Middle School Lesson Plans

Collaborative Research to Manage Stormwater Impacts on Coastal Reserves

Contents

These three lesson plans were developed as part of a research project that was funded by the NERRS Science Collaborative in 2016. Graduate students wrote and piloted the lessons in collaboration with the Scientific Research and Education Network in North Carolina.

To learn more about this program, visit: https://sciren.org/

To learn more about the research project that supported this effort visit: http://www.nerrssciencecollaborative.org/project/Noble16

National Estuarine Research Reserve System Science Collaborative

Don't Drink That!!!

Activity 1: Introduction to Pollutants

Think about the water that comes out of your kitchen sink. Now imagine if it looked dirty or was unsafe to drink because of pollutants!

Pollutants are any unwanted or harmful item that is introduced into the environment. These can range from trash (plastic bottles and bags, candy wrappers) to bacteria and chemicals which are harmful to humans and wildlife. Both fresh and salt water resources, including lakes, oceans, and rivers, are vulnerable to pollutants and need protection from water contamination.

Learning objectives:

Students will discuss sources of water pollutants and talk about what types of pollutants can contaminate water, especially in the contexts of water sources that humans use for recreation and drinking water. Students will also gain an appreciation of the need to keep our water supplies clean and better understanding of their individual impact on the environment.

Materials:

- Plastic cup or other see-through container
- Tap water
- Materials to create "polluted" water, which may include:
    - Dirt
    - Litter (bits of plastic, small objects like paperclips, etc.)
    - Food scraps (i.e. orange peels, egg shells, lettuce, etc.)
    - Bits of leaves or grass
    - Cooking oil
    - Food coloring
    - Sugar

Activity time:

15-20 minutes

Teacher-led discussion

What is a pollutant?

Pollutants are substances that make the air, soil or water harmful or unsafe for use.

Give some examples of sources of water pollution?

Oil spills, bacteria and other organisms, toxic chemicals, litter, volcanic eruptions, industrial waste, human waste, agricultural waste, pet waste etc.

What would you do if you turned on your faucet at home, and no water or dirty water came out? Where would you find water? Think of nearby bodies of water in your area. Is there a stream or river? A lake? The ocean?

Rivers offer a source of fresh water in our area, however in order to safely drink this it first needs to be treated. Carteret County is surrounded by other types of waterbodies such as beaches, marshes and estuaries that could serve as sources of water.

What are some commonly polluted places in our area? How does this impact communities and wildlife?

Rivers and beaches are commonly polluted places around Carteret County. Also, roadways and parking lots are areas we often times see trash accumulated.

Activity

Figure 1: Example of "polluted" water container

- Give each student a clear plastic container
- Have students fill container up with clean water
- Add various types of "pollutants" to the water; each "pollutant" added to the water represents a real source of pollution in the environment. For example, dirt could represent agricultural pollution (runoff from animal feeding operations, fields, etc.), and the cooking oil could represent oil from an oil spill or boats in the water.
- Encourage students to explain difference in water quality following every addition of pollutant added

Adaptations for advanced students:

- Calculate the amount of "pollutants" added to the water given an initial volume (incorporate fractions and decimals)
- Use Excel to make calculations and create simple bar graphs
- Perform dilution series using various pollutants to show observable differences in pollution totals

Activity 2: Let's clean that water!

Although Earth is covered with water (over 70% of Earth's surface), only about 3% of the water on our planet is not salt water. Of this tiny amount of freshwater, much is locked up in ice and glaciers. Of the remainder, less and less is available to humans because of rising populations and increased pollution. Because of the little abundance of available drinking water, it is important for us to understand how to obtain safe drinking water and, if necessary, clean polluted water properly.

In this activity, students will create their own filtration apparatus. They will be able to design and test their own filter in order to investigate how to effectively remove pollutants from water.

Learning objectives:

Students will create water filters to clean their "polluted" water (from Activity 1. Students will hypothesize what materials might be useful in filtering water and provide an explanation for their hypothesis. They will then experiment with sand, charcoal, coffee filters, and other materials that can be used to improve water quality. Students will then observe the results of their experiments, compare them to their peers, and draw conclusions.

Materials:

- Clear plastic cups (plastic soda bottles cut in half will also work)
- "Polluted" water from Activity 1
- Filtering materials, which may include:
    - Napkins or paper towel
    - Activated charcoal (avail for purchase on Amazon)
    - Coffee Filters
    - Cotton Balls
    - Clean Gravel and Sand
- Scissors (optional, if students need to shred their filtering materials)
- Funnels (tops of soda bottles make great funnels)

Activity time:

45-60 minutes

Teacher-led discussion:

What is water filtration and why is important?

Water filtration is the process of removing matter (contaminants or pollutants) from a liquid by means of a porous media (materials with holes). Filtration systems are important to providing safe drinking water to people all over the world by removing unwanted pollutants from the water body.

What are some materials you think will be good/bad at filtering?

We would expect materials with smaller pores to be better at filtering out pollutants vs materials with larger pores since smaller openings (pores) prevent larger material from passing through better.

What are some ways water is filtered in the environment?

Water treatment plants are a major man-made way water is filtered for us to use, this is an example of an engineering solution. Water is naturally filtered through soil and plants in the environment.

