ENGINEERING SOLUTIONS

Investigating Polluted Stormwater Runoff in Secondary Grades

DRAIN RANGERS
PUGET SOUND STARTS HERE

ENGINEERING SOLUTIONS

Investigating Polluted Stormwater Runoff in Secondary Grades

Developed by

PEI PACIFIC EDUCATION INSTITUTE

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DEPARTMENT OF ECOLOGY State of Washington

STORM STORMWATER OUTREACH FOR REGIONAL MUNICIPALITIES

A part of the campaign

PUGETSOUND PARTNERSHIP

Puget Sound Starts Here

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INTRODUCTION

The purpose of the Engineering Solutions stormwater curriculum is to develop a deeper understanding of the serious issues facing our community with stormwater runoff and specific actions we can take to improve the quality of our water. State and federal governments have established strict regulations regarding stormwater management, including funding to employ engineers who specialize in stormwater solutions. Students will learn what these engineers do and replicate the thinking process they use when they problem solve solutions to polluted stormwater runoff.

The three-week unit begins with students investigating the role of the stormwater engineer using online resources, responding to research questions, and writing an essay explaining the role and job description for a stormwater engineer. Students practice and apply Common Core ELA standards when they read complex materials, take notes, and synthesize their learning through research questions and an essay. Through this investigative process, the students build background knowledge that is fundamental to the problem solving process making up the remainder of the unit, which follows the engineering design process of the Next Generation Science Standards.

There are 2 pre-lessons; one on watersheds and the other on pervious and impervious surfaces.

After learning more about stormwater runoff and solutions to the problem, students will map their school yards to better understand the issues facing the stormwater engineer. Students will bring the eyes of the stormwater engineer to the process and look critically at the design of the schoolyard, consider solutions to improve runoff, and note how stakeholders might be impacted by any possible solution.

After evaluating proposed solutions, the students will select one action to recommend for implementation. Students will consider stakeholder priorities in their selection as well as environmental impact. After carefully evaluating the options for their schoolyard, the students will outline a specific implementation plan including how they might test the success of their plans. Testing will include visual as well as quantitative documentation. Students will submit their plans to the district administration for possible implementation.

Throughout this unit, students will grapple first hand with the problems we face with stormwater management and the important role of the engineer in problem solving issues and generating solutions. This is at the heart of Engineering Design (See graphic next page).

As they progress through schools, young people should develop skill in analyzing problems, locating and evaluating solutions, and implementing viable plans for improvement. The Engineering Solutions curriculum provides opportunities to be problem solvers and creative thinkers, to value the role of the engineer, and to engage in meaningful activities that promote a healthier Puget Sound.

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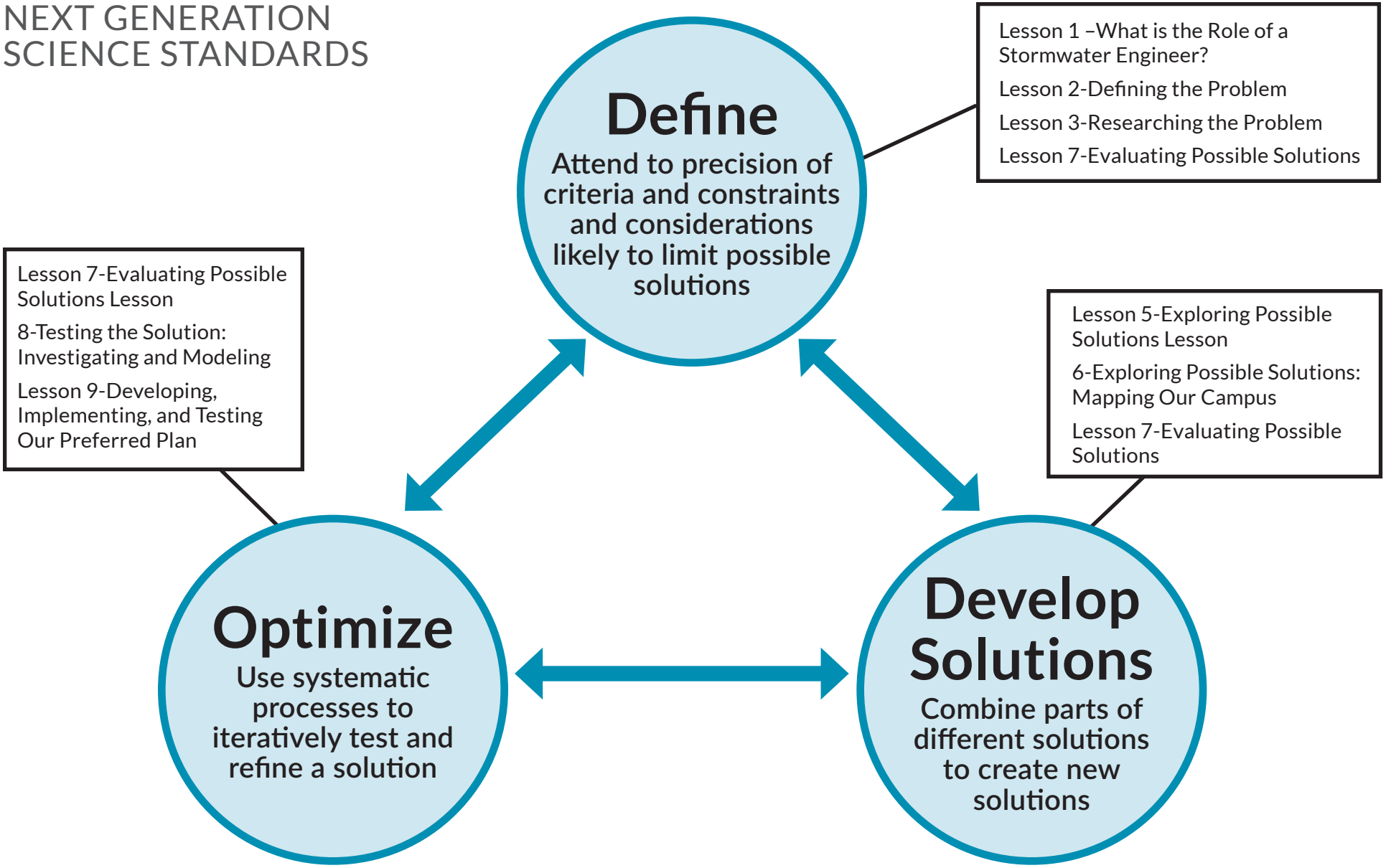
Lessons

