# 5-8 Groundwater & Runoff Activity

## Overview

**Focus Question**
How does the particle size of soil affect how much rainwater soaks in the ground and how much runs off?

**Activity Synopsis**
Students will use a jar of marbles to create a model of groundwater. They will identify groundwater, zone of saturation, zone of aeration and water table. Students will then observe and measure what happens when water is poured on samples of clay, sand and gravel to determine the effect particle size will have on the porosity and permeability of sediment. After these activities, when given the soil types of different regions of South Carolina, students will be able to predict whether the rainwater in that region is more likely to become groundwater or runoff.

**Time Frame**
One to two class periods.

**Objectives**
The learner will be able to:
- Create a model of groundwater and be able to identify and explain the zone of saturation, zone of aeration and water table
- Observe and measure the effect particle size has on porosity and permeability
- Given the predominant particle size in a sample of soil, predict whether the rainwater that falls on this soil is more likely to become groundwater or runoff

**Student Key Terms**
- groundwater
- permeability
- porosity
- surface runoff
- water table
- zone of aeration
- zone of saturation

**Teacher Key Terms**
- aquifer
- bedrock
- clay
- impermeable surface
- particle size
- sand
- soil

## Standards

***South Carolina College- and Career-Ready Science Standards 2021***

**5th Grade:** **5-ESS2-1**, 5-ESS3-1
**6th Grade:** 6-ESS2-4
**7th Grade:** 7-LS2-4, 7-ESS3-3

***Bold standards are the main standards addressed in this activity**

***2014 Academic Standards and Performance Indicators for Science***

# 5-8 Groundwater & Runoff Activity

South Carolina Aquarium

**5th Grade: 5.S.1A.1,** 5.S.1A.2, **5.S.1A.4, 5.S.1A.5**, **5.S.1A.6**, 5.S.1A.7, 5.S.1A.8, 5.E.3A.1, 5.E.3B.1
**6th Grade: 6.S.1A.1**, 6.S.1A.2, **6.S.1A.4, 6.S.1A.5, 6.E.4A.6**, 6.E.4A.7, 6.E.4B.8, **6.E.2A.3**
**7th Grade: 7.S.1A.1**, 7.S.1A.2, **7.S.1A.4, 7.S.1A.5, 7.E.4A.6**, 7.E.4A.7, 7.E.4B.8, **7.EC.5A.2**
**8th Grade: 8.S.1A.1**, 8.S.1A.2, **8.S.1A.4, 8.S.1A.5, 8.E.4A.6,** 8.E.4A.7, 8.E.4B.8, 8.E.5A.1

*** Bold standards are the main standards addressed in this activity**

***South Carolina College- and Career-Ready Science Standards 2021***

**5th Grade Performance Expectations**
**5-ESS2-1.** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
5-ESS3-1**.** Evaluate potential solutions to problems that individual communities face in protecting the Earth's resources and environment.

**6th Grade Performance Expectations**
6-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

**7th Grade Performance Expectations**
7-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
7-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

***2014 Academic Standards and Performance Indicators for Science***

**Fifth Grade Performance Indicators**
**5.S.1A.1** Ask questions used to (1) generate hypotheses for scientific investigations or (2) refine models, explanations, or designs.
5.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
**5.S.1A.4** Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation or graphing) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.
**5.S.1A.5** Use mathematical and computational thinking to (1) express quantitative observations using appropriate metric units, (2) collect and analyze data, or (3) understand patterns, trends and relationships between variables.
**5.S.1A.6** Construct explanations of phenomena using (1) scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
5.S.1A.7 Construct scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts.
5.S.1A.8 Obtain and evaluate informational texts, observations, data collected, or discussions to (1) generate and answer questions, (2) understand phenomena, (3) develop models, or (4) support hypotheses, explanations, claims, or designs. Communicate observations and explanations using the conventions and expectations of oral and written language.
5.E.3A.1 Construct explanations of how different landforms and surface features result from the location and movement of water on Earth's surface through watersheds (drainage basins) and rivers.
5.E.3B.1 Analyze and interpret data to describe and predict how natural processes (such as weathering, erosion, deposition, earthquakes, tsunamis, hurricanes, or storms) affect Earth's surface.