Activity:

- As a group, make predictions about which substances will be easiest/most difficult to remove and which filtration material will be most/least effective in removing pollutants.
- Ask students to consider the available filtering materials and construct written hypotheses and design plans.
    - Remind students that multiple materials can be used in their filter.
    - Ask students to consider not only **what** materials are used, but **how** they are organized in the filter (larger filtering materials should be placed near the top of the filter for optimal results)
- Give each student a clear plastic cup (to catch their filtered water) and a funnel (in which they will construct their water filter).
- Ask students to individually design their filter with materials they believe will best remove pollutants.
- Have students assemble their filtration device inside the funnel.
- Students should then test their devices by pouring their "polluted" water from Activity 1 through their filtration device.
- Ask students to evaluate the results of their experiment. Is there anything they would do differently?
- Students should be evaluated on their experimental design and set-up, as well as the clarity of their ideas and hypotheses.
    - An example worksheet is provided for students to record the process of the experiment; teachers should adapt the worksheet to fit their needs.

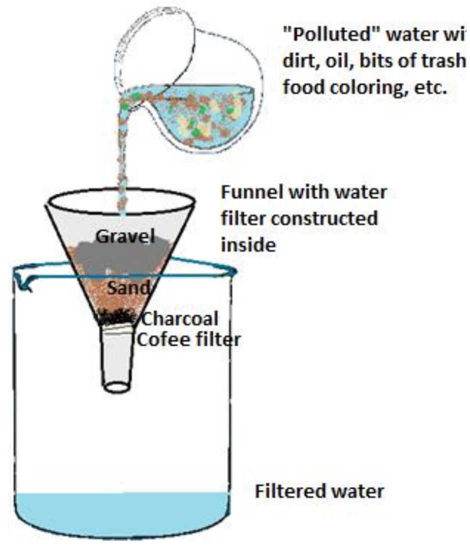

Figure 2: Example of filtration apparatus

Follow-up questions:

- Are there any pollutants that they were not able to filter out with their hand-made filters? If a slime layer is present, is it living?
- Even if the water looked clean, is it possible that the water was still undrinkable? Why?
- How might they remove contaminants from the water that cannot be filtered out?
- Does this change the way you think of pollutants in the environment?
- What are some things you and your family can do to reduce water pollution?

Safety notes:

All students should wash hands before and after the activity. Make sure that all materials used are safe to handle. Care should be taken with trash used and scissors. The filtration methods used in this activity are a simple demonstration and the water should not be considered safe for drinking.

Adaptations:

- More advanced students are encouraged to make more elaborate filtrations apparatuses using advanced engineering techniques such as structural design and conceptualization.
- A graphing component can easily be added to this activity; simply ask students to rate the appearance of their filtered water from 1 (cleanest) to 10 (dirtiest) and create as simple bar graph documenting class results. Use clean "unpolluted" tap water as an example set to 1 and some unfiltered "polluted" water from activity 2 as an example set to 10.
- Students can calculate flow of the water through the filter or rate of pollutant removal depending on setup of experimental design.

Example Worksheet

<u>Experimental set-up</u>

List the materials available for you to use in your water filtration device. How can each material be used to help clean dirty water?

What materials will you use in your water filtration device? Write a hypothesis describing why you think these materials will make an effective filtration device.

Does the way the materials are positioned in the water filtration device matter (for example if gravel is at the top or bottom of the filter)? Why or why not?

Draw the filtration device you will create. Label your drawing.

<u>Results</u>

How clear was your filtered water? Rate it from 1 (cleanest) to 10 (dirtiest).

Was your hypothesis correct? What would you differently next time?

Life in a Bottle

Ecosystem engineering to understand environmental change

- Grades 3 - 12
- Scientific Method
- Hands-on activities

Summary

This three part lesson plan teaches students to use the **Scientific Method** to understand the effects of various experimental treatments on **water quality** and **plant growth**. This lesson plan offers a list of experimental treatments to test and environmental variables to measure, making it adaptable to any grade level or standard listed below.

Once the educator (or class) decides what **experimental treatment** to test and environmental variables to measure, the class will be divided into **small groups** that will each receive a different level of the experimental treatment to test. In small groups, students will **engineer their own "ecosystem in a bottle"** and then **make hypotheses** about the effects of the class' chosen experimental treatment.

Small groups will **take measurements** every other day over a two-week span, and they will compile their results and share with the class as a whole. The students will discuss in small groups whether or not their results support their hypothesis, and they will **make conclusions** about the experiment. Optional extension activities are included to help apply the skills and knowledge developed during this lesson plan.

NC Essential Standards

Elementary: 3.L.2, 5.L.2

Middle: 6.L.1, 6.L.2, 8.E.1, 8.L.3

High: EEn.2.6, EEn.2.7, Bio.2.1, Bio.2.2

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SciREN

Activity 1: Introduction to Ecosystems (15 - 20 min)

"What is an ecosystem?"

In this activity, educators will discuss the various aspects of an ecosystem with students using provided visual aids.

