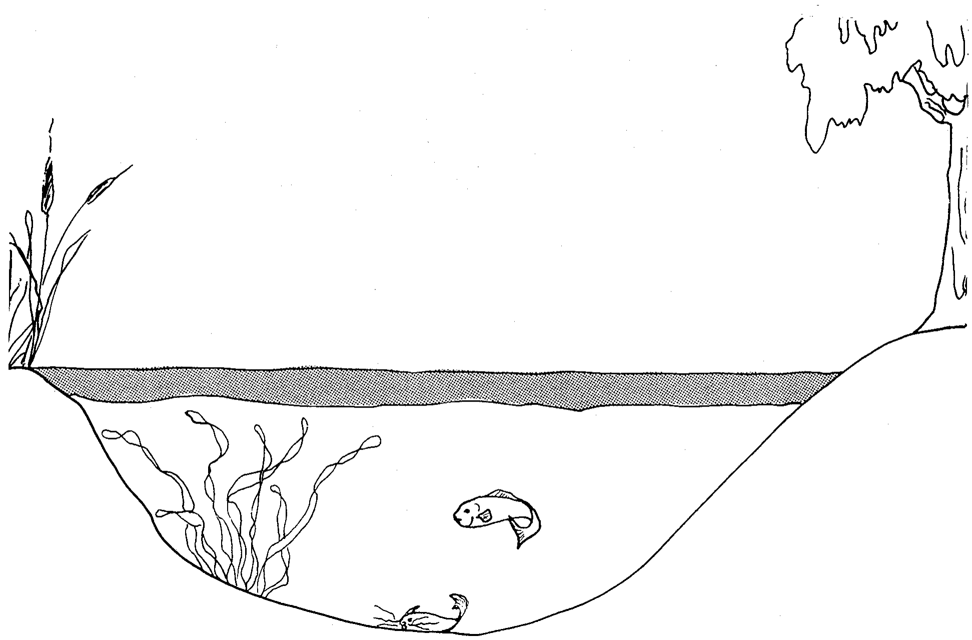
The can of water in the refrigerator will be near 40°F. At this temperature, water is nearly most dense. Therefore, it should have contracted as it cooled in the refrigerator and the water level should be slightly below the rim of the can. Demonstration of both expansion and contraction is more dramatic if tall, slender cans are used. However, the top of the container cannot be constricted or the expanding ice may break the container.

An even more dramatic demonstration of ice expansion involves freezing a water-filled and tightly closed glass jar. Place the jar in a plastic bag or other large container prior to freezing to catch the broken glass.

APPLICATION

Frost action on rocks is a major weathering agent. Water seeps into tiny cracks and expands on freezing with enough force to split fragments from the rock. In moist soils, freezing causes the soil to heave with devastating effects at times to roadways, sidewalks, parking lots and underground pipes and building foundations.

Ice forms at the surface of water bodies because it is less dense than liquid water. As a result, water freezes from the top down. In most lakes and ponds, water beneath the ice remains unfrozen and provides a suitable habitat for aquatic organisms.



ACTIVITY 1.3
WATER EXISTS IN THREE STATES

Water passes into all three physical states at temperatures common on the earth's surface. Water freezes and melts, evaporates and condenses.

GRADE LEVEL

K-3 (Appropriate for other levels with modifications)

MATERIALS

Ice cubes
Small dishes (large enough to hold the water for a melted ice cube)

PROCEDURE

1. Place one ice cube in a small dish and set it in the classroom. (Students should observe ice cubes set in locations of their choice. Some cubes could be in sunny areas, others in dark corners; some near a source of heat, others far from it.)

2. Discuss what will happen to the ice cube if it is allowed to set in one place for a long time.

3. Ask students to watch the cubes and resulting water throughout the day as they go about their normal routines.

4. If appropriate, students should take notes at each observation indicating time, state of water, change in volume and any other observations they make. Older students might weigh the dishes at intervals to detect the loss of water by evaporation.

5. Allow the water to evaporate completely.

DISCUSSION

This simple activity can do several things. First, it demonstrates that water can exist in three physical states-solid, liquid, gas. Second, it can demonstrate that certain factors (e.g., heat, air movement) can speed melting and evaporation. Third, the activity builds notetaking and observation skills.

APPLICATION

The ability of water to change states at common earth temperatures is vital to the water cycle and its availability to living things. Life as developed on this planet is dependent upon the supply of liquid water. Some scientists predict gradual changes in the earth's temperature, and with those changes will come corresponding changes in the amounts of water in each of its phases on the earth's surface.

Many life processes depend on the ability of water to evaporate at a certain temperature. Our own bodies, for instance, are cooled by the evaporation of water from our skin.

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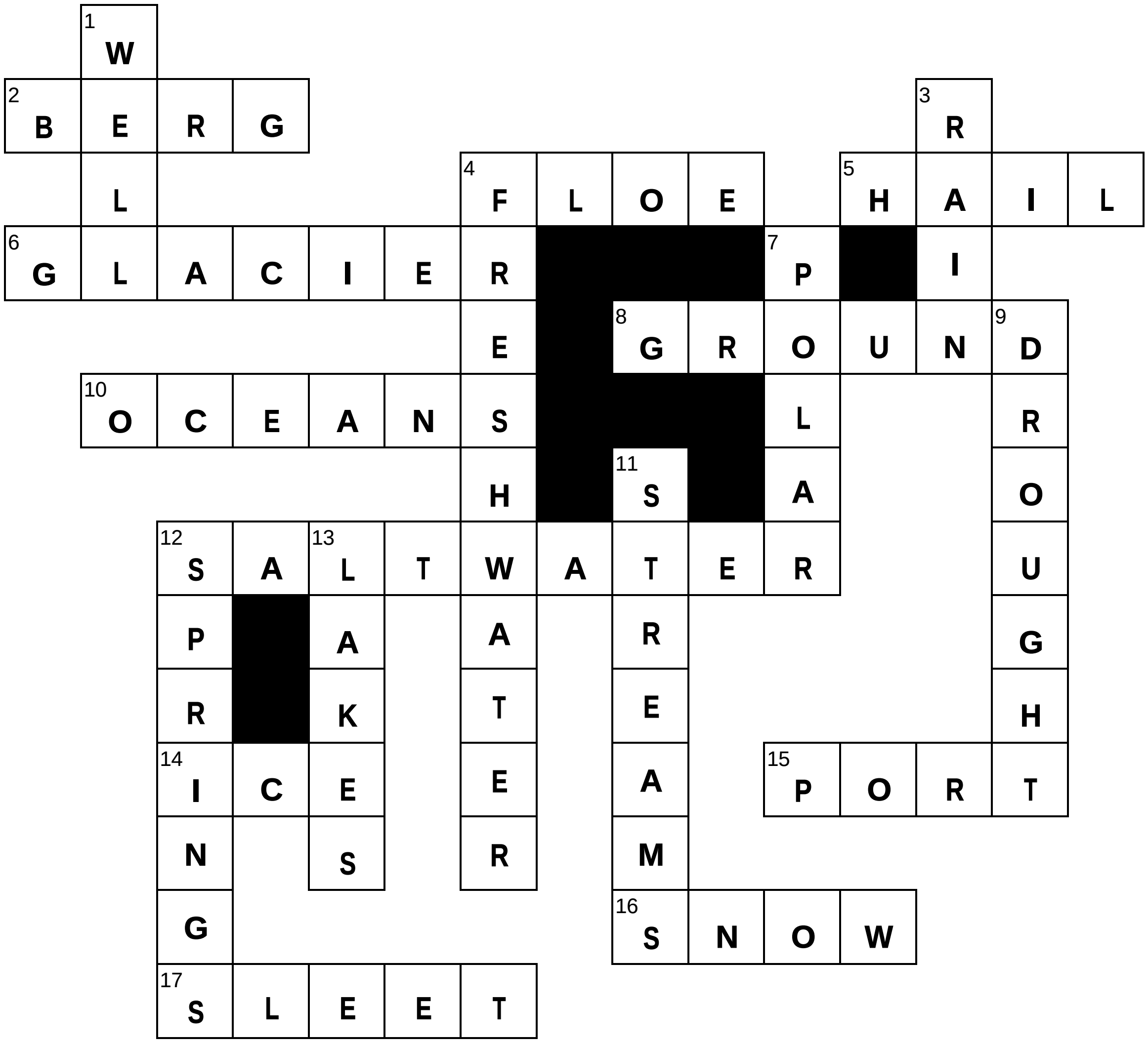
STUDENT WORKSHEET 1.1
WATER CROSSWORD PUZZLE



ACROSS

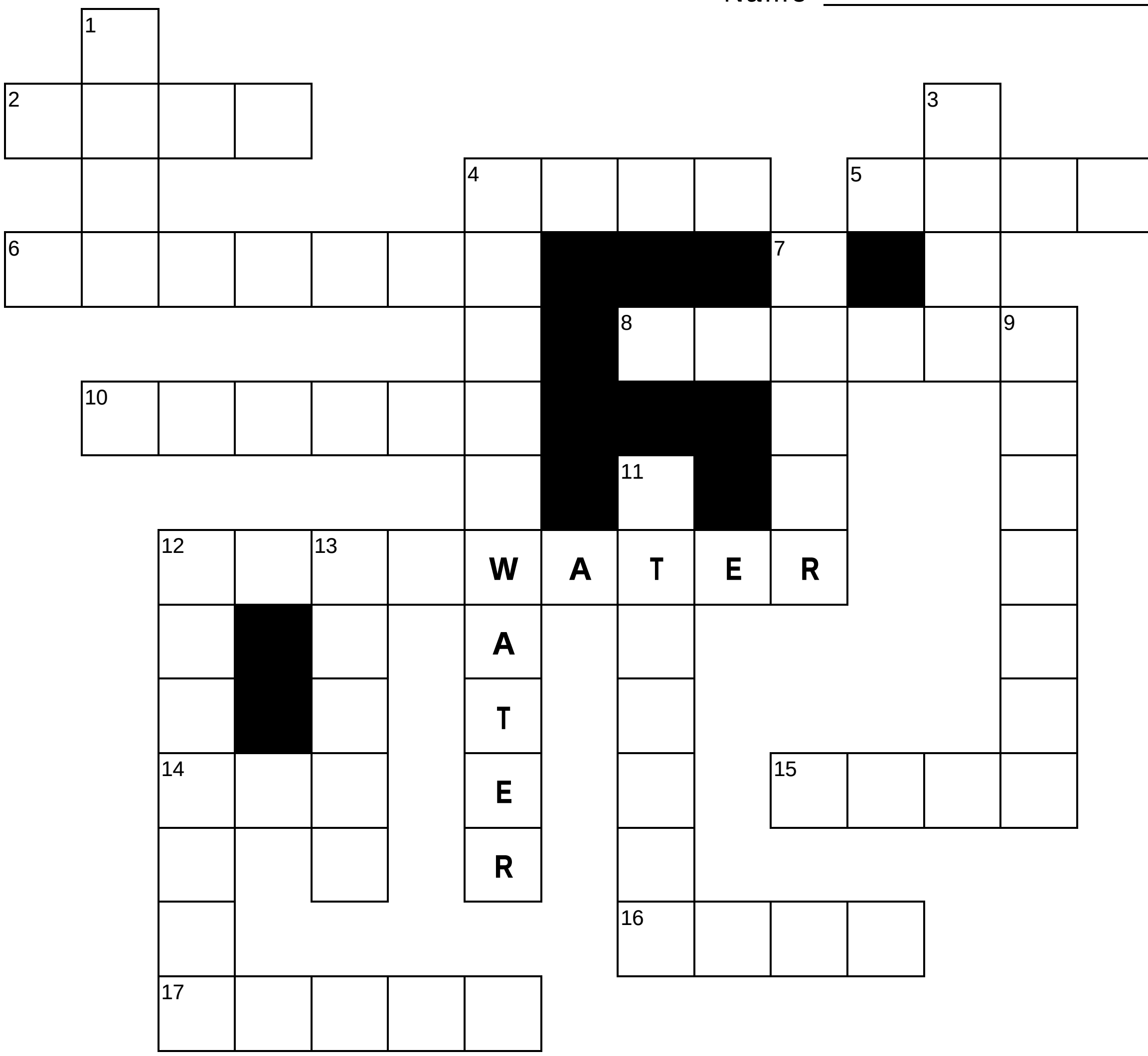
2. Large chunk of floating ice found in the ocean.
4. Flat floating ice similar to #2 across.
5. Frozen precipitation associated with thunderstorms in the summer.
6. Often known as Frozen River , also found at South Pole as large flat fields of ice.
8. Water found under the earth's surface is called __ __ __ __ __ __ water.
10. Our largest bodies of water on the earth's surface.
12. We cannot drink water in the ocean because it is __ __ __ __ water.
14. Frozen water.
15. Ships come into.
16. No two flakes are the same.
17. Frozen rain.

DOWN

1. Hole in the ground for taking groundwater.
3. Usual summer precipitation.
4. Term to describe good drinking water supply __ __ __ __ __ water.
7. Term which describes areas at North and South Poles.
9. Lack of rain may lead to __ __ __ __ __ __ __.
11. Surface flow of the water cycle. (Rivers and __ __ __ __ __ __ __)
12. Groundwater sometimes may appear on the surface through __ __ __ __ __ __ __.
13. Large bodies of water.

STUDENT WORKSHEET 1.1
WATER CROSSWORD PUZZLE

Name ______________________



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SECTION 2
THE WATER CYCLE

CONCEPT

Water is continually moving through our environment by a process known as the water cycle.

TEACHER BACKGROUND

The water cycle is a familiar yet powerful mechanism which continually moves water throughout our environment. The cycle is driven by energy from the sun which causes the evaporation and transpiration of liquid water into vapor from the earth's surface. As the water vapor rises, cools, and condenses, water once again falls to the earth's surface as precipitation. Once on the surface, the water may immediately be evaporated back into the atmosphere or run off into streams, rivers, and other water bodies, or it may infiltrate the ground. The water cycle is a dynamic natural process which has no beginning or end. All living things need water for sustaining their life processes and use the water during its various cycling stages. Therefore, man is also a part of the water cycle and as a part of that cycle we influence it greatly. A more detailed discussion about each stage of the water cycle follows.

Precipitation falls as rain, snow, sleet, and occasionally hail. The origin of this precipitation varies by region and season. For instance, in the western one-third of Pennsylvania, moisture is supplied largely from the Gulf of Mexico in the summer months with a significant contribution from the Great Lakes in the winter months. In the eastern two-thirds of the State, moisture is supplied largely from the Gulf of Mexico and Atlantic Ocean during the summer months; while, in the winter, there is some additional contribution from the Great Lakes region. The Pacific Ocean occasionally provides moisture from fast-moving fronts in the spring and fall but only in very small amounts (less than 5 percent of the total annual rainfall).

Precipitation totals vary regionally from an average of 35 inches per year in the area of Tioga and Bradford Counties to about 51 inches per year in Schuylkill, Carbon and Monroe Counties. Another area of high precipitation exists along the western edge of the Allegheny Mountains in Fayette, Westmoreland and Indiana Counties where precipitation averages 51 inches. To the east of the Allegheny Mountains, precipitation totals decline sharply along the Allegheny Front dropping to an average of 39 inches in western Bedford and Blair Counties. The precipitation map (Figure1) at the end of Section 2 illustrates rainfall variations across the Commonwealth for a 30 year period starting in 1961 and ending in 1990.

Fluctuations in precipitation can greatly affect our water resources and supplies. Precipitation deficits have been a problem in recent decades leading to drought conditions and water supply problems across the Commonwealth in the 1960s and several droughts in the 1980s and 1990s. Excess precipitation has been a major problem which has resulted in floods throughout the history of the Commonwealth.

Surface runoff is the water which directly runs off the land surface into streams, rivers or lakes. It may be seen as sheet runoff where water moves across the land surface, or channelization where water is diverted into a channel. Sheet runoff is best observed on a parking lot, whereas channelization may be best illustrated as a stream or river.

Water that does not run off infiltrates the ground. As it soaks through the soil it is absorbed through the root systems of plants and used for their physiological processes. Water not used by plants either adheres to soil particles or will continue to move through the soil in all directions. Eventually, the water will reach a saturated zone in the soil or bedrock. The top of this zone is called the water table. Water below this water table is called groundwater. Where the water table reaches the ground surface, groundwater may reappear as a spring or it may move directly into a flowing stream. This concept is important because without this subsurface movement of water and subsequent recharge of surface water, many streams would not flow between precipitation events. Subsurface drainage may be fast or very slow depending on soil types, depth to bedrock, slope and other climatic and geologic factors.

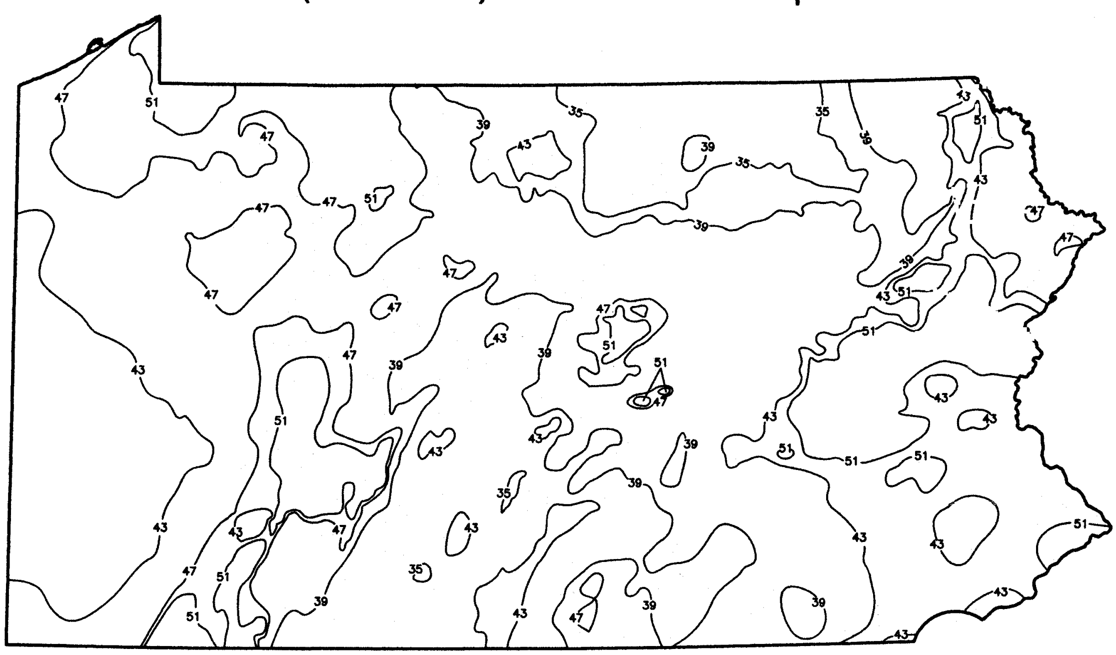
Water that reaches bedrock moves through cracks and fissures in the rock structure. It may move slowly through the rock formation or remain in place for hundreds of thousands of years. Rock formations that hold vast amounts of water are called aquifers, a term derived from the two Latin words "aqua" or water and "ferre" to bear to carry.

Man withdraws water from groundwater resources and surface water resources for his daily domestic and economic needs. Man's use of water greatly affects the natural recharge of streamflows and groundwater. Development projects involving the removal of natural land areas and paving may have adverse environmental impacts on soil erosion and streamflow levels and can prevent the natural recharge of our groundwater resources. Our utilization of this resource is a necessity, and, with careful planning adverse environmental impacts resulting from our interruption of the natural water cycle can be minimized.

FIGURE 1

RAINFALL DISTRIBUTION MAP OF PENNSYLVANIA

30 Year (1961-1990) Mean Annual Precipitation



LEGEND

Isohyet, precipitation in inches based on US Weather Bureau Precipitation data 1961-1990

- 35 Inches
- 39 Inches
- 43 Inches
- 47 Inches
- 51 Inches

ACTIVITY 2.1
CHARTING THE WATER CYCLE

In this activity, students trace the path of water through the water cycle.

GRADE LEVEL

4-6 (Appropriate for other levels with modifications)

MATERIALS

Student Worksheet 2.1
Pencils

PROCEDURE

1. Direct the students to fill in the correct term from the list at the bottom of the Student Worksheet 2.1 page for each of the numbered blanks.

2. Review the completed worksheet when all students are finished.

DISCUSSION

Consider making an overhead transparency of this worksheet so you can fill it in with the class as you review the assignment.

Try to make the point that this diagram is really only a simple model and not completely realistic. For instance, students themselves should be able to draw other arrows not shown on this worksheet. Give them a chance to come up with ideas of their own. They might include:

* Evaporation from animals
* Precipitation into the ocean
* Dew and fog as forms of precipitation
* Evaporation from precipitation
* Evaporation from soil

APPLICATION

Stress that our water resources depend on the normal cycling, however, man's activity can affect the cycle in many ways. For instance, groundwater recharge, an important part of the cycle, is prevented when we pave large land areas with concrete or macadam. Another result of large paved areas may be increased surface runoff into local streams and flooding where floods did not normally occur before the area was paved.

Students can examine the water cycle and find many more examples of ways humans interact with this natural process. Let them share ideas of their own.

