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ABSTRACT

The goal of this supplemental activity guide for elementary students in grades 3-5 is to develop awareness, knowledge, and skills for sound water use decisions. Materials developed for the program are compatible with existing curriculum standards established by State Boards of Education throughout the United States and teach concepts included in those standards by using water quality information as the content. The guide is divided into five chapters that cover the topics of: (1) an introduction; (2) drinking water and wastewater treatment; (3) groundwater; (4) surface water; and (5) wetlands. Sixty-one activities including "hands-on" components are designed to blend with existing curricula in the areas of general science, language arts, math, social studies, art, and, in some cases, reading or other areas. Each activity details: (1) objectives; (2) subjects; (3) time necessary; (4) materials; (5) background information; (6) advance preparation; (7) procedure (including activity, follow-up, and extension); and (8) resources. Contains factsheets and a 273-word glossary. (LZ)

THE WATER SOURCEBOOK

GRADES

3-5

Water Environment Federation
Preserving & Enhancing the Global Water Environment

WATER SOURCEBOOK

A Series of Classroom Activities for
Grades 3-5

Produced for

LEGACY, INC.
Partners in Environmental Education

in cooperation with

U.S. ENVIRONMENTAL PROTECTION AGENCY

Prepared by

TENNESSEE VALLEY AUTHORITY
Environmental Education Section

January 1994

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INTRODUCTION

The value of clean, safe water for individuals, communities, businesses, and industries cannot be measured. Every living thing depends on water. The economy requires it. Water issues should be everyone's concern, but most people take water quality and availability for granted. After all, clean, safe water is available to most Americans every time they turn on the tap. Water issues do not become a concern until there is a crisis such as a drought or wastewater treatment plant failure. Educating citizens who must make critical water resource decisions in the midst of a crisis rarely results in positive change. Developing awareness, knowledge, and skills for sound water use decisions is very important for children, for they will soon be making water resource management decisions. Properly equipping them to do so is essential to protect water resources.

WATER SOURCEBOOK PROGRAM

The Water Sourcebook educational program is directed specifically toward the in-school population. The program will consist of the development of supplemental activity guides targeting kindergarten through high school. Water Sourcebooks will be developed for primary (K-2), elementary (3-5), middle (6-8), and secondary (9-12) levels. Materials developed in the program will be compatible with existing curriculum standards established by State Boards of Education throughout the United States and will teach concepts included in those standards by using water quality information as the content.

The Water Sourcebooks will each include five chapters—Introduction, Drinking Water and Wastewater Treatment, Groundwater, Surface Water, and Wetlands.

DEVELOPMENT

The Water Sourcebooks are developed in three stages. First, classroom teachers are selected to write the activities with the assistance of education specialists. Teams of teachers are given the task of developing and writing the activities for each of the five instructional chapters. The second step involves testing the activities in the classroom. Other teachers are selected to use the activities in their classrooms, and each activity is tested by at least three of them. The teachers involved in this unit are elementary teachers from several states. From the evaluations provided by the testing teachers, revisions are made. Finally, technical reviews, editing, and illustrations are completed and the Water Sourcebook is published.

ACTIVITY DESIGN

All of the activities include "hands-on" components and are designed to blend with existing curricula in the areas of general science, language arts, math, social studies, art, and, in some cases, reading or other areas. Each activity details (1) objectives, (2) subject(s), (3) time, (4) materials, (5) background information, (6) advance preparation, (7) procedure (including activity, follow-up, and extension), and (8) resources. Factsheets and a glossary section are included at the end of the guide to help equip teachers to deal with concepts and words used in the text which may be unfamiliar.

ORGANIZATION OF INDIVIDUAL ACTIVITIES

Each activity is organized in the same way, detailing objectives, materials needed, background information, and procedures. Following is a brief summary of what you should expect to find in each activity:

OBJECTIVES: Describes what the student should be able to do when the activity is completed.

SUBJECT: The general subject(s) to which the activity applies: Science, Mathematics, Social Studies, Language Arts, and so on.

TIME: The approximate number of minutes needed to complete the main exercise(s). More time may be needed for the follow-up and extension exercises. Some activities or follow-ups may require collecting data over several days/weeks, but will only need major time blocks at the beginning and end of the activity to explain, present information, and reach conclusions.

MATERIALS: List of materials needed to complete activity. Alternatives and optional materials are listed where appropriate. If the basic materials are not immediately available in your classroom, they can often be borrowed from other classes in the school, or local college or university science departments, local government agencies, or area businesses.

BACKGROUND INFORMATION: Background information specific to the activity for the teacher's use. This material is suggested as a basis for teacher lecture and/or student discussion when the activity is introduced. (More general background information can be found in the factsheets located in the back of the guide.)

ADVANCE PREPARATION: Directions for the teacher to prepare materials in advance.

PROCEDURE: Complete directions to conduct the entire activity, including follow-up and extension ideas. Includes teacher sheets, student sheets, and teacher keys.

Setting the Stage Introduction of the main ideas of the activity to the students. This section may use student discussion questions/topics, sharing of pertinent background information, a demonstration or activity, or a combination of these.

Activity Step-by-step instructions on how to do the activity. This ends with questions to demonstrate that students understand what they have done.

Follow-Up Conclusion of the activity by summarizing the information and drawing conclusions if applicable. May be used as evaluation of the stated objectives.

Extension Suggestions for extending the activity into other subject areas and/or suggestions for other related activities. This part of the activity is optional. Some may be used as ongoing projects, while others may be used as additional classroom work for advanced students or for extra credit.

RESOURCES: Reference materials used either in developing the activity or to provide additional information and addresses for ordering materials used in the activity.

These special notations appear within some activities.

Caution: Special care is needed for this step/procedure.

Note: Further explanation about a procedure, used to clarify or reemphasize important directions.

Optional: Optional procedure or materials that may enhance part of the activity.

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ACTIVITY PREPARATION

Once you have decided on the activity(ies) you will be doing, check the materials list. You will need to take into account the number of students or student teams in your class(es). Many materials are readily available, but some may need to be borrowed or purchased ahead of time.

Prepare copies of all the needed student handouts and/or transparencies or other materials for your use. Each activity contains ready-made masters for these. These teacher and student sheets can be easily removed from the binder and replaced after photocopying or producing a thermofax master for spirit duplication. Some activities also contain suggestions to make a transparency for use with an overhead projector. Transparencies may be made by a thermofax, a photocopier, or by tracing.

If you plan to have the students do part or all of the extension suggestions, you will want to add additional materials to your list. You may also need to locate other sources of information or telephone numbers to complete the extension. Some extensions can be started simultaneously with the regular activity.

As you read through the activity, highlight any CAUTION or NOTE and decide whether you will do optional suggestions. Check the suggested time for completion of the activity and add time needed to do any extension activities. The time needed may vary from class to class. These activities have all been field tested in elementary school classrooms. However, you might want to do a trial run of the activity yourself to evaluate the time needed and areas where minor problems might occur. It is also a good idea to mark points in the text where natural breaks can be taken to divide the activity into class periods.

The factsheets included in the back of the guide and the background material included in each activity should provide the information necessary for your preparation. Further reading may be found in the list of resources at the conclusion of each activity. If these resources are not readily available, you may want to check other books on environmental concerns.

PAGINATION

Each chapter is page-numbered separately and is designated with an appropriate chapter number. For example, the "Introduction" chapter begins with page 1-1, the "Drinking Water and Wastewater Treatment" chapter begins with 2-1, and so on.

CORRELATION—CHAPTER 1

	Water Chemistry	Water, Water Everywhere!	The Returning Raindrop	Water All Over the World	Let's Go Down Under!	By the Sea	Shedding Light on Watersheds	Planning Land Use	What's the Difference?	For Sale: Used Water	Water's Journey	Saving a Resource in Jeopardy	What a Water Job!
MATHEMATICS													
basic computation (addition, subtraction, multiplication, and division)													
use measurements	x						x					x	
make estimates and approximations		x		x									
formulate and solve problems													
probability and statistics													
charts and graphs		x							x	x		x	
SCIENCE													
problem formulation													
formulation of hypothesis									x				
gather information	x					x			x	x	x	x	x
organize and analyze information			x							x		x	
interpret data												x	
draw conclusions	x			x	x	x		x		x			
observation and experimentation (experiment, demonstration)	x			x	x	x		x	x	x		x	
LANGUAGE ARTS													
language (acquiring and using)		x	x	x	x	x			x			x	
writing (mechanical, persuasive, creative, letters)	x	x		x	x		x	x	x		x	x	x
speaking and listening		x								x		x	x
reading and literature		x			x								
communication/presenting ideas		x			x			x			x	x	x
SOCIAL STUDIES													
map skills		x		x		x	x	x			x	x	
collecting/recording/categorizing data		x			x	x				x	x	x	x
comparing and contrasting	x	x			x							x	
inferences/generalizations		x	x	x	x								x
social/human problems & decisionmaking		x			x						x	x	x
RELATED ARTS													
the arts (art, music, drama)		x	x	x	x	x	x		x	x	x	x	x
health													
computer													

CORRELATION—CHAPTER 2

	Water Goes Around and Comes Around	Water Works	Will That Hold Water?	The Invisible Water Source	Hard or Soft?	Get the Salt Out!	The Main Drain	The Wastewater Story	Wetland in a Bottle	Settling the Wastewater Problem	Waste Not, Want Not	Water Patrol	
MATHEMATICS													
basic computation (addition, subtraction, multiplication, and division)	x										x		
use measurements		x									x		
make estimates and approximations	x												
formulate and solve problems	x												
probability and statistics													
charts and graphs	x		x				x	x					
SCIENCE													
problem formulation					x	x							
formulation of hypothesis										x	x		
gather information		x		x			x	x			x	x	
organize and analyze information					x			x		x	x		
interpret data	x			x					x	x	x		
draw conclusions	x			x	x				x	x			
observation and experimentation (experiment, demonstration)	x	x	x	x	x	x	x		x	x	x		
LANGUAGE ARTS													
language (acquiring and using)		x	x						x				
writing (mechanical, persuasive, creative, letters)		x					x	x		x	x	x	
speaking and listening						x		x	x	x	x		
reading and literature									x				
communication/presenting ideas												x	
SOCIAL STUDIES													
map skills			x	x		x							
collecting/recording/categorizing data	x					x				x			
comparing and contrasting	x		x		x	x	x			x			
inferences/generalizations	x			x		x			x	x		x	
social/human problems & decisionmaking	x					x						x	
RELATED ARTS													
the arts (art, music, drama)	x		x			x	x	x	x			x	
health					x							x	
computer													

CORRELATION—CHAPTER 3

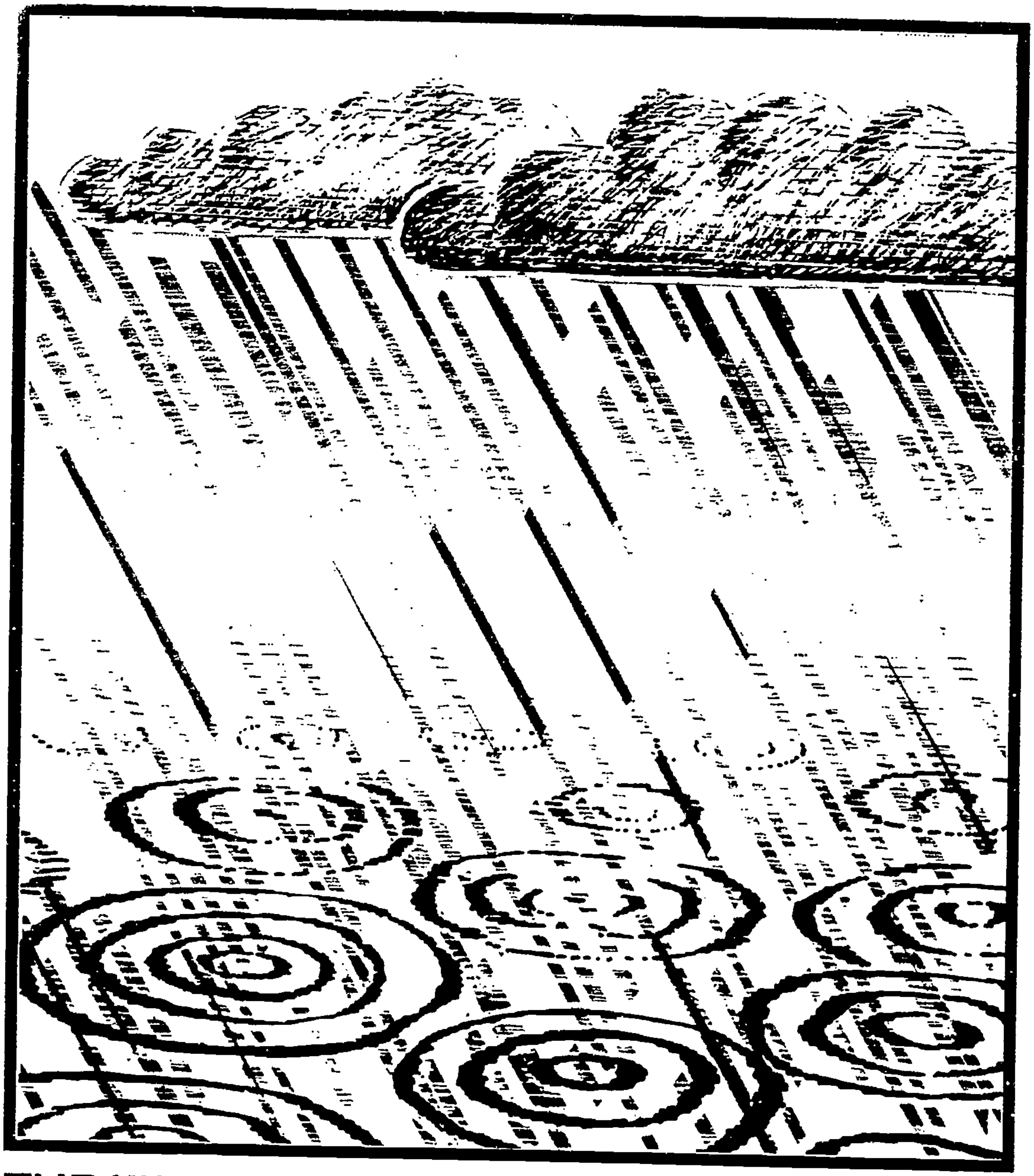
	A Salt-Water-y World	Watery Words and Places	Living in Water	Posted! No Fishing, No Swimming	Cleaning Up	Acid Rain, Go Away!	N, B, & T: Pollutants Three	Stop That Sediment	Working Together to Prevent Pollution	Water-Wise Landscaping	Whose Water Is It?	Pollution Pete Patrol	
MATHEMATICS													
basic computation (addition, subtraction, multiplication, and division)					x								
use measurements													
make estimates and approximations	x												
formulate and solve problems													
probability and statistics													
charts and graphs	x											x	
SCIENCE													
problem formulation													
formulation of hypothesis													
gather information			x			x			x	x			
organize and analyze information	x												
interpret data	x						x						
draw conclusions	x				x	x				x			
observation and experimentation (experiment, demonstration)	x	x	x		x	x	x	x				x	
LANGUAGE ARTS													
language (acquiring and using)		x	x			x		x	x	x			
writing (mechanical, persuasive, creative, letters)		x	x	x		x	x	x					
speaking and listening										x	x		
reading and literature		x											
communication/presenting ideas			x	x						x	x	x	
SOCIAL STUDIES													
map skills	x	x								x	x		
collecting/recording/categorizing data		x				x	x			x	x	x	
comparing and contrasting								x					
inferences/generalizations											x	x	
social/human problems & decisionmaking									x		x	x	
RELATED ARTS													
the arts (art, music, drama)	x	x	x	x			x		x	x	x	x	
health				x									
computer		x								x			

CORRELATION—CHAPTER 4

	Aquifer Adventure	Believe It or Not!	At a Snail's Pace?	Porosity & Permeability: "Down and Dirty"	Checks and Balances	Wells: A Deep Subject	Cap Chemical	Flush Your Troubles Away	A Tale of Ooze	Stamp Out L.U.S.T.	Down on the Farm, Down in the Water	Goin' With the Flow	
MATHEMATICS													
basic computation (addition, subtraction, multiplication, and division)		x	x	x		x				x		x	
use measurements		x	x	x		x	x		x	x		x	
make estimates and approximations		x		x		x							
formulate and solve problems		x		x		x							
probability and statistics		x											
charts and graphs			x				x						
SCIENCE													
problem formulation	x				x				x			x	
formulation of hypothesis				x	x				x			x	
gather information	x			x	x		x		x			x	
organize and analyze information				x	x	x	x		x			x	
interpret data	x	x	x	x	x		x		x	x	x	x	
draw conclusions	x	x	x	x	x	x			x		x	x	
observation and experimentation (experiment, demonstration)	x	x	x	x	x	x	x	x	x	x	x	x	
LANGUAGE ARTS													
language (acquiring and using)	x		x	x		x	x	x	x	x		x	
writing (mechanical, persuasive, creative, letters)		x	x			x	x	x			x	x	
speaking and listening		x		x	x	x	x	x	x	x			
reading and literature			x			x						x	
communication/presenting ideas	x	x	x		x	x	x	x	x	x		x	
SOCIAL STUDIES													
map skills	x		x		x	x					x	x	
collecting/recording/categorizing data	x	x				x	x	x				x	
comparing and contrasting	x	x		x	x		x					x	
inferences/generalizations	x					x					x	x	
social/human problems & decisionmaking		x			x	x	x	x	x	x	x	x	
RELATED ARTS													
the arts (art, music, drama)					x	x	x	x		x	x	x	
health													
computer													

CORRELATION—CHAPTER 5

	Wonderful, Waterful Wetlands	Home, Wet Home	To Whom It May Concern	What Can You Do?	Where Did It Wear?	You Must Have Been a Beautiful "Bay-Bee"	Down in the Ocean Dumps!	The Inside on Red Tide	Trees by the Sea	Estuary Water	Coastal Conservation Scavenger Hunt	Coastal Food Web
MATHEMATICS												
basic computation (addition, subtraction, multiplication, and division)									x			
use measurements	x				x				x			
make estimates and approximations												
formulate and solve problems												
probability and statistics												
charts and graphs	x	x							x			
SCIENCE												
problem formulation												
formulation of hypothesis										x		
gather information	x	x		x				x		x	x	
organize and analyze information					x						x	x
interpret data								x	x			
draw conclusions	x					x	x	x	x	x		
observation and experimentation (experiment, demonstration)	x				x	x	x	x		x		
LANGUAGE ARTS												
language (acquiring and using)	x	x			x	x						x
writing (mechanical, persuasive, creative, letters)	x	x	x	x	x	x	x			x		
speaking and listening			x									
reading and literature		x	x	x								
communication/presenting ideas		x	x	x			x				x	
SOCIAL STUDIES												
map skills	x		x		x	x			x			
collecting/recording/categorizing data		x	x				x				x	
comparing and contrasting							x		x			x
inferences/generalizations	x							x				x
social/human problems & decisionmaking		x	x									
RELATED ARTS												
the arts (art, music, drama)	x	x	x	x	x	x	x	x				
health							x	x				
computer												



THE WATER SOURCEBOOK

INTRODUCTION TO WATER

WATER CHEMISTRY

OBJECTIVES

The student will do the following:

1. List reasons why water is important.
2. Investigate and graph the freezing points of different solutions.
3. Make flat models of water molecules.

SUBJECTS:
Science, Math

TIME:
90 minutes

MATERIALS:
3 clear plastic milk jugs
pitcher
cup of ice
water
salt
vinegar
measuring spoons
measuring cups
blue construction paper
red construction paper
scissors
hole punch
glue sticks
clear plastic cups (3 per team)
thermometers (1 per team)
masking tape
pencils
paper
graph paper

BACKGROUND INFORMATION

Water equals life. Where there is no water at all, there is no life and therefore water may be the most important substance on earth. Water is a colorless, odorless, tasteless substance. Each water molecule consists of one oxygen and two hydrogen atoms. In shape, a water molecule resembles a "Mickey Mouse" head. In its pure form, water is a good solvent, i.e., it can dissolve or mix with many substances. In fact, water has been called the "universal solvent" because of its ability to dissolve other substances. It is found everywhere and covers three-quarters of the planet. Water is found in our atmosphere, in our soil, and underneath the ground. The human body is about 75 percent water.

The total amount of water on earth stays the same, and the same water that exists now has always existed. Water can be found in all three states of matter (liquid, solid, and gas) on earth, most often in the liquid state. At 0°C (32°F) and normal atmospheric pressure, water freezes to form solid water (ice). At 100°C (212°F) and normal atmospheric pressure, water evaporates to form water vapor (steam).

Terms

freezing point: the temperature at which a substance begins to change from a liquid to a solid.

gas: a state of matter; a gas always has the same shape as the container it fills.

liquid: a state of matter; a liquid always has the same shape as its container.

solid: a state of matter; a solid generally has a shape of its own.

ADVANCE PREPARATION

A. Prepare the "mystery liquids" beforehand so they are ready for the activity. Use plastic milk jugs to prepare and store the liquids in.

   1. Liquid A is tap water.

   2. Liquid B is a 50/50 mixture of vinegar and water.

   3. Liquid C is salt water. Use 1 teaspoon (5 mL) of salt per cup (240 mL) of water.

B. Have on hand a pitcher of water, and a cup of ice.

C. Cut a large number of circles from blue construction paper. Cut twice as many smaller circles from red construction paper. (NOTE: You may use a hole punch to cut the red circles and make the blue circles about the size of a dime. Or, if you think it would be easier for students to work with larger pieces, use dimes to cut out the red pieces and quarters for the blue ones.)

D. Make arrangements to use the school kitchen's freezer for about an hour.

PROCEDURE

I. Setting the stage

   A. Show the students a cup of ice and ask them to describe it.

   B. Fill the cup of ice with water from the pitcher. Discuss the fact that liquid water and ice are both water though they look and feel different.

   C. Take a sip of the ice water and discuss with the students that water is essential for life. Ask the students to list ways water can be used.

II. Activities

   A. Show the students the three liquids you have prepared.

      1. Ask them to compare them. Can they guess what they are?

      2. Tell the students what they are; explain that water can dissolve and/or mix with many substances.

      3. Have the students suggest other things that are soluble or miscible (mixable) with water.

      4. (Optional) Allow the students to test various substances' solubilities or miscibilities. (Try sugar, cooking oil, rubbing alcohol, coins or other metal objects, and paper strips or other classroom items.)

   B. Divide the students into teams and have each team complete the following investigations:

      1. Give each team three cups and have them label the cups A, B, and C. Fill cup A one-third full with liquid A, cup B one-third full with liquid B, and cup C one-third full with liquid C. Give each team a thermometer.

2. Have the teams record the temperature of each liquid.

3. Choose one cup of each liquid (A,B,C) and put them (with thermometers in them) in the freezer. Have students record the temperatures every 15 minutes until all three are frozen. (Liquid A, tap water, will freeze first. The salt water in cup C will freeze next and the 50/50 mixture of vinegar and water in cup B will freeze last. This mixture is similar to the antifreeze solutions we use in automobiles.)

4. Have the students make a graph showing what happens to the temperature of each liquid.

5. Ask the students the following questions.

   a. How did the temperatures change? (gradually lowered until freezing took place)

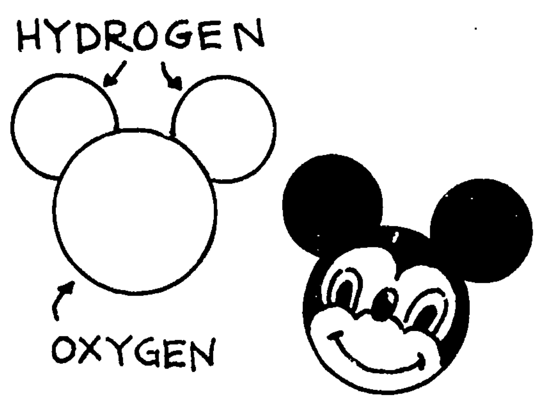
   b. At what temperature did each liquid freeze? (Results will vary somewhat, but the tap water should freeze at about 0°C.)

   c. Liquid A is water; B is water and vinegar; C is salt water. How do vinegar and salt affect the freezing temperature of water? (They lower it.)

   d. Antifreeze affects freezing temperature like salt in water. Why is it added to a car radiator in winter? (Antifreeze freezes at a lower temperature than water and when mixed with water prevents the water in the radiator from freezing.)

C. Introduce the students to water's chemical formula — H_2O. Explain that a glass of water has millions and millions of tiny water particles — the smallest possible water particles — called molecules.

1. Draw a large water molecule outline ("Mickey Mouse head") on the board. The "ears" are the two hydrogen atoms and the "face" is the oxygen atom. Relate this to the formula (H_2O).



2. Give each student a sheet of paper, a glue stick, and red and blue construction paper dots. Explain that the (smaller) red dots represent hydrogen atoms and the (larger) blue dots represent oxygen atoms. Tell them to imagine that the sheet of paper is a glass. They are to put water in the glass by gluing water molecules on the paper. Tell them to make "Mickey Mouse heads."

III. Follow-Up

A. Have the students write up the lab activity in the following form: problem, procedure, data, conclusions. In the conclusion, have the students propose reasons why the water freezes at different temperatures.

B. Have the students write the formula for water and draw a water molecule.

C. Have the students list three reasons water is important.

IV. Extensions

A. It has been proposed that icebergs in the Antarctic be towed to desert countries for use as drinking water. You can now buy bottled water from melted glacial ice in European countries. Discuss with the students the use of glaciers or icebergs as sources of water. What would be the advantages and disadvantages of such a use?

B. Have the students investigate how boiling temperatures vary with elevation.

RESOURCES

Elicle, C., "Water," Tennessee Conservationist Student Edition, January/February, 1988.

Holmes, N. J., et al., Gateways to Science (Grade 5), Webster Division, McGraw-Hill, New York, 1985.

WATER, WATER EVERYWHERE!

OBJECTIVES

The student will do the following:

1. Illustrate the quantity and distribution of water on the earth.
2. Recognize the amounts of water used in daily activities such as bathing.
3. Compare the amounts of water used by different groups such as farming and manufacturing.

SUBJECTS:
Geography, Social Studies, Language Arts, Science

TIME:
50 minutes

MATERIALS:
large sheets of paper (construction, newsprint, or posterboard)
art supplies
index cards (optional)
paste or glue stick
globe or map of the world
hole punch
ring binders or yarn
teacher sheet (included)
gallon jug of water (optional)

BACKGROUND INFORMATION

Water is one of our most important resources. We use water to produce food, provide energy, and manufacture and transport goods. Water is also essential for the life of every organism on our planet.

Because water covers three-quarters of the earth's surface, it is easy to think of it as an endless resource. Of all water, more than 97 percent is found in the oceans as salt water. Of the remaining 3 percent that is fresh water, two-thirds is frozen in ice caps, glaciers, and on snowy mountain ranges. Only about one-half of one percent of all the water on the earth is usable fresh water. Of this amount, experts estimate that there is 30 to 50 times more water found in aquifers (underground), than in all the lakes, rivers, and streams on the surface. Most of the water we use (78 percent), however, comes from these surface waters.

We use fresh water for a variety of purposes. About 11 percent is used in urban and rural homes, offices, and hotels. Another 8 percent is used in manufacturing goods and mining. The production of electricity accounts for almost 39 percent of water usage, although using water to cool power plants and to turn turbines in hydroelectric power plants does not consume the water. The largest consumer of water is agriculture, which uses about 42 percent.

As individuals, we use large amounts of water. An average American uses around 150 gallons (over 570 L) a day. We are even composed of water; our bodies are about 75 percent water.

ADVANCE PREPARATION

A. Gather enough large sheets of paper and art supplies for students in teams of 2 or 3.

B. Copy teacher sheet "Water Fact Cards" and cut into individual cards. (NOTE: These would be more durable if pasted to 3 x 5 inch [7.5 x 12.5 cm] index cards or construction paper.)

PROCEDURE

I. Setting the stage

A. Show the class a globe or map of the world.

1. Ask students which there is more of: water or land? (water)

2. Explain that water covers more than three-fourths of the earth's surface.

B. Instruct the students to think of as many different uses of water as possible in three minutes.

1. Briefly review their answers, noting unique responses.

2. Explain that everyone uses water for a variety of purposes. Today's lesson will illustrate the quantity of water in the world and how much is used for different purposes.

II. Activity

A. Have the class construct a "Big Book."

1. Divide the students into teams of two or three.

2. Pass out art supplies and large sheets of paper or posterboard.

3. Distribute one "Water Fact" card to each group.

4. Instruct the students to use the information on the card to make an illustrated page for the classroom big book on water facts. Each page should have:

a. The fact given on the card

b. An illustration of the fact (NOTE: Remind students to think about symbols that would help illustrate their fact. For example, a salt shaker may be a good symbol for salt water, especially if it is filled to the level noted on the card.)

c. The names of the illustrators.

5. Monitor and make suggestions to each team as they work.

B. Upon the teams' completion of the pages, punch three or four holes on the left-hand side and connect them together with loose-leaf rings or yarn.

III. Follow-Up

A. Allow each group to read and share their page with the class. (NOTE: Provide students with a gallon [4 L] jug of water to compare the amounts given in the book.)

B. Have the students write other questions about water quantities they think would be interesting to know.

IV. Extensions

A. Have the students find answers to their water quantity questions from III. B.

B. Assign groups to design a bulletin board or door covering to present information out of their "Big Book."

C. Have the students make charts or graphs of all the different percentages out of the book.

D. Present copies of the book to other classes or to the school library.

RESOURCES

Debnam, Betty, "Treat Water Well" (from "The Mini-Page" educational activities), Knoxville News-Sentinel, October 30, 1990, p. B6.

Namowitz, S., and N. Spaulding, Earth Science, D.C. Heath and Company, Lexington, Massachusetts, 1989.

Pringle, L., Water: The Next Great Resource Battle, Macmillan Publishing, New York, 1982.

"Water: Essential to Life (1992 Utah's Young Artist's Water Education Classroom Calendar)," International Office for Water Education, Utah State University, Logan, Utah.

WATER FACT CARDS

Water Fact Three-fourths of the earth's surface is covered with water.	**Water Fact** The largest user of water is agriculture, for growing crops and raising livestock. This uses 42% of our fresh water.
Water Fact 97% of our water is salt water found in the ocean.	**Water Fact** Our bodies are made of 75% water.
Water Fact While 3% of our water is fresh, 2% is trapped in ice caps, glaciers, and on snowy mountain ranges.	**Water Fact** It takes 1,400 gallons of water to produce a meal of a burger, fries, and a soft drink.
Water Fact Most of the fresh water we use comes from lakes, rivers, and streams (surface waters).	**Water Fact** The average American uses 150 gallons of water a day.
Water Fact There is about 40 times more fresh water in the ground than found in rivers, lakes, and streams.	**Water Fact** A person can use up to 50 gallons of water taking a bath.
Water Fact Homes, hotels, and offices use about 11% of our fresh water.	**Water Fact** For every inch of rain in a square mile, there will be more than 17 million gallons of water. (For every centimeter of rain in a square kilometer, there will be 10 million liters of water.)
Water Fact 8% of the fresh water we use goes to making goods and mining.	**Water Fact** A tree is 75% water.
Water Fact 39% of the fresh water we use helps us make electricity.	**Water Fact** If you leave the water running while brushing your teeth, as much as 10 gallons (40 L) of water can go down the drain.
Title Page Group Complete a title page with the following: 1) A catchy title about water facts, 2) An illustration about water, 3) The name of the grade, school, and teacher working on the book.	

THE RETURNING RAINDROP

OBJECTIVES

The student will do the following:

1. Realize that water moves in a never-ending natural cycle.
2. Build a model of the water cycle in the form of a terrarium.
3. Explain how a terrarium demonstrates the water cycle.

SUBJECTS:
Science, Art, Social Studies

TIME:
90 minutes

MATERIALS:
2-liter clear plastic bottles with caps
potting soil
gravel
small plants or moss
tape
ruler
scissors (teacher use only)
student sheets (included)
crayons or colored markers (optional)
drawing paper (optional)
writing paper (optional)
ice cubes (optional)
heat source (optional)
beaker, jar, or saucepan (optional)
cookie sheet (optional)
sealable plastic bag (optional)
teacher sheet (included)

BACKGROUND INFORMATION

Water moves in a never-ending natural cycle, so the water you are using may have been a drink for some dinosaur! The forms of water are always changing. They move from sky to earth and back to the sky again. This is called the water cycle. Water falls to earth as rain or snow. Some of the water soaks into the ground and is stored as groundwater. The rest flows into streams, lakes, rivers, and oceans. The sun warms surface water and changes some of it into water vapor. This process is called evaporation. Plants give off water vapor too in a process called transpiration. The heated water vapor rises into the sky and forms clouds. When the vapor in the clouds condenses, it falls back to the earth as rain or snow. The water cycle has then come full circle and begins again.

Terms

condensation: the change of water from a gas to a liquid.

evaporation: the process of converting or changing into a vapor.

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

water: a resource needed by all living things in an ecosystem.

water cycle: the cycle of the earth's water supply from the atmosphere to the earth and back which includes precipitation, transpiration, evaporation, runoff, infiltration, and storage in water bodies and groundwater.

water vapor: the gaseous state of water.

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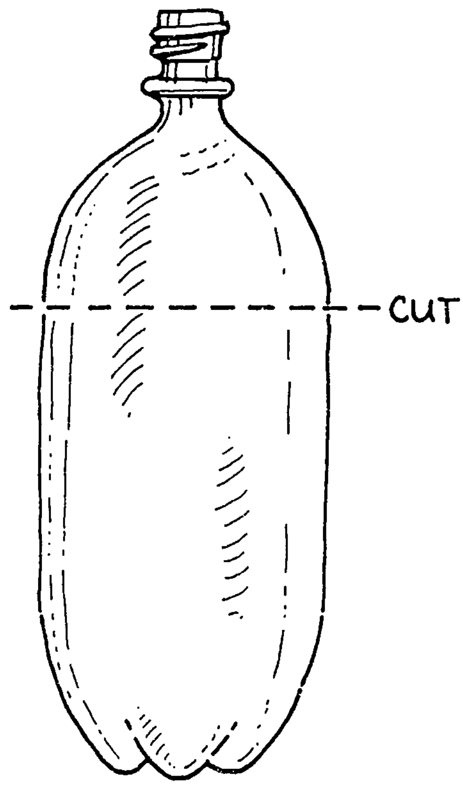
ADVANCE PREPARATION

A. Gather the materials for the terrarium(s). (NOTE: One terrarium can be made for a class demonstration or each student or team of students can make one. Materials for each terrarium include: a 2 liter clear plastic bottle, 2 inches (5 cm) of potting soil, small plants (moss works great), 1/2 inch (1.25 cm) of gravel, and tape.

B. Cut bottle(s) ahead of time. (NOTE: Scissors easily and evenly cut the plastic bottles.)



C. Make copies of each of the two student sheets for each student's use in follow-up exercises.

PROCEDURE

I. Setting the stage

A. Have the students name all the ways they use water in a day. Encourage them to include ways that water is used indirectly (e.g., food preparation, manufacturing, farming, etc.).

B. Tell the students the same water they are using today has been on earth from its beginning. It is recycled continuously in the water cycle.

II. Activity

A. Introduce and explain the new terms using the chalkboard (evaporation, water vapor, condensation, precipitation, water cycle). Give everyday examples of each term.

1. Condensation - water droplets on the outside of a cold soda can

2. Precipitation - snow, rain, sleet, hail

3. Evaporation - dew disappearing from the grass

4. Water vapor - steam rising from a boiling pan of water

5. Water cycle - snowfall or puddles appearing and disappearing (The technical term is the "hydrologic cycle." If your students enjoy "big" words, introduce this term and discuss with them the "hydro-" root word.)

B. So that students may observe the water cycle, build a terrarium (or have students or teams build their own). (NOTE: See teacher sheet, "Terrarium Concept.")

1. Place 1/2 inch (1.25 cm) of gravel in the bottom of the bottle. (This is for drainage.)

2. Cover the gravel with about 2 inches (5 cm) of rich potting soil.

3. Plant the small plants or moss you have gathered.

4. Gently water the soil until moist.

5. Place the top back on the bottle and tape securely in place.

6. Place in a well lighted – but not too sunny – area. If all goes well, the plants will thrive and the water cycle can be observed all year.

C. Together with the students, observe the container after 24 hours. Note all changes and discuss the water droplets on the inside of the terrarium(s).

D. Ask the students how this demonstrates the water cycle.

E. Ask the students where the droplets come from and where they go.

III. Follow-Up

A. Have the students complete the water cycle student sheet, "The Returning Raindrop." List the terms on the board. (NOTE: They may color the picture when they are finished.) (Answers: 1. evaporation, 2. condensation, 3. precipitation, 4. water cycle.)

B. Have the students draw a representation of the water cycle demonstrated in the terrarium. (See the teacher sheet.)

C. Relate the water cycle to lakes, rivers, or other water sources in your immediate area.

D. Have the students complete the water cycle term sheet, "Water Cycle Matching." (Answers: 1A, 2D, 3E, 4B, 5C, 6F, 7G.)

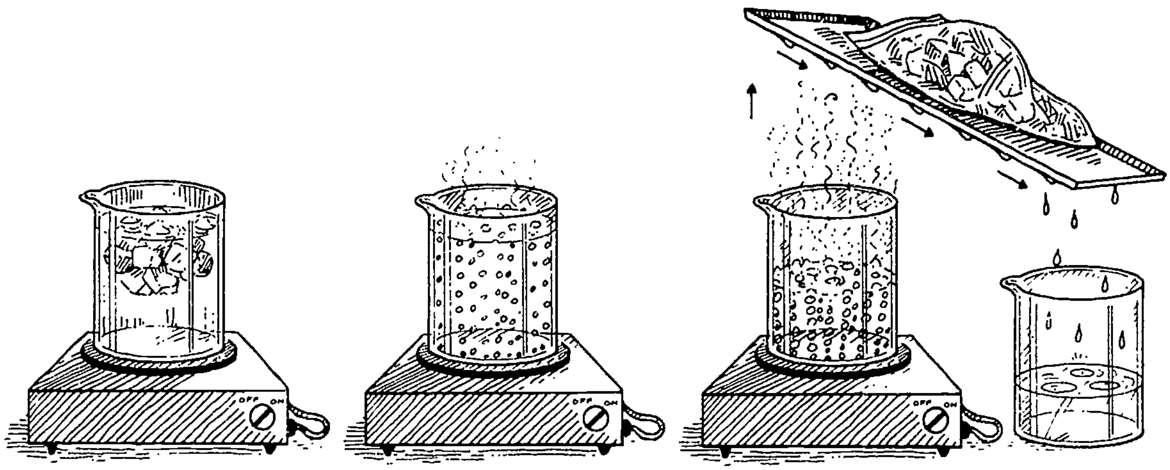
IV. Extensions

A. Discuss ways that water supplies become polluted and the water quality declines.

B. Have the students write a story about being a raindrop and traveling through the water cycle.

C. Demonstrate the three forms of water (solid, liquid, gas) as depicted below.

1. Ice cube - solid
2. Liquid - melted ice cube
3. Gas - evaporated water from melted ice cube.



RESOURCES

The Energy Sourcebook: Grades 3-5 Unit, Tennessee Valley Authority, 1990.

Hackett, Jay K., Science in Your World (Grade 3), Macmillan McGraw-Hill, New York, 1991.

"The Story of Drinking Water," American Water Works Association, Denver, Colorado, 1984.

TVA: A World of Resources, Tennessee Valley Authority, 1986.

"Water Fun," Los Angeles Department of Water and Power, Los Angeles, California, 1984.

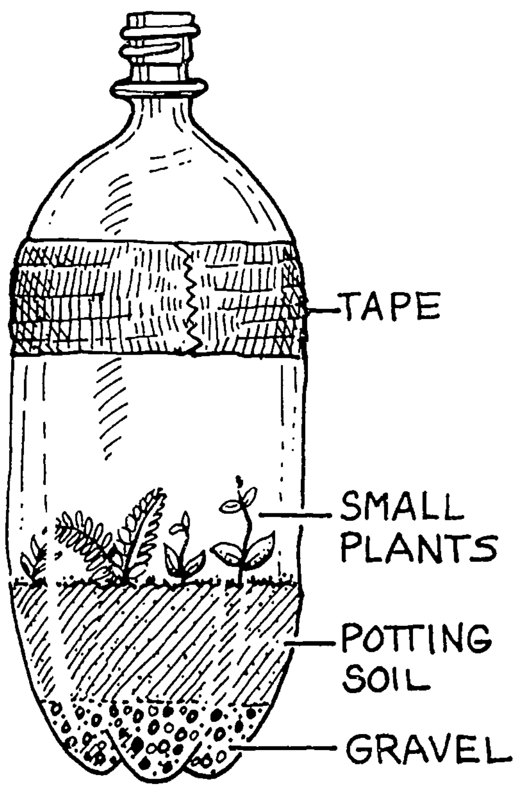
TERRARIUM CONCEPT

A terrarium is a simple and effective way for your class to watch the water cycle operating on a small scale. The plants take up moisture from the soil and release it through their leaves. The water molecules later condense on the inside of the plastic bottle and "rain" back to the soil. You never need to add water tc the terrarium as long as it stays closed.

This classroom water cycle works in miniature much the same way the water cycle works on a large scale for our planet. It is also a good introduction to the concept of ecological cycles.

The students can present terrariums as gifts to their parents. You might ask parents to donate some small plant cuttings as well as other supplies needed.

The terrariums are easily assembled, but be sure to cut the plastic bottles before starting the students on the assembly.



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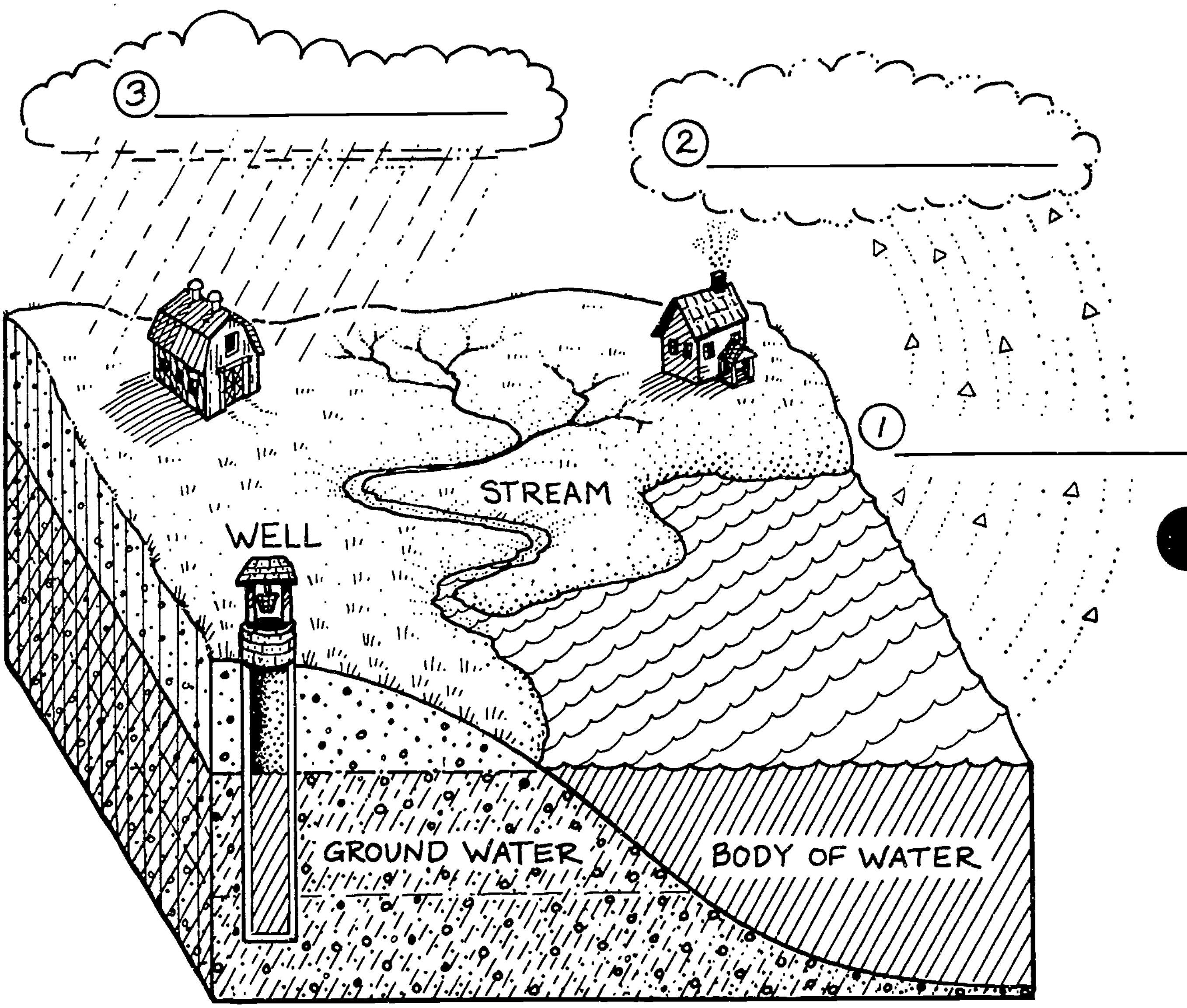
THE RETURNING RAINDROP

Fill in the blanks to label the picture. Use the terms at the bottom.



Terms: water cycle
evaporation
condensation
precipitation

④ ________________________

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WATER CYCLE MATCHING

Match the definitions with the terms in the word bank below. Put the letter of the term in the blank.

____1. The change of water from a gas to a liquid.

____2. The process in which water becomes a vapor in the atmosphere.

____3. The method in which water continually moves from the earth to the atmosphere and back again.

____4. A resource needed by all the living things in an ecosystem.

____5. The gaseous state of water.

____6. The forms of condensed water vapor such as snow, rain or sleet.

____7. Water stored in the ground.

Word Bank:

A. Condensation

B. Water

C. Water vapor

D. Evaporation

E. Water cycle

F. Precipitation

G. Groundwater

WATER ALL OVER THE WORLD

OBJECTIVES

The student will do the following:

1. Discuss why water is an important natural resource.
2. Observe how much of the earth's surface is covered by water.
3. Remove salt from water.

SUBJECTS:
Science, Social Studies, Language Arts, Geography

TIME:
60 - 90 minutes

MATERIALS:
dinner plate
saucer
glass bowl
table salt
water
old magazines
glue sticks
scissors
paper
globe or world map
paper clips
heavy black marker
student sheet (included)
teacher sheet (included)

BACKGROUND INFORMATION

Living things always need water. Water covers about three-quarters of the earth's surface. It can be found in the earth's oceans, lakes, streams, and other bodies of water, as well as ice, in the atmosphere, and underground. Water is used over and over again.

Water found in water bodies on the earth's surface is called surface water. Most surface water is salt water. Plants and animals that live on land or in fresh water cannot use salt water unless the salt is removed from it. The process of removing salt from salt water is called desalination.

Terms

desalination: the purification of salt or brackish water by removing dissolved salts.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, and reservoirs.

ADVANCE PREPARATION

A. Gather the materials.

B. Copy the student sheet for distribution.

PROCEDURE

I. Setting the stage

A. Using a globe or a world map, ask the students to describe the earth's surface. Have them identify the large land masses and bodies of water.

B. Ask the students what other bodies of water they can see.

C. Have students estimate about how much of the earth's surface is covered by water. (about three fourths)

II. Activity

A. Tell the students that water is a natural resource all living things must have. In some places there is not enough fresh water and the only water is salty ocean water. The people who live in those places must find ways to take the salt out of the water before using it. This is called desalination. Desalination is done in large plants (like factories). We will make a model of a desalination plant.

1. Make salt water by dissolving about 2 teaspoons (10 mL) of table salt in one cup (250 mL) of water.

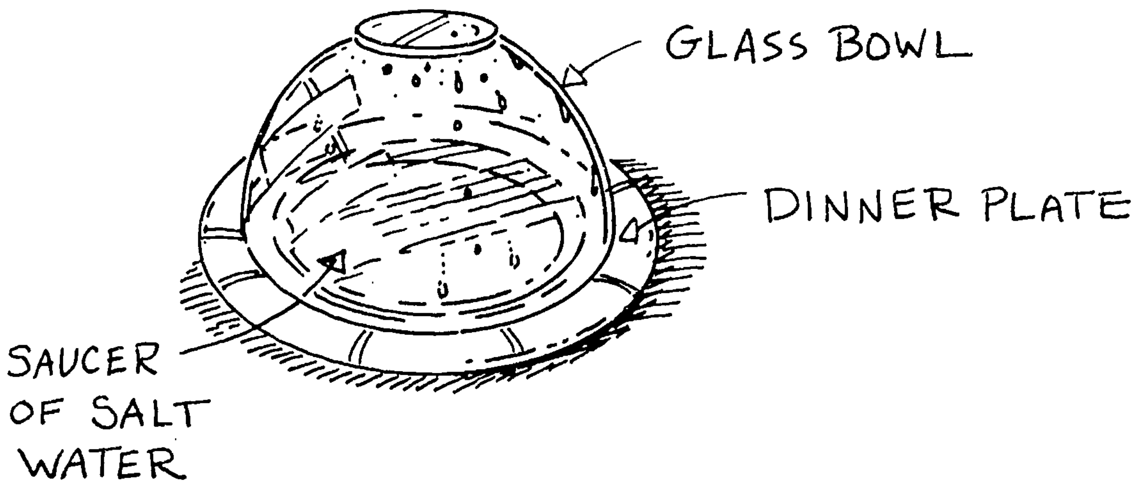
2. Get a dinner plate, a saucer, and a clear glass bowl that is wider than the saucer.

3. Put the saucer on the dinner plate.

4. Fill the saucer with salt water.

5. Place the glass bowl down over the saucer.

6. Put this apparatus outside in a sunny place. After a time, the students should see small drops of water on the inside of the bowl. On a very warm, sunny day this will happen quickly.



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B. Ask the students to address the following items after you are able to observe drops:

1. Describe what you would do to find out if the drops of water inside the bowl are fresh water or salt water. (They should be able to identify tasting as the simplest way to determine this, but discuss with them that unless they are specifically directed to taste something in an experiment, they should never do so.)

2. Describe what you would do to collect the drops of water that form inside the bowl.

3. Describe problems that might occur when water is being desalted.

C. Discuss again with the students how much more salt water there is than fresh water. Have them state why desalting water might be very important to people.

D. Ask the students what caused the water to evaporate in the model. (the sunshine's warmth or solar energy) Remind them that energy is always required by any process that changes matter. While solar energy is free, other forms of energy are not; people who use these energy resources must pay for them. Because of the large energy requirements of the desalination facilities, desalted ocean water is expensive. In places in the world that have very little fresh water (but lots of ocean water), people pay much more for their water. Ask the students how this might affect how people use water. (This would cause them to use water more carefully and less wastefully.)

III. Follow-Up

Give the students old magazines, paper, scissors, and glue sticks. Have them cut out pictures that show how water is used. Have them use the pictures to make collages of how water is used.

IV. Extensions

A. Have the students design and conduct experiments investigating desalination. For example, will the model work in a dark place, or how could the model be improved?

B. Have students write a poem based on a "water word." See the teacher sheet, "Water Word Poetry" (included).

1. List several water words on the board. Use descriptive words or geographic terms.

2. Have students brainstorm a list of words that describe or are related to each "water word." Put lists on the board under the appropriate words.

3. Explain how to write a shape poem and an alphabet poem. Put examples on the board.

4. Instruct students to choose one of these forms and one of the water words for the subject of their poem. Use the other words to construct the poem.

5. Display the poems in a prominent location.

C. Have the students complete the student sheet "Geographic Water Terms." This is a good activity for cooperative learning groups. The answers for the matching exercise are: 1-H, 2-C, 3-E, 4-I, 5-B, 6-J, 7-A, 8-F, 9-D, 10-G.

RESOURCE

Mallinson, G. and J. B. Mallinson, Science Horizons, Silver Burdett & Ginn, Morristown, New Jersey, 1989.

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WATER WORD POETRY

Alphabet Poems: Use a "Water Word" to construct an alphabet poem. The related word or describing word must begin with a letter corresponding to one of those in the water word.

Ex. W inding

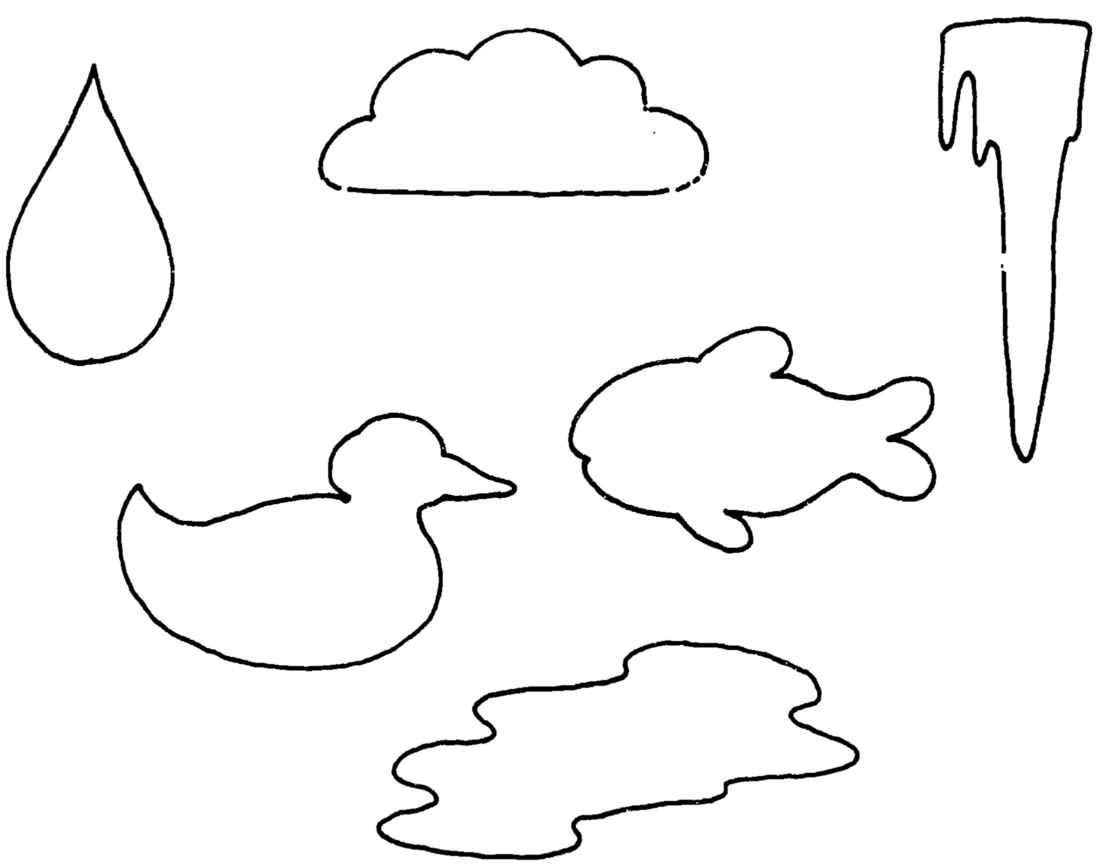
A round

T hrough

E arth

R eservoirs

Shape Poems: With a heavy black marker, draw a large simple shape (such as a water droplet). Place a sheet of paper over the pattern and clip it in place. After constructing the water word poem, rewrite it in the shape of the water droplet (or another appropriate shape).



GEOGRAPHIC WATER TERMS

Match the terms with their definitions. Use a globe or a world map to help you determine the answers.

____ 1. Bay

____ 2. Harbor

____ 3. Ocean

____ 4. Port

____ 5. Peninsula

____ 6. Lake

____ 7. River

____ 8. Gulf

____ 9. Island

____ 10. Coast

A. A large stream of water that flows across the land and usually empties into a lake, an ocean, or another river.

B. Land with water around it on three out of four sides..

C. A protected place where ships are safe from the ocean's waves.

D. A body of land entirely surrounded by water.

E. The largest body of water.

F. A large body of water that reaches into the land.

G. The land along a sea or ocean.

H. A small body of water reaching into the land.

I. A place where ships load and unload goods.

J. A body of water entirely surrounded by land.

Now use each term in a sentence. To be sure you have used them correctly, check the definitions in a dictionary. Rewrite any sentences you need to improve.

1. Bay ______________________________
2. Harbor ______________________________
3. Ocean ______________________________
4. Port ______________________________
5. Peninsula ______________________________
6. Lake ______________________________
7. River ______________________________
8. Gulf ______________________________
9. Island ______________________________
10. Coast ______________________________

LET'S GO DOWN UNDER!

OBJECTIVES

The student will do the following:

1. Define appropriate groundwater terms.
2. Explain where groundwater is found.
3. List the steps of the water cycle in correct sequence.
4. Identify sources of groundwater pollution and possible solutions.

SUBJECTS:
Science, Language Arts

TIME:
90 minutes

MATERIALS:
student sheets (included)
index cards
clear plastic sweater box or similar container
posterboard
string or fishing line
colored markers
clay
soil
sand
gravel
plastic sandwich bag
small plastic bowl
grass
plastic tree figures
water
teacher sheet (included)
materials to make puppets (optional)
posterboard and art supplies (optional)

BACKGROUND INFORMATION

Every day, people all over the world depend on a hidden resource—groundwater. Only 3 percent of the earth's water supply is fresh water and almost 2 percent of that is groundwater. In fact, more than 50 percent of the people in the United States get their drinking water from groundwater, including almost all who live in rural areas.

There is really nothing mysterious about groundwater. We just can't see it like we can see a pond, a stream, or the ocean. This water collects below the earth's surface in aquifers, spaces between soil and rock particles. It is also found in cracks and crevices and inside porous rocks.

The top surface of groundwater is called the water table. When the water table is high enough, groundwater comes to the surface naturally in springs, lakes, ponds and rivers, and it can also be brought to the surface by drilling wells. But the top level of the groundwater (the water table) is usually underground. Groundwater is a vital part of the water cycle and is replenished by rainfall. The amounts of groundwater in different areas of the world vary, and the amount at any one place can change due to prolonged drought, heavy withdrawal for human use, or other factors..

Groundwater quality is generally better than that of surface water because it is not as readily exposed to pollution sources. Also, the movement of groundwater through various layers of soil and rock filters out many impurities. However, some groundwater can be polluted by pesticides, chemicals, landfill leachate, and other materials that seep into groundwater supplies.

<u>Terms</u>

aquifer: an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water (a zone of saturation).

filter: to remove contaminants by using a porous material such as paper or sand.

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

impurities: substances that make another substance unclean.

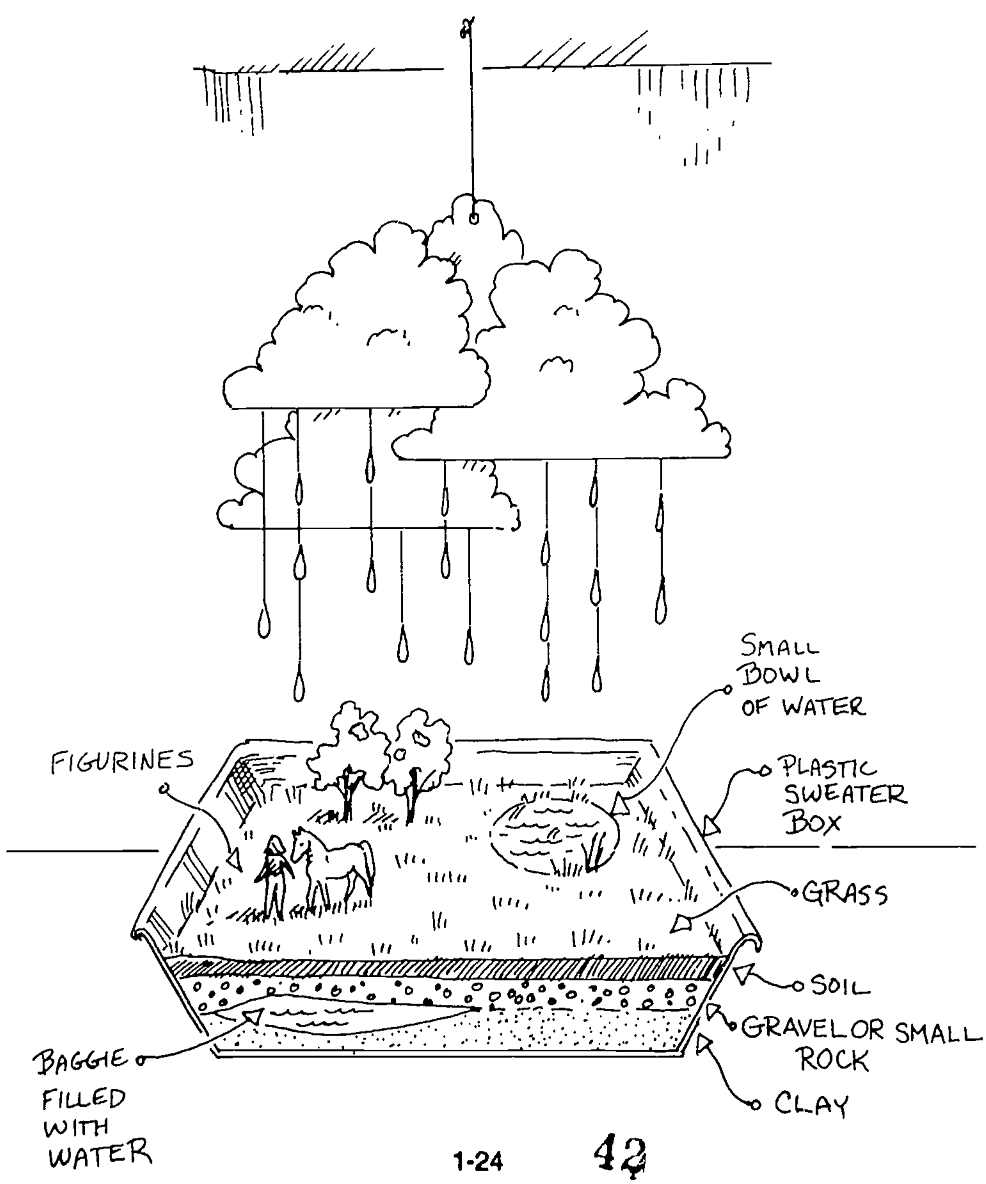
pollution: contaminants in the air, water, or soil that cause harm to human health or the environment.

porous: having pores or cavities that can hold substances such as water.

source: where something originates.

water cycle: the cycle of the earth's water supply from the atmosphere to the earth and back which includes precipitation, transpiration, evaporation, runoff, infiltration, and storage in water bodies and groundwater.

water table: the upper surface of the zone of saturation of groundwater.



ADVANCE PREPARATION

A. Construct model of water cycle. Use posterboard to make clouds and raindrops. Hang clouds with raindrops below them (use string or fishing line). In a clear container, such as a plastic sweater box, create "the ground" area. From the bottom up, layer the following: clay, gravel or small rock, a plastic sandwich bag filled with water, layer of soil, small plastic bowl filled with water (sink the bowl into the soil so the top will be at surface level to simulate a pond or lake), grass, trees, and other figures.

B. Photocopy and cut out 5-6 sets of game cards for "Pollution Solution" (similar to "Old Maid"). Glue the game cards to index cards for durability and uniformity.

C. Photocopy the student sheets, "What's Wrong With This Picture?," "The Water Cycle," and "Groundwater: Fact or Opinion?"

PROCEDURE

I. Setting the stage

A. Pour a small amount of water into the water cycle model. Ask students where the water went. Explain that since it soaked into the ground and will seep into underlying rock formations, it is called groundwater.

B. Explain that the top surface of the groundwater is called the water table.

C. Ask students which they think would be most easily polluted: surface water (lakes, ponds, etc.) or groundwater. Ask them to give reasons for their answers.

D. Point out the importance of groundwater as a part of the water cycle.

II. Activities

A. Discuss the steps in the water cycle. Refer to the model.

1. Distribute the student sheet "The Water Cycle." You may want to have the students do this in small groups or you may do this together, as a class.

2. Students number the steps in the water cycle in the correct sequence, beginning and ending with evaporation. (Answer: 4,3,6,5,2,1)

3. After students complete the activity, list the steps on the board as they call them out.

B. Divide students into 5-6 groups (of no more than 5) to play the card game, "Pollution Solution," which is similar to "Old Maid."

1. Hand out a card set to each group.

2. Explain that for each pollution card there is a corresponding solution card. After all the cards are dealt, students take turns laying down pairs of cards. If a student does not have a pair, he/she must draw a card from the person who played just before him. He then lays down cards if he makes a match, and it is the next person's turn. At the end, whoever is left with the "Groundwater Gobbler" loses.

C. Have the students do the "What's Wrong With This Picture?" worksheet. You might prefer to do this together as a class using the student sheet master to make a transparency. The illustration shows at least 17 possible sources of groundwater pollution. See the teacher key. (Have the students name at least 10 of these.)

III. Follow-Up

A. Have students complete the student worksheet called "Groundwater: Fact or Opinion?" (Answers: 1.0, 2.F, 3.0, 4.0, 5.F, 6.F, 7.0, 8.F, 9.0, 10.0)

B. Review with students the many sources of groundwater pollution. Summarize that anything that pollutes water can pollute groundwater, especially things stored on or under the ground or applied to it. Ask them to make a list of what they and their families can do to help keep groundwater clean.

IV. Extensions

A. After reviewing correct letter form, have students write to the American Groundwater Trust (and other sources) for additional information.

B. Have students make posters to display around the school using the information from III. B.

C. Have students write and direct a puppet show on pollution and its consequences and present it to another class.

RESOURCES

"America's Priceless Groundwater Resource," American Groundwater Trust, Dublin, Ohio, 1991.

"Groundwater Pollution Control," American Groundwater Trust, Dublin, Ohio, 1990.

THE WATER CYCLE

Number the steps in the water cycle in the correct sequence, beginning and ending with evaporation.

______Replenishes (recharges) water in rivers, lakes, streams, and ponds

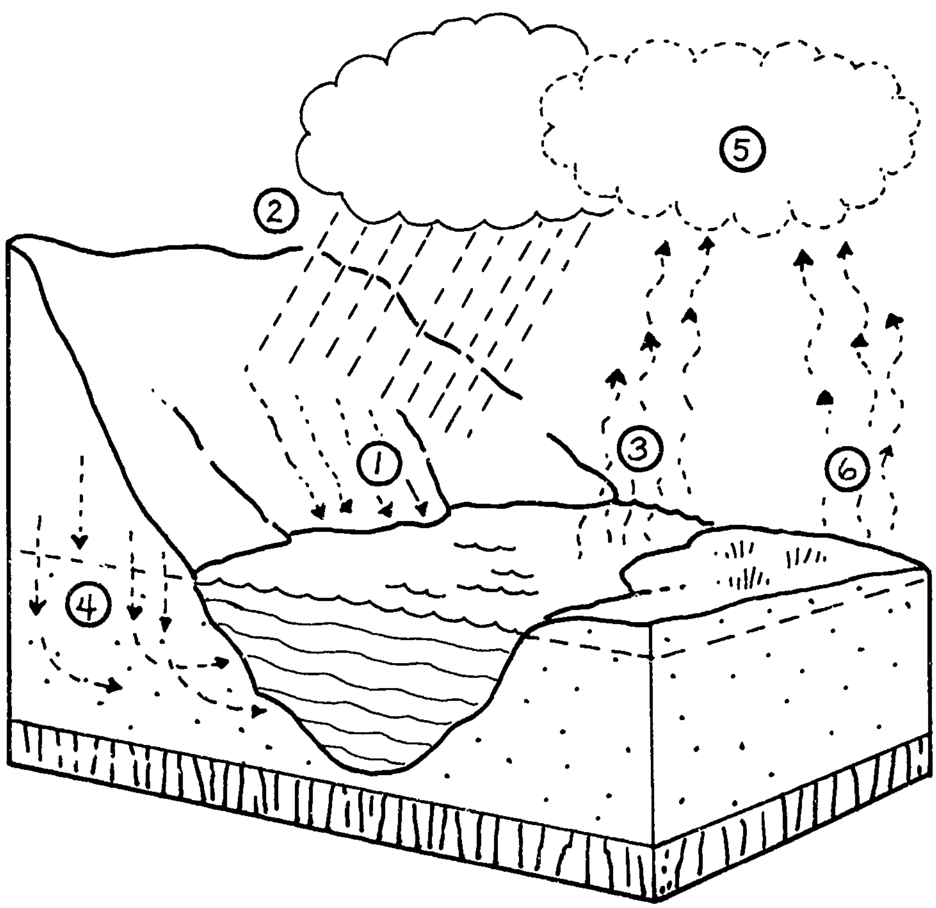
______Falls to th~ earth in some form of precipitation (rain, snow)

______Surface water evaporates again

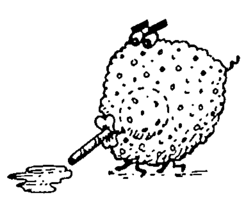
______Seeps into the ground and enters an aquifer

______Condenses in the atmosphere

______Evaporates from surface water, plants, and animals as water vapor



"POLLUTION SOLUTION" GAME CARDS

S Require that people disposing of manure, garbage, or industrial wastes get permission from the government or make laws to control where they can dispose of them	S Make underground storage tanks from something other than metal (it can get rusty and get holes) and check how much is put in and taken out (to see if anything is "missing")
S Make laws to control how facilities to handle human waste are built and installed and to limit the number of them in an area	S Using only the amount of fertilizer and pesticide that is really needed, and making laws to control how they can be thrown away
S Build the cattle or hog feedlots and the chicken houses so that rain will not wash animal wastes into streams or ponds	P Fertilizers and pesticides put on farmlands or yards to help crops or yards grow and be healthy
P Holding ponds and lagoons used to hold liquid wastes or wastes mixed with water	P Human waste leaking from septic tanks, cesspools, or privies
P Improper disposal of waste such as manure, garbage, or industrial wastes	S Checking pipes to make sure they are working properly and not leaking
P Slimy liquid from garbage (leachate) leaking out of landfills	P Animal wastes produced in large amounts at places where many cattle, hogs, or chickens are kept
S Don't allow holding ponds or lagoons unless they are leakproof	P Leaks from underground storage tanks that hold gas or oil
S Locating landfills in places that are less likely to let the leachate reach groundwater	S Cover the piles of road salt with plastic or put it in sheds
P Piles of road salt stored until it is needed in winter	P Leaks in big pipes that carry oil, gas, or wastes
GROUNDWATER GOBBLER 	

GROUNDWATER: FACT OR OPINION?

If the statement is a fact, put an F on the line. If it is an opinion, put an O.

______ 1. Groundwater is a mysterious source of water.

______ 2. Groundwater is found beneath the earth's surface.

______ 3. Groundwater tastes better than surface water.

______ 4. Groundwater is the most important of all natural resources.

______ 5. Groundwater is not as easily polluted as surface water.

______ 6. Groundwater is a part of the water cycle.

______ 7. Studying about groundwater is boring.

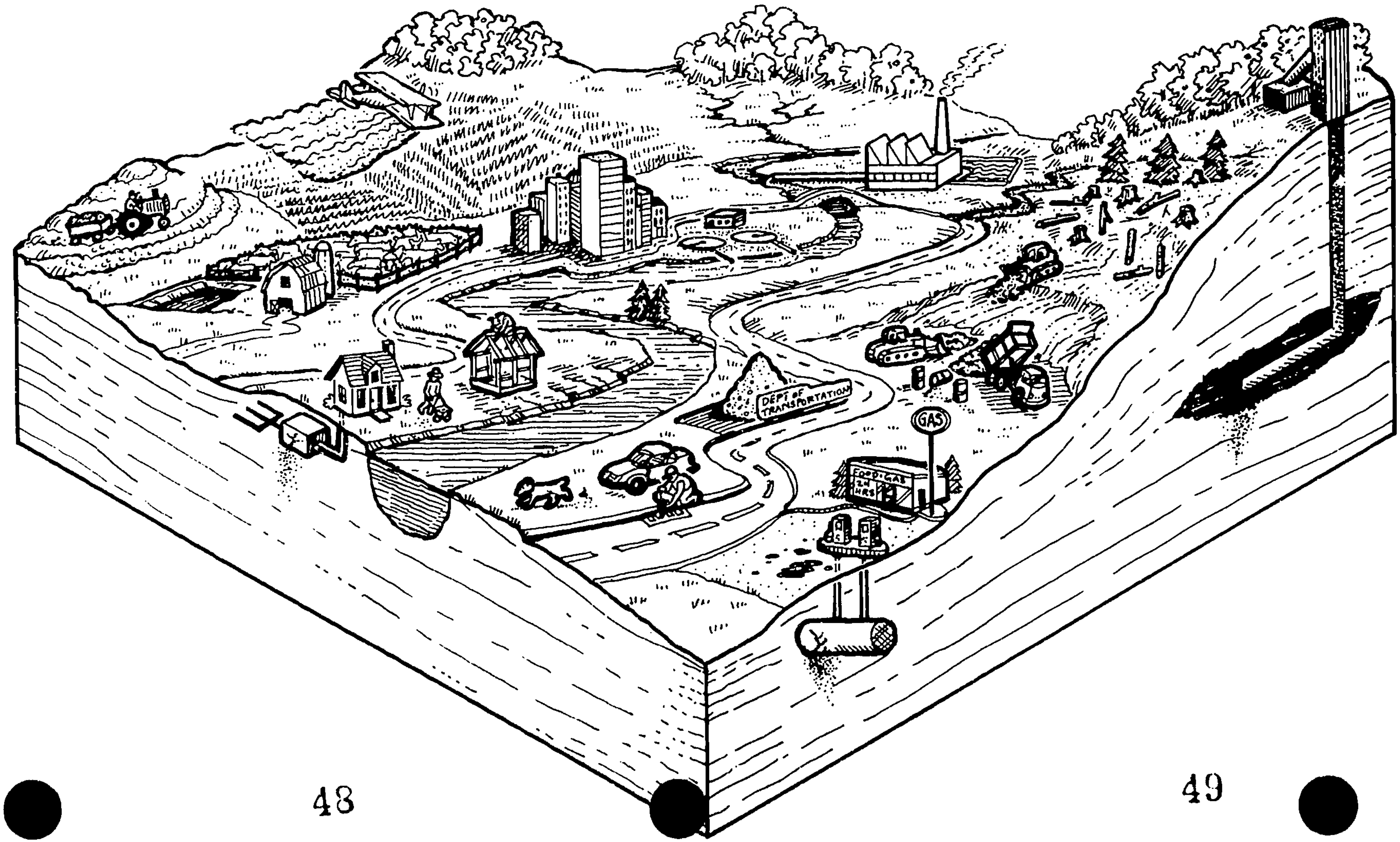
______ 8. One person's actions can affect groundwater.

______ 9. Landfills are yukky.

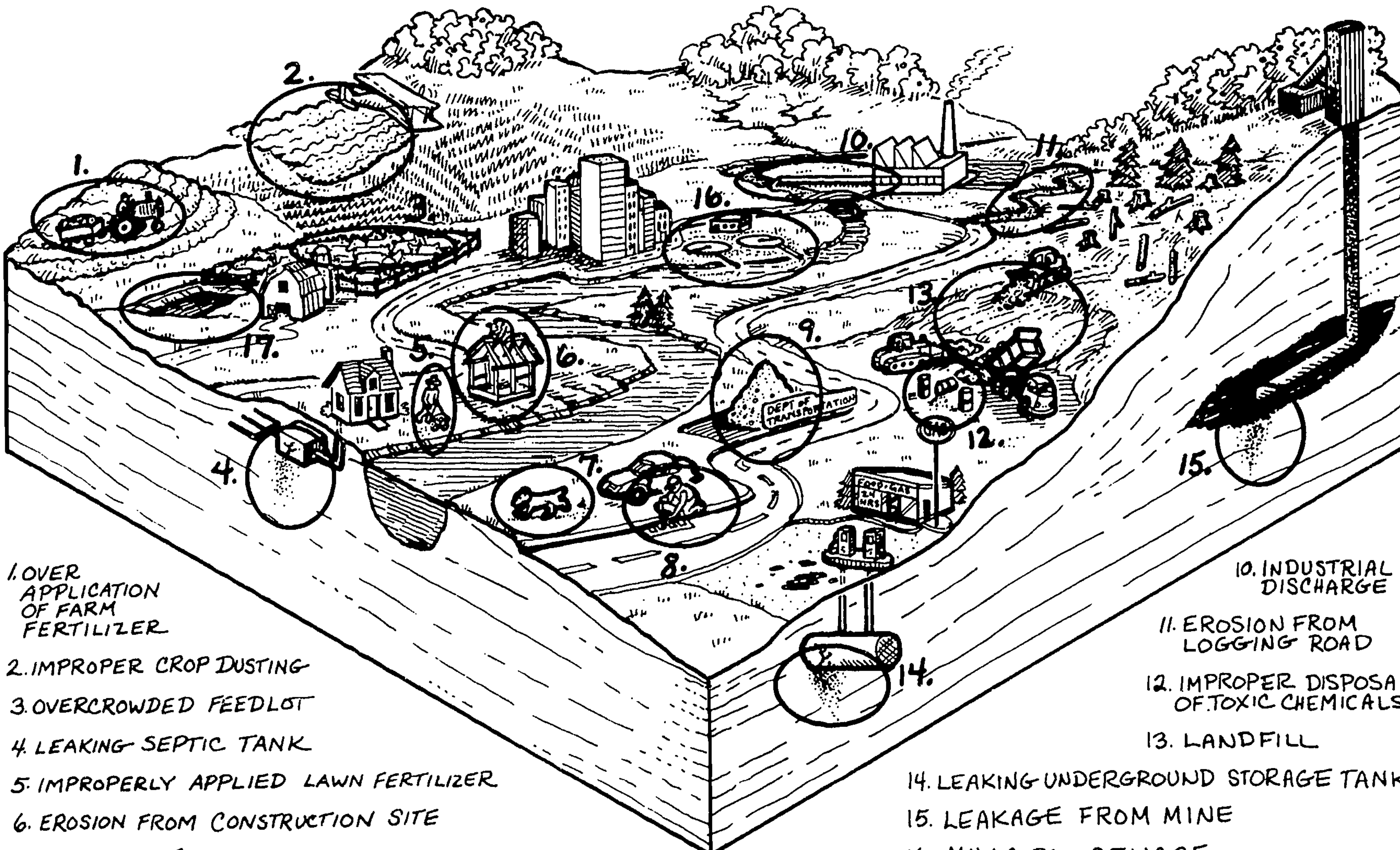
______ 10. Farmers should not use pesticides.

WHAT'S WRONG WITH THIS PICTURE?

There are 13 potential sources of water pollution in this diagram. Circle them and label each one.



WHAT'S WRONG WITH THIS PICTURE?
TEACHER KEY



1. OVER APPLICATION OF FARM FERTILIZER
2. IMPROPER CROP DUSTING
3. OVERCROWDED FEEDLOT
4. LEAKING SEPTIC TANK
5. IMPROPERLY APPLIED LAWN FERTILIZER
6. EROSION FROM CONSTRUCTION SITE
7. PET WASTE
8. IMPROPER DISPOSAL OF MOTOR OIL
9. ROAD SALT
10. INDUSTRIAL DISCHARGE
11. EROSION FROM LOGGING ROAD
12. IMPROPER DISPOSAL OF TOXIC CHEMICALS
13. LANDFILL
14. LEAKING UNDERGROUND STORAGE TANK
15. LEAKAGE FROM MINE
16. MUNICIPAL SEWAGE
17. LEAKING ANIMAL WASTE STORAGE LAGOON

BY THE SEA

OBJECTIVES

The student will do the following:

1. Define coastal waters.
2. Locate coastal waters on a map.
3. Label coastal waters on a map.

SUBJECTS:
Social Studies, Science

TIME:
90 minutes

MATERIALS:
globe or world map
teacher sheets (included)
acetate sheets
overhead projector
student sheet (included)
crayons or highlighters (one per student)
transparency pen (wipe-off)
blankets (optional)
volleyball and net (optional)
large size construction paper
blue tempera paint (optional)
paint brushes (optional)

BACKGROUND INFORMATION

Coastal wasters are the waters between the open ocean and the shore. Examples include bays, estuaries, gulfs, sounds, and straits (see definitions below). These waters provide habitats for many different plants and animals. They are rich fishing grounds and serve as nurseries or spawning grounds for many fish and shellfish. They offer year-round recreation opportunities for many people.

They also provide us with some of the fish used in aquariums, some sponge products, and shells which are collected or used to make commercial products.

Terms

bay: a large estuarine system (e.g., Chesapeake Bay).

estuary: the area where a river empties into an ocean; a bay, influenced by the ocean tides, resulting in a mixture of salt water and fresh water.

gulf: a part of the ocean or sea extending into the land.

sound: long, broad inlet of the ocean with its larger part roughly parallel to the coast.

strait: a narrow passageway connecting two large bodies of water.

ADVANCE PREPARATION

A. Prepare transparencies from the teacher sheets "Coastal Waters," and "United States Coastal Waters," and one from the student sheet "Coastal Waters Search" (included).

B. Make copies of the student sheet "Coastal Waters Search" (included) for each student.

PROCEDURE

I. Setting the stage

A. Ask the students if they ever visited an ocean beach and went swimming. Tell them that if they have, they have swum in coastal waters.

B. Ask how many have eaten shrimp, oysters, clams, or other types of shellfish. Tell them that those shellfish probably began their life and/or spent a part of their life in coastal waters.

C. Define coastal waters for the students and share the background information with them.

D. Use a globe or world map to point out examples of these coastal waters around the world. For example, point out the Bay of Bengal (between India and Southeast Asia), the Persian Gulf (in the Middle East), the Straits of Hormuz (at the south end of the Persian Gulf) or the Straits of Magellan (south end of South America), and the Mouths of the Amazon (South America) where there are extensive estuaries. Sounds are so small that you probably will not find one on a globe.

II. Activity

A. Display the "Coastal Waters" transparency.

1. Place your finger on the source of the river and trace it to the sea, explaining what an estuary is when you reach the sea.

2. Point out examples of coastal waters and briefly explain what they are. Be sure to include the bay, gulf, strait, and sound. (Include the others if your students are curious about them.)

B. Display the "United States Coastal Waters" transparency. (NOTE: You may wish to use maps or transparencies of other continents for this activity.) Locate and point out some examples of coastal waters, such as the Straits of Florida, the Gulf of Alaska, Long Island Sound, and Chesapeake Bay.

C. Give each student a copy of the student sheet "Coastal Waters Search." (NOTE: You may use this as a small group activity if you wish.)

1. Leave the "United States Coastal Waters" transparency on display for the students' use.

2. Tell the students they are to locate and label on their maps the coastal waters labeled on the transparency. For the estuaries, they should use a crayon or highlighter to mark with an "X" the location of a river's estuary on their maps. (NOTE: You may wish to have students use maps in their social studies books or atlases for this activity.)

III. Follow-Up

A. Review coastal waters terms and definitions.

B. Display the transparency of the student sheet, "Coastal Waters Search."

1. Allow individual students to come up to the projector and label one coastal water on the transparency. (Use a wipe-off transparency pen.)

2. Have the rest of the students check their maps against the transparency.

C. Collect the student sheets and check them for understanding.

IV. Extensions

A. Assign cooperative learning groups to prepare a presentation on a type of coastal water or a coastal water product. On the day of the presentations, have a "Beach Day." Each student should bring a sack lunch and dress for a day at the beach. After their presentations, put down blankets and have a picnic. (NOTE: You might play beach music while the students eat.) Later, go outside and play beach ball volleyball.

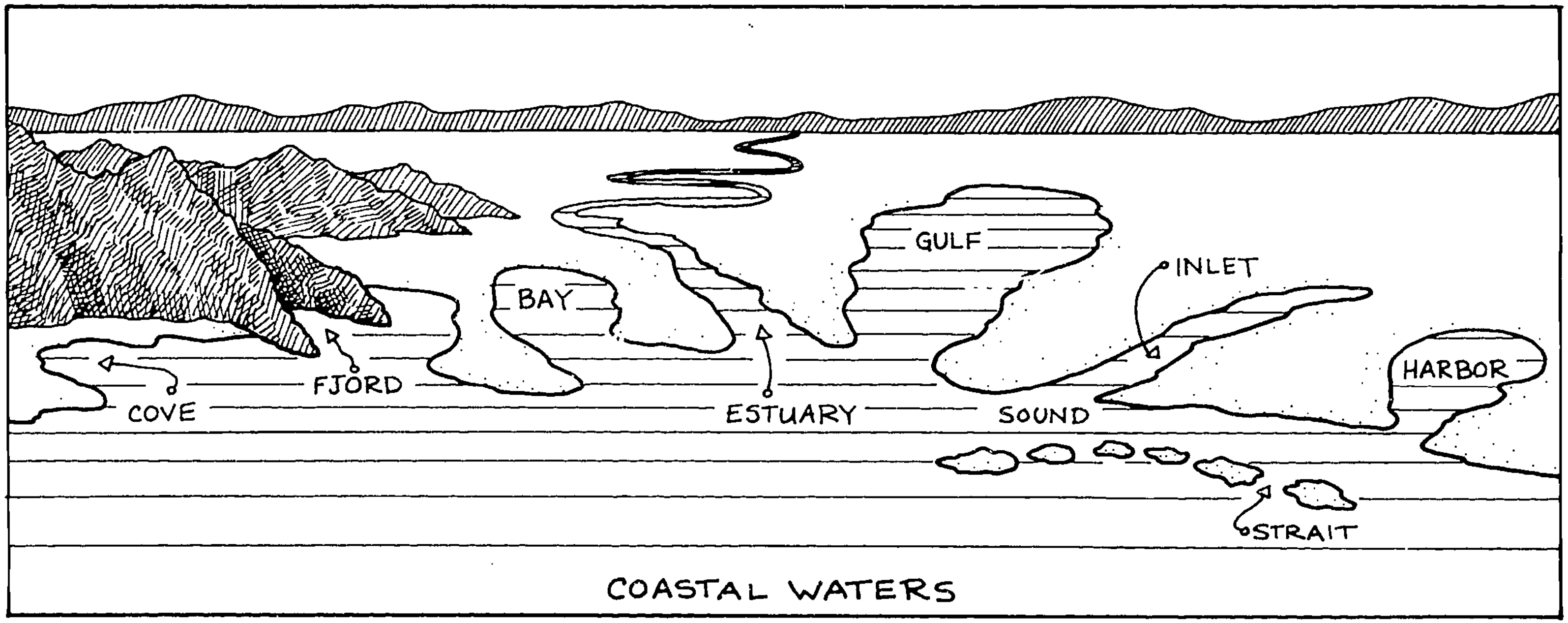
B. Have the students do crayon resist art pieces. Give each student a large sheet of white construction or drawing paper. Tell the students to draw a picture of what they think the bottom of a bay, lagoon, or other coastal water might look like. Be sure they include plants and animals they might see. After their crayon drawings are done, have them do a blue wash over their pictures using thin blue tempera paint and paint brushes. You might want to read The Little Mermaid or another appropriate book or story to them as they work.

RESOURCES

Hagans, Gloria P., et al., Geography Education Overheads, D. C. Heath and Co., Lexington, Massachusetts, 1989.

Hirst, Stephanie Abraham, Ph.D., The United States: Its History and Neighbors, Harcourt Brace Jovanovich, Orlando, Florida, 1988.

COASTAL WATERS



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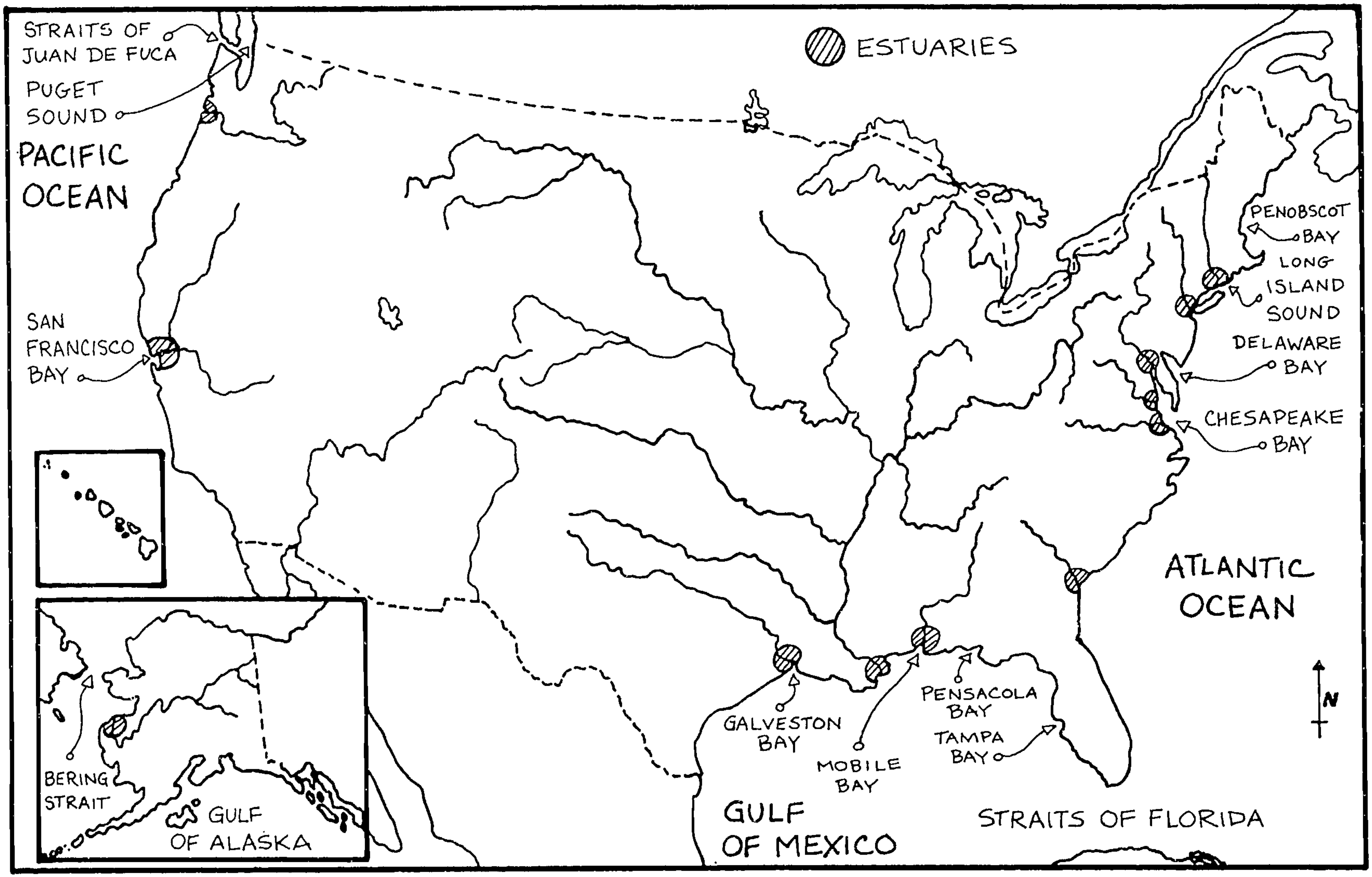
UNITED STATES COASTAL WATERS



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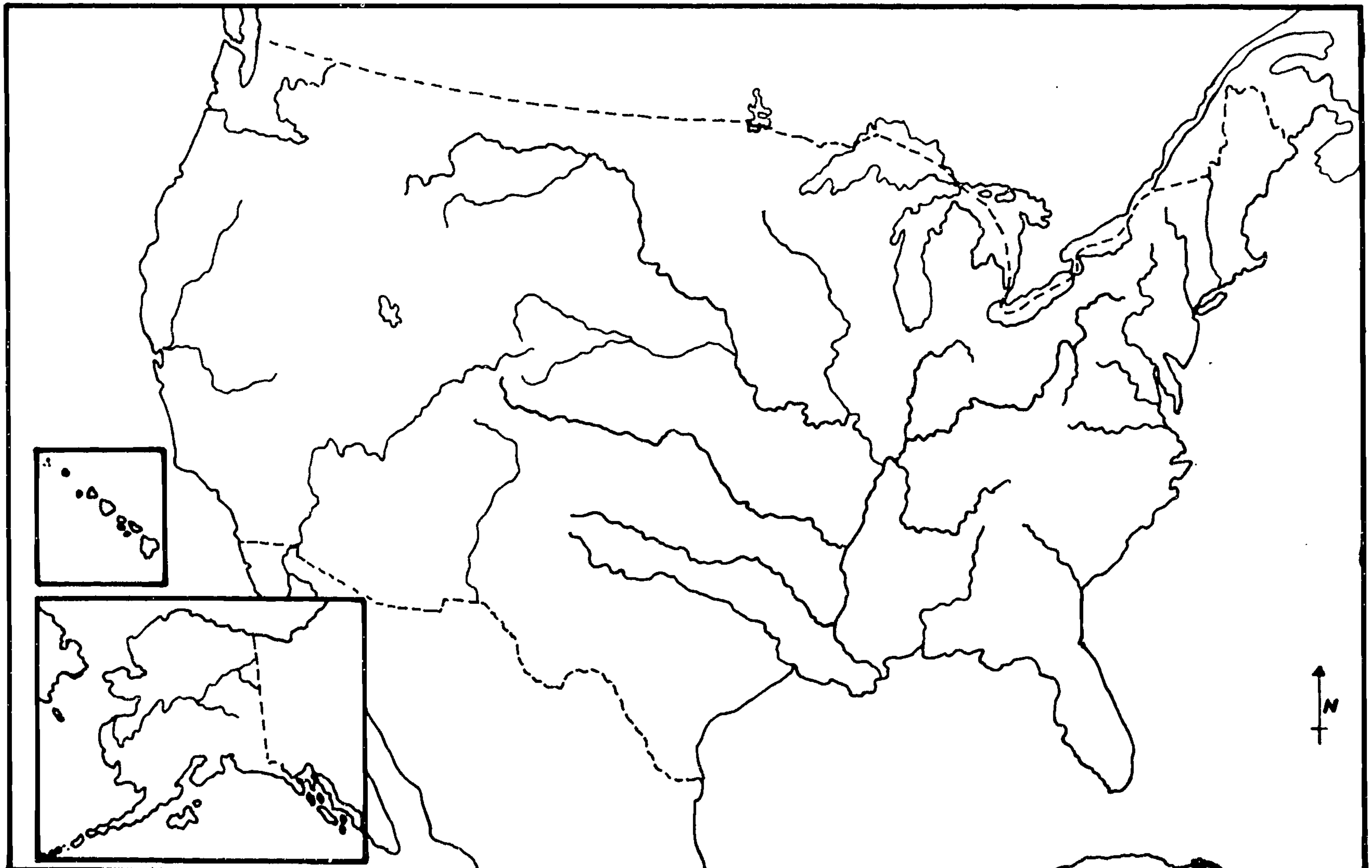
COASTAL WATERS SEARCH



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SHEDDING LIGHT ON WATERSHEDS

OBJECTIVES

The student will do the following:

1. Simulate runoff using a watershed model.
2. Explain why rivers are necessary to drain water from watershed area.

SUBJECTS:
Science, Social Studies

TIME:
60 minutes

MATERIALS:
maps showing area watershed (1 per student)
salt flour dough (recipe included)
water
paper
waterproof paint
picture of a river and surrounding area
sprinkling can
9" x 13" (25 x 35 cm) pan — at least 2" (5 cm) deep
drawing paper
measuring cup
world maps (1 per team)
U.S. maps (1 per team)
teacher sheets (included)
transparency
overhead projector

BACKGROUND INFORMATION

The concept of "watersheds" is a useful way to divide areas of land according to how the land and the water flowing over and through it interact. A watershed is an area or region which drains into a particular watercourse or body of water.

Watersheds are important because scientists can study them in order to help determine how much surface water is available for people's needs. The topography, vegetation, soil, rock formations, and climate of a watershed also determine an area's lakes, streams, and rivers.

Generally, two adjacent watersheds are separated by a high area of land called a divide. As an example, the watershed of the Columbia River and America's largest watershed, the watershed of the Mississippi River, are separated by the Great Divide in the Rockies.

Large amounts of runoff from watersheds, occurring in short periods of time, can lead to severe flooding and destruction of land and property. Sometimes heavy rains can result in flooding even when a watershed's rivers are quite large.

<u>Terms</u>

basin: a low lying area where surface water flows, such as a river basin.

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

topography: the physical features of a place or region.

watershed: land area from which water drains to a particular water body.

ADVANCE PREPARATION

A. Construct a generalized relief map of a watershed. Use salt dough in a pan at least 9" x 13" (25 x 35 cm) and 2" (5 cm) deep. (NOTE: The recipe for salt dough is on the teacher sheet "Salt Dough Relief Map" [included].)

B. Order or locate maps showing your local watershed area. Obtain one per student. (NOTE: Call the United States Geological Surveys Earth Science Information Center at 1-800-USA-MAPS to request specific maps. For local maps, contact the local water department, state agricultural department, state geological survey, or perhaps the department of geology at the nearest college or university.)

C. Obtain enough U.S. maps and world maps for there to be one for each team of four students.

D. If you invite a geologist to class, make sure he/she is informed as to what the objectives are and what to teach the students.

PROCEDURE

I. Setting the stage

A. Show the students a picture of a river and the surrounding lands.

1. Ask the students where the water in the river came from. Write their responses on the board.

2. Explain to the students that most of the water in our rivers comes from water that has drained off the surrounding land. Remind the students that water runs downhill. If it is a rainy day, observe this at your school. What you can observe in your schools' parking lot or yard also happens on a much larger scale over very large areas of land.

3. Discuss the words "runoff" and "watershed."

B. Show your class a transparency or photocopy of the teacher sheet, "Watersheds." Note that it shows two watersheds.

II. Activity

A. Give each student a copy of a watershed map (or any map showing topography) of your local area.

1. Have the students trace some of the paths water takes to get from the various parts of the watershed area to the streams, rivers, and lakes.

2. Ask the students to tell you where they think the river will eventually take the water collected from the watershed area.

B. Present the model of the watershed area to the class.

1. Explain the concepts of valley, hill, mountain, and so forth, to your students by pointing them out on the model.

2. Using a sprinkling can, have it "rain" over the model. Ask the students to observe how water runs over the area and to note where it collects. (the rivers)

3. Explain to the students that areas where water has "pooled" become our bodies of water, such as lakes, ponds, streams, and rivers.

C. Continue sprinkling the model until the pan begins to fill.

1. Explain to the students that if water has no way to be carried off, then flooding occurs. (Flooding also occurs when water cannot be carried off quickly enough.)

2. Ask the students what is needed to carry the water away from the watershed. (river)

III. Follow-Up

A. Ask the students to write a paragraph telling you how a watershed and a river are interrelated.

B. Pass out drawing paper to the students. Have the students draw a watershed area and color it.

C. Divide students into teams of four and give each team a map of the U.S. Assign each team a particular area of the U.S. (New England, Southeast, etc.) and have them find and record the major rivers in that section of the country.

1. Ask the teams to list states that are not part of the Mississippi River watershed.

2. Tell teams to find two rivers that do not empty into another river, but empty directly into the ocean. Explain to the teams that some rivers have very small watershed areas.

D. Pass out the world maps to the teams.

1. Have the teams trace and list a few rivers that flow into Africa's Congo River. Explain to the teams that the Congo is a major watershed river in Africa.

2. Ask the teams to trace and list some of the rivers that flow into South America's Amazon River. Explain to the teams that the Amazon River is a major river for South America.

IV. Extension

Invite a geologist to class to explain how topographical maps are made. If possible, request they bring booklets that can be given to each student.

RESOURCE

Douglas, L. S., et al., Experiences in Earth-Space Science, Laidlaw Brothers, Irvine, California, 1985.

SALT DOUGH RELIEF MAP

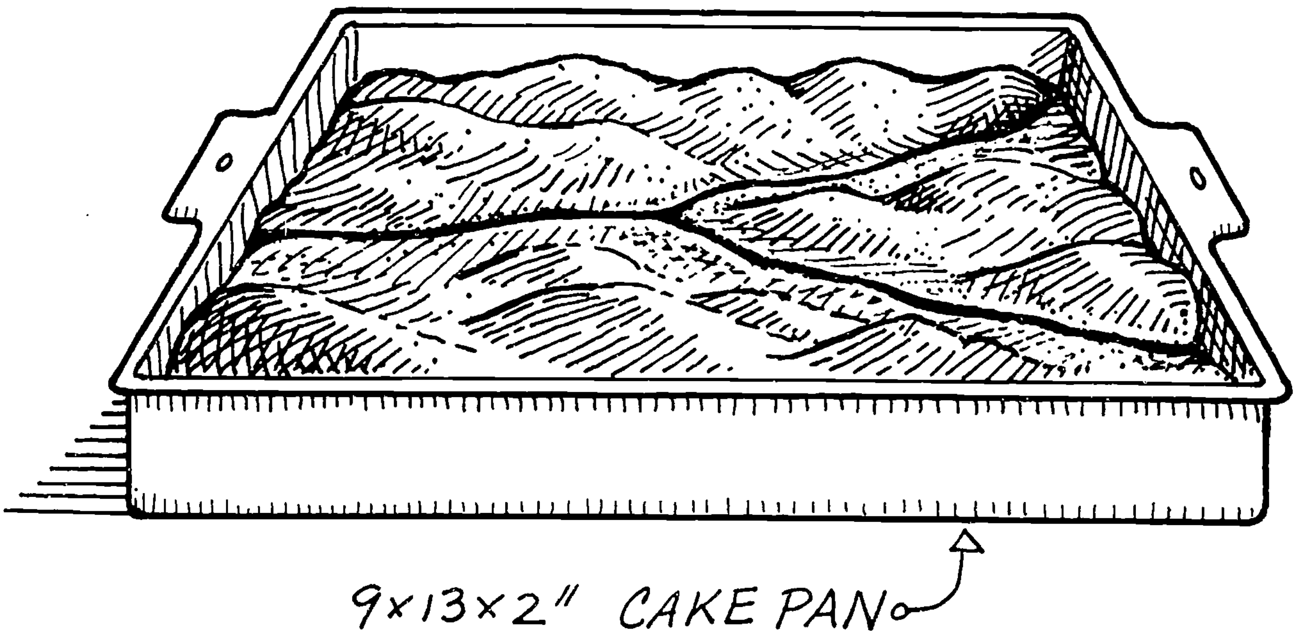
Salt Flour Dough (NOTE: Makes between 1-1/2 and 2 cups of dough. The recipe should be doubled in order to make enough for the relief map. You might make it in 2 batches to ensure success.)

1 cup (250 mL) flour
1/2 cup (125 mL) salt
1 cup (250 mL) water
1 tablespoon (15 mL) cooking oil
2 teaspoons (10 mL) cream of tartar

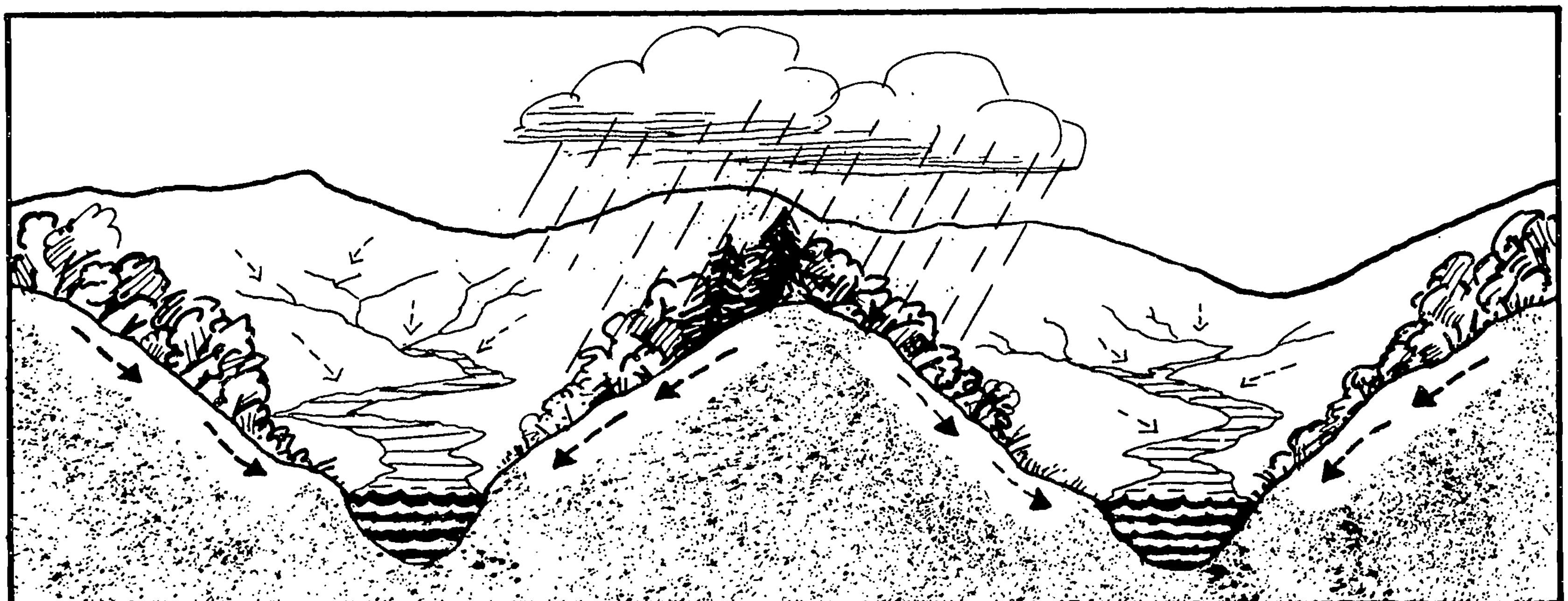
Mix and heat ingredients until a ball forms. Add a touch of food coloring if desired.

To make model: Try to create a relief map similar to what is depicted on the teacher sheet, "Watersheds." On one end of the pan, let the two major valleys come together to form one larger one (like a "Y"). Make a "riverbed" (depression) at the bottom of each major valley. Make sure that the end of the pan with the bottom of the "Y" is lower than the other end; i.e., the dough should be shallow at that end.

Allow the model to dry. Have several students paint it with waterproof paint. Using waterproof paint protects the model so that it can be reused.



WATERSHEDS



PLANNING LAND USE

OBJECTIVES

The student will do the following:

1. Write about feelings experienced in a wilderness setting.
2. Identify the land use zones on a planning map.
3. Identify land use patterns having possible negative effects on water quality.
4. Redraw existing land use maps for better environmental quality.

SUBJECTS:
Science, Language Arts, Social Studies

TIME:
100 minutes

MATERIALS:
paper
pencils
textbook or magazine pictures
crayons or colored pencils
posterboard
butcher or other large paper (for making rough copies)
rulers
student sheet (included)
local land use planning maps or aerial photographs (optional)

BACKGROUND INFORMATION

People determine how land is used in their communities. These decisions are usually driven by immediate economic considerations. In recent years, however, many communities have begun to plan their growth much more carefully. Part of the reason for this is that people have recognized that environmental quality and aesthetic value — clean, healthful, and attractive characteristics — are important considerations, along with economic concerns. Land use planners now take these less immediate concerns (as compared to economics) into account because the experience of many communities has proved that natural areas do indeed yield economic benefits in the long run by providing aesthetic value and increasing environmental quality.

Natural areas such as parks, tracts of forest or grassland, streams, and ponds are desirable features in any community. They increase an area's "livability," help people enjoy their community, and increase property values. Water bodies are highly desirable to most people. Planning to leave strips of natural area along these watercourses helps to protect water quality by filtering pollutants out of the runoff entering the water; it also provides habitat for plants and animals.

Commercial and industrial land use zones benefit from planned natural areas, as do residential areas. In any densely developed, heavily used area, the creative and sound planning of natural areas yields economic and environmental benefits for now and for many, many years to come.

Terms

agricultural: related to farming.

commercial: businesses, offices, hospitals, and stores.

industrial: factories.

land use patterns: the main ways we use land in specific areas.

open space: land that has no active use by people and is usually forest or grassland.

residential: neighborhoods consisting of houses, apartments, and mobile home parks.

responsible land management: planning for and using land in a way that benefits people and the environment.

ADVANCE PREPARATION

A. Gather the materials for the activity, including textbook or magazine pictures of dense urban areas, natural or wilderness areas, and urban areas that include trees, parks, streams, and so forth.

B. Photocopy the student sheet land use map of our county for each student.

PROCEDURE

I. Setting the stage

A. Have the students complete a sensory writing exercise.

1. Lead the students in a visualization of what it is like to have a wilderness experience. Suggest one involving water, e.g., sitting by a mountain stream hearing the water gurgle and splash over stones. Ask the students to use all their senses. Ask questions such as, "How does the light glisten on the water and move through the forest?" Prompt them with statements such as: Listen to the sounds and recall what the water sounds like and its soothing effect; Smell the forest and feel the cleanness and coolness of the air; Place your hand in the water and feel that it is cold; When you cup it to your nose, it has no smell.

2. Ask the students to then write about their experience and recall their favorite and most vivid images.

B. Discuss with the students the desirability of natural areas — forests, grasslands, streams, and ponds — even in developed or urban settings.

1. Show the students the two contrasting pictures: one of a densely developed urban area that has no open space, natural areas, or water bodies; and one of an urban area including a park or other area having trees, grass, and water (if possible).

a. Ask the students which picture they think represents the best place to live. Discuss their reasons for their choices. (They will probably prefer the area with the natural areas. Lead them to identify the natural areas and water bodies as desirable.)

b. Discuss with the students the picture of the heavily developed city scene again. Ask them what could be done to make this setting more desirable. (parks, trees, ponds, etc.)

2. Discuss with the students that people can plan ahead as they build their communities so that they can include natural areas (including water). If there are good local examples (parks, greenbelts, etc.) with which the students would be familiar, discuss these.

II. Activities

A. Introduce the students to the concept of responsible land management as discussed above.

B. Give each student a copy of the student sheet "Land Use Map." Explain that a land use map is a map that shows how we can use land, i.e., for what purposes local government has designated certain areas. Using the term definitions and the student sheet, explain the land use areas on the map. Discuss with them how the land use patterns may be detrimental to environmental quality. Note that:

1. Residential areas have no open spaces planned.

2. No open space is planned along creeks.

3. Commercial areas and industrial areas have limited open space planned.

4. There are industries located on streams.

C. Stress to the students that water is an important component of environmental quality. That is, wherever there is a "clean" environment, there is good water quality and vice versa.

D. Have the students complete the following planning activities.

1. Reemphasize the importance of clean water. (All living things must have it.) Remind the students that we are "stewards." "Stewardship" means taking care of our world and its resources. We must take care of our water and land.

2. Direct the students' attention to the land use maps.

a. Group the students in teams and have them look at their planning maps. Tell them that the purpose of this activity is to look at the ways people use the land. If we plan to protect the environment, then life will be better for all of us.

b. Tell the students that they will first analyze the map, looking for potential environmental problems. Have them look for possible sources of pollution or other things that affect water quality. Have them think about what they would like to have where they live. (For example, would they want to live right next door to a factory? Would they like to have a forest near where they live?)

c. Ask what activities fit or do not fit into the zones.

d. Allow the students to discuss their observations for five minutes, then ask the teams to list a proper and an improper use for each zone. Write their responses on the board.

3. Ask the students the following questions about existing land use. Have them identify the following on their maps.

a. What is a residential area? commercial area? industrial area? open space area?

b. On the map's legend, rank each of the land use areas from most area to least area in terms of size. (Have them number them with pencils.)

c. In which direction are the creeks flowing? (Have them trace the creeks with their fingers.)

d. List three land uses near creeks.

e. Describe three possible bad effects of these land uses near creeks. Why would these be bad?

III. Follow-Up

A. Tell the students to imagine now that each team is going back 40 years into the past and is going to make a land use plan. Remind the students of the need for environmental quality and quality of life for people, including water quality. Have the students imagine they are going to live in the community; they should make changes that they would like to see happen.

B. Allow time for team discussion and making a "rough" copy of their new land use map. Supply copies of the unmarked land use map for their use.

C. Ask the students to answer the following questions when they complete their new land use plans.

1. What is the biggest problem with the old map? Why?

2. What else is a problem? Why?

3. How will you solve these problems?

4. Could there be problems with your solutions? What might they be?

5. How would you make the residential areas better?

6. Was there disagreement in the team about land uses? How was the disagreement solved?

D. After answering the questions, have the teams redraw a final copy of their map on posterboard. Have them present the new plan to the class.

IV. Extension

A. Obtain planning maps or aerial photographs of your home community. (Check with your local Metropolitan Planning Commission or similar agency.) Let them analyze them as they did in this exercise.

B. Invite a member of the local planning commission to talk to the students about local planning issues.

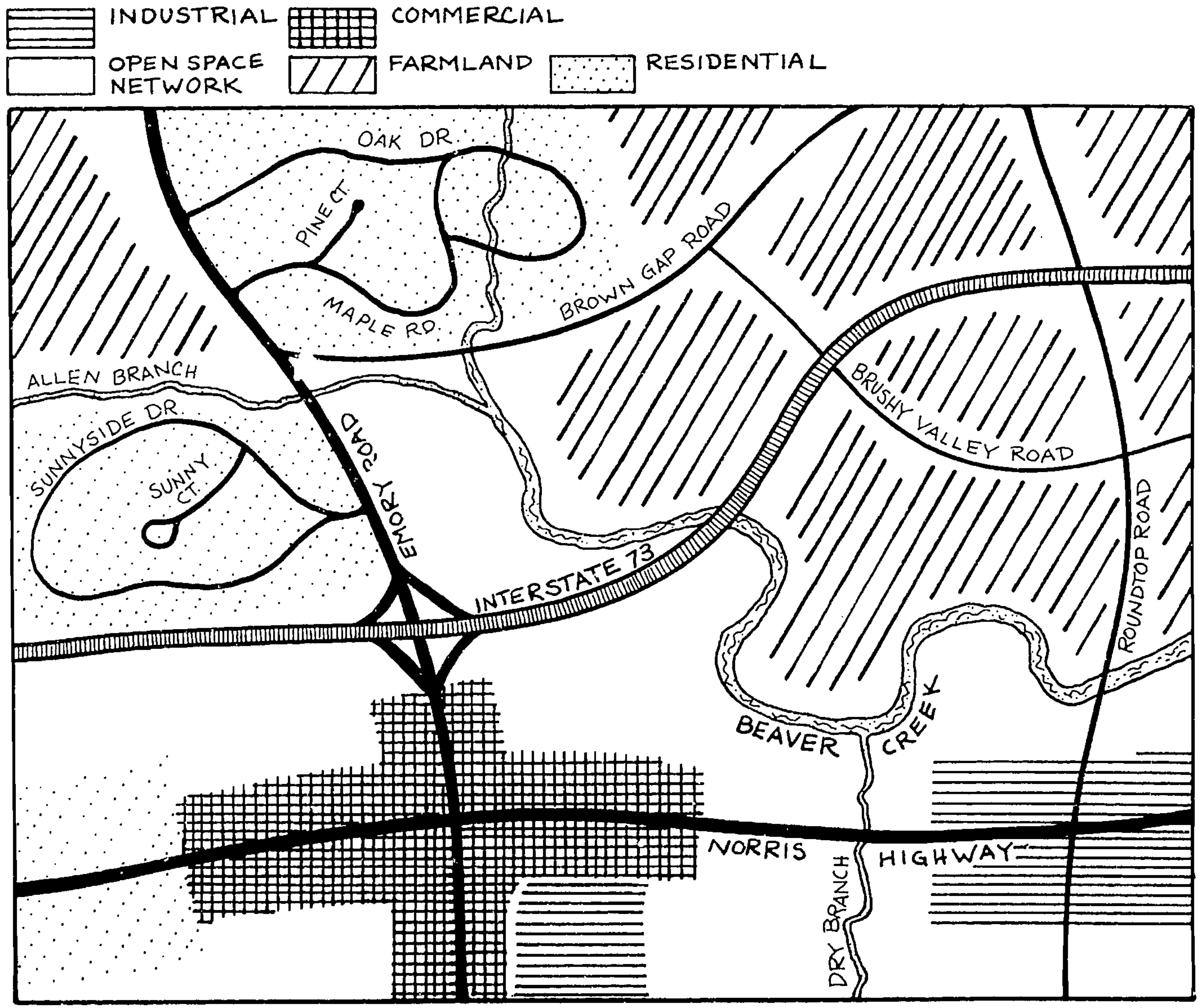
C. Have the students write songs or poems about water quality and responsible land management.

RESOURCES

Investigating the Human Environment: Land Use, Biological Sciences Curriculum Study, Teachers Guide, 1984 (ISBN 0-8403-3319-6).

O'Connor, Maura, "Living Lightly in the City," Schlitz Audubon Center, 1982.

LAND USE MAP OF OUR COUNTY



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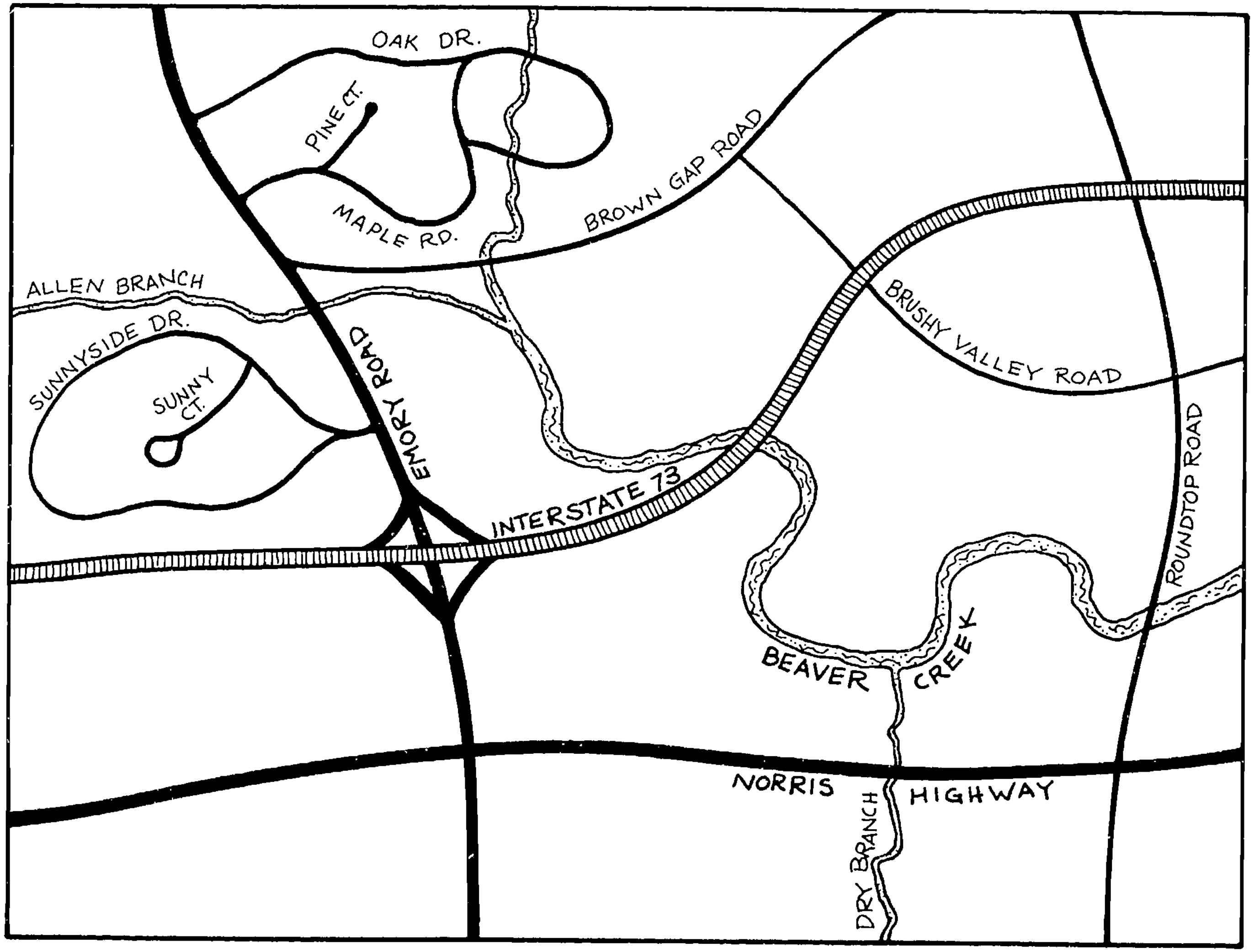
MAKE YOUR OWN LAND USE PLAN



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WHAT'S THE DIFFERENCE?