Learning objectives (Standards: 3.L.2, 5.L.2, 6.L.2, 8.L.3, EEn.2.6, EEn.2.7)

1. **List** qualities of ecosystems
2. **Compare** qualities of different ecosystems
3. **Discuss** how ecosystems can be connected

Educator instructions

Begin the lesson by writing the word "ecosystem" on the board and asking students to describe the meaning. Encourage the use of such words as "interaction," "living or nonliving," "energy" and "climate" to name a few. These will help guide students to the standard definition of ecosystem which is a "biological community of interacting organisms and their physical environment."

Use the provided pictures to continue the discussion with the class. Have them list qualities of each ecosystem. What makes them unique? How might they be connected? What constitutes an ecosystem? What type of ecosystem or ecosystems do we live in? See below for additional questions and answers.

Teacher-led discussion

Link to PowerPoint of provided pictures: Activity 1 Resources

Q: What are some examples of types of ecosystems?
A: Temperate forest, tropical rainforest, desert, grasslands, taiga, tundra, ocean

Q: Which ecosystem do we live in? Which ecosystem would be the coldest? Warmest? Driest? Wettest?
A: Temperate forest. Tundra. Desert. Desert. Tropical rainforest.

Q: Why do organisms interact with their environment?
A: Organisms interact to meet their needs for food to survive. Food is the energy they need to survive.

Q: **Is the sun important?**
A: The sun is very important. Without the sun, plants would not grow, weather would not occur, our planet would not be warm...

Q: **What are some ways an ecosystem can be damaged or polluted? How does this impact communities and wildlife?**
A: Air, water and land pollution are the three most common ways in which ecosystems are damaged and polluted. Air pollution may be caused by: burning of fossil fuels, car emissions, or natural ways like volcano eruptions. Water pollution may happen when chemicals (Ex. fertilizers or sewage) or trash enter waterways. Land ecosystems are harmed by cutting down trees and throwing away trash outside of landfills.

When ecosystems are damaged or polluted, this hurts the living and nonliving organisms that inhabit the area. Plants may be damaged and animals forced to move. The interactions between organisms is affected and may change.

Figure 1. Pictures provided for class discussion.

Suggested activity

Prior to the activity, have students bring in a personal object they assume to be a part of their ecosystem and describe the object’s interaction within the system.

Additional resources:

- Khan Academy, Intro to Ecosystems. Use this activity to discuss how energy flows through ecosystems.

Activity 2: Let's Make an Ecosystem! (30-45 min) + 2 wks

Background

In this activity, students will create their own ecosystem and watch it grow. They will be able to design and test changes within their system in response to different experimental treatments. This will allow students to investigate how ecosystems are affected by different environmental conditions and human-caused impacts.

Learning Objectives (Standards: 3.L.2, 6.L.1, 6.L.2, 8.L.3, EEn2.7, Bio.2.1)

1. **Plan** and **construct** a design for the ecosystem
2. **Hypothesize** how different variables will react under different conditions
3. **Observe** how the ecosystem changes over time

Teacher-led discussion:

Q: What can the mini ecosystem tell us about the environment?

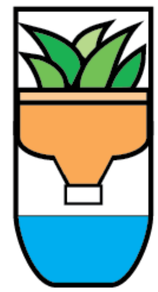
The ecosystem can show us how different environmental variables such as temperature, plant growth and water quality can change within the environment after being exposed to certain conditions.

Q: Which materials do you think will have the greatest impact on the ecosystem during the experiment? Smallest impact?

We would predict plant growth to be impacted greatest by water and nutrient availability (amount of fertilizer) as well as competition from other plants (number of seeds in the ecosystem) and sunlight exposure. Water quality and temperature would be greatly impacted by the number of plants in the ecosystem.

Q: How long do you think it will take before changes within the ecosystem will be observable?

Certain temperature changes may be observable within a few days depending on the amount of sunlight within the ecosystem, however, plant growth may only occur gradually and take 1-2 weeks before being observable.

Materials		
● Plastic 2-liter bottle or see-through container ● Waterproof marker ● Tap water and/or stream/pond water ● Soil and/or sediment ● Rubber bands ● Measuring cups ● Fertilizer ● String/Twine	● Seeds or small plants (Marigolds, beans, radishes) ● Coffee filters, netting, or screen ● pH strips, thermometer, ruler or other measuring devices	 Finished product

Educator Instructions

Step 1: Decide what **treatments** to do and **variables** to test. Create small groups and assign (or let them choose) what level of the selected treatment their group will use. Make sure that there is a "Control" group that will not use an experimental treatment.

Experimental treatments	Possible variables to measure
Water Stress Examples: Different amounts of watering, Covered top vs. open top	● Number of plants ● Height of plants ● Height of water in bottom ● Soil moisture
Temperature control Examples: Inside vs. outside, Next to window vs. far from window	● Number of plants ● Height of plants ● Height of water in bottom ● Soil moisture ● Soil temperature
Type or # of seeds Examples: Radishes vs. Marigolds, 10 seeds vs. 5 seeds	● Number of plants ● Height of plants ● Height of water in bottom ● Soil moisture

Amount of fertilizer Examples: Different levels of fertilizer in soil, Different levels of fertilizer in water	● Number of plants ● Height of plants ● Height of water in bottom ● Soil moisture ● pH of water ● Color of water (Especially if using pond from a stream or pond)

Variations for advanced students

- Add decomposers like earthworms to the ecosystem's soil in different quantities for a fun twist!
- Use more than one 2L bottle and take your engineering to the next level!
- Use natural sediment in the bottom of your ecosystem and fill water on top of it to see if you can detect different types of bacteria banding based on oxygen concentrations.

