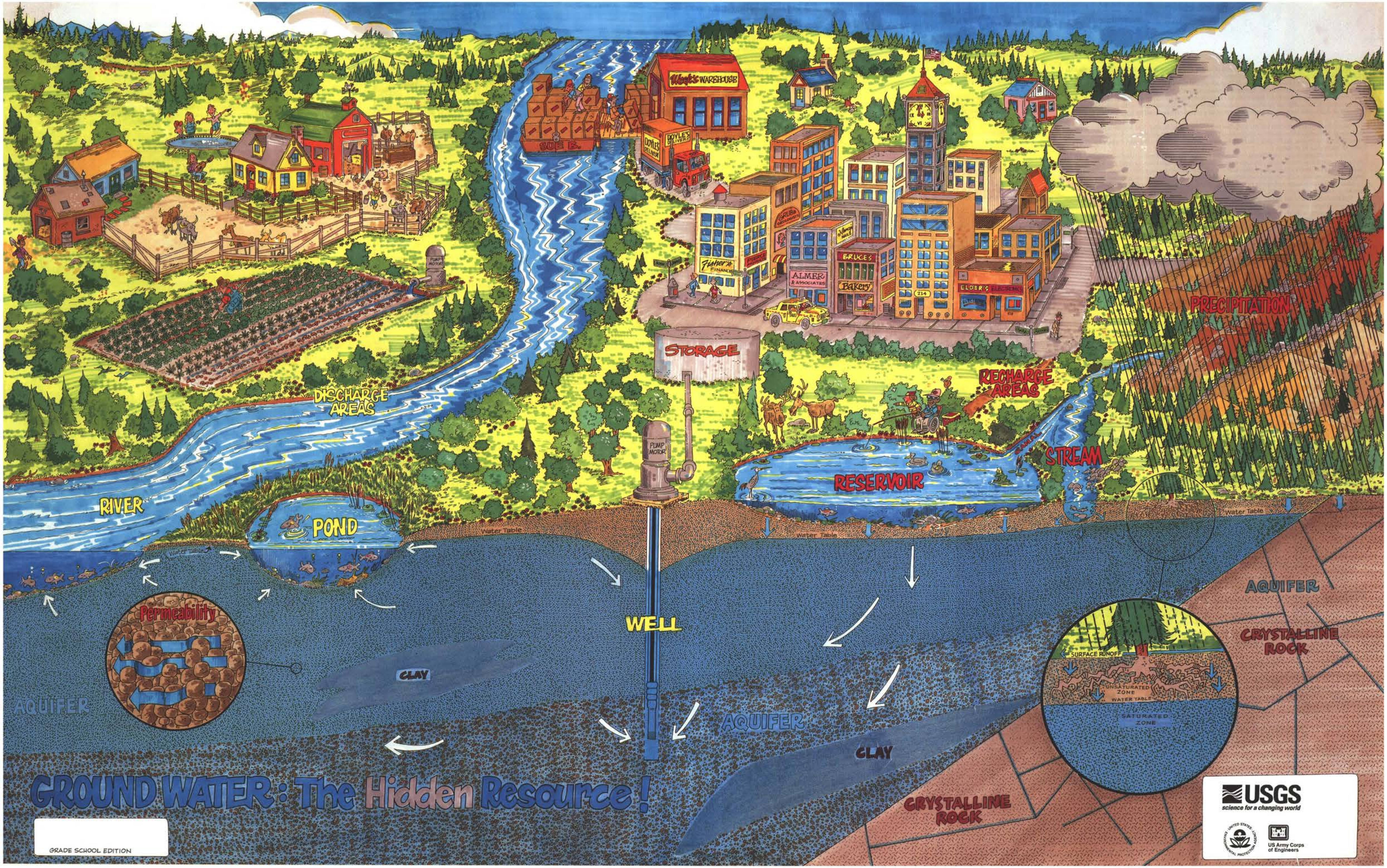


Week's WAREHOUSE
DOYLE'S DELIVERY
Fisher's FINANCE
ALMER & ASSOCIATES
BRUCE'S
Bakery
214
ELDER'S ELECTRONICS
TAXI
STORAGE
PUMP MOTOR
DISCHARGE AREAS
RECHARGE AREAS
PRECIPITATION
STREAM
RESERVOIR
RIVER
POND
Water Table
WELL
Permeability
CLAY
AQUIFER
AQUIFER
CLAY
AQUIFER
CRYSTALLINE ROCK
SURFACE RUNOFF
UNSATURATED ZONE
WATER TABLE
SATURATED ZONE
CRYSTALLINE ROCK
GROUND WATER : The Hidden Resource !
GRADE SCHOOL EDITION
USGS
science for a changing world
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
US Army Corps of Engineers

