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ABSTRACT

This is the teacher's guide to a student text designed to help users understand: (1) what groundwater is and how it is part of the hydrologic cycle; (2) how groundwater travels; (3) how groundwater is stored, purified, or contaminated; (4) the five physiographic regions in Virginia that store groundwater; and (5) the everyday activities that help protect this hidden resource. Included in each of the five units are: (1) objectives; (2) suggestions for instruction; (3) demonstrations; (4) additional activities; and (5) evaluation items. A test consisting of 15 multiple-choice items and 10 short-answer questions is appended. (YP)

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INSTRUCTOR'S GUIDE
to
Sandcastle Moats and Petunia Bed Holes

A book about groundwater

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INSTRUCTOR'S GUIDE

to

Sandcastle Moats and Petunia Bed Holes

A book about groundwater

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PREFACE FOR INSTRUCTORS

The primary aims of *Sandcastle Moats and Petunia Bed Holes* are to help users understand 1) what groundwater is and how it is part of the hydrologic cycle; 2) how groundwater is stored, purified, or contaminated; 3) the five physiographic regions in Virginia that store groundwater; and 4) the everyday activities that help protect this hidden resource.

The booklet is designed to be used with middle school students (age 12 and above) in a variety of ways, including:

1. to supplement or complement existing program and curriculum materials;
2. as a resource or instructional aid for special study groups, science fair participants, or individuals interested in the conservation of natural resources;
3. as a reference for individuals and groups interested in information on Virginia's groundwater and personal strategies for helping to maintain adequate, usable supplies of clean water.

The text of the booklet is presented in a conversational mode and is accompanied by graphics that illustrate important ideas and concepts. Simple and nontechnical terminology is used when possible and vocabulary words are defined the first time they appear in the text and are listed in the margins of each section. A glossary of all listed words is also included.

Six demonstrations involve students in the learning activities and help reinforce major concepts introduced in the text. Instructors should find the demonstrations practical and easy to conduct. Demonstrations call for commonly available materials and are easy to set up and maintain. Most demonstrations can be conducted in brief periods of time by either students or an instructor.

There are "sidebars" included in the student text. These sidebars offer additional information on subjects related to groundwater (the hydrologic cycle, wells, superfund sites in Virginia, and the process by which caves form) but provide more detail than is necessary for basic understanding of groundwater principles.

The information in this instructor's guide to groundwater education relates to each of the five sections of the student booklet. The information is organized in the following manner:

1. suggested learning outcomes;
2. activities and information related to the units;
3. additional activities, study topics, and science projects;
4. suggested field trips and additional demonstrations;
5. evaluation items to help assess attainment of the learning objectives.

The evaluation items are related to the concepts and key terms covered in the first four sections. The items are not intended to include all of the possible questions or types of questions an instructor might use to help assess student outcomes. An instructor may wish to add other items or to develop entirely different items for use with students.

After you have used or reviewed the materials, we would appreciate your taking the time to let us know how effective you think the materials are. Suggestions about what changes or improvements are needed will be incorporated into later editions. Address your responses to:

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UNIT 1: WHERE'S THE GROUNDWATER?

Objectives

Upon completion of this unit, the student will be able to

1. identify and describe what groundwater is
2. explain how the hydrologic cycle works
3. relate the connection between ground and surface waters and the water table
4. demonstrate the flowing of groundwater into a well and how recharge, subsidence, and a cone of depression are related to groundwater

Suggestions for Instructors

This section is designed to help students understand what groundwater is, how it is part of the hydrologic cycle, and how a well draws groundwater.