Other Variations

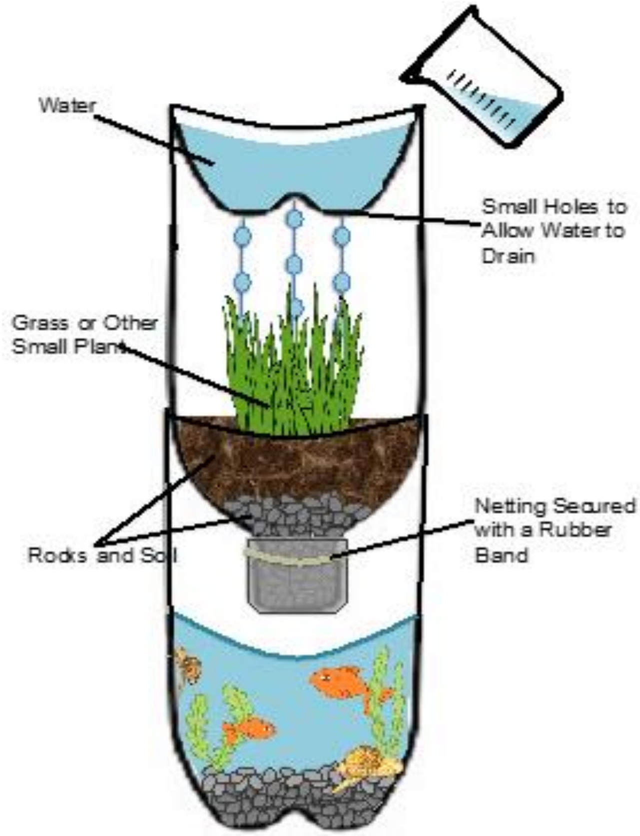
- Add fish to better demonstrate the flow of energy through ecosystems
- Add a discussion of energy flow through ecosystems (see "Additional Resources" from Activity 1).
- Cover your ecosystem with plastic wrap or aluminum foil to see if you can measure a temperature change (or the "greenhouse effect").

Step 2: Have students create hypotheses about how the experimental treatment will affect each of the measured variables. Students can write their hypotheses and answers to additional questions on the "**Activity 2 Student Worksheet**" included below.

Step 3: Distribute supplies to each group and have them begin ecosystem construction. The tops of each 2 liter bottle should be cut off so that a 2 liter bottle is turned into an open-top cylinder and a funnel that fits inside the cylinder when inverted. Soil and plants can be added on top of the funnel, but make sure to remove the bottle cap so water can drain and use coffee filters or netting to prevent soil from falling out the bottom. See example diagram below.

> **Safety note:** Cutting the 2 liter bottles can be dangerous for students. We recommend that educators perform this step before the lesson.

Step 4: Once students have created their ecosystems, supervise their measurements and data recording. Ecosystems should be watered according to the packaging of the seeds used in the experiment, but typically, ecosystems should be watered at least other day to keep soil moist. It is important to leave room between the water surface in the bottom of the bottle and the funnel of the bottle holding the soil to prevent waterlogging. If animals are incorporated, students should feed their animals every few days (ex. fish). See Activity 3 on how to conclude the experiment.



Example Ecosystem Design. Picture credit: "Ecosystem in a Bottle," Northern Arizona University

Additional Resources

- http://www.bottlebiology.org/ (Homepage for additional information about using bottles in biology lessons.)
- http://www.learner.org/channel/courses/essential/life/bottlebio/ (Includes additional lessons using soda bottles.)

Activity 3: How'd Your Ecosystem Do? (15-20 min)

Background

In this activity, students will discuss the results of their ecosystem experiment through a number of exploratory questions. There is a worksheet ("**Activity 3 Student Worksheet**") included below for students to record their conclusion

Learning Objectives (Standards: 3.L.2, 6.L.1, 6.L.2, 8.E.1, 8.L.3, EEn.2.6, Bio.2.1, Bio.2.2)

1. **Analyze** the results of the experiment
2. **Conclude** how well experiment was performed
3. **Apply** findings to real world applications

Teacher-led discussion:

Q: What changes did you see in your ecosystem over the course of the experiment?

Q: Name one thing that occurred in your ecosystem that you expected. Name one thing you didn't expect.

Q: Describe a hypothetical real-world example of the experiment that you just tested. How is your ecosystem similar to that example? How is it different?

Q: What are some other human activities that impact the environment, and how do they affect the environment?
A: Burning of fossil fuels (increased CO_2 & temperatures, ocean acidification), Deforestation (decreased soil quality, decreased plant life, decreased water quality), Excess fertilizer use (decreased water quality, algal blooms).

Q: If you were to do this project again, what would you do differently?