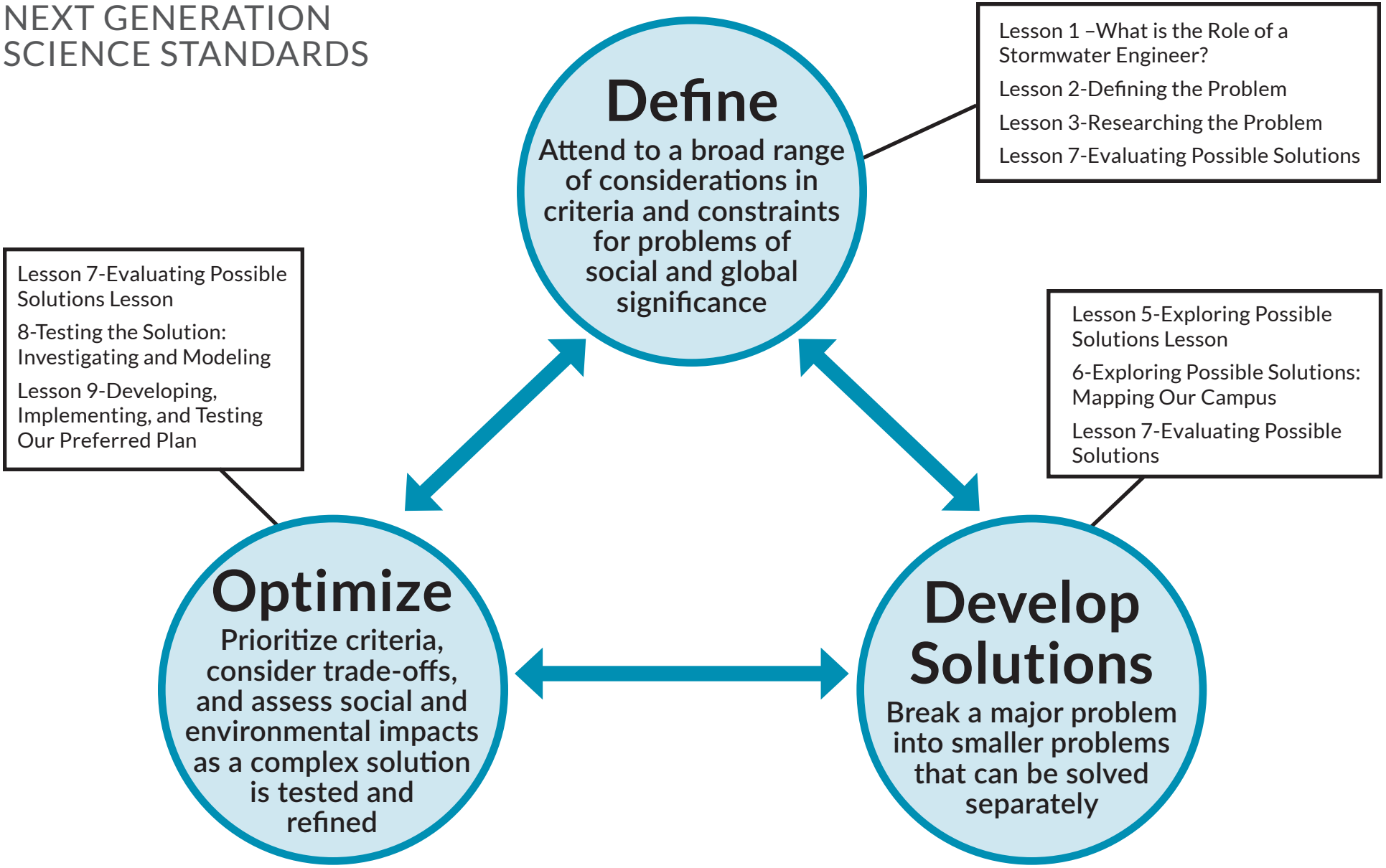
Engineering Design - Middle School

NEXT GENERATION SCIENCE STANDARDS



Engineering Design - High School

NEXT GENERATION SCIENCE STANDARDS



ENGINEERING SOLUTIONS LESSON OVERVIEW

Lesson	Activities	Concepts/Skills	Resources
Pre-Lesson 1-Finding out about Watersheds p. 9	Construct Models Analyze maps	Constructing models Map reading Analyze	Watershed videos Watershed component cards Watershed map links
Pre-Lesson 2-Changes in the Watershed p. 20	Analyze photos over time Construct Explanations-Write Conclusions	Finding evidence Analyzing Constructing explanations	Then and Now photo links Data Collection Sheet Student Reading Conclusion Sheet
1-What is the Role of a Stormwater Engineer? p. 31	Unit Pre-Assessment prior to this lesson Performance Task: Help Wanted! Stormwater Engineer	Summarizing What is stormwater? Stormwater solutions Role of the Stormwater Engineer	Pre-Assessment Stormwater Videos Essential Questions Performance Task Stormwater Engineer Job Description
2-Defining the Problem: Stormwater Pollution p. 51	Exploring Stormwater Runoff and Pollution Defining the Problem	Summarizing Problem Solving Stormwater Runoff and Pollution	Stormwater Videos Stormwater Reading Problem Solving Strategy Chart and Graphic Organizer Cognitive Content Dictionaires
3-Researching the Problem: Best Management Practices (BMPs) p. 64	Define BMP's Create Summary Posters Exit Slips Home-School Connection	Summarizing BMP's	BMP Overview and Examples: King County Stormwater Pollution Prevention Manual
4-Understanding Stakeholders p. 89	Define Stakeholder Explore the points of view of the various stakeholders: Stakeholder Matrix Exit Slips	Finding Evidence Point of View Evaluation Stakeholder	Stakeholder Matrix

Lesson	Activities	Concepts/Skills	Resources
5- Exploring Possible Solutions p. 96	Researching Engineering Solutions Short Presentations to the Class	Summarizing Engineering Solutions	Access to the Internet Presentation Scoring Criteria
6- Exploring Possible Solutions: Mapping Our Campus p. 101	Engineering solutions Map the school campus for these solutions Neighborhood Scavenger Hunts	Observing Analysis	Campus Maps Engineering symbols Powerpoint for Engineering Solutions
7-Evaluating Possible Solutions p. 108	Review possible site improvements Evaluate assigned solution Complete Evaluation Matrix Write Opinion Essay	Compare/Contrast Evaluation Stormwater Solutions Opinion Essay	Opinion Writing Rubric Evaluation Matrix
8-Testing the Solution: Investigating and Modeling p. 112	Determine success of solution by either investigating or using a model	Practices of Science investigating Modeling	Investigation examples Model examples for stormwater runoff solutions
9-Developing, Implementing, and Testing Our Preferred Plan p. 121	Complete Project Planning Template in small groups Submit plan for review Begin Artifact Collection: Monitoring Implementation	Goal Setting Project Planning	Project Planning Template
10-Unit Reflections p. 127	Student Self Reflections Post-Assessments Optional Extension: Engineering Fair	Summarizing Self-Reflection	Reflective questions Judges for Engineering Design Competition

