We All Live in a Watershed

Alignment to NC Essential Standards
Science 5.P.1, 5.P.2
Math 5.NBT.1, 5.NF.6, 5.MD.1, 5.MD.3, 5.MD.4, 5.MD.5

Learning Objectives
- Students will be able to define watershed and the components of the water cycle.
- Students will describe how components of the water cycle occur in the school yard.
- Students will apply knowledge of the concept of gravity to determine which direction water flows.
- Students will interpret measurements to calculate area and volume of water.

Time Required:
Activity 1: 45 minutes
Activity 2: 60-90 minutes, preparation time 30 minutes
Activity 3: 30 minutes

Materials
- Wax paper or foil
- Spray bottles
- Markers
- Temporary spray paint or chalk
- Meter measuring tape
- One or more compasses
- Flags, beanbags or other items to mark corners of the plots in activity 2
- 1 copy per student of *Water's Amazing Journey* Worksheet
- 1 copy per group of 4 students:
  - *Schoolyard Plot* Worksheet
  - *Volume of Rain Fall* Worksheet

Vocabulary
water cycle, watershed, runoff, infiltration, evaporation, transpiration, gravity, volume, precipitation

Overview

We all live in a watershed, which is defined as an area of land that drains to a common point. Every piece of land is part of a watershed. Our homes, schools, businesses and natural areas are located within a watershed. Everything we do from planting trees to paving parking lots, from throwing trash on the ground to ensuring our car does not leak oil, has an impact on the quality of our watershed. In a learning context, watersheds enable us to cover the water cycle while also including gravity, volume and ecosystems. In addition, watersheds provide an opportunity to study human impacts on the physical environment and also understand how human settlement patterns were and are shaped by the physical environment.

Background

A watershed is an area of land that drains to a common point. A watershed can be very large, such as the watershed (most commonly called a basin) of the Tar-Pamlico River, which drains to the Pamlico Sound. A watershed can also be very small. A grassy patch in the school yard that drains to a low spot where a puddle forms can be considered a watershed for that puddle. **Watersheds are separated by landforms that form high points.** When it rains, the water will run from the high point toward the lowest point, due to **gravity**.

In the lesson, *Observing Ecosystem Response to Human Activity*, students will explore the ecosystems that were in place on the school grounds before the school was built. They will also observe changes in a variety of physical factors after the school was built. These changes can alter the movement of water and thus the **water cycle** on school grounds. On school grounds with more pavement and concrete and less vegetation, rain water (**precipitation**) will move quickly as **runoff,** over the surface of the landscape toward the lowest point which is the nearest storm drain, drainage ditch or stream. When the vegetation remains in place, water soaks into the ground (**infiltration**) or is taken up by the roots of vegetation. Without vegetation to slow water down, the amount, or **volume,** of water increases and speed increases, enabling water to carry a large amount of material with it. It can scour chemicals off the pavement, erode soil and carry large debris down the landscape and into our streams, rivers and lakes. Water can even absorb heat from pavement and transfer it to the nearest

aquatic ecosystem. Understanding how rain water moves through the school yard as runoff is critical to understanding how nearby streams and rivers may become polluted.

Preparation

- For Activity 1: Photocopy *Water's Amazing Journey* worksheets, handouts and gather materials.
- For Activity 2: Go out to the school grounds in advance and identify areas of the outdoor landscape where students can work safely. Use temporary spray chalk or other markings to indicate one corner of what will end up being a 5 x 5 meter plot (which the students will delineate). To make it uniform, mark the top right corner so you can direct the students to all work in the same direction. It is best (but not necessary) if each plot contains a mix of surfaces such as pavement, grass, and trees.

Procedure

ACTIVITY 1
Understanding How Water Moves
Time: 45 minutes

1. Post this definition of watershed: *A watershed is an area of land that drains to a common point. Watersheds are separated by landforms that form high points.* Ask: what direction does water move? It moves down, due to gravity, through the processes of runoff and infiltration. Water can move quickly as runoff over a paved surface or slowly, if it lands on forested ground and infiltrates the soil. Even when not easily observed, water moves down slope. Have students complete the activity *Water's Amazing Journey* and discuss the results.
2. Ask students: *what processes of the water cycle can make water move up?* Evaporation and transpiration. These processes cause water to move out of the ground and into the atmosphere. (Note that activity 1 focuses only on water movement at ground level).
3. Demonstrate water moving over landforms using a paper model. Have each student gently crumple a piece of wax paper or tin foil and then undo it. Ask them to draw lines on the tops of the paper ridges with marker. Ask them to draw arrows that point which way they think water would move. Finally, have them put an x at the low points where they think the water will pool. Now have them gently spray water with a spray bottle straight down on their paper and observe where the water moves. Were their predictions correct?