OBJECTIVES

The student will do the following:

1. Distinguish between water pollution and water contamination.
2. Identify water pollutants and water contaminants.
3. Write sentences differentiating between water pollution and water contamination.

SUBJECT:
Science, Art, Language Arts

TIME:
60-90 minutes

MATERIALS:
pitcher of tap water
2 clear quart containers
or two 1-liter bottles with tops cut off
small amount of bleach, fertilizer, detergent, motor oil, vinegar, soil
small leaf, twig, and dead insect
1 piece 18"x12" (45 x 30 cm) construction paper per student
crayons
student sheets (included)
teacher sheet (included)
baby food jars
wide-range pH paper

BACKGROUND INFORMATION

Water contamination is pollution that occurs when materials of natural origin (such as soil, silt, or algae) gives water an earthy, fishy, woody, or other unpleasant taste or odor or discolors it.

Water pollution is pollution that occurs when unwanted wastes (such as sewage, industrial wastes, and agricultural wastes) are released into water sources. This is a result of human activities.

Terms

water contamination: the dirtying of water resources by natural materials.

water pollution: the dirtying of water resources, especially by human-generated wastes.

ADVANCE PREPARATION

A. Gather contaminants: small leaf, twig, dead insect, and soil.

B. Gather pollutants: fertilizer (represents agricultural waste), bleach and vinegar (represent industrial waste), and detergent and motor oil (represent domestic waste). Make sure all pollutants are properly disposed of after use (read their labels carefully).

C. If you choose to do the experiment in part IV.A, gather materials. You will need 1 jar and 1 pollutant or contaminant and a copy of student sheet "Experiment Journal" per team. Also, if you choose to use the pH paper, you will need to acquire it now. Call Carolina Biological Supply (800-334-5551) or other supply companies. You may be able to get some from a high school science teacher.

D. If you choose to do the fill-in puzzle in part IV.B, make a copy of the student sheet "What Is It?" for each student.

PROCEDURE

I. Setting the stage

A. Pour water into the two containers until they are about half full. Ask if there is any difference between the two jars of water.

B. Add a pollutant to one of the jars and a contaminant to the other. Again, ask if there is any difference between the two.

C. On the board write the words "Water Pollution" and "Water Contamination" and draw a vertical line between the two to make a chart. Under Water Pollution write "Human cause" and under Water Contamination write "Natural cause." Explain the difference to the students, giving examples like the following: After heavy rain, streams and rivers sometimes turn "muddy" because they are carrying a lot of silt that washed into the river from the land. Sometimes in the summer, a lot of algae grows in the water and makes it taste bad. These are examples of water contamination. If people cause things like chemicals or human or animal wastes to be put in streams or rivers, this is called water pollution.

D. Refer the students back to the two jars and ask them which is the pollutant and which is the contaminant.

II. Activity

A. Distribute construction paper to students and tell them to fold it in half lengthwise. With a crayon, ask them to draw a line down the fold then label the left side "Water Pollution" and the right side "Water Contamination."

B. In indiscriminate order, hold up the pollutants and the contaminants and explain what they are and what they represent. As you hold them up, have students write down the material in the correct column to indicate whether it is a pollutant or a contaminant. (NOTE: You may want to have a chart prepared with the materials listed for younger students to refer to.)

C. After you have displayed all the materials, go back over them with the students and ask them to tell you which column they belong in and why. Be sure to stress the difference: Pollution is the result of humans; contamination is the result of natural causes. Have students check and correct their charts as you do this.

III. Follow-Up

A. Review what water pollution and water contamination are. Ask students if they can think of other pollutants and contaminants. Add answers to chart, if appropriate.

B. Have students turn their papers over and draw another line down the fold. Tell students to draw a simple picture of a body of water (creek, river, lake, etc.) with a pollutant in it on one side and a body of water with a contaminant in it on the other side. Below the pictures, students should write complete sentences telling what the material is, whether it is a pollutant or contaminant, and why they classified it as such.

C. Collect papers and display them on a bulletin board.

IV. Extensions

A. Experiment

1. Divide students into six teams. Pour water into six baby food jars and place a pollutant or contaminant in each jar. Assign a jar to each team. Label the jars and place in a bright location. Do not place in direct sunlight.

2. Give each group a copy of student sheet "Experiment Journal" and have them fill out #1.

3. Tell students that each team is going to conduct an experiment on their water over the next four weeks and they are going to keep a journal of what happens during the experiment.

4. Have students fill out #2.

5. Allow teams 5 minutes to discuss their hypotheses, then write it down in #3.

6. Each week, allow teams time to write down their observations in their journals. If possible, supply teams with pH paper and allow them to test their water each week. (NOTE: See Advance Preparation for suppliers of pH paper.)

7. At the end of the experiment, allow time for the teams to draw a conclusion and record it in the journals. Then, have the teams share their journals and tell the class what happened.

8. To wrap it up, give teams 5 minutes to brainstorm an answer to the question "What can you do?" When doing this, tell students to think about prevention as well as a solution to the problem after it has already occurred.

B. Word Fill-in Puzzle

1. Give each student a copy of student sheet "What Is It?" and tell them to fill in the spaces using the words listed at the top. This is similar to a crossword puzzle.

2. Tell them that all horizontal words are pollutants and all vertical words are contaminants, or you may ask them if they can figure out the pattern themselves. (NOTE: The first step toward solving the puzzle is to sort the list into 2 categories.)

3. Challenge students to come up with more contaminants and pollutants to add to the puzzle.

C. Creative Writing

1. Tell students they are going to write a story about water pollution from a bear's point of view.

2. Ask them to close their eyes and imagine they are each a bear while you read the story starter on the "Bear Necessities" teacher sheet.

3. After reading the story starter, tell students to finish the story from the bear's point of view. Ask them to imagine that the water has been polluted and tell what the bear thinks and feels, and what the bear family will do.

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RESOURCES

Arnold, Caroline, Bodies of Water Fun, Facts, and Activities, Franklin Watts, New York, 1985.

Carlson, Carl W. and Bernice W. Carlson, Water Fit to Use, Day Co., New York, 1972.

Slattery, Britt E., WOW! The Wonders of Wetlands, Environmental Concern, Inc., St. Michaels, Maryland, 1991.

EXPERIMENT JOURNAL

1. Names of people on team: ______________________________

____

____

2. Problem: ______________________ is a ______________________
(material in water) (contaminant/pollutant)

It looks ______________________________

and smells ______________________________

3. Hypothesis: ______________________________

____

____

4. Week 1: ______________________________

____

____

5. Week 2: ______________________________

____

____

6. Week 3: ______________________________

____

____

7. Week 4: ______________________________

____

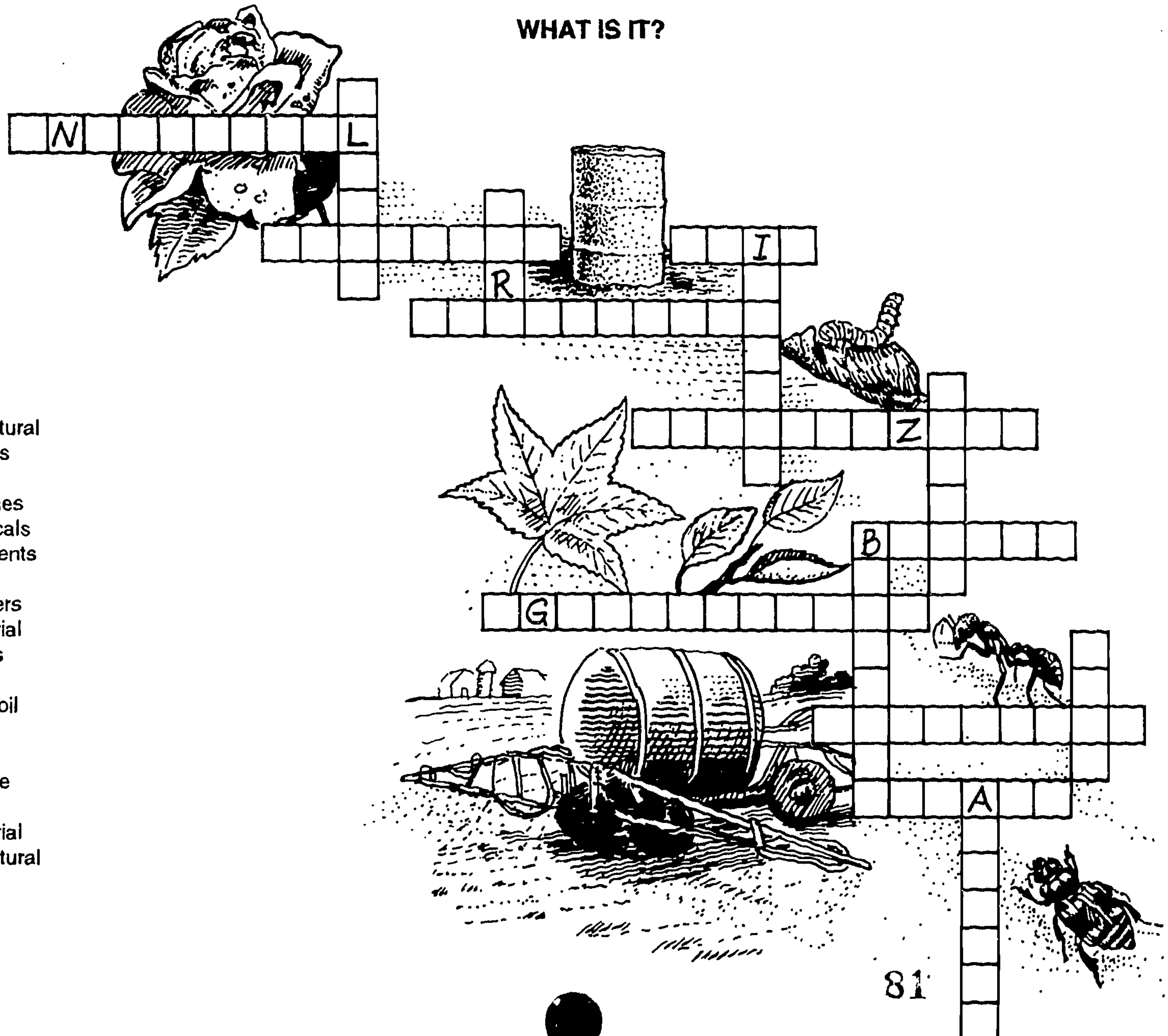
____

8. Conclusion: ______________________________

____

____

WHAT IS IT?



acid
agricultural
animals
bleach
branches
chemicals
detergents
dirt
fertilizers
industrial
insects
leaves
motor oil
plants
silt
sewage
plants
industrial
agricultural

80

81

STORY STARTER: BEAR NECESSITIES

Summertime is a good time to be a bear! There are lots of good things to eat so we have lots of energy to run and play in the forest. But even with all the trees for shade, we still get hot with all this thick fur covering us. One of our favorite things to do after a long, hot, tiring game of tag is to get a nice, cool drink of water from the stream, find a big tree to scratch our backs against, and then lay down in its shade for a nap.

This morning, my sister and I played tag for the longest time. We were looking forward to a refreshing drink of water but when we got to the stream, the water . . .

(NOTE: Now have the students finish the story.)

FOR SALE: USED WATER

OBJECTIVES

The student will do the following:

1. Describe and locate the parts of the drinking water treatment system: source, treatment, and distribution.
2. Describe and locate the parts of the wastewater treatment system: collection, treatment, discharge.
3. Describe the differences between drinking water treatment and wastewater treatment.
4. Locate and label the parts of their home's drinking water system and wastewater system.

SUBJECTS:
Science, Art, Math

TIME:
100 minutes

MATERIALS:
2 opaque plastic pitchers
tea bag
acetate sheets
2 clear glasses
tap water
posterboard
student sheets (included)
teacher sheets (included)

BACKGROUND INFORMATION

The amount of water on earth has always been the same. Water moves through the water cycle and is not destroyed. Three-fourths of the earth is covered by water. Oceans (salt water) make up 97 percent of earth's water, glaciers and ice caps make up 2 percent, and fresh water makes up 1 percent.

A commercial drinking water treatment system has three basic parts: source, treatment and distribution. Well water typically has a source and distribution although some well water is also treated. Sources of drinking water are surface water (streams, rivers, man-made reservoirs) and groundwater (water underground). Once collected, water is treated with chemicals to kill bacteria; remove contaminants, bad tastes, and odors; and clump solid particles together. The chemicals and particles settle out and the water is filtered through layers of sand, gravel, and charcoal. The last step is adding chlorine to disinfect, or kill bacteria, before distribution through many water pipes.

Once water is used it leaves your house as wastewater. The three parts of a wastewater treatment system are: collection, treatment, and discharge. Wastewater is collected in large pipes and sent to the wastewater treatment plant for primary treatment to have solid wastes removed by bar screens and settling tanks, for secondary treatment by aeration and growth of good bacteria and settling again, then advanced treatment where chlorine is added to further disinfect the water before it is discharged into the receiving stream or lake. Some homes may have a septic system which has a settling tank and drain field.

Terms

drinking water: cleaned and treated water ready to drink.

wastewater: water that has been used for domestic or industrial purposes.

water source: surface water (lakes, rivers and streams) and groundwater.

ADVANCE PREPARATION

A. Determine whether you will cover urban drinking and wastewater treatment, or rural well water and septic systems, or both. Choose whichever is appropriate for your students and delete the student sheets and teacher information you do not need.

B. Place a tea bag in a pitcher of water and leave it overnight. This will represent "dirty water." Keep it in a container that you can't see through.

C. Fill another pitcher with fresh tap water.

D. Post headings on the chalkboard (or posterboard) as follows:

Running Water	Sources of Water	Cleaning Drinking Water	Where Does Water Go?	Cleaning Wastewater

E. Make an overhead transparency of each of the four teacher sheets, "Drinking Water Treatment Plant," "Well Water," "Wastewater Treatment Plant," and "Septic System."

F. List terms and definitions on the board.

G. Copy the student sheets "Home Survey," "Drinking Water Treatment Methods," and "Wastewater Treatment Methods" for each student.

PROCEDURE

I. Setting the stage

A. Begin by asking who would like a drink of cool water.

1. In one glass pour the "clean" water and in the other glass pour the "dirty" water. Ask, "Which water would you like to drink?"

2. Ask how water gets "dirty." How does it get "clean?" Tell the class that today we are going to find out how our drinking water and wastewater are cleaned.

B. Ask the class the following questions to begin a question and answer discussion about water and list the answers on the board under the headings.

1. Where are some places we have running water? (homes, schools, businesses, etc.)

2. Can anyone tell me where your water comes from?

3. How is our water cleaned before we drink it?

4. Does anyone know where your water goes when it does down the drain?

5. Does the water that goes down the drain get cleaned?

II. Activity

A. Pass out the student sheets "Drinking Water Treatment Methods" and "Wastewater Treatment Methods".

B. Using the teacher sheet overhead transparencies "Drinking Water Treatment Plant," "Well Water," "Wastewater Treatment Plant," and "Septic System," lead the class through each diagram and have them label each stage of treatment.

C. Pass out the take home survey sheet (student sheet "Home Survey") and go over the directions. Tell the students to bring their sheets back the next day after completing the survey

D. The next day make sure all students have the worksheets "Drinking Water Treatment Methods," "Wastewater Treatment Methods," and "Home Survey." Explain that each person will diagram or draw his or her house and its drinking water supply system and wastewater disposal system and label all the parts.

III. Follow-Up

A. Display diagrams in the room or in the hallway.

B. Compile data from home survey sheets on the board under the headings: city water, well water, sewer, septic tank.

C. Have students make a pie chart to compare the percentages of each response.

IV. Extension

A. Have a representative from the drinking water treatment plant and/or wastewater treatment plant come and speak to the class, or take a field trip to your community's treatment plants.

B. Have a representative from the public health department come to talk to your class about well and septic system safety.

C. Make a mobile showing parts of drinking water treatment and waste water treatment systems.

RESOURCES

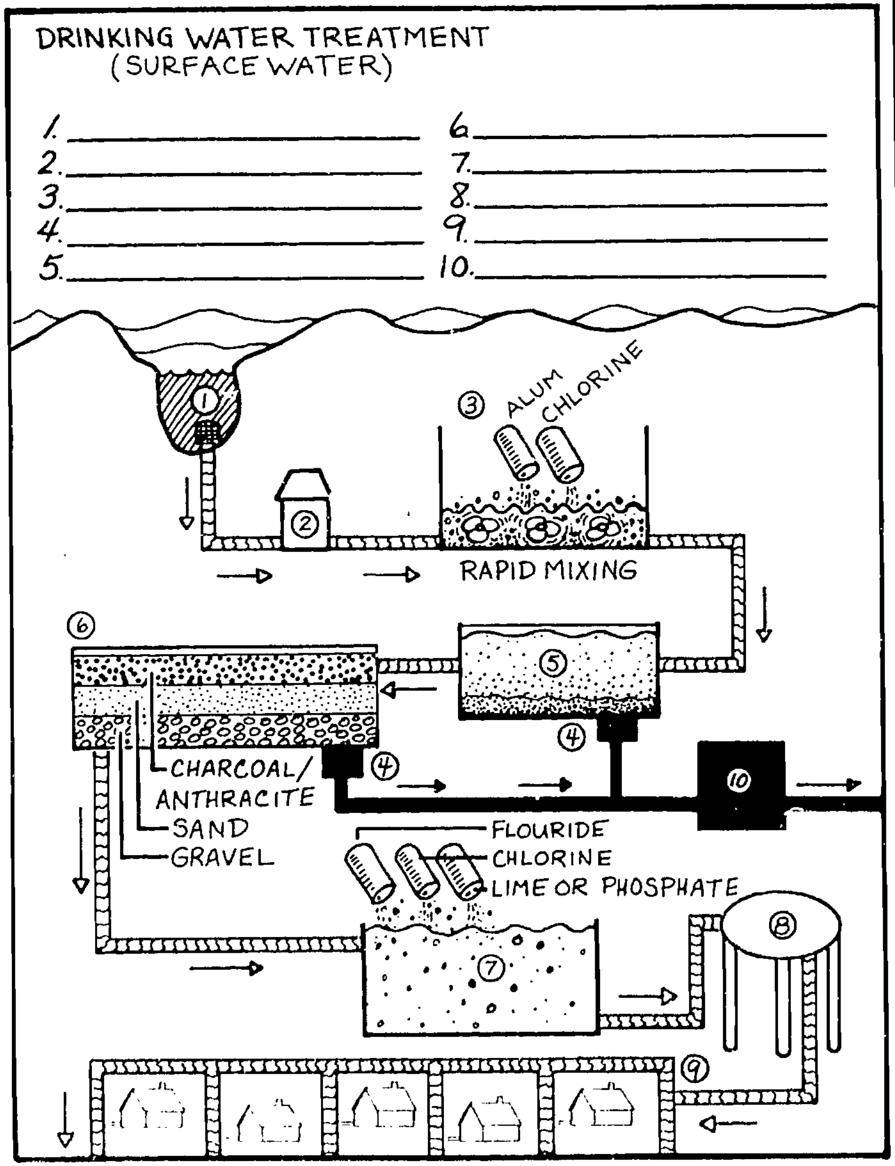
Bernstein, Leonard, et al., Concepts and Challenges in Earth Science, Globe Book Co., Englewood Cliffs, New Jersey, 1991.

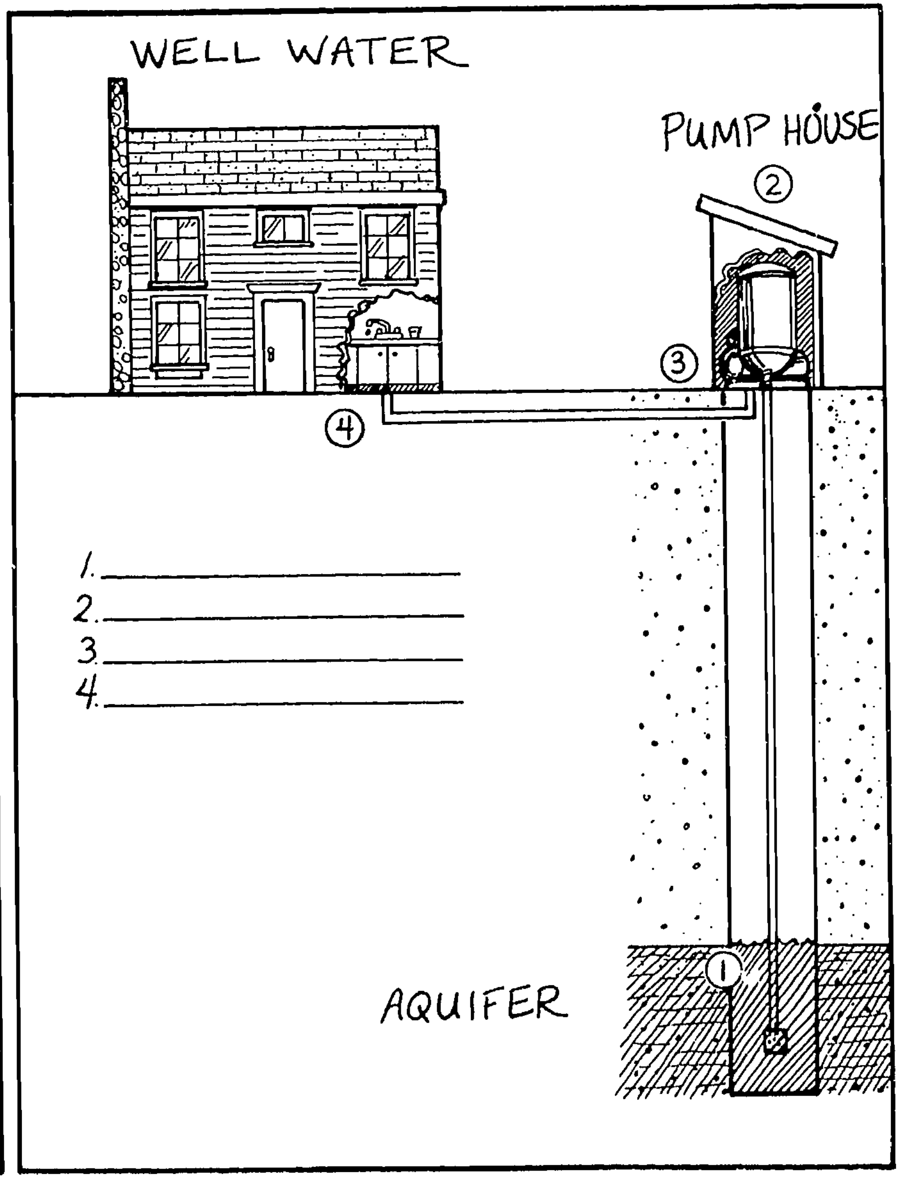
Cobb, Vicki, The Trip of a Drip, Little, Brown and Co., Boston, Massachusetts, 1986.

"Lets' Learn About Wastewater Treatment," Channing L. Bete Co., South Deerfield, Massachusetts, 1981.

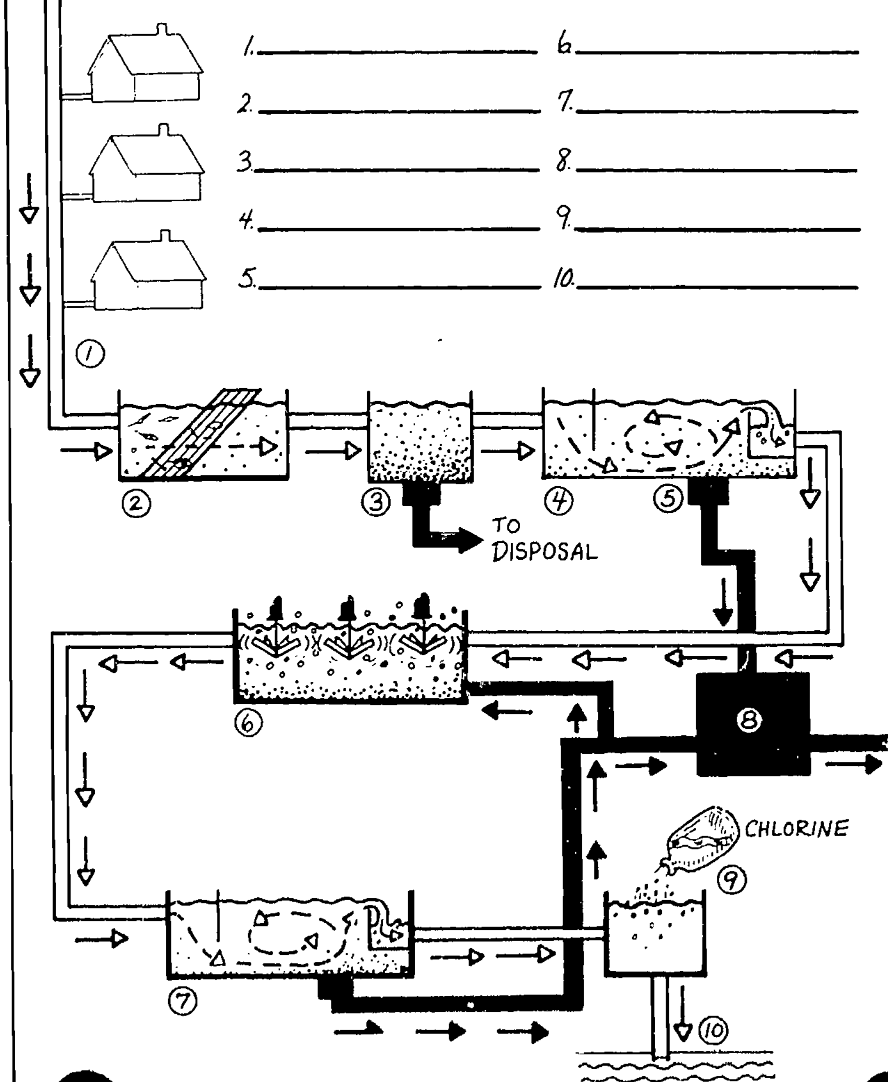
"The Story of Drinking Water," American Water Works Association, Denver, Colorado, 1984.

DRINKING WATER TREATMENT METHODS



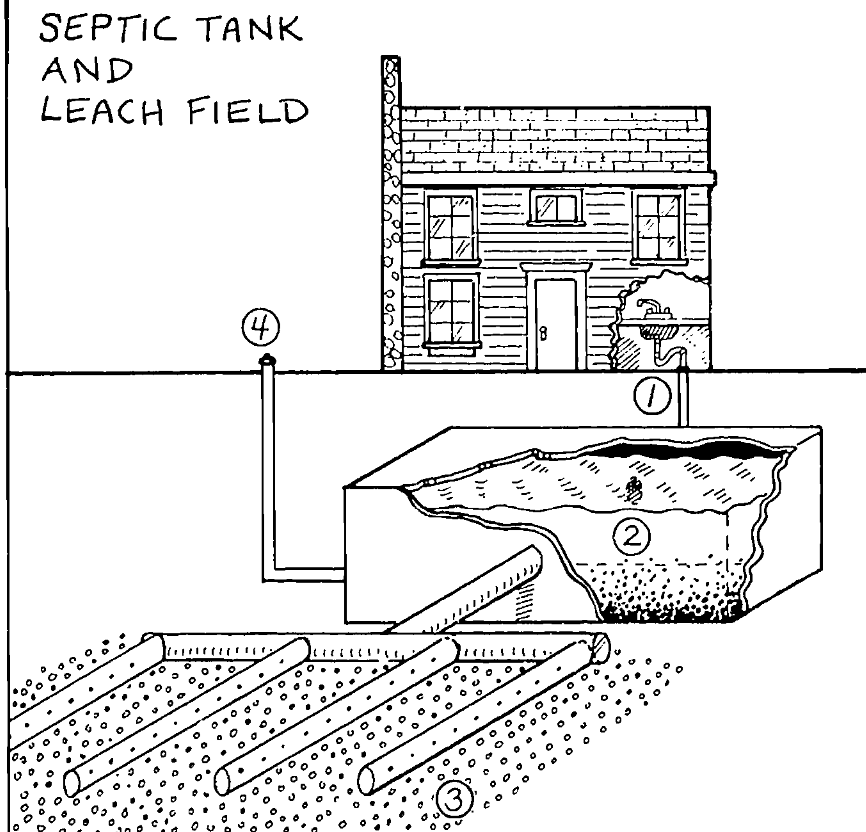


WASTEWATER TREATMENT METHODS



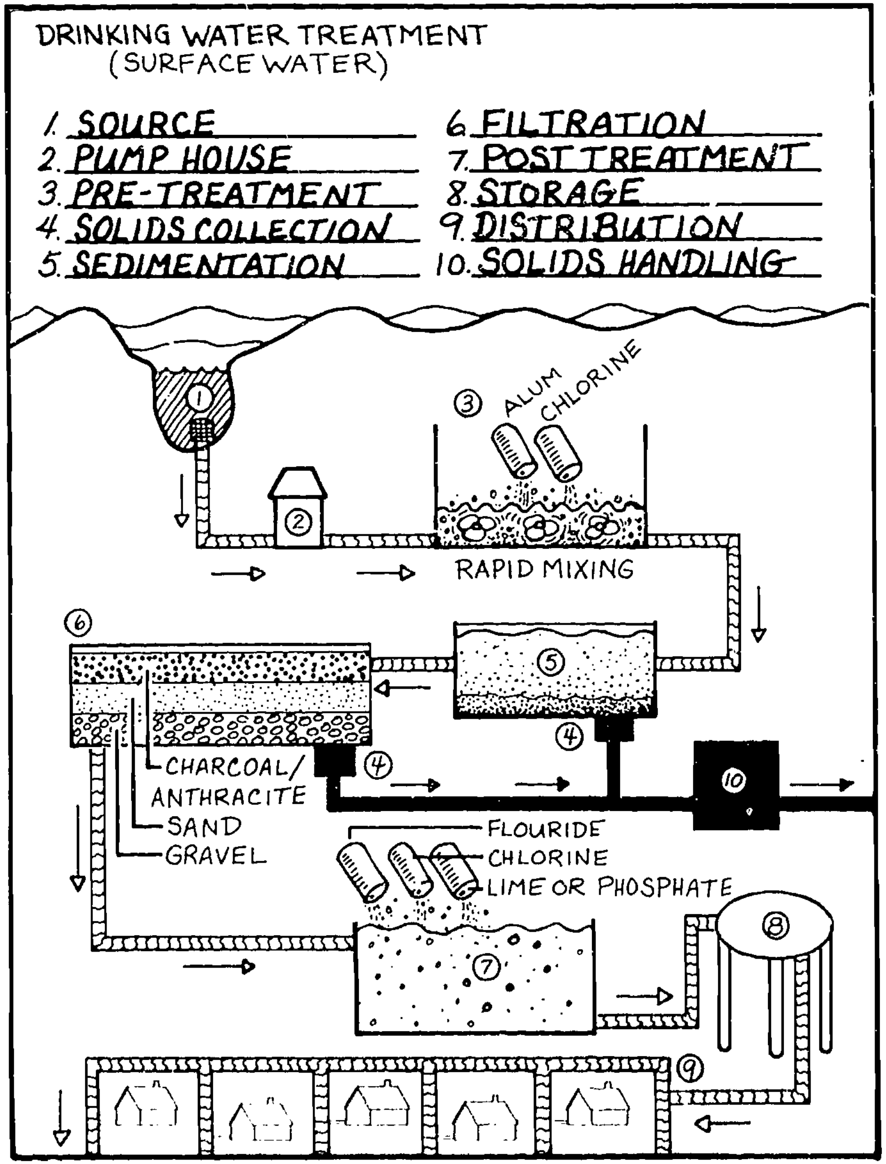
1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________
7. ________________
8. ________________
9. ________________
10. ________________

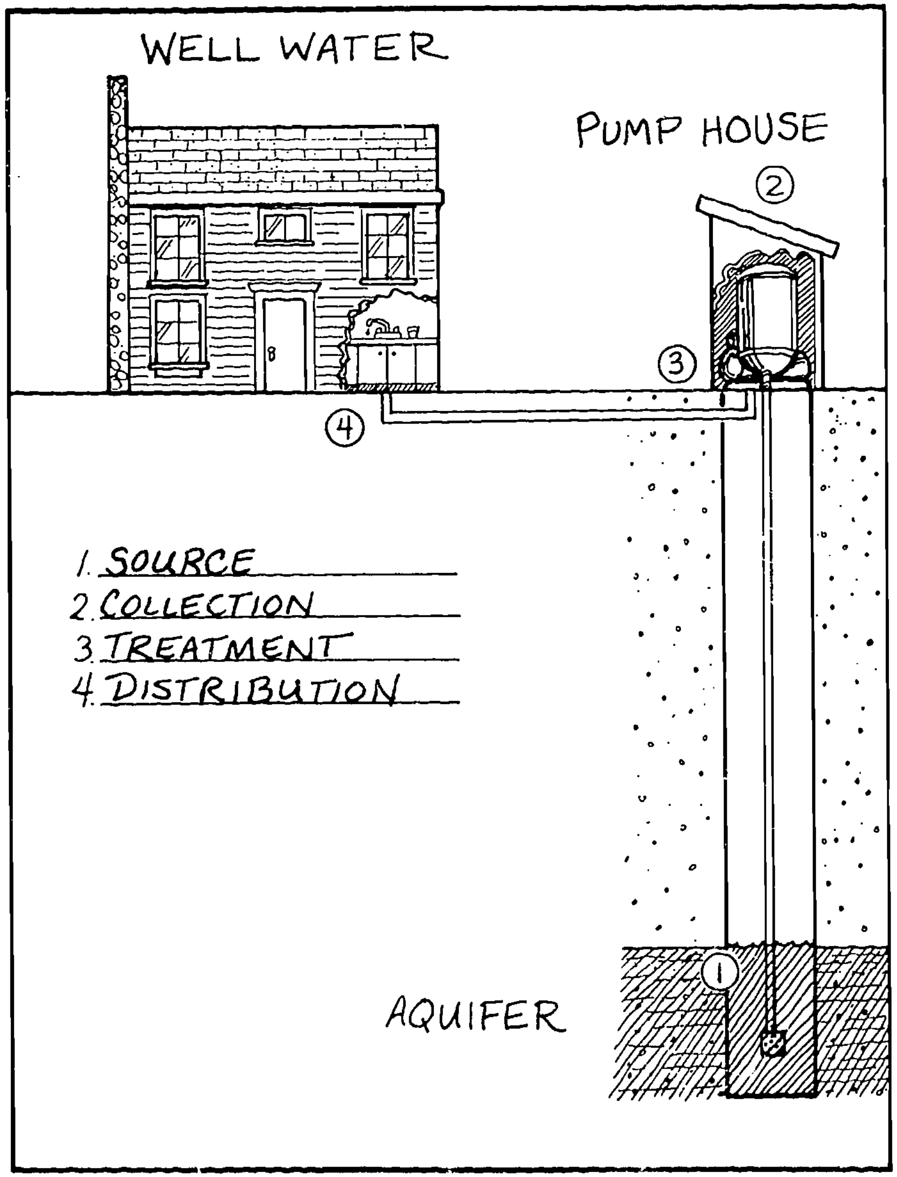
SEPTIC TANK AND LEACH FIELD



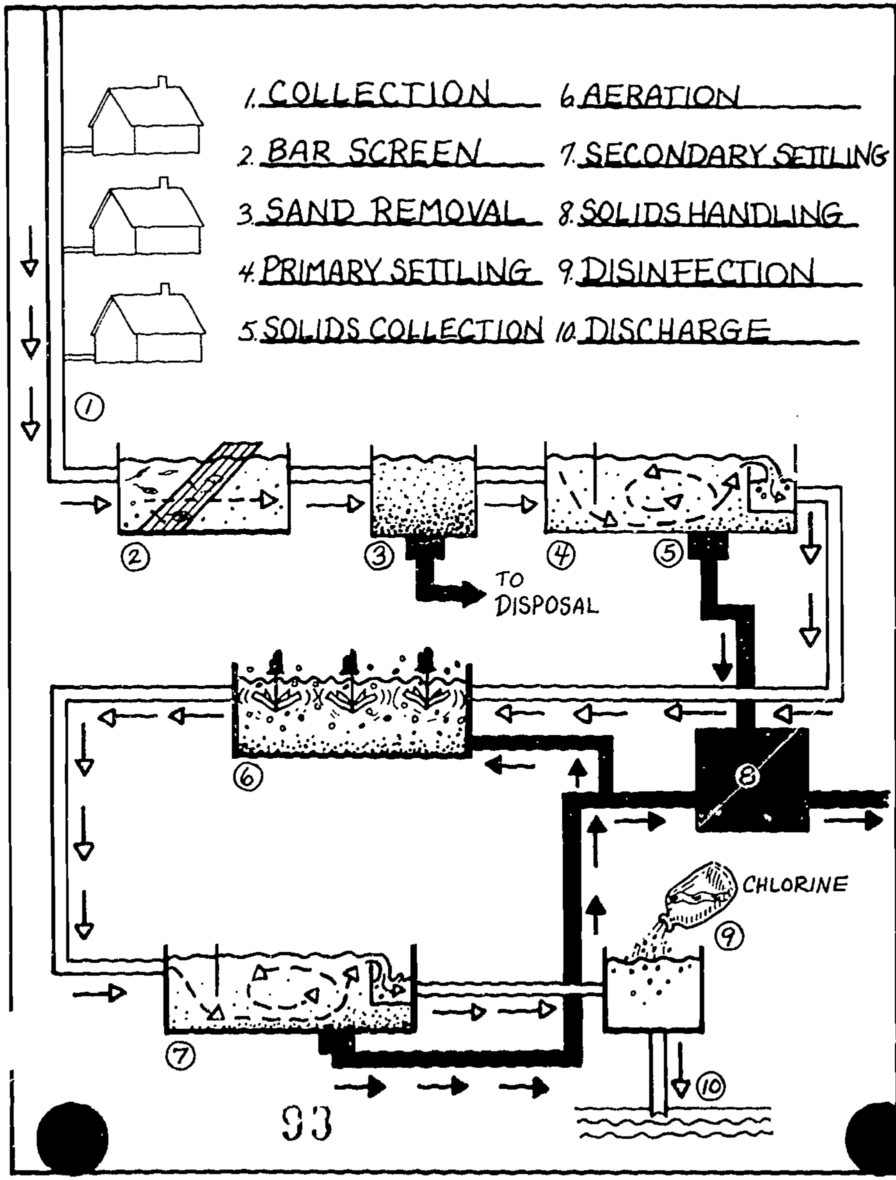
1. ________________
2. ________________
3. ________________
4. ________________

DRINKING WATER TREATMENT METHODS
ANSWER KEY





WASTEWATER TREATMENT METHODS
ANSWER KEY



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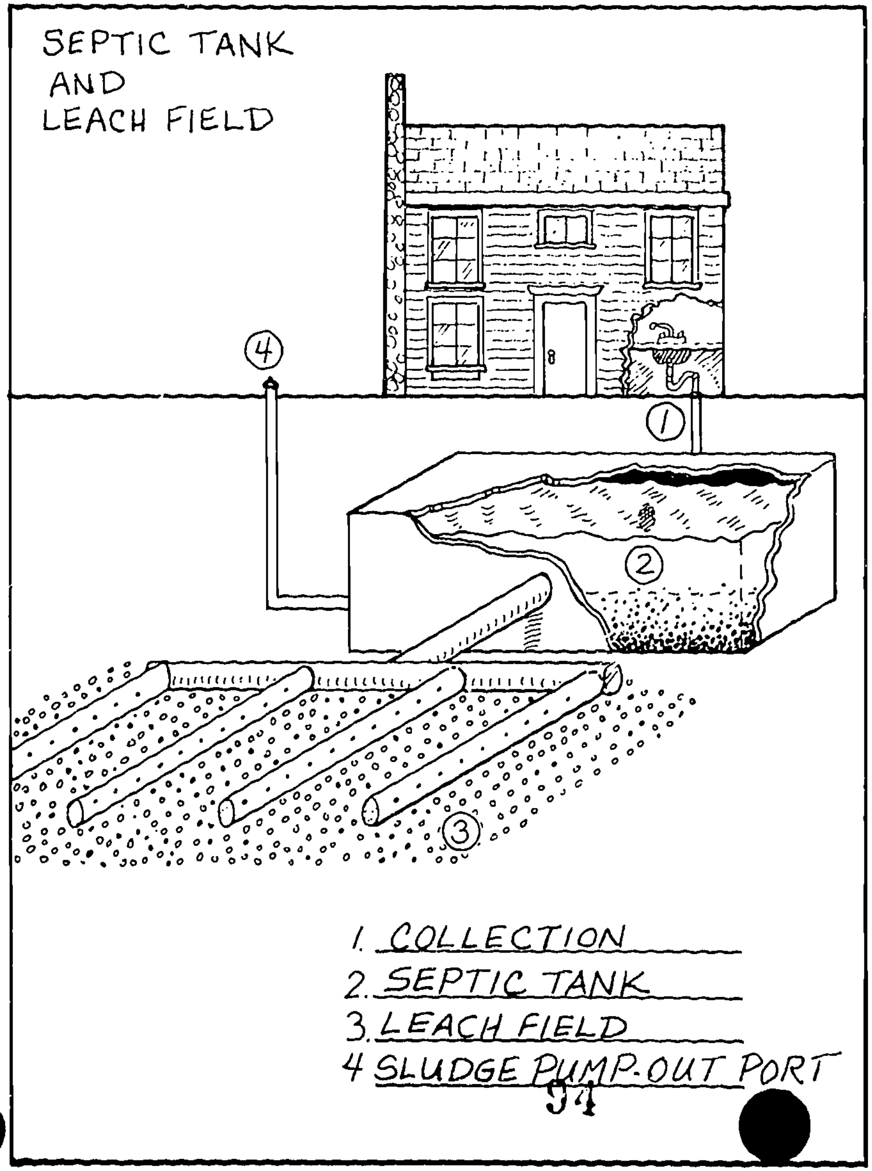

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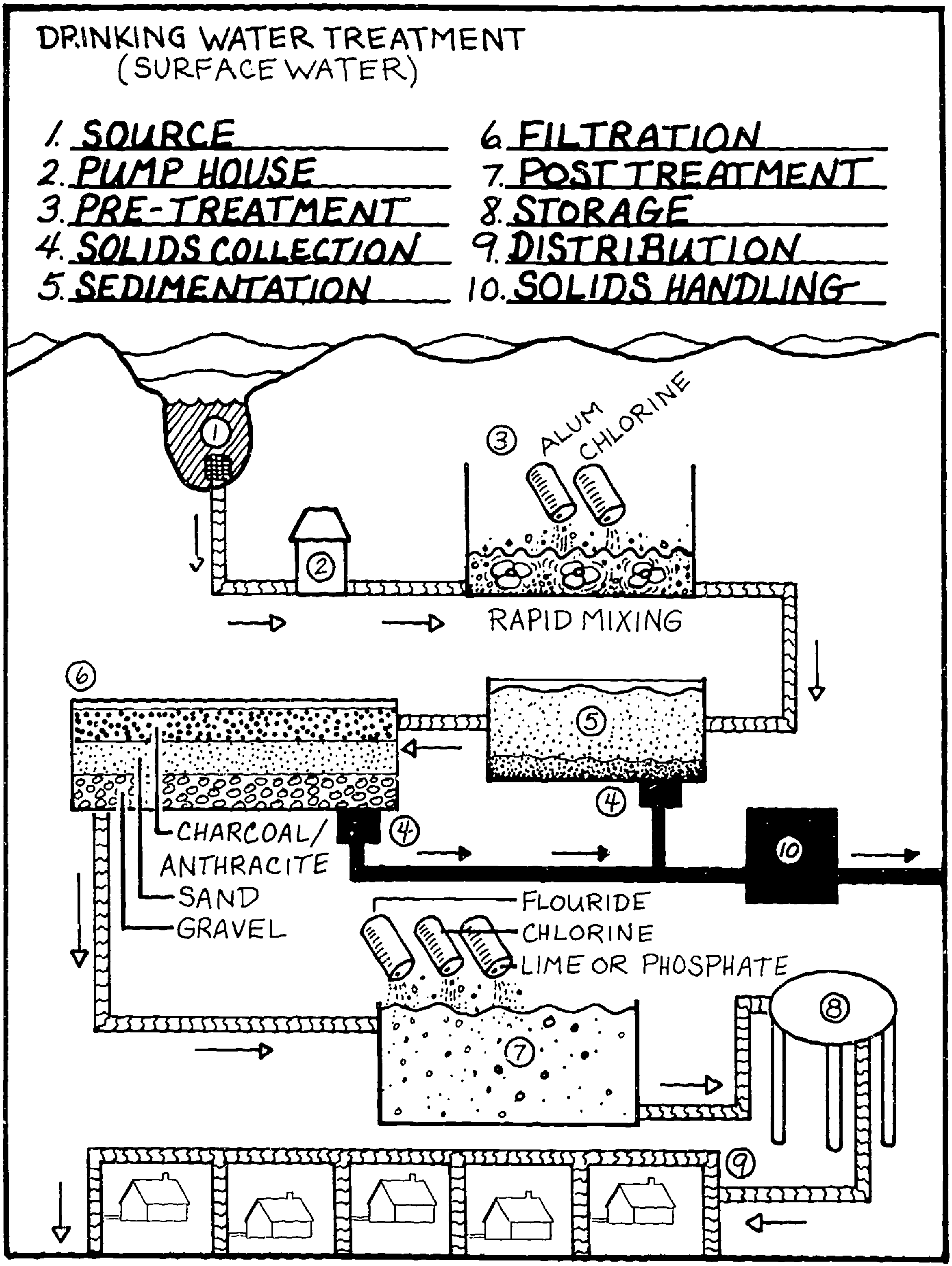
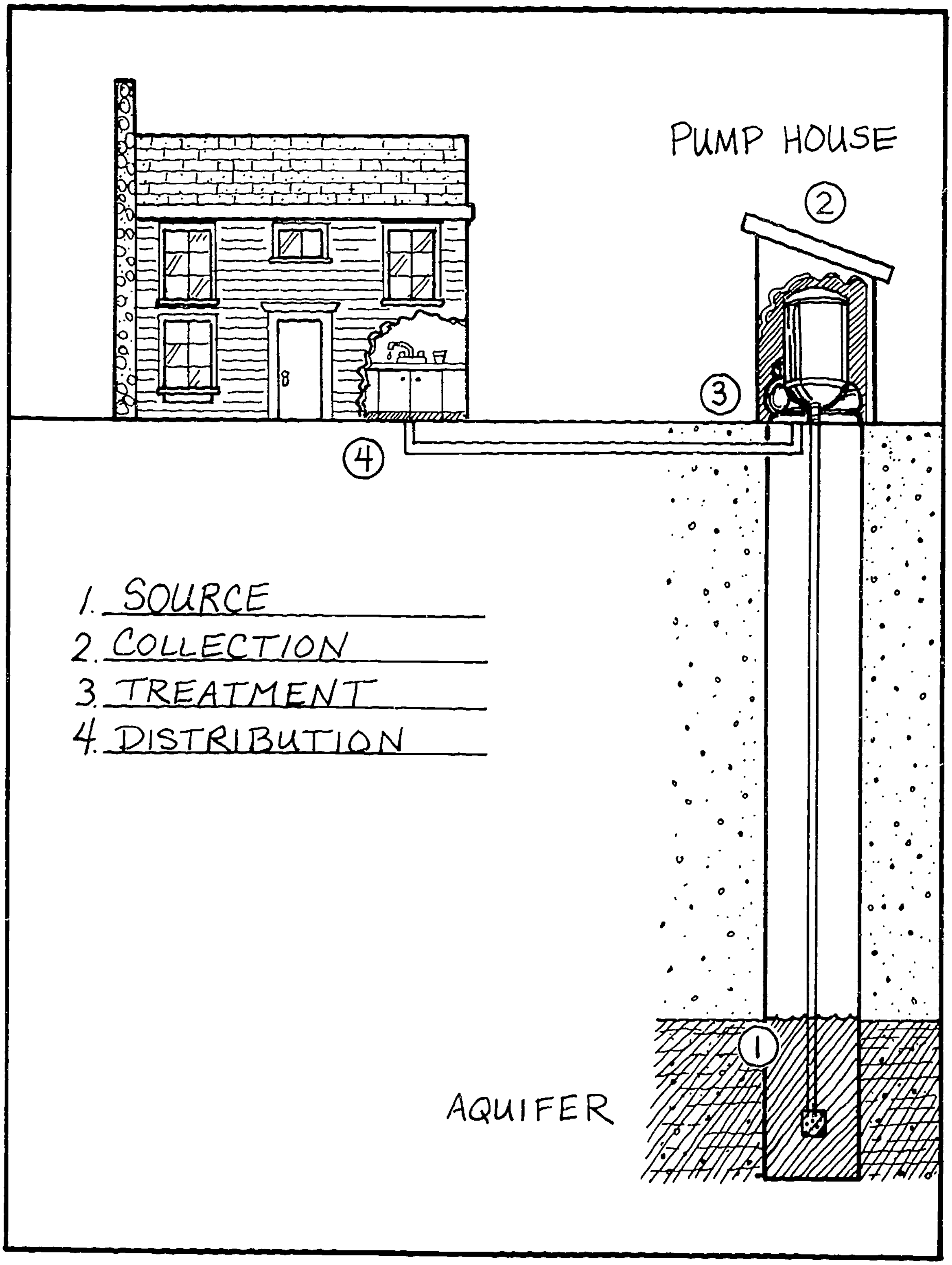
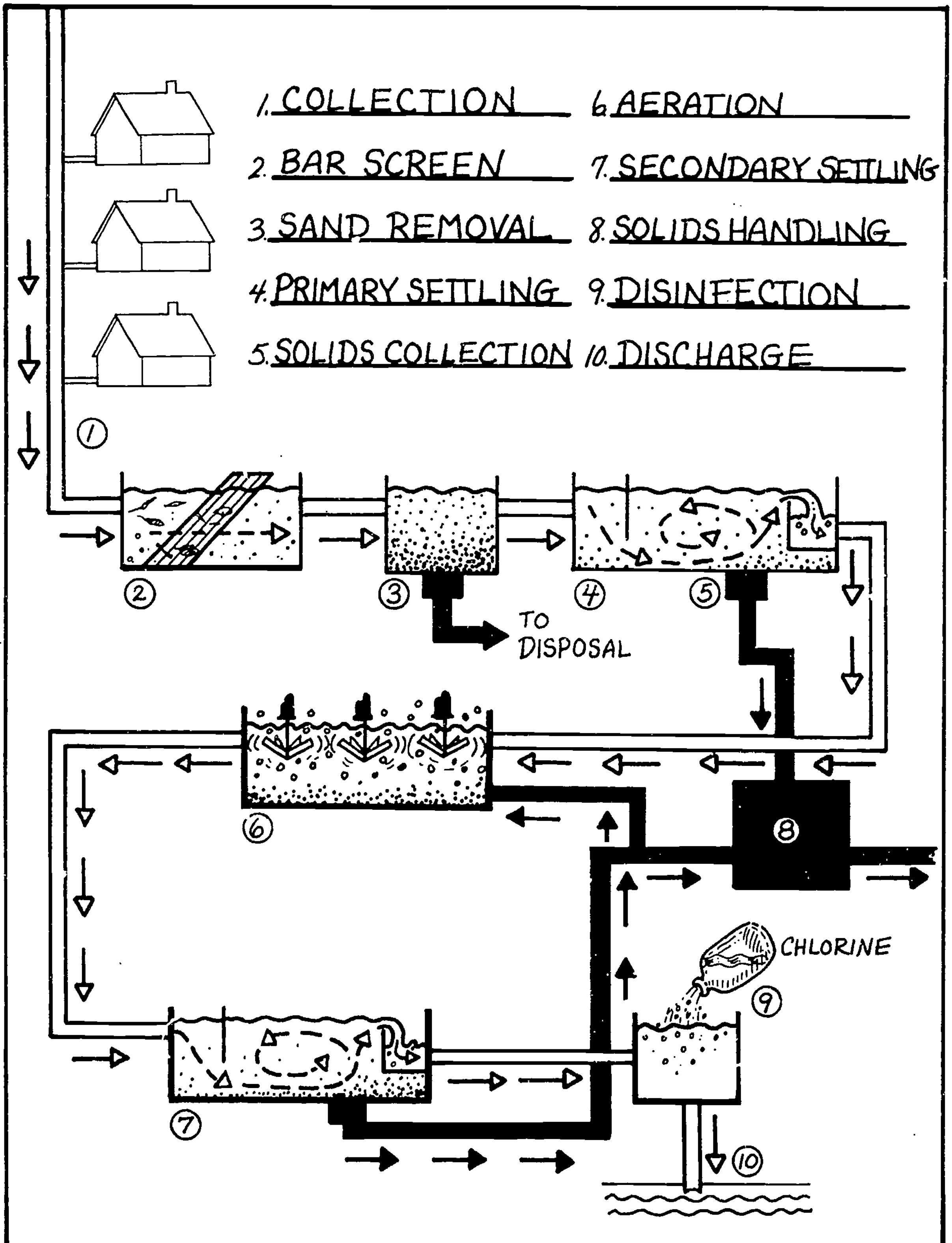
DRINKING WATER TREATMENT PLANT



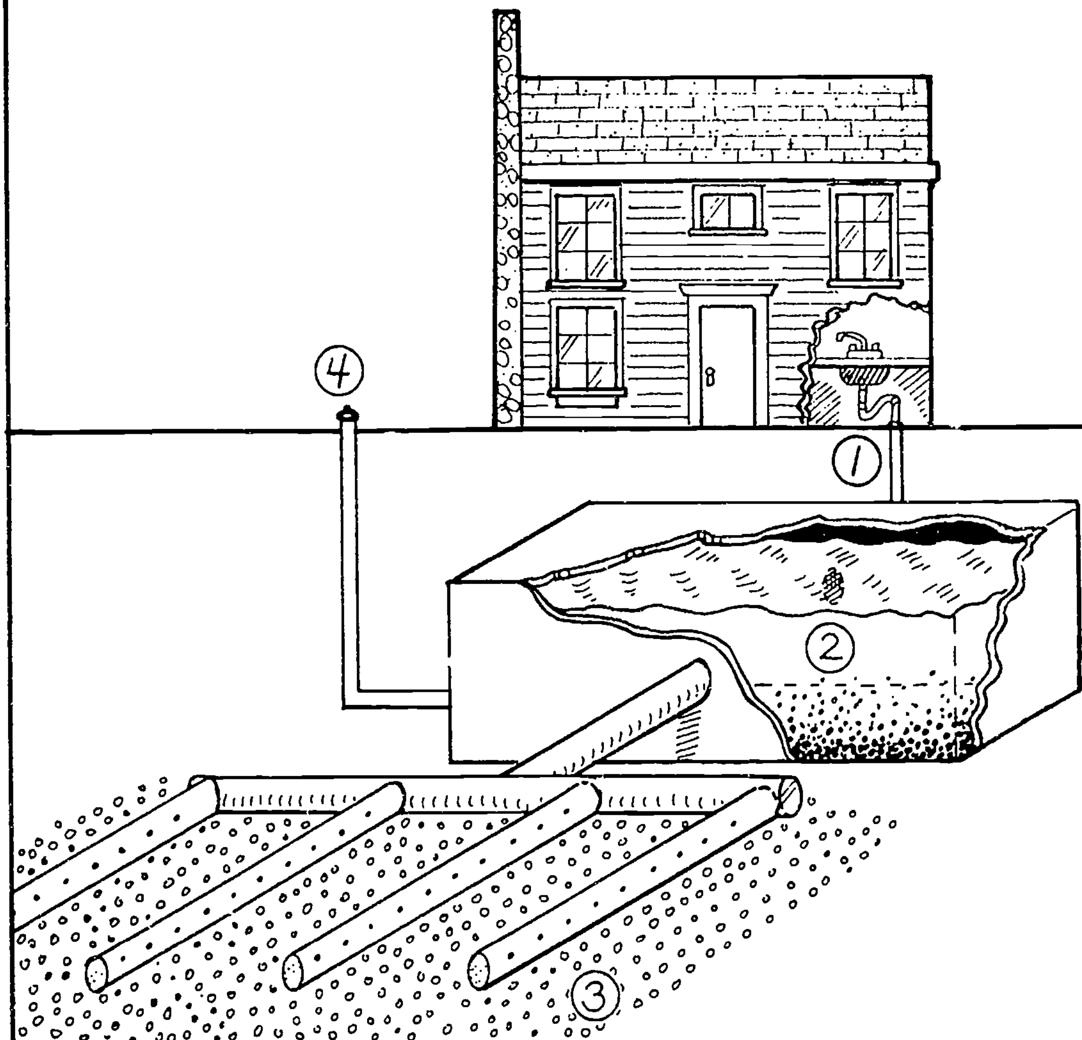
WELL WATER


PUMP HOUSE
2
3
4
1
1. SOURCE
2. COLLECTION
3. TREATMENT
4. DISTRIBUTION
AQUIFER

WASTEWATER TREATMENT PLANT



SEPTIC SYSTEM



1. COLLECTION
2. SEPTIC TANK
3. LEACH FIELD
4. SLUDGE PUMP-OUT PORT

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HOME SURVEY

Name ______________________________ Date ______________________________

Dear parent/guardian:
Our class is learning about the source and treatment of our drinking water supply and the disposal of our wastewater. Please take a few minutes to help your child answer the following questions to the best of your knowledge.

1. Is your water supplied by a water company? yes / no (If no, skip to question 2.)

   a. Is it treated with chlorir ? yes / no

   b. Is it treated with fluoride? yes / no

2. If you have well water...

   a. Where is the well located on your property? ______________________________

   b. How old is your well? ______________________________

   c. How deep is it? ______________________________

   d. Is your well water treated with any chemicals? yes / no What kind? ______________

   e. Does your well have a filtering system? yes / no What kind? ______________

   f. Have you ever had your well water tested? yes / no

3. Are you served by a sewer system? yes / no (If "no," skip to question 4.)

   a. Where is the wastewater treatment plant located? ______________________________

   b. What river or stream receives the treated wastewater from the treatment plant? __________

4. Where on your property is your septic tank located? ______________________________

   a. How many gallons does it hold? ______________________________

   b. How old is it? ______________________________

   c. How extensive is the tank's drainfield? ______________________________

   d. What problems, if any, have you had with your septic tank and drainfield? ______________

   ____

   ____

Thanks so much for your help!

WATER'S JOURNEY

OBJECTIVES

The student will do the following:

1. Demonstrate the cycle of water through a community.
2. Become aware of the uses of water in their community.
3. Recognize the need for water conservation in their community.

SUBJECTS:
Science, Social Studies, Art

TIME:
120 minutes

MATERIALS:
bulletin board
butcher paper or art pad
milk cartons (pints, quarts)
small boxes
markers
scissors
pictures cut from magazines
construction paper
masking tape, push pins, or thumb tacks
posterboard
crayons
acetate sheet
overhead projector
teacher sheets (included)
bell or buzzer (optional)

BACKGROUND INFORMATION

You may be surprised to know that you use the same water over and over again. The water you swam in last week may be the water you will drink today. The water that comes from the lake where you swim may be pumped to your local water treatment plant. Here, the water is treated (cleaned) and then it goes to your home where you will drink it, take a bath in it, or maybe water your plants. After you use water, it goes down the drain and travels to a wastewater treatment plant, where it is cleaned and put out into a lake or river.

Think of your water as if it is taking a journey. The next time you turn on your faucet you will have an idea of how far your water has come and where it is going. This is similar in concept to the natural hydrologic, or water, cycle in which water "travels" through various states of matter and parts of the natural environment. A community water cycle might be thought of as the human world's version of the natural water cycle.

Terms

conserve: to use a resource wisely and efficiently.

cycle: a process that repeats itself.

resource: a supply of a valuable and useful thing.

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ADVANCE PREPARATION

A. Gather materials for bulletin board (butcher paper to cover bulletin board, construction paper, markers, milk cartons for buildings, and pictures). If you are going to make the "3-D" bulletin board illustrated, gather small boxes (such as gift boxes, small food boxes [e.g., cereal, cookies, etc.], and small milk cartons) and cut off the bottom of each one (so you can reach into it to mount it with a thumb tack).

B. Make a transparency of the "Community Water Cycle" teacher sheet.

PROCEDURE

I. Setting the stage

A. Ask the students the following questions.

1. What is a community? (a group of people living together in a designated area) Review social studies community concepts with the students. Remind them that an important part of any community is the services and utilities that provide the things people need.

2. What is a cycle? (a complete process that repeats itself; the seasons of the year are a good example)

3. Can you describe a community water cycle? (a water distribution process that repeats itself through a community) Show the students a transparency of the "Community Water Cycle" teacher sheet.

B. How could we illustrate a community water cycle? Lead the students into developing a bulletin board.

II. Activity

A. Develop a bulletin board that represents a community water cycle. See the teacher sheet, "Community Water Cycle Bulletin Board," for a diagram of a bulletin board. Introduce the students to how a water utility serves the community (keeping a supply of safe drinking water, making sure water is safe from diseases, treating wastewater so it may safely be discharged).

B. Divide the students into teams.

1. Instruct one team to cover the bulletin board with butcher paper and draw or cut a "stream" from construction paper; this represents the source of water. Title the board "Water's Journey."

2. Have the other teams draw buildings and cut them out, or use magazine pictures, or small milk cartons and boxes decorated as buildings to represent the homes, schools, businesses, and other buildings that would be present in a community.

3. Then have the students place these "buildings" on the board to represent the distribution and use of water in a community. (Mount them with thumb tacks or push pins. You could staple them or try rolled pieces of masking tape to mount the cartons.)

C. Together with all of the students, construct or draw buildings to represent the water treatment facility and the wastewater treatment plant to show that water is treated (cleaned) before it is used and again after it is used, then returned to the stream.

III. Follow-Up

A. Ask the students to think of as many ways as possible that their community uses water. (residential–bathing, cooking, washing; industrial–factories; commercial–hospitals, businesses, and restaurants; habitat for wildlife; agriculture; public use) List these on the board or on an overhead projector.

1. Divide all the listed uses into two groups:

a. essential (drinking, bathing, flushing, cooking)

b. non-essential (watering lawn, washing car)

2. Discuss listings in the non-essential group and consider what each student can do to conserve water.

3. Would it be difficult to bring about change in community water use? Discuss this question with the students.

4. Who do the students think they should contact concerning changes in water conservation at the community level? (begin by contacting the water utility)

B. Have students or teams of students design posters reminding people to conserve water. (Post these in the hallways of school, in the community library, and in businesses.)

IV. Extensions

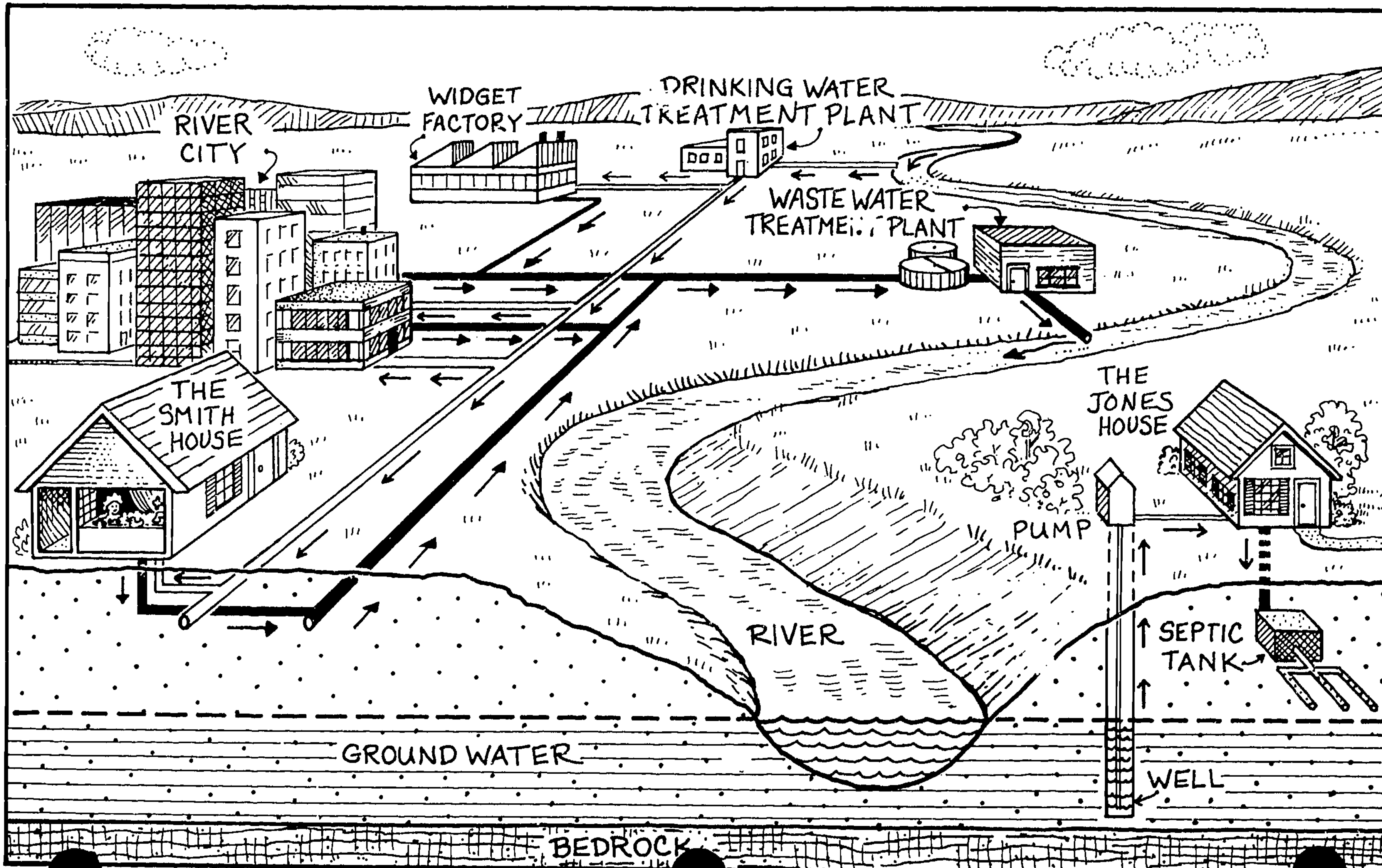
A. Ask the students or teams of students to write a commercial to encourage people in the community to conserve water.

B. Ask someone from the Agricultural Extension office to come in to speak to your students.

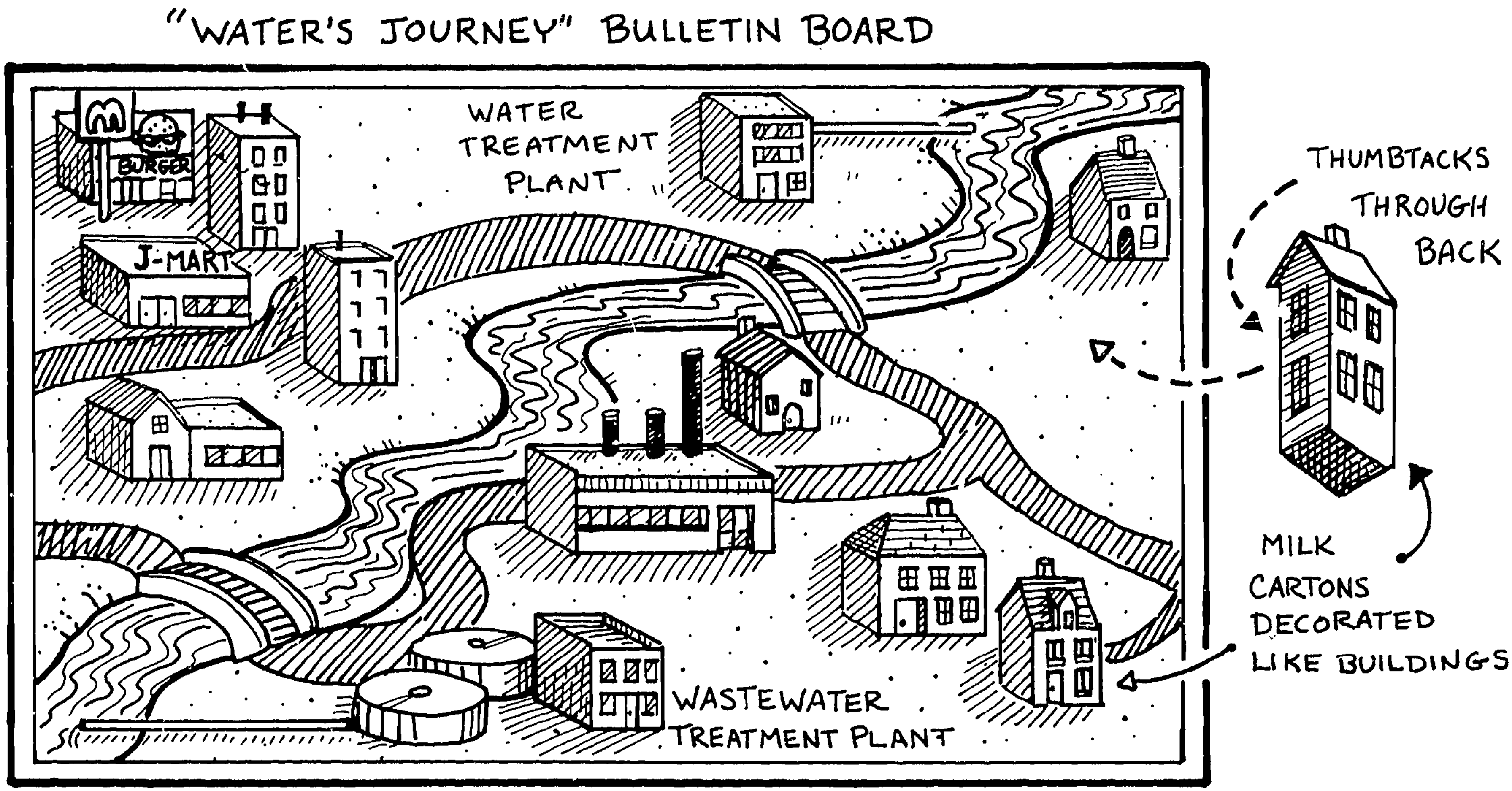
RESOURCE

"The Story of Drinking Water" (student booklet), American Water Works Association, Denver, Colorado, 1984.

COMMUNITY WATER CYCLE



COMMUNITY WATER CYCLE BULLETIN BOARD



105 106

SAVING A RESOURCE IN JEOPARDY

OBJECTIVES

The student will do the following:

1. Name many uses of water.
2. Classify water uses into four main categories.
3. Learn water conservation habits.

SUBJECTS:
Science, Social Studies, Language Arts, Math

TIME:
60 minutes

MATERIALS:
chalkboard
16 sheets of scrap paper
tape
marker
play money in 4 denominations
camcorder and video tape (optional)
clipboard
list of student's names for each teacher
teacher sheet (included)
bell or buzzer (one per team)

BACKGROUND INFORMATION

Water conservation saves energy, money, chemicals and fresh water supply. It takes a lot of energy to pump water to your home and, once it gets there, it takes both energy and money to heat water. Heating water is usually the second largest use of energy in the home. Everyone who uses water spends money for that privilege (both city water pumped to your house, school, office, recreational facility, etc., and well water—you pay to install a well). Chemicals are used at water treatment plants.

Communities face two problems. One is the increasing demand for clean water. The other is locating new water sources. The water we use often comes from underground reserves. If we use this water faster than nature can replace it, sometimes the land sinks. According to the U.S. Geological Survey, 35 states are pumping groundwater faster than it is being replaced. We are using the earth's water supply from hundreds of millions of years ago. In the water cycle it is used over and over again. We need to keep it clean and conserve it to make sure there is enough fresh water to meet our future needs.

Term

conservation: to protect from loss or depletion

ADVANCE PREPARATION

A. On the 16 sheets of typing paper, write \$1 on 4 pieces, \$5 on 4, \$10 on 4, and \$20 on 4 with a big magic marker. (Also, make the gameboard on posterboard if you won't be using a chalkboard.)

B. Get play money in a variety store's party supply section. (NOTE: Make sure the denominations on the typing paper sheets correspond with the play money denominations.)

PROCEDURE

I. Setting the stage

Have the students brainstorm as many uses of water they can possibly think of. Write these on the board. Next ask them to see if there are any similarities. Can they put these words in groups? Have the students suggest categories for the water uses they listed. Work on this as a class, and lead the students to use residential, agricultural/rural, industrial, and recreational as the categories.

II. Activity

Have the students play the Water Conservation Jeopardy Game.

A. Use a chalkboard to set up the categories like they do on television. On the chalkboard write the appropriate answers which are found on the teacher sheet, "Water Conservation Jeopardy Game." (For your benefit, the correct response [question] is underlined.) Cover the questions with pieces of paper with dollar amounts on them and pull them off to reveal the questions. When a team/individual gets a right answer on the first try, hand them a piece of play money.

Set up a chalkboard like this.

Residential	Agricultural	Industrial	Recreational
$1	$1	$1	$1
$5	$5	$5	$5
$10	$10	$10	$10
$20	$20	$20	$20

(NOTE: If you prefer, you may make a reusable chart on which to play this game. Also, if you cannot put the cover sheets on your chalkboard with small pieces of tape, use a bulletin board for your gameboard.)

B. Play the game in teams of boys vs. girls, blue-eyed vs. brown-eyed, type of shoe, or what they ate for breakfast or just divide the groups alphabetically. Each team must choose a spokesperson to give the answer for their team. The first team to answer correctly gets the play money and the right to choose the next question. Play the game as they do on TV. Have the team ring a bell or press a buzzer when they have the correct answer. When a team asks, for example, for Recreational $10, pull the sheet of paper away from that area and ask the team the appropriate question. (NOTE: The answers are constructed so that students can guess the correct answers if they think about them.)

III. Follow-Up

Have the students write a paragraph about "what they learned" from this activity. Ask them to state their favorite water conservation fact and the reasons they thought this was the most interesting.

IV. Extensions

A. Have the students read one of Wilder's Little House books (or read to them) or some similar book. Let them make the following comparisons:

Past	Present
__________	Turn on the faucet
__________	Bathe in the bathroom
__________	Hot water comes from a water heater
__________	Flush the toilet in the bathroom
__________	Pull the plug in the bathtub after a bath

B. Students can make a study of inventions and make a time line. Make a list of inventions/devices that have to do with the use of water. If you have the resources, find out when products concerning water were invented/patented and draw these on a time line. (Check on the bathtub, PVC pipe to get water to our homes, hot water heater, faucets, and tea kettle.)

C. For a creative writing/acting activity, have students work in cooperative learning groups. Each group is to create a play/skit/pantomime (their choice) to show how water can be conserved in these four areas—residential, agricultural/rural, industrial, recreational. They need a title for it when they finish. Encourage background music and/or "speaking parts." After composing the script or actions, videotape their rehearsal. Let them play back the tape and critique it for changes before they do the "real" thing for other classes or the PTA.

D. To incorporate math, conservation, and phone book skills, try the following activity.

1. Find the water meter in your school. Take a reading at the beginning and end of the day. If your school gets water from a utility company or city, call the water department.

2. Teach telephone book skills. Blue pages are government pages. Four sections (city, county/parish, state, national) exist. Find out how much 1 gallon of water costs your school. Call the central office for your school district and find out how much water your school uses in a certain month and how much it costs.

3. Have children devise a way to "catch" the water that is wasted by your school in (any time segment you think is appropriate) by students not turning off the faucet completely. How much money do you waste in one day, one month, the whole school year? How much money could you SAVE?

E. Have the students act as undercover water cops to encourage water conservation.

1. Each time students go to the bathroom, drink from a fountain, or use classroom sinks, have them take note of times students do not turn the water faucets completely off, or who run more water than they need.

2. At the end of the day, add all the students' lists (tallies) together for a count of the instances of wasting water.

3. Have the class make a list of the ways they can conserve water at school.

F. If your class has pen pals, write to them and ask them how much water costs in their city. If they don't have pen pals, let each child write to another city in the United States to find out what other people pay for water. (Addresses can be found in the World Almanac and telephone directories in public libraries.) Make a graph. Discuss why it would be different in different parts of the country.

RESOURCES

Miller, G. T., Environmental Science: Sustaining the Earth, Wadsworth, Belmont, California, 1991.

1991 Statistical Abstract, U.S. Department of Commerce, p. 239.

"The Official Captain Hydro" (Water Conservation Workbook), East Bay Municipal Utility District, Oakland, California, 1982.

Wilder, Little House books (various).

WATER CONSERVATION JEOPARDY GAME

Residential

$1 What two resources do you save by taking shorter showers? (Water/Energy, Water/Trees, Water/Air)

$5 If you wash your dishes with the tap running, how many gallons of water could you use? (5 gal./ 15 gal./30 gal.) (NOTE: About 5 gallons are used if you use a dish pan to hold the water.)

$10 How much more water do you use if you leave the water running while you brush your teeth? (2X/ 10X/100X) (NOTE: If you just wet the toothbrush and rinse it you only use about 1/2 gallon.)

$20 How many gallons of water do you use when you flush a standard toilet? (1 quart, 1 gallon, 5 gallons)

Recreational

$1 What do most people do "in" water? (fish, swim, brush teeth)

$5 Hockey is a team game played on a surface covered with water in which of these states? (solid, liquid, gas)

$10 Name two water sports that require a sail. (think) Team has to come up with 2. (Possible answers: sailing/wind surfing/parasailing.)

$20 In 1990 how much money was spent on buying pleasure boats? ($9 million, $9 billion, $9 trillion)

Industrial

$1 About how much does one U.S. gallon of water weigh? (2 lbs./8 lbs./108 lbs.)

$5 Do Canadian and U.S. gallons weigh the same? (yes/no) (NOTE: Canadian imperial gallon weighs 10 lbs.)

$10 Which of the following accounts for more of industry water use? (washing things, cooling things that get hot, mixing into things)

$20 About how many gallons of water were used for industrial purposes in 1985? (2 million, 2 billion, 29 billion) (Extra: Can anyone write this big number on the board? $29,000,000,000)

Agricultural

$1 If a farmer is irrigating on his farm, what is he/she using water for? (plants, animals, cleaning)

$5 If a rancher is watering his livestock, what is he doing? (watering his crops, washing out the barn, giving his animals a drink)

$10 About how much of our fresh water is used for agricultu. .? (10%, 20%, 40%)

$20 In the United States which of the following uses more of our water? (cities, industries, agriculture)

WHAT A WATER JOB!

SUBJECTS:
Science, Language Arts, Art, Social Studies

TIME:
180 minutes

MATERIALS:
acetate sheet
overhead projector
yarn
coat hangers
index cards
paper punch
paste or glue sticks
construction paper
markers or crayons
butcher or other large paper
student sheets (included)
teacher sheets (included)
prizes (optional)

OBJECTIVES

The student will do the following:

1. Know what makes a career water-related.
2. Discover careers of interest.
3. Identify information on the careers of their choice.

BACKGROUND INFORMATION

The area of water and related sciences, industries, and trades offers many career options. The expertise involved varies from on-the-job training to a doctorate in a water specialty. Each is important – from the plumber to the marine geophysicist. Some careers also offer recreational benefits, such as professional skiing and underwater photography. While we have many science fields involving water, we equally need tradesmen in water careers. Perhaps a water career will be of interest to your students.

Terms

career: a job one trains to do.

related: having a connection, going together.

water: a necessity for life on earth; found on the surface and under the ground.

ADVANCE PREPARATION

A. Make a transparency from the teacher sheet, "Water-Related Careers."

B. Make copies of the student sheet, "Student Interest Inventory" if needed.

C. Make copies of teacher sheet, "Fact Flash Cards," and cut them out. You will need one card per student. Punch a hole at the top of each one. Cut yarn in various lengths (eight inches and less).

D. Make copies of teacher sheet "Water Certificate" and fill them out for your students.

E. If you are going to hold a Water Day Festival, plan your activities now. Make copies of parent/ student sheet "Water Day Festival Announcement."

PROCEDURE

I. Setting the stage

Discuss the definition of water and how a career could be water-related. Ask students to name careers they think are water-related; list them on the board. Use a transparency of the teacher sheet, "Water-Related Careers," for additional water-related careers. Many of the careers listed will be unfamiliar to the students; tell them they will be investigating some of these.

II. Activity

A. Have each student write down a career that he/she is interested in and have them select four others, including two with which they are not familiar; they will research these. You might use an interest inventory to assign jobs. (NOTE: The student sheet, "Student Interest Inventory," might be helpful. You might also divide the students into small groups that can work together, rather than having individual students working alone.)

1. Each student will be responsible to find facts on 5 careers.

a. Information can be researched in the library using reference materials such as encyclopedias or books about appropriate topics. Ask your librarian to help your class by pulling a collection of books and magazines with the appropriate information..

b. If students know someone in a selected career they can interview that person. Information gained during an interview can be included on the flash cards students will make.

2. Give each student five fact flash cards (or blank index cards). Have students list at least 5 facts on one side and draw an illustration on the opposite side.

a. Use a piece of yarn to attach five flash cards to a coat hanger. Each card will have a different length of yarn to hang it with.

b. Place a piece of construction paper at the top of the hanger and label it "Water Jobs." Hang these career mobiles around the classroom.

B. Students will play a "stand-up" game.

1. Have them select their favorite career and write 5 clues for it. On the day your class plays "What's My Water Job?" they can bring in props such as a hat or instrument associated with that career.

2. When it is their turn students will stand up and, using their props, they will give one clue at a time.

a. Their classmates will guess their profession.

b. The student who guesses correctly receives points. The points correspond with how many clues they had (1 clue = 5 points, 2 clues = 4 points, 3 clues = 3 points, 4 clues = 2 points, 5 clues = 1 point).

3. At the end of the game the student with the greatest number of points receives a prize (such as a water toy, or a bottled water drink). A certificate made from the teacher sheet, "Water Certificate" could be given to the winners.

III. Follow-Up

Celebrate with "Water Day." Pick a day and plan water activities for the students. A warm day would be best for these activities.

A. Invite guest speakers that have water-related careers. (See the listing on the student sheet for ideas, and check the parent volunteer you get when you send the announcements home.)

B. Use the parent/student sheet, "Water Day Festival Announcement" to announce your festival.

C. Make posters of 5-foot humans (have students trace each other on butcher paper). Dress them for water-related careers. Decorate the halls with these career-minded paper dolls.

D. Students may make and display science or social studies projects involving water topics.

E. Have the lunchroom plan a meal and list the amount of water in each item on that day.

F. Play games outside like water balloon relay races or tosses, (clean) spray bottle squirt games, or building toy boats (e.g., from aluminum foil) and racing them in a wading pool. You may also hold taste tests for various bottled waters or have carnival games like a water version of "Go Fish."

IV. Extensions

A. Have students make a flag or banner for a water-related career. Use paper or cloth and attach to sticks or to dowel rods. Hang them up in your classroom.

B. Take the flash cards and play a game. Have the students work in small groups of 3 or 4 to create their games. Have them write down the rules for their game. Spend a class period and allow them to play the games they created.

C. Have students write letters to people in the water-related career of their choice.

D. Make a large group painting (a mural) using magazine pictures and original drawings. Water-related careers will be illustrated in the mural. Display in a visible place.

E. Play "Water Job Baseball," using the flash cards. Set the classroom up in standard baseball formation. Place a chair on each base and one for the pitcher. Divide the class into 2 teams. As each student comes up to bat a flash card is used to ask a question. Four clues without a response is an out. If they answer correctly they run (four clues=first base; 3 clues=second base; 2 clues=third base; 1 clue=HOME RUN). The team with the most runs is the winner. Change teams when one receives 3 outs.

WATER-RELATED CAREERS

boater
seaman
yachtsman
motor sailboater
plumber
water meter reader
wastewater treatment engineer
merchant marine
professional skier (water or snow)
ice skater
professional tournament fisherman
Coast Guard
Navy
submariner
water level controller
biosolids specialist
environmental chemist
water line installer
oceanographer
marine conservationist
underwater photographer
science teacher
snow hydrologist
meteorologist
marine geophysicist
marine geologist
limnologist

hydrologist
marine technician
groundwater contractor
health department environmental inspector
aundry attendant
lifeguard
scuba diver
aquarium director
bottled water company employee
desalination plant director
diver
fireman
landscape artist
potter
scuba instructor
Olympic/professional swimmer
recreation instructor
rafting guide
marine explorer
sunken treasure hunter
marine salvage engineer
water quality control officer
marine biologist
tugboat captain
boat builder
commercial fisherman
well driller

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STUDENT INTEREST INVENTORY

1. When you grow up what job would you like? ______

2. What water sport do you like best? ______

3. Can you think of a job that involves working with water? Do you want to know more about it? What is that job? ______

4. Do you have any hobbies? Tell me about them. ______

5. What are some fun things you do with your family? ______

6. What are the titles of your favorite books? ______

7. What are the names of your favorite television shows? ______

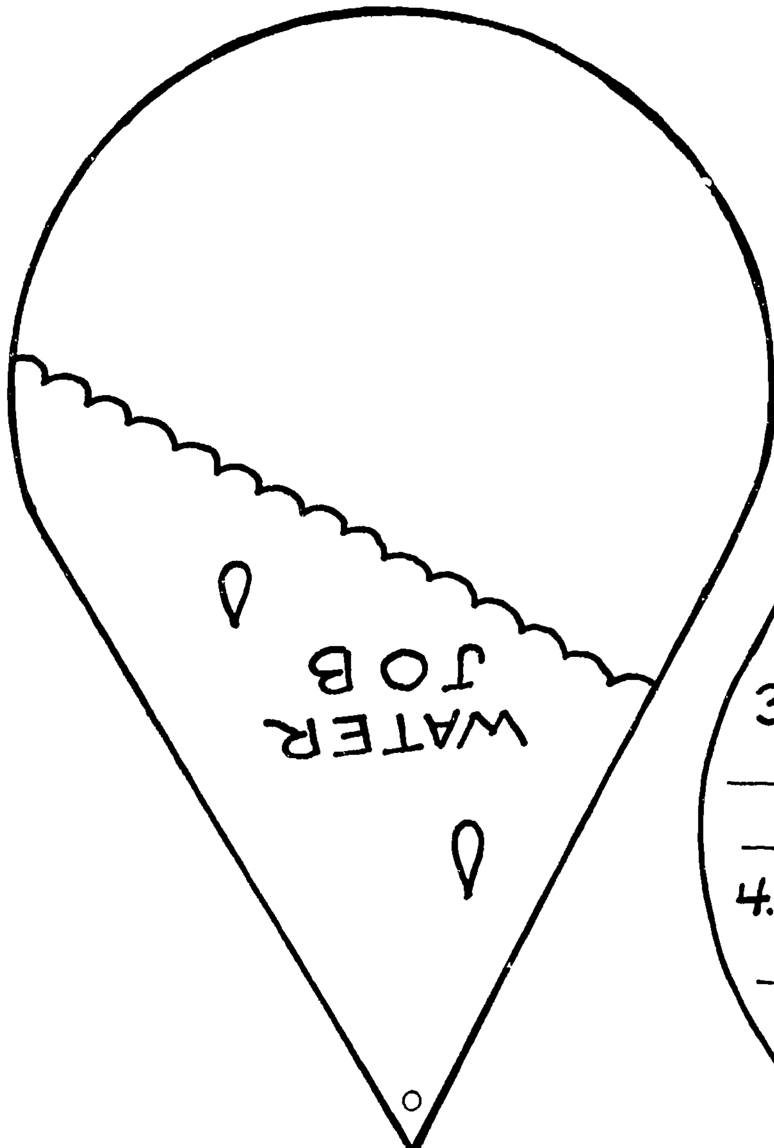
8. What are the names of your favorite games? ______

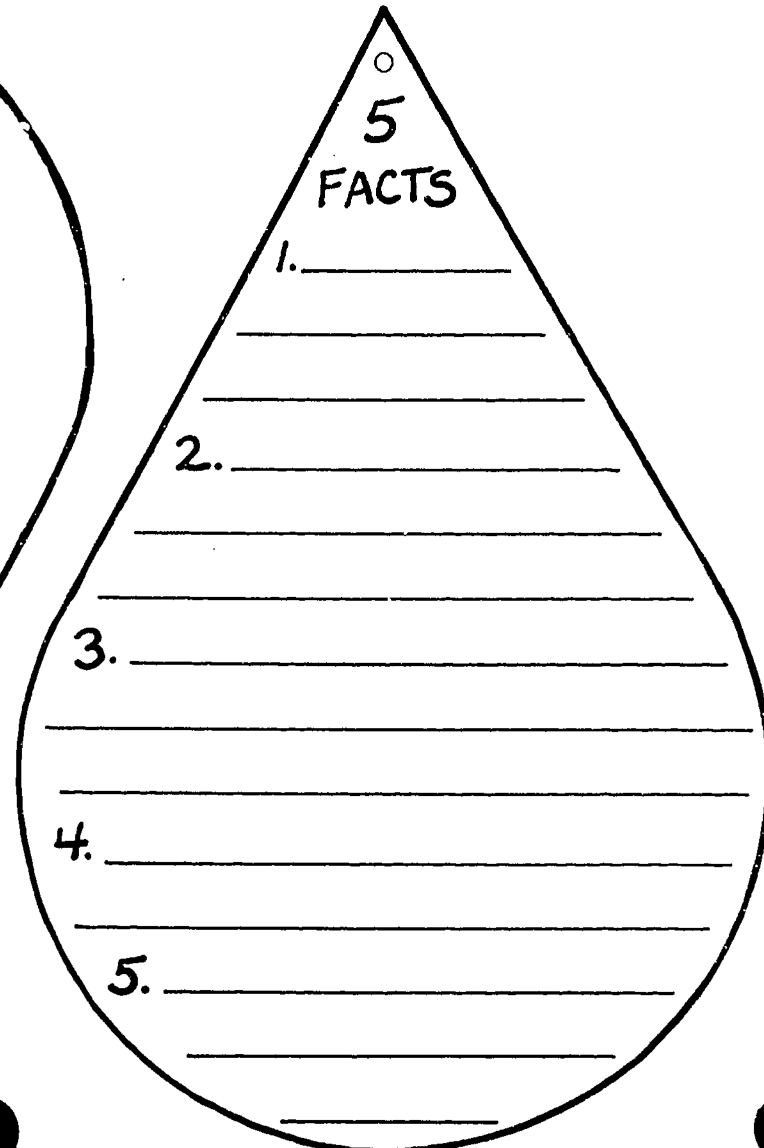
9. What are your favorite subjects in school? ______

10. What are three interesting things you can tell me about you? ______

Teacher Sheet

FACT FLASH CARDS





118

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Certificate

FOR

KNOWLEDGE OF WATER CAREERS

AWARDED TO

_______________________ _______________________

NAME DATE

119 120

WATER DAY FESTIVAL ANNOUNCEMENT

WHO:

WHAT:

WHERE:

WHEN:

DEAR ______________,

__________________ SCHOOL WILL CELEBRATE A WATER DAY FESTIVAL ON ____________. WE NEED GUEST SPEAKERS TO SHARE WHAT THEY DO IN THEIR WATER JOB. IF YOU OR A FRIEND HAVE A CAREER IN WATER, WE WOULD LIKE TO HEAR FROM YOU. WE CAN USE VOLUNTEERS IN OTHER ACTIVITIES— OR SHARE IN THE FUN! IF YOU CAN HELP US IN ANY WAY IT WILL BE APPRECIATED. THANK YOU!

MY CHILD'S NAME IS: ____________

____

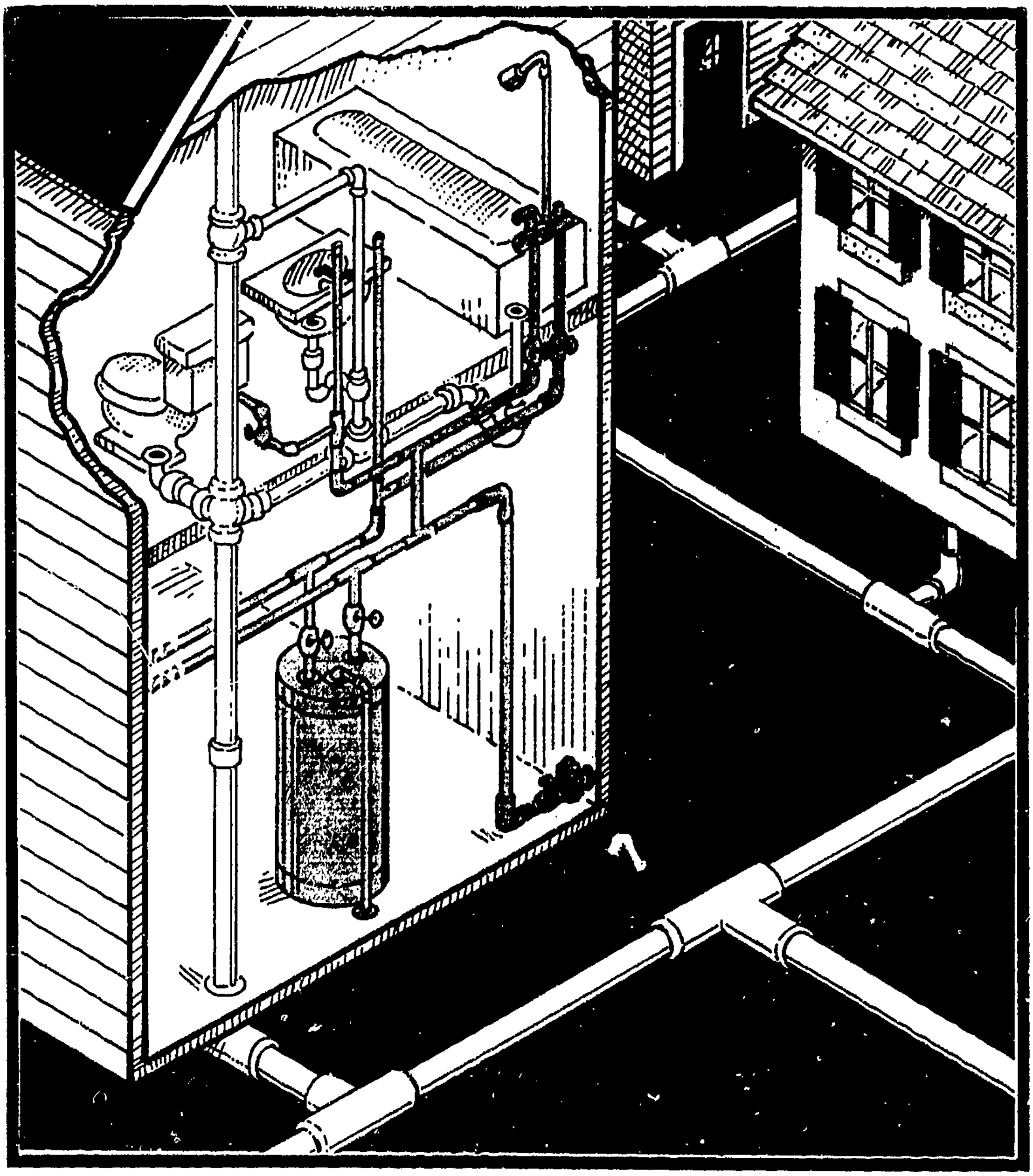
I CAN HELP WITH THE WATERDAY FESTIVAL.

____

MY WATER RELATED JOB IS:

OTHER:

____________ SIGN: ____________



THE WATER SOURCEBOOK

DRINKING AND WASTEWATER TREATMENT

WATER GOES AROUND AND COMES AROUND

OBJECTIVES

The student will do the following:

1. Build a model of a water system from the source to users.
2. Learn to read and interpret a water meter.
3. ?lan ways of water conservation at the community level.

SUBJECTS:
Science, Social Studies, Math

TIME:
120 minutes

MATERIALS:
large piece of cardboard
paper towel or bathroom tissue tubes
straws
different sizes of pasta (spaghetti, manicotti, etc.)
glue
paste or glue sticks
small boxes (matchboxes, small milk cartons)
markers
construction paper
student sheets (included)
teacher sheet (included)

BACKGROUND INFORMATION

It has been determined that each person in the United States uses about 150 gallons of water a day. Experts add the number of people who live in a city, town, or community, and multiply that number by 150 to determine how much water is used daily by that community.

People use water for drinking, cooking, bathing, flushing the toilet, laundry, washing cars, and watering lawns. Factories, farms, stores, public utilities, and homes use millions of gallons of water daily. It is a big job for water treatment facilities to supply clean drinkable water to a town, city, or community.

After the water treatment plant cleans the water, it sends it out to the users. As the water travels through a distribution system, it is diverted down different pathways to homes and businesses. The diameter of a pipe determines the quantity of water the pipe can hold and determines the rate the water can travel through the pipe. The volume of water needed for homes or businesses represents a small portion of the volume leaving the water plant. Therefore, smaller pipes are needed near the point of distribution, whereas larger pipes are needed near the treatment plant.

Water treatment plants pump water from a source (lake, river, or groundwater), treat the water, and pump it to holding tanks or water towers. If the water goes to a water tower, it flows by gravitational force from the water tower throughout the distribution system. Otherwise, water distribution is driven by motorized pumps.

Drinkable water is not free. Water treatment facilities and the distribution of drinking water are costly. Customers are charged according to the amount of water they use. A water meter is used to measure how many gallons (liters) or cubic feet (cubic meters) a household or business uses.

Because users pay for water and because there is only so much fresh water available for use, we must conse· ·our supplies, using them as wisely and efficiently as possible. We must not use water wastefully.

Many communities have already experienced shortages in water supplies due to lengthy droughts, growth in population that has outstripped the water system's capacity, or other problems. People in these communities have learned to eliminate unnecessary water uses.

Terms

community water cycle: the distribution of water from the source to user and back to the source.

wate- source: a place where water is collected and stored for use.

water meter: a device for measuring and recording the amount of water used.

ADVANCE PREPARATION

A. Gather materials for constructing the model. (NOTE: You may want to ask the students to bring in small boxes [matchboxes, milk cartons, etc.] to represent buildings in the commun"y, or you may choose to use construction paper to draw and cut "buildings.")

1. A large sheet of cardboard for each group to build model on.

2. Paper towel tubes, straws, and pasta.

3. The students may cut a river, stream, or lake from blue construction paper or draw this on the cardboard.

B. Prepare copies of student sheets and/or transparencies.

PROCEDURE

I. Setting the stage

Ask the students the following questions (which assume your students and school have water from a water utility):

A. How does the water that you drink get to your house? (It is piped from the river to the treatment plant, to a reservoir or storage tank, then to your homes.)

B. How does the water get to your school? (the same process)

C. What happens to the water when it leaves your home or school? (It goes to a wastewater treatment plant, then is discharged back to the river or lake.)

D. Where do people get water who do not live near water bodies and do not have city water systems? (wells) Where does wastewater from homes not connected to sewer systems go? (septic systems)

E. What do all these processes represent? (water cycles created by people)

F. Compare/contrast this human-created water cycle to the natural water (hydrologic) cycle. (The human water cycle comes from a lake or river, is distributed through the community, then goes to a treatment plant and back to the water supply. The hydrologic cycle is the movement of water from the atmosphere to the earth and its return to the atmosphere. Both cycles are continuous.)

G. Make very simple diagrams on the board to show a community water cycle and the natural water cycle.

II. Activities

A. Divide the students into groups of four or five and have each group build a model of your community water supply system from the source to the user.

1. Draw or cut from construction paper a river or lake and glue it to the cardboard.

2. Either draw houses and other buildings or construct them from small boxes to represent the community.

3. Show each group the illustration of the model of the water supply system to show them how to connect the "pipes" (paper towel tubes, straws, and pasta) with glue and lay them on the large piece of cardboard.

4. (Optional) The students may also show another set of "pipes" going to the wastewater treatment plant and returning to the source. (Use markers to color the wastewater lines a dark color.)

B. Ask the students the following questions:

1. How is the amount of water a home, school, or business uses measured? (A water meter measures the amount of water that is used so the customer can be billed correctly.)

2. Who reads the amount of water you use? (a meter reader from the water utility)

3. Explain to the students that water is not free and users must pay for its use. Water is paid for by the gallon (liter) or sometimes it is measured in cubic feet (cubic meters). What else is measured by the gallon (liter)? (gas, milk, juice)

C. Distribute the student sheet "Meet Your Meter" or you may want to use it as a transparency. Discuss and explain how to read a water meter. (You can get a meter face from your local water department. If you wish to concentrate on the meters most common in your community, call the billing department of your local water utility and ask about the meters where you live. Some people, like those who live in apartments, do not have individual meters. Their rent includes an estimated fee for water usage.)

1. The first meter is measured in gallons. Read and record the first meter that represents gallons. ______103,836

2. The second meter measures water in cubic feet. Read and record this amount.____192,787

3. The third meter is read like a digital clock. Read and record this amount.____3,429

D. Ask the students to read the meters on the student sheet "Meter Reader" to reinforce the skill. The answers are: 1. ...,092; 2. 072,150; 3. 824,736.

IV. Extensions

A. Have students complete "Read Your Meter," a take-home survey.

B. Brainstorm ways to conserve water.

1. List these suggestions on the blackboard or overhead projector.

a. Check toilets and faucets for leaks.

b. Keep a container of drinking water in the refrigerator.

c. Turn off the water while you brush your teeth.

d. Wash clothes only when you have a full load.

e. Wash dishes only when you have a full load.

f. Take shorter showers, or get a low-flow shower head.

2. Discuss the question, "Why should we conserve water?"

a. Water is a natural resource that we all share.

b. Wasting water wastes energy.

c. Conservation will save money and make clean water supplies last longer.

C. Appoint a water patrol of 3 or 4 students to check bathrooms and water fountains for leaks or to see if they are left running. Report their findings to the janitor or principal.

D. The students may check the newspapers and clip out articles that concern water.

1. These may be placed on the bulletin board.

2. Students may write reports on their findings.

RESOURCES

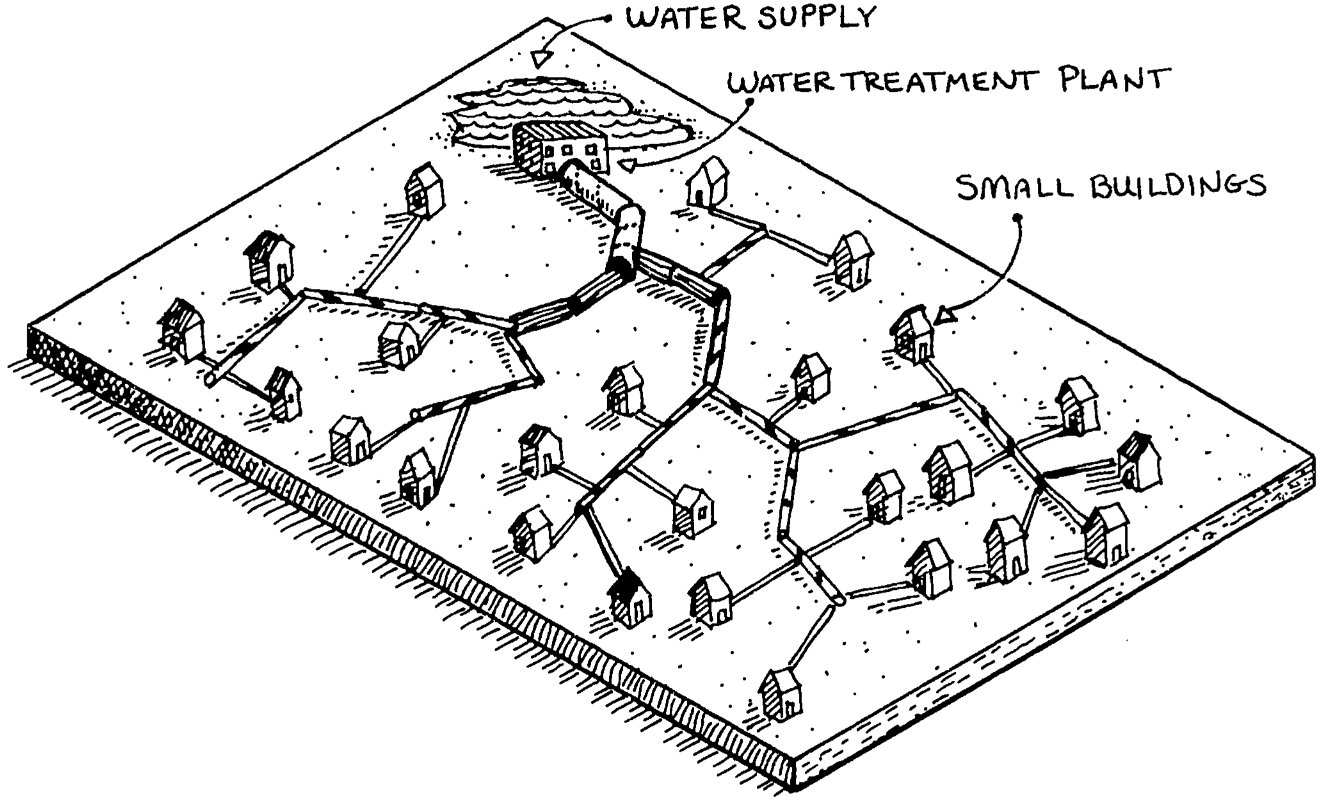
Cobb, V., The Trip of the Drip, Little, Brown and Company, Boston, Massachusetts, 1986.

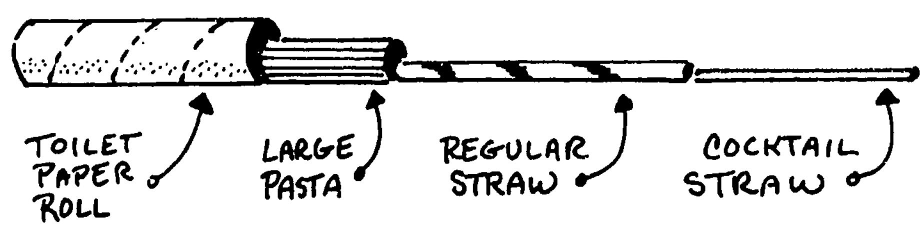
"Science Demonstration Projects in Drinking Water, Grades K-12," U.S. Environmental Protection Agency, Washington, DC, 1990.

"The Story of Drinking Water" (student booklet), American Water Works Association, Denver, Colorado, 1984.

"The Story of Drinking Water: Teacher's Guide, Intermediate Level, Grades 4, 5, 6," 2nd ed., American Water Works Association, Denver, Colorado, 1988, pp. 23-24.

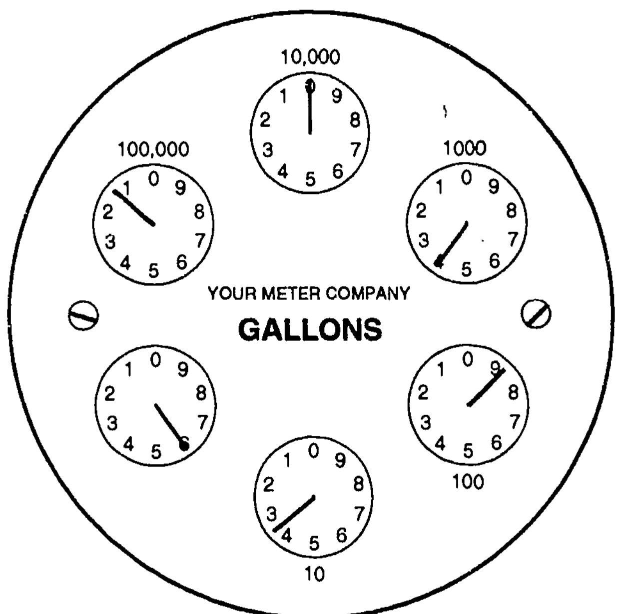
COMMUNITY WATER SUPPLY SYSTEM MODEL

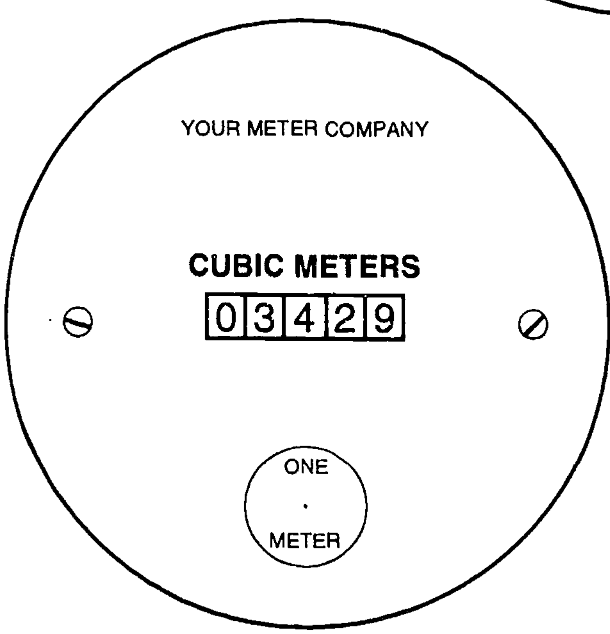


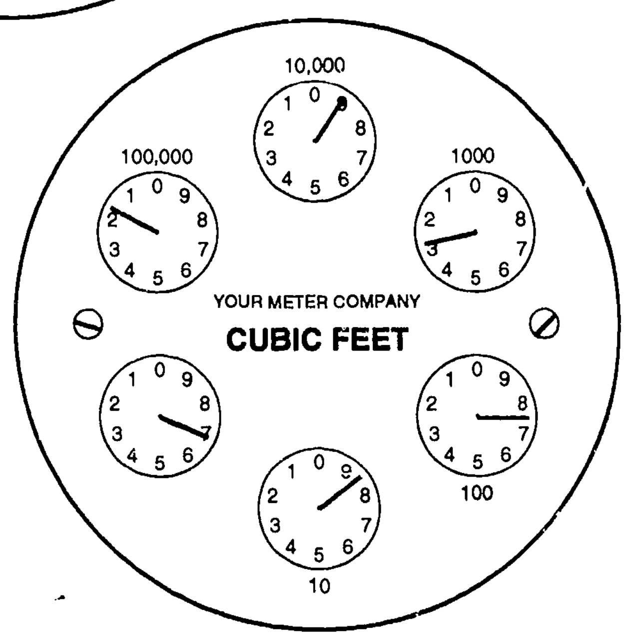


MEET YOUR METER

Your water meter probably looks like one of these. The first meter is read clockwise and measures water in gallons. The second meter measures water in cubic feet and is read in the same manner. (To convert cubic feet to gallons you must multiply the number on the meter by 7.5.) The third meter is read like a digital clock. Meters 1 and 2 have six dials, which are read clockwise. Begin with the "100,000" dial and read each dial to the "1" dial. Remember that when the dial is between two numbers, you read the smaller number. Read and record the number shown on each meter.



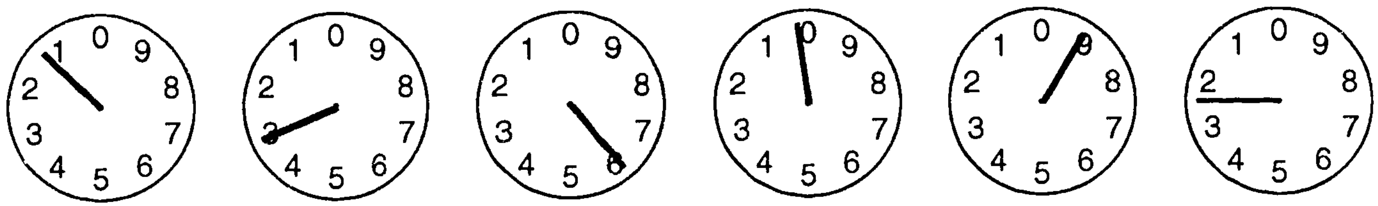




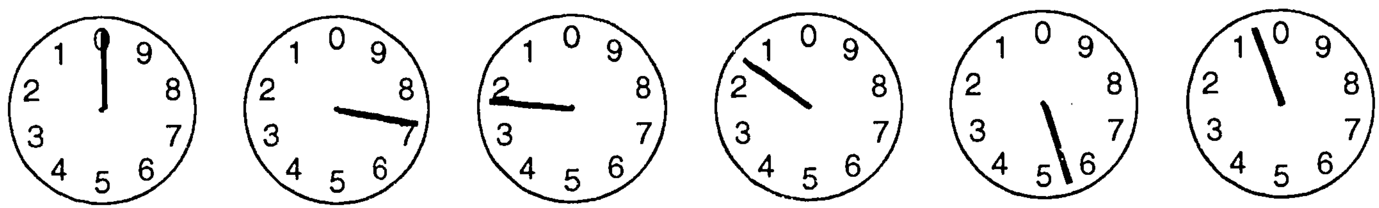
METER READER

Directions: Read the dials from left to right. When the dial is between two numbers, read the smaller number. Write the numbers in the blanks below the dials.

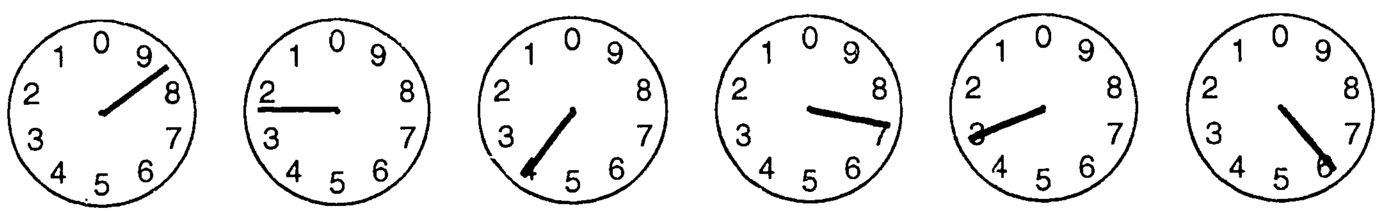
1.



2.



3.



READ YOUR METER

1. Does the meter at your home measure water in gallons or cubic feet? ________

2. Does your meter at home have a single dial (odometer- digital type) or a solid dial meter (like the three you read on the other student sheet)? ____________

3. Which type of water meter does the school have? ______________ How can you find out? ____

4. How many of gallons of water were used in your home last month? (Ask your parents to show you the water bill.) ______________

5. How many days were in the billing period? ____________

6. What was the average number of gallons your family used per day? (Divide the total number of gallons of water used by the number of days in the billing period.)

7. Find your meter at home and read your meter every day for the next week. If you don't have a meter at home, check with the janitor to see if you can read the meter at school.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Date							
Reading							
Daily Units							

Add all the daily units for your weekly total:

Weekly Total	

8. What was your family's average daily use? Add the weekly total, then divide the weekly total by the total number of readings (7).

9. Compare the daily average with the daily units. What did you find out? ______

10. What day of the week did your family use the most water? ______________
What day did they use the least? ________________________

WATER WORKS

OBJECTIVES

The student will do the following:

1. Demonstrate the process that water treatment plants use to purify water for drinking by conducting a water purification experiment.

2. Describe what happens in the water treatment process by writing a story.

SUBJECTS:
Science, Social Studies, Language Arts

TIME:
120 minutes

MATERIALS:
1 gallon (4 L) jug of water
2 1/2 cups (600 mL) soil or mud
acetate sheet
four 2-liter plastic bottles
funnel
scissors
2 tablespoons (30 mL) of alum
2 tablespoons (30 mL) of bleach
2 cups (500 mL) fine sand
2 cups (500 mL) coarse sand
1 cup (250 mL) fine gravel
1 cup (250 mL) coarse gravel
1 cup (250 mL) activated charcoal
cotton for plug
tap water
a tablespoon
clock
student sheets (included)
tape recorder with tape (optional)
camera with film (optional)
teacher sheet (included)

BACKGROUND INFORMATION

Water treatment is the process of cleaning water and making it safe for people to drink. Because water is a good solvent it picks up all kinds of contaminants. In nature, water is not always clean and safe enough for people to drink.

Our drinking water comes from both surface and groundwater. Water in lakes, rivers, and swamps contains impurities that may make it look and smell bad. Water that looks clean may contain harmful chemicals or bacteria and other organisms that can cause disease.

In the past, waterborne diseases were a major public health concern but today these diseases are no longer a health threat in the United States because of the improved water treatment. Technicians working in drinking water facility laboratories make thousands of tests each year to insure that our drinking water supply is free of disease-causing bacteria. These test results are reported to the state and local governments.

It takes the efforts of both federal and state governments as well as local water supply systems to keep our drinking water safe and in good supply. The Safe Drinking Water Act and its amendments set the standards for public drinking water. The Environmental Protection Agency administers these standards.

Water treatment plants clean and maintain the quality of drinking water by taking it through the following processes: (1) aeration, (2) coagulation, (3) sedimentation, (4) filtration, and (5) disinfection (see definitions in "Terms" below).

Terms

aeration: to expose to circulating air; adds oxygen to the water and allows gases trapped in the water to escape; the first step in water treatment.

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coagulation: the process by which dirt and other suspended solid particles are chemically "stuck together" so they can be removed from the water; the second step in water treatment.

disinfection: the use of chemicals and/or other means to kill potentially harmful microorganisms in the water; the fifth step in water treatment.

filtration: the process of passing a liquid or gas through a porous article or mass (paper, membrane, sand, etc.) to separate out matter in suspension; the fourth step in water treatment.

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

sedimentation: the process that occurs when gravity pulls particles to the bottom of the tank; the third step in water treatment.

sludge: solid matter that settles to the bottom of septic tanks or wastewater treatment plant sedimentation tanks; must be disposed of by bacterial digestion or other methods or pumped out for land disposal or incineration.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

water treatment: a method of cleaning water for a specific purpose, such as drinking.

ADVANCE PREPARATION

A. Make a copy of the diagram of a water treatment plant and water treatment word search puzzle for each student. You may use the diagram of a water treatment plant as a transparency.

B. Gather materials for demonstration of water treatment process.

C. Prepare "dirty water"; add approximately 2 1/2 cups (600 mL) of soil or mud to 1 gallon (4 L) of water.

D. Cut one 2-liter bottle in half, cut the bottom from another bottle, and cut the top from a third bottle.

E. Alum can be found at the grocery store in the spices section. It is commonly used for making pickles.

F. NOTE: You may want to construct the filter before beginning the activity or may choose to let a team of students prepare it. To prepare the filter use the bottle with its bottom cut off to construct the filter. Turn the bottle upside down. Loosely put a cotton plug in the neck of the bottle. Pour the fine sand over the cotton plug followed by activated charcoal, coarse sand, fine gravel, and coarse gravel. Clean the filter by slowly and carefully pouring through 1-2 gallons (4-8 L) of clean tap water.

PROCEDURE

I. Setting the stage

A. Ask the students the following questions.

1. How many of you used water in some way today?

2. How did you use water? (shower, brush teeth, flush toilet, prepare meal)

3. Where does your water come from?

4. How can you be sure your water is safe to drink?

B. Discuss the water treatment plant and what it does.

1. Hand out the diagram of a water treatment plant.

2. Discuss the process that takes place during each step. Use the definitions given to explain each step:

   a. Aeration – Vigorously stirring up water to add air to it and drive out other gases that might be dissolved in it; similar to "whipping" it with a mixer (as in cooking).

   b. Coagulation – Adding chemicals to make dirt and other particles clump together.

   c. Sedimentation – Letting the clumps settle out (they're heavier than water, so they sink to the bottom).

   d. Filtration – Pouring the water through a filtering system that has lots of layers of materials that trap things that did not settle out (including things too small to see).

   e. Disinfection – Adding chlorine to kill germs that might make people sick (similar to swimming pool methods).