**Sixth Grade Performance Indicators**
**6.S.1A.1** Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.

6.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
**6.S.1A.4** Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.
**6.S.1A.5** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.
**6.S.1A.6** Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
6.S.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts.
6.S.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.
**6.E.2A.3** Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).

**<u>Seventh Grade Performance Indicators</u>**
**7.S.1A.1** Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.
7.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
**7.S.1A.4** Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1)
reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.
**7.S.1A.5** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.
**7.S.1A.6** Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
7.S.1A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts.
7.S.1A.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.
**7.EC.5A.2** Construct explanations of how soil quality (including composition, texture, particle size, permeability, and pH) affects the characteristics of an ecosystem using evidence from soil profiles.

**<u>Eighth Grade Performance Indicators</u>**
**8.S.1A.1** Ask questions to (1) generate hypotheses for scientific investigations, (2) refine models, explanations, or designs, or (3) extend the results of investigations or challenge claims.
8.S.1A.2 Develop, use, and refine models to (1) understand or represent phenomena, processes, and relationships, (2) test devices or solutions, or (3) communicate ideas to others.
**8.S.1A.4** Analyze and interpret data from informational texts, observations, measurements, or investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning or (2) support hypotheses, explanations, claims, or designs.

**8.S.1A.5** Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) collect and analyze data, (3) express relationships between variables for models and investigations, or (4) use grade-level appropriate statistics to analyze data.
**8.E.4A.6** Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.
8.E.4A.7 Construct and analyze scientific arguments to support claims, explanations, or designs using evidence from observations, data, or informational texts.
8.E.4B.8 Obtain and evaluate scientific information to (1) answer questions, (2) explain or describe phenomena, (3) develop models, (4) evaluate hypotheses, explanations, claims, or designs or (5) identify and/or fill gaps in knowledge. Communicate using the conventions and expectations of scientific writing or oral presentations by (1) evaluating grade-appropriate primary or secondary scientific literature, or (2) reporting the results of student experimental investigations.
8.E.5A.1 Develop and use models to explain how the processes of weathering, erosion, and deposition change surface features in the environment.

### Cross Curricular Standards

***South Carolina College and Career Standards for Social Studies***
6.5.CX, 7.5.1.PR, 7.5.2.ER

***South Carolina College and Career Standards for Math***
6.RP.1, 6.RP.2, 6.RP.3, 6.EEI.9, 7.RP.1, 7.RP.2, 7.RP.3

***South Carolina College and Career Standards for ELA***
Inquiry (I) – 6-1.1, 6-3.1, 6-3.4, 7-1.1, 7-3.1, 7-3.4, 8-1.1, 8-3.1, 8-3.4
Reading Literary (RL) – 6-5.1, 7-5.1, 8-5.1
Communication (C) – 6-1.1, 6-1.2, 7-1.1, 7-1.2, 8-1.1, 8-1.2

***Common Core Math Standards***
6.RP.1, 6.RP.2, 6.RP.3, 7.RP.1

***Common Core ELA Standards***
Writing – 6.1, 6.4, 7.1, 7.4, 8.1, 8.4
Speaking/Listening – 6.1, 6.4, 7.1, 7.4, 8.1, 8.4
Language – 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3
Writing for Literacy – 6-8.1, 6-8.2, 6-8.7

## Background

**Key Points**
*Key Points will give you the main information you should know to teach the activity.*

- Rainwater that seeps into the ground is known as **groundwater**. Groundwater is the water below the surface that fills the spaces between **soil** and rocks. Groundwater is divided into the **zone of saturation**, the spaces that are completely filled with water, and the **zone of aeration**, the spaces that are partially filled by water and partially filled by air. The boundary between the zone of saturation and the zone of aeration is known as the **water table**.
- Runoff is water that flows or drains off surface features, such as lawns or paved areas.
- **Porosity** is the amount of water a substance can hold or, in other words, the amount of space available in the substance that can hold water. It is expressed as a percentage.
- **Permeability** refers to the ease at which water passes through a substance.

- In soils, large sediment sizes tend to have more spaces between them and so will have a higher porosity and permeability. On soils with large sediment sizes the water in rain is more likely to become groundwater. On soils with small sediment sizes, the water is more likely to become **surface runoff**.
- **Sand** has much larger **particle sizes** than **clay**.
- Because the Sandhill soils are made primarily of sand and have high porosity and permeability, the rain that falls on them is most likely to soak into the ground and become groundwater.
- Because the Piedmont soils are made primarily of clay and have low porosity and permeability, the rain that falls on them is most likely to become surface runoff.