Sample Worksheets

Activity 2 Student Worksheet ___________________

Materials

- 2L bottle, top funnel section cut off
- Rocks, soil, and/or sediment (these can be collected from outside or store bought)
- Water (tap water or water from a pond or other water body)
- Small plants or seeds
- Netting/screen/coffee filter
- Fertilizer, areas with temperature differences, different types of water or soil, and any other materials needed to test your hypothesis
- Ruler, pH strips, and any other tools you need to measure changes to your ecosystem

Instructions

In this activity, you and your classmates will construct an ecosystem in a bottle and use it to test the effects of a certain experimental treatment. Together with your small group, *fill out the questions listed below* to help design your ecosystem and create a hypothesis. Once you finish the questions, you can begin construction of your ecosystem. Once your ecosystem is constructed, you can begin taking measurements and recording them on a data collection sheet. You will continue collecting data every other day for 2-3 weeks.

1. In this activity, you'll be designing your own ecosystem and setting up an experiment to measure changes over time using the **scientific method**. Describe the steps in the scientific method.

2. What is a **variable**? What variables are you and your class planning to test in your ecosystems?

3. What is a **control**? Why are controls important for the scientific method? Describe the control or controls your class is using.

4. Write down a **hypothesis** predicting what the outcomes of your experiment will be. Be specific!

5. List the **materials** you are going to include in your ecosystem (these can be things you bring from home or that are available in your classroom). Describe how each material will be used in your ecosystem.

6. What tools will you use to evaluate the results of your experiment? How will you use these tools?

7. How often will you **measure** changes to your ecosystem?

8. Draw and label a schematic design of the ecosystem you are planning to build. Why did you design your ecosystem this way? How will it enable you to test your hypothesis?

Data collection sheet ____________________

	Temp.	pH	Plant Observed?	Plant Height	Water Color	Amt. of Water Added	Comments
Day 1							
Day 2							
Day 3							
Day 4							
Day 5							
Day 6							
Day 7							
Day 8							
Day 9							
Day 10							
Day 11							
Day 12							
Day 13							
Day 14							

Activity 3 Student Worksheet ___________________

In this activity, you will analyze the data collected over the past 2 weeks and make **conclusions** about the results of your experiment.

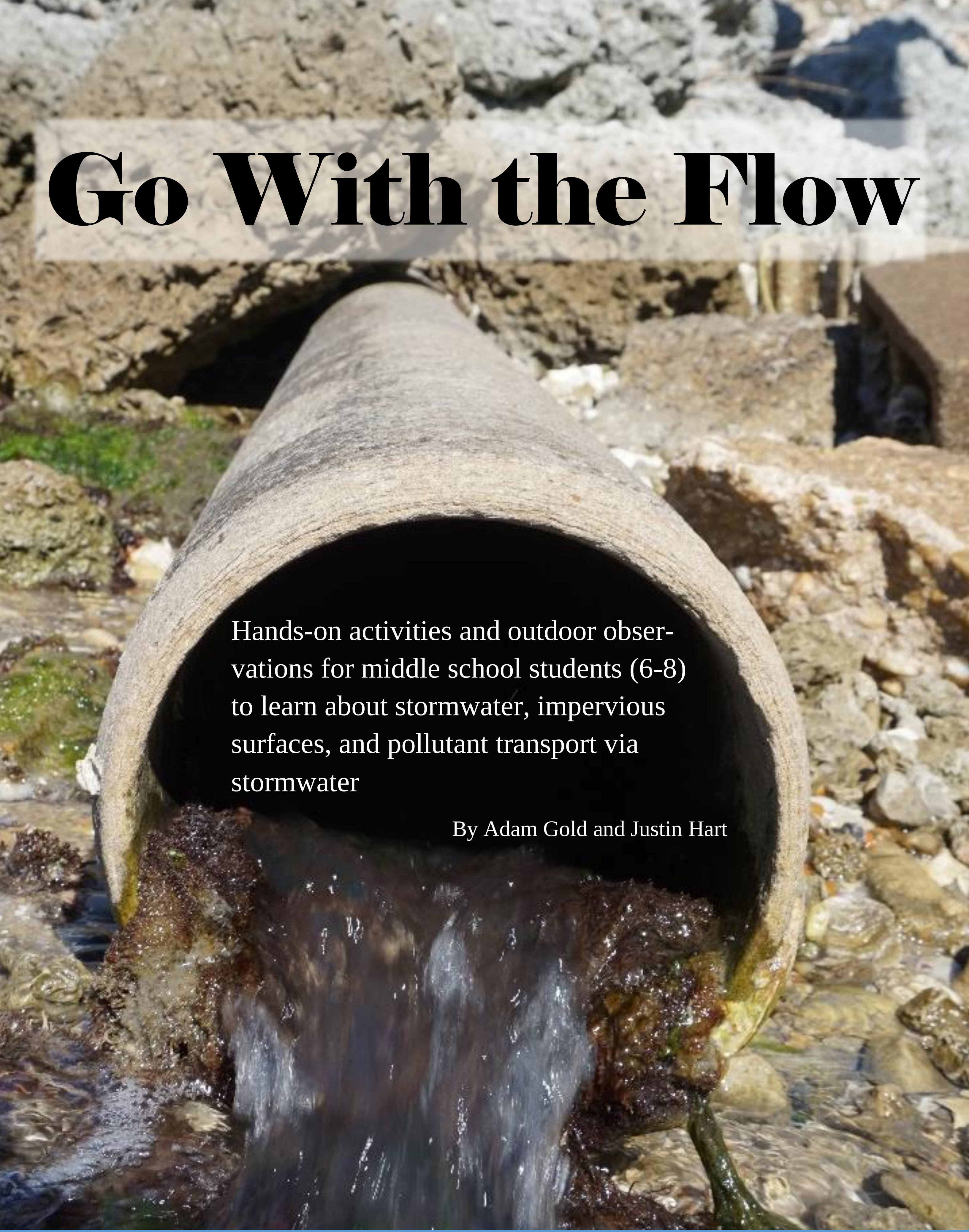
1. How did your mini ecosystems change over time? Was your hypothesis correct?