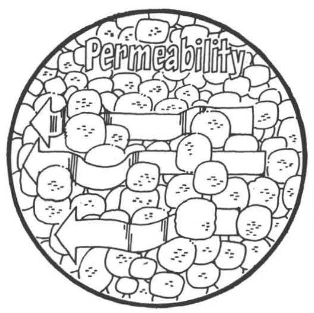
Ground water is water underground in saturated zones beneath the land surface. Contrary to popular belief, ground water does not form underground "rivers." It fills the pores and fractures in underground materials such as sand, gravel, and other rock. If ground water flows from rock materials or can be removed by pumping from the saturated rock materials in useful amounts, the rock materials are called aquifers. Ground water moves slowly, typically at rates of 7 to 60 centimeters per day in an aquifer. As a result, water could remain in an aquifer for hundreds or thousands of years. Ground water is the source of about 40 percent of water used for public supplies and about 38 percent of water used for agriculture in the United States.

One of the largest aquifers in the United States is the High Plains Aquifer. The aquifer is approximately the size of California and is located under parts of South Dakota, Wyoming, Kansas, Nebraska, Colorado, New Mexico, Oklahoma, and Texas. The High Plains Aquifer contains an estimated 4 quadrillion liters (4 with 15 zeros after it) of water.

This poster depicts an unconfined or water-table aquifer. An unconfined aquifer is an aquifer where the water surface — water table — is free to rise and decline as water moves from recharge areas to discharge areas. Recharge areas are places where an aquifer receives its water. The recharge sources shown are a reservoir, a stream, and precipitation. Their titles are red. The arrows represent the movement of water from the recharge sources to the discharge areas. The large circle on the right-hand side of the poster is a representation of how recharge occurs from precipitation.

The left-hand side of the poster shows conditions in a ground-water discharge area. Discharge areas are where ground water flows to the land surface or to surface-water bodies such as the pond and river shown on the poster. Ground water also can discharge by pumping a well. The titles of these ground-water discharges are yellow.

The poster is folded into 8.5" x 11" panels; front and back panels can easily be photocopied.



Permeability

For water to move in an aquifer, the pores between rock materials and fractures in rock must be connected. If there is a good connection among pore spaces and fractures, water can move freely and we say that the rock is permeable. The capacity of rock material to transmit water is called permeability. Water moves through different materials at different rates — faster through gravel, slower through sand, and much slower through clay. Therefore, gravel is more permeable than sand, which is more permeable than clay.

Ground-Water Movement

Introduction

Ground water must be able to move through underground materials at rates fast enough to supply useful amounts of water to wells or springs in order for those materials to be classified as an aquifer. For water to move in an aquifer, some of the pores and fractures must be connected to each other. Water moves through different materials at different rates, faster through gravel, slower through sand, and even slower through clay. Gravels and sands are possible aquifers; clays usually are not aquifers. The following activity demonstrates how different sizes of rock materials that make up an aquifer affect water movement.

Objectives--Students will:

1. Identify several sources of rock materials that make up an aquifer.
2. Discuss how water moves through gravel, sand, and clay.

Materials

1. At least 10 students.
2. Large area to conduct activity.

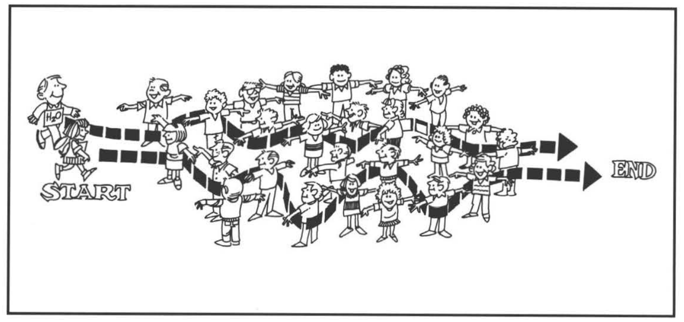
Teacher Preparation

This activity can be conducted in the classroom, gymnasium, or outside the school building. If conducted in the classroom, move all furniture to allow for sufficient room for the movement of students. This is a three-part demonstration that may create some excitement.

Procedures

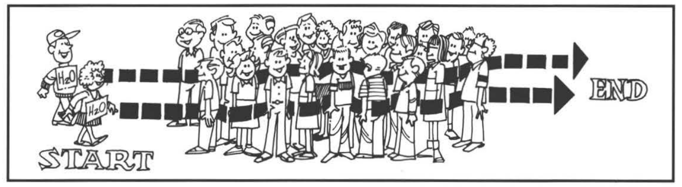
Select two or three students to be molecules of water. The remaining students will be rock materials.