3. Write the letters A, C, S, F, and D on the board. Review with the students the words they stand for. Write simple-to-remember phrases for each one, such as:

   a. A = Add air

   b. C = Create clumps

   c. S = Soil settles out

   d. F = Fine filters to trap tiny things

   e. D = Die, germs, die!

   Leave these on the board while the class builds the model.

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II. Activities

A. Review the diagram of the water treatment plant. Discuss with the students, checking for understanding. Allow for questions and comments from the students.

B. Divide the students into teams of four or five students. Each team will perform one step in the process. (Supervise closely.) Give Team I the materials and dirty water to start.

1. Team I should pour about 1.5 quarts (1.6 L) of "dirty water" into the uncut 2-liter bottle with the cap. (Use a funnel) Ask the students to describe the water.

2. Have a student in Team I put the cap on the bottle and shake for 30 seconds. Continue the aeration process by pouring the water back and forth between two bottles 10 times. Ask the students what part of the water treatment process we have demonstrated. (aeration) Ask the students to describe any changes they observe.

3. Team II should pour the aerated water into the 2-liter bottle with the top cut off. Add 2 tablespoons (30 mL) of alum to the water. Stir the mixture slowly for 5 minutes. Ask the students what process this group has demonstrated. (coagulation) Ask the students to predict what will happen.

4. Team III should allow the water to stand undisturbed for 20 minutes. Ask the students to observe the water at 5 minute intervals and record their observations as to changes in the appearance of the water. (NOTE: Other groups may do the student sheet word search during this time frame or Team IV may construct the filter from the bottle with its bottom cut off. If you prefer to construct the filter model yourself, you may do it now if you'd like.) Ask the students what step this is? (sedimentation)

5. Team IV should carefully, without disturbing the sediment, pour the top two-thirds of the water through the filter. Ask the students what step this is. (filtration) Have them quickly rest the filter model in the 2-liter bottle cut in half to collect the filtered water.

6. After waiting until you have collected more than half of the water poured through the filter, add 2 tablespoons (30 mL) of bleach to the filtered water. The bleach represents the chlorination process. (CAUTION: Wear eye protection when handling bleach and quickly wash it off your skin if some should splash.) This is disinfection. Ask the students: "Did we recover the same amount of water we started with?" Measure approximately. Discuss that there is a certain loss of usable water in the water treatment process.

C. Compare the treated and untreated water.

1. Ask the students whether treatment has changed the appearance and smell of the water. How has it changed?

2. Explain to the students that this is a simulation of the process that a water treatment plant does; therefore, this water is not safe to drink.

III. Follow-Up

A visit to the local water treatment plant is a valuable experience. If this is not possible, ask a representative from the water utility to visit the class.

A. As you tour the plant, use your A, C, S, F, and D memory devices to review the terms with the students.

B. Assign each student a responsibility to perform during the trip or visit. Develop assignments and questions in advance. You may use the student sheet, "Water Works."

C. Send the contact person at the water treatment plant a copy of the assigned questions before the visit so he/she will be prepared for the group.

D. One student could also tape record the experience and another student could take photos for a visual record.

IV. Extensions

A. Have the students write a story or draw cartoons about "Betty Bacterium," "Sediment Sam," or other fictional characters and describe what happens to these characters as they go through the water treatment process.