2. How did your results compare to others in your class? How did your results compare to the control?

3. Create a graphical representation of your results. Your teacher will help you to decide what type of graph will be best.

4. If you were to complete the experiment again, what could you do to improve your results?

5. Are there any variables you didn't test that you would like to? How could you redesign the experiment to look these variables?



Go With the Flow

Hands-on activities and outdoor observations for middle school students (6-8) to learn about stormwater, impervious surfaces, and pollutant transport via stormwater

By Adam Gold and Justin Hart

SUMMARY

This lesson plan introduces students to stormwater, the leading cause of water pollution. During two 50 minute activities, students will learn about the hydrosphere, how humans impact the hydrosphere, and how stormwater can affect receiving waters. Students will experiment with sand (representing natural ground cover) and aluminum foil (representing impervious surfaces) to learn how humans create and manipulate stormwater through development. They will also gather and interpret their own water quality observations and learn how stormwater can affect them and their community.

ENGAGE

This section will present students with a worksheet that contains initial questions about stormwater, maps to be used to answer math and unit conversion questions. The students will be presented with definitions for **impervious surfaces, stormwater run-off,** and **stormwater management structures.** Students will calculate impervious surface area for three different configurations of impervious surfaces. They will calculate the amount of stormwater run-off created during a storm. This section is intended to introduce students to stormwater, how it is created, and how it carries pollutants into water bodies. See attached student worksheet.

Materials List

Sand and gravel are relatively inexpensive in bulk at a hardware store. All of the materials for one demonstration cost around $20 and, except for the bins, there were enough materials left over for additional workstations. Each additional workstation will cost $5–$10 for the bin.

- Clear plastic bin (16”L x 11.5”W x 6.5”H. Size may vary)
- Sand
- Gravel
- Aluminum foil (may substitute wax paper)
- Food coloring (may substitute cocoa powder)
- Spray bottle (or a paper cup with several holes poked through the bottom)
- Paper towel
- A bucket to collect used sand

EXPLORE

Students will have the opportunity to assemble a physical stormwater model using the concepts from the introductory worksheet. This activity will offer a brief introduction on **groundwater** and **aquifers,** and allow students to observe how impervious surfaces facilitate runoff and pollutant transport to streams via stormwater. Students will compare three different “urban scenes” of varying imperviousness to relate the concepts from the student worksheet to a hands-on application. Students will also learn about the role of stormwater management practices (rain gardens, wetlands, ponds) in reducing stormwater and removing pollutants.

EXPLAIN

This section will have students answer questions as a class about the previous exercise. Topics for discussion include: What areas flood more? Why are there curbs on roads? How can humans clean and reduce stormwater? See attached sheet for a full list of questions.

ELABORATE

After a storm, students will have the opportunity to go outside and relate what they have learned about stormwater to their surroundings. Students will split into groups and look for puddles of water that have formed after storms. The attached worksheet will allow students to record data and observations about the location and appearance of the water that they may then analyze. If thermometers, refractometers, and pH strips are available, they can be used to gather temperature, salinity, and pH data. See attached data collection sheet and instructions.

EVALUATE

Throughout the lesson plan, students will be filling out a worksheet with questions and map activities. At the end of the lesson plan, students will calculate impervious area, the percentage of impervious area, and the runoff produced during a storm for an urban area. Students will compare runoff and pollutant transport from impervious and natural areas and design their own stormwater solutions using a hands-on model. Students will assess and/or measure water quality in their community after a storm and interpret the data.

STANDARDS

NC Essential Standards

8.E.1.4 - Conclude that the good health of humans requires: Monitoring of the hydrosphere, Water quality standards, Methods of water treatment, Maintaining safe water quality, Stewardship.

EEn. 2.2.1 - Explains the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization, and land use) past and present.

EEn. 2.3.2 - Explain how groundwater and surface water interact.

EEn. 2.4.1 - Evaluate human influences on freshwater availability.

EEn. 2.4.2 - Evaluate human influences on water quality in North Carolina’s river basins, wetlands and tidal environments.

EEn 2.8.3 - Explain the effects of uncontrolled population growth on the Earth’s resources.

EEn 2.8.4 - Evaluate the concept of 'reduce, reuse, recycle' in terms of impact on natural resources.