1. **Activity One:** Water movement through gravel. The students represent gravel by holding arms outstretched, leaving a 15- to 30- centimeter (cm) space between their outstretched arms. Locate these students in the center of the activity area. The students representing water molecules are to start on one side of their "gravel" classmates and move through them, exiting on the other side. The water molecules will move easily through the gravel.



2. **Activity Two:** Water movement through sand. The students represent sand by extending arms, bending them at the elbows and touching their waists with their fingers. Locate these students in the center of the activity area, spacing them approximately 15 cm apart. Once again, have the water molecules slowly make their way through their "sand" classmates. The water molecules will experience some difficulty, but should still reach the other side.

3. **Activity Three:** Water movement through clay. Students become clay particles by placing their arms straight down the sides of their bodies and standing approximately 10 cm apart. Locate these students in the center of the activity area. It will be a formidable task for water molecules to move through the clay. Without being rough, the water molecules should slowly make their way through the clay. The water molecules may not be able to move through the clay at all.



Interpretive Questions

1. Which one of the materials — gravel, sand, or clay — was the easiest for the water molecules to move through? (Answer: Gravel, then sand, then clay.) Why? (Answer: Because there are larger spaces between the gravel particles.)
2. If there were three rock units, one of gravel, one of sand, and one of clay, all containing the same quantity of water, in which would you drill a well? (Answer: Gravel. Water moves easier through gravel than sand or clay.)

Extension

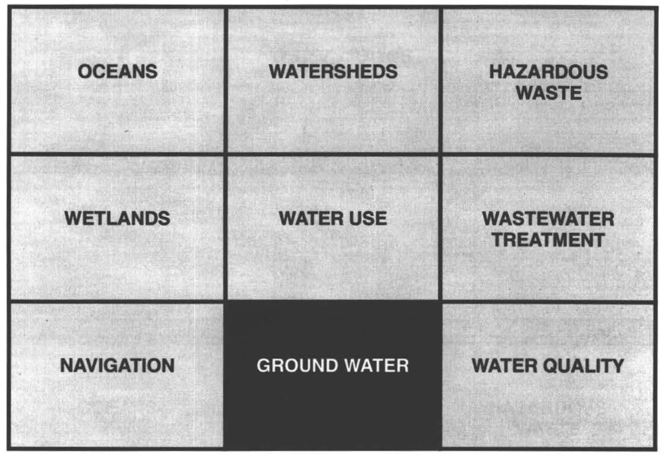
Obtain 250 milliliters (mL) of sand, 250 mL of pea-size gravel, 250 mL of clay, and three large funnels (top diameter approximately 12 cm). Force a piece of cheesecloth into the top of the spout of each funnel. This will prevent material from going through the funnel spout. Put each funnel into separate clear containers so that the spout of the funnel is at least 5 cm above the bottom of the container. Pour the sand into the first funnel, pea-size gravel into the second funnel, and the clay into the third funnel. Pour equal amounts of water (approximately 200 mL) onto the materials contained in the funnels. Select three students to pour the water, creating a permeability race. Time how long it takes the water to flow through the materials. Record on a data sheet. Which material did the water flow through the fastest? Why?

This activity was adapted from "Get the Ground Water Picture," National Project WET.

Poster Series

This poster is part of a series of water-resources education posters developed through the U.S. Geological Survey's Water Resources Education Initiative, a cooperative effort between public and private education interests. Partners in the program include the U.S. Geological Survey, Bureau of Reclamation, and the U.S. Fish and Wildlife Service of the U.S. Department of the Interior; the National Oceanic and Atmospheric Administration; the U.S. Environmental Protection Agency; the U.S. Army Corps of Engineers; the Nebraska Groundwater Foundation; and the National Science Teachers Association.

The other posters in the series are entitled "Oceans--Coastal Hazards: Hurricanes, Tsunamis, Coastal Erosion", "Watersheds: Where We Live", "Hazardous Waste: Cleanup and Prevention", "Wetlands: Water, Wildlife, Plants, & People!", "Water: The Resource That Gets Used & Used & Used for Everything!","How Do We Treat Our Wastewater?", "Navigation: Traveling the Water Highways!", and "Water Quality...Potential Sources of Pollution". The posters in the series are designed to be joined to create a large wall mural. A schematic of the wall mural is displayed on this panel. The gray shaded spaces represent the posters listed above. The black shaded space represents this poster.

