MSD Clean Water Education Teacher Resource Packet

A Free Stormwater Education Program for schools in the Metropolitan St. Louis Sewer District Service Area

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The MSD Clean Water Education program is a program of the Metropolitan St. Louis Sewer District in partnership with the EarthWays Center of the Missouri Botanical Garden. U.S. Environmental Protection Agency Region VII, through the Missouri Department of Natural Resources, provided partial funding for the initial phase of this project under Section 319 of the Clean Water Act, DNR Subgrant G06-NPS-22.

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Introduction: MSD Clean Water Education & Resource Project

The MSD Clean Water Education program is a focused stormwater and water quality education program that seeks to provide stormwater pollution awareness and resources to students, teachers, and community educators throughout the Metropolitan St. Louis Sewer District service area. The MSD Clean Water Education program, including materials, activity ideas, and resources are available at no cost to schools and educators throughout the entire Metropolitan St. Louis Sewer District service area.

While developed for 4th through 8th grades, lessons and Clean Water Education activities can be adapted to for students ranging in K-12th grades and beyond.

The MSD Clean Water Education program has three program components including:

EnviroScape® Model Loan Library

The EnviroScape® is a visual, hands-on tool that demonstrates how water pollution results from every-day activities. Using this tool, educators can demonstrate principles of water concepts such as water cycles, point/non-point source pollution, and more. Students learn how everyone in a community can work to reduce non-point source pollution and help create healthier watersheds. The program includes drop-off and pick-up of an EnviroScape® model, including all necessary components, and additional information hand-outs on this topic.

MSD Storm Drain Marker Program:

MSD's Storm Drain Marker Program provides a visible reminder of the consequences of improper waste disposal, and helps communicate to the community that storm drains can carry pollution to area rivers and streams. This activity helps empower students, and community groups, to be a part of the solution to water pollution. Program includes all the tools and equipment a group needs to help put knowledge into action with a storm drain marking project.

Regional Teacher Professional Development & Curriculum Support:

Workshops are held two times a year (spring and fall) and designed to help facilitate teachers' desire to learn more about stormwater management and water quality issues while discovering new ways to bring this topic to life to their classroom.

Workshops:

- **Discuss issues** related to stormwater management and water quality such as non-point vs point source pollution, pollution impact, and best management practices for our community.
- Discover **activity ideas** that tie to state standards while still providing meaningful, engaging, and **hands-on learning opportunities.**
- Train **area educators** to use the popular EnviroScape® watershed model.

In addition to the workshops offered biannually, this resource packet is made available for free distribution, reproduction, and use of materials to all educators. This resource packet includes ten hands-on learning activities that can be used paired with the other components of the program to extend learning, build understanding and awareness, and introduce students to best management practices for clean water issues.

Who We Are:

The **Metropolitan St. Louis Sewer District (MSD)** was formed on February 9, 1954, when voters approved the Plan of the District to provide a metropolitan-wide system of wastewater treatment and sewerage facilities for the collection, treatment and disposal of sewage. MSD began operations in January 1956 in an area roughly composed of the City of St. Louis and the portion of St. Louis County located east of Interstate 270, most of the remainder of St. Louis County was annexed by MSD in 1977. MSD's service area now encompasses approximately 520 square miles, including all 66 square miles of the City, and 454 square miles (approximately 87%) of the County. The current population served by MSD is approximately 1.3 million. MSD owns and operates the System, which consists of wastewater, stormwater and combined collection sewers, pumping stations, and waste-water treatment facilities in its service area. MSD provides sewer collection, pumping and treatment services within three major watersheds located within the MSD's service area including the Mississippi River watershed, the Missouri River watershed and the Meramec River watershed.

Missouri Botanical Garden's EarthWays Center enriches lives and protects plants and our environment by educating and connecting people to make practical sustainable choices where they live, learn, work and play. EWC has been a regional leader in environmental curriculum development and program delivery since 1988. We present a practical, positive approach to topics that include: energy efficiency and energy use; reducing toxics and protecting air quality at home and school; recycling, composting and waste reduction; conserving water and water quality issues; and efficient use of other resources. Our commitment is to teach participants how to think, not what to think. To that end, the MSD Clean Water program is based on building awareness, challenging essential questions, and investigating key components in understanding water quality issues.

History of the MSD Clean Water Project:

After 430,000 educational billing inserts, title "Everyone Lives in a Watershed," were sent to all MSD customers in St. Louis City and County the Metropolitan St. Louis Sewer District (MSD) conducted a survey by phone to a randomly selected sample of 426 residents. Seven percent (7%) of residents surveyed indicated that they lived in a watershed but 93% of respondents answered that they lived outside of a watershed, near a watershed, or did not know. This evaluation demonstrated a community need to strengthen the knowledge, understanding, and awareness of watersheds, stormwater management, and other clean water issues.

To increase public awareness about watersheds and clean water issues, MSD in collaboration with the Litzsinger Road Ecology Center, an outreach facility of the Missouri Botanical Garden, was awarded a grant. The Environmental Protection Agency Region VII, through the Missouri Department of Natural Resources, provided partial funding for an educational project under Section 319 of the Clean Water Act, DNR Subgrant G06-NPS-22. The project evaluated clean water issues for use in upper elementary and middle school curricula, selecting the best activities and compiling a resource packet for use in classrooms throughout the region. The packet was introduced to educators through a series of workshops over the next two and a half years. Each teacher was provided with access to resources, curriculum, and support.

After this initial development of the MSD Clean Water Education program and resources, MSD continued to provide valuable educational resources to teachers and schools. In September 2016, MSD partnered with the EarthWays Center of the Missouri Botanical Garden to provide assistance in continuing to maintain the program. In addition to continuing to maintain the EnviroScape® Model Loan Library and the Storm Drain Marker program, EarthWays helps facilitate program goals including: teacher support and resources; developing new activities, revising and updating established activities for the teacher resource packet; developing a public awareness workshop on clean water issues; and working within the region to increase the awareness and use of best management practices.

Program Goals and Lesson Overview

The overall goal of the MSD Clean Water program is to empower educators and students with the knowledge, tools, resources and strategies to be stewards of local community watersheds through the awareness and understanding of best management practices.

Outcomes Include:

- Increased understanding of our local watershed region
- Increased understanding of threats to water quality and environmental health
- Increased understanding, and practice, of Best Management Practices
- Students develop public speaking skills and communication skills to discuss environmental issues, especially water quality issues
- Teachers gain practical training to incorporate hands-on lessons about stormwater management and water quality issues
- Schools integrate sustainability, green building, water conservation, and best management practices into classroom curriculum
- All participants build awareness and understanding of the options for making more sustainable choices in their own lives, at school, and at home.

Essential Questions:

Consider the following questions to guide students through the MSD Clean Water Education Program:

- How does water move through a community?
- In what ways do humans, plants, and animals depend on healthy watersheds?
- How do my actions affect the watershed?
- How does a community change local and regional watersheds?
- Why is it easier to address some forms of water pollution over others?
- How can our community work together to protect our local watersheds?

Activities:

The following 10 activities are intended to provide teachers with high quality, interactive activities to incorporate clean water topics into their classroom instruction. All lessons were developed for use in upper elementary and middle school classrooms, but can be easily adapted by educators for all grade levels. The sequence of lessons is outlined in this resource packet so that later lessons build upon concepts learned in previous activities, however a teacher may create their own unique path to fit their classroom needs.

Certain activities have been tailored for the St. Louis region, and all lessons highlight the importance of students anchoring their learning to a place of significance in their lives. Lessons supporting basic watershed, stormwater runoff, and pollution concepts have been designed to better prepare students to transfer knowledge learned to their own homes and community watershed.

The ten activities in this resource packet are:

1. Create Your Own Water Cycle
2. What is a Watershed?
3. Schoolyard Watershed Walk
4. Runoff Roundup & Erosion Experiment
5. Impervious Business
6. Exploring Point & Nonpoint Source Pollution & Solutions
7. What's the Source?
8. Schoolyard Stormwater Assessment
9. Home Management Plan
10. Citizen Science: Water Quality Testing & Data Collection

Overview of Activities

Lesson 1 | Create Your Own Water Cycle

Students will make a small terrarium modeling the water cycle's major components and study the model to observe how the water cycle works.

Lesson 2 | What is a Watershed?

Students are introduced to the concept of a watershed by constructing simple watershed models in the classroom and studying various maps of their local watershed.

Lesson 3 | Schoolyard Watershed Walk

Students anchor their newly acquired knowledge about watersheds with real-world application by exploring their school grounds with maps and careful observations.

Lesson 4 | Runoff Roundup & Erosion Experiment

4a. Stormwater Runoff Roundup
Students use the scientific method to observe and compare the amount of surface water runoff and evidence of erosion in two different schoolyard sites.

4b. Erosion Experiment
Students investigate the processes of surface runoff, infiltration, and erosion by using a model to simulate rainfall on three different surfaces: bare soil, vegetation, and impervious.

Lesson 5 | Impervious Business

Students measure an area of impervious surface on their school grounds and calculate how much water will run off that surface in a given year in order to understand the cumulative effects impervious surfaces have on waterways.

Lesson 6 | Exploring Point and Nonpoint Source Pollution & Solutions

Using an EnviroScape® model students observe how human activities on land can result in pollution of local waterways. Students will learn about different types of pollution, sources, and things they can do to help prevent and minimize stormwater pollution.

Lesson 7 | What's the Source?

Students work together to identify best management practices and effectively communicate their ideas for reducing water quality issues related to nonpoint source pollution given specific scenarios, focus is on communication and applying the right BMP for a given problem.

Lesson 8 | Schoolyard Stormwater Assessment

Students apply their knowledge of watersheds, nonpoint source pollution, and stormwater management to a place of significance in their lives by conducting a stormwater assessment of their school grounds.

Lesson 9 | Home Management Plan

Students and parents evaluate their activities at home and develop a Clean Water Home Management Plan to help keep local waterways healthy.

Lesson 10 | Citizen Science: Water Quality Testing & Data Collection

Students participate in a Citizen Science project, created by Earth Echo, to test local water samples for common indicators of water quality including: turbidity, pH, dissolved oxygen, and temperature.

Meeting Educational Standards

Collectively, the lessons in this packet support student growth in many areas covered throughout the Missouri State Learning Standards*. Key concepts, as well as standard codes, are identified in the table below to help you find the right fit for your classroom.

SCIENCE	MATH	SOCIAL STUDIES	ELA
Key Concepts: • changes to land (erosion), • flooding, • human impact on environment, • designing solutions to reduce impact	Key Concepts: • measurements (length and width), • calculating volume, • calculating area, • analyzing survey data	Key Concepts: • reading, under-standing, and draw-ing map; • identify major rivers, creeks, streams of Missouri	Key Concepts: • constructing an argument for action, • stating an opinion, using supporting evidence
1.LSL.A.1 2.PS1.A.2 5.PS1.B.1 2.ESS2.B.1 3.LS3.D.1 2.ESS1.C.a 2.ESS2.A.1 2.ESS2.C.1 4.ESS2.B.1 K.ESS2.D.1 K.ETS1.C.1 3.ESS2.D.1 K.ESS2.E.1 4.ESS3.A.1 K.ESS3.B.1 3.ESS3.B.1 5.ESS3.C.1 K-5.ETS1.A.1 6-8.LS1.B.2 6-12.LS2.C.1 6-12.ESS3.A.1 6-12.ESS3.C.1 6-12.ESS3.C.2 6-12.EST1.A.1 6-8.ETS1.B.2 9-12.LS2.C.2 9-12.LS4.C.3 9-12.ETS1.A.2 9-12.ETS1.B.1	1.RA.B.5 2.NBT.B.9 2.GM.B.6 1.DS.A.2 2.DS.A.3 2.DS.A.5 3.GM.C.11 3.GM.C.12 3.GM.C.14 5.GM.D.9 6.GM.A.1 6.DSP.A.3 3.GM.B.7 4.GM.C.7 5.GM.B.4a 5.GM.B.5 8.GM.C.9a 7.DSP.A.2	2.EG.5.C.a 2.EG.5.C.b 2.EG.5.C.c 2.RI.6.D.a 2-5.TS.7.B.a 2.TS.7.E.c 3.PC.1.F.a 3.PC.1.F.b 3.GS.2.A.a 3.GS.2.B.a 3.GS.2.C.a 3.EG.5.F.a 3.EG.5.F.b 3.EG.5.G.a 3.RI.6.G.a 6-8.GEO.1.CC.E 6-8.GEO.1.GS.B 3.H.3.F.b 6-8.GEO.2.CC.C 6-8.GEO.2.G.c 3.H.3.G.b	K-5.W.2.A.a K-5.W.2.A.b K-5.W.2.B.a K-5.W.3.A.a K-5.W.3.B 6-12.W.2.B 6-12.W.2.C

**Updated with Missouri Learning Standards approved on April 19, 2016*

Review the following key pieces of background information to help prepare yourself to teach about stormwater and clean water issues.

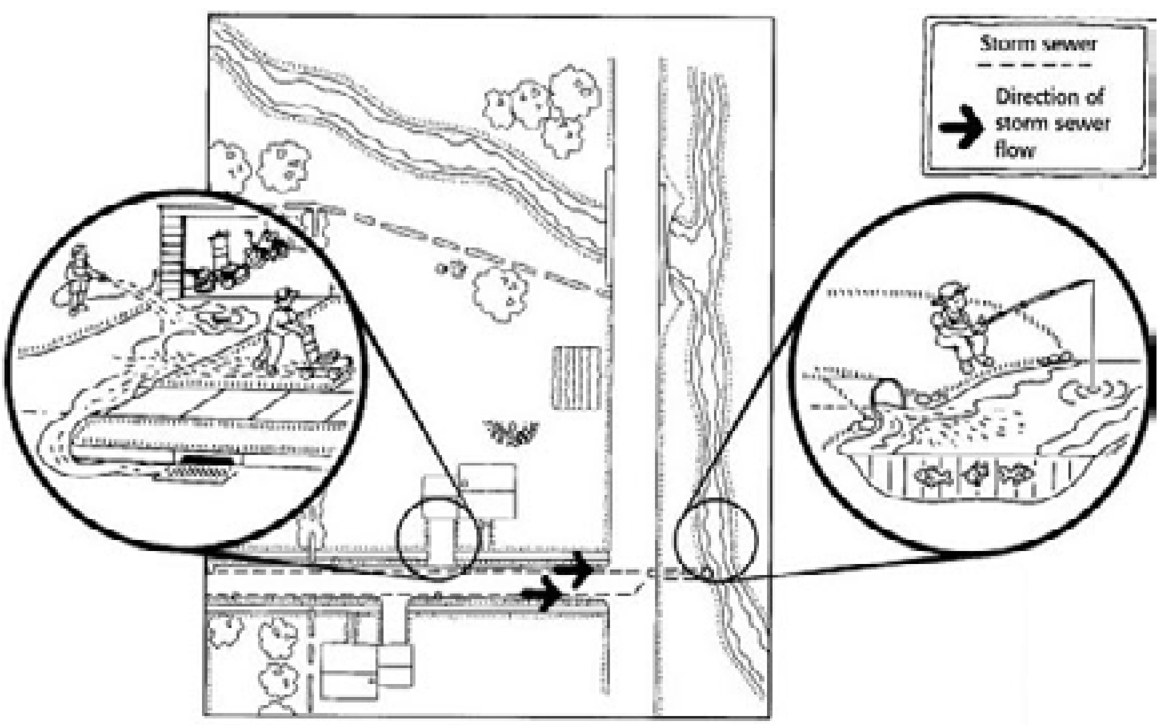
What is Stormwater and Why is it a Problem?

Stormwater is water from rain or melting snow that does not soak into the ground, but rather flows over the surface of the ground as runoff before making its way to a body of water. As you might imagine, impervious surfaces such as rooftops, parking lots, roads, and sidewalks can greatly increase the amount of stormwater runoff. Lawns, especially those on slopes, can also contribute to increased amounts of stormwater because of their very shallow root-systems. Greater amounts of stormwater runoff in developed areas can lead to increased flooding. In well-vegetated, undeveloped areas less runoff and problematic flooding occurs because more water is able to seep into the ground and enter into the groundwater system.

What Are the Sources of Stormwater Pollution?

Stormwater is one of the leading causes of pollution and environmental degradation of streams, rivers, lakes, and wetlands. As runoff flows downhill, it collects and transports soil, animal waste, road salts, pesticides, fertilizers, oil and grease, leaves, litter, and other potential nonpoint source pollutants. While some of these substances are benign by themselves, their cumulative effects are harmful to aquatic life and water quality. It doesn't merely take a heavy rainstorm to send pollutants rushing towards streams, wetlands, lakes, rivers, and oceans. A garden hose or sprinkler alone can supply enough water. Even if your property is not located near a waterfront, storm drains and sewers carry runoff away from buildings and developed areas to the nearest body of water. Contrary to popular belief, most storm sewers do not carry stormwater to wastewater treatment plants. Storm sewer pipes are laid underground, often below streets. Inlets or drains located along curbs and parking areas collect runoff and directs it to a nearby stream or other type of water body (Figure 1).

Figure 1: Stormwater runoff that flows into storm sewers goes directly to streams and lakes without proper treatment poses pollution problems and water quality issues for local watersheds.*



*Reproduced with permission from Home*A*Syst: An Environmental Risk-Assessment Guide for the Home (NRAES-87). Natural Resource, Agriculture, and Engineering Service. www.nraes.org

How Does Stormwater Pollution Affect Streams and Lakes?

This runoff causes harmful effects on drinking water supplies, recreation, fisheries, and wildlife. Excessive amounts of soil cloud water, degrade habitat for fish and water plants, and make many aquatic organisms more susceptible to disease. Nutrients such as phosphorus promote the growth of algae, which crowds out other aquatic life and contribute to depleted oxygen levels when they start to decompose. This is a process known as eutrophication. Toxic chemicals such as antifreeze and oil from leaking cars, carelessly applied pesticides and fertilizers, and road salts threaten the health of fish and other aquatic life. Altered water temperatures and flow regimes from the increased amount of impervious surfaces also have negative effects on aquatic life and their habitat.

Missouri's Stormwater Regulations

The Missouri Department of Natural Resources (MoDNR) administers federal stormwater regulations through the Missouri Clean Water Law and Code of State Regulations under the guidance of Missouri's Clean Water Commission. Communities subject to the Phase II stormwater regulations are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit from MoDNR. There are approximately 154 Missouri communities affected by these Phase II stormwater regulations. These small communities with Municipal Separate Storm Sewer Systems (MS4s) were required to obtain a NPDES permit by March 10, 2003. The permit requires these regulated MS4s to have their stormwater management program in place by March 10, 2008. The program must address six specific minimum control measures consisting of: (1) public education and outreach, (2) public involvement/ participation, (3) illicit discharge detection and elimination, (4) construction site stormwater runoff control, (5) post-construction stormwater management in new development and redevelopment, and (6) pollution prevention/good housekeeping for municipal operations. MSD, in partnership with 60 co-permittees developed the St. Louis County Phase II Storm Water Management Plan (SWMP) to comply with the stormwater permit requirements for small MS4s. The purpose of the SWMP is to prevent harmful pollutants from being carried by stormwater runoff into local water bodies and to improve water quality in the area. Under the permit, MSD is the coordinating authority for the development and implementation of the SWMP.

Ways to Help Prevent Stormwater Pollution

Best management practices (BMPs) are methods or devices we use to control, prevent or reduce the pollutants in stormwater runoff. Our St. Louis County Phase II Storm Water Management Plan (SWMP) includes BMPs that address potential sources of pollutants in stormwater as required by federal and state regulations.

BMPs can generally be divided into two categories: (1) structural and (2) non structural.

- **Structural** – BMPs that generally include site specific practices such as use of: silt fences, porous pavement, stream setbacks, grass strip biofilters, detention ponds, retention ponds, other filtration/infiltration systems, and the reduction of impervious pavement.
- **Non Structural** – Examples in this category include: public education and outreach, (i.e., storm drain stenciling), proper disposal of household hazardous waste, minimizing the use of fertilizers and pesticides, proper disposal of yard waste, recycling and other pollution prevention methods.