**Detailed Information**

*Detailed Information gives more in-depth background to increase your own knowledge, in case you want to expand upon the activity or you are asked detailed questions by students.*

When it rains, the water dissipates in various ways. Some of the water seeps into the ground while some of it runs off to nearby rivers and streams, some of the water is absorbed by plants and some of it evaporates back into the atmosphere. This is the water cycle.

Depending on where you are, the visible results of this will vary. In some areas of South Carolina, such as the Sandhills, it can rain all day and when it stops there are very few signs of the recent deluge of water. In other areas, such as downtown Charleston, it rains just a little and cars have to plow through three feet of water. What is the difference? Though there are many factors involved, one of the main things that affect the ratio between water saturation and water runoff is the **porosity** and **permeability** of the **soil**.

When it rains, the water is pulled down by gravity through the spaces between the soil particles and the cracks and fissures in the rocks. This water is known as **groundwater**. It is estimated that 95% of all freshwater available and approximately 50% of the water Americans drink is found in groundwater. Generally, groundwater is found within 100 meters of the surface.

As water seeps downward to the **bedrock** (the solid rock that underlies the soil) it begins to fill the spaces between soil particles and rock. The spaces that are completely saturated with water are known as the **zone of saturation**. This extends from the bedrock upward. The size of the zone of saturation is not permanent but changes when rainfall fluctuations and other factors add or remove water from the groundwater. Sometimes the zone of saturation can be a very thin layer and sometimes it can fill the soil to the surface. If large amounts of rain cause it to reach the surface, any excess rain cannot infiltrate the ground. The rain remains on the surface, sometimes causing flooding.

Generally, the zone of saturation does not reach the surface. Another layer of soil exists between the two. This layer has water in it, but is not completely saturated with water, air may be contained within it as well. This layer is known as the **zone of aeration**.

The boundary between the zone of saturation and the zone of aeration is known as the **water table**. The water table does not hold a permanently stable position in the soil, but is constantly moving up and down as rainfall amounts increase and decrease and water is drawn out of the soil by wells and natural processes.

The water underneath the water table in the zone of saturation is not permanently in one place either, but follows the sloping of the bedrock, moving slowly downwards in a lateral direction towards streams, rivers, lakes or the ocean. This is not a quick process, though. The rate of movement for this water resembles glacial speeds, generally being measured in meters per year and sometimes even less.

The amount of water that can be held by the soil is known as its porosity. Porosity is the ratio between empty spaces in the soil and the soil itself. It is expressed as a percentage. For example, if 30% of a volume of soil is open space, then 30% of it can contain water and thus it has a porosity of 30%. A liter (1000ml) of soil with a porosity of 30% can contain approximately 300ml (30% of a liter) of water.

Permeability is the rate at which water will flow through the soil to become part of the zone of saturation. Soils with high permeability allow water to flow through them very quickly. Soils and surfaces with low permeability do not allow water to flow through them very well, and have higher amounts of **surface runoff**.

Both porosity and permeability are affected by the **particle size** of the soil. Though all soil particles are small, there are microscopic differences in size. Very coarse grained- particles, 60 mm in diameter or larger, are characterized as cobbles and boulders. Coarse-grained particles, 2 to 60 mm, are classified as gravel. Medium-grained particles, 0.06 to 2 mm, are classified as **sand**. Fine-grained particles, 0.002 to 0.06 mm, are classified as silt. Very fine-grained particles, less than 0.002 mm, are classified as **clay**.

| Grain type | Size | Name of the grain |
|---|---|---|
| Very coarse grain | >60 mm | Cobbles and boulders |
| Coarse grain | 2-60 mm | Gravel |
| Medium coarse grain | 0.06-2 mm | Sand |
| Fine coarse grain | 0.002-0.06 mm | Silt |
| Very fine coarse grain | <0.002 mm | Clay |

Soils with relatively large particle sizes, such as sand and gravel, have larger gaps between their particles and thus have a higher porosity. These gaps also allow a quicker transfer of water leading to a higher permeability. Soils with small particle sizes, such as clay, have very tiny open spaces and thus have low porosity and permeability. Because soil is often a mixture of different sediment sizes, this can affect the porosity of the soil. Small particle size sediment can sometimes fill the gaps between large particle size sediment, thus lowering porosity.

