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

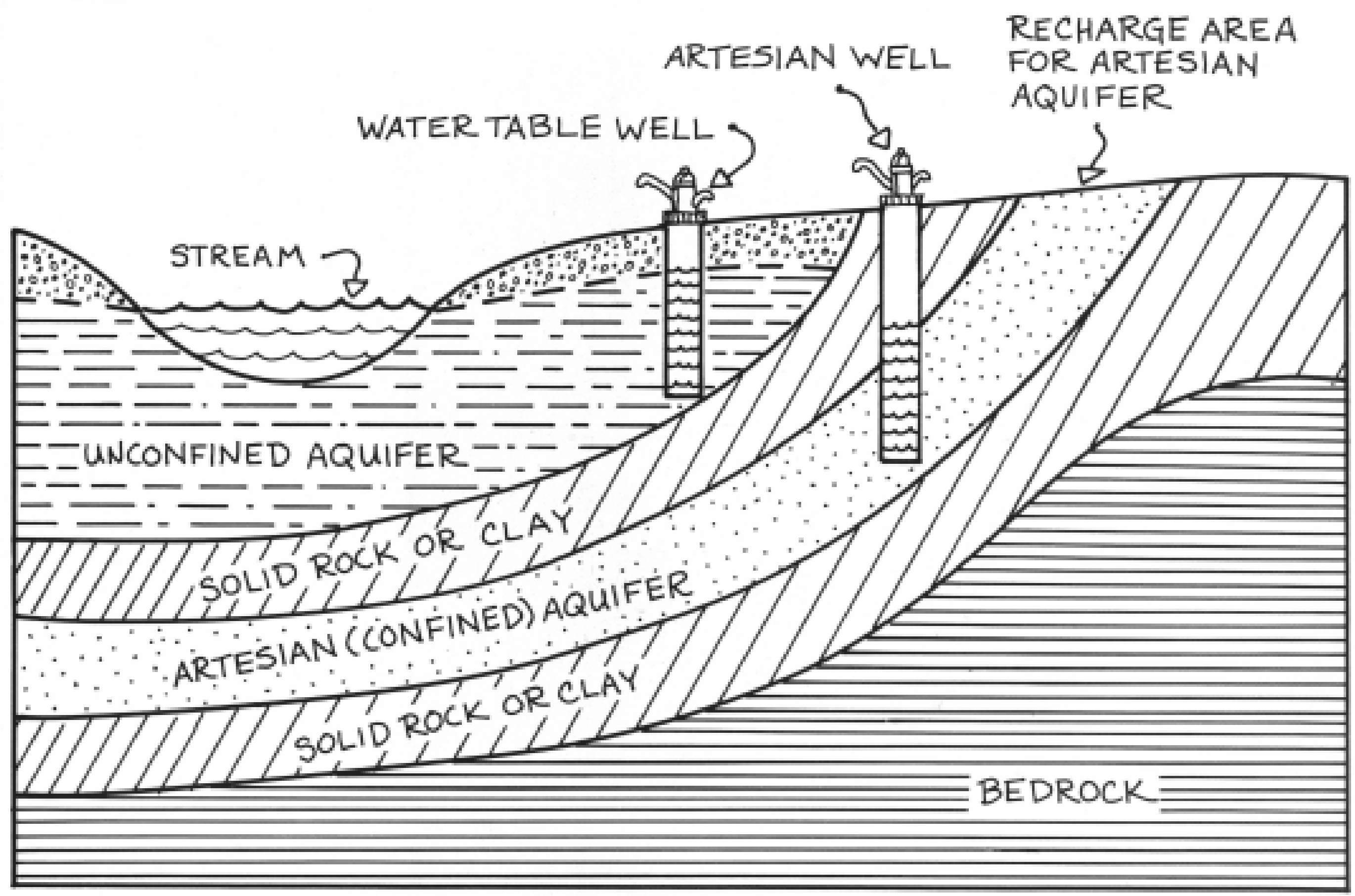
Branley, F. M., Water for the World, T. Y. Crowell, New York, 1982.

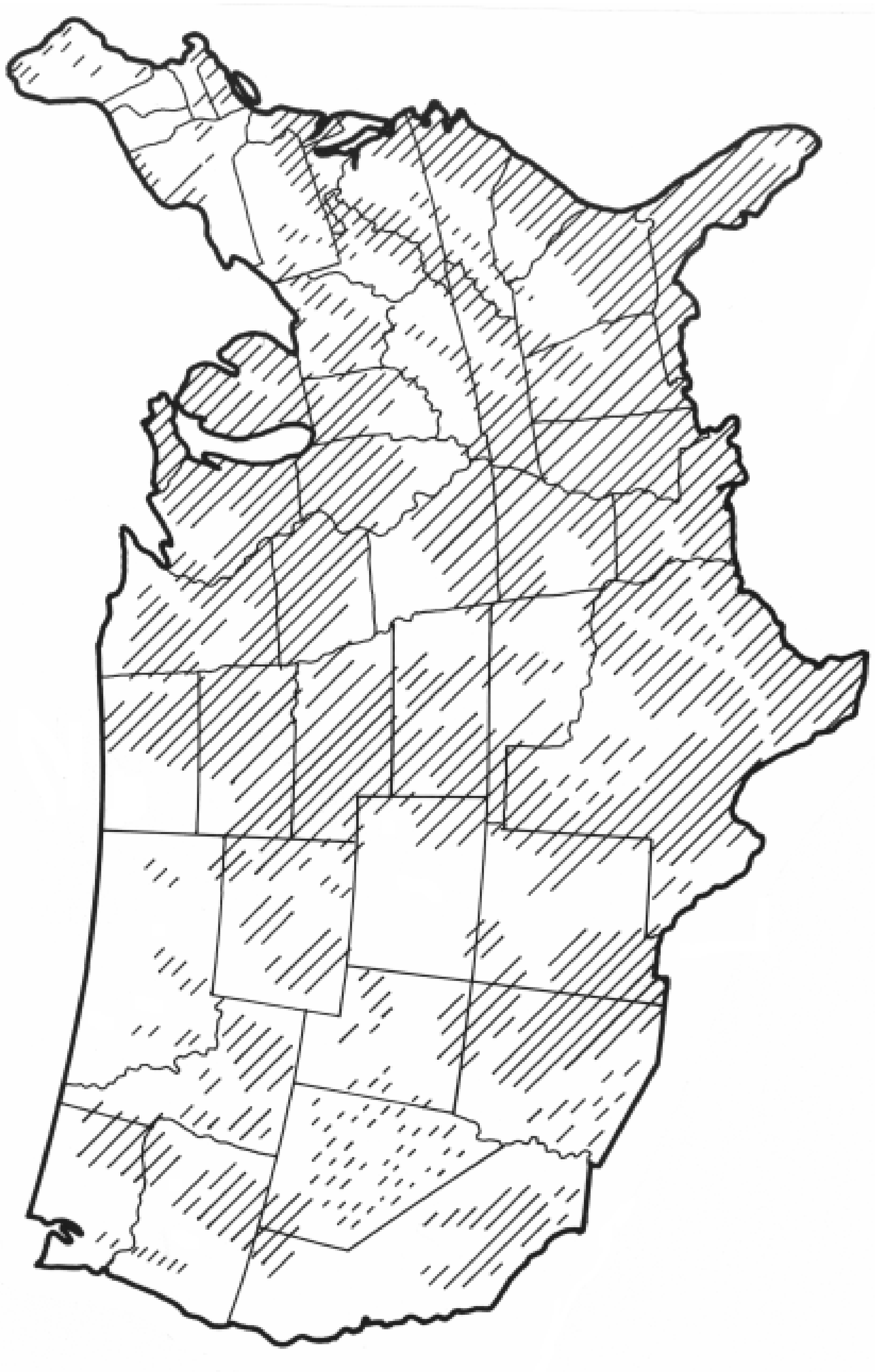
"Ground Water: Issues and Answers," American Institute of Professional Geologists, Arvada, Colorado, 1984.

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





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.

<u>Terms</u>

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 Ground Water 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.

Teacher Sheet

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).

Student Sheet

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?_______________________

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 60 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 plastic 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

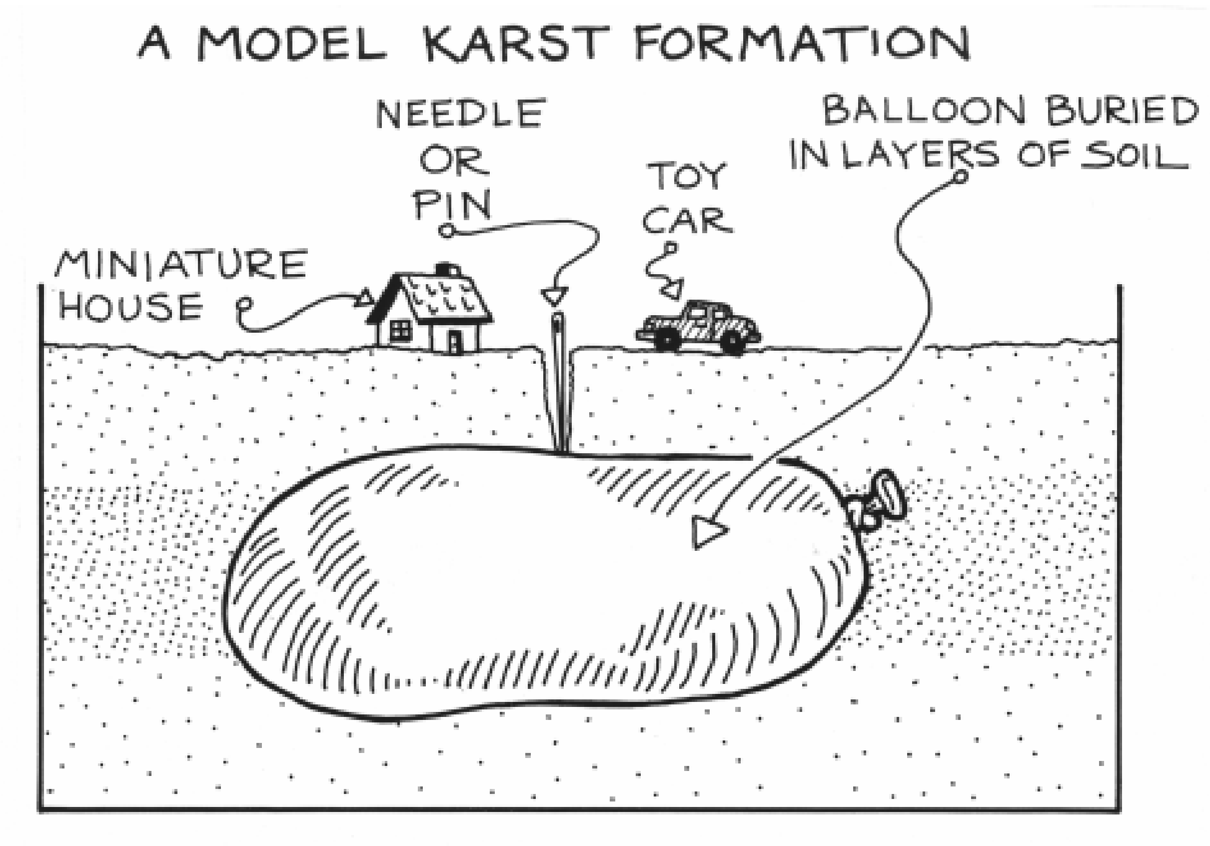
A. Have the students define groundwater, aquifer, and karst formation in their own words.