1. Share the stories/cartoons with the class.

2. Use as a bulletin board activity to reproduce the water treatment process.

B. Ask the students to do the student sheet "Water Treatment Words" if you did not use it in the activity.

The answers to the word search are as follows:

```
a g b f o n i f g r o u n
r g r v u t s l d a o n i
d i c o a g u l a t i o n
s e n f u u n t t r a t s
m n s t a n a f t e f s a
u m n r u x d a r a s t e
s u r f a c e t n t i o r
m r t a f a c i l m s n a
s w a t e r a o a e o x t
n e b a v l o n m n a o i
b a c t o n b a c t t e o
s e d i m e n t a t i o n
a e l r o u s m f g o n t
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RESOURCES

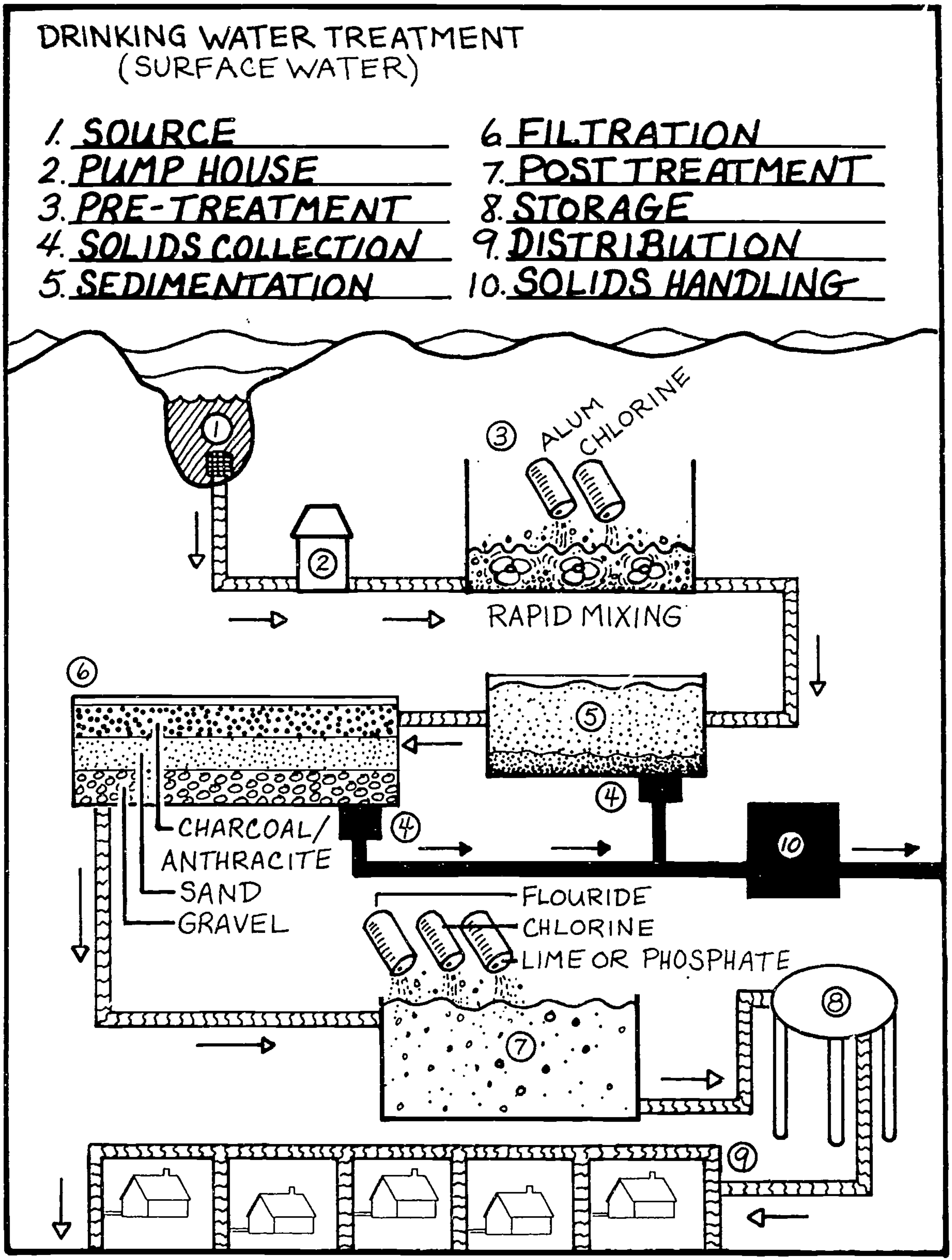
"Science Demonstration Projects in Drinking Water: Grades K-12," U.S. Environmental Protection Agency, Washington, DC, 1990.

"The Official Captain Hydro Water Conservation Workbook," East Bay Municipal Utility District, Oakland, California, 1982.

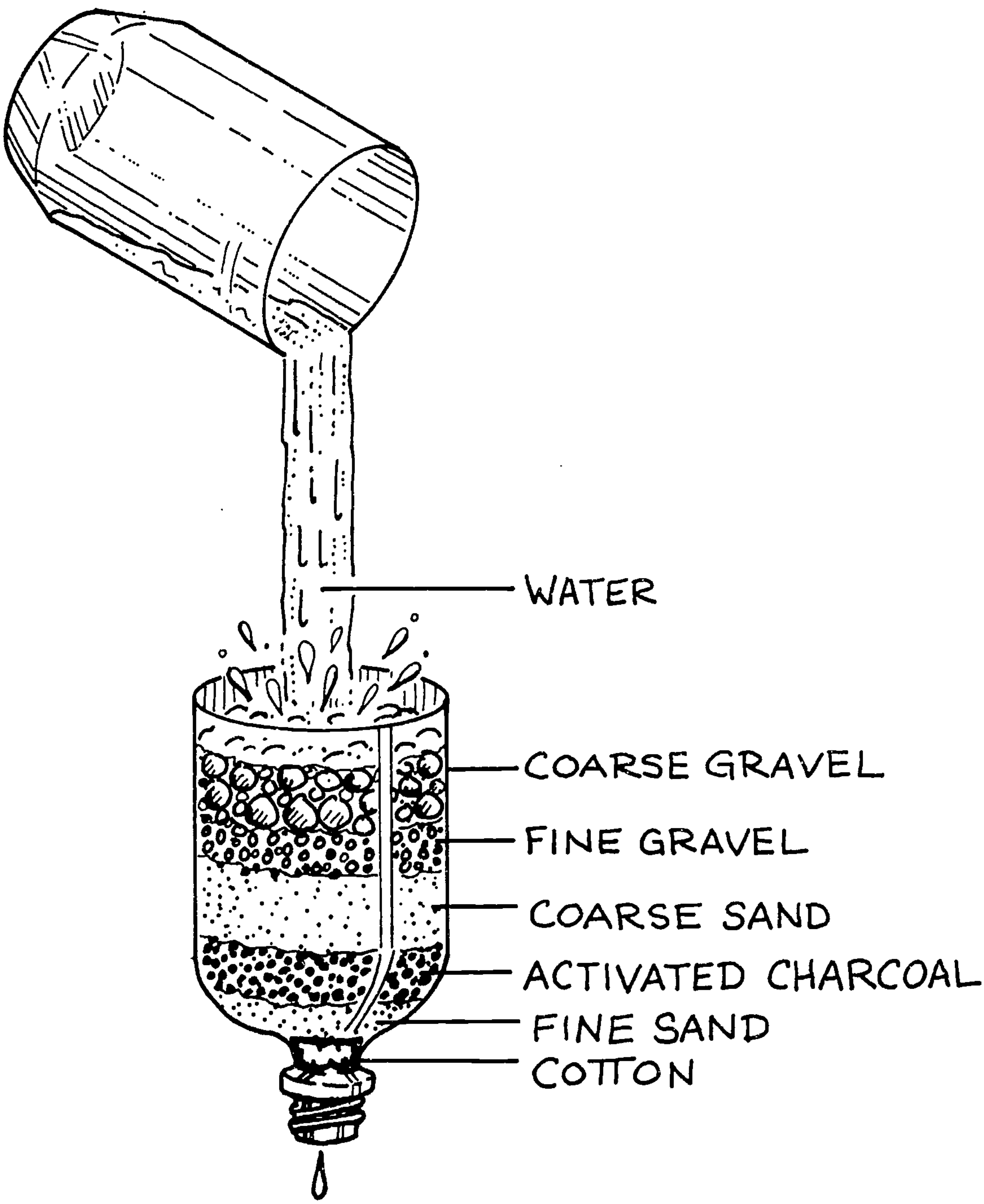
"The Story of Drinking Water" (student booklet), American Water Works Association, Denver, Colorado, 1984.

"The Story of Drinking Water: Teachers Guide, Intermediate Level, Grades 4, 5, 6," 2nd ed., American Water Works Association, Denver, Colorado, 1988.

DRINKING WATER TREATMENT PLANT



FILTER MODEL



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WATER WORKS

Answer the following questions.

1. Where does our water come from?
2. How much clean water is produced every day?
3. How is the water tested?
4. What is used to destroy the bacteria in the water?
5. What are the future plans for the water treatment system? As our community grows, will it be enlarged?
6. Who is in charge of or who owns the water utility?
7. How much water does the water source hold?
8. Do you use pumps or gravity to move the water?
9. How many people does this plant serve?
10. Is there anything unusual about this system?

WATER TREATMENT WORDS

Can you find these words? Find the words, circle them, and check them off the list.

aeration
coagulation
filtration
water
treatment
sedimentation
surface
ground

a	g	b	f	o	n	i	f	g	r	o	u	n
r	g	r	v	u	t	s	i	d	a	o	n	i
d	i	c	o	a	g	u	l	a	t	i	o	n
s	e	n	f	u	u	n	t	t	r	a	t	s
m	n	s	t	a	n	a	r	t	e	f	s	a
u	m	n	r	u	x	d	a	r	a	s	t	e
s	u	r	f	a	c	e	t	n	t	i	o	r
m	r	t	a	f	a	c	i	l	m	s	n	a
s	w	a	t	e	r	a	o	a	e	o	x	t
n	e	b	a	v	l	o	n	m	n	a	o	i
b	a	c	t	o	n	b	a	c	t	t	e	o
s	e	d	i	m	e	n	t	a	t	i	o	n
a	e	l	r	o	u	s	m	f	g	o	n	t

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WILL THAT HOLD WATER?

OBJECTIVES

The student will do the following:

1. Be aware of and discuss the five major purposes of dams.
2. Locate on a U.S. map the dams listed on the student sheet on the history of dams.
3. Build and test a model of a specific type of dam assigned to their team.

SUBJECTS:
Geography, Science, Art

TIME:
3 45-minute periods

MATERIALS:
5 half-gallon (2 L) cartons
6-8 quarter-inch (0.6 cm) dowel rods
glue
craft sticks
gravel
clay (ask the art teacher for some clay or you can use the cooked play dough recipe on teacher sheet)
teacher sheets (included)
paper towels
water
aluminum foil or aluminum pie pans
student sheets (included)
graph paper (optional)
paper cups (optional)
potting soil (optional)
bean seeds (optional)
plastic tray (optional)

BACKGROUND INFORMATION

People have built dams for thousands of years. Even earlier, beavers were damming streams to change their environment. Before 1905 no dam in the U.S. was taller than 200 feet. Fifty years later 159 dams 200 feet high or higher had been completed. Modern dams are designed to be multi-purpose dams. Their five major purposes are: water supply, irrigation, flood control, electric power production, and recreation. The lake created by damming a stream or river is called a reservoir. Some of the most famous dams in the U.S. are Hoover Dam in Arizona-Nevada; Grand Coulee Dam in Washington; Shasta in California; Bonneville in Oregon; Flaming Gorge in Wyoming-Utah; Kentucky Dam in Kentucky; Norris Dam in Tennessee; and Wheeler Dam in Alabama.

Hydroelectric dams use the energy of falling water from reservoirs to produce electricity by the use of turbines and generators. Hydroelectric power is non-polluting because it uses no fossil fuels and is non-consuming because it uses a renewable resource. (However, dams must be carefully planned so that they do not unnecessarily damage ecosystems when they flood an area and cause changes in the rivers they dam.)

Terms

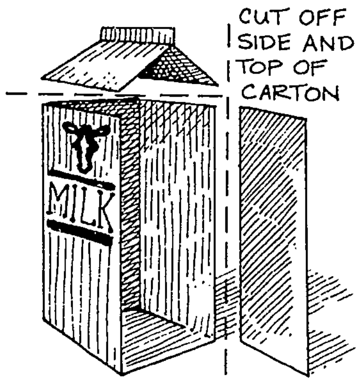
dam: a wall-like barrier across a stream or river to stop the flow of water.

drought: period of less-than-normal rainfall.

hydroelectricity: electricity produced by the power of falling water striking a turbine and turning a generator.

flood: period of more-than-average rainfall.

reservoir: a body of water stored in a natural or artificial lake.



ADVANCE PREPARATION

A. Cut one side and the top off of 5 half-gallon (2 L) cartons (or plastic milk jugs).

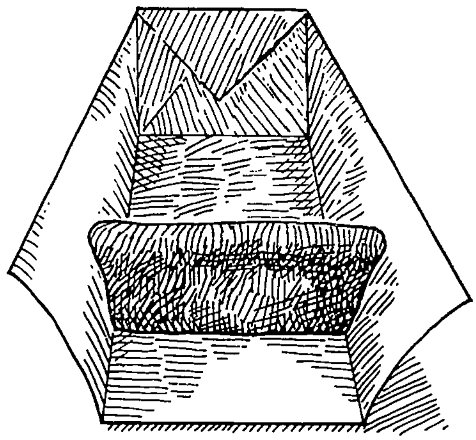
B. Cut 6-8 quarter-inch (0.6 cm) dowel rods into 3-inch (7.5 cm) pieces.

C. If you cannot get pottery clay, mix up 5 batches of the salt dough recipe and keep in an airtight bowl (see teacher sheet "Salt Dough Recipe").

D. Copy the student sheets "History of Dams," "Types of Dams," and "Will It Hold?"; make one per student.

E. Write the names of the 5 types of dams (rock, timber, embankment, masonry, and concrete) on slips of paper and put them in a cup.

F. Gather sticks, gravel, and other dam-building materials such as aluminum foil or aluminum pie pans.



PROCEDURE

I. Setting the stage

A. Begin the discussion by asking the class these questions:

1. What happens sometimes when it rains too much? (It floods Write "flood" on the board and define.)

2. What happens when it doesn't rain enough? (There is a drought and plants and crops die. Write "drought" on the board and define.)

3. Is there anything people can do to keep it from flooding and to save water to use during droughts?, (We can build dams. Write "dam" on the board and define. If some students are not familiar with dams, draw a simple diagram on the board showing that a dam blocks the flow of a river and causes a lake – reservoir – to fill up behind it. The dam has passageways in it through which we allow some water to pass, so there is still a river.)

B. Tell the class they are going to learn about dams and what dams do for people.

1. Pass out the "History of Dams" student sheet and ask for volunteers to read it.

2. List the five purposes of dams on the board. For each (water supply, irrigation, flood control, electric power production, and recreation), give an explanatory comment about how dams accomplish these things.

3. List the types of dams (earthen, rock, timber, embankment, masonry, and concrete) on the board.

4. List the famous U.S. dams on the board.

5. Ask for volunteers to locate them on a large U.S. map.

II. Activity

A. Begin the dam-building experiment.

1. Divide the class into five even teams (e.g., 5 teams of 5 for 25 students).

2. Explain that each team will be assigned to build a model of one type of dam. The class will build all but the earthen dam. You will provide clay, sticks, gravel, and other materials. They must determine how to use these to simulate the materials shown on the diagrams.

3. Pass out the "Will It Hold?" student sheet and have each team predict which dam will last the longest. (NOTE: You may elect not to do the formal experimentation, but to simply have the groups build and demonstrate the models.)

4. Have each team draw one slip of paper from the cup to see which model they will make.

B. Re-arrange the students' seating into teams (cooperative learning groups) and do the following:

1. Pass out the "Types of Dams" student sheets to each team and have them study the diagram of the dam they will build.

2. Each team should have a record technician, a time technician, a supply technician, a water technician, and a group leader. Let the students choose their roles.

3. The team will plan together how to build their dam. The record technician should record the plan in steps.

4. The supply technician will go to the supply table and get the needed materials for their team.

5. You will be available for technical advice, but should not physically help teams.

C. Once all dams are complete, they must dry for 5-7 days, after which testing will begin. (NOTE: You may omit the testing in step 2 and use the models for demonstration and display only.)

1. The water technician will slowly pour water behind the dam.

2. The time technician will call time intervals while the data technician records information. Data will be recorded every 15 seconds for the first 2 minutes and then every 2 minutes for the next 8 minutes.

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III. Follow-Up

A. Each team will graph their data from their experiment. The graphs can be used to make a bulletin board display on the strength of dams.

B. If you have omitted the testing, have each group draw a large diagram of their type of dam. (Supply the butcher paper and art supplies.) Display these drawings.

C. An excellent follow-up would be a field trip to a nearby dam. Ask the contact person at the dam to talk to your students about how and why the dam was built.

IV. Extensions

A. For lower grades, do a seed growing experiment. Discuss with the class how sometimes there is too much water (flooding) and sometimes there is not enough water (drought). In teams do the following:

1. Pass out three cups to each team and poke a small hole in the bottom with the pencil.
2. Number the cups 1-3.
3. Fill the cups with potting soil.
4. Plant three bean seeds in each cup.
5. Put all cups on the plastic tray.
6. Do the following every day:
   a. Do not water #1
   b. Water #2 until the soil is damp
   c. Water #3 until a layer of water covers the soil.
7. Keep the cups in a sunny window.
8. Keep a journal on what changes happen each day. (NOTE: The beans in #2 should sprout in about a week.)
9. Ask the students "Why didn't the beans in cups #1 and #3 sprout?" Relate this to how dams help control the amount of water available for us to use: They prevent water shortages and floods.

B. For higher grades have students investigate beaver dams and their impact on the environment. See teacher fact sheet "Beavers and Their Dams."

RESOURCES

Arnold, Caroline, Bodies of Water: Fun, Facts, and Activities, Franklin Watts Publishing Co., New York, 1985.

"Dams," Encyclopedia Americana, Grolier, Inc., Danbury, Connecticut, 1987.

Hunt, Bernice K., Dams: Water Tamers of the World, Parents' Magazine Press, New York, 1977.

Miller, James E., "Beavers", Program Leader, Fish & Wildlife, USDA - Extension Service, Natural Resource and Rural Development Unit, Washington, DC, 1983.

SALT DOUGH RECIPE

In a heavy sauce pan mix the following ingredients together:

1 cup (250 mL) plain flour
1/2 cup (125 mL) salt
2 tsp (10 mL) cream of tartar

Add the following:

1 cup (250 mL) water
1 tbs (15 mL) cooking oil
oil of wintergreen (optional)

Stir all together and cook at low temperature for 3 minutes or until it pulls away from the sides of the pan.

Almost immediately, knead lightly and store in an airtight container. You may add a few drops of oil of wintergreen to help the aroma.

It will take about a week for this to dry.

Make one batch for each team.

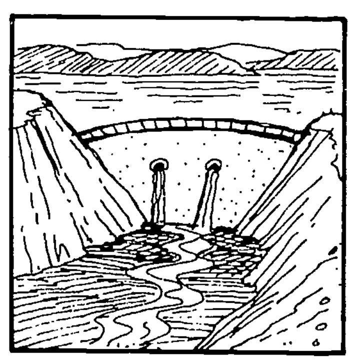
HISTORY OF DAMS

The first dam builders were beavers. Beavers build dams to change their environment more to their liking. People followed the beavers' lead and began building dams thousands of years ago to control and change their environments, to hold water, to control flooding, and to use water power.

The earliest reported dam was built on the Nile river about 5000 years ago to control flooding. Ancient dams were built to control flooding, provide drinking water, and supply water for irrigation. The Kaerumataike Dam in Japan is 2200 years old and is still used today. A dam on the Prontes River in Syria built 3300 years ago is still being used. The Romans built dams throughout their empire to control the water supply.

After the fall of the Roman Empire, dam-building ceased until it was reborn as a science during the 19th century. Modern dams are designed to be multi-purpose. The five major purposes of dams are water supply, irrigation, flood control, electric power production, and recreation.

In a fifty-year period of time ,159 dams 200 feet high or higher were built in the United States. Some of the most famous dams in the U.S. are: Hoover Dam in Arizona-Nevada, Grand Coulee Dam in Washington, Shasta in California, Bonneville in Oregon, Flaming Gorge Dam in Wyoming-Utah, Kentucky Dam in Kentucky, Norris Dam in Tennessee, and Wheeler in Alabama.



Modern dams are built to provide water supplies, protection from floods, and hydroelectric power, as well as for other purposes. Hydroelectric power is non-polluting because it uses no fossil fuels and is non-consuming because it uses a renewable resource.

Name ____________________

Date ____________________

WILL IT HOLD?

I. Predictions

1. Which type of dam will be less likely to leak? ____________________

2. Which type of dam will last the longest? ____________________

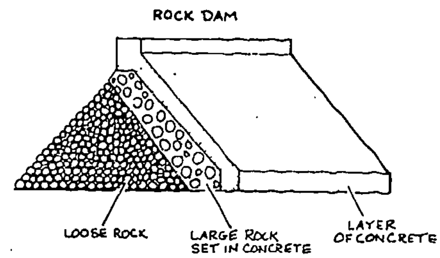
II. Building Plan (Record here.)

III. Testing (Record Observations)

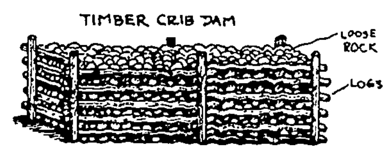
15 seconds		105 seconds	
30 seconds		2 minutes	
45 seconds		4 minutes	
60 seconds		6 minutes	
75 seconds		8 minutes	
90 seconds		10 minutes	

TYPES OF DAMS

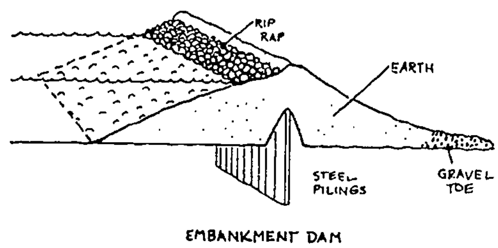
The earliest dams were made of earth and are called earthen dams. Earthen dams are sometimes the most practical even today. Some other kinds of dams are rock dams, timber dams, embankment dams, masonry dams, and concrete dams.



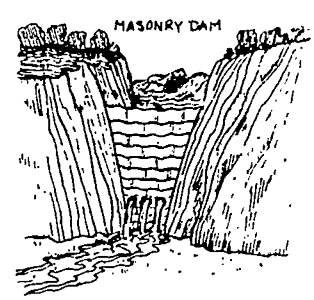
Rock dams are used in rocky areas. Often a concrete facing is added to a rock dam.



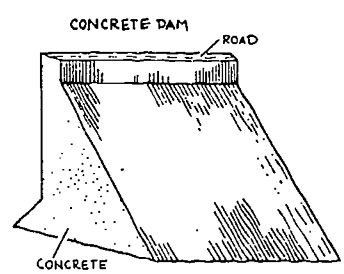
Timber dams are made of tightly fitting planks of wood supported and held together by rocks.



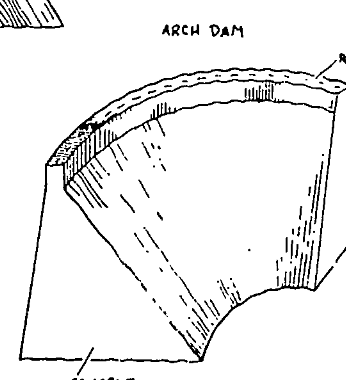
Embankment dams are good for damming broad streams. They are made by heaping up earth, clay, and gravel and then pressing it down until it is packed and watertight. The top layer is close-fitting stone called riprap.



Masonry dams were used to dam narrow streams running through mountain gorges. They are made with blocks of stone or concrete. Masonry dams are not good for broad streams but may be built extremely high.



Concrete dams can be built in many different shapes such as a gravity dam, buttress dam, or multi-arch dam.



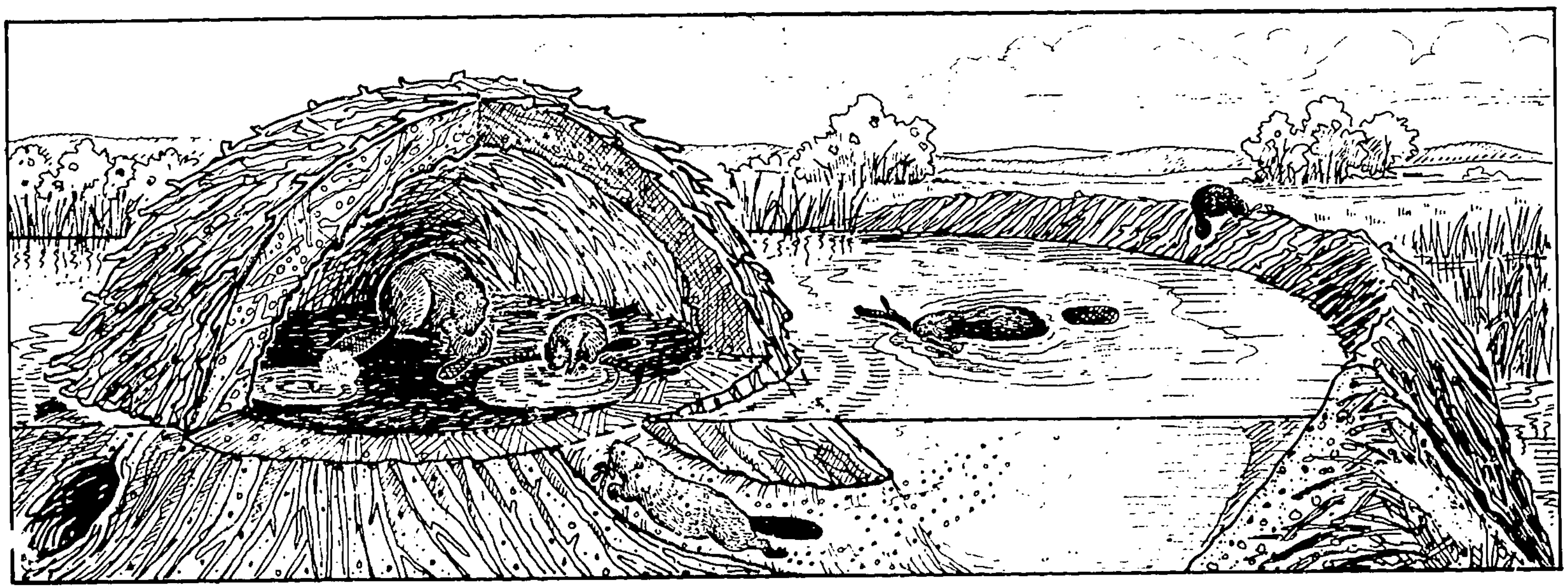
Dams must be built thicker at the bottom than the top so that they can stand up to the high pressure exerted by the water.

BEAVERS AND THEIR DAMS

Beavers love water. They live where there is a year-round source of water. They live in steams, lakes, ponds, swamps, wetlands, roadside ditches, canals, mine pits, drains from sewage disposal ponds, and below natural springs. Once beavers move into an area they quickly begin building dams to modify the environment to their liking.

Beavers build their dams with logs, branches, and twigs from the trees they cut down and with mud from the stream or lake. Beavers eat the trees as well as using them for building material. The size of a beaver dam can vary greatly. In some areas a dam may not be more than 36 inches (65 cm) high even though it may be one-quarter mile (0.4 km) long. In a mountainous area, a dam might be 10 feet (3 m) high and only 50 feet (15 m) wide.

A lodge or bank den is also built into the dam. The den is used for raising young, sleeping, and food storage. Beaver dens always have at least two entrances, and some have four or more.



THE INVISIBLE WATER SOURCE

OBJECTIVES

The student will do the following:

1. Identify various sources of drinking water.
2. Relate the water cycle to water supply.
3. Demonstrate the presence of water in a cloud.

SUBJECT:
Science, Art, Social Studies

TIME:
45 minutes

MATERIALS:
map of your state (1 for each student)
large jar
plastic bag of ice (to fit over the jar opening)
a sheet of black paper
flashlight
2 chalkboard erasers (used)
matches (for teacher use only)
blue markers or crayons

BACKGROUND INFORMATION

Water is a familiar substance. We drink it, wash with it, swim in it, and sometimes grumble when it falls from the sky. We are so accustomed to water that most of us are unaware that it is among the rarest and most unusual substances in the universe. Our planet has a vast supply of water but only a tiny fraction is readily available for use by people.

Most of the earth's surface is covered with water. More than 70 percent of the human body is water. Water is essential to all plant and animal life. No organism can live without it. So water supply and quality are critical. Much of our water supply is visible in the form of surface water in oceans, lakes, streams, rivers, and glaciers. Much of our water supply is unseen, as it is groundwater. Groundwater may be trapped in rock or sand formations or flow through porous rock or even underground rivers. The ability to access groundwater supplies through wells or springs is vital to the development of some areas. Deserts have been transformed into vital agricultural areas using groundwater resources. Today, the amount of water on earth remains the same as it always was!

<u>Terms</u>

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

river: a large natural stream of water emptying into an ocean, lake, or other water body.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

water: a transparent, odorless tasteless liquid, composed of hydrogen and oxygen.

ADVANCE PREPARATION

A. Maps of your state can be obtained from state social studies resource books. Road maps are a good source to use as outline maps. Universities have cartography labs that can help supply outline maps, and state water resource departments can also supply maps.

B. Place a jar on black paper or tape the paper to the back of the jar so you can't see through it. Fill 1/3 full with warm water. (NOTE: If a hot plate or source of heat is available, it can be used to keep the water warm until it is used.)

C. Have the bag of ice and matches nearby.

PROCEDURE

I. Setting the stage

A. Brainstorm with the students about areas of the world where they know there is water.

B. Ask the students where they have seen water in your state (rivers, oceans, rain, faucets, etc.). Write these sources (at least 10-15) on the board. Write specific names if they know them (e.g., Mississippi River).

C. Decide with the class which ones they could drink if they were thirsty. Erase the nondrinkable ones after discussing possible reasons why (e.g., ocean water is too salty to drink).

D. Ask the students if they know why the drinking water sources do not get used up even though people use them all the time. (They are renewed by the water cycle.)

II. Activities

A. Distribute maps of your state.

1. Have the students color all areas mentioned as water sources blue.

2. Explain that the areas colored blue are called "surface waters."

3. Explain that some of the areas not colored contain water underground that is called groundwater. Discuss ways people get water out of the ground, such as wells and springs.

B. Briefly review the water cycle to show that water is also present in the air. Help students comprehend that rainwater is not a drinking water source but feeds the surface waters and groundwater. If need be, draw a diagram of the water cycle on the board to remind students of how it works.

C. Point out to the students that there is a lot of (invisible) water in the atmosphere, as well as under the ground. (In fact, there is nearly 50 times more water in the atmosphere than in our fresh surface waters, and about 100 times more water underground than in those "blue waters.")

D. Explain that a cloud occurs when the invisible water vapor in the air becomes visible water droplets or ice crystals.

1. Clap two used erasers together.

   a. Have a student shine the flashlight into the dust "cloud."

   b. Explain that these chalk particles are similar to the dust particles that help form clouds.

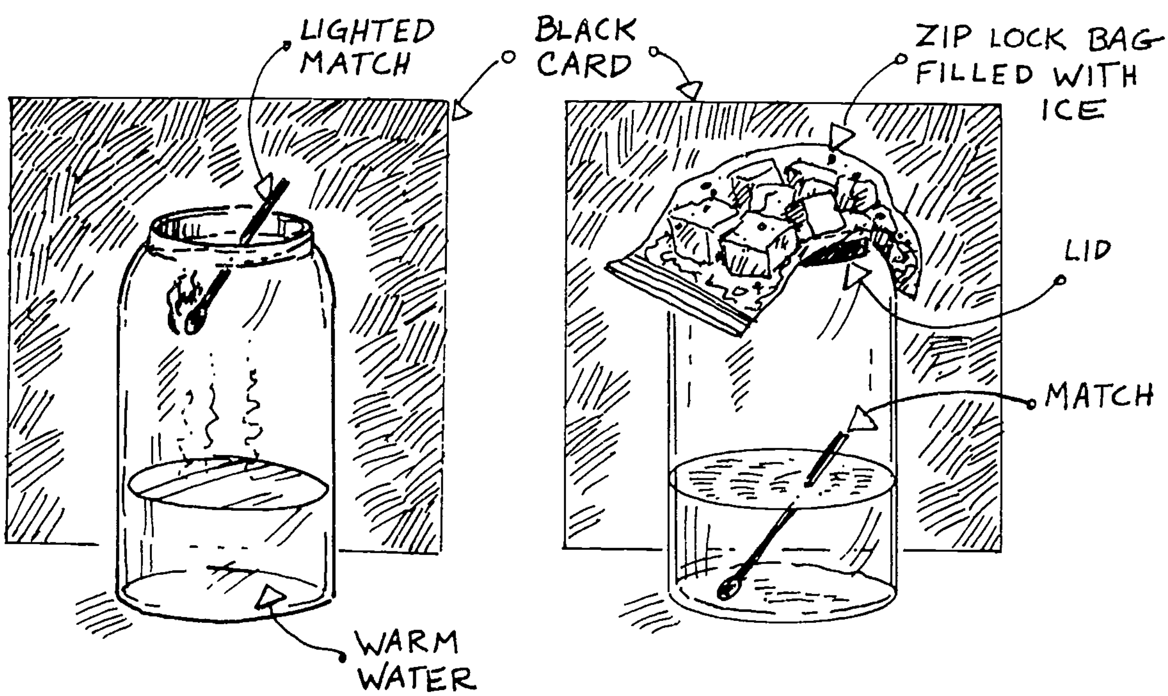
2. Make a cloud in a jar. Place the jar on black paper or tape the paper to the back of the jar. (This helps make the cloud more visible. The method used will depend on the number and location of your students during the activity.)

   a. Fill the jar 1/3 full with warm water. (The warmer the water, the better the results.)

      1) Light the match and hold it over the jar opening.

      2) After a few seconds, drop the match in the jar and cover the top of the jar with the bag of ice.

   b. Observe the inside of the jar against the black paper background.



3. Remind the students that clouds are important because we must have rain to renew our supplies of water.

III. Follow-Up

A. Ask what processes led to the cloud formation. (evaporation from warm water; condensation on dust particles because of the cooler air temperature from the ice bag) What if it was much colder? (Ice crystals would form and it would be "snow!")

B. Why was smoke from the match important to cloud formation? (Provided particles for vapor to "grab on.")

C. Review the student maps of water sources.

1. Ask where the surface waters get their water. (rain or groundwater)

2. Ask what happens to the rain or snow that falls on the ground. (Some replenishes surface or groundwater; some evaporates; some is used by living things.)

IV. Extensions

A. Observe the streams of rainwater runoff on a rainy day and discuss where they will end up.

B. Ask the students to pretend that the area they are living in has a drought.

1. What happens to the water supply? (decreases)

2. What living things mig: suffer? (Let them name various things, but be sure they understand that plants and animals–even people–will be harmed.)

C. Ask the students to think about what would happen if the nearby water source became polluted in a disaster and then discuss their ideas.

D. Explore the settlement of our country and discover the locations chosen around water supplies.

RESOURCES

Environmental Resource Guide: Nonpoint Source Pollution Prevention (Grades 6-8), Air and Waste Management Association, Pittsburgh, Pennsylvania, 1992.

Miller, G. Tyler, Living in the Environment: Concepts, Problems, and Alternatives, Wadsworth Publishing Co., Belmont, California, 1975.

"The Story of Drinking Water: Teacher's Guide, Primary Level," American Water Works Association, Denver, Colorado, 1984.

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HARD OR SOFT?

OBJECTIVES

The student will do the following:

1. Discover that water containing excessive dissolved minerals is called hard water.
2. Compare hard and soft water properties.
3. Identify health effects of hard water and soft water.

SUBJECTS:
Science, Language Arts, Health

TIME:
60 minutes

MATERIALS:
2 one-liter plastic bottles with caps
distilled water
Calgon® water softener
Epsom salts
liquid soap
2 quart-size (1-L) clear containers or two 1-liter bottles with the tops cut off
1/2 cup (125 mL) soil
student sheet (included)

BACKGROUND INFORMATION

In nature, water circulates through a system called the water cycle. There are two main sources of fresh water: surface water and groundwater. Surface water flows over the land in lakes, rivers, and streams. Groundwater seeps through the soil or through cracks and cavities in rocks.

Fresh, clean, unpolluted water is something no one should take for granted. Only three hundredths of one percent of the earth's water is drinkable (three out of 10,000 gallons of water on earth).

Minerals that cannot be seen are dissolved in water naturally. Water that is high in some minerals is called hard water. Hard water has economic, as well as health, effects. Laundry washed in hard water may require more detergent and energy to get clean. Links have been drawn to kidney stones in people and high dissolved mineral content in the water they drink.

Water that has a low mineral content reduces the amount of detergent needed, but generally has a higher level of sodium. Sodium in high levels is linked to heart disease, stroke, and high blood pressure. Water with low mineral content is usually corrosive and can leach lead out of solder in plumbing.

Depending on where you live, the water may have more or fewer minerals than water in other parts of the country. The amount of minerals in water makes it "hard" or "soft." "Hard" water gets its name because it is "hard" to make suds in it. The minerals in the water combine with soap to make a gray film instead of suds. It is this film that leaves a ring around a bathtub.

Terms

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

hard water: water that contains a large amount of dissolved minerals.

soft water: any water that does not contain large amounts of dissolved minerals but may be high in sodium.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans..

ADVANCE PREPARATION

A. Gather all the materials. Everything you need is available at grocery or drug stores (or maybe even in your home).

B. Fill the two clear containers. Add 1/2 cup (125 mL) soil to one container to make it "muddy" looking. You will be using the two containers to compare clear water to "muddy" water.

C. The activity will compare hard and soft water. In order to provide observable results, we will make our own hard and soft waters.

1. Begin by filling each of the liter bottles with distilled water, leaving an inch (2.5 cm) space at the top.
2. In one, dissolve 1/2 cup (125 mL) of Epsom salts. Label this one "Hard Water."
3. In the other, dissolve 1/2 cup (125 mL) Calgon® or similar brand water softener. Label this one "Soft Water." (This water will have a blue tint, but will become clear in a short time.)

D. Photocopy the student sheet.

PROCEDURE

I. Setting the stage

A. Ask the students to brainstorm different types of water pollution.

B. Show the class the two containers holding clear and "muddy" water.

1. Ask which one they would drink. (All will probably choose the clear water.)
2. Ask and encourage students to discuss the possible effects of drinking the dirty water.

C. Ask the students to brainstorm adjectives that might describe water. (clear, cold, muddy, etc.)

1. Tell the students that water can also be described as "hard" or "soft."
2. Write the terms "hard water" and "soft water" on the board. Can they imagine what this might mean?

D. Show the class the two bottles labeled "Hard Water" and "Soft Water."

1. Ask which one they would drink. (Most likelv. there will be indifference since both look clear.)

2. Ask and encourage students to discuss the possible effects of drinking either container of water.

3. Inform the students that sometimes it is difficult to distinguish whether drinking water is pure or impure.

II. Activity

A. Allow the bottles of water to sit overnight. (This will allow settling to occur. Encourage the students to compare the bottles and their sediments.)

B. Explain that minerals that cannot be seen exist in water naturally. The more dissolved minerals, the harder the water. (Optional: If you live in an area with hard water, you may have examples around your house of how this water can leave mineral deposits. Check your tea kettle for a crust of minerals left by water. You can probably find other examples in you home, too.)

1. Show one of the properties that distinguishes between hard and soft water by adding liquid soap (a hearty squeeze) to each. With the lids on tight, shake each as hard as you can. (NOTE: You might allow two students each to do one bottle.)

2. Observe the differences in the soap suds level. (More suds appear in soft water.)

3. Encourage class discussion on the effects of having hard or soft water in the home. (You need less soap to wash clothes, dishes, bodies, hair, etc., if you have soft water.)

C. Pass out student sheet, "Hard or Soft Water."

1. Discuss the sources and household and health effects of hard water.

2. Discuss the sources and household and health effects of soft water.

III. Follow-Up

A. Have each student repeat the suds demonstration at home.

1. The students should orally report their findings to the class the following day.

2. Make a class chart showing the results.

3. Have the students graph the results.

B. You may assign a student to test the school water supply (drinking fountain or sink).

C. Ask the students to answer the following questions:

1. You have hard water; your friend has soft water. Who will need more bubble bath for a tub full of bubbles? (you)

2. People in your community seem to have a lot of kidney stones. If the Health Department tests the water to check its mineral content, they might be expecting to find the water is very (hard/ soft)?

3. A community has very soft water, which corrodes peoples' plumbing. What metal can the soft water cause to be in the water from the pipes? (lead)

4. The water at your grandparents' house tastes very metallic. It is hard or soft water? (hard)

5. When you go to the beach, the water lathers your shampoo so much, you have a hard time rinsing it out of your hair. Is it hard or soft water? (soft)

IV. Extensions

A. Have a representative from your water utility answer questions about the local water supply. (Be sure to talk to the representative ahead of time about discussing only dissolved minerals.)

B. Invite a representative from the local health department to present a classroom presentation on the health effects associated with hard and soft waters.

C. Visit a water treatment plant.

RESOURCES

"About Safe Drinking Water," Channing L. Bete Co., New York, 1990.

Seehafer, Roger W, Health: Choosing Wellness (Teacher's Edition, Grades 9 - 12), Prentice-Hall, Englewood Cliffs, New Jersey, 1989.

HARD OR SOFT WATER

Type	Mineral Content	Problems to Household	Problems to Human Health
Hard water	High concentrations of minerals such as copper, limestone, iron, magnesium, and calcium. Low sodium content.	Metallic taste of water. Staining of porcelain and laundry. Need more detergents to clean and lather.	Kidney stones may be related.
Soft water	Low concentrations of minerals such as copper, limestone, iron, magnesium, and calcium. High sodium content.	Lathers soap easily. Common cause of plumbing corrosion.	Cardiovascular disease may be related. Lead in water increases due to plumbing corrosion.

GET THE SALT OUT!

SUBJECTS:
Science, Geography

TIME:
2 45-minute periods

MATERIALS:
world map
5 clear drinking straws
1/4 lb (100 g) clay
20 to 30 steel BB's
tap water
permanent ink pen
metric rulers
3 samples of liquids
3 clear glass quart jars
student sheet (included)
table-tennis ball
golf ball
clear plastic pitcher
mixing spoon
duct tape
2 glasses of water
teacher sheet (included)
two 2-liter bottles
black paint
12 inches (30 cm) of clear plastic tubing (as for aquarium)
aluminum foil
salt
small (bathroom) paper cups (1 per student)

OBJECTIVES

The student will do the following:

1. Demonstrate that salt water can be changed to fresh water by evaporation (desalination).
2. Make and use a hydrometer to measure the density (saltiness) of water.
3. Research places in the world where desalinated water is the main source of drinking water.

BACKGROUND INFORMATION

Salt water makes up 97 percent of all the water on the earth. Though abundant, salt water is not potable, or fit to drink.

Fresh water can be obtained from salt water by a process called desalination. There are several ways to desalinate salt water: evaporation, reverse osmosis, membrane electrolysis, and freezing. The least expensive of these methods is usually evaporation.

Desalination is seen as a solution to fresh water shortages by some people, but the energy requirements of these procedures cause desalinated water to be very expensive. Desalinated water costs six times as much per unit as fresh water.

As of 1985 about 600 desalination plants around the world produced approximately 250 million gallons (947 million L) of fresh water per day. That is only 0.4 percent of the U.S.'s daily water use and 0.006 percent of the world's daily water use.

A hydrometer is a device used to measure the density of liquids such as salt water. The hi ıer a hydrometer floats in a liquid, the more dense or salty the liquid is.

Terms

density: a measure of mass per unit of volume of a substance.

desalination: the purification of salt or brackish water by removing the dissolved salts.

evaporation: the process by which liquid water becomes vapor in the atmosphere.

hydrometer: a device that measures the density of water.

ADVANCE PREPARATION

A. Copy student sheet.

B. Thoroughly clean the two 2-L bottles. Paint one of them black.

C Obtain the clear tubing from any store selling aquarium supplies. Wash it out well.

D. Mix the following solutions in clear jars and label: 1) 2 tablespoons (30 mL) salt in 3/4 quart (750 mL) water, A; 2) 4 tablespoons (60 mL) salt in 3/4 quart (750 mL) water, B; and 3) 6 tablespoons (90 mL) salt in 3/4 quart (750 mL) water, C.

E. Prepare 2 glasses of water, one labeled as tap water with a price of 1 cent (A) and one labeled as desalinated water with a price of 6 cents (B).

F. Fill clear plastic pitcher with water.

PROCEDURE

I. Setting the stage

A. Display a map of the world and the two labeled glasses of water at the front of the room.

1. Discuss with the class the availability of water. Ask the following questions:

   a. Do you ever run out of water at your house? (no; except for unusual, and typically short-term, situations)

   b. Can you name a place on earth where people might run out of water to drink? (the desert)

   c. Can you drink sea water? Why not? (No, it's too salty.)

   d. Can you change sea water to make it drinkable? (Accept all answers. Then explain that sea water can be made drinkable.)

2. Point out Saudi Arabia on the map and explain to the class that in this region of the world people must get their water from the sea.

a. Hold up the two glasses of water and ask, "Who would like to buy a glass of water? Glass A costs 1 cent and glass B costs 6 cents."

b. Explain that water in Saudi Arabia costs six times as much as water in the U. S.

B. Write the word desalination and its definition on the board.

1. Explain that the Saudi water is desalinated sea water and that is why it costs six times as much as ours.

2. Tell the students that you will demonstrate how to desalinate water by the process of evaporation. See the diagram on the teacher sheet "desalination."

3. Add 2 tablespoons (30 mL) salt to the fresh water in the clear 2-liter plastic bottle and mix.

4. Pour the salt water into the black 2-liter bottle.

5. Attach the clear tubing to the black bottle and the clear bottle. Seal with duct tape.

6. Set both bottles in a sunny window with the black bottle 3 to 4 inches higher than the clear bottle.

II. Activity

A. Hold up a golf ball and a table-tennis ball. Ask the following questions:

1. Which ball is denser?

2. Which ball will float?

B. Write "density" and its definition on the board. Explain that the golf ball is denser than the table-tennis ball because the golf ball is solid, while the table-tennis ball is hollow.

C. Divide the students into teams of 5 each.

1. Pass out the student sheets on the hydrometer.

2. Write "hydrometer" and its definition on the board.

3. Explain that each team will make a hydrometer to test the density of three different liquids.

4. Have one student from each team pick up all the materials needed to make the hydrometer (listed on the student sheet "Hydrometer").

5. Students will follow the directions on the student sheet through Step 5 to complete the hydrometer. If hydrometers do not float, it is probably because the students have used too much clay. They should remove some of the clay and try again. (NOTE: For third grade, you may lead the groups step by step through the process.)

D. Groups will come up one at a time to the testing table to test the density of solutions A, B, and C.

1. Each team will record the results of their test.

2. Teams will answer the questions under observations and conclusions. (NOTE: This section may be done as a teacher-led discussion. The results should show that A is the least dense salt water, B has medium density, and C is the most dense. Tap water should prove to be even less dense than A.)

III. Follow-Up

After an observable amount of water has collected in the clear bottle from the desalination demonstration, pour water into cups from the black and clear 2-liter bottles. Have students taste each by giving each student a small paper cup and dispensing to each a very small taste from each of the two bottles. (NOTE: Remind the students never to taste anything used in an experiment unless it is a safe substance and they are specifically directed to taste it.) Was there a difference? (Water from the black bottle is salty tasting and water from the clear container is not salty.)

IV. Extensions

A. Allow the desalination demonstration to continue until enough water has collected in the clear bottle to test the density of it. Compare its density to the density of the water in the black bottle.

B. Have the students choose several countries they believe would use desalinated water and research whether those nations have desalination plants to provide drinking water.

C. Freeze salt water to separate the salt and water.

D. Try to float an egg in salt water and in tap water as another way to show their comparative densities.

RESOURCES

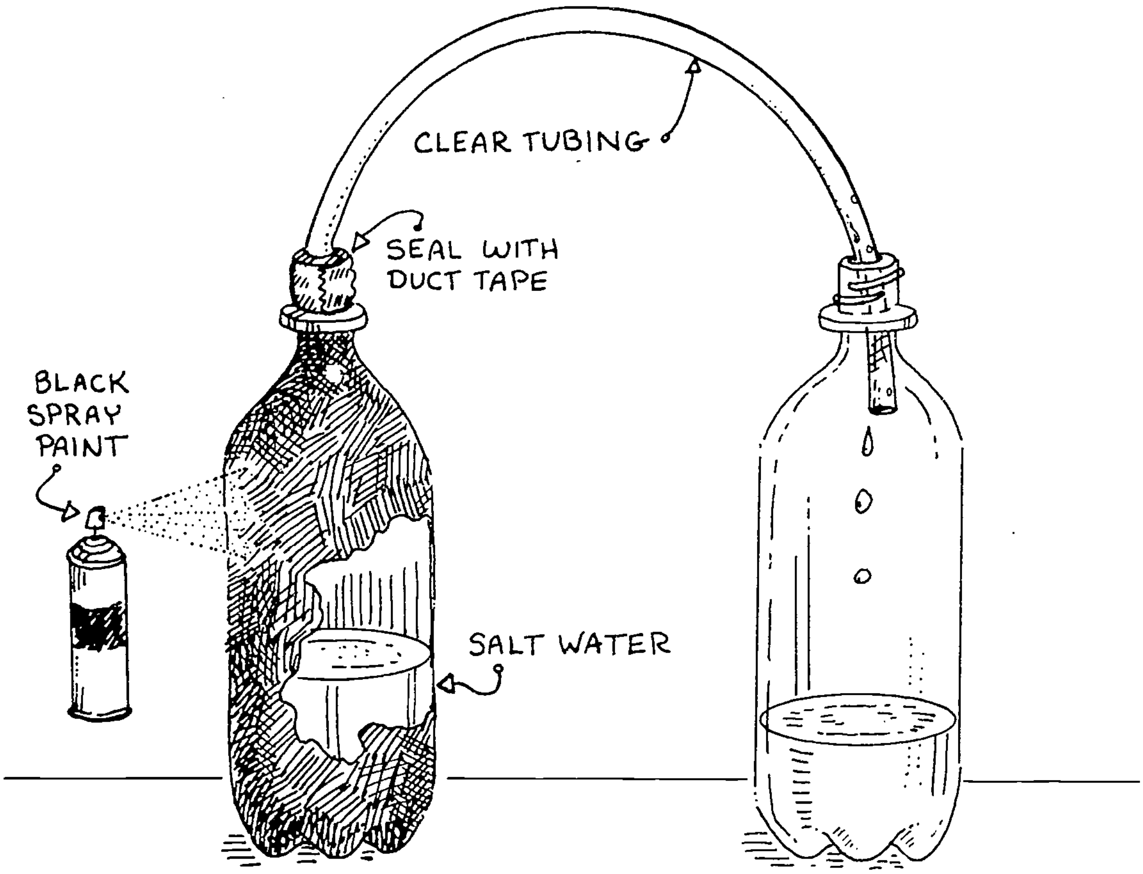
Handwerker, Mark, et al., Earth Science, Harcourt Brace Javanovich, Inc., Orlando, Florida, 1989.

Hurd, Dean, et al, General Science: A Voyage of Adventure, Prentice-Hall, Englewood Cliffs, New Jersey, 1989. (Laboratory activity adapted from p. 518.)

Miller, Tyler G., Environmental Science: An Introduction, Wadsworth Publishing Co., Belmont, California, 1986.

Miller, Tyler G., Living in the Environment: Concepts, Problems, and Alternatives, Wadsworth Publishing Co., Belmont, California, 1975.

DESALINATION



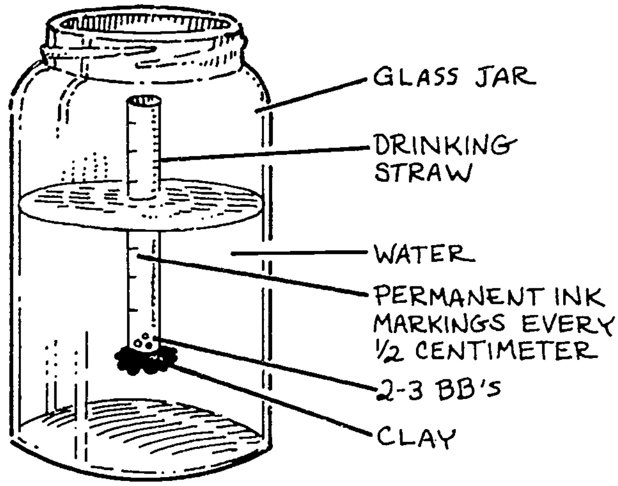
1. Spray paint one of the 2-liter bottles black before class.
2. In a clear pitcher mix 1/2 cup (125 mL) salt in 1 quart (1 L) of water.
3. Pour into the black 2-liter bottle.
4. Attach the clear tubing to both 2-liter bottles and secure with duct tape.
5. Set both bottles in a sunny window. Place the black bottle higher than the clear bottle.
6. Experiment with putting aluminum foil around the black bottle to heat it up more.

HYDROMETER

Name ____________________ Date ____________________

Materials (per team):

1 clear plastic drinking straw
small piece of clay
2 to 3 steel BB's
mayonnaise jar (or 2 liter
bottle with the top cut off)
fresh water
pencil of permanent ink pen
metric ruler



1. Cut straw in half and fill one end with clay.
2. Mark off 1/2 centimeters along the straw with a permanent ink pen.
3. Fill the jar 3/4 full of tap water.
4. Put 2 or 3 BB's in the open end of the straw. Let them roll down to the clay.
5. Put the straw into the water, clay end down. It should float. Add BBs until your hydrometer floats very low in the water. Only 2 or three lines should be above the water.
6. Record the exact level at which your hydrometer floats. When testing, the higher your hydrometer floats, the more dense or salty the liquid is. Pour the tap water out of the jar.
7. Your teacher will provide you with three samples to test. They are labeled A, B, and C.
8. Gently put your hydrometer into each liquid sample (one at a time) and record the level at which it floats each time.

Observations and conclusions:

1. Including your fresh water sample, list the samples in order of least dense to most dense.

____

____

2. In a liquid less dense than water, how would your hydrometer float?

____

3. In a liquid more dense, how would your hydrometer float?

____

4. Compare a floating object in salt water and fresh water.

____

THE MAIN DRAIN

OBJECTIVES

The student will do the following:

1. Identify the septic tank as an alternative method of wastewater treatment.
2. Observe how a septic tank works.
3. Demonstrate how a septic tank works.

SUBJECTS:
Science, Language Arts, Math

TIME:
45-60 minutes

MATERIALS:
one plastic or cardboard box or lid (6-8 inches [15-20 cm] deep)
one garbage bag (if cardboard box is used)
potting soil or topsoil
three empty paper milk cartons - one each: half gallon (2 L), quart (L) and pint (0.5 L) cartons
plastic straws
large needle
ice pick or awl
scissors
marking pen
masking tape
modeling or florist clay
ruler with English/Metric measurement
teacher sheet (included)

BACKGROUND INFORMATION

People who live in small towns and rural areas are often not connected to a sewage treatment system; therefore, they must depend on an alternative method of disposing of wastewater. Septic tank systems provide a safe and effective means for waste disposal if they are properly sited, installed, and maintained.

A septic tank is a large concrete or fiberglass tank that is buried underground. Drain pipes carry sewage and wastewater from buildings into the tank. By bacterial action, much of the sewage is reduced to liquid, which flows out of the tank through the drainpipe to the drainfield. The solids (sludge) settle to the bottom of the tank. This solid material must be periodically pumped out of the tank and disposed of at a waste treatment facility or an approved disposal site.

The drainfield allows wastewater to seep into the soil. The soil filters bacteria and nutrients from the wastewater. The water is further purified by the microorganisms that live in the soil.

Many states regulate the siting of septic systems and the distance between a septic tank and groundwater resource. They also may specify the types of soil where the system can be placed. Some states and local governments have regulations requiring inspection and maintenance schedules for septic systems.

Lagoons, wetlands, and sand filters are other alternative methods that rural areas may use to treat wastewater. However, if these methods are improperly sited, poorly constructed, and/or poorly maintained, they become a serious threat to groundwater quality and public health.

Terms

drainfield: the part of a septic system where the wastewater is released into the soil for absorption and filtration.

lagoon: an animal waste treatment method which uses a deep pond to treat manure and other runoff from a livestock operation. Lagoons can be aerobic or anaerobic. Both use bacteria to break down materials.

sand filter: a filter system used to treat wastewater where sand and gravel are mounted on top of the natural soil.

septic tank or septic system: a domestic wastewater treatment system into which wastes are piped directly from the home; bacteria decompose the waste, sludge settles to the bottom of the tank, and the treated effluent flows out into the ground through drainage pipes..

siting: the process of selecting the correct location for a septic tank.

sludge: solid matter that settles to the bottom of septic tanks or wastewater treatment plant sedimentation; must be disposed of by bacterial digestion or other methods or pumped out for land disposal or incineration.

wetland: an area that, at least periodically, has waterlogged soils or is covered with a relatively shallow layer of water.

ADVANCE PREPARATION

A. Gather materials for septic tank model. Prepare the cartons and straws as follows:

   1. Cut the top off the 1/2 gallon (2 L) milk carton. It should be 6 inches (15 cm) deep. Label this carton "house."

   2. Cut the quart (L) size to 3 inches (7.5 cm) deep and label it "septic tank."

   3. Cut the pint (1/2 L) size to 1/ 2 inch (1.3 cm) deep. Label it "drainfield tank."

   4. Cut the holes in the boxes for inserting the straws; use an ice pick or awl.

   5. Make holes in the straws using a large needle. Make numerous holes, enlarging them by working the needle back and forth.

B. If you do not have a plastic blanket or sweater storage box to use, cut a large cardboard box down (a copy paper box works fine); line it with plastic by inserting it in a garbage bag and tying off the bag with the box inside.

C. Have copies of the model diagram (teacher sheet) for the students to refer to during the construction.

D. Invite a water quality representative to come to speak to the class.

PROCEDURE

I. Setting the stage

   A. Put the following questions on the board or use sentence strips and place them on a pocket chart. (These assume that you are located in an area not served by a wastewater treatment plant.)

1. What happens to the wastewater and sewage when it leaves your house?

2. Where does the sewage/waste water go when it leaves the school?

B. Explain how a septic tank system works. Paraphrase the background information.

C. Compare/contrast a septic tank system and a wastewater treatment plant. List advantages and disadvantages of both.

II. Activities

A. The students will construct a model of a septic tank system with a drainfield.

B. Show the class the diagram of the model of a septic tank system.

1. Instruct the students to prepare the large box for the septic tank system model. The box should be filled 1/2 full of soil.

2. Cut the tops from the milk cartons (if this has not previously been done).

C. Assemble the septic tank system.

1. Instruct the students to connect the three boxes, from the largest to the smallest, with the straws (refer to diagram). Use ice pick or awl to make holes in boxes (if not already done). Fit the straws into the holes, connecting the boxes with the straws. Use small pieces of masking tape to seal leaks by making "collars" of tape around the connection between box and straw.

2. Instruct them to assemble the drainfield. Connect straws following the diagram of model. (To make the connections between straws, you will have to make large holes in the straw crosspiece; use the ice pick or awl.) Use a large needle to punch drain holes through the straws. Plug the ends of the drains (straws) with modeling or florist clay. Use masking tape to seal any leaks.

3. Test for leaks by putting the model in a sink and filling "house" with water. Water should only come out of the holes in the drain (straws).

D. As the assembly progresses, discuss with the students what each part of the model represents.

E. Test the septic tank system.

1. Put the model in the box with the porous soil.

2. Pour water in the "house" slowly. Observe what happens. Ask the students to explain what happens. (The water should go to the drainfield and trickle into the soil.)

III. Follow-Up

A. Have the students ask their parents what type of wastewater disposal they have. Construct a bar or circle graph to represent the type of wastewater disposal the students have in their home: (1) wastewater treatment plant, (2) lagoon, (3) septic tank, (4) wetland, (5) sand filter. What percentage does each group represent?

B. Did any parents tell what type of maintenance schedule has to be followed to keep the system working properly?

C. Brainstorm with the group the answers to these questions:

1. What happens if the system does not function properly? (Malfunctioning septic systems will have a smell or have noticeable wetness on the ground above them. Such systems represent a threat to public health and to nearby groundwater supplies.)

2. What do you think will happen to the water supply in the area if the waste disposal system does not work properly or is not maintained adequately?

IV. Extensions

A. Invite a water quality representative to come and speak to the class about wastewater treatment in their area.

1. Ask what type of waste disposal systems are represented in the area.

2. What kind of local or state regulations or restrictions are mandated for maintenance, siting, and construction of wastewater facilities in the area?

B. Write to a local or state water quality agency and ask them to send information about septic tanks.

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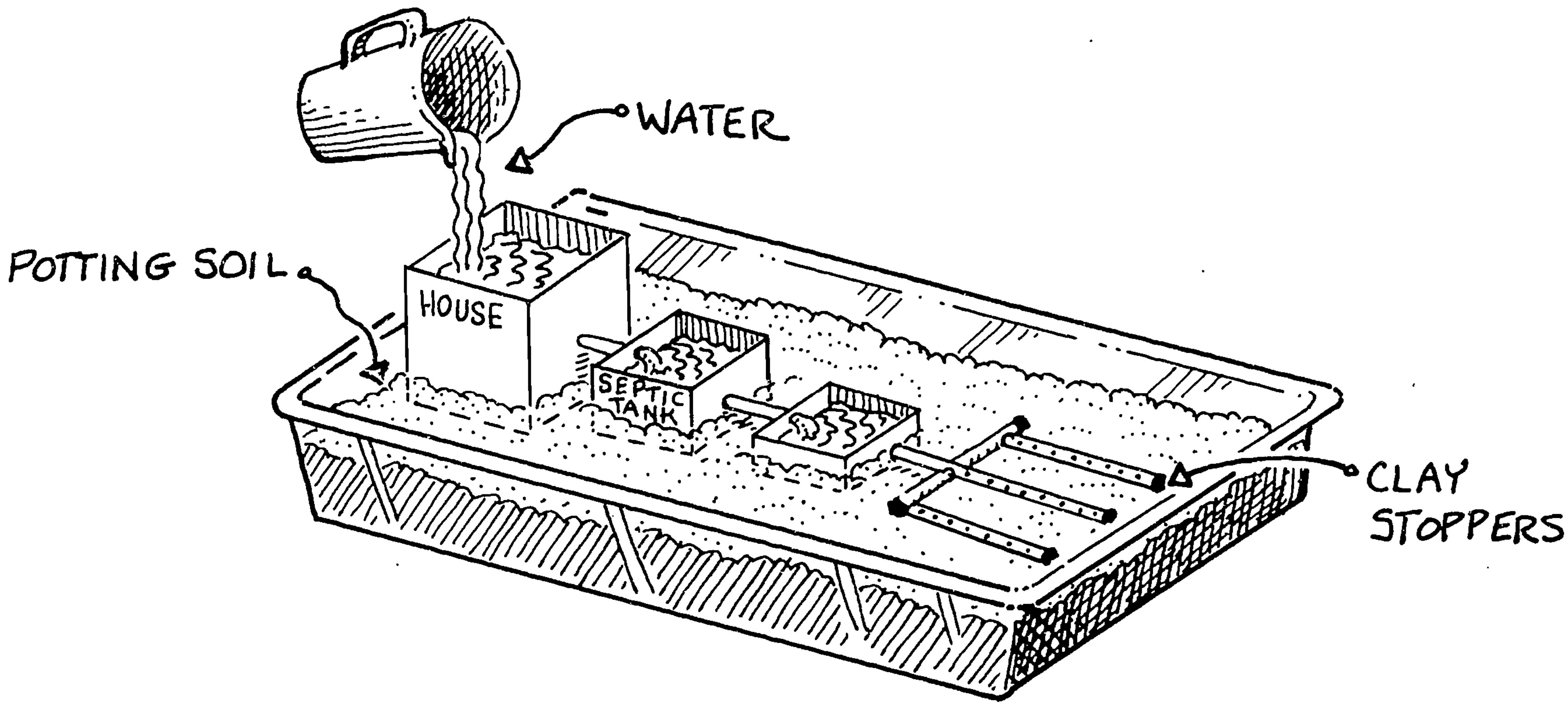
Jorgensen, Eric P., ed, The Poisoned Well: New Strategies for Groundwater Protection, Island Press, Washington, DC, 1989.

SEPTIC TANK MODEL



THE WASTEWATER STORY

OBJECTIVES

The student will do the following:

1. Identify what wastewater is and where it comes from.
2. Explain why wastewater must be treated before it is returned to the water supply.
3. Know the steps in the wastewater treatment process.
4. Utilize wastewater treatment vocabulary in a flow chart.

SUBJECTS:
Science, Art, Math

TIME:
45 minutes

MATERIALS:
overhead projector
acetate sheets
drawing paper
teacher sheets (included)
student sheets (included)

BACKGROUND INFORMATION

Each person uses an average of 150 gallons (570 L) of water a day. All of the clean water that comes into your house by one set of pipes, leaves your house by another set of pipes; clean water becomes wastewater. Wastewater comes from houses, schools, businesses, industry, and storm runoff.

In cities, wastewater goes into sewers and then to wastewater treatment plants. In the country, wastewater goes into large underground tanks called septic tanks.

Treatment of wastewater at a treatment plant includes the following steps; primary treatment, secondary treatment, and advanced treatment. The primary treatment of wastewater uses bar screens to filter out objects like sticks, rags, and rocks, and sedimentation tanks to settle out suspended solids. Suspended solids are pumped from the bottom into another settling tank. Secondary treatment uses a biological process where bacteria break down the wastes. The wastewater is run through aeration tanks where air is added and the waste is stirred to aid the growth of bacteria. The bacteria attach to suspended solids; these settle out in the secondary sedimentation tank. The advanced treatment process includes filtering through sand and gravel, disinfection using chlorine, ultraviolet light, or ozone to kill dangerous or pathogenic (disease-causing) bacteria.

The cleaned wastewater can be used for irrigation or released back into a lake or river. For discharge and disposal, wastewater must meet standards set by federal and state governments. Wastewater solids, meeting additional criteria for beneficial use, are called biosolids. They can be used as a nutrient-rich fertilizer. The average person produces approximately 200 pounds of biosolids per year.

Terms

advanced treatment: the third or last step in cleaning wastewater using sand and gravel filters; chlorine may be added after this.

bacteria: small living organisms that consume the organic parts of sewage.

biosolids: solid materials of organic origin resulting from wastewater treatment formerly referred to as "sludge"; meet federal standards for beneficial use, such as land application.

effluent: waste material (such as water from sewage treatment or manufacturing plants) discharged into the environment.

primary treatment: the first process in wastewater treatment which removes settled or floating solids.

reclaimed water: effluent usable for irrigation or ready for release into lakes and rivers.

secondary treatment: the wastewater process where bacteria are used to digest organic matter in the wastewater.

sewer system: an underground system of pipes used to carry off sewage and surface water runoff.

suspended solids: undissolved waste particles in wastewater.

wastewater: water that has been used for domestic or industrial purposes.

wastewater treatment facility: a facility for cleaning and treating wastewater before discharging into a water body.

water conservation: practices which reduce water use.

ADVANCE PREPARATION

A. Prepare a large poster or overhead transparencies from teacher sheets "Down the Drain," "Wastewater Treatment Process Answer Key," "Flow Chart Symbols," and "Flow Chart Answers."

B. Make copies of student sheets "Wastewater Treatment Process," "Flow Chart Directions," and "Flow Chart."

PROCEDURE

I. Setting the stage

A. Ask the class the following questions:

1. Who brushed their teeth today? Whose parents washed their clothes this week?

2. Count hands for each question and list numbers on the board.

B. Display the poster or overhead of the teacher sheet "Down the Drain" and ask these questions:

1. Where does this pipe (at the bottom of the diagram) go?

2. Where does the water go when it goes down the pipe?

II. Activities

A. Pass out a sheet of drawing paper to each student.

1. Have the students draw a picture of where they believe the pipe and water go.

2. Have the students describe their wastewater route in paragraph form. (NOTE: You may need to review proper paragraph form.)

B. Pass out the student sheet "Wastewater Treatment Process." Lead the class through the steps as explained on the teacher sheet "Wastewater Treatment Process Answer Key." (Use the transparency if you have made one.)

1. Write and explain vocabulary words on board.

2. Have the students label each step as you explain it.

C. Have the students complete a flow chart showing the wastewater treatment process.

D. Display the poster or transparency of teacher sheet "Flow Chart Symbols."

1. Explain or review what a flow chart is (a chart showing how to do something step by step).

2. Read over the explanation of each of the flow chart symbols.

3. Pass out the student sheets "Flow Chart Directions" and "Flow Chart." (Answers appear on the teacher sheet "Flow Chart Answers.")

4. Explain that the students will make a flow chart showing the steps in the wastewater treatment process using the student sheets to help them.

III. Follow-Up

Take the class to visit a wastewater treatment plant. As you tour the facility, remind the students of the flow chart and diagram.

IV. Extension

Simulate a flow chart with the students.

A. Assign process names to students. Give each a process card describing what happens at their station.

B. Tape paper scraps on the wastewater students.

C. As the wastewater students go through the cleaning process, each cleaning process student will describe his/her cleaning process and remove one paper scrap.

D. Continue until all wastewater students are clean water. (NOTE: You can time wastewater students 5 seconds apart to begin with and then shorten the time to show wastewater overload. This can lead to a discussion on water conservation.)

RESOURCES

Bernstein, Leonard, et al., Concepts and Challenges in Earth Science, Globe Book Co., Englewood Cliffs, New Jersey, 1991.

Burch, Sandra K., "Be Water Wise", Virginia Water Resource Center, Blacksburg, Virginia, May 1992.

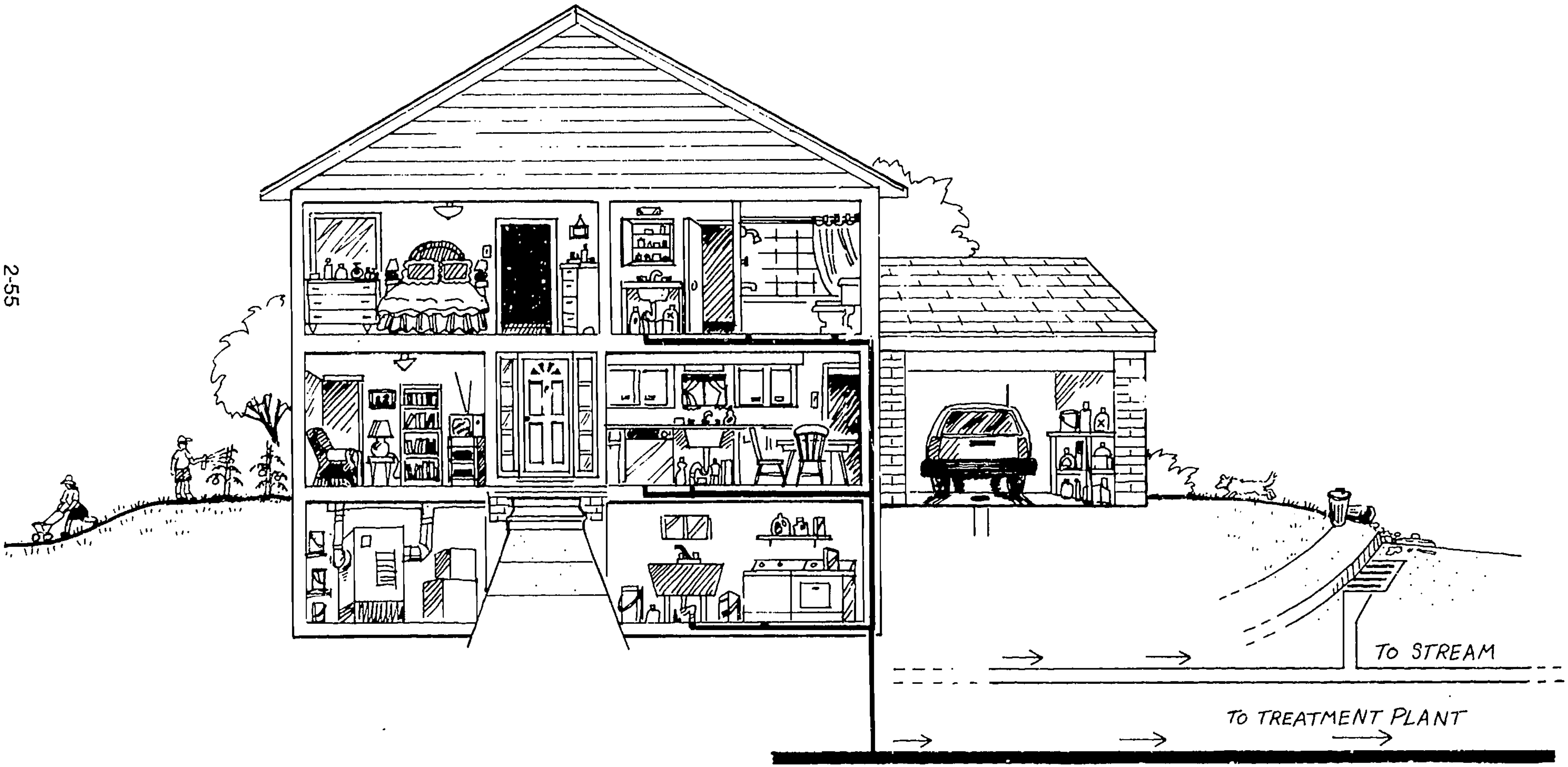
Cobb, Vicki, The Trip of a Drip, Little, Brown and Company, Boston, Massachusetts, 1986.

Duckworth, Carolyn, "Dropping in on Water," Ranger Rick, National Wildlife Federation, Vienna, Virginia, August 1992. p. 30-31.

"Let's Learn About Wastewater Treatment," Channing L. Bete Co., Inc., South Deerfield, Massachusetts, 1990.

Miller, Tyler G., Environmental Science: An Introduction, Wadsworth Publishing Co., Belmont, California, 1986.

DOWN THE DRAIN



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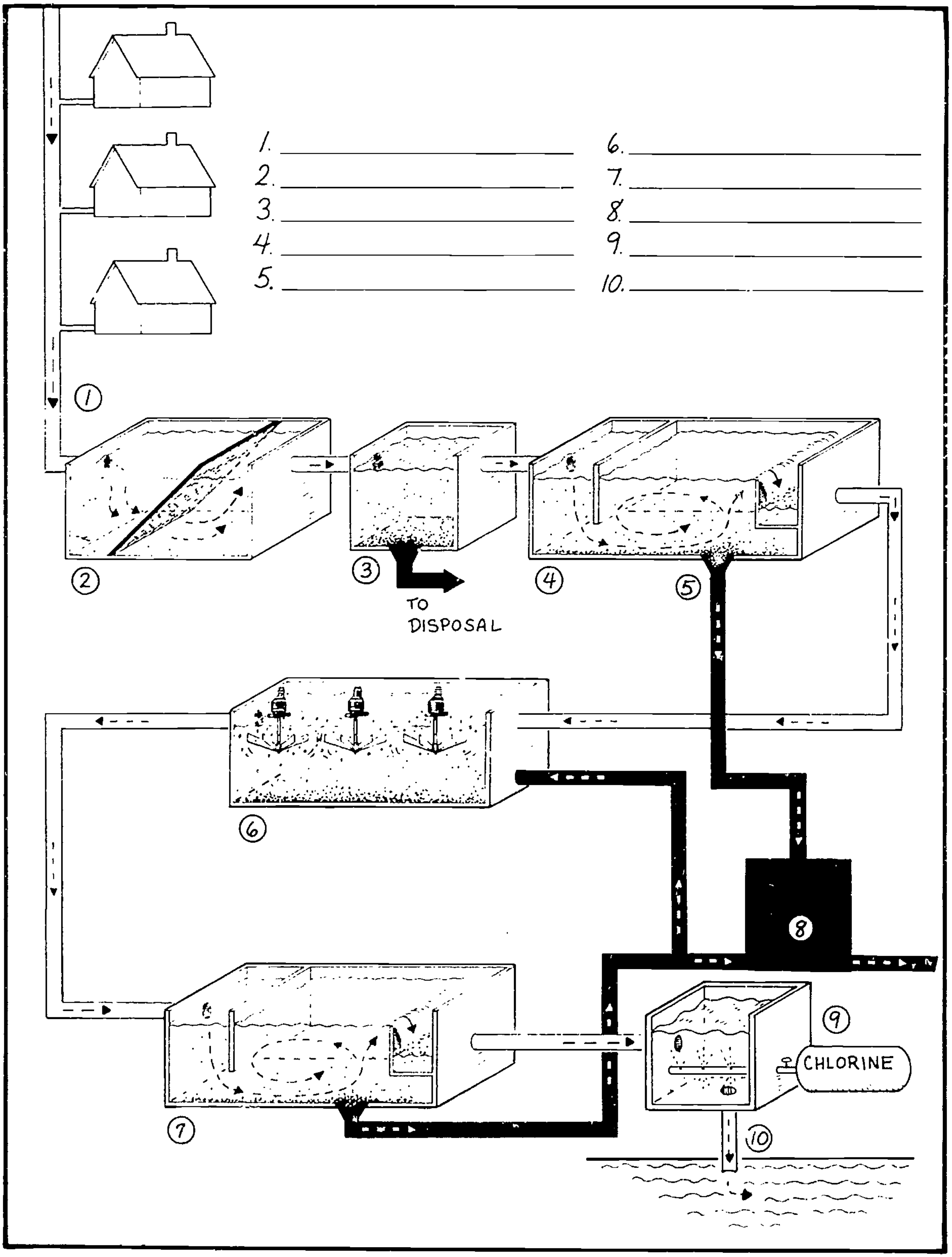
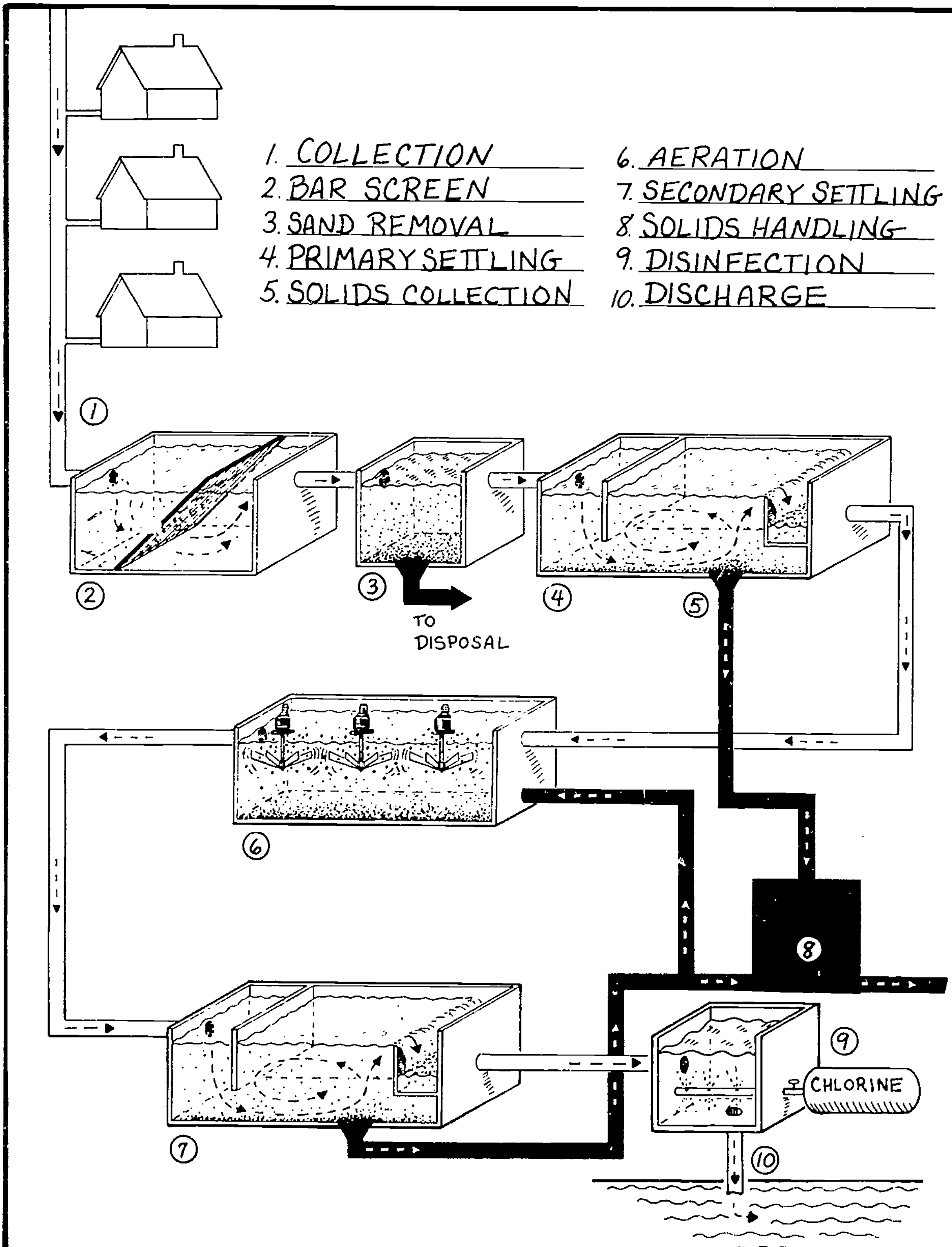
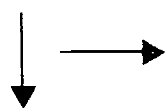
WASTEWATER TREATMENT PROCESS



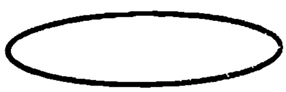
WASTEWATER TREATMENT PROCESS
ANSWER KEY



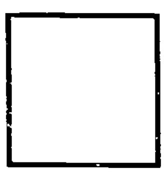
FLOW CHART SYMBOLS



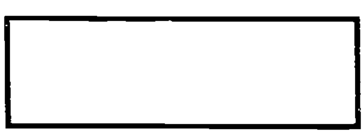
Arrows — Arrows show the direction of the flow of wastewater from process to process.



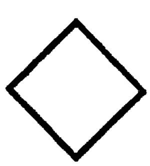
Start/Stop — An oval is used to show where the treatment process starts and stops.



Square — A square is used to show when chemicals are added to or materials are removed from the wastewater.



Rectangle — A rectangle is used to show when a treatment process is taking place.



Diamond — A diamond is used to show when parts of the wastewater flow go in two different directions.

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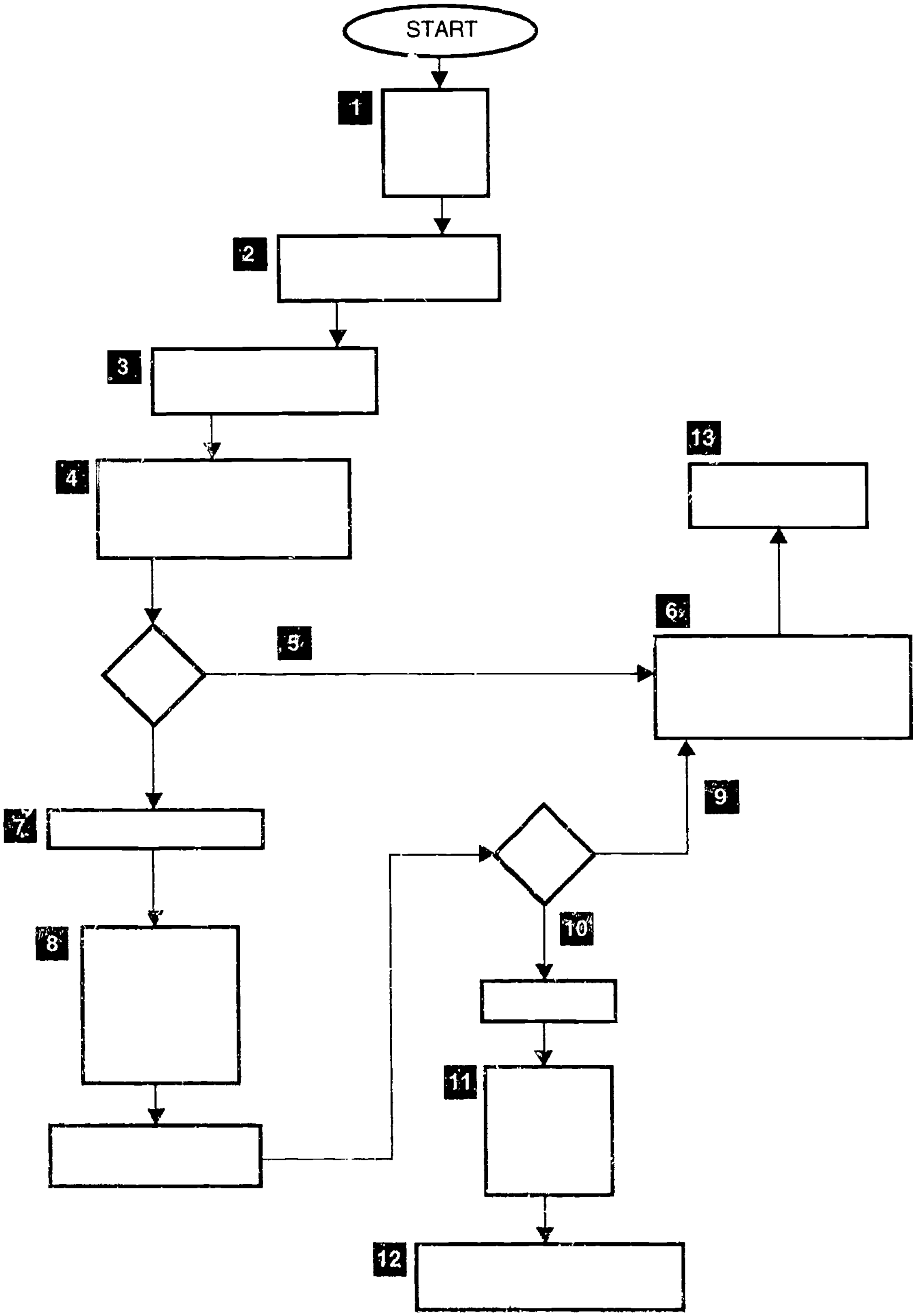
FLOW CHART DIRECTIONS

Name______________________ Date ______________________

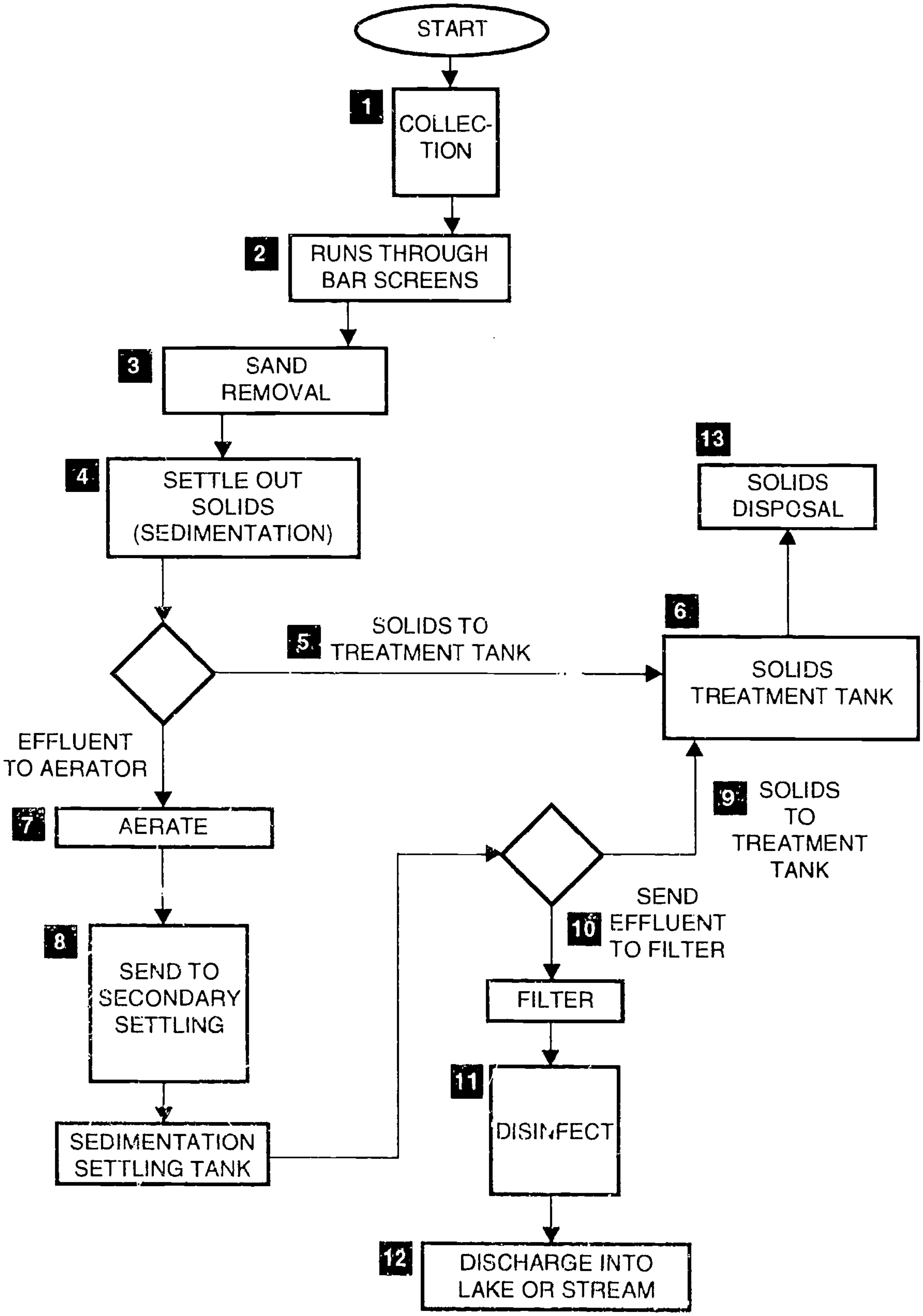
Steps to clean water

1. Intake wastewater (collection)
2. Run through bar screens
3. Remove sand
4. Settle out solids (sedimentation)
5. Send solids to wastewater solids treatment tank
6. Treat solids for disposal
7. Add bacteria to effluent and aerate
8. Send to secondary settling tank (sedimentation)
9. Send solids to wastewater solids treatment tank
10. Send through filtration
11. Disinfect using chlorine, ultraviolet light or ozone
12. Discharge into lake or stream
13. Dispose of solids

FLOW CHART



FLOW CHART ANSWERS



WETLAND IN A BOTTLE

OBJECTIVES

The student will do the following:

1. Differentiate between constructed wetlands and natural wetlands.
2. State that constructed wetlands can be used to treat domestic, agricultural, industrial, and mining wastewater.
3. Observe how plants in wetlands remove wastes from water.
4. State that plants have limited abilities to remove wastes.

SUBJECTS:
Science, Art, Language Arts

TIME:
90-120 minutes

MATERIALS:
teacher sheet (included)
student sheets (included)
8 celery stalks
food coloring
water
paring knife
2 glass jars or beakers
butcher paper or poster board (1 piece per group)
crayons
scissors
glue sticks
gallon (4 L) jar with lid
gravel
sand
soil
sphagnum moss
humus
plants (see teacher sheet)
small animals (see teacher sheet)

BACKGROUND INFORMATION

Natural wetlands are areas like marshes, swamps, bogs, sloughs, and floodplains that are covered with water at least part of the year. Constructed wetlands are similar to natural wetlands, but constructed wetlands are built to treat wastewater from domestic, agricultural, industrial, and mining processes. The water flow in a constructed wetland is spread evenly over the wetland area while the water flow in a natural wetland is confined to small channels.

As a means of treating wastewater, constructed wetlands are much less expensive to build (50 to 90%) than conventional treatment systems. The initial building costs of constructed wetlands are less than the costs of one year of conventional chemical treatment and, once built, the maintenance costs are little to none.

In a constructed wetland, wastewater flows through a septic tank or other primary treatment and into the cell or compartment of the wetland. The bottom and sides of the cell are lined with a waterproof liner to prevent leaks and keep the water level even. Plants such as cattails and bulrushes absorb trace metals. Suspended solids and other trace metals settle to the bottom of the wetland as sediment. As is the case in a wastewater treatment plant, bacteria do most of the work of removing pollutants. Though wetlands plants remove some pollutants, their chief benefit is to provide an enhanced environment for bacterial growth.

Another benefit of constructed wetlands is the creation of wildlife habitat. Constructed wetlands also become areas for educational opportunities.

Terms

constructed wetlands: wetlands that are designed and built similar to natural wetlands; some are used to treat wastewater. Constructed wetlands for wastewater treatment consist of one or more shallow depressions or cells built into the ground with level bottoms so the flow of water can be controlled within the cells and from cell to cell Roots and stems of the wetland plants form a dense mat where biological and physical processes occur to treat the wastewater. Constructed wetlands are being used to treat domestic, agricultural, industrial, and mining wastewaters.

natural wetlands: swamps, marshes, bogs, and low pieces of land soaked or flooded by water at least part of the year.

ADVANCE PREPARATION

A. Gather all the materials needed for the "Wetland in a Bottle."

B. Photocopy the student sheets "Wet What?" and "Plants, Animals, and Soils" for each student.

C. In order to simulate how wetland plants absorb pollution, put the freshly cut celery stalks in colored water 24 hours before the lesson (divide the stalks between 2 glass jars or beakers).

PROCEDURE

I. Setting the stage

A. Write the terms "Constructed Wetland" and "Natural Wetland" on the board.

1. Ask the students to define a wetland.
2. Write the definitions of the terms on the board.
3. Discuss the differences between constructed and natural wetlands.

B. Pass out the student sheet "Wet What?"

1. Ask volunteers to read aloud from "Wet What?"
2. Ask the students to write the definitions of constructed and natural wetlands on their papers.

C. Divide the class into teams and do the following:

1. Show the class the celery in the colored water.
2. Explain that the food coloring represents pollutants in wastewater.
3. Explain that the celery absorbs the colored water like some plants in a wetland absorb the pollutants in wastewater.
4. Give each team a stalk of celery.

a. Have each team cut the celery so everyone has a piece.

b. Have each student observe how the piece of celery shows absorption of the "pollution."

II. Activity

A. Having observed their pieces of celery, the students will write answers to the following questions on the back of their "Wet What?" student sheets.

1. If the food coloring represents pollutants, how does the celery represent a wetland plant? (It absorbs pollutants in the water.)

2. Was all the food coloring (pollutants) absorbed by the celery? (no) Explain why not. (Plants only absorb as much water as they need.)

B. Demonstrate a constructed wetland by building a wetland terrarium. (See the teacher sheet "Wetland in a Bottle.")

1. Explain step-by-step how to build the wetland as you build it.

2. Ask the following questions and discuss the answers with the students:

a. What absorbs the pollutants in our terrarium? (The plants soak up the pollutants.)

b. Where would a constructed wetland be beneficial? (to treat mine run-off, for failed septic tanks and field systems, for areas where septic tanks cannot be used, for small communities that cannot afford to build a conventional treatment plant, for industries and farm operations that cannot use a conventional plant)

III. Follow-Up

Divide the students into groups. Pass out the student sheet "Plants, Animals, and Soils," poster board or butcher paper, and art supplies.

A. Explain that each group will make a mural of a constructed wetland terrarium.

B. First, have them color soils and water as shown on the student sheet.

C. Next, have them color and cut out all the plants and animals.

D. Then, they will decide where to place their plants and animals on their piece of paper or poster board with the soils and water drawn on.

E. The students will complete their constructed wetland collage by drawing more plants and animals of their own to fill in. (Remind them that wetlands have lush vegetation.)

IV. Extensions

A. Students can research wetlands in encyclopedias, magazines, newspapers, and library books and give oral reports to the class.

B. Each student can imagine he/she is an animal who lives in a wetland and write a creative story about one day in his/her life.

RESOURCES

Breazeale, Janet, "What's in the Boxes? One Way of Handle Wastes," Inside TVA, Vol. 13, No. 15, Tennessee Valley Authority, Knoxville, Tennessee, 7/14/1992.

DeBruin, Jerry, Creative, Hands-On Science Experiences Using Free and Inexpensive Materials, Good Apple, Inc., Carthage, Illinois, 1986, p. 79.

McCarthy, Dennis, "The Wonders of Wetlands," Inside TVA, Vol. 13, No. 15, Tennessee Valley Authority, Knoxville, Tennessee, 7/14/1992.

"Natural Wetlands/Constructed Wetlands, (Factsheet)," Tennessee Valley Authority, October 1989.

Slattery, Britt Eckhardt, "WOW! The Wonder of Wetlands," Environmental Concern, St. Michael's, Maryland, 1991, p. 43.

WET WHAT?

Name ______________________ Date ______________________

Swamps, marshes, bogs, and low pieces of land that stay soaked or flooded by water are natural wetlands. Constructed wetlands are designed and built to treat wastewater from domestic, agricultural, industrial, and mining activities.

In a constructed wetland, wastewater flows through a septic tank or other primary treatment and into the cell or compartment of the wetland. The bottom and sides of the cell are covered with a waterproof liner to prevent leaks and to keep the water level even. Plants such as cattails and bulrushes absorb trace metals and other pollutants. Suspended solids and other trace metals settle to the bottom of the cell as sediment. The wastewater then flows into another cell, where it nourishes thick-growing wetland plants. Extra water soaks into the ground because the second cell is not lined. Water left over from this cell is clean enough to discharge.

Define the following:

Constructed wetlands - ____

____

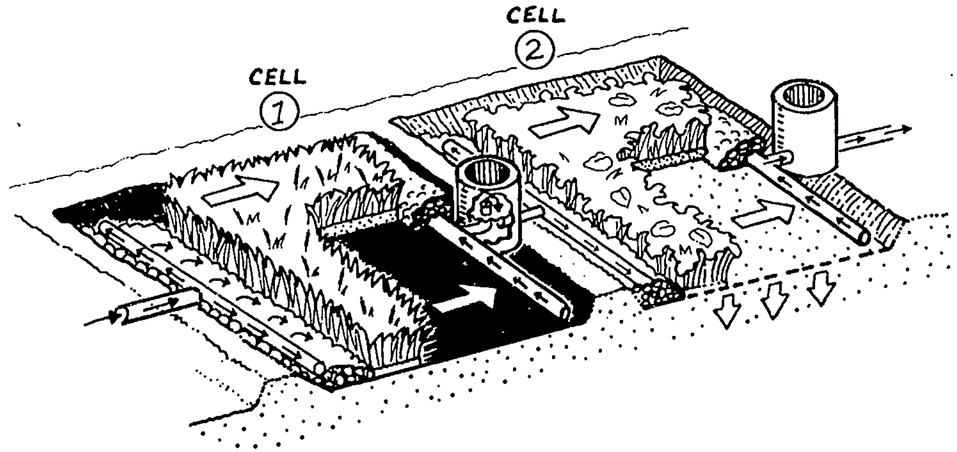
____

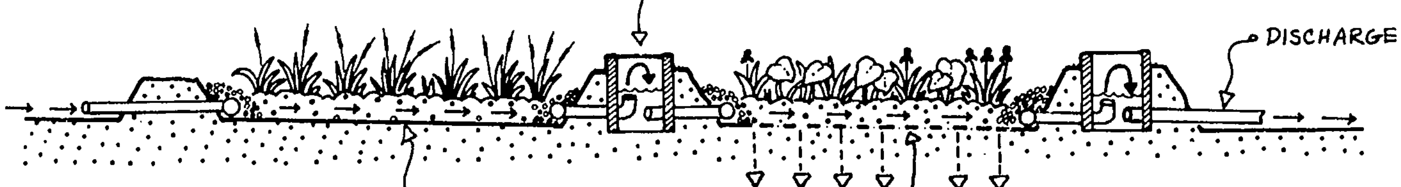
Natural wetlands - ____

____

____

WET WHAT?
(continued)





WETLAND IN A BOTTLE

Gallon (4 L) jar with lid
Gravel
Sand
Soil
Sphagnum Moss
Humus
Water
Plants (such as Venus' flytrap, bladderwort, ferns)
Small Animals (such as salamanders, frogs, turtles)

(NOTE: If you use Venus' flytraps, you will need to add live flies. Also, if you use salamanders, frogs, or turtles, you will need to obtain the proper foods and feed them.)

The soil of a wetland is very moist and surface water can vary from shallow to deep. Our terrarium needs shallow water.

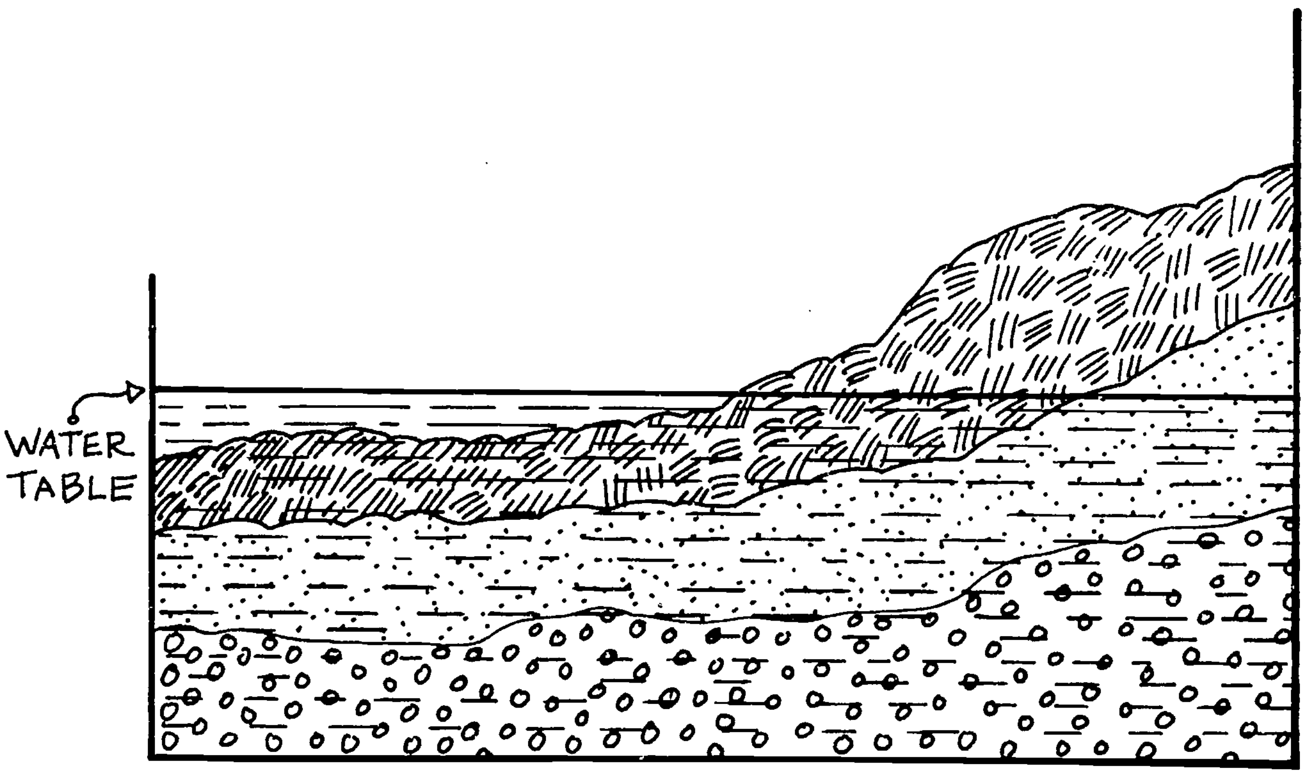
1. First add a layer of gravel.
2. Add a thin layer of sand and soil mixture.
3. Next, add a mixture of 2 parts sphagnum moss and one part humus in a thin layer.
4. Slope all the layers and the surface to make a low spot on one side.
5. Evenly space the plants.
6. Add water to the lowest level of soil.
7. Add animals last.
8. Then cover and place in a location with filtered sun.

PLANTS, ANIMALS, AND SOILS

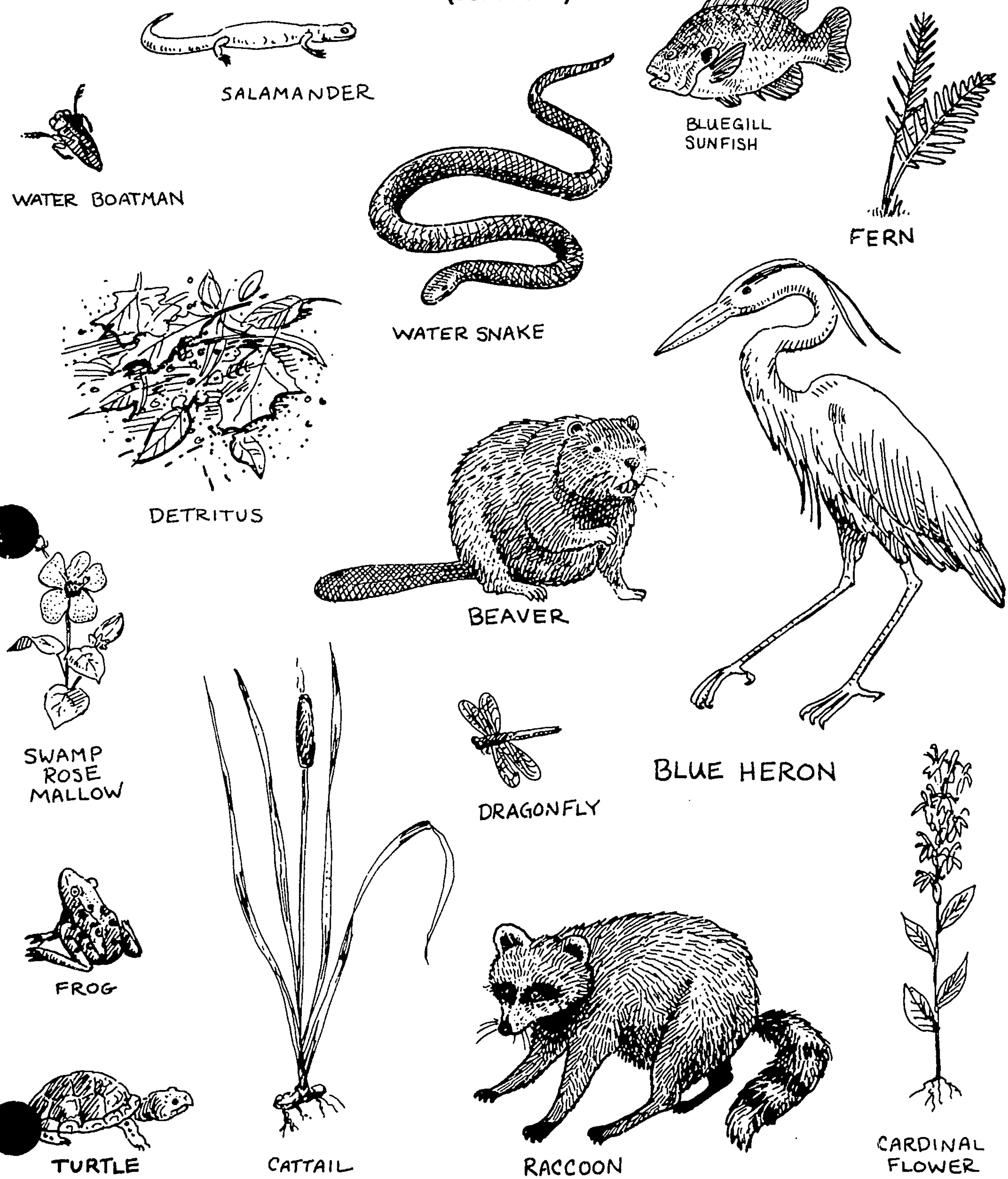
Name ______________________ Date ______________________

To make a constructed wetland mural:

1. Draw a rectangle or jar shape on your group's butcher paper or poster board.
2. Color layers of soil as shown below.
   a. Gravel layer
   b. Sand layer
   c. Sphagnum moss and humus layer
3. Color in the water in the wetland.
4. Color and cut out plants and animals and glue them on the mural.
5. Draw in more of your own plants and animals.



PLANTS, ANIMALS, AND SOILS (continued)



SETTLING THE WASTEWATER PROBLEM

OBJECTIVES

The student will do the following:

1. Name models that are representations of larger objects.

2. Suggest ways that industry, agriculture, and mining affect water quality.

3. Demonstrate the use of lagoons for treating wastewater.

SUBJECTS:
Science, Language Arts

TIME:
90 minutes

MATERIALS:
3 large jars
charcoal
6 smaller containers (such as small buckets)
ammonia
funnel or liter bottle with bottom cut off
pieces of wood
soil
paper towels
coffee grounds (or sterile gardening manure)
nylon hosiery
flour
medium rocks
vegetable oil
cotton balls
bleach
sand
iron filings
3 paper or plastic cups
small rocks
vinegar

BACKGROUND INFORMATION

Water pollution remains a serious problem in most parts of the United States. Sediment, nutrients, bacteria, and toxic material still find their way into the nation's waters where they damage ecosystems, cause health hazards, and prevent the full use of water resources.

In agriculture, all livestock operations face the growing concern of animal waste disposal. Animal wastes pollute the environment when not disposed of properly. Because of its nutrient value, animal waste should be viewed as a resource rather than as a waste. It provides the producer with a valuable soil conditioner and source of fertilizer. Animal waste doesn't have to be a pollution problem. A well designed and maintained waste management system benefits not only the producer, but the community as well.

Pollutants carried by runoff from such urban features as streets and roadways, commercial and industrial sites, and parking lots affect between 5-15 percent of surface waters. Urban runoff contains salts and oily residues from road surfaces and may include a variety of nutrients and toxic material as well.

Higher temperatures associated with industrial wastewater can result in "thermal pollution." Up to 10 percent of surface waters are adversely affected by acid drainage from abandoned mines, pollution from mill tailings, mining waste piles, and pollution from improperly sealed oil and gas wells.

All of these kinds of wastewater can be treated by allowing them to rest in settling/treatment ponds to clean the water for discharge.

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Terms

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

lagoon: an animal waste treatment method which uses a deep pond to treat manure and other runoff from a livestock operation. Lagoons can be aerobic or anaerobic. Both use bacteria to break down materials.

model: a small representation of a larger object.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

water treatment: the conditioning of water to make it acceptable for a specific use.

ADVANCE PREPARATION

A. Fill the 3 large jars (use gallon jars from the lunchroom) with clean water.

B. During the demonstration you will create models of agricultural, industrial, and mining wastewater by "dumping" the waste substitutes into the appropriate jar. Gather the following materials for the demonstration:

1. To simulate agricultural wastewater, obtain 1 cup (250 mL) ammonia, 2 cups (500 mL) soil, and 2 cups (500 mL) used coffee grounds or sterile gardening manure for the substitu: .d waste.

2. To simulate industrial waste, obtain 1 cup (250 mL) flour, 1 cup (250 mL) vegetable oil, and 1 cup (250 mL) bleach.

3. To simulate mining wastewater, obtain 2 cups (500 mL) soil, 1 cup (250 mL) iron filings, 1 cup (250 mL) small rocks, and 1 cup (250 mL) vinegar (for acidic smell). (NOTE: Iron filings are readily available from auto parts stores where they work on brakes; these are usually free.)

NOTE: Take extra care to make sure ammonia and bleach aren't accidentally mixed. Mixing them can release poisonous chlorine gas.

C. Gather the other materials. Try to avoid giving the students glass containers.

PROCEDURE

I. Setting the stage

A. Divide the class into 6 teams. Tell members of the first two teams they represent farmers; the third and fourth teams represent manufacturers; and the fifth and sixth teams represent miners.

B. Each group should have a funnel and several items available to them to attempt to purify the wastewater. Suggested items might include charcoal, pieces of wood, paper towels, nylon hosiery, rocks (small and medium size), moss, cotton balls, or sand.

C. You will divide the 3 wastewater supplies in half. Each group should have a large jar or pitcher (or a small bucket) of its own.

D. Tell the teams not to touch the jars until they are ready. This helps avoid spills and accidents.

II. Activity

A. Explain and give examples of a model representing a larger object. (globe = earth, model car = vehicle, doll = baby)

1. Tell the students that it is sometimes impossible to show real objects (like the earth) because of their size.

2. Have them cite other examples to show comprehension.

B. Show one of the jars of clean water. Tell the students that this jar is a model that represents 1 million gallons of water that falls on a large farm with fields and cattle operation.

1. Ask the students to suggest ways the water could become polluted. (runoff from animal waste, fertilizer, etc.)

2. Simulate the agricultural wastewater by "dumping" in the agricultural pollutants to make wastewater.

3. Explain what each pollutant represents: The ammonia represents animal urine. The soil represents eroded topsoil, and the coffee grounds or gardening manure represents solid animal waste.

4. Divide the agricultural wastewater between the 2 groups of "farming representatives," leaving about 1/3 of it for a further demonstration.

C. Select another jar of clean water. Tell the students that this jar is a model that represents 1 million gallons of water that flows from a manufacturing plant.

1. Ask the students to suggest ways the water could become polluted. (dumping, cleaning, mixing chemicals)

2. Simulate the industrial wastewater by "dumping" the industrial pollutants into the second jar. Explain what each pollutant represents: The flour represents biological wastes like paper pulp; the oil represents wastes like lubricating (motor) oil; and the bleach represents, and is very similar to, chemicals used by many factories.

3. Divide the industrial wastewater between the 2 groups of "manufacturing representatives," leaving about 1/3 of it for a further demonstration.

D. Select the third jar of clean water. Tell the students that this jar is a model that represents 1 million gallons of water that flows from a mine.

1. Ask the students to suggest ways the water could become polluted. (runoff, washing equipment, washing work clothes, etc.)

2. Simulate the mining wastewater by "dumping" the mining pollutants into the jar. Explain what each pollutant represents: The soil and rocks obviously represent the tons of earth material disturbed by mining; the iron filings represent the minerals exposed by mining; and the vinegar represents the acids that can leach from rocks dug up by mining.

3. Divide the mining wastewater between the 2 groups of "mining representatives," leaving about 1/3 of it.

E. Explain that the different land uses represented are necessary for us to live our lives the way we do, but the by-products of the activities represented in each of the three jars is the same: it is called "wastewater."

1. Ask that students the following questions. (NOTE: Remind the students that their jars each represent 1/2 million gallons of water.)

a. Would you drink this water?

b. Would you dump this water into the river or lake?

c. If you dumped this water down a drain, where would it go?

2. Tell the teams they must find a way to make the wastewater reusable since there is so much of it. Take the class outside; this is a messy process.

a. They are to use the materials available and attempt to remove as much of the odor and pollutants as possible using paper cups and smaller containers provided. (CAUTION: Containers may become slippery when wet.)

b. Allow the students to work on their own in their teams for about 15-20 minutes. Supervise for safety.

F. Let representatives from each team explain their processes and results.

G. Explain that there is another treatment method (if no one mentions it) that is less expensive and more feasible called a "holding pond" or lagoon.

H. Label each jar (agriculture, mining, and industry). Demonstrate the lagoon by allowing each jar to sit undisturbed overnight. (This allows settling to occur.)

1. Allow the students to observe and smell each jar after 24 hours.

2. Discuss the differences in the appearance of the wastewater.

III. Follow-Up

A. Compare the various methods the groups used to treat wastewater with the lagoon method.

1. Ask which method would be less expensive to treat large amounts of wastewater. (lagoon)

2. Ask which method would be easier to use with large amounts of wastewater. (lagoon)

3. Ask the students what else needs to be considered before the wastewater could be of better quality. (get rid of pollutants that did not settle—like smell and color)

4. How could the water from lagoons be used? (irrigation, discharge into streams, etc.)

B. Have each group write a report of their wastewater treatment results.

1. What products did not settle?

2. Which team's jar settled the most?

3. Which group would benefit the most from using a lagoon as a water treatment process?

4. How could the processed water be used?

C. Dispose of the simulated lagoons by pouring the water off the settled solids. Allow the jars to dry and, then dispose of the dry material in the trash, and wash out the jars for reuse.

IV. Extension

A. Visit a wastewater treatment plant.

B. Plan a field trip to a large farm, manufacturing plant, or a mining area that utilizes a lagoon.

C. Have a representative from each category above visit the classroom and discuss using a lagoon as a treatment method.

RESOURCES

Environmental Resource Guide: Nonpoint Source Pollution Prevention (Grades 6-8), Air & Waste Management Association, Pittsburgh, Pennsylvania, 1992.

EPA Journal Vol. 17, No. 5, U.S. Environmental Protection Agency, Washington, DC, November/ December 1991.

Leopold, Luna, Water Use and Development, U.S. Government Printing Office, Washington, DC, 1960.

"Nonpoint Source Pollution" (Water Quality Factsheet #4), Tennessee Valley Authority, 1988.

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WASTE NOT, WANT NOT

OBJECTIVES

The student will do the following::

1. Simulate the uses and conservation of water.
2. List 3 to 5 ways to conserve water.
3. Recognize wasteful uses of water in their own environments.

SUBJECTS:
Math, Ecology, Science, Language Arts, Conservation

TIME:
45-90 minutes

MATERIALS:
two 2-gallon (8 L) buckets
2 measuring cups
"Water Use" cards (included)
student sheets (included
teacher sheet (included)
ruler
scissors
glue
crayons or markers
heavy construction paper
brass paper fasteners

BACKGROUND INFORMATION

At this very second, somewhere on the earth, water is falling as snow, rain or sleet. Nature provides us with so much water that if all the mountains and hills were leveled, water would completely cover the earth to a depth of nearly 2 miles (3.2 km). Despite this abundance, water does not fall evenly over the earth's surface. Where precipitation supplies too little water, the result can be desolation. Organisms in a dry environment must be specially adapted to minimize their need for water. Liquid water is the most important single substance for life on earth. Some bacteria live without oxygen, but all known life forms require water.

Water makes up more than 70 percent of all living things. It is found in almost everything we see and touch. The use of water is required by almost every kind of economic activity. It is indispensable to our lives. Water is a natural resource that must be used wisely.

Term

conservation: the act of keeping, protecting, or preserving our natural resources.

ADVANCE PREPARATION

A. Prepare ahead of time by bringing two 2-gallon buckets (or similar containers). Label one "Water Supply" and one "Water Used." Fill the bucket labeled "Water Supply" with water.

B. Duplicate and cut out the water use number and letter cards (teacher sheets).

C. Make photocopies of the water conservation quiz (one per student).

PROCEDURE

I. Setting the stage

A. Have the students discuss all the various ways they use water in a single day.

1. List them on the board and encourage them to include ways that water is used indirectly (e.g., farming, manufacturing, food processing).

2. Categorize the list by having the students decide if the usage is play, work, or home.

B. Assign two students to special positions: one will be a recorder and the other will measure the amount of water used (this person will be the "Quantity Control Officer").

C. Show the students the bucket labeled "Water Supply." Measure the depth of water in the bucket with a ruler and have the "recorder" write the results on the board. Tell the students that the bucket labeled "Water Supply" represents the amount of fresh water allowed per day for the group.

D. Explain that in this simulation, there will be a Group 1 and a Group 2. (NOTE: This simulation is designed for 24 students. The number of participants can be varied as needed. Make sure there is an equal number of conserver and nonconserver cards.)

II. Activity

A. Divide the class into 2 groups.

B. Pass out the "Water Use Number Cards" to Group 1 and the "Water Use Letter Cards" to Group 2. Explain that these cards represent how much water each person will use in a day.

1. Begin with Group 1.

2. As each student reads his demand on the water supply aloud, the "Quantity Control Officer" should remove that amount of water from the water supply bucket and place it in the bucket labeled "Water Used."

3. Ask the student who has card number 1 to read his/her demand and the amount of water needed. Continue with subsequent numbers.

4. This process should continue until all the number cards are used.

C. Measure the depth of water left in the "Water Supply" bucket. Have the recorder write the results on the board.

D. Subtract the amount of water left from the starting amount. Record the difference for Group 1.

E. Repeat the process for Group 2, beginning with the same amount of water as before. (NOTE: If none of the water has been spilled, dumping the used water back into the first bucket should be equal to the same amount.)

1. Ask the student who has card A to read his/her demand and the amount of water needed. Continue with subsequent letters.

2. This process should continue until all the letter cards in the group are used.

F. Measure the amount of water left in the "Water Supply" bucket and record as before.

G. Subtract the amount of water left from the starting amount. Record the difference for Group 2.

H. Discuss the noticeable difference between the amounts left and have the students formulate explanations.

I. Interject the "Water Trivia" teacher sheet; share selected facts with the students.

III. Follow-Up

A. Have the students state the difference in the groups; they should notice how one group carefully used its water supply and the other used it without concern for the amount available.

B. Help the students explain the differences in behaviors in the water use by each group.

C. Ask the students how group 1 could have conserved more.

D. What things do the students do that could conserve water in their daily uses?

E. Have the students list 3 to 5 ways to conserve water.

F. Have the students complete the student sheet, "Water Conservation Quiz." (Answers: 1.W, 2.W, 3.W, 4.S, 5.S, 6.S, 7.S, 8.S, 9.W, 10.W)

IV. Extensions

A. Give the students copies of the "Water Use Detective Badge and Citation" student sheet. Have them color and cut out the badge; they can pin or tape it to their shirts. Have the students become "Water Use Detectives" by finding as many ways as possible the school wastes water. Make a list of their findings and suggested solutions on the citation. Post these lists or send them to the principal.

B. Have the students complete a checklist of conservation improvements and practices in their individual homes as a homework assignment.

C. Have the students categorize the teacher sheet information (trivia) and student water use suggestions as to whether they are home, work, or play uses. Design circle, bar, or line graphs to show the results.

D. Have the students write a letter to the local newspaper explaining their concerns to the public.

RESOURCES

"The ABC's of Water Conservation," Channing L. Bete Company, New York, 1981.

Burch, Sandra K., "Be Water-Wise," Virginia Water Resource Center, Blacksburg, Virginia, 1983.

Leopold, L. and W. Langhein, A Primer On Water, U.S. Government Printing Office, Washington, DC, 1960.

"The Story of Drinking Water: Teacher's Guide Primary Level," American Water Works Association, Denver, Colorado, 1984.

WATER USE NUMBER CARDS

Group 1

#1 I have been working in the sun and am very thirsty. I would like some cold water to drink. 1 CUP (250 mL)	#2 I have been playing basketball and need to take a bath. 3 CUPS (750 mL)
#3 Mom asked me to wash the breakfast dishes, so I put them in the dishwasher and turned it on. 2 CUPS (500 mL)	#4 Mom said my tennis shoes need cleaning, so I ran them through the washing machine. 2 CUPS (500 mL)
#5 Since it's so hot outside, I want to fill up the wading pool. 2 CUPS (500 mL)	#6 It is time for lunch and I need to wash my hands with the faucet running. 1 CUP (250 mL)
#7 Mom wants me to wash her car tonight. 2 CUPS (500 mL)	#8 Flush the toilet, please. 1 CUP (250 mL)
#9 Dad and I are growing a garden. Since plants need water, turn the sprinkler on, please. 2 CUPS (500 mL)	#10 I just ate an ice cream cone. I need to brush my teeth with the faucet running. 1 CUP (250 mL)
#11 Our grass needs water to grow every day. 1 CUP (250 mL)	#12 I noticed the faucet leaking but it's nothing more than a drip. 1 CUP (250 mL)

WATER USE LETTER CARDS

Group 2

A. I have been working in the sun and am very thirsty. There is a cold bottle of water in the refrigerator. 1/2 CUP (125 mL)	B. I have been playing basketball and I need to take a short 5-minute shower. 1/2 CUP (125 mL)
C. Mom asked me to wash the breakfast dishes. I will wait until our dishwasher is full. 1/2 CUP (125 mL)	D. Mom said my tennis shoes need cleaning. I'll run them in the washing machine when it is full of old towels or cleaning rags. 1 CUP (250 mL)
E. Since it is so hot outside, I want to fill the wading pool, but I don't need to fill it to the top. 1 CUP (250 mL)	F. It is time for lunch and I need to wash my hands. I'll just fill the sink halfway and not run the faucet. 1/2 CUP (125 mL)
G. Mom wants me to wash her car, so I'll use the water I saved from the kitchen and bathroom sinks instead of letting the water run down the drain. 0 CUPS (0 mL)	H. Please flush the toilet. There is a plastic bottle filled with stones in the tank. 1 CUP (250 mL)
I. Dad and I are growing a garden. We use a soaker hose and mulch the plants. I'll also use rainwater we have saved. 1/2 CUP (125 mL)	J. I just ate an ice cream cone. I need to brush my teeth. I never leave the water running. 1/2 CUP (125 mL)
K. Our grass needs water to grow, but not every day. We use a soaker hose. 1/2 CUP (125 mL)	L. I noticed the faucet leaking so I told my dad and he fixed it. 0 CUPS (0 mL)

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WATER TRIVIA

1. It takes 100,000 gallons (379,000 L) of water to manufacture one automobile.
2. 122 gallons (462 L) of water are needed to produce one loaf of bread.
3. It takes 50 glasses of water to grow 1 glass of orange juice.
4. 97 percent of all earth's water is salty; only 3 percent is fresh water.
5. 3/4 of the earth's surface is covered with water.
6. A 20-minute shower uses 16-20 gallons (60-75 L) of water.

   A 10-minute shower uses 8-10 gallons (30-38 L) of water.

   A 5-minute shower uses 4-5 gallons (15-19 L) of water.
7. It takes 3 gallons (11 L) of water to flush a toilet.
8. It takes 30-40 gallons (115-150 L) of water for a tub bath.
9. 10 gallons (38 L) of water is required to hand wash dishes.
10. It takes 20-30 gallons (75-115 L) of water to run a washing machine.
11. The average American home uses an average of 293 gallons (1,110 L) of water a day.
12. It takes 2,500 gallons (9,500 L) of water to produce one pound (2.2 kg) of beef.

WATER CONSERVATION QUIZ

Saving or Wasting

Print an "S" on the line before an action that saves water. Print a "W" on the line before an action that wastes water.

____ 1. Take long showers.

____ 2. Fill the bathtub full.

____ 3. Delay fixing a leaky faucet.

____ 4. Fix a leaky toilet.

____ 5. Wash only full loads in the washing machine or dishwasher.

____ 6. Fill the bathtub 1/4 full.

____ 7. Turn off water while brushing teeth.

____ 8. Fix leaky faucet.

____ 9. Wash a few clothes every day.

____ 10. Let water run while brushing teeth.

Water Waste *CITATION*

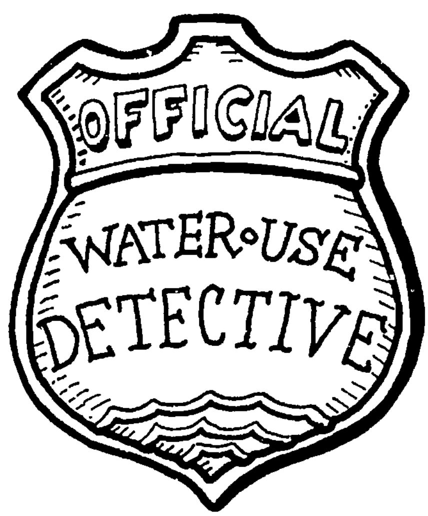
Location of water waste ____________________

Description ____________________

Suggested solution(s) ____________________

Issued by Officer ____________________
(name)

Date ____________________



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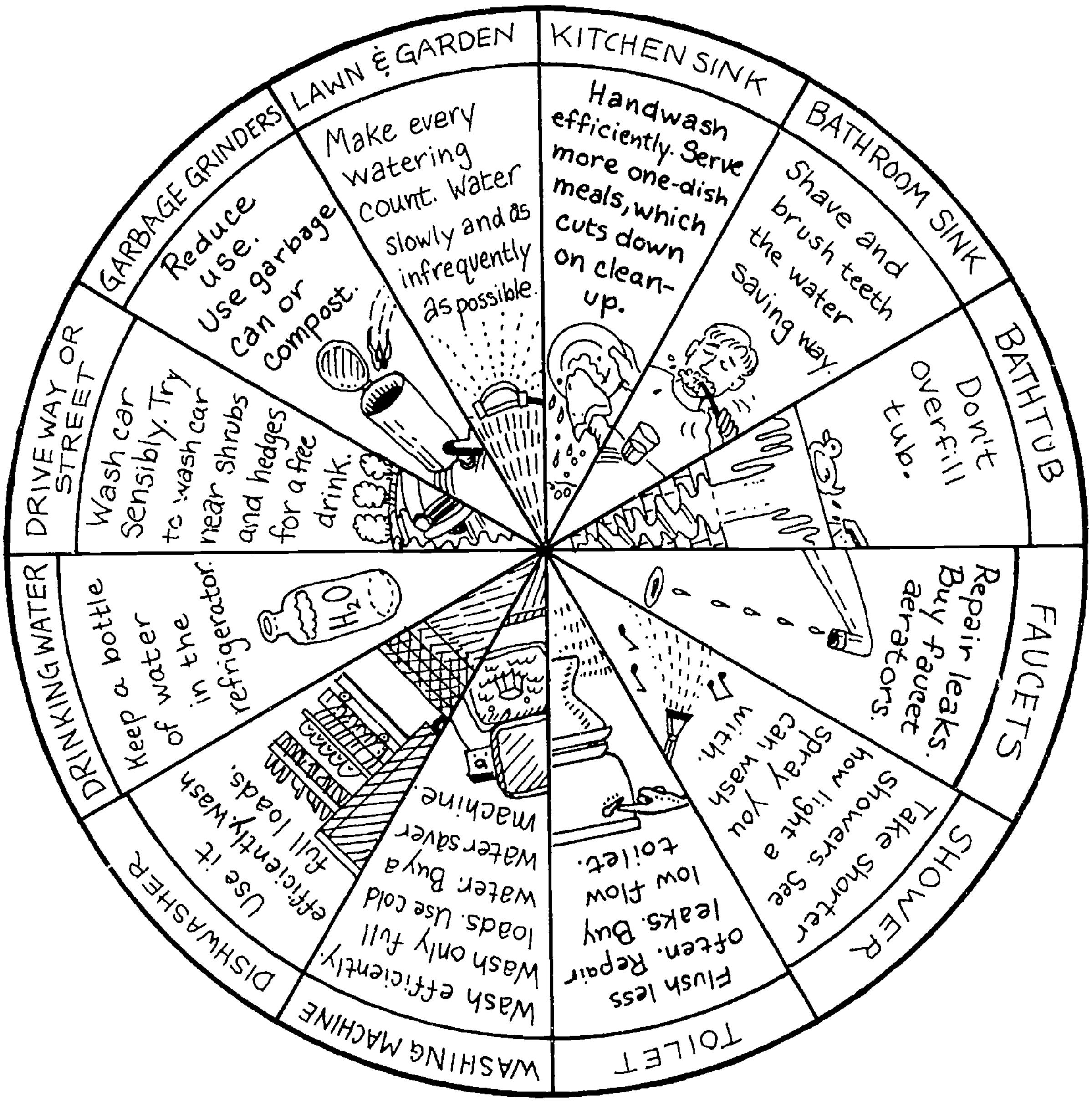
MAKE A WATER CONSERVATION WHEEL!



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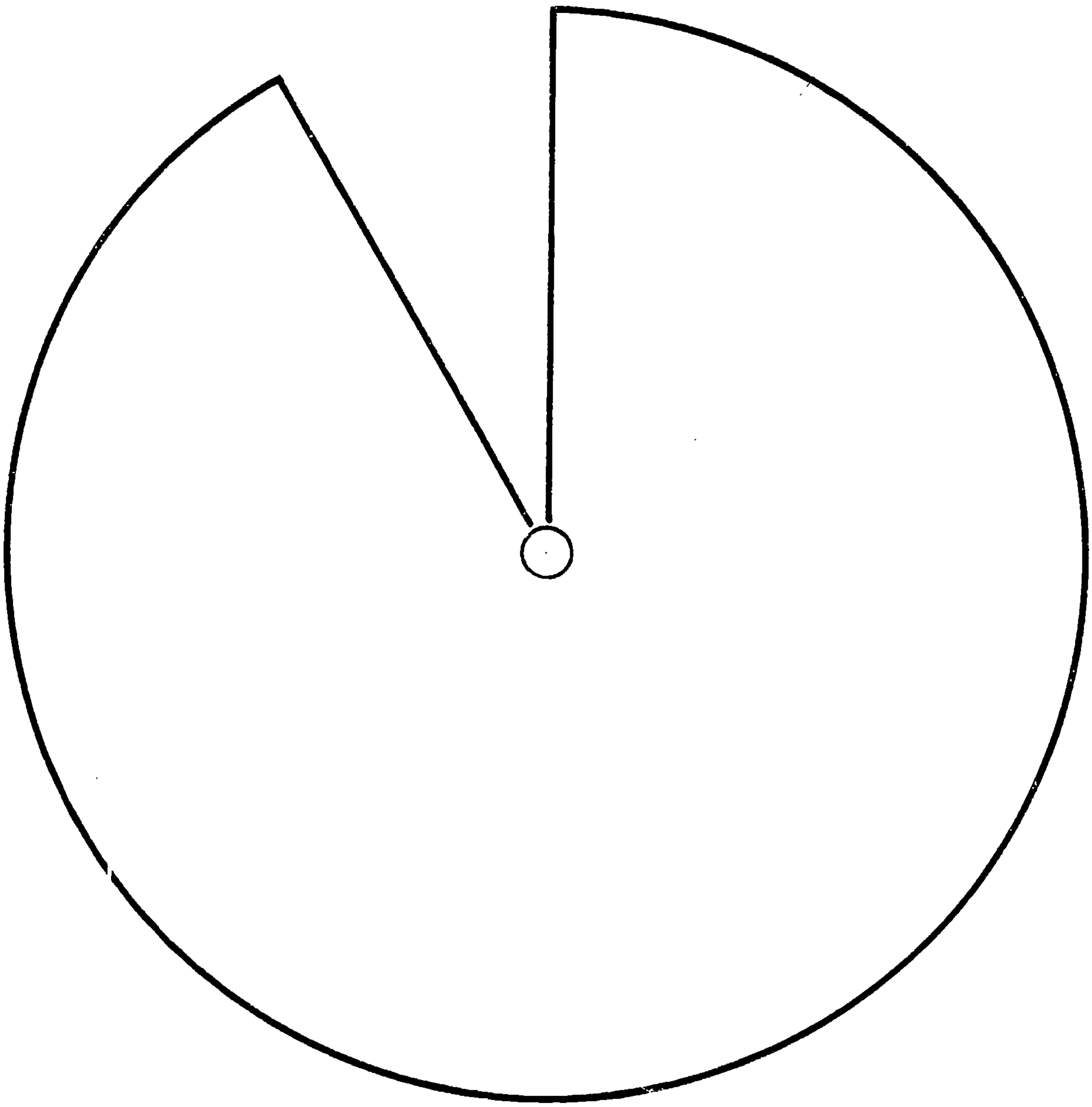
MAKE A WATER CONSERVATION WHEEL!
(continued)



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WATER PATROL

OBJECTIVES

The student will do the following:

1. Become aware that there are laws enacted and enforced to protect people's health and safety.
2. Demonstrate, through role play, different laws or acts that protect the health and safety of citizens.

SUBJECTS:
Science, Social Studies, Health, Language Arts

TIME:
45-90 minutes

MATERIALS:
hat or badge to represent police or fireman
posterboard or construction paper
markers
stapler
student sheet (included)
teacher sheet (included)

BACKGROUND INFORMATION

Most of us take safe, clean drinking water for granted. Prior to the passage of the Safe Drinking Water Act in 1974, the protection of public water supplies in the United States was guided by drinking water standards developed by the United States Public Health Service. Congress enacted the Safe Drinking Water Act in 1974 to ensure safe public drinking water. This law was amended in 1986 to expand the Environmental Protection Agency's role in protecting public health from contaminated drinking water. The amendments require the Environmental Protection Agency to:

1. Control specific disease-causing organisms and indicators of their presence in drinking water.
2. Require public water supply systems that use surface water sources such as lakes to filter their water unless it is established that their sources are very clean and well protected.
3. Require public systems to disinfect their water, unless the water comes from sources that are not at risk from microbiological contamination.

The Safe Drinking Water Act is primarily enforced by the states. Therefore, it is the responsibility of the local water supply system, the states, and the federal government to provide clean, safe drinking water to the public.

<u>Terms</u>

Environmental Protection Agency (EPA): the U.S. agency responsible for efforts to control air and water pollution, radiation and pesticide hazards, ecological research, and solid waste disposal.

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

Safe Drinking Water Act: a regulatory program passed by the U.S. Congress in 1974 to help ensure safe drinking water in the United States; sets maximum contaminant levels for a variety of chemicals, metals, and bacteria.

waterborne disease: a disease spread by contaminated water.

ADVANCE PREPARATION

A. Gather materials for the role playing. You may make hats or badges from poster board and/or construction paper to represent different people who enforce rules or laws (policemen, fireman, principal, mayor, governor, etc.).

B. You may also use toy badges or hats that represent these persons if they are available.

C. Make photocopies of the student sheet, "Cause and Effect," for each student.

PROCEDURE

I. Setting the stage

A. Ask the students the following questions:

1. What are laws? (any rule or principle that must be obeyed; relate to school rules that must be followed in the school environment)

2. Why do we have laws or rules that we must obey? (to protect people)

3. Give an example of a law or rule being broken. (e.g., exceeding the speed limit) Is this dangerous? (yes) Why? (It affects the safety of the driver and others.)

4. Who enforces the law?

a. On the local level, the mayor and those persons acting under his orders.

b. On the state level, the governor and those agencies that are under his jurisdiction.

c. On the federal level, the president and those agencies that are established for specific laws.

B. Share with the students the following information:

We only have to look around us to see the effects of rules or laws. We can see rules or laws being observed in our schools, in our community, and throughout our environment.

1. What do you think would happen if we had no rules in our school? (We would not be able to do our work, and/or it would not be safe.)

2. What do you think would happen if we had no rules or laws in our community? (People might not respect others' rights and our environment would not be a very safe or happy place to live; accept any answer.)

II. Activities

A. Have the students demonstrate laws being broken by role-playing "cops and robbers."

1. Have the students prepare a list of rules or laws that would protect their health or safety.

2. Have each student act out or role play (using props such as hats) one of the law breaking situations they have listed.

3. Ask the classmates to try to guess what rule or law is being portrayed. The first student to guess the rule or law being acted out, will role play the person who enforces that law and "arrest or reprimand" that person who has broken a law or rule.

4. Continue this process until all students have participated. (You may want to set a time limit for each student.)

B. Discuss with the students what laws or rules are being represented in each situation. Tell the students that they have a responsibility as a citizen to help to see that laws and rules are followed. Ask what they might do as citizens to help enforce the laws. (report wrongdoing they observe to the proper person who enforces the laws or rules)

C. Share the background information with the students. Emphasize that drinking water must be very clean or people could get sick. Ask the students to apply what they have learned about protecting er supplies and enforcing laws to ensure their water is safe to drink. Ask them these questions:

1. What can you do? (never pollute water in streams; report to proper authorities if you observe anyone dumping pollutants into drains, streams, and other bodies of water; accept any reasonable answer)

2. What law protects your drinking water? (the Safe Drinking Water Act)

3. Who enforces the Act? (the Environmental Protection Agency and the states)

4. What should you do if you suspect your water supply is contaminated? (You can contact your local water treatment plant or water utility to find out what steps you should take to have your water tested for contaminants. The address of your local facility will be on your bill.)

5. For detailed information, contact your local water treatment facility or health department. Ask them how they comply with the Safe Drinking Water Act.

III. Follow-Up

A. Have the students complete the student sheet, "Cause and Effect." (Answers: 1-c; 2-a; 3-f; 4-b; 5-c; 6-d.)

B. Have the students write a paragraph explaining why we have laws.

IV. Extensions

A. Have the students choose one of the following topics, look up its danger to drinking water, and write a report on how each could contaminate drinking water. Younger students might depict these on "mini-murals" (large construction paper sheets).

1. Landfills

2. Underground storage tanks

3. Hazardous waste

B. Contact your senator, congressman, or local state representative and ask what bills have been offered in the legislature to protect drinking water standards and groundwater in your state.

RESOURCES

Jorgensen, E. P., ed., The Poisoned Well: New Strategies for Groundwater Protection, Island Press, Washington, DC, 1989.

"Protecting Our Drinking Water from Microbes," U.S. Environmental Protection Agency, Washington, DC, 1989.

CAUSE AND EFFECT

Match the causes and effects.

Causes	**Effects**
1. Pour oil in drainage ditch	a. Serious damage to brain, kidneys, and nervous system
2. High concentration of lead in drinking water	b. Ensures clean drinking water to protect public health
3. Contaminated surface and groundwater	c. Stronger, healthier teeth
4. Safe Drinking Water Act	d. Sets national standards and monitors water supply operators
5. Adding fluoride to drinking water	e. Groundwater contamination
6. Environmental Protection Agency	f. Waterborne diseases


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WATER
POLLUTION
PATROL


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THE WATER SOURCEBOOK

SURFACE WATER

A SALT WATER-Y WORLD

OBJECTIVES

The student will do the following:

1. Observe a model of the distribution of the earth's water.
2. Compare the relative volumes and percentages of types of water on earth.
3. Demonstrate solar distillation.

SUBJECTS:
Science, Social Studies, Math

TIME:
50 minutes

MATERIALS:
two 1,000-mL graduated cylinders (or 1-L clear containers)
four 100-mL graduated cylinders (or small jars)
medicine dropper
food coloring
teacher sheet (included)
acetate sheet
overhead projector
large bowl or pan (1 per group)
small drinking glass (1 per group)
small rocks
plastic wrap
2-gallon bucket
water
soil
student sheet (included)

BACKGROUND INFORMATION

Humans must have fresh water to live, but about 97 percent of the earth's water is too salty to use. The remaining 3 percent is fresh water, but most of it is in polar icecaps, remote glaciers, and icebergs and is not easily accessible. Accessible fresh water, therefore, comes from surface water and groundwater sources. These sources represent less than one-half of one percent of all water on the earth.

Terms

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

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

ADVANCE PREPARATION

A. If you do not have two 1,000-mL graduated cylinders, use other clear liter containers. If you have access to laboratory glassware, fifteen 100-mL graduated cylinders will work. If you use the small cylinders, ten of them will hold 972 mL of salt water, while the remaining five will hold fresh water. A clear plastic jug (soft drink container) holding one liter of colored water can be used. Other clear glasses or jars can hold the smaller divisions. The following table shows the distribution of water for this demonstration.

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Earth's Total Water Supply	
972 mL	Ocean (salt water)
28 mL	Fresh water
1,000 mL	Total Water on Earth

Earth's Total Fresh Water Supply	
23 mL	Icecaps and glaciers
4 mL	Groundwater
2* drops	Surface water
1* drop	Water in air and soil
28 mL	Total Fresh Water on Earth

1 liter = 1,000 mL
*3 drops = 1 mL

B. Make a transparency from the teacher sheet "Water Distribution on Earth." (NOTE: You can make a chart rather than using a transparency and overhead projector.)

C. Duplicate copies of the student sheet.

D. Get a liter of water in the cylinder or bottle. Put food coloring in it so the students can see it.

E. Gather the materials to have 5-6 groups each build a distillation apparatus. Make muddy water by filling a 2-gallon bucket with water and mixing in about 2 cups of soil.

PROCEDURE

I. Setting the stage

A. Share with the students the background information.

B. Display the transparency or chart, "Water Distribution on Earth." Discuss this briefly with the students. Tell them you are going to show them what these proportions look like.

II. Activity

A. Place all the materials on a table in front of the class.

1. Fill one graduated cylinder with colored water to the 1,000 mL line. Tell the students that this represents the earth's entire supply of water. Pour 28 mL of this water into a second 1,000-mL graduated cylinder. The 28 mL of water represents the earth's total fresh water supply. The remaining 972 mL of water is salt water that occurs primarily in oceans.

2. Divide the 28 mL of fresh water by pouring portions of it into smaller containers: 23 mL for icecaps and glaciers, 4 mL for groundwater, 2 drops for surface water, and 1 drop for the water in the atmosphere and soil.

3. Refer the students again to the table on surface water distribution.

B. As the students examine and compare the different volumes of water in the graduated cylinders, ask the following questions:

1. Which of the four fresh water graduated cylinders represents the most fresh water on earth? (23 mL, representing icecaps and glaciers)

2. Is this a source of fresh water commonly used by humans for drinking, watering the lawn, cleaning, and so on? Explain. (No, icecaps and glaciers are usually too far away from population centers.)

3. Approximately what percentage of the earth's fresh water is groundwater? (0.4%, or less than one-half of one percent)

4. Where is most of earth's water found? (oceans)

5. Can cities such as San Francisco, Miami, and New York City, which are near oceans, use the water from the oceans for households and industry? Explain. (No, the ocean water contains salts that are harmful to humans, plants, animals, and metals.)

6. Can the salts be removed from water? Why isn't this commonly done? (Yes, but the desalination process is very expensive.)

7. Why is the little bit of water in the atmosphere important to plants, animals, and humans? (Water in the atmosphere is carried inland in the forms of rain, snow, sleet, and hail which supply fresh water sources such as lakes, streams, and groundwater.)

C. Have the students do the demonstration of desalination using solar energy found on the student sheet "Sun Power for Clear Water." (Choose a sunny day.)

1. Divide them into groups of about 5 students each.

2. Give each group the materials. Explain that you will use muddy water instead of salty water so they can see that the distilled water is clean.

3. Take the class outside and let them set up their distillation devices.

4. Allow the students to play or do outdoor education activities for about 20-30 minutes, then begin checking the devices.

5. When clear water has dripped into the glasses, discuss with the students how heat from the sun cleaned the water.

III. Follow-Up

A. Ask the class the following questions:

1. Which kind of water (fresh or salt water) do we have more of on the earth? (salt)

2. Can people drink salt water right out of the ocean? (no)

3. Is there more water underground than in all the lakes and rivers of the world combined? (yes)

4. Can people make fresh water out of salt water? (yes)

B. Have the students draw a picture of the distillation device and write a few sentences describing how it worked.

IV. Extension

A. Have the students write the percentages of water distribution, as given on the teacher sheet. Can they express this in hundredths and thousandths?

B. Have the students think of several ways that salt water could be distilled to make drinkable fresh water. (You might divide them into groups.) Allow them to sketch distillation devices to provide families or communities with large amounts of water.

C. Have the students sing the following song to the tune of "My Bonnie Lies Over the Ocean":

Sing a Sea Song

The Earth is all covered with ocean.
The Earth is all covered with sea.
The Earth is all covered with ocean.
More water than land, don't you see?

Chorus
Water, water, there's water all over the world, the world.
Water, water, there's water all over the world, the world.

So salty and cold is the ocean.
So salty and cold is the sea.
So salty and cold is the ocean.
Too cold and too salty for me.

Repeat Chorus

Atlantic, Pacific, the Arctic,
And then there's the Indian too.
These oceans all over our planet.
I named all of them, now can you?

Repeat chorus

RESOURCES

The Energy Sourcebook: Elementary Unit, Tennessee Valley Authority, 1990.

"Sing A Sea Song," Ranger Rick's NatureScope: Diving Into Oceans, National Wildlife Federation, Washington, DC, p. 8., 1989.

Vandas, S., "Water: The Resource That Gets Used and Used and Used for Everything!" (poster). Available from American Water Resources Association, 5410 Grosvenor Lane, Suite 220, Bethesda, Maryland 20814-2192, 301-493-8600 or The National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009, 202-328-5800.

WATER DISTRIBUTION ON EARTH

Earth's Total Water Supply

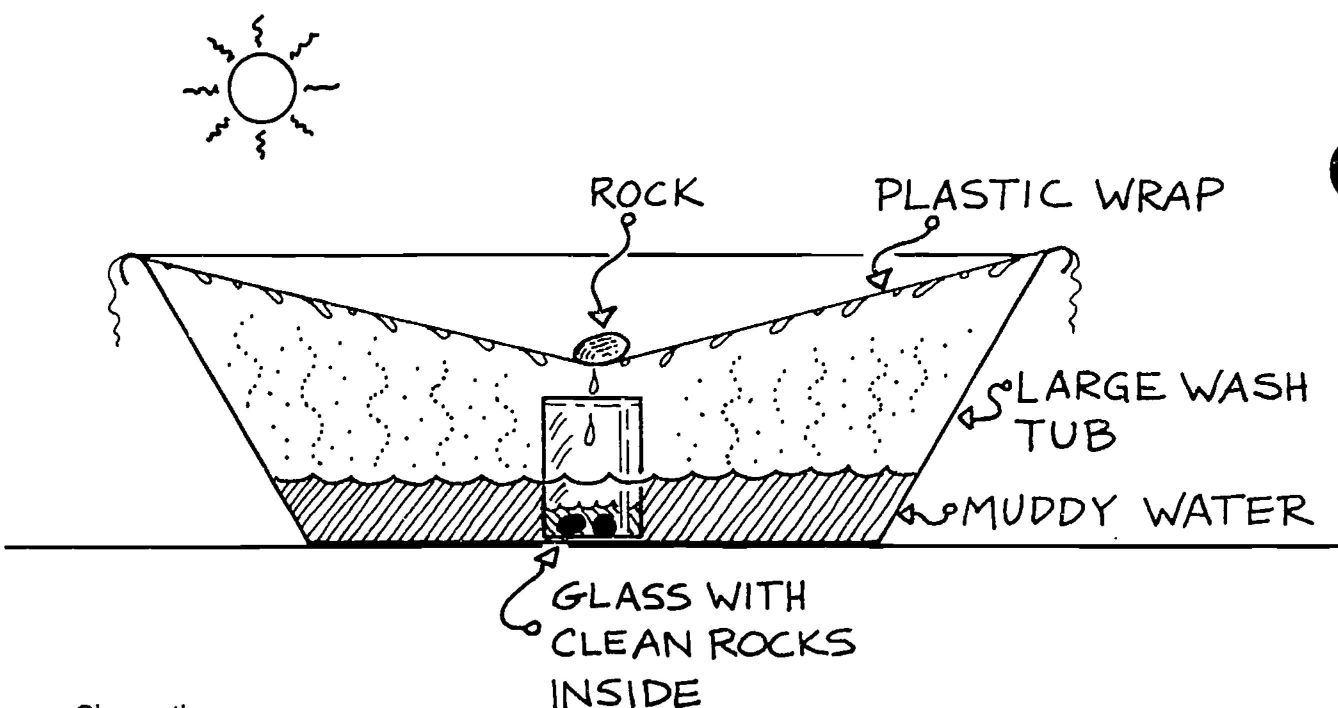
97.2 %	Oceans (salt water)
2.8 %	Fresh water
100.0 %	**Total Water on Earth**

Earth's Total Fresh Water Supply

2.38 %	Icecaps, glaciers
0.39 %	Groundwater
0.029 %	Surface water (lakes, rivers, etc.)
0.001 %	Air and soil
2.8 %	**Total Fresh Water**

SUN POWER FOR CLEAN WATER

1. Put muddy water in a large bowl or pan to a depth of 2 inches (5 centimeters).
2. Set it in a place where it will receive sun all day.
3. Place a small glass right-side up in the middle of the tub. You may have to weight it down by putting two small, clean rocks in it.
4. Cover the tub tightly with clear plastic wrap.
5. Place a rock on the plastic over the center of the glass. Do not let the plastic touch the glass. (Just weight it down in the middle.)
6. Observe what happens. Record your observations. Propose a way that this procedure, called "distillation," might be helpful on a larger scale.



Observations

____

____

Questions

1. What kind of energy cleaned the water? ______________
2. How might this process be useful to people? ______________

WATERY WORDS AND PLACES

OBJECTIVES

The student will do the following:

1. Name several kinds of bodies of water on earth.
2. Locate the major bodies of surface water in your state.
3. Construct a relief map of his/her state using a physical map.

SUBJECTS:
Geography, Language Arts, Art

TIME:
3-30 minute periods

MATERIALS:
3' x 5' (1 m x 1.5 m) piece of blue paper
magic marker
salt dough (recipe included)
food coloring (blue, green, brown)
physical map of your state (2 copies per student or team)
individual-sized pizza box for each student or team
glue
crayons
pencils
wall map of your state
student sheet (included)
teacher sheet (included)

BACKGROUND INFORMATION

Most of the surface of our world is covered by water. Salt water bodies include bays, estuaries, fjords, gulfs, harbors, oceans, seas, sounds, and straits. Fresh water bodies include coves, creeks, inlets, lagoons, lakes, ponds, reservoirs, rivers, rivulets, streams, tributaries, and waterfalls.

Term

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

ADVANCE PREPARATION

A. Have the blue paper "pond" ready.

B. Make salt dough for the relief map:

1 cup (250 mL) plain flour
1/2 cup (125 mL) salt
2 tsp (10 mL) cream of tartar
1 cup (250 mL) water
1 tbs (15 mL) cooking oil
food coloring (green, brown, or blue)

Stir the dry ingredients together in a heavy saucepan. Add the liquids and cook 3 minutes at low temperature or until it pulls away from the sides of the pan. Knead slightly almost immediately and store in an airtight container. Determine how many batches of each color you need by your state's geography and the number of maps to be made.

C. Obtain individual-sized pizza boxes (one per student or team) from a local restaurant.

D. Get 2 or 3 parent volunteers or aides to help you with the map activity.

E. Obtain a physical map of your state. Make two copies of a physical map of your state for each student or team; reduce or enlarge them as necessary to make them fit the small pizza boxes.

F. Make a copy of the word search puzzle (included) for each student.

PROCEDURE

I. Setting the stage

A. Have the students complete this analogy.

generic : common nouns :: brand name : ____________
(proper nouns)

B. Tell the students that in the following activity, they will be using common nouns.

C. Have the students brainstorm all the types of surface water they can think of. Write the appropriate words on the blue paper as they think of them.

II. Activities

A. Pass out the student page "Watery Words" (word search).

1. Have them find as many words as possible. (See the teacher key following the puzzle.)

2. Have the students select 5 words they are not familiar with. Look them up, and write the definitions on the back of their paper.

B. Have the students construct a relief map of your state. Use cooperative learning groups or, if you have enough supplies, let each student do his/her own map. (NOTE: You will need several adult helpers.)

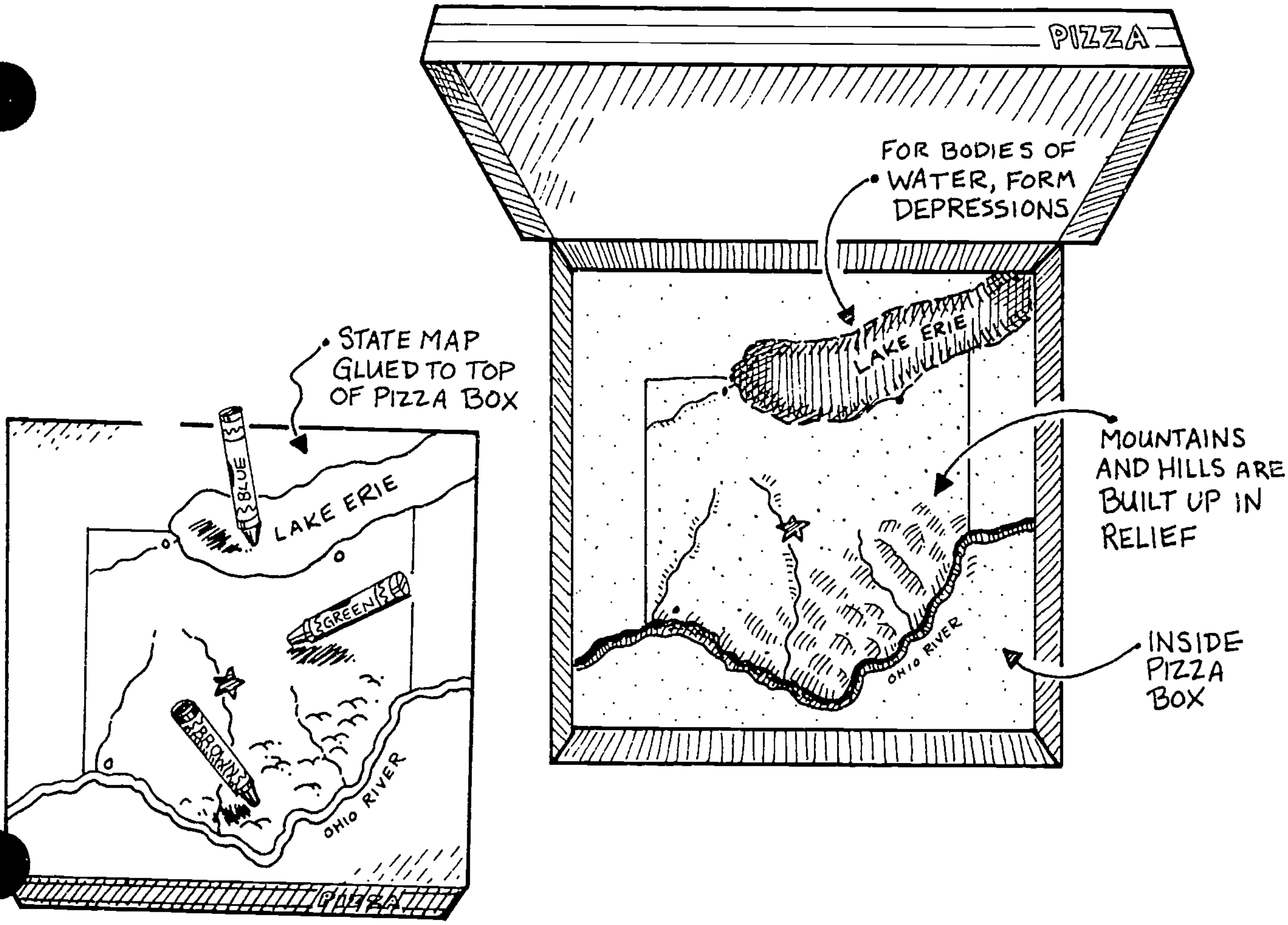
1. Have the students examine a wall map of your state. Discuss the most noticeable features of your state's geography.

2. Give the students two copies of the state's physical map and have them use blue, green, and brown crayons to color the maps. Have them make a legend and label the important bodies of water and cities.

3. Discuss the fact that many cities were originally located on rivers because of transportation and water source purposes.

4. Have the students glue this map to the top of the pizza box and glue the second map to the inside of the box.

5. Have them use the salt dough to build the relief map, starting with the green or brown dough to make the mountains, hills, and valleys. Tell them to do the blue bodies of water last. They will be in depressions. Let the maps dry.



III. Follow-up

A. Have the students redraw from memory a map of your state. Tell them to name the major bodies of water (choose appropriate requirements for you state and your students).

B. Have the students write sentences using 10 of the "watery words" correctly. (If you desire, you could modify this to require more words or to use a given number of them in a story.)

IV. Extensions

A. Have the students put the water words on your blue pond in alphabetical order.

B. Have the students look up different countries, cultures, and/or bodies of water around the world. What do they call their <u>boats</u>? (Examples: Hong Kong - sampan, junk; Alaska - kayak; Florida-hydrofoil; Navy - destroyer. What about ferry, tugboat, felucca, prau, scor, xebec, and dhow?)

C. Check the Macmillan 4th Grade Book, <u>Music and You</u> (pages 22-23) for the song "Little Blue Top." Teach it to the students.

D. Play the Alphabet Game: Form a circle with your class. Say, "I am going to start the alphabet game using <u>proper</u> nouns associated with water." Begin by saying, "A - Atlantic Ocean." The next person says "B -____________." (Rules: Students must say their letters then think of the word. This assures that they are working on the correct letter. You might want to give a time limit for thinking. If a student wants to pass, he/she may just say "pass." The next person must repeat the same letter and think of a word. If everyone in the circle passes, then the game continues with the first person that passed taking the next letter in the alphabet. (It should continue like this: B- Bay of Fundy, C-Caribbean Sea, etc.) (This may be difficult for them, but you could let them play in teams, with each team using a globe or world map.) You may play it with other categories of water words.

E. Have the students complete more analogies.

swam : swim :: sailed : __________ (sail)

NaCl : salt :: __________ : water (H_2O)

source: beginning :: outflow : __________ (end)

river: line :: lake : __________ (circle)

F. Have the students list water words related to prepositional water phrases. Put the following on the chalkboard. Get students to think of words to put in each column.

With Water	On Water	In Water
shower (example)	ski (example)	swim (example)

G. Read At the Edge of the Pond by Dewey to students. Ask your students to think of as many verbs as they can to describe how pond animals move. (slither, dart, gyrate, leap, etc.)

H. Ask your students to think of as many adjectives as they can to describe water in this phrase: the __________ pond (smooth, glassy, ripply, wavy, scummy).

I. If you have an Electronic GeoSafari Geography Game, this is a great time to use it.

J. Ask the students what body(ies) of water could they swim in where they would float most easily? (Great Salt Lake, Dead Sea) Have the students investigate where they would find inland salt lakes or seas. Look for information on "why" they are salty. Locate them on a world map.

K. Read Paul Bunyan stories that pertain to water to your class (see Resources section).

RESOURCES

Dewey, Jennifer Owings. At the Edge of the Pond, Little, Brown & Co., Boston, Massachusetts, 1987.

Electronic GeoSafari Geography Game, Educational Insights, Dominquez Hills, California, 1989.

"Little Blue Top," Music and You, 4th Grade Book, Macmillan, New York, pp. 22-23.

Rounds, Glen, "The Whistling River," Ol' Paul the Mighty Logger, Cadmus Books, Wisconsin, 1949.

Schwartz, Linda, I Love Lists, Learning Works, Santa Barbara, California, 1988.

Shephard, Esther, "Digging Puget Sound," Paul Bunyan, Harcourt, Brace & Co., New York, 1952.

WATERY WORDS

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

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WATERY WORDS
ANSWER KEY

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

LIVING IN WATER

OBJECTIVES

The student will do the following:

1. Create a pond model.
2. Research and report about plants and animals found in aquatic habitats.
3. Contribute to a pond mural.

SUBJECTS:
Science, Writing, Art

TIME:
120 minutes

MATERIALS:
aquarium or plastic containers
gravel
sand
small fish
snails
water
buckets or other containers
aquatic plants
butcher paper
blue tempera paint
magic markers
index cards
glue sticks or transparent tape
reference materials (encyclopedias, etc.)
teacher sheets (included)
acetate sheet
overhead projector
sentence strips
scissors
magnetic tape or masking tape
shoe boxes (optional)
typing paper (optional)
box cutter (optional)

BACKGROUND INFORMATION

A body of water where organisms live is called an aquatic habitat. One type of aquatic habitat is the freshwater habitat. Ponds, lakes, and streams are freshwater habitats. Many kinds of plants are found in or near the water. Cattails may grow at the water's edge. The roots of water lilies anchor at the bottom, while their leaves and flowers float on top of the water. Other plants live under the water.

Aquatic animals need oxygen. A few aquatic animals breathe with lungs. Most aquatic animals have gills instead of lungs, to take the oxygen they need from the water. Many animals in the water move around to find food and to get away from predators. Other animals attach themselves to objects in the water and collect their food as it floats past. Some animals that live in or near fresh water are fish, such as bass and trout; birds, such as ducks and geese; insects, such as dragonflies and mosquitoes; amphibians, such as frogs and toads; and reptiles, such as turtles and snakes.

When aquatic biologists (scientists who study things that live in or on the water) study a lake or other body of fresh water, they look at characteristics of the habitat to assess its "health." These would include (1) the amount of dissolved oxygen in the water; (2) algal content (enough to provide food but not enough to become a burden itself); (3) the health of the fish; (4) the diversity of bottom-dwelling insect larvae, worms, shellfish, and other invertebrates (simple animals with no backbone); and (5) the amounts and types of pollution settled into the mud on the bottom of the lake. When factors such as these are in order, the lake is likely to be a healthy place for plants and animals.

<u>Terms</u>

aquatic: living or growing in or on the water.

organism: any living being; plants and animals.

habitat: place where an organism grows or lives.

ADVANCE PREPARATION

A. Gather materials for this activity. (NOTE: Fish, sand, gravel, aquatic plants, and snails may be collected locally or purchased at an aquarium supply store or biological science supply company.)

B. For the "Password" game, write the sentences, cut up the sentence strips, and put magnetic tape on the backs of the pieces.

C. Make a transparency of the teacher sheet, "Checking Out the Neighborhood."

PROCEDURE

I. Setting the stage

A. Tell the students to imagine they are aquatic organisms. Let them imagine that the classroom is a large fishbowl or pond. (If you wish, let them "swim" around briefly.)

B. Tell the class to "become land-dwelling creatures again," and ask them to name things they think aquatic creatures would need to be healthy.

II. Activities

A. There are at least five characteristics that indicate a healthy lake or other body of fresh water. List these on the board and briefly share with the students the information for each. You might call these "5 for Life," or "A Fish's Wishes."

1. Algae: Just the right amount of algae means there is enough plant material for a strong food chain, but not so much that oxygen supplies are used up by the decay organisms that multiply excessively if there is too much algae (too much algae means too much dead algae).

2. Oxygen: Water has oxygen dissolved in it. Oxygen levels in the water affect the size and number of fish, as well as other life in the lake. Without oxygen, almost all aquatic life is driven away or dies.

3. Fish: The condition of the fish living in the water tells a lot about the condition of the lake or pond. If the fish are healthy and there are a lot of different kinds and sizes, the lake is in good condition.

4. Bottom Life: The mud, sand, or gravel from a healthy lake bottom will include a large number and wide variety of worms, snails, crayfish, mussels, clams, and aquatic insect larvae.

5. Sediment: Samples of mud taken from the bottom of the lake are checked to see if it contains harmful chemicals from human activities (metals, PCBs, or pesticides). This is important because pollutants settle to the lake bottom where many fish and other small animals live.

Show the students a transparency of the teacher sheet "Checking Out the Neighborhood." Review with them what each illustrated item means.

B. Have the students make a pond model.

1. For a class pond, use an aquarium. For individual ponds, have students or teams of students use large, clear plastic containers, such as large peanut butter jars. As the students watch and/or participate, review the five habitat factors.

2. Place aquarium gravel, sand, or soil on the bottom of the containers.

3. Plant the water plants from a biological supply house or aquarium supply store (many large discount stores carry aquarium supplies).

4. Add dechlorinated water. (NOTE: You may dechlorinate tap water by letting it stand out overnight or using dechlorination tablets. The water must be dechlorinated or the animals you add may become ill or die.)

5. Complete the pond by adding tadpoles or small snails and small fish to the aquarium.

6. Maintain the classroom model pond as a classroom aquarium for the remainder of the school year. Make sure animals have clean water and enough food and air.

C. Have the students draw a diagram of the model.

III. Follow-Up

A. Have the class make a pond mural.

1. Use blue tempera paint (thin works fine) to paint a blue oval on a long piece of white butcher paper.

2. Assign pairs of students a pond plant or animal.

a. Possible plants and animals:

Plants - iris, reed, water lily, willow tree
Insects - dragonfly, damselfly, water beetle, pond skater, water scorpion
Reptiles - snake, turtle
Amphibians - frog, toad, newt, salamander
Mammals - beaver, otter, mink, raccoon
Fish - carp, sunfish, perch, bullhead, bass
Birds - red-winged blackbird, duck, swan, heron, hawk
Mollusks and crustaceans - snail, mussel, crayfish

b. Have students research their plant or animal and write one fact about it on an index card. (Ask the librarian to pull some appropriate references. Encyclopedias can also be used.)

c. Provide magic markers and direct each pair to draw its plant or animal on the mural and paste or tape the index card near it.

d. Let the class name their "pond." Write the name on the mural and let each student sign it (like an artist).

3. Display the mural on a wall outside your classroom for everyone to learn from and admire.

B. Have the students play the "Password" game on the teacher sheet, "Aquatic Password."

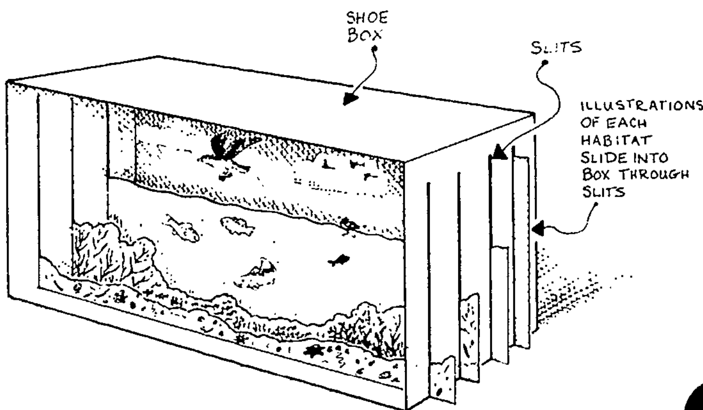
IV. Extensions

A. Have the students pretend they are pond plants or animals. Tell them to write sentences or a story describing their day without revealing what they are. Have them end their writing with the question, "What am I?" Then direct students to draw and label the mystery plant or animal on the back of their papers. Compile the papers into a class book titled, A Day at the Pond. The students will have fun as they "visit a pond" by reading each other's writings.

B. Have the students create water habitat models out of shoe boxes. (This is a good take-home activity.)

1. Cut slits on the sides of the box.
2. Use one sheet of typing paper for each aquatic habitat: bottom mud, plants anchored to the bottom, the water, and the air above the water.
3. Cut the paper to fit the slits. (The strips are progressively wider. See the figure.)
4. Have the students draw or illustrate each habitat on a separate strip of typing paper.
5. Slide the paper through the slits.

WATER HABITAT MODEL



(NOTE: You might let some students make dioramas.)

RESOURCES

Hackett, J. K. and R. H. Moyer, Science In Your World, Macmilllan/McGraw-Hill School Division, New York, 1991.

Gay, K., Water Pollution, Franklin Watts, New York, 1990.

Frank Shaffer, "Pond Life," School Days, New York, 1992, pp. 34-57.

"What's Happening in Your Lake?," RiverPulse, Tennessee Valley Authority, Water Resource Division, July 1992.

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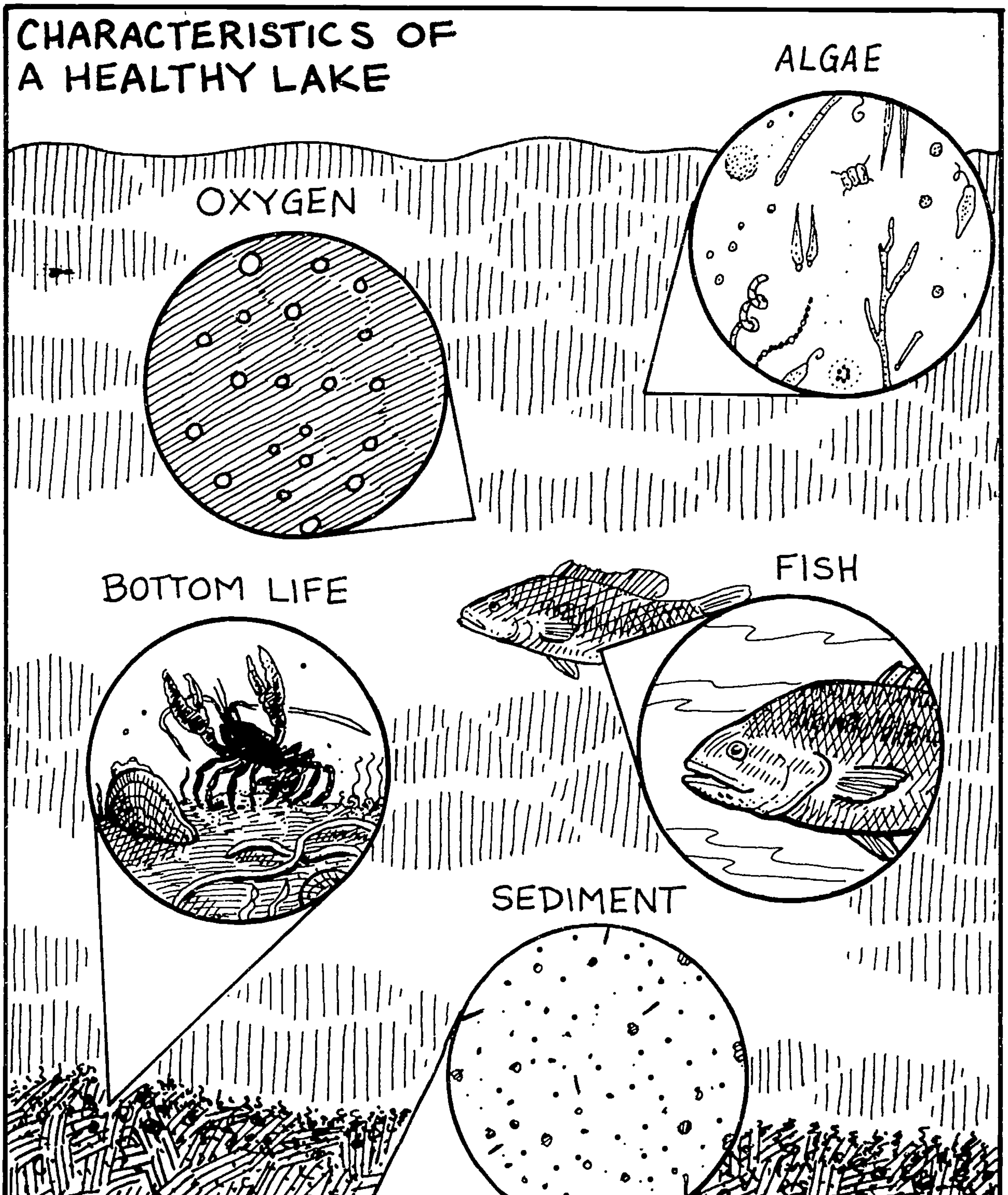
CHECKING OUT THE NEIGHBORHOOD



AQUATIC PASSWORD

Rules

Divide the class into six or eight teams. Let two teams come to the chalkboard at the same time. Have both teams face the classroom. At a given time, the two teams are to turn to the board. Each will arrange the mixed-up sentence in front of it in the right order. Both teams will have the same sentence. The winner is the team that finishes first. Let the teams compete, then let the winning teams compete.

Preparation

Write the sentences on colorful sentence strips. (Make two versions of each one.) Cut them up (separating the words) and put magnetic tape on the back to enable them to stick to the board (masking tape can be used).

Use the following sentences:

1. Water lily is an aquatic plant.
2. Water beetles, dragonflies, and water scorpions are insects.
3. A turtle is a reptile.
4. Frogs, toads, and salamanders are amphibians.
5. Raccoons, minks, and beavers are mammals.
6. Bass, perch, and sunfish are fish found in ponds.
7. A hawk is a bird.
8. A cattail is a water plant.
9. An otter is a mammal.
10. A heron is a bird.
11. Algae are plants.
12. Some small animals live in the bottom mud.

POSTED! NO FISHING, NO SWIMMING

OBJECTIVES

The student will do the following:

1. Play a game to learn that it is not always safe to eat fish they catch.
2. Write a story about taking a trip to the beach and finding swimming prohibited.
3. Recognize that environmental laws protect their health.

SUBJECTS:
Science, Health, Language Arts, Physical Education

TIME:
60 minutes

MATERIALS:
construction paper
scissors
markers
masking tape
art paper
crayons
U.S. map

BACKGROUND INFORMATION

The first Federal law dealing exclusively with water quality was passed in 1948. It set aside government money for research. Offenders of the law only received a weak punishment. In 1969 the National Environmental Policy Act started all the environmental protection legislation. In 1972 the Clean Water Act was passed and in 1977 and 1987 more water quality regulations were added. The protection of human health is the most important goal of these laws.

Despite the passage of such laws, we still must deal with water quality issues. Some polluting happens now, but often we are faced with pollution that entered the environment years ago. This is the case with chemicals like DDT and PCBs; they do not break down in the environment and so tend to settle and collect in sediment on the bottom of bodies of water. They sometimes find their ways into food chains, ending up in fish that may end up on fishermen's lines. Waters are posted in such cases to prevent people from eating fish that might contain dangerous levels of chemicals.

Sometimes warning signs are posted around water bodies to prevent swimming because the water has been found to have unsafe levels of coliform bacteria from fecal contamination (human and animal waste). Coliforms are used as indicators for the presence of pathogens (disease-causing organisms). Fecal contamination represents on-going problems with waste management, not a long-ago problem, as the chemical pollution sometimes does.

Terms

DDT (dichlorodiphenyltrichloroethane): an insecticide that does not break down in the environment. Once widely used but now p ohibited from most uses in the U.S.

dioxin: a toxic by-product of the manufacture of certain pesticides and other products.

mercury: a poisonous metallic element, Hg, atomic number 80, atomic weight 200.59, existing at room temperature as a silvery, dense liquid.

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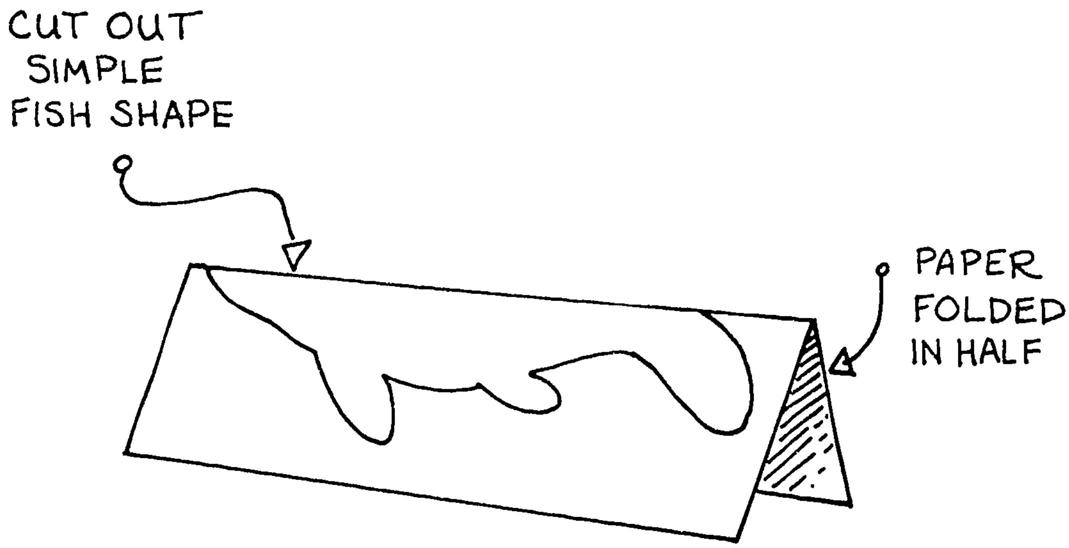
PCBs (polychlorobiphenyls): industrial chemicals that do break down in the environment; once widely used in electrical transformers but now prohibited in the U.S.A.

pesticide: any chemical or biological agent that kills plant or animal pests; herbicides, insecticides, fungicides, rodenticides, etc., are all pesticides.

ADVANCE PREPARATION

Make a fish for each of two-thirds of your students. Fold a sheet of construction paper in half and cut out a simple fish shape, leaving it hinged on the fold. For half of them, open the fish, and write one of the messages below ("I ate . . .") inside.



PROCEDURE

I. Setting the stage

Share the background information with the students (as appropriate). Remind them that when clean water becomes polluted, it can cause diseases and upset the balance of nature. This requires people to set standards for water quality.

II. Activities

A. Take the students outside to play the "Going Fishing Game."

1. Divide the class into three equal groups. One group will be the fishermen/women. Take the other two groups aside. They will not know if they are healthy fish or unhealthy fish. Each one will get a folded paper cut in the shape of a fish taped to his/her back. Half will be healthy fish with nothing written on the inside. The other half will have one of these notes written inside (where the fishermen can't see them): "I ate PCBs," "I ate pesticides," "I ate dioxin," "I ate mercury."

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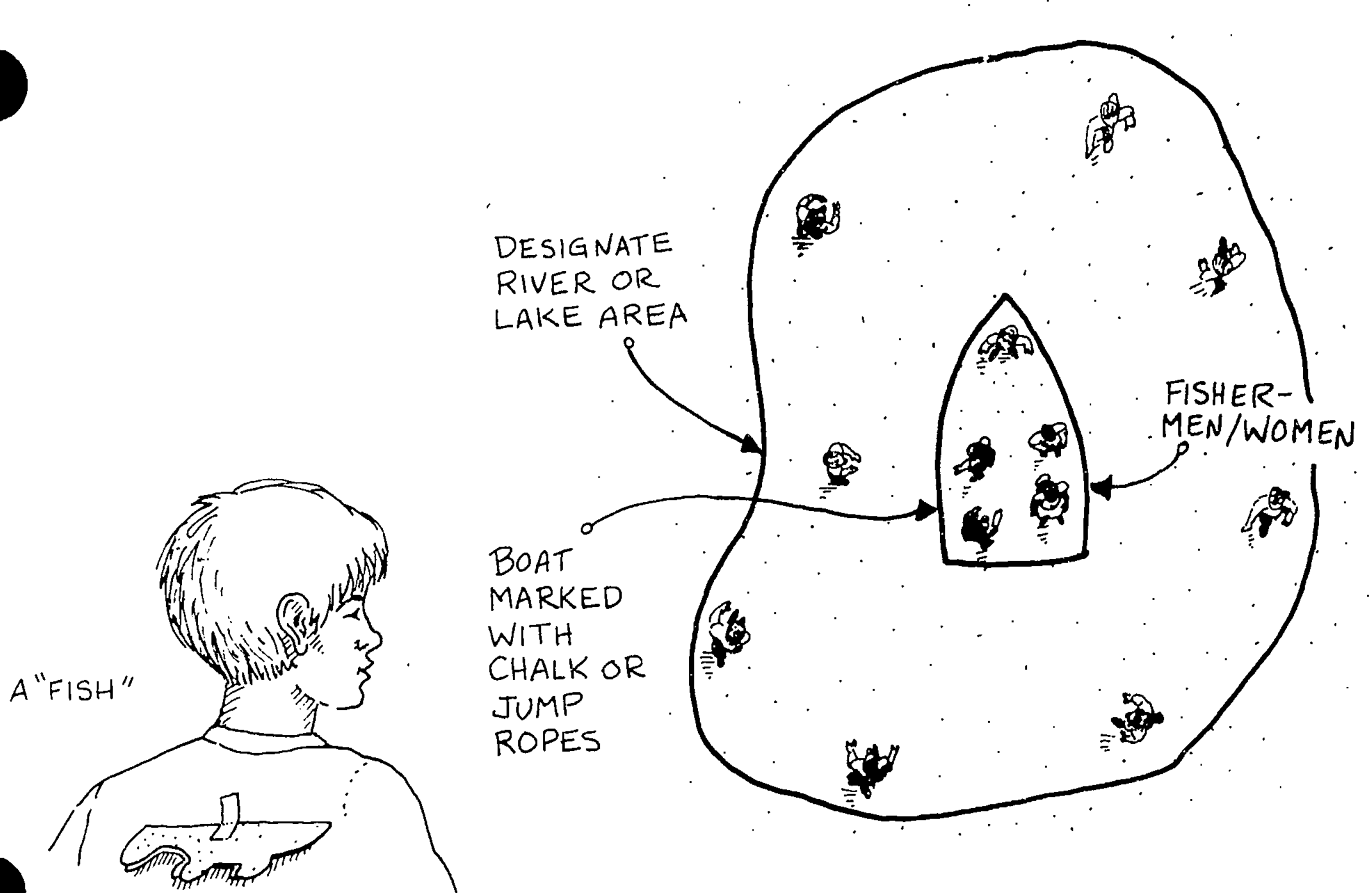


2. Designate the area that will be the lake or river. Fish must stay in this area. Designate (using chalk or jump ropes) the "boat" area that will be big enough to contain the whole class. Fishermen/women must start in the boat. On a given signal, fishermen/women start "fishing." They must run after the fish and catch two fish and take them back to the boat. When all the fish are caught and in the boat, the fishermen look inside the paper fish on each fish's back to see if they caught healthy or contaminated fish. If he/she catches 2 contaminated fish, he/she will not be dining on fresh fish (unless the family goes out to eat!).

3. Ask the students how many will be going out to eat. Should there be a sign at this lake that says, "No fishing"? (yes)

B. Have the students write a story about "My Imaginary Trip to (lake, ocean, river — whatever is near you)." Teach paragraphing by using the following topics:

1. Planning my trip
2. Packing for the trip
3. Arriving at the beach and seeing a "No Swimming — Polluted Water" sign posted
4. Feeling disappointed
5. (Optional) What I did instead of going swimming.

III. Follow Up

A. Ask the students what it means when a "No fishing" or "No swimming" sign is posted. Does this always mean the water is polluted? (No; it could mean something else, e.g., this lake is on private property and the owner doesn't want you to do these things.) Tell them that if the water is polluted, or if there is some other possible danger there, the signs will explain it.

B. Remind the students that the first goal of the laws to protect the environment is to protect people's health. Discuss with the students how they should react when they see a sign prohibiting fishing or swimming. Would they do it anyway? Why or why not?

C. (Optional) Have the students write a paragraph on what they learned in this lesson.

IV. Extensions

A. Have the students make signs like "No Fishing Allowed," "Polluted Water," "No Swimming," "Contaminated Water," and so on, and illustrate them.

B. Have them research places where water bodies have been closed to fishing and/or swimming and locate them on a U.S. map. (Or find out if any nearby waters have been closed to fishing and/or swimming.)

C. Have each student write a creative story or draw a cartoon in which he/she is a fish. Have them decide what species of fish they are, where they live, and what they eat, making up names for themselves and the lakes in which they live. (NOTE: Remind students these are proper nouns.) In the story or cartoon, have the fish fight water pollution.

RESOURCES

Lucas, Eileen, Water: A Resource in Crisis, Childrens Press, Chicago, 1991, p. 52.

"Water Quality Fact Sheets," Tennessee Valley Authority, TVA/ONRED/LER, 1988.

CLEANING UP

OBJECTIVES

The student will do the following:

1. Identify ways to prevent surface water pollution.
2. Simulate the removal of pollutants from water by filtration.
3. Compute the area of an illustrated pond.

SUBJECTS:
Science, Math

TIME:
50 minutes

MATERIALS:
cotton balls
toothpicks
clear plastic straws (large) or tubing
activated charcoal
water
plastic cups
spoons
food coloring
eyedroppers
scissors
metric rulers
student sheets (included)

BACKGROUND INFORMATION

For years people believed that materials dumped into water supplies would decompose or be diluted to the point that they were virtually harmless. It has been shown that unlimited and unmonitored dumping of wastes can be very harmful to water supplies. The vast quantities of industrial and human wastes produced must first be treated, either physically or chemically, before they are allowed to re-enter lakes, streams, rivers, and oceans. Bodies of water cannot clean themselves as fast as people pollute them—so people must try to keep pollution out of water.

Terms

cooling pond: a pond where hot water from factories and power plants is stored until it is the same temperature as nearby bodies of water.

diluted: reduced in strength.

industrial pond: a pond used to hold dirty water until it is clean enough to be put into a nearby body of water.

pollution: contaminants in the air, water, or soil that cause harm to human health or the environment.

ADVANCE PREPARATION

A. Preparation of Materials: Use large diameter clear straws or clear tubing for this activity. Cut the straws in half. Finely crush the charcoal. Pour food coloring into small dropper bottles. Activated charcoal may be purchased wherever aquarium supplies are sold; you may buy capsules of activated charcoal at the pharmacy. If activated charcoal is not available use regular charcoal, but crush it very fine before using it.

B. Wide clear plastic tubing may be used in place of large-diameter straws.

C. Provide a spoon and small paper cup for the Organizer to obtain the charcoal. One small bottle of food coloring can be shared by the entire class. At the end of the period, the straws, cotton and charcoal should be placed in solid waste receptacles. Water and foor' coloring may be flushed down the drain. Cups and droppers should be rinsed.

D. An alternative approach to doing the activity is to do it as a teacher demonstration for lower grades. Use a large piece of clear plastic tubing or a buret borrowed from a high school chemistry teacher.

E. Make copies of the student sheets. (You may prefer to make transparencies of "Water Pollution Solution" and "Plant's Pond.")

PROCEDURE

I. Setting the stage

A. Tell the students a story about a boy or girl whose room is really messy. Describe in comical details how dirty the room is and what a big job it will be to clean it up. Then ask the students what the owner should do. Keep probing until someone suggests that he/she should not let the room get so dirty; keeping it neat is less work than a big cleaning job.

B. Tell the students that water pollution has become one of the most serious environmental problems facing the United States as well as countries around the world. Industry, government, cities, and towns have spent billions of dollars on research and treatment plants to try to reduce water pollution. Three chief sources of water pollution are: industrial (factories) wastes, municipal (city) wastes (sewage), and agricultural (farm) chemicals and wastes. Oil spills are another source of pollution. This activity will help you realize how hard it is to clean up polluted water.

II. Activity

A. Ask the students to think of ways we could clean polluted water. Write their answers on the board. Direct their responses to the idea of filtering. Tell them they are going to work in teams to investigate filtering.

B. Divide the class into teams of at least five. Each group will have an organizer, investigator, manager, recorder, and reporter.

1. Have students draw numbers for the following roles:

a. Investigator - manipulates materials

b. Organizer - gathers and organizes materials, directs the cleanup

c. Manager - helps investigator, keeps time, makes sure safe procedures are followed, performs calculations, and encourages the team

d. Recorder - writes down the team's observations and answers to questions, and makes drawings as needed

e. Reporter - shares the team's results and conclusions with the class.

2. Give each student a copy of "Trying to Make It Clean and Clear."

3. Remind the students to use a very tiny piece of cotton to plug the straw. If the cotton is too dense, the water will not pass through the straw.

4. Tell the students to hold the dropper at an angle when dropping colored water into the straw.

5. Instruct the students to collect water filtered through cotton in cup B, and water filtered through cotton and charcoal in cup C.

C. Ask the designated student(s) in each team the questions below.

1. Manager, Recorder: How does the color of the water in cup B compare with that in cup C? (The water in cup B will still be colored, while the water in cup C will be clear.)

2. Investigator, Recorder: What could account for any difference in color? (Since the only difference between the two setups was the charcoal, the charcoal must have removed color from the water.)

3. Reporter: How do your results compare with those of your classmates? (NOTE: Results should be alike.)

D. Discuss with the students how the experiment they did relates to cleaning up pollution.

1. Does filtering work (at least for some kinds of pollutants)? (yes)

2. What if you had a whole lake full of polluted water? Would filtering it be practical? (no)

3. What might you do to clean the whole lake? (Accept all answers, asking for their reasons.)

4. Some pollutants cannot be filtered out of water. How might you clean water polluted with un-filterable pollutants? (Accept all answers; ask for reasons.)

5. Remind the students of the messy room story. What can we conclude about cleaning up pollution? (It is better to prevent pollution than to have to clean it up.)

E. Demonstrate that pollution does not "just disappear."

1. Set aside several cups having various amounts of food coloring in small quantities of water. Make sure that one is so dilute that the color is not readily observable.

2. Let them sit for a couple of days or until the water evaporates. Let the students observe the residue left when the water evaporated.

3. Put a drop or two of water into each cup to reconstitute the food coloring. They will see that the "pollution" remains, even though the water comes and goes.

4. Discuss with the students that even if people clean up water pollution, they still must do something with the pollutants. This is a very difficult problem.

III. Follow-Up

Have the students complete the "Water Pollution Solution" student sheet. The answers are: 1. F, 2. no, 3. charcoal, 4. F, 5. cotton and charcoal, 6. F, 7. fish, 8. F, 9. prevention, 10. (answers will vary).

IV. Extensions

A. Take a field trip to a wastewater plant. Tour the treatment facility. Have the students develop a list of questions to ask about the plant beforehand.

B. Hold a debate about an environmental issue, such as uses of pesticides, sewage treatment, or thermal pollution. Each issue has pros and cons. Allow students time to research the point of view they are to represent. Establish debate rules and procedures before beginning.

C. Have the students complete the student sheet "Plant's Pond." (Answer: 360 sq. meters.)

RESOURCES

Cohen, M. R., T. M. Cooney, and C. M. Hawthorne, Discover Science, Scott, Foresman and Company, Glenview, Illinois, 1991.

Mallinson, G. G., J. B. Mallinson, Linda Froschauer, and J. A. Harris, Science Horizons, Silver Burdette & Ginn, Morristown, New Jersey, 1991.

TRYING TO MAKE IT CLEAN AND CLEAR

1. Investigator: Pull a small piece of cotton from a cotton ball. With a toothpick or paper clip, stuff this piece into one end of each of the two straws. In one straw pour a layer of charcoal 1 cm high. The charcoal should be above the cotton.

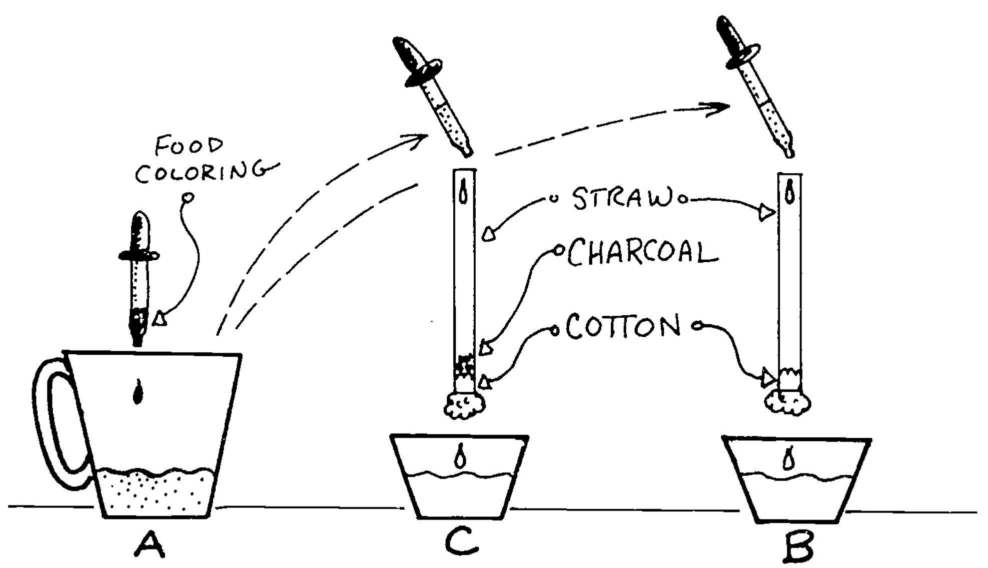
2. Manager: Fill a plastic cup, cup A, 1/3 full of water. Add 1 drop of food coloring. With the eyedropper, mix the food coloring and water thoroughly.

3. Investigator, Manager: Using the eyedropper, add colored water to the straw that has only cotton in one end. Catch the water dripping from the straw in cup B.

4. Investigator: Repeat step 3, using the straw with charcoal and cotton. Collect the water in cup C.

5. Manager: Compare the water color in cup B with that in cup C.

6. Recorder: Record the results.



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WATER POLLUTION SOLUTION

Answer these questions by filling in the blank or circling the correct answer.

1. T F It will be very easy to clean up water pollution.

2. Our experiment showed that we can filter some pollution out of water. Is this always possible? yes no

3. We used cotton and ______________ to filter the water.

4. T F It is impossible to clean up water pollution.

5. Which worked better? just cotton cotton and charcoal

6. T F Pollution will disappear if we wait long enough.

7. Which of these is not a source of water pollution?
   factories cities farms fish oil spills

8 T F There is nothing we can do to prevent pollution.

9. What is the very best solution to pollution?______________________________

____

10. This is a thinking question. What would you do to clean up water pollution if you were in charge of protecting the environment?

____

____

____

____

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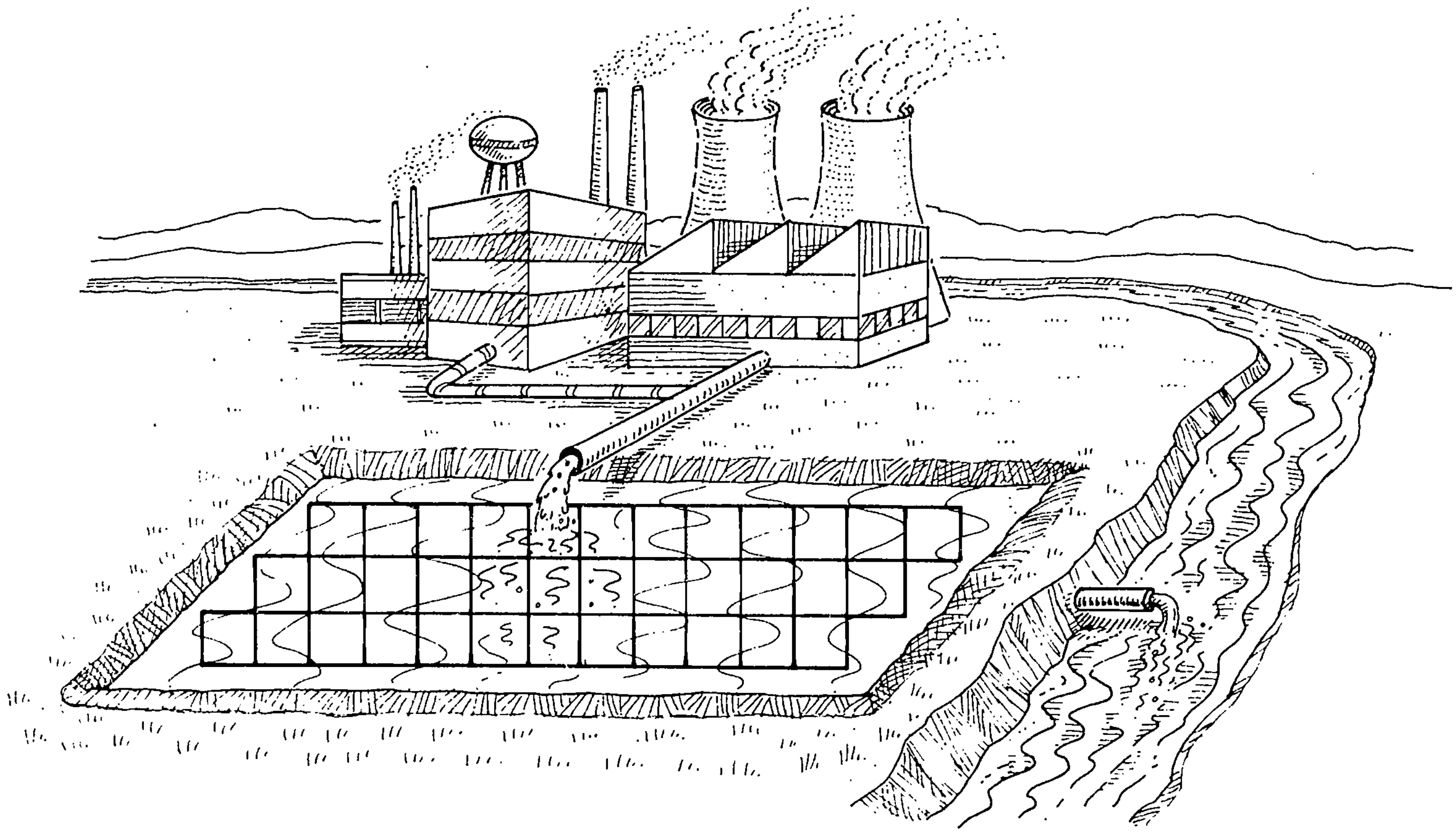
PLANT'S POND

Factories and power plants do many things to keep from polluting lakes and rivers. They store hot water in special ponds called cooling ponds. When the water cools, it can safely be released. They store dirty water in special ponds called lagoons. When the dirt settles out, the clean water can be released.



If the diagram represents a pond and each square is ten square meters, what is the area of the plant's pond? ______________

ACID RAIN, GO AWAY!

OBJECTIVES

The student will do the following:

1. Define acid rain.
2. Simulate the effects of acid rain on limestone.
3. Write a paragraph about life in a dying lake.

SUBJECTS:
Science, Language Arts

TIME:
60 minutes

MATERIALS:
vinegar
cups (4 per team)
marble chips
regular chalk (not "dustless")
water
safety goggles
student sheet (included)

BACKGROUND INFORMATION

"Acid rain" is the term used to describe the result of a chain of complex chemical, atmospheric, and environmental processes that start with air pollutant emissions from utilities, industries, and motor vehicles, as well as natural sources (like volcanoes). When rain mixes with certain kinds of smoke and pollution in the air, acid forms. When these substances fall with rain, it is known as "acid rain." Acid rain can slowly do damage by killing plant life and water-dwelling creatures, and by damaging metal and stone, such as that in statues and buildings.

The air pollutants that result in acid rain are sulfur oxides and nitrogen oxides. The major source of sulfur oxides are coal-burning power plants and industrial boilers. The major sources of nitrogen oxides are automobiles and coal-fired boilers at power plants and industries

The most cost-effective (and the only reliable) solution to the problem of acid rain is to control the offending pollutants at their source. The goal must be to emit fewer sulfur oxides and nitrogen oxides into the air so that fewer acids form in the atmosphere. Today power plants and industries emit a small fraction of what they did years ago. As pollution control technologies improve, and as society's commitment to environmental quality grows, we will emit even fewer acid-forming pollutants.

<u>Terms</u>

acid: a kind of chemical; acid in food is sour, sharp, or biting to the taste.

acid rain (or acid precipitation): rain with a pH of less than 5.6; results from atmospheric moisture mixing with sulphur and nitrogen oxides emitted from burning fossil fuels; may cause damage to buildings, car finishes, crops, forests, and aquatic life.

acidic: tending to form an acid.

pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

vegetation: plant life.

ADVANCE PREPARATION

A. Gather the materials needed. Note that the chalk must be regular chalk, not "dustless." Obtain marble chips wherever landscaping supplies are sold.

B. Make copies of the student sheet "Acid Rain, Go Away!"

PROCEDURE

I. Setting the stage

A. Have the students imagine they are on a trip to some mountains far away. They want to visit a beautiful lake they once saw in a picture. Describe a trip from where you are located to such a place. Tell the students that when they arrive at the lake, it looks even more beautiful than in the picture. The lake is deep, clear, and very blue; it reflects the sky perfectly. Describe how quiet and serene it is there. Then introduce an ominous note by saying that it is "too quiet."

Describe how the students would start to notice that there were no fish jumping in the lake, no frogs "ribbet"-ing along the shore, and no dragonflies buzzing about the edge of the water. Because they have been good science students, they know that a lake should have all kinds of creatures and plants in and around it. As they start to examine the lake, they find no living things in the water — just some old shells, insect cases, and dead moss. This lake is dead!

Ask the students what they think happened. How could such a crime have been committed? Who is the murderer of the lake? Tell them they will learn to be better environmental detectives in this lesson.

B. Continue the story by telling the students that just as they are discussing what happened to the lake, they hear someone coming. (Could it be the criminal?) The students look for a place to hide, but before they can hide, Ranger Dave rides out of the forest on his faithful horse, Giddyup. He waves and smiles. The students are relieved. They crowd around as he climbs down from his mount, asking him about the dead lake. The ranger frowns, takes his hat, and says only two words..."Acid Rain." What on earth does it mean? How could rain hurt the lake? How could the rain be acidic? Ranger Dave shook his head and drawled, "You folks best be getting back to class. The next lesson is about acid rain, and if you don't hurry, you're gonna miss it!"

II. Activity

A. Share with the students that sometimes moisture in the air mixes with certain kinds of smoke and other types of air pollution, producing acids in the rainwater; this is known as "acid rain." When acid rain falls, it affects the land it falls on. The worse the problem, and the longer it goes on, the greater effect on the land.

B. Discuss the problem with the students. Acid rain may have recently been in the newspaper or magazines. Scientists cannot say exactly what the effects of acid rain on every place are, but they do know that there are places where acid rain has had serious effects. In Scandinavia and the Adirondack Mountains in the U.S., there are "dead" lakes like the one in our story. In many beautiful and historic old cities, famous buildings and statues seem to be "melting" because acid rain slowly dissolves the stone they are made out of.

C. Have the students explore the effects of acid rain on building materials. They will simulate this process.

1. Divide them into small teams. Give each student a copy of the student sheet "Acid Rain, Go Away!" (included), and have them complete this activity. They are to follow the directions on the student sheet. While they are waiting the 15 minutes, have them look up these terms in their dictionaries and write the definitions down.

   a. pollutant

   b. acid rain

   c. vegetation

   d. acidic

   e. acid

2. Ask, "How did vinegar affect the chalk?" Explain to the students that they should see a noticeable dissolving effect because the acid in vinegar will react with the calcium in chalk.

3. Ask, "How did the vinegar affect the marble chips?" Explain that the vinegar does not affect the marble chips as noticeably, although they too contain calcium. Stress that the (sulfuric) acid in rain is different from the (acetic) acid in vinegar, so the effect is not exactly the same. This is a simulation—something like what really happens.

D. Tell the students that acid rain affects water environments, too. Over a long period of time, a lake's water can collect acid and other chemicals (e.g., metals that acidic rainfall leaches out of soil around the lake) that are harmful to the living things in the water. If the problem becomes severe enough, the smallest animals and plants will die first; then the larger animals will die. Finally, nothing will be alive in the lake.

E. Have the students research local newspapers to find out if acid rain or snow is a problem in your area. What are the causes and possible solutions?

III. Follow-Up

Have the students imagine that they are fish living in a lake where there has been acid rain. Have them write a paragraph describing their experiences. Ask them to answer the question "What is life like for you in your lake?" What is happening to you, your neighbors, and your home?"

IV. Extensions

A. Have the students write their senators and representatives about the problem of acid rain.

B. Contact the Environmental Protection Agency or your state's environmental protection office for information about acid rain.

RESOURCE

Hackett, J. K. and R. H. Moyer, Science In Your World, Macmillan/McGraw-Hill, New York, 1991.

ACID RAIN, GO AWAY!

1. Label four plastic cups A, B, C, & D.
2. In cup A place a piece of chalk in water.
3. In cup B place some marble chips in water.
4. In cup C place some marble chips in vinegar.
5. In cup D place a piece of chalk in vinegar.
6. Now stand back and wait. After 15 minutes, examine the materials in the cups.
7. What has happened in cup A? ______________________________

   ____

8. What has happened in cup B? ______________________________

   ____

9. What has happened in cup C? ______________________________

   ____

10. What has happened in cup D? ______________________________

    ____

Vinegar has acid in it, though not exactly like the acid in pollution. Notice what it does to the chalk in cup D. The acid in acid rain is not the same strength as that of vinegar, so the effect in nature will occur at a different speed than in your test, but in the end the effect is similar.

11. How might acid rain affect buildings and monuments? ______________________________

    ____

12. What might the acid do to trees and plants? ______________________________

    ____

13. Judging from the activity, would you say tap water has acid in it? ______________________________

    ____

14. Define acid rain. ______________________________

    ____

    ____

N, B, & T: POLLUTANTS THREE

SUBJECTS:
Science, Art, Language Arts

TIME:
60 minutes

MATERIALS:
5 baby food jars with lids
six 2-liter plastic bottles
gallon (4 L) milk jug
water
soap or detergent
vinegar
flea powder
food scraps
five 3-liter plastic bottles (clear, not tinted)
pond water
teaspoon
crayons or markers
student sheet (included)

OBJECTIVES

The student will do the following:

1. List and describe three types of surface water pollution (nutrient, bacterial, toxic).
2. Observe the effects of various water pollutants on algae growth.
3. Illustrate a cause of each of the three types of pollution.

BACKGROUND INFORMATION

Nutrients from fertilizer have been major water pollutants since the 1940's. Although plants and animals need these for growth, if there is too much phosphorus and nitrogen in water, algae and other aquatic plants grow too rapidly. Rapidly growing plants in water also means more plants die and decay, and in the process they use up the oxygen dissolved in the water. As a result, fish and other aquatic life die.

Another major water pollutant is human and animal wastes. Lakes and beaches are often closed to swimmers and anglers because of high counts of fecal coliform bacteria from raw sewage (human waste) and feedlot runoff that makes its way into rivers and streams then empties into the lakes and oceans. Although coliform bacteria are not harmful themselves, they usually indicate that pathogens, disease-causing organisms, are present.

The third major type of water pollutant is toxic, or poisonous, chemicals. Toxic pollution is most often from pinpointable sources, such as industrial discharges or accidents in transportation (such as oil spills). It can also come from less identifiable sources, including runoff from both urban and rural areas, and fallout from the atmosphere.

The sources of pollutants that cause water pollution vary. In some cases, pollutants may come from a pipe discharging into a river, a boat, irrigation ditch, underground storage tank, or other single source, called a "point source" of pollution. But frequently they are varied sources, collectively called a "nonpoint source," that could include industries, agriculture, and other human activities.

Point source problems are the easiest to correct. Their cause—wastewater emptied into the lake through a pipe—can be dealt with directly. Nonpoint source problems are more difficult to fix. Fixing nonpoint source problems usually requires a lot of cooperation by every part of society.

Terms

bacterial water pollution: the introduction of unwanted bacteria to a water body.

conservation: preserving from loss, waste, or harm.

erosion: the wearing away of the earth's surface by running water, wind, ice, or other geological agents; processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is removed from the earth's surface.

fertilizer: any one of a large number of natural or synthetic materials, including manure and nitrogen, phosphorous, and potassium compounds, spread or worked into the soil to increase its fertility.

nonpoint source pollution (NPS): pollution that cannot be traced to a single point, because it comes from many individual places or a widespread area (e.g., urban and agricultural runoff).

nutrient pollution: a nourishing contamination that causes unwanted plant growth in water.

point source pollution: pollution that can be traced to a single point, such as a pipe or culvert (e.g., industrial and wastewater treatment plant discharges).

pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

pollution: contaminants in the air, water, or soil that cause harm to human health or the environment.

sewage: human waste.

toxic pollution: harmful, chemical contamination in water.

ADVANCE PREPARATION

A. Cut the tops off the five 3-liter bottles. (Scissors work fine. Just cut the top section off each, and recycle.) You may use large, clear jars as long as all of them are exactly the same.

B. Take five 2-liter bottles to a pond, lake, or river, and fill each with water.

C. Gather the other jars, bottles, and so forth, and the "pollutants."

D. Run a jar (approximately a pint, or 500 mL) of tap water and let it set overnight so the chlorine will dissipate.

E. Copy the student sheet for distribution.

PROCEDURE

I. Setting the stage

A. Ask students to guess how much water they use each day. Then tell them that each person in the United States uses about 150 gallons (570 L) of water each day for drinking, bathing, cleaning, flushing the toilet, watering lawns, and so on. Provide a gallon (4 L) milk jug and a 2-liter soft drink bottle of water to show gallons and liters of water.

B. Point out to the students that while we progressed as a nation we became very careless with our water. Farmers used chemicals to help crops grow and kill insects, and later the rain and snow washed these chemicals into streams and lakes. Factories made many useful products from chemicals, such as medicine, clothes, automobile lubricants, and household goods. Water was always used in the process, and wastewater was discharged into streams. People added pollutants to water when they used it in their homes. They added soap, toothpaste, shampoo, bleach, detergent, fertilizers, insect spray, human wastes, paint, oil, grease, plus many more. Tell the students many of these activities continue today.

C. Emphasize to the students that people thought that because rivers and lakes had so much water, they could clean themselves. We now know that a little here and a little there can eventually add up to a lot. In the '60s, lakes and streams were overnourished with phosphorus that came from detergents; they became choked with algae. Nutrients from fertilizers and untreated sewage added to the problem. Fecal coliform bacteria from raw sewage flowing into the lakes and streams caused a lot of beaches and lakes to be closed. Now we know that we must clean water before it can be used again; we pollute bodies of water too much for them to clean themselves.

II. Activity

A. Have the students list sources of each of the three categories of pollutants (nutrient, bacterial, toxic).

1. Write the three categories on the board. (These are the "N, B, & T" pollutants to which the title refers.) Make them headings for columns.

2. Ask the students to identify the kinds of substances causing each kind of pollution. Lead them to summarize: nutrient - fertilizer, bacterial - human waste, toxic - chemicals. Write these terms beside the headings.

3. Have the students list as many sources as possible for each of the three kinds of pollution. Write their answers in the columns.

B. Do this activity to show that a little pollution here and there can do harm.

1. Prepare "pollutants" to mix with the pond water. Have the students help you measure, mix, and label them. Use the tap water you have let set to dechlorinate. Mix the following in small jars (e.g., baby food jars).

a. Pour 1/4 cup (60 mL) of plain water into the first jar. You will not add a pollutant to this jar.

b. Mix a scant half-teaspoon (2-3 mL) soap or detergent and water (1/4 cup or 60 mL).

c. Mix a solution of vinegar (1-1/2 ounces or 45 mL) and water (1/4 cup or 60 mL).

d. Mix a scant half-teaspoon (2-3 mL) of flea powder and water (1/4 cup or 60 mL).

e. Mix a scant half-teaspoon (2-3 mL) food scraps and water (1/4 cup or 60 mL). (NOTE: You may want to avoid using any meat scraps because they will become very smelly.)

2. Use five 3-liter plastic bottles (with the tops cut off) or other clear containers. Fill each "pond model" with pond water. They will be identical; then add one of the following to each. As you do this, point out to the students that the models are just alike except for the pollutants added to them. This is very important in an experiment. Identify each as to its pollution category.

   a. Add the plain water.

   b. Add the mixture of soap and water. This represents nutrient pollution.

   c. Add the solution of vinegar and water. This represents toxic pollution.

   d. Add the mixture of flea powder and water. This represents toxic pollution. The powder is similar to the chemicals used to kill pests on crops.

   e. Add the food scraps and water. This represents bacterial pollution; the bacteria will break the food down.

3. Label the models with treatment type and the date and time of the treatment.

4. Have the students predict what will happen to each.

C. Ask the students what a "monitor" is. (someone who keeps a check on something) Ask them to give examples. Tell them they will be "monitoring" the progress of the models. Tell them scientists monitor our water for water pollutants. This helps keep us safe from polluted water.

D. Have the students observe daily and record any differences in growth and development of the algae for about 10 days to two weeks. (NOTE: If the smell becomes too unpleasant in the food scraps pond, you may have to discard it.). Discuss their observations. (The model plain water was added to should look the same, the vinegar and flea powder should show no growth [toxic], the detergent should have extensive growth of algae [nutrient], and the food scraps should be smelly [bacteria].) Can the students explain these results in light of what was added? (Algae and algae spores were present in the pond water that was collected for the experiment.)

E. When you are through observing the pond models, the algae and water (with the additives) may be safely flushed down the toilet.

III. Follow-Up

A. Have students complete the sheet "A Little Here and There is Too Much."

B. Have students write a poem or a song about the N, B, & T Pollutants (Nutrients, Bacteria, Toxics)

IV. Extension

A. Have the students imagine they are each the governor of a state. They are having three major problems: 1) Businesses are discharging hazardous wastes into the lakes; 2) Farmers are using chemical fertilizers that run off into the rivers; and 3) The sewage treatment plant leaks raw sewage into the rivers. Have the students write ways they would take care of these concerns. (NOTE: Younger students might act out their solutions to these problems.)

B. Have the students examine local newspapers to find out what their community's major water pollutants are.

RESOURCES

Elick, C., "Water," Tennessee Conservationist-Student Edition, Nashville, Tennessee, January/February, 1988.

Gay, K., Water Pollution, Franklin Watts, New York, 1990.

Holmes, N. J., et al., Gateways to Science: Grade 5, Webster Division, McGraw-Hill, New York, New York, 1985.

"Your Lake Is Unique," RiverPulse, Tennessee Valley Authority, Water Resources Division, July 1992.

A LITTLE HERE AND THERE IS TOO MUCH

Draw a picture to illustrate a cause for each kind of pollution.

NUTRIENT POLLUTION

F
E
R
T
I
L
I
Z
E
R
S

BACTERIAL POLLUTION

S
E
W
A
G
E

TOXIC POLLUTION

C
H
E
M
I
C
A
L
S

STOP THAT SEDIMENT

OBJECTIVES

The student will do the following:

1. List soil conservation methods.

2. Identify sediment as a result of soil erosion and a water supply problem.

3. Demonstrate contour farmin´ windbreaks, and terracing as erosion preveruon methods.

SUBJECTS:
Science, Social Studies

TIME:
100 minutes

MATERIALS:
1 quart (liter) jar or 2 liter bottle
sand
topsoil
pea gravel
world map or globe
acetate sheet
overhead projector
teacher sheet (included)
three plastic-lined boxes
sphagnum moss (or rye grass seed)
three 1-liter plastic bottles or large spray bottles

BACKGROUND INFORMATION

When it rains or when snow thaws, the water in a river becomes muddy. The water is carrying sediment. Sediment is picked up by the water on its way over the land and through the stream channels. Water is in contact with the soil nearly everywhere. Some times and in some streams, the water carries more sediment than at other times or in other streams due to varying amounts of precipitation and varying land slopes. Sediment is a water supply problem because when water is to be used for municipal supply or for industry, sediment in it must be removed and disposed of.

Erosion is the carrying of soil from one place to another by water and wind. It is a natural process but people have accelerated its pace. Much erosion results from the removal of vegetation from the land. For example, forests can be completely removed to make room for farms or to harvest timber or firewood (people in many developing countries depend on wood for heat and cooking).

In developing countries, erosion is a growing problem because there is pressure to develop and people lack the knowledge and means to implement environmentally-sound agriculture practices. The resulting lack of vegetative cover (with spreading roots to help hold soil) increases the loss of topsoil by wind and water. To slow soil loss by wind erosion, farmers can put rows of trees — windbreaks — between their fields. Farming methods can prevent erosion. For example, plowing up and down a slope causes erosion. A better method, called contour farming, is to plow horizontally across the face of a slope. Another method is called terracing, in which a farmer builds a series of level plots in step-like fashion on the slope. Contour farming and terracing slow runoff and allow water to soak into the soil.

Across the world, topsoil is being lost at a yearly rate of up to 10 times the rate at which new soil forms.

<u>Terms</u>

contour farming: plowing horizontally across the face of a slope.

erosion: the wearing away of the earth's surface by running water, wind, ice, or other geological agents; processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is removed from the earth's surface.

sediment: insoluble material suspended in water that consists mainly of particles derived from rocks, soil, and organic materials; a major nonpoint source pollutant to which other pollutants may attach.

terracing: a series of level plots in step-like fashion on a slope.

topsoil: the rich upper layer of soil.

windbreak: rows of trees between fields to prevent loss of soil by wind.

ADVANCE PREPARATION

A. Prepare three plastic lined boxes ahead of time. (Empty soda boxes [that hold 24 cans] lined with plastic garbage bags work well.) Half fill each box with soil. (Use regular topsoil, not commercial potting soil.) These will be used by the students to demonstrate contour farming, windbreaks, and terracing as methods of erosion prevention.

B. Have enough sphagnum moss for each team to successfully complete its project. You may have the students sew rye grass seed if you wait about a week for it to sprout.

C. Make a transparency of the teacher sheet, "Soil Conservation." If this isn't practical, each team should have a copy for reference.

D. To demonstrate sediment, fill the quart (liter) jar with water and have the "sediment samples" (one handful each of pea gravel, sand, and soil) nearby. Your students may be able to see it better if you use a 3-liter bottle.

E. You will need to fill, or ask a student to fill, the three 1-liter bottles with water. Spray bottles of water are more efficient in the demonstrations and less messy, but are expensive and will need to be purchased if not available. (Suggestion: Have parents lend them from home. Wash them out carefully before letting the students use them.)

PROCEDURE

I. Setting the stage

A. Ask the students the following questions:

1. Where have you ever seen muddy water? (puddles, rivers, streets, etc.)

2. What do you believe causes the water to become muddy? (Soil washed into it.)

3. How would soil get washed into a water source? (rain, etc.)

B. Show the quart (liter) jar of water.

1. Explain that this jar represents one of the water sources they mentioned.

2. Explain that soil washed into the water is called sediment.

a. Put in the "sediment samples" as you explain this (the water will become muddy).

b. Shake it vigorously and set it down (the soil particles will begin to settle).

c. Observe that large particles settle first and finer particles settle slowly. Wait a few minutes to allow settling that is noticeable, then ask the students to describe the settling.

d. Note that the process of settling took place while the water was still.

e. Shake the jar again. Explain that in a moving stream, the motion of flow keeps stirring up the water and the sediment.

C. Ask the students the following questions:

1. In what ways would sediment in a flowing water source be good? (new fertile land like the Mississippi Delta or along the Nile River) Have the students point these places out on a world map or globe.

2. In what ways would sediment in a flowing water source be a problem? (drinking water, loss of depth in shipping and barge channels, flooding, clogging of streams, loss of fish and other aquatic life)

II. Activity

A. Divide the class into three teams.

B. Write the word "erosion" on the board. Define erosion as the transport of soil from one place to another by water and wind.

1. Ask the students what kinds of actions might result in erosion. (cutting away trees, farming, heavy rains, etc.)

2. Tell the students to think of the box of soil in their group as barren land.

3. Tell the students to blow on one end of the box to show how wind blows away the top layer.

a. Explain that the top layer of soil is called topsoil and is very important to grow vegetation.

b. Ask the students to brainstorm ways to prevent wind erosion.

4. Tell the students to have two people elevate one end of the box to represent a slope.

5. Tell each team to have one student SLOWLY and carefully pour or spray a little water from their bottle across the end (from left to right) to show water erosion. Ask the students to brainstorm ways to prevent water erosion.

C. Show the overhead transparency of the teacher sheet "Soil Conservation" (or pass out copies to each team). Explain the method used in each picture.

D. Assign one of the methods used to each team. (NOTE: You may take the students outside for this activity.)

1. Tell Team One to construct a windbreak across their field using the sphagnum moss.

2. Tell Team Two to construct patterns of contour farming using rows of sphagnum moss and tilting their box to demonstrate a slope.

3. Tell Team Three to build terraces with the soil and "plant" sphagnum moss on each one. (NOTE: The team may need to moisten the soil to perform this task.)

E. After each team completes its task, ask them to again blow across the "field" to simulate wind erosion. (NOTE: Team Three should blow from the top to the bottom of their terrace.)

F. Ask each team to SLOWLY and carefully pour water from their liter bottle to simulate water erosion. (NOTE: Team Three should pour water from the top to the bottom of their terrace.)

G. Observe the differences in runoff.

H. Ask each team to report on its results.

III. Follow-Up

A. Have the students demonstrate their knowledge of soil conservation by performing the following tasks.

1. Explain how water sources get muddy. (water erosion; open, bare fields; etc.)
2. Define sediment. (tiny bits of rocks, soil, and other materials washed into water sources)
3. Name some problems associated with sediment. (flooding, contaminated water supplies, etc.)
4. Define erosion. (the transport of soil from one place to another by water and wind)
5. Name three ways to prevent soil erosion. (windbreaks, contour farming, and terracing)

B. Have the students write a paragraph in which they tell of a terrible rainstorm and a community's resulting problems with muddy water. Tell them to choose one particular problem (e.g., bad taste, dirtying of laundry) that would occur and let them make up the source of the eroded soil and what could be done to stop the soil loss. (Review paragraphing with them first.)

IV. Extensions

A. Invite a soil conservation representative to discuss methods of preventing erosion.

B. Ask the students to draw pictures showing soil conservation and non-conservation farming methods.

C. Have the students research areas of their state where sedimentation in a water source has created problems and present their findings to the class.

D. Ask the students to find articles in magazines and newspapers concerning erosion, sediment, or soil conservation. Create a bulletin board with the articles.

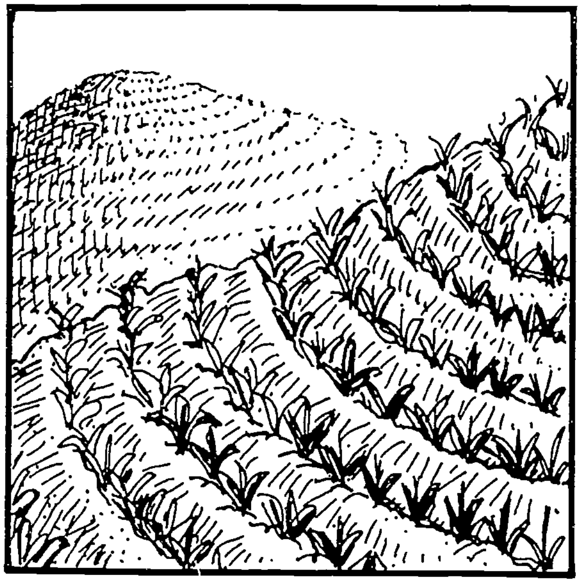
RESOURCES

Coher 'lichael R., Discover Science (Grade 3), Scott Foresman, Glenview, Illinois, 1991, pp. 214-215.

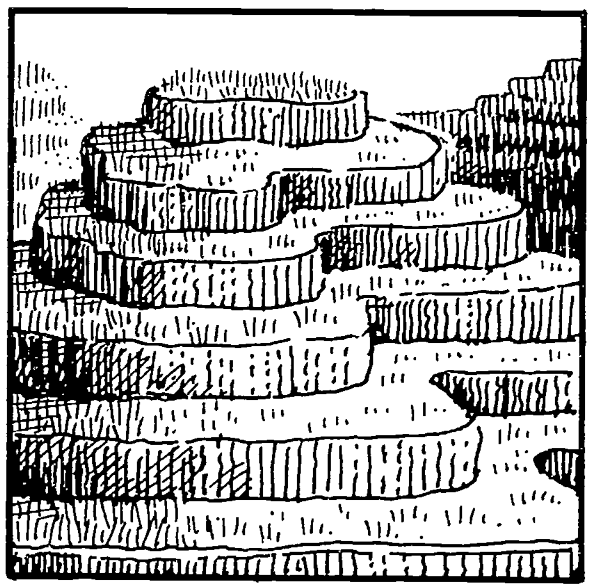
Hurd, Dean, General Science: A Voyage of Exploration (Grade 5), Prentice-Hall Publishers, Englewood Cliffs, New Jersey, 1989, pp. 536-539.

SOIL CONSERVATION

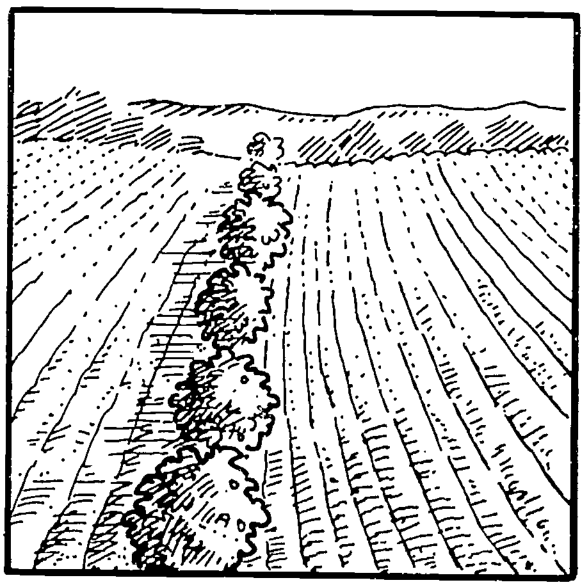
CONTOUR FARMING



TERRACING



WINDBREAK



WORKING TOGETHER TO PREVENT POLLUTION

OBJECTIVES

The student will do the following:

1. Distinguish between point source and nonpoint source pollution.
2. List ways to prevent nonpoint source pollution.
3. Sing a song about working together.

SUBJECTS:
Science, Music, Art

TIME:
90 minutes

MATERIALS:
posterboard (one per group)
old magazines
scissors
glue
markers
crayons
teacher sheet (included)
acetate sheet
overhead projector
student sheet (included)

BACKGROUND INFORMATION

The sources of pollutants that cause water pollution vary. In some cases, pollutants may come from a pipe discharging into a river, from a boat, irrigation ditch, underground storage tank, or other single source, called a "point source" of pollution. But frequently they are varied sources, collectively called "nonpoint sources," that could include pollutants from industries, agriculture, and other human activities.

Point source problems are the easiest to correct. Their causes — wastewater emptied into bodies of water through pipes — can be dealt with directly. Additional treatment can be required, water conservation programs can be started, or other measures can be used to prevent water quality problems.