Soils are mixtures of gravel, sand, silt, clay and organic material. The texture of soil is characterized by the percentages of sediment particle sizes in its make-up. It can be predominately sand, predominately clay, fairly even mixtures of both or various other combinations. Soils in South Carolina are composed primarily of sand or clay, and so are sandy or clay soils.

Sandy and clay soils have very different properties. Because of their larger particle size, sandy soils have a higher porosity and permeability. Water drains through them quickly, and they have more capacity to contain water. Because of the relatively large gaps between their grains, though, water loses its cohesive property and sand cannot hold water in its zone of aeration. For this reason, the topsoil of sandy soils tends to be well aerated, but very dry.

Clay soils have a smaller particle size, and thus have a lower porosity and permeability. Water drains very slowly, most of it running off before it can seep through. Because of the tiny gaps between the small clay particles, water that does seep through is held in the clay by cohesion. This is what gives clay its slimy, sticky feel. Because clay soils hold water so well, they become almost completely saturated with water and there is little space for air to infiltrate the clay. For this reason, clay soils are very moist soils, but not well aerated.

In South Carolina, the sediment types found in major regions affect saturation to runoff ratios. Each of these regions can be encountered in the Santee River watershed. In the Blue Ridge Mountain region of the state, the soil layer is very thin, with impermeable rock close to the surface. The Mountain region has the highest rainfall rate in the state, averaging over 60 inches a year. Because of the high amount of rainfall and the small amount of soil that can be saturated, most of the rain that hits the mountains becomes run off. This run off manifests itself in the streams and waterfalls found throughout the mountain region.

The streams of the Mountain region flow into the rivers of the Piedmont region. The soil layer in the Piedmont region is much thicker than that of the Mountain region. It is soil made up of sediment eroded from the mountains and is composed primarily of clays. Clays have the smallest particle size, and for this reason are virtually impermeable to water. Because of the impermeability of the soil, almost all rain that falls in the Piedmont region runs off. This, combined with the large amounts of water flowing in from the Mountain regions of both South and North Carolina, creates the large rivers that characterize this region. These rivers include the Savannah, Broad, Saluda and Catawba rivers. Each of these rivers flows eastward towards the Atlantic Ocean.

Midway through the state, these rivers cross the Sandhills, the boundary between the Piedmont and the Coastal Plain. The Sandhills are the remnants of ancient sand dunes, formed when the ocean reached this part of the state about 9 to 12 million years ago during the Miocene Epoch. As can be gathered from the name, Sandhill soils are composed primarily of sand. Sand has a much larger particle size than clay, approximately the same size difference as a basketball has to a golf ball. Because of the large size of its particles, the soil is looser and has more open space for water transport and so has a very high permeability. When it rains in the Sandhills, almost all of the water quickly soaks into the ground. Because the soil cannot hold water for very long, it resembles a desert because the topsoil is so dry. Only vegetation adapted to this type of habitat, such as cacti and briars, grows there.

Past the Sandhills, the rivers enter the Coastal Plain. The Coastal Plain is a region of sand, clay and limestone characterized by large winding rivers and large areas of wetlands. The soil is the result both of the sediment brought in by the ancient oceans, and the sediment brought in and deposited by the rivers from the Mountain and Piedmont region that is still occurring today. The sand and limestone both have a high porosity, and with the impermeable clays around them keeping the water in place, they act as **aquifers**, porous bodies of rock that allow water to pass through easily, for the majority of South Carolina's groundwater.

The Coastal Plain is also characterized by many wetlands. Wetlands and groundwater have an important relationship. Wetlands collect and hold water that recharges the groundwater. They also return the favor by being receptors for large amounts of water discharged from the groundwater.

With the spread of human populations, and the increase in construction of buildings, roads and parking lots, humans have thrown a wrench into the groundwater/runoff works. Almost any human construction creates an **impermeable surface**, a surface that water cannot run through, decreasing the amount of surface area that water can infiltrate, and causing rainwater to run off. As pavement is often covered with contaminants such as garbage and oil spilled by cars, these contaminants are picked up by the runoff water and carried to streams and other bodies of water, and are a major source of non-point pollution (pollution that has entered an aquatic environment but which cannot be traced back to the source).