Sample Calendar

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	**Pre-Lessons** on Watersheds if needed for background student knowledge	**1-What is the role of the stormwater engineer?** Part 1 Performance Task: Research Questions →	Part 2 Performance Task: Informational Essay	**2-Defining the Problem: Stormwater Pollution**	**3-Researching the Problem: Best Management Practices**
Week 2	**4-Understanding Stakeholders**	**5-Exploring Possible Solutions** →	→	**6-Exploring Possible Solutions: Mapping Our Campus for Stormwater Solutions**	**7-Evaluating Possible Solutions** →
Week 3	**7-Evaluating Possible Solutions** (continued) →	**8-Testing the Solution: Investigating and Modeling** →	→	**9-Developing, Implementing, and Testing Our Preferred Plan** →	**10-Unit Reflections Optional Extension: Engineering Fair- Stormwater Solutions** →

This curriculum is designed to go through engineering design as described in the Next Generation Science Standards and integrate with English Language Arts assessment performance tasks. The curriculum can be done in its entirety or just by doing one to several of the lessons. Here are some possibilities:

Unit Length	1 – What is the Role of a Stormwater Engineer ELA-Performance Task	2 – Defining the Problem: Stormwater Pollution	5 – Exploring Possible Solutions	6 – Exploring Possible Solutions: Mapping Our Campus	7- Evaluating Possible Solutions	9-Developing, Implementing, and Testing Our Preferred Solution	10 – Unit Reflections
2 Days	✓						
3-5 Days	✓	✓	✓		✓		
5-6 Days with Outdoor Component	✓	✓	✓	✓	✓		
2 Weeks	✓	✓	✓	✓		✓	✓

PRE-LESSON 1

Finding out about Watersheds

Part 1 from *Forests of Washington: Ecosystems and People* Pacific Education Institute and Washington Forest Protection Association.

Overview

The class builds a demonstration model of a watershed and identifies the parts. Then, human activities are put on the watershed to demonstrate that we all live in a watershed. In part 2 students examine maps of their watershed and identify features and flow of water from their school to streams, lakes and eventually Puget Sound.

Objectives

PART 1

- Students define a watershed as, "an area of land that drains to a particular body of water," and identify the natural and human components of a typical watershed.
- Students construct a model of a watershed.

PART 2

- Students use maps to locate their watershed and follow the path of water from their school to their nearest lake or Puget Sound.

Background

We all live in a watershed. No matter where you live, you live in a watershed. That's because everywhere rain falls or water flows over the land: is part of a watershed. A watershed is the entire area from which water drains into a particular surface water body. Watersheds can be big or small. The Columbia River in the Western United States has a watershed that is 258,000 square miles. The biggest watershed in the country is the Mississippi River, which drains all the land between the Rocky Mountains and the Appalachian Mountains.

Watershed boundaries are defined by the elevation of the land, with the highest elevation points, "ridges," marking the boundary of a watershed. These ridges are also called, "divides." The Continental Divide of the U.S. for example, is in the Rocky Mountains. All the rain and snow falling on the west side of the divide flows into the Pacific Ocean. All the rain and snow falling on the east side of the divide, sooner or later, ends up in the Atlantic Ocean. All water is connected. Simple choices in our daily activities affect the quality of water that we drink and the water that fish and other wildlife rely on.

Science
Grades - Secondary
Setting - Indoors
Pre-Lesson 1 (1-2 50 min. classes)

Materials

PART 1

- Watershed video https://www.youtube.com/watch?v=f6 3pwrMXkV4
- Large black plastic garbage bag
- Spray bottle
- Newspapers
- Watershed Component Cards - provided
- Human Activity Cards to be made with activities mentioned in lesson
- Watershed Graphic

PART 2

- Blue highlighters
- Watershed maps: https://www.epa.gov/puget-sound
- U.S. Geological Survey, Science in your Watershed http://water.usgs.gov/wsc/index.h tml
- Watershed address videos: https://www.youtube.com/watch?v=JGeOhFdhF1o

  https://www.youtube.com/watch?v=0_R6P0mj7rc

Introduction: Build a Watershed

Teacher Note: There are many watershed models and many providers can come into the classroom and share a model with students.

Procedure

1. Ask students to look at the watershed poster. Explain that we all might not live in a forest, but we all live in a watershed. Explain that all water that flows into a waterway or body of water is defined by that water body. All the water that flows into Jones River is in the Jones River Watershed.
2. Watch the EPA watershed video for a nice visual of a watershed https://www.youtube.com/watch?v=f63pwrMXkV4
3. You are going to make a model of a watershed with your students. Have students crumple up the newspapers and toss into a pile.
4. Mark the West side of the model.
5. Have a student drape a large, black plastic garbage bag loosely over the crumpled newspapers. The idea is to create a hilly contour with a mountain and a valley in the middle, sloping to the "sea" on the West.
6. Allow every student to use the spray bottle to "rain" on the mountains coming from the west. Each student gets 3-4 sprays.
7. Explain to students that the region that drains into a body of water is the watershed for that body of water. Discuss what another source of water might be, i.e. snow.
8. Describe to students the ridges that define a watershed in your model. Rain and snow falling on the other side of ridges flows to different rivers. Watersheds are defined by the body of water they flow into. Your model may demonstrate two watersheds.

Common Core ELA Standards

- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on various topics and texts, building on others' ideas and expressing their own clearly.

Glossary

- Watershed: The entire land area from which water drains into a particular surface water body such as a lake, stream, or river.
- Headwaters: Where a creek, stream, river begins – the source of that waterway.

9. Ask students how this model is similar to a real watershed and how it is different. You may want to do a think, pair, share with this so that everyone has a chance to think about the comparison. Some examples:
    a. Similar - water flows and collects from high points to low points
    b. Similar - water comes from West to the mountains
    c. Different - the ground is permeable and will soak up water
    d. Different - there are also springs in a real watershed
10. Pass out the watershed component (feature cards). Have students say what their feature is, give definition written on the card, and then place the card where it might be on the watershed model.

    The components are:

    Puget Sound - a large salt water estuary fed by highly seasonal freshwater from the Olympic and Cascade Mountain watersheds.

    Forest - a group of trees that includes all the plants and animals above and below ground

    Glacier - a large body of slow moving ice that melts, thereby feeding creeks and rivers

    River - a large body of water that runs into a lake, ocean or other river

    Tributary - a stream which joins a larger river or stream

    Spring - groundwater that comes to the surface

    Lake - an area where water collects that is fed by creeks, streams, or rivers. This area is usually in a basin or depression in the landscape.