Suggested Activity

Fill a plastic cup with gravel and pour in enough water to fill the cup half full. Point out the *saturated zone, unsaturated zone,* and the *water table.* Insert a spray pump and pump out some of the water. Explain that the spray pump is very much like a well and that as the water is withdrawn from the saturated zone it leaves a space for the surrounding water to flow into. Pumping out too much water is *overwithdrawal* and this may cause the land to sink (*subsidence*) or in coastal areas may cause saltwater to mix with the fresh groundwater (*saltwater intrusion*). As you pour some more water into the cup explain that precipitation entering the groundwater system is called *recharge.* The water coming out of the ground, as in the well and spray pump, is *discharge.* This activity should help students relate the part groundwater plays in the *hydrologic cycle* and how pumping our groundwater creates a *cone of depression.*

Additional Activities for Students

Fill a glass jar three-fourths full with a mixture of sand and gravel. Slowly pour water into the jar. Allow the jar to stand until all the water has percolated to the bottom. Using a small square of old nylon stocking, cover the end of the spray pump tubing. A rubber band wrapped around the tube should hold the stocking in place. (The stocking will act like a screen used on some wells to prevent sand from entering.) Insert the pump and spray it several times to lower the water table. Around the edge of the jar, put several drops of red food coloring on the gravel and sand mixture near the inside of the glass jar. Gently pour a small amount of water on the food coloring in the jar so that it mixes with the water and percolates down through the sand and gravel mixture. Ask students:

1. What happens to the food coloring?
2. What happens to the water already in the jar? Spray the pump several times. Then ask students:
3. What does this activity tell you about discharge and recharge?

Other Activities

1. A terrarium in a closed aquarium is a good class project to illustrate the water cycle.
2. Ask a well driller to speak to the class about drilling wells and locating a usable source of water. (Look for Water Well Drillers in the Yellow Pages.)
3. Take a field trip to where a well is being drilled.
4. Have students survey well owners to determine the depth of wells in the area. Plot the data on a chart or graph. Make a cross-section of the area showing the average well depth in each section.
5. Keep a month-long record of precipitation amounts. Compare the rainfall levels to average amounts. Make a chart and discuss how drought conditions, flooding, and normal precipitation affect the water table.

6. Research topics related to this unit

   a. desalination
   b. water rights
   c. water resorts of the 1800s
   d. soil erosion and runoff
   e. water as a solvent
   f weather patterns and cloud formations

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UNIT 2: HOW DOES IT TRAVEL?

Objectives

Upon completion of this unit, students will be able to

1. demonstrate an understanding of porosity and permeability
2. define aquifer, perched water table, and confined aquifer
3. indicate how water moves through sedimentary rock, crystalline rock, rock fractures and faults, and unconsolidated deposits
4. name or identify the factors that result in an artesian well

Suggestions for Instructors

This section is designed to help students understand what percolation is and how the different soils can affect it and the size and locations of aquifers. The unit contains two demonstrations, one each on porosity and permeability. Introduce the demonstrations with a discussion of the differences in soils. Ask students to think about childhood experiences of making mud pies, building sandcastles, and digging in flower beds. Talk about the size of the particles that make up these soils and how fast water flows through them.

Demonstration 1: Porosity (page 9 of text)

Both the size and the shape of a soil particle determine the porosity of the soil. The amount of open space between the particles (pores) determines how much water that soil type will hold. The marbles and sand in the demonstration represent unconsolidated deposits like limestone and sand that have pore spaces that water can travel through. The marbles and sand in the cups are more porous than rock formations of granite, schist, or marble. Nonporous rocks transport water through cracks and faults.

Demonstration 1: Questions and Answers

1. What could the marbles represent?

   The marbles represent any earth material which has large spaces through which water can flow readily. Gravel and other large, loose rocks are like the marbles with plenty of space between individual chunks. The marbles also represent any rock with pores, even if those pores are not easily visible. This is the key concept in porosity. Water moves through rock layers in the same way it moves through gravel or the marbles in the jar. The reason is many rocks are not really solid, but have pores large enough for water to move through.

2. How is the sand different from the marbles?

   The irregular shape of the sand grains and their smaller size means there is less space separating each grain of the sand. Therefore, there is less overall pore space in the sand cup. The more closely particles fit, the less pore space available.

3. Which takes up more space in the cup, marbles or sand?

   Sand takes up more space in the cup than the marbles because it takes less water to fill the sand cup than to fill the marble cup. The smaller pore spaces between the sand left less room for the water.