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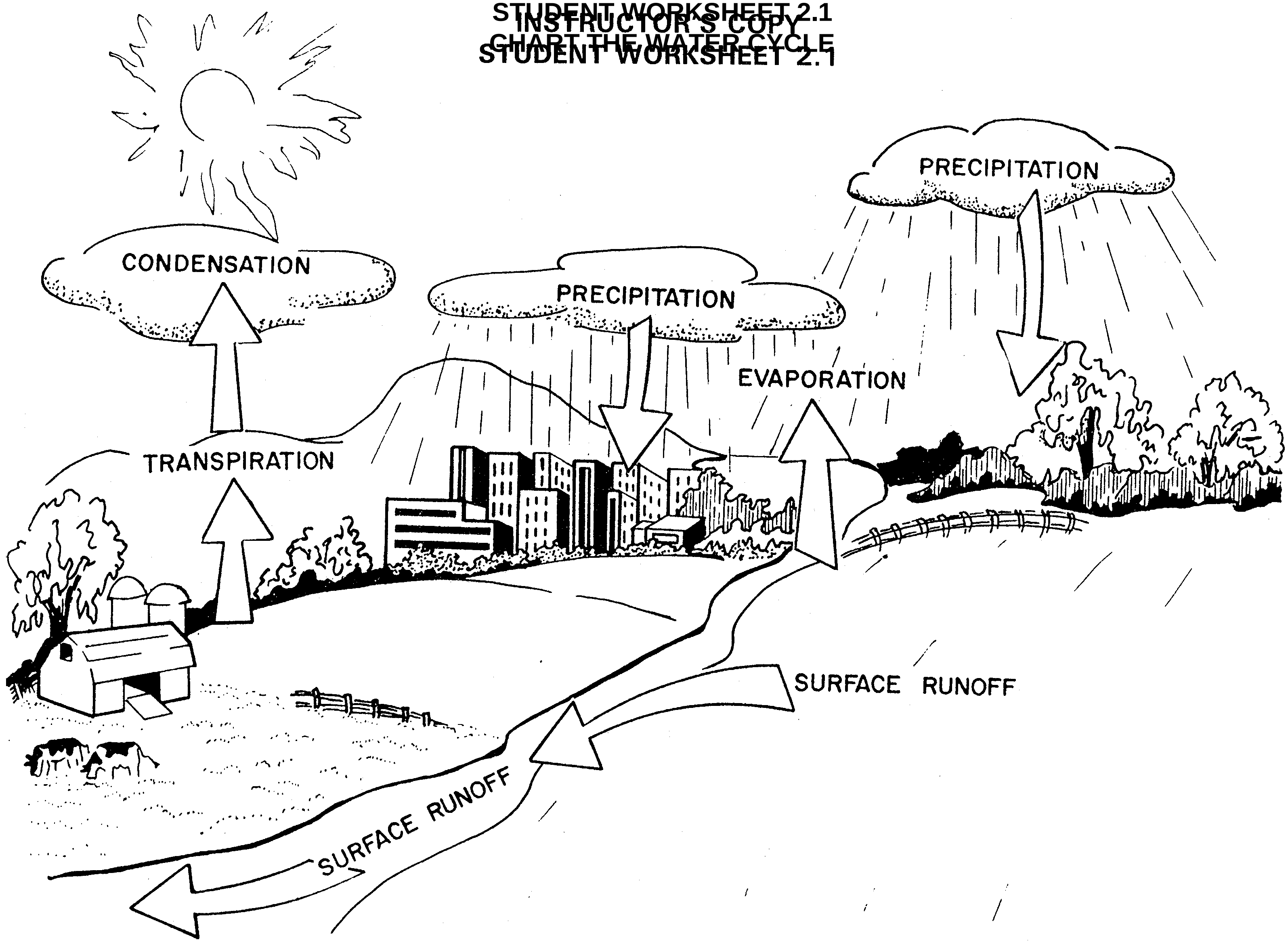
STUDENT WORKSHEET 2.1

CHART THE WATER CYCLE

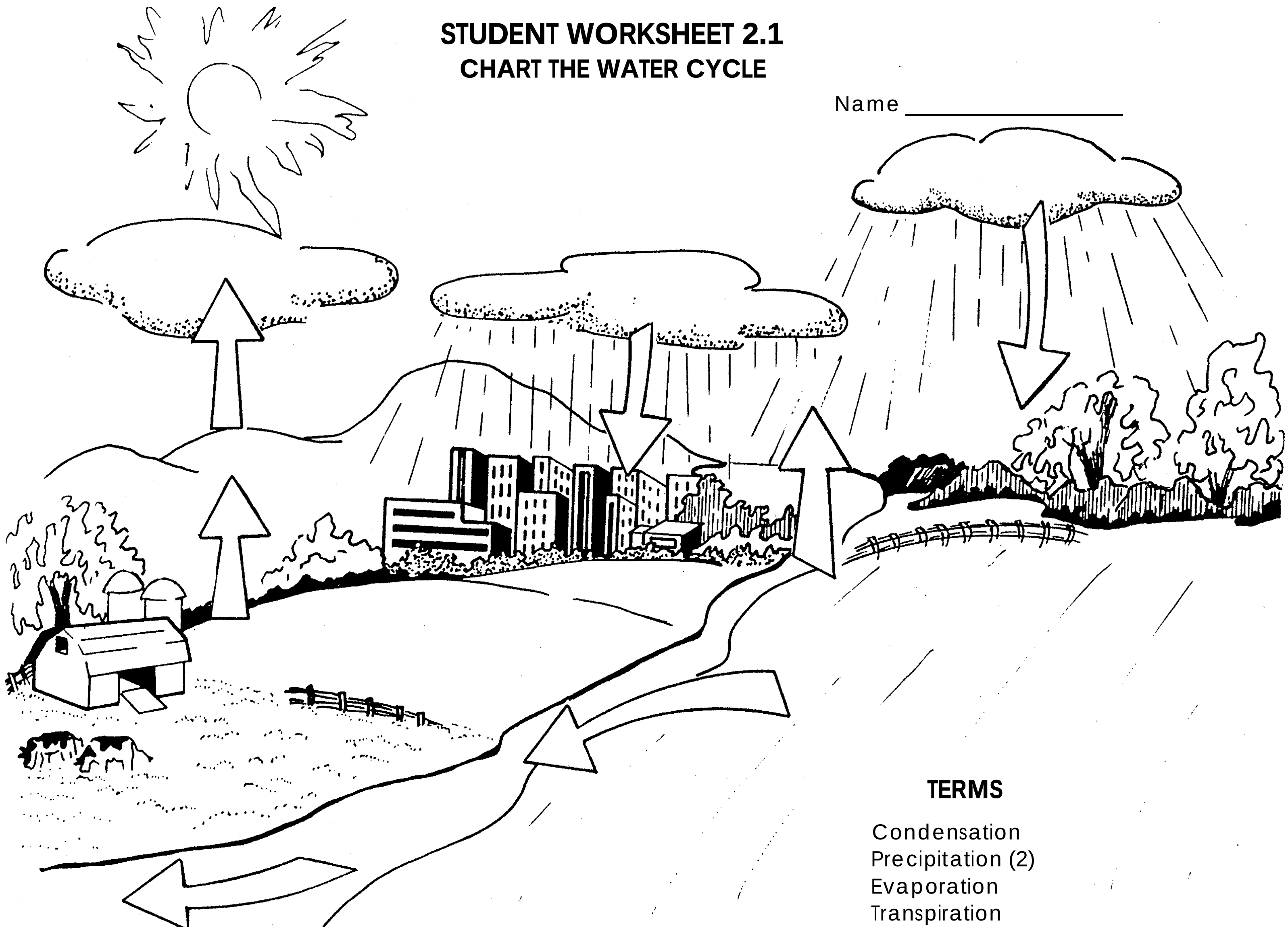
INSTRUCTOR' S COPY

STUDENT WORKSHEET 2.1



STUDENT WORKSHEET 2.1
CHART THE WATER CYCLE

Name ___________________



TERMS

Condensation
Precipitation (2)
Evaporation
Transpiration
Surface Run Off

ACTIVITY 2.2
A MODEL WATER CYCLE

This activity illustrates the evaporation, condensation and precipitation of water in a model water cycle. It is a long-term activity and the model should stand undisturbed for at least one week.

GRADE LEVEL

K-3 (Appropriate for other levels with modifications)

MATERIALS

Aquarium
Plastic wrap
Incandescent desk lamp

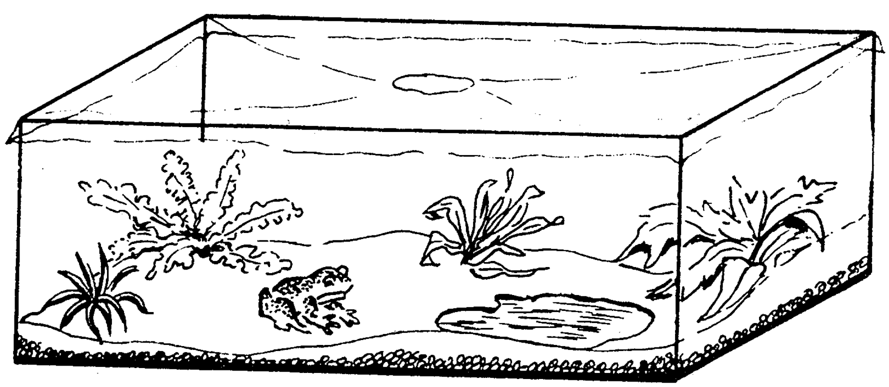
PROCEDURE

1. Add water to an empty aquarium to a depth of several inches.

2. Cover the top of the tank with plastic wrap. Tape the edges to the glass and add a small weight to the center of the plastic wrap so that it sags an inch or two in the center.

3. Shine an incandescent desk lamp on the water to heat it and to speed evaporation, or set the tank where it receives bright sunlight.

4. Ask students to watch the tank during the next few days and to look for evidence that water is cycling inside.



DISCUSSION

The water that evaporates in the tank will condense on the plastic surface and drop again into the water below. Be certain the center of the plastic sags so that water drops join together and drip from the center. Otherwise, the small condensed droplets may never coalesce and become heavy enough to drop.

You and your class might go a step further to make the model even more realistic. Build a terrarium in your tank with soil, plants and a small toad or salamander. Leave a shallow depression at one end for a pool of water. Add a layer of stones on the bottom to provide good soil drainage.

Now your model demonstrates infiltration into the soil, evaporation from plants and animals, and perhaps runoff from the soil back to the pool of water.

Another important concept is that the water cycle is powered by the sun. In our model, the desk lamp provided most of the heat energy needed to evaporate water. In nature, water absorbs heat energy from the sun in order to change from liquid to gas. When it condenses, water releases this heat into the atmosphere where it becomes one of the major forces driving our weather systems.

APPLICATION

The model is a nearly closed system. Once built, it receives no water from the outside. Its water changes state from liquid to gas and back to liquid as it flows throughout the tank. As it moves, it makes life possible for the plants and animals that live in the terrarium. Of course, energy is coming into the tank from the outside and there is also an exchange of gases. If you have a small animal in the system, you'll also have to provide it with food.

The earth is also a closed system. It receives no new water but recycles what it has from gas to liquid to make life possible on earth. Our responsibility is to be sure our own actions do not damage this natural cycle.

ACTIVITY 2.3
A HOME WATER CYCLE

The water we use was taken from the water cycle and will return to it. This activity makes that connection clear.

GRADE LEVEL

K-3 (Appropriate for other levels with modifications)

MATERIALS

Student Worksheet 2.3
Crayons or Colored Pencils

PROCEDURE

1. Distribute Worksheet 2.3.

2. Instruct the students to color the water pipes according to whether the water carried by the pipes is clean treated drinking water, wastewater or treated wastewater. Color the water pipes blue to symbolize water ready to be used by us for drinking, cooking, bathing, laundry, etc. Color the pipes red to illustrate wastewater which is water after we have used it in our daily household activities. Lastly, use the color green to represent treated wastewater that is discharged to our natural water resources.

3. Allow students time to work alone and assist where necessary.

4. Generate a discussion to make students aware of the need for water treatment and wastewater treatment plants. Water treatment facilities treat water withdrawn from streams, rivers, reservoirs or aquifers for our use. The purpose of wastewater treatment plants is to purify water after we have used it before returning the water to its natural environment. Through this discussion students can see the connection between where the water comes from for use in their homes and where water goes to once it leaves their homes.

DISCUSSION

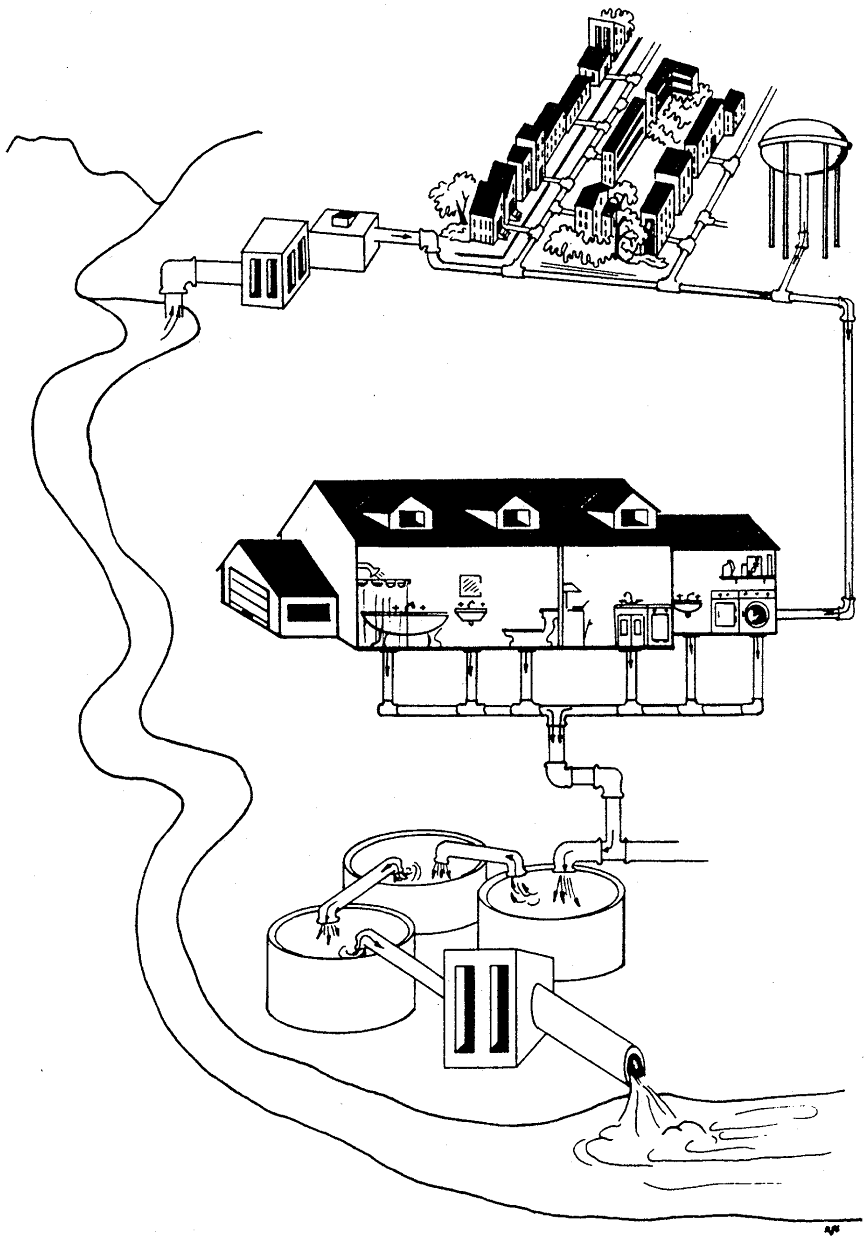
Older students could develop this activity on a grand scale. Construct a large mural on a bulletin board, the wall of the hallway or a display case in the school lobby. Use magazine photos or drawings to depict the water treatment and wastewater plants. Other pictures could illustrate water-using appliances in the home. Finally, connect them all with plumbing to show water taken from a source, treated, used, treated again and released.

APPLICATION

Many students fail to make the connection between the water they use in their homes and the natural water cycle. That water comes from either groundwater or surface runoff supplying the water system in their locality.

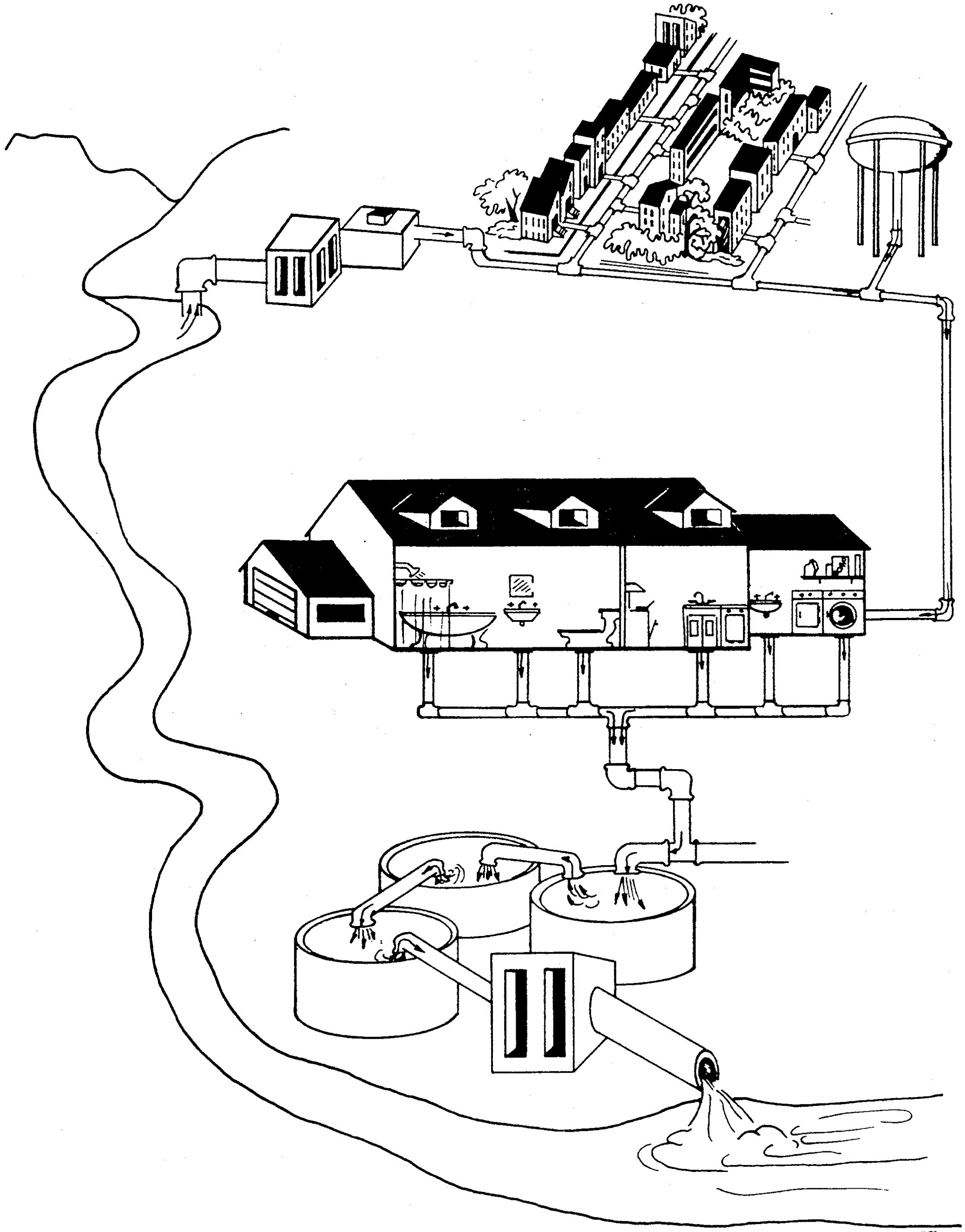
While it is true the water we use ultimately returns to the water cycle, it's also true that the way we use it can create difficulties for other people, even ourselves. A town that withdraws more water than necessary from a stream for its own use may leave little water for towns downstream who also depend on that stream for their water needs. In dry periods, the homeowner who uses water to wash cars, porches or driveways may be using water that someone else needs for drinking or even fighting fires.

The way students, and their families, use or misuse water, therefore, has an effect on the water cycle as a whole and on other neighbors who also depend on that water.



STUDENT WORKSHEET 2.3
A HOME WATER CYCLE

Name ____________________



ACTIVITY 2.4
THE GREAT WATER CATCHER

The amount of water that infiltrates into the soil is determined by a number of factors. In this activity, students estimate the amount of water prevented from infiltrating the soil by paved parking lots.

GRADE LEVEL

7-9 (Appropriate for other levels with modifications)

MATERIALS

Student Worksheet 2.4

PROCEDURE

1. Use Worksheet 2.4 to introduce the idea that paved surfaces prevent infiltration.
2. Help students with calculations where necessary.
3. Consider using actual dimensions of a mall parking area near you, or even the school parking lot, to make this concept realistic.
4. Look for local examples of water volumes that help students comprehend the vast amounts collected in a year. Consider volumes of local lakes, reservoirs, swimming pools or the volume of drinking water used by your town in one day.

DISCUSSION

The idea of taking a class field trip to a local mall just to measure the area of the parking lot may seem a bit unusual. That novelty, however, could make the lesson a memorable one. Your own school parking lot might be a reasonable substitute.

The students should look for storm drainage grates, waterways and grass buffer areas to try to understand how the designers provided for the water collected by the paved area. As more water runs off the ground, less infiltrates to recharge groundwater supplies. Is that important? If all the water that falls on the paved surface is directed downstream, in just a few hours that water could be well on its way to the ocean again. But if it had soaked into the soil, that same water may have been held there and available for use for months or even years into the future.

APPLICATION

Paved surfaces can interfere with the water cycle in a measurable way. In the past, designers built systems that carried water away quickly and efficiently, but in so doing, discarded water that might have previously been held in the natural system for some time. New design features such as retention ponds, porous surfaces, grass buffer zones and on-site recharge areas, are being used in modern designs to help manage stormwater and lessen the effect of development.

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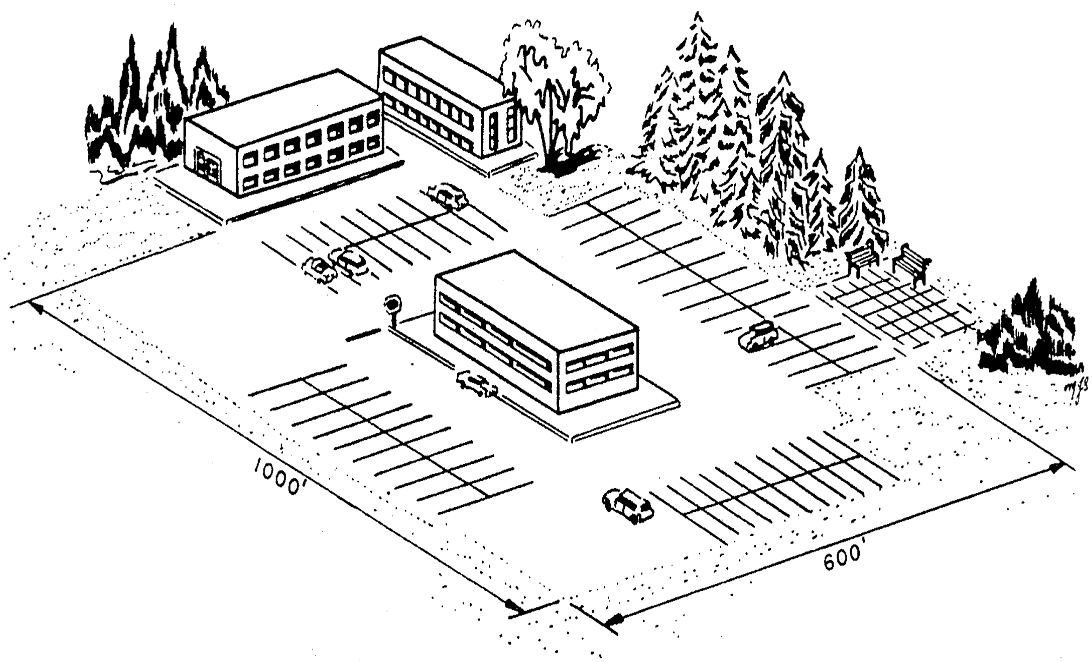
STUDENT WORKSHEET 2.4
THE GREAT WATER CATCHER



1. What is the length of the mall and parking area? 1,000 feet

2. What is the width of the mall and parking area? 600 feet

3. What is the area of the mall in square feet? 1000 ft x 600 ft = 600,000 square feet

4. Assume this mall is located in a part of the state that receives 40 inches of precipitation per year. How many cubic feet of water fall on this site each year? Remember to convert 40 inches into feet. (40 inches ÷ 12 inches/foot = 3.3333 cu. ft.) 600,00 sq. ft x 3.3333 cu ft. = 2,000,000 cubic feet

5. How many gallons of water fall on this site each year? (There are 7.48 gallons of water per cubic foot.) 2,000,000 cubic feet x 7.48 gallons = 14,960,000 gallons

6. 212,200 cubic feet of water flow over Niagara Falls each second. How many seconds would it take all the water that falls on our mall site each year to flow over the falls?
2,000,000 ÷ 212,200 = 9.42 seconds

7. What happens to the water that falls on this site?

Does it infiltrate the ground? No

Does it help recharge the groundwater supplies? No

8. If all the precipitation runs off this site to the east, what may happen to homes in this area during heavy rains?

Possible flooding depending on severity of the storm.

9. If each person uses 62 gallons of water per day, how many people would the water that falls on this area support each year?

14,960,000 ÷ 365 days = 40,986.3
40,986.3 gallons ÷ 62 gallons per person = 661 people

10. List some ways that this water could be saved or ways to encourage groundwater recharge.

A. Plant grass areas throughout the site to improve recharge.
B. Design retention or detention ponds - areas that the water would flow to so it can slowly infiltrate the ground.
C. Porous pavement or macadam.

VOLUME OF WATER

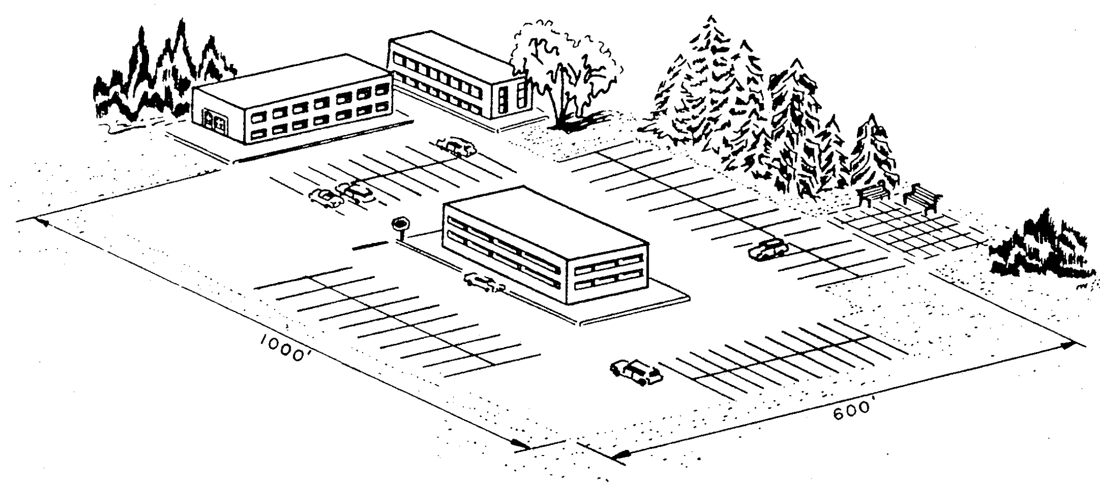
To further enhance a student's understanding of volumes of water, use the following table to equate gallons and cubic feet of water to a room size or some other visual area. Determine the cubic feet of your classroom and equate it to gallons by multiplying the cubic feet by 7.48. (There are 7.48 gallons of water in 1 cubic foot.)