Types of Water Pollution

Water pollution is the contamination of water bodies such as lakes, rivers, oceans, aquifers and groundwater sources. Contamination occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds, chemicals, and other particulates. Water pollution affects the plants, animals and communities that depend live in or depend on these bodies of water. Water pollution can be grouped into one of two categories based on the general source or cause of the pollution: 1) point source and 2) nonpoint source pollution.

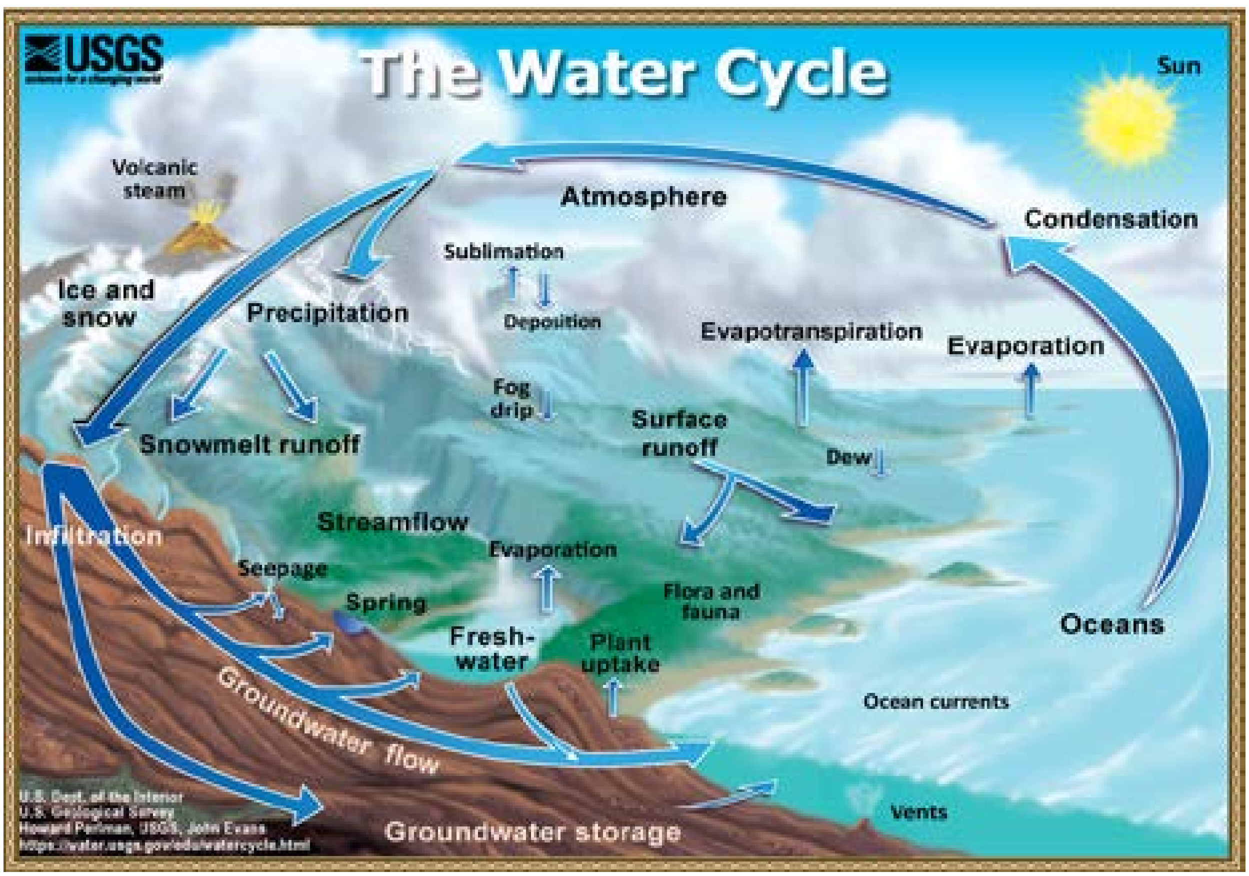
- **Point Source Pollution** is contamination that comes from a single, clearly recognizable source, such as a pipe which discharges material from a factory into a lake, stream, river, or other body of water. Since the early 1990s, state and federal regulations have defined certain sources of stormwater runoff as point sources requiring a National Pollutant Discharge Elimination System (NPDES) permit. Point source pollution is relatively easy to identify through water testing, data collection, and the monitoring of rivers and streams.

- **Nonpoint Source Pollution** is derived from a broad area and a variety of causes and thus, is more difficult to identify. Examples of nonpoint source pollution include: improper use of pesticides, fertilizers, and road salt which drain into our creeks and streams. Because of its wide variety of sources, this type of pollution can be difficult to control.

The Water Cycle

The water cycle describes how water evaporates from the surface of the earth, rises into the atmosphere, cools and condenses into rain or snow in clouds, and falls again to the surface as precipitation. The water falling on land collects in rivers and lakes, soil, and porous layers of rock. Much of this water eventually flows back into the oceans where it will once more evaporate. **Studying the water cycle is an essential component to understanding water resource issues in our region.** Knowing the different components of the water cycle and how water is distributed on the planet provides a greater appreciation of how precious freshwater resources are to our community.

The material supplied in this packet on the water cycle is intended to be a brief overview for teachers and students. Teachers should review the water cycle with students and discuss how it works. A diagram on the water cycle created by the USGS is provided below to help aid in this review process.



This diagram is public domain and can be downloaded for use from the U.S. Geological Survey's "Water Science for Schools" website: https://water.usgs.gov/edu/watercycle.html.

Activity 1 | Create Your Own Water Cycle

Overview: Students will make a small terrarium modeling the water cycle's major components and study the model to observe how the water cycle works.

Estimated Time
Two, 50-minute class periods

One class period to review the water cycle & prepare jars

One class period for observations

Materials
- USGS water cycle diagram
- Glass jar with lid
- Bottle cap
- Small stones
- Sand
- Soil
- A few small plants
- Copies of worksheet: *Create Your Own Water Cycle*

Key Terms
- water cycle
- evaporation
- condensation
- precipitation
- runoff
- infiltration
- transpiration

Objectives
Students will . . .

- Describe how the water cycle works
- Explain the processes of the water cycle (evaporation, transpiration, condensation, precipitation, surface runoff/groundwater flow)
- Describe how the water cycle affects living things

Essential Questions

- What does the word "cycle" in the term "water cycle" actually mean?
- How much water is actually available for humans to use? Why is that important to me?
- Why is important to conserve water?

Introduction
All the water found on Earth is recycled, not created as new. The scientific formula for water is H_20 and is the only natural resource found on our planet in three forms: gas, liquid, solid. There are two atoms of hydrogen and one atom of oxygen in a molecule of water.

About 79% of Earth's surface is covered in water. The mighty oceans hold about 96.5% of all Earth's water, leaving only 2.5% of water available as freshwater. Approximately 68.7% of this freshwater is stored in glaciers and icecaps and 30% is stored in groundwater supplies, leaving only 0.007% of Earth's water to be stored in rivers and lakes, the primary source of human use.

The water cycle does not have a beginning or an end and it does not necessarily have to occur in a set pattern. When the sun heats the water on the Earth's surface, some of the water changes into a gas, or vapor. The change from a liquid to a gas is called **evaporation**. After water evaporates, it rises into the air. This warm vapor mixes with cooler air in the atmosphere to create moisture or **condensation**. The moisture that falls back to the Earth as rain, hail, sleet, or snow is called **precipitation**. When it reaches the Earth, it returns to oceans, rivers, lakes, and wetlands in the from of **runoff** or by soaking into the ground via **infiltration**. Water can also make its way from the ground to the atmosphere via the **transpiration** of plants. This process of water moving from the Earth into the atmosphere and back to Earth again is called the **water cycle**. This is nature's way of recycling one of its most important natural resources.

Procedure

1. Review the USGS's diagram of the water cycle and how the water cycle works with your students.

2. Use a large jar with a wide top (example: pickle jar) to build a terrarium:

   Layer small stones in the bottom and then cover with sand.
   Fill jar with soil until half full. Place a few small plants in the soil.
   Fill a small cap (example: soda bottle cap) with water and place next to the plants in the jar.
   Tighten the lid on the jar. Place jar in the sun for a few days.

   Note: Students can build a class, group, or individual terrariums depending on available materials.

3. Hand-out the *Create Your Own Water Cycle Observations* student worksheet, found on page 13. If you are not planning to use the student worksheet, have students set-up a place in their science notebook to record observations or establish another system to collect observations.

4. Have students form a hypothesis about what will happen inside the jar. Over the next few days have students make and record careful observations about what takes place inside the terrarium. Did condensation form? Give students the opportunity to explain where, why, and how changes take place.

5. Review student observations as a class and help students connect their observations to different components of the water cycle.

Evaluation

Have students respond to one or more of the following questions:

- How does the water cycle work?
- What are the processes of the water cycle?
- How does condensation form inside the terrarium?
- How does the water cycle affect living things?

Assessment

Have students write a story about the journey of a water droplet as it goes through the water cycle.

Extension Opportunities

Experiment with the terrariums:
Prepare four small jars to represent different water conditions and factors that affect evaporation. Pour equal amounts of water into each bowl; securely cover the first with plastic wrap; leave the second uncovered; dissolve salt in the third; cover the fourth with the large, opaque bowl; place the four small bowls in a sunny spot. Other conditions you may consider including in the experiment: clear large bowl; different colored plastic wrap; other things besides salt to dissolve in water; water plants, such as elodea; shady rather than sunny spot. Let the students suggest other scenarios based on their ideas about the factors that affect evaporation.

Have students keep a water cycle journal:
As students learn more about water and the water cycle, have them keep a journal that records the different forms of water and different components of the water cycle they see in their lives - at home and at school.

Adapted with permission from Protecting Our Water Resources: Student Activities for the Classroom. Stormwater Management Academy. University of Central Florida, Orlando, Florida. http://www.stormwater.cecs.ucf.edu/toolkit/vol3/Contents/pdfs/Student%20Activities/student_activities.pdf

Activity 1 | Create Your Own Water Cycle Observations

Name:

Directions:

- Formulate a hypothesis, an idea, about what you think will happen to the water in the jar.
- To test your hypothesis, or idea, you'll need to observe the jar over the next couple of days and record what you see.
- Record your observations and use them to complete the remainder of the worksheet.

Hypothesis

What do you think will happen to the water in the jar?

Observations

What did you observe happen to the water in the jar?
For each observation you make, record the date and time of your observations.

Date	Time	Observations

Drawing Conclusions

Based on your observations, how does the water cycle affect living things?

Reflection

In the space below tell the story about the journey of a water droplet as it goes through the water cycle. Draw a picture in each of the boxes showing four scenes from your story.

Write story here:

Draw four different scenes from your story here:

1

2

3

4

Activity 2 | What is a Watershed?

Overview: Students are introduced to the concept of a watershed by constructing simple watershed models in the classroom and studying various maps of their local watershed.

Estimated Time
One, 50-minute class period

Additional time may be needed for the *Watershed Shapes & Sizes* exercise

Materials
One set of the following for each student group. Recommended group size is 3-4 students each:

- Shallow baking pan
- Assortment of blocks, cups and other small objects
- Aluminum foil
- Wooden boards, or other suitable objects to be placed on one side of the pans to create a slope
- Cup, watering can, or spray bottle
- Watershed maps
- A few small plants
- Copies of worksheet: *Watersheds: Shapes & Sizes*

Key Terms
- watershed
- water body
- tributary
- runoff
- infiltration
- groundwater
- elevation
- confluence

Objectives

Students will . . .
- Learn how to describe a watershed
- Predict where water flows to and from in a watershed
- Explore the natural drainage patterns of water with the use of maps and an easily constructed model
- Discover that everyone lives in a watershed

Essential Questions

- How can I help protect my watershed?
- What decisions or actions can I do to help?
- What are the most important parts of a watershed?
- How can maps help me learn about my community?

Introduction

A **watershed** is an area of land that drains or "sheds" water into a common **water body**, such as a stream, river, lake, or wetland. This water eventually makes its way to one of the oceans. A watershed starts at the highest **elevation**, or points on the landscape, like mountain peaks and ridgelines that divide one valley or drainage from another. The largest of these divides is called the Great Continental Divide.

The Mississippi River Watershed is an enormous watershed. The Mississippi River is the second longest river in North America, flowing 2,350 miles from its source at Lake Itasca through the center of the United States to the Gulf of Mexico. Rainwater that falls on over a third of the land in the United States is drained by the Mississippi River into the Gulf of Mexico and eventually to the Atlantic Ocean.

Watersheds come in all shapes and sizes. Small watersheds are usually part of larger watersheds. In the St. Louis vicinity, the Deer Creek Watershed is a sub-watershed of the River des Peres. The River des Peres is a small river draining a relatively small amount of land. Eventually all of the smaller feeder streams or **tributaries** of the River des Peres Watershed feed into the Mississippi River. (See series of maps on pages 18-23.)

Everything is connected—small streams flow into small rivers, which flow into larger rivers, and eventually flow into the ocean. Not only does water **runoff** into streams and rivers from the surface of a watershed, but water also **infiltrates** through the soil into the **groundwater** system. Some of this water may eventually come in contact with the surface of the Earth again, such as by using a well for drinking water or through a gaining stream that will recharge a stream or river with additional water.

Procedure

1. Divide the class into groups of three to four students. Give each group a set of the model making materials.

2. At one end of the baking pan, have students place the small blocks and other small items.

3. Explain that the blocks and other items will serve as hills and mountains, and the aluminum foil represents the surface of the Earth. Crinkle the aluminum foil, un-crinkle it and cover the blocks to form the Earth's surface. Remove the blocks from underneath to form the pool.

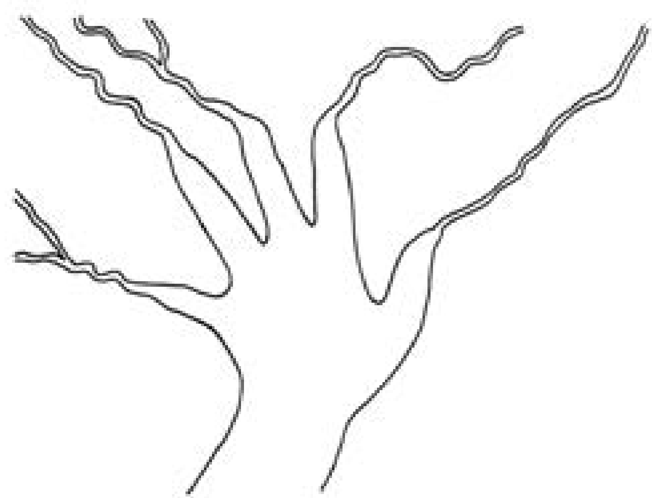
4. Prop the end of the pan with the board, book or other support to create a slanted model. The "pool" end of the pan should be the low end.

5. Have the students identify the hills, mountains, streams, rivers, and lakes on their models.

6. Have the students carefully pour a cup of water on the high end.

7. Ask the students:
    a. Where did the water run to? Possible Answer: Downhill to the lake.
    b. Is this what happens on Earth? Possible Answer: Yes, on Earth most of the water that falls as rain or other forms of precipitation drains off the surface of the Earth or through the soil into streams and rivers, and eventually into large bodies of water such as lakes, seas, and the oceans.

8. Introduce the term watershed. A watershed is an area of land that drains or "sheds" water into a common water body, such as a stream, river, lake, or wetland.



9. To help students understand the concept of watershed, trace your hand, wrist and part of your lower arm on the board (see diagram at right). Color the spaces in between your fingers and label your arm the "Blue River." Explain that this is a watershed and that your fingers represent smaller rivers, or tributaries, feeding into the larger "Blue River." The spaces between your fingers is land.

    Explain that a watershed is usually named for the main stream or river, so what would this watershed be called? Answer: The Blue River Watershed.

10. Watersheds come in all shapes and sizes. They can be very large like the Mississippi River Watershed or they can be as small as the area of land that drains into a mud puddle. There isn't anywhere on Earth that is not part of a watershed. Reference the students' watershed models to explain how high points in elevation (like a mountain or hill top) determine the boundaries of a watershed and influence which way water will flow. Use your hand once again to demonstrate this by making a "mountain" with your fist. Explain how water that hits one side of the mountain (your knuckle) will drain one way into a watershed and how water falling on the other side of the mountain will drain the

opposite way into a different watershed. The most extreme example of this is the Great Continental Divide in the Rocky Mountains where water that falls on the west side of the divide all drains to the Pacific Ocean and water that falls on the east side drains to the Atlantic Ocean and the Gulf of Mexico.

11. Use the series of watershed maps provided to show the students as you discuss these concepts.

12. To reinforce for the students that large watersheds include many small watersheds comprised of tributary streams feeding into larger streams and rivers, give each student a copy of the *Watersheds Shapes & Sizes* student worksheet (page 24).
    Ask them to circle:
    - the Black Creek Watershed in yellow,
    - the Deer Creek Watershed in green,
    - and the River des Peres Watershed in red.

13. Check to make sure that all the students have correctly identified the watersheds before cleaning up.

Evaluation

Have students respond to one or more of the following questions:

- What is a watershed?
- How does water move on land?
- How do smaller watersheds affect larger watersheds?
- What is our watershed?
- Is there anywhere on Earth that is not part of a watershed?

Assessment

Have students write a story about their watersheds, be sure students have stated the proper name for the watershed they live in.

Extension Opportunities

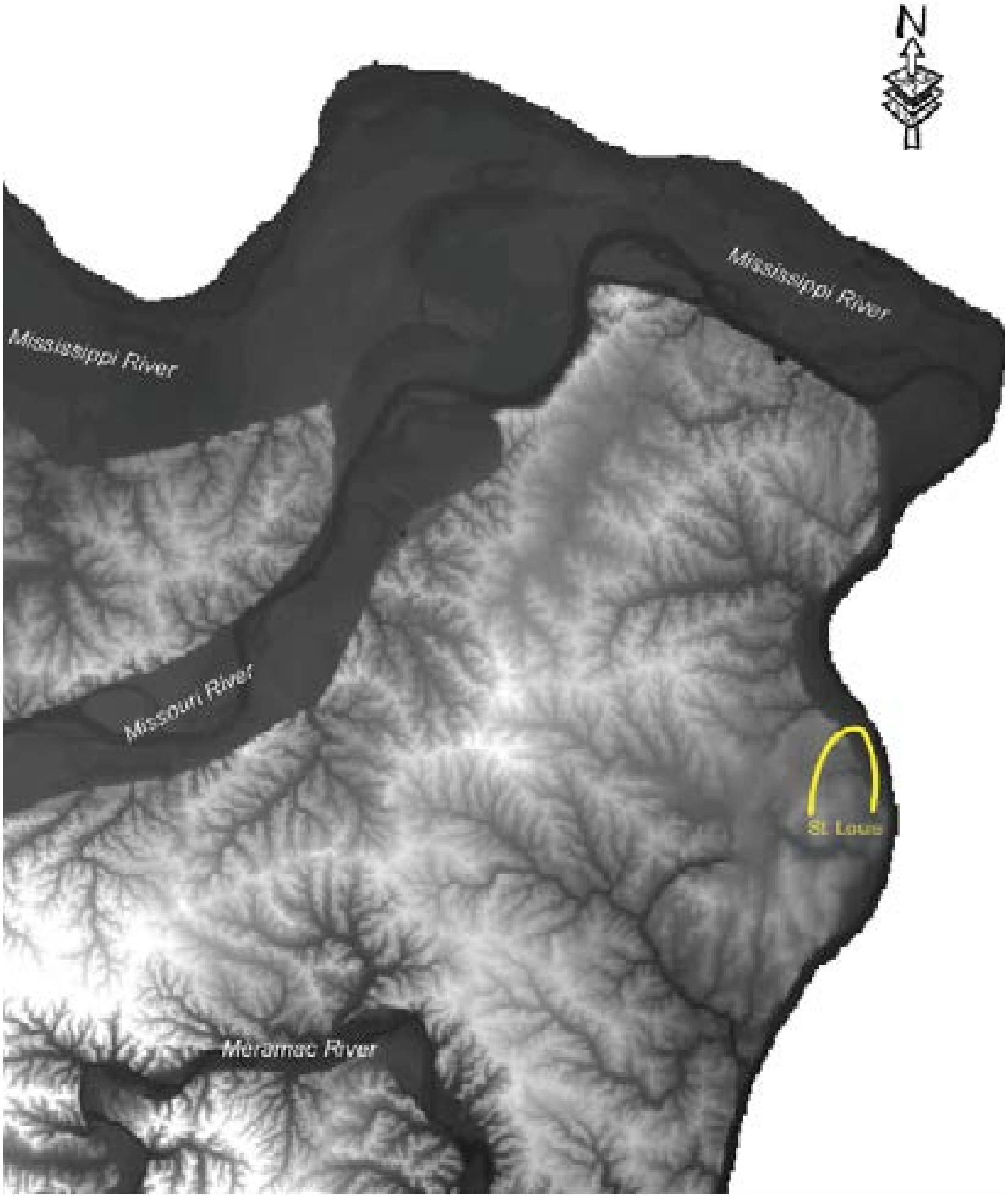
Explore Your Watershed:
Explore your local watershed by taking a watershed walk and documenting what you see along the way, or using an online tool such as Google Earth. The USGS has map opportunities that allow an individual to add different unique layers, such as watersheds to a Google Earth map.