4. Which takes up more space, a marble or a grain of sand?

   Obviously, a marble takes up more space than a grain of sand. What may seem like a contradiction to some students is that even though individual marbles are larger than individual sand grains, there is more room for water in the cup of marbles than in the cup of sand. Because pore spaces between the marbles are larger than between the sand grains, the cup with marbles can hold more water.

5. How do marbles and sand represent real ground or earth?

   Marbles and sand are examples of unconsolidated deposits. They are most like gravel and sand and loose layers of soil.

6. How are they different from real situations?

   The cups of marbles and sand are more porous than most "solid" rocks. Some like granite, schist, gneiss, or marble do not have pore spaces. Nonporous rocks transport water through cracks and faults.

Demonstration 2: Permeability (page 10 of text)

The permeability of a rock is its ability to transmit water or other liquids. Permeability depends on how well connected the pores in a soil are. Students should see that the cups containing sand and gravel will allow the water to pass through quickly. The cup with clay may not allow any water to pass through. Cups containing a mixture of soils will be less permeable than the cup of sand and gravel because the large pore spaces will be filled in by the smaller soil particles. **Caution:** It is very important that all cups are saturated and drained before timing results as explained in the directions.

Demonstration 2: Questions and Answers

1. What earth material was the most permeable? The least?

   The material through which the water traveled the fastest (fewest seconds timed) is the most permeable. The slowest is the least permeable.

2. How did mixtures fare against single-material cups?

   The cups with soil mixtures are less permeable than some of the single-material cups because the large pore spaces that would have existed between larger chunks have been filled in by the smaller particles.

3. How is porosity different from permeability in a solid rock?

   In a solid rock the permeability depends on how well the pore spaces are connected to each other. Because all of these pieces are loose, the pore spaces are connected. An example of unconnected pore spaces would be air bubbles trapped inside a rock but not connected to each other.

Additional Activities

1. The porosity and the permeability of soils affect the filtration process which purifies groundwater naturally. Demonstrate filtration in the following procedure:
   a. Cut a plastic gallon milk jug in half.
   b. Place a layer of small pebbles, a layer of gravel, a layer of coarse sand, and a layer of fine sand in the neck of the jug with the top pointing down. (Stretch a piece of old stocking over the neck opening. Secure with a rubber band.) This top portion is the filter.
   c. Collect muddy water from a rain-swollen stream or street gutter. Or mix some dirt and water together.
   d. Hold the jug portion with the filter over the bottom half of the jug and pour the muddy water into the filter. The layers will filter the mud and clean water will pass into the jug.
2. Science Fair Projects
   a. Construct a model depicting the geology of the local area. Include rock formations, fault lines, and different soil types. The model can be constructed using real materials and set up in an aquarium or made from modeling clay molded to cardboard. Both methods are described on the following pages.
   b. Set up a porosity-of-soil demonstration.
   c. Demonstrate attenuation of different types of soil. An ant farm model makes a good demonstration of this process.
3. Research topics related to this unit
   a. Percolation tests — how and why they are conducted
   b. Area geologic maps
   c. Formation and properties of different rocks (igneous, sedimentary, metamorphic)
   d. Artesian wells

4. Field Trips

   a. Highway road cuts to see the geology of the area

   b. Water treatment plant

   c. Wastewater treatment plant

Models of Groundwater Systems

Aquarium Model

Using a 10-gallon aquarium, build a model simulating the geology of the area. Ceramic clay, vermiculite sand, aquarium gravel, and potting soil can be used to represent the different formations. Identify the layers with labels attached to the outside of the glass. Indoor-outdoor carpet or a living ground cover and model railroad houses can be placed on the surface to represent the countryside.

Two-Dimensional Clay Cross-Section

Materials: Cardboard or fiber board; plastic wrap or aluminum foil; food coloring, paints, washable black ink; sand; soil; pebbles; clear plastic straw; floral clay, modeling clay or homemade clay made from 1 cup of flour, 1/3 cup salt, 1/3 cup water, 1 teaspoon vegetable oil.