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

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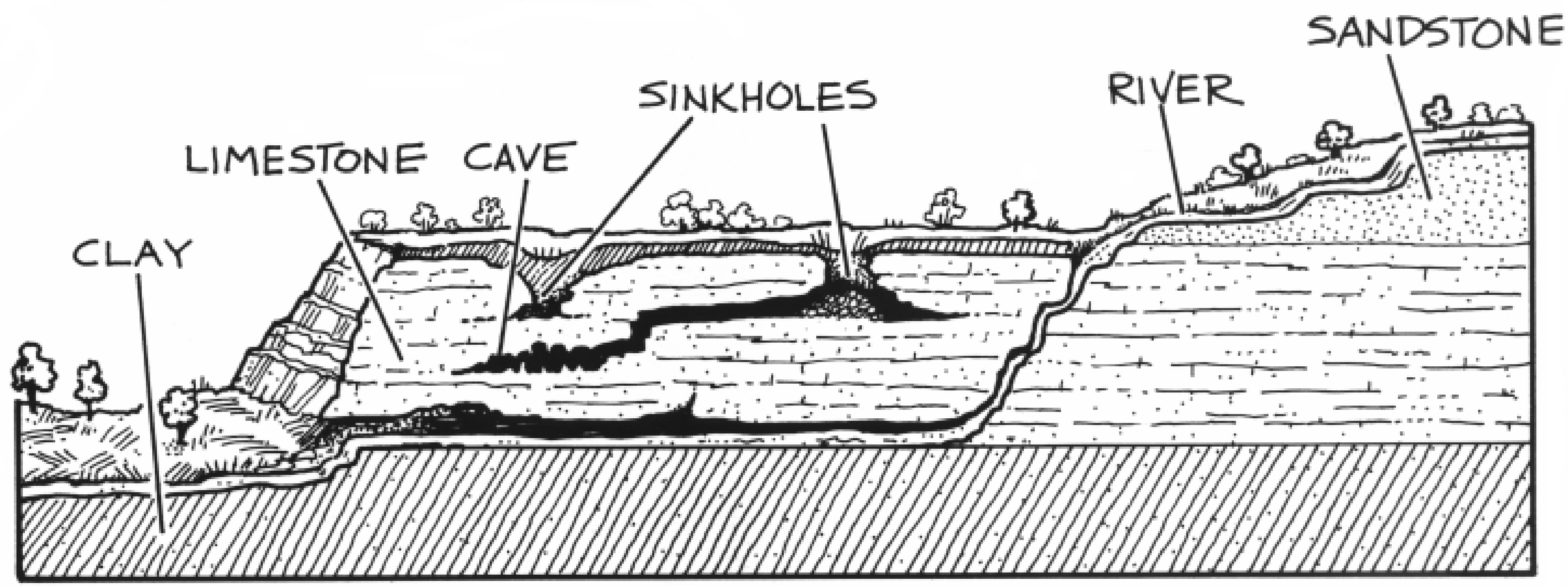
Namowitz, Samuel N., and Nancy E. Spaulding, Earth Science, D. C. Heath and Co., Lexington, Massachusetts, 1989.

"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"

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.

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

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

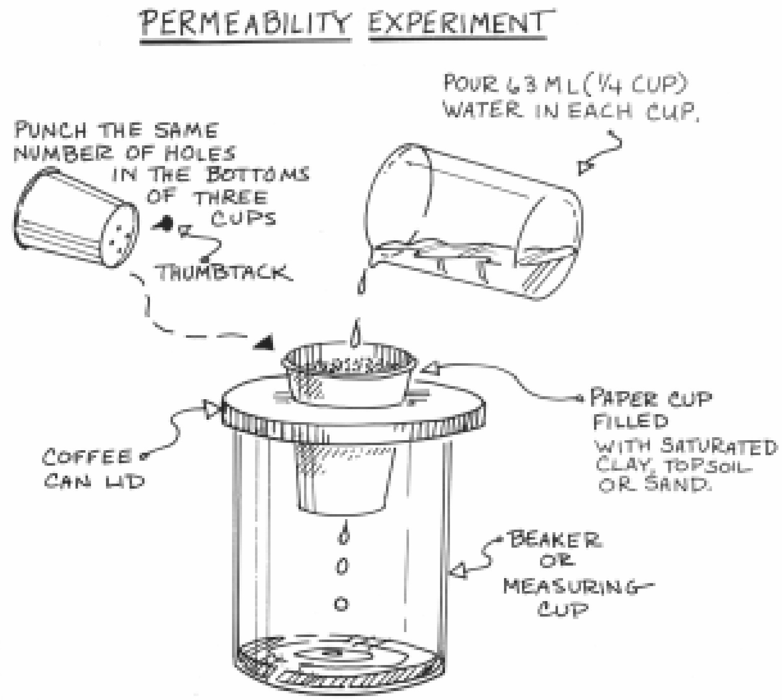
A. Explain that there are several types of soil. Some soil is mostly sand, some is mostly clay, and some is a mixture of sand, clay, rock, and other things, like dead plants. The composition of soil determines its ability to absorb water and to allow water to move through it.

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.

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.

Student Sheet

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? ____

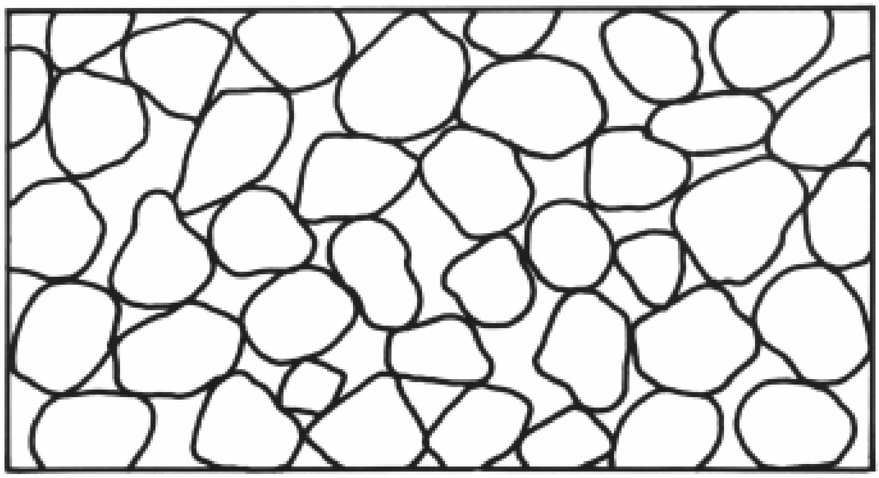
____

Student Sheet

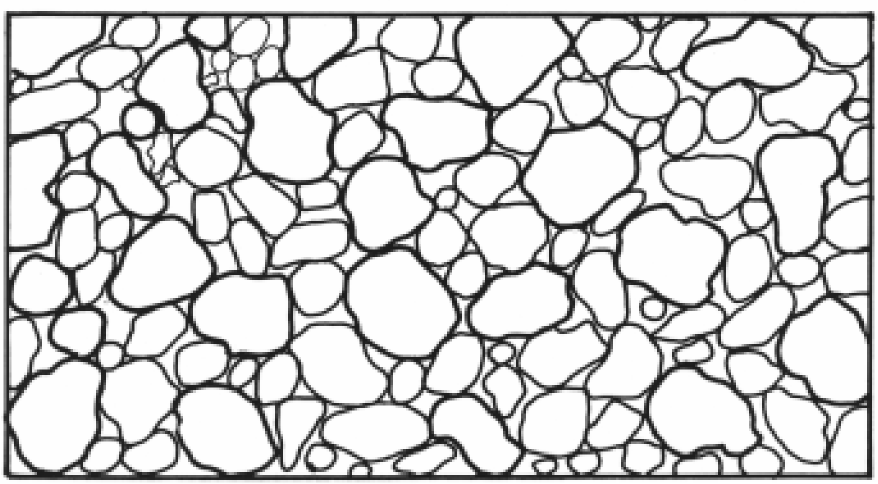
Name Date

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? ____________________

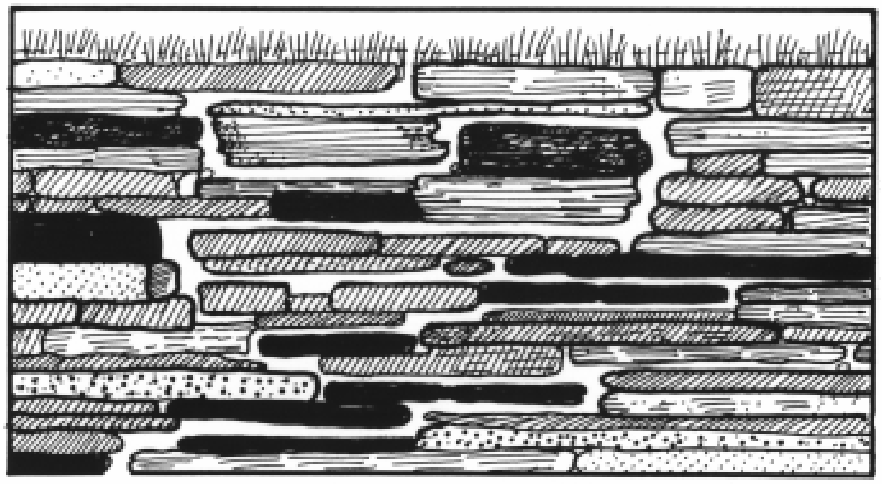
Why? ____

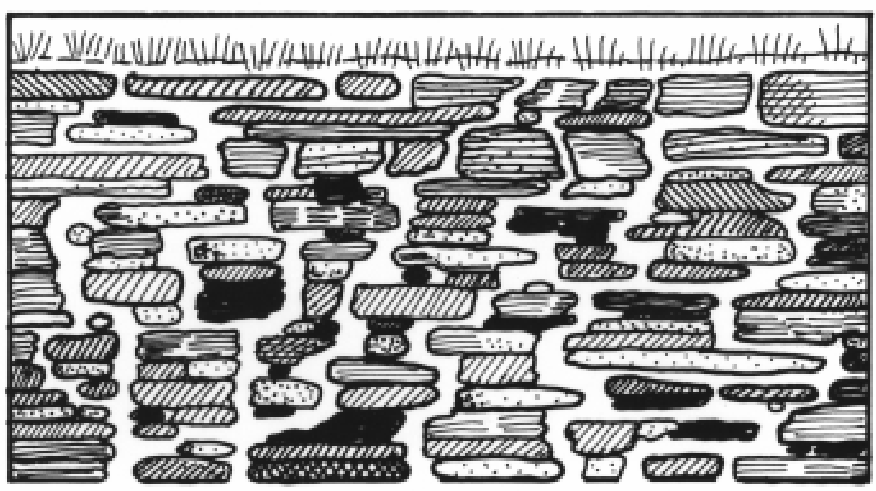
Student Sheet

POROSITY & PERMEABILITY PUZZLERS - PART 2

Name Date

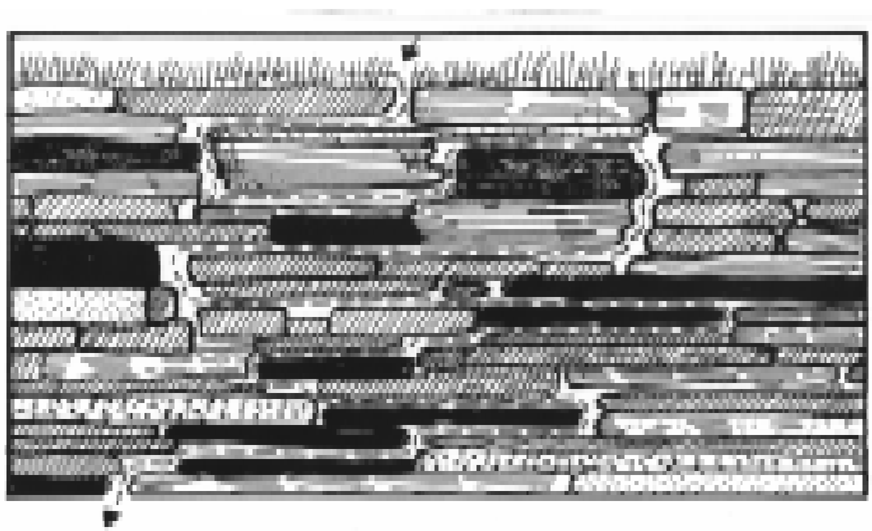
Permeability: Do the two mazes below. Show the paths water can take between the particles by using a blue crayon or marker.

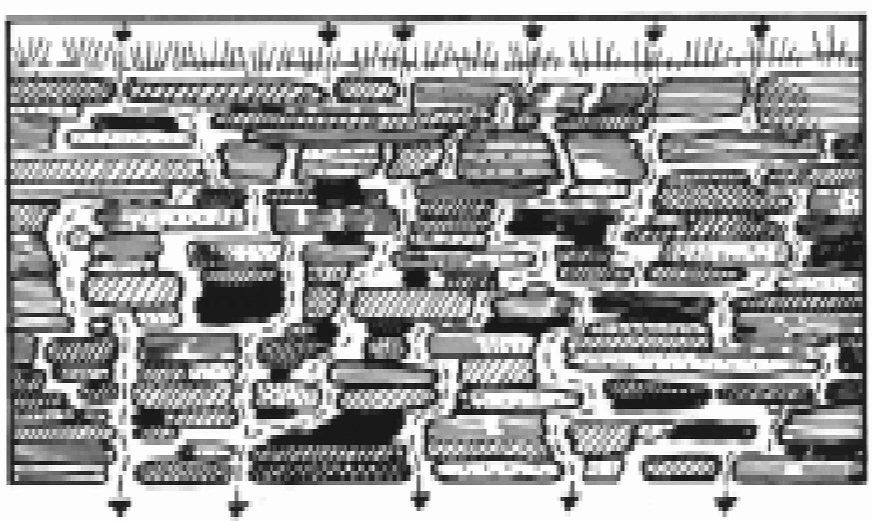




Which allows water to flow more freely? ______________________________________

POROSITY & PERMEABILITY PUZZLERS - PART 2
(ANSWER KEY)





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.")