With these explorations have students make observations about what features are included in their watershed. Are there local creeks and small rivers that run to their main watershed river? What kind of land use is present (rural, heavy urban, agricultural)? What kind of green space or permeable surfaces do they notice?

Watershed Map 1: Elevation & Watersheds

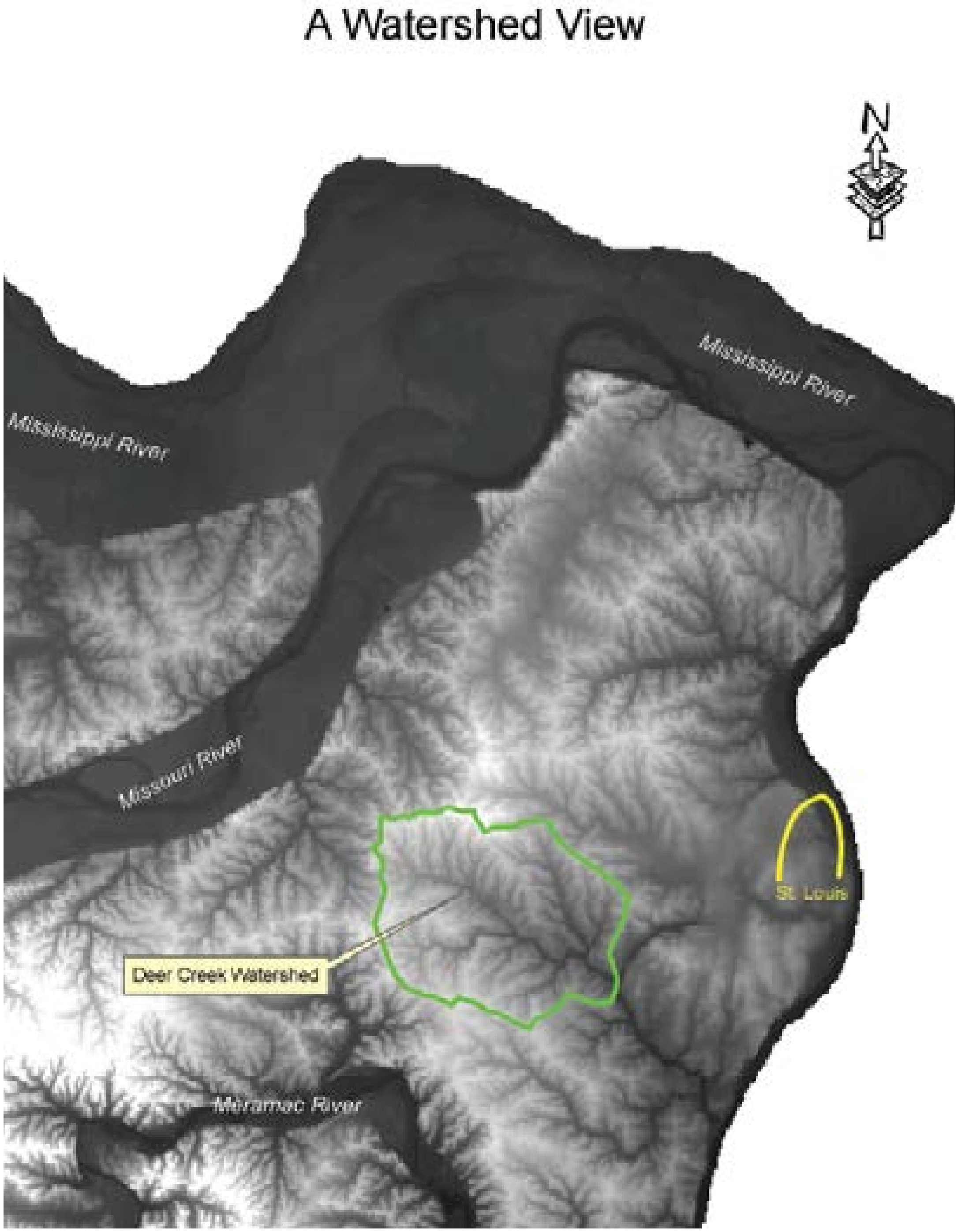
This is a digital elevation model map of the St. Louis region. It depicts drainage patterns on the Earth's surface. The lighter colored areas are higher elevations from which water drains away and the darker areas are lower elevations where water concentrates. Notice the natural branching pattern that results from smaller, tributary streams feeding into larger streams and rivers. Students may relate to other branching patterns such as that of trees, of a human's central nervous system, or a network of roads and highways.

A Watershed View



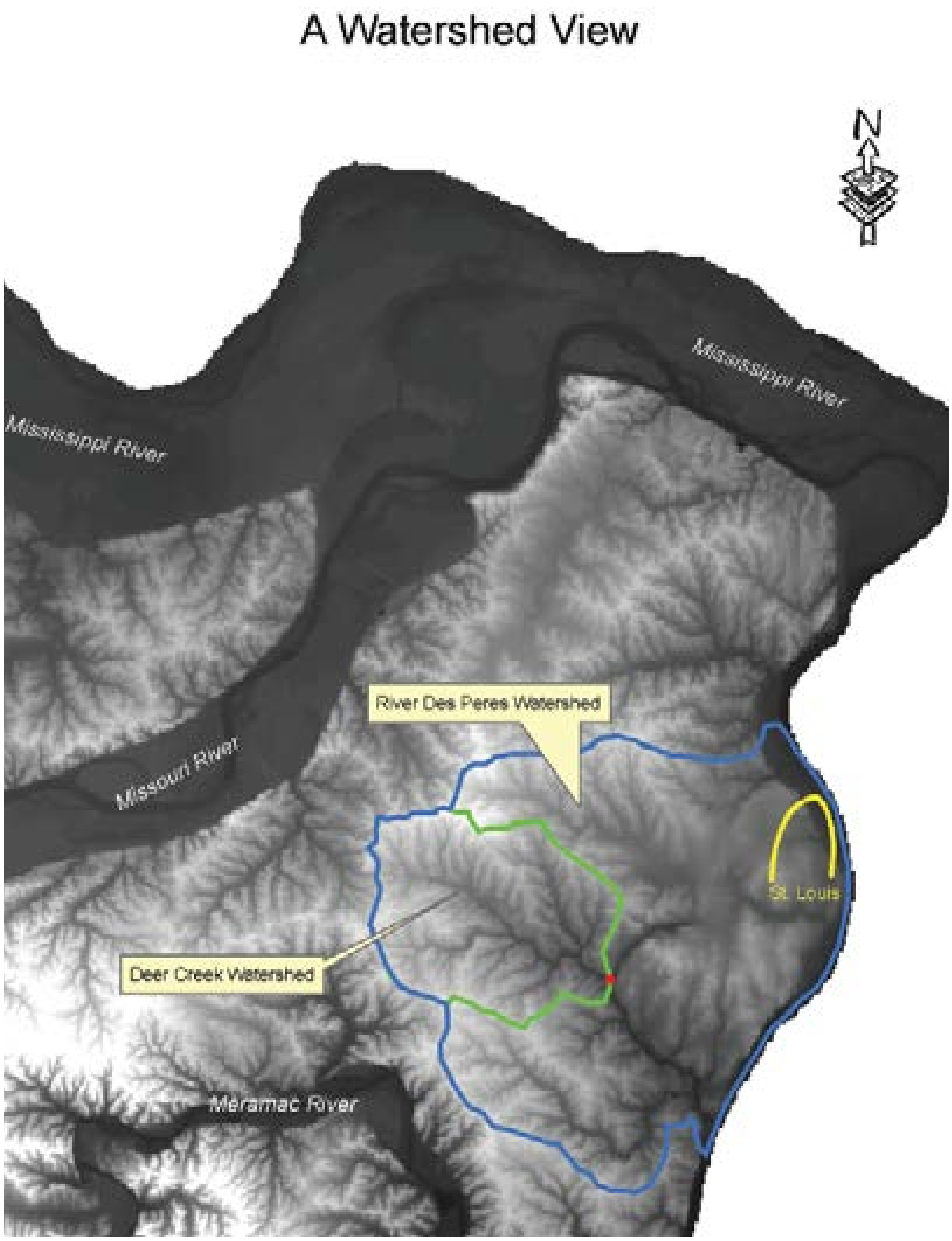
Watershed Map 2: Deer Creek Watershed

This is the same digital elevation model map of the St. Louis region except this map shows the boundary of one of the major sub-watersheds in the St. Louis region, the Deer Creek Watershed. The green boundary line connects all of the high points of elevation surrounding Deer Creek and its tributaries. Water that falls inside the green boundary line drains into the Deer Creek Watershed and water that falls outside the green line drains into different watersheds.



Watershed Map 3: Deer Creek Watershed & River des Peres

This map shows how the Deer Creek Watershed (bordered in green) is actually a smaller, sub-watershed of the larger River des Peres Watershed (bordered in blue.) Trace and follow the paths of both Deer Creek and the River des Peres to find where they intersect. Point out the **confluence** of the two rivers, the point where the two rivers join together, for the students to see. The confluence is shown on this map in red and located in the Shrewsbury/Maplewood area. Point out that the River des Peres eventually flows into the Mississippi River, making it part of the even larger Mississippi River Watershed.



Watershed Map 4: Missouri Hydrologic Unit Codes

A hydrologic unit code is a sequence of numbers or letters that identify a hydrological feature like a river, river reach, lake, or area like a drainage basin (also called watershed (in North America) or catchment. The United States is divided and sub-divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged or nested within each other, from the largest geographic area (regions) to the smallest geographic area (cataloging units). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

The first level of classification divides the Nation into 21 major geographic areas, or regions. These geographic areas contain either the drainage area of a major river, such as the Missouri region, or the combined drainage areas of a series of rivers, such as the Texas-Gulf region, which includes a number of rivers draining into the Gulf of Mexico. Eighteen of the regions occupy the land area of the conterminous United States. Alaska constitutes region 19, the Hawaii Islands are region 20, and Puerto Rico and other outlying Caribbean areas are region 21.

Map of Water Resource Region adapted from U.S. Geological Survey: https://water.usgs.gov/GIS/regions.html.

Our Regions:

Region 10 Missouri Region -- The drainage within the United states of: (a) the Missouri River Basin, (b) the Saskatchewan River Basin, and (c) several small closed basins. This region includes all of Nebraska and parts of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wyoming.

Region 07 Upper Mississippi Region -- The drainage of the Mississippi River Basin above the confluence with the Ohio River, excluding the Missouri River Basin. Includes parts of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, South Dakota, and Wisconsin.

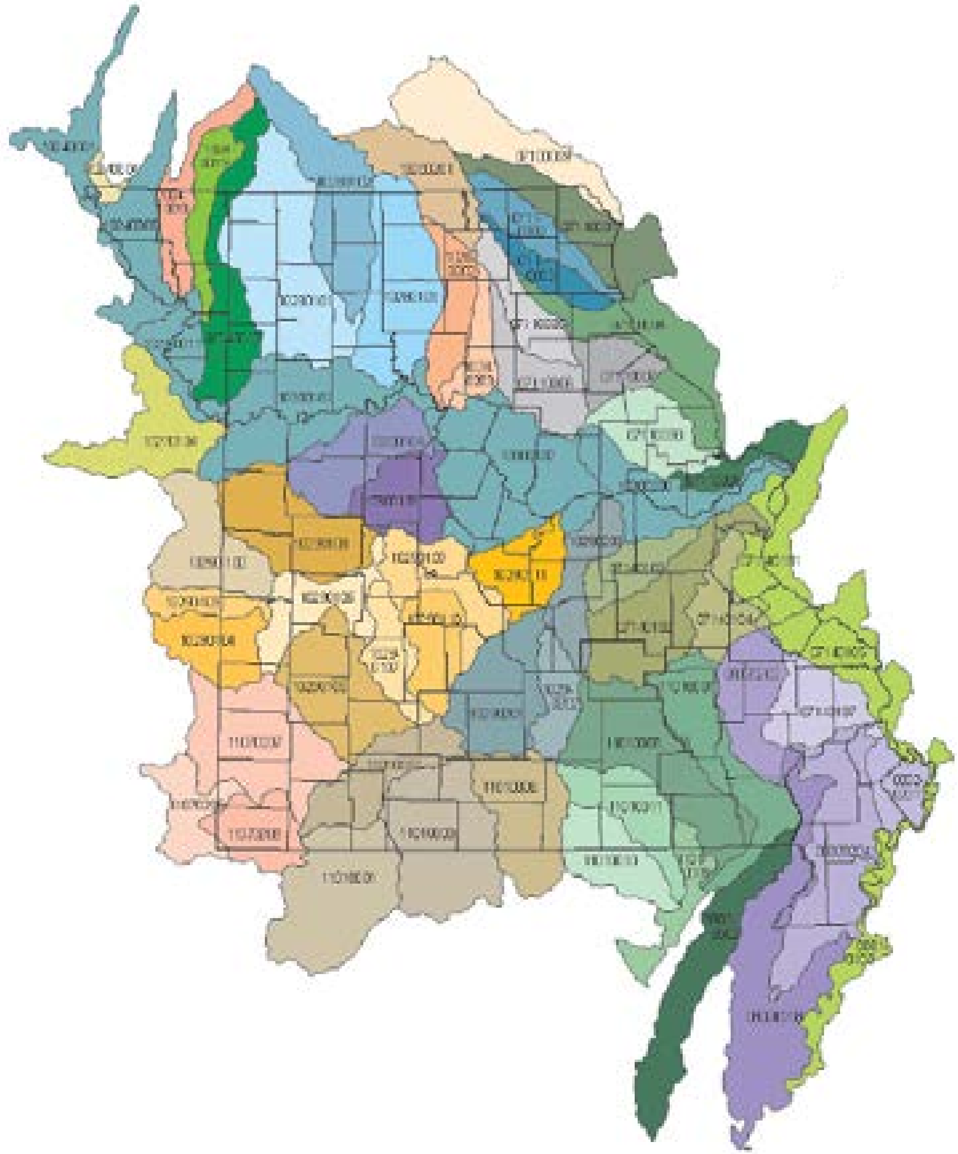
Region 11 Arkansas-White-Red Region -- The drainage of the Arkansas,White, and Red River Basins above the points of highest backwater effect of the Mississippi River. Includes all of Oklahoma and parts of Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, and Texas.

Region 08 Lower Mississippi Region -- The drainage of: (a) the Mississippi River below its confluence with the Ohio River, excluding the Arkansas, Red, and White River Basins above the points of highest backwater effect of the Mississippi River in those basins; and (b) coastal streams that ultimately discharge into the Gulf of Mexico from the Pearl River Basin boundary to the Sabine River and Sabine Lake drainage boundary. Includes parts of Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee.

Watershed Map 4: Missouri 8-digit Hydrologic Unit Codes

Hydrologic Unit Delineations by 8-digit Hydrologic Unit Code.

Watersheds grouped by color represent the larger watersheds to which they belong. Notice how the watersheds may or may not coincide with all of the state's political boundaries shown in black.



Upper Gasconade 10290201
Big Piney 10290202
Lower Gasconade 10290203
Lower Missouri-Crooked 10300101
Lower Missouri-Moreau 10300102
Lamine 10300103
Blackwater 10300104
Lower Missouri 10300200
Beaver Reservoir 11010001
James 11010002
Bull Shoals Lake 11010003
North Fork White 11010006
Upper Black 11010007
Current 11010008
Lower Black 11010009
Spring 11010010
Eleven Point 11010011
Lake O' the Cherokees 11070206
Spring 11070207
Elk 11070208
Lower Des Moines 07100009
Bear-Wyaconda 07110001
North Fabius 07110002
South Fabius 07110003
The Sny 07110004
North Fork Salt 07110005
South Fork Salt 07110006
Salt 07110007
Cuivre 07110008
Peruque-Piasa 07110009
Cahokia-Joachim 07140101
Meramec 07140102
Bourbeuse 07140103
Big 07140104
Upper Mississippi-Cape Girardeau 07140105
Whitewater 07140107
Lower Mississippi-Memphis 08010100
New Madrid-St. Johns 08020201
Upper St. Francis 08020202
Lower St. Francis 08020203
Little River Ditches 08020204
Cache 08020302
Keg-Weeping Water 10240001
Nishnabotna 10240004
Tarkio-Wolf 10240005
Nodaway 10240010
Independence-Sugar 10240011
Platte 10240012
One Hundred and Two 10240013
Lower Kansas 10270104
Upper Grand 10280101
Thompson 10280102
Lower Grand 10280103
Upper Chariton 10280201
Lower Chariton 10280202
Little Chariton 10280203
Lower Marais Des Cygnes 10290102
Little Osage 10290103
Marmaton 10290104
Harry S. Truman Reservoir 10290105
Sac 10290106
Pomme De Terre 10290107
South Grand 10290108
Lake of the Ozarks 10290109
Niangua 10290110
Lower Osage 10290111

Watershed Map 5: Mississippi River Basin

The watersheds in the St. Louis region and all of Missouri are part of the larger Mississippi River Watershed, which encompasses 31 states, two Canadian provinces, and covers more than one third of the country. The headwaters of the Mississippi River Watershed start along the Missouri River in Montana, and its mouth empties into the Gulf of Mexico.

This map (below) was taken from http://wyominghydrology.com/watershed-management/.