Cubic Feet And Gallons

Gallons	Cubic Feet	Approximate Room size to Nearest Whole Foot				
1,000,000	133,690	116'	x	116'	x	10'
750,000	100,267	100'	x	100'	x	10'
500,000	66,845	82'	x	82'	x	10'
250,000	33,422	58'	x	58'	x	10'
100,000	13,369	37'	x	37'	x	10'
75,000	10,027	32'	x	32'	x	10'
50,000	6,684	26'	x	26'	x	10'
45,000	6,016	25'	x	25'	x	10'
40,000	5,348	23'	x	23'	x	10'
35,000	4,679	22'	x	22'	x	10'
30,000	4,011	20'	x	20'	x	10'
25,000	3,342	18'	x	18'	x	10'
20,000	2,674	16'	x	16'	x	10'
15,000	2,005	14'	x	14'	x	10'
10,000	1,337	12'	x	12'	x	10'
5,000	668	8'	x	8'	x	10'
2,500	334	6'	x	6'	x	10'
1,000	134	4'	x	4'	x	10'

STUDENT WORKSHEET 2.4
THE GREAT WATER CATCHER

Name ___________________



1. What is the length of the mall and parking area? ____________________

2. What is the width of the mall and parking area? ____________________

3. What is the area of the mall in square feet? ____________________

4. Assume this mall is located in a part of the state that receives 40 inches of precipitation per year. How many cubic feet of water fall on this site each year? Remember to convert 40 inches into feet. 40 inches ÷ 12 inches/foot = 3.3333. ____________________

5. How many gallons of water fall on this site each year? (There are 7.48 gallons of water per cubic foot.) 2,000,000 cubic feet x 7.48 gallons = ____________________

6. 212,200 cubic feet of water flow over Niagara Falls each second. How many seconds would it take all the water that falls on our mall site each year to flow over the falls? 2,000,000 ÷ 212,200 = ____________________

7. What happens to the water that falls on this site?

   A. Does it infiltrate the ground? ____________________

   B. Does it help recharge the groundwater supplies? ____________________

8. If all the precipitation runs off this site to the east, what may happen to homes in this area during heavy rains?

____

____

9. If each person uses 62 gallons of water per day, how many people would the water that falls on this area support each year? ____________________

10. List some ways that this water could be saved or ways to encourage groundwater recharge.

ACTIVITY 2.5
THE RAIN CATCHERS

In this long-term activity, students make simple rain gauges and set them outside to measure rainfall over a period of several weeks.

GRADE LEVEL

4-6 (Appropriate for lower grades with some modifications)

MATERIALS

Commercial rain gauges
or
Coffee cans, milk cartons or other straight-sided containers
Standard ruler in English or metric units

PROCEDURE

1. Determine if individual students, or teams of students, will construct and monitor rain gauges.

2. Give each student, or team, a rain gauge and demonstrate its use.

3. Go outside with the class and help them choose collection sites for each rain gauge. Avoid roof overhangs, trees and other obstacles that could interfere with the rainfall.

4. Position each can on, or just above, ground level and support it in some way to keep it upright.

5. Monitor the gauges on a regular basis. Record all rainfall amounts on a class chart.

DISCUSSION

Scientific equipment supply houses offer small, inexpensive rain gauges that are ideal for this activity. However, it's also possible to make rain gauges out of common materials students can bring from home. Any straight-sided container can be used as a rain collector if the diameter of the mouth is the same as the diameter of the container.

One-pound coffee cans are good choices. They have a diameter of nearly four inches and are durable. They can be painted, decorated and calibrated with a depth scale on the inside of the can to make measurements easier to read. However, measuring the depth of the collected water is the greatest problem in any homemade rain gauge.

The simplest approach to measuring the water is to place a ruler into the can and read the depth directly. This is difficult to do, though, when only small amounts of rain are collected from brief showers. For this reason, commercial rain gauges are designed to collect water through a large diameter opening and concentrate it in a small diameter vessel. The depths of small volumes are exaggerated in this way and are thus easier to read on an appropriate scale.

Another way to calculate the depth of water in the can is to measure its volume and then compare it to some known equality. For example, one inch of water in a coffee can with a four inch diameter will have a volume of approximately 200 milliliters (ml). Therefore, a volume of 50 ml would represent a rainfall of 1/4 inch. Using this method, students would have to collect their cans, transfer the water to some measuring container and then convert that volume to inches of depth. Still another way to measure water collected in a common coffee can involves transferring the water to a can of smaller diameter, measuring the depth in the smaller can and then calculating the depth according to the following formula:

$P = H\,(d/D)^2$ where,

P = Depth of precipitation
H = Depth of water in the smaller can
d = Diameter of the smaller can
D = Diameter of the coffee can

Rather than expecting students to complete these calculations, you can complete the ratio within the parentheses for standard containers of your choice and then simply multiply that constant by the depth of water in the smaller can.

As an example, suppose you collect rainfall in a four inch diameter coffee can and pour it into a narrow jar with a diameter of one inch. The calculations would look like this:

$P = H\,(d/D)2$
$P = H\,(1/4)2$
$P = H \times 0.0625$

Now, if the depth of water in the smaller jar was two inches:

$P = 2'' \times 0.0625$
P = 0.125 inch (1/8 inch)

APPLICATION

This activity illustrates the variations in rainfall over a period of time. Students will notice that rainfall amounts vary and that there are often lengthy periods of rainless weather. Over the long term of a year, we can expect rainfall averages to be similar to expected norms; However, variations in rainfall during critical months can lead to water shortages on one hand or floods on another.

The major point is that our water supplies are dependent on unpredictable weather systems. With that in mind, it makes good sense to manage all water resources for the most efficient use.

ACTIVITY 2.6
THE CLOUD MAKER

This demonstration illustrates the formation of "clouds" in a homemade cloud chamber.

GRADE LEVEL

1-9

MATERIALS

Matches
1,000 or 500 ml flask
One-hole stopper
2 inch length of glass tubing to fit stopper
12 to 18 inch length of rubber tubing
(Substitutes for the above items can be found in most homes)

PROCEDURE

1. Carefully insert the glass tubing into the stopper and attach the rubber tubing to the glass.
2. Add 50 to 100 ml of warm water to the flask and insert the stopper and tubing assembly tightly.
3. Swirl the water in the flask to promote evaporation.
4. Decrease the air pressure in the flask by sucking air out through the tube. Hold the tube shut so air cannot re-enter.
5. Hold a lighted match near the end of the tube, blow it out and open the tube so that the smoke is drawn into the flask.
6. Once again, decrease the air pressure by sucking on the tube and your cloud will appear.

DISCUSSION

The haze formed in the flask is not always dramatic. You might find it easier to see if you gently inhale and exhale repeatedly. The "cloud" will appear and disappear with each change in air pressure.

APPLICATION

Three physical properties are required for the formation of clouds: moisture, low air pressure and condensation nuclei. In our flask we can control the air pressure by withdrawing air through the tube. The smoke provides the condensation nuclei (very small particles of dust present in the atmosphere) which provides a surface on which water vapor can condense.

The formation of clouds in our natural environment is not as simple because of the many physical properties which effect the necessary combination of moisture, air pressure and condensation nuclei. However, this exercise does illustrate the fundamentals of cloud formation.

ACTIVITY 2.7
PIRATES

Students will become familiar with components of the water cycle by using a word association.

GRADE LEVEL

4-6 (Appropriate for other levels with modifications.)

MATERIALS

Student Worksheet 2.7
Pencils

PROCEDURE

1. Discuss the water cycle to familiarize the students with the terms used in the worksheet.
2. Distribute Worksheet 2.7.
3. Allow students time to work alone and assist where necessary.
4. Review the answers to the worksheet.

DISCUSSION

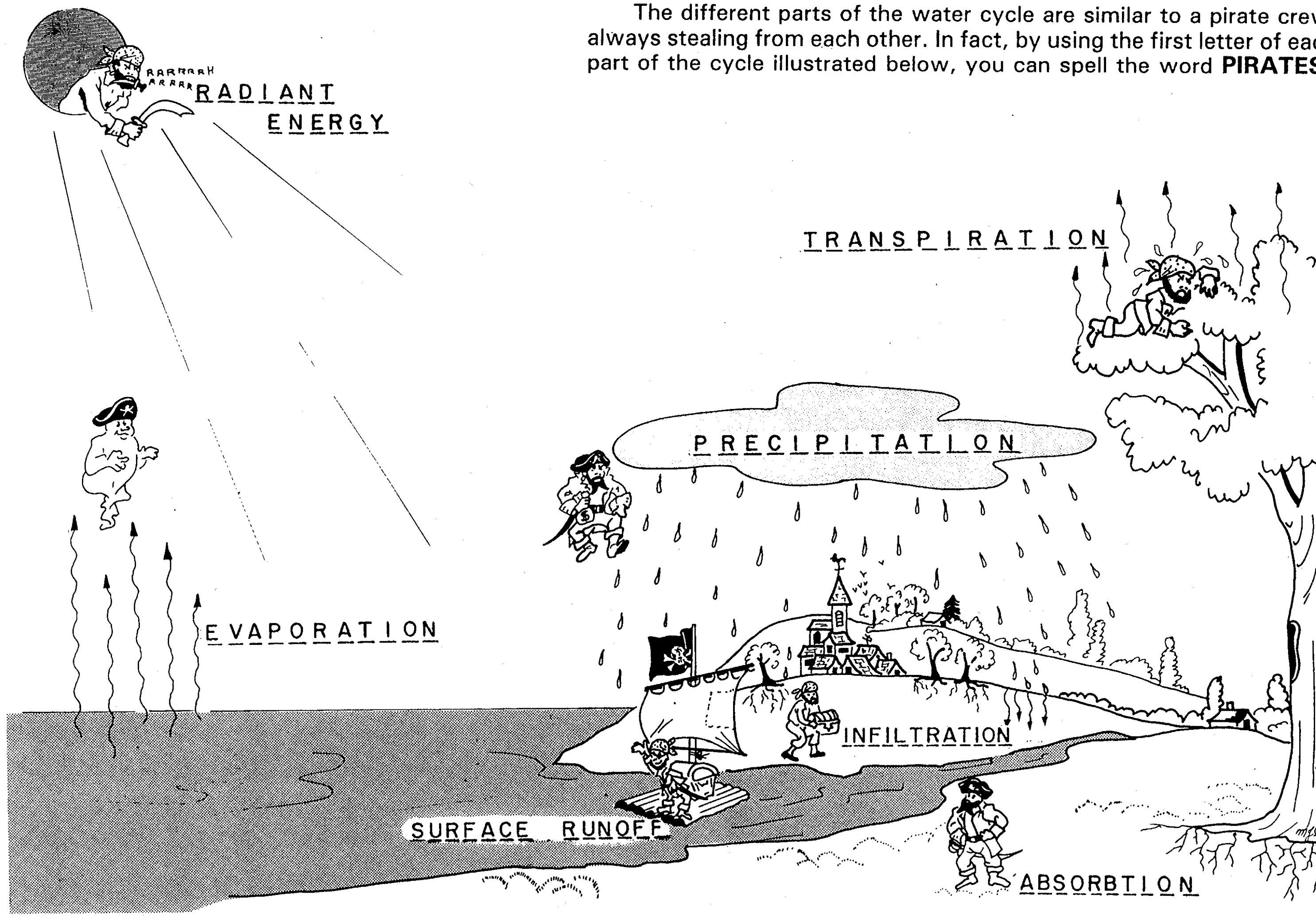
This is a good activity to stress the differences between these water cycle terms. Many students may or may not realize what happens to the water once it rains; they may not recognize the water cycle as an ongoing, continuous process having no real beginning or end.

APPLICATION

This activity can easily be adapted to younger students by filling in the blank spaces on the worksheet with all consonants or all vowels depending on the age level.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 2.7
WATER CYCLE PIRATES

The different parts of the water cycle are similar to a pirate crew, always stealing from each other. In fact, by using the first letter of each part of the cycle illustrated below, you can spell the word **PIRATES!**

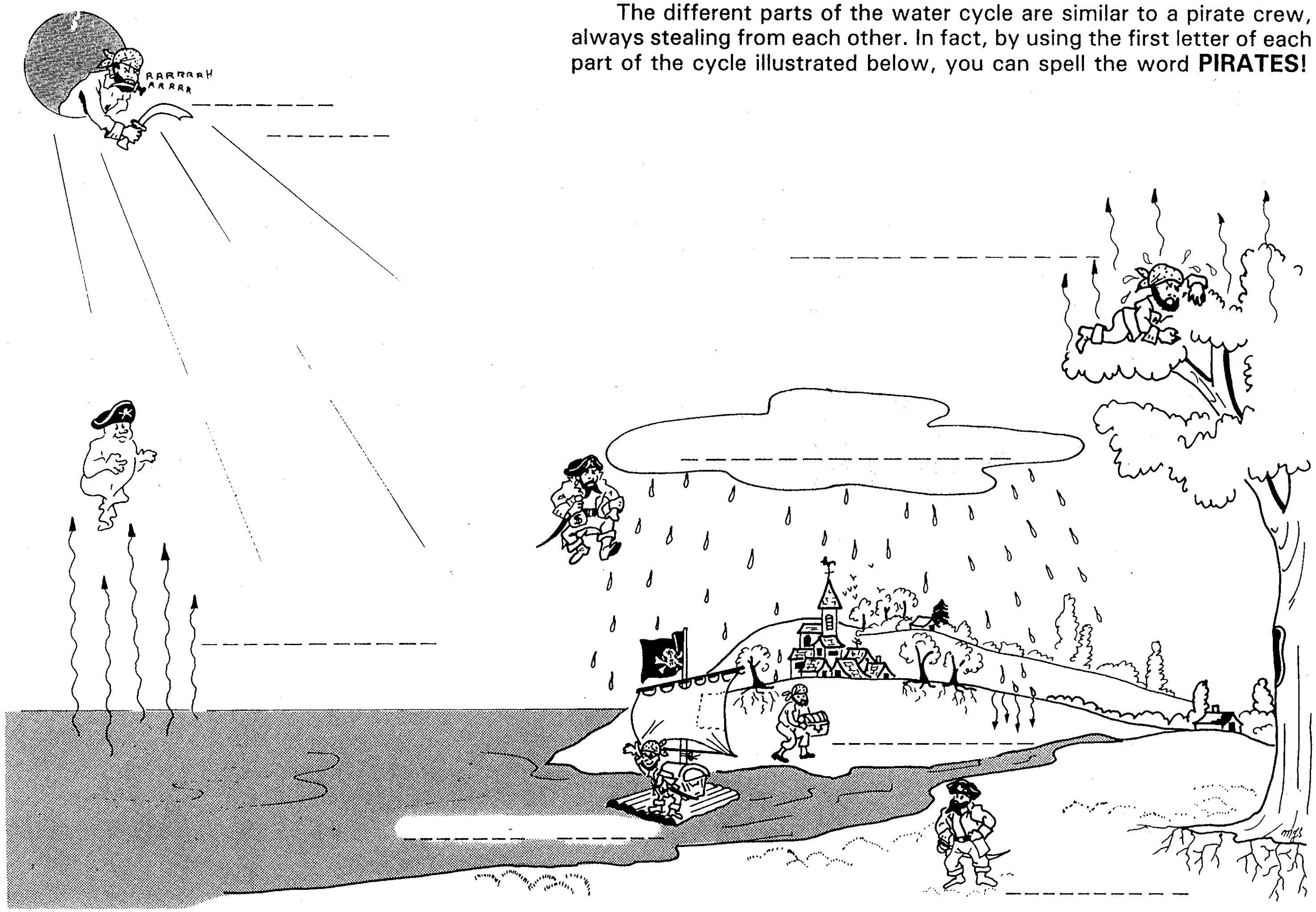


STUDENT WORKSHEET 2.7

WATER CYCLE PIRATES

Name ____________________

The different parts of the water cycle are similar to a pirate crew, always stealing from each other. In fact, by using the first letter of each part of the cycle illustrated below, you can spell the word **PIRATES!**



SECTION 3
SOURCES OF WATER ON THE EARTH

CONCEPT

The earth has several large sources of stored water, although most of the water from those sources is not usable by humans.

TEACHER BACKGROUND

A visitor approaching the earth from space would certainly believe this to be a water planet. About 71 percent of the earth's surface is covered with water. In fact, there's so much water that, if the earth's surface were perfectly smooth, water would completely flood the entire surface to a depth of 800 feet.

Where is this water? Is it all in the oceans? How important is the water frozen at the poles?

Estimates vary somewhat, but usually authorities believe 97 percent of the earth's total water supply is in the oceans. This is salty and cannot be used for most purposes. The remaining 3 percent is fresh water. Although only 3 percent, this is still a tremendous supply and more than enough to satisfy our demands if it could be distributed appropriately.

Let's now look at just the fresh water. Where is it located? Approximately 75 percent of the fresh water is frozen as glacial ice and permanent snow in the polar areas. Some of this breaks off in huge chunks (icebergs, floes) and melts as it floats into warmer ocean water. However, for practical purposes, this frozen water is not usable by man.

The second largest supply of fresh water is under our feet. About 24 percent of the world's fresh water is found as groundwater in the soil and rock formations.

Groundwater supplies are very important in many areas of the world, and scientists are now concerned about the rate at which water is being pumped from our groundwater resources. In some areas, we are withdrawing groundwater faster than it can naturally recharge. Therefore, our supplies are gradually being depleted due to our increasing demands.

If you've been adding percentages, you noticed that polar ice and groundwater account for 99 percent of our fresh water supply. All the water in lakes, rivers, the atmosphere and living bodies account for less than one percent of the total.

Actual numbers vary somewhat from one authority to another, but the following list will give a fair approximation of our water resources:

EARTH'S WATER SUPPLY

Salt water	317,000,000	cubic miles
Fresh water		
Polar ice	7,000,000	
Groundwater	2,000,000	
Rivers and streams	30,000	
Soil moisture	16,000	
Atmosphere	3,000	
Total	326,049,000	cubic miles

The important concept here is that the water problems we experience are not totally due to a lack of sufficient fresh water but, rather, to the geographical and seasonal distribution of water as well as increases in usage. In 1900, when the Commonwealth's population was about 6 million people, the average water consumption was just 5 gallons per person per day. Today, with the population approaching 12 million people, the average consumption in the Commonwealth is about 62 gallons per person per day.

The water cycle constantly circulates water throughout the system. What we use today was used before and will be used again tomorrow.

DISCUSSION

The last millimeter (i.e., 999 to 1,000 mm) will be no wider than the line drawn at the 1,000 mm mark. Emphasize this line with a colored marker.

If you would rather do this activity in the more familiar English units, use the following measurements:

0 to 35 inches	=	Ocean water
35 to 35.75 inches	=	Polar ice
35.75 to 35.99 inches	=	Underground water
35.99 to 36 inches	=	Other fresh water

Again, the last quantity will be represented by only a line at the end of the water column.

APPLICATION

Most of the earth's water is saline and not usable for domestic, personal or industrial purposes. However, salt water could be de-salted and polar icebergs could be towed to warmwater harbors and melted into fresh water. Both are expensive processes and are not feasible for economic reasons at this time.

A more reasonable alternative is to understand the water cycle as it applies to each geographic region and to manage existing water supplies for the most efficient use of all the water we have. That management strategy includes water conservation methods to prevent the waste of water, especially during drought events.

ACTIVITY 3.1
THE WATER LINE

Students use adding machine paper to illustrate the supplies of water on the earth.

GRADE LEVEL

4-6

MATERIALS

Meter sticks
Adding machine paper
Colored pencils, crayons or markers

PROCEDURE

1. Give each student a piece of adding machine paper at least 1,000 mm long.

2. Ask each student to use a meter stick to measure 1,000 mm on the paper strip and to mark this length with two lines.

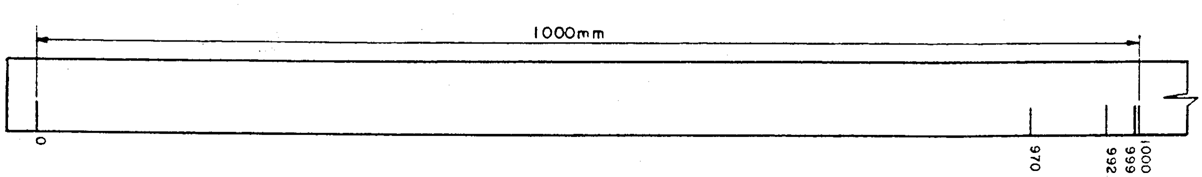
3. Label the line on the left "0" and the one on the right "1000".

4. Now ask the students to draw additional lines at the following points: 970 mm, 992 mm, 999 mm.

5. After the lines are drawn, have the students color and label each space to represent the different major sources of the earth's water:

0 to 970 mm	=	Ocean water
970 mm to 992 mm	=	Polar ice fresh water
992 mm to 999 mm	=	Underground fresh water
999 mm to 1,000 mm	=	Fresh water in lakes, rivers and atmosphere

THE WATER LINE



DISCUSSION

The last millimeter (i.e., 999 to 1,000 mm) will be no wider than the line drawn at the 1,000 mm mark. Emphasize this line with a colored marker.

If you would rather do this activity in the more familiar English units, use the following measurements:

0 to 35 inches	=	Ocean water
35 to 35.75 inches	=	Polar ice
35/75 to 35.99 inches	=	Underground water
35.99 to 36 inches	=	Other fresh water

Again, the last quantity will be represented by only a line at the end of the water column.

APPLICATION

Most of the earth's water is saline and not usable for domestic, personal, or industrial purposes. However, salt water could be de-salted and polar icebergs could be towed to warm-water harbors and melted into fresh water. Both are expensive processes and are not feasible for economic reasons at this time.

A more reasonable alternative is to understand the water cycle as it applies to each geographic region and to manage existing water supplies for the most efficient use of all the water we have. That management strategy includes water conservation methods to prevent the waste of water, especially during drought events.

ACTIVITY 3.2
WHERE IS ALL THE EARTH'S WATER?

In this activity, primary students will identify the many sources of water on the earth's surface,

GRADE LEVEL

K-3

MATERIALS

Worksheet 3.2

PROCEDURE

1. Use the worksheet to help students connect the words to the appropriate picture.

2. Ask the students to think of another source of water not pictured here and draw it in the empty box.

3. Have students color the pictures when all connections are made.

DISCUSSION

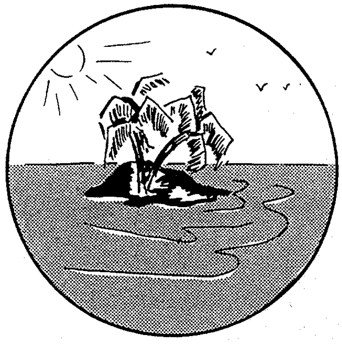
Depending upon the ability of your students, continue this lesson by asking students where they believe most of their water comes from. Some of them will probably guess it comes from the ocean; others will be likely to guess almost any of the sources pictured. Most of them will just say it comes out of the faucet! Getting them to know there is a source behind that faucet is a major step at this age level.

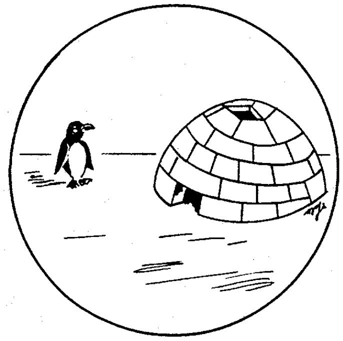
APPLICATION

If your school has a well on the property, take a short walk to the well cover and tell the youngster that the school's water comes from deep underground at that point. You probably won't be able to see very much but pointing to almost any visible part of the system will help them to understand that the water inside the building comes from an outside source. Inside the building, you can trace some of the incoming water lines and perhaps find a water meter.