Nonpoint source problems are more difficult to fix. They result when rain from your lawn, city streets, parking lots, and barnyards runs off into lakes and streams. This runoff may contain oil, fertilizers, antifreeze, pesticides, bacteria, and other substances harmful to water quality. Another type of nonpoint source pollution is erosion of soil from farm lands, construction sites, and stream banks.

Fixing nonpoint source problems usually requires a great deal of cooperation. Communities, farmers, homeowners, forest managers, developers, and companies —all of us— must all take better care of the land to reduce nonpoint source pollution.

Terms

conservation: preserving from loss, waste, or harm.

contaminant: an impurity that causes air, soil, or water to be harmful to human health or the environment.

erosion: the wearing away of the earth's surface by running water, wind, ice, or other geological agents; processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is removed from the earth's surface.

fertilizer: any one of a large number of natural or synthetic materials, including manure and nitrogen, phosphorous, and potassium compounds, spread or worked into the soil to increase its fertility.

nonpoint source pollution (NPS): pollution that cannot be traced to a single point, because it comes from many individual places or a widespread area (e.g., urban and agricultural runoff).

point source pollution: pollution that can be traced to a single point, such as a pipe or culvert (e.g., industrial and wastewater treatment plant discharges).

pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

pollution: contaminants in the air, water, or soil that cause harm to human health or the environment.

ADVANCE PREPARATION

A. Gather needed materials. Use travel, outdoor sports, and home and garden magazines for the most appropriate pictures.

B. Make a transparency of the teacher sheet.

C. Copy the student sheet for distribution.

PROCEDURE

I. Setting the stage

A. Begin by asking the students what water pollution is. Help them clarify their definition.

B. Ask them whose fault water pollution is. Discuss the issue of responsibility with them.

C. Tell the students that protecting water quality and controlling pollution is everybody's business! The Clean Water Act gives states the authority to control pollution sources, but each of us must share in the responsibility.

II. Activity

A. Write "point source pollution" and "nonpoint source pollution" on the board. Can the students guess what these mean?

1. Give the students the definition of each term.

2. Ask them to give examples of each one.

3. Ask them which kind of water pollution they would be most likely to cause by their own actions. (nonpoint source) Have them identify some ways they might prevent this. (e.g., not littering, using the right amount of fertilizer and bug spray)

B. Have the students complete the exercise on the teacher sheet "Point or Nonpoint?" (use it as a transparency). These answers are 1.P, 2.N, 3.N, 4.P, 5.N.

C. Give each student a copy of the mini-poster "Do What You Can Do." Discuss it with them. Let the students decorate the sheet. Have them take it home to their families.

III Follow-Up

A. Have the students work in teams of three or four. Supply them with posterboard, scissors, glue, old magazines, and markers. Each team should prepare a poster display on ways to reduce nonpoint source pollution. Suggest collages of applicable photos and words. Have the teams share their posters. Hang them in local libraries, sporting goods shops, and community centers.

B. Have the students sing the following to the tune of "The More We Get Together."

The more we work together, together, together,
The more we work together, the happier we'll be.
For your lake is my lake and my lake is your lake.
The more we work together, the cleaner it will be.

IV. Extensions

A. Take a field trip to your local lake or river. If there is a dam there, arrange to have someone give your class a guided tour. Have the students ask pre-prepared questions about point source and nonpoint source pollution.

B. Have the students make up more verses to the song. Suggest they use local water bodies and point/nonpoint differentiation in their lyrics.

RESOURCES

Gay, K., Water Pollution, Franklin Watts, New York, 1990.

"Your Lake is Unique," RiverPulse, Tennessee Valley Authority, Water Resources Division, July 1992.

POINT OR NONPOINT

Identify the following as point sources or nonpoint sources of water pollution. Write "P" or "N" in the blanks

1. Leaking underground storage tank _____
2. Neighborhood yards to which weed killer has been applied _____
3. Farmlands to which fertilizer has been applied _____
4. Factory with wastewater discharge pipe _____
5. All the town's construction sites _____

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DO WHAT YOU CAN DO

1 Learn as much as you can about your lake or river. Become informed about the conditions there. Ask he state agencies responsible for managing water quality and fisheries.

2 Share your concern about our lakes and streams with others—friends, parents, neighbors, and elected representatives. Join forces to protect and improve water quality by joining a lake association in your area. The North American Lake Management Society can help you start one if there is not a lake association in your area. Write to them at: NALMS, 1 Progress Boulevard, Box 27, Alachua, FL 32615.

3 Take action. Set an example for your friends. Help your family learn about best management practices and apply them in managing their land. Avoid over-fertilizing your lawn. Have your septic tank pumped out occasionally to keep the field lines from clogging and failing. Fence livestock out of streams and properly manage animal wastes. Encourage other relatives to do their part in

WATER-WISE LANDSCAPING

OBJECTIVES

The student will do the following:

1. Use the telephone book to find the phone number and invite a guest speaker.
2. Develop interviewing techniques.
3. Read rainfall and seed package maps to compare climate conditions.
4. State the definition of xeriscaping.

SUBJECTS:
Science, Social Studies, Language Arts, Art

TIME:
2 - 4 hours

MATERIALS:
U.S. wall map
reference books
acetate sheets
several telephone books
teacher sheets (included)

BACKGROUND INFORMATION

Xeriscape ("zeer uh scape") is a word coined in 1981. It is so new that it probably is not in a dictionary. "Xeros" is a Greek word meaning "dry." The word "xeriscape" means landscaping that reduces the need for water. This is important because people use so much water to water their lawns, trees, gardens, and ornamental plants such as shrubs and flowers. More than 40 states in the U.S. now have xeriscaping programs.

All plants need water, but different plants have differing requirements for it. For example, houseplant owners know that their potted plants will not thrive (or maybe even survive) if they water them with equal amounts on a set schedule (e.g., once a week). Of course there are many reasons this is true, but one of the main reasons is that different kinds of plants have different needs. The same is true for outdoor plants with which we landscape our houses, schools, and other buildings.

Considering that we often use utility water (for which we pay) to water our landscapes, it makes sense both practically and economically to choose plants that are adapted to our locales' normal rainfall and temperature ranges. In arid areas, it is very important that people not use too much water for landscapes filled with thirsty shrubbery, lawns, and flowers. In those areas, it is especially important that landscapers choose plants that thrive without a lot of watering.

<u>Term</u>

xeriscape: a way of landscaping that reduces the need for water.

ADVANCE PREPARATION

A. Make transparencies from the teacher sheets.

B. Collect enough telephone books so that each team of four has one.

C. Ask your librarian to pull library books with pictures of trees, shrubs, and flowers for a small class library. (NOTE: You may also make use of colorful seed/plant catalogs.)

PROCEDURE

I. Setting the stage

A. Ask the students to list things plants need to live. (water, air, nutrients from soil, sunlight) Write their responses on the board.

B. Ask them how plants get the water they need. (rain, or someone "waters")

C. Tell the students they are going to investigate using plants that do not require much watering.

II. Activities

A. Show the students a transparency of the teacher sheet showing six different species of plants and ask where these plants might grow best.

1. Let the students match the plants with the regions listed on the transparency.

2. The answers are:

Cypress-	Southeastern U.S. (coast)
Cactus-	Southwestern U.S. (desert)
Palm-	Florida & Southern California
Birch-	Northeastern U.S.
Sassafras-	Eastern U.S.
Giant Redwood-	Northern California

3. Let the students locate the areas on a large wall map.

B. Show the students the transparency of the annual average rainfall in the continental United States. Compare major areas of the country. Discuss how climate (including rainfall and temperature ranges) affects the plant species native to any region.

C. Have the students look through the library books (and/or seed catalogs) to find a favorite (1) flower, (2) shrub, and (3) tree that they would like to put in their yards. (NOTE: If a student does not have a yard, substitute the schoolyard or a city park.) They should write the names of these plants on a sheet of paper and make a sketch of each of them.

D. Divide the students into teams of four. Have each team use the telephone book to find the phone number for the County Agricultural Extension Agent. Have one student call and invite your County Extension Agent to come to your school for about 1-1/2 hours. (Set the date and time beforehand.) Be sure the student communicates to the agent that you are studying xeriscaping. (NOTE: Follow up with your own call to the agent.)

E. As a homework assignment, have the students watch the news and pay special attention to a newscaster interviewing someone. The next day discuss good interviewing techniques.

F. Let the class decide on the logistics of how they can efficiently and effectively interview their County Extension Agent. (For example, they might have 3 x 5 cards listing their questions.)

G. Have an interview session with the County Extension Agent. Be very clear that he/she needs to advise students as to whether their favorite flowers, shrubs, and trees will require too much or receive too much water to grow well in your area. (Don't plant a cactus in Seattle or impatiens in Arizona.)

III. Follow-Up

A. Have the students write in their own words what "xeriscaping" means.

B. Have the students take a tour of the school grounds to evaluate the landscaping. Then have them design an improved landscape for your school. You might have them present this to the principal or the parent-teacher organization.

IV. Extensions

A. "Xeriscaping" is a very new word. Investigate other new words in our language. Talk about how language changes over time.

B. Read the Paul Bunyan story, "Why There Are No Trees on the Desert."

C. Invite a landscaper, horticulturist, or landscape architect to talk to your class about his/her job, plants native to your area, or some other topic related to landscaping.

RESOURCES

Electronic Geosafari Geography Game, "Biomes card," Educational Insights, Dominguez Hills, California.

Rounds, Glen, "Why There Are No Trees on the Desert," Ol' Paul, The Mighty Logger, Cadmus Books, Milwaukee, Wisconsin, 1949.

Wade, Gary, et al., Xeriscape - A Guide to Developing a Water-Wise Landscape, Cooperative Extension Service, College of Agriculture and Environmental Services, University of Georgia, Athens, Georgia.

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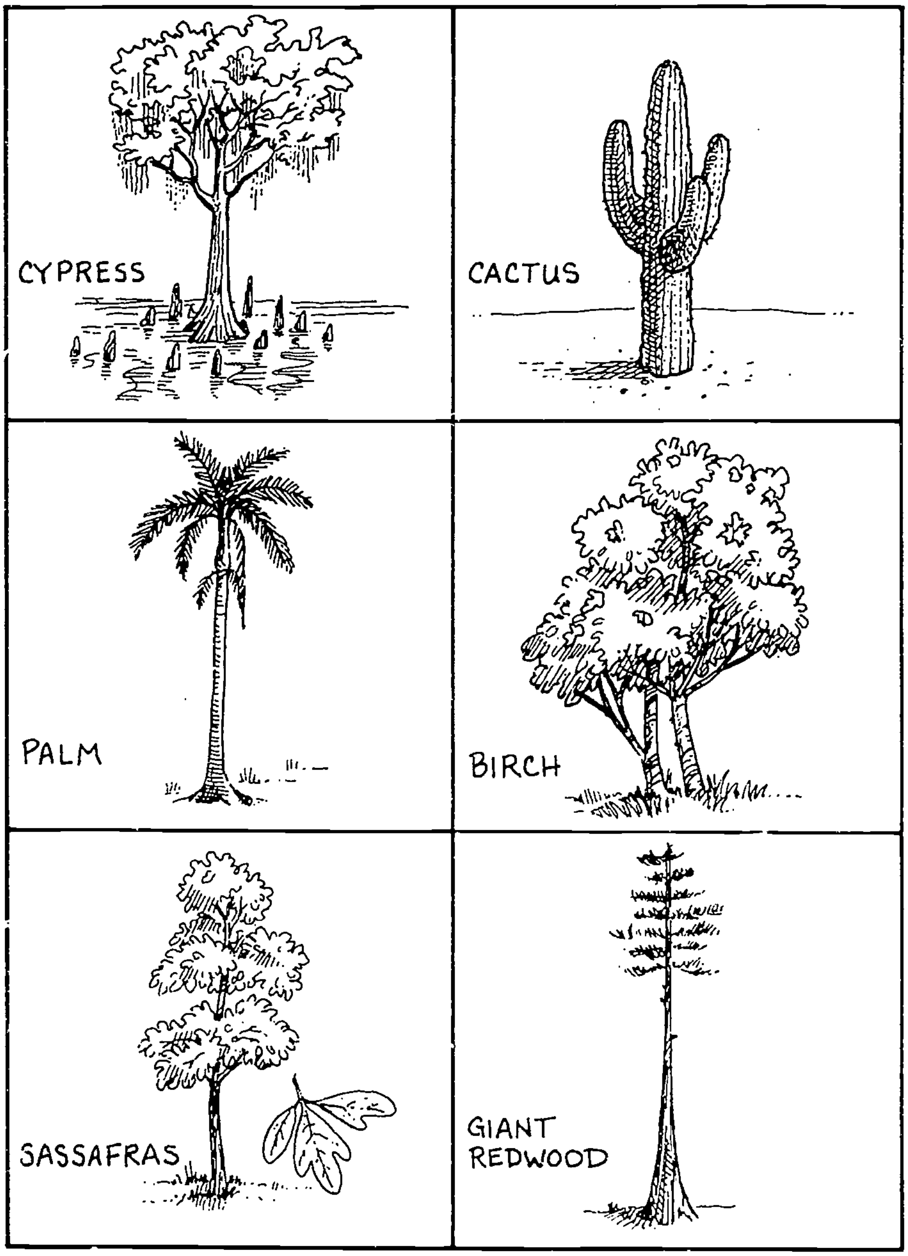
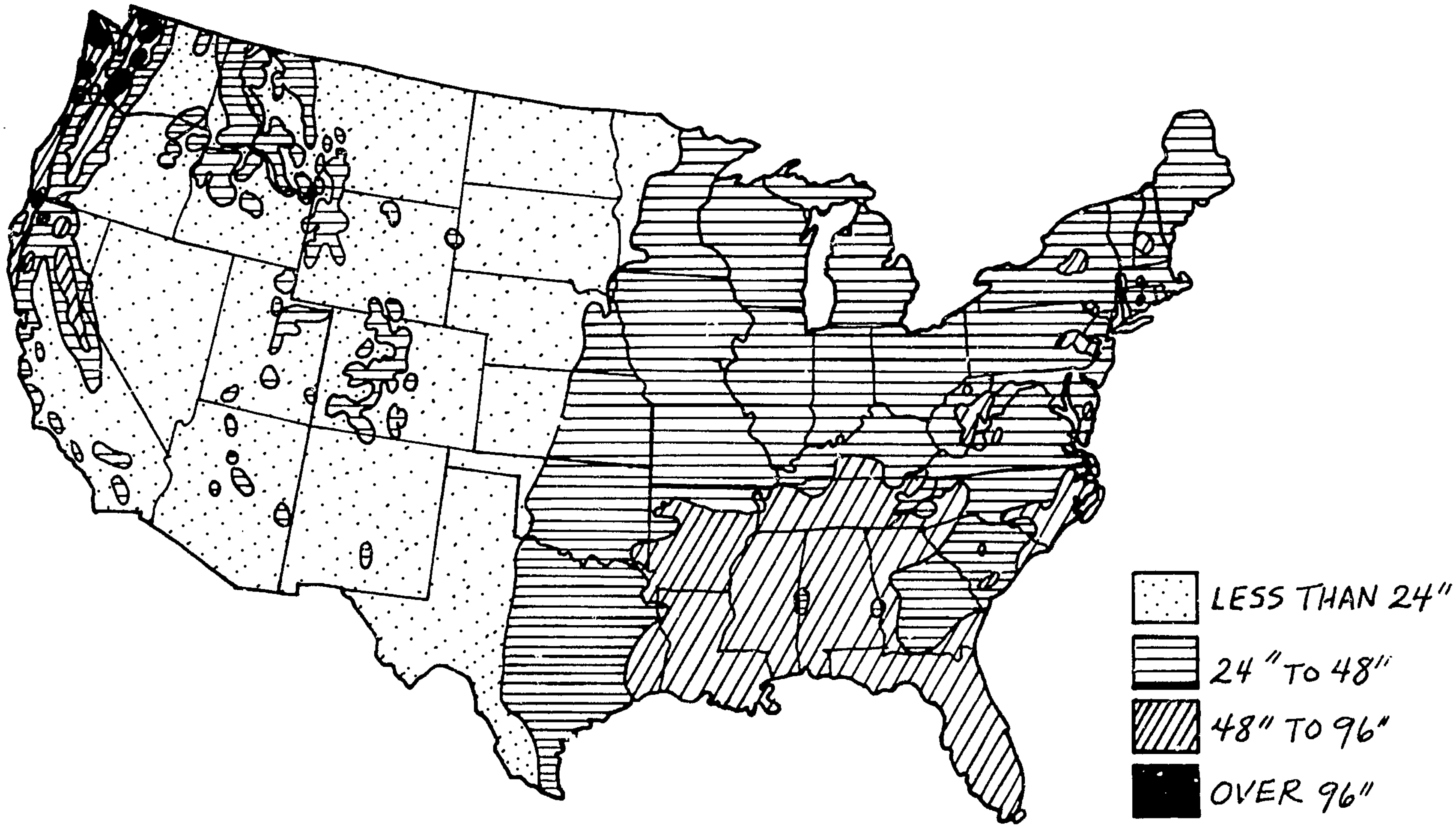
WHERE DOES THIS GROW BEST?

Match these kinds of plants with the region in which they grow best.



Northern California	Southeastern U.S. (coast)	Florida & Southern California
Eastern U.S.	Northeastern U.S.	Southwestern U.S. (desert)

RAINFALL MAP



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WHOSE WATER IS IT?

OBJECTIVES

The student will do the following:

1. Understand that sometimes it is very difficult to determine what is "fair."
2. Role play holding various viewpoints on an issue.
3. Recognize and state how valuable water is when it is scarce and how this causes social problems.

SUBJECT:
Geography, Social Studies

TIME:
90-120 minutes

MATERIALS:
small pitcher of cold water
one small cup per student
symbols representing each group (e.g., cowboy hats for ranchers, headdress for Indians; optional)
western states map
highlighter
teacher sheet (included)
acetate sheet
overhead projector
butcher paper
markers
pan (optional)
water (optional)
10-25 pounds of non-hardening clay (optional)

BACKGROUND INFORMATION

Seven states are drained by the Colorado River. This means that all the rainwater runoff and naturally occurring springs drain eventually to the Colorado River. The Upper Colorado Basin lies in Utah, Wyoming, Colorado, and New Mexico. The Lower Basin lies in California, Nevada, and Arizona. The Colorado River's source is in Rocky Mountain National Park, Colorado. It flows 1,450 miles into the Gulf of California.

Demand for water from the river is high in the dry Southwest. Cities like Las Vegas, Phoenix, Tucson, Palm Springs, and San Diego use water from the Colorado River; it comes through canals or aqueducts, some of which are hundreds of miles long. Agricultural lands have been developed in Southern California and Arizona, where desert once lay, using water diverted from the Colorado River. In addition to these demands there are many ranchers and others who need the river's water. Native American tribal groups claim some of the water for use in their fields and in their communities. By the time the Colorado River gets to Mexico, its flow is a mere fraction of what it otherwise would be; as you might expect, Mexican government officials and farmers are not pleased with this.

There is considerable controversy over who should be able to divert this water and in what amounts. It is very complicated because the issue involves a number of states, two nations, Native Americans, and many other groups (like farmers and ranchers) – not to mention large cities.

Terms

drought: a long period without rain

outflow: where a river flows out to a larger body of water (usually an ocean or sea).

Riparian Rights: water law or doctrine that authorizes the use of water in a stream or river based on ownership of the land adjacent to the river.

source: where a river begins (usually high in mountains).

ADVANCE PREPARATION

A. Obtain a map of the western states. (If you are a member of the American Automobile Association [AAA], you can get some free.)

B. Collect some symbols (Native American headdress, cowboy hat, etc.) to place on groups of desks to indicate where groups will sit.

C. Make a transparency of the teacher page.

D. Prepare a pitcher of cold water just before the lesson.

PROCEDURE

I. Setting the stage

A. After recess when the students are thirsty, distribute a small paper cup to each student. Have on hand a pitcher of cold water. Call on the first row of students to come to the front and drink as many small cups of cold water as they want. If there's any left, call the next row. (NOTE: See how long it takes before someone speaks up about the "unfairness" of this scenario.) After the point has been made, then let the other students get their drinks.

B. First have the students find the Colorado River from source to outflow on a U.S. map or western states map. Use a highlighter to mark the Colorado River. Then ask them what states and cities it goes through. Ask, "Who do you suppose owns that water?" (Encourage lots of discussion.) Now use the transparency on the overhead projector and show them the dams and canals. Discuss what cities the water goes to (especially San Diego and Tucson, a long way away).

II. Activity

A. Role Playing - Divide the class up into groups by drawing names. Groups are: Native Americans (the first ones there), farmers, ranchers, city landscapers, homeowners, environmentalists, recreation enthusiasts, and Mexican citizens.

1. Have them work in their groups to find as many uses for water as they can for the group they are in. Begin by brainstorming. Older students may use reference material from the library (or copies of the magazine articles in the resource section). (Note that the long article is from National Geographic; most libraries have this resource.)

2. Now have the class make a bulletin board. Use an overhead projector to enlarge the teacher sheet of the Colorado River or just hand copy the teacher sheet on the bulletin board. Have each group draw a symbol to locate where they live along the river. (Some groups live all along the river and therefore may make many symbols along the course of the river.)

3. Have them write slogans, make posters/banners, write a speech/advertisement/public service announcement for their needs for the water.

4. Let each group present its most important needs (suggest 3-5 needs).

B. The students will have a mini-debate. Divide the class in half. Explain that they will be role playing for a few minutes. One group will be the "selfish" group at the upper end of the river. The other group will be the "deprived" group that lives far downstream on the Colorado River. Let each group get together to develop its arguments about its need for water. Each group needs to elect a spokesperson. Remind them again that they are role playing. Let them have a mini-debate over the use of the Colorado River. When they finish, tell them they are through role playing. Each student gets to vote according to how he/she "really" feels. Let the students decide what they will vote on and how to organize the election.

III. Follow-Up

A. Have a discussion on what happened to them as groups. What were their feelings? What about the need for informed decisions? What about laws? What's fair?

B. Have each student write a paragraph on the most fair solution to the problem of allocating the river's water.

IV. Extension

Make a model of the Colorado River using non-hardening clay and water in a plastic pan. Mark off the states with a pencil point and the river with your finger. Indicate where each group lives.

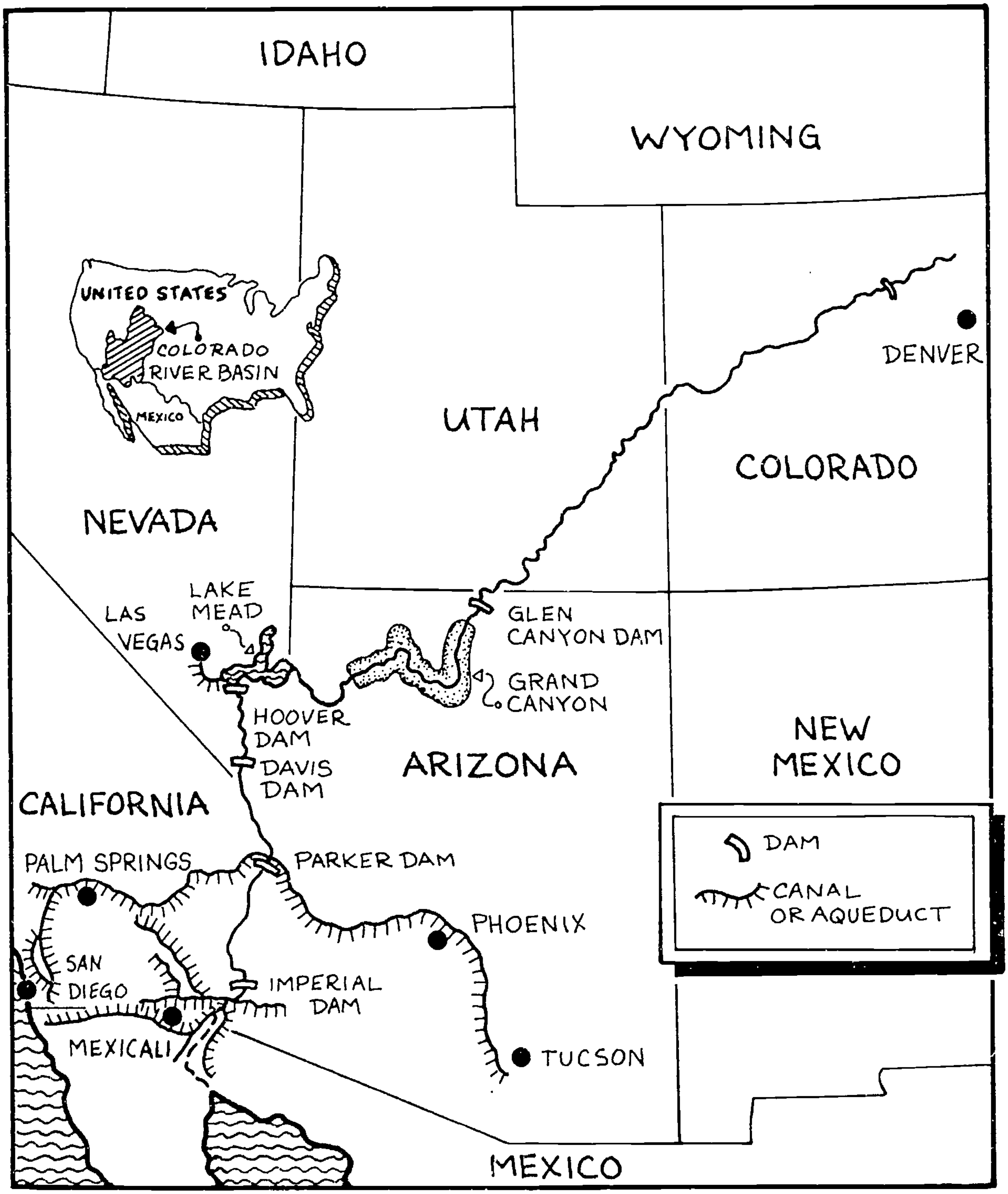
RESOURCES

Carrier, Jim, "The Colorado - A River Drained Dry," National Geographic, Washington, DC, June 1991, pp 2-35.

Gray, Paul, "A Fight Over Liquid Gold," Time, July 22, 1991, Vol. 138, #3, pp 20-26.

Speidel, Ruedisili, and Agnew, eds., Perspectives on Water Uses and Abuses, Oxford University Press, New York, 1988.

THE COLORADO RIVER



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POLLUTION PETE PATROL

OBJECTIVES

The student will do the following:

1. Brainstorm recreational uses of surface water.
2. Be aware that federal laws prohibit the dumping of garbage and pollutants into surface water.
3. Simulate the impact of recreational pollutants on surface water.

SUBJECTS:
Science, Art, Social Studies

TIME:
2 50-minute periods

Materials:
drawing paper
crayons or colored markers
10-gallon (40 L) aquarium
pump from liquid soap bottle
plastic caps from soda bottles
plastic 6-pack rings
plastic bags
scissors
glue stick
vegetable oil
used coffee grounds
small toy boat
rubber gloves
fish hooks
fishing line
foods (such as crackers, chips, bread)
milk carton [washed out] from the cafeteria)
posterboard
student sheet (included)
teacher sheets (included)

BACKGROUND INFORMATION

All forms of recreation on and around surface waters have the potential for polluting the water. Houseboats pollute with human sewage wastes; boats pollute with garbage, motor oil, and gasoline; boat docks with human wastes, motor oil, and gasoline; boat launching pads and parking areas with run-off oils and gas; campsites with wastewater, garbage, human wastes, and erosion; and swimming with human wastes.

Polluting our waters is against several federal and international laws. The Refuse Act of 1899 prohibits the throwing, discharging, or depositing of any refuse matter of any kind (including trash, garbage, oil, or any other liquid pollutants) into the waters of the U.S. The Federal Water Pollution Control Act prohibits the discharge of hazardous substances or oils into U.S. navigable waters. The MARPOL Annex V international law restricts overboard dumping of garbage. The U.S. law of Annex V prohibits the dumping of plastic trash and limits the overboard dumping of other garbage.

If you witness a boat discharging oil or hazardous substances into the water (or if yours does) you must notify the U.S. Coast Guard. You must give this information: (1) location, (2) source, (3) size, (4) color, (5) substance, and (6) time observed.

All recreational boats with toilet facilities must have a working marine sanitation device (MSD) on board. The Coast Guard must certify all installed MSDs.

Terms

contaminant: an impurity that causes air, soil, or water to be harmful to human health or the environment.

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pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

recreation: any activity, sport, or hobby that refreshes your mind and body.

ADVANCE PREPARATION

A. Secure a 10-gallon (40 L) aquarium the day before the lesson is taught (may borrow one from a parent) and fill it half full with water.

B. Collect the following items several days before the lesson: pump from a liquid soap bottle, plastic caps from soda bottles, plastic six-pack rings, plastic bags, vegetable oil, used coffee grounds, small toy boat, fish hooks, fishing line, foods (such as crackers, chips, bread), milk carton (washed out) from the cafeteria.

C. Make a copy of the student sheet "Pollution Pete Patrol" for each student.

D. Mix the used coffee grounds with water and put the mixture in the milk carton (only fill 1/3 to 1/2 full so it will float). Seal the end and make a small round hole, with a pencil, in the side of the milk carton to insert the hand soap pump into.

PROCEDURE

I. Setting the stage

A. Lead the students in a brainstorming session on the recreational uses of surface water.

1. List the student examples on the board. (Examples, swimming, fishing, boating, camping, etc.)

2. Add to the list if needed or limit the list if needed. (NOTE: See teacher sheet "Overboard.")

3. Conduct a survey of the class to determine how many students participate in the listed recreational activities. Graph the results.

B. Have the students create a picture showing as many of the listed activities as they enjoy doing. Give each a sheet of drawing paper.

C. Lead a discussion on how each of the listed activities can pollute surface waters. (Note: See teacher sheet "Overboard" for examples.)

1. After the discussion the students will examine their recreation drawings to identify possible sources of pollution.

2. Give each student a copy of the student sheet "Pollution Pete Patrol." Let them color the "Pete" symbols.

3. The students will mark the possible pollution sources in their drawings by gluing a cut-out "Pollution Pete" symbol beside the possible pollution sources.

4. Post the drawings around the classroom.

II. Activity

A. Set the half-filled aquarium on a table in front of the class. Explain that the aquarium represents a lake (or other body of surface water). (NOTE: See the teacher sheet "Recreational Pollutants Demonstration.")

1. Ask individual students to name pollution sources they depicted in their drawings.

a. As each student reveals his/her pollution sources, simulate the pollution by adding representatives of the pollution to the aquarium. (NOTE: You might wear rubber gloves.)

b. Continue the process until each student has revealed his or her pollution sources. (NOTE: Repetitive naming of sources will only heighten the visual impact of the activity.)

c. Allow the students to come to the aquarium and observe and smell the water.

B. Ask the students how many of them would like to use this lake for their recreation fun.

1. Ask the students the following questions:

a. What can we do about this pollution?

b. Are there any laws against polluting?

c. What should you do if you see someone polluting the lake?

2. Explain the Refuse Act of 1899, the Federal Water Pollution Control Act and the MARPOL Annex V international law to the students. (NOTE: Use the teacher sheet "Recreational Pollutants Demonstration" for this information.)

C. To extend the student's thinking beyond pollution to the cleaning up of polluted waters, let the students plan some ways to attempt to clean it up.

D. When you are through with your lesson, remove all the solid trash from the aquarium. Throw away what you cannot recycle. The liquid may be discarded down the drain or toilet (try to decant it off the coffee grounds, leaving them in the bottom). Scrape the coffee grounds out. Compost them if possible; if not, put them in the trash. Clean the aquarium with a biodegradable cleanser.

III. Follow-Up

A. Have the students make posters on the theme of "Stopping Recreation Pollution with Pollution Pete." Encourage the students to come up with catchy slogans for their posters.

B. Ask community businesses—especially sporting goods shops, boat shops, marinas, and campgrounds—to display the finished posters.

IV. Extensions

A. Contact a local wildlife, fisheries, or forestry officer to come and talk to your class about recreational pollution.

B. Create pledge cards to join Pollution Pete's Patrol. Have students "join" the patrol and check the community for any recreational pollution.

C. Invite a newspaper representative to class to see and hear about what the Pollution Pete Patrol is doing to help stop recreational pollution. Have pictures taken of the posters for inclusion in the newspaper.

D. Make a study of how pollution affects wildlife. Look carefully at how plastic trash (especially 6-pack rings and plastic bags) affects water-dwelling creatures. For example, birds and marine mammals get plastic rings around their beaks or necks, which causes choking and/or starving. Some animals ingest plastic, which stops up their intestines and starves them.

RESOURCES

Federal Requirements for Recreational Boats, United States Coast Guard, U.S. Department of Transportation.

Kathryn O'Hara/CMC, "Tossing This Trash Overboard Could Leave Death in Your Wake," S & S Graphics, Inc., May 1991.

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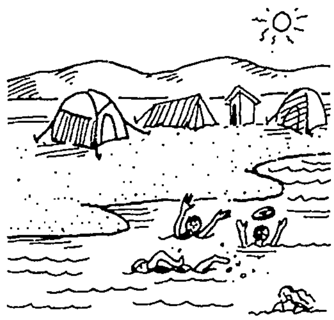
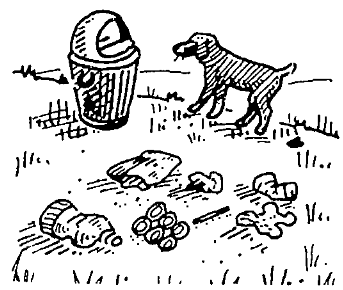
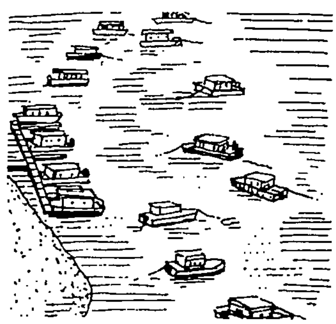
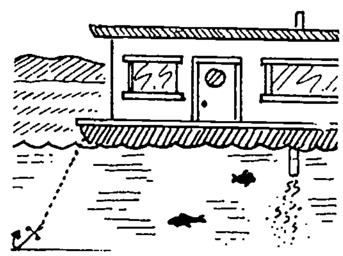
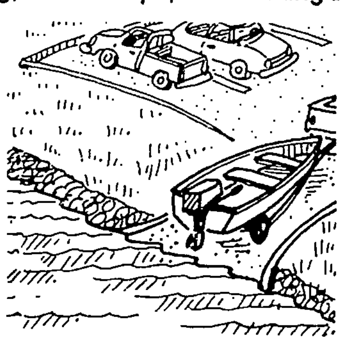
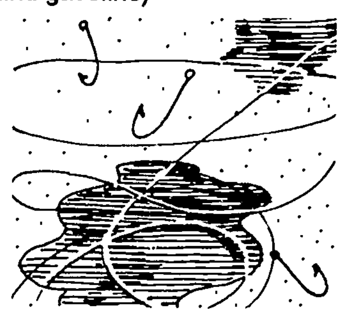
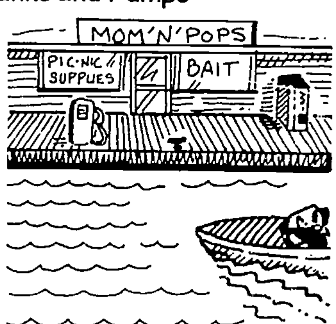
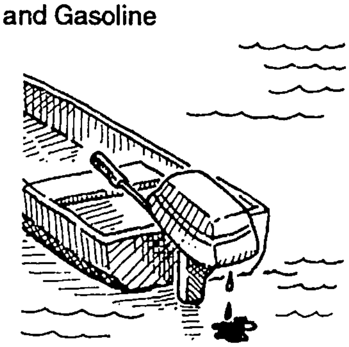
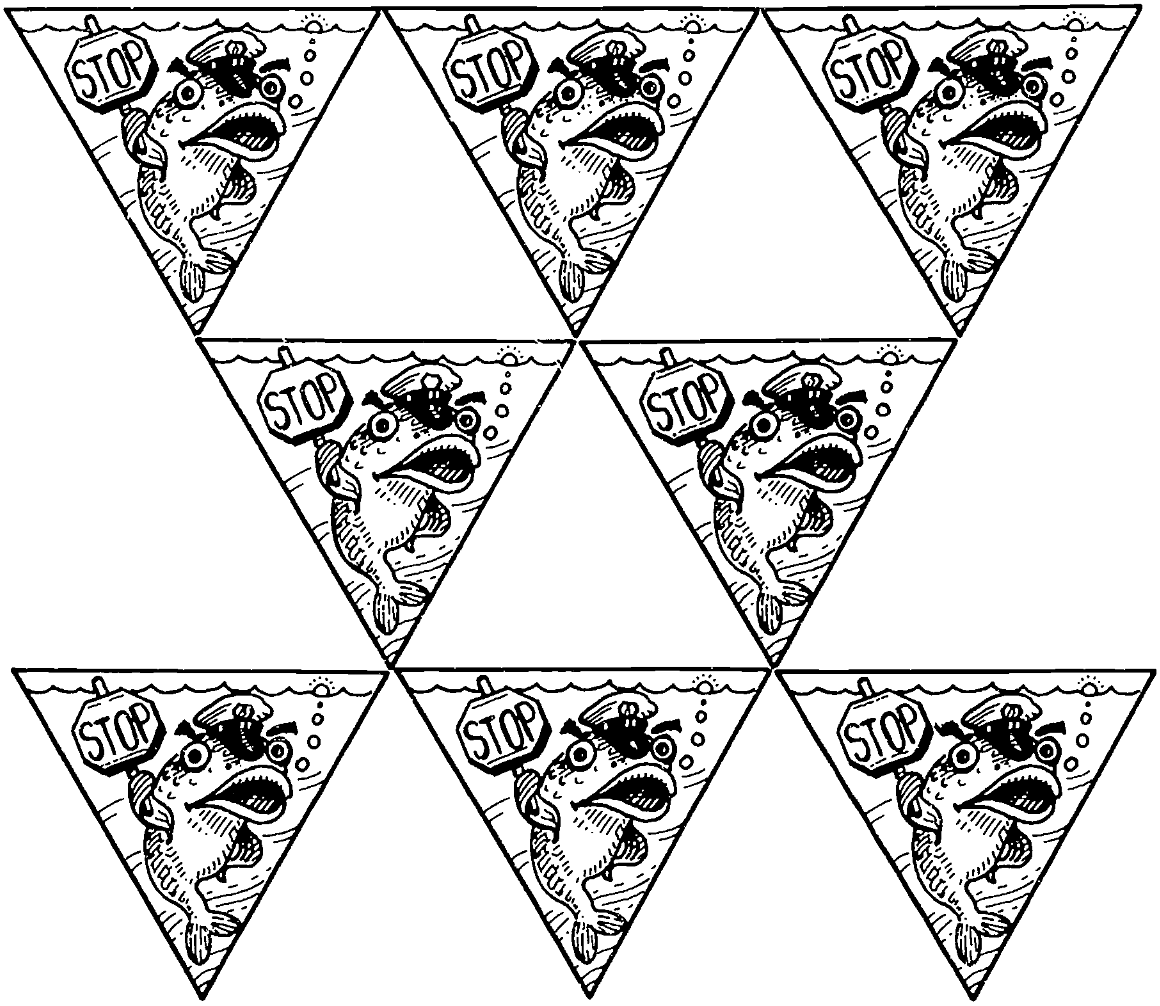
OVERBOARD

Recreational Uses of Water	Recreational Pollutants
Camping, Swimming, and Picnicking 	Litter (plastic bottles, cans, 6-pack rings, plastic bags, and pet waste) 
Houseboats 	Litter and Wastewater (human wastes) 
Boating, Boat Ramps, and Parking Lots 	Litter and Waste (fishing hooks, fishing line, oil, and gasoline) 
Gas Tanks and Pumps 	Oil and Gasoline 

POLLUTION PETE PATROL

Hi! I'm Pollution Pete! I'm here to help you stop Recreational Pollution!

Look at your recreation drawing and find the things that could cause pollution of your lake or river. Cut out my symbol and glue it beside the possible pollution sources.



RECREATIONAL POLLUTANTS DEMONSTRATION

1. Mix used coffee grounds with water and pour into a milk carton, filling it 1/3 to 1/2 full; it will still float. Poke a hole in the side of the carton with a pencil to insert the liquid soap pump into it. With the coffee grounds inside and the pump installed, float the "bilge model" in the aquarium. For each mention of the human waste pollutant sources, pump a small amount of the mixture into the water.

2. Pour a small amount of the vegetable oil into the plastic toy boat and float it in the aquarium. With each mention of oil and gas from boats, tip the boat and allow some "pollutant" to leak out.

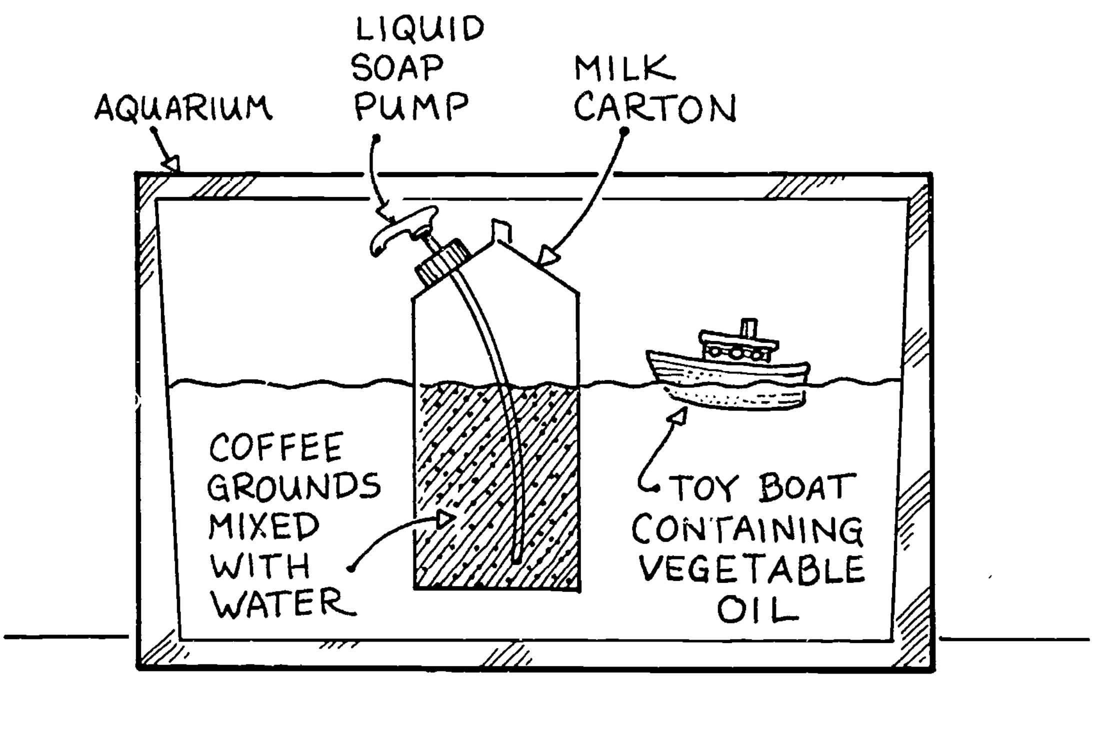
3. Add other items as the listed pollutants are mentioned.

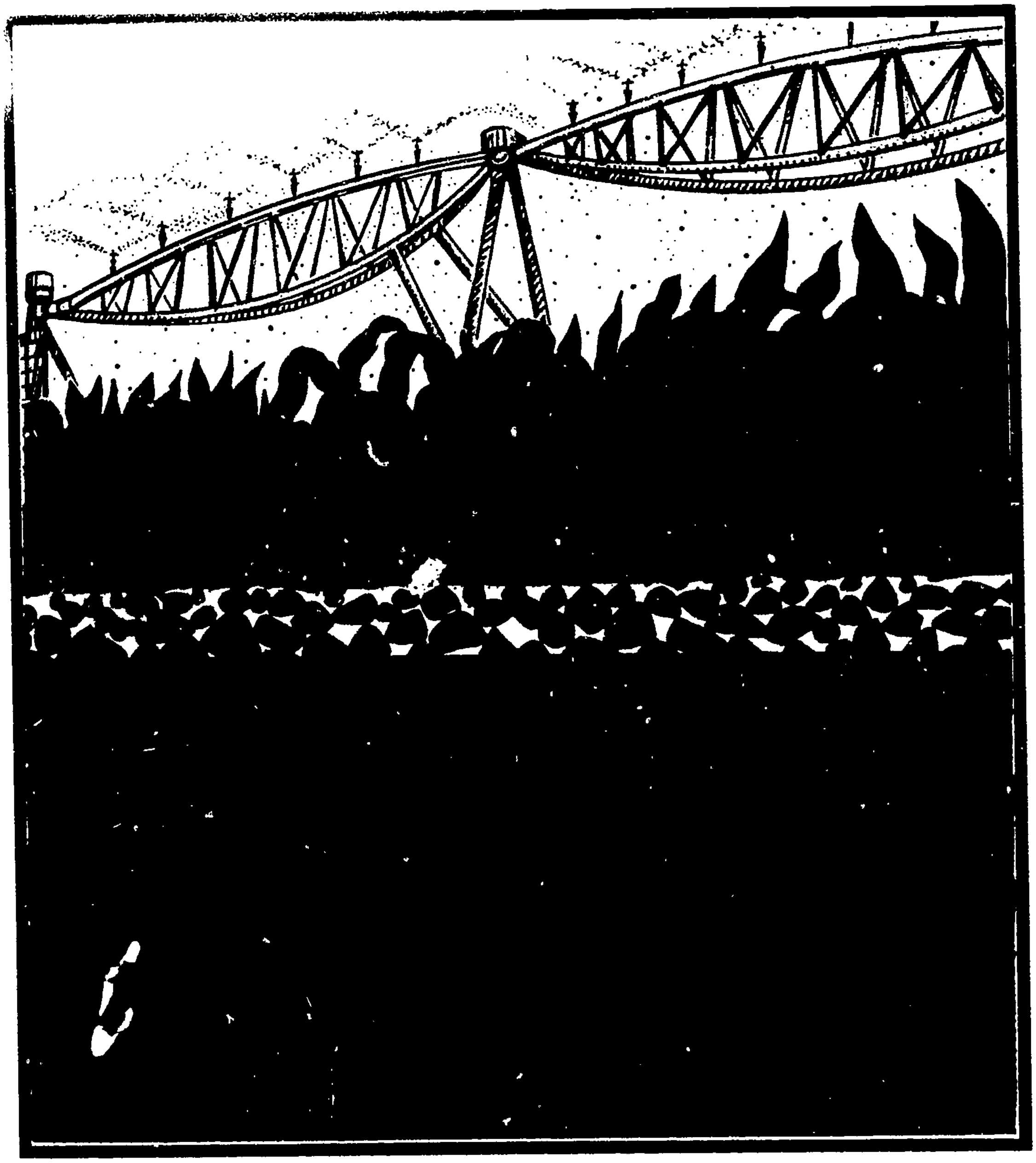
4. As more students reveal their possible sources of pollution, add more representatives of that pollution to the aquarium. Keep adding as many times as needed. Repetition will give a stronger impact.

What the laws say:

The Refuse Act of 1899 prohibits the throwing, discharging, or depositing of any refuse matter of any kind (including trash, garbage, oil, or any other liquid pollutants) into the waters of the U.S. The Federal Water Pollution Control Act prohibits the discharge of hazardous substances or oils into U.S. navigable waters. The MARPOL Annex V international law restricts overboard dumping of garbage. The U.S. law of Annex V prohibits the dumping of trash and limits the overboard dumping of other garbage.

If you witness a discharge or your boat discharges oil or hazardous substances into the water, you must notify the U.S. Coast Guard. You must give the following information: (1) location, (2) source, (3) size, (4) color, (5) substances, and (6) time observed.





THE WATER SOURCEBOOK

GROUNDWATER

GROUNDWATER

AQUIFER ADVENTURE

OBJECTIVES

The student will do the following:

1. Observe and/or use several simple aquifer models.
2. Locate areas of major aquifers on a U.S. map and name states.
3. Infer the meaning of terms based on the Latin root word "aqua."

SUBJECTS:
Science, Social Studies, Language Arts

TIME:
90-120 minutes

MATERIALS:
acetate sheets
overhead projector
wipe-off transparency pens
U.S. map
clear plastic cups (1 per student)
drinking straws (1 per student)
chipped ice
lemonade or juice drink
clear glass bowl
aquarium gravel
modeling clay
water
jar or bottle
blue food coloring
pump (from liquid soap bottle)
teacher sheets (included)

BACKGROUND INFORMATION

An aquifer is an underground layer of rock or soil that holds the water that we call groundwater. The word "aquifer" is derived from the Latin "aqua," meaning "water," and "fer," meaning "to yield." The ability of a geological formation to yield water depends on two factors—porosity and permeability. Porosity is determined by how much water the soil or rock can hold in the spaces between its particles (as with a sponge). Permeability means how interconnected the spaces are so that water can flow freely between them.

There are two types of aquifers. One is a confined aquifer, in which a water supply is sandwiched between two impermeable layers (geological formations through which water cannot pass). These are sometimes called artesian aquifers because when a well is drilled into this layer, the pressure is so great that water may spurt to the surface without being pumped. This is an artesian well. The other type of aquifer is the unconfined aquifer, which has an impermeable layer (or one of lower permeability) under but not above it. It is the most common type.

Aquifers may be categorized according to the kind of material of which they are made. A consolidated aquifer is composed of a rock formation (that is porous or fractured). An unconsolidated aquifer is composed of a buried layer of sandy, gravelly, or soil-like material.

The top surface of the groundwater is called the water table. The water table depth varies from area to area and fluctuates (rises and falls) due to seasonal changes and varying amounts of precipitation. Excessive pumping from the aquifer can also lower the water table.

Perhaps the largest aquifer in the world is the Ogallala aquifer located in the Midwestern part of the United States. This aquifer is named after a Sioux Indian tribe. It is estimated to be more than two million years old and to hold about 650 trillion gallons (2,500 trillion liters)! It underlies parts of 8 states, stretching about 800 miles (1,288 km) from South Dakota to Texas. The Ogallala aquifer supplies vast amounts of water to irrigate the crops grown in this vitally important agricultural area.

Terms

aquifer: an underground layer of unconsolidated rock or solid that is saturated with usable amounts of water.

artesian aquifer: an aquifer that is sandwiched between two layers of impermeable materials and is under great pressure, forcing the water to rise without pumping. Springs often surface from artesian aquifers.

confined aquifer: see artesian aquifer.

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

impermeable: not permitting water or other fluid to pass through.

unconfined aquifer: an aquifer containing unpressurized groundwater, having an impermeable layer below but not above it.

water table: the top surface of the groundwater.

ADVANCE PREPARATION

A. Collect materials for activities and demonstrations.

1. Fill a jar or bottle with water. (Size will depend on how large the glass bowl is.) Tint the water blue with food coloring (probably one drop). Set it aside.

2. Pat out a "pancake" of modeling clay. Size it to fit into the glass bowl with a good (but not necessarily tight) fit.

B. Make a transparency of each of the teacher sheets.

C. Have several dictionaries available.

PROCEDURE

I. Setting the stage

A. Pass out clear plastic cups and drinking straws to each student.

B. Put the word "aquifer" on the board and ask students if anyone knows what the word means. Then put the Latin derivation on the board so they can see the parts of the word and how we arrived at its definition.

C. Tell students they are all going to make a model aquifer. Fill each cup with chips of ice. The ice represents rock and soil-like materials underground. Pour into each of their cups lemonade or juice drink. The drink represents groundwater. Explain that the cup and drink represent an aquifer and groundwater. The bottom of the cup is the layer of rock or soil that keeps the water from seeping down any further. The top of the water is the water table, the top of the underground water layer.

D. Have students sip some of the liquid. Explain that they have just simulated a well by using their straw to "pump" the liquid from the aquifer. They have lowered the water table.

E. Ask what they would have to do to bring the water table back up to its original level. Compare adding more liquid to rainfall, which replenishes or "recharges" groundwater.

II. Activity

A. Show the students the transparency of the aquifer diagram teacher sheet.

1. As you point out the aquifers, the water table, and the wells, relate these to the drink cup model. (NOTE: Do not go into differentiating between confined and unconfined aquifers at this time. You will do this later.)

2. Let several students color the diagram with wipe-off transparency pens. Have them use blue for water (including groundwater) and other colors for the ground's layers. This will make it more clear for the students.

B. Construct a more complicated aquifer model for the students to observe.

1. Use one glass bowl (instead of cups each student used before). As you layer materials in the bowl, talk to the students about what each one represents. (NOTE: Leave the aquifer overhead up.)

2. The bottom of the bowl is an impermeable layer (water cannot pass through it), just as impermeable layers of rock or clay underlie other layers underground.

3. Put in a layer of sand. It represents an aquifer (it can hold water). Pour enough of the blue-tinted water into the sand to saturate it. What kind of water is this? (groundwater)

4. Put in a layer of modeling clay overlying the sand aquifer. Clay is impermeable, so the aquifer is trapped between two impermeable layers. Ask the students what kind of aquifer this is. (confined) Point out the confined aquifer on the overhead.

5. Pour a layer of aquarium gravel on top of the clay. This represents an aquifer. Pour in some blue-tinted water. Tell the students to note the top of the water. What is this called? (water table) What kind of aquifer is this? (unconfined, because there is no impermeable layer on top of it) Point out the unconfined aquifer on the diagram.

6. Tell the students that this is quite like the ground under their feet may be. Aquifers are present in many locations, although in some places they are deeper in the ground than in other places.

7. Put the pump from a liquid soap or other container in the model's unconsolidated aquifer. Ask the students what they think will happen if you work the pump. Let one of them try it while you hold it so the end of the tube stays above the modeling clay layer. Dispense some blue-tinted water into a cup.

8. Tell the students that this is much the way a well works. Remind them of the demonstration they completed using the drink cups. Point out the well on the overhead.

9. (Optional) The students may be curious about the artesian well on the overhead. Tell them that your "groundwater-in-a-glass-bowl" model will not show how an artesian well works. A model is a <u>representation</u> of something else; it cannot actually function like the real thing does.

C. Have the students examine a map showing groundwater resources in the United States.

1. Share the following information with the students: Groundwater is almost everywhere. The layers of rock and soil-like material under the ground hold water in varying amounts. Some places have a lot of groundwater, but it is deep in the earth and not easy to get from wells. Some places do not have as much groundwater. Some places have abundant supplies of groundwater. In these places people rely on water from wells for irrigating crops and for water supplies for both individual families and whole communities.

2. Show the students the transparency of the teacher sheet "Major U.S. Aquifers." Explain that the crosshatching on this map marks the places in the continental U.S. where abundant fresh water is available from aquifers. In these areas, large groundwater supplies are used by industries, communities (municipal water systems), and irrigation of crops. In the areas where there are no markings there is less likely to be plentiful groundwater available. These places will, however, have wells that supply individual households and livestock operations.

3. Ask a student volunteer to come up and mark on the map (with a wipe-off transparency pen) about where your community is located. Is it in an abundant aquifer region?

4. Ask the students to answer the following questions by naming states. (Allow them to refer to a labeled map if it is needed.)

   a. Name several states where plentiful groundwater is available almost everywhere. (Florida, Mississippi, Louisiana, Iowa, Delaware, Nebraska, Michigan, New Jersey)

   b. Name several states that have the least groundwater in many places. (Montana, Wyoming, Colorado, Utah, Pennsylvania, Kentucky, West Virginia, New York, Vermont, New Hampshire, Maine)

III. Follow-Up

A. Have the students choose their state and four others (their choice). Have each student write down his/her five states and indicate whether each is likely to have large groundwater supplies or not. They may use yes/no answers, a symbol of their choice, or a sentence.

B. Have the students research specific U.S. aquifers (and perhaps others in different parts of the world). After sharing the information with the rest of the class, the students could plot the U.S. aquifers on the maps from activity II C.

IV. Extensions

A. Share with students the following information about dowsing or "water witching" and divining rods. Some people will not have a well drilled without calling a "water witch" or a "dowser" to locate the groundwater. Water witches or dowsers have been around for hundreds of years. They use metal or wooden sticks ("divining rods") to locate places where wells should be drilled. Some even predict the depth of the water table. Dowsers are not always successful in their efforts, but many people believe in their special ability to find water. Ask students to research the local use of dowsing.

B. Refer the students to the Latin derivation of the word "aquifer." Write on the board a list of other words that share the root word "aqui" or "aqua." Have the students list the words on their paper. (List these words on the board: aquacade, aqualunger, aquamarine, aquanaut, aquaplane, aquarelle, aquarist, aquarium, aquarius, aqueduct.) Divide the students into groups. Have them discuss and record what they think each word means, then look each one up in a dictionary to see how close they came to the correct definition. If they were not correct, have them write the dictionary meaning.

RESOURCES

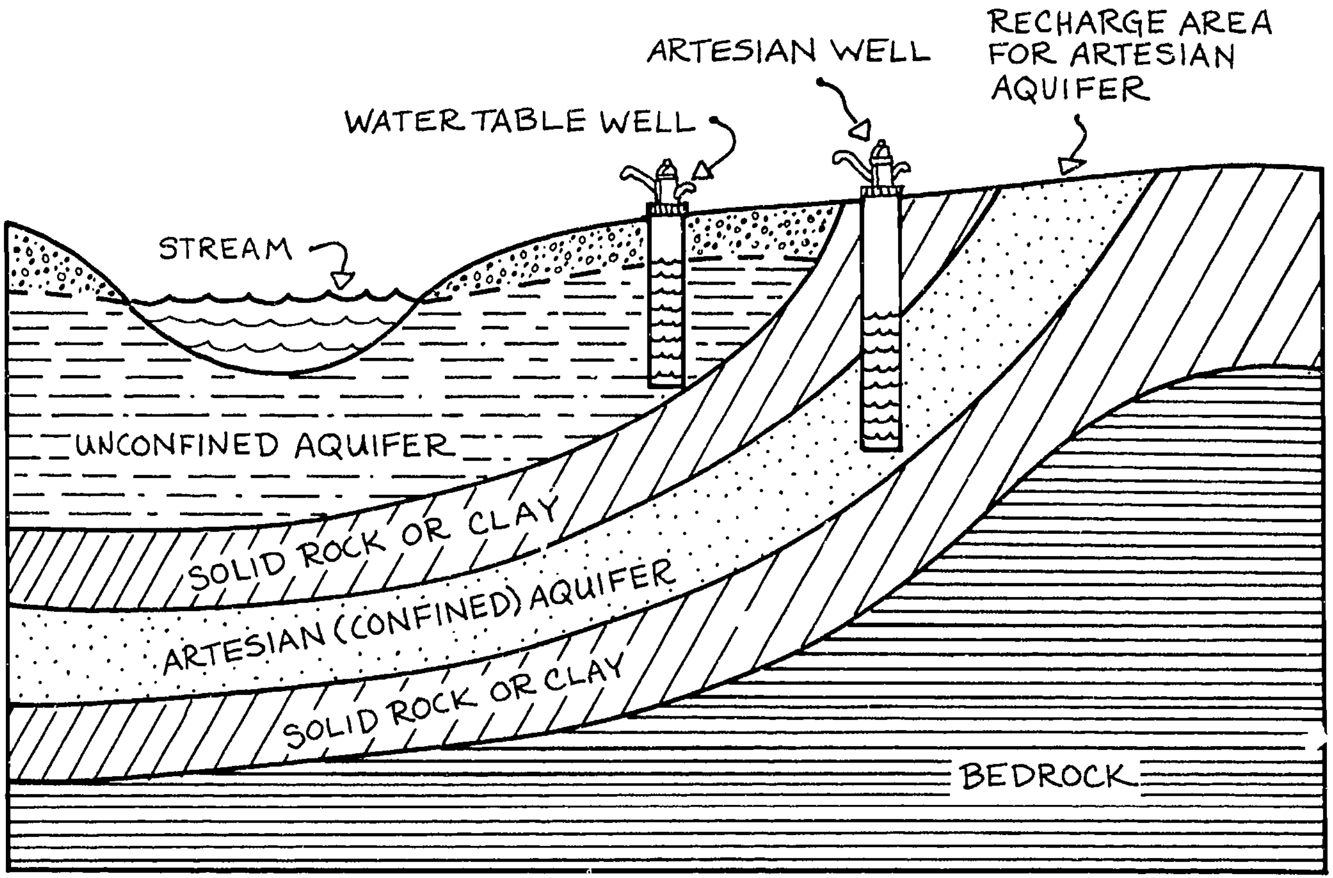
Branley, F. M., Water for the World, T. Y. Crowell, New York, 1982.

"Ground Water: Issues and Answers," American Institute of Professional Geologists, Arvada, Colorado, 1984.

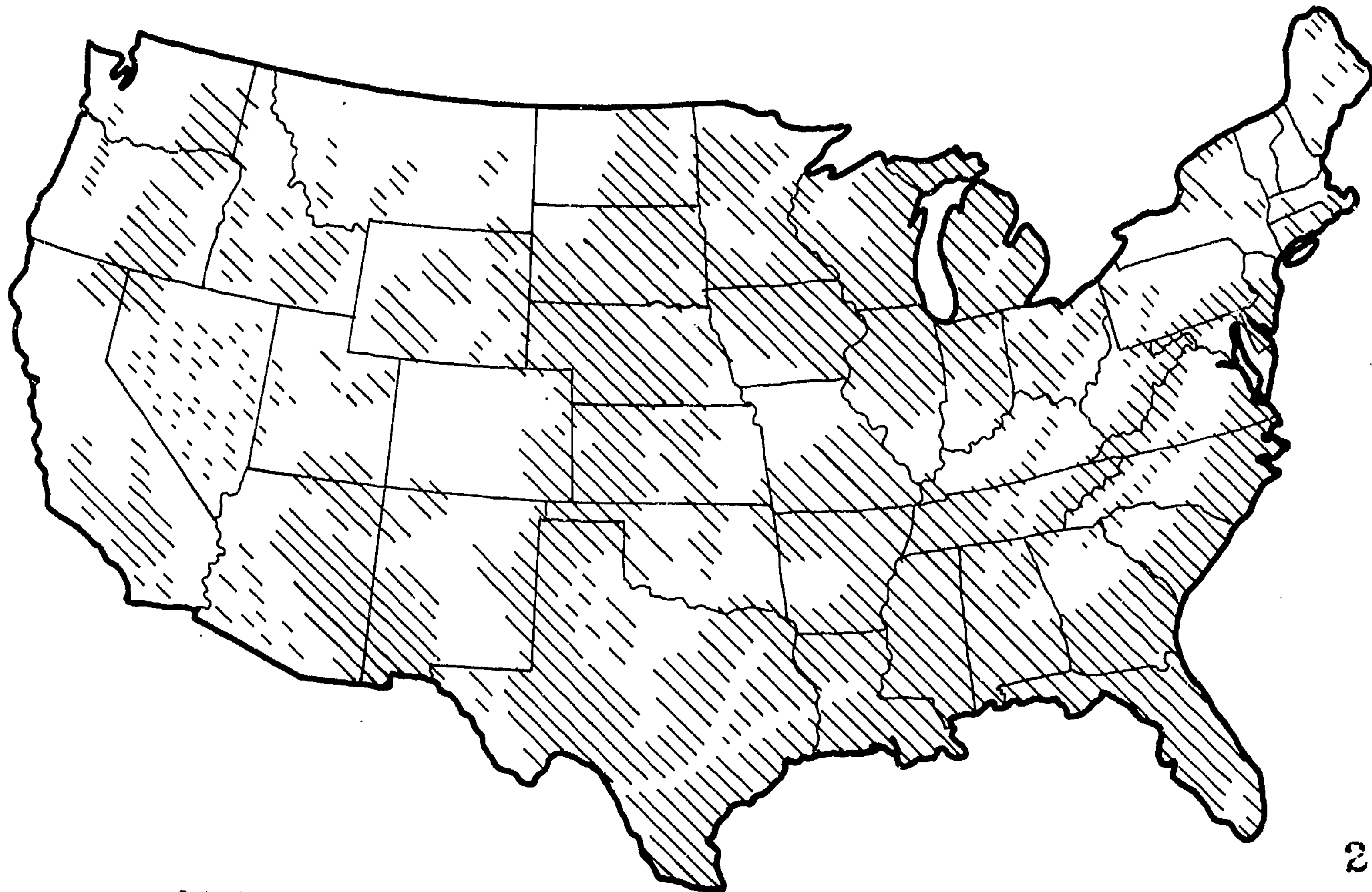
Haberman, M., Water Magic, American Waterworks Association, Denver, Colorado, 1991.

Pringle, L., Water: The Next Great Resource Battle, Macmillan Publishing Co., New York, 1982, pp. 68-70.

AQUIFER DIAGRAM



LOCATION OF MAJOR U.S. AQUIFERS



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BELIEVE IT OR NOT!

OBJECTIVES

The student will do the following:

1. Define groundwater supply.
2. Recognize that groundwater is unevenly distributed throughout the world.
3. Answer groundwater supply questions by using statistical information provided.

SUBJECTS:
Science, Math, Language Arts, Social Studies

TIME:
120 minutes

MATERIALS:
acetate sheet
overhead projector
teacher sheet (included)
student sheet (included)

BACKGROUND INFORMATION

Fresh water is not evenly distributed worldwide. In some areas, water is so scarce that people harvest plants such as succulents and cacti for water. In other areas, people have more water than they use. Some people take fresh, clean water for granted, while others treasure every drop and use it for all it's worth.

The amount of water we have depends on several factors: the rate of precipitation, the rates of evaporation and transpiration , the amount of stream flow, the amount of groundwater flow, and people's use of water.

Terms

aquifer: an underground layer of unconsolidated (porous) rock or soil that holds (is saturated with) usable amounts of water.

groundwater supply: the amount of fresh water stored beneath the earth's surface.

evaporation: conversion of a liquid to the vapor state by the addition of heat.

transpiration: the passage of water from plants and animals directly into the air in the form of a vapor.

precipitation: any or all of the forms of water particles, whether liquid of solid, that fall from the atmosphere and reach the ground.

ADVANCE PREPARATION

A. Make a transparency from the teacher sheet, "Believe It or Not! (Groundwater Supply Factsheet)."

B. Contact a guest speaker from your local water utility. Brief him/her on what questions the students will ask.

C. Copy the student sheet for distribution.

PROCEDURE

I. Setting the stage

A. Focus the students' attention on the "Believe It Or Not" transparency.

B. Have different students read aloud one fact each.

C. Ask the students which fact they find to be the most amazing and why they chose that fact.

D. Ask the students whether they think their area has too little groundwater, just the right amount, or a surplus. Have them give reasons for their answers.

II. Activity

A. Review the statistical information on the transparency by drawing pie charts for the figures given in fractions and percentages.

B. Review with the students how to write a good paragraph with a topic sentence, supporting details, and a conclusion.

1. Have each student choose one of the three main topics from the outline on the transparency and develop at least one paragraph from the listed facts.

2. Students will exchange paragraphs when finished and proofread each other's papers. They will check to see that the supporting details do support the topic sentence and that there is a conclusion. Students will also check for punctuation and capitalization errors. Then they will return papers to their owners.

3. Students will make corrections and turn in both the rough draft and revised first copy of their paragraphs.

C. Students will use the facts on the transparency to complete the student sheet, "Believe It or Not!" The answers are as follows:

1. for 2 people; 300 gal. (1140 L)
for 3 people; 450 gal. (1710 L)
for 4 people; 600 gal. (2280 L)
for 5 people; 750 gal. (2850 L)
for 6 people; 900 gal. (3420 L)

2. about 40%

3. Great Britain

4. California

5. 7 in or 17.5 cm (35 in x 0.20 or 87.5 cm x 0.20)

6. 80

7. 97

III. Follow-Up

A. Prepare for the guest speaker: Working in small teams, students will prepare a list of three to four questions per team to ask the guest speaker.

B. When the speaker visits, let the student teams take turns asking their questions. A team secretary can record the answers as they are given.

C. Afterwards, the class can prepare its own "Fact Sheet on Groundwater," using the information given by the speaker.

IV. Extension

A. Have the students research a different state or country to find out more about the groundwater supply in other places. Almanacs are a good source of world information; they also list addresses of foreign embassies that will send information upon request. Check encyclopedia articles for information about contacting states.

B. Let the students draw their own charts to show some of the statistical information given in the lesson. For example, they could make pie charts, bar graphs, or imaginative graphs like measuring cups, partially filled buckets, or other water-related images.

RESOURCES

"America's Priceless Groundwater Resource," American Groundwater Trust, Dublin, Ohio, 1991.

Branley, Franklyn M., Water for the World, T. Y. Crowell, New York, 1982, pp. 33-36.

Dent, Joan, "Blue Thumb Facts," American Waterworks Association, Denver, Colorado.

"The Groundwater Adventure," Water Pollution Control Federation, Alexandria, Virginia, 1989, p. 18.

"Ground Water: Issues and Answers," American Institute of Professional Geologists, Arvada, Colorado, 1984.

Keller, Edward A., Environmental Geology, Charles E. Merrill Publishing Co., Columbus, Ohio, 1985.

Miller, G. Tyler, Jr., Environmental Science, Wadsworth, Inc., Belmont, California, 1986, p. 116.

Tennessee Valley Authority, "Groundwater Factsheet," N.p.: Tennessee Valley Authority, March, 1986.

Utah State University, International Office for Water Education, "Water: Essential to Life" (Utah's Young Artists' Water Education Classroom Calendar), Utah State University, Logan, Utah, 1992.

Water Ways, Division of Public Information, St. John's River Water Management District, Palatka, Florida, 1991, p. 22.

BELIEVE IT OR NOT!
(GROUNDWATER SUPPLY FACTSHEET)

I. United States (U.S.) Facts

A. The estimated supply of groundwater in the U.S. is 65 quadrillion gallons (246 quadrillion liters).

B. About 1/5, or 20%, of the rain that falls in the U.S. becomes groundwater.

C. Groundwater is an excellent source of water for drinking water supplies. Many medium-sized cities and small communities use groundwater. Some large systems, like Long Island, New York (part of New York City metropolis); Miami, Florida; San Antonio, Texas; Honolulu, Hawaii; and Memphis, Tennessee, use groundwater. Most of the community water systems in the U.S.—about 4/5 or 80%—withdraw groundwater.

D. If you add up all the people who depend on groundwater for their drinking water, they amount to about 1/2, or 50%, of the people in the U.S.

E. Almost everyone (97% of the people) who lives in rural areas depends on groundwater.

F. The average American uses 150 gallons (570 liters) of water per day for household and personal uses.

G. In some places, we are using groundwater about 100 times faster than rainfall replaces it.

H. About 2/5, or 40%, of the water used for irrigating crops is groundwater. Most of this occurs in dry midwestern and western states.

II. Regional U.S. Facts

A. The Ogallala aquifer in the Midwest (from South Dakota down to Texas and New Mexico) supplies water to irrigate over 12 million acres (4.8 million hectares) of farm land—1/5, or 20%, of all the farm land in the U.S.

B. In the western states, about 7/10, or 70%, of the water used for irrigation comes from wells.

C. There is about 1/5, or 20%, as much water in Florida's aquifer as there is in all the Great Lakes combined.

D. California pumps many times more groundwater per day than any other state.

III. World Facts

A. In Germany, more than 7/10, or 70%, of the water comes from groundwater.

B. Just over half, or 54%, of the water used in Israel is groundwater.

C. Only about 20% of Great Britain's water is groundwater.

D. If all the groundwater in the world was pumped to the surface, it would cover the earth to a depth of about 10 feet (3 meters).

BELIEVE IT OR NOT!

1. If the average American uses 150 gallons (570 liters) of water per day, how many gallons would all the people who live in your house use in one day? ____________

2. How much of the groundwater used in the U.S. is used for irrigating agricultural crops? ____________

3. What country (of those listed in this lesson) uses the lowest percentage of groundwater? ____________

4. What state uses many times more groundwater as any other state? ____________

5. If the annual rainfall in the entire U.S. last year averaged 35 inches (87.5 cm), about how much of that rain would probably have become groundwater? ____________

6. Out of every 100 American communities, how many of them have water supply systems that withdraw groundwater? ____________

7. Out of every 100 Americans living in rural areas, how many of them get their water from groundwater?____________

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AT A SNAIL'S PACE?

OBJECTIVES

The student will do the following:

1. Define groundwater, aquifer, and karst formation.
2. Demonstrate that variations of soil and rock materials affect water movement differently.
3. List three features of karst formations.

SUBJECTS:
Science, Mathematics, Social Studies, Language Arts

TIME:
120 minutes

MATERIALS:
4 lengths plastic tubing (4 in. or 10 cm long and 1/2 in. or 1.25 cm in diameter)
4 pieces gauze or cloth (small squares)
4 rubber bands
sand (1/4 cup or 6C mL)
soil (1/4 cup or 60 mL
clay (1/4 cup or 60 mL)
aquarium gravel (1/4 cup or 60 mL)
measuring cup
water
U.S. map
graph paper
teacher sheet (included)
acetate sheet
overhead projector
student sheet (included)

BACKGROUND INFORMATION

Groundwater is always on the move, but the rate of movement may vary from a few inches (centimeters) a year in unconfined aquifers to several miles (kilometers) a day in karst limestone aquifers. Groundwater may remain in the same general area in which it was collected for many years; because of this, groundwater that becomes contaminated can remain contaminated for a long time, even hundreds of years. The less it moves, the less it is filtered.

The rate at which groundwater moves depends primarily on the geological structure of an area and on gravity, and it can move both vertically and horizontally. Porosity and permeability of the underlying rock and soil are among the factors determining the rate and direction of movement. Water moves quickly through layers of loose soil and unconsolidated rock and through fractured rock; it moves less rapidly through materials such as clay that are not very permeable. Water that is moving vertically will begin flowing horizontally when it reaches an impermeable material.

Groundwater that moves through limestone will eventually create what is known as a karst formation. In these aquifers, flow is more rapid – more like that of a surface stream. Caverns, caves, and sinkholes are features of karst formations.

Terms

aquifer: an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water (a zone of saturation).

confined aquifer: an aquifer that occurs between two impermeable layers of rock or other material that reduces the flow rate, also known as an artesian aquifer.

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

karst formation: a geological formation that occurs in limestone, dolomite, or gypsum and is characterized by sinkholes, caves, and underground drainage.

permeability: the property of a membrane or other material that permits a substance to pass through it.

porosity: the property of being porous, having pores; the ratio of minute channels or open spaces (pores) to the volume of solid matter.

unconfined aquifer: an aquifer that has an impermeable layer under but not above it.

ADVANCE PREPARATION

A. Gather the materials.

B. Make a transparency from the teacher sheet.

C. Make copies of the student sheets. (NOTE: You may use these as transparencies to save paper.)

PROCEDURE

I. Setting the stage

A. Ask the students if they know what "spelunking" is. (exploring caves or "caving")

B. Have the students imagine they are spelunking. Tell them they are in a limestone cave far underground. What do they think it would be like? What would their senses tell them? (accept their answers)

C. Tell them that what they would experience might surprise them. Of course, it would be totally dark except for their carbide lights or flashlights. It would be cool. It would probably be damp, and may be very muddy. (Ask them what this means. [It means there is water underground.]) A cave can even be noisy; can they guess what kinds of noises they might hear? (It is common to hear dripping and trickling noises. Again, this means there is water in the cave.)

D. Ask the students if they have ever heard of underground rivers or lakes. Tell them that while these sometimes occur, most of the water underground moves through tiny spaces between rock and soil particles or through fractures in rock formations. This lesson considers how water moves underground.

II. Activities

A. Share the background information with students. Show a transparency made from the teacher's sheet "Karst Formations." Also explain the appropriate terms.

B. Have the students demonstrate that water percolates through different materials at different rates.

1. Divide the students into four teams. In each team, there should be one student who obtains the materials, one who assembles the testing column, one who holds it, one who measures and pours the water, one who times and measures the water that runs out, and one who reports the results. (Let them choose their roles.)

2. Have each group complete the following:

   a. Take one piece of plasti tubing and place a gauze square over one end of it. Secure the gauze with a rubber band.

   b. Place your selected material (clay, sand, gravel, and/or topsoil) in the tube. The tube will be filled about halfway up.

   c. Pour 4 oz. (60 mL) of water through the tube. Hold it over a cup.

   d. Record the length of time it takes for the water to pass through the tube. Measure the volume that is collected in the cup below.

3. Make a chart on the board and have the student reporters fill in the time and volume information.

4. Have the students draw conclusions from the activity by asking the following questions:

   a. Did the water flow through all the materials at the same rate?

   b. Did the same amount of water pass through all the materials? If not, what happened to it?

5. Point out how much more rapidly the water passed through the aquarium gravel. When there are large spaces between rocks or particles, water can move more rapidly.

C. Have each student make a bar graph using the information from the above demonstration.

D. Share the following information with the students about the formation of caves, caverns, and sinkholes. Refer back to the transparency as necessary.

The word "karst" originates from the Kars Plateau in Yugoslavia. Karst formations occur where limestone rock underlies the land. In karst formations, the water flows through cracks in the limestone for hundreds or thousands of years, dissolving some of the limestone and forming holes that become caves and caverns. Natural rainwater is slightly acidic and contains a little of the weak acid (carbonic acid) that you find in carbonated soft drinks. This slight acidity causes it to be able to dissolve limestone better. Some famous caves and caverns that have formed this way are Howe Caverns in New York State, Shenandoah Caverns and Luray Caverns in Virginia, Mammoth Cave in Kentucky, and Carlsbad Caverns in New Mexico.

Sinkholes form when the roof of a cave or cavern "caves" in or when the rock just under the topsoil erodes away. Excessive pumping of groundwater can also cause this to happen.

E. Have students locate on a map each of the famous caves and caverns mentioned above.

III. Follow-Up

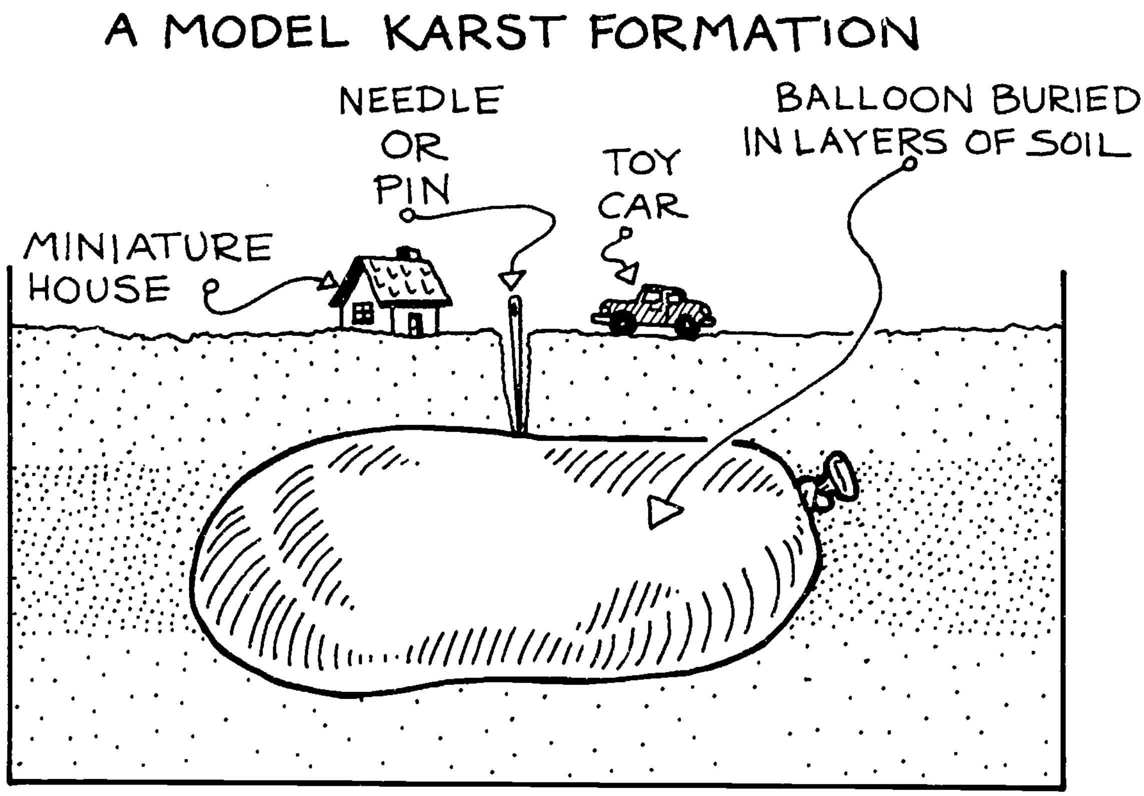
A. Have the students define groundwater, aquifer, and karst formation in their own words.

B. Have the students list the three different types of karst formations discussed in this lesson. (caves, caverns, sinkholes)

C. Have the students complete the student sheet, "At A Snail's Pace?" (Answers: 1. 10; 2. D; 3. No (it will take 3 years); 4. 1/2 inch [1.25 cm])

IV. Extensions

A. Allow the students to make a model of a sinkhole. (A sinkhole model can be made using soil underneath, an inflated balloon in the middle, and a layer of soil on top. Prick the balloon to form the sinkhole.) Interested students might locate pictures of large, spectacular sinkholes (e.g., several in Florida during the '80s).



B. Have the students make travel brochures for the caves and caverns mentioned in the lesson.

1. After reviewing correct letter form, have students write letters to each of these famous cave sites requesting information. Two of the addresses are included here:

   Mammoth Cave National Park, Mammoth Cave, Kentucky 42259

   Carlsbad Caverns National Park, 3325 N. Park Highway, Carlsbad, New Mexico 88220

2. When students receive the information, have them use it to create a travel brochure. (They can work in small teams.)

3. Have students critique the finished brochures and decide which one is most persuasive in convincing them to visit the location. (Stress constructive comments here.)

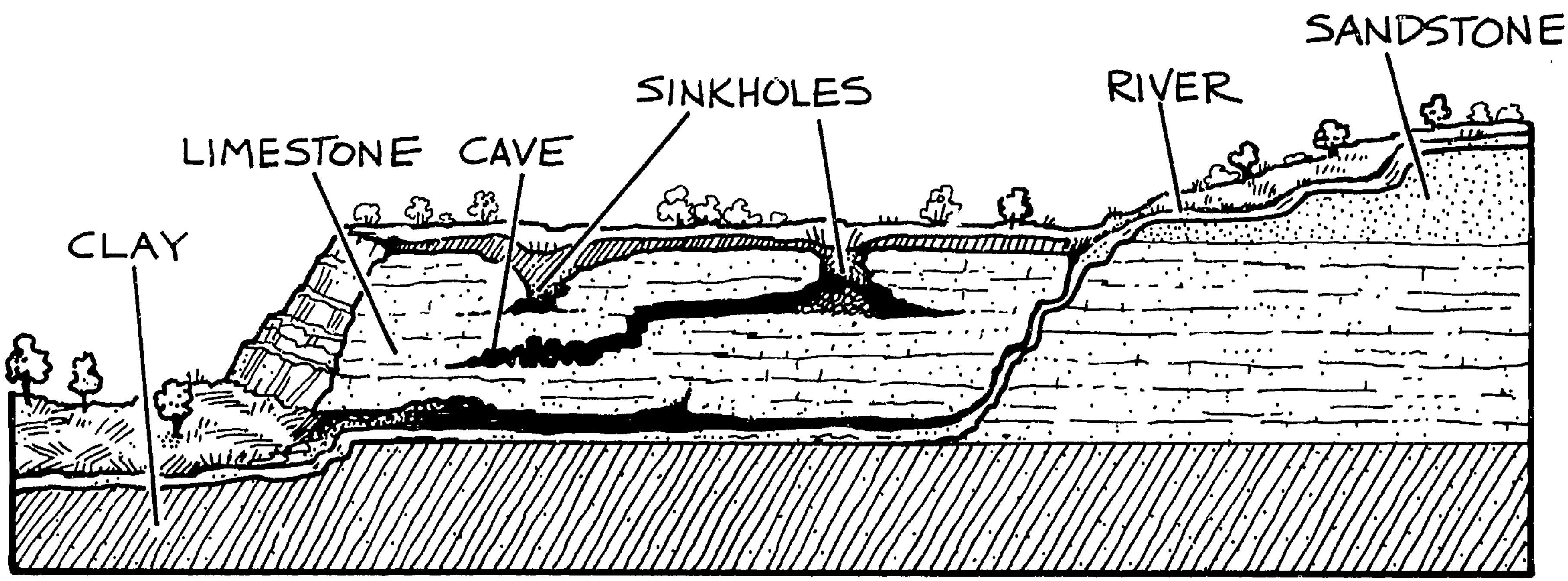
RESOURCES

Gay, Kathlyn, Water Pollution, Franklin Watts, New York, 1990, p. 20.

Namowitz, Samuel N., and Nancy E. Spaulding, Earth Science, D. C. Heath and Co., Lexington, Massachusetts, 1989.

"The Groundwater Adventure," Water Pollution Control Federation, Alexandria, Virginia, 1989, p. 22.

KARST FORMATIONS



AT A SNAIL'S PACE?

Solve these groundwater math problems.

1. If the groundwater is moving at the rate of 6 inches (15 cm) per year, how many years will it be until it reaches a location 5 feet (1.5 m) away?

2. The groundwater in Houston, Texas, is moving at the rate of 3 feet (0.9 m) per month. Will it reach a location 186 feet (55.8 meters) away in: A. exactly one year, B. less than one year, C. 1 to 2 years, or D. longer than 2 years?

3. The water in a confined aquifer moved 125 miles (201.25 km) last year. If it is carrying contaminated water toward a location 375 miles (603.75 km) away, will it reach that location in 2-1/2 years?

4. If the groundwater is moving at the rate of 7 inches (17.5 cm) every 98 days, how many inches (centimeters) would that be per week?

POROSITY & PERMEABILITY: "DOWN AND DIRTY"

SUBJECTS:
Science, Language Arts

TIME:
60 minutes

MATERIALS:
3 large paper or plastic cups
3 plastic container lids
water
thumbtack
watch or clock
student sheets (included)
sand
topsoil
clay
pencil
four 250-mL beakers or measuring cups
scissors
chalkboard or large paper
blue crayons or markers
teacher sheet

OBJECTIVES

The student will do the following:

1. Discover that the more open space in rock or soil (porosity), the more water it can hold.
2. Determine that soil with the same size particles will hold more water (is more porous) than soil with different-sized particles.
3. Identify the characteristics that make certain soil types more permeable, or better able to transfer water, than others.

BACKGROUND INFORMATION

According to many experts, there is over 40 times more water underground than found in all the lakes, rivers, and streams on earth. Groundwater is a vital part of the water cycle. As precipitation replenishes groundwater sources, the water is affected by the soil and rock layers through which it must filter. Soil and rock layers have two basic characteristics that determine its effect on water flow: porosity and permeability.

Porosity refers to how much space there is in a volume or formation of rock or soil. The more space between particles, the more water the formation is able to hold. For example, loosely packed soil can hold more water than soil that is tightly packed. Also, soil with the same sized particles can hold more water than soil with different sized particles because smaller particles fill the spaces between the larger particles, leaving less space for water to occupy.

How well soil or rock allows water to flow through it is called its permeability. Formations with large, interconnected pores usually transmit water more quickly. Rock formations with large cracks, like fractured limestone, also allow water to move through more quickly.

These two characteristics affect groundwater in important ways. For example, the rate at which an aquifer regains and retains water depends on both porosity and permeability. Movement of contaminants such as septic seepage or spilled or leaked gasoline also depend upon the porosity and permeability of soil and rock layers.

<u>Terms</u>

porosity: the property of being porous, having pores; the ratio of minute channels or open spaces (pores) to the volume of solid matter.

permeability: the property of a membrane or other material that permits a substance to pass through it.

ADVANCE PREPARATION

A. Gather needed materials.

B. Obtain the clay, topsoil, and sand for the "P VS. P Experiment." (NOTE: Avoid using commercial potting mix. Use topsoil.)

C. Copy the student sheets "P VS. P Puzzlers;" and "P VS. P Experiment."

D. Prepare the cups for the experiment in advance.

   1. Using 3 cups, fill one with sand, one with clay, and one with topsoil. (Leave 1 inch [2.5 cm] of space at the top of the cups.)

   2. Using a thumbtack, punch several small holes in the bottom of each cup. Be sure to punch the same number of holes in each cup.

   3. Using scissors, cut a hole in each plastic container lid so that a cup can be inserted and lodged in the hole. Put the lids (with the cups stuck in them) on the beakers or measuring cups.

PROCEDURE

I. Setting the stage

   A. Have the students brainstorm as many different and unusual words to describe "soil" as possible. Record these on the chalkboard or large paper.

   B. Discuss some of the words given by students. Point out the useful words.

   C. Explain that while soil has many uses, two often overlooked uses are filtering water (that becomes groundwater) and acting as a pipeline for our underground water supplies.

II. Activity

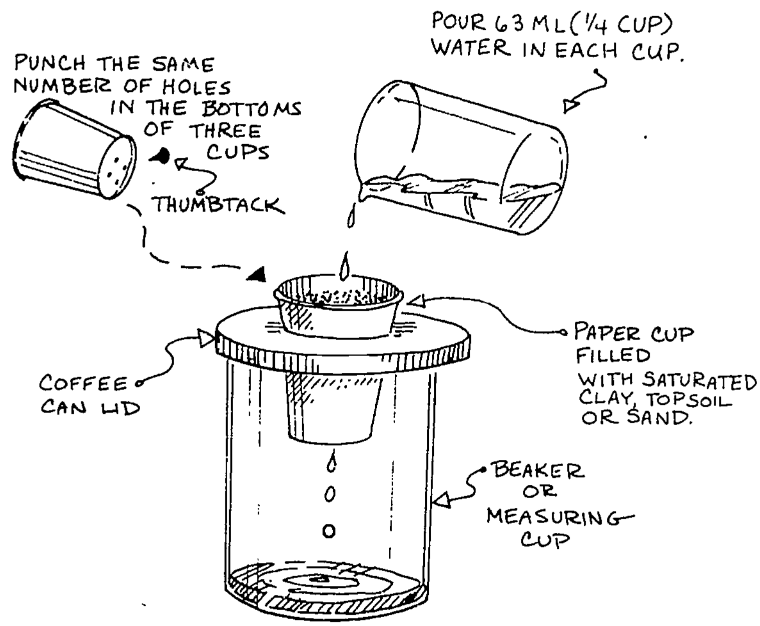
   A. Explain that there are several types of soil. Some soil is mostly sand, some is mostly clay, and some is a mixture of sand, clay, rock, and other things, like dead plants. The composition of soil determines its ability to absorb water and to allow water to move through it.

   B. Permeability Experiment (NOTE: May be performed as a classroom demonstration, as illustrated, or as a small team activity.)

      1. Distribute the student sheet "P VS. P Experiment."

      2. Have the students examine the samples and hypothesize which type of soil will allow water to pass through the most quickly. Point out that a soil type's ability to let water move is called permeability. Students should record their hypotheses on the handout.

PERMEABILITY EXPERIMENT



3. Pour 1/4 cup (63 mL) of water into the first cup. Have the students record the time when the water was poured.

4. Have the students record the time when the first water drips from each cup.

5. Repeat this procedure for the second cup, then for the third. Compare each time. Have students rank the times in order from fastest to slowest.

6. Ask the students to explain why each permeability rate was different and write their conclusions on the space on the worksheet.

7. Explain that soils with larger, interconnected spaces tend to allow water to move more quickly. (NOTE: Your results will depend somewhat on what kind of topsoil you use. You may, however, expect the sand to be most permeable and, probably, the clay to be least permeable.)

C. Porosity Test

1. Explain to the students that soil and rock also have differing abilities to hold water. This depends on how much of the sample is made of empty spaces between the particles and how large the spaces are. This is called porosity.

2. Have the students record a hypothesis about which soil type will hold the most water on their worksheet.

3. Allow water to drip for another 10-15 minutes. (NOTE: During this time, you may wish to proceed to follow-up or extension activities.)

4. Measure and record the amount of water in each beaker or measuring cup. Have the students record this on their sheets. Instruct them to subtract this amount from the starting amount to determine the total amount of water held for each soil type. Have them record this information. (NOTE: You will have to help them subtract the fractions. Milliliters will be easier for them to use.)

5. Using the total amount of water held, have students rank in order the porosity of the soil types and write a conclusion on the worksheet.

6. Ask the students to explain why the highest ranking soil held the most water. (NOTE: Again, your choice of topsoil will affect the results.)

III. Follow-Up

A. Have the students complete the student sheet "P VS. P Puzzlers."

B. Record the number of correct hypotheses made by students during the experiment and discuss the conclusions reached.

IV. Extensions

A. Contact your local cooperative agricultural extension office or Soil Conservation Service office for information about the soil in your area.

B. Have the students gather different samples around their home and perform the experiment, reporting on the results.

RESOURCES

Bernstein, L., et al., Concepts and Challenges in Earth Science, Globe Book Company, 1991.

Cedar Creek Learning Center, Groundwater: A Vital Resource (Student Activities), TVA Environmental & Energy Education Program, Knoxville, Tennessee, 1986.

Spangler, J. T., Focus on Earth Science, Teacher's Laboratory Manual, Charles E. Merrill Publishing, Columbus, Ohio, 1984, p. 103-104.

POROSITY & PERMEABILITY EXPERIMENT

Permeability of soil or rock: The ability of soil or rock to let water pass or move.

Hypothesis: Which soil type do you think will allow the water to pass through it most quickly:

______________________ Why? ____________________________________

____

Soil Type	Clock Time of Water In	Clock Time of Water Out	Time (seconds)
Sand			
Topsoil			
Clay			

Conclusion: Which soil allowed the water to move through the most quickly? ______________

Why? ____

____

Porosity of soil or rock: The ability of soil or rock to hold water.

Hypothesis: Which soil type do you think will hold the most water? ______________

Why? ____

Soil Type

Sand	1/4 cup (63 mL) poured in — ___ amount that passed through amount held in soil
Topsoil	1/4 cup (63 mL) poured in — ___ amount that passed through amount held in soil
Clay	1/4 cup (63 mL) poured in — ___ amount that passed through amount held in soil

Conclusion: Which soil held the most water? ______________________

Why? ________ ______________________________________

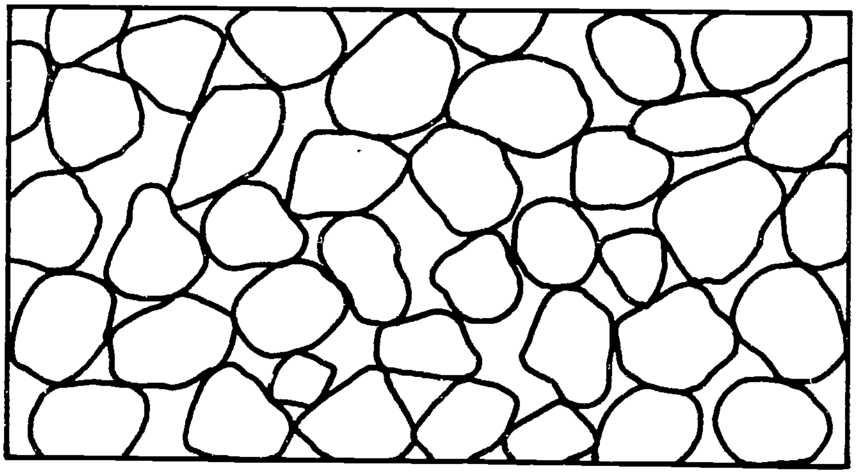
____

POROSITY & PERMEABILITY PUZZLERS

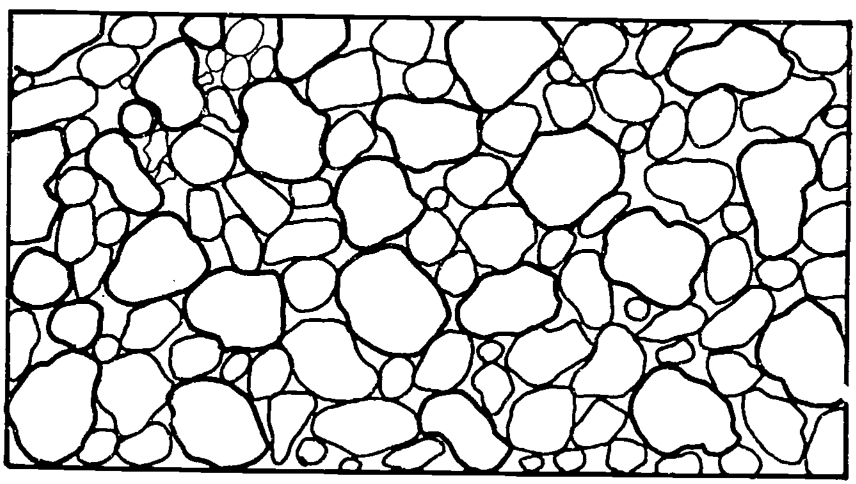
Name ______________________ Date ______________________

Porosity: Color in the spaces between the particles to see which soil is more porous. Use a blue crayon or marker to represent water.

#1



#2



Which has the most open spaces? ______________

Which would hold the most water? ______________

Why? ____

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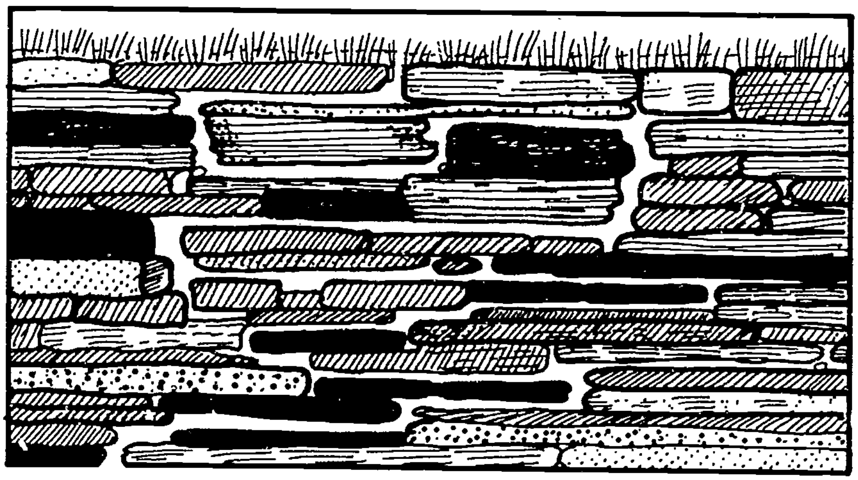
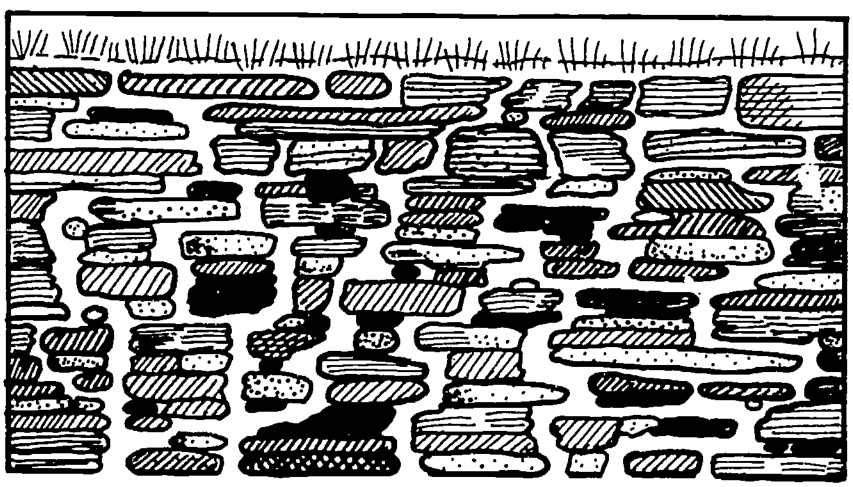
POROSITY & PERMEABILITY PUZZLERS - PART 2

Name ____________________ Date ____________________

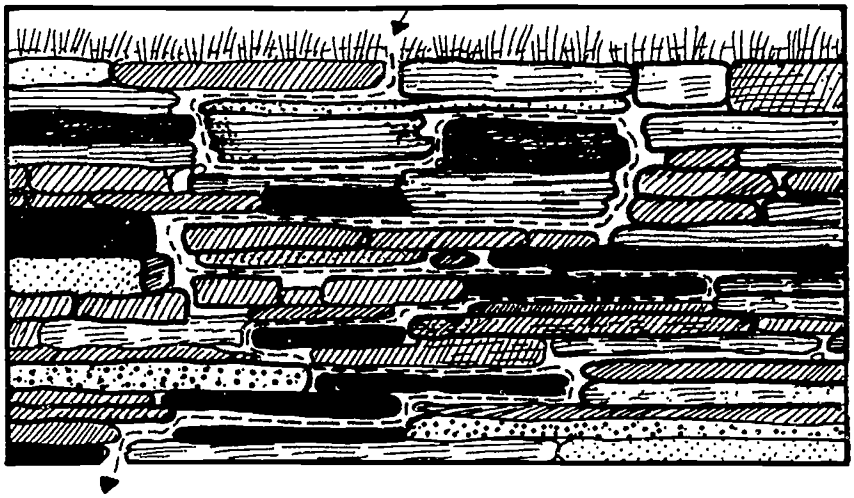
Permeability: Do the two mazes below. Show the paths water can take between the particles by using a blue crayon or marker.

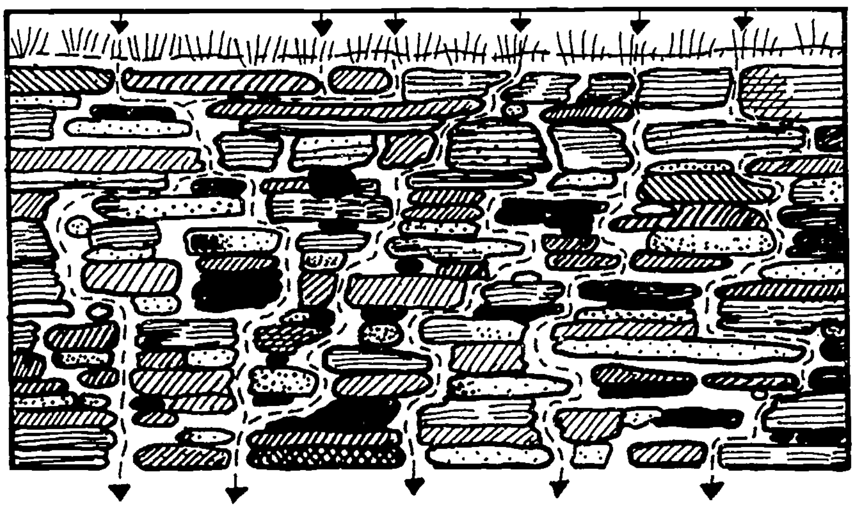




Which allows water to flow more freely? ____________________

POROSITY & PERMEABILITY PUZZLERS - PART 2
(ANSWER KEY)





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CHECKS AND BALANCES

OBJECTIVES

The student will do the following:

1. Identify conditions of recharge, surplus, supply, and deficit as they apply to groundwater.
2. Define saltwater intrusion.
3. Explain problems associated with a serious lack of groundwater recharge.

SUBJECTS:
Science, Social Studies, Language Arts

TIME:
180 minutes

MATERIALS:
two 3 x 4 ft. (0.9 x 1.2 m) cardboard boxes
2 garbage bags
gravel
soil
sharp scissors
pieces of styrofoam in different shapes and sizes
small piece of sod cut into strips
5-6 sponge pieces
2 rubber or plastic hoses (12" long [30 cm] and 1/2 in. [1.25 cm] diameter)
4 large plastic drink bottles
sprinkler type watering can
2 eyedroppers or plastic spoons
drinking straws
food coloring
pump from soft soap or lotion bottle
duct tape
U.S. Map
student sheets (included)
teacher sheet (included)

BACKGROUND INFORMATION

Groundwater recharge reduction and saltwater intrusion are problems in many parts of the world. Groundwater supply works like a checking account at the bank. A person can withdraw only the amount that he or she has deposited (put in). When that amount has been withdrawn, a deposit must be made before more money can be withdrawn. Likewise, groundwater supplies must be recharged if we are to keep on withdrawing groundwater. In other words, the well will run dry if recharge does not keep pace with withdrawal.

Our groundwater supply is replenished (recharged) primarily by precipitation, and human activity may reduce the amount of recharge from precipitation. When an area is growing rapidly, with a surge in real estate development, the amount of undeveloped land for the rainwater to seep into is greatly reduced. Driveways, buildings, and parking lots cause too much water to run off into surface water bodies, and not enough to soak into the ground. If recharge is reduced enough, the threat to the groundwater supply can be serious.

Another problem is that the water that pools on pavement and other impermeable surfaces collects pollutants. This polluted water ends up in storm sewers, flowing directly back into area lakes and streams. This affects the quality of surface water--and of groundwater, since some surface water soaks through lake and stream beds to groundwater aquifers. In this case, a recharge problem becomes a groundwater quality problem.

Saltwater intrusion is another problem that can result when withdrawal outstrips recharge. It occurs primarily in coastal areas when the water table drops due to excessive pumping of freshwater wells. When the water table drops below sea level, salt water from the ocean flows into the freshwater supply. When this happens, the water drawn from those wells is no longer suitable for drinking purposes or even for watering the lawn; salty water can also cause pipes to rust. New wells must then be drilled and the old ones capped.

When either overuse of groundwater (resulting in wells "drying up") or saltwater intrusion occurs, the process can be reversed. If recharge increases or if pumping decreases, groundwater supplies can recover, but it may take several years before the wells will be usable again.

Terms

groundwater recharge: resupplying an aquifer, primarily by rainfall.

saltwater intrusion: contamination of fresh water by salt water, occurring when the water table drops below sea level.

water table: the top surface of groundwater.

ADVANCE PREPARATION

A. Gather the materials for the models. Use very thin black tempera paint for "murky" water in II.B.

B. Make two copies of the "Recharge Models" student sheet. Copy the other student sheet for distribution to each student.

C. Make a transparency of the teacher sheet "Saltwater Intrusion."

PROCEDURE

I. Setting the stage

A. Ask students what would happen if they had $50 in an account at the bank and kept taking money out but they never deposited any more in the account to replace it.

B. After listening to (and guiding) their responses, explain that groundwater recharge works the same way. If too much groundwater is removed without being replenished, the supply will eventually be gone.

II. Activity

A. Share the background information on recharge with the students.

B. Have the students conduct the following demonstration.

1. Divide the class into two teams (or more).

2. One team will construct a model of a developed area where recharge is reduced.

3. The second team will construct a model of an area showing how builders can plan an area in such a way that groundwater recharge is not as diminished. (See student sheet, "Directions for Recharge Models.")

4. After completing the activity, discuss the results.

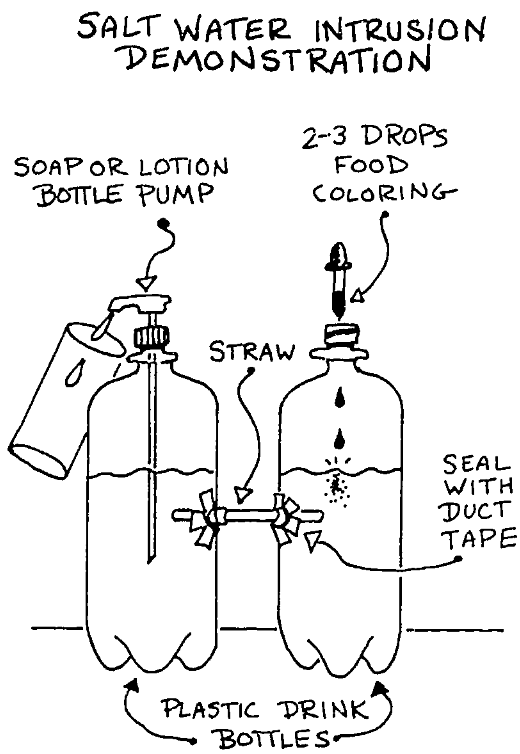
C. Explain to students the concept of saltwater intrusion by conducting the following demonstration:

1. Take two plastic drink bottles. Poke a small hole in the side of each bottle about half-way from the bottom. Connect the two bottles with a straw, sealing the openings with duct tape.

2. Fill each bottle with water to just above the straw.

3. Put a pump (from a soap or lotion bottle) in one of the bottles.

4. Drop two to three drops of food coloring in the second bottle as you begin pumping water rapidly from the first one. The colored water will "contaminate" the water in the other bottle, just as salt water contaminates fresh water when the water table drops below sea level in a coastal area.



5. Show the students the transparency of the teacher sheet "Saltwater Intrusion." Explain that this usually happens in coastal areas where recharge falls short of withdrawal.

D. Share the following information with your students:

One area of the U.S. where excessive groundwater pumping is a very serious problem is an area served by the Ogallala aquifer (named after a Sioux Indian tribe). This aquifer supplies water for parts of 8 midwestern states: South Dakota, Texas, Kansas, Nebraska, Oklahoma, Wyoming, New Mexico, and Colorado. It is said to be the largest aquifer on earth and is estimated to hold 650 trillion gallons (2,500 trillion liters) of water.

Farmers in this area are depleting the groundwater supply because of the great demand for water for irrigation of crops and for cattle to drink. This problem is compounded by the fact that the area gets little rainfall, and water is not being replaced at anywhere near the rate at which it is being used. In some locations, withdrawal occurs 100 times the rate of recharge.

1. Ask the students what they think could/should be done to try and solve the problem and what people in that area will do when the water runs out. Some think this could happen within 40 years. Remind them that this area is a vitally important agricultural area. Ask them what would happen if farmers there could not water their crops?

2. Have the students point out the states served by the Ogallala Aquifer on a U.S. map.

E. Explain to the students the meanings of the terms supply, recharge, usage, and deficit as they relate to groundwater.

1. Hand out copies of the student sheet entitled "Groundwater Recharge" with figures of the four processes.

2. Have them label each diagram as you talk through the page. Discuss the images with them.

III. Follow-Up

Divide the students into teams of four. Assign each student on a team a different picture from the student sheet "Groundwater Recharge" included in this activity. Students will make a torn paper picture to show either supply, deficit, recharge, or surplus. (Tear pieces of colored paper and glue it to another surface, making a collage-type picture.)

IV. Extension

Explain to the students that another problem that can occur when excessive groundwater pumping occurs is land surface subsidence in which the area of land over the emptying aquifer literally (although gradually) sinks. This can result in many problems for the communities on that land. Have the students discuss and write a story about a place that is sinking because of groundwater overuse. What would happen to buildings, streets, and other structures? What would happen to the people who live there?

RESOURCES

Tennessee Valley Authority, Environmental Resource Guide: Nonpoint Source Pollution Prevention, Grades 6-8, Air and Waste Management Association (publisher), Pittsburgh, Pennsylvania, 1992.

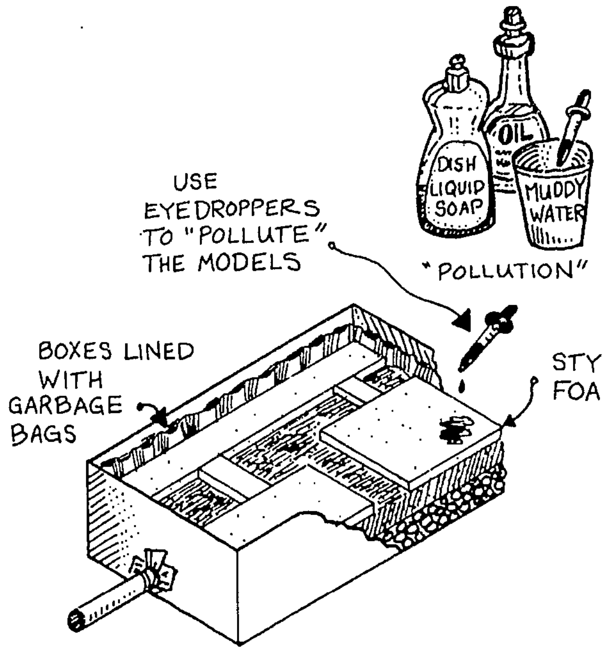
Namowitz, Samuel and Nancy E. Spaulding, Earth Science, D. C. Heath and Co., Lexington, Mass. 1989, p. 135.

Pringle, Lawrence, Water, the Next Great Resource Battle, Macmillan Publishing Co., New York, 1982.

DIRECTIONS FOR RECHARGE MODELS

A. The low recharge model:

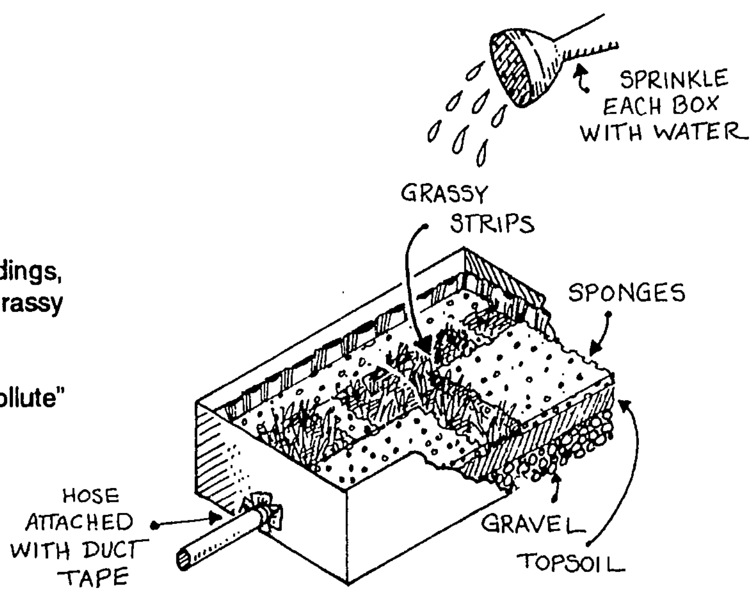
1. Line a 3 x 4 ft (0.9 x 1.2 m) box with a garbage bag.
2. Poke a hole in one end of the box.
3. Attach a hose to the hole with duct tape.
4. Fill the box about 1/4 way up with a layer of gravel covered with a layer of soil (to about 1/2 full).
5. Cut out pieces of styrofoam to represent buildings, driveways, and parking lots. Place on the surface of the model.
6. Use eyedroppers or plastic spoons to place murky water on the "structures" in the model.
7. Place a container under the hose to catch runoff, then use a sprinkler-type watering can to simulate a heavy rainstorm. This will wash the "pollution" into the storm sewer (the hose), which is a direct, unfiltered route back to a river or stream and, eventually to groundwater.



LOW RECHARGE MODEL

B. The high recharge model:

1. Prepare the box as in A through step 4.
2. Use different sizes of sponges for buildings, parking lots, and driveways; but place grassy strips between these for better recharge.
3. Use eyedroppers or plastic spoons to "pollute" the area as in step 6 above.
4. Do step 7 as above.



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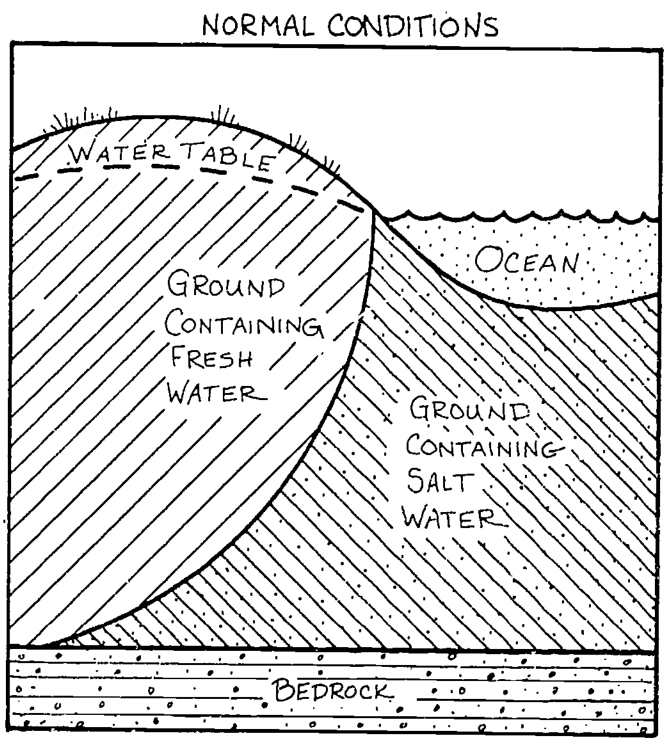
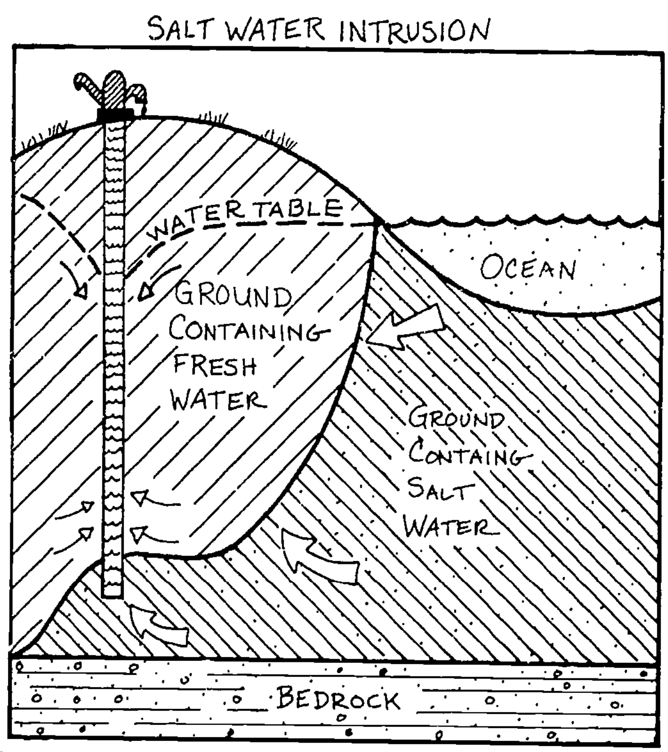
HIGH RECHARGE MODEL

SALTWATER INTRUSION





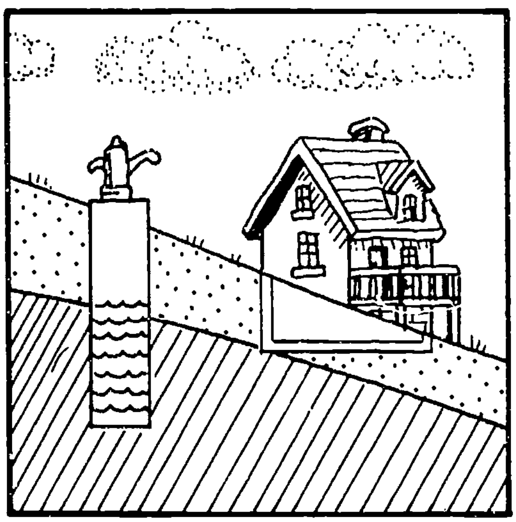
GROUNDWATER RECHARGE

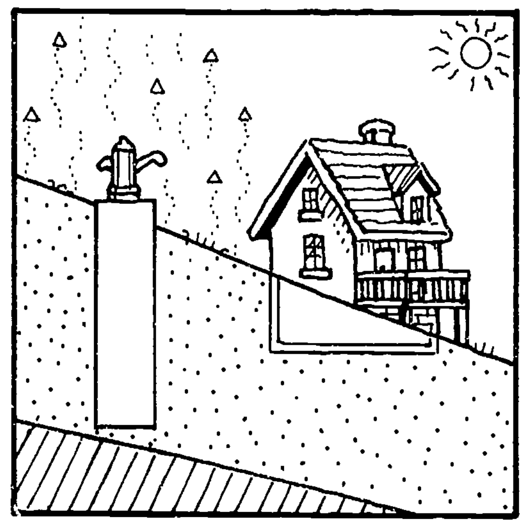
RECHARGE occurs when it rains, water is absorbed into the soil, and the water table rises.

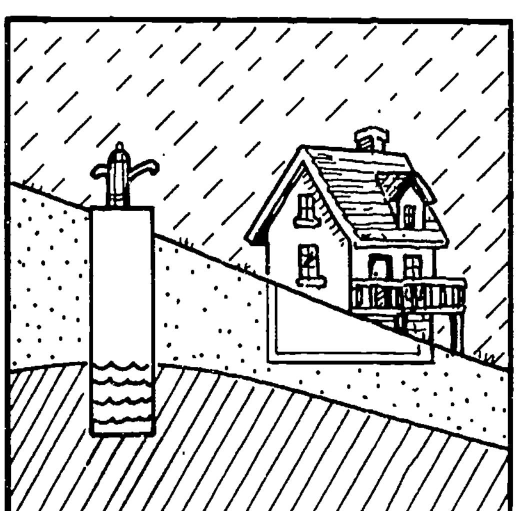
USAGE occurs when water is used from the groundwater supply and the water table lowers.

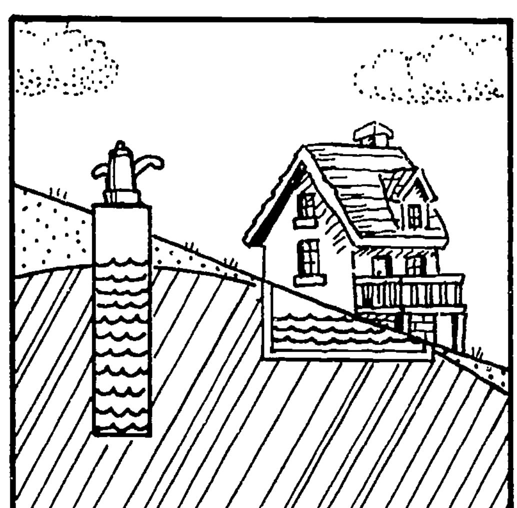
SURPLUS occurs when it keeps raining until the soil is saturated and the water table rises.

A DEFICIT occurs during a period of little or no rainfall when the water table lowers because water is being used faster than it is replaced.









WELLS: A DEEP SUBJECT

OBJECTIVES

The student will do the following:

1. Discover and explain how a well works.
2. Examine a well's relationship to the water table.
3. Apply principles of well placement.

SUBJECTS:
Science, Language Arts

TIME:
50 minutes

MATERIALS:
2-liter soda bottle
gravel
sand
pump from the top of a soap dispenser or spray container
blue and yellow food coloring
three paper cups
student sheets (included)
markers
teacher key (included)

BACKGROUND INFORMATION

About half of the U.S. population gets its drinking water from the groundwater. There are about 12 million individual wells and around 50,000 community-owned groundwater systems.

A well is a hole in the ground that reaches into the groundwater. In ancient days, these wells were dug by hand and lined with stones or bricks to prevent the sides from collapsing. Today, most are formed by drilling a 2-4 inch (5-10 cm) hole and lining it with metal or plastic piping.

A well must be dug deeper than the water table (top surface of the saturated zone). Water is usually pumped by hand, windmill, or motor-driven (electric- or fuel-powered) devices.

The biggest problem facing well water is contamination. Sources of groundwater pollution are leaking underground storage tanks, leaking septic tanks, landfill seepage, animal waste, fertilizer, pesticides, industrial waste, road salt, and some natural contaminants. When a groundwater source is contaminated, it is very difficult and expensive to correct. The best way to protect well water is to prevent contamination from occurring. Wells should be properly located in order to avoid contact with contaminants.

ADVANCE PREPARATION

A. Make copies of student sheets "Well, Well, Well," and "Well, Well, Well Map" (one of each per student).

B. Prepare model for well demonstration.

   1. Cut the top off a 2-liter soda bottle.

   2. Fill the bottom with gravel. Gravel can be purchased in the pet section of many department stores.

3. Locate a pump from the top of a soap dispenser.

PROCEDURE

I. Setting the stage

A. Start by asking students the following questions about wishes.

1. What are wishes? If someone could give you one wish, what would you wish for?

2. According to superstition, where could you go to get a wish? (a wishing well) What would you have to do at a wishing well to have your wish granted? (throw in a coin)

B. Explain that wells, in some cultures, have been believed to hold "magical" powers. People were amazed that water could come up through the ground, appearing from deep within the earth. They developed rituals and superstitions associated with wells.

C. Explain what is really important about wells today. About half of the U.S. population gets its drinking water from wells. While most wells are safe, the potential exists for their contamination or pollution.

II. Activity

A. Place the demonstration material where all students can observe. Explain that you are about to demonstrate how a well works.

1. Using the 2-liter bottle, fill with 3 to 4 inches (7.5 to 10 cm) of gravel and sand. (See the illustration below.)

2. Pour in 2 to 3 inches (5 to 7.5 cm) of water colored blue with food coloring.

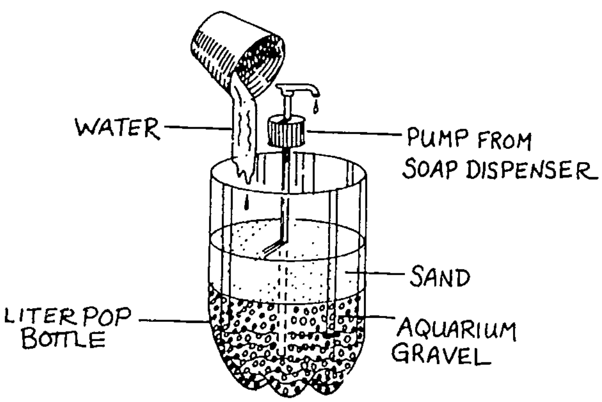
a. Tell the students that water found beneath the ground is called groundwater.

b. Explain that the top surface of the saturated zone that holds the water is called the water table. Mark the water table with the marker.

3. Place the pump into the gravel with the tube extending into the water.

a. Tell the students that today, a well is usually drilled. It is around 2 to 4 inches (5 to 10 cm) wide and lined with a metal or plastic pipe. Why do you think it needs to be lined? (to keep the dirt/sides from falling in)

b. Ask the students to notice that for the well to work, the tubing must extend below the water table.



WATER PUMP MODEL

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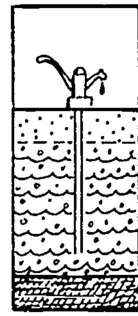
4. Pump water out of the model (catching the water in the cup).

    a. Ask "When we take water out of the ground, what happens to the water table?" (it goes down) Mark this level with a marker of a different color.



    b. Ask the students how water gets back into the groundwater supply. (when it rains, etc.) Ask a volunteer to demonstrate the action of precipitation and how it affects the groundwater by pouring more of the blue water back in until the original water table level is restored. (This is called "recharge.") Remind students that some groundwater sources cannot be replenished because they are sealed both above and below by solid rock or another ground material that will not let water soak down.

5. Explain that just as the rainwater or snowmelt can soak down into the groundwater, so can harmful contaminants like agricultural waste, sewage, road salt, and other chemicals.

    a. Pour water colored with yellow food coloring into the container.

    b. Ask them what happened to the water. (It changed color when the yellow reached it.)

    c. Explain that while many contaminants can be seen, others cannot. Ask the students to determine how we can tell if well water is contaminated even if we can't see the pollutants. (by testing the water)

    d. Explain to the students that contaminants are not always of human origin; some are naturally occurring. For example, radioactive radon is found in many areas of the United States. Radon can get into groundwater, making it unsafe to drink. There are tests to determine levels of radon.

B. Distribute copies of "Well, Well, Well" and the accompanying map.

1. Tell the students that one way to keep a well free of contaminants is to select a good site before it is drilled. (NOTE: This lesson does not require that the students consider the <u>direction</u> of groundwater flow, which would be a major consideration in a real case. For age appropriateness, we will only use distance in this exercise.)

2. Instruct the students to read the instructions and guidelines to the handout and select a place to drill the well. Students may draw a symbol to illustrate the well.

3. Check the student responses with the teacher key. (NOTE: The key may be used as a transparency to better illustrate the correct procedures for well placement.)

III. Follow-Up

A. Have the students draw a cross-section of a well and the water table. Instruct students to write one sentence that describes how a well affects the water table.

B. Have the students list at least four possible sources of groundwater contamination.

IV. Extensions

A. Have students contact their local health department for guidelines on digging new wells.

B. Have students research legends, folklore, and superstition about wells. Use the student sheet "Wishing 'U' Well" if you desire. Research may result in a creative writing assignment of a modern-day well legend.

C. Write the American Groundwater Trust (6375 Riverside Drive, Dublin, Ohio 43017) for more information about wells and groundwater protection.

RESOURCES

Banks, M., British Calendar Customs, Volume 1, William Glaisher, Ltd., London, 1937.

"Groundwater Pollution Control," American Groundwater Trust, Dublin, Ohio, 1990.

Korab, H., Land and Water: Conserving Natural Resources in Illinois, University of Illinois at Urbana-Champaign, Champaign, Illinois, 1989.

Nickson, Pat, Sandcastle Moats and Petunia Hotbeds: A Book About Groundwater, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1989.

WELL, WELL, WELL

Object: You must find a place to drill a water well where it is least likely to be contaminated.

Guidelines:

1. Each block equals 50 feet.

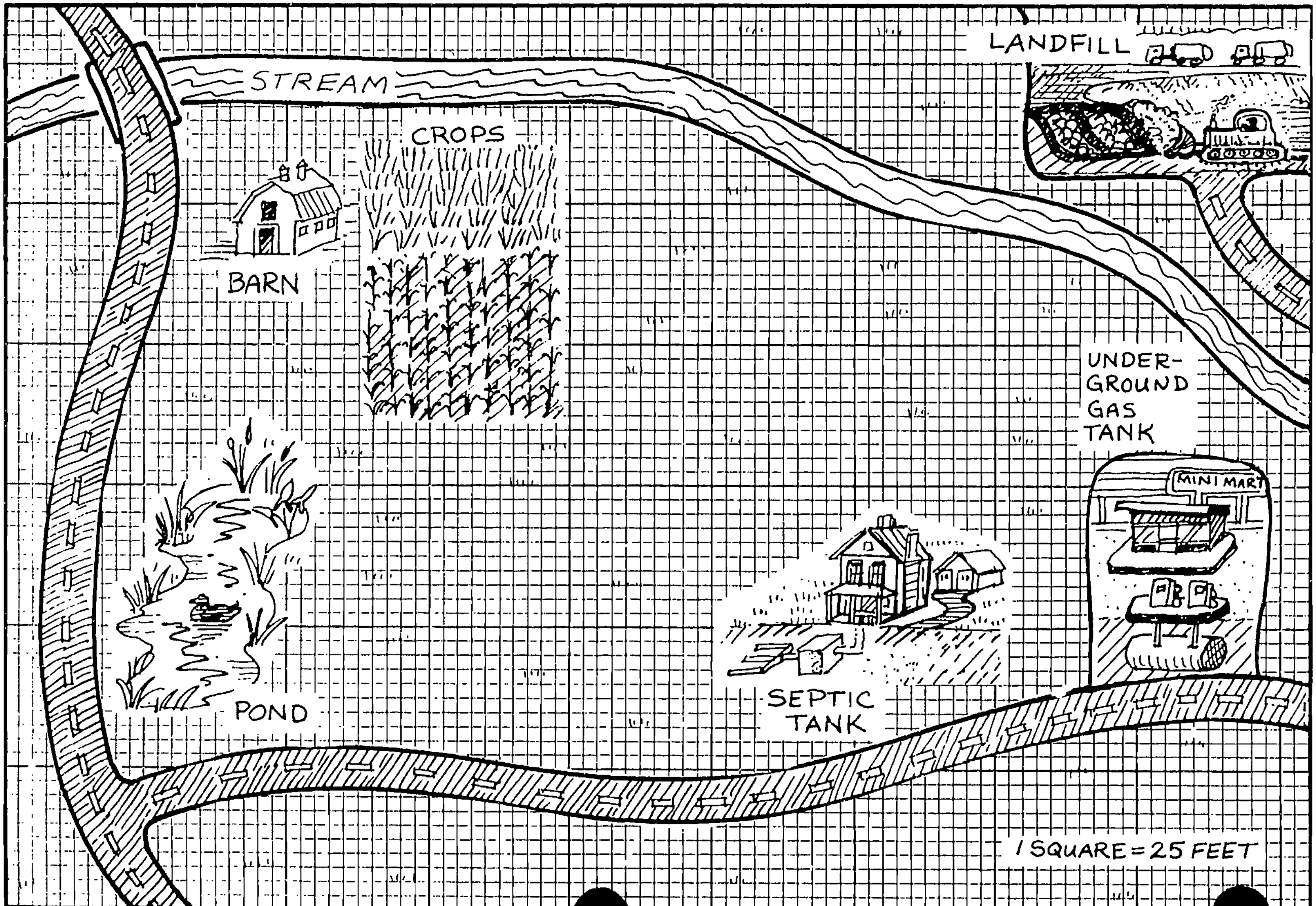
2. The following are things you will find on the map and the distance the well must be away to avoid possible contamination.

   a. a house with a septic tank and lines (50 feet)
   b. an underground gas tank (200 feet)
   c. a pond and a stream (200 feet)
   d. a barn used to store animal feed, manure, fertilizer, and chemicals for farming (200 feet)
   e. crop fields which are sprayed with fertilizer and pesticides (200 feet)
   f. roads that produce runoff and road salts are used (200 feet)
   g. a landfill (200 feet)

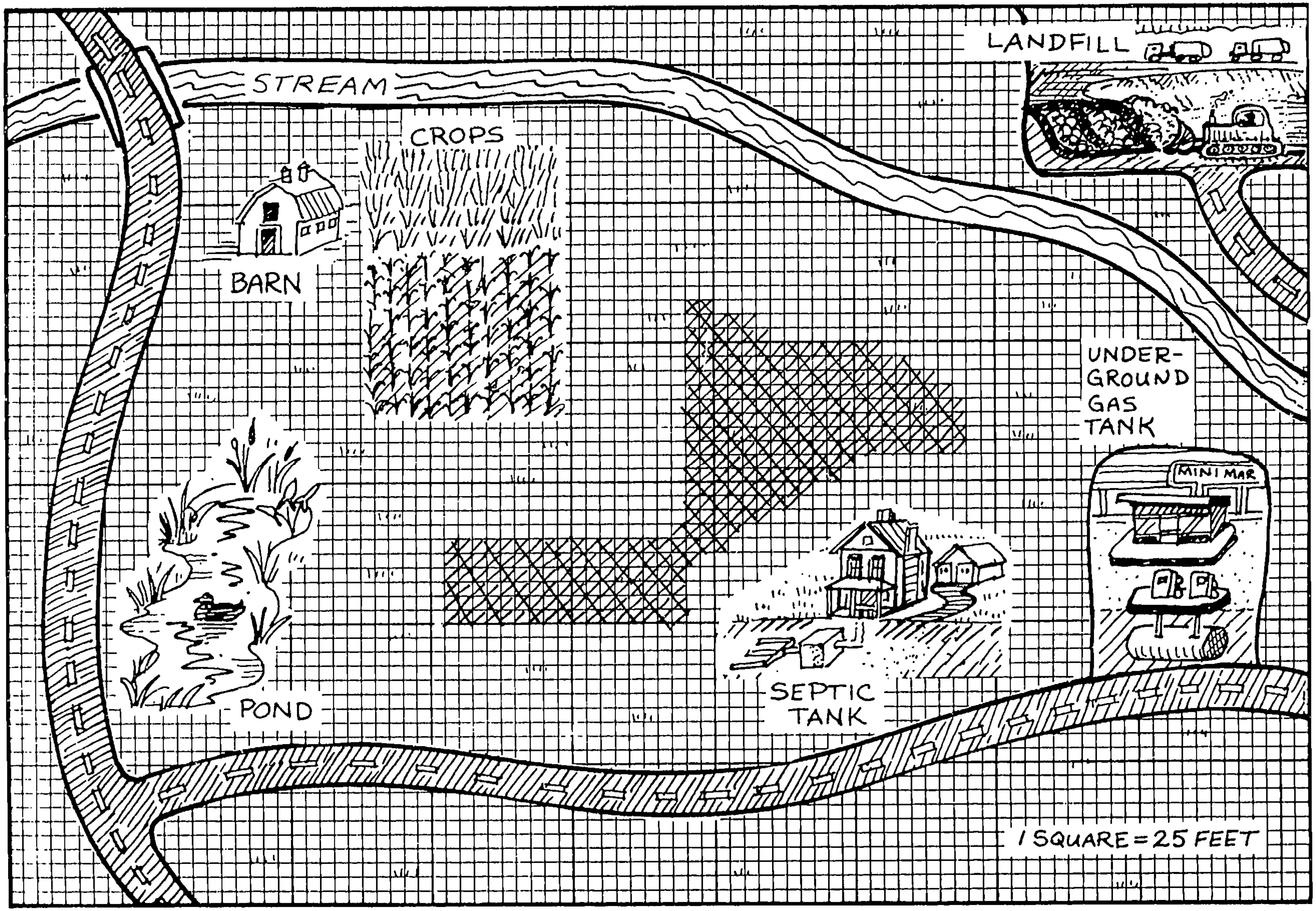
3. If you are unsure about the distances, play it safe and go to the long side of your measurement.

4. Mark the place on your map where you think the well should be dug. You may even want to draw a picture to illustrate your site, like a windmill, bucket well, or a gush of water.

WELL, WELL, WELL MAP



WELL, WELL, WELL MAP
ANSWER KEY



WISHING "U" WELL

In medieval Scotland, people believed that wells, or places where water came out of the ground, held magical powers that could heal illnesses or grant wishes. While wells were thought to have power to heal sick people, certain wells were believed to specialize in certain illnesses. Here are a few:

Illness	Well to Visit
Deafness	Craig-a-Chow
Skin diseases	Fergan Well
Insanity	Saint Fillan
Stomachache	Well at Newhills
Toothaches	Saint Mary's Well
Warts	Well of Warts
To insure another year of life	Carbet's Well

You had to be careful, however, to follow certain rules to make the wish come true. Here are a few examples:

* Go on certain days. The first week in February, May, August, and November seemed to be the most effective days to visit wells.
* Water must be either drunk or bathed in *after* dark and in complete silence.
* Leave part of your clothes or rags to get rid of the evil causing your sickness.
* Throw money into the well as a "thank you." Not leaving money would be considered an insult by the well and no wish would be granted.

Now it's time to make up your own well. Decide on a name, what your requirements for granting a wish will be, and what wishes you will specialize in granting.

CAP A CHEMICAL

OBJECTIVES

The student will do the following:

1. Conduct a home survey of hazardous household products.
2. Observe a simulation of urban contamination of groundwater by hazardous wastes.
3. Create a video for less hazardous alternatives to common household products.

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

TIME:
3-5 (45-minute) class periods

MATERIALS:
2-liter bottles
cherry drink mix
white aquarium gravel
baking soda
2 quart (2 L) pitcher
paper cups
water
paper towels
newspaper
liquid detergent bottles or spray cleaner bottles
videotape and camera (optional)
student sheets (included)
student/parent sheet (included)

BACKGROUND INFORMATION

mericans use 90 billion gallons (340 billion liters) of groundwater everyday. Of those billions only 14 percent is drinking water. About half the people in America use groundwater for drinking. More than 63,000 chemical compounds are used in the United States; some are potential hazards to our drinking water when they are not used and disposed of properly.

One hundred years ago, many of the products we used were made of natural ingredients. Many things were used over and over again. Waste disposal became more serious when we began using complex chemicals and petroleum-based products. These kinds of products cannot safely be disposed of in the same way that wastes used to be handled. We are researching better ways of disposing of toxic chemicals.

Today we know that some products should never be poured down the drain or on the ground. Some of these chemicals are readily available in our homes. It is essential that we begin to understand how these substances can contaminate water supplies. In septic tanks, these chemicals can either (1) kill all the bacteria that decompose waste in domestic wastewaters and cause untreated sewage to seep into the ground and potentially enter groundwater or (2) they can pass through the system untreated and enter groundwater. In either case, groundwater could become contaminated; this could pollute well water and make it unfit to drink. Polluted groundwater can even seep into surface water and pollute it.

While laws protect consumers from the sale of patently unsafe products, many of the chemicals available for use by consumers are hazardous and must be used and disposed of according to the directions given on the package. Consumers should also be careful not to overuse these products or to use them when less dangerous products would do.

Terms

chemical: related to the science of chemistry; substance characterized by a definite molecular composition.

chemistry: the scientific study of the properties, composition, and structure of matter, the changes in structure and composition of matter, and accompanying energy.

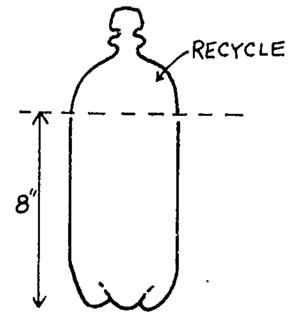
contamination: an impurity.

hazardous household product: chemical products for home use that are potentially dangerous to human health and/or the environment.

pollution: impurities in air, soil, or water that are harmful to human health or the environment.

urban: having to do with cities.

waste: refuse, or excess material.



ADVANCE PREPARATION

A. Make copies of the student and student/parent sheets.

B. Cut the 2- liter bottles (one per group) as shown.

C. Pour enough white aquarium gravel into the cut bottles to fill them halfway. Sprinkle some powdered drink mix in the middle of the gravel. Pour more gravel on top.

D. You may make a transparency of the student sheet "Where Wastewater Goes."

PROCEDURE

I. Setting the stage

A. Discuss with students what happens to things they pour on the ground and down the drain. Just because they are out of sight does not mean they won't come back. Explain where groundwater is and how sewers and septic lines relate to it.

1. Use the student sheet, "Where Wastewater Goes." Ask the students to list examples of household products that are put into a home's wastewater. Students may color the student sheet if they have extra time.

2. If you use the student sheet as a transparency, you can have your students trace the path a toxic chemical compound would take if poured down the drain.

B. Divide the class into groups of 3 or 4 students. Provide each group with a pre-cut 2-liter bottle containing aquarium gravel and a small amount of cherry drink mix (dry).

1. Have the students add water and observe. The red represents the hazardous chemicals we often pour down our drains or on the ground. These are potential contaminants for our water.

2. Discuss hazardous chemicals. Use the first part of the student/parent sheet, "'Cap A Chemical' Survey" for discussion.

II. Activity

A. Send home with the students the student/parent sheet, "'Cap a Chemical' Survey." This is to survey the household chemicals found at home.

1. Be sure students understand they are not to inventory household chemicals by themselves. (Have an alternative for students whose parents won't do a survey.) Go over the survey with them and make sure they understand that they need a parent to help them.

2. When the survey is completed, take the information and make a class bar graph. Make the graph on the chalkboard. Have the students use graph paper. Which chemicals are in most homes?

B. Lecture on safer chemicals we can use in our homes.

1. Tell the students that we can use safer products instead of potentially dangerous ones. Examples of alternative products include: cleanser - baking soda and water (use like a scouring powder); air freshener - baking soda or fresh flowers; carpet freshener- baking soda (sprinkle it on the carpet and then vacuum up); rug cleaner - non aerosol shampoo (use a small amount and rinse with water); detergents - biodegradable (check the label); window cleaner - lemon juice (or vinegar) and water; floor cleaner - a small amount of detergent and white vinegar; mothballs - cedar shavings.

2. Show the students some sample household products you brought from home. (NOTE: You might save some empty containers and rinse them out before you bring them.) Read labels on products to the students so they can see what is in them. If the ingredients are not listed, call the 800 number and ask.

3. Share with the students the following pointers: If you must use toxic chemicals, then buy only what you need. Use less. Find out from local authorities where you can properly dispose of leftovers. Remember that some chemicals kill bacteria needed in a septic system.

C. Have a fun contest using one of the terms for this lesson.

1. Ask the students how many words they can make out of a selected term. For example, "CONTAMINATION." (Answers: nomination, nation, contain, ton, on, ant, into, no, I, can, cat, not, a, can.......)

2. Reward the student with the most words when you call time.

D. Have the students write and perform a commercial on less toxic products and reasons to use them. Have them work in small cooperative groups of 3 or 4 students.

1. Have students write, revise, and rewrite their commercials. Give them the student sheet "'Cap A Chemical' Commercial" to write on. Remember to include props to add excitement. Students may bring an object from home or make their own props. Students could create a jingle to go with their commercial.

2. If you have the equipment available, videotape the commercials and play them at a parent organization meeting.

3. Try to get a local television or radio station to play the commercials.

III. Follow-Up

Have your students clean the room and their desks using safer products.

A. Using empty liquid detergent or spray cleaner bottles, mix 2 tablespoons (30 mL) baking soda and 1 cup (250 mL) water to make a safer cleanser. Scour the desks with this mixture. Remember to rinse the residue off with clean water.

B. Clean the windows with 1 cup (250 mL) clean water with 1 tablespoon (15 mL) lemon juice in it. Use newspapers to rub the glass. (Then recycle the paper!)

C. Have the students share with the group how they feel about improving their environmental attitudes and behavior.

D. Celebrate with clean, safe ice water to drink.

IV. Extensions

A. Have students design the packaging for their safer products (See II D.). Bring in old boxes for household products and cut them apart. Notice how the flaps fold in to form the box. Students will draw their own boxes and design logos for their products. Students can use the boxes in their commercial.

B. Using magazines, have the students cut out pictures of household chemicals that are potentially hazardous. Pictures of products that are less hazardous should also be cut out. Have students glue pictures to a posterboard that has a line down the center. On the left, glue less hazardous products and on the right, glue the most hazardous. Use the poster on a bulletin board.

C. Investigate new programs aimed at trying to clean up groundwater. A company owned by Dow Chemical (AWD Technologies) developed a system to clean up contaminants found in groundwater. The system is called AquaDetox/VES System. You might locate more information about this or other experimental systems.

D. For more information write to the American Chemical Society, Dept. of Public Affairs, 1155 16th Street NW, Washington, D.C. 20036.

RESOURCES

Jorgensen, Eric, ed., The Poisoned Well, Island Press, Washington, DC , 1987.

Lord, John, "Hazardous Wastes from Homes," Enterprise for Education, Inc., Santa Monica, California, 1986. (Address: 1320A Santa Monica Mall, Santa Monica, California 90401.)

Naft, Barry, "New, Improved Groundwater Cleanup Technology," Environmental Science Technology., American Chemical Society, Washington, DC, 1992, pp. 871-872.

Tennessee Valley Authority, Waste: A Hidden Resource, TVA, 1989.

U.S. Environmental Protection Agency, Let's Reduce and Recycle: Curriculum for Solid Waste Awareness, EPA, Washington, DC, 1990.

Water Pollution Control Federation, "Household Hazardous Waste: What You Should and Shouldn't Do," Water Pollution Control Federation, Alexandria, Virginia (Address: 601 Wythe Street, Alexandria, Virginia 22314-1994. Phone: 703-684-2438)

"CAP A CHEMICAL" SURVEY

Dear Parent,

Please take a few minutes to help your child fill out this survey. It is important that you assist your child as some home chemicals may be toxic. Your child will use the information at school during class activities. Please sign below after you and your child have completed this survey. Thank you for your time and interest in your child's education.

These common products are found in many homes. They have the potential to be hazardous to human safety and health. Improper use and disposal may endanger our groundwater resources. How many of these do you have in your home? Write the products in your home on the survey form on the back of this sheet.

CLEANERS
bleach
ammonia
lye
*floor care
*furniture polish
*silver polish
*window cleaner
oven cleaner
bathroom cleaner
disinfectant
toilet bowl cleaner
tub and tile cleaner
spot cleaner
rug cleaner

PERSONAL
medicine
*nail polish
*nail polish remover
hair spray
hair dye

GARAGE
*antifreeze
*automatic transmission fluid
*battery
*brake fluid
*car wax
*diesel fuel
*gasoline
*kerosene
*motor oil
*brush cleaner
latex paint
*oil-base paint
paint thinner
turpentine

YARD
*bug spray
*fertilizer
*fungicide
*insecticide
*rat poison
*weed killer
flea powder

OTHER
*lighter fluid
*mothballs

(ALERT: Never mix chlorine bleach and ammonia; it produces a potentially dangerous gas.)

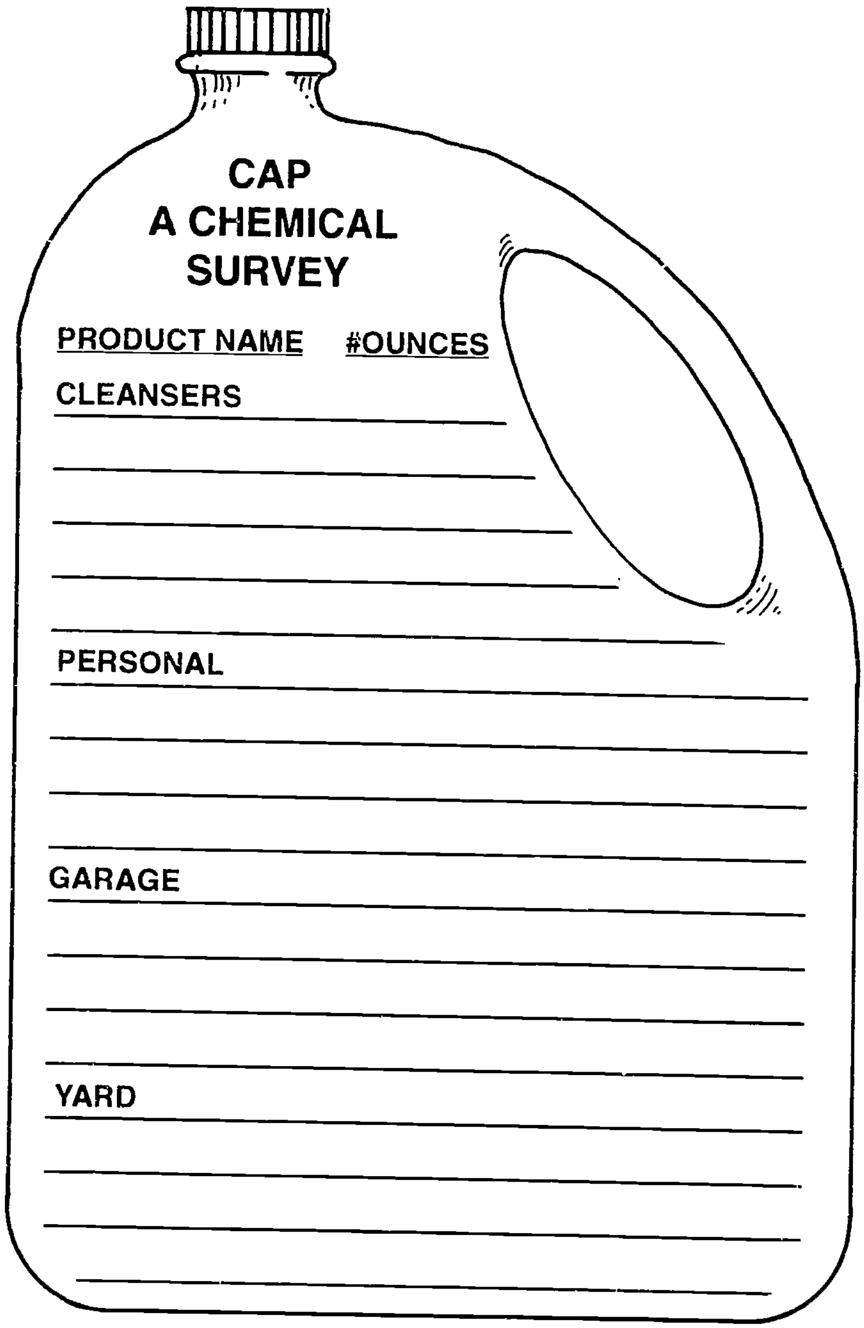
* = hazardous waste (Do not dump on ground!)

My child and I have surveyed our home for hazardous products that may pose a threat to groundwater quality if improperly used or disposed of. The results of our survey are written on the form on the back of this sheet.

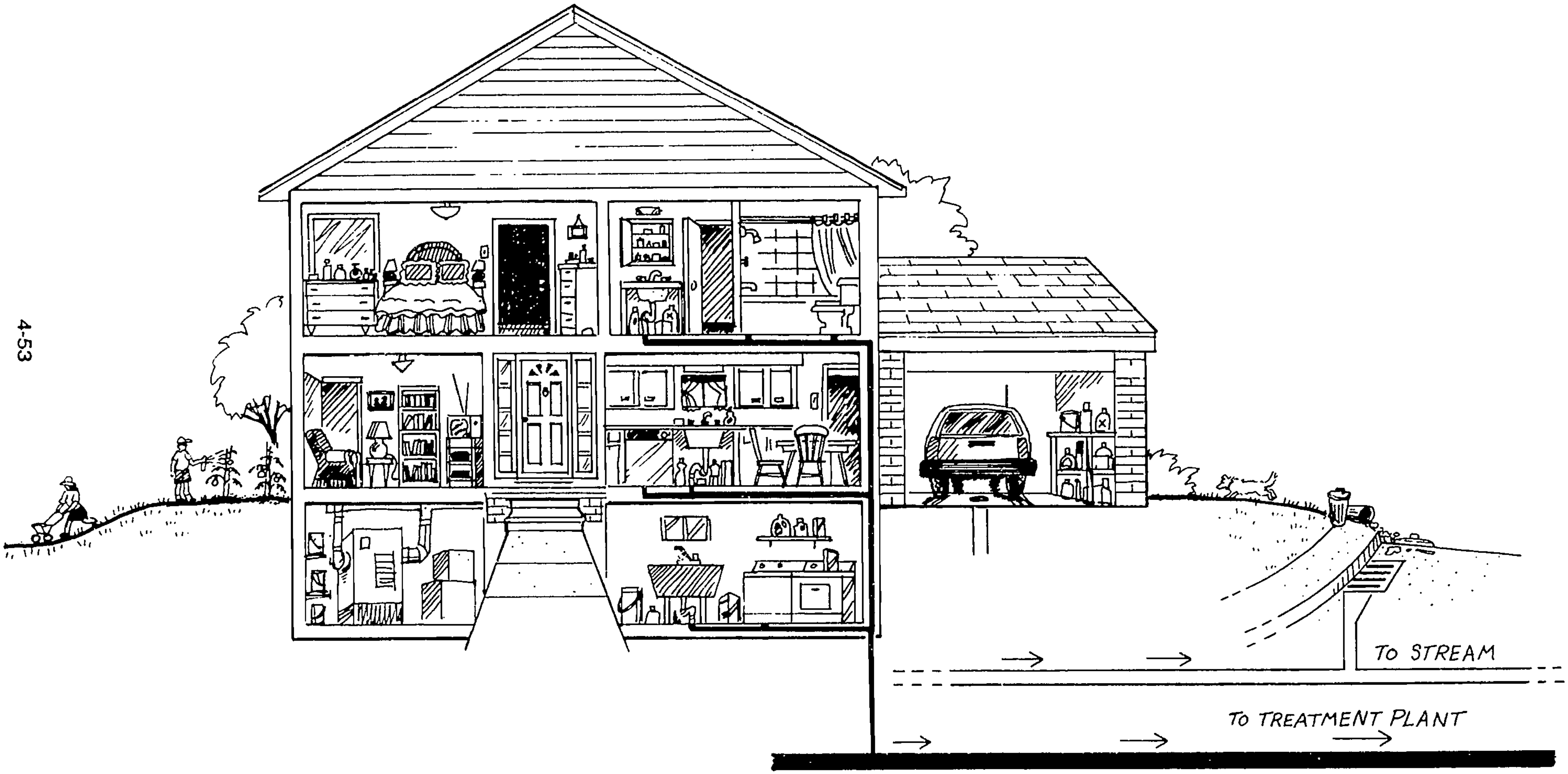
Signed: ______________________

"CAP A CHEMICAL" SURVEY
(continued)

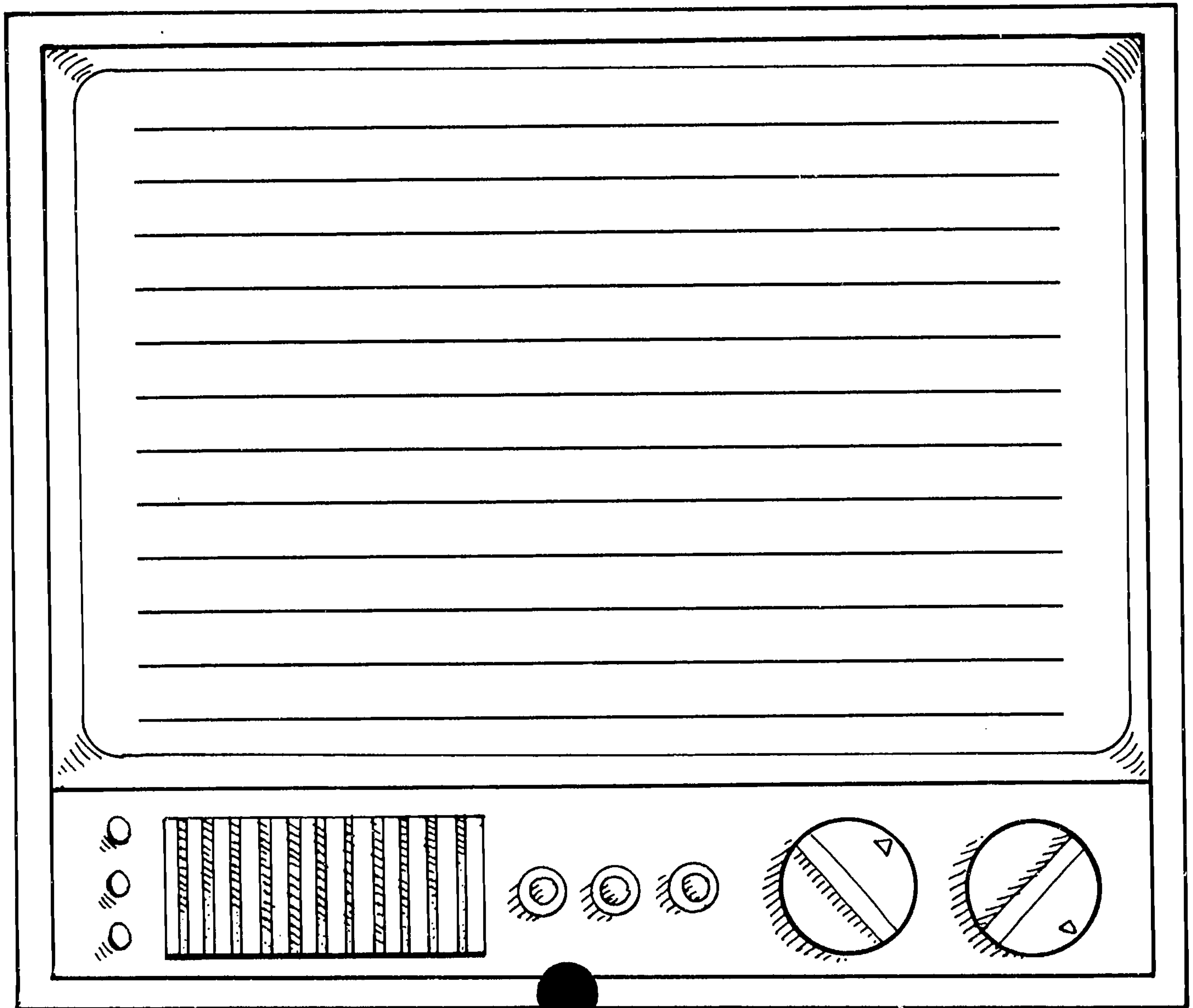
Using the list of hazardous household products on the front of this page, identify the listed products found in your home. Write them on this survey form.



WHERE WASTEWATER GOES



CAP A CHEMICAL COMMERCIAL



FLUSH YOUR TROUBLES AWAY

OBJECTIVES

The student will do the following:

1. Identify the basic parts of a septic system.
2. Relate septic system failures and contamination of groundwater to human health.
3. Write and illustrate a newspaper article about the effect of septic contamination of groundwater and its prevention.

SUBJECTS:
Science, Language Arts, Art, Social Studies

TIME:
3 45-minute class periods

MATERIALS:
2 clear glasses
black tempera paint
water
wax drink sticks (found in the candy section of the grocery store)
markers or crayons
watercolor paints
old newspapers
student sheets (included)

BACKGROUND INFORMATION

When it comes to septic systems, the most important rule is: If it smells bad it needs to be fixed. Failed septic systems are a big problem for contamination of our groundwater. Most homes in rural areas have septic systems. New construction usually requires that systems be installed. A few older homes without any sanitary system still exist. When we began to use sewers and separate ourselves from human waste we began to live longer; diseases which were passed in these wastes were easier to control.

Today we find groundwater contamination from septic systems still occurs but can be avoided. Some wells in rural areas produce water carrying coliform bacteria (an indicator of fecal contamination). Septic systems or poor management of animal wastes have polluted the water. We must learn not to position wells for drinking water too close to a septic system. Properly maintained septic systems are our way of avoiding disease and preventing pollution of the groundwater. We also protect our groundwater through proper use of the land.

A properly installed and maintained septic system will handle the waste produced in a home. The wastes are carried from the house by water through pipes into a large container called a septic tank. These containers are often made of concrete or steel. Newer designs may be made of other materials. When the waste enters the tank, the liquids rise to the top and the solids go to the bottom. Bacteria help break down the solids. The liquids flow to a pipe which leads to the drainfield lines. The drainfield is an important part of the system and allows the liquid to drain through the soil and be cleansed before coming in contact with the groundwater. Before installing a septic system, a test of the soil should be conducted, since some soils are not permeable enough to allow the water to pass through.

Terms

coliform bacteria: bacteria found in waste products of humans and animals; by themselves, most coliforms are not a health risk, but they often indicate the presence of other microbes that may cause illness if ingested.

contamination: an impurity.

failure: does not work.

groundwater: water under the ground's surface.

septic tank or septic system: a domestic wastewater treatment system into which wastes are piped directly from the home; bacteria decompose the wastes, sludge settles to the bottom of the tank, and the treated effluent flows out into the ground through drainage pipes.

ADVANCE PREPARATION

A. Fill one clear glass with clean water and fill the other with dirty water (you can add some black tempera paint to make it look dirty).

B. Photocopy the student sheets.

PROCEDURE

I. Setting the stage

A. Hold up a glass of clean water and a glass of dirty water. Ask which one the class would prefer to drink. Explain that many rural and urban people rely on groundwater for their drinking water.

B. Using the student sheet "Flush Your Troubles Away," explain the basic parts of a septic system and drainfield. If you use it as a transparency, cover the labels and ask students to name the sections. This will reinforce these ideas.

1. Have the students trace the wastewater coming from various points in the house.

2. Point out the location of the groundwater.

3. Brainstorm for information on your students' water needs and ways they use water. Ask your students what they see wrong with the student sheet "Flush Your Troubles Away." Point out the clog and the leaks in the system. Remind the students that the tank holds sludge that the bacteria have not broken down. How would they correct the problem?

4. Relate these problems to groundwater contamination.

II. Activities

A. Broken field pipes are one source of septic failures. Broken pipes leak and can contaminate the groundwater. Ask your students how polluted groundwater would affect them. Small teams of 3 or 4 students work best in simulating this concept. Make sure newspaper is covering the desk area. Model this activity as the teams simulate it.

1. Take a drink stick and hold it up. Tell your students it represents a septic system field pipe. If something heavy puts pressure on it (such as a vehicle driving over it) it could break.

2. Break the stick in half and let the liquid pour out over the newspaper. Discuss how pipes could be reinforced or how better preventive methods (such as not putting field lines where a vehicle would run over them) could be employed. For example, large trucks often deliver home heating oil or gas where drainfields underlie their paths.

B. Discuss with students what coliform bacteria are and why they indicate a health risk. Discuss possible ways they could contaminate the groundwater.

1. Preventive measures include properly maintaining a septic system. For example, we should make careful choices of tissue and never flush cardboard, plastic, or home chemicals that kill bacteria. All these efforts will help maintain a functional septic system.

2. Septic tanks need bacteria to break down solids. Bacteria can be purchased at home supply stores and flushed into the tank.

3. Some parts of the United States and other places around the world do not have any method of sanitarily dealing with human waste. Things such as the outdoor privy, or outhouse, (with no home septic tank) still exist. Contaminated groundwater can make you sick and affect all living things that depend on it.

4. A septic tank needs to be pumped out as frequently as recommended by local health authorities (e.g., every 5 years).

C. Students will design and lay out the front page of a newspaper (use the student sheet with layout).

1. Each student will independently make a newspaper. (NOTE: For younger students, this may be more suitable as a group activity.)

   a. Original, creative articles will be written.

   b. A picture will be included in the space provided. This picture can be hand-drawn, a photograph, or a magazine picture.

   c. The students will use creative articles written about preventing septic system failures and reasons for protecting our groundwater. Made up stories of the results of groundwater contamination can be included; for example, the story could be about a family that is sick. They have not had their septic tank pumped out for 20 years, and they recently allowed a heating oil company to drive its heavy truck over their field line. The hospital has determined they drank water contaminated with microorganisms that made them sick. The local health department tested the well water on their farm and determined it was contaminated. A local company is pumping the tank and putting in a new field line.

   d. Have the students describe some problems that may be unusual in your area. (Perhaps you are located near a water body or in the desert.)

2. You may contact your local health department and find out what regulations exist where you live concerning installation and maintenance of septic systems, such as mandatory soil percolation testing.

3. Display the newspapers in the classroom and ask the school paper to include some articles in their next edition. If you don't have a school paper ask your community paper to include some articles as a public service.

III. Follow-up

A. Have the students use the following matching exercise to demonstrate their knowledge of the terms for this lesson.

1. Use the student sheet "Flush Your Trouble Terms" or write the exercise on the chalkboard.

2. The answers are as follows: 1. c, 2. e, 3. d, 4. a, 5. b.

B. Conclude this lesson with question time. Ask the following:

1. If it hasn't rained in several days but it is wet over your drainfield, you should . . . (Tell your parents you suspect a septic system failure.)

2. It is wet over your drainfield all the time. Your well is close to it. You have been sick and many members of your family have too. What will you do? (Ask your parents to have the well tested for coliform bacteria contamination.)

3. The tissue is used up. Should you remove the cardboard tube and drop it in the commode? Why or why not? (No, it takes up space and requires a long time to decompose. It is better to put it in the garbage can.)

4. Your family is having problems with your septic system and it hasn't been pumped out in 15 years. What should you do? (Have it pumped out as often as local health authorities recommend.)

IV. Extensions

A. Have the students investigate alternative septic systems.

B. Have each student paint a landscape using watercolor paints. Include at least one water source such as an ocean, lake, or river. Use "dirty" water (mix 1 teaspoon [5 mL] black tempera paint in the water used to paint). The effect will be a dark, "polluted" scene.

C. Have teams of students design posters with safe septic system tips. If you live in a rural community place the posters in local stores, libraries, or in your school.

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"Is Your Drinking Water Safe?" U.S. Environmental Protection Agency, Washington, DC, 1989.

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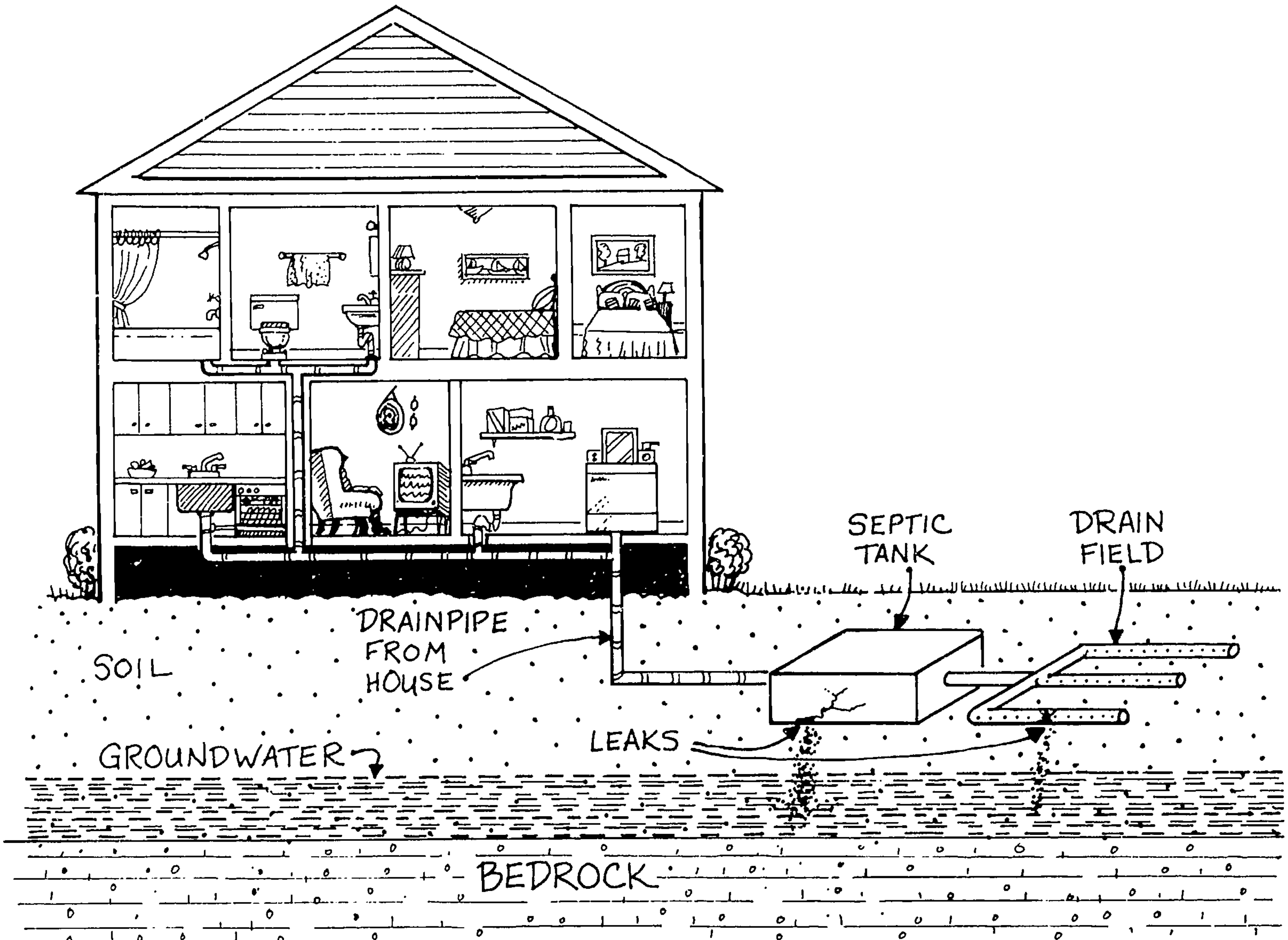
FLUSH YOUR TROUBLES AWAY



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NOWTOWN NEWS

DATE ________ PLACE ____ 25¢

by

FLUSH YOUR TROUBLE TERMS

Match the word to the correct definition.

_____ 1. septic system

_____ 2. contamination

_____ 3. groundwater

_____ 4. failure

_____ 5. coliform bacteria

a. does not work

b. bacteria found in human and animal wastes

c. a tank and pipe system where human wastes and household wastewater are piped so that wastes can be broken down by bacteria and water can be cleaned

d. water under the ground's surface

e. an impurity

A TALE OF OOZE

OBJECTIVES

The student will do the following:

1. Construct a model of a non-lined landfill.
2. Perform an experiment on the formation of leachate.
3. Write a paragraph on the prevention of groundwater pollution by landfill leachate.

SUBJECTS:
Social Studies, Science, Math, Language Arts

TIME:
2-3 45-minute periods (plus time on 10 additional days for gathering data)

MATERIALS:
3-liter plastic bottles (2 per team)
soil
household waste
3.5 inch (8.75 cm) squares of gauze or cloth
aquarium gravel
measuring tapes
measuring cups
rubber bands
ziplock baggies
student sheets (included)
masking tape

BACKGROUND INFORMATION

Humans have always produced waste. Prehistoric cliff dwellers in Colorado used the back rooms of their cliff homes to dump waste. Around 500 B.C., the first known regulations against throwing waste in the streets were issued in Athens, Greece. Dumps were established. Archaeologists explore the waste of prehistoric peoples to better understand their society, culture, and the way they lived.

Growing populations and the great number of new products have increased the problems with landfills. When rain, snow, or runoff water soaks into and through a landfill, it can dissolve some of the landfill's contents and carry it on down to the groundwater. This mixture is called leachate. As the amount of waste increases, the potential for leachate to enter the groundwater increases.

Groundwater supplies vary around the world. When groundwater is the only source of water, it is an especially valuable resource. Clean water is essential for the existence of life. Contamination of groundwater is difficult and expensive to reverse and may remain for a very long time.

In various parts of the world, including the U.S., regulations are established to protect groundwater. Barriers such as plastic or clay layers must be installed in new landfills today. Research is continuing to determine even more efficient ways of preventing pollution of our groundwater.

Terms

barrier: blocks or stops further movement.

contamination: an impurity.

containment: holds something within a defined space.

environment: the total circumstances surrounding an organism or group of organisms.

groundwater: water under the grounds' surface.

landfill: an area of land where public waste is disposed of.

leachate: the liquid formed when water (from precipitation) soaks into and through a landfill, picking up a variety of suspended and dissolved materials from waste.

liner: plastic or clay used to seal an area.

pollution: a contaminant (impurity) in the air, water, or soil that can cause harm to human health or the environment.

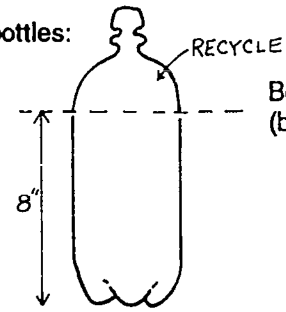
waste: a useless or worthless by-product; the undigested residue of food eliminated from the body; garbage or trash.

ADVANCE PREPARATION

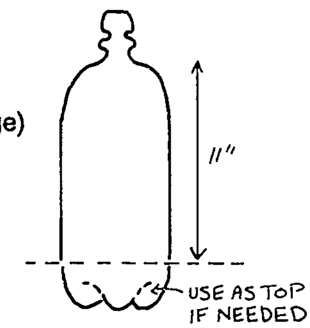
A. Cut the plastic bottles, dividing the materials up so you have what you need for each team. (Note: Cover the tables with old newspapers.)

How to cut your bottles:

Bottle #1 (invert to form a container for your landfill)



Bottle #2 (base to contain leakage)



B. Photocopy student sheets. (NOTE: You might make a transparency of the sheet "Landfills.")

C. Be sure to plan for this lesson to be taught on non-consecutive days.

D. If possible, have an aide or parent volunteer present to help the groups.

PROCEDURE

I. Setting the stage

A. Lead students in a discussion of what groundwater is and where it is located.

B. Discuss garbage and how long people have produced it. Help students realize humans have always produced waste. Increased populations and technological development added to the amount and types of waste. Eventually we began to regulate where and how wastes are disposed of.

II. Activities

A. Discuss the student sheet, "Landfills." Compare the lined and non-lined landfills. Students may want to add color to their handout if they have time. (NOTE: You could use this sheet later for reinforcement or a pop quiz. Remove the labels to use as a quiz.)

B. Teams of students will simulate how a landfill contaminates groundwater. (NOTE: This may be done as a class demonstration.)

1. Cooperative learning teams construct a model showing how landfills may affect groundwater. Each team will construct a model. Small teams of two or three work best. After you provide materials to each team, they will construct their models. Pass out the student sheet, "Non-Lined Landfill Model."

   a. Students will place the gauze strainer or piece of cloth over the narrow end of a pre-cut bottle , attaching it with a rubber band. Invert the bottle and place in the 8-inch (20-cm) base.

   b. Place about 1/4 cup (60 mL) of gravel in the inverted bottom.

   c. Now alternate layers of the measured waste mixture and soil. Discuss with the students that people began covering their dumps with soil because of problems with smell, rodents, and flies. Ancient dumps were often places of continuously burning fires. In 1916, "sanitary landfills," where soil was placed on top of the dump each day, were developed.

2. After they have constructed the models, have students write their predictions about what will happen to them over time.

   a. Give the students the log sheet ("Landfill Experiment Log") on which to record their observations.

   b. They will water the models daily with 2/3 cup (160 mL) water for several days until it is saturated and then for a couple more days. The models will be kept in a warm, well-lighted area.

3. Observe how leachate forms and how it might enter groundwater.

   a. Students will measure the amount of liquid going in and coming out.

   b. This is recorded in the log along with anything else students see.

   c. At the end of two weeks, have the students discuss their results in groups. Each group will formulate a conclusion.

C. Play a game called "Ooze Ball" using the terms from this lesson. Place masking tape approximately 10-15 feet (3-5 m) from the garbage can.

1. This game is patterned after a foul shot in basketball. Students take turns spelling or defining the term they are given.

2. Students who correctly spell or define their term get to take a paper wad and throw it at the garbage can.

3. If the paper wad goes in, that student gets 3 free shots. Give two bonus points for each "can" (a paper wad going into the garbage can).

D. Hand out the student sheet "Landfill Terms." Students will write each term in a complete sentence. (NOTE: Younger students will probably need to do this in groups or as a class.)

E. Discuss government regulations that affect landfills. Barriers such as plastic and clay liners are now required in the U.S. to contain the leachate. Double liners are presently installed in new landfills. Permits are required to open or close landfills. Recordkeeping is also required of those operating landfills. Demonstrate the double liner using 2 ziplock baggies.

1. Take a dark color liquid tempera paint and pour a small amount in a baggy.

2. Squeeze the air out and seal the baggy up.

3. Place the sealed baggy into the second baggy and seal it up. This illustrates how the liner in the landfill operates. In this way a leak should be contained.

III. Follow-Up

A. Student groups will take the data from their experiment and prepare an oral presentation on their results and conclusions.

B. Direct a class discussion on the similarities and differences between group conclusions to end this activity.

C. Take the c' ss on a field trip to a landfill or invite a guest speaker with knowledge of your local landfill to visit your class. Be sure to let a guest speaker know exactly what you want him or her to discuss. Have the students formulate questions to ask the guide at the landfill or the guest speaker.

IV. Extensions

A. The model activity could be extended. Have different teams prepare their landfills with a barrier they want to test. Use plastic from a garbage bag as a liner. Remember to double it.

B. Students could examine the used landfill model and determine what wastes put into it are biodegradable. They could rank items in the order that they are disintegrated.

C. Some landfills are now being made into wildlife refuges when they are full. (Remember that they are covered with a thick layer of soil.) Native plants and trees are planted. Birds and other wildlife return. Have each student divide a sheet of typing paper in half and draw a picture of his/her landfill as it looks today. Draw a second picture of how it would look covered with soil, plants, and trees.

D. Have the students investigate alternative solutions to prevent groundwater contamination by leachate. Solutions should include ways to reduce, reuse, or recycle wastes so they don't end up in landfills. Have them invent their own solutions and illustrate them.

E. Students could create a collage using waste items attached to cardboard. The landfill colla be contained in a plastic wrap cover. Students could write about alternative solutions to ou waste. Alternatives might include recycle, compost, or incinerate waste. This would be ed to the collage and displayed on a bulletin board in the classroom.

F. Have students write creative futuristic stories about a day when the items in our landfills become a warehouse of treasures. Perhaps the metals would be needed, or maybe a fuel source lies in that pile.

G. Many landfills are filling up. Let the students decide where the next landfill will be located in their community. They should be prepared to defend their choice of location.

H. Perhaps the students could begin a recycling project at your school, collecting aluminum cans, paper, and plastic for recycling.

RESOURCES

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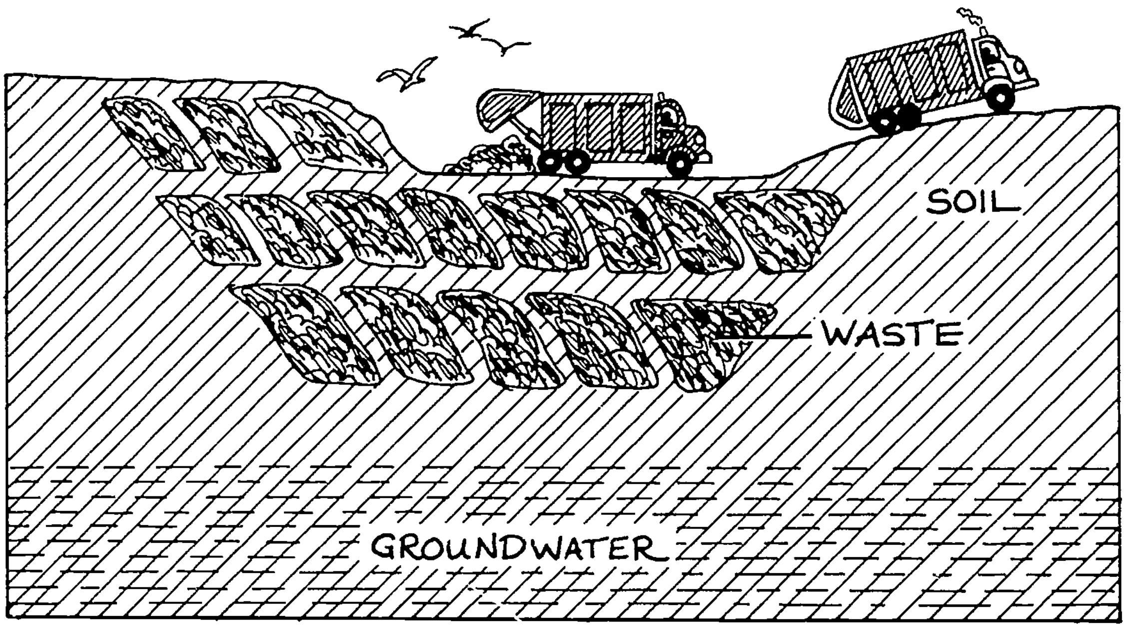
Pollock, Cynthia, Mining Urban Wastes: The Potential for Recycling (Worldwatch Paper 76), Worldwatch Institute, Washington, DC, 1987.

"Bottle Biology Resources Network," University of Wisconsin-Madison, pp. 13-37. (Address: 1630 Linden Dr., Madison, Wisconsin 53706)

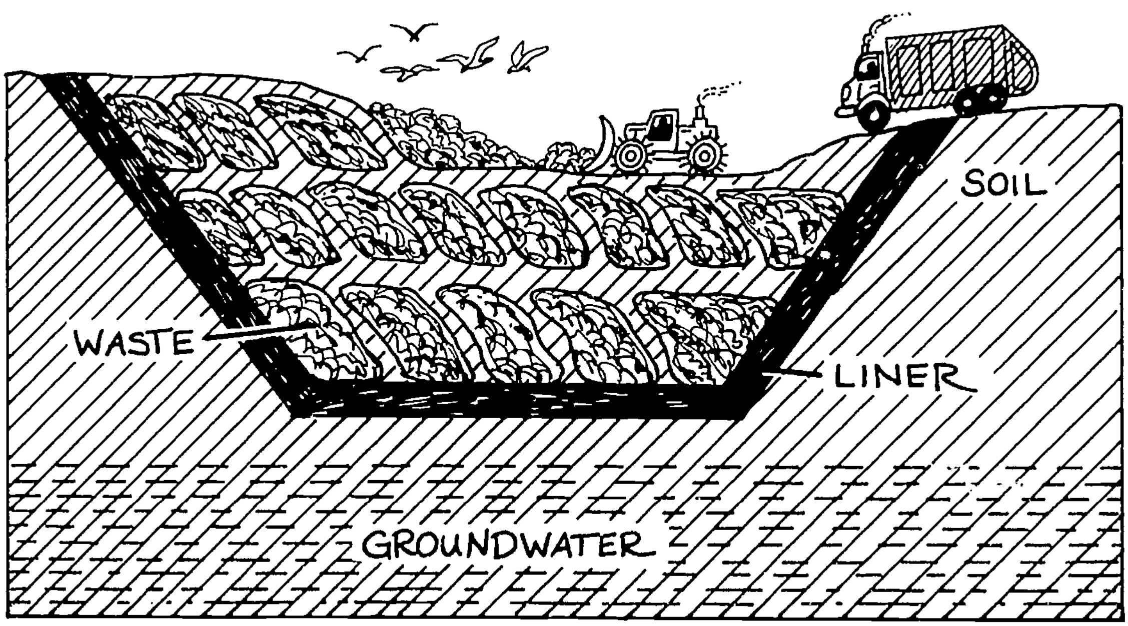
Werben, Linda, and Michael DiSpezio, "A Historical Perspective," Science and Children, Vol. 28, No. 4. January 1991, pp. 33-35.

LANDFILLS

Non-Lined Landfill
(potentially unsafe for our groundwater)

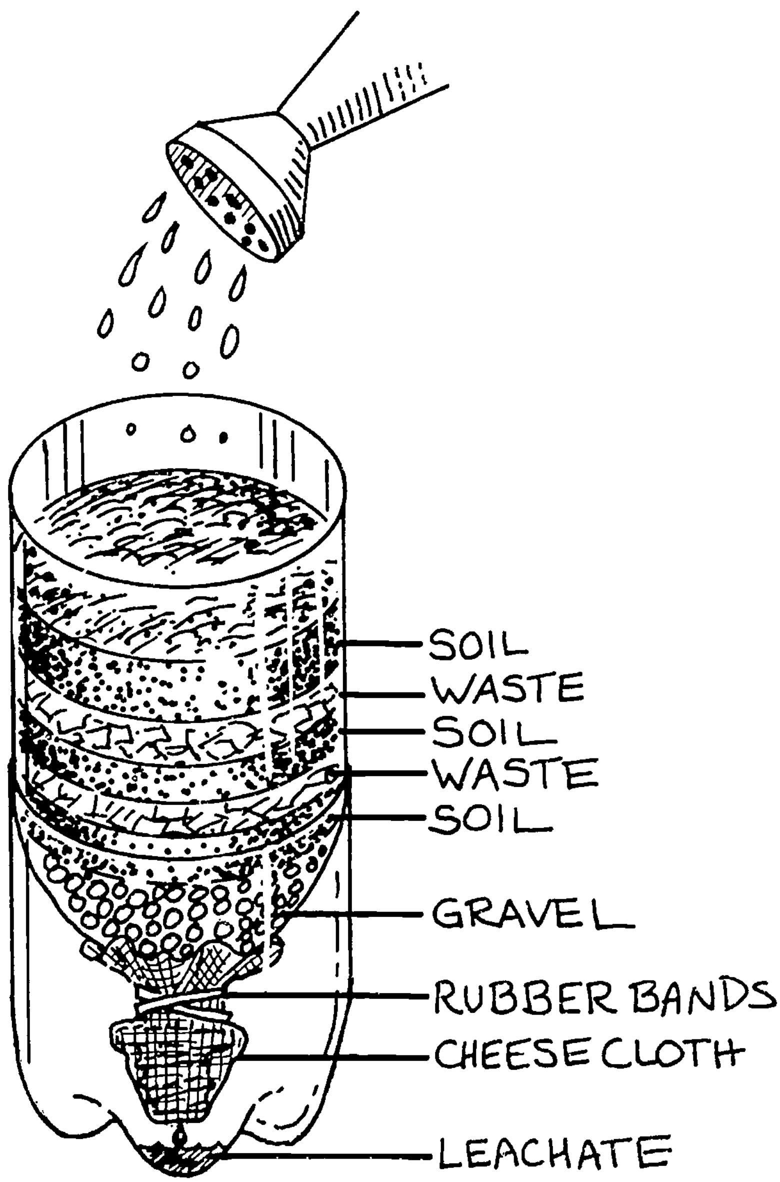


Lined Landfill
(built according to regulations and safer)



NON-LINED LANDFILL MODEL

soil	1 cup (250 mL)
waste	2 cups (500 mL)
soil	1 cup (250 mL)
waste	2 cups (500 mL)
soil	1 cup (250 mL)
gravel layer	1/4 cup (60 mL)
gauze or cheesecloth	
rubber band	



LANDFILL EXPERIMENT LOG

Name ______________________________ Date ______________________________

PREDICTION ____

____

Date of Entry	Water Applied	Observation Record

(Hint: Keep your log under your landfill model so it won't get lost!)

Results ____

____

____

____

Conclusion ____

____

____

LANDFILL TERMS

Use each of the following terms in a complete sentence. Write the sentences as a paragraph. Be sure to describe how we construct landfills so as to protect groundwater. Remember to use capital letters and punctuation correctly.

contamination	leachate	pollution	liner
environment	barrier	groundwater	landfill
containment	waste		

STAMP OUT L.U.S.T.

OBJECTIVES

The students will do the following:

1. Demonstrate how Leaking Underground Storage Tanks can contaminate groundwater.
2. Calculate the differences between the amounts of gasoline received and sold to determine if gas stations have Leaking Underground Storage Tanks.
3. Design a postage stamp on the theme of preventing contamination of groundwater by Leaking Underground Storage Tanks.

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

TIME:
3 45-minute class periods

MATERIALS:
1-gallon (3.8 L) milk jug
clean mustard squeeze bottles (with a nozzle)
clear boxes
liquid black tempera paint
sand
8-oz. (240-mL) clear jar with lid
blue food color
cooking oil
stamp hand out
markers or crayons
student sheets (included)
acetate sheets
teacher sheets (included)
overhead projector

BACKGROUND INFORMATION

Groundwater is an important source of clean drinking water for humans. Only a small amount of groundwater used by people is polluted, but we know it can be polluted and must be protected. One of the ways we are trying to protect it is through the L.U.S.T. Program. "L.U.S.T." is an acronym for "leaking underground storage tanks." This government program began in 1984 and regulates both tanks in use and newly installed ones.

Old underground storage tanks (USTs) corrode and rust, allowing contents to leak out into the soil and ultimately the groundwater. In the United States, new tanks buried to contain petroleum products, such as gasoline, must have better structures. (These containers are constructed of fiberglass, coated steel, or metal with added protection against rust.) Many regulations exist today and monitoring takes place. Regulations are strictly enforced.

There are approximately 1.5 million USTs in the United States. Many businesses of different sizes have them. Stores, schools, farms, and any businesses that have vehicles could have them. In the event of an accidental spill, businesses have 24 hours to notify the proper authorities and begin clean up immediately. Most of the compounds that make up gasoline float on water. Benzene is one component which is water soluble. It has been found in groundwater in some parts of the country. This is one reason for strict enforcement of the L.U.S.T. Program. The impact on our environment can be devastating.

The L.U.S.T. Program does not regulate above-ground storage tanks. It does not include tanks on small farms or home tanks for less than 1,100 gallons of heating oil. Septic tanks are not controlled under this program either.

Terms

chemical: a substance characterized by a definite molecular composition.

containment: holds something within a defined space.

contamination: an impurity.

environment: the total circumstances surrounding an organism or group of organisms.

fiberglass: fibers of spun glass that are bound together with a substance such as acrylic to form tanks used in underground storage and other things such as boat hulls and some vehicle bodies.

gasoline: a petroleum product used as a fuel in internal combustion engines.

groundwater: water that is trapped under the ground's surface.

hazard: something that is dangerous.

L.U.S.T.: acronym for leaking underground storage tanks (such as are often used to store gasoline or oil).

liner: plastic or clay used to seal an area.

pollution: an impurity in air, soil, or water that can cause harm to human health or the environment.

steel: a metal consisting of a mixture of iron and carbon.

ADVANCE PREPARATION

A. Photocopy the student sheets.

B. Make a transparency of the "The [Math] Problem of Leaking Underground Storage Tanks" teacher sheet. One problem is blank so you can make up some problems of your own, or you may have the students make them up.)

C. Make a transparency of the teacher sheet "L.U.S.T. = Leaking Underground Storage Tank."

PROCEDURE

I. Setting the stage

A. Begin by discussing groundwater and where it is located.

B. Inform students of what an underground storage tank is and what some uses for them are. Use the transparency "L.U.S.T.= Leaking Underground Storage Tank" to show where the tanks are in relation to groundwater. Discuss liquids that could be stored in them.

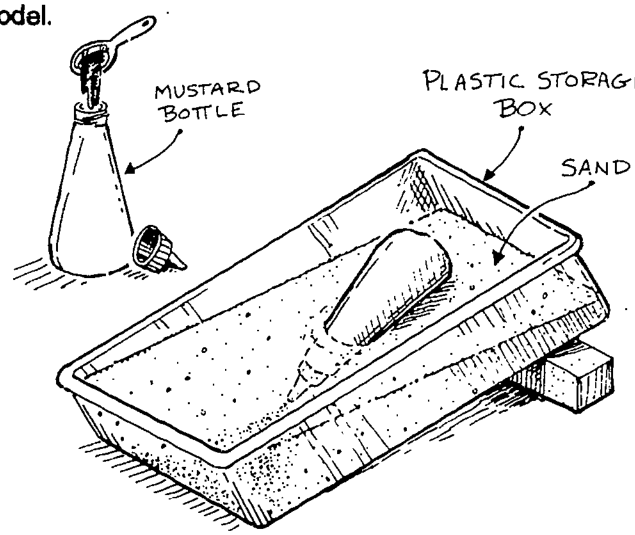
C. Show how small an amount of gasoline it takes to pollute our waters. Show the students a one gallon (4 L) milk jug and have them guess how much water one gallon (4 L) of gasoline will dangerously contaminate. After a few students have guessed, write 1,000,000 gallons (4,000,000 L) on the board. One million gallons (four million liters) of water can be contaminated by only one gallon (4 L) of gasoline. Most gasoline stations have three 10,000-gallon (40,000 L) tanks.

II. Activities

A. (NOTE: This can be done as a class demonstration or an activity with teams of 4 students.) Simulate the leaking underground storage tank as follows:

1. Take a mustard bottle and pour in 2 tablespoons (30 mL) of black tempera, then fill with water. Place the cap on the bottle. This represents an underground storage tank (UST).

2. Set the bottle on its side in a clear plastic storage box with a thin layer of sand in the bottom. Discuss how the students might imagine that groundwater is located deeper in the ground under the "tank" in your model.



3. Open the nozzle of the bottle and squeeze slightly. Black liquid will come out the opening and fill the bottom of the box. Students will be able to see how a dangerous leak could get into their water supply. The mustard bottle now represents a leaking underground storage tank; its contents would eventually seep into the groundwater.

4. Ask if the students would want a leaking underground storage tank in their community.

5. Discuss again the teacher sheet, "L.U.S.T. = Leaking Underground Storage Tank." Brainstorm with your students. Ask "What is wrong with this picture?" It has contaminants leaking into the groundwater. Help your students understand this concept and the consequences of it. Students may want to color this sheet when they have extra time.

6. Use the student sheet, "Find the L.U.S.T. Words" to reinforce the terms for this lesson.

B. Explain to students that alternative tanks that are resistant to rust are available. Fiberglass tanks are replacing the old steel tanks. In some instances liners are used; tanks have a resistant coating on the inside. The older tanks in use in the U.S. must be upgraded; eventually, older tanks not upgraded will have to be dug up and replaced. The students may have noticed that some older gas stations' tanks are now being dug up and removed or replaced.

C. Share with the students two methods of testing for leaks.

1. Monitoring wells (special wells dug to check on groundwater) allow us to check the groundwater for gasoline leaks in many areas. A group simulation of how a well can be used to check for a leak in the groundwater is as follows:

a. Each team of students will take a clear container and add 1/2 cup (125 mL) of water, adding 2 drops of blue food color to represent the groundwater.

b. Students will pour 1/4 cup (60 mL) cooking oil, which represents gasoline, into the water and observe it floating on top. Explain to the students that most chemicals in gasoline float on top of the groundwater; a monitoring well would detect it.

2. Another method of checking a tank for a leak is to compare the number of gallons (liters) of gasoline delivered to a station with the number sold in a certain period of time. By subtracting these figures we can see if there are any discrepancies.

   a. The math sheet on leaking underground tank problems is to be completed at this time. The students will de' rmine how many gallons (liters) have leaked. If any did, they must decide what the penalty will be.

   b. Play a game in teams of 2 - 4 students. Answers: 1. 41 gal (164 L), (answers will vary on the other questions); 2. none; 3. 974 gal (3.896 L), 26 gal (104 L), (answers vary).

   c. Let each team make up its own problem and questions for the fourth one. You might let them quiz each other as part of the game.

III. Follow-Up

Students will design a new stamp for the post office showing that safe underground storage tanks means safe groundwater.

A. This stamp will follow real stamp format.

   1. Use the student sheet, "Stamp Out Leaking Underground Storage Tanks." (NOTE: To save paper, you might draw your own version of the pattern on the board and let the class copy it on their paper.)

   2. Have students bring in stamps they have torn off old letters. These will help students visualize what a stamp looks like.

   3. Students should color these designs by using markers or crayons.

B. Have a class or school campaign to see which stamp should be produced and send the winner to the Postmaster General as a suggestion. Your local post office will have the name of the current postmaster and his or her address.

IV. Extensions

A. Possible storage tank materials can be buried on campus. Make sure you ask your principal for permission. A soup can, small cola bottle, and paper tissue roller are possibilities. At the end of the school year these items would be dug up to see if they rusted or disintegrated.

B. A papier-mache' model of an underground storage tank could be made using any small container as a base. Remember to add pipes by taping straws in locations needed. (Use the underground storage tank diagrams to see where pipes are necessary.) Cover the container with 1-inch (2.5-cm) strips of thin paper dipped in a wheat paste mixture. When the shape is covered let it dry. Later you can paint and display it.

C. Play a game called "Around the World Stopping Contamination." Two students stand up to challenge each other (pick 2 seated close to each other). The questioner asks a question about storage tanks. These could be math problems. The student who answers first correctly wins.

That student will challenge the next student (one close to him or her). The process continues around the classroom (which is why it is called "Around the World"). You could go down rows so students would know who to challenge each time. The student who wins the greatest number of his or her challenges is the winner. Give a round of applause to the winner.

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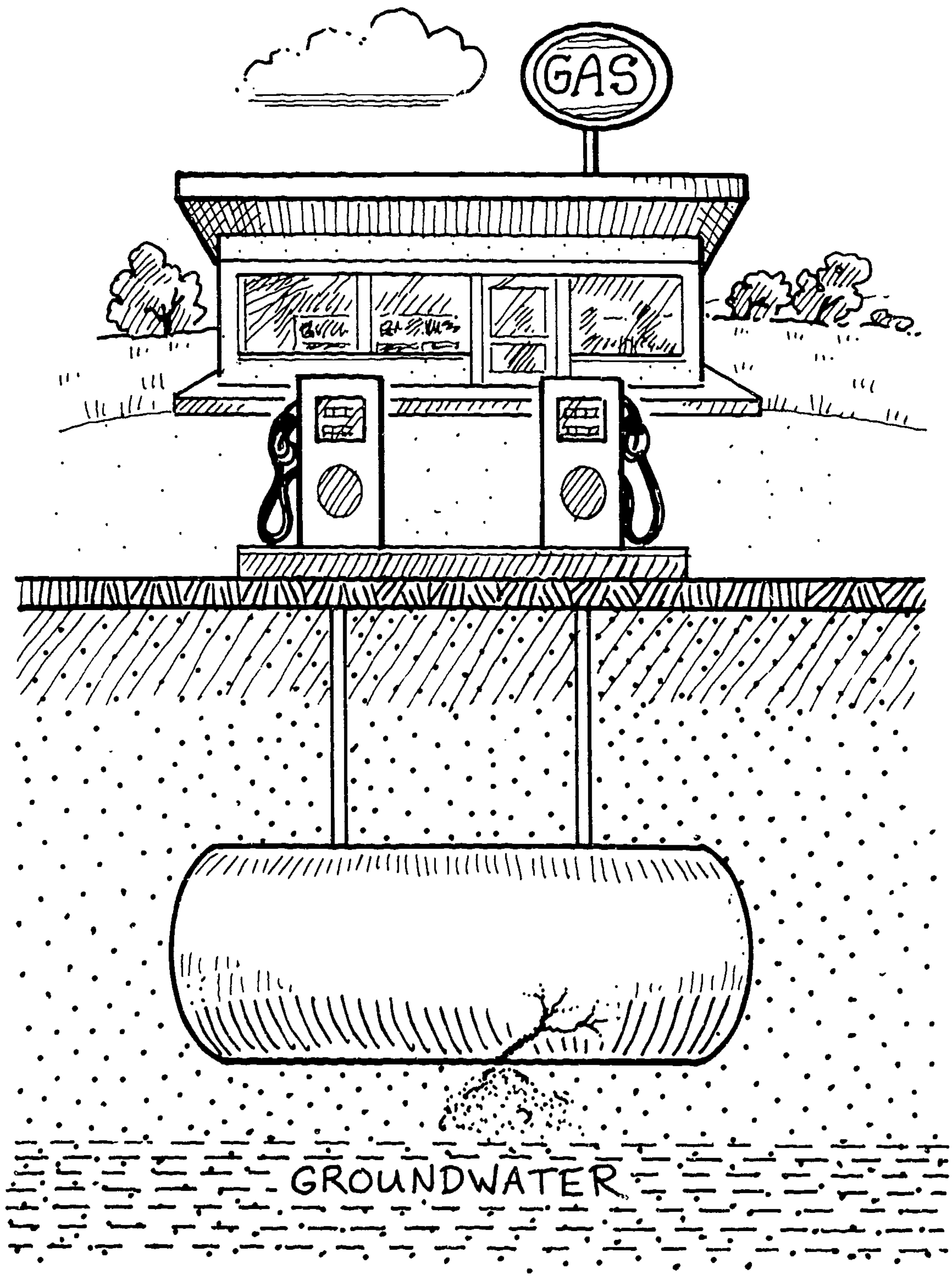
L.U.S.T. = LEAKING UNDERGROUND STORAGE TANK



FIND THE L.U.S.T. WORDS

Find 11 terms listed below. They may be corner to corner, side to side, or up and down.

groundwater	pollution	fiberglass	containment
contamination	L.U.S.T.	steel	gasoline
environment	chemicals	liner	

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

FIND THE L.U.S.T. WORDS
ANSWER KEY

Find 11 terms listed below. They may be corner to corner, side to side, or up and down.

groundwater	pollution	fiberglass	containment
contamination	L.U.S.T.	steel	gasoline
environment	chemicals	liner	

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

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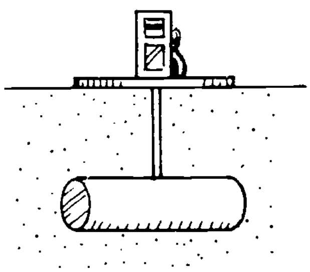
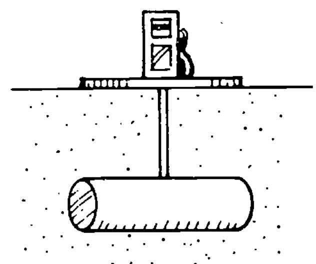
THE PROBLEM OF LEAKING UNDERGROUND STORAGE TANKS

Find the answer to the following math problems. Use only the information needed to find the answer. Answer all parts of each question.

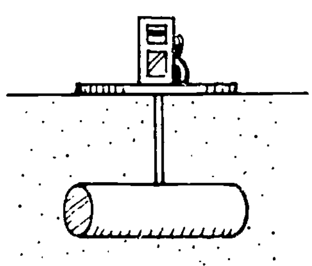
#1
In December, Station S received 2,500 gallons (10,000 L) of gasoline. During the next month they sold 2,459 gallons (9,836 L). The tanks were empty at the end of the month. How many gallons of gasoline disappeared? What do you think happened to the missing gasoline? What action do you recommend?



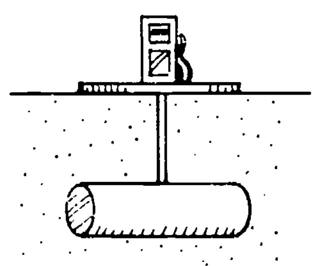
#2
Last month at the local Hurried Gas Station they received 48,082 gallons (192,328 L) of gasoline. During this month they sold 48,082 gallons (192,328 L). How many gallons of gasoline disappeared? What action do you recommend?



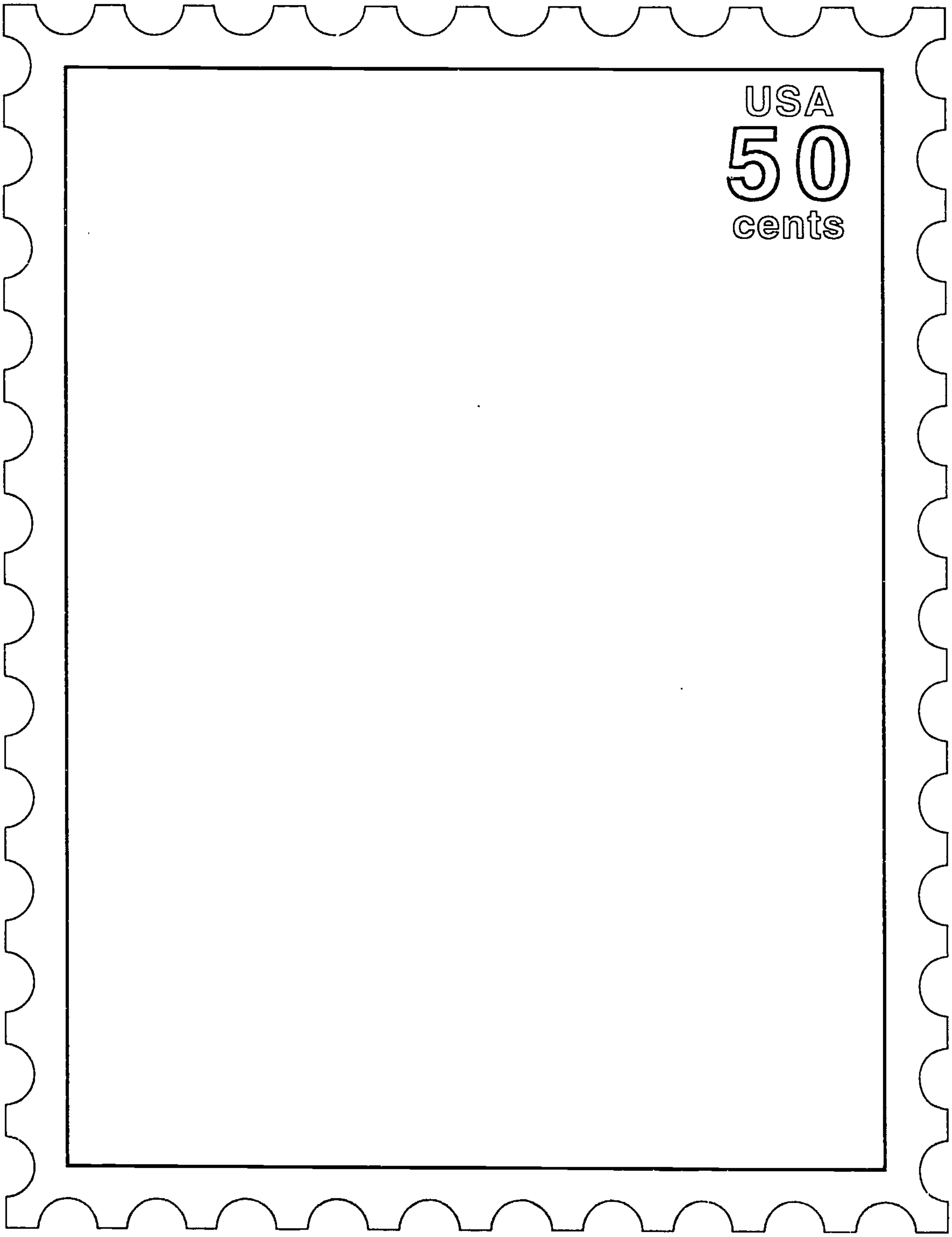
#3
Last week at We-Gas-Um they sold 598 gallons (2,392 L) of gasoline. They also sold 36 orange cola drinks. This week they sold 376 gallons (1,504 L) of gasoline. How many gallons (liters) of gasoline did they sell at We-Gas-Um the past 2 weeks? They received 1,000 gallons (4,000 L) during the past 2 weeks. How much gasoline disappeared? Do you recommend any action?



#4 (Make up your own problem!)



STAMP OUT LEAKING UNDERGROUND STORAGE TANKS



DOWN ON THE FARM, DOWN IN THE WATER

OBJECTIVES

The student will do the following:

1. Compare location of U.S. agricultural areas to location of major aquifers.
2. Describe how nitrates from animal waste and fertilizers percolate through the soil.
3. Identify alternative uses for livestock waste.

SUBJECTS:
Science, Social Studies, Language Arts

TIME:
90 minutes

MATERIALS:
Miracle-Grow® or other commercial fertilizer
3 paper cups
topsoil
water
blue markers or crayons
green markers or crayons
student sheets (included)

BACKGROUND INFORMATION

The increasing world population has placed a huge stress on agricultural systems to produce food. Amazingly, improved management techniques and technological advances such as fertilizers, pesticides, and irrigation have allowed world agricultural production to keep up with the population growth. While food distribution remains a problem, new advances in agriculture are encouraging.

Most countries use a large amount of their water resources for agricultural purposes. In the U.S., agriculture accounts for 42 percent of water consumption. For crop irrigation, most of the areas of high production depend on water from underground sources – groundwater. In recent years, scientists have measured drastic falls in the water tables of important aquifers like the Ogallala, which underlies most of the Great Plains area. These aquifers are almost impossible to replenish.

The by-products of agriculture also are affecting the groundwater. While pesticides and fertilizers are greatly responsible for production increases, residues from these products can filter down through the soil and into groundwater. Animal waste, or manure, has also contributed to groundwater contamination. Nitrates (nitrogen-containing substances), from both the manure and agricultural chemicals, can contaminate drinking water supplies. Nitrates have been linked to various health problems, including the "blue baby" syndrome, which affects young children and results from getting nitrates in the bloodstream. These concerns increase as many areas become like Western Europe — a "manure-surplus" region, or an area that produces more waste than can be absorbed.

On the positive side, many of these threats can be diminished through efficient farming methods and creative problem solving. By using manure instead of commercial fertilizer to enrich land, farms and the environment can both profit. Reducing the amount of pesticides and applying them only in critical times can also save money and lower the risk of contamination. Other alternative uses for manure range from enriching landfill cover soil to producing an alternative energy source (methane gas). Recent surveys involving farmers in the Midwestern U.S. indicate that many farmers would welcome more efficient techniques and that the use of such techniques has increased.

Terms

aquifer: an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water (a zone of saturation).

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

manure: animal excrements or waste.

nitrates: nitrogen-containing substances that can seep into the groundwater; sources include animal waste and fertilizers; linked to health problems.

ADVANCE PREPARATION

A. Fill one of the cups 3/4 full of water and add 1 teaspoon (5 mL) of Miracle-Grow® or other commercial fertilizer. Place in a safe place until ready for use.

B. Photocopy student sheets.

C. Gather remaining materials.

PROCEDURE

I. Setting the stage

A. Distribute copies of the student sheet "Areas of Major Agricultural Activity" to the students, along with green markers or crayons.

1. Ask, "Which areas in the U.S. are the chief producers of farm products?" (Great Plains, California, Southeast, and upper Midwest)

2. Instruct the students to circle the major areas on the sheet with a heavy green line. (Approximations work fine for their purposes here.)

B. Distribute copies of "Location of Major U.S. Aquifers," along with blue markers or crayons.

1. Have the students circle the areas of major groundwater resources with a heavy blue line. (Monitor for accuracy; approximations will work.)

2. Instruct the students to place the "Agricultural Areas" sheet over the "Aquifers" handout. (They may need to hold them up to the light.)

3. Ask, "What relationship do you see between the areas of agriculture and the location of the groundwater resources?" (They cover about the same areas.)

C. Explain that agriculture depends heavily on groundwater resources in many areas of the country. Today's lesson will discuss the impact agriculture has on groundwater.

II. Activity

A. Introduce the problem of nitrate contamination of groundwater.

1. Tell the students that the earth's population has grown to more than 5 billion people. Ask the students what all these people need to live. (food, water, shelter)

2. Explain that farmers all over the world have been faced with the problem of feeding more people by growing crops and livestock on less land. New farming methods, pesticides (bug and weed killer), and fertilizers (plant nutrients) have helped farmers keep up with population growth. These chemicals help increase the food grown by farmers. Pesticides and fertilizers also have nitrogen-containing substances called nitrates. Nitrates can seep down through the soil as they are carried in water that soaks into the ground.

   Along with increasing crops, farmers have also grown more livestock, especially cattle. Cattle produce wastes called manure, which consists of feces and urine, in large quantities. Manure can be useful, as it contains nitrates and can be applied to cropland as a fertilizer. The problem comes when there is more manure than can be used as a fertilizer. Many farmers store manure in large piles. When these piles get wet (as in rain), nitrates and harmful bacteria can filter down through the ground until they reach the groundwater.

B. Perform the following demonstration to show how fertilizers can travel through soil.

1. Punch 3 holes in the bottom of a cup and fill it three-fourths full with topsoil.

2. Show the students the color of the fertilizer solution in the cup. (It will be bright blue.)

3. Hold the soil-filled cup over an empty cup.

4. Pour the fertilizer solution into the soil-filled cup. Instruct the students to observe the color of the water that seeps out of the soil-filled cup.

5. Have the students form a conclusion about the fertilizer that has filtered through. How do they know there is fertilizer in the water? (It is still bluish in color.)

6. Ask, "Did the soil remove all of the fertilizer?" "What would happen if there were a high concentration of manure or chemical fertilizer above a groundwater source?" (While the soil would filter some of the contaminants, there would still be the possibility of contamination.)

C. Distribute copies of the student sheet "Nitrate Knock-Out" and discuss the ways efficient management can cut down the risk of groundwater contamination. (NOTE: This handout may be used as a teacher transparency.)

III. Follow-Up

A. Divide the students into teams of three and instruct them to brainstorm additional uses for manure. Let them use the bottom half of the student sheet to write their ideas.

B. Still in teams, have the students write a song emphasizing groundwater protection to the tune of "Old MacDonald Had a Farm." Let each team share its song with the class.

IV. Extensions

A. Check with local horticulturists or landscapers about the benefits of using manure as a soil enricher. Determine if there are any areas in your region that could use manure in this way.

B. Check with local farm agencies about programs to reduce the usage of chemical fertilizers and pesticides on farms.

C. Invite a local farmer to come as a guest speaker. Ask him/her to discuss groundwater use and protection on the farm.

RESOURCES

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"Manure Surplus Forces Research in Pennsylvania," Successful Farming, No. 86, December, 1988, p. 51.

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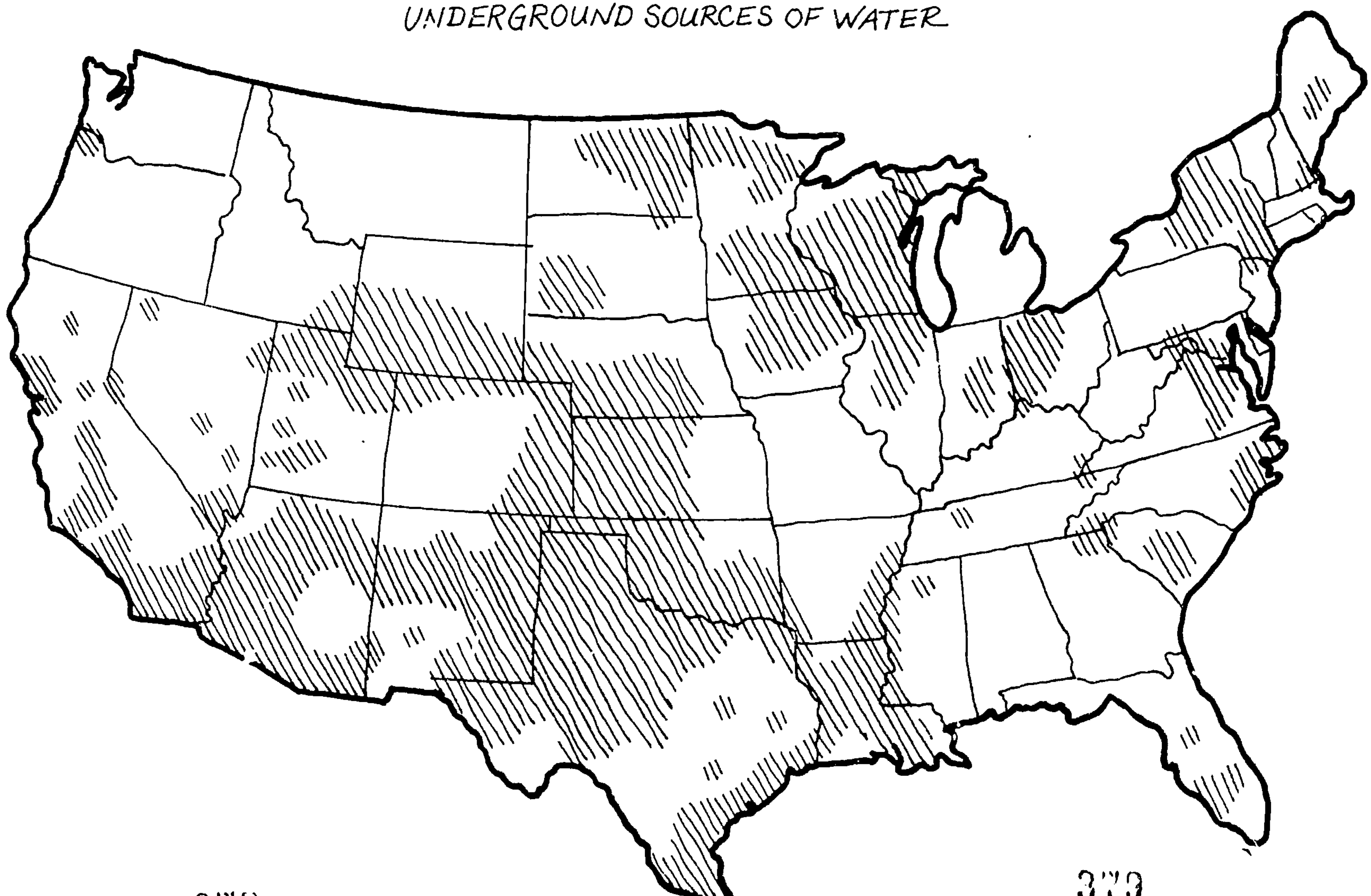
LOCATION OF MAJOR U.S. AQUIFERS

UNDERGROUND SOURCES OF WATER



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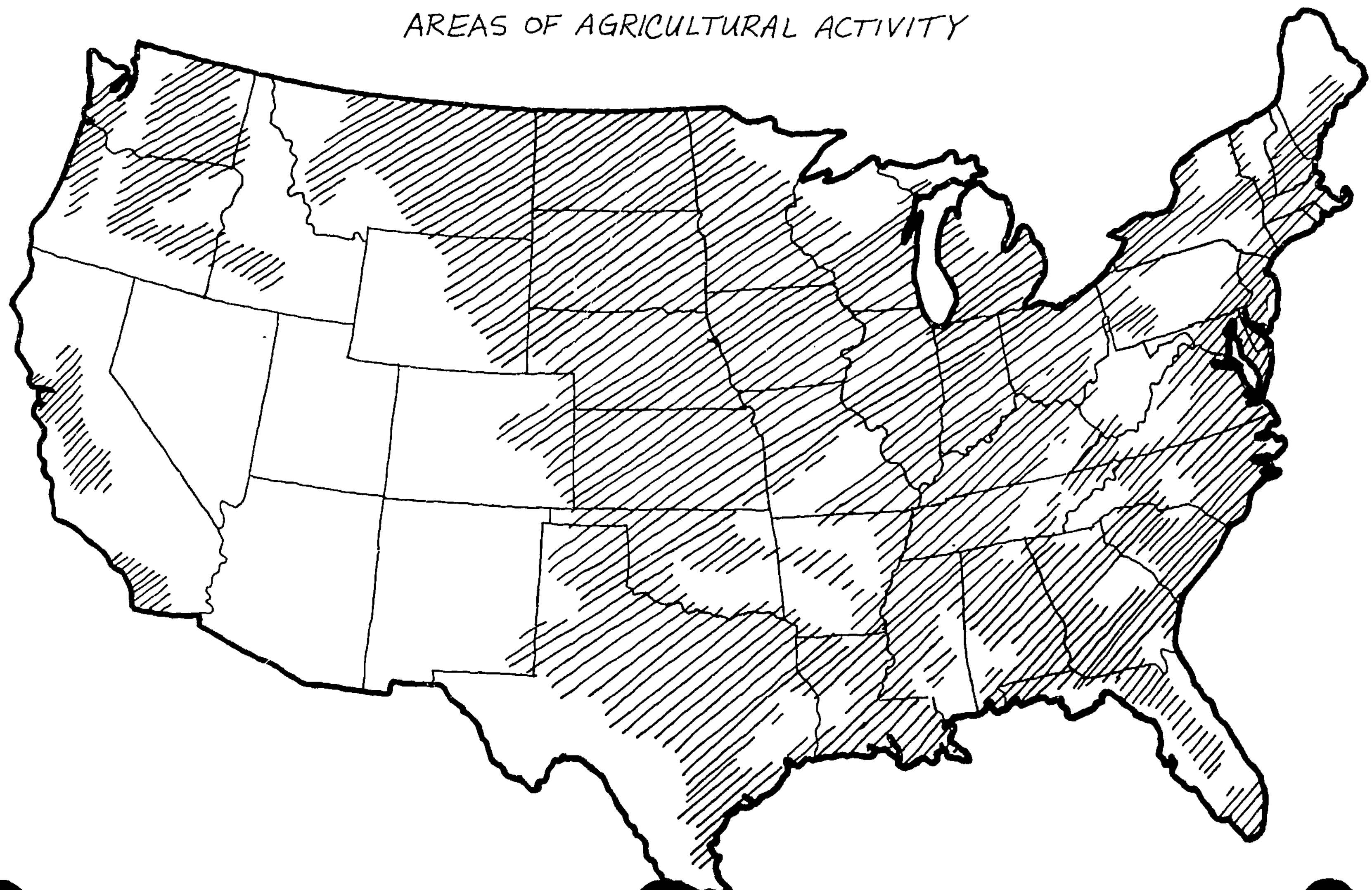
AREAS OF MAJOR AGRICULTURAL ACTIVITY



NITRATE KNOCK-OUT

(Ways to Protect Groundwater from Agricultural Contaminants)

1. Cut down on commercial fertilizers (which may be easy to use) by:

   • using natural fertilizers like manure

   • fertilizing in smaller amounts (this will save the farmer money, too!)

2. Use lower amount of pesticide by applying only when needed.

3. Control manure "pile-ups" by:

   • Using manure as a soil enricher, instead of chemical fertilizers
     -on the farm
     -on landfills covered with dirt
     -on clearcut areas (to grow trees)

   • As part of a composting project
     -Combine farm manure with yard clippings from urban areas to make a good soil enricher (it cuts down on both manure and wasted landfill space used for clippings)

   • As part of a manure bank
     -Send manure from places that have a surplus to areas that could use it to make soil more productive.

   • Research possibilities of using manure as an alternative energy source
     -When manure decomposes, it releases a clean burning gas called methane.
     -Burn dried manure as a fuel. (Native Americans knew this — they used dried buffalo waste as a fuel when trees couldn't be found on the Great Plains. Many other people, even today, use dried dung as a fuel.)

List other ideas for using manure:

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GOIN' WITH THE FLOW

OBJECTIVES

The student will do the following:

1. Define irrigation.
2. Chart the role of irrigation throughout history.
3. Investigate problems and possible solutions related to modern irrigation techniques.

SUBJECTS:
Social Studies, Science, Mathematics, Creative Writing

TIME:
120 minutes

MATERIALS:
1 small potted plant
2 wrapping paper tubes
aluminum foil (optional)
utility knife
container of water
large sheets of paper (enough for teams of 2-3 students)
art materials
spray bottle(s)
2 graduated measuring cups or beakers
2 milk cartons
topsoil
small section of old garden hose or plastic tubing
clay
ice pick or awl
liter bottle with the bottom cut off
duct tape
student sheets (included)
teacher sheet (included)
acetate sheet
overhead projector
globe or world map

BACKGROUND INFORMATION

Since the beginning of civilization, people have transported water into dry areas for the production of crops. Irrigation allowed its first users, the Mesopotamians, to expand gardens into large crop fields. With such a large increase in production, it took fewer farmers to feed the community, allowing human resources to be used for other purposes. The Mesopotamians used these resources to construct massive buildings, develop elaborate religious ceremonies, create new art works, and develop new ideas in the areas of math, engineering, and soil sciences. To the present, virtually all great cultures have been served by the extensive use of irrigation. By 1990 reports, agriculture accounts for 70 percent of global water use. In many places in the world, much of the water used for agriculture is groundwater.

Overuse of water can, however, consume groundwater supplies more quickly than they can be naturally replaced. This problem is widespread throughout the world. It is evident in the U.S. by the depletion of the Ogallala Aquifer, which supplies irrigation water to portions of eight states on the Great Plains. Irrigation can also hurt the soil by concentrating minerals such as salts, eventually making the land unproductive. After periods of intensive irrigation, the land may become "water-logged," or oversaturated, making the land an unproductive bog.

Fortunately, many of these problems can be corrected or prevented by using new technologies and agricultural methods. Efficient drip irrigators, using surface water when available, and irrigating during optimum times promise to make better use of our groundwater supplies.

Terms

Irrigation: transporting water into dry areas for the primary purpose of growing crops.

Irrigation canal: a constructed waterway (similar to a large ditch).

waterlogged: saturated with water.

ADVANCE PREPARATION

A. Gather needed materials.

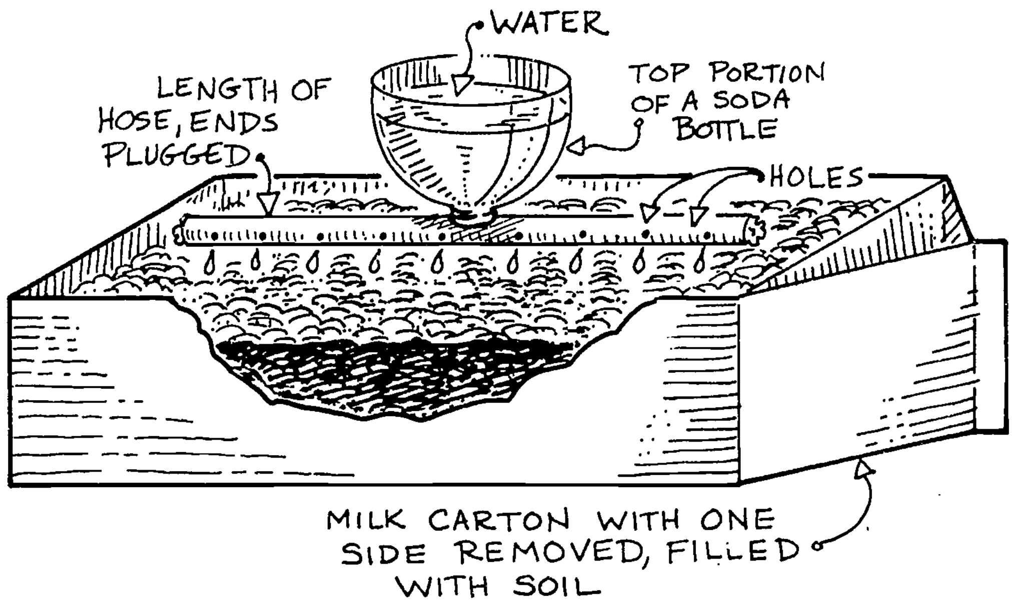
B. Make drip irrigation unit(s). (NOTE: "Drip vs. Spray" experiment may be performed as a class demonstration or as a team project.)

1. Cut the end of a liter bottle off so that you have a section (with the bottle's neck) that is about 4 inches (10 cm) tall.

2. Cut a section of old hose or plastic tubing about 6 inches (15 cm) long and cut a hole in the center big enough to fit the neck if a liter bottle in it. Use an ice pick or awl to poke holes in the piece of hose as shown. Plug hose ends with clay.

3. Insert the bottle into the hose and secure it in place with duct tape.

4. Cut a side out of a milk carton as shown. Put 1 cup (250 mL) of topsoil in the carton and shake down until the surface is even.



C. Prepare the second milk carton the same way.

D. Make a transparency from the teacher sheet "Irrigation: Problems and Solutions."

E. Photocopy the student sheets.

PROCEDURE

I. Setting the stage

A. Place a container of water on one end of a table and a potted plant on the opposite end.

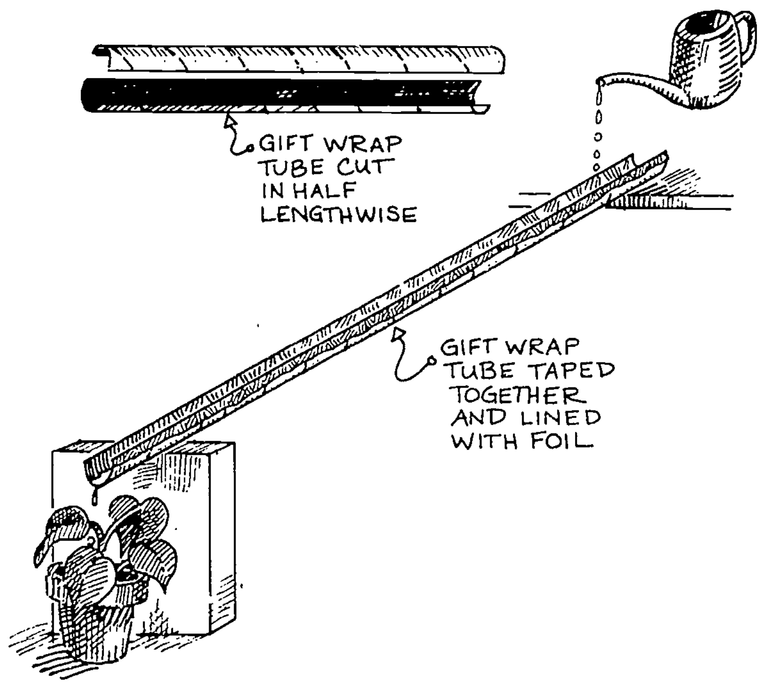
1. Ask "What do these two things have in common?" (Both containers contain water-- water in glass, water in plant and soil.)

2. Ask "What would happen to the plant if it went without water?" (It would die.)

3. Explain that there are places in the world that face the problem of getting water to land so that it will grow crops.

B. Have students brainstorm ways to get the water to the plant without moving either item.

1. Use a wrapping paper tube cut in half lengthwise; join the two pieces with duct tape (as shown). Place one end into the pot while pouring water into the other end. (NOTE: You may want to line the tube with aluminum foil if you plan to repeat the demonstration because the cardboard will get soft after you pour water on it.)



2. As the water is flowing, explain that getting water to a dry place that needs it to grow crops is called irrigation. The cardboard tube is a model irrigation canal.

II. Activity

A. Explain that irrigation was one of the earliest forms of technology used by people to grow crops. Its importance is noted throughout history, even to our present times.

1. Divide the students into teams of two.

2. Distribute the student sheets "Irrigation in History."

3. Distribute art supplies and large sheets of paper.

4. Instruct students to draw a long line across the middle of the paper (lengthwise). This will be the basis of their time line.

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5. Instruct students to read each block of information, making a mark on the time line for each one. They will have to decide how to divide the line. (NOTE: You may have to help younger students.)

6. Have the students locate on a globe or large wall map of the world each area designated in a block of information. (NOTE: Do this together as a class with younger students.)

7. Instruct students to use the information to provide the following for each mark:

   a. The approximate date

   b. One- to two-sentence summary

   c. A picture representing each block.

8. After completing the tasks, have the students write at the bottom of the page one summarizing sentence that describes the role of irrigation in our world's history.

9. Share and discuss the time lines.

B. Explain that while irrigation has been a great benefit to humans by helping produce more crops, its use has also caused problems where it has used too much of the groundwater.

   1. Show the transparency "Irrigation: Problems and Solutions." Discuss each item briefly.

   2. Point out that although the problems can be severe, they can be prevented or slowed down by simply irrigating more efficiently.

C. Conduct a drip irrigation vs. spray irrigation experiment as a demonstration. Have students help you.

   1. Explain that the most popular method of irrigating land is using the pivot-sprayer. A large sprayer (some 1000' [300 m] long) turns in a circle spraying water on the plants; this is like a gigantic lawn sprinkler. This experiment is designed to compare two ways to distribute irrigation water.

   2. Distribute the student sheets.

   3. Place the milk cartons on several newspapers or towels. Point out that they contain equal amounts of soil.

   4. Fill the sprayer with 1 cup (250 mL) of water. This water will be used to simulate spray irrigation.

   5. Fill another container with 1 cup (250 mL) of water. This water will be used with the drip irrigation unit.

   6. Have students formulate a prediction of which method will use the most water to saturate the soil. They are to record this on the student sheets.

   7. Using student assistants, spray water into one carton while pouring water into the drip system.

a. Sprayers are usually located in the center of the field and spray as they turn in a circle. Have the students simulate this. Allow the sprayer to "overspray" as this will visually demonstrate how the water sometimes misses its intended destination.

b. Continue until both pans of soil are saturated. (NOTE: You may need to add more water to the sprayer or the container. Keep track of exactly how much water is used.) Consider them saturated when a small amount of water is standing on the soil. Watch carefully for this.

8. Carefully pour the remaining water out of the sprayer bottle into a measuring cup or beaker and have the students record the amount on the student sheet. Repeat for the drip supply. Instruct the students to subtract the remaining amount of water from the starting amount (250 mL) to find the total amount used by each irrigation device.

9. Have the students compare the results of the experiment and record their conclusions.

   a. Ask "Which was the most efficient method? Why?"

   b. Ask "If this experiment were held outside in a hot and dry region, how would the conditions affect the outcome?" (the water would evaporate more quickly from the sprayer)

III. Follow-Up

A. Have students brainstorm other ways to make irrigation more efficient.

B. Have students or teams of students write a narrative describing how the world would be different without irrigation.

C. Have each student write a definition of irrigation in his/her own words.

IV. Extensions

A. Write your local or state agricultural extension office for more information about irrigation.

B. Have the students research the engineering aspects of irrigation, using diagrams and/or models to display their findings.

C. Have the students look through magazines and newspapers for articles relating to food supply and irrigation.

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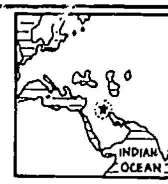
IRRIGATION IN HISTORY

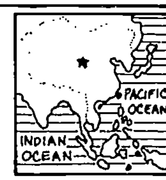


MESOPOTAMIANS
When: 4,000 B.C.
Where: The Middle-East, between the Tigris and Euphrates Rivers

The people who lived in Mesopotamia were the first to irrigate water to raise crops. Because they could move water to dry areas and grow more crops, fewer farmers were needed to feed the people. This left people free to work at other jobs like building huge buildings, inventing new tools, creating new art, and discovering more about math.

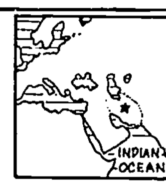
EGYPTIANS
When 3,500 B.C.
Where: Along the Nile River

The Egyptians had one of the greatest water resources in the world: the Nile River. Away from the riverbanks, though, all the land was a desert. Once the farmers learned how to irrigate, they began to grow two and three crops a year. This allowed workers to do other things such as building pyramids and attempting to conquer the world with a gigantic army of soldiers. Crops were also used to trade for goods from other countries.



SOUTHEAST ASIA
When: 3,000 B.C.
Where: What today is China, Vietnam, and Korea

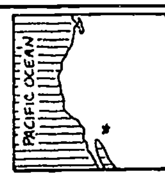
To grow more crops, the peoples of Southeast Asia began to learn new ways to use the land. On steep hillsides, they carved stair-step fields called terraces to keep the soil from washing away. They also used dams to store water for irrigation. Rice, their most important crop, needed a lot of water. Irrigation helped these farmers grow their rice.



PERSIANS
When: Around 3,000 B.C.
Where: In the Middle-East, now known as the areas around Iran

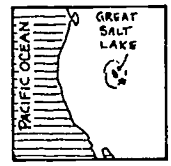
The Persians lived in one of the harshest deserts in the world. They believed that water would turn this desert into a lush garden. To build canals, however, wouldn't help much because the hot sun would cause the water to evaporate as it crossed the desert. The Persians solved this problem by digging underground irrigation canals called quanats.

IRRIGATION IN HISTORY
(continued)



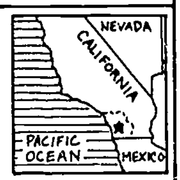
HOHOKAMS
When: 100 B.C.
Where: The American Southwest, known today as Arizona

The Hohokams were Native American farmers who learned to grow corn and cotton in the fertile soils between the Gila and Salt Rivers. To provide water for these crops, they dug nearly 25 miles of canals in the desert.



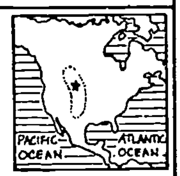
MORMONS
When: 1840s
Where: The Salt Lake area, now known as Utah

After a long and dangerous journey across the western frontier in covered wagons, the Mormons settled in the dry area around the Great Salt Lake. With determination and skill, the Mormons turned the desert into cropland by using irrigation.



CALIFORNIANS
When: 1880s
Where: Southern California

If you buy fruits and vegetables today, chances are that at least some came from Southern California. By using underground water supplies to irrigate the dry but fertile soil, Californians turned the valleys into one of the world's largest producers of fruits and veggies.



THE GREAT PLAINS
When: 1880s and again in the 1940s
Where: The North American Great Plains

A symbol of the Great Plains farmers has long been the windmill. These were used to pump water from beneath the ground to irrigate some of the most fertile lands on earth. In the 1940s cheap electricity, new drilling methods, and improved farming skills led to large increases in irrigation. Water is drawn from the world's largest underground aquifer, the Ogallala, which ranges from South Dakota to North Texas. People now worry that too much water is being taken from the aquifer.

IRRIGATION: PROBLEMS AND SOLUTIONS

Problems

- Water either evaporates or is lost by soaking into the ground in the canals.
- Water carries concentrations of salt, pesticides, and fertilizers into the ground.
- The continuous irrigation of land can cause waterlogging, filling the land so full of water that it can't hold any more. Plants can't grow in these conditions.
- Depletion of the groundwater supply. We are pumping out more water than goes back in. Sooner or later, we'll run out.

Solutions

- Use more efficient methods of applying water. The sprayers now used lose a lot of water to evaporation. New drippers will apply water in more manageable amounts.
- Irrigate only when plants need water.
- Use surface water to irrigate when possible. These water sources are easier to replenish.
- Use urban wastewater for irrigation when possible.

DRIP VS. SPRAY EXPERIMENT

Name ______________________ Date ______________________

Hypothesis: I think the ______________________ method will be the most efficient because

____

____.

Dropper		Sprayer	
300	mL starting water	300	mL starting water
-_____	water remaining	-_____	water remaining
	mL water used		mL water used

Conclusion: ____

____

____

____

____

____

If I were a farmer and I needeo to put an irrigation system on my farm, I would choose a __________ irrigation system because ____

____

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THE WATER SOURCEBOOK

WETLANDS/COASTAL

WONDERFUL, WATERFUL WETLANDS

OBJECTIVES

The student will do the following:

1. List characteristics of wetlands.
2. Describe the functions of a wetland.
3. Observe a demonstration using a wetland model.

SUBJECTS:
Science, Language Arts

TIME:
60 minutes

MATERIALS:
glass lasagna pan (or clear plastic sweater box)
modeling clay
strip of indoor-outdoor carpet (3" [7.5 cm] wide by width of pan)
measuring cups
clear water
muddy water
pictures of different kinds of wetlands
construction paper (1 sheet per student)
student sheet (included)
teacher sheet (included)

BACKGROUND INFORMATION

Wetlands are areas of land that are wet at least part of the year. They are often transition zones between dry land and open water. Some wetlands are consistently covered with water, while others are flooded only at certain times. All wetlands do have water-soaked soil at some time, which affects the kinds of plants and animals that live there. Wetlands can be found in all parts of the world and are classified into many types. There are freshwater and saltwater wetlands. Some examples of freshwater wetlands are swamps, marshes, bogs, pasture ponds, and prairie potholes. Saltwater wetlands include mangrove swamps and saltwater marshes. Estuaries are the bodies of water found where rivers empty into the sea; they include saltwater wetlands. The water in estuaries is a mixture of fresh and salt (sea) water, and its salinity usually varies with its distance from the open ocean.

Terms

bog: a plant community that develops and grows in permanently water logged areas having a thick layer of peat (partly decayed organic material).

estuary: (EHS • choo • ehr • ee) the bay area of a river, where it widens to meet the ocean, that receives and mixes with tidal salt water.

mangrove swamps: saltwater wetlands located in tropical and sub-tropical areas and dominated by woody shrubs called mangroves.

marshes: wet areas sometimes found at the edges of ponds, lakes, and rivers, usually treeless and having plants with soft stems, grasses, rushes, and sedges.

pocosin: (peh • KOH • sehn) an inland swamp of the southeastern United States coastal plain.

prairie potholes: wetlands occurring in the North Central United States and South Central Canada that provide nesting grounds for waterfowl.

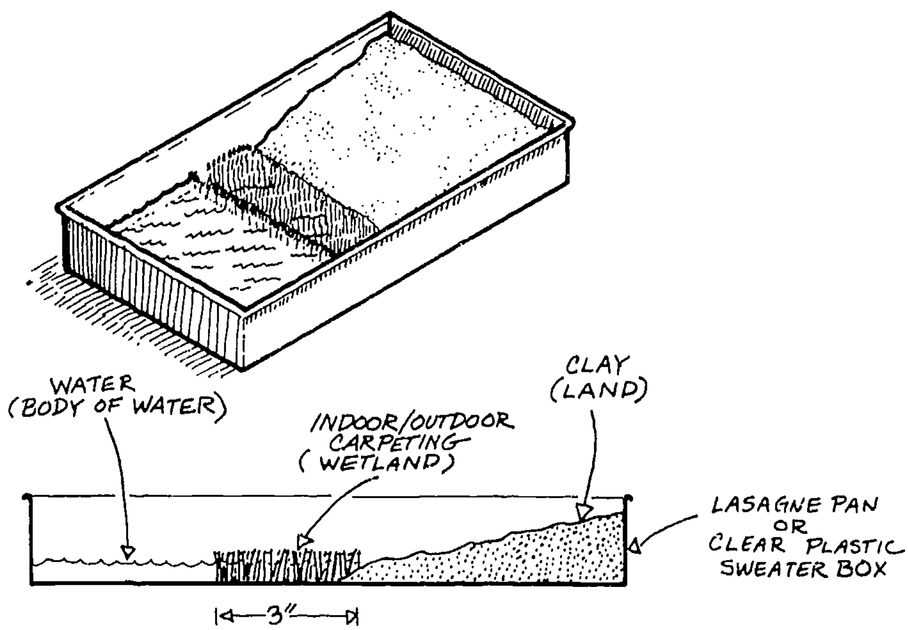
salinity: saltiness, or the amount of salt, in water or other liquids.

saltwater marshes: wetlands found in coastal areas; the transition zones between land and sea (the tide rises and falls in these marshes twice each day).

swamps: land (with saturated soils for some of the year) supporting a natural vegetation of mostly trees and shrubs.

ADVANCE PREPARATION

A. Spread a sloping layer of plasticene modeling clay in half of the lasagna pan or sweater box to represent land. Leave the other half of the pan empty to represent a lake or other body of water. Shape the clay so that it gradually slopes down to the body of water (see the diagram below). Smooth the clay along the sides of the pan to seal the edges.



B. Cut a piece of indoor-outdoor carpeting that will completely fill the width of the pan along the edge of the clay (see diagram). This will represent the wetland. <u>Do not</u> place the carpet into the model yet.

C. Use the enlargement capability of your school's photocopier to make copies of the small drawings on the teacher sheet "Wetland Pictures." Also, check your school or public library for books from which to get pictures. Travel or outdoor sports magazines are also good sources..

D. If you choose to do the word search puzzle in part IV. D, make a copy of the student sheet "Wonderful, Waterful Wetlands" for each student.

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PROCEDURE

I. Setting the stage

A. Without giving the students a definition of wetlands, ask them to tell you what they think wetlands are. List their answers on the chalkboard and derive a definition from their answers.

B. Explain what a wetland is, comparing your definition with the students' answers. Stress that all wetlands have water-soaked soil, are covered with water at least part of the year, and support specialized plants that are adapted to life in wet conditions.

C. Show the students pictures of different kinds of wetlands and explain what they are. (NOTE: Use enlargements of those provided on the teacher sheet. If possible, get additional pictures from books or magazines.) Allow the students to compare the pictures (and definitions) to find the characteristics listed above.

II. Activity

A. Tell the students that until recently, most people did not consider wetlands to be important to our environment. Over the years, scientists have discovered that wetlands perform several vital functions for our environment.

B. Show the students the wetland model and explain what it and the clay represent. Explain to them that wetlands are complex systems and that no one yet knows exactly how they work. We do know, however, that there are three important functions wetlands perform; you will use your simplified model of a wetland to demonstrate these functions. (NOTE: For older students, you may adapt this procedure for cooperative groups. You may have them conduct it as an experiment.)

C. Begin the demonstration by pouring clear water slowly on the clay (this can represent rainfall, melting snow, drainage, etc.). Ask the students to describe what happens.

D. Drain the water back into the original container. Show the students the carpeting and, as you place it in the model, explain that it represents a wetland. Ask the students to predict what will happen when you pour the water onto the clay again.

E. Pour the same amount of water on the model again. Be sure to perform this exactly as you did before. Let the students describe what happens. (The water will drain more slowly into the body of water because it is now hindered by the wetland.) Explain that most wetlands are shallow basins that collect water and slow its rate of flow. Using the model, explain how this helps reduce flooding and prevent the deposition of eroded soil (sediment) in bodies of water. List these functions on the board.

F. Pour out the clear water. Leaving the carpet in place, pour some muddy water onto the clay. Ask the students to compare the water that flows through the wetland and into the body of water with the water left in the jar. Ask what happened. (Students should conclude that part of the soil in the muddy water was trapped by the wetland and that wetlands can act as a filter for sediment and some pollutants.) Add this function to the list on the board.

G. Remove the carpeting and repeat step F. Ask the students why all the soil particles end up in the body of water. The students should infer that without the wetland to act as a filter, most of the soil (and perhaps pollutants) flow directly into the body of water.

III. Follow-Up

A. Refer the students back to the list of wetlands characteristics written on the board. Review the definition of a wetland and the functions demonstrated. Ask questions such as "Why are wetlands important?" and "How can they help us?" Tell the students that wetlands are also important because they improve water quality, reduce erosion, provide habitats for a wide variety of wildlife and plants, help to store floodwaters, help to replenish groundwater during dry times, and provide recreation for many people to fish and hunt. They are also an important source of products such as seafood, rice, and timber.

B. Give each student a piece of construction paper. Have the students fold the paper in half, lengthwise. On one side of the fold, have them draw a picture of one of the demonstrations, and on the other side have them write a complete sentence telling what wetland function they have illustrated. For older students, you might want to reinforce paragraph writing by having them write a topic sentence about the important functions of wetlands and supporting sentences telling the functions that were demonstrated in Activity II.

IV. Extensions

A. If possible, take a field trip to a wetland near you. Include activities such as listing several types of plants or animals the students encountered, sounds they heard, and other observations. Back at school, extend these activities by having the students classify the types of animals, write a story or report about one of the animals, or illustrate one of the animals.

B. Divide the students into teams and provide each team with materials to create its own wetlands model. Have each team use measuring cups (NOTE: Canning jars with measurement marks work well for this) to measure an amount of water and add it to the model with carpet; then measure the amount of water that collects in the body of water. Have them repeat the experiment without the carpet, again measuring the water that runs off. They should repeat each step five times. Have them chart the measurements and compare them.

C. Acquire map(s) of wetlands in your area from the U.S. Geological Survey Earth/Science Information Center at 1-800-USA-MAPS (or the Canadian equivalent). Have the students research the type or types of wetlands most common in your area and report on the types of plants and animals found there.

D. To reinforce wetlands vocabulary, give each student a copy of the student sheet "Wonderful, Waterful Wetlands." Have the students find and circle the listed terms in the word search puzzle. A key is provided on the accompanying teacher sheet.

RESOURCES

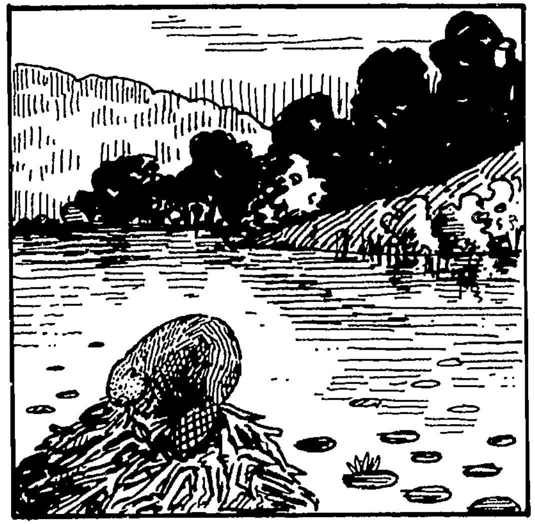
"Wading Into Wetlands," NatureScope, Vol. 2, No. 5, National Wildlife Federation, Washington, DC, 1986.

"Wild About Wetlands," Nature Naturally (newsletter), Vol. 13, No. 3, Ida Cason Calloway Foundation, Pine Mountain, Georgia, 1990.

WETLAND PICTURES


MARSH


BOG


LAKE OR POND


SWAMP


RIVER OR STREAM


COASTAL WETLAND

WONDERFUL, WATERFUL WETLANDS

Find these words in the word search puzzle below. As you find each word, circle it, and mark it off the list. The words may go across, up and down, diagonally, or backwards.

animals
body of water
bogs
clean water
dry land
filters
flooding
freshwater marshes
habitats
important
mangrove swamps
plants
pocosins
pollution
prairie potholes
saltwater marshes
soil erosion
swamps
transition zone
water soaked soil
wetlands
wildlife