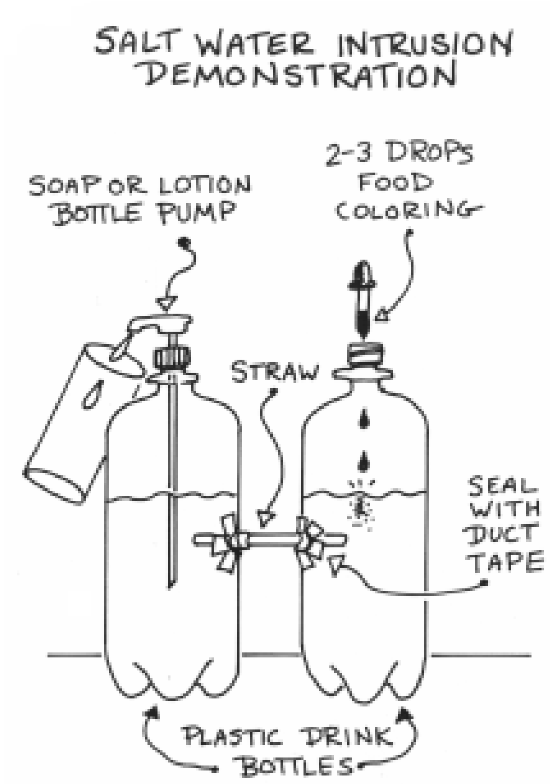
4. After completing the activity, discuss the results.

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

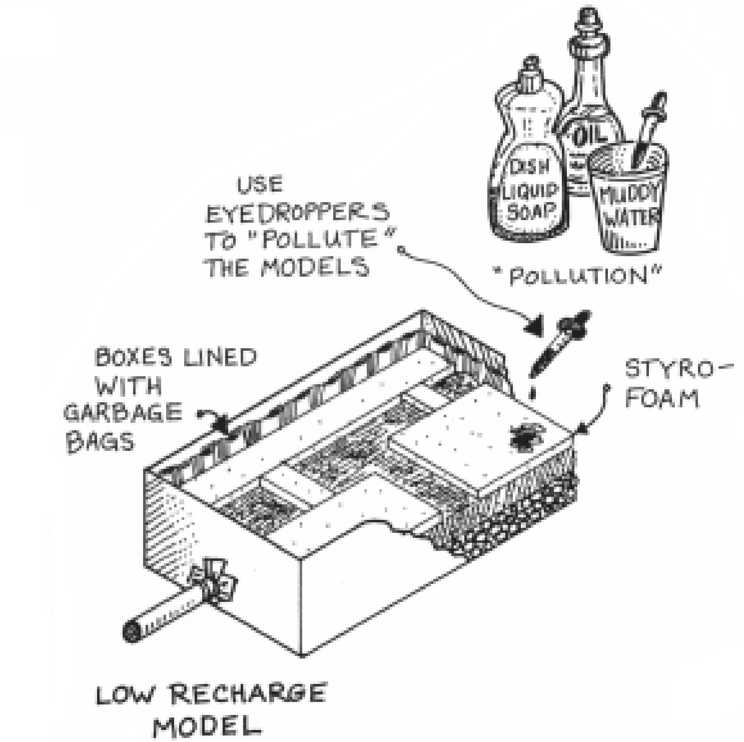
Namowitz, Samuel and Nancy E. Spaulding, <u>Earth Science</u>, D. C. Heath and Co., Lexington, Mass. 1989, p. 135.

Pringle, Lawrence, <u>Water, the Next Great Resource Battle</u>, Macmillan Publishing Co., New York, 1982.

DIRECTIONS FOR RECHARGE MODELS

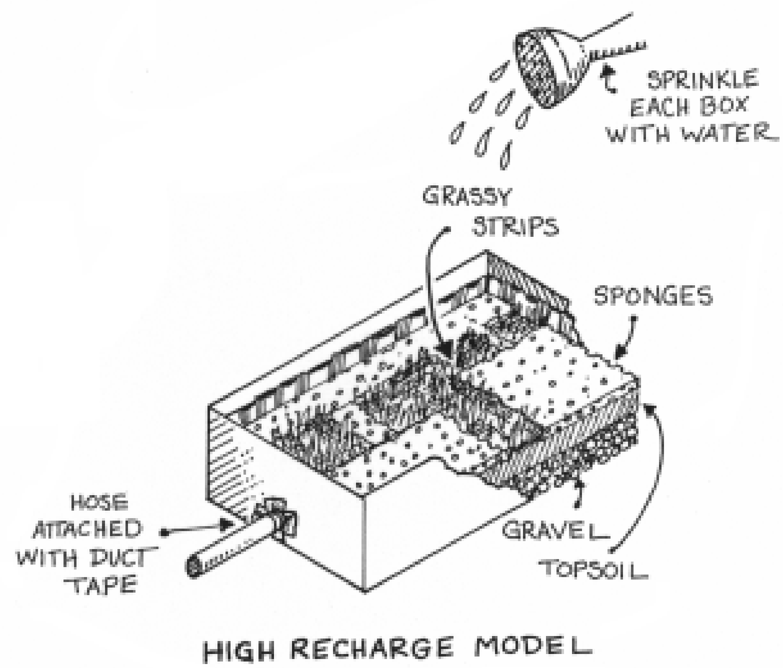
A. The low recharge model:

1. Line a 3 x 4 ft (0.9 x 1.2 m) box with a bag.
2. Poke a hole in one end of the box.
3. Attach a hose to the hole with duct ta
4. Fill the box about 1/4 way up with a lay covered with a layer of soil (to about
5. Cut out pieces of styrofoam to represer driveways, and parking lots. Place on t of the model.
6. Use eyedroppers or plastic spoons murky water on the "structures" in the
7. Place a container under the hose to ca then use a sprinkler-type watering can a heavy rainstorm. This will wash the into the storm sewer (the hose), which unfiltered route back to a river or st eventually to groundwater.

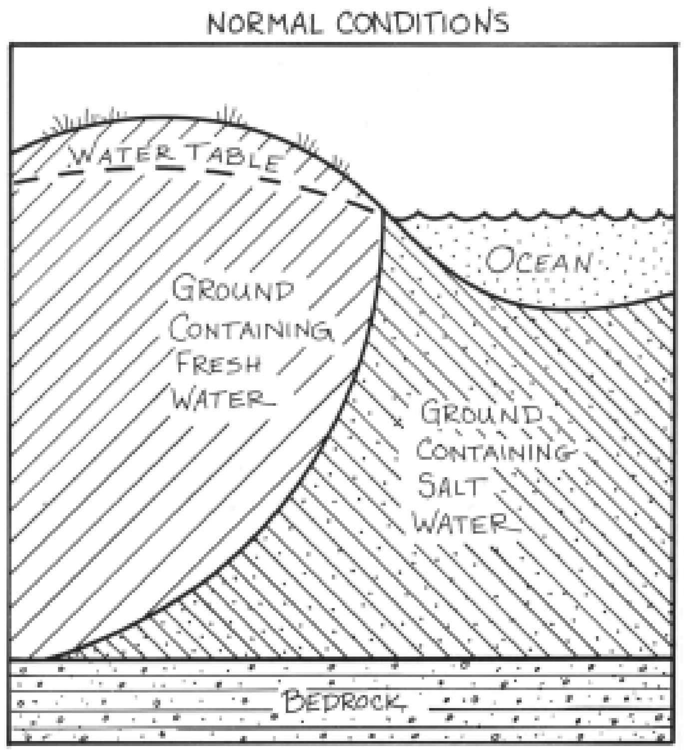


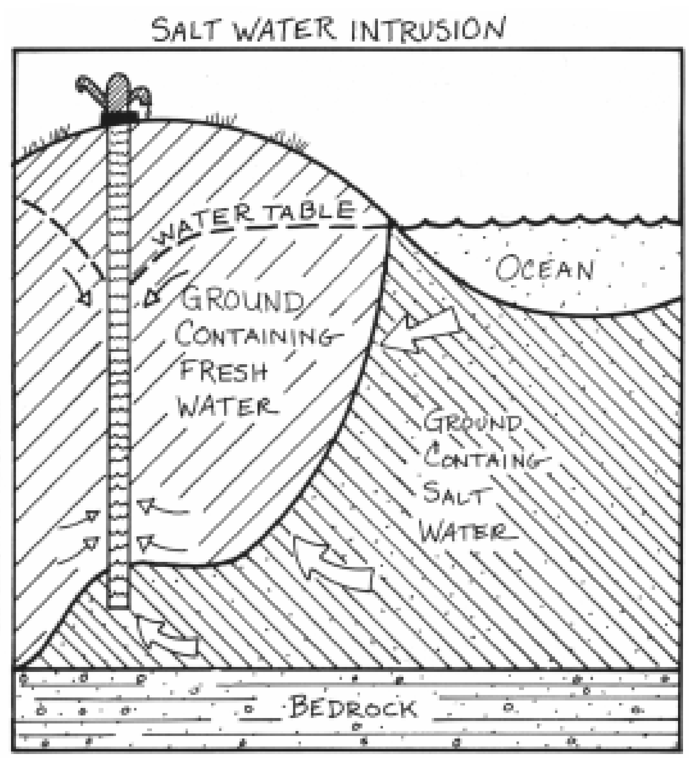
B. The high recharge model:

1. Prepare the box as in A through step
2. Use different sizes of sponges for parking lots, and driveways; but pla strips between these for better recha
3. Use eyedroppers or plastic spoons t the area as in step 6 above.



SALTWATER INTRUSION





4. Do step 7 as above.

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 ng
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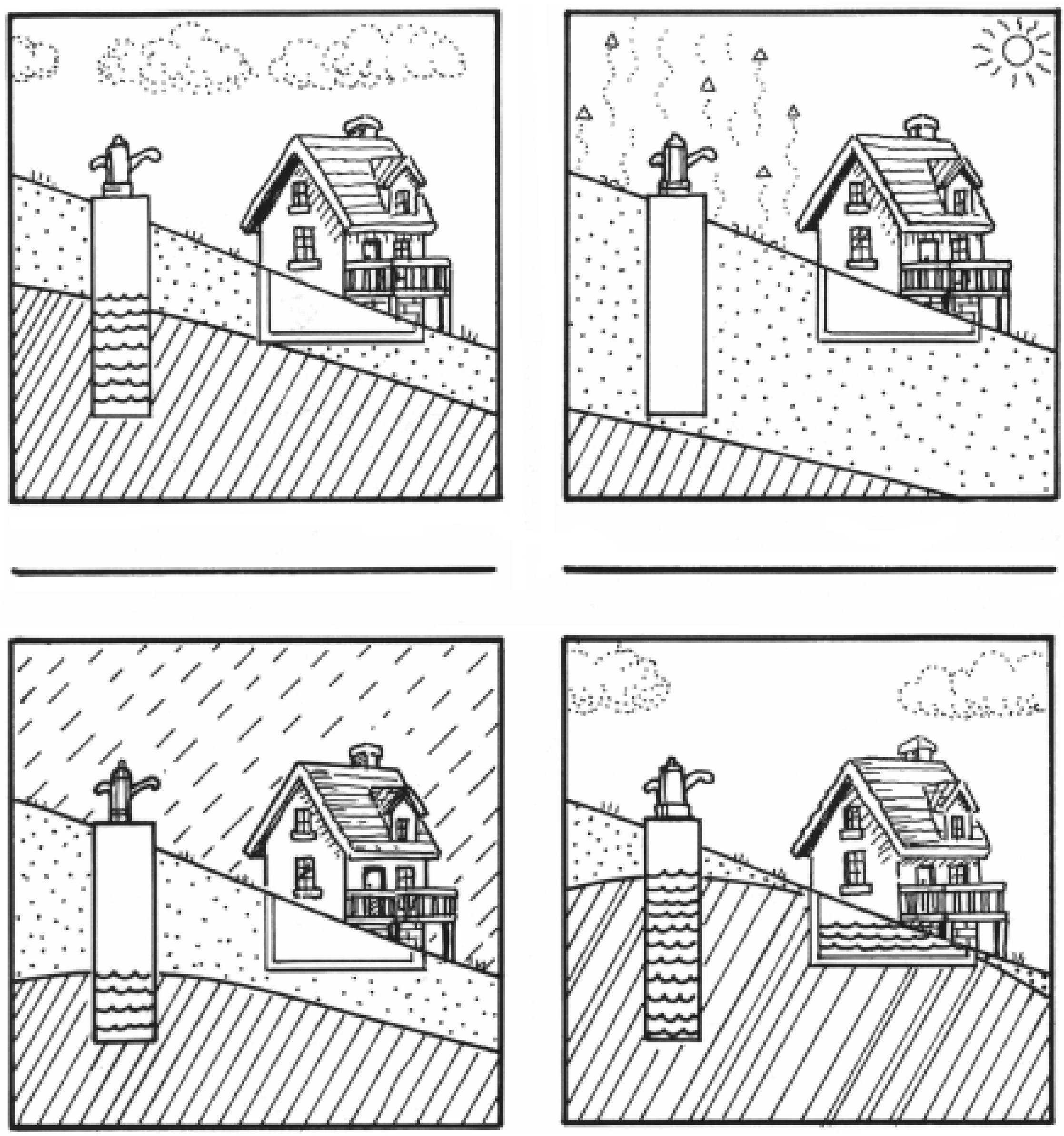


WELLS: A DEEP SUBJECT

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)

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.