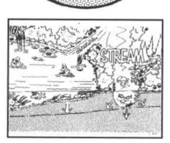


Water-resources topics of the posters are drawn in a cartoon format by the same artist. All poster are available in color. The reverse sides of the color posters contain educational activities: one version for children in grades 3-5 and the other for children in grades 6-8.

Recharge Areas

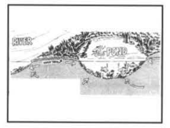
Recharge is the addition of water to the ground-water system. The recharge of freshwater begins as precipitation. Precipitation occurs in several forms, including rain, snow, and hail, but only rain is displayed on the poster. Some of the rain infiltrates into the soil. If the rate of the rainfall exceeds the rate of infiltration, surface water will flow over the land surface to surface-water bodies such as rivers and streams.

Water can infiltrate faster from the land surface into sandy soils than silty or clay soils. Water infiltrates into the soil and the unsaturated zone. The unsaturated zone occurs immediately below the land surface and contains both water and air in the pores and fractures in the rock materials. Water moves, or percolates, down through the unsaturated zone to the saturated zone. The saturated zone is where all the pores or fractures in rock materials are filled with water. The top of the saturated zone is called the water table.

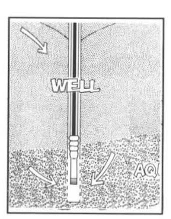


Because surface-water and ground-water systems are connected, surface water can recharge ground water. Aquifers can obtain water from such surface-water bodies as reservoirs and streams when and where the water table is lower than the surface-water body. Recharge areas usually are higher in elevation than discharge areas.

Discharge Areas



Places where ground water flows from aquifers to springs, seeps, wetlands, ponds, or streams are called ground-water discharge areas. Ground-water discharge to these natural areas occurs when the water surface of the aquifer (water table on the poster) is at or above the elevation of the discharge area (river and pond on the poster). Surface-water and ground-water systems are interconnected. The flow of most streams is sustained by ground water seeping into the stream. The water surfaces of many ponds and wetlands are an extension of the local ground-water table. Springs occur where ground water flows from an aquifer to the land surface.



Ground water can be brought to the land surface by pumping from a well. A well is an opening that has been drilled or dug into an aquifer below the water table. Water from the aquifer flows into this opening to replace water removed by pumping water from the well. The water table slopes from areas of recharge to discharge areas like rivers, ponds, wells, and springs.

ACTIVITY
Recharge - Discharge

Introduction

Recharge is the addition of water to an aquifer. Recharge can occur from precipitation or from surface-water bodies such as lakes or streams. Water is lost from an aquifer through discharge. Water can be discharged from an aquifer through wells and springs, and to surface-water bodies such as rivers, ponds, and wetlands. The following activity is designed to demonstrate the recharge and discharge of water to a model aquifer.

Objectives--Students will:

1. Identify several sources of recharge for ground water.
2. Identify several sources of discharge for ground water.
3. Discuss how water moves from recharge to discharge areas.
4. Discuss the connection between surface water and ground water.

Materials

1. One clear container at least 15-cm wide x 22-cm long x 6-cm deep for each group. Possible containers include clear plastic salad containers or clear baking pans.
2. Sufficient pea-size gravel to fill the container approximately 2/3 full.
3. Two 472-mL paper cups for each group.
4. One pump dispenser from soft-soap or hand-lotion containers for each group.
5. 472 mL of water.
6. Grease pencils, one for each group.
7. Twigs or small tree branches, to represent trees on the model (optional).
8. Colored powdered-drink mix or food coloring (optional).

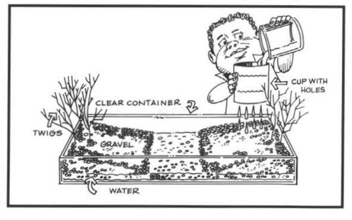
Teacher Preparation

1. Display a copy of the poster titled "Ground Water: The Hidden Resource" on the classroom wall several days prior to conducting this activity.
2. Using an ice pick or awl, punch 8 to 10 small holes in the bottom of one of the paper cups. When filled with water, this cup will be used to simulate rain.
3. Fill the clear containers 2/3 full with pea-size gravel.

Procedure

- Divide the class into small groups. Provide each group with one clear container filled 2/3 with pea-size gravel, one 472-mL cup with holes punched in the bottom, one 472-mL cup with no holes, and one pump dispenser.

- Students make models to represent hills and a valley. One student from each group fills the 472-mL cup without holes in the bottom with water. Each group makes a valley in the center of the model by pushing gravel to the farthest opposite ends of the container so the valley extends completely across the width of the container. About 2 cm of pea-sized gravel remains in the bottom of the valley.