Construction: Select a piece of cardboard or fiber board the intended size of the model and cover the front surface with plastic wrap or aluminum foil. Tape the excess to the back and make sure edges are sealed so that any moisture will not seep through. Using different modeling tools and colors, create the various rocks and formations. Suggested illustrations include: a water table, a confined aquifer, an aquifer in fractured crystalline rock, a well with a cone of depression, the unsaturated zone, discharge locations of groundwater, leachate from a landfill, and a fault zone. Modeling methods for each of the layers are listed below. (NOTE: The model can also be built in a clear plastic box with labels attached to the outside.)

Crystalline Rock

Onto a small lump of white clay sprinkle two or three drops of black ink and knead only until the color is marbelized. This technique produces a material similar to schist, a crystalline rock.

Clay

Thoroughly mix red and brown and yellow paints with a piece of thhe clay to produce a southern red clay.

Limestone

Tint the clay a light gray and knead into a rope. Stretch the rope gently to produce a grainy, fissured texture which represents limestone with solution channels.

Unconsolidated Deposits

Use small pebbles pressed into a thin layer of clay to represent unconsolidated deposits.

Sandstone

Sand pressed into the surface of the clay will give a grainy texture characteristic of sandstone.

Faults and Fractures

Mold sharp edges in the clay to represent the fault zone. For the fault line make sure the two sides of the indentation are offset with one side shifted upward relative to the other side. For a fracture an irregular crack is a good representation.

Saturated Zone

Use blue coloring to indicate water within the rocks and soil of the saturated zone. For the water table, color only the lower portion of the clay blue and leave stratum above uncolored.

Soil Layer

Mix soil with a small amount of glue and press into a layer of clay which has partially dried out. Potting soil, sphagnum moss, or garden loam that is a mixture of sand, clay, and some organic matter will add realism to this layer.

Well

Use the clear straw to indicate the well shaft. Pieces of aluminum foil can be modeled to represent the hardware and pipes in a well. Sandcrusted clay makes a good simulated grout. A little blue coloring in the surrounding earth materials can indicate the height of the water table and the extent of the cone of depression.

UNIT 3: WHAT'S IN GROUNDWATER?

Objectives

Upon completion of this unit, the student will be able to

1. explain how the decay of vegetation affects the acidity of groundwater
2. determine the pH level o. different sources of ground and surface water
3. describe how what is in the soil can affect the quality of water that passes through it
4. demonstrate the solubility of several household solutes
5. describe how minerals are added to groundwater
6. identify human activities that affect groundwater quality
7. understand that groundwater can become contaminated by waste disposal
8. discuss alternatives to keep water-soluble materials from leaching from a landfill
9. relate the demonstrations on dissolving of solutions and leaching from a landfill to other potential sources of pollution to an aquifer
10. evaluate alternatives for human activities that affect groundwater quality

Suggestions for Instructors

This section is designed to help students understand how natural and human activities affect the quality of groundwater. It is important for students to understand that the quality of groundwater is influenced by human activity and the quality affects the usability of the resource.

Demonstrations in this section illustrate how groundwater becomes acidic; how groundwater dissolves soluble substances; and how waste disposal can affect groundwater quality. The additional activities and discussion items are designed to help students relate the demonstrations to real liife situations and to evaluate the alternatives available to protect groundwater resources.

Demonstration 3: Questions and Answers (page 13 of text)

1. What does the decaying food represent in a natural system?

   The decaying food represents dead plants and animals that are decomposing in the soil.

2. What connection was there between the decaying food and the change in the pH level of the water?

   Carbon dioxide from the decaying food is dissolved by the water, producing a weak carbonic acid. The lower the number on the pH scale, the more acidic the drain water is.

3. Could changes in the seasons cause differences in the level of groundwater acidity?

   The seasonal death of plant matter provides an abundance of raw materials needed to acidify the groundwater. Cold weather slows the decomposition rate and warmer weather accelerates the rate.