```
E Z B A W C K S R F L O C D I N G R E T I S S A L
N T O M I F R M J A S O N M D B J B A L T J U Y M
O X N H L H A M J L W E E A T O C O S W A M P S E
Z O E C D H A B I T A T S W F G P D U L A D R A H
N D S B L I R E I H T E S T S S Q Y A W V P R P W
O R A G I E S O I L E R O S I O N O F C G O B X E
I E L U F C E U C O R G D A H P L F D L T C A F T
T S T A E G N R A C S R A T R E V W A E Y O T V L
I A W P A V D I D H O Y T A X B L A S A L S Y G A
S R A N I M A L S T A M A R B Q M T L N M I X S N
N R T R P E E D O U K S T N A L Y E A W B N I Q D
A Y E Y P S T B F R E S H W A T E R M A R S H E S
R U R C O E N M R R D C V A I K S R E T L I F A I
T G M I L M A A E D S N S C O R S M A E M Q F G K
U H A U L R T B A S O A A N Q B R W D R Y L A N D
L N R T U B R P R A I R I E P O T H O L E S B N O
E L S T T I O S E O L A R N Q X P N V F Q N J G R
Y U H M I E P N L R D Y A H C F W K W K R X W M G
S E E E O O M A N G R O V E S W A M P S N I P K H
B R S R N Y I E R Y U R O K C P L A N T S B R X W
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WONDERFUL, WATERFUL WETLANDS
ANSWER KEY

Find these words in the word search puzzle below. As you find each word, circle it, and mark it off the list. The words may go across, up and down, diagonally, or backwards.

animals
body of water
bogs
clean water
dry land
filters
flooding
freshwater marshes
habitats
important
mangrove swamps
plants
pocosins
pollution
prairie potholes
saltwater marshes
soil erosion
swamps
transition zone
water soaked soil
wetlands
wildlife

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

HOME, WET HOME

OBJECTIVES

The student will do the following:

1. Identify components of a community.
2. Research an animal of a wetland community.
3. Illustrate an animal of a wetland community.