STUDENT WORKSHEET 3.2
WHERE IS ALL THE EARTH'S WATER?

Name ____________________





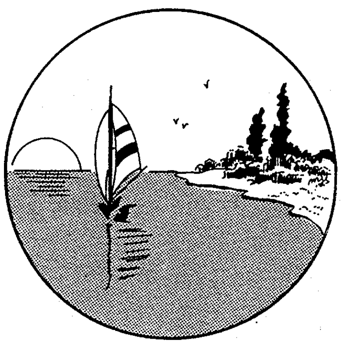
RIVERS

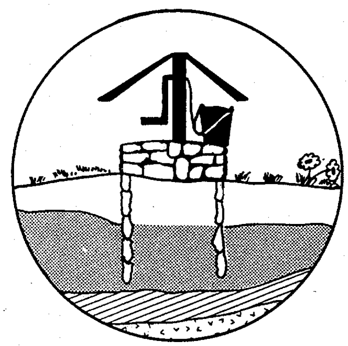
UNDERGROUND

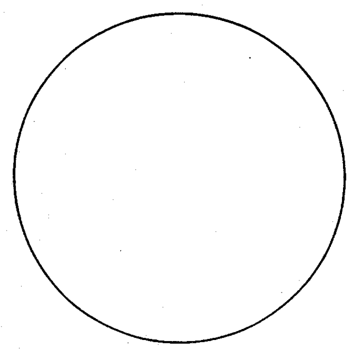
LAKES

OCEANS

POLAR ICE







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STUDENT WORKSHEET 3.3
WORD FIND

Directions

Locate the following water words in the word puzzle:
CREEK, ICE, LAKE, OCEAN, POND, RAIN, RIVER, SLEET, SPRING, SNOW, STREAM, WELL.

A	D	H	L	P	S	T	X	B	W
L	T	R	U	X	C	L	A	K	E
G	S	N	O	W	R	Q	E	T	L
F	T	A	H	C	E	U	G	E	L
C	R	S	T	R	E	A	M	W	T
M	Q	P	R	I	K	A	V	U	T
V	N	R	F	V	P	E	N	M	P
R	E	I	C	E	Y	O	K	B	I
Z	O	N	L	R	A	I	N	F	C
A	M	G	Y	K	D	W	P	D	G

STUDENT WORKSHEET 3.3
WORD FIND

Name ___________________________

Directions

Locate the following water words in the word puzzle:
CREEK, ICE, LAKE, OCEAN, POND, RAIN, RIVER, SLEET, SPRING, SNOW, STREAM, WELL.

A	D	H	L	P	S	T	X	B	W
L	T	R	U	X	C	L	A	K	E
G	S	N	O	W	R	Q	E	T	L
F	T	A	H	C	E	U	G	E	L
C	R	S	T	R	E	A	M	W	T
M	Q	P	R	I	K	A	V	U	T
V	N	R	F	V	P	E	N	M	P
R	E	I	C	E	Y	O	K	B	I
Z	O	N	L	R	A	I	N	F	C
A	M	G	Y	K	D	W	P	D	G

SECTION 4
THE UNEQUAL DISTRIBUTION OF PRECIPITATION

CONCEPT

Because of its movement through the water cycle, water is not uniformly distributed, or constantly available, in all geographic areas.

TEACHER BACKGROUND

One of the comforting aspects of the water cycle is that it seems to tell us we will always have a continuous supply of water carried to us from the vast oceans. When we use simple, generalized models (as we often must with young people) we run the risk of implying ideas that are simply not true.

The water cycle is not a fair water distributor. Some areas of the earth's surface receive enormous amounts of precipitation while others receive scarcely any.

Perhaps the rainiest spot on earth is Cherrapunji, India, where the usual rainfall for the year is over 400 inches. Cherrapunji holds the all-time record for the greatest annual rainfall of 1,041 inches of rain in the mid-1800's. To get an idea of that amount of water, remember that Pennsylvania gets about 40 inches of precipitation each year!

The driest places are hot deserts. Annual rainfalls of less than 10 inches are common. Yuma, Arizona, receives about 3 inches each year, Khartoum, Sudan, receives 6 inches and Lima, Peru, gets less than 2 inches. Still other desert areas receive no rain at all-or at least in almost negligible amounts. One town in Chili's northern desert received no rain for four years. During the fifth year, a passing shower gave the town a half inch of rain.

Even more important than the annual amount of precipitation is its distribution throughout the year. Monsoon regions receive huge amounts of water during their rainy season but very little rain through the remainder of the year.

In our own mid-western prairie states, rainfall averages about 18 inches each year. This would be insufficient to grow most crops if it were spread equally throughout the year. Fortunately, the heaviest rainfall occurs during the growing season which enables the area to enjoy a strong agricultural economy.

Still another interesting point is that not all rainfall is equally important to water supplies. For example, summer rains in Pennsylvania contribute little to groundwater supplies because so much is absorbed by plants at that time of the year. It is the winter, spring, and fall precipitation that recharges our water resources and builds the supplies we use.

The main point of the activities that follow is that precipitation varies in amounts at different places and at different times. Where that happens, and when the demand for water is constant, some form of water management is necessary to provide adequate water supplies all year.

ACTIVITY 4.1
WET PLACES/DRY PLACES

Students compare precipitation data for several cities around the United States to demonstrate the unequal distribution of water.

GRADE LEVEL

4-6

MATERIALS

Worksheet 4.1

PROCEDURE

1. Distribute copies of Worksheet 4.1

2. Explain how to use the data and the scale to plot a histogram showing precipitation at each location.

3. Allow time for independent work, then review their work together.

4. Students could also color the bars to accent the differences.

DISCUSSION

You might mention some of the really outstanding examples of great and small rainfall amounts. Refer to the Teacher's Background information for several examples. Those cities were not included in this activity because of difficulties they would pose in graphing.

APPLICATION

The major point of this activity is to stress the fact that the water cycle does not distribute water equally over the earth's surface. Some places receive much water; others receive very little. Everyone must develop good water management plans in order to use the water they have most efficiently.

Here are some interesting precipitation facts about Pennsylvania:

- The greatest amount of rainfall in one 24-hour period occurred on July 17, 1942 when 34.5 inches of rain fell at Smethport in McKean County.

- The greatest total annual precipitation occurred in 1952 at Mt. Pocono, Monroe County, when 81.64 inches of precipitation was recorded.

- The least annual precipitation occurred in 1965 at Breezewood, Bedford County when only 15.71 inches of precipitation was recorded.

- Here is a trick question for the students. Where did the least amount of precipitation fall in any 24-hour period in Pennsylvania? Answer-0.0 inches, everywhere or anywhere.

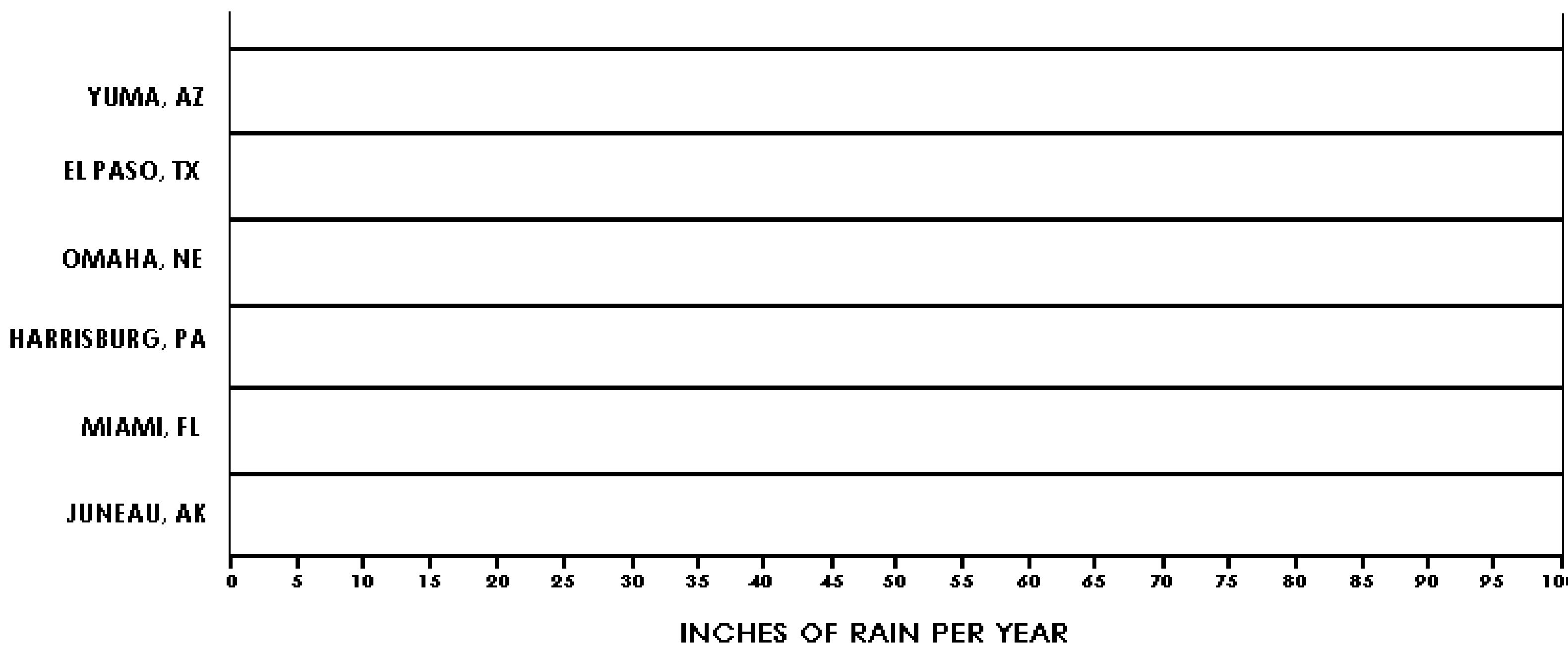
STUDENT WORKSHEET 4.1
WET PLACES/DRY PLACES

Name ______________________

NOT EVERY PLACE ON EARTH RECEIVES THE SAME AMOUNT OF PRECIPITATION. USE THE FOLLOWING DATA TO CONSTRUCT A HISTOGRAM THAT REPRESENTS THE RAINFALL AMOUNTS:

INCHES OF RAIN EACH YEAR

YUMA, AZ 3	HARRISBURG, PA 39
EL PASO, TX 9	MIAMI, FL 59
OMAHA, NE 25	JUNEAU, AK 83



ACTIVITY 4.2
WET MONTHS/DRY MONTHS

Because of unpredictable weather patterns, water is not uniformly distributed or constantly available, in all geographic areas.

GRADE LEVEL

6-9

MATERIALS

Worksheet 4.2

PROCEDURE

1. Distribute Worksheet 4.2

2. Explain how to use the data table to answer the questions.

3. Allow time for students to work independently, then review their work with them.

4. Answers:
   - Question 1. Miami
   - Question 2. Los Angeles
   - Question 3. Seattle
   - Question 4. Springfield
   - Question 5. Miami
   - Question 6. Los Angeles
   - Question 7. Seattle
   - Question 8. Miami
   - Question 9. New York

DISCUSSION

Monthly precipitation information can be obtained at your local library or weather station. Also, many newspapers provide monthly totals in their weather summaries that can be extremely useful for many classroom activities.

A useful extension of this activity would be to have students graph the data as a histogram. The variation in monthly precipitation will be even more obvious in graph form.

APPLICATION

Precipitation is not equally distributed over the earth's surface. Some areas receive much; others receive little. The annual rainfall in one place maybe evenly distributed throughout the year or may be concentrated in only a few months.

Water management obviously has to work to provide adequate water during all seasons. During periods of ample water, some methods have to be used to store some of that supply for the drier months of the year. As we will also see, just as the water supply varies, so does the water demand. When demand is high and supplies are low we may have serious water problems.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 4.2
WET MONTHS/DRY MONTHS

The following table gives the average precipitation for each month at several cities in the United States. Use this information to answer the questions below:

Annual Precipitation Distribution

Month	**Los Angeles CA**	**Miami FL**	**New York NY**	**Springfield IL**	**Seattle WA**
January	2.40	2.01	3.42	.74	5.38
February	2.51	2.08	3.27	.77	3.99
March	1.98	2.39	4.08	2.04	3.54
April	.72	2.85	4.20	2.66	2.33
May	.14	6.21	4.42	4.52	1.70
June	.03	9.33	3.67	3.87	1.50
July	.01	5.70	4.35	3.51	.76
August	.15	7.58	4.01	3.24	1.14
September	.31	7.63	3.89	3.72	1.88
October	.34	5.64	3.56	3.28	3.23
November	1.76	2.66	4.47	1.49	5.83
December	1.66	1.83	3.91	1.02	5.91
Totals	12.01	55.91	47.25	29.86	37.19
Ave.	1.00	4.65	3.93	2.48	3.09

Summer	June 20 - October 22
Fall	October 23 - December 21
Winter	December 22 - March 19
Spring	March 20 - June 19

Questions

1. Which city receives the most precipitation each year? Miami
2. Which city receives the least precipitation each year? Los Angeles
3. Which city receives most of its rain during the winter months? Seattle
4. Which city receives the least amount of rain during the winter months? Springfield
5. Which city receives most of its rain during the spring month? Miami
6. Which city receives the least amount of rain during the spring month? Los Angeles
7. Which city receives most of its rain during fall months? Seattle
8. Which city receives most of its rain during the summer months? Miami
9. Which city has the least variation from its monthly average precipitation? New York

STUDENT WORKSHEET 4.2
WET MONTHS/DRY MONTHS

Name ___________________________

The following table gives the average precipitation for each month at several cities in the United States. Use this information to answer the questions below:

Annual Precipitation Distribution

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August	.15	7.58	4.01	3.24	1.14
September	.31	7.63	3.89	3.72	1.88
October	.34	5.64	3.56	3.28	3.23
November	1.76	2.66	4.47	1.49	5.83
December	1.66	1.83	3.91	1.02	5.91
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Ave.	1.00	4.65	3.93	2.48	3.09

Summer	June 20 - October 22
Fall	October 23 - December 21
Winter	December 22 - March 19
Spring	March 20 - June 19

Questions

1. Which city receives the most precipitation each year? _______________
2. Which city receives the least precipitation each year? _______________
3. Which city receives most of its rain during the winter months? _______________
4. Which city receives the least amount of rain during the winter months? _______________
5. Which city receives most of its rain during the spring month? _______________
6. Which city receives the least amount of rain during the spring month? _______________
7. Which city receives most of its rain during fall months? _______________
8. Which city receives most of its rain during the summer months? _______________
9. Which city has the least variation from its monthly average precipitation? _______________

ACTIVITY 4.3
SHORTAGES AND SHORTAGES

Students examine precipitation data to learn that the seasonal distribution of rainfall is as important as total rainfall.

GRADE LEVEL

6-9 (Appropriate for other levels with modifications)

MATERIALS

Worksheet 4.3

PROCEDURE

1. Distribute Worksheet 4.3.
2. If necessary, help students work through the questions to complete the assignment.

DISCUSSION

The questions should guide students to add the columns of data and then to add rainfall amounts for the individual questions.

This exercise demonstrates that although total yearly precipitation may be near normal, water supply problems may still exist due to the distribution of that precipitation.

APPLICATION

This exercise stresses that the continued replenishment of our water supply depends on the water cycle, especially regular precipitation. However, it is important that the students understand that precipitation in all its forms varies constantly. This variation may result in long periods of little precipitation and drought conditions or short periods of excess precipitation and flood situations. Ideally, we would like to receive between 3 and 4 inches of precipitation evenly distributed each month.

The even distribution of precipitation throughout the year is especially important. Autumn, winter and early spring precipitation is very important because it recharges our groundwater and surface water resources. Almost all of the precipitation which falls during the late spring and summer either evaporates into the atmosphere or is used by trees, grasses and other vegetative cover and, therefore, does little to augment our usable water supplies.

The consequences of wide variations in seasonal precipitation have been observed many times in recent history. In Central Pennsylvania in 1983, we had ample water supplies. However, because of a 12-week period of little precipitation during the summer, we experienced a summer drought which adversely affected our farming industry. In the eastern portion of the Commonwealth, during 1984 and 1985, we received less than normal amounts of precipitation during the autumn, winter and spring. Water supplies were significantly reduced and mandatory water conservation measures were implemented. Monthly precipitation totals returned to almost normal conditions during the summer, but this did little to augment the water supplies. Although we had green lawns and healthy farms, we were still in the midst of a severe water supply drought. Mandatory water restrictions stayed in effect until the end of the growing season when normal rainfall once again recharged our groundwater and surface water supplies.

Other significant droughts in Pennsylvania occurred in the years 1988 and 1989 and from 1991 to 1993. On July 7, 1988 a drought watch, the least serious of the three drought stages, was issued for all of Pennsylvania's 67 counties. One month later on August 24, 1988 the drought watch was increased to a drought warning, the second most serious of the three drought stages, for 42 of the 67 counties with the remaining 25 counties still in drought watch. The drought began to lessen on December 12, 1988 with only seven counties in drought warning and 35 in drought watch. However, by March 3, 1989 the drought had spread eastward with all of the 14 counties in the Delaware River Basin placed under drought warning while 35 other counties continued under drought watch. The spring rains adequately recharged the groundwater aquifers and surface water sources so that by May 15, 1989 the drought was declared to be over with all counties returning to their normal status.

The second and most lengthy of the recent droughts began on June 28, 1991 when 33 counties were placed under drought warning. One month later on July 24, 1991 a drought emergency, the most serious of the three stage drought status, was declared for 39 counties in the Commonwealth. From September 13, 1991 to January 16, 1992 the drought emergency status declined from 55 to 44 counties. In the spring all counties were downgraded to drought warning on April 19, 1992. By early summer, June 23, 1992, only 20 counties remained in drought warning. However, it was not until January 15, 1993 that the final 16 counties in drought watch were declared to be in normal status making the 1991-1993 drought one of the longest in the history of the Commonwealth.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 4.3
SHORTAGES AND SHORTAGES

The monthly distribution of our total annual precipitation is very important. The table below shows monthly precipitation distribution for a fictitious town in Pennsylvania. The first column of the table gives average monthly precipitation for the previous 30 years. The second and third columns give monthly precipitation totals for 1996 and 1998.

Pennsylvania experienced water shortages during both years. However, the problems were not the same and did not affect all Pennsylvanians in the same way. During one year, there was a serious agricultural drought when many acres of crops were lost due to a lack of rain. During the other year, there was a severe water supply shortage and many people were required to conserve water.

Your assignment is to identify which year had the agricultural drought and which had the water supply shortage. The questions that follow will help you examine the data and reach a conclusion.

Month	**30-year Average**	**1996**	**1998**
January	2.8	3.9	1.2
February	2.5	4.2	1.7
March	3.6	4.8	1.3
April	3.3	4.2	1.6
May	3.6	1.1	2.0
June	3.9	1.8	3.8
July	3.4	0.7	4.0
August	3.3	2.2	3.9
September	3.5	3.1	3.6
October	2.8	4.7	4.8
November	3.1	4.1	6.5
December	3.1	5.3	4.4
Totals	38.9	40.1	38.8

Questions

1. What is the annual precipitation for:

   A. 30-year average? 38.9

   B. 1996? 40.1

   C. 1998? 38.8

2. Both years experienced some form of water shortage. Was the annual precipitation lower during 1996 and 1998 than the 30-year average precipitation?

   No, 1998's annual precipitation was lower than 30-year average, but 1996's annual precipitation was actually higher.

3. Water supplies are recharged mainly by winter, early spring and fall precipitation. Summer rains, when plants are actively growing, are absorbed by plant roots and relatively little water gets into our water supplies. Which year had the least rainfall during the period of January to June? 1998

4. Which year had the least rainfall during the summer growing period (May to August)? 1996

5. Which year had the agricultural drought? 1996

6. Which year had the water supply drought? 1998

STUDENT WORKSHEET 4.3
SHORTAGES AND SHORTAGES

Name ____________________

The monthly distribution of our total annual precipitation is very important. The table below shows monthly precipitation distribution for a fictitious town in Pennsylvania. The first column of the table gives average monthly precipitation for the previous 30 years. The second and third columns give monthly precipitation totals for 1996 and 1998.

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Your assignment is to identify which year had the agricultural drought and which had the water supply shortage. The questions that follow will help you examine the data and reach a conclusion.

Month	30-year Average	1996	1998
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July	3.4	0.7	4.0
August	3.3	2.2	3.9
September	3.5	3.1	3.6
October	2.8	4.7	4.8
November	3.1	4.1	6.5
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Questions

1. What is the annual precipitation for:

   A. 30-year average?

   B. 1996?

   C. 1998?

2. Both years experienced some form of water shortage. Was the annual precipitation lower during 1996 and 1998 than the 30-year average precipitation?

3. Water supplies are recharged mainly by winter, early spring and fall precipitation. Summer rains, when plants are actively growing, are absorbed by plant roots and relatively little water gets into our water supplies. Which year had the least rainfall during the period of January to June?

4. Which year had the least rainfall during the summer growing period (May to August)?

5. Which year had the agricultural drought?

6. Which year had the water supply drought?

SECTION 5
WATER MANAGEMENT

CONCEPT

Sound water management is important all the time, especially in areas where supplies may be limited due to drought situations or excessive demands on the resource.

TEACHER BACKGROUND

Generally, Pennsylvania is considered water rich. However, due to the increasing population and demand for water, we are now facing water supply problems in many areas of the state. Sound water management programs must include the allocation of water as well as the conservation of the resource.

Local and state agencies responsible for the management of water resources use various strategies to ensure that existing supplies are sufficient to meet our needs. Advance planning allows water resource managers to implement water conservation measures before water supplies reach critical levels.

RESERVOIRS

The obvious function of a reservoir is to store water. However, the reason for storing that water may be to reduce floodwaters, provide a source of water for public and private use, to augment stream flows during dry periods, to generate power or to provide recreation.

If a dam was constructed to control floods, the water level is generally lowered before anticipated high streamflows to provide storage for water which previously would have flooded homes and other property. Although floods still occur, this type of water management greatly reduces the impact of these events.

There are many small reservoirs throughout the Commonwealth which were constructed to provide a water resource for communities. These reservoirs fill with melting snow and rain during the spring and provide water throughout the summer when the demand for water is at its peak.

Some reservoirs, such as Blue Marsh Reservoir in Berks County and Beltsville Reservoir in Lehigh County, were constructed to augment streamflows. When the streamflow on the Delaware River reaches a critical level, water from these and other reservoirs is released to maintain a streamflow sufficient enough to keep the salt water in the Delaware Bay from intruding up the Delaware River. This is an important management strategy because without this flow augmentation procedure, salt water could very possibly move upstream to the point where the City of Philadelphia withdraws fresh water for its water supply. In severe situations, the salt water could possibly intrude groundwater resources and make them unusable.

Hydropower dams are constructed to generate electricity for our businesses and communities.

Reservoirs have many side benefits. They provide recreation such as boating, swimming, fishing and areas for picnicking and of scenic beauty. However, reservoirs are very expensive to construct and flood large tracts of land, and sometimes small communities, so they are not generally constructed without serious economic and environmental consequences.

INTERBASIN TRANSFER

The interbasin transfer of water involves pumping water from one watershed to another. New York City, for example, withdraws water from reservoirs located at the headwaters of the Delaware River. This transfer does not usually present a problem. However, during periods of less than normal precipitation, water planners must carefully balance the amount of water withdrawn by New York City and the amount of water released to the Delaware River to ensure that everyone has sufficient water supplies.

WATER CONSERVATION

Water conservation is probably the least expensive and most practical method of effectively using our available water supply. Water conservation does not require us to live without water, but it does require better water management.

There are new low-flow water conserving devices for showers, faucets and toilets as well as water conserving clothes washers and dishwashers. Businessmen and managers are now implementing water recycling programs in industry and large water using facilities. These measures are usually inexpensive and ultimately reduce operating costs when implemented. Better methods of irrigation not only help the farmer produce higher crop yields, but also conserve water.