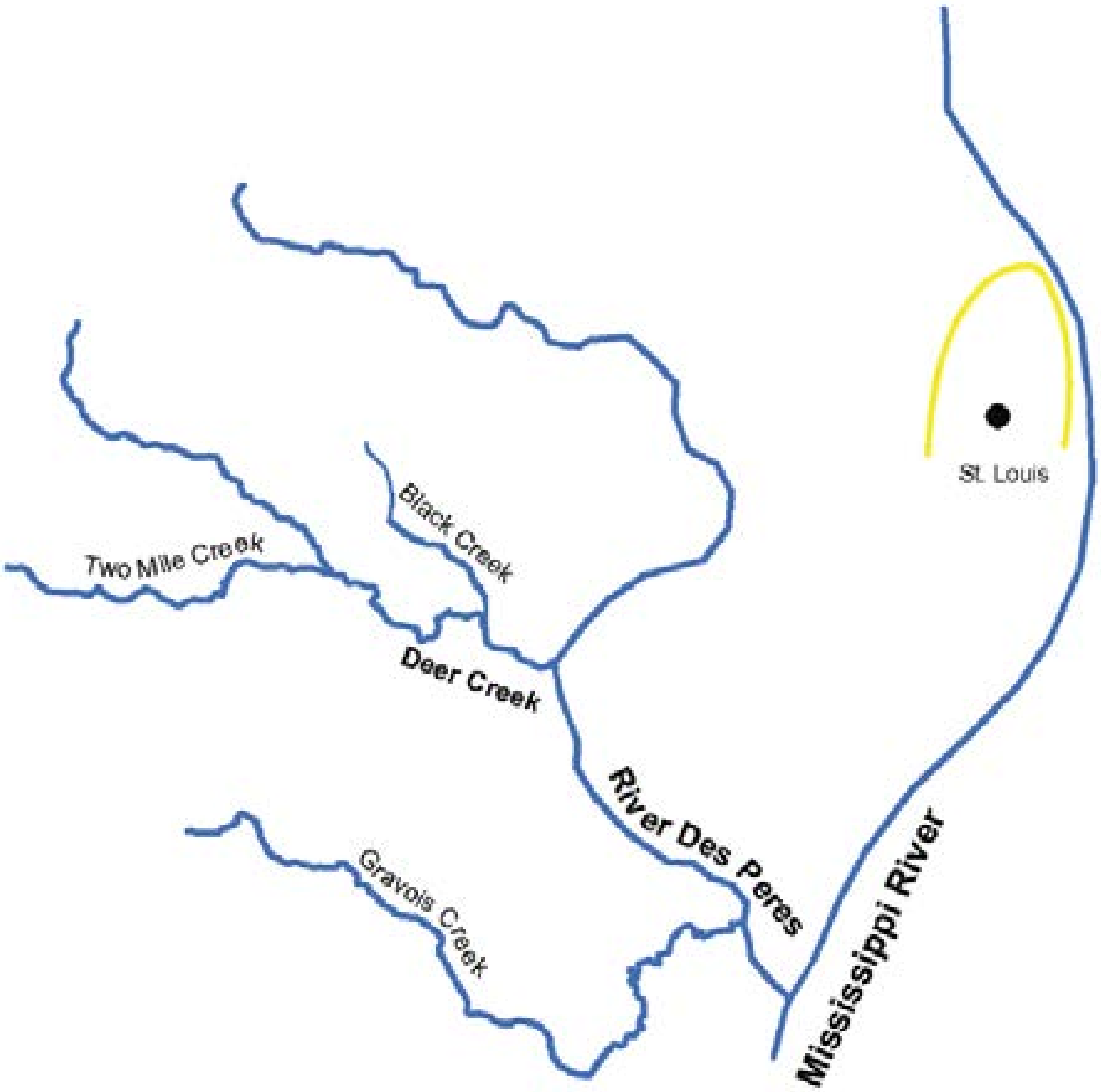
River Basins in the United States by Imgur User: Fejetlenfej *Image available at: https://imgur.com/gallery/N4cUA ment/.*

Watch: Animation showing every river that empties into the Mississippi River at: http://digg.com/2016/rivers-empty-into-mississippi-map

Name:

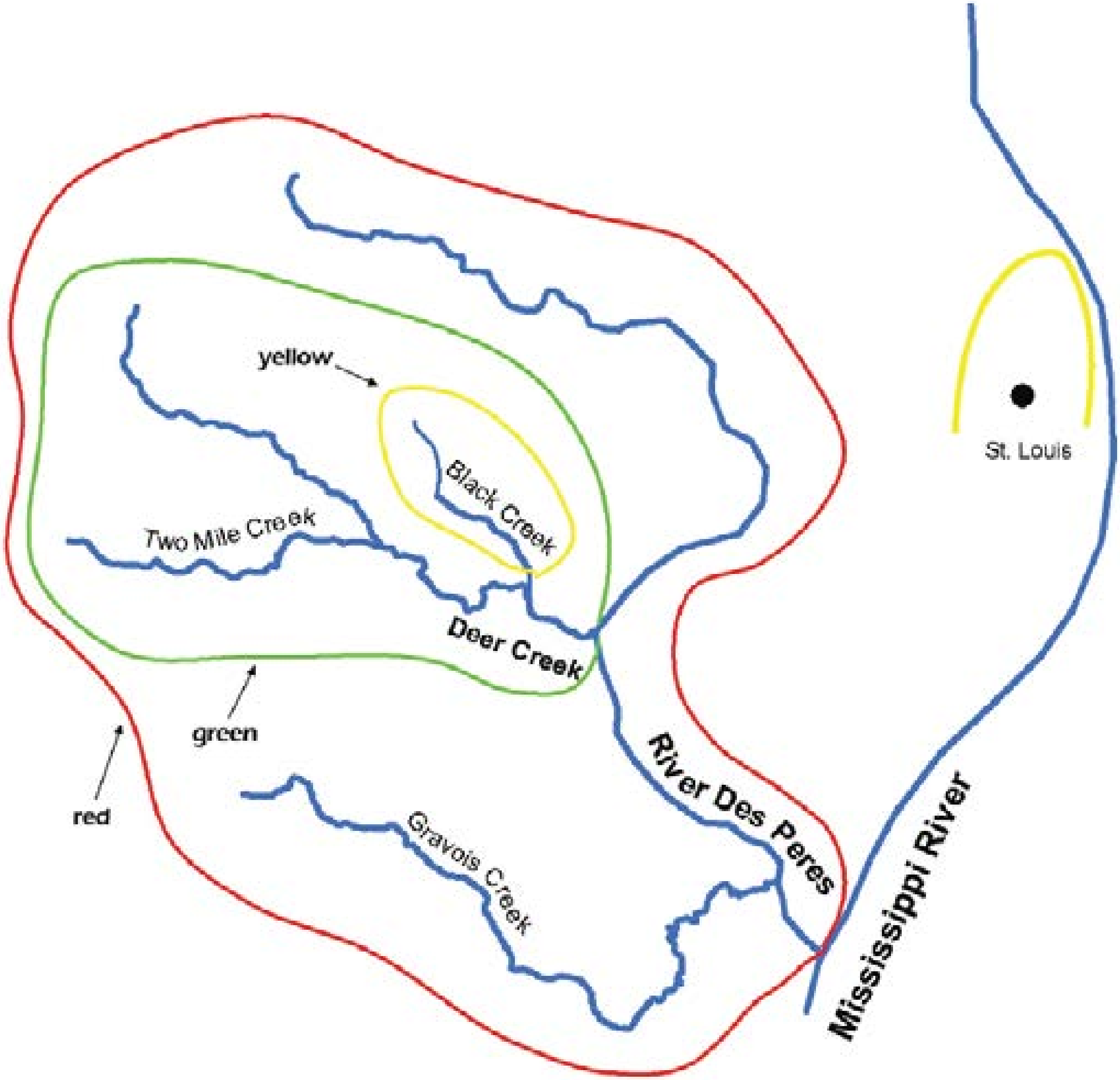
Directions: Label the map below as instructed and answer the following questions.

- Circle the Black Creek Watershed in YELLOW
- Circle the Deer Creek Watershed in GREEN,
- Circle the River des Peres Watershed in RED



What is a watershed?

What is the relationship between the Deer Creek Watershed, River des Peres Watershed, and Mississippi River?


yellow
Black Creek
Two Mile Creek
Deer Creek
green
red
Gravois Creek
River Des Peres
Mississippi River
St. Louis

Overview: Students anchor their newly acquired knowledge about watersheds with real-world application by exploring their school grounds with maps and careful observations.

Estimated Time
One, 50-minute class period

Materials
One set of materials for each student group. Recommended group size is 2-3 students each.

- "Base" map of the school grounds (made by teacher)
- Clipboard
- Pencils and/or colored pencils
- Optional: Compasses
- Optional: Adult volunteers to help supervise students

**Note: save maps to use for other activities in unit*

Key Terms
- watershed
- elevation
- tributary

Objectives
Students will . . .

- Demonstrate how water is drained by changes in the land's elevation.
- Develop map reading and orienteering skills.
- Apply concepts in a place that has significance in their lives.
- Discover that their schoolyard is a part of a watershed.
- Record observations in an outdoor setting.

Essential Questions

- Do you (the students) live in a watershed?
- How are maps used as tools?

Introduction
Students will explore their schoolyards, looking for physical features that suggest changes in **elevation**. These features may be areas such as high places where water might flow downhill and low places where water might collect to form features like puddles. This will provide students with an opportunity to record their observations in an outdoor setting. It will also help to reinforce how water is drained by changes in land elevation, as they apply this concept to a place of significance in their lives and to an understanding of their own local **watershed**.

Preparing for the Lesson
1. Create a Base Map
Teachers should prepare a base map of the school grounds on which students will draw and record their observations. This map can be simple, include a grid system for reference, and feature identifiable features that can be used as a reference point such as buildings, parking lots, sports fields, playground equipment, fences, walkways, trees, etc.

Create a legend displaying easily recognized symbols that will be used to represent certain things.

Mark the cardinal directions on the map so that students can practice orienting themselves and their maps. Compasses would be useful for this activity, but they are not essential, especially if a lot of time is needed to teach the students how to use them. Referencing specific landmarks will be enough for the purposes of this activity.

See sample map on page 29 of a teacher created base map. Arrows will be added by students during the activity.

Create a Base Map, Continued
Leave plenty of space for the students to draw on the map and add symbols to the legend. **Note that these maps will be used again for another activity in the study unit, so make arrangements for the students to save their maps for later use if you are planning to complete additional activities.*

Create Guided Questions
On another sheet of paper, or perhaps on the back of the map, provide a few questions that will help guide the student's observations. A sample worksheet can be found and used on page 30.

Here are a few suggested questions to include:

- Where is the highest point on the grounds?
  Possible answer: rooftop, hilltop
- Where is the lowest point on the grounds?
  Possible answer: in a ditch, at the bottom of the hill, where that puddle has formed
- Where did you or where might you find puddles?
  Possible answer: at the lowest places, where there are depressions in the ground
- Which way does the water flow?
  Possible answer: downhill; from a high to a low, have students add arrows to map to indicate observations in direction of water flow.

Prepare Yourself
Walk the school grounds while keeping these questions in mind so that you will know the best places to take the students or important places of discussion you may want to feature during the activity.

Note: This activity would also be great if planned for a rainy day and if appropriate rain gear was available. Seeing the schoolyard in the rain may help students conceptualize the drainage and movement of water.

Procedure

1. Organize students into manageable working groups before venturing out onto the school grounds.

2. Review the procedure for completing this activity with students. Discuss with students the idea of an "outdoor classroom" and explain that the map they will be working with will be used again for another activity later.

3. If possible, assign groups to different sections of the schoolyard to avoid traffic jams. Depending on how spread out your schoolyard is, you may want to secure a couple of parent volunteers to help supervise the students. This however may not be necessary and teachers should use their own judgment regarding student safety.

4. Assign a group leader to help the students familiarize themselves with their map. Maps should all be facing the same direction.

5. Assign students the task of determining where the water that falls on their school grounds drains and collects.

6. Have students draw in any water features on the school grounds such as ponds, streams, etc.

7. Have students draw arrows indicating the direction and path that water may flow on their school grounds. Arrows should point away from areas the water drains off of (high points) and towards areas that it drains to (low points).

8. Make sure students take the time to write down the answers to some of the questions asked about

the drainage of water on their school grounds.
9. If there is time have students share their findings with the other groups.

10. Wrap up by discussing how the schoolyard is part of a watershed.

11. Have students put their names on their maps before turning them in and remind them that they will be using them again at a later time for another activity.

12. Assign the homework, or complete in class the *Where in the Watershed?* worksheet.

Evaluation
Have students respond to one or more of the following questions:

- How do changes in elevation influence the way water moves?
- What watershed do you live in? Is the school in?

Assessment
Have students draw a map of their watershed.

A good way to reflect on what the students know is by doing a group drawing activity. Students should form groups of 2-3, and each receive a large piece of paper.

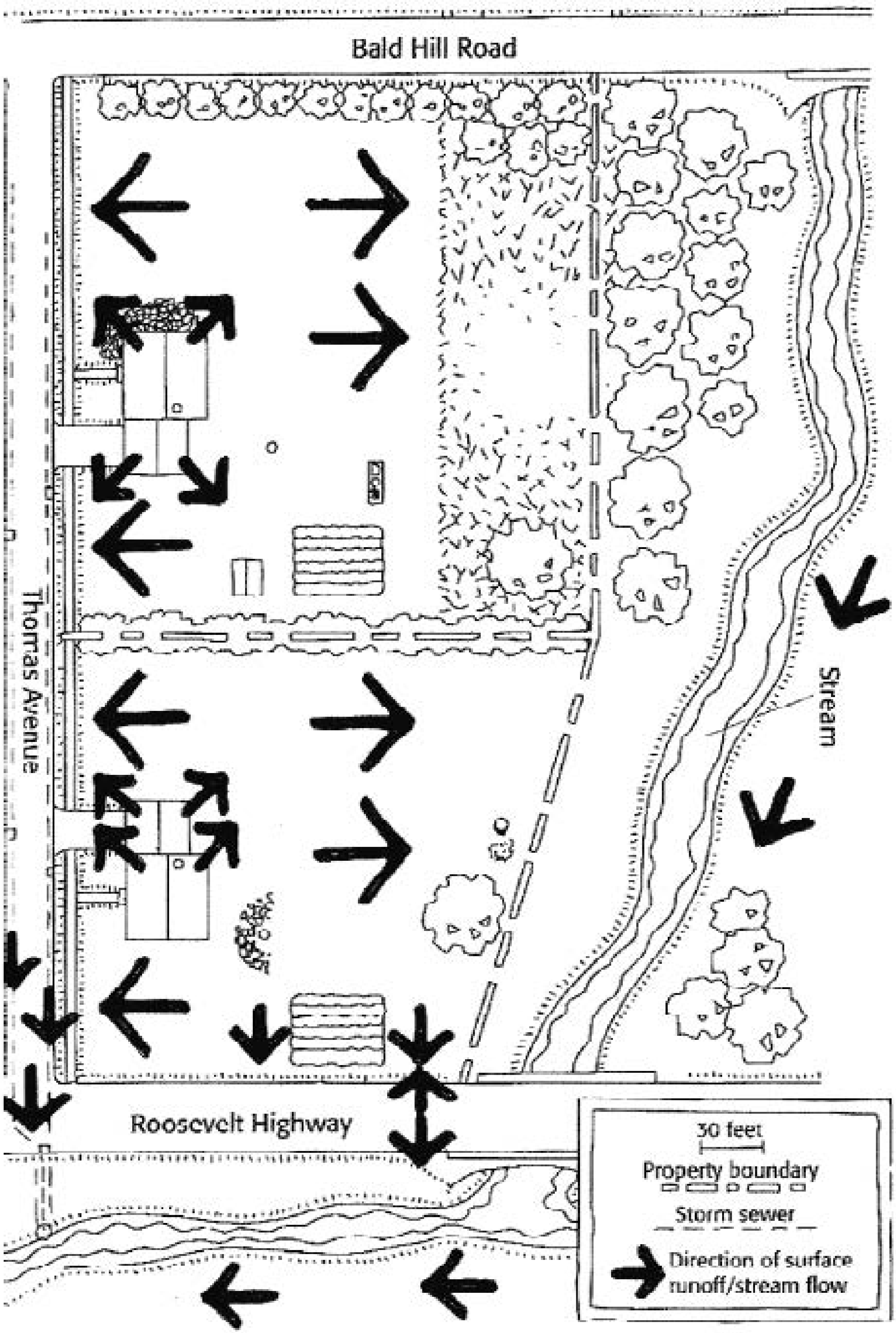
First, ask the students to draw a picture of their watershed.
Second, tell the students to think about pollution and what they've seen, and add anything that harms their watershed.
Last, ask the students to draw things that help solve the pollution problems, or what it means to be a good water steward.

After drawing, have each group share their drawing and describe what they drew and why.

Extension Opportunities
Have students draw maps of their individual neighborhoods. Display each students' map in the class-room and discuss how the each drawing is a part of the same few watersheds.

Explore Waterway Data
Have your students use the *My Waterways* online tool available through the U.S. EPA's website to learn the condition of local streams, lakes and other waters in their neighborhood or anywhere in the United States. See if your local waterway was checked for pollution, what was found, and what is being done. The source of this information is a US Environmental Protection Agency (EPA) database of State water quality monitoring reports provided under the Clean Water Act.

Online tool available at: https://watersgeo.epa.gov/mywaterway/



*Reproduced with permission from Home*A*Syst: An Environmental Risk-Assessment Guide for the Home (NRAES-87). Natural Resource, Agriculture, and Engineering Service. http://www.nraes.org*

Activity 3 | Schoolyard Watershed Walk

Name:

Directions: As you walk the school grounds make careful observations and add these features to your map. Use arrows, symbols, and notes to capture what you see. Answer the following questions as you work:

Where is the highest point in the schoolyard?

Where is the lowest point in the schoolyard?

Where did you or (where might you) find puddles?

Which way does the water flow? Be sure to draw some arrows on the map to indicate which direction water would flow.

Name:

Directions: Can you find where your school is located in the watershed? Your home? Mark each location on the map, then answer the reflection questions.

Label the following on your map:

- ☐ Your home
- ☐ Your school
- ☐ The 3 major rivers that appear on the map

Reflection Questions

Do you live in a watershed? Explain your answer.

What is the name of the watershed you live in?

What is the name of the watershed your school is in?

What is the closest tributary, creek, or river to your house? Circle it on your map.

Are you familiar with the closest tributary, creek, or river to your house? Describe what you know about this waterway.

Overview: Students use the scientific method to observe and compare the amount of surface water runoff and evidence of erosion in two different schoolyard sites.

Estimated Time
60-80 minutes depending on grounds covered

Materials
One set of materials for each student group. Recommended group size is 2-3 students each.

- Copies of *Runoff Roundup* worksheet for each group
- Clipboards
- Pencils and/or colored pencils
- Bucket of water
- Clear plastic measuring cup
- (Optional) Marker flags
- Water cycle diagram for review

Key Terms
- water cycle
- precipitation
- evaporation
- runoff
- erosion
- impervious surface
- infiltration
- water quality

Objectives

Students will . . .

- Observe and compare the amount of surface water runoff in two different schoolyard sites.
- Identify areas likely to experience greatest runoff during a rainstorm.
- Describe the negative impacts of excessive surface water runoff on water quality.
- Explain how plants reduce the amount of surface water runoff.
- Record observations and data in an outdoor setting.

Essential Questions

- How can my schoolyard be a problem for the watershed?
- How do decisions I make about what grows in my yard have an impact on the watershed?
- What things can we do as a community on land to help improve water quality?

Introduction

Students will explore their schoolyards, looking at two sites to better understand how runoff occurs as a result of concrete structures, and other hard surfaces which do not allow the water to slow down and soak into the ground. Students will conduct an experiment in their own schoolyard to test predictions about what type of surface contributes to more run-off, and then identify other locations in their schoolyard that pose a potential problem.

Preparing for the Lesson

1. Select Site Locations for Experiments

Before exploring with the class, you should plan where you will take your students.

Scan the school grounds and locate two runoff study sites. If possible, mark the boundaries of each study site with marker flags or flagging tape.

Each site should accommodate the entire class at one time, this is especially important if you will only have one or two adults with the group during the activity. Good candidates include an exposed dirt playground, a paved or gravel parking lot, or a steeply-sloped gully or ditch.

Select another site with little surface water runoff during a rainstorm. Good candidates include a flat, well-vegetated area or an area covered with mulch.

Procedure

Before Going Outside (10-15 Minutes):

1. Briefly review the water cycle and its components, using a chart or diagram if possible. Ask students what can happen to water after it falls to the ground as precipitation. Make sure students realize that, once water hits the ground, it can:
   - evaporate back into the atmosphere,
   - be absorbed into the ground (infiltration), or
   - be carried along the surface of the ground (runoff), eventually emptying into a body of water as a lake, river, or constructed drainage.

2. Explain that during this activity students will be working in groups to determine what factors affect the amount of runoff occurring in an area.

3. Divide students into groups of three to four and distribute the "Runoff Roundup" worksheets and a clipboard to each group.

Exploring Outside (30-35 Minutes):

4. Lead students to the first study site and ask students to write a description of the site.

5. Next ask students to predict what they think happens when heavy rain falls on the site.

6. Demonstrate the procedure for testing students' predictions and distribute measuring cups and buckets of water.

7. Instruct students to pour five cups of water over the exact same location in their study site and observe what happens. Students should record their observations on the worksheet.

8. Lead students to the second study site and repeat the procedure.

After Going Outside (20-35 Minutes):

9. Have groups complete the "Comparisons" section of the worksheet and conduct a class discussion addressing some of the Unit Questions.

10. Introduce the idea of erosion as one negative impact of excessive runoff. Define **erosion** as the gradual wearing away of the surface of the land due to factors like wind and water.
    - Ask students how rainfall could cause erosion.
    - Next ask students which areas of the schoolyard might be subject to erosion from rainfall. Students should realize that open, exposed areas like a dirt playground or dirt foot paths made by students repeatedly walking across the same grassy area are especially susceptible to erosion from rainfall.