Runoff of impermeable surfaces is a particular problem in urban areas. The concentration of development not only increases the problems of water contamination, but also creates problems with flooding. Having no permeable surfaces causes the rainwater to run in the streets. To prevent flooding in the streets, cities construct storm sewers that drain the streets and discharge the water into nearby streams. This sudden expulsion of urban water in the streams often leads to flooding, contamination by pollutants and rapid temperature increases from water off of sun-heated roads. In Charleston, SC, the high water table, brought on by the close proximity of the city to the ocean and to two major rivers (the Ashley and the Cooper) and the fact that most of the city was built on wetland areas, causes the storm sewers to be ineffectual, as they are already filled with water. When it rains, many streets fill up with one, two and even three feet of water and suddenly amphibious cars do not seem like such a bad idea.

This activity is designed to allow you to teach students about how the particle size of soil affects porosity and permeability and thus groundwater. It provides a visible hands-on demonstration of this. With this background information, you can discuss with the students how the concepts learned in this activity can be applied to the real-life habitats of South Carolina

## Procedures

**Materials**

*Day 1*

- Potted plant
- Journals/paper
- Clear plastic or glass jars that hold at least a liter (3 per student team)
- Liter measuring beaker
- Liter of marbles
- Liter of clay (clay that is not water-based)
- Liter of sand
- Liter of gravel
- Pitchers (one per student team)
- Water
- Groundwater and Runoff Data Sheet (one per student)

*Day 2*

- Liter of clay (clay that is not water-based)
- Liter of sand
- Liter of gravel
- Cylindrical funnel (one per student team)
- Nylon netting or pantyhose (one per student team)
- Rubber bands
- Stopwatch (one per student team)
- Pitchers (one per student team)
- Water
- Groundwater and Runoff Data Sheet (same as Day 1)

**Procedure**

*Day 1* - Porosity

1. Introduce this activity by having the students observe what happens to the water that is poured onto the soil of a potted plant. Does it all seep into the soil at once? Does some of it sit on top? What would happen to the water that sits on top if you tilted the plant at an angle? Does it run off? How does this correlate with the rainwater that falls on the ground? Discuss the questions and observations with the students and write their thoughts and ideas on the board. Use the students' ideas to introduce the concepts of groundwater and runoff to the students.

2. Break up students into small groups. Each group will be given a glass jar with a liter of marbles in it and a measuring beaker. Students should pour 250ml of water into the jar of marbles. The marbles represent soil particles and the water represents rainfall. They should observe what happens to the water as it falls on the particles.

3. After the students have done this, ask the class to look at their jar and to consider these questions: Is there part of the volume of the jar where the marbles are completely saturated by water? Do the marbles above this saturated part have any water on them? (Students may want to pick up one of the top marbles to see if it is wet). After discussing these questions with the students introduce the concepts: **zone of saturation**, zone of aeration and water table. Students will identify these features in their jar of marbles. Students should draw a diagram of their jar of marbles and label each of these zones and the water table on their Groundwater and Runoff Data Sheet. The class should then discuss how this correlates to what is happening with groundwater.

4. Have the students measure a liter of water in their measuring beaker and pour this into the jar of marbles until the water table reaches the surface of the marbles. By adding the amount of water poured into the marbles to the original 250ml of water that was in the jar they will determine what volume of water it takes to saturate the liter of marbles, and then write this amount down on their data sheet.

5. Introduce the concept of porosity to the students. Using the amount of water it took to saturate the marbles, the students will calculate the porosity of the marbles. (For example if it took 500ml of water to saturate 1000ml of marbles, the marbles have a porosity of 50%. If it took 275ml of water it has a porosity of 27.5%).

6. Have students fill 3 beakers, one with 100ml of clay, one with 100ml of sand and one with 100ml of gravel. The clay should be kneaded into the beaker so that no large spaces exist along the edges. Students should predict which of these sediments will be porous or not porous. Students will pour water into each beaker until water saturates the sediment to the top. Measure and record the amount of water it takes to saturate each sediment type. Have students calculate the porosity of each (For example, if it takes 40 ml of water to saturate 100 ml of sand, the sand has a porosity of 40%).

7. Students should compare their findings with their predictions. Think about these questions: Why did or did not the predictions differ from the actual findings? Does the sediment have uniform sizes and shapes? Which is more like nature, sand or marbles?