SUBJECTS:
Science, Art, Math, Language Arts

TIME:
1-2 hours

MATERIALS:
Between Cattails by Terry Tempest Williams
(or other similar book)
field guides or other books about animals
butcher paper
white paper (1 sheet per student)
crayons
scissors
glue or paste
teacher sheet (included)

BACKGROUND INFORMATION

All wetlands provide unique habitats for many plants and animals. Wetlands are busy communities with many specialized populations, all of which are uniquely adapted to living in an aquatic or semi-aquatic environment. Populations of wetlands creatures are displaced by the destruction of wetlands. Without their wet homes, these water-loving organisms cannot survive. Perhaps the first step to help make sure that we do not displace too many wetlands creatures is to be aware of their great numbers and variety and to appreciate the roles they each play in their wetland communities.

Terms

community: a related group of plants or animals living in a specific region under relatively similar conditions.

habitat: the area where an organism lives; the habitat supplies food, water, shelter, and space to live.

organism: a living being; plants and animals.

population: organisms of the same kind that live in the same place.

ADVANCE PREPARATION

A. From your school or local library, put together a classroom library of encyclopedic books about animals for the students to use to briefly research animals that live in the community you will study.

B. This lesson takes a "whole language" approach; it begins with the reading of a book. Obtain Between Cattails or one of the other books from the wetland habitat list in the Resource section. Read the book and make a chart listing the animal populations mentioned in the book.

C. Using white butcher paper, prepare a mural background appropriate for the habitat in the book you choose. A suggested background for a marsh community to be used with Between Cattails can be found on the teacher sheet, "Mural Background" (included). (NOTE: You may want to involve students in this part.)

PROCEDURE

I. Setting the stage

A. Explain to the students what an organism and an organism's habitat are. Ask the students if they are organisms. (yes) Have them identify their habitats.

B. Define the terms "population" and "community" for the students. Ask them to identify their communities and the populations of plants and animals (and other organisms such as fungi and microbes) which are part of their communities.

II. Activity

A. Tell the students that you are going to read them a story about a wetland community. Ask them to listen for the populations which make up the community as you read.

B. Read Between Cattails or one of the other books from the list in the Resources section. Share the pictures as you read.

C. After reading, display the populations chart you made and discuss the various organisms and populations which make up the wetland community. (NOTE: Population charts will vary depending upon the resource used.)

D. Tell the students they are going to briefly research an animal from the community and then create a mural of the community.

E. Assign each student an animal. (NOTE: Depending on the size of your class, you may want to assign the same animal to more than one student.) Using the books in the classroom library, allow the students to look up their animals and briefly familiarize themselves with them. Ask them to look for one interesting fact about their animals. (You might require more of older students.)

F. Give each student a sheet of white paper. Allow 15 minutes for each student to draw, color, and cut out a picture of his/her animal. Be sure to stress to the students that their pictures need to be outlined with a dark crayon to facilitate cutting and to help it show up on the mural. While the students work, lay out the mural background on a large table or the floor.

G. As the students finish, have them paste their animals to the mural background.

III. Follow-Up

A. After the mural is completed, review the components of a community. Then allow time for each student to point out his/her animal, tell what it is, and share the interesting fact with the class.

B. As the students share with the class, jot down the names of the animals and the interesting facts. (NOTE: You might tape record the students as they share.) Later, on a chart tablet, record the names of the animals along with the interesting facts.

C. Display the mural, along with the chart, in the hallway for all to enjoy.

IV. Extensions

A. Explain to the students that plant and animal populations in the wetlands are threatened when wetlands are destroyed (for example, when people fill in wetlands to build things on them). Have each student design a bumper sticker or t-shirt showing his/her wetland animal and a slogan for protection of the animal and its habitat.

B. Divide the students into cooperative learning groups. Have them classify the populations of the mural community into mammals, reptiles, amphibians, insects, and birds. Make a bar graph showing the number of populations in each group.

C. Have the students extend their research about their animals, then write a story telling about a day in the life of the animals.

D. Borrow the book, Small Habitats (by Lilo Hess), from the library. It includes instructions for constructing a semi-aquatic or marshland terrarium. Gather the specified materials and allow the students to help you plan and construct the terrarium. Create a "Terrarium Maintenance Crew" of students on your helper list and give them the responsibility of caring for the terrarium.

E. Obtain a copy of the play Willa in the Wetlands from the Wetlands Division of the U.S. Environmental Protection Agency and let your class present it. This play tells about a wetlands community; a Teacher's Guide is available upon request.

RESOURCES

Hess, L., Small Habitats, Charles Scribner & Sons, New York, 1976.

Lewis, P., and R. Chalcroft, Willa in the Wetlands, Wetlands Division, U.S. Environmental Protection Agency, Washington, DC, 1991.

Wetland Habitat Booklist:

Cortesi, W. W., Explore a Spooky Swamp, National Geographic Society, Washington, DC, 1978.

Dewey, J. O., At the Edge of the Pond, Little, Brown and Company, Boston, 1987.

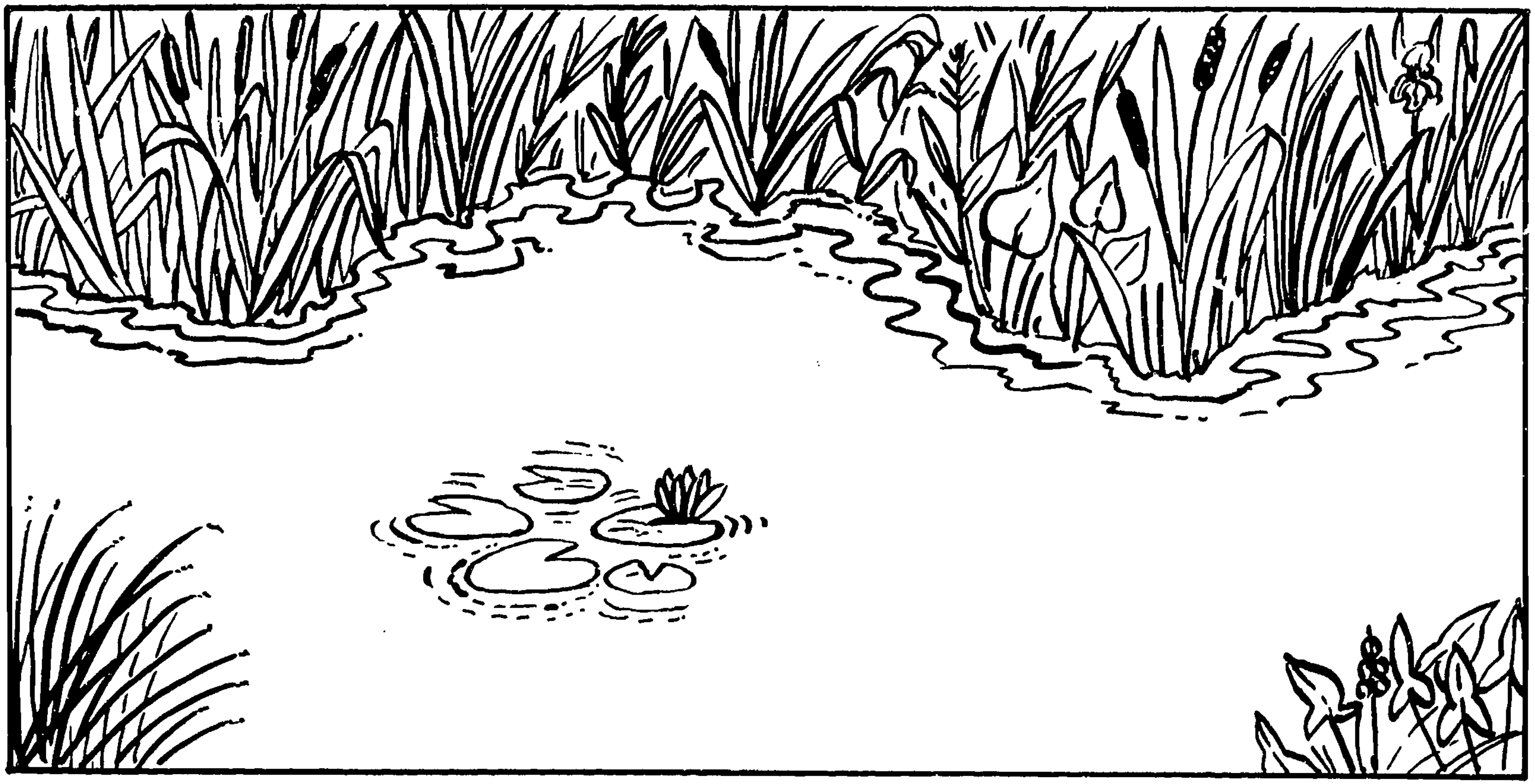
Hirschi, R., Who Lives in Alligator Swamp?, Dodd, Mead & Co., Inc., New York, 1987.

Lavies, B., Lily Pad Pond, E. P. Dutton, New York, 1989.

McClung, R. M., Green Darner, Wm. Morrow & Co., New York, 1980.

Williams, T. T., Between Cattails, Charles Scribner & Sons, New York, 1985.

MURAL BACKGROUND



TO WHOM IT MAY CONCERN

OBJECTIVES

The student will do the following:

1. Identify the importance of maintaining wetlands.
2. Identify the five parts of a letter.
3. Write a letter concerning the importance of wetlands.

SUBJECTS:
Language Arts, Social Studies, Science

TIME:
1 hour

MATERIALS:
Were You a Wild Duck Where Would You Go? (by George Mendoza)
acetate sheets
overhead projector
teacher sheets (included)
writing paper
wipe-off transparency pen
pencils or pens
envelopes (optional)
stamps (optional)

BACKGROUND INFORMATION

At one time, many people looked upon wetlands as wastelands—no more than sources of mosquitoes, flies, and unpleasant odors. It is estimated that more than half of America's wetlands have been lost to development. Recently, however, we have begun to appreciate the importance of wetlands to our environment. Attitudes are changing. Scientists have discovered that wetlands are valuable natural resources that provide many important benefits to people and the environment. Among other things, wetlands help improve water quality, reduce flood and storm damage, reduce shoreline erosion, and provide important fish and wildlife habitats.

ADVANCE PREPARATION

A. This lesson is based on a "whole language" approach and, therefore, begins with the reading of a suggested book.

   1. Obtain the book Were You a Wild Duck Where Would you Go? from your local public or school library.

   2. If this award-winning book is not available, use the alternative method of reading a short encyclopedia article about a selected species of waterfowl (such as mallards). Check encyclopedia entries for "ducks, wild."

      a. After reading key information to the students, ask them to imagine that their class is a small flock of (your selected) birds on their long migration flight.

      b. Use a globe or wall map to show the students the migratory path of your selected bird.

c. Have the students identify when wetlands are important to the bird (such as nesting and raising young, resting during migration, and overwintering). Ask the students what things wetlands have that are important to your selected waterfowl. (land, water, plenty of food)

d. Have the students imagine that they are each waterfowl. Ask them what they would do if more and more of the wetlands along their flight path disappeared (were drained or filled and used for agriculture or real estate development). Have several students share what they think would happen. (What really happens is that fewer birds survive, thrive, and reproduce; numbers of the birds decrease over time.)

B. Prepare transparencies from the teacher sheets "10 Reasons Wetlands Are Important" and "Parts of a Letter."

C. Read the "10 Reasons Wetlands Are Important" (information) sheet and prepare to judge the summary statements formulated by the student teams. Write an appropriate version of each of the 10 reasons on an index card (one per card). For additional information on wetlands, check the factsheet chapter for the factsheets on wetlands.

PROCEDURE

I. Setting the Stage

A. Read the book Were You a Wild Duck Where Would You Go?" (by George Mendoza) to the class. Discuss Mallard's problem, making sure that students understand the main character, Mallard, is a wetland bird and his home has been destroyed. (NOTE: If this book is unavailable, and you use the alternative detailed above, your students will miss the lovely free verse of the book but will learn about a selected species of waterfowl. The lesson can proceed successfully.)

B. Explain to the students that many of our wetlands are being destroyed in various ways. Give examples of destructive practices, such as polluting the waters that empty into wetlands, draining wetlands for agricultural use, and draining and/or filling wetlands for housing development, shopping centers, factories or other real estate development purposes.

C. Display the "10 Reasons Wetlands Are Important" transparency. Tell the students they are going to help you fill in the spaces on the transparency.

1. Divide the class into 10 teams. Give each team an index card with an age-appropriate reason written on it.

2. Have each team read the reason and write their own version of the reason. Ask them to include all of the most important information but to put it in their own words. Tell them they will share this with the class.

3. Have each group share its reason. Write them in the spaces on the transparency. (NOTE: Use a wipe-off pen so you can re-use the transparency.)

II. Activity

A. Explain to the students that when they are concerned about something that affects them or their environment, one way they can express that concern is by writing a letter to a government official or agency. This will not always result in the actions requested but it lets the government know what their concerns are. In some cases, the people in government will take notice and do something. Stress that the government is _their_ government and this is one important way they can participate in it.

B. Tell the students they are going to write a letter to a government official or agency concerning the importance of protecting America's wetlands.

C. Display the "Parts of a Letter" transparency and explain the five parts of a letter. (NOTE: You may simplify this step by writing the information on the board.)

D. Supply the students with the addresses of local, state, or federal government officials or agencies to which they can write concerning wetlands. (NOTE: Addresses can be obtained from your local public library or by calling numbers in the blue pages of your phone book.) Ask the students to choose one person or agency to write to, or you may want to choose one address and display it on the transparency or board.

E. Distribute writing paper and do the heading and greeting of the letter as a group. Then have the students finish their letters by writing why they think wetlands are important and expressing their concerns about the destruction of wetlands. If you wish, you may display the transparency with the "10 reasons" at this time.

III. Follow-Up

A. After the students have completed their letters, collect them. If time allows, proofread and revise the letters with each student individually. Or, you may wish to have the students exchange letters with a partner for proofing and revising. You might proofread them yourself and hand them back for the students to rewrite.

B. After revisions have been made and the final copies are ready, collect the letters and share them with the class. As you share the letters, review the importance of wetlands and discuss why people need to get involved in the protection of wetlands.

C. Mail the letters and be sure to share any response with your students.

IV. Extensions

A. Refer the students to the story you read or the imaginative exercise they did at the beginning of the lesson. Ask them to imagine they and their families have been away on a long trip and they come home to find their homes are gone. Have each student write a story telling what it would be like and what he/she would do.

B. Divide the students into four groups. Assign each group the name of a wetland bird (ducks [different varieties], herons, hawks, eagles, etc.). Tell each group it is a family of wetland birds flying to its wetland habitat. Allow time for each group to prepare a role-play telling what happens when it finds its habitat has been destroyed.

C. Divide the students into cooperative learning groups. Have them research endangered species that might be further endangered by the destruction of wetlands. Have each group prepare a presentation on the species and the importance of wetlands to its survival. This can be done in the form of a commercial, a report, a play, or other method. Encourage creativity and let the groups go! Suggested species include the whooping crane, American crocodile, snail kite, Florida panther, red wolf, Pine Barrens tree frog, manatee, and pitcher plant.

D. Most of the wetlands lost in our country have been lost to agricultural development. By draining wetlands and cultivating them, farmers gain direct economic benefit from land that otherwise might have been an inconvenience or problem for them. (Imagine having to always cultivate around a prairie pothole or other wetland, or not being able to cultivate a sizeable tract of land along a river.) For many farmers, wetlands on their lands would seem to be more valuable if they were drained and used for crops. Government policies used to encourage this. Now regulations protecting wetlands are sometimes challenged by farmers as being too restrictive and too much interference with their rights as landowners. Have the students briefly debate this issue. (This may be especially appropriate in farming communities.)

RESOURCES

"America's Wetlands: Our Vital Link Between Land and Water," U.S. Environmental Protection Agency, Washington, DC, 1988.

Mendoza, George, Were You a Wild Duck Where Would You Go?, Stewart, Tabori, and Chang, New York, 1990.

"Wild About Wetlands," Nature Naturally (newsletter), Vol. 13, No. 3, Ida Cason Calloway Foundation, Pine Mountain, Georgia, 1990.

10 REASONS WETLANDS ARE IMPORTANT

(transparency)

1. Fish, wildlife, and plant habitats:

2. Critical habitats for endangered species:

3. Flood control and protection:

4. Water quality improvement:

5. Shoreline erosion control:

6. Reduction of storm damage:

7. Groundwater recharge:

8. Natural products:

9. Recreation and aesthetics:

10. Education and research:

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10 REASONS WETLANDS ARE IMPORTANT

(information)

1. Fish, wildlife, and plant habitats: Wetlands are critical to the survival of a wide variety of organisms. For many, wetlands are the only places they can live. For others, wetlands provide important food, water, or cover.

2. Critical habitats for endangered species: A number of rare and endangered species depend on wetlands for their survival. The destruction of wetlands endangers these species even more.

3. Flood control and protection: Some wetlands store either flood waters or water that collects in isolated depressions. Trees and other wetland plants can help to slow the speed of flood waters. These functions help protect nearby property from flood damage.

4. Water quality improvement: Wetlands are good water filters. They can filter surface water runoff before it reaches an open body of water and help filter nutrients, waste, and sediment from flood waters.

5. Shoreline erosion control: Wetlands located between rivers and high ground can help to buffer shorelines against erosion. Wetland plants strengthen the sediment by binding soil with their roots; they also dampen wave action. Some states are recommending the planting of wetland vegetation to control shoreline erosion in coastal areas.

6. Reduction of storm damage: Wetlands serve as buffers between the winds and waves of storms and the areas beyond. Property located behind wetlands along the seashore or large lakes often fares much better during storms than those that are not located behind wetlands.

7. Groundwater recharge: Water sits in wetlands and is slowly released into the ground. The released water is filtered as it works its way down through the wetland, thereby improving the quality and quantity of the water which eventually reaches and replenishes our groundwater supplies.

8. Natural products: Wetlands produce a wealth of natural products, including timber, fish and shellfish, wildlife, blueberries, cranberries, and wild rice.

9. Recreation and aesthetics: Wetlands provide many opportunities for recreational activities, such as hunting, boating, and fishing. Many artists and photographers seek to capture the beauty of wetlands and wetland plants and animals each year.

10. Education and research: Although much more is known about the functions of wetlands today than in the past, researchers are still studying them to determine all the bei . and values they bring to people and the environment.

PARTS OF A LETTER

Date

Heading < Name

Return Address

Dear , < Greeting

Body

Sincerely, > Closing

> Signature

WHAT CAN YOU DO?

OBJECTIVES

The student will do the following:

1. Identify ways people can help protect wetlands.
2. Design a wetlands conservation poster.

SUBJECTS:
Science, Art, Language Arts

TIME:
1 hour

MATERIALS:
duck stamp
posterboard (1 sheet per group)
markers or crayons (one set per group)
Were You a Wild Duck Where Would You Go? (by George Mendoza)
globe or world map

BACKGROUND INFORMATION

During the past 200 years, more than half of America's wetlands have been destroyed, mostly by draining and/or filling and using them for purposes such as agriculture or real estate development. As we learn more and more about the values and benefits wetlands provide to us and our environment, many people are taking steps to protect these valuable areas. However, we continue to lose between 300,000 and 500,000 acres of wetlands every year. Government legislation now helps reduce wetland destruction; several programs are currently being administered (see Terms), but it is still very important for all of us to be knowledgeable about and active in the protection of our wetlands.

Further information on wetlands protection can be obtained by calling the EPA Wetlands Hotline at 1-800-832-7828.

Terms

Federal Duck Stamp Program: Administered by the U.S. Fish and Wildlife Service, this program raises money to buy or lease wetlands for waterfowl habitats. It requires that all waterfowl hunters over 16 years of age purchase a duck stamp (sticker) to affix to their hunting licenses each year. The stamps are collectors items, and anyone can buy a stamp to help. (Check with local sporting goods stores or post offices.)

North American Waterfowl Management Plan: This plan includes a special fund established for enhancing, restoring, and acquiring important waterfowl habitats in Canada, Mexico, and the U.S.

Section 404 of the Clean Water Act: This legislation requires that proposed activities for wetlands be reviewed and approved by the Army Corps of Engineers and the Environmental Protection Agency.

ADVANCE PREPARATION

A. This lesson is based on a "whole language" approach and, therefore, begins with the reading of a suggested book.

   1. Obtain the book Were You a Wild Duck Where Would you Go? from your local public or school library.

2. If this award-winning book is not available, use the alternative method of reading a short encyclopedia article about a selected species of waterfowl (such as mallards). Check encyclopedia entries for "ducks, wild."

   a. After reading key information to the students, ask them to imagine that their class is a small flock of (your selected) birds on their long migration flight.

   b. Use a globe or world map to show the students the migratory path of your selected bird.

   c. Have the students identify when wetlands are important to the bird (such as nesting and raising young, resting during migration, and overwintering). Ask the students what things wetlands have that are important to your selected waterfowl. (land, water, plenty of food)

   d. Have the students imagine that they are each waterfowl. Ask them what they would do if more and more of the wetlands along their flight path disappeared (were drained or filled and used for agriculture or real estate development). Have several students share what they think would happen. (What really happens is that fewer birds survive, thrive, and reproduce; numbers of the birds decrease over time.)

B. Obtain a duck stamp from a sporting goods store or post office (or borrow a hunter's license with a duck stamp affixed).

C. Obtain the materials necessary for the group production of duck stamp prints.

D. If you choose to use the student sheet "Duck Stamp," photocopy it for your students.

PROCEDURE

I. Setting the Stage

A. (NOTE: If you have taught the lesson "To Whom It May Concern," skip this step.) Read the book Were You a Wild Duck Where Would You Go? by George Mendoza. Discuss the book, making sure that students understand the main character, Mallard, is a wetland bird and his home has been destroyed. (NOTE: If the book is unavailable, and you use the alternative detailed above, your students will miss the lovely free verse of the book but will learn about a selected species of waterfowl. The lesson can proceed successfully.)

B. Tell the students that many of our wetlands are being destroyed because pollution is being dumped into the waters that drain into them, they are being drained for agricultural use, or they are being drained and/or filled for housing development, shopping centers, office buildings, or factories, or other real estate development.

C. Briefly discuss the reasons for protecting wetlands. (NOTE: You may use the teacher sheet "10 Reasons Wetlands Are Important" from the previous lesson ["To Whom It May Concern"] to facilitate this discussion.)

D. Explain to the students that today they are going to learn about some things that other people are doing to protect our valuable wetlands, and they will discover things they can do to help.

II. Activity

A. Show the students a Federal Duck Stamp or show a copy of the brochure about the stamp. Discuss the stamp and the program. Tell the students that many people (even those who may not hunt) collect duck stamps because each year's design is a pretty picture by a famous wildlife artist. A duck stamp now costs about $15 (98 cents of every dollar goes to buying or leasing wetlands).

B. Share briefly the definitions (see "Terms") of Section 404 of the Clean Water Act and the North American Waterfowl Management Plan. Tell the students that these programs are some of the things their government is doing in an attempt to protect wetlands.

C. Discuss with the students the importance of getting individuals involved in the protection of wetlands. Divide the students into cooperative learning groups. Challenge the groups to brainstorm things they could do to get involved in protecting wetlands. Allow five minutes for the groups to work on this problem.

D. Call time, then have the groups share their ideas with the class. (NOTE: To save time, as one group shares its ideas, have the other groups cross off any they might have on their list.)

III. Follow-Up

A. Tell the students they are going to design and create a "Wetlands Conservation Poster." Briefly, review the importance of wetlands and why they should be protected. Break into small groups again and ask each group to decide upon one idea for getting involved that they think is best.

B. Distribute posterboard and markers to the groups. Before they begin, give them about five minutes to plan their poster. Stress that they should keep in mind the reasons wetlands are important to people and the environment, and remind them their posters should show things individual people can do to help protect wetlands. Afterwards, when they have a good idea of what they are going to do, have them work as a group to create their poster.

C. When the posters are complete, allow each group to present its poster to the class. When all posters have been presented, display them around the room for everyone to enjoy.

IV. Extensions

A. Give each student a copy of the student sheet "Duck Stamp" and have them create a design for the Federal Duck Stamp Program. (NOTE: You may save photocopies by having each student use a sheet of plain white paper.) Tell the students that each year there is a very involved contest to choose the painting for the Federal Duck Stamp. You might have a class contest.

B. Find out if there is a local organization active in wetlands protection. (Check to see if there is a local affiliate of Ducks Unlimited.) If there is, ask a member to speak to your class about what is being done to conserve wetlands in your area. An alternative is to invite a local agent of your state's wildlife agency. After the visit, have the students write a thank you letter to the visitor.

C. Have the groups research their community to locate wetlands near them. If possible, arrange a field trip to visit a wetland area. Afterwards, have groups design t-shirts or bumper stickers to promote conservation of wetlands in their community.

RESOURCES

America's Wetlands: Our Vital Link Between Land and Water, U.S. Environmental Protection Agency, Washington, DC, 1988.

Mendoza, George, Were You a Wild Duck Where Would You Go?, Stewart, Tabori, and Chang, New York, 1990.

"Wild About Wetlands," Nature Naturally (newsletter), Vol. 13, No. 3, Ida Cason Callaway Foundation, Pine Mountain, Georgia, 1990.

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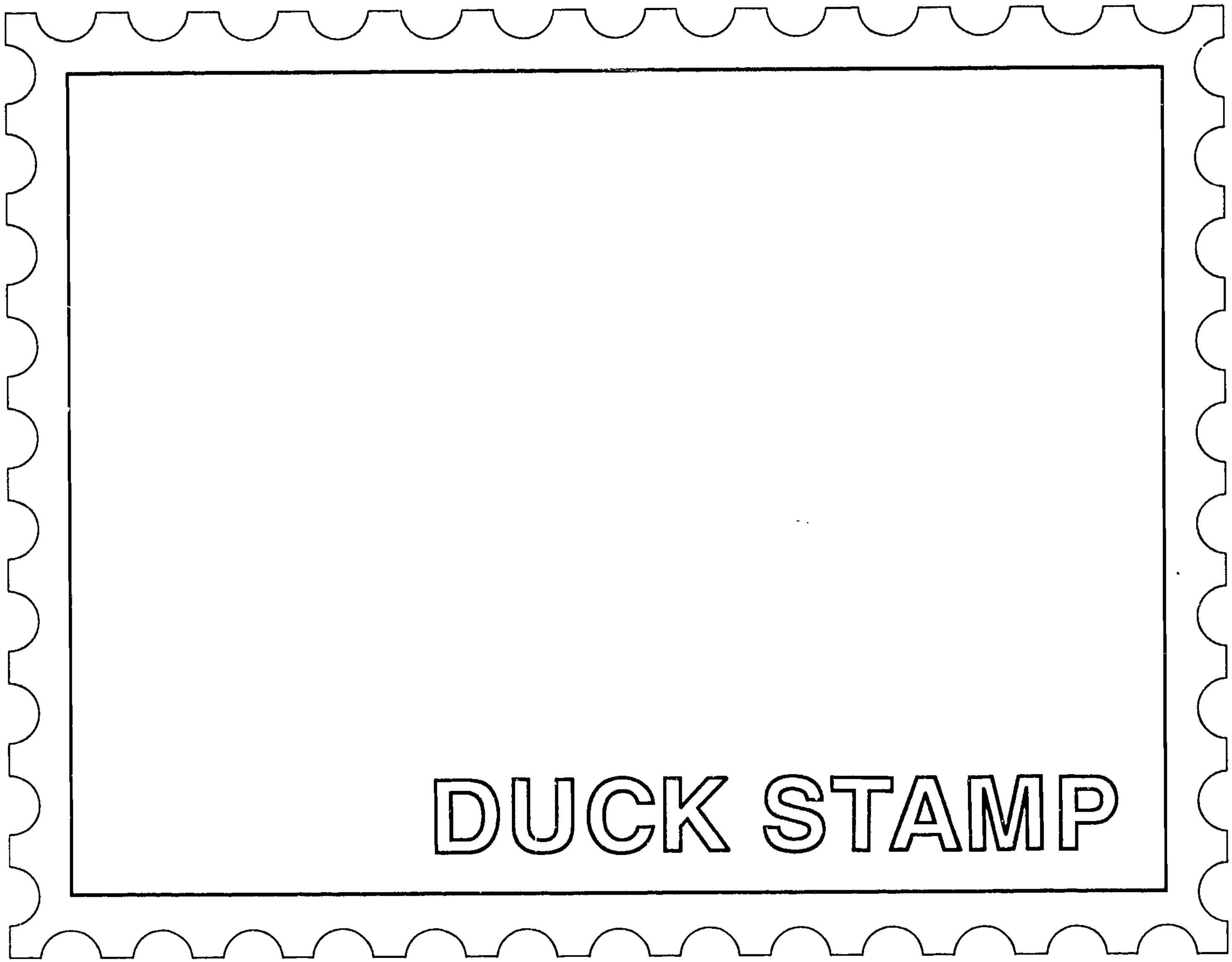

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WHERE DID IT WEAR?

OBJECTIVES

The student will do the following:

1. State two causes of beach erosion.

2. Demonstrate two ways used to prevent or reduce erosion.

SUBJECTS:
Science, Language Arts, Social Studies

TIME:
60-90 minutes

MATERIALS:
sand
trays for each student or team
safety goggles
water
measuring cups or cylinders
gravel
art paper
pencil
rye grass seed (small handful)
atlases
teacher sheets (included)
acetate sheet
overhead projector
graduated cylinder or measuring cup for each student
student sheet (included)

BACKGROUND INFORMATION

Beach shifting is natural. Over a period of time, coastlines change because of erosion and shifting. Sand washed away from one stretch of coast is deposited further up (or down) the coast. Beach erosion is the loss of beach soil (e.g., sand), due mostly to water (wave action) and wind. This is a problem chiefly because of human uses of beaches and adjacent lands. For example, beaches may erode out from under beachfront homes and wide, sandy beaches enjoyed by tourists are important to coastal communities' economies.

A tremendous effort is now under way to halt the severe erosion of our coasts. We can take action to modify where beaches are eroded or built up; this includes building barrier structures to lessen the force of waves or other structures to anchor the beach or to catch shifting sand. We can control development so that people do not build things where erosion will damage them later on. And we can stop human actions that speed up erosion, like the taking of naturally growing seagrasses (that help anchor sand dunes) or the unwise use of all-terrain vehicles on fragile beaches.

Terms

beach: a nearly level stretch of land near a sea, lake, or ocean; often washed by high water.

coastline: the line that forms the boundary between the land and the water, especially of an ocean or sea.

erosion: the removal and transport of earth materials usually by wind or water.

ADVANCE PREPARATION

A. Make a transparency of the teacher sheet, "A Changing Coastline," showing change in a coastline.

B. Sow rye grass seeds in a tray of sand to demonstrate how grasses help slow erosion. (Rye grass is a common lawn grass. Check at a garden shop, lawn service, or farmers cooperative.) The seeds should germinate in four to seven days.

C. Make copies of the student sheet, "'Wear It Out' Wordfind."

D. Trays of any size can be used as long as they have sides. Perhaps trays from the cafeteria could be used for the lesson. Play sand and gravel can be purchased at variety and pet supply shops.

E. Safety goggles are needed to protect the students from getting sand in their eyes.

PROCEDURE

I. Setting the stage

A. Show the students the transparency.

1. Point out the change in the coastline over time.

2. Define "erosion" for the class.

3. Explain that erosion has played a major role in changing our coasts.

B. Ask the students to predict some effects of coastline erosion. What do they think the future might hold if we do not do what we can to control it?

II. Activity

A. Pass out white art paper. Have the students fold the sheet in half. On one half, they will draw a beach scene. On the other half, they will draw what they think the coastline would look like if erosion continued for a long time.

B. Distribute trays to students or teams of students. Have the students measure one cup (250 mL) of sand. They are to pour the sand onto each tray and shape it into a mound. (CAUTION: Have the students wear safety goggles to protect their eyes.) Instruct the students to blow on the sand. Ask them to tell you what happened. Point out that this is a demonstration of wind erosion.

C. Repeat activity B, only have the students measure 1/4 cup (63 mL) of water and pour the water in a of water over the sand instead of blowing on it. Explain that coastal erosion acts much in the same way. (NOTE: If you do not have enough cups or cylinders for each student, let them use any small container that holds water.)

D. Using a tray, mound sand at one end of tray. Build the sand up to represent a beach area. Put water in the tray. Rock the tray back and forth to create a wave action. Point out that wave action at the beach also causes erosion.

E. Ask the students to remound the sand.

1. Pass out the gravel to the students.

2. Instruct them to cover the sand thoroughly with gravel.

3. Have the students blow on the sand. Tell the students that gravel, rocks, and boulders can be used to hold sand in place (to slow erosion).

4. Ask the students to compare what happened to the sand with and without gravel.

F. Show the students the tray of seeded grass.

1. Point out that roots of grass help hold the soil in place.

2. Stress that grass planted in masses helps cut down on wind erosion.

3. Have the students take turns blowing on sand or pouring water on sand, continually pointing out how the sand does not move as much.

G. Tell the students that we can also build structures that protect beaches from erosion. Sometimes fence-like structures on the beach are effective. Sometimes we can build big barriers out in the water to take some of the force of the waves. We can even build wall-like structures from the beach out into the water to catch sand as it is being washed away from a stretch of coastline.

III. Follow-Up

A. Have the students write two causes of beach erosion and two ways it can be prevented.

B. Divide the students into teams. Give each team an atlas. Have students write down the names of states that have a coastline. (Or, write the countries which have a coastline.) Tell them not to forget to include Alaska and Hawaii.

C. Have the students complete the wordfind on the student sheet, "'Wear It Out' Wordfind." Ask the students to use each word in a sentence.

IV. Extension

If your school has an embankment, remove a small area of grass from it. Pour water daily over the embankment. Have the students observe and record the changes in the area of the embankment. Then reclaim the area by planting new grass and covering it with mulch. Be sure to get permission from the school administrator.

RESOURCES

King, D. C., et al., Environments, American Book Company, New York, 1979.

Namowitz, S. N., et al., Earth Science, D.C. Heath and Co., Lexington, Massachusetts, 1989.

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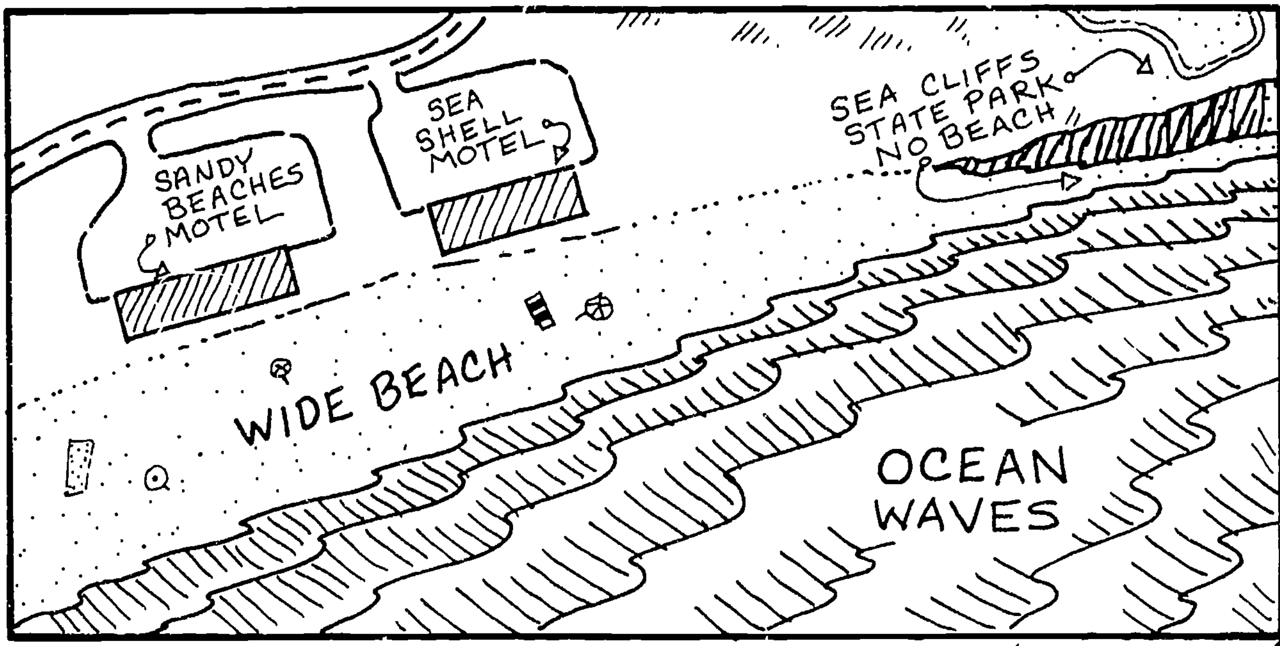
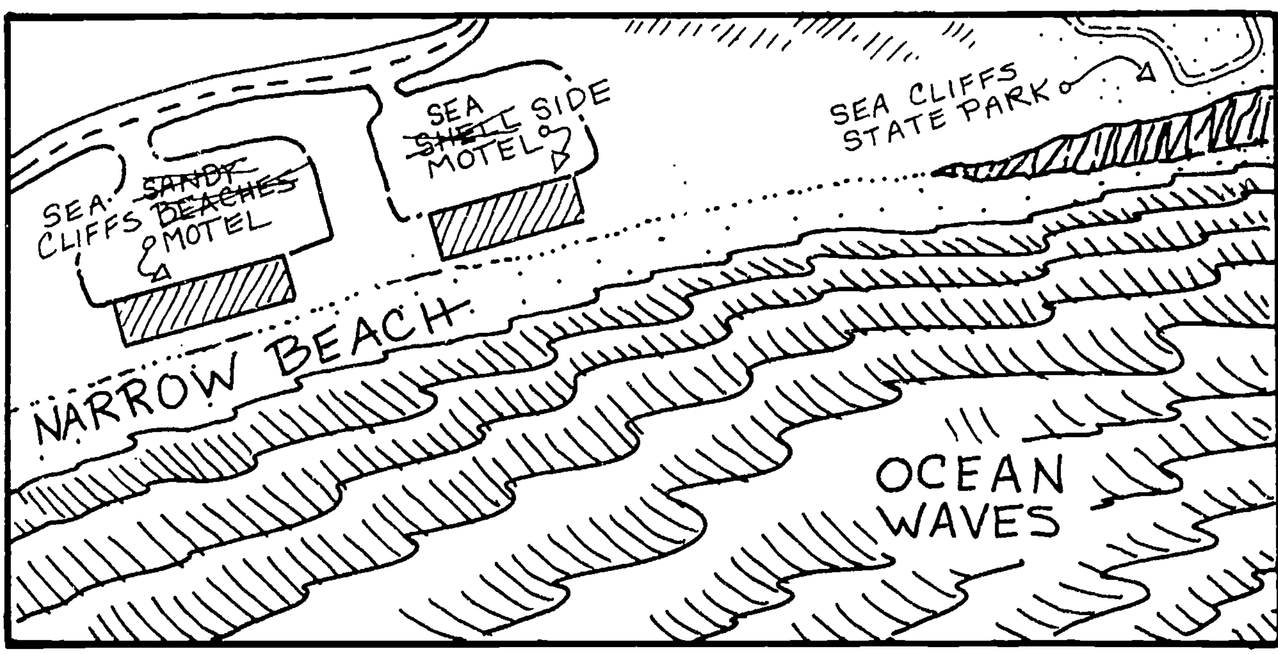
A CHANGING COASTLINE

A CHANGING COASTLINE



A FEW YEARS LATER....



"WEAR IT OUT" WORDFIND

Find these words in the wordfind puzzle below. (Optional: Look for other words not in the list.)

atlas	plants
beach	prevent
coast	rainfall
coastline	sand
embankment	water
grass	waves
gravel	wind

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A T L A S B C D A S B E A C H M O O N C
A R A I N F A L L R A I J O W A S P T O
L O O K H A R D F O R S E A L M N S A A
S A L T P R E V E N T L E S G R O G D S
T L W L I N C O L N A B E T R O O K E T
N A A D A L L A S O N O O L N R S T E L
A B V E G R A V E L O R J I A B S C D S
L O E M I C K E Y L O E D N A B S C E A
P O S T L W I N D J R T E E O R A M E N
L K A B E C C A K E M A O P R E R V A D
E M B A N K M E N T S W G O O D G L E N
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"WEAR IT OUT" WORDFIND
ANSWER KEY

Find these words in the wordfind puzzle below. (Optional: Look for other words not in the list.)

(These words are circled.)

atlas	plants
beach	prevent
coast	rainfall
coastline	sand
embankment	water
grass	waves
gravel	wind

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

Other words not in list: (These words have lines through them.)

Band	Dallas	Loon	Rot
Base	Deed	Lot	Salt
Bet	For	Men	Seal
Book	Good	Mickey	Soon
Bred	Hard	Moon	Tee
Cake	Lincoln	Rag	
Care	Look	Rook	

YOU MUST HAVE BEEN A BEAUTIFUL "BAY-BEE"

OBJECTIVES

The student will do the following:

1. Identify bays on a world map.
2. Distinguish between point and nonpoint source pollution.

SUBJECTS:
Science, Geography, Art, Language Arts

TIME:
30-60 minutes

MATERIALS:
wall map of world
pins with colored heads
pictures of different bays
sand
water
tray
powdered drink mix or instant coffee
watering can
old magazines
scissors

BACKGROUND INFORMATION

A bay is a large body of water around which the land forms a curve. Bays are similar to gulfs, but are smaller. The Chesapeake Bay is an example.

Bays are much more than just points of entry for water travel and areas of recreation. They are homes to many unique and important plants and animals. Some of our bays, however, have become polluted and unsafe for human and other animal use.

Much of the pollution comes from boats and ships, liquid and solid waste dumping, dredging, and runoff from cities, suburbs, and farms. As a result, not only has the water become unsafe, but many marine animals have become threatened because their habitats have been greatly changed.

Terms

bay: a large body of water around which the land forms a curve, usually smaller than a gulf, but of the same general character.

effluent: a liquid discharged as waste.

gulf: a large body of water of the same general character as a bay, only larger.

nonpoint source pollution: pollution which comes from many widespread sources, such as runoff from cities, suburbs, and farms.

point source pollution: pollution which comes from a specific source, such as effluent from waste water treatment plants.

ADVANCE PREPARATION

Collect old magazines (e.g., travel, outdoor sports, or nature magazines or National Geographic) from which to cut out the pictures of bays. Make sure that the pictures include over-developed bays as well as unspoiled bays. (NOTE: You may find all the pictures you need in geography texts. If you do, make black and white or color photocopies from the books.)

PROCEDURE

I. Setting the stage

A. On a wall map of the world locate major bays and place pins with colored heads at their locations. Use a different color for each bay. Call on the students to find the specific color pin as you call them out. When the pin is located, ask the students to name the bay. (NOTE: You might modify this to be a small group activity.)

B. Define the term "bay." Point out to the students the difference between a bay and a gulf. Have the students locate gulfs on the map and compare gulfs and bays. Ask them which gulfs and bays they have heard of.

C. Show the class pictures of bays. Ask them to identify items in the pictures which make up a "bay" environment. Ask the students to suggest animals which we might find in a bay. Point out that many cities have developed around bays and that this has added to the pollution woes of our bays.

II. Activity

A. Tell the students that some of the water pollution affecting our bays is nonpoint source pollution. The following steps will help demonstrate nonpoint source pollution.

1. Fill one side of a tray with sand which has been mixed with powdered drink mix or instant coffee. Pack tightly. Make sure you use enough drink mix or instant coffee.

2. At other end of the tray, pour water to create a pool of water. (If sand continues to absorb too much of the water, separate the sand from the water by inserting a ruler or other object to use as a "wall" to hold back the sand.)

3. Using a watering can, gently pour water over the sand. Ask the students to observe the pool of water. (The water will begin to change color.)

4. Point out to the students that simulated pollution (drink mix or coffee) was in the sand. The pollution was not put directly into the water; it came from the land and wound up in the water. This is an example of nonpoint source pollution.

B. The following activity demonstrates point source pollution.

1. Use more of the same materials from activity A above, except do not mix the drink mix with the sand. Pour the powder directly into water.

2. Ask the students to tell you what happened to the water. Explain to the students that when pollution is placed directly into water, it is called point source pollution.

III. Follow-Up

A. Have the students pretend to be "Pollution Detectives" working to solve a mystery. The mystery is how pollution from a farm (20 miles inland) can end up in a bay (20 miles away). They can use the library or ask their parents to help solve the mystery. Other adults or students can also help.

B. Ask the students to draw a picture of a bay that shows point source pollution. (You may need to suggest several ideas to the class, such as effluent from factories, dumping of garbage in water, etc.)

C. Using old travel, outdoor sports, ar.d nature magazines, have the students search through them for pictures of bays and animals we find in bays. Make a bulletin board collage of the pictures. (NOTE: This may also be an excellent group activity.)

D. Ask the students to list the things we throw away in our bays that we could recycle to help reduce solid waste pollution in our bays.

IV. Extensions

A. As a class project, construct a bay environment model featuring appropriately scaled model houses, trees, buildings, and so on. (Cardboard is plentiful and cheap.)

B. Have the students write stories to go with the bay collages they made. These might be about real or imaginery trips to bays or simply descriptive pieces.

RESOURCE

Slattery, B. E., WOW! The Wonders of Wetlands, Environmental Concern, Inc., St. Michaels, Maryland, 1991.

DOWN IN THE OCEAN DUMPS!

OBJECTIVES

The student will do the following:

1. Observe that ocean dumping is a form of water pollution.
2. Brainstorm ways solid wastes can harm marine life.

SUBJECTS:
Science, Language Arts, Art

TIME:
60 minutes

MATERIALS:
drawing paper
markers or crayons
red food coloring
colored markers
aquarium or large fishbowl
water
small rusty cans
plastic wrappers
plastic forks, spoons, and straws
discarded food
any object considered garbage (which could be added to aquarium)
test tubes with stoppers (or baby food jars with lids)

BACKGROUND INFORMATION

United States law allows dumping some wastes in the ocean. Each year barges and ships legally dump about 190 million tons (210 metric tons) of solid waste into our coastal waters. About 80 percent of this is dredge spoils scraped from the bottoms of harbors and shipping channels. Most of the remaining 20 percent is industrial waste and sewage sludge removed from wastewater at sewage treatment plants. (These are classified by law as "solid waste" because they are contained before they are released.) Almost all of the solid wastes go into deep ocean waters off the coast from New York City.

Nevertheless, many tons of garbage find their way into the oceans – most of it is dumped by ships (to save disposal fees they would have to pay in port). Merchant ships throw nearly a half-million plastic containers into the ocean every day. Littering by beachgoers and boaters is also a significant source of trash.

The vastness of ocean waters and their constant mixing dilute and disperse many types of wastes to harmless levels, but their capacity to do so has limits. The huge quantities of waste discharged near the coast can overload an ocean's natural purifying system.

Although many wastes dumped into the ocean are degraded over time, many of the solid wastes dumped into the ocean cannot be readily degraded. Plastic and other synthetic materials are the chief examples of this. These materials car ecome a serious problem for marine life, causing injury and, in some cases, even death. Recent studies indicate that up to 2 million seabirds and more than 100,000 marine mammals, including whales, seals, dolphins, sea turtles, and manatees die each year as a result of plastic pollution.

Terms

contaminate: to make impure (not pure) by contact or mixture; to introduce a substance into the air, water, or soil that reduces its usefulness to humans and other organisms in nature.

degradable: capable of decomposition; chemical or biological.

dilute: to thin or reduce the concentration of (a solution).

disperse: to break up and scatter in various directions.

marine life: any plant or animal which lives in or on the sea.

pollute: to contaminate with a substance that is harmful to human health or the environment.

solid waste: any solid product discarded and thought of as useless or no longer needed.

ADVANCE PREPARATION

A. If a health official is invited to class, brief him/her on what you want the students to get from lesson.

B. Fill an aquarium or large fishbowl with water. (NOTE: If you have some available, put some sand and shells in first.)

PROCEDURE

I. Setting the stage

A. Tell the students that the water in the aquarium represents the water in the ocean. Ask the students to orally give the names of animals and plants that live in the ocean. Write the student responses on the board.

B. Write the word, "garbage" on the board. Ask the students to come up with their own definitions of the word. Point out that garbage doesn't disappear and that it has to go somewhere. Explain to the students that a great deal of our garbage is being dumped in our oceans.

C. Have the students brainstorm how the dumping of garbage could harm marine life. Write the responses on the board. Possible answers: birds and other animals eat the garbage which could kill them or make them sick; animals could choke on plastic or could cut themselves on sharp edges; harmful bacteria could make animals that others eat unsafe (affecting the food chain); and so on. Point out that some bacteria cause diseases in some animals, and if these animals are eaten, then the disease is passed on to others.

II. Activity

A. Pour a small amount of red food coloring in the aquarium. (For a small [5-gal. or 20-L] aquarium, one or two drops will do.) Agitate the water so that the coloring becomes diluted and dispersed (disappears). Ask the students what happened to the color. Point out that the food coloring is still there; they just cannot see it. Likewise, the movement of the ocean helps dilute and disperse some wastes, but the ocean has limits and can only handle so much waste.

B. Add several small plastic items (such as wrappers, spoons, forks, and straws) to the aquarium. Agitate once again. Ask the students to compare what happened to the dye and what happened to the plastic. (Plastic did not disappear.) Stress to the students that plastic is not degradable; it will remain in the ocean, or may eventually wash up on the shore.

C. Begin to add items to the aquarium water such as discarded food, rusty cans, etc. The students will begin to see how the water is affected by garbage. Point out to the students that marine animals eat some of the garbage we discard and that this might harm them.

D. Divide the students into small teams. Have each team create a list of ways that humans could be harmed by ocean dumping. Let the groups share their lists and discuss them together.

III. Follow-Up

A. Have the students write a paragraph on how dumping harms the ocean environment.

B. Brainstorm with the class about what could be done to stop people from "trashing" the oceans.

C. Pass out art paper. Have half of the students draw their ideas of what a clean ocean should look like. Have the other half draw a "polluted" ocean. Let the students compare polluted and clean ocean drawings.

IV. Extensions

A. Investigate the "pollution's" effects on the aquarium water. Take a sample of water from the aquarium that has been polluted. Place it in a test tube and stopper it. (NOTE: You may use a baby food jar.) Have students observe the changes in the water each day for about a week. Ask them to keep a little journal with their observations. (The water should get murkier as time goes by.)

B. Invite a health official to class to talk about some of the health problems that ocean dumping could cause to animals, including humans.

C. Have a "Save the Ocean" poster contest. Instruct the students to design posters showing the dangers of ocean dumping. Give the students large sheets of art paper. The winner could be given some free time (or whatever you decide), and the winning poster should be put in a place of honor.

D. As a class project, suggest to the students that they write a letter to the President, their senators and congressman, or their governor expressing their concerns about ocean dumping and pollution.

RESOURCE

Miller, G. T., Jr., Living in the Environment, 6th ed., Wadsworth, Belmont, California, 1990.

THE INSIDE ON RED TIDE

OBJECTIVES

The student will do the following:

1. Identify the cause of red tide.
2. Construct a bulletin board showing how red tide poison passes from animal to animal.

SUBJECT:
Science

TIME:
60-90 minutes

MATERIALS:
2 clear glass jars or 2 liter bottles with the tops cut off
red food coloring
coffee
algae (directions for growing algae can be found in extension activity)
fishbowl or aquarium
water
sponge animals
trays with sides
reference books on marine life
student sheet (included)

BACKGROUND INFORMATION

Algae can be found in most waters in the world. Certain microscopic algae in our coastal waters, known as dinoflagellates, are red-pigmented; when these algae flourish, the water turns reddish. This is commonly referred to as a "red tide." These algae produce a toxin. When there is an abundance of the algae, great amounts of this toxin are produced.

At times, this toxin can become concentrated in marine animals such as clams and mussels. Clams and mussels are filter feeders. As they filter the water to obtain their food, the toxin is taken in by these animals. Sometimes red tide toxin kills shellfish (and other fish); sometimes it does not. If toxin-loaded clams and mussels are eaten, the toxin can fatally poison the consumer. Also, ocean spray containing the toxin can cause respiratory problems in humans.

Algae that can produce red tides multiply rapidly in water which has been enriched by nutrients from treated sewage or by runoff from fertilized soil. The algae can become so thick that it can actually damage or destroy the marine environment. The multitude of tiny algae may even block the sunlight needed by many coastal plants and animals.

Terms

algae: a major group of single-celled or multicellular plants, chiefly aquatic, having no roots or stems.

red tide: a term which applies to water tinted red due to a heavy growth of red-pigmented algae called dinoflagellates.

toxin: a poisonous substance that is secreted by certain organisms.

ADVANCE PREPARATION

A. Make copies of the student sheet.

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B. Begin growing algae four or five days before doing the lesson (see extension).

C. Animal-shaped sponges can be purchased at most toy stores.

D. A disposable pie or cake pan can be used as the tray.

E. Make sure red food coloring does not stain. (You might use very thin red tempera paint.)

F. Add water and red foo. coloring to a jar. Mix in a little coffee for a brownish tint.

G. Collect a supply of reference books like field guides or topical books (like those for coastal animals and plants).

PROCEDURE

I. Setting the stage

A. Hold up the jar with clear water and show the jar to the class. Next, hold up the jar that has been colored brownish red with red food coloring and coffee. Ask the students which water would probably be safer for marine animals to live in. Explain to the students that there is a certain type of microscopic algae that produces a reddish pigment and that this algae colors the water just as the dye colored the water in the jar. This algae a' o produces a toxin which is released in the water, making the water toxic or poisonous. This a. ae is found in our oceans.

B. (NOTE: You may show the students the algae you have grown in an aquarium or fishbowl.) Stress to the students that algae are lower plants. Algae are found in most waters. Many kinds of algae have large forms, such as kelp or seaweed. Some form "pond scum." Some algae, like those responsible for red tides, are microscopic; they become noticeable only when there are so many of them that there are literally hundreds of thousands (even up to two million) of them per liter of water. Emphasize that not <u>all</u> algae produce toxins, only certain types.

II. Activity

A. Pass out trays to each student or team of students. Fill each tray with water. Give each student a foam or sponge animal. Instruct the students to put his/her sponge animal in the water. Point out to the students that the animal has absorbed some of the water. (NOTE: If you have studied tidal pools, let each group make a model of a tidal pool.)

B. Repeat the activity above, but color the water with the red food coloring. (NOTE: Make sure the amount of food coloring is sufficient to remain noticeable when the sponges are squeezed.) Tell the students to put the sponge animals in the water again.

1. Have the students remove the animals and gently squeeze out the water. Ask them what color the water is that came from the sponge animals.

2. Review the term "toxin." Explain to the students that animals in the ocean can absorb the poison from the "red tide" similar to the way the sponge animals absorbed the dye.

C. Pass out the student sheet. Have the students use marine life reference books and encyclopedias to identify the plants and animals. They should write the names of the plants or animals in the boxes on the sheet. (The answers vertically down the left, then the right column are as follows:

Blue Crab, Salt Marsh Cord Grass, Atlantic Ribbed Mussel, Northern Puffin, Horseshoe Crab, Lined Seahorse, Sting Ray, Brown Pelican, Fiddler Crab, Sea Lavender, Shrimp, and Eel Grass.) Which of them could be affected (i.e., are shellfish and are likely to be of special concern) when a red tide occurs? (mussels, crabs, and shrimp) Emphasize that when other animals eat animals that have accumulated the poison, they consume the poison.

III. Follow-Up

A. Have the class make a list of ocean animals that might be poisoned by "red tide."

B. As a class project, construct a bulletin board showing how poison can travel from animal to animal in the ocean, ultimately ending with humans.

C. Have the students draw an ocean food chain and ask each student to share with the class their individual food chain. Relate this to the previous item showing how the toxin can be passed from one organism to another.

IV. Extension

Grow your own algae! In a glass fishbowl or an aquarium, simply add tap water which has been dechlorinated, or better yet, water from a local pond. Keep it in a sunny location. Have the students monitor it each day to observe the algae growing. Add about a teaspoon of detergent with phosphate to the water to encourage faster algae growth.

RESOURCES

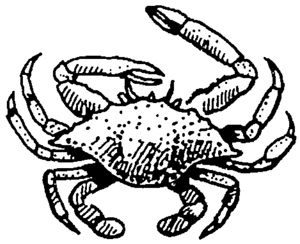
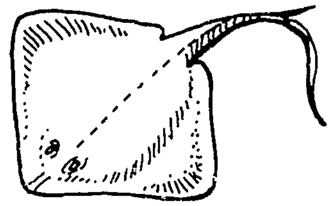
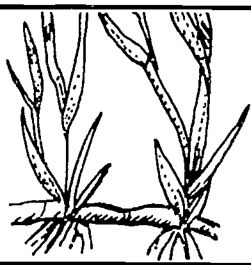
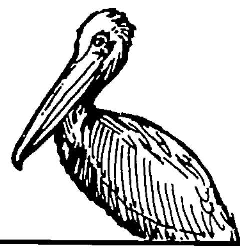
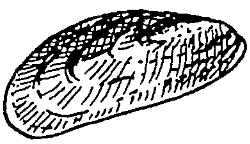
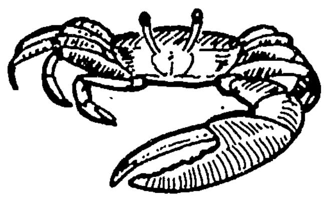
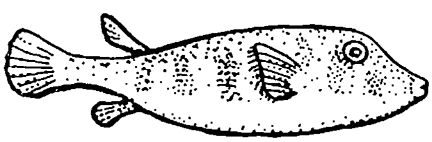
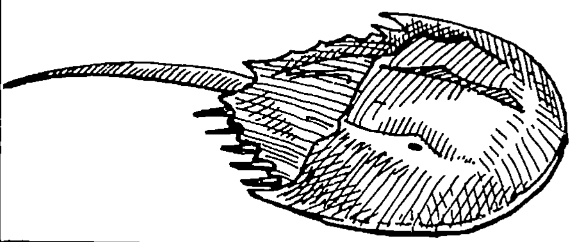
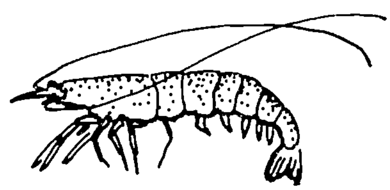
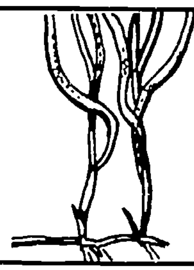
Goodman, H. D., et al., Biology Today, Holt-Rinehart-Winston, New York, 1990.

Oram, R. F., Biology-Living Systems, Merrill Publishing, Columbus, Ohio, 1989.

"Water Education Lesson Plans (K-12)," Water and Man, Inc., Salt Lake City, Utah, 1987. (Address: 220 South Second East, Salt Lake City, Utah 84111.)

MARINE LIFE

Look these coastal creatures up to find out what their names are. Write their names in the boxes with their pictures.

TREES BY THE SEA

OBJECTIVES

The student will do the following:

1. Compare a natural, undeveloped coastline to a seawalled coast.
2. Compute and graph shoreline lengths.
3. Identify ways that mangrove forests are important.

SUBJECTS:
Science, Math, Social Studies

TIME:
60 minutes

MATERIALS:
acetate sheet
overhead projector
measuring stick
string
scissors
student sheets (included)
teacher sheet (included)

BACKGROUND INFORMATION

Mangrove forests are coastal wetlands dominated by varieties of mangrove trees. These mangrove forests are very valuable ecologically. They also protect the coast from erosion and provide storm protection for inland communities. Coastal states are now also recognizing the economic value of these wetlands, saving them from real estate development and oil exploration. In the past it was common to clear the forests, straighten the coastline, and build seawalls along the beach to develop beachfront real estate.

In the past, mangrove forests were viewed as smelly waste places that bred mosquitoes and had no value. Biological research has shown them to be critically valuable breeding grounds for fish and shellfish and vital to almost every form of wildlife in the coastal ecosystem.

The formation of mangrove forests required thousands of years. People can clear a mangrove forest, fill in low-lying areas, and begin building housing developments and streets within a matter of weeks. The coastline will never be the same, and although the people enjoy living on beachfront property, they now face the hazards of coastal life, such as hurricanes and other storms.

Terms

estuary: the lower course of a river where its current is met and influenced by the ocean tides, producing water of varying salinity.

mangrove forest: a tropical or subtropical marine swamp distinguished by the abundance of low to tall trees, especially mangrove trees.

salinity: salt, or the amount of salt, in a liquid.

seawall: a wall built to protect beachfront areas from erosion and high water in storms.

ADVANCE PREPARATION

A. Photocopy the student sheets, "Mangroves to Seawalls" (one per pair of students) and "Shoreline Graph" (one per student).

B. Cut one piece of string approximately 18 inches (45 cm) long for each pair of students.

C. Make a transparency from the teacher sheet "Mangrove Forest."

PROCEDURE

I. Setting the stage

A. Discuss the background information with the students, emphasizing the ecological importance of natural wetlands, such as mangrove forests. Use other examples of local wetlands to make the topic more relevant. Examples may include local bogs, floodplains of creeks or streams, marshy areas around ponds, and spring-fed marshes.

B. Use the transparency "Mangrove Forest" to show students some of the common resident species found in this habitat. Point out that the open ocean lies to the left and the forest land lies to the right on the figure.

II. Activity

Have the students compare a natural coastline with mangrove forest to a developed coastline with a seawall.

A. Divide the students into pairs. Give each pair an 18-inch (45 cm) piece of string, one copy of the "Mangroves to Seawalls" student sheet, and two of the "Shoreline Graph" student sheets. Each student will complete his/her own graph.

B. Have the students look at the diagrams on the "Mangroves to Seawalls" student sheet.

1. Explain to them that these are like maps of a coastline. In 1960 (the first diagram), the coastline was natural. There was a dense, swampy mangrove forest all along the beach. Then people decided they wanted to build houses and businesses at the beach. Because people do not like to live in mangrove forests, they cleared them, straightened out the coastline, and built a seawall to protect their houses from the ocean. By 1980, the original coastline was replaced by a housing development. The forest was pushed back and a seawall kept the ocean away from the houses.

2. Ask the students to think about the differences in the undeveloped coastline and the later, seawalled coast. For example, what about the plants and animals that live at the coast? Can they live where people have built their houses? What happens when a storm (e.g., a hurricane) comes? Ask them to describe what they see in the 1990 diagram (storm damage). Point out that mangrove forests along a coast would be damaged by storms, but that the forests protect houses built away from the beach from storms and erosion. Talk with the students about the advantages and disadvantages of living along a coast. (For example, beach houses are fun to live in, but storms are dangerous and costly.)

C. Have the students work together to place the string on the "mangrove line" for 1960. After the string has been placed over the entire line, they are to hold it at the point that marks the length of the coastline. They will then measure the length of the string with the "mile ruler" at the bottom of the "Shoreline Graph" page. (Explain that one inch [2.5 cm] of string represents one-half mile [.08 km] of coastline.)

D. Have each student record the length of the 1960 shoreline and make a bar for this number on the Shoreline Graph.

E. Have the students repeat the measuring and graphing procedure for 1970 and 1980.

III. Follow-Up

A. Have the students answer the following questions. (NOTE: These may be used before and after the activity as a pre- and post-test.) Read the questions and have the students answer "true" or "false."

1. Mangroves are coastal trees that live in coastline areas. (true)
2. Mangroves cause erosion of our shorelines. (false)
3. When a shoreline is seawalled the length of the shoreline is increased. (false)
4. Mangroves are important to the economy of an area. (true)
5. More plants and animals live in a mangrove forest than along a seawalled coast. (true)

B. After measuring shorelines and recording the data, have the students answer and discuss the following:

1. How much was the shoreline shortened from 1960 to 1980?
2. If a storm occurred, how would the presence of a mangrove forest help people? What might happen to beachfront homes behind a seawall in a storm?

IV. Extensions

A. Have the students report on some specific ways that mangrove forests are productive biologically and economically. Can they list fish and shellfish that people eat that rely on breeding grounds along mangrove coastlines?

B. Have the students research how states are trying to convert some of their developed coastal areas back to their natural state.

C. Let the students study detailed physical maps of coastal states to determine where mangrove forests may be found.

RESOURCES

Frank, James, Mangroves & Seawalls, Lee County Board of Public Instruction, Fort Meyers, Florida, 1983,

"Saltwater Wetlands," Ranger Rick's NatureScope: Wading Into Wetlands, National Wildlife Federation, Washington, DC, 1986, pp. 18-32.

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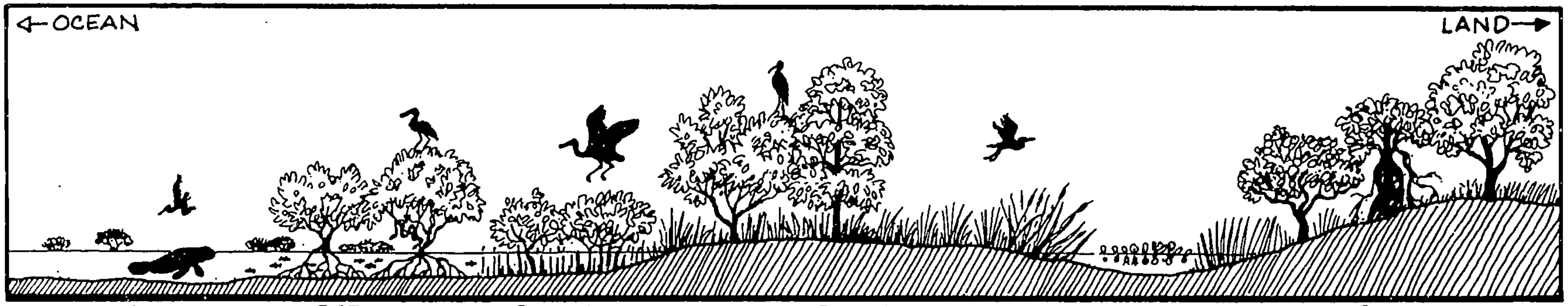
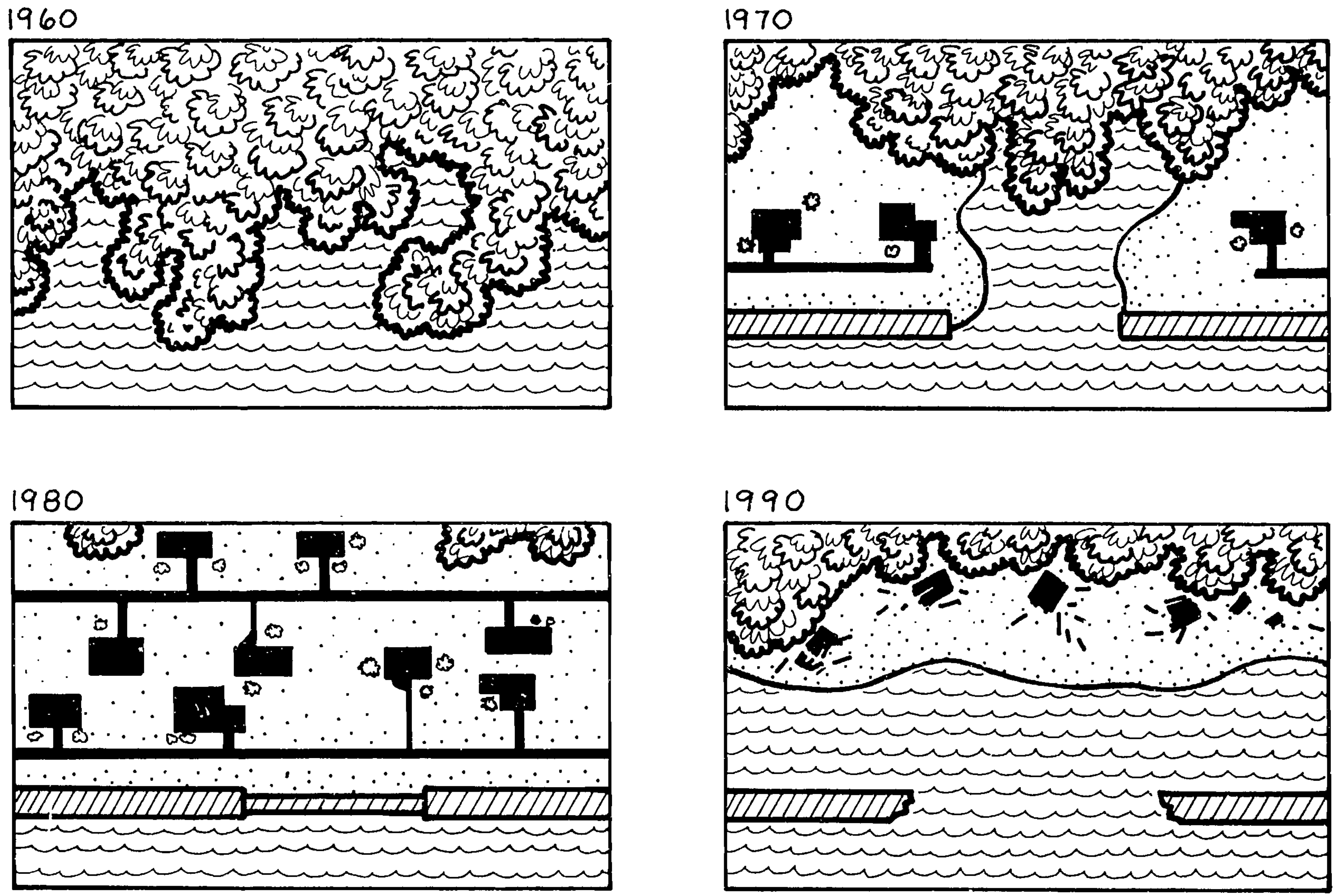
MANGROVE FOREST

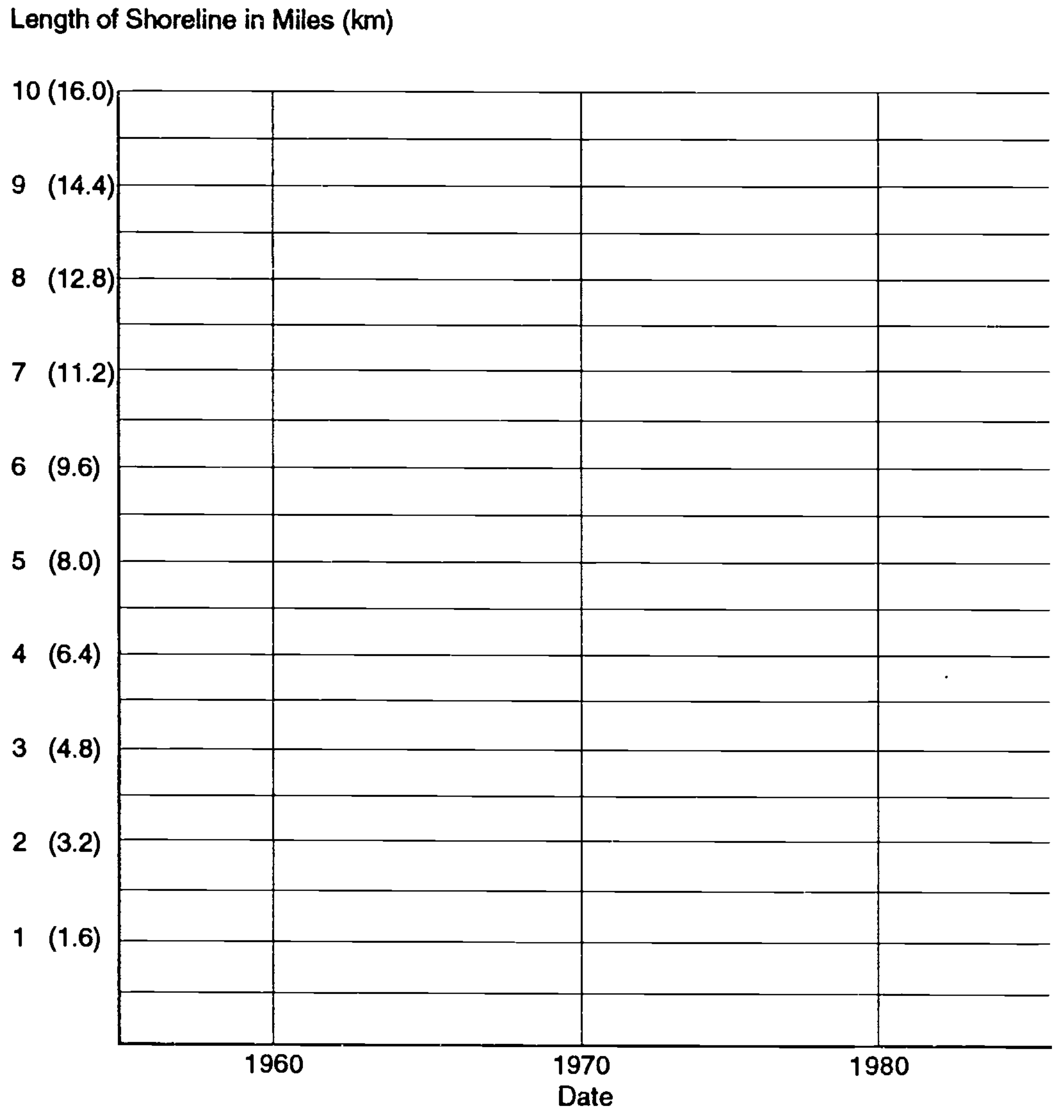
MANGROVE SWAMP FOREST



MANGROVES TO SEAWALLS

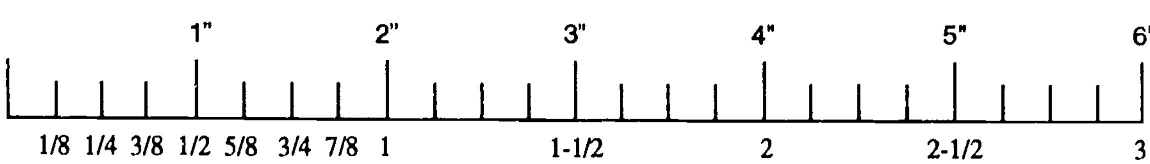


SHORELINE GRAPH



MILE RULER

1" (2.5 cm) = 0.5 mile (0.8 km)



ESTUARY WATER

OBJECTIVES

The student will do the following:

1. Observe the effects of varying concentrations of salt on the aquatic plant Elodea.
2. Define estuary and describe why estuaries are important.
3. Draw conclusions about Elodea and its ability to tolerate different concentrations of salt.

SUBJECT:
Science

TIME:
1 hour + observation time

MATERIALS:
four 2-liter bottles
three 1-liter bottles
test tubes or small baby food jars
test tube rack or plastic cups to hold test tubes
pond water
salt (NaCl)
gram scales or balance
Elodea
1-liter measuring cup or bowl
masking tape
student sheet (included)

BACKGROUND INFORMATION

Estuaries are defined as partially enclosed bodies of marine water fed by freshwater sources, such as where a river flows into a bay. Their water is mixed with sea water. Salinity can vary with distance from the inflow of fresh water and other factors. Estuaries form a fragile boundary between marine and freshwater habitats. They are very valuable as breeding grounds for thousands of species of aquatic animals and plants, as recreational areas, as shipping lanes, and as commercial fisheries.

Estuary water will range from low salt concentrations where rivers empty into bays to high concentrations near the bay's opening to the sea. The aquatic plants present in different areas of estuaries also vary with these changing concentrations of salt. Elodea ("eh-loh-DEE-uh") is a common freshwater plant which can be found in estuaries where freshwater is abundant. It is often used in biological studies.

Terms

estuary (EHS-choo-ehr-ee): an arm of the sea that extends inland to meet the mouth of a river.

ppt: parts per thousand; e.g., salt water having 10 parts salt per 1000 parts water has a concentration of 10 ppt.

salinity: salt, or the amount of salt, in a liquid.

ADVANCE PREPARATION

A. Obtain water from a pond, lake, or stream. Fill four 2-L bottles about three-fourths full so that you will have plenty.

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B. Prepare a set of stock solutions:

1. Dissolve 10g NaCl (salt) in 1000 mL pond water for 10 ppt salt water.
2. Dissolve 20g NaCl in 1000 mL pond water for 20 ppt salt water.
3. Dissolve 30g NaCl in 1000 mL pond water for 30 ppt salt water.
4. Pond water (control) (NOTE: Use water from a river, lake, or stream; do not use tap water.)

Measure the salt on a balance.

C. Obtain Elodea at a local aquarium shop. If you must order it from a science supplier, allow for shipping time.

D. Have four test tubes or small jars for each team of students (baby food jars work fine).

E. Copy the student sheet "Elodea observations."

PROCEDURE

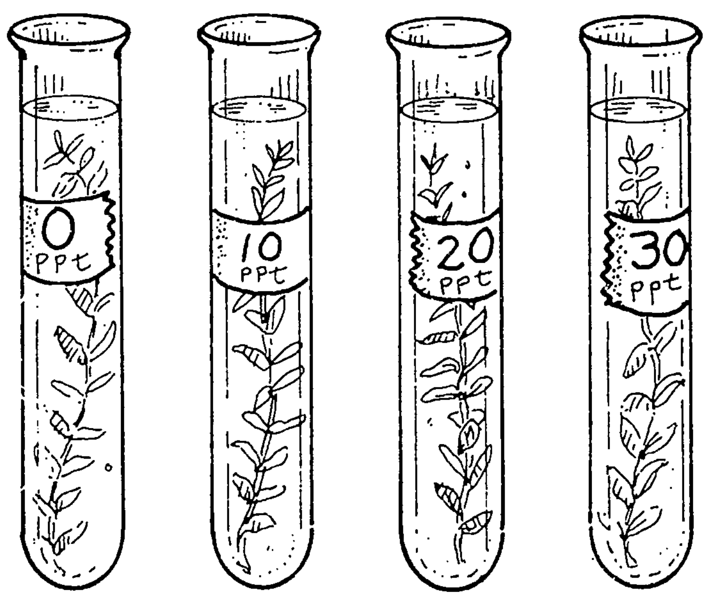
I. Setting the stage

Share the background information with the students. Write the word "estuary" on the board. (For more information, check the factsheets on wetlands.)

II. Activity

Have the students investigate the effects of various salt concentrations on a freshwater aquatic plant.

A. Divide the students into teams of four and provide four test tubes or jars per lab team.



B. Fill each test tube or jar with a different concentration of salt water. Have the students label each with a piece of masking tape and mark it with the salt concentration (ppt). Fill one jar with pond water. Remind the students of why it is important to have a control group in an experiment.

C. Put a short length of Elodea in each tube or jar.

D. Give each student a copy of the student sheet "Elodea Observations."

1. Have each student write down his/her prediction of the experiment's outcome.

2. Have the students observe the plants for four days and record their observations. Keep the test tubes in racks, or place the jars where they will be undisturbed.

E. Have the students answer and discuss the questions on the student sheet, "Elodea Observations."

III. Follow-Up

A. Have the students continue to observe the Elodea clippings each day for several days.

B. Each student should write a paragraph stating his/her conclusions and the reasons for it.

IV. Extension

A. Have the students research and report on members of estuary plant and animal communities.

B. Have the students investigate other components of salt water and report on its minerals and nutrients and their effects on marine plants and animals.

C. Have the students investigate how many seafood species live in estuaries for at least part of their life cycles..

RESOURCES

"Chesapeake Bay: Introduction to an Ecosystem," U.S. Environmental Protection Agency, Washington, DC, 1982.

"Estuaries and Tidal Marshes," U.S. Fish and Wildlife Service, Washington, DC, 1985.

ELODEA OBSERVATIONS

I predict that ____

____

	Observations			
Tube	Day 1	Day 2	Day 3	Day 4
Control 0 ppt				
#1 10 ppt				
#2 20 ppt				
#3 30 ppt				

Questions

1. Which of the four containers had the healthiest looking plants? ____

2. Describe in a paragraph what happened over four days to the other containers of Elodea. ____

3. Based on the experiment, how much salt can Elodea tolerate and still remain healthy? ____

4. What would this mean about where you would find Elodea in an estuary? ____

COASTAL CONSERVATION SCAVENGER HUNT

OBJECTIVES

The student will do the following:

Gather information from a variety of sources on coastal habitats and the importance of conserving coastal ecosystems.

SUBJECTS:
Science, Social Studies

TIME:
1 week project

MATERIALS:
student sheets (included)

BACKGROUND INFORMATION

This lesson outlines a scavenger hunt project in which students will employ interesting methods of obtaining information about conserving coastal ecosystems. The information could then be used in either written reports or oral reports to the class.

ADVANCE PREPARATION

A. Prepare to display the information gathered; provide space on walls or bulletin boards.

B. Students may also suggest additional projects that do not appear on the scavenger hunt list. In this case, teams should get your permission and have you assign a point value for their suggestions. (NOTE: You may modify this lesson's approach for younger students.)

C. It is helpful to post each team's point total goal and a project chart (such as filling a bar graph). This provides a running total and checks progress. (This is also a great motivator!)

D. Photocopy the student sheets, one copy of each for every student.

E. Enlist the help of your school librarian. The teams will need his/her help in library research.

PROCEDURE

I. Setting the stage

A. Explain to the students that they will be working in teams to accumulate as much information and performing as many activities as their team decides upon. All information/activities will contribute to their understanding of the need to protect coastal areas.

B. Prepare the teams for the scavenger hunt.

1. Divide the class into teams of four. Tell the teams they will have a week to gather information and create their products. (NOTE: You may adjust the time for your students.)

2. Hand out the student sheet, "Items to Collect and Create."

3. Give the teams 10 minutes to go over the list and plan the team strategy. Stress the importance of developing a team strategy. Suggest steps to the completion of the activity, such as assigning individual duties and deciding their point total goal.

II. Activity

A. Share with the students the following:

Pollution of our coasts and oceans is a serious problem. Our oceans are being used as giant garbage cans with humans putting in thousands of tons of garbage each year. There are many things people can do to help our oceans. Learning about the problem along our coasts and in our oceans is a good first step. This scavenger hunt will help you find out much about this complicated problem.

B. Share with the students the rules of the scavenger hunt:

1. Work is done in teams with each person helping equally.

2. You can go anywhere appropriate to get what you need. Cameras and tape recorders can be used. Notes on TV shows and hand-drawn maps and diagrams are acceptable.

3. Write down where you find all the information.

III. Follow-Up

After the scavenger hunt is complete, give each student a copy of the student sheet, "Evaluation Sheet for Scavenger Hunt." Allow 5 minutes for teams to discuss the questions, then 10 minutes for each student to complete the evaluation individually. (NOTE: An oral review is recommended.)

IV. Extensions

A. Have the students develop a list of actions to address some of the issues about which they have learned.

B. Have the students write letters to politicians or others in decision-making positions.

RESOURCES

A Citizen's Guide to Plastics in the Ocean, Center for Marine Conservation, Washington, DC, 1988.

McRae-Campbell, Linda, The Ocean Crisis, Zephyr Press, Tucson, Arizona, 1990.

ITEMS TO COLLECT AND CREATE

1. Collect two magazine articles that explain efforts to slow or stop development on the coastline. Have written summaries. (15 points)

2. Create a chart that lists reasons to keep coastal areas natural. (10 points)

3. Watch a TV show about the problem of ocean pollution. Create a chart or poster that shows what you learned. (10 points per program)

4. Make a chart that lists organizations that help fight ocean pollution. Include the names, addresses and phone numbers. (10 points)

5. Choose one of these problems. Write a poem or song that includes at least five facts about the problem. Mention in the song the need for finding ways to solve the problem. (20 points)

   A. overgrowth of algae

   B. contamination of shellfish

   C. destruction of food chains

   D. overfishing

   E. filling in coastal wetlands

6. Create a time line that shows the development of the U.S. coastline from 1950 to the present. (15 points)

7. Design a poster that informs others about ocean pollution. (15 points)

8. Make a list of five kinds of dangerous chemicals that are dumped into the ocean. Explain how the chemicals are used. (10 points)

9. Design a bumper sticker which shows the need for protecting the oceans. (10 points)

10. Design an art project which would show garbage washing up on our beaches. (10 points)

11. Read and summarize (3 paragraphs) an article on the effects of plastics in the ocean. (15 points)

12. Make a mosaic of pictures showing the effects of ocean pollution. (10 points)

13. Make an "Ocean Alphabet Book" that describes the problem. Find one coastal fact for each letter of the alphabet. (25 points)

14. Prepare and perform a skit for your class that includes at least 10 facts about ocean pollution. (15 points)

15. Create your own item for a scavenger hunt on ocean pollution. Get teacher approval and point value.

EVALUATION SHEET FOR SCAVENGER HUNT

Name ______________________________ Date ____________________

Team Members ____

____

1. What information did you discover that was most important? ____________________

____

____

2. What was the most interesting thing you discovered? Why? ____________________

____

____

3. `Which item or activity gave you the most useful information? Why? ____________________

____

____

4. What did you like best about this activity? ____________________

____

____

5. What would you change about this activity? ____________________

____

____

6. While I was working on the scavenger hunt, ______________________ helped me by . . .

____

____

7. If I were evaluating my scavenger hunt, I would say I have earned ____________________ because . . .

____

____

8. If I were evaluating my team's scavenger hunt work, I would say we have earned ____________________ because. . .

____

____

COASTAL FOOD WEB

OBJECTIVES

The student will do the following:

1. Identify members of the coastal food web.
2. Label food web members as plants or animals (herbivores, carnivores).
3. Construct coastal food chains and webs.

SUBJECTS:
Science

TIME:
90-120 minutes

MATERIALS:
student sheets (included)
index cards
masking tape (or pins)
marker
string or yarn
teacher sheet (included)

BACKGROUND INFORMATION

All life systems depend on green plants which use the energy of sunlight to produce sugars, fats, and proteins. They are the ultimate food sources for all life. Green plants produce food. Animals must obtain energy from either plants or other animals. Animals that eat plants are herbivores. Animals that eat other animals are carnivores. Even organisms that break down dead plants and animals get their food directly or indirectly from plants.

Plants and animals are linked by food relationships and form food chains. Food chains are linked together into food webs. Decomposers are members of the web because when animals and plants die their decomposed forms are broken down into essential nutrients that are used by green plants.

Terms

carnivore: a meat-eating organism.

food chain: animals and plants which have direct food relationships; energy passes through the food chain.

food web: interrelated food chains; shows direct and indirect food relationships.

herbivore: a plant-eating organism or first level consumer.

ADVANCE PREPARATION

A. Write the name of each organism on the student sheet "Coastal Food Web Questions" separately on index cards.

B. Photocopy the student sheets, one for each student.

C. Compile a small reference library so that the students can look up coastal plants and animals.

PROCEDURE

I. Setting the stage

Share the background information with the students.

II. Activities

A. Review food chains with the students. Have them suggest some simple food chains, and let volunteers role-play several food chains.

B. Give each student an index card with a coastal organism's name on it.

1. Have each student cut out a picture of the organism (from the "Coastal Organisms" student sheet) and glue it to the back of the index card.

2. Use masking tape or pins to attach each student's card to his/her clothing.

C. Have the students make coastal food chains.

1. Tell all the students with plant names to form a group.

2. Tell all the students with animal names to form a group.

3. Have the "animal" group divide itself into plant-eaters and meat-eaters. Tell the plant-eaters they are "herbivores." Tell the meat-eaters they are "carnivores."

4. Have the students link hands with other students to form food chains.

D. Have the students make a coastal food web.

1. Have all the students stand in a circle.

2. Hold up a ball of yarn or string and tell them that it will represent the links in a food web—many related food chains. Give the yarn to a student.

3. Have the student tell what organism's name and picture is on his/her card, then throw the yarn to a classmate. He/she must hold on to the end of the yarn.

4. The classmate will share the name and picture on his/her card and tell how the organism is related to the first one. (NOTE: You may have to help with this.) He/she will hold onto the yarn and throw the ball.

5. Repeat the process until all the students are holding onto the yarn and a large web has been created. This illustrates the interrelationships in the coastal ecosystem.

E. Have the students examine the student sheet "Coastal Food Pyramid." The pyramid illustrates the transfer of energy and other resources from food through food chains. Relate this to the activities above.

III. Follow-Up

A. Give each student a copy of the student sheet, "Coastal Food Web Questions." Have them answer the questions, then discuss the answers with them.

B. Give each student a copy of the student sheet, "Coastal Crossword." Have them complete the puzzle and let them check each other's papers.

IV. Extensions

A. Have students report on groups of these organisms and make sketches of lower members of the food web, especially planktonic organisms.

B. Have a seafood festival and invite a grocery store to donate seafood items for a tasting party.

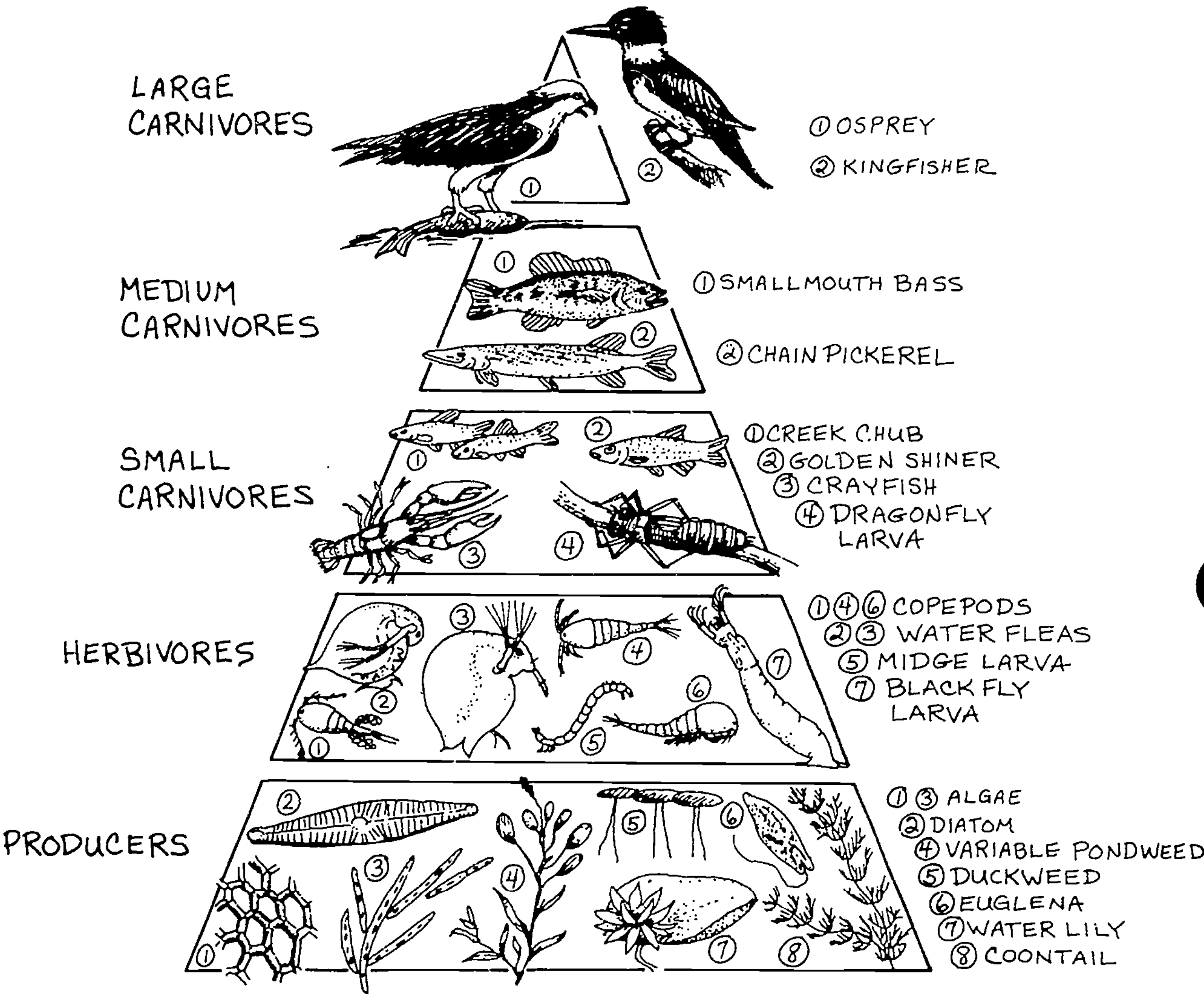
C. Give each student a copy of the student sheet, "Coastal Word Search," and have them find the hidden words. The answers are provided on the accompanying key. (NOTE: You might let the students look up definitions of unfamiliar terms for extra credit or enrichment.)

RESOURCES

"Estuaries and Tidal Marshes," U.S. Fish & Wildlife Service, Washington, DC, 1985.

Marine and Estuaries Ecology: Man and the Gulf of Mexico, Mississippi-Alabama Sea Grant Consortium, University Press of Mississippi, Oxford, Mississippi, 1984.

COASTAL FOOD PYRAMID



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COASTAL ORGANISMS

COASTAL FOOD WEB QUESTIONS

1. Do plants make their own food? YES NO

2. Do animals make their own food? YES NO

3. Each of the following lists has one organism that differs from the rest. Cross off the one in each list that does not belong. Then label the list "plants" or "animals."

____________	____________
bald cypress	algae
crabs	eel grass
oyster	mangrove tree
osprey	alligator

____________	____________
sea bass	beach grass
harbor seal	wild rice
poison ivy	sea oats
killer whale	muskrat

4. In these lists there are plants, herbivores, and carnivores. Cross off the organism that does not belong and label the list.

____________	____________
red fox	wild celery
bald eagle	palmetto
person	deer
palm tree	cattail

____________	____________
marsh hawk	grasshopper
pelican	rabbit
manatee	mouse
blue heron	turtle

5. Make up two food chains using some of the organisms above. Each food chain must begin with a plant and must have two animals. Write the words and draw arrows between them to make the food chains.

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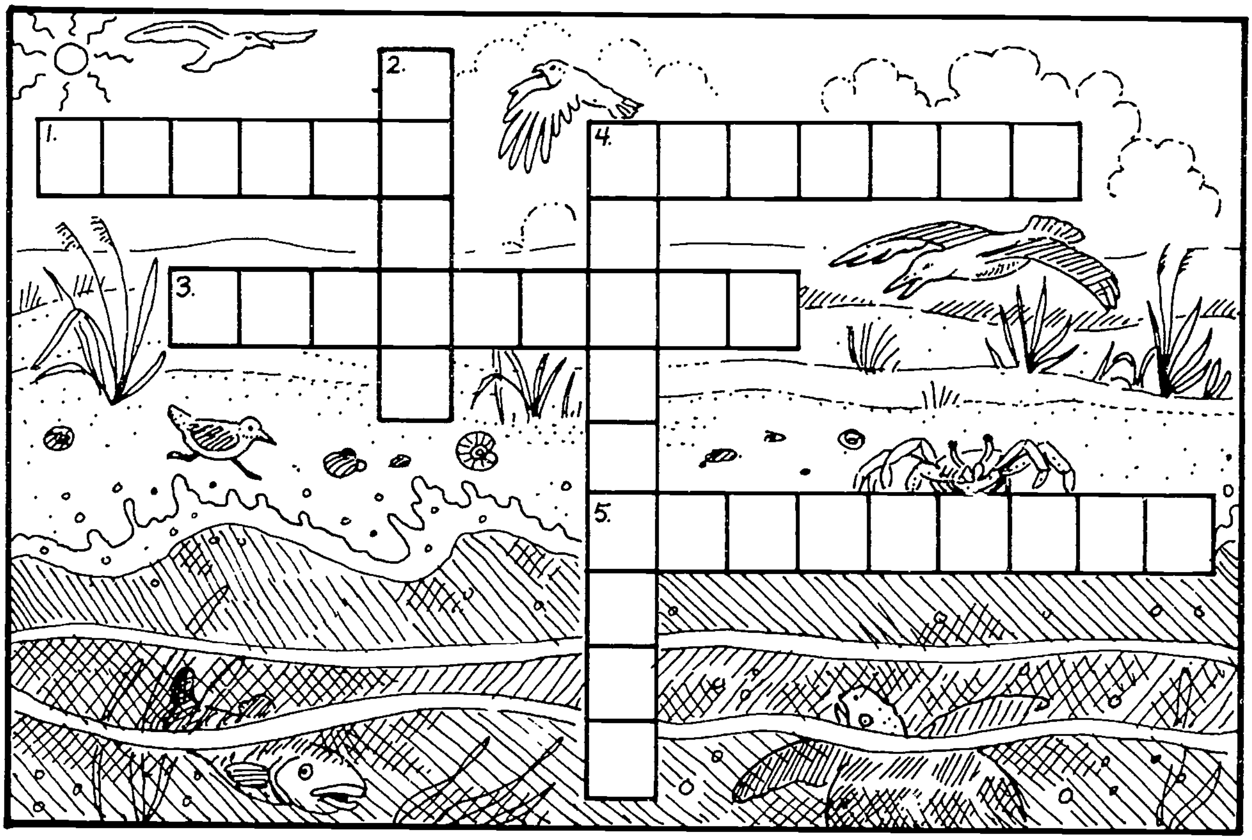
COASTAL CROSSWORD



ACROSS

1. If you can't make your own food, you must be an ________________.
3. The animal that eats meat.
4. A ________ _________ shows how food chains are related.
5. An animal that eats plants. ______________________________

DOWN

2. If you make your own food, you must be a ___________.
4. A ________ ________ shows what plant is food for what animal and so on.

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COASTAL WORD SEARCH

Can you find the following terms associated with food chains?

biotic	zooplankton	snakes	detritus
estuary	radiant	disease	salinity
water	tides	carnivores	herbivores
producers	benthic	decomposers	marsh
algae	striped bass	crabs	oyster borer
swans	mink	ducks	oyster
catfish	owls	geese	muskrat
food	clam	omnivores	copepods

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

COASTAL WORD SEARCH
ANSWER KEY

Can you find the following terms associated with food chains?

biotic	zooplankton	snakes	detritus
estuary	radiant	disease	salinity
water	tides	carnivores	herbivores
producers	benthic	decomposers	marsh
algae	striped bass	crabs	oyster borer
swans	mink	ducks	oyster
catfish	owls	geese	muskrat
food	clam	omnivores	copepods

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

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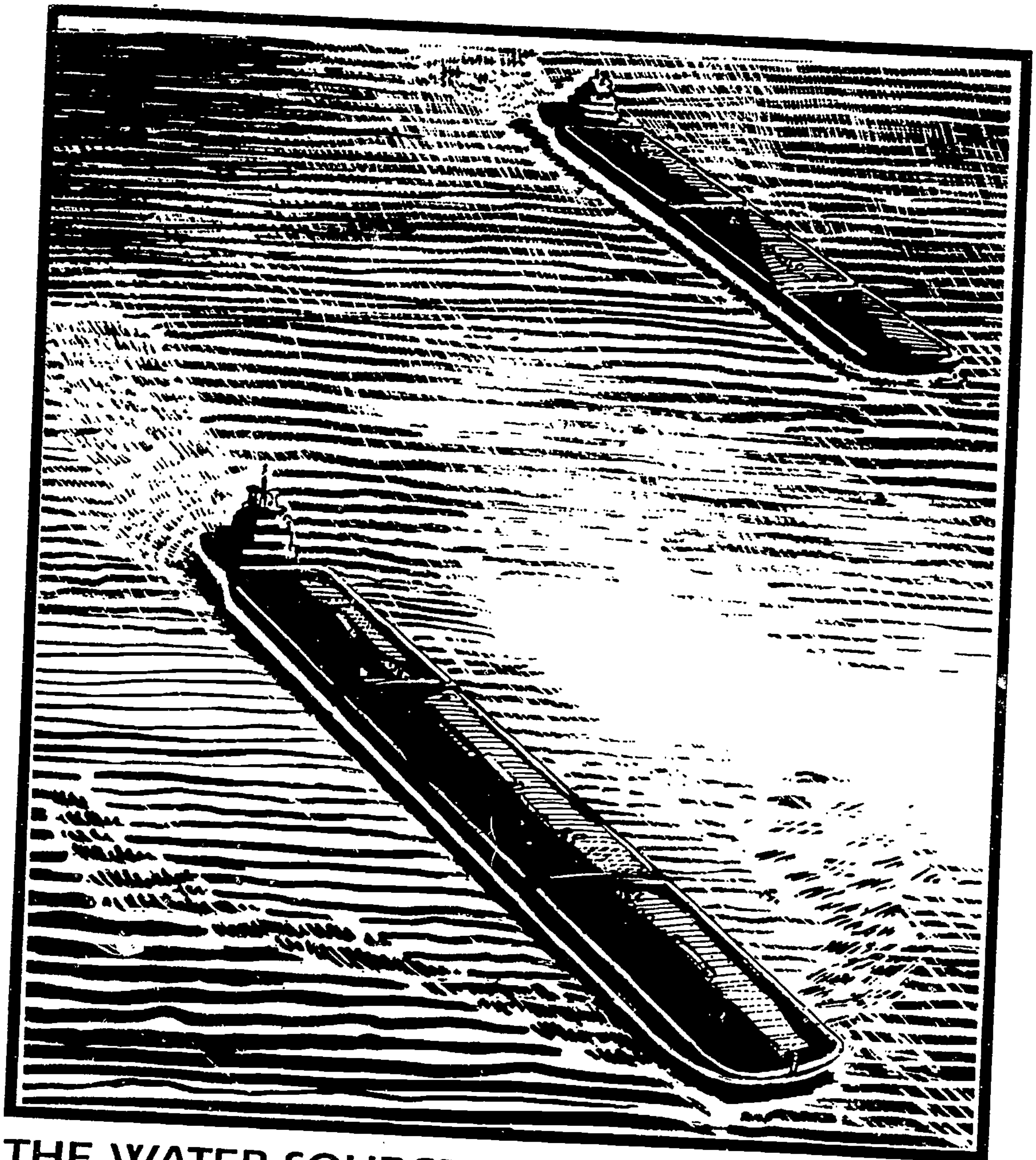

THE WATER SOURCEBOOK

GLOSSARY

GLOSSARY

abandoned well: any well (drinking water, oil and gas, etc.) which is not used for a long period of time, is not maintained properly, and/or is not properly sealed when its useful life is over.

acidity: the strength (concentration of hydrogen [H^+] ions) of an acidic substance; measured as pH.

acid rain (or acid precipitation): rain with a pH of less than 5.6; results from atmospheric moisture mixing with sulphur and nitrogen oxides emitted from burning fossil fuels; may cause damage to buildings, car finishes, crops, forests, and aquatic life.

The Act to Prevent Pollution From Ships: legislation regulating the discharge of oil, noxious liquid substances, or garbage generated during normal operations of vessels.

aeration: to expose to circulating air.

aerial photography: high altitude pictures taken from an aircraft or satellite.

aerobic: living or occurring in the presence of oxygen.

agriculture: the science, art, and business of cultivating the soil, producing crops, and raising livestock; farming.

algal bloom: a heavy growth of algae in and on a body of water; usually results from high nitrate and phosphate concentrations entering water bodies from farm fertilizers and detergents; phosphates also occur naturally under certain conditions.

alum: as used in drinking water treatment, aluminum sulfate; added to water in drinking water treatment facilities to cause dirt and other particles to clump together and fall to the bottom of settling basins.

amendments: revisions or changes (as to laws).

anaerobic bacteria: any bacteria that can survive in the complete or partial absence of air.

anthracite: the hardest grade of coal, having very high carbon content: may be used as a filter medium in drinking water treatment.

Army Corps of Engineers: Branch of the U.S. Army; responsible for maintaining and regulating inland waterways.

artesian well: a well in which the water comes from a confined aquifer and is under pressure. One type of artesian well is a flowing well where water just flows or bubbles out of ground without being pumped.

aquacade: an entertainment spectacle of swimmers and divers, often performing in unison to the accompaniment of music.

Aqua Lung: a trademark for a self-contained underwater breathing apparatus (scuba).

aquamarine: a transparent blue-green variety of beryl, used as a gemstone.

aquanaut: a person trained to live in underwater installations and conduct, assist in, or be a subject of scientific research.

aquaplane: a board on which one rides in a standing position while it is pulled over the water by a motorboat.

aquarelle: a drawing done in transparent water colors.

aquarist: one who maintains an aquarium.

aquarium: a tank, bowl, or other water-filled enclosure in which living aquatic animals and, often, plants are kept.

Aquarius: a constellation in the equatorial region of the Southern Hemisphere near Pisces and Aquila.

aquatic life: plants, animals, and microorganisms that spend all or part of their lives in water.

aqueduct: a conduit designed to transport water from a remote source, usually by gravity.

aquifer: an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water (a zone of saturation).

atmospheric transport: the movement of air pollutants from one region to another by wind; may be hundreds of miles.

bacterial water pollution: the introduction of unwanted bacteria into a water body.

bay: a large estuarine system (e.g., Chesapeake Bay).

biocontrol agent: an organism used to control pests (e.g., lady bugs used to control aphids in a garden).

biodegradable: capable of being decomposed (broken down) by natural biological processes.

biosolids: solid materials resulting from wastewater treatment that meet government criteria for beneficial use, such as for fertilizer.

blackwater: domestic wastewater containing human wastes.

blue baby syndrome: a pathological condition, called methemoglobinemia, in which blood's capacity for oxygen transport is reduced, resulting in bluish skin discoloration in infants; ingestion of water contaminated with nitrates or certain other substances is a cause.

bog: a poorly drained freshwater wetland that is characterized by a build-up of peat.

bottom lands: low-lying land along a waterway.

catch basin: a sedimentation area designed to remove pollutants from runoff before being discharged into a stream or pond.

centrifugal force: the force that causes something to move outward from the center of rotation.

cesspool: a covered hole or pit for receiving untreated sewage.

chemical: related to the science of chemistry; a substance characterized by a definite chemical molecular composition.

chemical pollution: introduction of chemical contaminants into a water body.

chlorination: water disinfection by chlorine gas or hypochlorite.

chlorine: a chemical element, symbol Cl, atomic number 17, atomic weight 35.453; used as a disinfectant in drinking and wastewater treatment processes.

cholera: an acute, often fatal, infectious epidemic disease caused by the microorganism *Vibrio comma*, that is characterized by watery diarrhea, vomiting, cramps, suppression of urine, and collapse.

Clean Water Act: water pollution control laws based upon the Federal Water Pollution Control Act of 1972 with amendments passed in 1977, 1981, and 1987; main objective is to restore and maintain the "chemical, physical, and biological integrity of the Nation's waters."

coliforms: bacteria found in the intestines of warm-blooded animals; used as indicators of fecal contamination in water.

communities: related groups of plants and animals living in specific regions under relatively similar conditions.

compost: an aerobic mixture of decaying organic matter, such as leaves and manure, used as fertilizer.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund): legislation passed in 1980 and amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA); provides for short-term actions called removal actions in response to accidents and improper handling of hazardous materials which pose an immediate threat to human health and safety. It also provides for long-term actions called remedial actions for cleanups of other sites which pose no immediate threat to public safety.

cone of depression: the cone-shaped area formed when the spaces in the rock or soil are emptied as water is withdrawn from a well.

confined aquifer (artesian aquifer): an aquifer with a dense layer of compacted earth material over it that blocks easy passage of water.

conservation farming: the management of farm activities and structures to eliminate or reduce adverse environmental effects of pollutants and conserve soil, water, plant, and animal resources.

constructed wetlands: wetlands that are designed and built similar to natural wetlands; some are used to treat wastewater. Constructed wetlands for wastewater treatment consist of one or more shallow depressions or cells built into the ground with level bottoms so that the flow of water can be controlled within the cells and from cell to cell. Roots and stems of the wetland plants form a dense mat where biological and physical processes occur to treat the wastewater. Constructed wetlands are being used to treat domestic, agricultural, industrial, and mining wastewaters.

contaminate: to make impure (not pure) by contact or mixture; to introduce a substance into the air, water, or soil that reduces its usefulness to humans and other organisms in nature.

contaminant: an impurity, that causes air, soil, or water to be harmful to human health or the environment.

cooling towers: a towerlike device in which atmospheric air circulates and cools warm water, generally by direct contact (evaporation).

corrosivity: ability to dissolve or break down certain substances, particularly metals.

"cradle to grave": phrase used to describe regulations that are part of the Resources Conservation and Recovery Act (RCRA), which requires that hazardous wastes be tracked from their points of origin to their proper disposal; these regulations are designed to protect groundwater, as well as other resources, from contamination by improper treatment, storage, and disposal of solid wastes and are aimed at ending irresponsible "midnight dumping."

cumulative: increasing or enlarging by successive addition; acquired by or resulting from accumulation.

debris: dead organic material (leaves, twigs, etc.) and sediment.

decompose: to decay or rot; a result of microbial action.

de-foaming agents: chemicals that are added to wastewater discharges to prevent the water from foaming when it is discharged into a receiving water body.

degradable: capable of decomposition; chemical or biological.

depression storage: the storage of water in low areas such as puddles, bogs, ponds, and wetlands.

desalination: the purification of salt or brackish water by removing the dissolved salts.

detergent: a synthetic cleansing agent resembling soap; has the ability to emulsify oil and remove dirt; contains surfactants that do not precipitate in hard water.

digestion: decomposition of organic waste materials by the action of microbes; the process of sewage treatment by the decomposition of organic matter.

discharged: released into a water body.

disinfect (disinfected): to cleanse of harmful microorganisms.

dissolved oxygen (DO): oxygen gas (O_2) dissolved in water.

dissolved solids: materials that enter a water body in a solid phase and dissolve in water.

distribution box: a place where one pipe or line enters and exits through several pipes or lines; they are used in municipal drinking water systems to distribute water to homes, in municipal wastewater systems to retrieve wastewater, and by electric companies to distribute power.

divining rod: a forked branch or stick used in an attempt to locate subterranean water or minerals; it is said to bend downward when held over a source.

downstream: in the direction of a stream's current.

dowsing: to use a divining rod in an attempt to find underground water or minerals.

drainage basin: an area drained by a main river and its tributaries.

drainage system: a network formed by a main river and its tributaries.

drainfield: the part of a septic system where the wastewater is released into the soil for absorption and filtration.

dredging: the cleaning, deepening, or widening of a waterway using a machine (dredge) that removes materials using a scoop or suction device.

duck stamp: required, for a fee, of all duck hunters over age 16 by the U.S. Fish a.d Wildlif Service; a conservation program aimed at preserving wetlands.

ecosystem: an ecological community together with its physical environment, considered as a unit.

effluent: waste material, such as water from sewage treatment or manufacturing plants, discharged into the environment.

electroplating: to coat or cover with a thin layer of metal using electricity.

elements: substances such as iron, sodium, carbon, nitrogen, and oxygen with distinctly different atoms which serve as some of the 108 basic uilding blocks of all matter.

The Emergency Planning and Community Right-to-Know Act of 1986 (SARA Title III): law requiring federal, state and local governments and industry which are involved in either emergency planning and/or reporting of hazardous chemicals to allow public access to information about the presence of hazardous chemicals in the community and releases of such substances into the environment.

emission: a substance discharged into the environment.

endangered animal species: a species of animal identified by official federal and/or state agencies as being faced with the danger of extinction.

environme- the sum of all external conditions and influences affecting the development and life of organisms.

Environmental Protection Agency (EPA): the U.S. agency responsible for efforts to control air and water pollution, radiation and pesticide hazards, ecological research, and solid waste disposal.

epidemic diseases: diseases that spread rapidly and extensively by infection among many individuals in an area.

erosion: the wearing away of the earth's surface by running water, wind, ice, or other geological agents; processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is removed from the earth's surface.

estuarine intertidal emergents: herbaceous vegetation that grows in saltwater marshes.

estuarine intertidal forested/shrub: a saltwater wetland containing larger woody plants.

estuarine intertidal unconsolidated shores: beaches and sand bars.

estuarine subtidal: a habitat of open water and bay bottoms continuously covered by salt water.

estuarine unconsolidated bottom habitats: sandy bottom area in open water estuaries.

estuary: the area where a river empties into an ocean; a bay, influenced by the ocean tides, resulting in a mixture of salt water and fresh water.

eutrophic: pertaining to a lake containing a high concentration of dissolved nutrients; often shallow, with periods of oxygen deficiency.

eutrophication: a naturally occurring change that take place after a water body receives inputs of nutrients, mostly nitrates and phosphates, from erosion and runoff of surrounding lands; this process can be accelerated by human activities.

evaporate: to convert or change into a vapor with the application of heat.

evapotranspiration: combination of evaporation and transpiration of water into the atmosphere from living plants and soil.

Federal Water Pollution Control Act (Clean Water Act): the law to restore and maintain the "chemical, physical, and biological integrity of the Nation's waters."

feedlots: confined areas where livestock are quartered and fed, often these are holding areas where animals are fattened-up prior to being shipped to market.

fertilizer: any one of a large number of natural and synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread or worked into the soil to increase its fertility.

fill: material added to a wetland area to make it suitable for building.

filtration: the process of passing a liquid or gas through a porous article or mass (paper, membrane, sand, etc.) to separate out matter in suspension.

fish kill: the sudden death of fish due to the introduction of pollutants or the reduction of the dissolved oxygen concentration in a water body.

flood conveyance: the transport of floodwaters downstream with minimal, if any, damage.

fluoride: a binary compound of fluorine with another element; added to drinking water to help prevent tooth decay.

food chain: a succession of organisms in a community that constitute a feeding order in which food energy is transferred from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member.

fossil fuel: a hydrocarbon fuel, such as petroleum, derived from living matter of a previous geologic time.

fresh water: water containing an insignificant amount of salts, such as in inland rivers and lakes.

gaining streams: streams that appear from the ground or cracks in rocks because they are flowing directly out of an aquifer.

grade: the slope of the surface of the earth.

green zones: areas along river- and streambanks, wetlands, lakes, and ponds where there is high productivity and diversity.

greywater: domestic wastewater that does not contain human wastes such as tub, shower, or washing machine water.

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

hardness: the amount of calcium carbonate dissolved in water.

hazardous chemicals: chemical compounds that are dangerous to human health and/or the environment.

heavy metals: metallic elements (e.g. cadmium, chromium, copper, lead, mercury, nickel, and zinc) which are used to manufacture products; they are present in some industrial, municipal, and urban runoff.

herbaceous: describes animals that are strictly plant-eating.

holding pond: an animal waste treatment method which uses a shallow pond to temporarily store animal wastes for land application.

holding tanks: a container where wastewater is stored before it is removed for treatment; confined livestock operations have holding tanks to store animal wastes for land application at a later time.

hydroelectric: that generation of electricity which conveys the energy of running water into electric power.

hydrogen sulfide gas (H_2S): a flammable, toxic, colorless gas with an offensive odor (similar to rotten eggs).

induced recharge: replenishing a water body or aquifer by transporting water from somewhere else and putting it into the water body or aquifer.

industrial pollution: pollution caused by industry.

infiltration: the gradual downward flow of water from the surface of the earth into the soil.

injection wells: a well in which fluids (such as wastewater, saltwater, natural gas, or used chemicals) are injected deep in the ground for the purpose of disposal or to force adjacent fluids like oil into the vicinity of oil producing wells.

inorganic nitrogen: nitrogen not derived from organic matter.

inorganic phosphorus: phosphorus not derived from organic matter.

irrigation: to supply (dry land) with water by means of ditches, pipes, or streams.

karst: a topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.

lacustrine: refers to lake or river habitats.

lagoon: as a wastewater treatment method, an animal waste treatment method which uses a deep pond to treat manure and other runoff from a livestock operation, may be aerobic or anaerobic (both use bacteria to break down wastes).

landfill: a large, outdoor area for waste disposal; landfills where waste is exposed to the atmosphere (open dumps) are now illegal; in "sanitary" landfills, waste is layered and covered with soil.

land use: how a certain area of land is utilized (e.g., forestry, agriculture, urban, industry).

leachate: the liquid formed when water (from precipitation) soaks into and through a landfill, picking up a variety of suspended and dissolved materials from the waste.

leaking underground storage tank (LUST): an underground container used to store gasoline, diesel fuel, home heating oil, or other chemicals that is damaged in some way and is leaking its contents into the ground; may contaminate groundwater.

legislation: a proposed or enacted law or group of laws.

limiting factor: a factor whose absence exerts influence upon a population and may be responsible for no growth, limited growth (decline), or rapid growth.

liner: a clay or plastic material placed between garbage and soil in a landfill to prevent rotting garbage from coming in contact with groundwater.

losing streams: streams which seem to disappear because they flow into an aquifer.

marine intertidal: a coastal saltwater wetland flooded by tidewaters.