The management of water is not an exact science, and a balance between the utilization of reservoirs, wells, interbasin transfers, water use and water conservation must be attained. We must remember that we all should bear the burden of reduced water supplies as well as enjoy the benefits when water is plentiful.

ACTIVITY 5.1
WATERSHED EXERCISE

Students will study the concept of watersheds and the relationship between upstream and downstream areas.

GRADE LEVEL

7-9

MATERIALS

Worksheet 5.1

Maps 5a-5f

PROCEDURE

Watershed-A part of the surface of the earth that is occupied by a drainage system which consists of a lake or river together with all tributary surface streams and bodies of water.

This activity will illustrate the concept of watersheds at the local or regional level. It illustrates that precipitation failing within a small area may ultimately end up thousands of miles apart via the various water courses into which the water flows. This activity will also lead into other activities which illustrate that the competing uses of water between upstream and downstream areas are interrelated.

Ideally, watersheds are delineated by plotting the highest points between streams and rivers on "contour" or topographic maps. For this watershed delineation exercise, we will use a stream map. By using a stream map, we can still approximate a watershed boundary by simply looking at a stream and its tributaries without having to explain the principles of reading topographic maps. For more exact watershed boundaries, a topographic map must be used.

The unique aspect of this exercise is that parts of three major watersheds, or river basins are represented on the watershed exercise map, the Genesee, the Ohio and Susquehanna River Basins. The Instructor's Copy of the Student Worksheet 5.1 map shows the watershed boundaries. Because of space limitations, we cannot show the major rivers, but we can still arrive at the watershed boundaries by providing the following information:

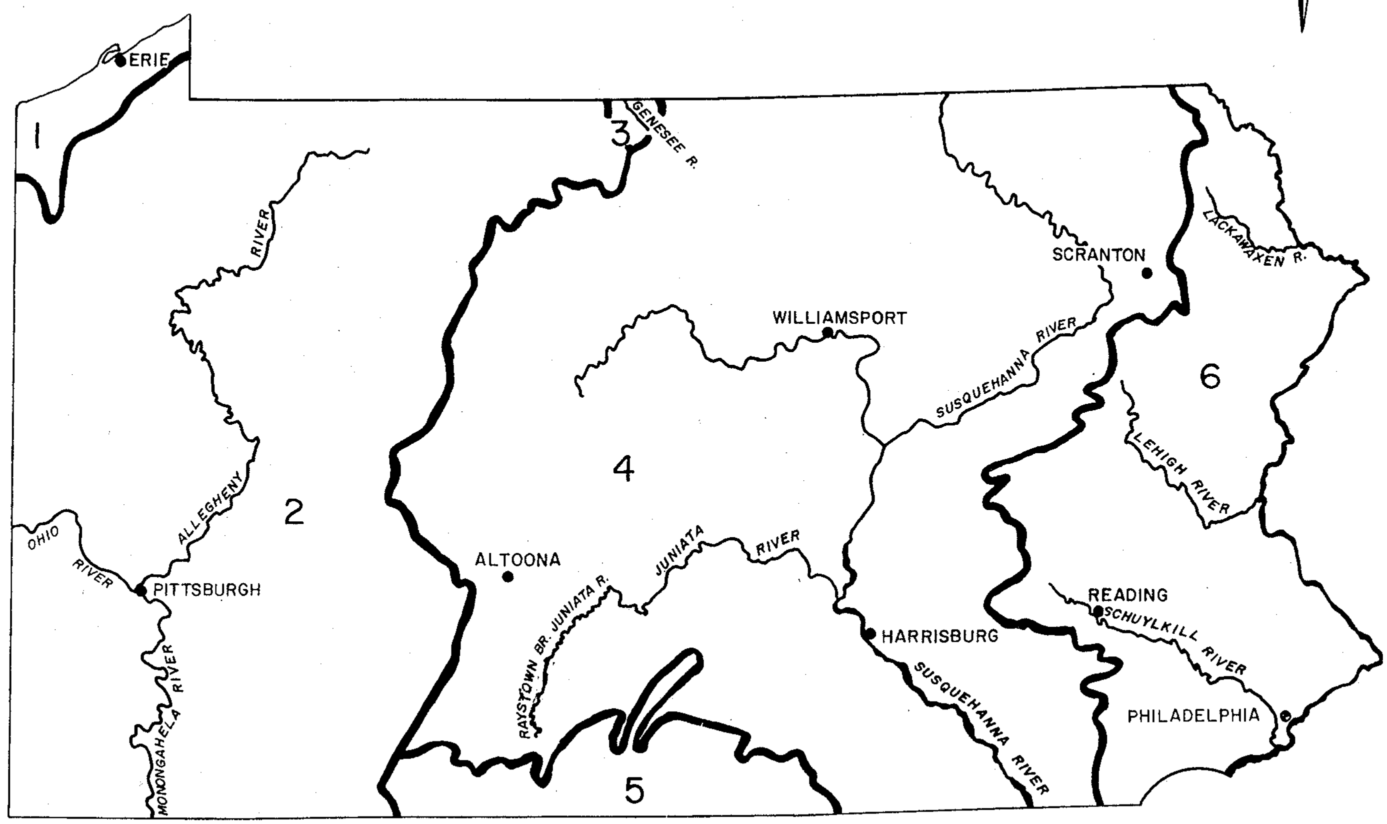
1. The Oswayo and Allegheny Rivers are tributaries in the Ohio River Basin. The Ohio River flows into the Mississippi River which ultimately flows into the Gulf of Mexico.

2. The Genesee River flows north to Lake Ontario which flows into the St. Lawrence River which flows into the Gulf of St. Lawrence and ultimately to the North Atlantic Ocean.

3. Sinnemahoning, Kettle and Pine Creeks and the Cowanesque River are all tributaries in the Susquehanna River Basin. The Susquehanna River flows into the Chesapeake Bay and ultimately to the Atlantic Ocean.

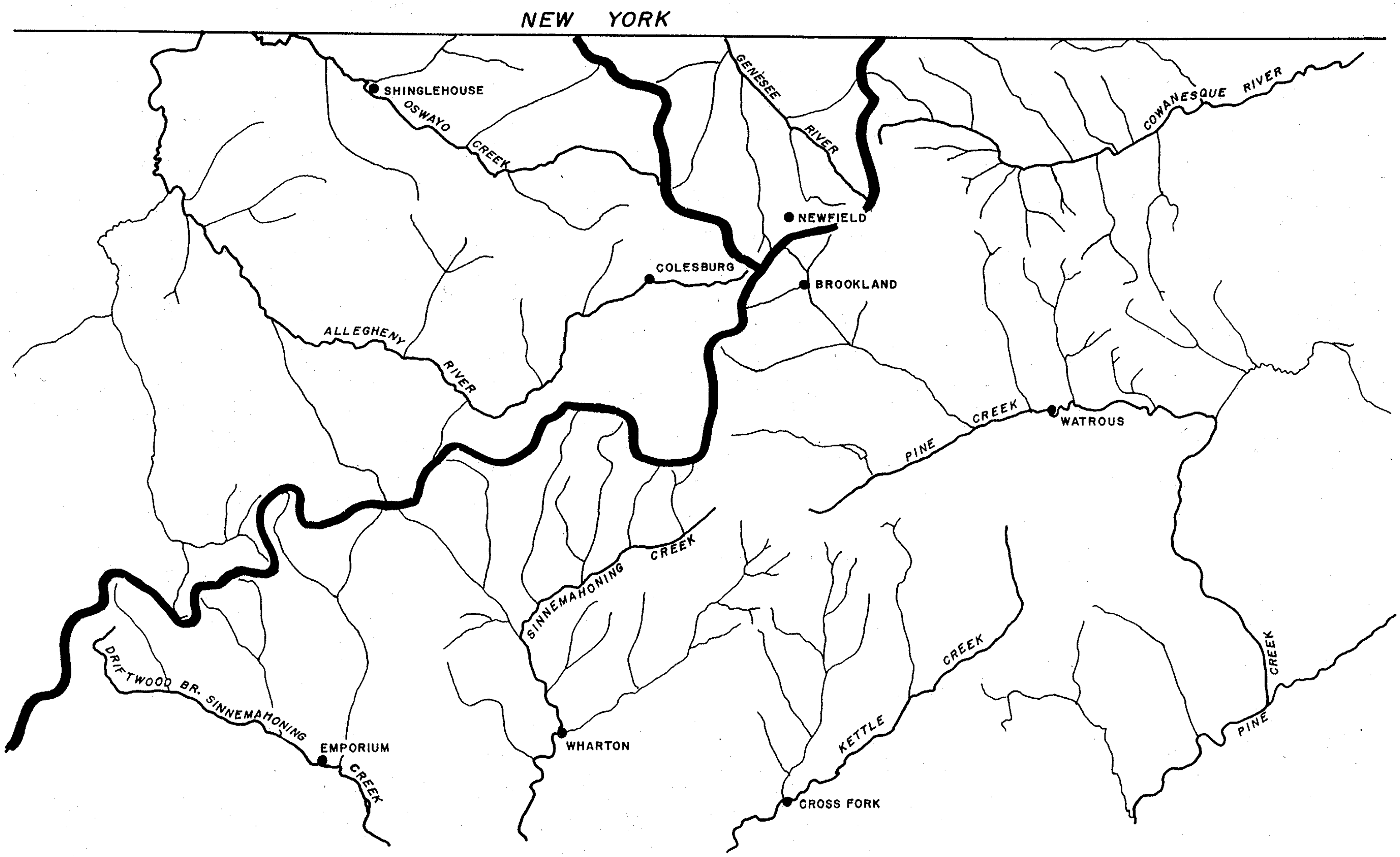
Remember that a watershed boundary can never cross a natural stream or tributary and watershed boundaries cannot cross each other.

Map 5a
MAJOR WATERSHEDS IN PENNSYLVANIA



	NAME	AREA		NAME	AREA
1.	LAKE ERIE	509 sq.m.	4.	SUSQUEHANNA RIVER BASIN	20,926 sq. m.
2.	OHIO RIVER BASIN	15,442 sq. m.	5.	POTAMAC RIVER BASIN	1,582 sq. m.
3.	GENESEE RIVER BASIN	994 sq. m.	6.	DELAWARE RIVER BASIN	6,470 sq. m.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 5.1
WATERSHED EXERCISE



DISCUSSION

After the watersheds are identified in the Student Worksheet 5.1, Watershed Exercise, notice the area of Colesburg, Newfield and Brookland. Although these towns are within 8 miles of each other, the precipitation falling on each town will ultimately end up thousands of miles apart because they are each located within separate drainage basins. At the intersection or "divide" of the three basins, precipitation falling several feet apart will ultimately end up thousands of miles apart as illustrated on Map 5b, Stream Destination.

Questions

1. Precipitation on Newfield eventually flows to the (a.) St. Lawrence River.

   a. St. Lawrence River
   b. Ohio River
   c. Delaware Bay

2. Precipitation falling on Brookland flows into the (b.) Chesapeake Bay.

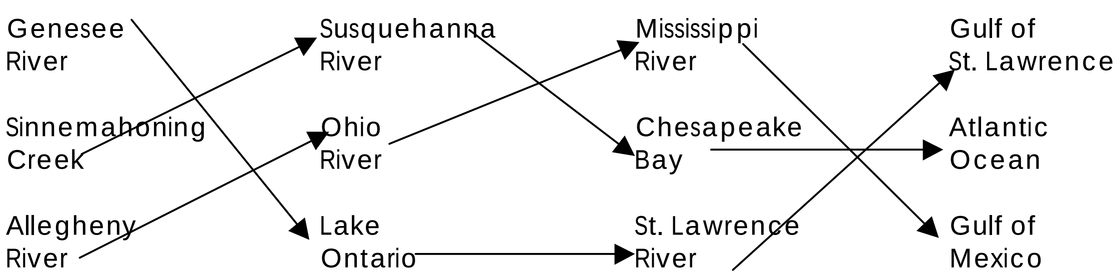
   a. Ohio River
   b. Chesapeake Bay
   c. Potomac River

3. The precipitation falling on Colesburg flows to the (c.) Gulf of Mexico.

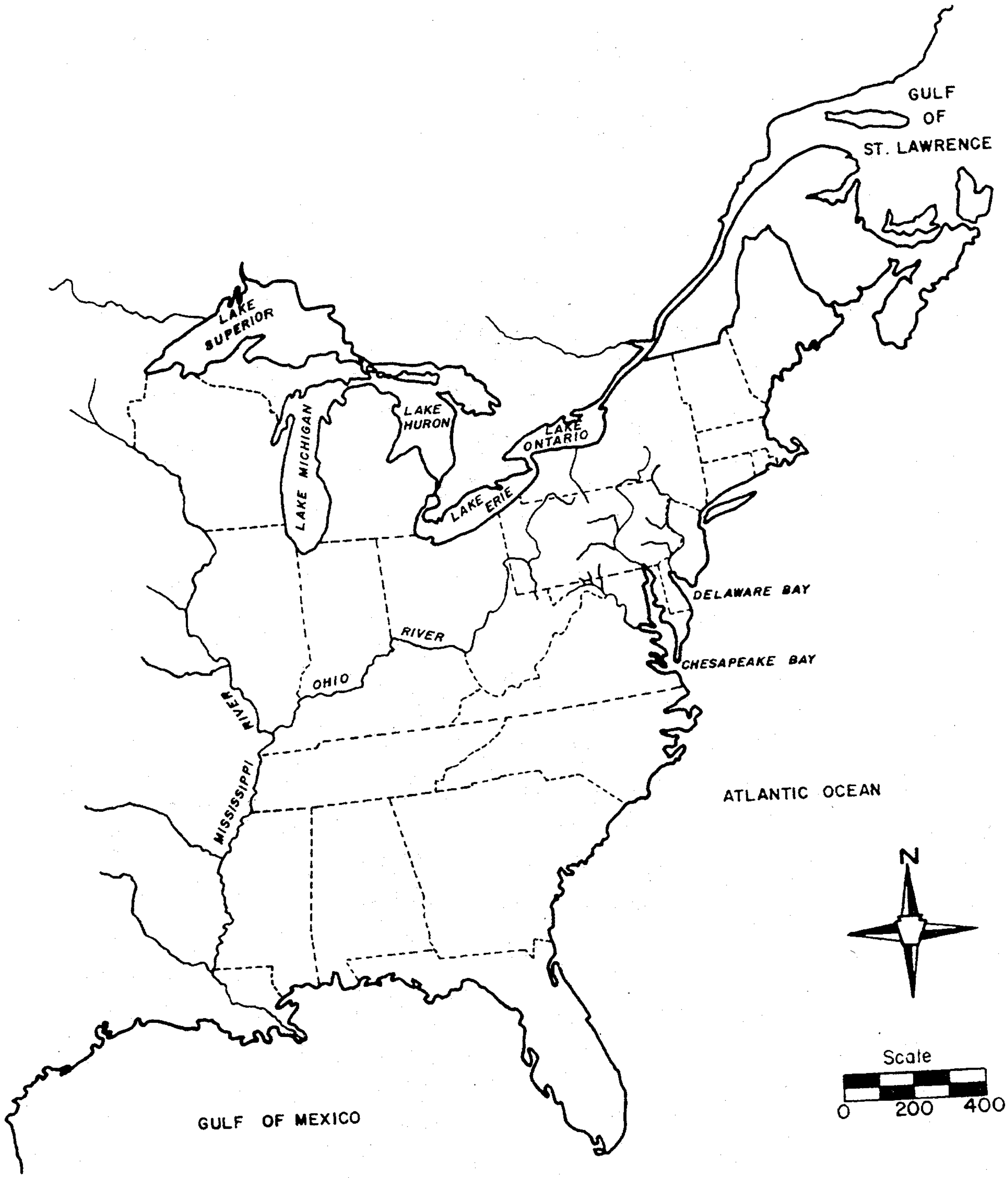
   a. Susquehanna River
   b. Gulf of Mexico
   c. Gulf of St. Lawrence

RIVER FLOW CHARTS

CONNECT THE RIVERS AND DESTINATIONS



Map 5b
STREAM DESTINATION



APPLICATION

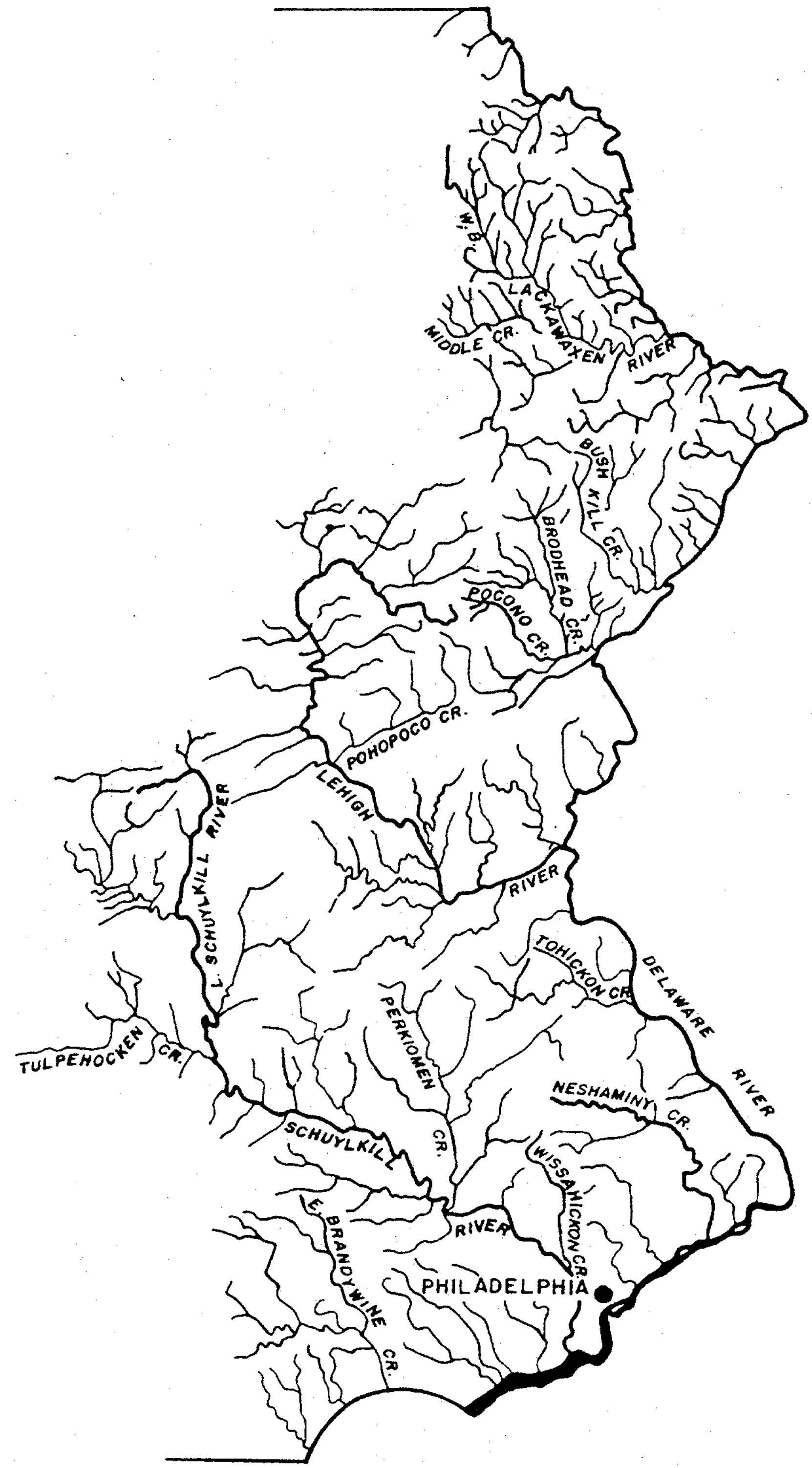
To apply this exercise to your location, we have provided Maps 5c - 5f of the major watersheds found within Pennsylvania. By using the same method of delineating watersheds, you can identify the minor watershed in which your school is located. Starting at the point where the stream in your watershed joins a major stream or river, encircle the stream and all of its tributaries until you return to your starting point. For example, if your school is located in Collegeville, PA, near the Perkiomen Creek, Map 5c-1, we can plot that watershed by starting at its confluence with the Schuylkill River and encircling the Perkiomen and all of its tributaries until we return to our starting point. Precipitation that falls within this encircled area flows into the Perkiomen as surface runoff.

You can also develop a river flow chart for your local stream or river. In our example of the Perkiomen Creek the flow chart would be:

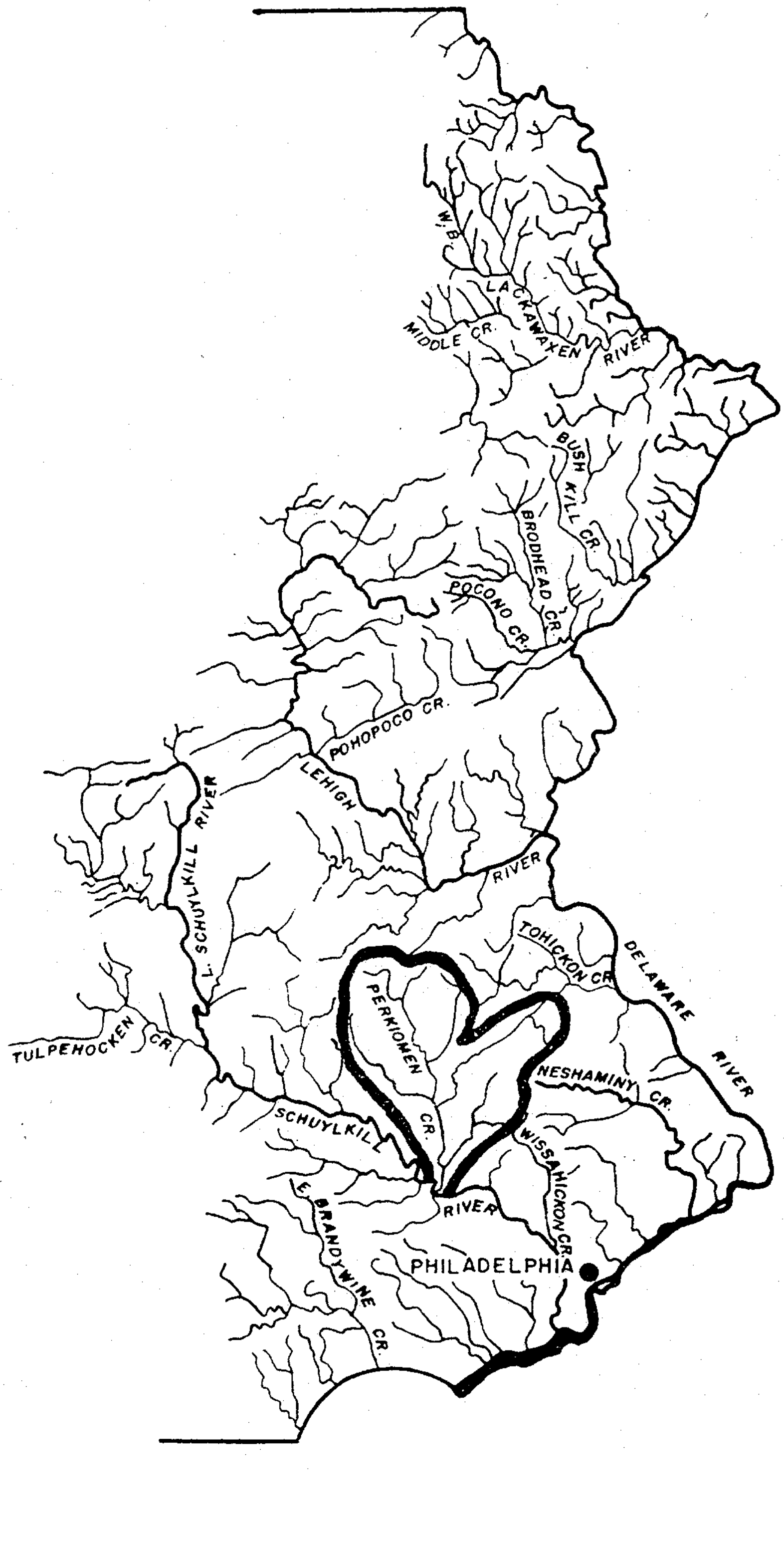
Perkiomen Creek → Schuylkill River → Delaware River → Delaware Bay → Atlantic Ocean

Because watersheds cross political boundaries you may have some difficulty in delineating your local watershed. If this is a problem, we suggest you examine a Pennsylvania State Highway Map which includes some geographical information of adjacent states. Remember streams often change direction dramatically without regard to political boundaries. In our watershed exercise earlier we observed that the Oswayo and Allegheny Rivers actually flow north into New York State, but the Allegheny reenters the state flowing south to Pittsburgh.