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.

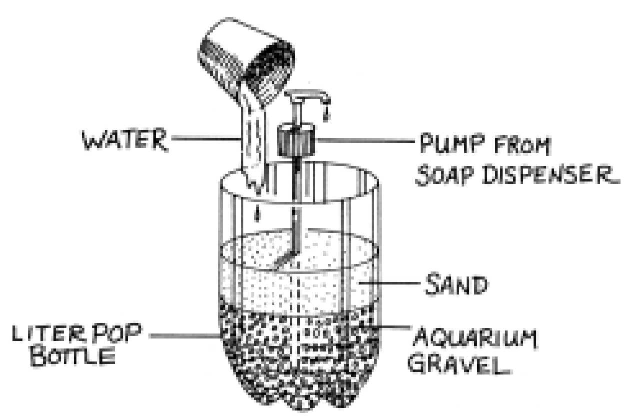
b. Explain that the top surface of the saturated zone that holds the water is called the water table. Mark the water table with the marker.

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)

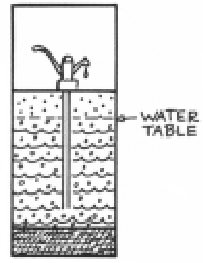
b. Ask the students to notice that for the well to work, the tubing must extend below the water table.

4. Pump water out of the model (catching the water in the cup).



WATER PUMP MODEL

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 Ground Water 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 Ground Water 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.

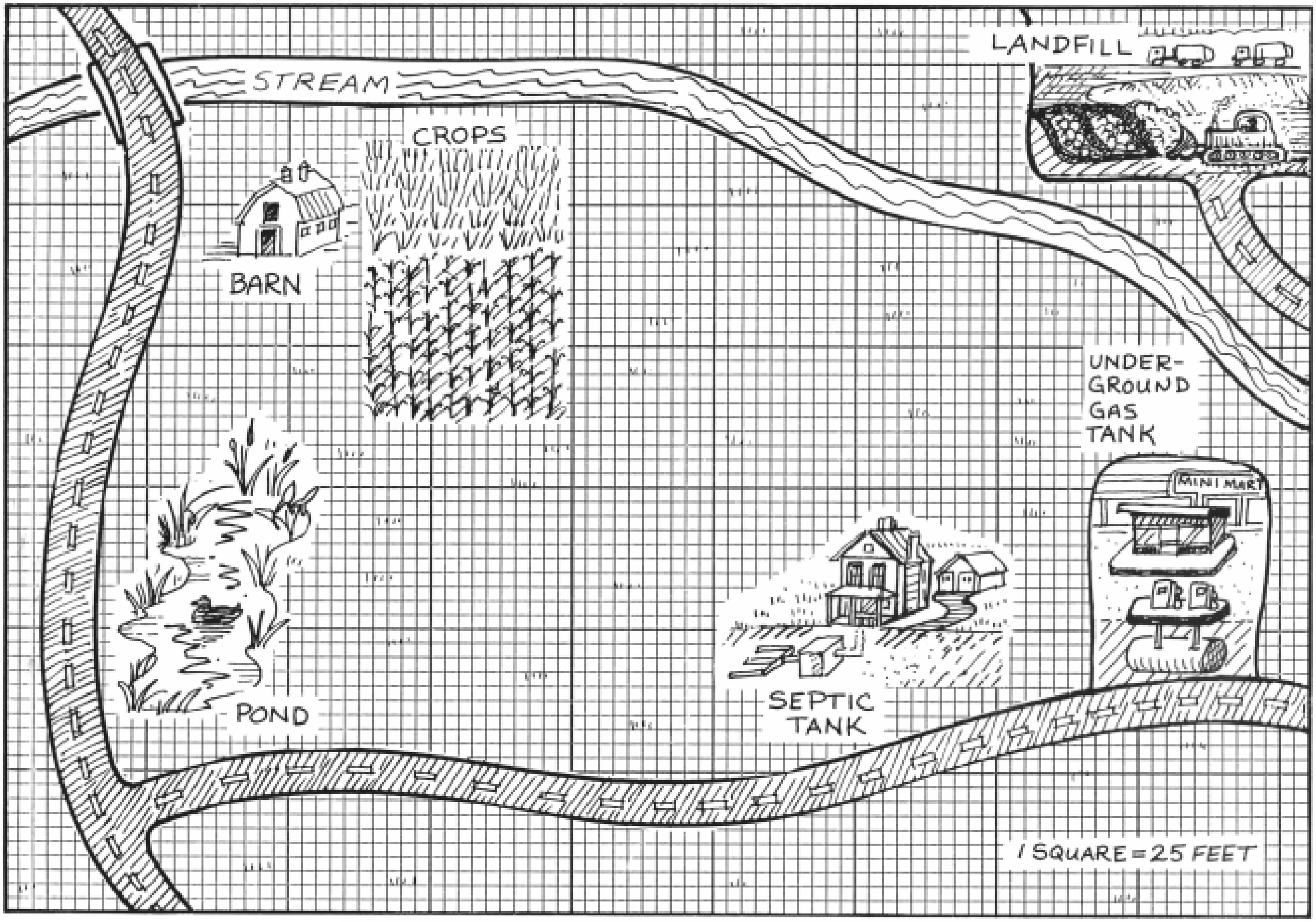
2. The following are things you will find on the map and the distance the well must be away to avoid possible contamination.

   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)

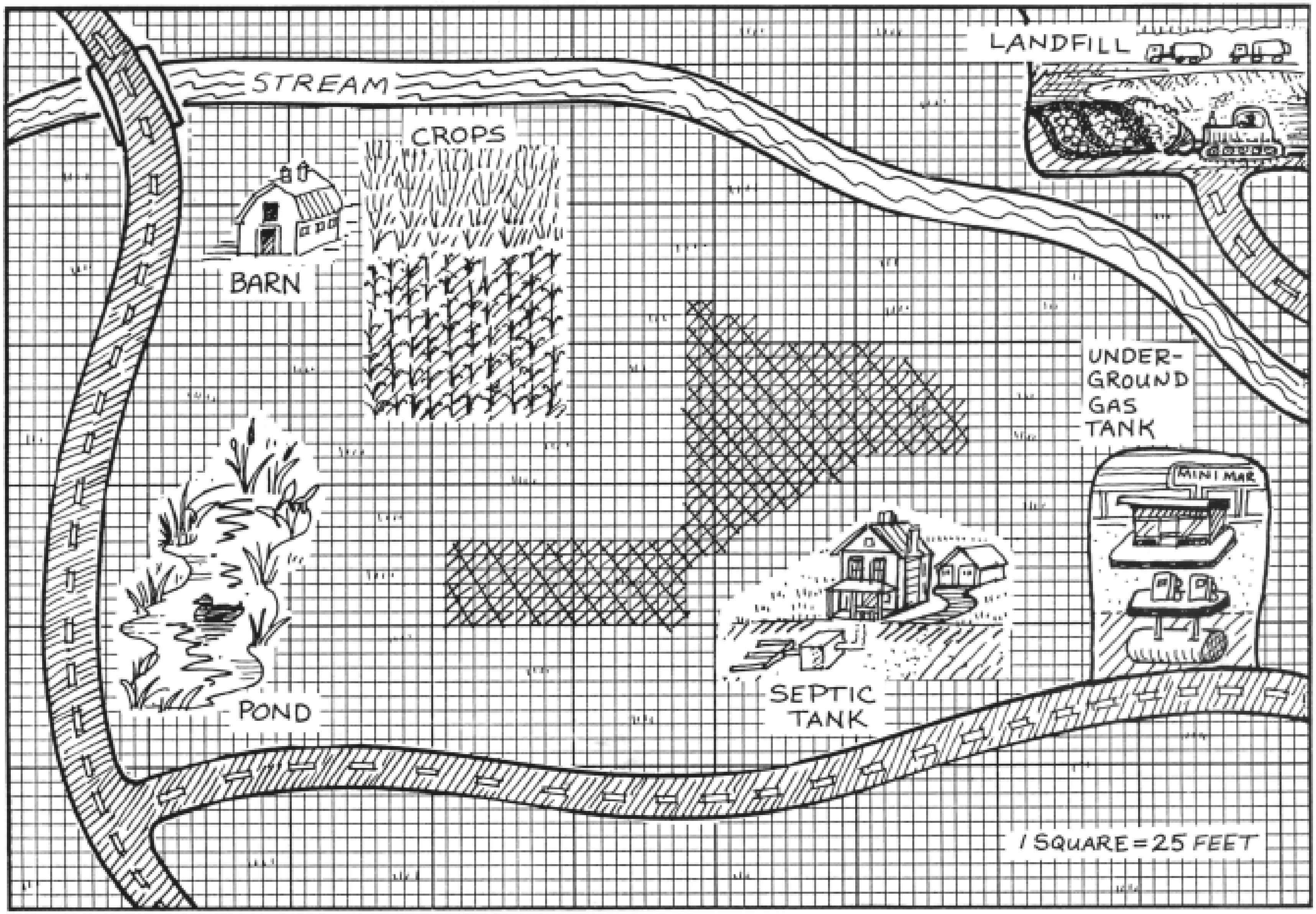
3. If you are unsure about the distances, play it safe and go to the long side of your measurement.

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

Americans 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.

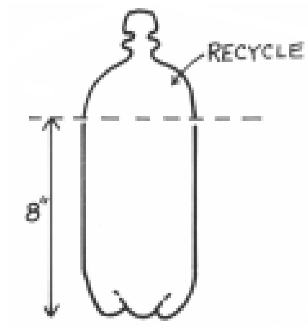
contamination: an impurity.

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, DC 20036.

RESOURCES

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Tennessee Valley Authority, Waste: A Hidden Resource, TVA, 1989.

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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)

Student/Parent Sheet

"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!)