Common Core Math

6.EE.9 - Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

7.G.6 - Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

8.SP.1 - Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

8.SP.2 - Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

Next Generation Science

MS-ESS3-3, Earth and Human Activity - Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

REFERENCES

Public Schools of North Carolina. *North Carolina Essential Standards - 6-8 Science. http://www.ncpublicschools.org/curriculum/science/scos/support-tools/#standards*

Public Schools of North Carolina. *North Carolina Essential Standards - Earth/Environmental Science. http://www.ncpublicschools.org/curriculum/science/scos/support-tools/#standards*

National Governors Association Center for Best Practices, Council of Chief State School Officers. 2010. *Common Core State Standards for Mathematics.* Washington D.C.: National Governors Association Center for Best Practices, Council of Chief State School.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, by states*. Washington, D.C.: National Academies Press. *www.nextgenscience.org/next-generation-science-standards.*

BACKGROUND READING RESROUCES FOR EDUCATORS

Urban Stormwater:
https://www.epa.gov/sites/production/files/2015-10/documents/nps_urbanfacts_final.pdf

Green Infrastructure:
https://www.epa.gov/green-infrastructure/what-green-infrastructure#raingardens

ACKNOWLEDGEMENTS

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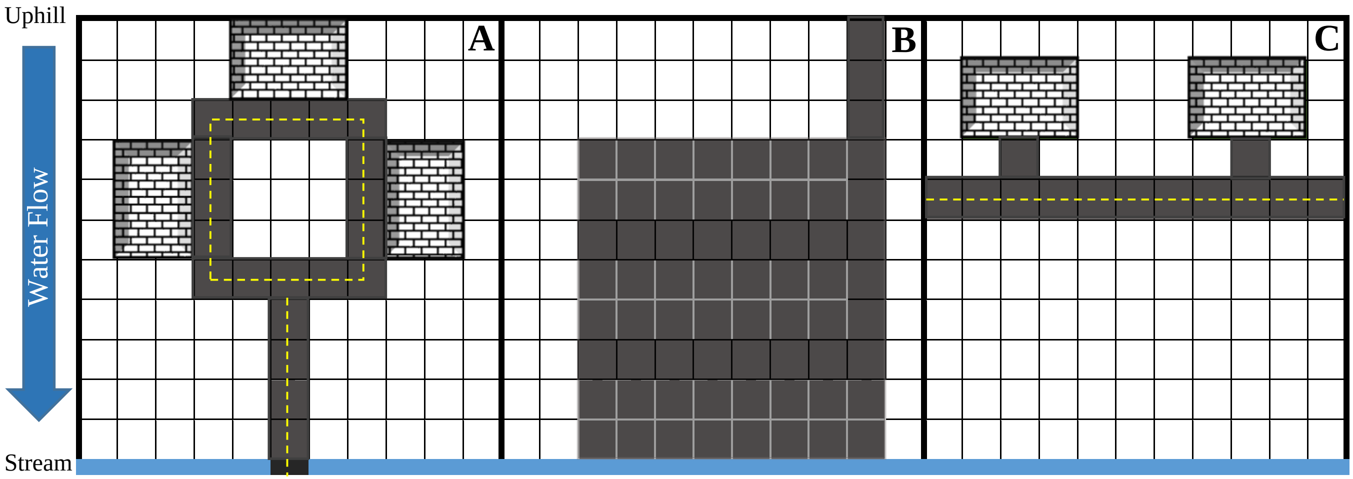
Go with the flow - Student Worksheet



Instructions: The picture above shows aerial views of three different urban areas. The grey squares represent surfaces that do not allow rain to soak in. These surfaces are called **impervious surfaces**, and they include roads, parking lots, roofs, and driveways. Each of the three scenes (A, B, C) is an 11 x 11 grid where each small square has an area of 1 meter squared (m^2). Scene A represents a cul-de-sac with houses, Scene B represents a large parking lot, and Scene C represents a regular road with houses. The top of the scene is uphill and the bottom of the scene is a stream with water flowing downhill to the stream.

Questions:

1. Calculate the area of impervious surfaces in each of the three scenes.

2. Calculate the percentage of total area for each scene that is covered by impervious surfaces.

Rain that falls on impervious surfaces does not soak into the ground. Instead it stays on top of the impervious surface, flows downhill, and is called **stormwater run-off**. Rain that falls on surfaces that allow the rain to soak in (example: Forests, lawns, flower beds) produce much less stormwater run-off than impervious surfaces. In areas where there is a lot of impervious surface area, **stormwater management structures** can be created to soak up and filter stormwater. Examples of these structures are rain gardens, wetlands, swales, and ponds.

3. If it rains 3 centimeters (cm) during a storm, what volume of run-off will be created by the impervious surfaces for each scene?

Name: ____________________
Date: ____________________
Class: ____________________

Hands-on activity

Background: For this activity, you will split into groups to compare how water and pollutants flow downhill in the three different urban scenes (A, B, C) from the beginning of the worksheet. Each group will be provide a model of a hill. The bottom of the model is made of gravel, and this represents an **aquifer**. Aquifers are geologic formations deep underground that store water. The water stored in this aquifer is called **groundwater.** When rain falls on areas that soak it up, the water eventually flows deep down into the ground and eventually ends up in an aquifer. The sand on top of the gravel represents soil. Your group will construct each of the three urban scenes out of aluminum foil and place the aluminum foil cutout on top of the sand one scene at a time. Make each aluminum foil cutout appropriately sized to fit on top of the hill model. Your teacher will provide specific instructions for exploring impervious surfaces, pollutants, and stormwater.