11. Ask students how erosion could affect the quality of surface water running into natural bodies of water like lakes or streams. Make sure students realize that surface water containing lots of soil particles can make a lake or stream cloudy, and that water loaded with soil particles can harm fish and other water organisms by clogging gills and decreasing the amount of sunlight needed for aquatic plants to produce oxygen needed by other aquatic organisms.

12. Finally, ask students what can be done to reduce erosion due to rainfall. Explain that one of the easiest ways to control erosion from rainfall is to cover exposed slopes with vegetation.

Evaluation

Have students respond to one or more of the following questions:

- How does the slope of an area affect the amount of surface water runoff? (The steeper the slope, the greater the amount of runoff.)

- How does the type of material covering the surface of the ground affect the amount of surface water runoff? (Runoff is much greater from impervious surfaces like cement or most types of asphalt.)
- How does the amount of vegetation in an area affect the amount of surface water runoff? (Generally, plants help slow the flow of water through an area and allow the water time to soak into the ground. As a result, the amount of runoff is reduced.)
- What kinds of areas are likely to experience the greatest runoff during a rainstorm? (Steeply sloped, paved, exposed, and unvegetated areas are likely to experience the greatest amounts of runoff.)
- How does runoff and erosion affect water quality?

Assessment

Ask students to create a diagram that shows the relationship between rainfall, erosion, and water quality. Have students add possible solutions to their diagram based on what they observed and class discussions.

Extension

While completing this activity, have students also complete Activity 5 | Impervious Business.

You may also have students make weather observations and conduct research to hypothesize how much water falls on their schoolyard during the course of a year.

Adapted with permission from Stormwater Education Toolkit . Stormwater Management Academy. University of Central Florida, Orlando, FL.
http://www.stormwater.cecs.ucf.edu/toolkit/vol3/Contents/pdfs/Lesson%20Plans/runroundup.pdf

Name:

Directions: At each site, complete a site description and predict how much runoff will occur. Then, conduct a test to check your prediction. Record the results.

Site 1

DESCRIPTION
What does this site look like?

Record the following information about site 1:

Elevation (flat, slight slope, steep slope)	
Surface (cement, asphalt, sand, soil, etc.)	
Vegetation (covered with plants, few spare plantings, no plants)	
Location (open/exposed or shaded/protected)	

PREDICTION
What do you think happens when heavy rain falls on this site?

OBSERVATIONS
To test your prediction, pour five cups of water over the same spot in your site. Observe and describe what happens to the water and site.

Observations:

How much waste was absorbed by the ground? (all, some, none)	
How much water ran off the surface? (all, some, none)	
Was your prediction correct? Explain why or why not.	

Site 2

DESCRIPTION
What does this site look like?

Record the following information about site 2:

Elevation (flat, slight slope, steep slope)	
Surface (cement, asphalt, sand, soil, etc.)	
Vegetation (covered with plants, few spare plantings, no plants)	
Location (open/exposed or shaded/protected)	

PREDICTION
What do you think happens when heavy rain falls on this site?

OBSERVATIONS
To test your prediction, pour five cups of water over the same spot in your site. Observe and describe what happens to the water and site.

Observations:

How much waste was absorbed by the ground? (all, some, none)	
How much water ran off the surface? (all, some, none)	
Was your prediction correct? Explain why or why not.	

Comparisons:

Was the amount of runoff in the two sites different?

What factors can increase the amount of runoff in an area?

Activity 4b | Runoff and Erosion Experiment

Overview: Students investigate the processes of surface runoff, infiltration, and erosion by using a model to simulate rainfall on three different surfaces: bare soil, vegetation, and impervious.

Estimated Time
30 minutes to prepare
60 minutes including:
30 minutes for experiment
30 minutes for discussion

Materials

- Three shallow boxes (shoe box size works well)
- Plastic lining for each boxes (trash bags, grocery sacks)
- Watering can
- Three measuring cups with wide opening
- A wooden board (or another object that can be placed under one side of the trays to create a slope)
- Loose soil
- Piece of sod OR several sponges to serve as vegetation
- Plastic wrap or foil
- Scissors
- Two stopwatches
- Copies of student worksheet and data table

Key Terms
- runoff
- erosion
- infiltration
- impervious
- water body

Objectives
Students will . . .

- Observe and compare how runoff is influenced by the presence or absence of bare soil, vegetation, and impervious surfaces.
- Understand how the type of material covering the surface of the ground can affect the amount of runoff occurring in an area.
- Explain how plants can help reduce the amount of surface water runoff.
- Perform simple calculations to analyze and interpret data.

Essential Questions

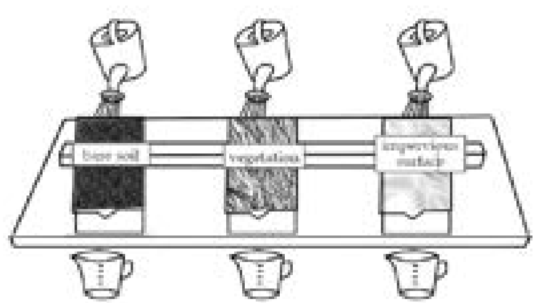
- How can runoff affect water quality?
- How does our choice of ground covering (concrete, turf grasses, plants, etc.)affect water quality?
- What can we do as a community on land to help improve water quality?

Introduction
Students will investigate the processes of surface **runoff**, **infiltration**, and **erosion** by using a model to simulate rainfall on three different types of surfaces. This experiment can either be demonstrated by the teacher or worked through in small groups, depending on the number of supplies and the amount of time available.

Preparing for the Lesson
Prepare the Demonstration Boxes
1. Make a uniform V-shaped notch at one end of each box.
** Note: the deeper you make the notch the less soil you will have to use to fill each box.*

2. Line each of three boxes with plastic so the boxes will not leak during the experiment.

3. Set the boxes on a table and put a piece of wood under one end of each box so they are on a slope. The end of the box with the V cut should hang slightly over the end of the table. Place each of the three measuring cups under the V-shaped spout on each box.



See page 41 for full Experiment Instructions.

Prepare the Demonstration Trays

4. Prepare each of the trays in the following manner:
    - Fill tray #1 with only soil. This will represent bare soil.
    - Fill tray #2 with a piece of sod OR sponges (representing roots), followed by soil, and then topped with leaf mulch and grass clippings or sphagnum moss to represent vegetation.
    - Fill tray #3 with soil and then cover it with plastic wrap or aluminum foil so that no soil is exposed. This will represent impervious surfaces such as roads, parking lots, and rooftops.

5. Fill the watering can by measuring out a standard amount of water (350 mL recommended) and record the units in milliliters. *Note: It is important to use the same amount of water each time you run the experiment to allow for cross comparisons.*

6. Make enough copies of the worksheet for each student.

7. Make preparations for the data table (provided on page 42) to be viewed by everyone so that it can be filled out as a class.

Procedure

1. Introduce or review the following terms:
    - Runoff: When water from precipitation flows over the surface of the ground and eventually makes its way to a stream or river. Runoff can pick up soil and pollutants from the land and carry them to a body of water such as a stream, lake, wetland, or ocean.
    - Erosion: The wearing away of the land's surface by wind or water; a loss of soil.
    - Infiltration: When water soaks into the ground. Once in the ground, this water can be used by the roots of plants or stored in the groundwater system.
    - Impervious surface: A surface that does not allow water to soak into or pass through it.

2. Pass out the student worksheets and demonstrate the experiment for all three different land surface types. See the instruction sheet for detailed instructions on how to demonstrate the experiment.

3. Have students record data on their worksheets. A data table has been provided in this packet if you choose to record the data as a class and then have students copy it onto their own worksheets.

4. Ask students to complete the questions and calculations on their student worksheets. Students may need additional instruction in setting up equations depending on skill levels.

Evaluation

1. Discuss the students' findings and have them relate how the experiment is similar to what happens in a watershed. The watering can represents precipitation, the trays represent the Earth's surface and how water can either infiltrate or run off, and the measuring cup represents a type of **water body** such as a stream, river, lake, or wetland.

2. Discuss which surface had the most erosion. Encourage students to offer evidence to support their conclusions (bare soil; dirty looking water). Which surface had the most runoff?

3. Emphasize how vegetation helps to slow the water down and allows the water to soak into the ground. Discuss how the roots act like sponges that soak up the water and store it. Talk about how the roots also help to filter and clean the water of pollutants.

4. Discuss how an impervious surface speeds up the water and does not allow any water to soak

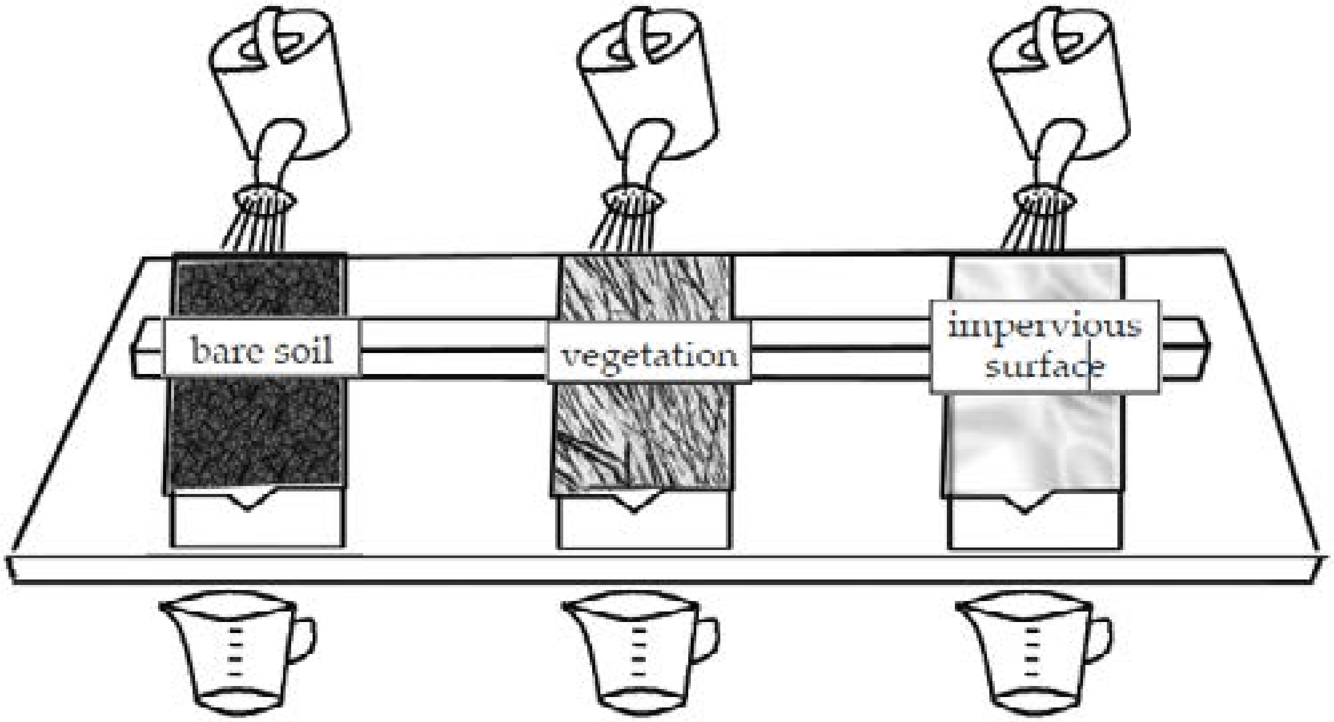
into the ground. Ask students what they think might happen if all that runoff suddenly entered a stream. What do they think all that fast moving runoff might do to the stream banks?

Note: Don't let students be fooled by the clear catchment cup under the impervious surface tray. Mention the fact that many different types of pollutants can be carried by runoff from impervious surfaces, but note that this is a concept that is to be explored in much greater detail with the EnviroScape® model.

Extension

Guide students in how to graph or display data in a meaningful way. If you are able to perform the experiment with multiple groups, have students compare each group's answers graphically and calculate the average or median values.

Adapted from Watersheds: We All Live Downstream. Produced by the Missouri Department of Conservation in cooperation with Southwest Missouri State University; St. James, MO (2002).



1. Set-up the experiment as shown in the picture above.

2. Measure 350 mL of water with one of the measuring cups and pour it into the watering can. This will be the water you will pour onto the surface of the box. Record this amount in the appropriate place on the data table.

3. Assign roles to help you demonstrate and time the experiment:
    - Rain simulator—in charge of measuring and pouring water onto the box.
    - Stopwatch watcher #1—in charge of timing the "soak in" time.
    - Stopwatch watcher #2—in charge of timing the "runoff" time.

How do you know when to start and stop the timers?

- Time to soak in: Start the timer as soon as water starts to fall onto the surface of the box. Stop the timer once water starts to run out of the box and into the measuring cup.

- Time to runoff: Start the timer when water first starts to run out of the box and into the measuring cup. Stop the timer when water no longer flows into the measuring cup in a steady stream, but starts to drip.

4. Once everyone has a clear idea about what they will be doing, run the experiment by pouring the water onto the surface of the "bare soil" box and begin timing what happens next.

5. Record the times in the appropriate places in the data table.

6. Measure and record the amount of water that is present in the measuring cup.

7. Determine the amount of soil erosion by examining the water in the measuring cup.

8. Repeat the steps for the remaining two surface types.

Activity 4b | Runoff and Erosion Experiment

Names of Group Members:

Directions: Record the results from the Runoff and Erosion Experiment in the table below. Use your data to answer the questions.

	Land Surface Type		
Data	**Bare Soil**	**Soil with Vegetation**	**Impervious Surface**
Water Input (mL)			
Time to Soak in (seconds)			
Time to runoff (seconds)			
Water Output (mL)			
Soil Erosion (none, a little, a lot)			

1. Which of these surfaces had the most amount of erosion? Describe how you know.

2. Figure out how much water each of the surfaces held. Fill in the table below and circle which one held the most water. *Hint: Compare how much water you put in to how much water came out.*

Bare Soil	Soil with Vegetation	Impervious Surface

3. Which of these surfaces held the least amount of water?

For the next two questions, calculate the runoff rate (volume of water per second) and enter it in the table below. *Hint: The runoff rate is the water output divided by the time of runoff.*

Bare Soil	Soil with Vegetation	Impervious Surface

Units are mL/sec.

4. Which of these surfaces had the fastest runoff rate (most volume of water/second)?

5. Which of the three surfaces had the slowest runoff rate (least volume of water/second)?

Overview: Students measure an area of impervious surface on their school grounds and calculate how much water will run off that surface in a given year in order to understand the cumulative effects impervious surfaces have on waterways.

Estimated Time
30 minutes to prepare
60 minutes including:
30 minutes for experiment
30 minutes for discussion

Materials

- Yardstick
- Writing Materials
- Graph paper
- Ruler
- Tape measure or twine marked in one-foot intervals
- Clipboards
- Protractors
- Calculators
- Average local rainfall data
- Map of school grounds

You can use the same map created for the "Schoolyard Watershed Walk" activity

Key Terms

- impervious
- pervious
- runoff
- erosion
- thermal pollution

Objectives

Students will . . .

- Calculate the area of an impervious surface on their school grounds (such as a parking lot or playground)
- Understand the differences and effects of pervious and impervious surfaces on waterways.
- Determine the volume of water that falls and runs off a selected impervious surface on their school grounds.

Essential Questions

- What data and tools can we use to estimate the potential affect of an impervious surface in an average year?
- What impact does my schoolyard have on our local watersheds?

Introduction

Students will measure an area of **impervious** surface on their school grounds and calculate how much water will run off that surface in a given year in order to understand the cumulative effects that impervious surfaces have on waterways. *Note: If time will allow, the outdoor portion of this activity can be done in conjunction with the"Runoff Roundup" activity.*

Background Information

This information will help you better understand the importance and reason behind studying runoff in relation to water and water quality topics.

Pollutants can enter our water supply from a variety of sources. **Runoff** from large areas of pavement is particularly likely to contain pollutants, since none of the water or pollutants can be absorbed through the pavement. Urban stormwater runoff may contain sediment, debris, oil, gas, and heavy metals.

Urbanization and other development may negatively affect stream and river health by increasing the volume of surface runoff and decreasing the amount of time in takes water to runoff an area. When it rains in areas with lots of **impervious** surfaces (parking lots, roads, roofs), more water runs off more quickly to the receiving water body. This rapid increase in volume of water can lead to increased **erosion**, flash-floods, and a number of pollution problems.

Depending on the type of pollutants in the runoff, this can result in fish kills or algae blooms. Suspended materials, like soil and other compounds in the runoff can also absorb and store heat, which increases water temperature and can cause thermal pollution. These increases in water temperature, along with general increase in runoff temperatures from hot impervious surfaces, like black asphalt, can also harm aquatic life by acting as **thermal pollution**. In contrast to these impervious surfaces, areas with lots of vegetation helps to absorb rainwater, slow runoff, filter pollutants, and regulate water temperatures.

Gathering Local Rainfall Data

Extension Idea: Have your students research and gather this information.

- Call the local weather center or local Soil and Water Conservation District to find out the average annual rainfall for your area.

- **For most of the St. Louis region, the average annual rainfall is 34-38 inches.**

- Use an online resource to discover the total sum of rainfall for the prior year, five years, ten years to calculate rainfall based on this information. Use Websites such as:
    - www.weather.gov
    - https://www.wunderground.com/history

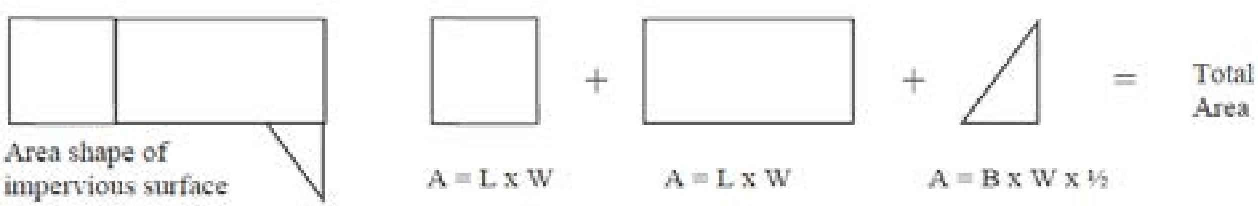
Procedure

1. Divide the class into teams of 3–5 students.

2. On the board, draw a sketch of the impervious surface area to be measured. The impervious surface can be any paved surface on the school grounds such as a parking lot, basketball courts, or rooftop.

3. Divide the surface area into smaller study plots. Have each team select an area they wish to measure. This will be their study plot. *Note: Make sure students understand what units of measure such as feet or meters they will be using.*

4. To calculate the area of impervious surface, measure the length and width (students may use a tape measure or if unavailable, a length of twine marked in meter or one-foot increments). *Hint: If the area has an irregular shape, break the area up into more manageable shapes and calculate the total area as shown in the following diagrams:*



5. Have the students go outside and take the needed measurements. Have students sketch their study plot on graph paper with all the measurements included. *Note: You may want to have students transfer or label measurements directly to their base map of the school grounds.*

6. Have students determine the direction runoff would flow off the impervious surface and direct them to mark this with arrows on their map. Have students note where the runoff from their study plot goes. If possible, carry out this step for the entire school grounds. See sample map from Activity 3 on page 29 for reference.

7. Back in the classroom, transfer and display all of the measurements from each groups' study plot on the board so everyone can see.

8. Have the students estimate the area of the parking lot by adding together all of the individual shapes to find the total area of the parking lot as indicated above. The values should be in the units the measurements were taken in.

9. Next, determine the volume of rain falling on the study area annually. Multiply the average rainfall (convert to feet or meters) by the area of the study plot (square feet or meters).

1 cm = 0.01m; number of cm/100 = number of meters
1 inch = 1/12 foot; number of inches/12 = number of feet

10. Volume should be recorded in cubic feet (ft3) or cubic meter (m3). Students should multiply the area of their study plots (m2 or ft2) times the amount of rainfall. This will give you the volume of rain in cubic meters (m^3) or cubic feet (ft3).