    Estuary - the mouth of the river where freshwater meets saltwater

    Wetlands - low areas covered my shallow water most of the time, where plants that,"like to have their feet wet," grow. The following are examples of wetlands:

    - Marsh - a wetland where mostly grass-like plants grow, i.e. cattails
    - Swamp - wetland where mostly trees and shrubs grow
    - Saltmarsh - a marsh in an estuary, inundated by tides twice a day
11. Pass out the human activity cards and have students place them on the watershed model.

    The human activity cards include:

    - Camping
    - Logging
    - Dam-building
    - Fishing
    - Building towns (stores, houses, roads, etc.)
    - Skiing
    - Farming
    - Shipping
    - Working in Factories
12. Discuss the ways human activity impacts the watershed. Discuss how we have many protections in place for watersheds - example construction projects are not allowed to let dirt leave their project site and pollute streams.

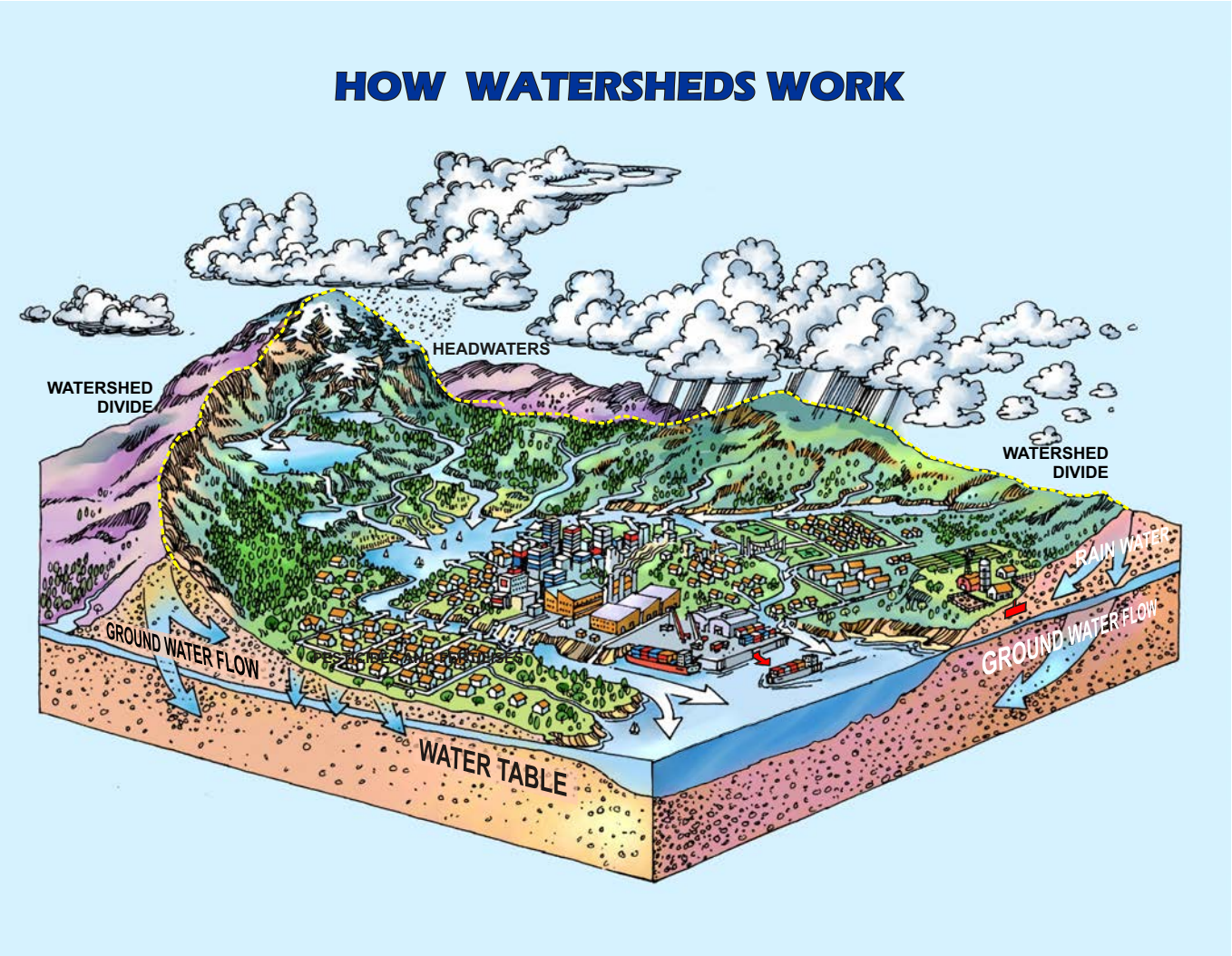
Introduction: Build a Watershed

Procedure

1. Watch the Watershed Address https://www.youtube.com/watch?v=JGeOhFdhF1o
2. Prepare maps for students using a map of your area from your local city, county, or the watershed sites given. One for every two students if possible. **Tip**: If you don't want to make new maps every year you could have students use tracing paper on the maps.
3. Explain to students that they are now going to look at their Watershed Address.
4. Students will be guided by the student page as they examine their watershed. Have students examine the maps and find the following and mark in someway:
    - Their school
    - Their community
5. On the maps have students identify the larger bodies of water: streams, rivers, lakes, and Puget Sound.
6. Students then follow where water would go from their school to the local stream, river, lakes, and eventually Puget Sound. **Note**: Students may need to view that part of the video again to understand how water that falls on their school reaches Puget Sound.
7. Have students reflect on what they have learned about watersheds.
8. Share with students that now they are going to examine their region for how watersheds have changed overtime.