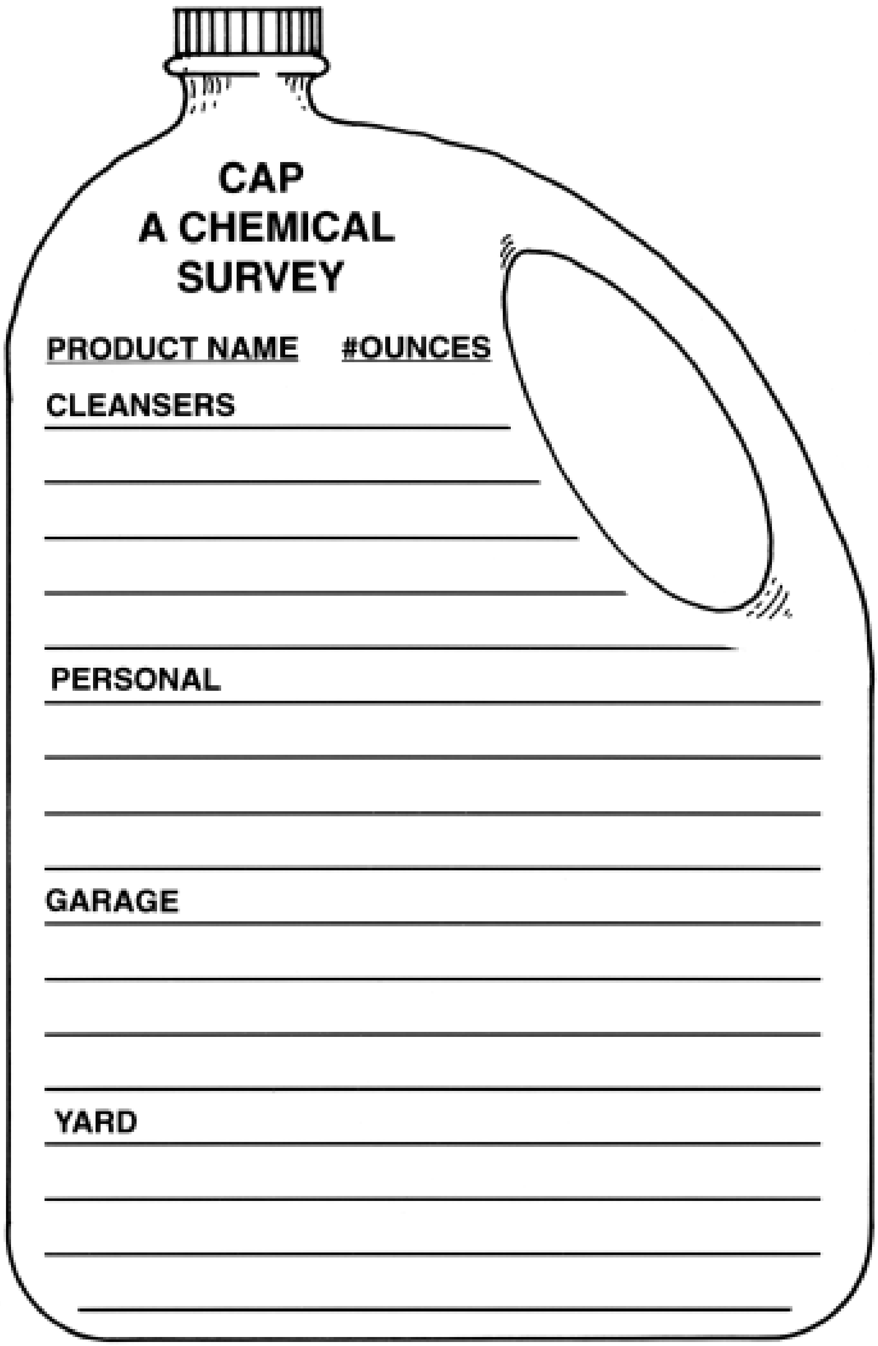
My child and I have surveyed our home for hazardous products that may pose a threat to groundwater quality if improperly used or disposed of. The results of our survey are written on the form on the back of this sheet.

Signed: ______________________________

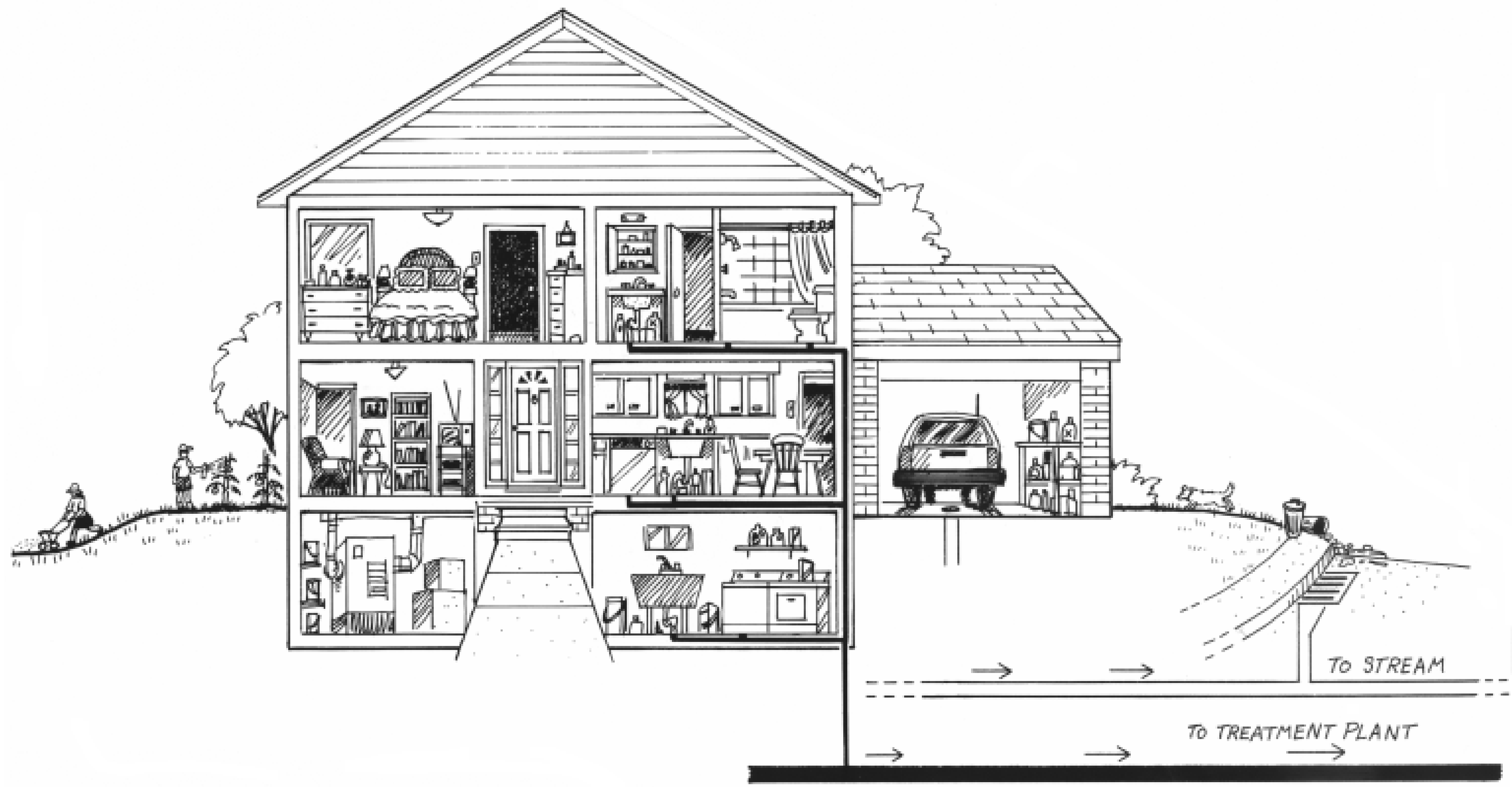
"CAP A CHEMICAL" SURVEY

(continued)

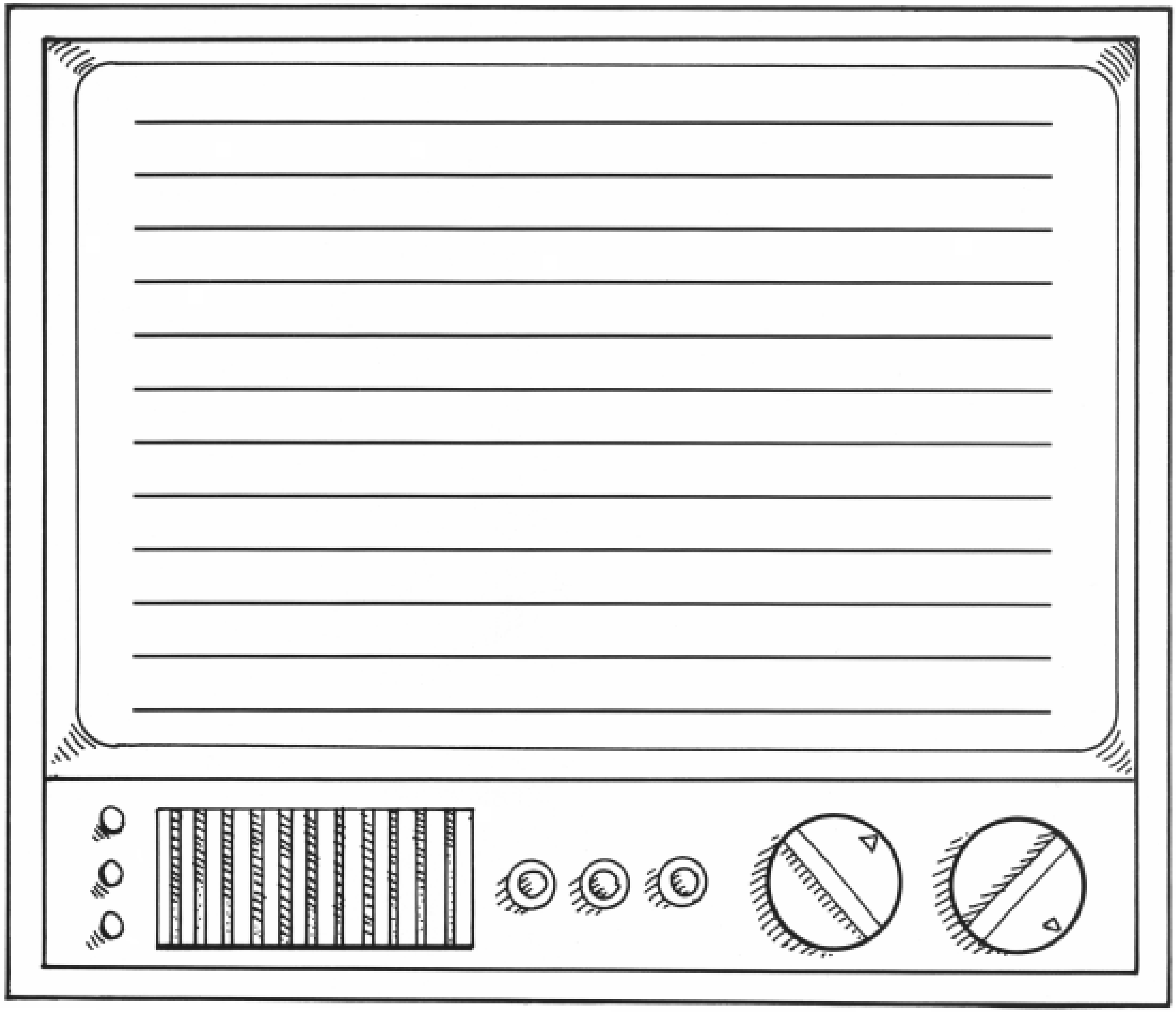
Using the list of hazardous household products on the front of this page, identify the listed products found in your home. Write them on this survey form.



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 con-tamination 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.

RESOURCES

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Haberman, Mary, "Water Magic, Water Activities for Students & Teachers," American Water Works Association, Denver, Colorado, 1991, p. 31.