ACTIVITY 2
Determining Water Flow
Time: 60 to 90 minutes

1. Prior to taking the students outside, identify areas of the outdoor landscape where students can work safely. Use temporary spray chalk or other markings to indicate one corner of what will end up being a 5 x 5 meter plot (which the students will delineate). To make it uniform, mark the top right corner so you can direct the students to all work in the same direction. It is best (but not necessary) if each plot contains a mix of surfaces such as pavement, grass, and trees.

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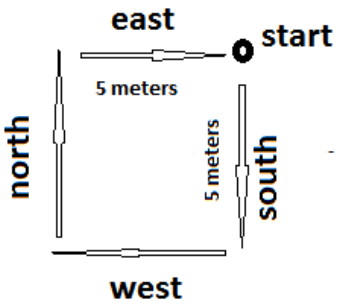

2. Divide the students into small teams (4 per plot). Using a compass and meter measuring tape, instruct each group to measure out a 5 x 5 meter square plot, assuming the chalk mark you made is the upper right corner of the plot. Use the compass to help make 90 degree angles. (See diagram below.) Give the students flags, beanbags or more spray chalk to mark off their other 3 corners.
3. Distribute *Worksheet 1: Schoolyard Plot*. Have the team draw their plot on the worksheet, indicating which way is north. Have each team calculate the total area of the plot.
4. Have students estimate, as best they can, how much of the plot area is covered with different land surfaces (pavement, grass, plants, shrubs, trees) and draw those on the map. Ask them to estimate the percentage of each surface type and write that down. The worksheet divides the plot into 25 squares, each representing 1x1 meter. Using this information, the students can count how many squares are covered with a certain land surface and then work out the fraction and percentage of the total plot.
5. Ask students to determine which end of their plot has the highest elevation and tell them to place an x on the drawing at the place with highest elevation.
6. Now ask them to imagine it is raining, and based on what they know about runoff, infiltration, evaporation and transpiration, what do they expect the rain to do when it hits their plot? If it runs off, which direction will it move? Have them draw arrows on their map indicating the direction of runoff. Note that even water that does not visibly runoff on the surface will infiltrate the soil and move down slope. Have them indicate that direction with arrows. Do they expect any evaporation or transpiration to take place on their plot?
7. ***Hint for which way water flows if the slope is not obvious***: All water that runs off the school grounds will go to the closest storm drain or ditch, which empties into the closest stream. Have students identify this stream. (Directions on how to identify your stream are at the end of this lesson.) The stream may not be big, it may even look like a ditch, but it is the lowest point and will move water to the next point, which will be a bigger stream and eventually the river.

ACTIVITY 3:
Measuring Volume of Rainfall
Time: 30 minutes

Determine the volume of water that falls on the student's plots using Worksheet 2: Volume of Rainfall.

1. Start with the area of their plot, which they have already calculated.
2. Provide students with average annual rainfall for your area. (Louisburg 45 inches, Rocky Mount 44 inches, Greenville 49 inches, Washington 49 inches). Make sure to convert measurements to meters. You can find average annual rainfall for other towns at this site: http://www.usclimatedata.com/climate/north-carolina/united-states/3203.
3. Multiply average rainfall by area of plot. Volume should be recorded in cubic meters (m^3).
4. Determine how many showers they could take with the volume that falls on just their plot each year. A 5 minute shower uses about 95 liters of water.

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DISCUSSION

As the students have probably experienced, even the amount of water coming through a hose can move a lot of dirt and oil on the ground. Water cleanses the parking lot and grassy areas, but it also carries the dirt and chemicals into the stream. This process of rain water washing off dirt and pollution from the land and carrying it to the streams, rivers, lakes and oceans is called *nonpoint source pollution* because there is not one point of pollution, it is an accumulation of pollution coming off the school yard, grass playing fields, parking lots and rooftops. If we can slow the water down, it will have less power to move a lot of pollutants. If the water can soak into the ground, the pollutants will settle in the soil and not be carried into water bodies.

Extensions

Confirming the movement of water

For activity 2, if weather permits, during a rainstorm, create a video of the movement of water on the student's plots. Show the class the video. Did the stormwater runoff move as they predicted? Another option is to bring a 5 gallon bucket of water outside, or a hose with a spray attachment and have the students pour the water onto their plot to see what happens.

Calculating total volume of water

In activity 3, unless the students' plots were heavily vegetated, most of the precipitation will move downslope toward the stream. In this activity, you will determine how much total volume of water will move to the stream during a 1-inch rainstorm.