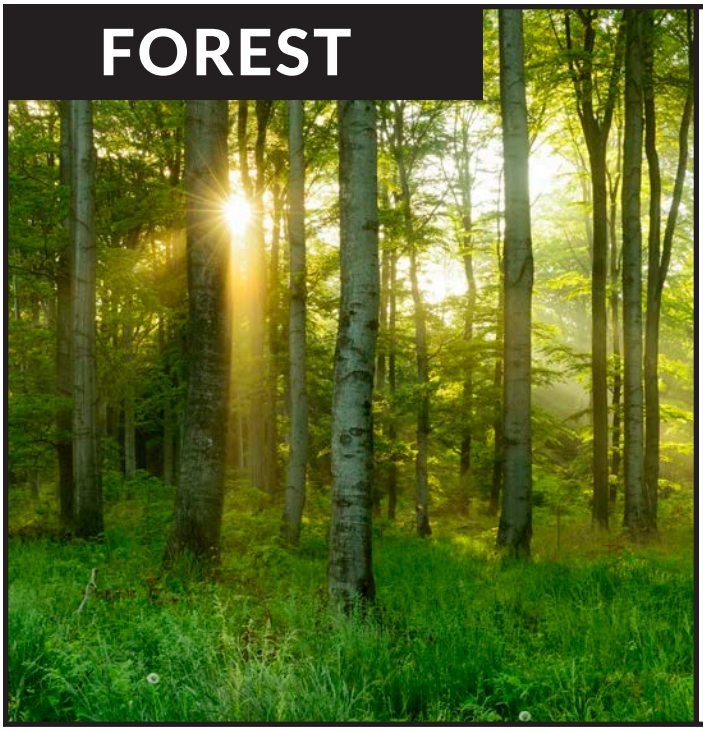
Your Watershed Address

1. Examine the map noticing the larger watershed boundaries. These boundaries are located on ridge lines as we saw in our model. Again watersheds are defined by the body of water they flow into.
2. Identify your school on the map. Label it with a black pen.
3. Find your community on the map and label it.
4. Locate bodies of water. Label lakes, rivers, streams in your area.
5. Follow where water would go from your school to the closest lake and highlight that course with the blue highlighter.
6. Continue following the water path as it reaches a lake, Puget Sound or in some cases it may seem to stop as a stream goes underground.
7. Think about all the places in the region that you visit. Do these places cross watershed boundaries? Are all these watersheds part of the larger Puget Sound Watershed?



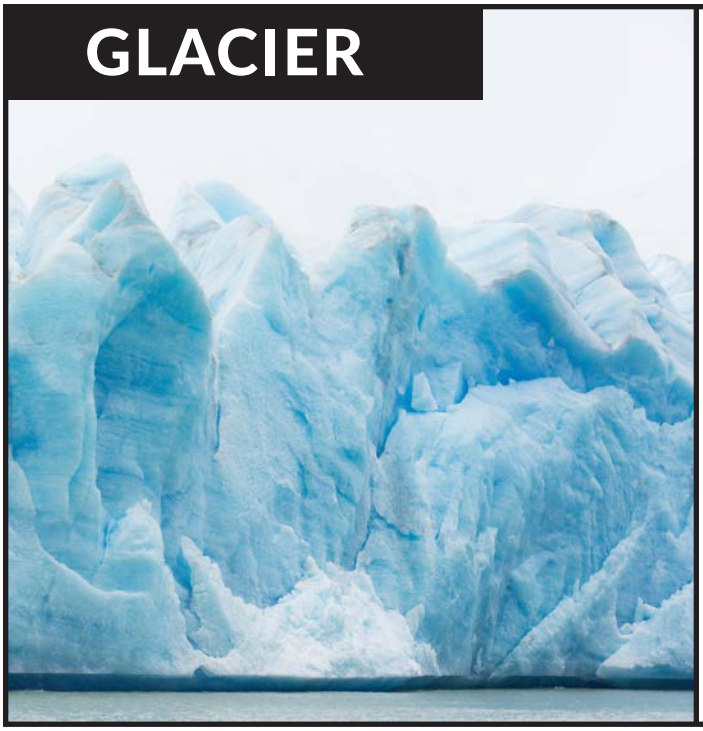
WETLAND/WATERSHED MODEL - TERMS & PHOTOS

FOREST



A group of trees that includes all plants and animals above & below ground

GLACIER

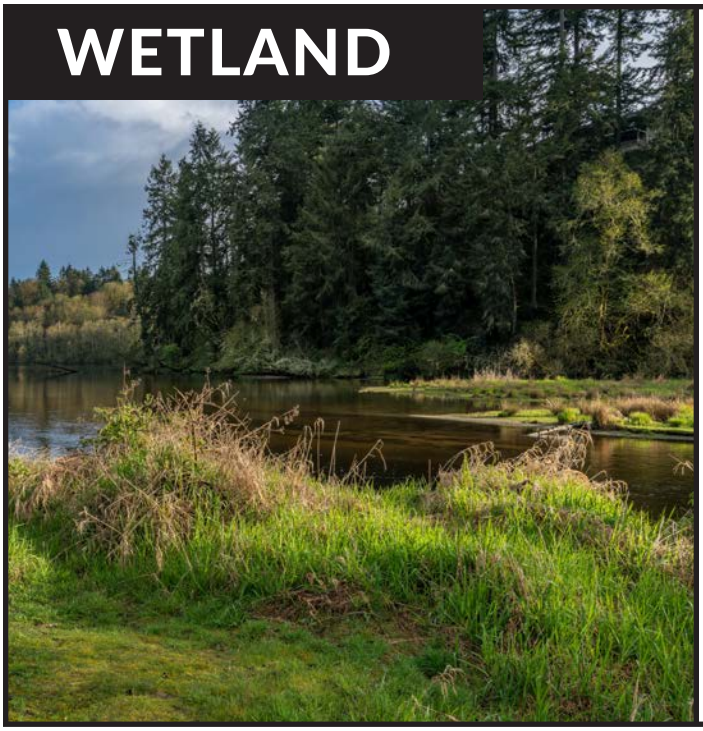


A large body of slow moving ice that melts thereby feeding creeks and rivers

PUGET SOUND

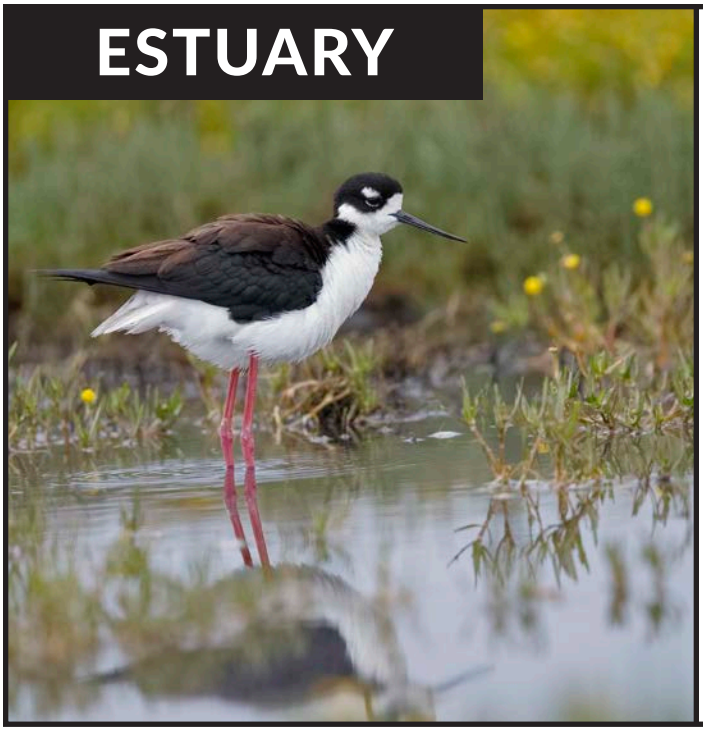
Puget Sound is a large salt water estuary, or system of many estuaries, fed by highly seasonal freshwater from the Olympic and Cascade Mountain watersheds