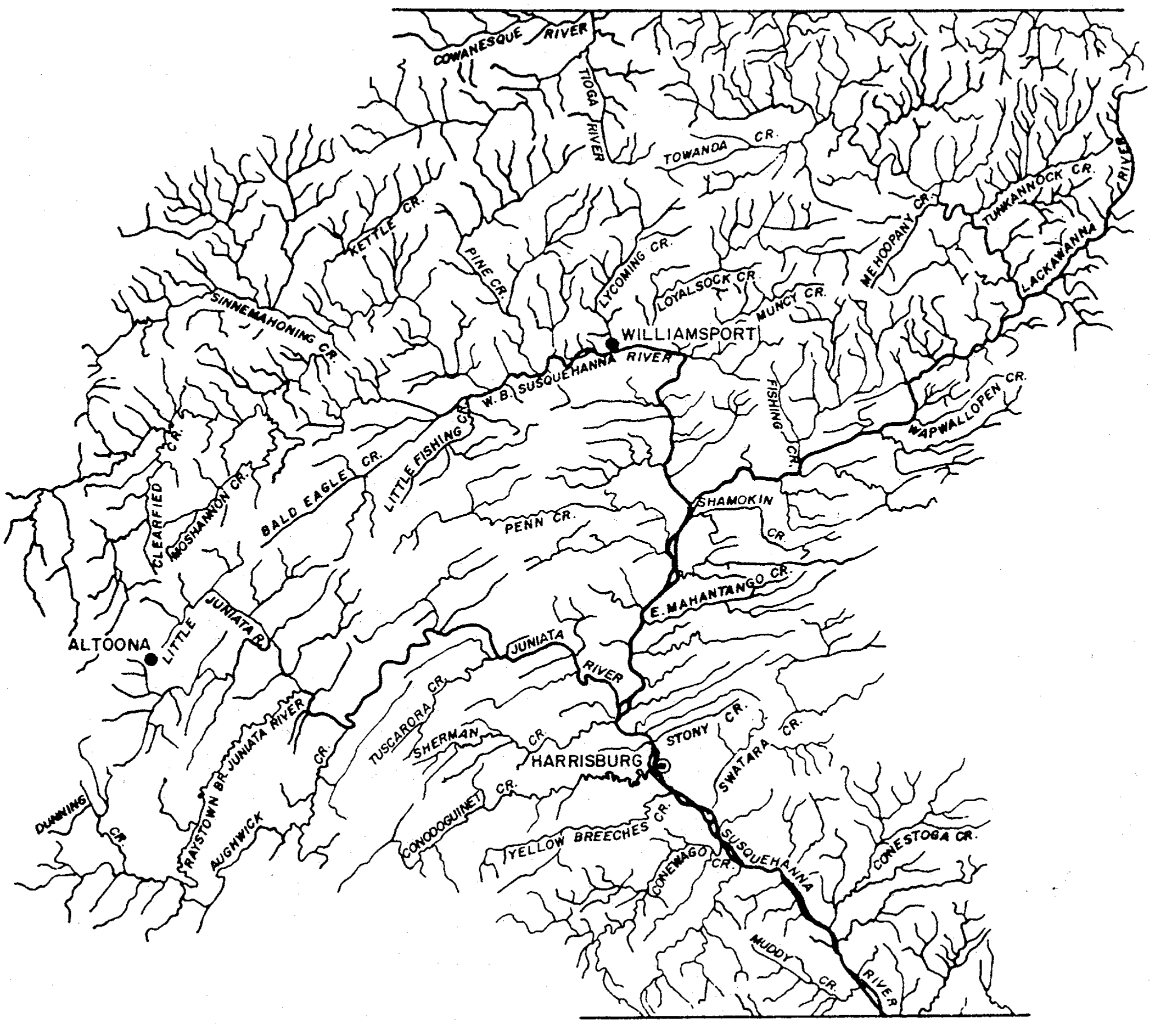
Map 5c
DELAWARE RIVER BASIN



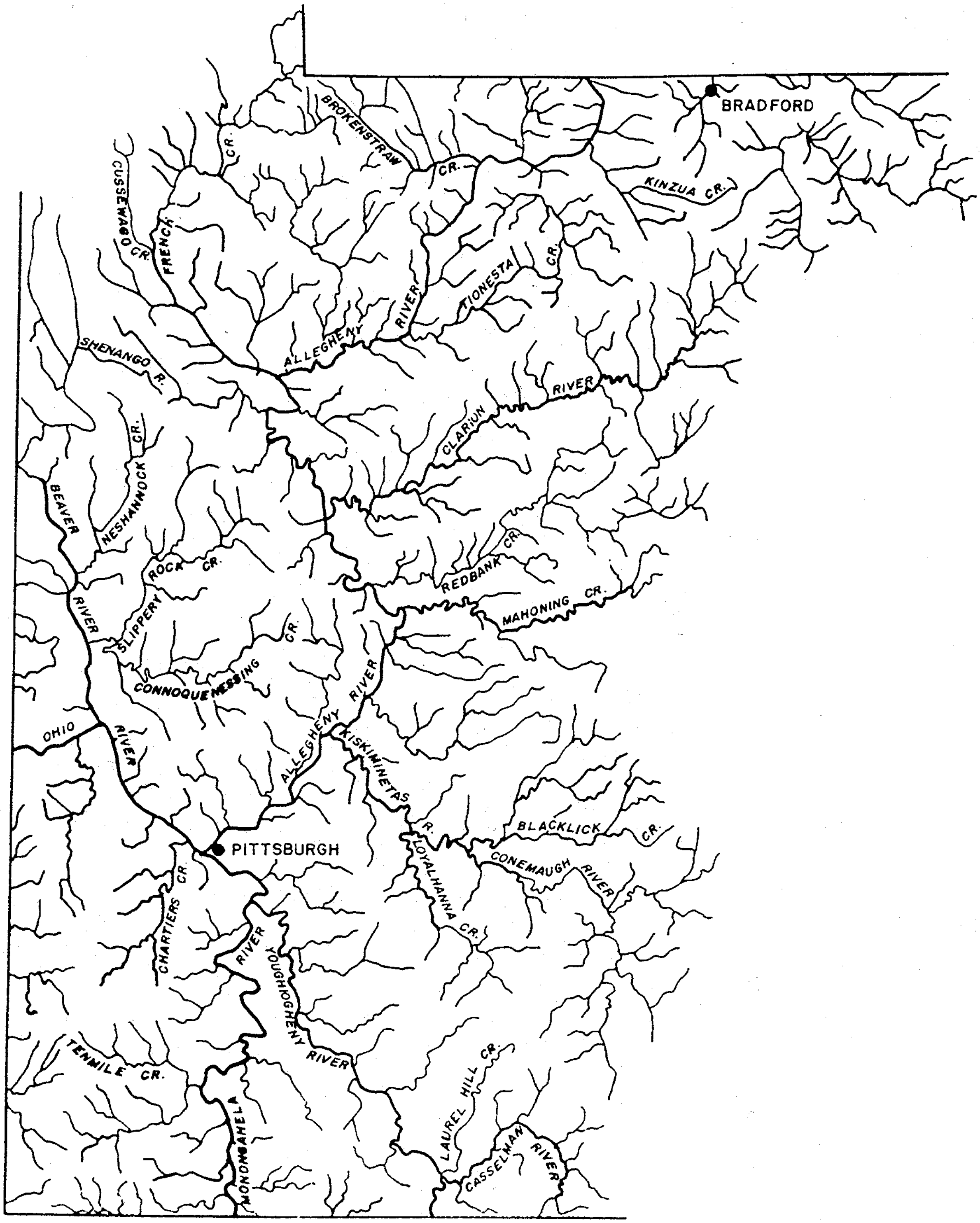
Map 5c-1
DELAWARE RIVER BASIN
PERKIOMEN WATERSHED



Map 5d
SUSQUEHANNA RIVER BASIN

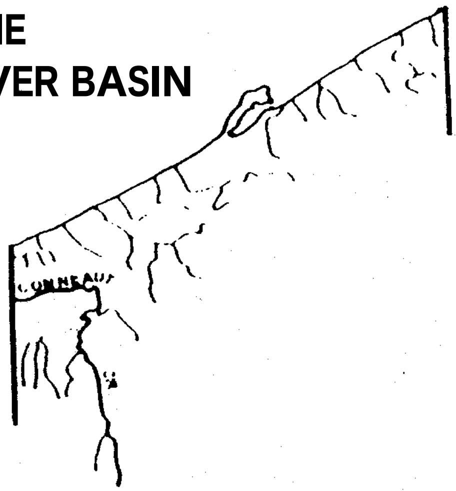


Map 5e
OHIO RIVER BASIN



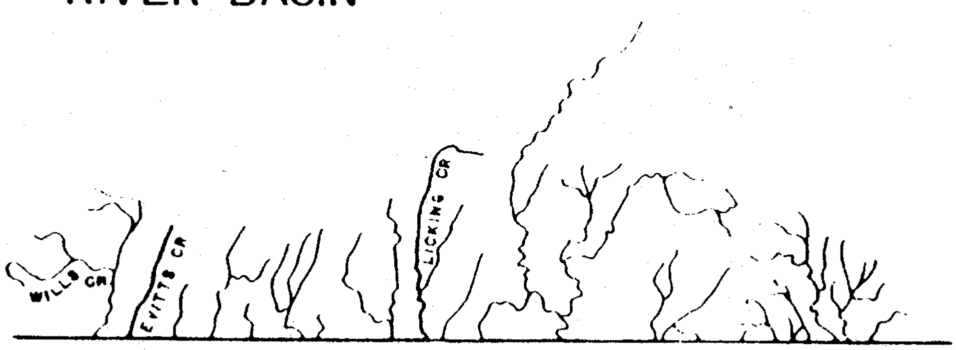
Map 5f

ERIE
RIVER BASIN



GENESEE
RIVER BASIN

POTOMAC
RIVER BASIN



STUDENT WORKSHEET 5.1
WATERSHED

Name____________________

Watershed-A part of the earth's surface that is occupied by a drainage system, which consists of a lake or river together with all tributary streams and bodies of water.

INSTRUCTIONS

1. Review Map 5a of the Major Watersheds In Pennsylvania.

2. On the Student Worksheet 5.1, Watershed Exercise map, mark the watershed boundaries between the three watersheds listed below.

<u>Ohio River Basin</u>

The Oswayo and Allegheny Rivers are tributaries in the Ohio River Basin. The Ohio River flows into the Mississippi River that ultimately flows into the Gulf of Mexico.

<u>Genesee River Basin</u>

The Genesee River flows north to Lake Ontario which flows into the St. Lawrence River, which flows into the Gulf of St. Lawrence and ultimately to the North Atlantic Ocean.

<u>Susquehanna River Basin</u>

Sinnemahoning, Kettle and Pine Creeks and the Cowanesque River are all tributaries in the Susquehanna River Basin. The Susquehanna River flows into the Chesapeake Bay and ultimately to the Atlantic Ocean.

Remember that a watershed boundary can never cross a natural stream or tributary and watershed boundaries cannot cross each other.

After the watersheds are identified, notice the area of Colesburg, Newfield and Brookland. Although these towns are within 8 miles of each other, the precipitation falling on each town will ultimately end up thousands of miles apart because they are each located within separate drainage basins.

Questions

1. Precipitation falling on Newfield eventually flows to the________________________________ .

   a. St. Lawrence River
   b. Ohio River
   c. Delaware Bay

2. Precipitation falling on Brookland flows into the_______________________________________ .

   a. Ohio River
   b. Chesapeake Bay
   c. Potomac River

3. The precipitation falling on Colesburg flows to the ____________________________________ .

   a. Susquehanna River
   b. Gulf of Mexico
   c. Gulf of St. Lawrence

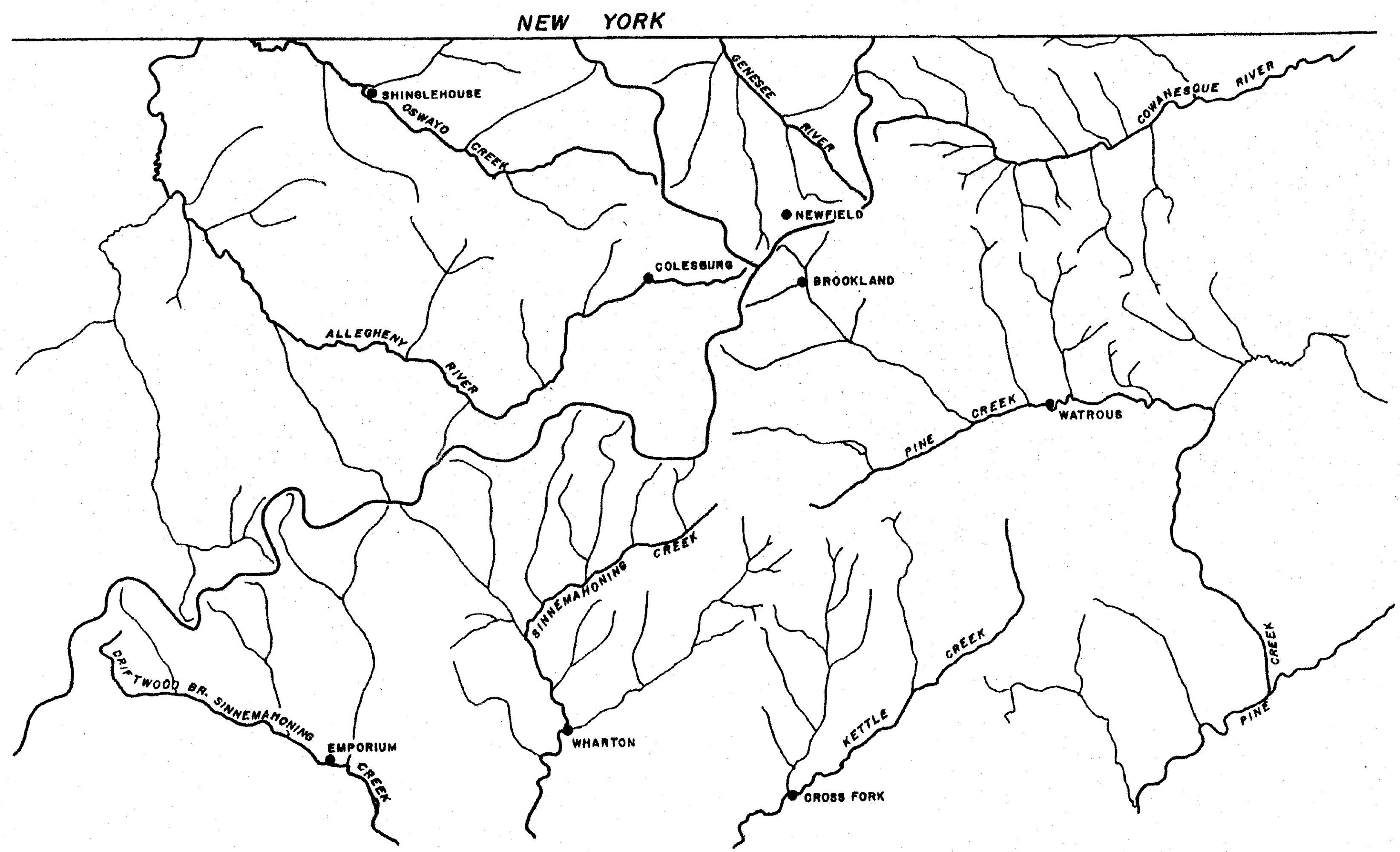
RIVER FLOW CHARTS

CONNECT THE RIVERS AND DESTINATIONS

Genesee River	Susquehanna River	Mississippi River	Gulf of St. Lawrence
Sinnemahoning Creek	Ohio River	Chesapeake Bay	Atlantic Ocean
Allegheny River	Lake Ontario	St. Lawrence River	Gulf of Mexico

STUDENT WORKSHEET 5.1
WATERSHED EXERCISE MAP

Name ______________________



ACTIVITY 5.2
THE BAY COUNTY RIVER

Students will study the water uses of a fictitious river and its surrounding communities.

GRADE LEVEL

7-9

MATERIALS

Worksheet 5.2
Map 5g

PROCEDURE

1. Review background material and discussion material with students.
2. Distribute Worksheet 5.2 and Map 5g
3. Ask students to review the instructions and answer the questions.
4. This may be an individual or group project.
5. It may be interesting to assign each student or group a role in the exercise to argue their need for water, i.e. power, industry, farmers, townspeople, environmentalists, etc.

DISCUSSION

It is very important that the students understand that every type of activity which uses water from a stream, river, reservoir or groundwater reserve impacts all other users of that resource. In groundwater resources if someone continuously pumps water out of the ground, it may cause other nearby wells to go dry. Overuse of a river or stream can also adversely affect other users of that resource.

In our exercise of the Bay County River, we will examine the various uses of water as it flows to the sea. But first, we need to explain two concepts - consumptive water use and saltwater intrusion.

Not all water we withdraw from a stream or river is lost to that resource. In fact, much of the water is returned to the stream after we use it through our sewage treatment plants, power plants and industries. The water that is not returned is consumptively used. This water may be evaporated, incorporated into products, used by plants or lost through other uses that do not return it to the watershed.

The interface between the fresh water flowing down a river and the salty ocean water is called a salt front. It is not a stationary front; it constantly moves, depending on streamflows and tides. If withdrawals from a given river are high and consumptive uses prevent much of the water from being returned to the river, the streamflow will be significantly reduced. During periods of lower than normal precipitation, this presents a serious problem. Because of the reduced streamflow, the salt front is able to move upstream, which may eventually threaten communities that withdraw water from the river for their fresh water supplies. In very severe instances the salt water may intrude groundwater reserves and render them unusable.

APPLICATION

Saltwater intrusion is a very real threat to communities along the lower Delaware River. Wells have already been polluted with salt water during past droughts. Due to the increase of consumptive water use, salt water intrusion could be a greater threat if similar drought conditions should recur in the future. We attempt to alleviate this problem by flow augmentation releases from reservoirs throughout the Delaware River Basin and the implementation of mandatory water conservation programs for all users of waters that eventually flow to the Delaware.

The Bay County River exercise is designed to show the effects of consumptive uses and salt water intrusion. Although this is a simple example of a complex problem, it will show the effects of the multiple use of a common resource.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 5.2
BAY COUNTY RIVER

Instructions

The Bay County River is a mythical river which flows to a saltwater bay. Because of the close proximity of the Baytown Water Supply and Baytown Farms to the bay it is very important that the streamflow in the river be maintained so that the salt front does not move upstream. Your job as the Water Manager for Bay County is to monitor the streamflow and protect the freshwater resources from saltwater contamination. All withdrawals reflect the consumptive water use-that water taken out of the river but not returned. For every 5 million gallons per day loss in streamflow the salt front will move 5 miles upstream. One million gallons of water per day is released from Blue Water Reservoir, which has a total capacity of 200 million gallons.

Questions

1. To maintain the salt front at Point "A" you must have a streamflow of 200 mgd at Point "A". What must the streamflow be at the county streamflow gauge?

   236 mgd

2. If the Bay County Streamflow Gauge was recording a flow of 250 mgd, would the salt front be north or south of Point "A"?

   South

   250 mgd-36 mgd consumptive use = 214 mgd

   214 mgd is greater than the 200 mgd therefore the increased streamflow would force the salt front to the south.

3. If the streamflow at the Bay County Streamflow Gauge was 230 mgd, would there be any problems? Explain.

   Yes. The intake at Baytown would be withdrawing salt water which is not usable for the community's purposes.

4. What activities would be threatened if the streamflow at the Bay County Streamflow Gauge was 223 mgd?

   Both Baytown Water Supply and Baytown Farms would be withdrawing saltwater from the river.

5. As the county water manager, what could you do to augment or add to the streamflow if the salt front was 10 miles above Point "A"?

   1. Release water from the Blue Water Reservoir to increase the streamflow to push the salt front downstream.

   2. Ask all users of the water to reduce their consumptive water use.

6. Suppose you decide to ask residents of River City and Baytown to reduce their consumptive use of water to reduce the withdrawal of water. List two consumptive uses of water they could eliminate.

   1. Lawn watering.
   2. Car washing.
   3. Filling swimming pools.
   4. Using hoses to clean driveways and sidewalks.
   5. Water fountains.
   6. Fire hydrant flushing.
   7. Street cleaning.

7. If each community could reduce its consumptive use by 25 percent, how much water would be added to the streamflow? ______________________

River City	16 mgd x 25% =	4 mgd
Baytown	8 mgd x 25% =	2 mgd
Total water saved	=	6 mgd

8. If each community did reduce its consumptive water use by 25 percent, what would the flow at the Bay County Streamflow Gauge need to be to keep the salt front at Point "A"?

   230 mgd. The consumptive use is now only 30 mgd, therefore, to maintain the salt front at Point "A" we only need to have a streamflow of 230 mgd at the gauge.

STUDENT WORKSHEET 5.2
BAY COUNTY RIVER

Name ______________________

Instructions

The Bay County River is a mythical river which flows to a saltwater bay. Because of the close proximity of the Baytown Water Supply and Baytown Farms to the bay it is very important that the streamflow in the river be maintained so that the salt front does not move upstream. Your job as the Water Manager for Bay County is to monitor the streamflow and protect the freshwater resources from saltwater contamination. All withdrawals reflect the consumptive water use-that water taken out of the river but not returned. For every 5 million gallons per day loss in streamflow the salt front will move 5 miles upstream. One million gallons of water per day is released from Blue Water Reservoir, which has a total capacity of 200 million gallons.

Questions

1. To maintain the salt front at Point "A" you must have a streamflow of 200 mgd at Point "A". What must the streamflow be at the county streamflow gauge?

   ________________________ mgd

2. If the Bay County Streamflow Gauge was recording a flow of 250 mgd, would the salt front be north or south of Point "A"?

   ____

3. If the streamflow at the Bay County Streamflow Gauge was 230 mgd, would there be any problems? Explain.

4. What activities would be threatened if the streamflow at the Bay County Streamflow Gauge was 223 mgd?

5. As the county water manager, what could you do to augment or add to the streamflow if the salt front was 10 miles above Point "A"?

6. Suppose you decide to ask residents of River City and Baytown to reduce their consumptive use of water to reduce the withdrawal of water. List two consumptive uses of water they could eliminate.