- Explain to the students that the gravel mounds on both sides of the container represent hills with a valley in between. The students can place twigs or small branches on the hills to represent trees. Instruct a student to hold the 472-mL cup with holes over the model. Then add 472 mL of water to this cup. Tell the students that they are simulating rain. Have the students observe how the water infiltrates into the gravel and becomes ground water.

- Introduce the word recharge--the addition of water to the ground-water system. Observe that water is standing in the valley. Have the students use a grease pencil to draw a line identifying the water level in the container. The line should traverse the entire model, identifying the water level under the hills and in the valley. There will be a pond in the valley.

- Explain that they have just identified the top of the ground water in their model. The top of the ground water is called the water table. Discuss with the students how the ground water becomes a pond in the valley. This is because the water table is higher than the land surface (gravel) in the valley.

- Have the students insert the pump into one of the hills on the side of the valley, pushing the bottom down to the ground water. Allow each of the students in the group to press the pump 20-30 times after the water in the pump has begun to flow. Catch the water in the paper cup with no holes in the bottom. After each student takes a turn pumping, instruct them to observe the location of the water table in relation to the grease-pencil line. Where did the water go? What happened to the pond? Discuss discharge, the removal of water from the ground. Discuss the effect of ground-water pumping on streams and lakes.

Interpretive Questions

1. Where does ground water come from?

Answer: Precipitation (rain, snow, sleet, etc.) Also, if the water table is at or below the surface of the water in a stream or pond, water can move from the stream or pond to recharge the ground-water system.

2. What would happen in the students' neighborhood (name a local stream or pond) if a well was drilled near that stream or pond and enough water pumped to lower the water table around the stream or pond?

Answer: Some water from the stream or pond would be removed by the pump through the well. If enough water is removed, a pond or small stream could go dry.

Extension

Sprinkle a colored powdered-drink mix or food coloring on top of one of the hills and repeat the above activity by having it rain on the model. Discuss the movement of "pollution" from the hill to the ground water to the lake.

ORDERING INFORMATION

Copies of all the posters in the series (see Poster Series Panel) can be obtained at no cost from the U.S. Geological Survey. Write to the address below and specify the poster title(s) listed on the Poster Series panel, and grade level(s) desired. The poster entitled "Water: The Resource That Gets Used & Used & Used for Everything!" is also available in black-and-white, intended for coloring by children in grades K-2. In addition, the poster entitled "Water: The Resource That Gets Used & Used & Used for Everything!" with activities intended for grades 3-5 is available in Spanish.

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DEFINITIONS

Aquifer	- An underground body of porous sand, gravel, or fractured rock filled with water and capable of supplying useful quantities of water to a well or spring.
Crystalline Rock	- Igneous or metamorphic rock consisting of relatively large mineral grains.
Freshwater	- Water that contains less than 1,000 milligrams per liter of dissolved solids.
Ground Water	- Water beneath the land surface in the saturated zone.
Ground-Water Discharge	- The flow or pumping of water from an aquifer.
Ground-Water Recharge	- The addition of water to an aquifer.
Infiltration	- Movement of water from the land surface into the soil.
Permeability	- The capacity of porous rock for transmitting water.
Public Supplies	- Water supplied for domestic, commercial, thermoelectric power, industrial, and other public uses.
Saturated Zone	- Zone below the land surface where all the pores or fractures are filled with water.
Surface Water	- Water on the Earth's surface.
Unsaturated Zone	- The zone immediately below the land surface where the pores or fractures contain both water and air.
Water Table	- The top of the water surface in the saturated zone of an unconfined aquifer.

ACKNOWLEDGMENTS

The following individuals contributed to the development of this poster:

Project Chief, Principal Author, and Layout: Stephen Vandas, U.S. Geological Survey, Denver, Colorado

Art Work: Frank Farrar, Frank Farrar Graphics, Denver, Colorado, under contract to the American Water Resources Association

U.S. GEOLOGICAL SURVEY (USGS)

As the Nation's largest water, earth, and biological science and civilian mapping agency, the USGS works in cooperation with more than 2,000 organizations across the country to provide reliable, impartial, scientific information to resource managers, planners, and other customers. This information is gathered in every state by USGS scientists to minimize the loss of life and property from natural disasters, to contribute to the conservation and the sound economic and physical development of the Nation's natural resources, and to enhance the quality of life by monitoring water, biological, energy, and mineral resources.

U.S. Department of the Interior
U.S. Geological Survey

GRADE SCHOOL