WETLAND



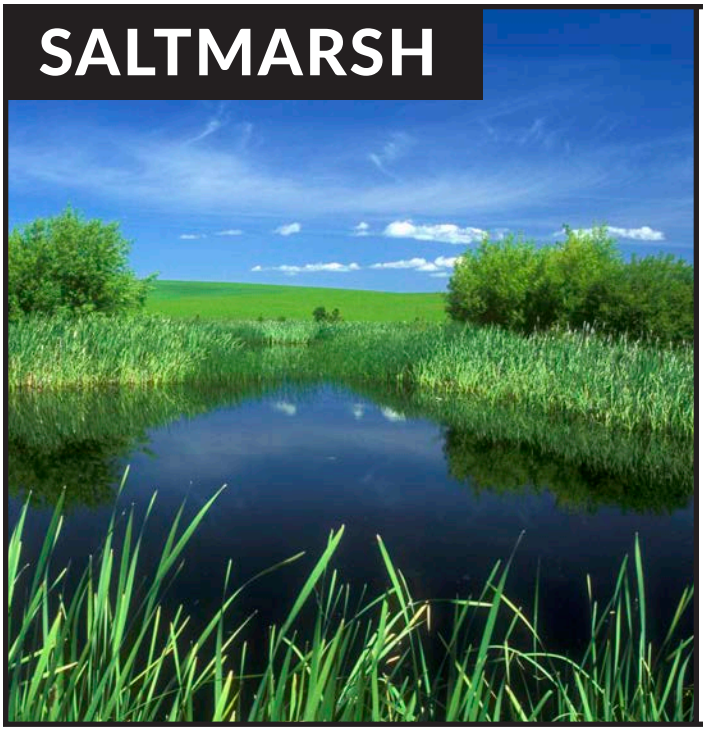
Low area covered by shallow water most of the time, where plants that like to have their feet wet grow

ESTUARY



The mouth of the river where fresh-water meets saltwater

SALTMARSH

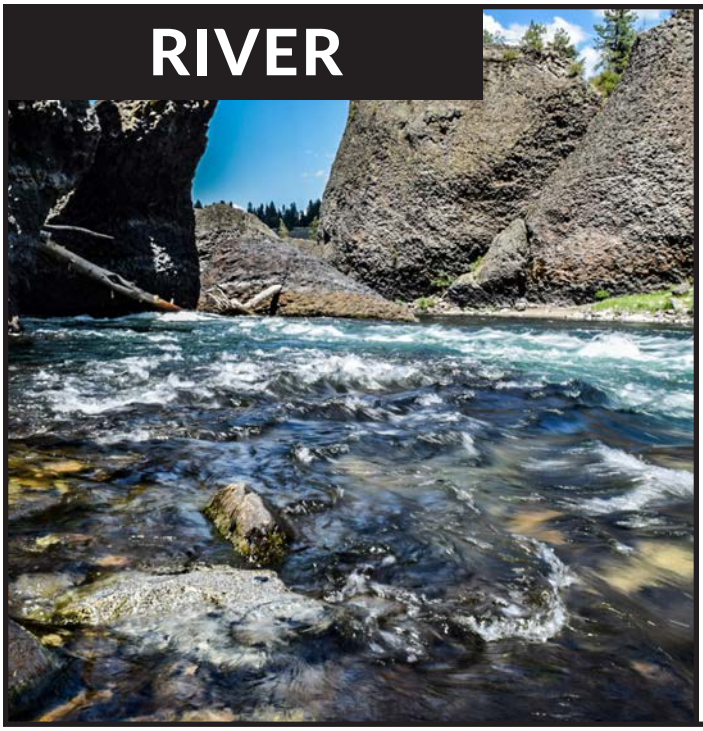


A marsh in an estuary, inundated by tides twice a day

SPRING

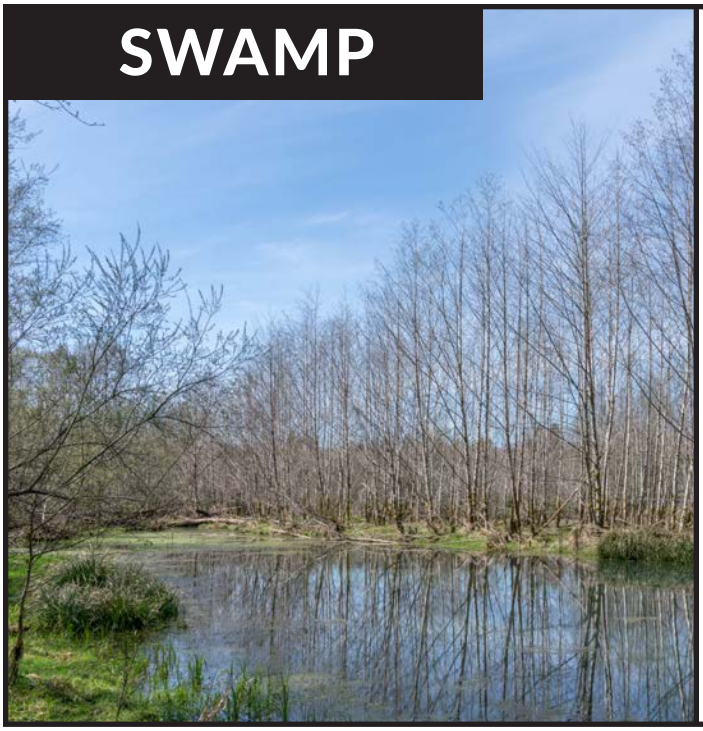
The mouth of the river where fresh-water meets saltwater