1 cubic meter = 1000 liters
1 cubic foot = 7.5 gallon

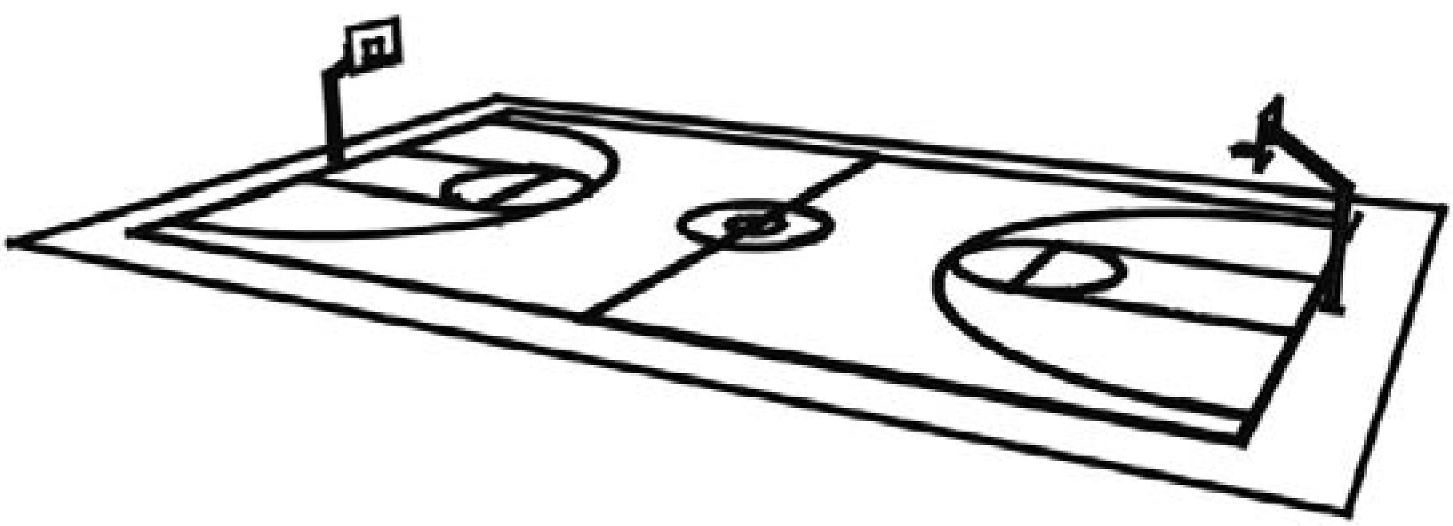
Evaluation

3. Ask students to think about what they observed at their study site, did anyone observe signs of pollutants? Evidence of runoff?

2. Ask students to consider or determine where the runoff from their schoolyard study site will go?

3. Discuss the students' findings and have them respond to the Essential Questions.

4. If you've already completed Lesson 4b - Discuss how the calculations they did to determine the surface runoff of their plot area ties to the Runoff and Erosion Experiment.



Adapted with permission from Protecting Our Water Resources: Student Activities for the Classroom. Stormwater Management Academy. University of Central Florida, Orlando, FL. http://www.stormwater.cecs.ucf.edu/toolkit/vol3/Contents/pdfs/Student%20Activities/student_activities.pdf

Overview: Using an EnviroScape® model students observe how human activities on land can result in pollution of local waterways. Students will learn about different types of pollution, sources, and things they can do to help prevent and minimize stormwater pollution.

Estimated Time
30 minutes to prepare
45 minutes for demonstration

Materials

- EnviroScape® Model
- Writing Materials
- Water source
- Sponge/Paper towels

Key Terms

- watershed
- precipitation
- stormwater
- storm sewer
- runoff
- pollution
- point source pollution
- nonpoint source pollution
- erosion
- impervious
- Best Management Practices
- nutrients
- sediment
- combined sewer overflow
- wastewater treatment plant
- pesticide
- fertilizer

Objectives

Students will . . .

- Learn how stormwater pollution occurs in our community through daily activities and development.
- Understand the differences between point and nonpoint source pollution.
- Track pollution and runoff as rain falls over a landscape, transporting soil, chemicals, and oil through a watershed to a body of water.

Essential Questions

- What impact does my schoolyard/community have on water quality and aquatic life?
- Who in a watershed is responsible for the quality of our water?
- What things can we do to help prevent or minimize stormwater pollution in the community?

Introduction

The model you will be using is the non-point Source Model, representing a community watershed. This hands-on model will allow students to visually see the relationship between human land use and water quality.

The EnviroScape® Watershed/Nonpoint Source model brings the environment to life. It is an interactive tool used to gain a better understanding of the effects common land use activities have on the health of our waterways. Negative effects can be demonstrated through the application of various pollutants and simulated rain on the model landscape. The EnviroScape® can also be used to illustrate **best management practices (BMPs)** we can use to help minimize negative impacts.

Note: Your school does not need to own an EnviroScape model to complete this lesson. Please e-mail us at MSDCleanwater@mobot.org or call 314.577.0207 to reserve a model for your classroom.

Procedure

Presentation Outline Overview

Introduction – Students define key vocabulary words and build understanding of the term watershed.

Part I: Exploring Pollutants – Students discuss the various pollutants that can contaminate a local watershed and the environmental impacts of these pollutants.

Part II: Pollution Solutions & Best Management Practices – Students apply activities and practices that a community can do to prevent non-point source pollution to the model and observe changes in water quality.

Conclusion – Students discuss their observations and reflect on the demonstration experience. For a more challenging conclusion, have students evaluate or compare and contrast the different BMPs applied.

Introduction

1. Hand out the EnviroScape® Student Worksheet and have students observe the model and let them know that today the focus is on stormwater and water quality. Ask students to describe what they see on the model. Have students define the terms stormwater and watershed.

2. Use the map provided to examine where the school is, where students live and identify the watershed. Ask students to define the term watershed.

3. Discuss the big picture and importance of understanding watersheds. Have the students visualize how our watershed empties into the Gulf of Mexico, and therefore contributes to environmental issues such as the "dead zone". The dead zone is an area of low oxygen where nutrient pollution, primarily from the Mississippi River leads to algae blooms and kills off other living organisms such as fish, other topics that can be explored with the model include plastic pollution of the ocean, global impacts of water pollution, and more.

4. Ask students how they define "pollution". Ask them to define non-point and point source pollution. Have them "point" out examples of each on the EnviroScape®. The Factory is the point source on the model.

Part 1: Exploring Pollution

5. Discuss and define the differences between point and nonpoint source pollution. A good way to think about it is that point source pollution has a person, or entity, that can be identified as responsible - such as a factory pouring chemicals directly into a body of water. Nonpoint source pollution comes from a variety of sources and does not have one person who is responsible. Nonpoint source pollution is much harder to address.

6. Demonstrate point source pollution by showing the Factory on the model and pointing out the sewer treatment plant. Refer to the Pollution Chart on page 49 to review pollutants and their environmental impacts.

7. Demonstrate nonpoint source pollution. For each pollutant in the kit describe, or let students describe the general area these pollutants come from, why, and the environmental impact.

As you or your students describe each pollutant, either sprinkle the "pollution" or have a student sprinkle the pollutant onto the model in the correct location.

8. Ask students to describe what is happening to the model watershed.

9. Ask students to now consider "what is going to happen when it rains?" Have two students make it rain using the spray bottles provided. As the "rain" is falling, have students make observations where all the water and pollution is flowing. You may want to demonstrate upstream flow and show how the yard waste and trash cause blockages accumulated at bridges using one of the three bottles with the spray nozzle removed and pouring water upstream of the channels.

10. Ask students if they think the water is safe to drink. Would they like to swim in the lake/river? Eat fish out of that lake/river?

11. Pull the plug out of the lake/river and drain the water, try to clean the lake area with "rain" and a paper towel.

Part 2: Pollution Solutions & Best Management Practices
12. Ask the students to consider what could be done to prevent the pollution from going into the lake/river.

13. Define the term **best management practices (BMPs)** and have the students brainstorm ways to apply the BMPs to the watershed model to prevent pollution.

14. Refer to the Best Management Practices Chart on page 50 for directions and brief explanation of each BMP. For each BMP, apply the model-object to the EnviroScape®.

15. If you have time, you may have the students "rain" on the model after applying BMPs to compare the results from the first demonstration.

Evaluation

16. Discuss what evidence of pollution they saw on the model and any real world examples the students may have observed.

17. Have students get into small groups and reflect on the demonstration and respond to an Essential Question.

18. Have students think about what might they say to someone to help encourage them to act in protecting their local watershed.

Extension

What questions do they have about their own local watersheds? Have students research the quality of their own local watershed, rivers, streams and creeks. If desired, have students conduct water quality tests of a local water body.

Plan a clean-up or action project for their school community.

Organize and participate in a Storm Drain marking event with your students. MSD can provide all the materials needed for you to get started.

The MSD Clean Water Education program has Water Quality Testing Kits and Storm Drain Marking Event Kits available for teacher use. Contact us at MSDCleanwater@mobot.org or 314-577-0281 to learn more or make your reservation today.

Pollutant	Area	Represented By	Environmental Impact
Fertilizer	Golf Course Farm Residential Home	Pepper	A nutrient (food) for plants that contains chemicals like nitrogen, phosphorous, and potassium that plants use to grow. When these chemicals go into our lakes, they can also cause algae to grow. Too much algae is a problem, though. When lots of algae die, they use up the oxygen in the water to decompose, causing a problem for fish. Too much algae at the surface of the water can also block sunlight from reaching other plant life at the bottom of lakes.
Pesticide	Golf Course Farm Residential Home	Pepper	A chemical used to treat for unwanted pests. Can be toxic to the environment. When pesticides enter our water bodies they can be transferred to organisms living in the water. For example, fish can absorb pesticides through their skin by swimming in the water. They also breathe in pesticides through their gills. Fish might also drink the pesticide-contaminated water or feed on other organisms that have eaten pesticides. Other animals eat fish, and thus the pesticide toxins travel up the food chain. When fish eat, drink or breathe pesticides, it can cause them to have trouble reproducing, to be more susceptible to diseases, and to have trouble escaping from predators.
Loose Soil/Sediment	Construction Site Farm Deforestation/ Logging operation on mountain area	Cocoa Powder	Loose soil adds sediment to our water. Loose soil increases the cloudiness of the water, which increases the temperature, and decreases the amounts of oxygen in the water. The sediment also forms like a "slip-in-slide" on the lake floor and many organisms cannot lay eggs and reproduce. Sediment can also build up on the bottom of a river or stream, which affects the depth of the water. This could then cause a problem for boating and recreation.
Animal Waste	Farm Near Dog	Chocolate Sprinkles	Animal waste and septic sewage adds harmful bacteria to the water. This can cause people and animals to become ill. Excess sewage in a body of water can even cause officials to close portions of a lake for swimming and recreation.
Litter & Yard Waste	Household areas Vacant areas & bridges Stream banks (illegal dumping)	Litter: black hole punches/ paper scraps Yard Waste: Parsley Flakes	Litter can injure people and animals. This pollutant can also cause blockages in creeks and streams. *Optional: Discuss or show Peanut the Turtle, a turtle that became entangled in a soda ring and was rescued by the Missouri Department of Conservation.*
Oil & Other Chemicals	Factory (Point Source Pollution) Spilled Oil Tanker, cars, Houses Storm drain	Soy Sauce	The used oil, as well as detergents, dirty water and soaps from washing your car, are carried through city drains into nearby watersheds. Used oil from a single oil change can pollute up to one million gallons of freshwater. When factories pollute, they are often not following the law. Either the factory hasn't obtained written authorization, does not have the right equipment to treat contaminated water or is in violation.
Salt	Roads Houses	Salt	Road salt and other de-icing products contain harmful chemicals for our waterways.

Filter	Factory	Sponge – place in front of factory drain
Infill Redevelopment; Keeping buffers and wetlands	Deforestation/Logging Operations	Add felt strips and plant trees around area.
Reduction in application of fertilizer and pesticide	Golf Course; Farm	Reduce the amount of pepper applied to model.
Planting more vegetation; planting native vegetation that doesn't require as much fertilizer or pesticide to grow	Golf Course; Farm; Houses	Add felt strips to areas; reduce amount of pepper applied to the model; discuss reduction in application and timing (for example, don't spray when rain is expected).
Inlet Markers	Houses	Show Storm Drain Marker and discuss importance of signage to build community awareness; eliminate oil poured in storm drain tube. This is a key BMP for students to help put in place.
Pick-up pet waste; waste stations; sealed bags	Houses	Reduce/Eliminate number of sprinkles near the houses.
Fix car leaks; maintain septic tanks;	Houses; Roads	Reduce oil spilled on roadways.
Plant rain gardens; native gardens; install community gardens; bioswales	Houses	Add bean-shaped green felt strips to areas.
Shovel snow; use brine	Houses; Roads	Reduce salt sprinkled in the area.
Reduce illegal dumping and dumping of yard waste in stream banks	Houses, along stream banks	Reduce the amount of pollutant on the board; add fence near stream banks; discuss signage and community efforts.
Cut grass higher, use mulching blades	Houses	Reduce pollutant added to the model.
Planting buffer of grasses or berm	Construction Site; Farm	Add green felt near construction site; add a clay wall along edge of construction site and farm to stop soil erosion.
Carpool; hybrid cars; and alternative transportation methods	Roads	Reduce oil spilled on roadways.
Clean-up Events	Stream banks; Bridges; Houses; Vacant areas	Reduce "litter" spilled.
Plant a riparian buffer	Farm	Add a green felt strip to the edge of the farm.
Contour plowing	Farm	Plow so water runs away from channel to watershed.
Build fence to control livestock	Farm	Add fence to model; prevents livestock from reaching stream banks.
Composting	Farm; Houses	Discuss composting of yard waste and manure; reduce pollutants added to model.
Planting Trees	Deforestation/Logging Operations; Farm	Add additional trees to the model – planting trees holds soil in place.

12.02.2019

EnviroScape® with some BMPs

Deforestation/Logging Area

Farm berm with trees

Construction Site with berm

Community rain garden

12.02.2019

Activity 6 | Exploring Pollution with the EnviroScape® Model

Name:

Directions: Record observations of pollution you see in the model. For each pollutant you identify determine if it is a point or nonpoint source pollutant and provide ideas or examples of how to address, solve or prevent further contamination.

Location	Pollutant	Point or Nonpoint?	Cause	Solutions/BMPs

1. What is the difference between point and nonpoint source pollution?

2. Whose responsibility is it to help prevent pollution and protect local watersheds?

3. What is one way you can be involved in protecting our watershed?

Activity 7 | What's the Solution?

Overview: Students work together to identify best management practices and effectively communicate their ideas for reducing water quality issues related to nonpoint source pollution given specific scenarios, focus is on communication and applying the right BMP for a given problem.

Estimated Time
One to Thee classes
45-minutes each

Materials
One set of the following for each student group. Recommended group size is 2-3 students each:

- Water Pollution Scenario Cards
- Access to computers and/or
- library for research
- Optional, dependent on student communication method:
  - Video equipment
  - Drawing supplies
  - etc.,

Key Terms

- elevation
- groundwater
- infiltration
- runoff
- water body
- watershed
- Best Management Practices
- nonpoint source pollution

Objectives

Students will . . .

- Identify sources of water pollution in a given scenario
- Properly select appropriate solutions, including Best Management Practices to water quality issues
- Communicate their thoughts and ideas effectively
- Explore how to advocate for a solution/action

Essential Questions

- How do I effectively communicate my thoughts, ideas, and beliefs?
- Why is it important to help others learn about water quality issues?
- How is protecting the watershed a community responsibility? A personal responsibility?

Introduction

A **watershed** is an area of land that drains or "sheds" water into a common **water body**, such as a stream, river, lake, or wetland. This water eventually makes its way to one of the oceans. A watershed starts at the highest elevation, or points on the landscape, like mountain peaks and ridgelines that divide one valley or drainage from another. The largest of these divides is called the Great Continental Divide. Small watersheds are usually part of larger watersheds. In the St. Louis vicinity, the Deer Creek Watershed is a sub-watershed of the River des Peres. The River des Peres is a small river draining a relatively small amount of land. Eventually all of the smaller feeder streams or tributaries of the River des Peres Watershed feed into the Mississippi River. Everything is connected—small streams flow into small rivers, which flow into larger rivers, and eventually flow into the ocean. Watersheds often become polluted from a variety of sources, including point and nonpoint source pollutants. In order to best know how to solve a water pollution problem, we have to be able to properly identify the problem and the right Best Management Practice (BMP) to apply to the situation. BMPs are regulated ways to reduce stormwater pollution and help communities improve the health of their local watersheds.

Procedure

1. Briefly review the EnviroScape® lesson, including potential pollutants, their impacts, and Best Management Practices strategies.

2. Explain that during this activity students will be working in small groups to identify possible pollution and communicate with others about how to solve water quality issues.

3. Divide students into groups of two to three and have each group select a Water Pollution Scenario Card, each card has a different problem, responsible party, and represents a BMP with their solution.

4. Pass out the Water Pollution Scenario Worksheet and instruct the students to answer the questions on the worksheet as they discuss their scenario within their group.

5. After the students have had the opportunity to discuss their scenario, tell the students that they are now going to take action and help create a solution to the problem. Instruct each student group to develop a strategy for communicating solutions to the people in their Water Pollution scenario.

Depending on the resources available students may:

- Write a persuasive letter to the person in their scenario
- Create a Public Service Announcement that addresses the pollution issue and solution described in their scenario
- Draw and create door-hangers that can be left on homes in their scenario
- Create a billboard, magazine ad, or radio spot addressing their scenario
- Make a short presentation for the community in their scenario
- GET CREATIVE; Encourage students to explore creative opportunities for promoting their BMP

6. Allow students time to research and plan what their solution will be to address the pollution issue in their scenario. Provide students with enough time to work, 1-2 class periods should be enough time for most student groups to complete their project.

7. Have each student group present their scenario and solution to the class.

8. As a class, discuss what made each groups presentation effective.

Assessment
Use a rubric, see sample rubric on page 57, to assess the success of the students projects.

Evaluation
Discuss the scenarios and have students identify real-world examples of the issues described in the scenario. Ask the students if the solutions proposed would be effective in their community? Why or why not?

Extension Opportunities
Instead of using scenario cards, provide students with a real-world problem that relates to the school's impact on water quality. Have students develop their solutions, project presentations, and as a class decide which group was the most effective communicators. Have this group present to a community group such as the School Board, another class, the PTO, etc.,

Neighbor Ned doesn't like to wait for the town to pick-up his yard waste so he takes it to the nearby creek and dumps it along the creek bed.	Walter uses twice the recommended amount of fertilizer on his lawn. Walter also didn't look at the weather report and applies this fertilizer right before a big storm blows into town.
Mr. Shaw changes the oil in his truck every few months on the street in front of his house and disposes of the oil in the storm drain.	H.S. Development Inc. is building an apartment building on the side of a creek and has no controls in place to keep soil from eroding into the creek.
Fisherman Steve is reporting Lake Key has mysteriously turned a bright green and the lake once full of prize catches is full of nothing but small fish.	H.S. Botanical Widgets Company is storing materials in a way that is resulting in oils and metal shavings being washed into a nearby storm drain when it rains.
The Professor and his poodle go for a walk every day. The Professor is very forgetful and always forgets to bring a bag to pick up his doggie's doo, so he just covers the mess with leaves and walks away.	Neighbors are reporting that the dumpster behind Lucky Restaurant is smelly, dirty, and there is liquid leaking out from the bottom of the bin.
Mary and her friends tried to have a picnic by the river, but their view was interrupted by heaps of trash caught in the reeds by the water's edge. Among the wrappers, cans, and plastic bags, there is a strange, shimmery color to the water.	The water downstream from Farmer Carol's farm shows high levels of bacteria, nitrates and phosphates. Farmer Carol wants to be a good water steward for her community, but doesn't know what to do.

Activity 7 | What's the Solution?

Names:

Directions: Review your group's scenario and work together to answer the following questions:

Describe what action or event is happening in the scenario? Who are the people involved?

What is happening in your scenario that could pollute the waterways?

Is this an example of a point or nonpoint source solution? Why?

What possible solutions or Best Management Practices could help reduce this source of pollution?

What are three key points you would like to tell the people involved in this scenario about water pollution and Best Management Practices?

1.

2.

3.