- Add all of the student plot areas together.
- 1 in = 0.0254 m so determine total volume of water for a 1-inch rain.
- Convert to liter where $1m^3$=1,000 liters.
- Convert to kilograms where1 liter = 1 kg. Determine how many kilograms of water moves into that stream during a 1 inch rain from your plots.
- Convert kilograms to pounds. 1 kg = 2.20462 lbs.
- Just for comparison, the average car weighs 3,500 lbs.

Assessment

Have students draw a landscape in which they think the water will move most slowly toward the stream. They may incorporate trees and plants to include transpiration and vegetated soils that do not erode but enable infiltration. Ask them to label the drawing identifying biotic and abiotic features and include vocabulary used in the lesson. Have them write a paragraph explaining why they included what they did in their landscape.

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WATER'S AMAZING JOURNEY Worksheet

We have learned that water will flow down toward the lowest point.

But what determines how fast it will get there? Take a look out the window at the different types of ground surface. You might see pavement, dirt, grass and maybe leaves or pine needles if you're near a forest. Differences in the ground's surface will control how water flows on the ground.

Let's look at a few examples:

Pavement

Pavement makes travel safe and fast because it is a very durable surface for our streets and parking lots. However, pavement in the wrong place can be harmful to water. What happens when rain falls on pavement? Because it is a smooth surface and does not allow water to soak in, water becomes runoff on pavement. That's why we have to be smart about where and how we plan our new roads and parking lots.

Grass

Grass will slow water down far better than pavement. However, when we get a lot of rain at one time, grass can't hold all the water long enough for it to soak in, causing some runoff. Remember, runoff can carry pollutants with it. What pollutant can come from a lawn? Fertilizers can help your lawn stay healthy and green, but they aren't good for our streams. If we are careful with how much fertilizer we use, we can have healthy lawns and healthy streams.

Forest

We have saved the best for last. What happens to rainfall in a forest? Before it can even get to the ground, it is slowed down by the tree tops, branches and leaves. Once the rainfall does get to the ground, it contacts a thick layer of leaves and mulch that act like a big sponge, slowing the water down and allowing it time to soak into the soil. Many times, runoff in a forest is so small that it's hard to see. Since water gets filtered by the forest soil, the best water quality usually comes from a forest.

Trees aren't just for the woods!

Urban areas, such as towns or cities, have a lot of paved surfaces. As you now know, all that pavement can create lots of runoff which can harm streams and cause flooding. City managers are realizing that trees and forests can help fix these problems. By taking care of existing trees and planting new trees in the city, the amount of runoff from pavement can be reduced before it reaches the stream. Plus, trees offer shade, help to clean our air, provide a home for animals, and simply make the city a nicer place to be.

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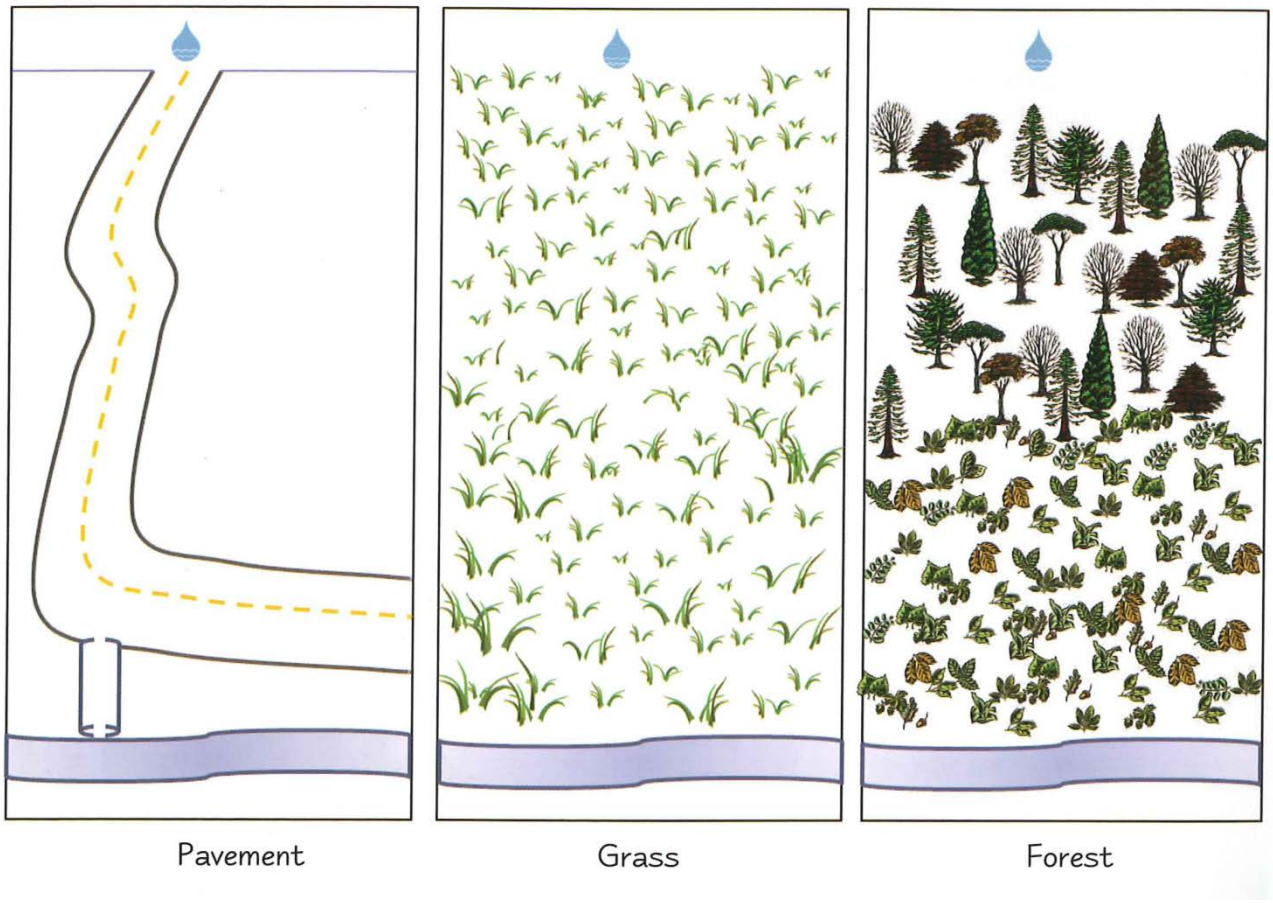
WATER'S AMAZING JOURNEY Worksheet