RIVER



A large body of water that runs into a lake, ocean, or other river

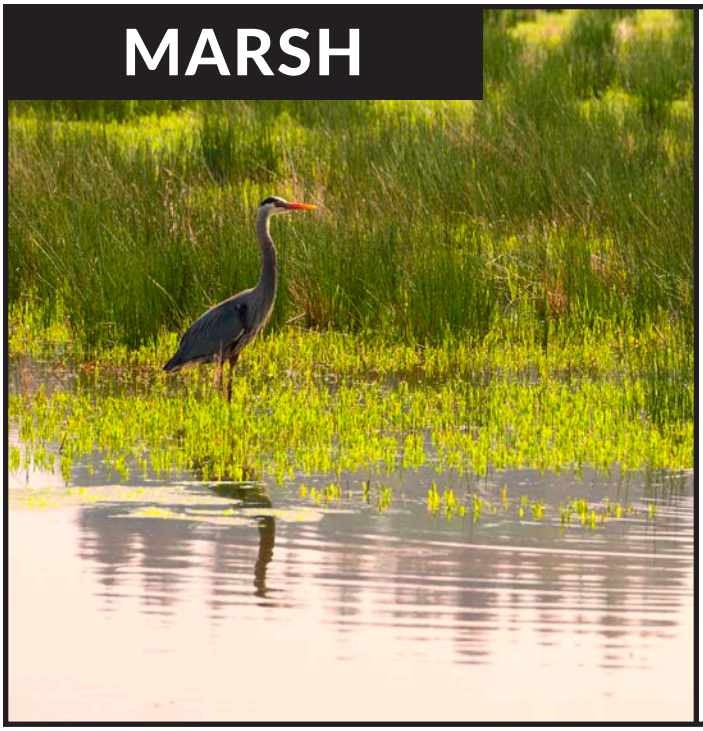
SWAMP



A wetland where mostly trees and shrubs grow

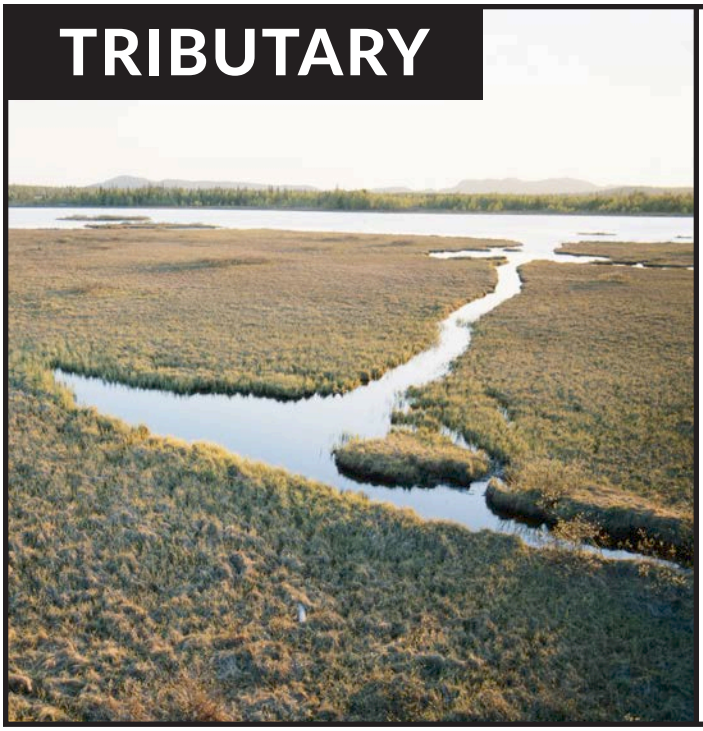
(i.e. willows)

MARSH



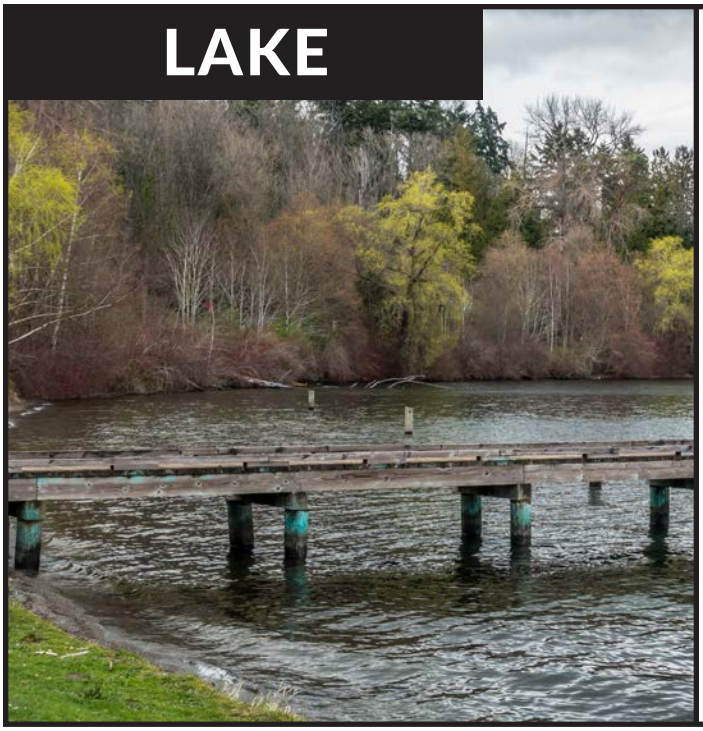
A wetland where mostly grass-like plants grow

TRIBUTARY



A stream which joins a larger body of water

LAKE



A large body of water surrounded by land

Changes in the Watersheds

Part 1 is adapted from the "Then and Now" Lesson. Science and Civics, Project WILD.

Overview

Part 1

- Students will analyze current photos and past photos of their region for vegetative cover.

Part 2

- Students will look at how urban pipe ways have changed the water flow in our urban watersheds.

Objectives

Part 1

- Students will analyze current photos and past photos of their region for percent vegetative (pervious) cover versus impervious cover.

Part 2

- Students describe the three pipe ways in urban watersheds that have changed how water flows in these watersheds.

Activities

Part 1: Then and Now

Teacher Note: Locate your school on Google Earth. Adjust the map to the preferred scale. Save the screen or do a screen clipping into a document (Power Point works well for this). Then go back to the map in the same scale and click on history tab above. There should be images from years past of the same location at the same scale. Save the screen or do a screen clipping again and save as a separate page of the document. Make both photos black and white and print enough copies for every two students.

Procedure

1. Watch all or part of the *Watershed Address* video, if you haven't already.
2. Have students read the, "Then and Now," investigation reading and answer the questions.

Science
Grades - Secondary - Indoors
Pre-Lesson 2 (50 minutes)

Materials

Part 1: Then and Now

- Current and past photos of the school's region from Google Earth or other source at the same scale
- Aerial photos from the early to mid-1990s throughout WA state: http://rocky2.ess.washington.edu/data/raster/doqs/index.html
- Another resource for photos: http://wagda.lib.washington.edu/data/type/photography/
- Another resource for photos is http://collections.washingtonhistory.org/
- Transparencies sheets
- Vis a Vis markers
- Watershed Address Videos https://www.youtube.com/watch?v=0_R6P0mj7rc