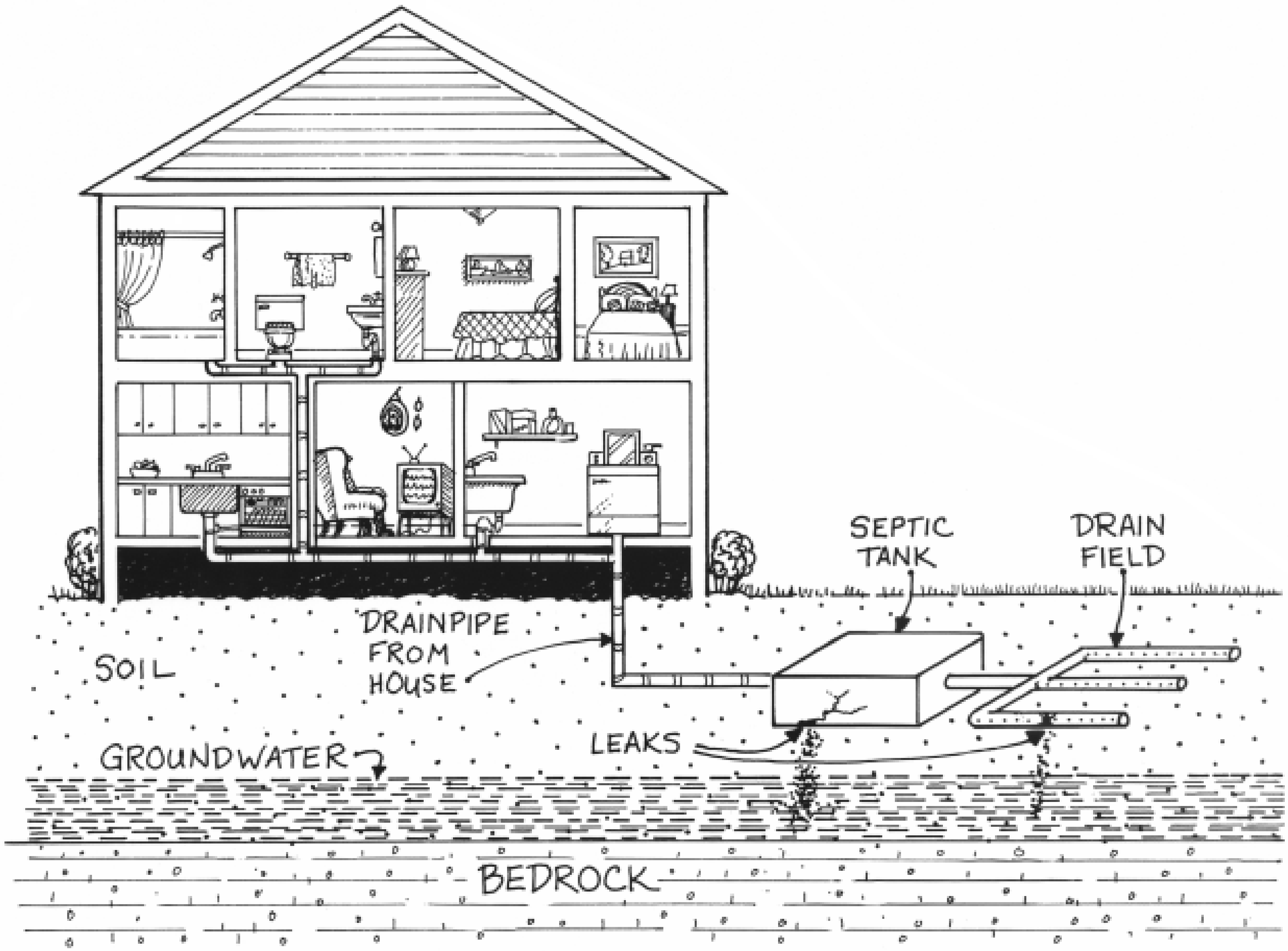
"Is Your Drinking Water Safe?" U.S. Environmental Protection Agency, Washington, DC, 1989.

Lord, John, Hazardous Wastes from Home, Enterprise for Education, Santa Monica, California, 1986. (Address: 132A Santa Monica Mall, Santa Monica, California 90401.)

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

Waste: A Hidden Resource, Tennessee Valley Authority, 1988.

FLUSH YOUR TROUBLES AWAY



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.

<u>Terms</u>

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.

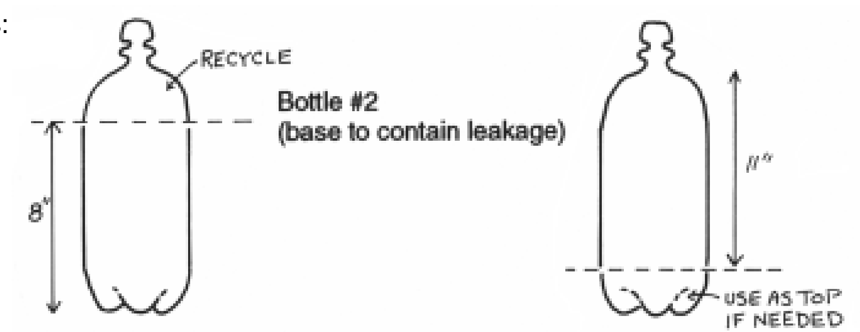
waste: a useless or worthless by-product; the undigested residue of food eliminated from the body; garbage or trash.

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)



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 class 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 collage will be contained in a plastic wrap cover. Students could write about alternative solutions to our landfill waste. Alternatives might include recycle, compost, or incinerate waste. This would be attached 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

DiSpezio, Michael A, and Linda Werben, "Where Does All The Garbage Go?" Science and Children, Vol. 28, No. 2, October 1990, pp. 33-34.

Jorgensen, Eric, ed., The Poisoned Well, Island Press, Washington, DC, 1987.

Pollock, Cynthia, Mining Urban Wastes: The Potential for Recycling, Worldwatch Paper 76, Worldwatch Institute, Washington, DC, 1987.

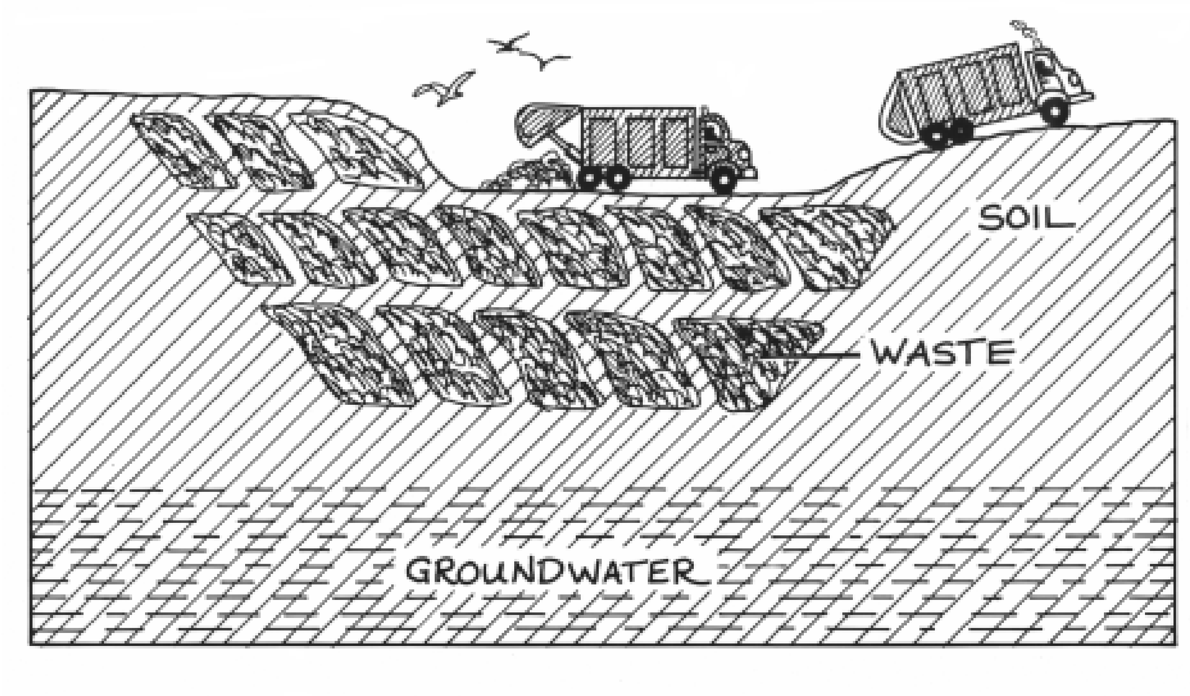
"Bottle Biology Resources Network," University of Wisconsin-Madison, pp. 13-37. (Address: 1630 Linden Dr., Madison, Wisconsin 53706)

Werben, Linda, and Michael DiSpezio, "A Historical Perspective," Science and Children, Vol. 28, No. 4. January 1991, pp. 33-35.

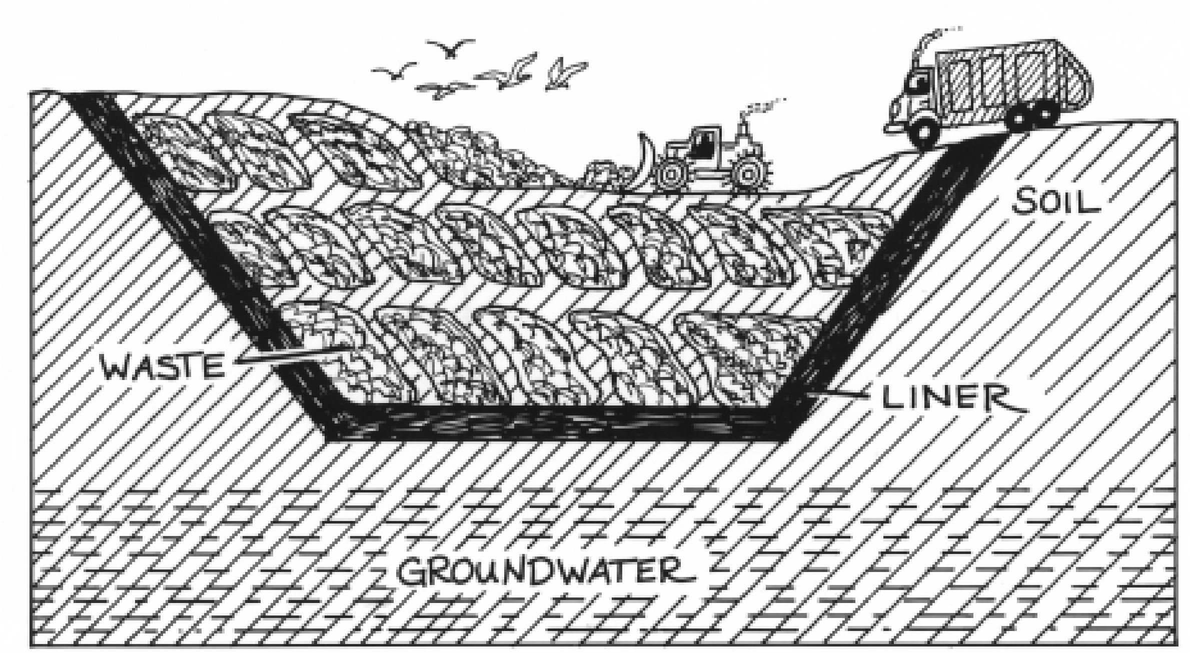
Student Sheet

LANDFILLS

Non-Lined Landfill
(potentially unsafe for our groundwater)

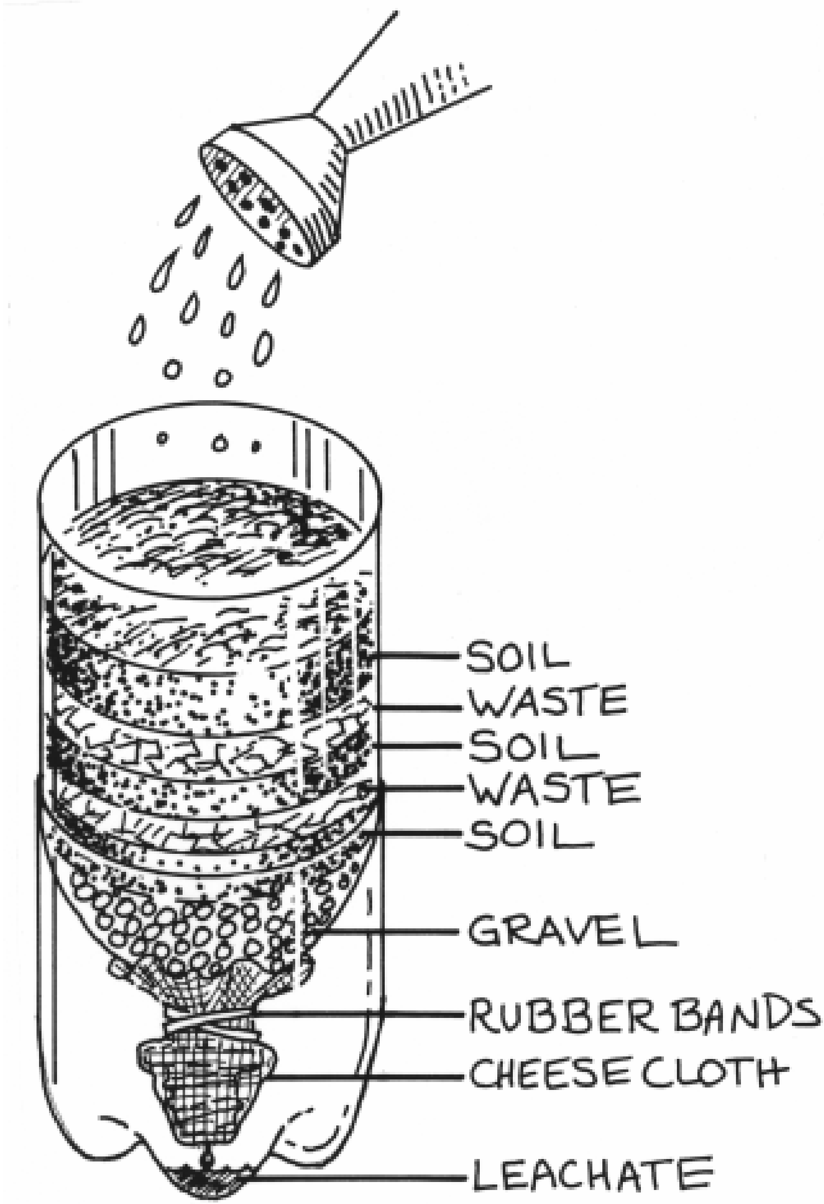


Lined Landfill
(built according to regulations and safer)



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 ____

____

____

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.