4. Why does water collected from different sources have different pH levels?

   The different pH levels are caused by the presence of different substances in the water. For example, lemon juice and vinegar have pH levels of 2 and 2.2 respectively. Ammonia is very basic with a pH level of 11.

Demonstration 4. Questions and Answers (page 14 of text)

1. What natural activity is represented by pouring water over the mixtures?

   The watering represents precipitation in the hydrologic cycle.

2. What might the salt and cornstarch represent?

   These ingredients represent water-soluble substances in the soil. Rocks and soils contain soluble minerals such as iron, calcium, magnesium. Decaying plants and animal matter give up carbon dioxide and nitrogen. Man-made substances such as industrial chemicals, fertilizers, and household products also contribute to the leachate.

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3. Does a material have to be buried to contribute to the leachate? How else might materials leach into groundwater?

   A material does not have to be completely buried to contribute to leachate. Soluble substances such as highway deicing salts left in a pile can contribute to leachate. Roadside dumps, over-fertilized fields, items dumped in a sinkhole can leach into groundwater.

Demonstration 5: Questions and Answers (page 17 of text)

1. What types of materials are found in landfills?

   Household garbage, appliances, furniture, brush, and household hazardous waste such as paint thinners and solvents are but a few of the items buried in landfills. In addition, some landfills accept industrial wastes, construction materials, automobiles and tires.

2. What can be done to keep water-soluble materials from leaching from a landfill?

   The less water that enters a landfill, the less likely it is that leachate will leave a landfill. Some ways to minimize how much water a landfill receives are: capping a landfill to prevent water from entering; barriers beneath a landfill to prevent liquids from leaching; and drainage systems to collect storm runoff and leachate from the landfill.

3. Where might the leachate end up?

   Leachate which has percolated to the saturated zone eventually might find its way into drinking water supplies.

4. What are the similarities between landfills and roadside trash heaps?

   These dumps can produce leachate in the same way as a landfill. However, since many of these sites have no protective barriers to prevent leachate, they pose a real threat to groundwater.

Additional Activities

1. Expand the number of solutions in Demonstration 4 to include flavored gelatin (colored) powder, baking soda, vegetable oil, laundry detergent, powdered drink mix. Have students record the results and consider why only parts of the gelatin powder and the drink mix dissolve. Discuss what will happen over time to the soil with oil, the slow dissolving gelatin, and the laundry detergent. Expand the activity again by recording the pH level of each leachate.
2. A demonstration illustrating how long it takes for different types of waste materials to decompose will help students understand the problems with landfills and groundwater.
   a. Fill 10 glass jars such as used for peanut butter or mayonnaise with soil typical of the area.
   b. Put a different waste material in each one and label the jar. Bury some of the waste next to the glass. Possible items: aluminum pull tabs; pieces of rubber bands; plastic bottles; paper towels; wire; fabric; plastic foam; cardboard; newspaper; food — a mixture of bread, orange rinds, coffee grounds, tea bags, egg shells, etc.
   c. Saturate the soil and drain off the water. Seal the jars with screw lids.
   d. Place the jars on the window sill or in an area where students can observe them each day.
   e. Observe the changes to the waste matter. Some items will decompose quickly while others will remain relatively the same. NOTE: This activity can be carried out over the entire school year.
   f. Ask students to make judgements about the necessity of a variety of items that are discarded and alternatives for disposal. Discuss recycling, composting, incineration, and procedures for diminishing waste materials.
3. Have students collect articles from newspapers and magazines discussing hazardous waste and the effects on groundwater and human health.