	Excellent	Good	Satisfactory	Needs Improvement
Understanding of Water Quality Issues and BMPs	Showed a clear understanding of water quality issues and chose appropriate BMPs to utilize as a possible solution. Information was presented effectively and convincingly. All information was clear, accurate and thorough.	Showed a clear understanding of water quality issues and some BMPs were utilized as a possible solution. Presented with ease. Most information presented in the was clear, accurate and thorough.	Demonstrated the understanding of water quality issues, but did not identify any BMPs in the solution. Information presented those with ease. Most information presented in the debate was not always clear and accurate, or complete.	Did not show an adequate understanding of water quality issues. No solutions identified. Information was not presented clearly or effectively. Presentation contained more than 2 inaccuracies that distracted from the right information being presented.
Communication Methods	Group demonstrated ability to use their chosen format to effectively communicate their ideas. Group used gestures, eye contact, tone of voice and a level of enthusiasm in a way that kept the attention of the audience.	Group demonstrated ability to use format to effectively communicate their ideas. Group used gestures, eye contact, tone of voice and a level of enthusiasm in a way that kept the attention of the audience for most of the presentation.	Group may have been more effective using a different communication format. Group rarely used gestures, eye contact, tone of voice and a level of enthusiasm in a way that kept the attention of the audience.	Group did not choose an appropriate format. Format used was distracting and did not add to the effectiveness of the presentation. Group did not use gestures, eye contact, tone of voice, or enthusiasm to keep the attention of the audience.
Use of Evidence	Every major and even some minor points, was well supported with several relevant facts, statistics and/or examples.	Every major point was adequately supported with relevant facts, statistics and/or examples.	Every major point was supported with facts, statistics and/or examples, but the relevance of some was questionable.	Main points were not support with facts, examples, or other pieces of evidence.
Respect for Other Groups	Group respected others when in the audience. All questions, statements, body language, and responses were respectful and used appropriate language.	Group respected others when in the audience. All statements, body language, and responses were respectful and used appropriate language. Questions may have been slightly off-topic.	Group was mostly respectful when in the audience. Most statements and responses were respectful and used appropriate language, but there were some distracting moments.	Group was not respectful to others when in the audience. Statements, questions, responses and/or body language were consistently not respectful.

Overview: Students apply their knowledge of watersheds, nonpoint source pollution, and stormwater management to a place of significance in their lives by conducting a stormwater assessment of their school grounds.

Estimated Time
50 Minutes or more depending on action projects and wrap-up

Materials

- Base map of school (can be the map used from Activities 3 and 5)
- Stormwater Assessment Survey Copies
- Clipboards and pencils
- Colored pencils or markers (green, yellow, red)
- Measuring Tape (optional)
- Compass (optional)

Key Terms

- pollution
- Best Management Practices
- pesticide
- fertilizer
- rain garden
- rain barrel

Objectives

Students will . . .

- Survey and identify potential nonpoint source pollutants and various site factors that influence amounts of stormwater runoff.
- Understand that everyone contributes to and is responsible for the water quality of our waterways.
- Identify solutions and BMPs to reduce pollution and the amount of surface runoff.

Essential Questions

- What impact does my schoolyard /community have on water quality and aquatic life?
- Who in a watershed is responsible for the quality of our water?
- What things can we do to help prevent or minimize stormwater pollution in the community?

Introduction

Students will apply their knowledge of watersheds, nonpoint source pollution, and stormwater management to a place of significance in their lives by conducting a stormwater assessment of their school grounds.

By utilizing a map of their school grounds and a simple site survey, students will examine the potential risks to water quality from stormwater runoff. Specifically, students will identify and assess the following:

1. Potential pollutants that might be picked up and carried away by runoff leaving the property.

2. Various landscaping factors influencing the amount of runoff and how it is managed.

Preparing for the Lesson

Note: you may wish to engage additional adult volunteers to help supervise students.

1. Retrieve copies of students' schoolyard maps that were used in the Schoolyard Watershed Walk and Impervious Business activities.

2. Review the Schoolyard Stormwater Assessment Survey.

3. Walk the school grounds and complete the survey in advance by yourself so that you know the best places to

direct student investigations and so you are aware of any safety issues you may need to bring to their attention.

4. Prepare to have students to work in small groups to complete the survey.

Procedure

1. Organize students into manageable working groups before venturing out onto the school grounds.

2. Remind students about the idea of an "outdoor classroom" and how this activity is preparing them for being able to do a similar assignment at their own homes.

3. Pass out materials and go over the instructions as a class.

4. Tell students they will be using the map of their school grounds and a simple site survey to look for evidence of point and nonpoint source pollution and examine the potential risks these may have to water quality from stormwater runoff.

5. Brainstorm and review some of the pollution sources they learned about using the EnviroScape® model. Refer to the diagram on page 61 and the Stormwater Assessment Common Pollutants & Sources chart on page 62 to aid in this review process.

6. Explain that students will be challenged to think and focus their observations on two main areas. With the help of the rating system outlined on their stormwater assessment surveys, they will identify and assess:

- potential pollutants that may be picked up and carried away by water leaving the property (i.e., oil and grease on a parking lot) and
- various landscaping factors influencing the amount of runoff and how it is managed (i.e., impervious surface that would prevent water from soaking in and increase the amount of runoff).

7. Take note of the color codes assigned to the survey rating system and explain that once students assess if the observation is of low, medium, or high risk they will mark the location of their observation on their maps with a dot depicting the color of the rating level they gave it. Students should also write the category of what is being assessed next to the dot (i.e., write erosion or bare soil next to the color rated dot), unless the symbols on the map already indicates this (i.e., no need to write storm drain on the map next to the color rated dot if there is a symbol on the map and in the legend depicting a storm drain).

Conducting the Assessment

1. If possible, assign groups to different sections of the schoolyard to avoid traffic jams. Notify them of any safety issues or areas that are to remain off limits.

2. Have the students walk the school grounds with their base map and assign them the task of completing the Schoolyard Stormwater Assessment Surveys.

3. Combine survey results as a class back in the classroom. Use the "Action Checklist Chart" on page 65 to record all the high and medium risks.

4. Identify each of these risks on the school base map so that everyone can see. Use the color code system assigned to each of the risks to indicate where they are on the map.

5. Brainstorm things that could be done to reduce each of these risks, thereby reducing the amount of runoff and water pollution leaving their school grounds.

Evaluation

Discuss results from the schoolyard assessment, reflect on one or all of the Essential Questions.

Summary of Risk Level:
Scoring System—90 points total

75–90: LOW RISK – EXCELLENT!
Congratulations if high points were earned. This means that your school grounds are at low risk of contributing nonpoint source pollution to our streams and rivers. You and your school community are doing a good job of helping to lower the amount of polluted stormwater leaving your school's property. Keep up the good work and let others know what you've learned!

55–75: MEDIUM RISK – OK
You may have elements beyond your control that are contributing to polluted stormwater leaving your school's property. By brainstorming about how you can help to educate your school community about nonpoint source pollution and some Best Management Practices dealing with stormwater, you may be able to make some positive changes to help keep our streams and rivers clean!

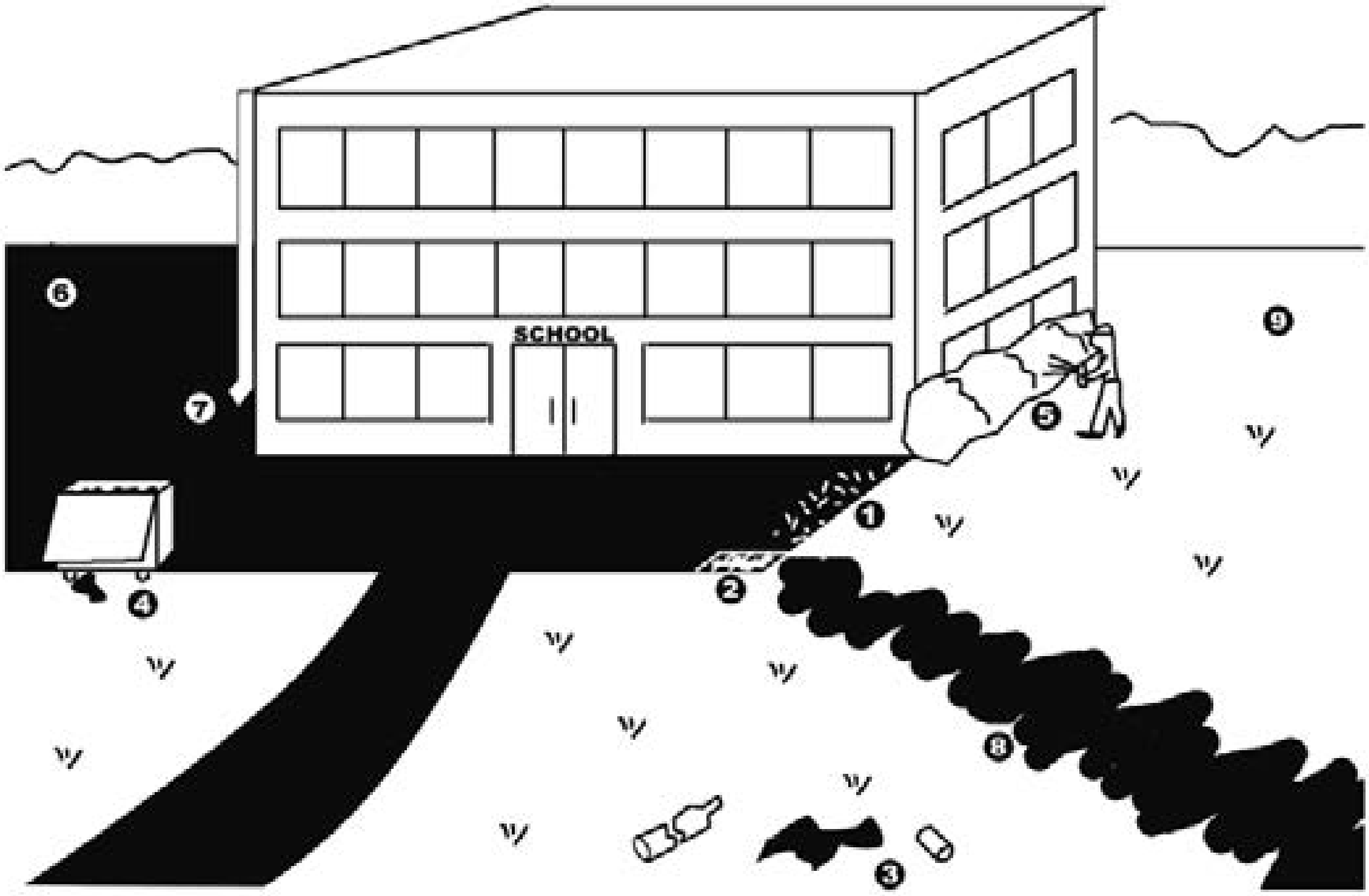
Below 55: HIGH RISK – TIME TO MAKE SOME CHANGES!
There are many ways the school can improve their school ground health! Share your findings with your teachers, principal, and PTA Grounds Committee. Refer to some of the Best Management Practices outlined in this packet. You can also contact some of your local community organizations for assistance with managing stormwater runoff. The agencies that can help include: your local municipality, St. Louis County Department of Health, Metropolitan St. Louis Sewer District, Litzsinger Road Ecology Center, Soil and Water Conservation Districts, Missouri Department of Conservation, and the Missouri Department of Natural Resources.

Extension

Take action as a class on one of the brainstormed solutions that could help make a difference in our water quality. Develop a list of action steps and determine who the students would need to consult to try and implement the Best Management Practices to reduce the amount of runoff and water pollution leaving school's property. Make sure to go through the proper school authorizations. Have students do additional research on how they would best go about carrying out the desired project.

See the list website resources in the back of this packet to gain more information about some of the potential projects listed below:

- Storm drain stenciling
- Erosion control though the planting of native plants
- Design and planting of a rain garden
- Install rain barrel(s) at base of downspout(s)
- Organize a community litter pick-up
- Monitor a nearby stream's water quality



1. Grass clippings, leaves, and other yard wastes are left on sidewalks, streets, and other paved areas to be carried off by stormwater.

2. Storm drains are covered or clogged with leaves, litter, mud, other debris and are not labeled to prevent dumping.

3. There is a lot of trash and litter on the ground.

4. Dumpster lids are open and trash, grease, and other leaky liquids can be seen on the ground.

5. Chemical products are used in higher amounts than what is recommended on the label.

6. Paved surfaces are used extensively, accounting for more than 25% of the schoolyard area.

7. Most drainage from the roof discharges onto paved surfaces, or downspouts are connected directly to storm drains.

8. There are several places with bare soil. Soil has been carried onto sidewalks or parking lots. Gullies have started to form on slopes with no vegetation in place.

9. There are few trees and bushes on the property which does little to slow the flow of stormwater.

Common Pollutants	Sources
Sediment	Bare soil, construction sites, stream banks, and dirty vehicles. Sediment can transport other pollutants that are attached to it including nutrients, trace metals, and hydrocarbons. It is harmful to aquatic life.
Nutrients	Landscapes, over-application of fertilizers and grass clippings. Applying fertilizers before a rain event. The use of nutrients can result in excessive or accelerated growth of algae, resulting in a loss of clarity to water. High levels of nutrients can cause low dissolved oxygen levels and can be toxic to fish and other aquatic organisms.
Bacteria	Leaky and poorly maintained septic systems, sanitary sewer overflows, and improper disposal of animal waste. High levels of bacteria can be harmful to public health and can lead to the closure of lakes and rivers for recreational uses.
Oil and Grease	Illegal dumping of oil down the storm drain, leaky vehicles, spills, improper waste oil disposal and restaurants. Toxic to some aquatic organisms at low concentrations.
Metals	Sources of metal in the environment include: galvanized metal, paint, automobiles, or treated wood which enter stormwater as the surfaces corrode, flake, dissolve, decay or leach. These can be toxic to aquatic organisms, bioaccumulate in fish, and contaminate drinking water supplies.
Organics	Adhesives, cleaners, sealants, and solvents that may be improperly stored and disposed and deliberate dumping of these chemicals into storm drains. Harmful to our waterways.
Pesticides	Over-application, spills, and applying before a rain event. Toxic to aquatic life and harmful to human health.
Gross Pollutants	Improper disposal of trash, street litter, debris, leaves, grass clippings and other landscape maintenance items. Lowers the dissolved oxygen in streams and can cause fish kills.
Vector Pollutants	Standing water greater than 72 hours creates a source of vector reproduction and habitat (i.e., mosquitoes, flies, and rodents). Can be harmful to the public and transmit disease.

Adapted from: California Stormwater Quality Association, Stormwater Best Management Practices Handbook (Municipal), 2003.

Name:

Directions: Complete the Assessment Surveys for your school by selecting the option that best describes what you know and observe on the schoolyard. Then, determine your school's risk for impacting water quality in your community. Complete the Schoolyard Action chart to document actions you, your school, and your community can take to reduce harmful impacts.

Source of Pollution	Low Risk - Green (10 points)	Medium Risk- Yellow (5 points)	High Risk - Red (0 points)	Risk Level/Score
Leaves, grass clippings, and other yard waste	Grass clippings, leaves, and other yard wastes are swept off paved surfaces and onto lawns away from water flow routes. If possible, yard waste is composted on site.	Leaves and other yard wastes are bagged or piled on the lawn next to the street for collection.	Grass clippings, leaves, and other yard ways are left on sidewalks, streets, and other paved areas to be carried off by stormwater.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Storm Drains	Storm drains are clear of litter, mud, plants or other debris. Storm drains are labeled to prevent pollution and to teach people that drains lead directly to streams.	Storm drains are clear of litter and other debris, but they are not labeled to prevent dumping.	Storm drains are covered or clogged with leaves, litter, mud, and other debris and are not labeled to prevent dumping.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Litter	Trash is disposed of properly, and there is no litter to be seen on the ground. Trash cans and recycling bins have closed lids and are emptied frequently.	There is very little trash and litter present on the ground, however, there are no designated containers for recycling.	There is a lot of trash and litter on the ground and recycling is not practiced.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Dumpsters	Dumpster lids are kept closed and are clean and free from grease or liquids.	Dumpster lids are open, but nothing appears to be leaking from them.	Dumpster lids are open and trash, grease, and other leaky liquids can be seen on the ground.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Handling and use of chemicals such as pesticides, fertilizers, and road salts or deicers	Minimal amounts of these chemicals are used and are always applied according to the label. Use of fertilizers is delayed to avoid rain.	Applications of pesticides or fertilizers are not delayed to avoid contact with rain.	Chemical products are used in higher amounts than what is needed or recommended on the label.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________

Source of Pollution	Low Risk - Green (10 points)	Medium Risk- Yellow (5 points)	High Risk - Red (0 points)	Risk Level/Score
Impervious Surface	Paved surfaces are minimized to less than 10% of the schoolyard. Alternatives such as wood chips or previous pavers are used for walkways.	Only some areas are paved for activities like basketball courts. Paved surfaces account for approximately 10-25% of the schoolyard.	Paved surfaces are used extensively, accounting for more than 25% of the schoolyard area.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Roof Drainage	Roof drainage is collected into rain barrels or underground cisterns for water reuse and/or it is directed to a rain garden for retention, where it slowly soaks into the ground.	Downspouts and drip lines direct roof drainage onto a grassy area or patch of rocks where water has a better chance of soaking into the ground.	Most, if not all, drainage from the roof discharges onto paved surfaces, or downspouts are connected directly to storm drains.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Bare Soil	There are few places with bare soil. Bare patches in lawns are quickly reseeded and covered with straw; mulch is used to cover bare soil in garden or landscaped areas.	Grass or other ground cover is spotty, particularly on slopes. There is evidence of some erosion.	There are several places with bare soil. Soil has been carried onto sidewalks or parking lots. Gullies have started to form on slopes with no vegetation in place.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________
Vegetation	Many trees, bushes, and deep-rooted, native plants are present on the property. Landscaping is designed to slow the flow of stormwater runoff and provide areas where water soaks into the ground. Unmowed buffer strips of thick vegetation are left near any ditches and waterways	No areas are landscaped to encourage water to soak in, but there are some trees and bushes that dot the landscape. Mowed grass or spotty vegetation exists adjacent to ditches and waterways.	There are few trees and bushes on the property. Landscaping does little to slow the flow of runoff and stormwater.	☐ Low (10) ☐ Medium (5) ☐ High (0) Score: ___________

After completing the assessment, total all Risk Level Scores to get the Schoolyard Risk Level.

Total Score (90 points total):

Risk Level:

☐ Low Risk - EXCELLENT! (75-90)

☐ Medium Risk - OK (55-75)

☐ High Risk - TIME TO MAKE SOME CHANGES (Below 55)

Activity 8 | Schoolyard Stormwater Assessment - Actions Chart

Write all high and medium risks from your Assessment Survey below.	**What can you, or your school, do to reduce the risk?**
Example: There is a lot of trash and litter on the ground.	*Set a good example for others by always placing trash or recyclable items in the appropriate containers.* *Organize a litter pick-up day and start a recycling program at your school if it doesn't already have one.* *Get out the word about being a good watershed neighbor by educating others about proper trash disposal and recycling practices.*

*Adapted with permission from Home*A*Syst: An Environmental Risk-Assessment Guide for the Home (NRAES-87). Natural Resource, Agriculture, and Engineering Service. Http://www.nraes.org*

Activity 9 | Home Management Plan

Overview: Students and parents evaluate their activities at home and develop a Clean Water Home Management Plan to help keep local waterways healthy.

Estimated Time
Two 30 minute classes

Materials

- Copies of Home Stormwater Assessment
- We Are Making a Difference Survey

Key Terms

- Stormwater runoff
- Sediment
- Impervious surfaces

Objectives

Students will . . .

- Be able to effectively communicate to a parent, guardian or community member about stormwater, runoff, and water quality issues.
- Explain what individuals can do at home to make a difference and improve water quality.

Essential Questions

- Can the things we do at home have an impact on our community?
- Will things you do at home have an impact on local watersheds?
- What things can we do to help prevent or minimize stormwater pollution in the community?
- Whose responsibility is it to protect our waterways?

Introduction

Students will examine the potential risks to water quality from stormwater runoff and identify:

1. Potential pollution that might be picked up and carried away by runoff leaving the property.

2. Various landscape factors influencing the amount of runoff and how it is managed on their property.

Students will be asked to complete a survey of their homes entitled, "We Are Making a Difference," in which they will identify:

- Three best management practices (BMPs) the family currently uses to protect water quality.