*Day 2* - Permeability

1. Introduce and explain the concept of permeability to the students. Have students get back into the same teams as Day 1 (they will use the same data sheet too). The students should stretch nylon netting along the bottom of their funnel and wrap it around with a rubber band. Fill the funnel will with 100ml of clay. Knead the clay into the funnel so no large spaces exist along the edges. Place the funnel over a graduated beaker. Measure out 200 ml of water. The students should pour the water into the funnel and time how long it takes 100 ml of water (half of the 200 ml) to go through the funnel to the beaker below. Students should begin the timer as soon as the water is poured and stop timing when 100 ml of water flows into the graduated beaker. Have the students write the time down on their data sheet.

2. Have students fill the funnel with 100 ml of sand and repeat the procedure used with the clay.

3. Have students fill the funnel with 100 ml of gravel and repeat the procedure used with the clay.

4. The students should then compare the different times they recorded to infer how particle size affects permeability. Have them write their thought on the data sheet.

5. Discuss the particle size difference between clays and sands. The teacher will explain that clays and sands are the predominant sediment types in South Carolina. The teacher will ask the students to predict the porosity and permeability differences between a predominately sandy area such as the Sandhills and the predominantly clay area such as the Piedmont. They will also predict the differences between groundwater and runoff amounts in these areas. They will write their predictions, either on their date sheet. You could also have them draw diagrams showing what they think will happen in each of these regions.

**Follow-up Questions**

- When the water table was at the surface of the marbles, what would happen to the water if the students kept pouring? How does this correlate with what happens in nature?
- Leave the permeability part of this activity set up for one day and then have students measure how much water flowed through to the beaker below, how much water was retained in the sediment, and how much water (if any) remained on top of the sediment. Does all 200ml of water ever flow through for any of the sediment types? Does the water ever completely seep through the clay? How much water is retained in the different sediments? Have students research how sediment can hold on to water.
- How would roads and buildings affect the porosity and permeability of the area they are on?
- When water soaks into sand, would some of the water molecules enter the spaces between the atoms in the sand grain? Can water “dissolve” in sand the way salt dissolves in water?

## Assessment

The assessment of this activity is the Groundwater and Runoff Data Sheet. The students’ predictions about permeability and porosity in South Carolina’s Piedmont and Sandhills regions will be the main assessment of learning, by determining if the new knowledge can be applied to the natural world. In their predictions in writing and/or diagrams, students will hopefully:

- Determine that the sandy soils of the Sandhills will have a high porosity and permeability and the Piedmont will have a low porosity and permeability because of the clay.
- Determine that the Sandhills will have a larger amount of water infiltrating the ground to become groundwater, than running off.
- Determine that the Piedmont will have a larger amount of water running off than infiltrating the ground to become groundwater.

*Scoring rubric for out of 100 points*

Day 1

| | |
|---|---|
| Marble diagram correctly labeled: | **15 points (5 for each term)** |
| Correct calculation of saturation: | **5 points** |

| | |
|---|---|
| Correct calculation of porosity: | **5 points** |
| Table filled out correctly: | **5 points** |
| Good explanation of table results: | **10 points** |

Day 2

| | |
|---|---|
| Table filled out correctly: | **5 points** |
| Good explanation of table results: | **15 points** |
| Predict the Sandhills will have a high porosity and permeability: | **10 points** |
| Good explanation of Sandhills groundwater and runoff amounts: | **10 points** |
| Predict the Piedmont will have a low porosity and permeability: | **10 points** |
| Good explanation of Piedmont groundwater and runoff amounts: | **10 points** |

## Cross-Curricular Extensions

**STEM Extension**
There has been growth in your area and more parking is needed for apartments and businesses. Have students design a parking solution taking into consideration what they learned about in the activity about porosity and permeability.

**Science Extension**
Students will create their own soil mixture. Students will measure various amounts of clay, sand, humus, etc. to fill a 100 ml container. Students will record the amount of each sediment placed in the mixture. Students will conduct porosity and permeability experiments like the ones in the activity and compare the results of the different mixtures. Which is more like real soil, the pure sand or the mixtures the students create?

**Social Studies Extension**
The students will research the regions of South Carolina to see how soil types in different regions have affected the way the land and water were used and impacted by human populations. Student groups will research different regions of the state to see what soil types were common and to determine how this influenced the development of agriculture. Student groups will come together to create a classroom map that shows the soil types and the crops of the different regions. The class will discuss the differences.