4. Take the class on a field trip to a landfill and/or recycling center.
5. Have students do a research project on a situation involving groundwater quality in the community. Or research and write a report on these related items:

   injection well disposal

   how a water softener works

   aerobic and anaerobic bacteria — how they break down substances in the saturated and unsaturated zones

   pH level of various substances

   technological advances in landfill designs

   radon in Virginia

   community household hazardous waste disposal efforts

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UNIT 4: VIRGINIA'S GROUNDWATER

Objectives

Upon completion of this section, students should be able to

1. list the five physiographic regions of the state
2. identify the region where they live and the type of geology in the area
3. demonstrate how sinkholes and caves form
4. describe how rainfall, carbon dioxide, and limestone interact to form caves
5. define stalactites and stalagmites
6. identify the Virginia regions most likely to have caves, saltwater intrusion, be polluted by coal mining, and yield usable amounts of water a few hundred feet from the surface

Suggestions for Instructors

This section is designed to help students identify the groundwater conditions, rock formation, and general geologic characteristics of the area where they live. The formation of sinkholes is illustrated in Demonstration 6 and information on how caves form in limestone areas is described.

Demonstration 6: Questions and Answers (page 24 of text)

1. What natural process does the watering represent?

   The water represents precipitation in the hydrologic cycle.

2. What rock does the sugar represent?

   The sugar represents a rock which is soluble in groundwater. Limestone is one such rock.

3. What characteristics must a rock have for sinkholes and caverns to form?

   To form a sinkhole or cave, the rock must be soluble in groundwater

4. Why did the sinkhole form only over the sugar deposit?

   Because sugar is soluble and the sand is not, the sinkhole formed over the water-soluble deposit.

Additional Activities

1. Expand Demonstration 6 by replacing the sand with small gravel and the sugar cube. Try the demonstration also using a clay mixture, and then a mixture of sand and gravel. Have students hypothesize in advance if they think a sinkhole will form in each of the different soil types.
2. Collect postcards, brochures, and pictures of Virginia's caves. (Many are tourist attractions and have free, colorful brochures.) Using a map of the geologic provinces in the state, identify the areas where caves are located. Expand the project to a bulletin board display that also includes the many mineral springs and health spas so popular in the late 19th century.
3. Using a Virginia map, list all the localities that have groundwater-related terms in their names. A few examples are Mineral Springs, Hot Springs, Rockbridge Baths, Weyers Cave, and Belspring.
4. Using a topographic map of your area, locate lakes, streams, sinkholes, springs, mines, and landfills. Record the surface elevations of the lakes and streams and construct a profile map of the elevations of all water/land intersections. On the profile map draw a line connecting the different water bodies. Determine if landfills, sinkholes, and mines are close to the water table.
5. Possible research topics related to this section are

   Overdevelopment of coastal areas

   Weather patterns, recharge, and runoff

   The effect of rising sea levels on coastal aquifers

   Mining limestone and dolomite

UNIT 5: WHAT WE CAN DO TO HELP

Objectives

Upon completion of this section, students should be able to

1. identify three common threats to groundwater
2. list individual activities that help protect groundwater
3. list safe practices for use of a well
4. list proper maintenance for septic systems
5. list five water conservation practices

Suggestions for Instructors

This section is designed to show how individual, everyday activities can help protect groundwater resources. It is important for students to realize that careless disposal can have a long-range effect. The information in this section is practical and students should be encouraged to offer their own suggestions for protection.

Additional Activities

1. Have students investigate the sources of and problems caused by nitrates in groundwater.
2. Have students discuss alternatives to fertilizers, animal feedlots, waste disposal, and disposal of household hazardous waste.
3. Other areas of research and study are

   Local ordinances on septic systems, wells, land use, landfills

   Trash collection, roadside dumps

   Toxic ingredients in common household products

   Water conservation

   Oil recycling

4. Community Activities

   Many communities in Virginia have organizations that run recycling programs and collect newspapers, aluminum cans, glass, and help service stations with collecting used motor oil. Investigate what types of programs are active in your community. Encourage students to participate or start a program if none exists.

5. Class Project: Press Conference or Newsletter on Local Groundwater Issues

   As a culminating activity for this text, have students conduct a press conference or produce a newsletter on groundwater issues in their community. Have students invite authorities from the county health department, Virginia Water Control Board, the town council, a well driller, and a professional hydrologist to the class to answer their questions. Have the students prepare the questions or use the ones listed here and give them to the presenters several days in advance of the class meeting. On the day of the press conference, have each student ask their question of the panel of experts. If videotape equipment is available, record the proceedings.