You will see three simple mazes below. Draw a line that connects the water drop to the stream without touching any lines or objects in the maze. Measure how much time it takes to complete each maze.



How long did it take you to complete each maze?

Which one was the fastest: pavement, grass or forest?_____

Which one was the slowest: pavement, grass or forest?_____

Next time it rains, watch how the water moves across the different surfaces around your home or school. You will be surprised how much you can learn about your environment just through what you see around you.

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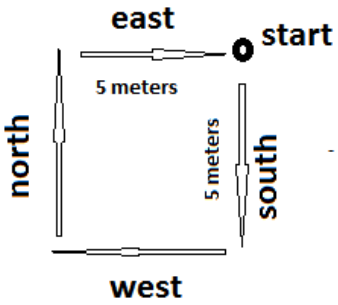
SCHOOLYARD PLOT Worksheet

Team Members _____

1. Use the drawing to the right as a guide. Measure a 5 by 5 meter square. From the start point, use a compass to walk directly south for 5 meters. Mark that corner. Now walk west 5 meters. Mark that corner. Now walk north for 5 meters and mark that corner. You should now have a 5 x5 meter square.



2. Use the square on the back of this page to draw your plot following the directions below.

3. Turn your drawing so that the top is facing north.

4. You should have measured a 5x5 meter plot. What is the total area of your plot?_____ m^2

5. Decide which part of the ground in your plot is highest. Place an X on your drawing to show where the highest point of your plot is located.

6. Look at the different types of ground surfaces in your plot. How many different types are there? List all under your plot drawing.

7. Draw the different surface types onto your plot drawing and label them. Use the small squares to help you show the amount of different types of land surface. How much of your plot is covered by each surface type? Estimate your answer as a percentage of the whole plot. Write down the percentage of each below your drawing.

8. Imagine it is raining. What will the rain do when it hits each type of surface in your plot? For each surface write down what process you think will take place: **T**ranspiration, **E**vaporation, **R**unoff or **I**nfiltration. More than one process may happen on each land surface type. Write T, E, R or I on each surface type in your drawing.

9. If you expect runoff to take place, draw arrows showing which way the water will move down slope. (Hint: If you marked an X at the highest part of your plot, the water is going to move away from that high spot.)

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SCHOOLYARD PLOT Worksheet

Surface type 1 _____ % cover _____

Surface type 2 _____% cover _____

Surface type 3 _____% cover _____

Surface type 4 _____% cover _____

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VOLUME OF RAIN FALL Worksheet

Name _____

1. What is the area of your plot? _____m^2
2. Write the average annual rainfall (given to you by your teacher in inches) _____in.
3. Convert inches of rainfall to meters _____m
4. Multiply the area of your plot by the meters of annual rainfall _____m^3
5. 1 m^3 = 1,000 liters. How many liters of water fall on your plot? _____L
6. A five minute shower uses about 95 liters. How many showers can you take with the amount of water that falls on your plot each year? _____

Where does the water go?

If your plots were all forested, what would happen to the water?