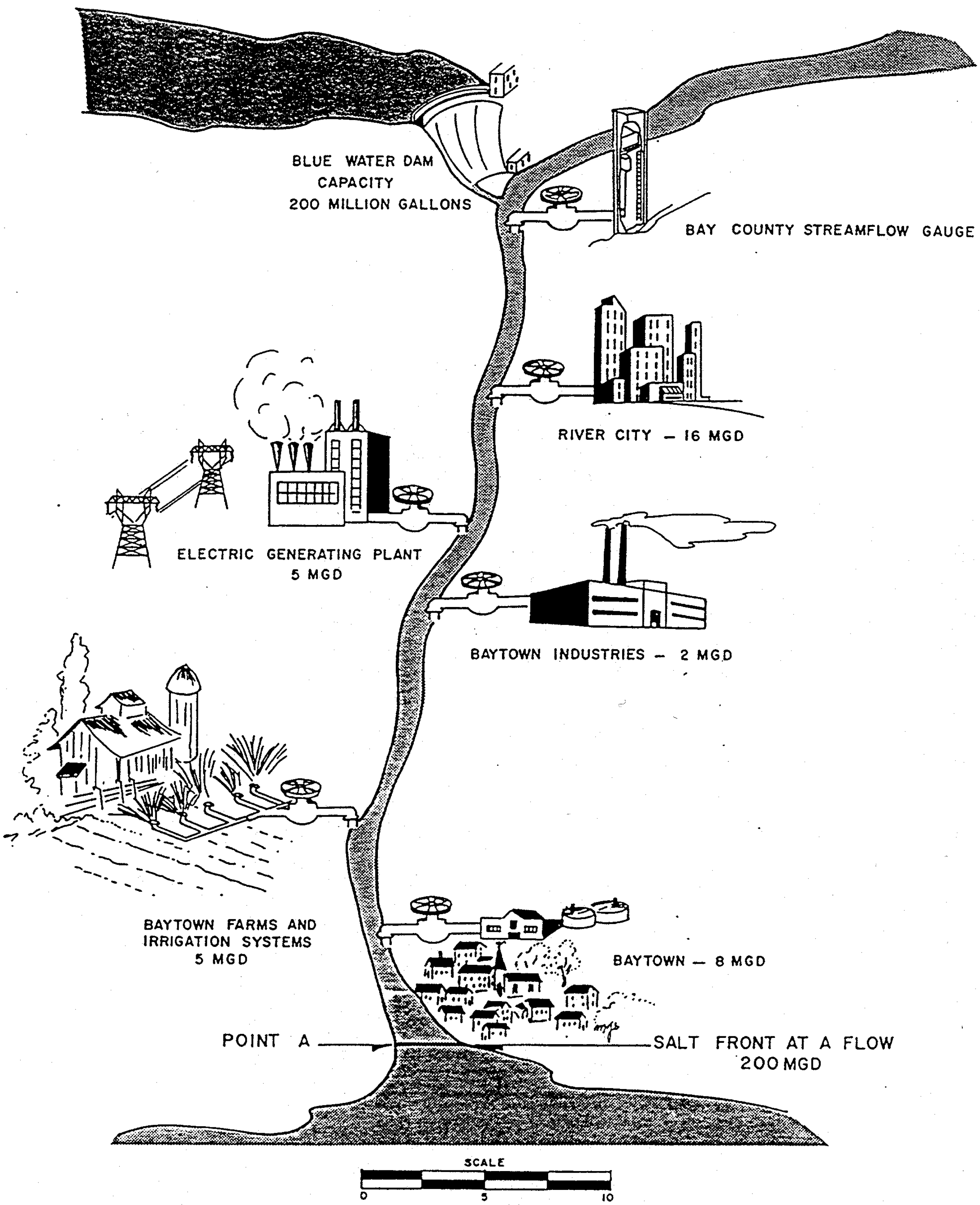
7. If each community could reduce its consumptive use by 25 percent, how much water would be added to the streamflow?

   ____

8. If each community did reduce its consumptive water use by 25 percent, what would the flow at the Bay County Streamflow Gauge need to be to keep the salt front at Point "A"?

   ____

MAP 5g
BAY COUNTY RIVER



Note : ALL USE IS CONSUMPTIVE USE . MGD = MILLION GALLONS PER DAY.

SECTION 6
MULTIPLE USES OF WATER

CONCEPT

We rely on water for a wide variety of uses such as: generation of power, industrial processes, agricultural needs for irrigating crops and watering livestock and domestic uses for the health, welfare and safety of communities and ourselves.

TEACHER BACKGROUND

Water is used by our communities in a variety of ways. At times, especially when supplies are low, these uses can compete with one another. It may even be necessary to reduce water use by some selected users to have it available for more important uses. An awareness of these various uses is therefore important. Emergency conservation programs that curtail such uses as car washing and lawn watering, for instance, can be unsettling to some citizens who fail to recognize the constant, and often inflexible, demands of agriculture, industry and such public uses as firefighting.

In Pennsylvania, electrical power plants use more than 10 billion gallons of water each day. Most of this water is used for cooling to condense steam in the generation of electricity. One Pennsylvania plant, for example, uses cooling towers 37 stories high to cool water from 115 degrees Fahrenheit to 85 degrees. One tower circulates 225,000 gallons each minute and loses approximately 3,500 gallons each minute through evaporation. This type of water loss is called a ***consumptive*** loss because the water is not returned to the resource from which it came.

Industry accounts for the second major share of water used in our state. Approximately 5.5 billion gallons are used each day for industrial processes. Some processes incorporate water as an actual component of the product being manufactured such as beverages, food products and other liquid products. Water is also used for cleaning, mixing, and cooling.

Public water supply is the third major water use in Pennsylvania, using 1.5 billion gallons each day. This water is used for fire protection, street cleaning and a host of domestic uses such as bathing, drinking and car washing. In fact, most water uses that youngsters mention will fall under this heading.

Mining which uses 252 million gallons per day accounts for the fourth major water use in our state. This water is used for the extraction of naturally occurring ores, coal, gas and petroleum. It also includes water used in quarrying, milling and other mine site related activities.

Agriculture is not a major water user in Pennsylvania, although its use is significant in western states. Irrigation, livestock watering and other agricultural uses account for less than 650 million gallons per day in our state.

Two other uses cannot be described by the number of gallons they require per day. First, transportation is very important in areas where waterways must remain open as navigable water highways. Second, recreational uses such as swimming, boating and fishing require bodies of water that are uncontaminated and of reliable quantity.

The activities that follow illustrate these various uses of our water. Their goal is to make students more aware of water demands that compete for the resource we all share.

ACTIVITY 6.1
WORD PUZZLE

Student solves a word puzzle that focuses on uses of water.

GRADE LEVEL

4-6

MATERIALS

Worksheet 6.1

PROCEDURE

1. Distribute Worksheet 6.1.

2. Explain that the words may be found horizontally, vertically, or diagonally in the puzzle.

3. Allow time for students to work on the puzzle alone or in groups.

DISCUSSION

This activity could work well as a learning station where the words are scattered on a bulletin board or poster after being removed from the worksheet. Also, the worksheet could be used for students who complete another assignment earlier than most students.

APPLICATION

Water is a valuable commodity. Only its abundance keeps its cost very low. Actually, it is one of our most versatile and most used substances. Too often, many of us take water for granted. We assume that it will always be as abundant as it is today and that our personal use of water could never seriously endanger its supply. However, our personal use of water is only one of the many demands placed upon water supplies and at times our personal needs are in competition with many other demands.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 6.1
WATER WORD FIND

Directions

There are twenty-five water uses in this word find. Can you find them all?

E	H	I	O	N	N	O	I	T	A	G	I	R	R	I	L
F	Y	R	D	N	U	A	L	P	O	N	K	Y	R	W	O
T	D	D	I	S	H	W	A	S	H	I	N	G	O	F	R
L	R	V	R	H	U	C	C	W	I	T	B	Y	L	F	F
U	O	I	A	I	Y	O	O	I	J	N	T	U	E	I	R
H	E	R	W	P	N	O	O	M	I	U	S	T	S	R	U
O	L	K	M	P	U	K	L	M	Y	H	R	H	T	E	I
U	E	R	A	I	J	I	I	I	I	M	I	Y	G	F	T
S	C	E	T	N	O	N	N	N	P	N	D	R	N	I	W
E	T	H	E	G	C	G	G	G	G	H	B	R	I	G	A
K	R	B	R	U	S	H	I	N	G	T	E	E	T	H	S
E	I	A	I	O	O	B	Y	I	D	R	S	F	A	T	H
E	C	R	A	O	L	F	E	H	L	E	S	C	O	I	I
P	I	G	L	I	V	E	S	T	O	C	K	T	B	N	N
I	T	E	N	B	E	O	U	A	V	F	E	S	E	G	G
N	Y	S	N	U	N	O	U	B	G	X	W	A	P	A	L
G	N	I	H	C	T	A	W	D	R	I	B	L	O	K	M

DOMESTIC
1. bathing
2. drinking
3. flushing
4. brushing teeth
5. cooking
6. laundry
7. dishwashing
8. housekeeping

INDUSTRY AND POWER
1. raw material
2. cooling
3. stream
4. solvent
5. hydroelectricity

RECREATION
1. boating
2. swimming
3. fishing
4. hunting
5. birdwatching

AGRICULTURE
1. irrigation
2. livestock
3. fruit washing

PUBLIC WELFARE
1. firefighting

TRANSPORATION
1. shipping
2. barges
3. ferry

STUDENT WORKSHEET 6.1
WATER WORD FIND

Name ______________________

Directions

There are twenty-five water uses in this word find. Can you find them all?

E	H	I	O	N	N	O	I	T	A	G	I	R	R	I	L
F	Y	R	D	N	U	A	L	P	O	N	K	Y	R	W	O
T	D	D	I	S	H	W	A	S	H	I	N	G	O	F	R
L	R	V	R	H	U	C	C	W	I	T	N	Y	L	F	F
U	O	I	A	I	Y	O	O	I	J	N	T	U	E	I	R
H	E	R	W	P	N	O	O	M	I	U	S	T	S	R	U
O	L	K	M	P	U	K	L	M	Y	H	R	H	T	E	I
U	E	R	A	I	J	I	I	I	I	M	I	Y	G	F	T
S	C	E	T	N	O	N	N	N	P	N	D	R	N	I	W
E	T	H	E	G	C	G	G	G	G	H	B	R	I	G	A
K	R	B	R	U	S	H	I	N	G	T	E	E	T	H	S
E	I	A	I	O	O	B	Y	I	D	R	S	F	A	T	H
E	C	R	A	O	L	F	E	H	L	E	S	C	O	I	I
P	I	G	L	I	V	E	S	T	O	C	K	T	B	N	N
I	T	E	N	B	E	O	U	A	V	F	E	S	E	G	G
N	Y	S	N	U	N	O	U	B	G	X	W	A	P	A	L
G	N	I	H	C	T	A	W	D	R	I	B	L	O	K	M

DOMESTIC
1. bathing
2. drinking
3. flushing
4. brushing teeth
5. cooking
6. flushing
7. dishwashing
8. housekeeping

INDUSTRY AND POWER
1. raw material
2. cooling
3. stream
4. solvent
5. hydroelectricity

RECREATION
1. boating
2. swimming
3. fishing
4. hunting
5. birdwatching

AGRICULTURE
1. irrigation
2. livestock
3. fruit washing

PUBLIC WELFARE
1. firefighting

TRANSPORATION
1. shipping
2. barges
3. ferry

ACTIVITY 6.2
WATER FOR "STUFF"

Students will complete a matching game which stresses the need for water to manufacture common products.

GRADE LEVEL

4-6

MATERIALS

Worksheet 6.2

PROCEDURE

1. Distribute Worksheet 6.2.

2. Allow time for students to work independently, or work with them if necessary.

3. Compare answers among students and then with the answers given below.

DISCUSSION

Answers

1 pound of sugar? (14 gal)
1 quart of milk? (223 gal)
1 barrel of oil? (770 gal)
1 pound of meat? (5,000 gal)
1 pound of potatoes? (23 gal)
1 loaf of bread? (150 gal)
1 pound of oranges? (47 gal)
1 automobile? (65,000 gal)
1 pound of tomatoes? (125 gal)
1 egg? (120 gal)

Estimates like these come from a variety of reports and studies. The exact method of estimation is usually not known so it's often difficult to explain just how the figures were determined. However, most include water that is indirectly used in the production process. For example, the estimate for the egg includes water for growing grain to feed the chicken!

APPLICATION

Most of the products we use each day require water in some form during their production. It's easy to overlook these uses of water and to minimize their importance.

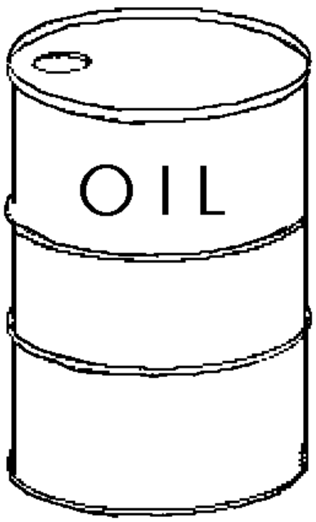
STUDENT WORKSHEET 6.2
WATER FOR "STUFF"

Name ________________________

Directions

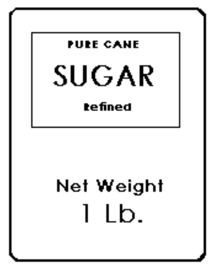
How much water is needed to make the "stuff" we use every day? Try to guess how much water is used for each of the items listed below.

How much water does it take to produce:



1 barrel of oil ____

1 pound of meat ____



1 pound of sugar ____

1 quart of milk ____

1 pound of tomatoes ____

1 egg ____

ACTIVITY 6.3
WATER USES

Students will compare the uses of water in Pennsylvania for the years 1985 and 1995.

GRADE LEVEL

7-9

MATERIALS

Worksheet 6.3

PROCEDURE

1. Distribute Worksheet 6.3.
2. Allow time for students to work independently or in small groups on the worksheet.
3. Review the answers to the worksheet.

DISCUSSION

Estimated Statewide Water Use

(Million Gallons Per Day)

Use	1985	1995
Public	1,600,000,000	1,150,000,000
Domestic	184,000,000	181,000,000
Commercial	27,000,000	30,000,000
Irrigation	11,000,000	16,000,000
Livestock	70,000,000	55,000,000
Industrial	2,060,000,000	1,680,000,000
Mining	148,000,000	252,000,000
Power Generation	10,200,000,000	5,920,000,000
Total	14,300,000,000	9,680,000,000

Answers to Questions

1. The three largest uses of water were power, industry and public for both years.

2. The largest water use in both 1985 and 1995 is power generation referred to as thermoelectric.

3. The water use categories that decreased from 1985 and 1995 include: public, domestic, livestock, industrial and power.

4. The water use categories that increased in water use from 1985 to 1995 include: commercial, irrigation and mining.

5. The trend in agricultural water use which includes the irrigation and livestock categories is one of declining water use from 1985 to 1995.

1985		1995
11,000,000	Irrigation	16,000,000
70,000,000	Livestock	55,000,000
81,000,000		71,000,000

6. Water saving plumbing fixtures (toilets, showerheads, faucets) have helped to decrease water use in the public and domestic use categories.

7. The water use category that has shown the greatest decrease in water use from 1985 to 1995 is power generation or thermoelectric.

8. The water use category that has shown the smallest increase in water use from 1985 to 1995 is commercial use.

9. The water use category that has shown the greatest increase from 1985 to 1995 is mining.

APPLICATION

The demands on Pennsylvania water are many and varied. Public water supplies are only a portion of the total water supply that keeps our economy strong and provides the basic needs of our citizens. In times of drought, we all need to recognize that there is strong competition for water and that good management planning is essential to provide adequate supplies for all segments of our society.

STUDENT WORKSHEET 6.3
WATER USES

Name ________________________

Estimated Statewide Water Use

(Million Gallons Per Day)

Use	1985	1995
Public	1,600,000,000	1,150,000,000
Domestic	184,000,000	181,000,000
Commercial	27,000,000	30,000,000
Irrigation	11,000,000	16,000,000
Livestock	70,000,000	55,000,000
Industrial	2,060,000,000	1,680,000,000
Mining	148,000,000	252,000,000
Power	10,200,000,000	5,920,000,000
Total	14,300,000,000	9,680,000,000

Questions

1. What were the three largest water use categories in Pennsylvania in 1985 and 1995?

____

____

____

2. Which water use category is the largest in both 1985 and 1995?

____

3. Which water use categories decreased from 1985 to 1995?

____

____

____

____

____

4. Which water use categories increased from 1985 to 1995?

____

____

____

5. What is the trend in agricultural water use from 1985 to 1995?

____

6. Water saving plumbing fixtures (toilets, showerheads, faucets) have helped to decrease water use in what two categories?

____

____

7. Which water use category has shown the greatest decrease in water use from 1985 to 1995?

____

8. Which water use category has shown the smallest increase from 1985 to 1995?

____

9. Which water use category has shown the greatest increase from 1985 to 1995?

____

ACTIVITY 6.4
HOW MUCH WATER DO WE USE?

Students will gain visual appreciation for the amount of water they use each day.

GRADE LEVEL

4-6 (Appropriate for other grades with modifications)

MATERIALS

62 empty one-gallon plastic jugs (non-returnable)
Wide masking tape or glue
Paint-red, blue, green, yellow

PROCEDURE

1. Have the students save empty gallon plastic jugs, you will need 62. (Be sure to rinse.)

2. Initiate discussion about how we use water each day.

3. Paint jugs according to the table listed below in the discussion of the various household daily uses for each person either red, blue, green, or yellow.

4. Connect the jugs together in groups of nine in a square, three jugs on a side, according to the different uses, but only join together those jugs of the same color. You may tape them together using "donuts" made from masking tape or you may use rubber cement.

5. Make labels of the four uses (toilet, hygiene, kitchen, laundry) to attach to the milk jugs once stacked.

6. Stack each group of nine jugs one upon the other according to the four uses in some systematic order and tape labels to the appropriate use.

DISCUSSION

On the average, each person in Pennsylvania uses approximately 62 gallons of water every day to flush the toilet, shower, wash their hands, dishes and laundry. The following chart will give your students an idea of how much water is used for each household activity.

Uses	Gallons	Color
Toilet flushing	20	Red
Shower and Bathing	14	Blue
Clothes Washing	16	Yellow
Kitchen	12	Green
Total Gallons Used Per Day	62	

How much is 62 gallons of water?

- 62 Gallons is 8.28 cubic feet – (62 ÷ 7.48 gallons/cubic foot)

- 62 Gallons weigh 517.08 lbs. – (62 x 8.34 lbs./gallon)

- Bottled water purchased at your local supermarket at 74 cents per gallon, would cost each person $45.88 a day assuming they were using bottled water for all water related activities in the home including flushing toilets.

- Compare the cost for 62 gallons or 8.28 cubic feet of water used per person per day with the cost for a similar amount of water purchased from the community water system.

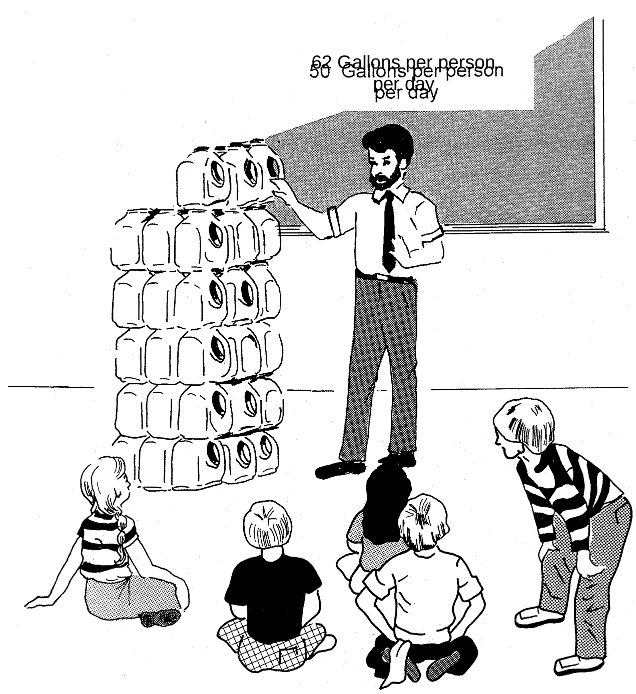
For most of us, water use is a habit. We are accustomed to having water available at the twist of a faucet. We usually do not think about how much water we use because of the mere fact that it's inexpensive and easily available.

Generate a discussion in ways you and your students can conserve can reduce the amount of water used daily. (See Teacher Background, Section 7.)

APPLICATION

This exercise will make students aware of the vast quantity of water each of us consumes during our daily household activities.

To apply this exercise to a younger age group, the instructor may have to spray paint and glue jugs.



SECTION 7
CONSERVATION: EVERYONE'S RESPONSIBILITY

CONCEPT

Water management depends upon conservation at work and at home.

TEACHER BACKGROUND

The long-term health of our water supplies depends on proper management. Such management might involve planning to store water in times of plentiful rainfall to use when rainfall is sparse and supplies become low. Also, management might include a plan to monitor withdrawals from reservoirs or groundwater sources to determine when critical conservation practices are necessary. Water management is complex because of the variable nature of the rainfall each year and because of changing demands.

However, one component of good water management which is easy to understand is water conservation. The wise use of water simply means that water should be utilized in the most efficient way and waste should be reduced wherever possible.

All water users need to conserve this valuable resource. Many large volume users have already reduced their water use as a way of reducing operating costs. Home users need to conserve also.

Home water saving techniques fall into two categories: mechanical and behavioral. Mechanical techniques focus on proper maintenance of plumbing fixtures and use of watersaving appliances. Behavioral conservation techniques, on the other hand, involve the way we use water and might require changes to establish better water use habits.

The activities in Section 7 will focus the students' attention on the following water conservation practices:

MECHANICAL CONSERVATION TECHNIQUES

Bathroom

1. Check toilets, showerheads and faucets for leaks. Install a water shut-off valve on the showerhead if the unit was purchased before 1992.
2. Install a plastic bottle in your toilet tanks if the toilet was purchased before 1992.
3. Purchase new low-flow plumbing fixtures including toilets, showerheads and faucets.

Kitchen/Laundry

1. Use automatic dishwater only for full loads.
2. Purchase water saving appliances including dishwashers and front loading clothes washers.
3. Check faucets and pipes for leaks.

Outside

1. Use a drip irrigation system for gardening instead of spray type.
2. Cover swimming pools to reduce evaporation.

Basement

1. Insulate water heater and pipes.

BEHAVIORAL CONSERVATION TECHNIQUES

Bathroom

1. Don 't use the toilet as a trash can.
2. Take baths instead of long showers.
3. Tun off the water while brushing your teeth.
3. Rinse your razor in the sink instead of under the faucet.

Kitchen/Laundry

1. Don 't leave the water running to rinse dishes washed by hand.
2. Use the dishwasher and washing machine only with full loads.
3. Don 't let the faucet run while your clean vegetables.
4. Keep a bottle of drinking water in the refrigerator instead of running the tap to get cold water.

Outside

1. Water your lawn only when it needs it.
2. Deep soak your lawn to develop deep root structures.
3. Use mulch to reduce evaporation.
4. Water during the cool parts of the day (early morning or late day).
5. Plant native or drought resistant grass and plants.
6. Do not use water from hose to clean driveways and walks, use a broom.
7. Turn the hose off between rinses while washing the car.

ACTIVITY 7.1
FAULTY FAUCET

Students measure water dripping from a faulty faucet and calculate wasted water over a period of time.

GRADE LEVEL

4-6

MATERIALS

Bucket or other large container
Quart or gallon measurer
Access to a faucet

PROCEDURE

1. Adjust a faucet to a steady drip.
2. Ask students to estimate how much water would drip from this faucet in one hour. Write the estimates on the chalkboard for later comparison.
3. Place a bucket under the faucet and begin timing for one hour.
4. At the end of the hour, measure the water in the bucket and compare the result with the estimates on the chalkboard.
5. Multiply the volume of water lost during one-hour, times 24 hours to determine the volume of water lost during the day.

DISCUSSION

You can begin this activity then go on to something else for an hour. Keep an eye on the bucket and if it appears it will overflow before the hour is up, simply stop collecting at the half-hour and multiply your resulting volume by 48 (half hours) rather than 24 hours for the answer to Procedure 5 above.

This is a good activity to stress the difference between an estimate and a measured quantity. Calculations based on the rate of dripping are estimates. The water you collected in the bucket represents an actual measured amount, not an estimate.

APPLICATION

Dripping faucets could be major water wasters in any home. Your estimates might show that a faucet could waste as much water in a day as is used in one washing machine load of laundry. That's like running a washing machine, without laundry, once each day!

Dripping faucets and leaks of all sorts should be repaired. Little losses over time become large losses.

ACTIVITY 7.2
THE WATER TRAP

Plastic bottles are easily cut and placed in toilet tanks to reduce the water used for each flush. This activity shows students how to use these bottles to conserve water.

GRADE LEVEL

4-9

MATERIAL

Plastic bottles, gallon or half-gallon
Scissors

PROCEDURE

1. Cut the tapered top and handle from the plastic bottle.

2. Demonstrate how to place and weight the bottle in the toilet tank so it does not interfere with the flush mechanism.

3. Ask students to experiment with their bottle in a toilet tank at home ***after their parents give permission.***

DISCUSSION

The flushing action of a toilet depends on the height of the water in the tank to generate sufficient water velocity, and on the water volume. However, generally in older type toilets, the volume of water can be reduced if the height of the water is not changed. Therefore, it's possible to trap some of the water in the tank during the flush cycle by using a "bottle kit." The water that is retained by the bottle reduces the amount of new water that must flow into the tank for the next flush.