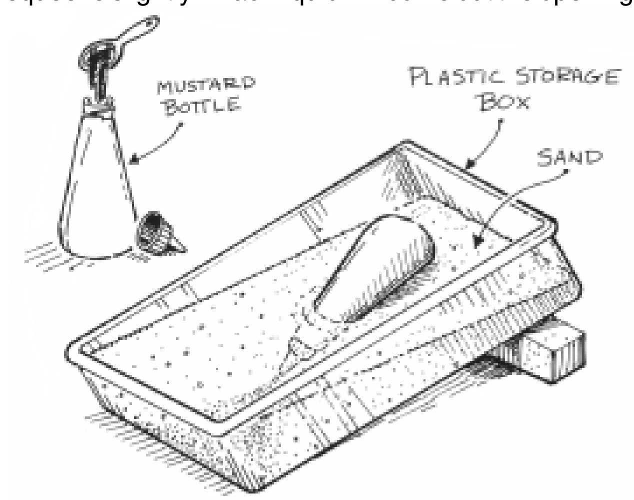
II. Activities

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 determine 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.

RESOURCES

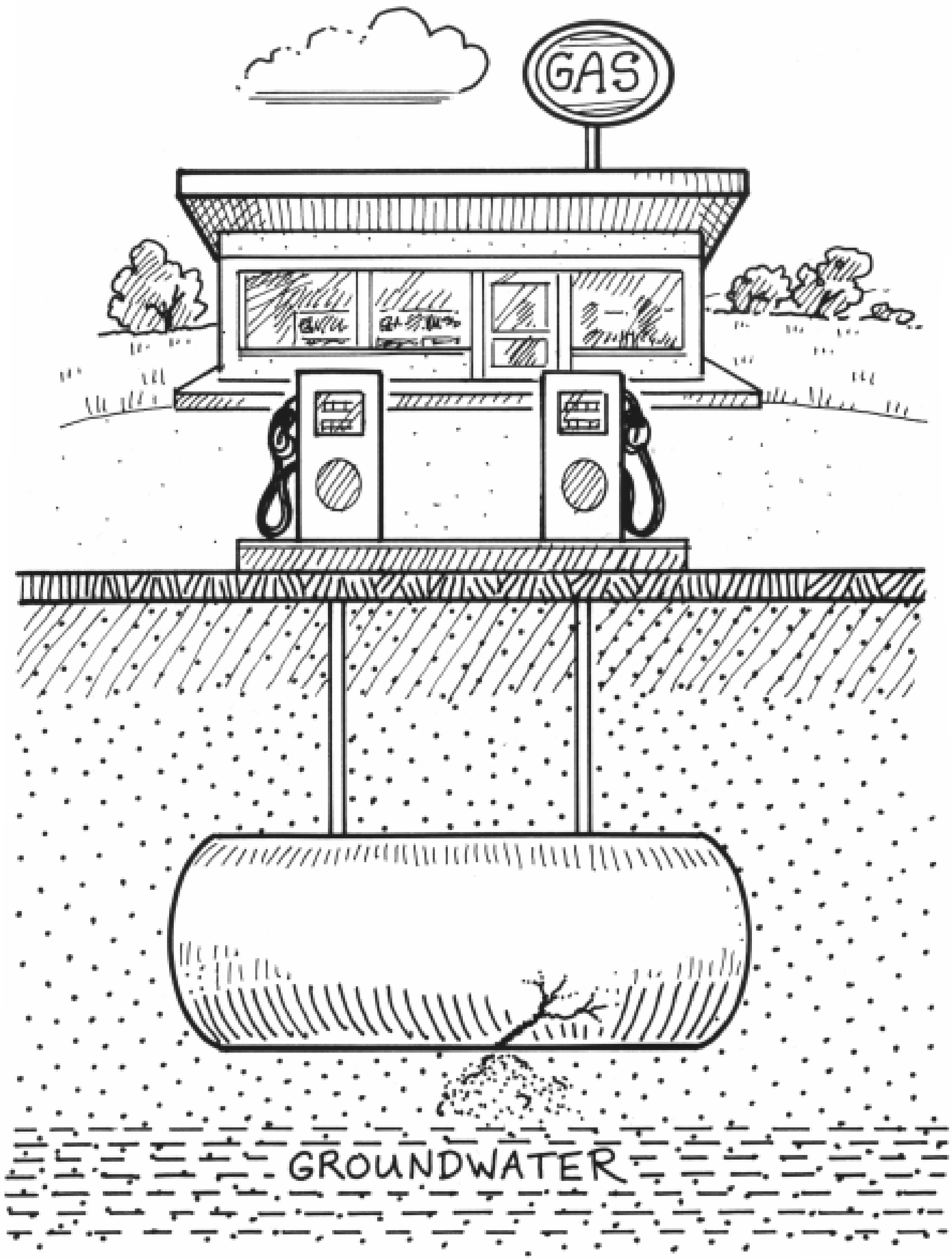
Hadley, Paul W., and Richard Armstrong, “Groundwater,” January-February 1991, pp. 35-39.

Jorgensen, Eric, ed., The Poisoned Well, Island Press, Washington, DC, 1987.

"Straight Talk on Tanks: A Summary of Leak Detection Methods for Petroleum,” U. S. Environmental Protection Agency, Washington, DC.

L.U.S.T. = LEAKING UNDERGROUND STORAGE TANK

Student Sheet



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
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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.

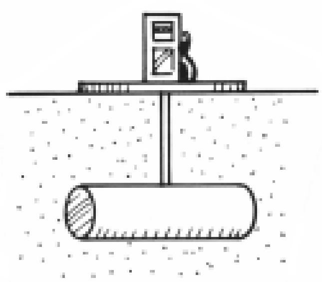
groundwater	pollution	fiberglass	containment
contamination	L.U.S.T.	steel	gasoline
environment	chemicals	liner	

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

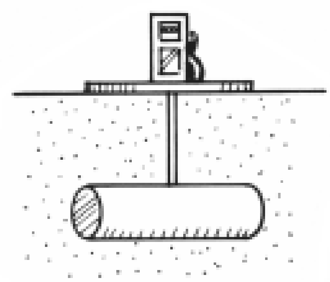
THE PROBLEM OF LEAKING UNDERGROUND STORAGE TANKS

Find the answer to the following math problems. Use only the information needed to find the answer. Answer all parts of each question.

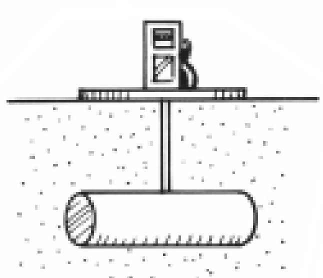
#1
In December, Station S received 2,500 gallons (10,000 L) of gasoline. During the next month they sold 2,459 gallons (9,836 L). The tanks were empty at the end of the month. How many gallons of gasoline disappeared? What do you think happened to the missing gasoline? What action do you recommend?



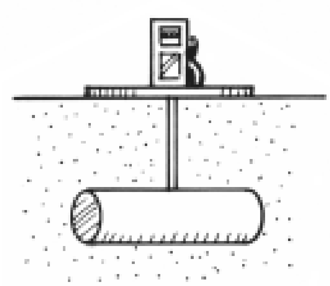
#2
Last month at the local Hurried Gas Station they received 48,082 gallons (192,328 L) of gasoline. During this month they sold 48,082 gallons (192,328 L). How many gallons of gasoline disappeared? What action do you recommend?



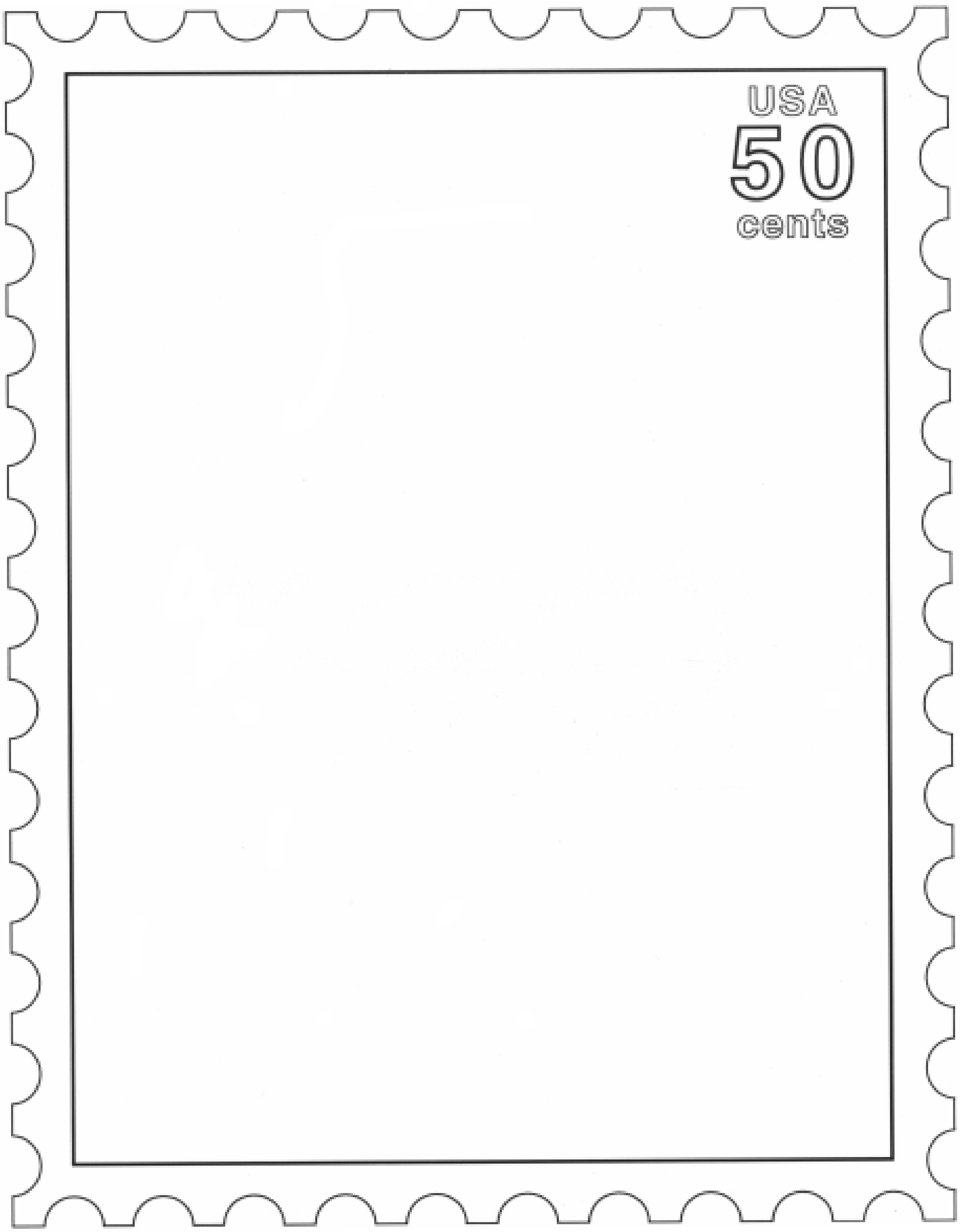
#3
Last week at We-Gas-Um they sold 598 gallons (2,392 L) of gasoline. They also sold 36 orange cola drinks. This week they sold 376 gallons (1,504 L) of gasoline. How many gallons (liters) of gasoline did they sell at We-Gas-Um the past 2 weeks? They received 1,000 gallons (4,000 L) during the past 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.