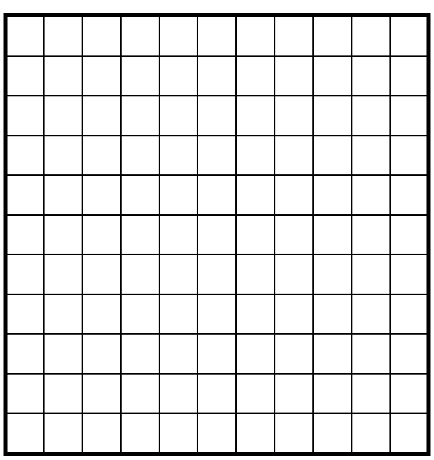
Questions:

1. Compare how water and pollutants flow on the aluminum foil and sand.

2. Choose the urban scene aluminum foil cutout that worked the ***best*** at keeping pollutants away from the "stream" (downhill part of hill model). Explain why you think it performed the ***best***.

3. Choose the urban scene aluminum foil cutout that worked the ***worst*** at keeping pollutants away from the "stream". Explain why you think it performed the ***worst***.

4. As a group, construct your own urban scene that includes impervious surfaces and stormwater management solutions with the purpose of keeping pollutants out of the "stream". Sketch your group's scene below by shading in the appropriate squares of the grid and give reasons why you think your design will work.



Go With the Flow - Teacher Instructions for Explore Activity

SUMMARY

This activity may take up to 50 minutes. Each group of students will have the opportunity to assemble the stormwater model using the concepts from the introductory worksheets. Each station will need the materials listed in the materials list on the *Go With the Flow* document.

INSTRUCTIONS

1. Pour the gravel into the bin.

2. Cover gravel with sand to create a hill with one end of the bin representing a lower elevation (Stream) and the other side of the bin representing the top of a hill (See student worksheet to approximate configuration).

3. Have students make predictions about what will happen when water is sprayed onto the model.
   - Remind the students that the spray bottle represents a storm and the water they spray represents rainfall.
   - Using the spray bottle, spray onto different parts of the model and have the students make observations.
   - Compare these observations to the students' initial predictions.

4. Ask the students whether they think aluminum foil is an impervious surface.
   - Ask students what this aluminum foil could represent
     - Students may give responses about various types of impervious surfaces related to the introductory worksheet.
   - Have the students cut out aluminum foil into three separate shapes: a parking lot, a cul-de-sac, and a street.
   - Place the aluminum over a portion of the model, then have students make predictions about what will happen when water is sprayed onto the aluminum foil.
   - Using the spray bottle, spray water onto the aluminum foil and make observations.
   - Ask the students to make observations and comparisons about the different cutouts.

5. Next, add drops of food coloring to the model. Place at least one drop on the aluminum foil, and at least one drop onto uncovered sand. Add food coloring close to the edge of the bin so that as the water infiltrates into the sand the color may be visible.

- Tell students that this represents a form of contamination, and ask students to think of types of contamination.
    - Remind students that contamination is not always an exotic chemical—this food coloring can represent the fertilizer their parents use on the lawn, soap used to wash a car, or even dog poop that an owner forgets to clean up.
- Have students make predictions about what will happen to the food coloring once water is added.
- Spray the food coloring with water and make observations as it infiltrates or runs off through the model.

6. Place a piece of paper towel downstream from the food coloring, and ask the students to make predictions about what will happen.
    - Ask the students what the paper towel could represent.
        - Students may respond that the paper towel represents a wetland or rain garden, as described in the student worksheet.
    - Ask students what happens to the food coloring when it comes in contact with the paper towel.

7. If there is remaining time, ask students to design ways to reduce the volume of stormwater runoff.

8. Clean up: if more students will be using the materials in a later class, ask students to throw away used aluminum foil and paper towel and put the sand back how they found it so that the model has slopes for the water to run down. Consider having students scoop discolored sand into a separate bucket to “reset” the stormwater model. Students in the final class of the day may help put supplies away.

Teacher Questions: Explain

If you were building a house on a hill like the model, where on the hill would you put it?

Why are there are curbs on roads?

Plants and soils are great at soaking up water and pollutants. What are some ways that humans could use them to clean up and reduce amounts of stormwater?

What kind of pollutants would you expect to find larger amounts of in urban streams compared to forested streams?

What are some ways that humans can decrease the impact of impervious surfaces on stream water quality?

Graphing Stormwater Data

Collect all of the data from the different groups. Select one of the variables from the stormwater quality field data sheet and fill in the table below.

Sample Site	Variable:

Using the table above, plot your variable on the graph provided.

Was your selected variable higher in the stormwater or in the receiving water? Explain why you think this might be the case.

Compare your results with other variables. Which variables were higher in the receiving waters? Which were higher in the stormwater?

Based on the data you collected and what you know from the sandbox stormwater model, argue whether you think the water you sampled is contaminated.

Stormwater Quality Field Data Sheet

General Information

Investigator Names:

Date: Time:

Describe the site you sampled: ____________________

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____

Circle the weather conditions:

Heavy Rain Rain Light Rain

Windy Light breeze No wind

Sunny Cloudy

Other:

Sampling Data

Test	Measurement
Water temperature	°C
Salinity	ppt
Turbidity (visual test)	High Medium Low
pH	
Wind direction	

What color is the water? Can you see anything in it (such as dirt, algae, or garbage)?

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____

Do you have any other observations?

____

____

____

____

Title: ____