The Marine Protection, Research, and Sanctuaries Act of 1972 (Ocean Dumping Act): legislation regulating the dumping of any material in the ocean that may adversely affect human health, marine environments, or the economic potential of the ocean.

marsh: an area of low-lying wetland.

maximum contaminant levels: the highest content levels of certain substances allowable by law for a water source to be considered safe.

membrane: a soft pliable sheet or layer, often of plant or animal origin.

mercury: a poisonous metallic element, Hg, atomic number 80, atomic weight 200.59, existing at room temperature as a silvery, dense liquid.

Mesopotamians: people from the ancient country of Mesopotamia located in southwest Asia between the Tigris and Euphrates rivers.

microbial digestion: breakdown and use of a substance by microorganisms.

microbiology: the science and study of microorganisms, including protozoans, algae, fungi, bacteria, and viruses.

microorganisms: organisms too small to be seen with the unaided eye, including bacteria, protozoans, yeasts, viruses, and algae.

midnight dumping: a term used for illegal disposal of hazardous wastes in remote locations often at night, hence the term "midnight."

mill tailings: rock and other materials removed when minerals are mined; usually dumped onto the ground or deposited into ponds.

miscible: capable of being mixed.

monitoring: scrutinizing and checking systematically with a view to collecting data.

mulch: a protective covering of various substances, especially organic; placed around plants to prevent evaporation of moisture and freezing of roots and to control weeds.

municipality: a political unit, such as a city or town, incorporated for local self-government.

municipal sewage: sewage originating from urban areas (not industrial).

National Environmental Policy Act of 1969 (NEPA): law that requires environmental impact statements be submitted for any major construction projects that uses U.S. federal money.

National Pollutant Discharge Elimination System (NPDES): part of the Clean Water Act requiring municipal and industrial wastewater treatment facilities to obtain permits which specify the types and amounts of pollutants that may be discharged into water bodies.

national water quality standards: maximum contaminant levels for a variety of chemicals, metals, and bacteria set by the Safe Drinking Water Act.

nitrates: used generically for materials containing this ion group made of nitrogen and oxygen (NO_3^-); sources include animal wastes and some fertilizers; can seep into groundwater; linked to human health problems, including "blue baby" syndrome (methemoglobinemia).

nitric acid (HNO_3): a component of acid rain; corrosive; damages buildings, vehicle surfaces, crops, forests, and aquatic life.

nonbiodegradable: not biodegradable.

non-compliance: not obeying all the federal and state regulations that apply.

non-permeable surfaces: surfaces which will not allow water to penetrate, such as sidewalks and parking lots.

nonpoint source pollution (NPS): pollution that cannot be traced to a single point, because it comes from many individual places or a widespread area (e.g., urban and agricultural runoff).

nutrient: an element or compound, such as nitrogen, phosphorus, and potassium, that is necessary for plant growth.

The Oil Pollution Act: legislation that imposes substantial penalties and liability for oil spills in the ocean; violators are r sponsible for the cost of the cleanup and restoration of natural resources.

organism: any living being; plants and animals.

oxygen depletion: the reduction of the dissolved oxygen level in a water body.

package plants: a small, semi-portable prefabricated wastewater treatment system that services an apartment complex, trailer park, camp, or self-contained business that is not connected to a city sewer system and is not on a site appropriate for a septic system.

palustrine aquatic beds: inland areas which contain floating or submerged aquatic vegetation.

palustrine emergents: plants growing in inland marshes and wet meadows.

palustrine forested: inland areas such as forested swamps or bogs.

palustrine shrub: inland wetland area with shrub growth.

palustrine unconsolidated bottom: muddy bottom of open water ponds.

percolate: to drain or seep through a porous substance.

permeability: the property of a membrane or other material that permits a substance to pass through it.

pesticide: any chemical or biological agent that kills plant or animal pests; herbicides, insecticides, fungicides, rodenticides, etc., are all pesticides.

petroleum products: products derived from petroleum or natural gas.

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

phosphate: used generically for materials containing a phosphate group (PO_4^{3-}); sources include some fertilizers and detergents; when wastewater containing phosphates is discharged into surface waters, these chemicals act as nutrient pollutants (causing overgrowth of aquatic plants).

plankton: minute animal and plant life in a body of water.

point source pollution: pollution that can be traced to a single point source, such as a pipe or culvert (e.g., industrial and wastewater treatment plant discharges).

pollutant: an impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms.

pollution: contaminants in the air, water, or soil that cause harm to human health or the environment.

porosity: the property of being porous, having pores; the ratio of minute channels or open spaces (pores) to the volume of solid matter.

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

primary treatment: the first process in wastewater treatment which removes settled or floating solids.

pristine: describes a landscape and/or a water body remaining in a pure state.

privy: an outhouse; a latrine.

quadrillion: the cardinal number represented by 1 followed by 15 zeros.

radioactive: having the property of releasing radiation.

radioactive pollution: the introduction of a radioactive material.

radon: a colorless, radioactive, inert gaseous element (atomic number 86) formed by the radioactive decay of radium; exposure to high levels causes cancer.

recharge: replenish a water body or an aquifer with water.

recharge areas: an area where water flows into the earth to resupply a water body or an aquifer.

reclaim: to return to original condition.

red tide: a reddish discoloration of coastal surface waters due to concentrations of certain toxin-producing algae.

reforestation: replanting trees and establishing a forest after forest harvesting or destruction.

regulation: a governmental order having the force of law.

reservoir: a body of water collected and stored in a natural or artificial lake.

Resource Conservation and Recovery Act (RCRA): legislation passed in 1976 aimed at protecting the environment, including waterways, from solid waste contamination either directly, through spills, or indirectly, through groundwater contamination.

restoration: reestablishing the character of an area such as a wetland or forest; cleaning up a contaminated area according to specifications established by the U.S. Environmental Protection Agency.

reverse osmosis: a process where water is cleaned by forcing water through an ultra-fine semi-permeable membrane which allows only the water to pass though and retains the contaminants; these filters are sometimes used in tertiary treatment and to pretreat water in chemical laboratories.

ridge planting: a conservation farming method where seeds are planted in ridges which allows warmer soil temperatures and traps rainwater in the furrows between the ridges.

riparian area: the area along a waterway.

river: a large natural stream emptying into an ocean, lake, or other water body.

riprap: large rocks placed along the bank of a waterway to prevent erosion.

riverine habitats: tidal and non-tidal river systems that feed into wetlands.

The Rivers and Harbors Act of 1899: legislation regulating the discharge of refuse of any kind into navigable waters.

rough (scavenger) fish: non-sport species of fish that tolerate polluted water.

runoff: water (originating as precipitation) that flows across surfaces rather than soaking in; eventually enters a water body; may pick up and carry a variety of pollutants.

Safe Drinking Water Act: a regulatory program passed by the U.S. Congress in 1974 to help ensure safe drinking water in the United States; sets maximum contaminant levels for a variety of chemicals, metals, and bacteria in public water supplies.

saline intrusion: the salt water infiltration of freshwater aquifers in coastal areas, when groundwater is withdrawn faster than it is being recharged.

salt water: water associated with the seas distinguished by high salinity.

saturated zone: underground layer in which every available space is filled with water.

secondary treatment: the wastewater process where bacteria are used to digest organic matter in the wastewater.

sediment: insoluble material suspended in water that consists mainly of particles derived from rocks, soil, and organic materials; a major nonpoint source pollutant to which other pollutants may attach.

sediment pollution: the introduction of sediment into a water body.

sediment pond: a natural or artificial pond for recovering the solids from effluent or runoff.

septic system: a domestic wastewater treatment system (consisting of a septic tank and a soil absorption system) into which wastes are piped directly from the home; bacteria decompose the waste, sludge settles to the bottom of the tank, and the treated effluent flows out into the ground through drainage pipes.

settling tank: a vessel in which solids settle out of water by gravity during drinking and wastewater treatment processes.

sewage contamination: the introduction of untreated sewage into a water body.

sewer system: an underground system of pipes used to carry off sewage and surface water runoff.

silage: livestock food prepared by storing and fermenting green forage plants in a silo.

sinkhole: a natural depression in a land surface connected to a subterranean passage, generally occurring in limestone regions and formed by solution or by collapse of a cavern roof.

slough: a stagnant swamp, marsh, bog, or pond, esp. as a part of a bayou, inlet, or backwater.

sludge: solid matter that settles to the bottom of septic tanks or wastewater treatment plant sedimentation; must be disposed of by bacterial digestion or other methods or pumped out for land disposal or incineration.

solar radiation: radiation emitted by the sun.

solvent: a liquid capable of dissolving another substance (e.g., paint thinner, mineral spirits, and water).

stormwater runoff: surface water runoff that flows into storm sewers.

stream use classification: a system for classifying streams according to the intended use of the water (e.g., recreation, industrial cooling, irrigation).

strip mine: an open mineral mine (e.g., coal, copper, zinc, etc.) where the topsoil and overburden is removed to expose and extract the mineral.

substance: a material of a particular kind or constitution.

suffocate: to die due to the lack of oxygen.

sulfuric acid: the acid (H_2SO_4) formed when sulfur oxides combine with atmospheric moisture; a major component of acid rain.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

swamp: land having soils saturated with water for at least part of the year and supporting natural vegetation of mostly trees and shrubs.

temperate climates: climates that are neither hot nor cold; mild.

terrain: the characteristic features of a tract of land's surface; topography.

thermal pollution: the increase in temperature of a body of water due to the discharge of water used as a coolant in industrial processes or power production; can cause serious damage to aquatic life.

toilet dam: a device that is placed inside the tank portion of a toilet to reduce the amount of water the tank will hold by partitioning off part of the tank.

toxic: having the characteristic of causing death or damage to humans, animals, or plants; poisonous.

toxic chemical: a chemical with the potential of causing death or damage to humans, animals, or plants; poison.

toxin: any of various poisonous substances produced by certain plant and animal cells, including bacterial toxins, phytotoxins, and zootoxins.

transpiration: direct transfer of water from the leaves of living plants or the skins of animals into the atmosphere.

treatment plant: facility for cleaning and treating fresh water for drinking, or cleaning and treating wastewater before discharging into a water body.

turbidity: the cloudy or muddy appearance of a naturally clear liquid caused by the suspension of particulate matter.

turbine: a device in which a bladed wheel is turned by the force of moving water or steam; connected by a shaft to a generator to produce electricity.

typhoid (fever): an acute, highly infectious disease caused by the typhoid bacillus, *Salmonella typhosa*, transmitted by contaminated food or water and characterized by bad rashes, high fever, bronchitis, and intestinal hemorrhaging.

ultraviolet light: light waves having energy greater than visible light and less than x-rays; a component of sunlight not visible to the human eye.

unconfined aquifer: an aquifer without a confining layer above it; the top surface of water in an unconfined aquifer is the water table.

underground storage tanks: large tanks buried underground for storing liquids (e.g., gasoline, heating oil); potential source of groundwater contamination if the tanks leak.

unsaturated zone: an area underground between the ground surface and the water table where the pore spaces are not filled with water, also know as the zone of aeration.

upstream: toward the source of a stream or current.

wastewater: water that has been used for domestic or industrial purposes.

wastewater treatment: physical, chemical, and biological processes used to remove pollutants from wastewater before discharging it into a water body.

waterborne disease: a disease spread by contaminated water.

water conservation: practices which reduce water use.

water quality criteria: the degree of water quality needed to support a designated use for a body of water.

watershed: land area from which water drains to a particular water body.

well: a deep hole or shaft dug or drilled in the ground to obtain water, oil, gas, or brine.

wellhead: the area of land surrounding drinking water wells which contributes water to the aquifer supplying the well.

wellhead contamination: the addition of substances to the area of land surrounding a water well which reduces the well's water quality and prevents its use unless the water is treated.

wellhead protection area: the surface and subsurface areas surrounding a water well or well field supplying a water system.

wetlands: areas that, at least periodically, have waterlogged soils or are covered with a relatively shallow layer of water.

xeriscaping: landscaping technique designed to minimize the need for watering.

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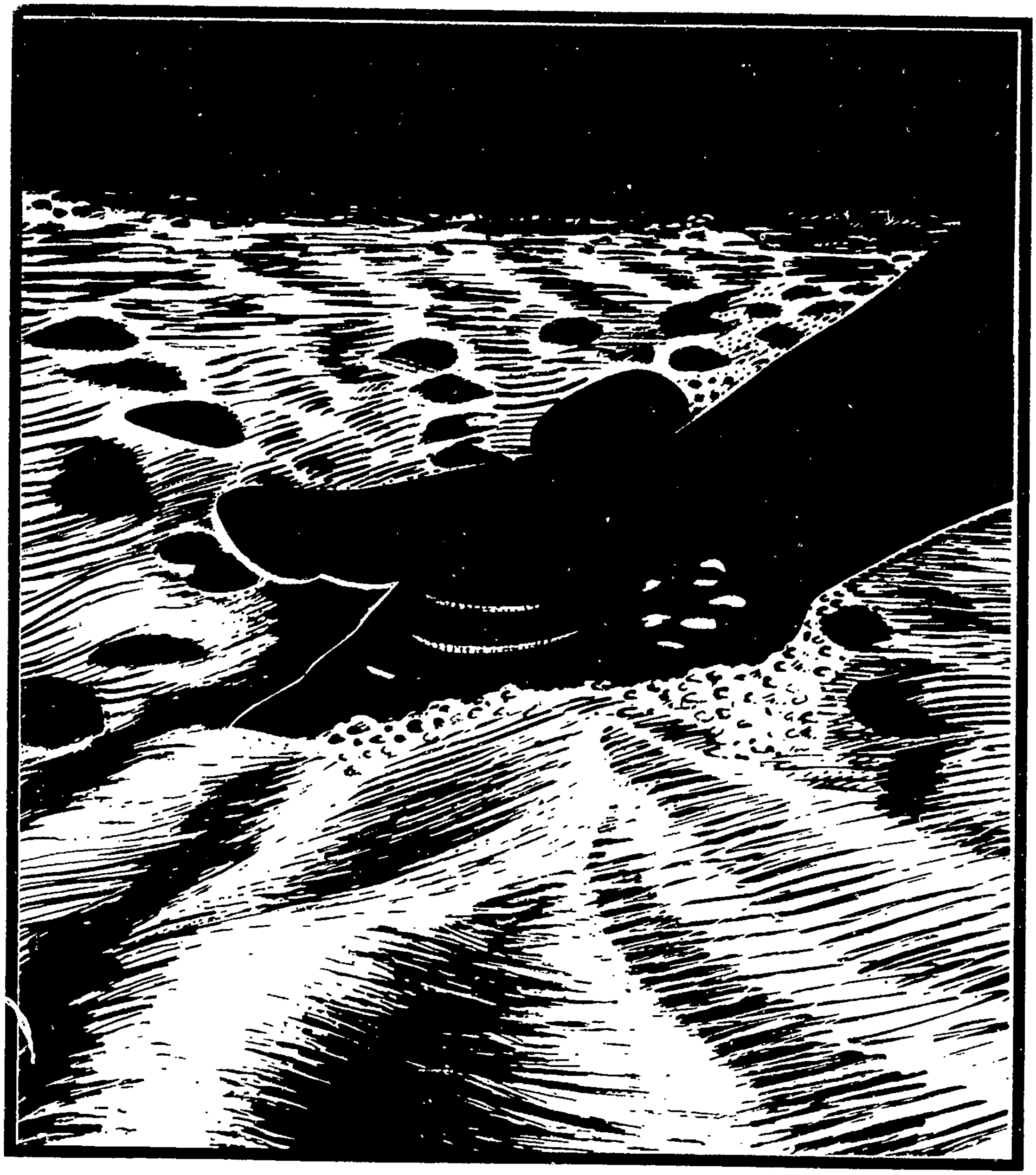

THE WATER SOURCEBOOK

FACTSHEETS

THE WATER CYCLE

Water is perhaps the ultimate example of recycling. Water constantly renews its purity by cycling itself from a liquid (or a solid) into vapor and back again. The change to a vapor removes most impurities and allows water to return to Earth in its clean form.

The study of water, or **hydrology**, starts with the **water cycle**, or the process by which water renews itself. Since the cycle is continuous, it doesn't really have a beginning, but a convenient place to start studying it is with **precipitation** (rain, snow, sleet and hail). When precipitation falls to earth, several things can happen. It can be absorbed into the soil. This is called **infiltration**. This process allows water to seep into the earth and be stored underground as **groundwater**. Precipitation can also become **runoff**, flowing into rivers and streams. Water can **evaporate**, or it can be returned to the atmosphere by **transpiration** through plants. Since it is often difficult to separate these two processes, they are often lumped together and called **evapotranspiration**.

Precipitation can also be **stored**. An ice cap is a form of storage. In temperate climates, water is found in depression storage or surface water—puddles, ditches, and anywhere else that runoff water can gather. This is a temporary form of storage. Water will evaporate from the surface and will infiltrate into the ground below it. It will be absorbed by plants and transpired back into the air. It will flow to other areas. This "cycling" of water is continuous.

A number of factors such as soil type, slope, moisture conditions, and intensity of storm event affect how water travels through this cycle. For example, when rain falls, some of it will infiltrate into the ground, but this rate of infiltration may be fast or slow. If the soil is already wet and saturated, much of the rain will become runoff. If the soil has low moisture content, a large percentage of it may be absorbed. The type of soil will also impact the rate of infiltration. Clay or packed soil allows little water to seep in. Sandy or loose soils allow more infiltration.

The rate of rainfall is a factor to consider. If rain is hitting the ground faster than it can infiltrate, it becomes runoff. The grade or slope can also influence runoff. Water infiltrates very little on steep grades. Man-made structures can reduce infiltration even farther. Virtually no water infiltrates through paved roads and parking lots, so almost all of it becomes runoff. This affects the entire water cycle.

WATERSHEDS

Watersheds have a big impact on the water cycle. A watershed, also called a drainage basin, is the area in which all water, sediments, and dissolved materials drain from the land into a common body of water, such as a river, lake or ocean. A watershed encompasses not only the water but the surrounding land from which the water drains. This can be an area as large as the Mississippi River drainage basin or as small as a backyard.

A watershed may be either a large or small area, and its characteristics can greatly affect how water flows through the watershed. For example, the flow in a particular stream may fluctuate dramatically with rainfall because of the characteristics of the watershed. Heavy storms may cause streams to rise rapidly. Human-made features of the watershed like dams or large paved areas can change stream flow and alter the watershed. If the topography is steep, changes in stream flow due to runoff can be significant.

In some watersheds, stream flow may take a long time to respond to rainfall runoff. On heavily vegetated, relatively flat terrain, infiltration is great, or runoff is slowed by vegetation. Eventually, however, runoff will make its way through the watershed and become stream flow. In these areas, stream flow will rise slowly, but also recede slowly.

The stream flow characteristics of a watershed can be a key to evaluating the quality of the water in the watershed. Streams start out in higher elevations, and flow downward, eventually finding their way to the sea. But they don't travel in straight lines. Their paths vary. The terrain may be steep in some areas, causing rapid flow, and flat in other areas, allowing the water to get deeper and spread out. These grade changes create different habitats in the stream which support different forms of life and change the quality of water in the watershed.

Water quality is critically impacted from everything that goes on within the watershed. Mining, forestry, agriculture, and construction practices, urban runoff from streets, parking lots, chemically treated lawns, and gardens, and failing septic systems, and improperly treated municipal sewage discharges all affect water quality. Reducing pollution and protecting water quality requires identifying, regulating, monitoring, and controlling potential pollutants. Some examples of control practices include protecting streambanks and shorelines by maintaining vegetated buffer strips, treating all wastes to remove harmful pollutants, or using grass-lined catchment basins in urban areas to trap sediment and pollutants.

THE COMMUNITY WATER ENVIRONMENT

Community water environments, have their own water "cycle within a cycle" based on the factors within the community that affect water uses and flow.

Rainfall, soil composition, terrain, large surface bodies of water, man-made structures, pollution sources, surface water, weather patterns, and other factors can all have an impact on the "community" water environment. For example, a desert community may have a water environment with very little rainfall, while a marine coastal climate like the Northwest will see months of rain. An urban community will have its water environment affected by fast runoff due to paved areas, high water consumption due to large populations, water contaminants from industrial operations, urban runoff, domestic sewage, and construction. A rural area may have its water environment affected by lakes and streams that put large amounts of water into the air through evaporation or forests that contribute water vapor through evapotranspiration. Agriculture can use large amounts of water for irrigation and to water livestock or potentially pollute the rural water environment with fertilizers and pesticides if improperly applied or animal wastes if improperly managed.

In most urban communities, water is withdrawn from either a surface water body like a lake, reservoir, or stream or from a underground aquifer. This water is usually treated at a drinking water treatment plant and distributed to individual homes, businesses, and industries through a vast network of underground pipes. Water is then used by citizens, businesses, and industries and the used water either flows into a drain and travels to a wastewater treatment plant though a network of sewer pipes or is deposited onto the ground. For example, water used to wash the car or water the lawn may either soak into the ground or flow over the earth and run into nearby water body or a network of storm drains which flow into a nearby water body. Some storm drains are connected to wastewater treatment plants. At the wastewater treatment plant, most pollutants are removed and the treated water is released into a nearby surface water body and the cycle begins again.

In rural areas, water is usually withdrawn directly from the ground through a well and piped into the house and other buildings via a network of pipes. Used water is either deposited onto the ground where is soaks in or runs off or it flows through pipes into a septic tank. Wastewater in the septic tank undergoes treatment and flows from the tank into a series of pipes called a drainfield where it percolates into the soil.

In both urban and rural communities the primary source of water is from precipitation which is either stored as surface water or groundwater. In special cases, some communities store water in water towers.

WATER QUALITY

Every time water completes its cycle from vapor to liquid or solid and back to vapor again, its quality is renewed. However, water quality can be damaged by any number of pollutants in the air, on land, or from other water supplies. The amount of water available for use depends on its quality, and the availability of water dictates where we can live, build cities, and create industry.

On the average, every American uses about 150 gallons of water a day. That makes daily water consumption in the United States alone over 372 **billion** gallons per day. It's no wonder that in some highly populated areas, water supplies are getting tight. Some areas, such as Southern California, have water conservation laws in effect to manage limited water supplies.

Each time we use water, we change its quality by adding substances to it. These materials are such things as municipal sewage, toxic chemicals, solvents, automotive oils, fertilizers, detergents, pesticides, and even extra heat. Some materials, even in small quantities, can damage water quality to the point to make it unusable. A single quart of motor oil, for example, could pollute as much as 250,000 gallons of water.

WATER QUALITY STANDARDS

Water may have different quality "standards," depending on its use. Water can be of high enough quality for livestock to drink but not be pure enough for humans to consume. Or water may provide a fine environment for bass, bluegill and other lake fish while not having enough oxygen content to support trout. Water quality is often in the "eye of the beholder."

Laws involving water quality date back as far as 1914. The first Federal law dealing exclusively with water quality was passed in 1948. Under this law, the states retained primary responsibility for water quality standards and protection. The Federal government supplied money primarily for research. The law provided only weak punishments for offenders. During the 1960s, amendments provided for Federal water quality standards, Federally approved state standards, and increased funding for research. However, as water pollution increased in many areas of the country, public concern resulted in passage of three more very important environmental laws.

The National Environmental Policy Act of 1969 (NEPA) required states to improve water quality through their own water resources agencies. The Federal Water Pollution Control Act (Clean Water Act) which was passed in 1972 and amended in 1977 and 1982, provides the basis for water quality standards today. In 1974, Congress passed The Safe Drinking Water Act (SDWA), which requires public drinking water systems to provide water treatment, monitor drinking water to ensure proper quality, and notify public of contamination problems. The Environmental Protection Agency is responsible for establishing quality standards and enforcing SDWA.

LAND USE AND WATER QUALITY

Land use can have a tremendous effect on water quality. Farmlands can be the source of sediment, fertilizer, pesticides, and animal waste pollution. When forests are cut down, they can be major sources of sediment pollution. Cities pose numerous water quality problems due to the demand for clean water, industrial and commercial pollutants, and human and pet wastes, and urban runoff from lawns and paved areas.

So it's important that when we decide to use land for a specific purpose, we take into account water quality, not just in the immediate area but within the whole watershed. This means considering the **amount** of water available as well as how it must be processed before and after use. For example, crops require tremendous amounts of water. If there's not enough rainfall to support crop growth, they must be irrigated, which means transporting water from lakes, streams, or wells. Irrigation may require so much water that aquatic life in lakes and streams may be adversely impacted, or the water table may be lowered, causing wells and wetlands to dry up. Another good example is the case of a computer chip manufacturer in California. The manufacturing plant may take great care to avoid discharging dangerous pollutants, but still come under attack by environmentalists for the amount of water it uses in an area where water supplies are severely limited.

Certain land use practices can minimize negative impacts to the environment. For example, planting trees and other vegetation to protect soil and reduce erosion, fencing livestock to prevent access to streams, properly treating animal wastes, minimizing use of fertilizers and pesticides, properly treating all waste products from industries, using less harmful chemicals and other products in homes, businesses, and industries, and reducing, recycling, and reusing commercial products can all help reduce water pollution.

WATER POLLUTION

Water has the remarkable ability to renew and cleanse itself. If you deposit waste materials into a river, they eventually settle out, break down or become so diluted in the flow that they pose no real problem—unless the amount of materials dumped is too great. That's the big problem: our society has too many waste materials, and unless they are managed, they cause water pollution.

There are a number of sources of water pollutants. These can be classified into two main categories: **point source** pollution and **nonpoint source** pollution. The difference between the two types is simple. Point source pollution is any type of pollution that can be identified as coming from a clear, easy-to-spot source. This may be a factory, a previously polluted stream, or other source that is obviously causing pollution. Point source pollution problems are often simpler to control because it's easier to see the cause of the pollution and to do something about it.

Nonpoint source pollution problems are more difficult to resolve because they often cannot be traced to one specific location. Nonpoint source pollution includes sediment from rainwater runoff or fertilizer pollution as storms wash nutrients from fields. Nonpoint source pollution can be runoff from animal wastes, construction sites or mines, and leachate from landfills. Nonpoint source pollution could even be acid rain from atmospheric pollutants that falls to earth in polluted rain or snow and contaminates waterbodies. There are six major types of water pollutants:

*Biodegradable wastes

*Plant nutrients

*Heat

*Sediments

*Hazardous and toxic chemicals

*Radioactive wastes

Biodegradable wastes include human and animal wastes, food scraps, and other types of organic materials. Biodegradable wastes can cause water pollution by providing nutrients for bacteria. If there are excessive nutrients, bacteria multiply too rapidly, consuming the oxygen in a stream and making it uninhabitable for some species of fish and other aquatic life. In fact, if the bacteria grow too fast, they consume enough oxygen so that virtually everything in the water dies, leaving only anaerobic bacteria (bacteria that do not require oxygen to live) that create foul smelling gases.

Biodegradable wastes can also cause water pollution by spreading disease-causing bacteria. This type of pollution was the cause of typhoid and cholera epidemics that led to the development of public water treatment systems.

Many of the **nutrients** used to bring the earth to life can "overfeed" a waterway to death. Sources of **nutrient pollution** are sewage and septic runoff, livestock waste, fertilizer runoff, detergents, and industrial wastes. Some of these are point source causes, while others are nonpoint source.

Nutrients like phosphates and nitrates stimulate plant growth, and are primary ingredients in fertilizers. These compounds occur naturally, but in excess quantities they can cause great damage. Approximately

80 percent of nitrates and 75 percent of phosphates added to lakes and streams in the U.S. are the result of human activities.

Natural nitrates and phosphates usually are **limiting factors** in the growth of plant life. In other words, they occur in limited amounts that help govern the growth of different organisms and keep nature in balance. But when excess amounts of these nutrients are introduced into a waterway, some plant species can experience explosive growth, literally choking off other life forms.

When soluble inorganic nitrogen concentrations in water reach just 0.3 parts per million and inorganic phosphorus concentrations reach 0.01 parts per million, algae "blooms," or multiplies rapidly. The algal blooms can become so severe that an entire lake can be fouled with a green, foul-smelling slime. Clear water can become so cloudy that visibility is restricted to a depth of a foot or less, destroying the aesthetics of the lake.

Once a bloom occurs, its negative effects can multiply rapidly. The green slime can foul up boat propellers and make swimming unpleasant. Nutrients can also cause weeds and other undesirable plants to flourish, increasing the problem. The algal bloom impairs water quality, and if the waterway is a source for municipal water supplies, it can be expensive to remove impurities and odors. Masses of algae can wash up on shore, decaying and producing hydrogen sulfide gas, which smells like rotten eggs. Certain marine algae can also release toxics that concentrate in fish and shellfish which cause human digestive problems. In fact, in some areas it is dangerous to eat foods like oysters at certain times of the year because of "red tide," a phenomenon caused by a marine algal bloom.

When an algal bloom clouds water, it can block sunlight from other plants and aquatic life, killing them or limiting their growth. And as the algae die, the bacteria which feed on them can deplete oxygen levels in the water to the point where it cannot support other life forms. This condition leads to **eutrophication.** Eutrophication is a naturally-occurring process of changes that take place after a waterbody receives inputs of nutrients, mostly nitrates and phosphates from erosion and runoff of surrounding lands. Usually this process occurs slowly over millions of years. Human activities can accelerate this process and the results can be very serious. Eutrophication caused Lake Erie to "age" nearly 15,000 years between 1950 and 1975.

Heat, or **thermal pollution**, can be a deadly water pollutant. An important relationship exists between the amount of dissolved oxygen in water and its temperature. The warmer the water, the less dissolved oxygen. Thermal pollution can be natural, such as in hot springs or shallow ponds during summer months, or it can be man-made, when water used to cool power plants or other industrial equipment is discharged back into streams. The amount of oxygen in water affects the life it can support. Some sport fish like trout need cold water with high levels of dissolved oxygen and cannot live in warm water. Other nongame fish like carp and suckers thrive in warm water and can take over habitats from other fish if waters become too warm. This can result in greatly reduced diversity of fish species important for the environmental health of the stream.

Thermal pollution has been such a problem that most states have passed laws requiring power plants and industries to cool water before releasing it back into streams.

Sediment is one of our most destructive water pollutants. America's water is polluted by more than one **billion** tons of sediment annually. Every day, Americans lose about one million dollars because of sediment pollution.

Sediment is mineral or organic solid matter that is washed or blown from land into lakes, rivers, or streams. It can be point source or nonpoint source pollution. Typically, it comes from nonpoint source causes. Sources of sediment pollution include construction, row cropping, livestock operations, logging, flooding, and runoff from city streets, parking lots, and buildings. Sediment by itself can be a dangerous pollutant, but it is also considered serious because other contaminants such as heavy metals and toxic chemicals can be transported with it.

The effects of sediment pollution can be devastating. It can clog municipal water systems. Lakes or reservoirs can receive so much sediment that they actually fill in. Sediment can turn a deep lake into a shallow wetland area over time. Fine sediment can blanket the bottoms of lakes and rivers, smothering aquatic life such as fish eggs and insects and damaging fish gills. This can disrupt the entire food chain, and cause great damage to an ecosystem. Sediment can also be detrimental before it settles, while it is still suspended in water. It can make water cloudy, or turbid. High turbidity makes water aesthetically unpleasant and can destroy recreational opportunities. Some species of fish, such as smallmouth bass, will not thrive in a highly turbid aquatic environment, and studies indicate that high turbidity decreases fishing success.

Sediment in water can also create thermal pollution problems. Sediment darkens water, and allows it to absorb more solar radiation. This raises water temperatures to the point where it may not support some forms of life. At the same time, sediment blocks light from reaching aquatic plant life, slowing or stopping plant growth. And since plants add oxygen to water, oxygen levels can be reduced to the point that fish kills can occur.

This type of damage to the ecosystem is cumulative. As plants and fish die, the waterway loses its ability to break down wastes and materials that are naturally washed into it. These materials begin to accumulate and form another source of pollution.

Chemical pollution is usually human-made. Modern nations rely on thousands of organic and inorganic chemicals in industry, agriculture, and the home. These materials provide many benefits, and new chemical compounds are constantly being developed to improve existing processes.

But with modern chemicals come modern pollution problems. Improperly used or disposed of, reasonably safe chemical compounds cause toxic reactions. The effects of such toxics can be short term or long term and are regarded as a major national and international health concern.

Toxic water pollution is most often linked to point source causes, such as improperly treated industrial discharges or accidents in transportation (such as oil spills). But it can also come from nonpoint source causes. These include runoff from both urban and rural areas, and atmospheric transport.

The hard-surfaced roads and parking lots and urban areas collect toxics such as lead, oil, cadmium (from tires) and other pollutants, which can be washed into streams through storm drains. These materials can cause immediate toxic effects as well as long-term effects by accumulating in sediment or in living organisms. (In the 1970s many people suffered severe health problems from eating swordfish and tuna containing high levels of mercury, which accumulated in the fish over a long period of time.) In agricultural areas, pesticides containing toxic compounds are applied to crops to improve crop quality and increase yields. Their proper use has helped eliminate hunger in many parts of the world. But improper application of pesticides can create serious water pollution problems, because runoff from fields can introduce large amounts of toxics into waterways. Pesticides can also cause groundwater contamination.

The cost of disposing of toxic chemicals created by industry is high. Federal and state laws require careful monitoring of industrial processes and specific storage and disposal procedures of these materials. This cost has caused some unscrupulous people to illegally dispose of toxic chemicals, a process called "midnight dumping." Pollution from this source may go undetected for years, and when discovered, it can be very difficult to determine the source. Legislation adopted since the late 1970s has imposed large fines and jail sentences for people caught illegally dumping toxic wastes.

Another, perhaps surprising, source of toxic water pollution comes from individuals. Household chemicals such as cleaners, dyes, paints, pesticides, and solvents are a large source of toxic water pollution, particularly in urban areas. Many of these materials are simply poured down drains or flushed down toilets with no regard to their consequences. And while the toxic chemicals from one household may not seem like much, they can cause problems. In fact, a single quart of used motor oil can pollute a quarter of a million gallons of water. And homeowners may use ten times the amount of pesticides per acre as farmers. The amount of toxics released by an entire city—one person at a time—can be staggering.

Radioactive pollution can be man-made or natural. It can come from wastewater discharges from factories, hospitals or uranium mines, or it can come from naturally-occurring radioactive isotopes in water like radon. Radiation accumulates in your body, and children are more sensitive to the effects of radiation than adults. Radiation can cause cancer, and in high concentrations, death.

Facilities that use radioactive materials are highly regulated and carefully monitored to prevent pollution. However, one of the potential problems of radiation pollution is stored radioactive wastes. Tons of waste have accumulated over the years, and they will remain dangerous for centuries. Unless suitable storage methods are found, these wastes could pollute groundwater or streams through improper storage. Work continues to create ways to safely dispose of radioactive wastes.

WATER CONTAMINATION (NATURAL DISASTERS)

Water pollution can also come from natural occurrences. Storms can create large amounts of runoff that carry pollutants into water supplies. Fires destroy ground cover and cause sediment pollution. Earthquakes can break sewer lines and cause pollution from man-made sources, or they can even change river courses, destroying some aquatic habitats while creating others. Naturally occurring elements in soils can cause water pollution when they leach into water in concentrations that exceed water quality standards or criteria. For example, desert soils are naturally high in concentrations of salt, boron, and other trace elements. Irrigation can cause these elements to wind up in high concentrations in the water supply, causing pollution that is a danger to crops and wildlife.

WATER POLLUTION PREVENTION

Different pollution sources have different methods of prevention. The fight against **biodegradable wastes and bacterial water pollution** is almost as old as human beings. Epidemic diseases such as cholera killed hundreds of thousands of people before the link to polluted water supplies was established. In third world countries, the lack of clean water still results in critical health problems.

Proper sewage treatment is key to stopping bacterial pollution. Modern municipal sewage treatment plants typically are capable of controlling bacterial pollution, unless storm water loads overwhelm the treatment systems. Private septic systems, however, can be a significant problem. Well-designed and properly operating septic systems will safely treat waste water, but a failing system can lead to pollution of both ground and surface water. The Environmental Protection Agency reports that most waterborne diseases are caused by old or poorly operating septic systems. Systems should be periodically pumped out and cleaned, with the removed material disposed of properly.

Proper management of livestock and domestic animal wastes can eliminate bacterial pollution problems affecting both humans and animals. Well-designed and properly managed animal waste management systems prevent water pollution and use these wastes to fertilize crops and condition soil. Specials devices like "pooper-scoopers" are now required in larger cities to collect and dispose of pet waste before it washes into nearby water bodies.

Since many sources of **nutrient pollution** are man-made, they have the potential to be controlled. It has been estimated that the amount of fertilizers used has increased more than 15 times since 1945. There is discussion of reducing the use of high phosphate and nitrate fertilizers in areas where nutrient pollution is a problem, even though crop yields would be reduced. Land management practices, such as crop rotation to reduce fertilizer requirements, is another option.

Homeowners can also adopt more environmentally sound lawn and garden practices. In many places, chemical tests indicate that individuals use 10 to 50 times more fertilizer than necessary for good plant health. Substituting compost as a mulch and fertilizer for gardens and landscaping can eliminate this potential pollution source. Care should also be taken when using fertilizer. (Composting also reduces waste going into landfills.)

Good sewage treatment plants only remove about 50 percent of the nitrogen and 30 percent of the phosphorus from domestic sewage. This still allows an estimated 200 to 500 million pounds of phosphates into waterways every year. The use of lower phosphate detergents has been encouraged to reduce this, along with providing more advanced sewage treatment systems to remove more nutrients before water is released.

Proper management of livestock can reduce nutrient pollution from animal wastes. Catch basins in feedlots can trap nutrient pollution. Federal and local wastewater release regulations govern industrial releases of many materials that could contribute to nutrient pollution.

Heat or thermal pollution from man-made sources can be controlled by requiring power plants and industry to have cooling towers, holding ponds, and other facilities that allow water to cool before being released back into lakes or streams.

Because many causes of **sediment pollution** are nonpoint source, finding solutions to the problem can be difficult. In some cases, solutions are ongoing activities like dredging sediment deposits and water filtration. Over 2,000 billion gallons of drinking water are filtered annually to remove silt.

However, many causes of sediment water pollution can be reduced or eliminated through proper land management, particularly for activities that create erosion, such as agriculture, construction, mining, or logging. Farming accounts for the largest amounts of sediment pollution. However, careful land management can cut erosion and sediment problems dramatically.

Bare earth erodes quickly, since there is no plant cover to protect soil from rainfall or wind. Construction sites and strip mined areas can lose soil to erosion at a rate up to 70 tons per acre per year—fifteen times higher than the normal rate from croplands.

Many federal and local laws require construction and mining companies to reclaim land instead of leaving it bare to the ravages of erosion—and subsequent sediment pollution. In some cases, certain harmful land use practices have been eliminated completely.

Since sediment pollution is often caused by nonpoint sources, new ways of identifying sources have been created. Aerial photography is now being used to determine land use in specific areas, identify drainage patterns, and erosion rates. Information can be quickly gathered in this manner and steps taken to reduce problems.

Better livestock management practices have also been used to reduce sediment pollution from livestock runoff. Runoff is channeled into lagoons, where sediment settles before water is released into streams. The nutrient-rich sediment is then used to fertilize croplands. And proper management of croplands and logging areas can reduce runoff, improving crop yields and making reforestation easier.

Increased concerns over **chemical pollution** have created strict regulations for most companies, ranging from large plants to small businesses such as dry cleaners, which use potentially toxic solvents. Since the effects of some toxics have not yet been determined, it is expected that even more regulations will be created in the future to limit the material that can be released into the nation's waterways. The introduction of many new chemicals for industrial, mechanical, and other uses presents difficult challenges in determining their safety and impact on the environment. This creates a major challenge for industry to keep up with changing regulations and develop ways to meet new requirements.

Control of air emissions that cause acid precipitation are critical to eliminating this pollution problem. Burning of fossil fuels like coal, oil, and gasoline are prime contributors. The use of non-polluting methods of electric generation, such as hydroelectric, thermal, and solar, can help, as can making sure automobiles are properly tuned and pollution control devices are working. Reformulated gasoline is also designed to reduce these emissions.

Solid wastes buried in landfills can cause pollution problems if harmful leachate percolates into aquifers and contaminates groundwater supplies. Newer landfills are being constructed with double liners and monitoring wells to prevent leachate from reaching groundwater supplies and detect leaks before they become a problem. Solving past problems will take research and work. One way to reduce this dilemma is to reduce the amount of waste going into landfills through recycling and by using products with less packaging and discardable materials.

RIPARIAN AREAS

Riparian areas are the green zones along the banks of rivers and streams and around springs, bogs, wetlands, lakes, and ponds. These are some of the most productive ecosystems in nature, and display a wide diversity of plant and animal life. In the south, "bottom lands" are an example of riparian areas. These areas are important for flood storage, water quality, cover and shade for plants and animals, and agriculture.

Because of their value, rights to riparian lands are a subject of great interest, especially on public lands. Federal and state agencies have created a variety of land management programs designed to protect public riparian lands. These include leaving vegetation strips along fish bearing streams to prevent stream erosion and maintain habitats. Livestock may be prohibited from riparian lands during summer months to keep them from "camping" at the water's edge and destroying vegetation or causing animal waste pollution. In some areas, dams have been constructed to help preserve riparian areas and sometimes beavers are introduced into ecosystems to provide "natural engineering" to rehabilitate eroding streams. And land use around riparian areas must be taken into account. Water drainage from streams or lakes can affect riparian areas by reducing water levels and causing vegetation to die.

BEST MANAGEMENT PRACTICES

Not all water pollution can be avoided. Some manufacturing processes, farming, and other activities are going to create pollutants that can contaminate water. In cases where water pollution is expected to happen, companies and individuals can uses **best management practices** to control pollutants and keep them from causing damage to water supplies.

Examples of best management practices include the agricultural practice of collecting animal wastes in a lagoon to settle before discharging wastewater into streams. It may also mean waiting until certain times to spray pesticides or apply fertilizers to prevent runoff. Best management practices can mean taking water quality into account when planning a housing development or new factory, or it may mean controlling wastewater discharge in conjunction with stream flow. Best management practices may mean planning wastewater treatment for a mine in advance of mining operations. Best management practices are designed to keep any unavoidable water pollution in as much control as possible.

INDIVIDUAL ACTIONS

Individual actions can also have a big impact on pollution problems. One very effective way to reduce water pollution is to simply reduce water consumption. This can be done by changing a few habits. For example, putting a bottle of water in the refrigerator rather than letting water run from the tap until it gets cold. Wash full loads. Turn off the water while brushing your teeth. Take shorter showers. Install low flow showerheads, faucet aerators, and toilet dams. Wash the car using buckets of water instead of a hose. And finally, water plants in early morning or late evening only when they really need it. Better yet, choose plants which require less watering. Other ways to reduce water pollution is to keep litter, pet wastes, and debris out of street gutters and storm drains as they flow directly to waterbodies. Apply lawn and garden chemicals sparingly according to package directions. Homeowners can substitute biocontrol agents, like praying mantises or ladybugs, for pesticides. Other natural insect repellents include plants like mint (which discourages ants), garlic, and marigolds. The use of herbicides should also be avoided.

Virtually every liquid in an automobile is a serious pollutant, and care should be taken to avoid spilling oil, antifreeze, or other fluids from automobiles. In some cases, it may be more ecologically sound to have repairs done by a reputable garage than to attempt messy do-it-yourself work if the community does not have proper disposal centers. Dispose of used oil and antifreeze properly by taking them to your local service station or recycling center.

Household cleaners can add toxics or nutrients to water. In most cases, harsh chemicals are not necessary to do an effective cleaning job, and less damaging substances can be substituted. Baking soda can be used as a scouring powder and water softener to increase the cleaning power of soap. Soap biodegrades safely without adding phosphates or dyes to water like many detergents. Borax cleans, deodorizes, and disinfects. An all-purpose cleaner made of a teaspoon of liquid soap, two teaspoons of borax and a teaspoon of vinegar in a quart of water is an effective grease cutter. A quarter cup of baking soda followed by a half cup of vinegar makes a good drain cleaner. Consumers should also take care in disposing of potentially dangerous household chemicals like batteries, nail polish, drain cleaner, and paint. Do not dispose of any unused portions of these items down drains, toilets, or storm sewers. Many communities offer regular hazardous waste pickups to collect these items. If your community doesn't have one, ask your local government to establish one. The EPA Resource Conservation and Recovery Act hotline (703-486-3367) can supply more information.

Citizens can also become more politically involved. For example, encourage your local government officials to enforce construction/sediment control ordinances in your community or encourage city officials to use sand instead of salt to de-ice roads. Participate in public meetings to plan water policy. Organize litter cleanup campaigns and hold local fairs to educate your community about water resource issues.

WATER QUALITY LEGISLATION

Laws involving water quality date back as far as 1914. The first Federal law dealing exclusively with water quality was The Water Pollution Control Act, passed in 1948. Under this law, the states retained primary responsibility for water quality standards and maintenance. The Federal government supplied money primarily for research. There were no water quality standards established, and the law provided only weak punishments for offenders. During the 1960s, amendments provided for water quality standards for interstate waterways, Federally approved state standards, and increased funding for research. However, as water pollution increased in many areas of the country, public concern resulted in passage of two more very important environmental laws.

The National Environmental Policy Act of 1969 (NEPA) required states to improve water quality through their own water resources agencies. It also required environmental impact studies to be undertaken before any major building or industrial projects.

The Federal Water Pollution Control Act (Clean Water Act) which was passed in 1972 and amended in 1977, 1981, 1984, and 1987, provides the basis for water quality standards today. The Clean Water Act allowed the Federal government to assume a lead role in cleaning up the nation's waterways. National goals for pollution elimination were set, and the National Pollution Discharge Elimination System (NPDES) established a permitting system that made pollution discharge without a permit illegal. Generators of pollution (sources) must apply for NPDES permits, which are issued by EPA-approved state agencies. The limits on what the generators may release vary from small amounts (for suspended biodegradable organic material and solids) to none allowed (for some toxics). The stringency of the requirement is greatest for the most dangerous water pollutants. Each pollution source is evaluated separately, and a permit may take years for approval, depending on the materials to be released.

The Clean Water Act also established four national policies for water quality:

1. Prohibit the discharge of toxic pollutants in toxic amounts

2. Assist publicly owned wastewater treatment works with Federal grants and loans

3. Support area-wide waste treatment planning at Federal expense

4. Create a major research and development program for treatment technology

Today, 75 percent of streams meet water quality standards. In 1973, only 36 percent of streams were of high enough quality to meet standards. Future amendments to the Clean Water Act are likely to make ecosystem protection as important as providing potable water for human use. Amendments are also likely to establish water quality standards for lakes and to focus more specifically on preventing storm water nonpoint source pollution.

Other Federal laws that deal with water quality are the Toxic Substances Control Act of 1976, the Resources Conservation and Recovery Act of 1976, the Surface Mining Control and Reclamation Act of 1977, and the Rivers and Harbors Act of 1899.

WASTEWATER TREATMENT

Wastewater is water that has been used for a particular purpose. After water is used, it must often be treated to avoid polluting another body of water. Almost any use will add contaminants to water that must be removed before it can be returned to the environment.

WASTEWATER TREATMENT PROCESS

Wastewater treatment is designed to kill dangerous bacteria and reduce or remove chemicals and solids before water is returned to lakes and streams or groundwater.

Wastewater treatment may be a simple process or it may be complex, depending on how many pollutants are added to water during use. Water from a household may require minimal treatment before it can be returned to natural bodies of water, while industrial wastewater may need several processes before it is safe to release. Municipal and home treatment systems have been in use for years to prevent health risks from wastewater. Laws enacted in the 1960s and 70s began placing more stringent controls on water released from industrial plants to reduce pollution from these wastewater sources. Since this water quality "wake-up call," pollution laws have progressively become more strict on protecting water quality.

Most municipalities with wastewater treatment systems are required to have two stages of treatment. In the primary treatment stage, screens and settling tanks remove most of the solids in the water. Solids make up about 35 percent of the pollutants in wastewater. In the secondary treatment stage, bacteria are used to digest the remaining pollutants in the water. One process mixes microorganisms and oxygen with wastewater to speed up the digestion process. Another method allows the wastewater to trickle down through a layer of rock and gravel covered with bacteria that break down pollutants. Large settling tanks then allow most of the remaining solid material to settle out, and some systems will run the water through sand filters to further cleanse it. Finally, the water is disinfected with chlorine, ozone, or ultraviolet light and discharged. By the time it is discharged, about 85 percent of the pollutants have been removed from the wastewater. The solids remaining in the treatment plant are rich in nutrients and can often be used on farm and forest lands as fertilizer.

In some cases, **tertiary** (advanced) treatment of wastewater is done. This is a third stage of treatment that is designed to remove more of the impurities from wastewater. This step may involve filtering the wastewater through carbon or sand filters to remove solids or even allowing the water to flow into a natural or constructed wetland area to purify it further.

In 1988, more than 144 million people had secondary or more advanced levels of wastewater treatment. More than 23 million households had on-site disposal systems such as septic tanks.

MICROBIAL DIGESTION OF WASTES IN WASTEWATER

Microorganisms need nutrients to survive, and they can process the nutrients in wastewater, providing a very effective method of treatment. **Anaerobic** bacteria break down waste materials without oxygen or aeration. **Aerobic bacteria** break down waste material with oxygen. Both types reduce concentration of nutrients, making it safe to dispose of wastewater. Aerobic bacteria break down wastes without as much odor, but require more surface area (for aeration) than do processes using anaerobic bacteria. Both types of bacteria are usually present in wastewater treatment systems.

BIOSOLIDS

The solids recovered during wastewater treatment are not worthless; in fact, they can be used as high quality fertilizers in many cases. Wastewater solids, or sludge, meeting strict criteria for beneficial use are called **biosolids.** The nutrient rich biosolids can be spread on croplands. A ton of animal manure is equal to about 100 pounds of high quality chemical fertilizer.

Biosolids must be treated before disposal or use. Primary sludge is combined with bacteria for partial digestion, and then it is thickened by using centrifugal force or gravity to remove water. It is then collected and transported to the site of disposal or spreading.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

The single most important provision of the Clean Water Act is the National Pollutant Discharge Elimination System (NPDES). The Clean Water Act requires that each source of water pollution—cities, factories, power plants, animal feedlots, and so on—treat their wastewater to meet effluent discharge limits and performance standards set by the EPA before releasing the wastewater to streams or lakes. Generators of pollution (sources) must apply for NPDES permits, which are issued by EPA-approved state agencies. The limits on what the generators may release vary from small amounts (for suspended solids) to none allowed (for some toxics). The stringency of the requirement is greatest for the most dangerous water pollutants. Each pollution source is evaluated separately, and it may take a number of years for a permit to be issued, depending on what is to be discharged.

NPDES also makes it illegal to discharge pollutants without a permit, and sets civil and criminal penalties for violations. Penalties can include fines of $25,000 per day of violations and prison sentences of up to 15 years, with limits doubled for repeat offenders.

ALTERNATIVE WASTEWATER TREATMENT METHODS

Smaller communities may have different approaches to wastewater treatment. Some communities, hotel complexes, or apartment buildings use **package plants** to process wastes. These prefabricated units utilize procedures similar to those used by as full-scale plants. **Lagoons** are another form of treatment. Lagoons allow solid wastes to settle, and then rely on a biological interaction of sunlight, algae, and oxygen to clean wastewater.

NATURAL WETLANDS TO TREAT WASTEWATER

One very practical use for natural wetlands is to further treat wastewater. Wetlands are good water "filters" for removing and retaining nutrients, processing chemicals, and organic wastes, and reducing sediment loads to receiving waters. Wastewater can in some cases be beneficial to wetlands by providing nutrients that the diverse plant life in wetlands needs.

CONSTRUCTED WETLANDS TO TREAT WASTEWATER

In some cases, constructed wetlands can be used to treat wastewater. They can be used to treat domestic, agricultural, industrial and mining wastewaters. They generally cost less than conventional wastewater treatment systems and operating costs are very low. They are also more aesthetically pleasing than wastewater plants and attract desirable wildlife.

Wastewater to be treated flows into a constructed cell that has been lined to prevent leaks and assure adequate water for wetland plants. Flow is distributed evenly across the cell. Plants such as cattails and bulrushes are planted in the cell, and their roots produce a dense mat of materials through which the wastewater circulates. Chemical, biological, and physical processes filter out contaminants from the wastewater. A second cell may be added for more treatment. It may be unlined to allow water to filter and can contain attractive wetland plants like iris, elephant ear, and arrowhead. Plants transpire water into the atmosphere and provide oxygen for bacteria and other organisms to break down biodegradable wastes.

Wetlands may or may not discharge treated waters into surface waters, depending on their size, design, and local site conditions.

RAPID INFILTRATION

Rapid infiltration is a wastewater treatment method that can be used in areas where solid permeability is moderate to high. A basin area can be flooded with appropriately pre-treated wastewater and allowed to infiltrate into the ground. The ground then filters the wastewater as it infiltrates into the ground water or into the local surface waters. After a basin is filled, it is allowed to drain and dry, which restores the aerobic conditions in the soil which help treat the wastewater as it infiltrates.

OVERLAND FLOW

Overland flow is a process where water is allowed to flow down a sloped surface, usually planted with thick grasses. Soils are nearly impermeable, which forces the water to flow through the vegetation, where physical, chemical, and biological processes treat it. It is then collected into runoff channels and discharged. Overland flow is normally used as a secondary treatment, but under the right conditions, it can have some primary treatment applications.

SLOW RATE IRRIGATION/SILVICULTURE

These two processes are related in that in both, wastewater is used to irrigate land the land and is used to treat wastewater. Slow rate irrigation allows wastewater to flow onto land parcels at a rate that doesn't overburden the land's ability to allow the water to infiltrate and process impurities. Silviculture is the practice of using large areas of land as a treatment site for wastewater and planting the land with crops or trees that will flourish during the treatment. Both processes are based on ancient ideas and practices of wastewater treatment that have proven themselves for centuries.

AQUACULTURE

Aquaculture is the practice of using aquatic plant and animal species to treat wastewater, similar to the use of wetlands for this purpose. An aquaculture area might be constructed with a number of ponds for different levels of wastewater treatment. Each pond contains specific plant and animal life for wastewater treatment, and wastewater may be allowed to flow from one pond to another as it is being treated. Plant life may be harvested or maintained in the ponds to maximize system performance, and aquaculture systems have been able to remove impurities such as heavy metals from wastewater.

SEPTIC TANKS AND SEPTIC SYSTEM ALTERNATIVES

Septic systems are the wastewater treatment method for most Americans in rural areas. Septic systems typically consist of an underground **septic tank** that collects wastewater from a home. Solids from wastewater are allowed to settle in the tank, and bacteria in the tank digest some of the heavier solids and household grease and oils. During the decomposition, gas is produced and usually vented through a pipe in the roof of the home. The partially treated water, or effluent, flows out of the tank into a **distribution box** where it is channeled into a series of perforated pipes or open tile. Water percolates out of the pipes into the system's **drain field**, where it is filtered and treated by organisms in the soil. Eventually, treated wastewater returns to the groundwater supply.

Well-operating septic systems will safely treat wastewater, but a failing system can lead to pollution of both ground and surface water. The Environmental Protection Agency reports that most waterborne diseases are caused by old or poorly designed septic systems. Systems should be periodically pumped out and cleaned, with the removed material disposed of properly. To avoid septic system problems, make sure the system is regularly inspected and solids pumped out when necessary. Avoid putting solids such as coffee grounds, disposable diapers, cigarette butts, plastics, and other bulky wastes into the septic system. Pouring liquid fats and grease down the kitchen sink can cause problems as these wastes solidify and block the system's operation. Use of a kitchen sink garbage disposal should also be avoided unless the septic system has been designed to accommodate extra wastes, A garbage disposal can increase loads on the system by as much as 50 percent. Keep toxic and hazardous chemicals like paint thinner, petroleum products, and pesticides out of the septic system. Systems don't break down these materials, and pouring them into a septic system means that you're just pouring them directly into the groundwater supply.

Alternatives to septic systems may be used when soil does not readily allow systems to work or there are too many households in an area to provide adequate septic fields. Alternatives to septic fields are also used as ways to conserve water. Some systems separate **blackwater** (water from toilets) from **greywater** (water from showers, dishwashers, etc.). Blackwater requires more treatment, while greywater may need only minimal treatment before it can be used for other household purposes, such as watering the lawn. Other alternatives to septic systems include devices such as incinerating, chemical, or composting toilets, which process wastes before they are released; and holding tanks that are regularly pumped out instead of processed on site. Water conservation methods like low-flow faucets and shower heads, energy efficient appliances, and other products also reduce septic system loads.

COMMERCIAL/INDUSTRIAL WASTEWATER TREATMENT

Wastewater treatment for industrial plants may be more complex than that for residential areas due to hazardous pollutants added to wastewater during manufacturing. Many plants have invested millions of dollars into their own wastewater treatment facilities. New processes even use ultraviolet radiation to kill microorganisms or break down chemicals in wastewater.

Even small businesses such as dry cleaners, gas stations, restaurants, and photo labs may have specialized treatment processes to clean wastewater. For example, a photo lab may have an electroplating system to remove silver from wastewater. The silver can then be processed and sold back to photographic film companies for use in making new film.

INDUSTRIAL WASTEWATER TREATMENT METHODS

Public wastewater treatment plants were not designed for industrial wastes, especially toxic substances. Toxic wastes from industrial plants can actually damage public systems by killing useful bacteria. So modern industrial plants separate their wastewater into several categories for treatment:

*Wastewater that can be treated and reused within the plant

*Wastewater that can be treated in a wastewater treatment plant designed to accommodate the needs of industry

*Wastewater that can be sent to public treatment facilities, either directly or after treatment at the industrial site

*Wastewater that is so toxic that it must be treated on site or disposed of as hazardous waste

New techniques for treating industrial wastewater are continually being developed. These can include chemical reactions to remove hazardous materials from the wastewater. One innovative method uses ultraviolet light to break down hazardous organic materials into more common biodegradables.

MINING WASTEWATER TREATMENT METHODS

Mining is an industry that can create severe water pollution problems from sediment, chemicals, metals, and acids. Federal law now requires mines to treat wastewater before releasing it into waterways. Since most mine sites are remote, lagoons are a common form of treatment. Lagoons (which must be lined to prevent groundwater pollution) allow sediment to settle out, eliminating a major water contaminant, and depending on the type of mining, other water treatment processes can be applied as necessary. These may include adding lime to reduce acidity, removing heavy metals, or skimming off oils or petroleum wastes. Constructed wetlands have also been used to treat mining wastewater.

EMERGING WASTEWATER TREATMENT ISSUES

RECLAMATION AND REUSE OF WASTEWATER

For industry and municipalities, water use efficiency means cost efficiency. Wastewater treatment is expensive, so most industries analyze water use as carefully as they do any other raw material. Many industrial plants have wastewater treatment plants to treat wastes that can't be handled by public treatment plants, but they may also treat wastewater for reuse instead of paying for additional water or discharge. Efficient uses of reclaimed water in industry can be for heating or cooling, irrigation, or materials processing. Many municipalities also reclaim wastewater with calcium, fluoride, and argon for other uses.

STORM WATER TREATMENT

Storm water runoff can be a serious waste water treatment problem because large amounts of runoff can overload wastewater treatment systems and cause untreated water to be released into streams. Another problem with storm water runoff is chemical contamination from industrial sources or simply from greases and oils on parking lots and roadways.

A new provision of the Clean Water Act is designed to reduce pollution from storm water. It requires industry and large municipalities to have permits or pollution prevention plans for storm water runoff, and to have provisions for keeping pollutants out of the runoff.

DRINKING WATER

WATER SUPPLY

The world's supply of water is 326 million cubic miles. If it were poured on the United States, it would submerge the country to a depth of 90 miles. But only a small portion of that water supply is usable fresh water. In fact, of the Earth's total water supply, less than one-half of one percent is usable fresh water. Only 0.03 percent is surface water. Of every 10,000 gallons of water on Earth, fewer than 50 are potentially usable fresh water; only 3 gallons are found in surface water bodies such as rivers, lakes, and streams.

The United States is water "rich." We have 39,400,000 acres of lakes and reservoirs, and over 35,000 square miles of estuaries. The Great Lakes cover 98,000 square miles and contain about 1/5th of the world's fresh water supply. About four percent of the U.S. land mass is covered by surface water.

The United States has nearly 60,000 community water supply systems, but only 20 percent of these systems use surface water as their primary source. Groundwater is the primary source of water for 80 percent of U.S. communities—nearly 40 percent of the entire U.S. population.

INTRODUCTION TO DRINKING WATER

Water is vital for life. Our bodies are approximately 75 percent water. Water makes up 83 percent of our blood, transports body wastes, lubricates body joints, keeps our temperature stable, and is a part of every living cell in our bodies. On the average, every American uses about 150 gallons of water a day. That makes daily water consumption in the United States alone over 372 **billion** gallons per day. It's no wonder that in some highly populated areas, water supplies are getting tight. Some areas, such as Southern California, have water conservation laws in effect to manage limited water supplies. One aqueduct in California is over 450 miles long to transport water from its source to Los Angeles where it is needed.

DRINKING WATER STANDARDS

In 1974, Congress passed the Safe Drinking Water Act (SDWA), setting up a regulatory program among local, state, and federal agencies to help ensure safe drinking water in the United States. The Safe Drinking Water Act states that public water systems must provide water treatment, monitor drinking water to ensure proper quality, and provide public notification on contamination problems. The act set maximum safe levels for a variety of chemicals, metals, and bacteria. Amendments continue to strengthen the act and enhance drinking water quality. Significant penalties are imposed for non-compliance.

SDWA applies to all public water systems, defined as having at least 15 service connections or regularly serving at least 25 individuals. States are required to enact their own drinking water regulations that are at least as stringent as Federal standards. SDWA protects drinking water supplies through required treatment, required testing, and groundwater aquifer protection, since over 92 percent of public drinking water supplies come from groundwater.

SDWA requires that maximum contaminant levels be established for 83 specific inorganic chemical, organic chemicals, bacteria, and radioactive elements. SDWA also sets secondary standards for qualities that affect aesthetic qualities relating to public acceptance of drinking water. These include color, corrosivity, foaming agents, odor, and metals.

EPA is in the process of selecting 25 contaminants per year to set maximum safe levels for as provided for in the SDWA. This process will continue until Congress changes the law or all chemicals standards have been determined. SDWA also regulates underground injection wells by permit, and takes other steps to prevent contamination of aquifers or water supplies at the wellhead.

RESERVOIRS FOR SUPPLY/DAM CONSTRUCTION ON STREAMS

Reservoirs from dams serve a variety of water needs. They provide ways of storing large supplies of water for industrial and residential use. They control floods and other natural disasters that can cause water pollution. They generate power and provide sources for recreation. While creating dams removes certain types of habitats, it also creates new habitats which support thousands of species of wildlife.

Since 1933, the Tennessee Valley Authority has been charged with developing and managing water resources in the Tennessee Valley. This has meant constructing more than 30 dams, including the largest dams east of the Mississippi River. TVA has also assumed management of a number of dams already constructed in the area before the agency came into existence.

TVA's role in protecting and improving water quality differs from that of any other Federal, State, or local water quality program. TVA monitors water quality to identify problems and detect changes. TVA research programs study the relationships among water quality and land use, wastewater treatment, stream flow, and other factors. Reservoir water quality management plans identify better ways to protect and use the Valley's water resources. Monitoring for problems and changes, working with others to correct identified problems, demonstrating new solutions, and planning to prevent pollution are cornerstones of TVA's approach to water quality management.

DRINKING WATER TREATMENT

Water is in its purest form the moment it condenses from vapor into a liquid, but it quickly picks up impurities. Rain or snow can pick up dust, smoke, and other particles in the air. Runoff water dissolves minerals and carries small particles of soil. Streams can carry sediment, man-made pollutants and other materials. Once water is used by man, it picks up even more pollutants and impurities before it is returned to nature. The need for a supply of clean water led mankind to develop methods of treating water so that it can be safely used.

Since very early times, people have created ways to remove debris from drinking water to make it look and taste better. Ancient Egyptian inscriptions describe water purification by boiling, exposure to sunlight, charcoal filtration, and settling in an earthen jar. The Chinese were the first to discover the purifying effect of boiling water, and as early as 400 B.C., Hippocrates, the father of medicine, recommended boiling water and straining it through cloth to remove particles.

However, it wasn't until the 1850s that scientists suspected that disease could be spread through water. The rise of microbiology identified a number of diseases that were transmitted by water supplies, and the first attempts were made to disinfect drinking water by using chlorine. Around the turn of the century, Middlekerke, Belgium became the first city to install a permanent chlorine disinfection system. Chlorination was first used in the United States in 1908 to destroy bacteria in drinking water. The widespread use of chlorination wiped out waterborne diseases such as typhoid and cholera.

Obviously, water used for drinking requires more treatment than wastewater, or water being returned to a lake or stream. But the two can have an impact on each other. The extent to which drinking water must be treated depends on the quality of the raw water supply, so a community downstream from other cities may find its water quality affected by the wastewater released by those cities.

Drinking water from a well may require little or no treatment before it is used. Water from a lake exposed to recreational activities or sewage contamination may need significant treatment before it can be used as drinking water. National drinking water quality standards were created in 1974 by the Safe Drinking Water Act to help ensure water quality. Since then, the Act has been amended to further improve water quality.

Conventional water treatment for drinking water consists of the following steps:

*Water is pumped from the water source, such as a lake, river, or reservoir and is strained to keep fish and large objects out of the system.

*Alum or other materials are added to the water to cause the dirt and other particles to coagulate, or clump together and fall to the bottom of settling basins.

*The then-clear water is filtered through layers of sand, charcoal/anthracite, and gravel to remove more impurities.

*Chlorine is added to kill bacteria remaining in the water. Some water systems add fluoride to help prevent tooth decay. Other chemicals (lime or phosphate) may be added to adjust the acidity of the water.

*Finally, the treated water is pumped through pipelines to homes and businesses or it is stored for future use. Throughout the process, water is monitored to make sure it meets the requirements of the Safe Drinking Water Act, which measures some contaminants in concentrations as low as parts per trillion.

Public water supply systems in the United States produce more than 34 **billion** gallons of drinking water per day. The United States' more than 60,000 community water supply systems are valued at over $175 billion. The average price of water in North America is about $1.27 per 1000 gallons. A penny buys 160 glasses of drinking water.

DRINKING WATER CONTAMINATION

Drinking water can be contaminated from a variety of sources and by a variety of contaminants. Contaminants can come from runoff from precipitation, spills of hazardous chemicals, leaking underground storage tanks, animal wastes, leachate from landfills, excess fertilization of farmland and other sources. Groundwater protection from pollution is especially important since groundwater is a major source of drinking water. Individuals can pollute their own drinking water from wells if they overuse pesticides on their lawns, dump even small amounts of petroleum products, flush household chemicals into a septic field, or fail to keep their septic systems functioning properly.

WELLHEAD CONTAMINATION

Wellhead contamination is the contamination of a well from pollutants that come from around the well itself. Wellhead pollution protection requires the protection of the area around the well from pollutants that could affect the groundwater and therefore the well water supply. A wellhead protection area (WHPA) can be established for any type of aquifer and can include the well's cone of depression, recharge area, and surrounding aquifer. A growing number of states and communities are starting to create wellhead protection areas to guard against contamination of well water. These areas may be large or small, depending on the characteristics of the aquifer and the potential hazards that could threaten groundwater. States can apply for wellhead protection grants to protect community groundwater supplies.

EMERGING ISSUES: DRINKING WATER

DESALINATION

Since sea water makes up over 97 percent of the Earth's water supply, it is a readily available and plentiful water source. However, because of its salinity, sea water is unsuitable for drinking, and it must be treated before it can be used. Desalination is a relatively expensive process that is principally used in arid and coastal areas where water is so scarce that the process becomes cost effective. One desalination process is simple evaporation, where water vapor from salt water is collected and allowed to recondense as fresh water. Another process is reverse osmosis, in which water is filtered through membranes with holes tiny enough to allow water molecules to pass through, but keeps larger salt molecules from following. The salt can then be collected and used for other purposes.

As water supplies become tighter, desalination becomes more cost effective and more practical to use. Some desalination plants are operating in Southern California to meet the area's tremendous water demand.

WELLHEAD PROTECTION

In areas where a single aquifer is the sole or principal source of water, states are required to create protection programs to guard aquifers against pollutants. Amendments in 1986 to the Safe Drinking Water Act of 1974 (SDWA) also call for wellhead protection to identify the area around the wellhead that needs protection and set up measures to protect it from contaminants. SDWA also calls for contingency plans to locate alternate drinking water supplies in the event of well or wellhead contamination.

SDWA applies to public water sources, but individuals who use private wells need to have their own groundwater protection strategies, including not dumping household wastes that could pollute groundwater, making sure septic systems are in proper working condition, and avoiding over fertilization of lawns or excessive accumulation of livestock wastes that could damage groundwater supplies.

Federal and state laws protect groundwater supplies. SDWA sets specific goals for implementation of groundwater protection. SDWA requires states to prohibit the use of underground injection wells for waste disposal except by permit. Permit applicants are required to satisfy the state that underground injection would not endanger drinking water sources, and permit holders are required to inspect, monitor, and keep records on injection well use.

LEAD IN PIPES

Lead is a cumulative poison and relatively small amounts can cause brain, kidney, or nerve damage, anemia, or death. It is a particular threat to children because it can result in behavioral problems and mental retardation. Pregnant women are also at risk. Since lead is a very soft, easy to work with metal, it was often used in pipes before it was determined that lead in pipes could poison human beings. Lead solder was also used to help seal pipes to prevent leaks.

The SDWA amendments of 1986 ban future use of lead pipe and solder in all public drinking water systems because of the possibility of leaching. In 1988, SDWA was amended to provide for the recall of water coolers and fountains with lead content higher than 8 percent in the piping and 0.2 percent in solder. EPA published a list of water cooler models which fail these tests. Lead in pipes and solder in new water supply piping was also banned.

NITRATE CONTAMINATION

Nitrate contamination can make water taste and smell bad and cause algal growth, but it normally is not dangerous for adults and older children. However, in infants, stomach acids are not strong enough to prevent some forms of bacterial growth. Bacteria can convert benign nitrates into harmful forms that bind with hemoglobin in the blood to prevent oxygen from getting to the rest of the body. The result is methemoglobinemia, which can cause "blue baby" symptoms and can be fatal.

Nitrates get into drinking water from fertilizers, animal wastes, malfunctioning septic systems, and normal vegetation decay.

WATER CONSERVATION

On the average, every American uses about 150 gallons of water a day. That makes daily water consumption in the United States alone over 372 **billion** gallons per day. It's no wonder that in some highly populated areas, water supplies are getting tight. Some areas, such as Southern California, have water conservation laws in effect to manage limited water supplies.

Of the 150 gallons each of us uses every day only one half-gallon is used for drinking. The other 149 and a half gallons go for cleaning, cooking, flushing, watering the lawn, washing cars, and other uses. One very effective way to reduce water pollution is to simply reduce water consumption. Wastewater treatment plant operators report that they treat millions of gallons of water that shouldn't have been used in the first place.

Effective personal water conservation can be done by changing a few habits. A bottle of water in the refrigerator for drinking saves water over letting water run into the sink until it gets cold. Peel fruits and vegetables and **then** rinse them. That can save two gallons every minute. A dishwasher uses less water than washing by hand—about six gallons a load. And washing an entire load of dishes—or clothes—saves water over washing several partial loads.

New washing machines can reduce water consumption by one third, or more than 400 gallons monthly for a family of four. But the most water use occurs in the bathroom. Simply turning off the water while brushing your teeth could save as much as ten gallons per person per day. Taking a shower instead of a bath can save about 25 gallons, and new low-flow shower heads can reduce consumption even more.

A large percentage of the water used every day is flushed down the toilet. New toilets use less than one-third the water of old models, and older toilets can still work effectively with less water. Devices like toilet dams block part of the water in the tank and reduce the amount used with each flush. If a toilet dam sounds too difficult to install, you can get the same effect simply by putting a water-filled plastic bottle in the toilet tank. This displaces water and means that less is used. Don't use a brick; it can break apart and clog pipes.

Repair leaks immediately. Even a small drip can waste hundreds of gallons of water a day—and add to the treatment loads of the sewer or septic system. Watering the lawn or garden is more efficient in the early morning or at night when the sun won't cause as much evaporation. It is best to water lawns and plants early in the morning. Washing the car with a running hose will use more than 100 gallons of water. Using a bucket and sponge cuts that by 90 percent.

XERISCAPING

Xeriscaping is a landscaping program that can help in water conservation. It was developed in 1981 in Colorado in response to prolonged drought. Xeriscape landscaping is a package of seven common-sense steps for making a landscape more water-efficient. These are:

- Planning and design to minimize expense and maintenance.
- Using turf only where needed for functional purposes. Turf alternatives such as mulches and drought tolerant ground covers are substituted.
- Using drought-tolerant plants and planning placement around sun exposure.

- Using mulches for water retention, long-term fertilization, and weed control.
- Efficient irrigation through grouping plants according to water needs.
- Improving the soil to allow for better absorption of water.
- Maintaining the landscape properly to save maintenance costs.

Today, there are xeriscape programs in over 40 states, and a National Xeriscape Council is headquartered in Atlanta, Georgia.

SURFACE WATER

When runoff from precipitation occurs, it goes downhill, eventually winding up at a point where it gathers, such as a stream, lake, wetland, or ocean. This is **surface water**, or water you can see.

Surface waters are a major source of the usable water on the planet. Surface waters supply water for drinking, recreation, transportation, crop irrigation, and power generation. Most of our major cities have grown up around large bodies of surface water. More than 80 percent of the Earth's surface is covered by water, but less than 0.03 percent of all water is found in surface water bodies other than oceans.

The world's supply of fresh water is 326 million cubic miles. If it were poured on the United States, it would submerge the country to a depth of 90 miles. The United States is water "rich." We have 39,400,000 acres of lakes and reservoirs, and over 35,000 square miles of estuaries. The Great Lakes cover 98,000 square miles and contain about 1/5th of the world's fresh water supply. About four percent of the U.S. land mass is covered by surface water.

Even though the U.S. is water rich this water is not distributed evenly across the country. For example, the western parts of the country contain large desert areas and limited fresh water supplies.

AQUATIC ECOSYSTEMS

Surface water can be broken down into five categories:

- Oceans
- Lakes
- Rivers and Streams
- Estuaries
- Wetlands

Oceans cover two-thirds of the earth's surface. These salt water bodies also contain much of the world's plant and animal life. The resources of the world's oceans are vast, and although ocean water is too salty to drink, the plant and animal resources of the ocean are harvested for food and hundreds of other uses.

Lakes are bodies of fresh water contained within a larger land mass. Lakes can be natural or human-made. Lakes are used by humans for many purposes, such as water storage, flood control, recreation, and fisheries. The number of lakes has increased as humans have created them to provide clean, fresh water resources.

Rivers and Streams are created from runoff water and water that previously infiltrated and is now coming up out of the ground and entering the stream as well. Streams, therefore, are made up of two distinct water sources—runoff and groundwater. The fast-moving action of rivers and streams causes the mixing of water and air, which allows oxygen to be dissolved into the water. This process, **aeration**, gives rivers and streams the oxygen levels they need to support wide varieties of life. If oxygen levels, drop, then streams can lose their ability to be habitats for many life forms. Rivers are often used to dilute pollution, such as water released from wastewater treatment plants.

Estuaries form where rivers meet oceans. This unique environment serves as a spawning ground or nursery for many animal species. Shellfish are a good example of creatures who thrive in estuaries. Estuaries are rich in commercial fishing and recreational opportunities, but because of their complexity and their location at the end of rivers, they can be seriously affected by deposits of sediment and pollutants. They can also be adversely affected when dredging channels changes the salt/freshwater balance in the estuary. Some estuaries, such as Chesapeake Bay and Puget Sound, have become seriously polluted.

Wetlands are lowlands that are periodically covered with water. They may be known as swamps, marshes, bogs, and sloughs. They can be coastal (salt water) or freshwater. The true importance of wetlands is just being realized. Wetlands keep surface waters clean by filtering out sediment and trapping pollutants. Coastal wetlands cushion dryer lands from the full impact of storms. They help control floods by temporarily storing runoff waters. They also provide breeding grounds for many of the fish species that make up a **$9 billion** food market.

Wetlands have traditionally been regarded as wastelands, and since colonial times, over half the wetlands in the United States have been destroyed. But new Federal and state regulations are protecting wetlands and regulating the way they are used.

TYPES OF AQUATIC HABITATS

Aquatic habitats are as diverse as the types of surface water. A single stream or body of water may be home to a number of habitats, and during the life of the body of water, habitats may change, due to natural processes or man-made pollution.

The major determinant of aquatic habitats is the amount of dissolved oxygen in water. Cold, fast-running mountain streams that run over rocks and splash down slopes dissolve high amounts of oxygen, making them perfect habitats for fish like trout, which require high levels of oxygen. As waters level out and become more still, they absorb heat from the sun and lose oxygen content. Trout may not be able to survive in them, but other fish like bass and sunfish like crappie and bluegill thrive. If water gets too warm and oxygen content gets lower, then "rough" fish like carp and suckers move in.

Plant life also thrives around lakes and streams. The immediate area around a body of water is known as a **riparian** area because it supports so much plant life. Like almost everything else in nature, riparian areas also benefit wildlife and fish populations, providing cover and shade to keep water from getting too warm and losing oxygen content. On public waterways, riparian areas are carefully managed to keep water ecosystems balanced.

Wetland areas have their own unique habitats. They are such complex areas that hundreds of species of plants and animals live there. They are nurseries for many species of animals and provide food to nourish our most productive fishing beds. Almost 35 percent of all rare and endangered animal species are either located in wetland areas or are dependent on them. About 66 percent of the commercial fish catch taken along the Atlantic and Gulf coasts depends on wetlands for survival.

SURFACE WATER QUALITY STANDARDS

Under the Clean Water Act, water quality standards are based on two key components: stream use classification and water quality criteria, or the degree of water quality needed to support a designated use for a stream. Water quality criteria can include dissolved oxygen content, turbidity, chemical and nutrient contents, and other factors.

Stream use classifications can include:

- Domestic water supply
- Industrial water supply
- Fish and aquatic life
- Recreation
- Irrigation
- Livestock watering
- Wildlife
- Navigation

Streams may be divided into segments with a different set of uses established for each segment. Different uses dictate different levels of water quality.

Criteria used in assessing water quality include:

- Dissolved oxygen
- pH
- Hardness, or mineral content
- Total dissolved solids
- Solids, floating materials and deposits
- Turbidity or color
- Temperature
- Coliforms
- Taste and odor
- Toxic substances
- Other pollutants

Depending on the designated stream use, only certain criteria may be used. To evaluate drinking water quality, all eleven criteria are taken into account, but only seven are used to protect livestock watering and wildlife uses. Individual criteria requirements may also vary with different uses. A trout stream requires 6 mg/L dissolved oxygen content. For other fisheries, 5 mg/L is sufficient, and allowances may be made down to 3 mg/L.

In 1974, Congress passed the Safe Drinking Water Act (SDWA), which requires public water systems must provide water treatment, monitor drinking water to ensure proper quality, and provide public notification on contamination problems. The act set maximum contaminant levels for a variety of chemicals, metals, and bacteria. Amendments continue to strengthen the act and enhance drinking water quality. Significant penalties are imposed for noncompliance.

WATER QUALITY MONITORING

Water quality monitoring depends on stream use, land management, and state and federal regulator. Under the Clean Water Act, the owner or operator of a facility covered by a National Pollution Discharge Eliminator System (NPDES) permit is required to monitor effluent or wastewater quality at regular intervals, maintain complete and accurate records, and report the results. Regulators can also monitor water quality at such sites to determine compliance with permit requirements and notify the operator of any violations. States are required to have adequate monitoring programs to be eligible for federal funding. Under the Safe Drinking Water Act, operators of water processing facilities are also required to monitor water quality at regular intervals.

Industrial plant operators or land managers may also choose to monitor water quality frequently if changes in quality have an adverse affect on operations or on plant and animal life.

Water quality monitoring measurements can include on-site chemical tests to detect pollutants, laboratory water analysis, observations on plant and animal life in the area, and even catching fish for field or laboratory analysis. Even if other indicators show no problems, changes in fish health may signal a pollutant or ecosystem imbalance that needs to be corrected.

LAND USE AND WATER QUALITY

Land use can have a tremendous effect on water quality. Farmlands can be the source of sediment, fertilizer and animal waste pollution. Forests may not be the source of pollutants, but they can be damaged severely by water pollution. Human activities affecting forests (forestry practices such as clear cutting and road construction) can impact water quality. Cities pose numerous water quality problems due to the high water demand, industrial pollutants, and human wastes.

So it's important that when we decide to use land for a specific purpose, we take into account water quality, not just in the immediate area, but downstream and upstream as well. This means considering the **amount** of water available as well as how it must be processed before and after use.

For example, crops require tremendous amounts of water. If there's not enough rainfall to support crop growth, they must be irrigated, which means transporting water from lakes, streams, or wells. Irrigation may require so much water that aquatic life in lakes and streams may be affected, or the water table may be lowered, causing wells to dry up. The complete water cycle must be considered for irrigation. Irrigation drainwater must be properly discharged or recycled to avoid causing pollution as well.

Another good example is the case of a paper mill on a small mountain river. Paper production requires lots of water, and the wastewater discharged back into the stream contains a large number of pollutants, including some toxic chemicals. A paper company might come under attack from environmental groups for this mill but receive praise for how mills are operated in other areas on larger rivers. One reason is the **amount** of water available for use. The small mountain river doesn't have enough flow to support the operation of the paper mill.

AGRICULTURAL IMPACTS

Agriculture can create serious demands on water supplies and cause several serious types of pollution, as salt and trace elements are leached from the soil. Runoff and seepage of agricultural chemicals like fertilizer, herbicides, and pesticides introduce nutrients, toxics, and sometimes bacteria into waterways and groundwater. Sediment, however, is the major pollution source from this land use.

Animal wastes can enter streams, ponds, or lakes in pasture lands in which animals have direct access to water, or wastes can be washed into streams by rain or enter groundwater through the soil. Animals produce large amounts of waste (cattle create about ten tons of manure per head yearly, swine about two tons), so pollution problems can be severe around large livestock farms. Nutrients, sediment, bacteria, and organic toxics can all come from these "natural" sources of pollution.

One practice for reducing erosion and sediment pollution from agriculture is conservation tillage. Instead of plowing under the residue from a previous crop and exposing bare soil, conservation tillage uses a disc or other device to cut through the residue so seeds can be planted. This process allows a protective layer of vegetation to remain on top of the soil to retard erosion and to retain more water in the soil. One negative is that this process may require increased use of herbicides. Another process, called ridge planting, puts seeds in ridges of plowed soil. This method allows warmer soil temperatures for planting and traps rainwater in the furrows between the ridges.

Agricultural extension services also provide soil testing to farmers so that fertilizers can be properly used. The tests indicate which nutrients may be needed for the type of soil and the crop being used so that over fertilization does not occur. Not only does this practice reduce pollution, it can reduce the cost of producing a crop.

Other best-use practices include crop rotation, which may replace a row crop with a grain or other plant that covers more ground and reduces erosion. Planning field layouts can also reduce erosion and sediment pollution by changing the direction of rows or creating runoff channels that allow sediment to settle before the runoff water is released into streams.

Waste management systems can be used to convert animal wastes to reusable resources such as fertilizer or methane for energy. A ton of animal manure is equal to about 100 pounds of high quality chemical fertilizer.

There is no one single system that is best for animal waste operations. Depending on the size and type of livestock and the potential for pollution, systems may need to be customized to a particular location. Considerations for system design include local environmental regulations, the number of animals, fertilizer needs, location of water sources and the location of residences around the livestock operation.

A waste management system has three basic components: collection, transportation, and storage or disposal. For some farms, a system may provide collection and transportation functions, with the wastes delivered to another location for storage or disposal. Collection methods vary, ranging from scraping to washing and flushing. Transportation methods include conveyors, pumps, wagons or manure spreaders.

Collection and storage methods are based on the principles of either keeping wastes for later use or providing a safe method for their treatment and disposal. Proper storage facilities are important because wastes can lose nutrients and fertilizer value. A common treatment facility is a lagoon. Anaerobic lagoons break down waste materials without oxygen or aeration. Aerobic lagoons break down waste material with oxygen. This type of lagoon creates less odor than anaerobic lagoons. Aerobic lagoons require more surface area. Both types reduce concentration of nutrients, making it safe to dispose of wastes by irrigation.

Other alternatives include collection of wastes and drying them for use as household fertilizers or even additions to silage for animal feeds, or as alternative fuel for energy.

URBAN IMPACTS

Densely populated urban areas, which are covered by non-permeable surfaces like streets, sidewalks and buildings, create a great deal of runoff. The high concentrations of people in these areas tends to produce greater quantities and varieties of pollutants, including nutrients, bacteria, and toxic chemicals. Automobiles and manufacturing are two primary sources of toxics.

Less densely populated suburban areas have three primary water contamination problems. The first is runoff and seepage of lawn and garden chemicals. These chemicals are often used in much higher concentrations than in agriculture, and they can wash off into storm sewer systems or percolate through soil into groundwater. Faulty septic systems are another source of pollution, which can produce nutrient, bacteria, and even toxic contamination. Many household chemicals like pesticides, herbicides, solvents, paints, and cleaners are so toxic that they would require specialized disposal in industrial situations. A third source of pollution is runoff from streets, driveways, and parking lots. This runoff contains large amounts of petroleum contaminants, as well as bacteria and nutrients.

Control of both point source and nonpoint-source pollution in urban and suburban areas is increasing. Tremendous investment by government and industry has helped control pollution problems immensely. Municipal sewage treatment facilities have grown faster than the nation's population. However, more improvements are still needed to make sure that water treatment systems can keep up with needs. Federal and state laws, beginning with the landmark 1972 Clean Water Act, are continually being developed that limit what types of contaminants can be released into water systems. These controls have stopped many of the fish kills and other problems associated with pollution in the 1970s. Many urban area lakes that were considered "dead" are now clean enough to support many fish species and other aquatic life.

Urban runoff is still controlled primarily by voluntary means, but cities have adopted new practices like leaf collection and street cleaning at critical times, that can reduce the flow of sediment and other contaminants into waterways. City planning places new emphasis on water conservation and source control, particularly in areas where water supplies may be limited. Detention-retention ponds have been incorporated into some water control systems to allow contaminants to settle, and to feed rainwater into runoff channels at a controlled rate. New Federal regulations may require cities and industry to combine storm sewers with city sewers to treat urban runoff if studies indicate urban runoff as a significant source of pollution.

In some cases, building codes limit construction based on water demand. A single new household consumes more than a hundred thousand gallons of water each year, placing more demand on water supplies and on wastewater and sewag[illegible]atment systems.

Education programs designed to teach people proper use of water and disposal of potential pollutants are also having a positive impact. These programs show people the staggering amounts of water they consume each day, and steps they can take to reduce consumption. Less consumption means less waste water that has the ability to carry pollutants.

INDUSTRIAL IMPACTS

Industrial impacts on water can be severe. Industry can introduce toxic chemicals into a stream or lake, either through manufacturing or through an accidental spill. Thermal pollution from power plants or factories can raise water temperatures and change the ability of the water to support life. Nutrients from detergents or other organic chemicals can cause nutrient pollution that chokes the life out of waterways.

Since most industrial pollution is point source pollution, cleanup efforts can be focused and effective. NPDES point source pollution control requires any industry that discharges a pollutant into a water supply to have a permit specifically to do so. Severe penalties are established for failure to have a permit or exceeding permit limits. Many industries are required to treat wastewater before releasing it back into streams.

Construction is an industry that can create nonpoint source pollution as well as point source pollution. Construction contaminates water in two ways. Sediment pollution can be created when plant cover is removed, with erosion occurring at much greater rates than for undisturbed land. Toxics from construction materials, such as paint, solvents, acids, and glues can also pollute water.

Construction must take into account both short term and long term water pollution management practices. Construction removes vegetation from the ground, inviting erosion and sediment pollution. Practices to reduce this include temporary measures such as diverting water flow through trenches or sediment ponds that allow silt and other materials to settle before water runs off into streams. Hay bales, mulch, and other materials may also be used as temporary controls, as well as the planting of temporary grasses to control erosion before more permanent landscaping can be done. Perennials or other long lasting vegetation can be used to provide more permanent ground cover for sites that won't be landscaped.

One key to success in best use practices for construction is proper site planning. The type of soil, the location of streams, and the topography of the area must all be considered before the construction process begins. Permanent measures may have to be taken to ensure that slow erosion doesn't create problems several years in the future. These measures may include storm drains; "riprap," a permanent layer of stone that retards water flow and enhances infiltration; or even construction of grassed or lined waterways that convey excess storm water away from developing areas or critical slopes. The construction process itself may be modified to include a stone "pad" at the construction entrance to reduce the transportation of mud off the building site by vehicles or runoff.

FORESTRY IMPACTS

Forests are one of the least-polluting land uses. However, chemicals like insecticides used on tree farms can soak into groundwater or wash into streams. Logging can cause erosion and sediment pollution, particularly if care is not taken in cutting logging roads and planning loading and stacking areas. Forestry has different environmental impacts in different parts of the country.

Forestry practices have been modified voluntarily and by law to reduce their pollution potential. To reduce soil erosion, many logging companies now employ buffer zones and streambank protection procedures which reduce erosion and other impacts on the land. Many forest products companies have found that proper land management can actually increase their profits by increasing forest yields.

For softwoods like pine, which are used for paper production and lumber, forest product companies manage their own "plantations" of timber, replanting several trees for every one cut down. This has increased the amount of usable timber available in the U.S., and has reduced the potential of pollution. Site planning is now an important consideration. Logging road paths may wind around hills to reduce erosion and allow natural growth to quickly "retake" the land after cutting is finished.

MINING IMPACTS

Improper mining can threaten ground and surface water supplies. Sediment, toxics, and rubble from mines are water contaminants. Rainwater running through discarded mine material (tailings) can become acidic, poisoning aquatic plant and animal life.

Mining is one activity that is specifically regulated as a potential source of pollution. Since 1965, more than three million acres of land have been disturbed by strip mining activities. Severe problems have been created by erosion and acidity. However, mined lands must now be "reclaimed," or restored to acceptable condition after operations are complete.

The practices included in this process are preplanning to determine how the site will be used after operations are finished, stabilization of the site while work is in progress so that it does not create an immediate source of pollution, creation of storm water control and storage, and re-creation of natural beauty by replanting the site so it has minimum aesthetic impact on the area. Since mining can destroy topsoil, new soil or nutrients may need to be added before plants can thrive, or different vegetation requiring less nutrients may be used to start growth.

Underground mines can also be pollution sources, particularly for groundwater. These are also subject to reclamation and laws require that steps be taken to keep sediment or toxics from entering waterways.

COMMERCIAL BUSINESS IMPACTS

We normally think of major industries as creating the most pollution, but small business can also be pollution sources. In fact, many small businesses may pollute and not realize it. Local garages that dump waste oil instead of collecting it can be serious contributors to water pollution. A single quart of oil can pollute as much as 250,000 gallons of water. Photo labs can be sources of heavy metal pollution, such as silver. Dry cleaners use a variety of solvents that can be toxic. And trash created by businesses that goes into landfills can ultimately result in water pollution.

Many smaller businesses have voluntarily adopted approaches to reduce pollution. Recycling of automotive wastes is becoming standard practice for many garages, and other businesses regularly practice recycling of a variety of materials to reduce costs and waste. Businesses such as photo labs that create water pollution have installed systems that recover silver by electroplating to be used again and reduce potential water pollution. Laws regarding toxic substances also apply to small businesses, and many wastes that used to be dumped into water supplies are now collected for proper disposal.

RECREATION IMPACTS

Recreation can impact surface water in a number of ways. Boating traffic can create pollution from petroleum products. Too many people can damage waterways and destroy habitats. Litter and other refuse can find its way into streams and cause pollution. Proper management of recreation areas, education programs to help people understand proper land use, and laws that prevent land misuse are ways to control problems associated with recreation.

SURFACE WATER ISSUES

ACID RAIN

The water cycle helps renew water as a pure resource. But the flow and cycling of water can also help spread pollution sources.

Acid precipitation is a prime example. Air pollution from industrial sources and automobiles releases sulphur oxides and nitrogen oxides into the air. When mixed with water vapor, they form sulfuric and nitric acids, which fall to the ground in the form of acid rain, snow, fog, or dew. Acid precipitation can cause damage to buildings, car finishes, crops, and forests.

This acid precipitation can also pollute clean waterways through runoff. Increased acidity of water can negatively affect fish and other aquatic life. The effects of acid precipitation may not be felt for many months. Acidic snowmelt may create acid "shock" in a stream and cause serious fish kills in the Spring.

NONPOINT SOURCE POLLUTION

Water pollution is identified in two categories. **Point source pollution** is contamination that comes from a single, clearly identifiable source, such as a pipe which discharges material from a factory into a lake, stream, river, bay, or other body of water. Point source pollution could also include stormwater runoff that is channeled from a drain directly into a waterway, or even a polluted tributary that regularly adds contaminants to a body of water. Point source pollution is relatively easy to identify.

Nonpoint source pollution is more difficult to identify. This is pollution which originates over a broad area from a variety of causes. Examples of nonpoint source pollution include improper application of pesticides and fertilizers; sediment from construction and logging; leachate from landfills and septic tanks; petroleum-based products from streets and parking lots; and atmospheric fallout. Because of its dispersed sources, this type of pollution can be difficult to control.

GROUNDWATER

Groundwater begins with precipitation that seeps into the ground. The amount of water that seeps into the ground will vary widely from place to place, depending on slope of the land, amount and intensity of rainfall, and the type of land surface. Porous, or permeable, land containing lots of sand or gravel will allow as much as 50 percent of precipitation to seep into the ground and become groundwater. In less permeable areas, as little as five percent may seep in. The rest becomes runoff or evaporates. Over half of the fresh water on Earth is stored as groundwater.

As water seeps through permeable ground, it continues downward until it reaches a depth where water has filled all the porous areas in the soil or rock. This is known as the **saturated zone**. The top of the saturated zone is called the **water table**. The water table can rise or fall according to the season of the year and the amount of precipitation that occurs. The water table is typically higher in early Spring and lower in late Summer. The porous area between the land surface and the water table is known as the **unsaturated zone**.

AQUIFERS

Water bearing rock, sand, gravel, or soil that is capable of yielding usable amounts of groundwater is called an **aquifer**. The water yield from an aquifer depends greatly on the materials that make it up. Mixtures of clay, sand, and fine particles yield small amounts of water because the spaces between the particles don't allow water absorption and flow. Materials sorted into distinct layers will yield high amounts of water from coarse-grained materials like large sand grains and gravel, but low amounts from fine-grained sand, silt, or clay. Bedrock aquifers will yield substantial amounts of water if there are large openings or cracks in the rock. The capacity of soil or rock to hold water is called its **porosity**; the capacity for water to move through the aquifer is called **permeability**.

There are two types of aquifers: **confined**, or **artesian** aquifers, and **unconfined**, or **water table** aquifers. Artesian aquifers contain groundwater that is trapped under impermeable soil or rock and may be under pressure. **Artesian wells** are wells that pierce artesian aquifers. The water in these wells usually rises toward the surface under its own pressure. If the water level in the well is higher than the land surface, it may be a flowing artesian well. A well in an unconfined aquifer has the same water level as the water table around it.

GROUNDWATER RECHARGE

Water that seeps into an aquifer is known as **recharge**. Recharge comes from a variety of sources, including seepage from rain and snow melt, streams, and groundwater flow from other areas. Recharge occurs where permeable soil allows water to seep into the ground. Areas in which this occurs are called **recharge areas.** They may be small or quite large. A small recharge area may supply all the water to a large aquifer. Streams that recharge groundwater are called **losing streams** because they lose water to the surrounding soil or rock.

GROUNDWATER DISCHARGE

Groundwater can leave the ground at **discharge points**. Discharge happens continuously as long as enough water is present above the discharge point. Discharge points include springs, stream and lake beds, wells, ocean shorelines, and wetlands. Streams that receive groundwater are called **gaining streams** because they gain water from the surrounding soil or rock. In times of drought, most of the surface water flow can come from groundwater. Plants can also contribute to groundwater discharge, because if the water table is close enough to the ground, groundwater can be discharged by plants through transpiration.

GROUNDWATER MOVEMENT

Groundwater usually moves slowly from recharge areas to discharge points. Flow rates within most aquifers can be measured in feet per day, though in Karst bedrock the rate of flow can be measured in miles per hour. Flow rates are faster when cracks in rocks or very loose soil allow water to move freely. However, in dense soil, groundwater may move very slowly or not at all.

Groundwater typically moves in **parallel paths**, or layers. Since movement is slow, it doesn't create enough turbulence to cause the mixing of groundwater, so layers of groundwater remain relatively intact. This can be an important factor in locating and determining the movements of contaminants that might enter the groundwater supply. But eventually contaminants will disperse through part or all of an aquifer.

Wells affect groundwater flow by taking water out of an aquifer and lowering the nearby water table. Removed water is recharged from the water table, and the lowered water table caused by the well is called a **cone of depression**. The cone of depression from a well may extend to nearby lakes and streams, causing the stream to lose water to the aquifer. This is known as **induced recharge**. Streams and wetlands have been completely dried up by induced recharge from well pumping.

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GROUNDWATER PROBLEMS

SOURCES OF GROUNDWATER CONTAMINATION

Groundwater contamination can come from a number of natural and man-made sources. These can include:

***Leaks and spills at factories and commercial facilities**

Spills and leaks can be caused by accidents, lack of employee training, inadequate maintenance, and/or not having proper procedures in place to contain and clean up spills if they do occur. Spills may include gasoline or petroleum products, hazardous chemicals, or a variety of other materials.

It's difficult to eliminate accidental spills, but the damage they cause can be reduced by proper design and maintenance of facilities and proper employee training. The Emergency Planning and Community Right-to-Know Act of 1986 (SARA Title III) requires businesses to have plans for responding quickly in the event of an accidental spill. Workers are informed as to what hazardous chemicals they may be working with, and what to do in case of an accident. This act has prevented or reduced many instances of groundwater contamination.

***Improper industrial waste disposal**

Improper industrial waste disposal can come from a variety of sources, including major industrial plants and small businesses. The local dry cleaner uses a number of solvents and hazardous chemicals for cleaning clothes, and these must be handled as carefully as any other hazardous waste to prevent groundwater contamination. Industrial wastes can create groundwater pollution problems that take years to resolve.

The disposal of hazardous industrial wastes is now carefully regulated under the Resources Conservation and Recovery Act (RCRA), which requires industry to have a "cradle to grave" system of tracking hazardous wastes. This system is designed to prevent inadvertent (and sometimes purposeful) release of hazardous materials into the environment by requiring businesses to report wastes and account for their proper disposal. The law establishes severe penalties for noncompliance. Another Federal law, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) responds to environmental threats from improper disposal of hazardous wastes and sets standards for cleanup—even for sites that were contaminated years ago where the source of contamination may not be easily identifiable.

Individuals can also be sources of hazardous waste pollution If you dump oil in your driveway, pour paint thinner in the toilet or dispose of wastewater with hazardous cleaners in the bathtub, you could be a source of hazardous pollution. Ways to avoid this are to recycle oil and other petroleum based chemicals at service stations or recycling centers. Avoid using hazardous chemicals when possible and substitute more environmentally friendly materials. Many communities sponsor household chemical disposal days so that individuals can take solvents and other hazardous wastes to a site for proper disposal.

***Improper use and disposal of pesticides**

Pesticides used on farms and even on individual lawns can create serious groundwater pollution. Improper pesticide use can cause people and animals to become ill, kill plants, and have adverse effects on aquatic life in nearby streams. Improper pesticide use can include excessive or ill-timed application, improper storage, or improper disposal of excess pesticides. If you overuse pesticides on your yard, you could be polluting your own groundwater. It's been estimated that individuals use over 100 times as much pesticides and fertilizer on their yards as farmers use on the same amount of land.

Avoiding pesticide pollution of groundwater is relatively easy. Follow instructions carefully. Reduce pesticide use in areas known to be recharge areas for groundwater. Use natural pest control methods rather than chemicals. Homeowners can substitute biocontrol agents, like praying mantises or ladybugs, for pesticides. Other natural insect repellents include plants like mint (which discourages ants), garlic, and marigolds.

***Leachate from landfills**

If landfills are not properly constructed, liquid from decomposition of materials, or **leachate**, can leak out of the landfill into an aquifer. Leachate can contain high levels of bacteria, hazardous chemicals, metals, and ammonia. Runoff water from landfills after rains can also carry pollution to groundwater recharge areas—and hence into groundwater.

New landfill construction methods are designed to prevent pollution of groundwater. Landfills now are built with liners to prevent leachate from seeping through soil into aquifers. Leachate collection systems store the liquid away from the water table. Clay caps prevent rainwater runoff from carrying pollutants from the landfill into the groundwater.

***Septic systems**

Septic systems can be a source of groundwater pollution if too many systems are located in an area, if a system is overloaded, or if a system is improperly used for disposal of chemicals or other materials. If a septic system is not working properly, it can contaminate groundwater with bacteria, viruses, and hazardous cleaning materials or household chemicals. Even properly working well-maintained septic systems can contribute nitrates to groundwater. These can show up in well water around the septic system.

Methods of preventing groundwater pollution from septic systems include proper system installation and maintenance. If the concentration of households in an area is too great, then a public sewer and waste treatment system may be necessary. Dumping hazardous chemicals into septic systems should also be avoided.

***Saline Intrusion**

In coastal areas, too much demand on potable groundwater can create induced recharge from ocean waters, resulting in saline intrusion into groundwater supplies. This can also happen in times of severe drought. (Induced recharge can not only contaminate groundwater, but enough induced recharge has been known to dry up wetland areas and destroy habitats for wildlife.)

Careful planning of coastal communities and water conservation are ways to avoid saline intrusion into groundwater supplies.

***Salts and chemicals used to de-ice roads**

In northern climates, tons of salt and other chemicals are used for de-icing roads, and these can create groundwater contamination problems. Runoff from storage areas and highways can seep into the ground and cause high levels of chlorides in well water. Prevention of pollution from this source can be through protection of storage areas, minimal salt use, and substitution of other materials, such as sand or gravel.

***Liquid waste storage lagoons**

Storage lagoons are used by industries, farms, cities, and mines as a way of preventing pollution by allowing solid wastes to settle before wastewater is released. However, storage lagoons can cause groundwater pollution if they leak or overflow. They can be sources of bacterial or chemical groundwater pollution.

Groundwater contamination from lagoons can be avoided through proper installation and maintenance and by locating lagoons away from sensitive groundwater areas.

***Fertilizers**

Like pesticides, misuse of fertilizers can cause groundwater pollution. Overuse can allow nitrates from fertilizer to seep into the water table. In sensitive groundwater areas, rainfall seepage can cause fertilizer to migrate and contaminate an aquifer.

Careful use can avoid or minimize these problems.

***Animal wastes**

Animal wastes are sources of bacteria and nitrates. They can contaminate groundwater if too many animals are located in too small a lot, or if the lot has improper drainage. Lagoons used to trap animal wastes can be a source of groundwater pollution if they leak or if the water table is too close to the land surface. Proper siting of animal lots, along with regular cleaning and avoiding overloading, can prevent animal waste pollution. Wastes can be recovered and used as fertilizer.

***Leaking underground storage tanks**

Leaking underground tanks are a large groundwater pollution problem. And no one is really sure how large the problem will be. It's been estimated that the locations are known of only about **half** the underground storage tanks in the U.S. Many of these are old, corroded, and beginning to leak and cause problems. Underground storage tanks are common for service stations, and gasoline pollution is a big pollution problem. Many stations have replaced old steel tanks with fiberglass tanks that don't corrode.

Federal law now requires specialized installation of storage tanks so that they have a secondary containment system should the primary tank fail. Careful monitoring of tank inventories can be used to detect leaks and correct them, and tanks that are no longer in use can be removed or filled with inert materials to prevent water from pooling in them, becoming contaminated, and leaking out.

***Pipeline breaks**

Pipeline breaks can be sources of localized groundwater pollution. Breaks can be severe enough so that they are immediately detected, or they may be small and cause significant groundwater contamination before they are noticed. Pipeline breaks can cause pollution from sewage, petroleum products, or other chemicals. They can occur around roadways due to vibration from vehicles, or they can even be caused by plant roots, which slowly crack pipes and cause leaks. Careful inspection of pipelines and regular maintenance can reduce pollution problems from this source.

***Inadequately sealed wells or abandoned wells**

It's sometimes difficult to imagine wells, our chief way of tapping into groundwater supplies, as a source of groundwater pollution, but they can be pathways for pollutants to enter the groundwater system. If a well isn't sealed or cased properly, polluted water from runoff can enter at the well cover or along its walls and be channeled directly into groundwater. Open abandoned wells can be a significant source of groundwater pollution. And if a well is deep enough to reach a layer of groundwater that is otherwise protected by impermeable soil from pollution from surface seepage, it can create severe contamination of an otherwise pure water source.

Groundwater pollution from wells can be prevented by properly sealing wells which will no longer be used with concrete or earth. Well covers and tight casings are used as temporary measures. Procedures have also been developed to properly seal and plug abandoned wells.

***Underground injection wells**

Underground injection wells are a method of waste disposal. Wastes disposed by this method include industrial chemicals, sewage effluent, cooling water, storm water, and salt water. Typically, injection wells inject wastes below sources of drinking water, but if injection wells have leaks or are used improperly, they can inject wastes directly into the usable groundwater supply.

Injection wells are carefully monitored by state and Federal regulations to prevent pollution. Businesses using injection wells are required to have permits for their use.

***Radon contamination**

Radon is a naturally occurring radioactive element that has been linked to cancer in humans. It occurs in certain geologic areas, and can be an air or water pollutant. Radon can collect as a gas in a basement, or it can contaminate well water. Test kits for radon detection are available for individual use. Once detected, radon can be removed from a home or a water well.

COASTAL WETLANDS

IMPORTANCE OF COASTAL WETLANDS

Coastal wetlands provide a wide variety of important functions, including:

Water quality. Some wetlands contribute to improving water quality by removing excess nutrients and many chemical contaminants.

Barriers to waves and erosion. Coastal wetlands reduce the impact of storm tides and waves before they reach upland areas.

Flood storage. Coastal wetlands can store floodwater and release it slowly, lowering flood peaks.

Sediment control. Reduced flood flow provided by coastal wetlands allows floodwater to deposit sediment.

Wildlife habitat. Coastal wetlands can support wide varieties of wildlife.

Fish and shellfish. Coastal wetlands are important spawning and nursery areas for fish and shellfish, and provide good sources for commercial fishing.

Sanctuary for rare and endangered species. Protection of wetlands often means providing good habitats for endangered animals. An estimated 43 percent of the threatened and endangered species in the U.S. rely directly or indirectly on wetlands for their survival.

Aesthetic value. The natural beauty of wetlands is a source of visual enjoyment.

Education and research. The rich ecosystems of wetlands are natural locations for biological research and observation.

Recreation. Wetlands provide sites for hunting, fishing, and observing wildlife.

Food production. Wetlands have potential for the production of plant products, including marsh vegetation, and for aquaculture. Wetlands also produce great volumes of food in the form of decaying plant and animal matter or detritus. Detritus is consumed by many aquatic invertebrates and fish which are food for game fish, waterfowl, and mammals.

Water supply. With the growth of urban areas, wetlands are becoming more valuable as sources fr water supply.

COASTAL HABITATS

Coastal salt water wetlands contain a number of habitats. **Marine intertidal** habitats are near the shoreline and are flooded by tidewaters. **Estuarine sub-tidal** habitats are open water and bay bottoms that are continuously covered by salt water. **Estuarine intertidal emergents** are salt marsh areas that are covered by vegetation during the growing season. **Estuarine intertidal forested/shrub** habitats contain larger woody plants. **Estuarine intertidal unconsolidated shores** are beaches and sand bars, and **estuarine unconsolidated bottom** habitats are open water estuaries. **Riverine** habitats are tidal or non-tidal river systems that feed into wetlands.

ESTUARIES

Estuaries form where rivers meet oceans. Estuaries are deep water tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open or at least some access to the open ocean. Ocean water in estuaries is partly diluted by freshwater runoff from rivers, but the salinity of still waters in estuary wetlands may be occasionally higher than that of the ocean due to evaporation.

BAYS

Bays are large estuarine systems. The Chesapeake Bay is the largest estuary in the United States and one of the most productive biological systems in the world. The bay is approximately 200 miles long and ranges from 4 to 30 miles wide, but averages a depth of only about 28 feet. This makes it ideal for shellfish and other productive fish species, but it alsc akes it sensitive to natural changes in temperature and wind and man-made pollution. Other key bays in the United States include Puget Sound in Washington, Long Island Sound in New York, Albemarle/Pamlico Sounds in North Carolina, and San Francisco Bay in California.

COASTAL WETLANDS BENEFITS TO HUMANS

Coastal wetlands are critical to human food supplies. About 66 percent of the commercial fish catch taken along the Atlantic and Gulf coasts depends on wetlands for survival. Coastal wetlands produce millions of tons of organic matter that provide food for invertebrates, shellfish, and small fish that are in turn food for larger commercial fish such as bluefish and striped bass. Most freshwater fish feed upon wetland produced food and use wetlands as nurseries for their young. Waterfowl hunters spend over $300 million annually to harvest wetland-dependent birds. Wetlands also provide blueberries, cranberries, and wild rice. And wetlands have further potential for contributing to the food supply, through the harvesting of marsh vegetation and aquaculture.

FRESHWATER WETLANDS

Like saltwater coastal waters, freshwater wetlands offer a variety of benefits, including:

Water quality. Some wetlands contribute to improving water quality by removing excess nutrients and many chemical contaminants. They are sometimes used in tertiary treatment of wastewater.

Flood conveyance. Wetlands can form natural floodways that allow floodwater to move downstream without causing damage.

Flood storage. Wetlands can store floodwater and release it slowly, lowering flood peaks.

Wildlife habitat. Inland wetlands can support wide varieties of wildlife.

Sanctuary for rare and endangered species. Protection of wetlands often means providing good habitats for endangered animals. An estimated 43 percent of the threatened and endangered species in the U.S. rely either directly or indirectly on wetlands for their survival.

Aesthetic value. The natural beauty of wetlands is a source of visual enjoyment.

Recreation. Wetlands provide sites for hunting, fishing, and observing wildlife.

Education and research. The rich ecosystems of wetlands are natural locations for biological research and observation.

Water supply. With the growth of urban areas, wetlands are becoming more valuable as sources for water supply. Some wetlands help recharge ground water supplies.

Food production. Wetlands have potential for the production of marsh vegetation and aquaculture.

Timber production. Properly managed, wetlands can provide good sources of timber.

Historical value. Some wetlands were locations for Indian settlements and provide significant historical and archeological value.

WETLAND HABITATS

Freshwater wetland habitats include **palustrine forested**, or forested swamps and bogs; **palustrine shrub**, or shrub wetlands; **palustrine emergents**, or inland marshes and wet meadows; **palustrine unconsolidated shores**, or freshwater shores and sand bars; **palustrine unconsolidated bottom**, or open water ponds; **palustrine aquatic beds**, or floating aquatic or submerged vegetation; and **lacustrine**, or lake and river habitats.

COASTAL WETLANDS ISSUES

EROSION

Erosion poses a problem fc shorelands by removing soils and sediment that support plant and animal life. Erosion can strip away important sediment layers and change the habitat's ability to support life. Extreme erosion can create stream flows that drain coastal wetland areas.

DREDGING AND COASTAL WETLAND LOSS

Dredging, filling, and draining of wetlands has destroyed hundreds of thousands of acres of coastal habitat. Also, dredged materials from navigation channels are often deposited alongside streams in wetland areas. For many years, it was thought good land practice to improve wetland "wastelands" by filing them in or draining them for mosquito control.

Wetlands are now protected by Section 404 of The Clean Water Act. Under this law, the discharge of dredged or fill materials into the waters of the U.S. requires a permit from the Army Corps of Engineers. This has prevented the loss of many wetlands, however, wetland loss and degradation continue to be a significant environmental concern.

RED TIDE

Red tide is a natural phenomenon brought on by too many nutrients in the water which can cause uncontrolled growth of microscopic organism or type of plankton called a dinoflagellate. These organisms can multiply to the point where water actually looks red. The organisms contaminate shellfish, making them unsafe for human consumption. Red tide can also cause fish kills and damage vegetation.

NONPOINT SOURCE POLLUTION IN BAYS

Nonpoint source pollution is a problem for bays as well as any other waterway, but here its consequences can be more severe. Since bays are typically shallow, nonpoint source sediment pollution can quickly fill and clog waterways and wetland areas. Sediment can also cause temperature changes that can reduce oxygen levels and kill marine life.

Nutrient pollution from farmlands can also create havoc in bays. Algal blooms from nonpoint source pollution can have similar effects of reducing oxygen levels and killing existing life. And toxic pollution can quickly settle into shallow bay waters and infiltrate productive fishing and spawning beds, killing or contaminating fish and plant life.

DEVELOPMENT OF COASTAL AREAS

Coastal development has been and continues to be a major threat to wetlands. Coastal property has high real estate value, and developers find it difficult to preserve wetland areas when faced with profit potential from private wetland areas. And even if wetlands aren't destroyed during development, the additional pollution from development can disrupt the delicate environmental balance of wetlands, changing habitats forever. The nation's largest estuary, Chesapeake Bay, suffers many environmental problems as a result of extensive development within its watershed.

OCEAN DUMPING AND SPILLS

Ocean dumping and accidental spills pose a severe pollution problem, and many coastal areas have received significant environmental damage. A number of Federal laws are now in place to protect the coastal environment.

*The Clean Water Act, which sets limitations on pollutant discharge and sets penalties for noncompliance.

*The Oil Pollution Act, imposes substantial penalties and liability for oil spills. Violators are responsible for the cost of cleanup and restoration of natural resources.

*The Comprehensive Environmental Response, Compensation, and Liability Act, which authorizes the government to force responsible parties to clean up or contain hazardous wastes.

*The Resources Conservation and Recovery Act, which requires permits for hazardous waste management and imposes severe criminal and civil penalties for violations.

*The Marine Protection, Research and Sanctuaries Act, which regulates dumping of materials into ocean waters and requires permits for ocean dumping. Civil and criminal penalties are established for violations.

*The Act to Prevent Pollution From Ships, which regulates the discharge of oil, noxious liquid substances, or garbage generated during normal operations of vessels.

*The Rivers and Harbors Act of 1899, which prohibits the discharge of refuse of any kind into navigable waters.

DESTRUCTION OF WETLANDS

At the time of European settlement, it is estimated that over 200 million acres of wetlands existed in the United States. In 1975, wetlands were estimated to be 99 million acres. Iowa, for example, has lost 99 percent of its wetland areas. Many wetlands have been converted to agricultural areas, and wetlands have also been lost to real estate development and conversion to forested areas for timber production. Laws used to encourage wetlands destruction for "useful purposes."

Wetlands are still being destroyed at an alarming rate, but there is a new awareness of wetlands value, and an increased interest in preserving wetland areas. Some wetlands have been restored, and governments and private groups have begun purchasing wetlands areas for conservation. Future amendments to laws such as the Clean Water Act are expected to focus on protecting existing habitats.

PROTECTION OF WETLANDS

Because so many acres of wetlands have been lost, Federal and state governments have worked hard to establish ways to protect and revitalize remaining coastal areas and wetlands. Private concerns have also worked toward wetland preservation.

Approaches toward wetlands protection have included acquisition of wetland areas, both by governments and private groups such as The Conservation Foundation and The Nature Conservancy. Buying duck stamps at the post office also raises money for wetlands conservation. Economic incentives for wetland preservation have included tax reductions and deductions for wetland donation, and economic **disincentives** to wetland destruction have also been put in place. A provision of the Food Security Act eliminates farm program benefits for wetlands converted into farmlands.

Specific regulation of wetlands comes with Section 404 of the Clean Water Act, amended in 1987. Under this law, the discharge of dredged or fill materials into the waters of the U.S. requires a permit from the Army Corps of Engineers. This has prevented the loss of many wetlands, but it is not a comprehensive program for protection. For example, some isolated yet ecologically valuable wetlands are not regulated.

Most coastal states have laws in place to protect coastal wetlands, but fewer than 20 states have enacted provisions to protect inland wetland areas. The National Estuary Program, established in 1985, now includes 12 of the nation's largest estuaries and addresses problems affecting the estuaries, such as loss of habitat, contamination of sediments by toxic materials, depletion of oxygen, and bacterial contamination. Management plans for each estuary are due to be completed in the early 1990s and steps taken to restore their environmental—and economic—benefits.

RESTORED WETLANDS FOR HABITAT

An estimated 43 percent of all rare and endangered animal species are either located in wetland areas or are dependent on them. Government agencies have recently undertaken restoration of wetlands in large-scale projects. One example is the restoration of thousands of acres of floodplain marsh along Florida's Kissimmee River. Some wetland habitats, such as freshwater marshes are relatively easy to reproduce and regenerate, while others, such as high salt marshes and forested wetlands, may take generations to recreate.

The restoration of wetlands habitats is a young and very complex science that will take years to understand fully. Wetland restoration must overcome a variety of problems, such as financial considerations, invasion of unwanted vegetation, proper water recharge and sediment control, and interaction of wetlands with adjacent waterways.

WATER RELATED CAREERS

Hydrology and other water related careers offer rewarding and challenging work. Water related careers include:

***Chemistry.** Chemists analyze water and determine contaminants that affect its quality. This may involve testing at water treatment plants or analysis of groundwater to see if pollutants have moved through groundwater supplies. Chemistry requires a college education, and quite often, post-graduate work to qualify for more advanced jobs.

***Engineering.** Now more than ever, water is an engineering function. Major engineering projects require environmental impact studies and city development may be based on the ability to engineer around available water supplies. Engineers also control surface water flow for navigation, recreation, and power generation.

***Utilities.** Wastewater treatment and management is a field growing in importance and complexity and we work to clean water even more before returning it to nature. Water specialists for utilities become involved with plant operations, planning, emergency procedures, and maintenance of the nation's water plants.

***Forestry.** Forest and wetlands contain many water resources. How we manage them will govem our water supplies in the future. Forestry jobs related to water can include timber harvest planning to avoid pollution problems, watershed protection, and water analysis to identify and control pollution problems.

***Agriculture.** Water is essential for agriculture, and as water supplies dwindle, their management in agriculture becomes more important for irrigation purposes and to prevent pollution from agricultural sources. Agricultural pollution tends to be nonpoint source pollution that is still difficult to spot and control. Agricultural careers involving water could even include developing plant species that require less water to produce.

***Biology.** Since water is necessary for all life, biologists must consider water supplies and water quality when considering any life form. Biologists can be involved in drinking water and wastewater treatment, land management, and other key water-related job functions. Specialized jobs include oceanographer, fisheries biologist or limnologist.

There are dozens of other water-related jobs and careers. These can include service in the Coast Guard, Marines, Army Corps of Engineers, or Navy; commercial fishing; wastewater treatment plant technician; water meter reader; construction (such as plumbing or septic system installation); service in the merchant marine; meteorologist or weatherperson; bottled water supplier; lifeguard; fishing or rafting guide; and others. Almost any career or job has some relationship to water or the water supply.

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