   A student-produced newsletter can be an activity that will improve writing and reporting skills. Have each student write one article based on a local groundwater issue. The questions listed here could also be used for the newsletter. Or have students develop articles on subjects of interest to them. Let students design the newsletter and produce it for distribution to class members, local authorities, civic groups and for display on bulletin boards. Suggestion: If computer word processing and print shop software are available, have students use them for typing, editing, and laying out a newsletter.

Questions for Groundwater Newsletter/Press Conference

1. How many wells are in this community? What is the average depth? What is the average cost?
2. What type of testing is done on well water and springs to be sure it is safe to drink? What is the cost of testing well water? How many wells were tested last year?
3. How many wells in this county have known contamination problems? What is the type and source of the contamination?
4. What are the locations, ages, and types of landfills in this area? Are there any roadside dumps? What ordinances pertain to dumps and landfills?
5. Where is industrial waste in this area disposed of? What type of waste is it? Are there any waste pits or lagoons?
6. Which local industries use groundwater? How much? For what?
7. Where does this school get its water? How many gallons a day are used? Does the school use water-saving fixtures and devices?
8. How is a well drilled? What does a well driller have to do to be qualified to drill a well?
9. What is a percolation test and how are the results used? Who does the test and for what reason?
10. What is the geology of this area? How does it affect the quality and availability of groundwater?
11. What is the source of the public water supply? During a drought, is groundwater used to supplement supplies?
12. Are there any sites in this area that are historically important because of groundwater? Describe.
13. Do you need a permit to install a septic system? Why? Under what circumstances do you need a permit to repair a septic system?
14. What illnesses and health problems can result from drinking contaminated well water?
15. How does soil erosion and runoff affect the quality of groundwater?

Name ______________________________

Date ______________________________

Period ______________________________

Groundwater Test

Using the list below, supply the word(s) that fits each definition.

conservation	recharge	caves
groundwater	leachate	porosity
permeable	discharge	water table
recycling	aquifer	saltwater intrusion
hydrologic cycle	saturated zone	toxic materials

1. The process by which water is added to an aquifer. ______________________________
2. Water that is stored under the earth's surface. ______________________________
3. The zone of the ground where the pores of the rocks are full of water. ______________________________
4. The top level of an underground area which is saturated with water. ______________________________
5. Water leaving an aquifer by way of springs, wells, or geysers. ______________________________
6. The cycle or circular path through which water goes in the environment. ______________________________
7. The amount of space between rock particles. ______________________________
8. The ability of a rock to transmit water. ______________________________
9. An underground rock zone or soil layer that contains usable amounts of groundwater. ______________________________
10. Liquid which has filtered down through a landfill. ______________________________
11. Substances which are harmful to humans and animals. ______________________________
12. Formed when acidic groundwater dissolves limestone rocks. ______________________________
13. Overwithdrawal of water in coastal areas can cause this problem. ______________________________
14. Disposal method for used motor oil. ______________________________
15. Wise water use. ______________________________

Short-Answer Questions

1. Explain how the hydrologic cycle works.

2. How are ground and surface waters connected?

3. How are recharge, subsidence and a cone of depression related to groundwater?

4. Why does water move at different rates through different soil types?

5. Name the factors that result in an artesian well.

6. What is a perched water table?

7. Describe how minerals are added to groundwater.

8. Identify five human activities that affect groundwater quality.

9. Explain how a cave is formed.

10. Name the five physiographic regions in Virginia.

Answers to Groundwater Test

1. recharge
2. groundwater
3. saturated zone
4. water table
5. discharge
6. hydrologic cycle
7. porosity
8. permeable
9. aquifer
10. leachate
11. toxic materials
12. caves
13. saltwater intrusion
14. recycling
15. conservation