**Art Extension**
While sculpting with clay, students will consider how the properties of clay and water make it effective for art.

**Math Extension**
Students will take a soil sample from the schoolyard and using four different sized strainers, sift through the soil to determine the particle sizes that make up the soil. Students will then measure the volume of each sediment size, compare to the volume of the soil sample it was taken from and then determine what percentage of each sediment size is found in the sample.

## Resources

**Teacher Reference Books**

Cvancara, Alan M. *A Field Manual For The Amateur Geologist: Tools and Activities for Exploring Our Planet,* John Wiley & Sons, Inc., New York,1995.
This field guide contains information on the physical environment.

Kovacik, Charles F. and John J. *Winberry. South Carolina: the Making of a Landscape,* University of South Carolina Press, Columbia, 1989.
This wonderful reference book provides information on the abiotic factors that determine the habitats of South Carolina.

Murphy, Carolyn Hanna. *Carolina Rocks!: The Geology of South Carolina*, Sandlapper Publishing Co., Inc., Orangeburg, 1995.
Information on the geology, topography and formation of all of the regions in South Carolina.

Plummer, Charles C. and David McGeary. *Physical Geology,* Wm. C. Brown Publishers, Iowa, 1991.
Though admittedly college textbooks are often a little too dry and in-depth, with their text, photographs and illustrations they are often the best resources for finding information on a particular subject. This college textbook is an excellent resource for anyone wanting to know more about geology.

**Teacher Reference Websites**

*Chesapeake Bay Foundation Environmental Education*
www.cbf.org/
The Chesapeake Bay Foundation has put together an exemplary watershed protection program that encompasses many states. This site includes information on what they have done in this program as well as curricula and other education related items.

*EPA'S Environmental Education Center*
www.epa.gov/teachers/
Provides information on water and watersheds and links to other sites.

*EPA Office of Water: Office of Wetlands, Oceans and Watersheds*
www.epa.gov/owow/
Provides information on watersheds, wetlands, water quality plus much more.

*South Carolina Department of Health and Environmental Control (DHEC): Bureau of Water*
www.scdhec.net/water
This site offers information on drinking water, water pollution control, watersheds plus much more.

*Southern Appalachian Watershed Conservation Clearinghouse*
http://sunsite.utk.edu/samab/proj/watershed.html
This site offers links to a number of websites related to watershed conservation in the Southeastern United States.

*Surf Your Watershed: A Service to Help You Locate, Use, and Share Environmental Information about your Place*
www.epa.gov/surf
This site allows you to learn specific information related to the watershed your town is located in.

*U.S. Geological Survey*
www.usgs.gov/
This site offers valuable earth science information on a variety of topics.

*Water Science for Schools*
http://ga.water.usgs.gov/edu/
Background information on water and watersheds is provided on this site.

**Student Reference Books**

*Eyewitness Books: Earth,* Susanna Van Rose. Dorling Kindersley, London, 1994.
These very attractive books use photographs, illustrations and text to teach the reader about the earth.

Haslam, Andrew. *Make It Work! Rivers,* World Book Inc./ Two-Can, Hong Kong, 1996.
Readers will explore the rivers of the world and determine how they affect Earth.

Levete, Sarah. *Closer Look At: Rivers and Lakes,* Copper Beech Books, Connecticut,1999.
This book uses photographs, illustrations and text to teach the reader about rivers and lakes.

Taylor, Barbara. *Earth Explained: A Beginner's Guide to Our Planet,* Henry Holt and Company, New York, 1997.
This book uses photographs, illustrations and text to teach the reader about the earth.

**Curricula**

*JASON Science: Education through Exploration*
The JASON Science is an interdisciplinary curriculum for K-12 teachers focusing on the geology, climate, biology and biodiversity of specific regions in the world. The activities cover a broad range of topics.
For more information click on: http://www.jason.org/public/whatis/start.aspx

*SC MAPS*
SC MAPS is a standards-based interdisciplinary curriculum for middle school teachers that focus on the geology of the regions of South Carolina using aerial photographs, images and topographic maps. Great source for good maps!
For more information visit the website at http://www.cas.sc.edu/cege/resources/scmaps/scmaps.html