The placement of the bottle in the tank is critical. It must be weighted with water to prevent it from floating into the flush mechanism. If it blocks the flapper valve and prevents it from closing securely, more water may leak from the tank in a short time than the bottle kit will ultimately save.

In 1992 the Federal Energy Policy Act established national standards for water using fixtures. These standards set specific flush volumes at 1.6 gallons-per-flush for all residential toilets manufactured after 1992. As a result, Activity 7.2 is only appropriate for older toilets manufactured before 1992.

APPLICATION

Using such a simple water saving technique can save water. If the average family of four flushes their toilet 20 times each day, and if the bottle holds just a half gallon during each flush, that family can conserve 10 gallons of water each day. That's more than 3,600 gallons per year.

ACTIVITY 7.3
PART 1: TOILET VOLUME

Students estimate the volume of water used by their toilet tanks at home.

GRADE LEVEL

4-6 and above

MATERIALS

Worksheet 7.3, Part 1
Quart liquid measure

PROCEDURE

(Special note: Involve parents, if possible, to help with this activity at home. Also, stress that water valves should not be forced if they are corroded in an open position.)

1. Distribute Worksheet 7.3, Part 1.

2. Illustrate the method of determining toilet tank volume on a toilet at school if possible. Older students may be able to follow directions without this step.

3. Assign students Worksheet 7.3, Part 1.

4. Collect all completed worksheets for use with Activity 7.3, Part 2.

DISCUSSION

Many references give average flush volumes at 5 to 7 gallons per flush. However, most toilets your students measure will probably fall below this range. Plumbing fixture manufacturers are making advances in the design and production of water-saving toilets. It is important for students to recognize that toilet-flushing demands more water than any other water use in the home. By gaining an understanding of the amount of water used for toilet flushing in their homes compared to the amounts used by the most recently developed water-saving toilets or by toilets modified to flush less water, students will be better prepared to make basic but important decisions regarding wise household water use.

APPLICATION

The toilet is the largest user of water in our homes. Two factors, volume per flush and number of flushes, determine the total volume of water used. The toilet is also one of the easiest appliances to monitor because its volume per flush is relatively fixed, unlike showers, hand washing and baths.

ACTIVITY 7.3
PART 2: COMPARING TOILETS

Students compare toilet volumes collected by their classmates.

GRADE LEVEL

7 - 9

MATERIALS

Worksheet 7.3, Part 2

PROCEDURE

1. Distribute Worksheet 7.3, Part 2.

2. Write the toilet volumes from Activity 7.3, Part 1 on the chalkboard or duplicate them and distribute a copy to each student.

3. Allow time for students to complete the worksheet.

DISCUSSION

Some students could be embarrassed or offended if their toilet is the largest water user in the class. If possible, handle all data in a confidential manner. Students should not be able to link data with any particular student although, of course, each student should recognize his or her own data.

The discussion of this activity should cover several essential points:

1. Toilet tanks vary in the amount of water they use, and those differences amount to huge differences over a period of time.

2. New toilets are designed to use less water. Students whose families are building new homes will be installing "water saver" toilets designed to flush with very small amounts of water.

3. Toilet volume can be reduced by placing some device in the tank that will hold water during the flush cycle. Weighted plastic bottles filled with water work well as long as they do not interfere with the flushing mechanism in the tank.

STUDENT WORKSHEET 7.3
PART 1: TOILET VOLUME

Name______________________

Toilet tanks vary in size and in the amount of water they use for each flush. Some toilets use 5 to 7 gallons per flush while newer models use only 1 to 3.5 gallons of water to do the same job.

You can easily measure the amount of water your toilet uses and then compare the results with your classmates. Here's how:

1. Carefully lift off the cover of your toilet tank.
2. Mark the level of the water with a pencil or a piece of tape.
3. Turn off the water supply valve usually found under the tank.
4. Now, flush the toilet.
5. Did all the water flush from the tank?
6. Next, pour measured amounts of water into the tank using a quart or gallon container. How many gallons did you have to add to bring the water to its initial level?
7. Your answer to Question 6 is equal to the amount of water used for ***every*** flush!
8. Have more than one toilet in your house? Then repeat this procedure for each toilet. Do they all use the same volume? First, though, you'd better place the tank lid back where it belongs and turn the water valve on again. Good Luck!

STUDENT WORKSHEET 7.3
PART 2: COMPARING TOILETS

Your teacher will give you volumes of toilet tanks from various homes. Using that data, complete the following steps:

1. Arrange the numbers in order from high to low.
2. Count how many volumes fall into each of these categories:

Over 5 gallons	___________
4.5 to 5 gallons	___________
4.0 to 4.5 gallons	___________
3.5 to 4.0 gallons	___________
3.0 to 3.5 gallons	___________
Less than 3.0 gallons	___________

3. What volume is the most common? ________________________________

ACTIVITY 7.4
SHOWERS vs. BATHS

Students will compare the amount of water they use for baths and showers to determine which really uses more water.

GRADE LEVEL

5 - 9

MATERIALS

Worksheet 7.4
Tape
Gallon liquid measure

PROCEDURE

1. Distribute Worksheet 7.4.

2. Review the process outline on the worksheet to estimate the bath and shower water volume.

3. Make this arrangement for a period of time that will allow for each student to take a shower and a bath.

DISCUSSION

Some students might not have both facilities available and should then record only the one they use. Tub bathers can estimate the volume of water they use for baths. Shower bathers can measure the rate of flow of their shower using a bucket and timer. Then, they can time their own showers and calculate the water used.

APPLICATION

It's often said that showers use less water than tub baths. This might be true in some cases but not in all. One estimate puts the typical bath at 25 gallons while most shower flow rates vary from 3 to 10 gallons per minute depending on the water pressure in the system. Some shower bathers spend 20 minutes or more enjoying their hot spray. In that case, the shower is probably more costly than a typical bath.

Try to guard against embarrassment of any student by collecting and working with all data in strict confidence. Even though it seems easy, don't have students read their data from their homework papers while you write them on the board. When high numbers are read, that student could become the focus of jokes that could hurt feelings. All data should be anonymous.

STUDENT WORKSHEET 7.4
SHOWERS vs. BATHS

Name________________________

Which uses more water– a shower or a bath? Of course, that depends on how deep your bath is and how long your shower lasts!

Here's a fun way to compare your own bath and shower water:

1. The next time you take a shower, close the drain and collect all the shower water. At the end of your shower, mark the level of the water with masking tape.

2. The next time you take a bath draw a normal bath.

3. Compare the level of the shower water with the level of your bath.

4. Which used more water– bath or shower?

To estimate your shower use you will need a bucket and a watch which you can read in seconds. Turn the shower on at the normal level of use. Collect the water coming out of the shower for 30 seconds. Measure this amount of water and multiply by two to determine the flow rate in gallons per minute. Time your next shower and multiply the gallons per minute times your shower time to determine the amount of water you use for each shower.

Tub users can estimate their water use in a similar fashion by measuring the flow coming from the tub faucet and timing the minutes it takes to fill the tub to a normal bath level. Because of the higher flow rate, collect water for 15 seconds instead of 30 and then multiply by four to get gallons per minute.

ACTIVITY 7.5
DO'S AND DON'TS

Students will choose methods that save water at home.

GRADE LEVEL

2-6

MATERIALS

Worksheet 7.5

PROCEDURE

1. Distribute Worksheet 7.5.
2. Direct students to read each statement and to mark it WS for Water Saver or WW for Water Waster.
3. Allow time for students to complete the task independently or with your help if necessary.

DISCUSSION

After students complete this activity, you might discuss each statement with the class to see how sensible, or silly, each statement is. Some students might even be encouraged to actually measure the amount of water saved by following some of these hints. In addition, they might construct a bulletin board display of their own Do's and Don'ts.

APPLICATION

There are many ways to save water at home that are not expensive and do not require a drastic change in lifestyle. As future water consumers, students can develop sound water use habits now and implement these practices in their daily lives.

STUDENT WORKSHEET 7.5
DO'S AND DON'TS

Name ______________________

There are many ways to save water at home. Everyone can help. However, not all the ideas listed below will save water. You decide if each hint is a water saver or a waterwaster.

WS = WATER SAVER   WW = WATER WASTER

_______ 1. Repair leaky faucets.

_______ 2. Sweep sidewalks with a broom.

_______ 3. Allow water to run while shaving.

_______ 4. Mulch around trees and plants.

_______ 5. Wash only full loads of clothes.

_______ 6. Take long, long showers.

_______ 7. Flush facial tissues, spiders and food wastes down the sink or toilet.

_______ 8. Rinse dishes well before washing them in a dishwasher.

_______ 9. Inspect toilets for leaks.

_______ 10. When drawing hot water save the first cold water for plants and pets.

_______ 11. Water your lawn thoroughly every day.

_______ 12. Use a bucket of water to wash your car and a hose only to rinse it.

_______ 13. If your shower has a shut-off valve, turn off the shower when you lather up then turn it back on to rinse.

_______ 14. Wash cars on the grass.

_______ 15. Allow an outside faucet to drip constantly for pets and birds.

ACTIVITY 7.6
WASTED WATER

Students will examine one way water is wasted in many homes.

GRADE LEVEL

4-6 and above

MATERIALS

Worksheet 7.6
Quart measure
Tape

PROCEDURE

1. Distribute Worksheet 7.6.

2. Review the activity directions.

3. When all data have been collected, compare them in some way that provides anonymity for each student.

DISCUSSION

Depending on the age and ability of your students, you might demonstrate this activity in a classroom sink before making the assignment. Again, with some classes such a demonstration might be as far as you can go with this idea.

APPLICATION

Very little water is actually required to brush one's teeth or to shave, yet many people allow the water to run continuously while doing these daily activities. Even if the rate of flow is turned back to just one or two gallons per minute, the several gallons, though not great, are still wasted.

Perhaps an even more significant aspect of this activity is that turning the water off while brushing is such an easy conservation practice. Young students are limited in what changes they can make at home to improve water use. However, they can become aware of their own activities and evaluate the way they use water.

STUDENT WORKSHEET 7.6
WASTED WATER

Name ____________________

Do you allow the faucet to run while you brush your teeth? If you do, you're wasting lots of water! Here's a way to calculate just how much you lose each time:

1. Start with a dry sink. Apply a piece of tape vertically on the side of the sink from the drain to the top rim.

2. Close the drain and add one quart of water. Mark this water level on the tape.

3. Continue adding quarts of water one at a time and marking the water level after each one until the sink is nearly full.

4. Drain the water from the sink and again close the drain.

5. Now, brush your teeth as you normally do, but leave the water run the whole time to collect in the sink.

6. When finished brushing, turn the water off and record the water level in the sink.

7. How much water is used in this way? ________________________________

8. Is this a good use of water? ____

ACTIVITY 7.7
COMPARING WATER USE

Students will use meter readings from three fictitious families to determine the factors that influence water use at home.

GRADE LEVEL

4-6 and above

MATERIALS

Worksheet 7.7

PROCEDURE

1. Distribute Worksheet 7.7.
2. Review the directions for completing the calculations and answering the questions on the worksheet.
3. Calculate the gallons used per quarter for each family by subtracting the appropriate meter readings given in the table.
4. Allow time for students to answer the questions independently, in small work groups or with your help if necessary.
5. When all students have completed their work, compare answers by reviewing each question.

DISCUSSION

Please note that the starting point on each meter is different. It is important that the student calculate each quarter's use and not determine water use by simply looking at the meter reading. Discussion material on water use characteristics is in the Teacher's Background for Section 7.

APPLICATION

The major point of this activity is to illustrate differences in water consumption from one family to the next. Statistical averages tell us the daily water use for a family of four looks like this:

	Gallons	Percent
Toilet Flushing	80	32
Showering & Bathing	56	23
Clothes Washing	64	26
Kitchen (Dishwashing, Cooking, Drinking, Cleaning)	48	19
Total	**248**	**100**

However, there are wide variations in the actual use from family to family and it is possible to recognize factors that cause such differences. Some factors, such as size of family and age of family members, may have a profound effect on water consumption but may not be wasteful. Other attitudes and behavior patterns may be wasteful and, once recognized, could be altered.

INSTRUCTOR'S COPY
STUDENT WORKSHEET 7.7
COMPARING WATER USE

Water meters record the amount of water used by a home, business or industry. Many home meters are read every three months so that homeowners receive four water bills each year. These three month periods are often called quarters.

The meter readings below give the yearly water use for three different families with very different water use habits. Your task is to determine which of the described families is family A, B, and C. Use the meter readings to determine actual water use for each family and to answer the questions that follow:

Mr. and Mrs. Average User *– This* family tries to be sensible in their water use even though there are several ways they could reduce their water use even more.

Mr. and Mrs. Water Waster *– This* family has little concern for the water they use, in fact, they take water for granted and expect it to be available whenever they want.

Mr. and Mrs. Water Conserver *– This* family has studied their home water appliances and their own water use habits. They have learned to use water efficiently without drastic changes to their lifestyle.

METER READINGS

	Family A	Family B	Family C
Start of Year	150,000	100,000	200,000
First Quarter	170,000	126,000	216,000
Second Quarter	190,000	152,000	232,000
Third Quarter	215,000	191,000	252,000
Fourth Quarter	235,000	217,000	268,000

Questions

1. Use the meter readings to calculate the gallons of water used by each family in each quarter. Write your answers in the "gallons" column of the table.

GALLONS

	Family A	Family B	Family C
First Quarter	20,000	26,000	16,000
Second Quarter	20,000	26,000	16,000
Third Quarter	25,000	39,000	20,000
Fourth Quarter	20,000	26,000	16,000
Total Water Use Per Year	85,000	117,000	68,000

2. Which family used the most water during the year? B

3. Which family used the least water during the year? C

4. Assume that each family has two adults and two children. What factors could cause one family to use more water than another family?

   Factors affecting the quantity of water used by a family could include: age of family members, water consumption of individual appliances in each home, attitudes and behavior patterns of each family member toward water use.

5. What quarter of the year shows the greatest use of water? 3

6. Why is most water used in that quarter?

   More outside water use– washing cars, watering lawns and gardens, washing windows, filling swimming pools, etc.

7. Which family A, B, or C, is the Water Waster family? B

8. Which family A, B, or C, is the Average User family? A

9. Which family A, B, or C, is the Water Conserver family? C

STUDENT WORKSHEET 7.7
COMPARING WATER USE

Name _________________________

Water meters record the amount of water used by a home, business or industry. Many home meters are read every three months so that homeowners receive four water bills each year. These three month periods are often called quarters.

The meter readings below give the yearly water use for three different families with very different water use habits. Your task is to determine which of the described families is family A, B, and C. Use the meter readings to determine actual water use for each family and to answer the questions that follow:

Mr. and Mrs. Average User– -*This* family tries to be sensible in their water use even though there are several ways they could reduce their water use even more.

Mr. and Mrs. Water Waster– *This* family has little concern for the water they use, in fact, they take water for granted and expect it to be available whenever they want.

Mr. and Mrs. Water Conserver– *This* family has studied their home water appliances and their own water use habits. They have learned to use water efficiently without drastic changes to their lifestyle.

METER READINGS

	Family A	Family B	Family C
Start of Year	150,000	100,000	200,000
First Quarter	170,000	126,000	216,000
Second Quarter	190,000	152,000	232,000
Third Quarter	215,000	191,000	252,000
Fourth Quarter	235,000	217,000	268,000

Questions

1. Use the meter readings to calculate the gallons of water used by each family in each quarter. Write your answers in the "gallons" column of the table.

GALLONS

	Family A	Family B	Family C
First Quarter			
Second Quarter			
Third Quarter			
Fourth Quarter	________	________	________
Total Water Use Per Year	________	________	________

2. Which family used the most water during the year? _______

3. Which family used the least water during the year? _______

4. Assume that each family has two adults and two children. What factors could cause one family to use more water than another family?

5. What quarter of the year shows the greatest use of water? _______

6. Why is most water used in that quarter? ____

____

7. Which family A, B, or C, is the Water Waster family? _______

8. Which family A, B, or C, is the Average User family? _______

9. Which family A, B, or C, is the Water Conserver family? _______

ACTIVITY 7.8
WATER USERS

Primary students will identify water using home appliances.

GRADE LEVEL

1-3

MATERIALS

Worksheet 7.8

PROCEDURE

1. Distribute Worksheet 7.8.

2. Tell the students you are going to think of items at home that "use" water.

3. Ask students to look at each picture in each row and circle all the water users.

4. Also, ask your students to draw a picture in the open box of some other water user that they can think of.

DISCUSSION

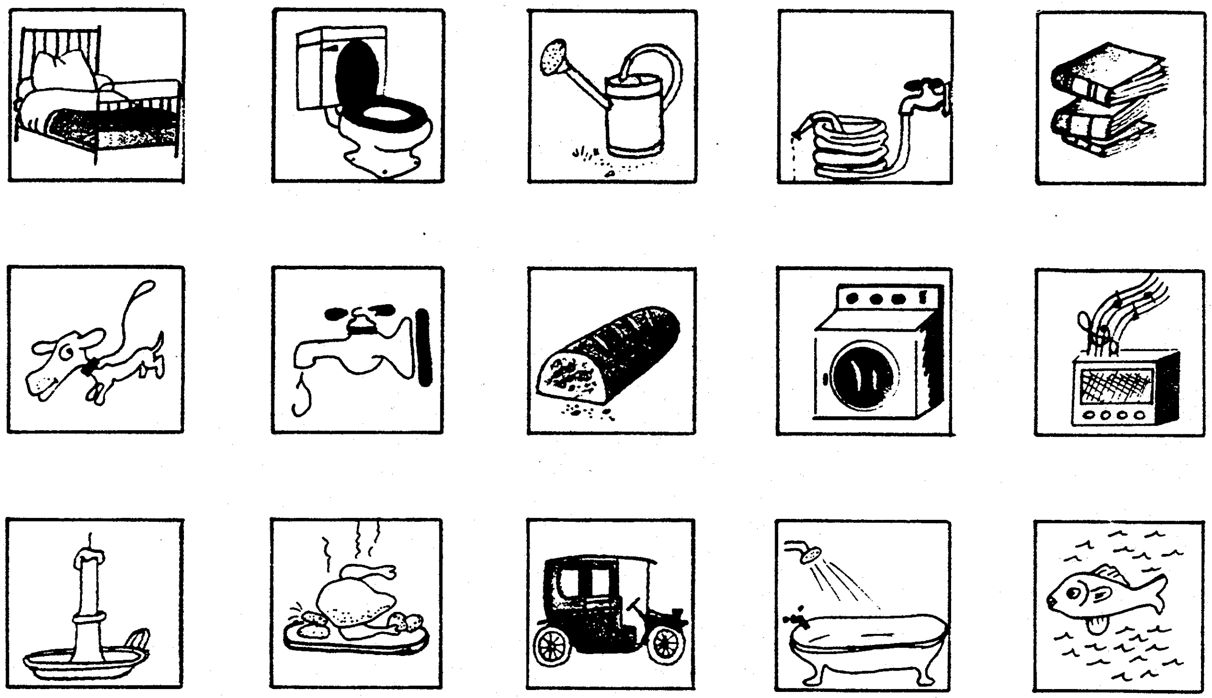
An extension of this activity would be to ask youngsters which of the water-using items they have used recently - maybe today, before they came to school.

APPLICATION

Awareness is always the first important step to realizing our own role in conservation. Primary students can realize that, as part of their family, they too share in the use of water at home.

STUDENT WORKSHEET 7.8
WATER USERS

Name ______________________________



ACTIVITY 7.9
WATER CONSERVATION COLORING BOOK

Students brainstorm a list of ways to conserve water and then draw pictures to illustrate one conservation method of their choice.

GRADE LEVEL

2-5

MATERIAL

Drawing materials

PROCEDURE

1. Help the students to brainstorm a list of ways to conserve water at home or school. Some ideas might include:

   Don't allow water to run while you brush your teeth.
   Don't flush the toilet unless it is necessary.
   Fix leaky faucets.
   Turn water faucets completely off.
   Take five minute showers.
   And more!!

2. When the list is complete, ask each student to choose one of the statements and to draw a picture illustrating that idea.

3. Photocopy all the pictures, or trace them onto spiral masters, and publish a booklet for each student to color independently.

DISCUSSION

Photocopying is the simplest method of producing many copies if your school has that capability. Tracing each drawing onto a spirit master can be a tedious job. Another option is to use the students' drawings directly to produce a thermal spirit master. However, be certain that the medium the students use will be registered by the thermal machine.

APPLICATION

This project integrates many science, art and language skills. In addition, taking the booklet home is a good way to reinforce conservation, habits with the entire family.

GLOSSARY

Aerator - A faucet spout fitting that mixes air with water.

Aquifer - A water bearing body of permeable rock, sand, or gravel.

Atom - The smallest particle of an element that can exist either alone or in combination.

Calorie - The amount of heat required at a pressure of one atmosphere to raise the temperature of one gram of water one degree Centigrade.

Condensation - A reduction to a denser form as from water vapor to liquid water; the quality or state of being condensed.

Consumptive use - A use of water in which some, or all, of the water is not returned to the resource from which it was taken.

Density - The quality or state of being dense, marked by compactness or crowding together of parts; the quantity per unit of volume, unit area, or unit length, as the mass of substance per unit volume or the distribution of a quantity per unit, usually of space.

Drought - A prolonged period of less than normal precipitation, resulting in a lack of sufficient water to provide for a need or purpose.

Evaporation - The process by which water passes from the liquid to the vapor state.

Flow restrictor - A device that reduces the flow rate of water; usually, in a faucet or showerhead.

Groundwater - Water within the earth that supplies wells and springs, and provides the base flow for streams and rivers.

Histogram - A bar graph; a representation of a frequency distribution by means of rectangles whose width represent class intervals and whose areas are proportional to the corresponding frequencies.

Infiltration - The flow of water downward from the land surface into and through upper soil layers.

Latent heat - Heat given off or absorbed in a process (as fusion or vaporization) other than a change of temperature.

Low-flow showerhead - A showerhead that reduces the rate of water flow to 3.0 gallons per minute or less.

Molecule - The smallest part of a substance that retains the properties of the substance and is composed of one or more atoms.

Monsoon - A seasonal wind; usually in the Indian Ocean and Southeast Asia.

Non-consumptive use - A use of water that returns the water to the resource from where it was taken.

Percolation - The downward movement of excess water through the soil due to the pull of gravity.

Porous - Possessing or full of pores, having minute openings allowing absorption or passage of liquid.

Recharge - The addition of new water to an aquifer or to the zone of saturation.

Reservoir - An artificial lake or containment structure where water is collected and kept in storage for use.

Saltwater Intrusion - The movement of saltwater into freshwater zones due to a decrease in flow or pressure of the freshwater.

Saturated - Full of moisture; made thoroughly wet.

Solvent - Usually a liquid substance capable of dissolving or dispersing one or more other substances.

Specific heat - The heat in calories required at a pressure of one atmosphere to raise the temperature of one gram of a substance one degree Centigrade.

Stormwater runoff - Rain water intercepted and prevented from infiltrating soil by paved surfaces, roots, and other impervious structures or materials.

Surface runoff - Rain water that flows on the surface of the ground.

Surface tension - A condition that exists at the free surface of a body (as a liquid) by reason of intermolecular forces about the individual surface molecules and which is manifested by properties resembling those of an elastic skin under tension.

Transpiration - The passage of water vapor from a living body through a membrane or pores. The process by which plants give off water vapor through their leaves.

Toilet dam - A barrier placed in a toilet tank to prevent the tank from emptying completely during the flush cycle.

Watershed - A region or area which is bounded peripherally by a water parting and which drains ultimately to a particular water course or body of water.

Water conservation - Any beneficial reduction in water losses, waste reduction or water uses.

Water table - The upper limit of the portion of the ground that is wholly saturated with water.

The Department of Environmental Protection maintains an Environmental Education and Information Center in its central office in Harrisburg in the Rachel Carson State Office Building, 400 Market Street. Stop by to look over all its resources or call (717) 772-1828, for help with your specific education needs, or visit our website through the Pennsylvania homepage at www.state.pa.us or visit DEP directly at www.dep.state.pa. (choose Subjects/Water Management).

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