- Three BMPs the family will commit to implementing in the future to protect water quality.

Procedure

Note: you may wish to engage additional adult volunteers to help supervise students.

1. Retrieve copies of students' school ground maps that were used in the Schoolyard Watershed Walk and Impervious Business activities.

2. Review the Schoolyard Stormwater Assessment Survey.

1. Brainstorm and review with the class the different types of nonpoint source pollution they learned using the EnviroScape® model. If students completed the Exploring Pollution with the *EnviroScape® Model* worksheet they should refer their notes during this review process.

2. Assign two homework assignments in the Home Management Plan for students to complete with the help of a parent or guardian:

- Home Stormwater Assessment
- We Can Make a Difference Survey

3. Review the *Home Stormwater Assessment* with the students. This assessment is a tool to help the students introduce stormwater runoff to the parent and identify possible problem areas at their home.

4. Instruct students to leave the risk level of the *Home Stormwater Assessment* blank if the pollution source is not applicable to their home. The parent may keep the Home Stormwater Assessment.

5. Review the *We Are Making A Difference Survey* with the students to complete with the help of an adult. Students should not handle any chemical products. The student will identify:

- Three best management practices they currently use to protect water quality
- Three BMPs they will commit to implementing in the future to protect water quality.

6. After completing the survey, it should be returned to the teacher for the follow-up.

Share Your Story: Follow-up

1. After the assignment has been completed, complete the *Classroom Results Form* on page 68.

2. As a class, determine the results of the survey. On the results form identify a heading listed under "We have been helping the environment" and ask the group to raise their hand if they picked A, B, C, etc. Write the total number in the blank space for each item. Continue the process with the second section "We want to do more to help keep our water clean".

3. Have the students take the Student Clean Water Education post-test and answer the questions on the Student Model Evaluation form.

4. Fill out the Teacher Evaluation form. Return the completed surveys to:
Katherine Golden
EarthWays Center of Missouri Botanical Garden or e-mail: MSDCleanwater@mobot.org
4651 Shaw Blvd.,
St. Louis, MO 63139

Activity 9 | Home Management Plan - Class Results

Directions: Add the number of students reporting each practice and enter it in the corresponding box. When complete, share this information with the class and discuss the impact the class is having on their community, the local watershed, and others through these efforts.

Share Your Story: Tell MSD and EarthWays Center about your class discussion and results. E-mail or mail a copy of this Results Sheet to:

Katherine Golden
EarthWays Center of Missouri Botanical Garden
4651 Shaw Blvd.,
St. Louis, MO 63139

Or

E-mail: MSDCleanwater@mobot.org

Management of Stormwater Runoff	Do Now	Will Do
A		
B		
C		
D		
E		
F		
G		

Trash/Litter	Do Now	Will Do
A		
B		
C		
D		
E		
F		

Household Chemicals	Do Now	Will Do
A		
B		
C		
D		
E		
F		
G		

Pet Waste	Do Now	Will Do
A		
B		
C		
D		
E		
F		

Car Maintenance	Do Now	Will Do
A		
B		
C		
D		
E		
F		

Bare Soil	Do Now	Will Do
A		
B		
C		
D		

Landscape (Yard) Maintenance	Do Now	Will Do
A		
B		
C		
D		
E		
F		
G		
H		

Vegetation	Do Now	Will Do
A		
B		
C		
D		
E		
F		

Name:

Directions: Take the survey can tell us how you plan to make a difference!

We are Making a Difference!

Tell us how! Put an X in the box of three practices you are currently doing..
Put a ✓ in the circle of three practices you will start doing.

1. **Management of Stormwater Runoff** *Storm water runoff is one of the leading causes of pollution and the erosion of our streams and rivers.*	DO NOW	WILL DO
a. Reduce the amount of paved areas around the home	❏	❍
b. Increase amount of vegetated areas on your property where storm water can soak in the soil	❏	❍
c. Never allow roof gutters to drain directly to the street or storm drains	❏	❍
d. Construct a rain garden. Rain gardens are shallow depressions planted with native plants that allow rain water to soak into the soil and filter pollutants	❏	❍
e. Disconnect roof gutters draining directly to the street or storm drains (if allowed by city)	❏	❍
f. Purchase a rain barrel and attach to your roof's downspout to capture and store rainwater for later gardening use	❏	❍
g. Plant buffer strips of native vegetation to slow runoff near a water source	❏	❍

2. **Trash/Litter** *Controlling litter and trash at its source reduces the cleanup and maintenance costs of local communities.*	DO NOW	WILL DO
a. Clean up discarded trash around the property	❏	❍
b. Replace leaky dumpsters	❏	❍
c. Have regular, frequent service to dispose of waste	❏	❍
d. Do not dispose of waste into the storm drains	❏	❍
e. Cover exterior waste containers with a lid to prevent stormwater contact	❏	❍
f. Provide an adequate number of trash and recycling receptacles for the waste generated by your home	❏	❍

3. **Household Chemicals** *Many products used in homes and businesses contain chemicals that are potentially harmful to the environment. For example: paint, paint thinner, bug killer, drain cleaners, and motor oil.*	**DO NOW**	**WILL DO**
a. Recycle reusable materials	❑	❍
b. Purchase and use nontoxic, biodegradable products whenever possible	❑	❍
c. Choose the least hazardous product to do the job	❑	❍
d. Buy only as much as you need to avoid excess	❑	❍
e. Follow the instructions on the label for use, storage, and disposal	❑	❍
f. Use up household chemicals completely or give unused portion to friends	❑	❍
g. Properly dispose of hazardous waste at a household hazardous waste collection event	❑	❍

4. **Pet Waste** *Bacteria from pet waste can cause health risks to humans and other animals and result in the spread of disease.*	**DO NOW**	**WILL DO**
a. Pick up after your pet	❑	❍
b. Flush waste down the toilet into the sanitary sewer systems for treatment or put waste in a sealed bag and place in the trash	❑	❍
c. Bury waste in the soil at least 6 inches deep	❑	❍
d. Minimize pollution by having pets defecate in tall grass (greater than 4 inches)	❑	❍
e. Comply with city ordinances concerning proper disposal	❑	❍
f. Prevent farm animals from entering the water by strategically placing fence enclosures along waterways	❑	❍

5. **Automotive Maintenance** *Detergents, solvents, and other chemicals used to clean or repair cars are pollutants of stormwater runoff*	DO NOW	WILL DO
a. Keep your vehicle maintained regularly	❑	❍
b. Do not dump waste oil into the storm sewer	❑	❍
c. Change your oil at a local service station	❑	❍
d. Repair fluid leaks immediately	❑	❍
e. Recycle used auto fluids at designated auto service stations	❑	❍
f. Wash your car on your lawn or other unpaved surface	❑	❍
g. Use a commercial car wash	❑	❍

6. **Bare Soil** *Excess sediment can clog stream channels, increase flooding, and harm aquatic life. Soil particles often carry excess nutrients from pesticides and fertilizers to rivers and streams, further degrading water quality.*	DO NOW	WILL DO
a. Control erosion by planting native plants and other suitable ground cover to stabilize erosion-prone areas	❑	❍
b. Reduce the amount of paved areas around the home and increase the vegetated areas	❑	❍
c. Reseed and/or place mulch around plants and landscaped areas to help maintain soil moisture and reduce the amount of bare soil exposure	❑	❍
d. Filter runoff at construction sites with straw bales or silt fences	❑	❍




7. **Landscape Maintenance** *Grass clippings, leaves, brush, and other "biodegradable" debris, decreases water quality by producing algae blooms and decreasing the amount of oxygen available for aquatic life.*	**DO NOW**	**WILL DO**
a. Mow grasses at higher heights	☐	○
b. Leave grass clippings on the lawn	☐	○
c. Use chemical fertilizers sparingly	☐	○
d. Consider using slow-release nitrogen fertilizers	☐	○
e. Avoid using fertilizers before a rain event	☐	○
f. Do not dump yard waste into or near a waterway	☐	○
g. Consider composting yard waste	☐	○
h. Prevent grass clippings, leaves, and other yard wastes from being washed into storm drains by keeping gutters and paved areas clear	☐	○

8. **Vegetation** *Proper gardening techniques can reduce pollutant runoff and water use.*	**DO NOW**	**WILL DO**
a. Plant native plants; plants native to Missouri are adapted to our environmental conditions and thus, require less overall maintenance, including less water once established and no need for fertilizers. Native plants also have extensive root systems that help water soak into the ground more readily.	☐	○
b. Remove weeds by hand, being sure to remove all of root systems and avoid using chemicals whenever possible	☐	○
c. Test soil to determine the proper fertilizer usage	☐	○
d. Keep water from sprinklers off pavement and use automatic timers to minimize over watering and runoff	☐	○
e. Apply water at rates that do not exceed the infiltration (absorption) rate of the soil	☐	○
f. Other__________________	☐	○

Activity 10 | Citizen Science - Water Quality Testing & Data Collection

Overview: Students participate in a Citizen Science project, created by Earth Echo, to test local water samples for common indicators of water quality including: turbidity, pH, dissolved oxygen, and temperature.

Estimated Time
One class period - Collection
One class period - Data analysis

Materials

- Copies of Water Quality Lab
- Identified sample source
- Earth Echo Water Quality Testing Kids

Key Terms

- Stormwater runoff
- Sediment
- Turbidity
- pH
- Impervious surfaces

Objectives

Students will . . .

- Understand and explain the four main indicators of water quality.
- Collect, record, and analyze data about local waterways.
- Identify ways to improve water quality.

Essential Questions

- Can the things we do at home have an impact on our community?
- How can our community help protect water quality?
- How can we measure the health of a watershed?
- Whose responsibility is it to protect our waterways?

Introduction

During this activity students will become citizen scientists as they collect data, analyze water, and brainstorm action steps related to water in their community. Student data is contributed to a collective of global water quality data organized by the Earth Echo Water Challenge.

The Earth Echo's Water Challenge is a water quality monitoring activity that encourages groups to test local water samples, record and share data, and research actions to help protect their local watershed.

For this activity we are using the basic Classroom Kit. As part of the MSD Clean Water Education program, you can borrow a kit with all the necessary supplies to conduct the activity with your class from the EarthWays Center by contacting them at MSDcleanwater@mobot.org.

The Classroom Kit includes five sets of hardware and enough reagents to conduct up to 50 rounds of testing for pH, dissolved oxygen, temperature, and turbidity. For more information visit: http://www.monitorwater.org/order-kits/classroom-test-kit.

Procedure

Note: you may wish to engage additional adult volunteers to help supervise students.

1. Star a discussion with your students asking them to explain what it means to have "clean" or "safe" water.

2. Ask them the question, "how can we tell if our watershed is healthy?" If you have a local river, creek, stream, etc., you may wish to ask about that specific waterway to help ground your students with a sense of place. Have students hypothesize or brainstorm methods for testing water.

2. Explain that they will be collecting data to help learn more about components make up a source of water's quality and if to determine if their local waterway has any problems to address.

3. Review the procedures of sampling water, testing the water, and reporting data. Review the four main indicators of water quality with students prior to the start of any testing. Have students hypothesize what factors may influence changes in each of the four areas they will be testing.

The four indicators tested in this activity are:

Temperature	The degree of hotness or coldness of water; a measure of the average kinetic energy of the particles in water, expressed in terms of units or degrees typically Celsius or Fahrenheit.
Turbidity	The measure of how "cloudy" a sample of water is, not color. Turbidity comes from solid particles of different sizes, floating in the water. Sometimes, turbidity can be so strong that it makes the water cloudy or even opaque. Turbidity can be measured in many ways and represented by different units of measure. Formazine Turbidity Unit (FTU) is identical to the Nephelometric Turbidity Unit (NTU). The other two methods used to test for turbidity and their measurement units are the Jackson Turbidity Unit (JTU) and the Silica unit (mg/l SiO2) U).
Dissolved Oxygen (DO)	Amount of oxygen gas dissolved in a given quantity of water at a given temperature and atmospheric pressure. It is usually expressed as a concentration in parts per million or as a percentage of saturation. DO levels can fluctuate seasonally and over a 24-hour period. Anything below 5 mg/L can be dangerous for organisms living in the water.
pH	A measure of relative acidity or alkalinity of water. Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasingly basic solutions.

Additional Information for each indicator provided in the Indicator Chart, this chart may be provided to student's as background information.

4. Have students test each indicator and record the results on their group's Citizen Science | Water Quality Log. We recommend that each group member take leadership for a specific indicator test.

5. After the students have completed their tests, and recorded the results on their Citizen Science | Water Quality Log, you'll need to enter the data into the Earth Echo Water Challenge - this is what makes it Citizen Science, citizens collecting and reporting data for others to observe.
Note: You'll need to create a log-in for the students to enter data in before this step.

6. Once students have measured the indicators, discuss whether each indicator indicates that the water is healthy or unhealthy. If any of the measurements indicate that the water is unsafe, have students brainstorm possible sources of pollutants causing the indicator to be unsafe.

7. After completing a list of possible pollutants, discuss with the students possible solutions to the issues they listed. Refer to the Best Management Practices in Lesson 6 for a quick reference of potential solutions. If warranted, have students conduct research and present the best solution for the problem they identified.

Evaluation

Once students have measured the indicators, discuss the results as a class. Is the water sampled healthy or unhealthy? If any of the measurements indicate that the water is unhealthy have students brainstorm possible sources of pollutants causing the indicator to be out of the expected range. What are some solutions the students have to address these problems or improve the quality of the water sampled?

Here are some possibilities:

High water temperatures:
Possible cause - thermal pollution from streambank collapse
Possible action - daylight the waterbody through restoration

High turbidity levels:
Possible cause - too much runoff is entering the waterbody
Possible action - develop a riparian buffer or plant a raingarden

Low dissolved oxygen
Possible cause - eutrophication from increased nutrients entering the waterbody
Possible action - install a log deflector to aid in creating turbulence

Non-neutral (~7) pH
Possible cause - nonpoint source pollution contaminating the waterway
Possible action - restore wetland surrounding the waterbody

Extension

Take this project one step further by allowing students the opportunity to work through a problem they've identified including research, brainstorming solutions, taking action, and evaluating their project or have student's participate in a community clean-up event.

Compare your data to other bodies of water from around the world. Have your students research, hypothesize, analyze, and compare results of their tests to other bodies of water.

Visit: www.worldwatermonitoringday.org to view other results submitted in the Earth Echo Water Monitoring Day Challenge.

If you don't have access to a body of water to sample, you can still use data collected from other areas to analyze and draw conclusions about the health of water, impacts of human systems, and much more. Visit: www.worldwatermonitoringday.org/tools/action-guides-lesson-plans for lesson plans, data sets, and more to make this topic come to life in your classroom.

Indicator	What is it?	Why is it important?	What can affect it?
Temperature	The degree of hotness or coldness of water; a measure of the average kinetic energy of the particles in water, expressed in terms of units or degrees typically Celsius or Fahrenheit.	Organisms are sensitive to temperature changes and require a certain range to survive and thrive. If temperatures remain outside that range for a long time organisms can get stressed and die. Temperature also affects the amount of oxygen water can hold, the rate of photosynthesis by aquatic plants, and sensitivity of organisms to toxic waste, parasites, and disease	Warm water discharged from industrial operations, removal of trees and vegetation that shade streams, runoff from city streets
Turbidity	The measure of how "cloudy" a sample of water is. Turbidity comes from solid particles of different sizes, floating in the water. Sometimes, turbidity can be so strong that it makes the water cloudy or even opaque. Turbidity can be measured in many ways and represented by different units of measure. Formazine Turbidity Unit (FTU) is identical to the Nephelometric Turbidity Unit (NTU). The other two methods used to test for turbidity and their measurement units are the Jackson Turbidity Unit (JTU) and the Silica unit (mg/l SiO_2) U).	Turbidity is clarity of water, not color. High turbidity indicates that there are solid particles such as clay, silt, organic and inorganic matter, and microscopic organisms suspended in the water that make it hazy. These particles can clog fish gills, block light from aquatic plants, and absorb heat.	Soil erosion, urban runoff, algal blooms, and bottom sediment disturbances such as from boat traffic or an abundance of bottom-feeding fish.
Dissolved Oxygen (DO)	Amount of oxygen gas dissolved in a given quantity of water at a given temperature and atmospheric pressure. It is usually expressed as a concentration in parts per million or as a percentage of saturation. DO levels can fluctuate seasonally and over a 24-hour period. Anything below 5 mg/L can be dangerous for organisms living in the water.	Most aquatic animals need oxygen to survive. Natural waters with consistently high dissolved oxygen levels are most likely a healthy and stable environment capable of supporting a diversity of aquatic organisms. With low levels of oxygen, a river or stream would be unable to support a diverse number of aquatic organisms.	Natural and human-induced changes to the environment, high levels of bacteria, large amounts of rotting plants, water temperature, runoff from a combined sewer system, leaf litter in creeks and streams.
pH	A measure of relative acidity or alkalinity of water. Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasingly basic solutions.	Organisms have specific pH levels that they can survive and thrive in, moving away from this desired levels may result in death, slowing of reproduction, or migration from an ecosystem. Most organisms prefer a pH range of 6.5 to 8.0, but each species is unique.	Acid rain, wastewater discharge, drainage from mines, leaching from naturally occurring sediment found in the area, illegal discharging of pollutants

Collecting Your Sample

1. Record the date, time, and location of where you are collecting your sample.
2. Remove the cap and rinse the white sample jar 2-3 times with sample water.
3. Hold the jar near the bottom and plunge it (opening downward) below the water surface.
4. Allow the water to flow into the jar for 30 seconds.
5. Cap the full jar while it is still submerged.

Testing Temperature

6. Place the thermometer ten centimeters below the water surface for one minute.
7. Remove the thermometer from the water and read the temperature. The temperature will be the number with the green background on the high-range thermometer.
8. Record the temperature reading in your group's Water Quality Log.

Testing Turbidity

9. Pour out water sample until the white sample jar is filled to the fill line located on the label.
10. Hold the color comparison chart on the top edge of the sample jar. Looking down into the jar, compare the appearance of the Secchi disk sticker in the sample jar to the chart.
11. Record the result as turbidity in JTU.

Testing Dissolved Oxygen

12. Submerge the small glass vial into the water sample. Carefully remove the vial from the water sample, keeping the vial full to the top.
13. Drop two Dissolved Oxygen TesTabs into the vial. Water will overflow when the tablets are added.
14. Screw the cap on the vial. More water will overflow as the cap is tightened. Make sure no bubbles are present in the sample.
15. Mix the sample by inverting the vial over and over until the tablets have dissolved. This will take about four minutes.
16. Wait five more minutes for the color to develop. Compare the color of the sample to the color comparison chart.
17. Record the result as ppm dissolved oxygen.

Calculating Saturation % of Dissolved Oxygen

18. Locate the temperature of the water sample on the % saturation chart to the right.
19. Locate the dissolved oxygen result of the water sample at the top of the chart. The % saturation of the water sample is where the temperature row and the dissolved oxygen column intersect.
20. Record the result in your group's Water Quality Log.

Testing pH

21. Fill the plastic test tube to the 10 mL line with the water sample.
22. Add one pH Wide Range TesTab.
23. Cap and mix the sample by inverting until the tablet has completely dissolved. Bits of material may remain in the sample.
24. Compare the color of the sample to the color comparison chart.
25. Record the result in your group's Water Quality log as pH.

		Dissolved Oxygen, ppm		
		0 ppm	4 ppm	8 ppm
Temperature, °C	2	0	29	58
	4	0	31	61
	6	0	32	64
	8	0	34	68
	10	0	35	71
	12	0	37	74
	14	0	39	78
	16	0	41	81
	18	0	42	84
	20	0	44	88
	22	0	46	92
	24	0	48	95
	26	0	49	99
	28	0	51	102
	30	0	53	106

Activity 10 | Citizen Science | Water Quality Log

Names:

Directions: Today you will test for four indicators of water quality. For each indicator, select a group member to conduct the test. Record the data from each test in the chart below.

Parameter	Group Member Responsible	Results	Example
Date & Time			September 18, 2018 1:00 PM
Location			Potomac Park
Air Temperature			21° C
Water Temperature			23° C
Turbidity			40 JTU
Dissolved Oxygen			4 ppm
% Saturation			47%
pH			7