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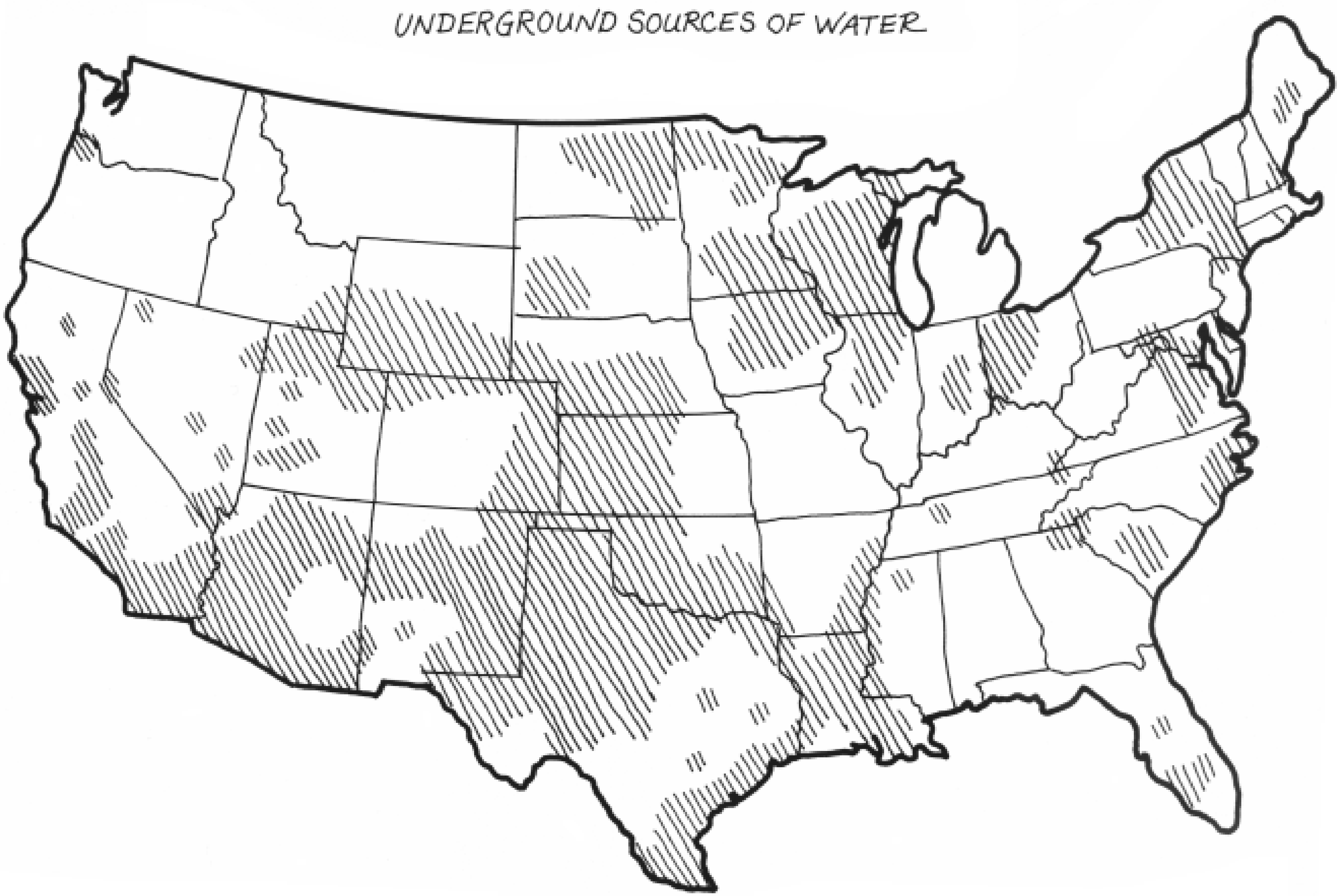
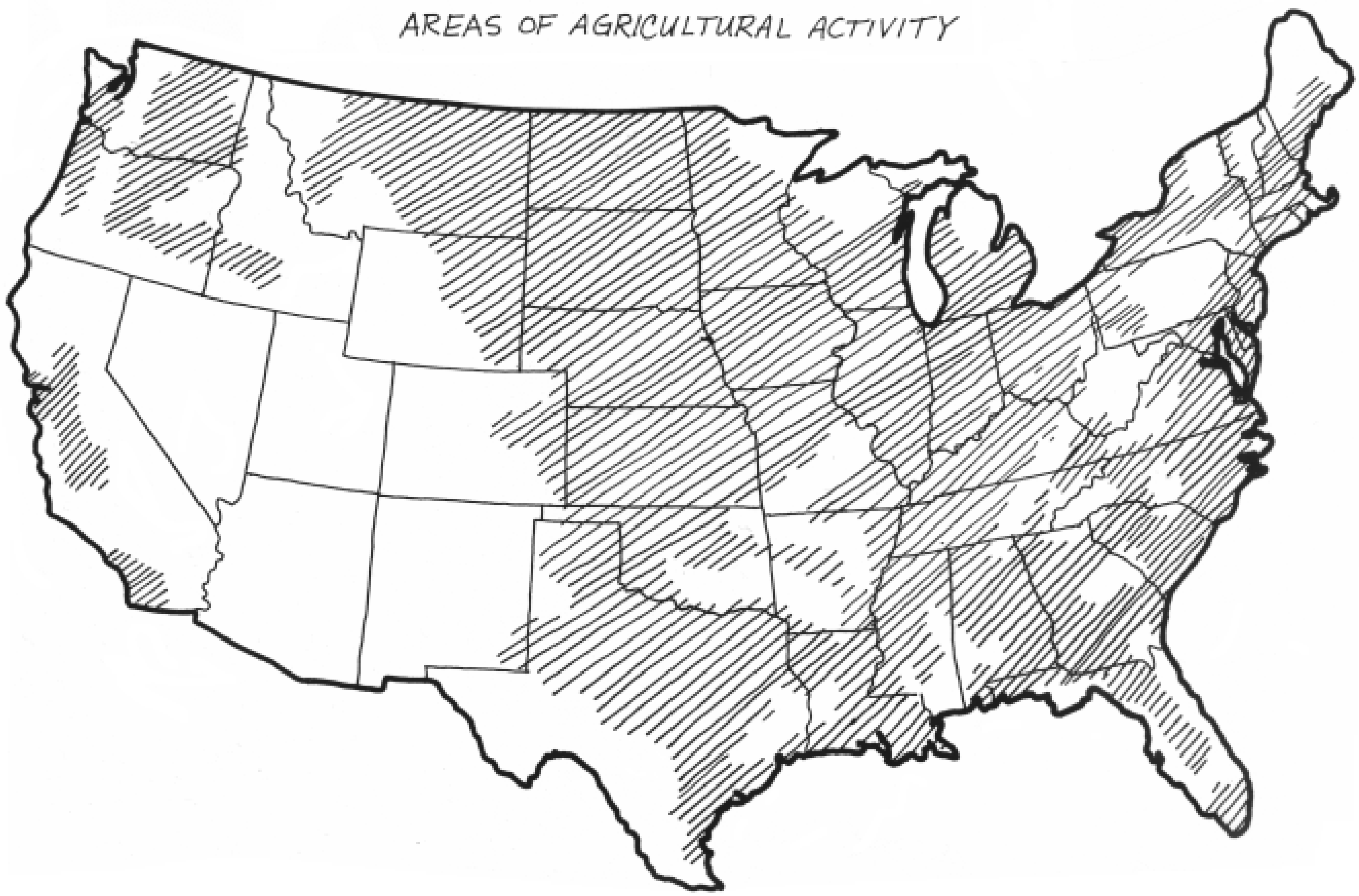
Lasley, P., and J. Fellows, "Farm Family Adaptations to Severe Economic Distress: Regional Summary," Results from the 1989 Regional Farm Survey, North Central Regional Center for Rural Development, Ames, Iowa, 1990.

"Manure Surplus Forces Research in Pennsylvania," Successful Farming, No. 86, December, 1988, p. 51.

LOCATION OF MAJOR US AQUIFERS



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:

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.

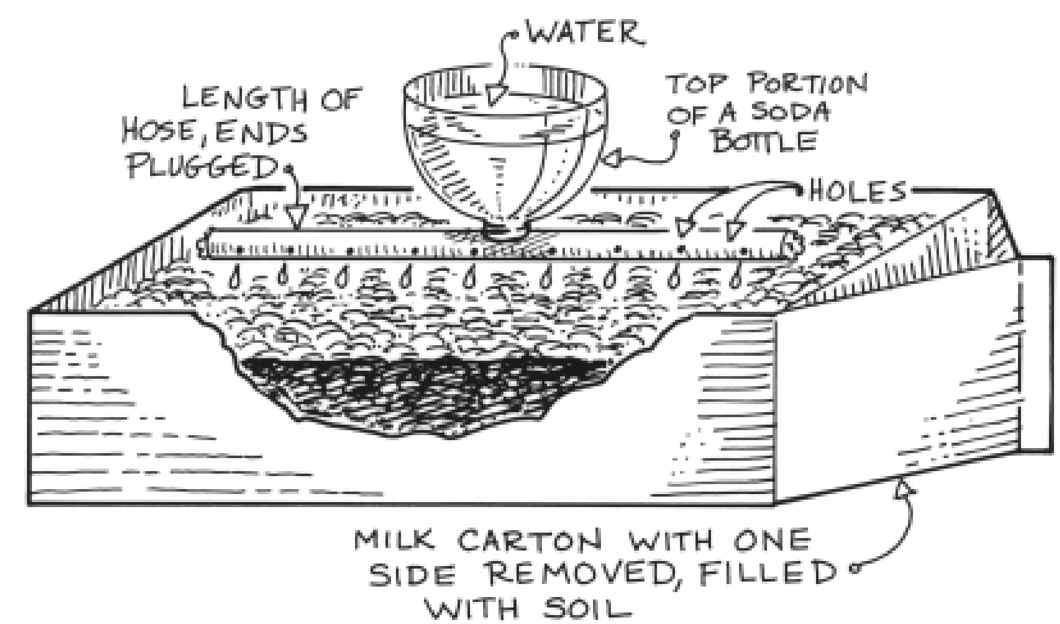
B. Make drip irrigation unit(s). (NOTE: "Drip vs. Spray" experiment may be performed as a class demonstration or as a team project.)

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.

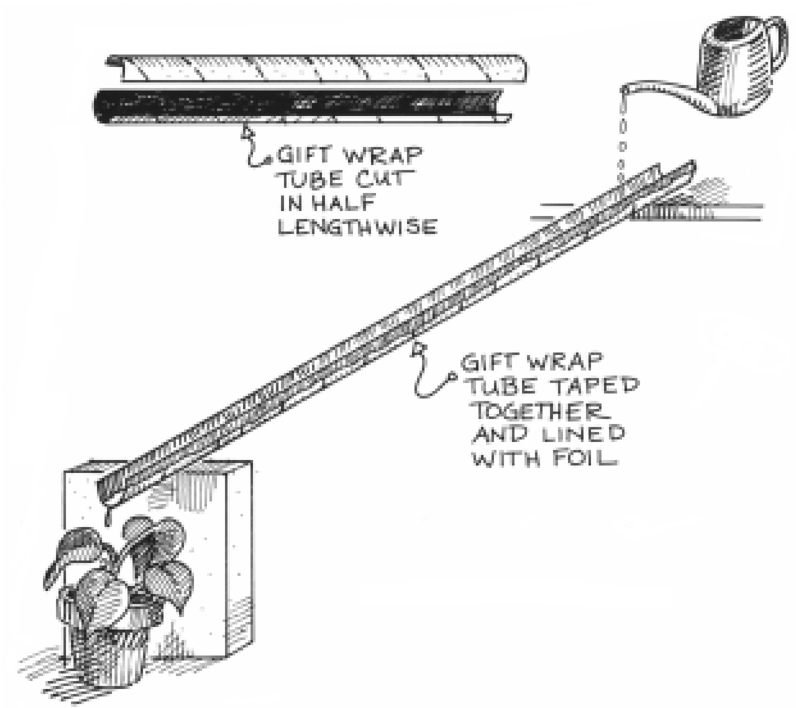
1. Ask “What do these two things have in common?” (Both containers contain water-- water in glass, water in plant and soil.)

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.

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.

RESOURCES

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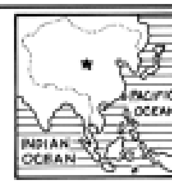
IRRIGATION IN HISTORY

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.

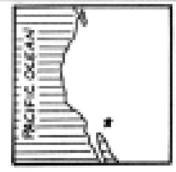


SOUTHEAST ASIA
When: 3,000 B.C.
Where: What today is China, Vietnam, and Korea

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.



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: ____

____

____

____

____

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If I were a farmer and I needed to put an irrigation system on my farm, I would choose a ____________ irrigation system because ____

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