  https://www.youtube.com/watch?v=JGe0hFdhF1o

Changes in the Watershed

3. Explain to students that they are going to be doing an investigation using aerial photos to see how their part of the watershed has changed over time in terms of pervious vs. impervious surfaces. They are asking the comparative question: Which year has a higher percentage of vegetative cover (pervious surfaces) _____ or _____?"
4. Pass out the transparency sheets and the Vis a Vis markers to groups of 2-3 students. Have students lay the transparency over a 8 ½ x 11 sheet of paper and mark two corners. Give each group a number and tell them that each group is a sample and their number is their sample number.
5. Next have students randomly put 25 dots on their transparency and number them. They could do this using random number generator or dice to see where dots would go on a grid.
6. Hand out the Then and Now instruction and data collection sheet, and go over the directions. Have students turn and talk to each other about the directions.
7. Hand out the photos from the two different years to each group. Have students first look at the photos, and record any changes they see.
8. Have students follow the directions lining up the transparency on each photo and counting whether the dots land on vegetative (pervious) or non-vegetative surfaces (impervious).
9. Instruct each group of students to calculate the percentage of vegetative cover (pervious surfaces) and make a class chart of the percentages. Each group of students is a trial. Teacher Note: Because the each team observes for twenty five dots (locations) percentages can be averaged. If groups' had observed a different number of dots, percentages cannot be averaged.
10. Have students construct an explanation to answer this comparative question, "Which year has a higher percentage of vegetative cover (pervious surfaces) _____ or _____?"
11. What does this information mean for water flow and stormwater runoff in your area of the watershed? How has the Common Core ELA Standards whole region changed over time?

Teacher Note: There is an example from Mill Creek for 2010 and 1978 on pages 27 and 28.

Science
Grades Secondary
Setting Indoors
Pre-Lesson 2 (50 minutes)

Common Core ELA Standards

- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on various topics and texts, building on others' ideas and expressing their own clearly.

Part 2: Changing Water Flow – Everything Goes down a Drain

1. Review with students what they just learned about pervious and impervious surfaces and how these surfaces impact water flow in the watershed. Tell students to think about the Watershed Address video and the article they read. Ask them, "Where does the water go that comes off of impervious surfaces?"
2. Ask students to brainstorm how we use water every day. What happens to the water we use everyday?
3. Replay the portion of the Watershed Address video that talks about pipes again. Ask students, "What about all these pipes?"
4. Explain to students that urban areas have two sets of pipes and in some cities three (Seattle in particular). There are:
    a. Storm Drains that take the water from impervious and other land surfaces to creeks, streams, lakes, and Puget Sound.
    b. Sewer pipes that take our waste water from our homes, schools, and offices that goes to the sewage treatment plant to be cleaned.
    c. In some cities, some of the pipes are combined where water off of streets, driveways and other impervious surfaces combines with the sewage pipes and is sent to the sewage treatment plant to be treated before entering a lake, or Puget Sound.

5 Have students look at the diagram from Seattle Public Utility that shows the two major types of pipes. The red lines represent the path of wastewater from buildings going to a sewage treatment plant to be treated, and then flow into waterways, and the blue lines represent the path of water running off surfaces and going directly into waterways. (You may want students to work in pairs to decide what all the parts of the diagram represent.) Have students observe the diagram and then summarize what it means for how the water flows in urban areas in the watershed-where does the water go? How is this different from the natural landscapes of forests and fields? What does this mean for the quality and quantity of water reaching the water ways and the speed to which water reaches those waterways?

6. With this background knowledge about watersheds and the flow of water, tell students that they will now learn about the problems these changes cause in stormwater runoff in watersheds and how stormwater engineers help solve these problems. Further, they will follow the practices (steps) engineers use to help solve the stormwater runoff problems in their watershed.

"Then and Now" Investigation

Adapted from: http://www.doe.virginia.gov/instruction/science/elementary/lessons_bay/lesson_plans/does_it_soak/index.shtml

MAKING CONNECTIONS
PERCOLATION AND POLLUTION

What does the soil in your schoolyard have to do with pollution in the Puget Sound? Think back to the Watershed Address video we saw. You learned that when rain falls, the stormwater flows over the land picking up chemicals, garbage, pet waste, sediment and other pollutants. The video illustrated how most of this polluted surface runoff flows over "impervious surfaces", such as driveways, roads, and parking lots, and directly into storm drains that flow into Puget Sound, instead of soaking into the soil. Also, excessive runoff, especially when it flows at high rates of speed, causes erosion and flooding. Pervious (or permeable) surfaces are land surfaces that act like a "sponge" and allow polluted stormwater to soak in (or "percolate") instead of running off into storm drains. Further, pervious surfaces allow stormwater to soak in (or percolate) to slow the flow (speed) of water reducing erosion and flooding. The video compared grass versus a driveway as an example of pervious and impervious surfaces.

Some pervious surfaces are better than others at allowing water to percolate or soak in. In this field study, you will perform a percolation test to measure the rate (time) at which water soaks into the soil. The rate of percolation is determined by how porous a surface is (for example, sand v. clay), the presence of vegetation, the amount of organic matter (humus), the amount of rock in the soil, and the amount of compaction in the soil. All of these factors can affect the ability of soil to act as a sponge for soaking up polluted stormwater and reducing the speed of water flow. Soil that has less pore space does not allow water to soak in as easily (less pervious) as soils that have more pore space and contain a greater amount of organic matter (more pervious). When water can soak into a surface and travel through the ground slowly, much of the pollutants are filtered out through the soil. Water that runs off the land quickly, on the other hand, carries pollutants directly to thewaterways.

Review

1. What does impervious mean?
2. Name some examples of impervious surfaces in the city?
3. What is it called when water can soak into the ground?
4. What are two ways impervious land surfaces effect water flow in a watershed stormwater runoff?

Then and Now Comparative Investigation:

Puget Sound Starts Here

Which year has a higher percentage of vegetative cover (pervious surfaces) _____ or _____?"

1. Look over the two aerial images of the region. List structures that have been constructed, altered, or eliminated in the left column. Examples:
   - Constructed-roads, ponds, houses, industrial parks, farm buildings, and reservoirs
   - Altered-streams, rivers, and lakes
   - Eliminated-railroads, forests, trees, grassland, meadows, lakes, and wetlands
2. Place the transparency with dots over the 19 _____ photo, lining up the edges.
3. In the 19 column, record whether or not there is vegetation at each of the twenty five random dots.
4. Place the transparency with dots over the 201 _____ photo, again lining up the edges.
5. In the 201 _____ column, record whether or not there is vegetation at each of the twenty five random dots.
6. Calculate the percentage of dots that have vegetation (pervious surfaces) for each year/aerial image and write a conclusion.

Construction, Alterations and Eliminations	Dot #	19 Vegetation (Yes)	201 Vegetation (Yes)
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
	21		
	22		
	23		
	24		
	25		
	Total		
	% Veg		

Question: Which year has a higher percentage of vegetative cover (pervious surfaces)_____ or _____?

Year	Vegetative Cover %										
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Average Percent Vegetative Cover

Then and Now Comparative Investigation:

Puget Sound Starts Here

Conclusion:

Construct an explanation for this investigation.

In your explanation, be sure to:

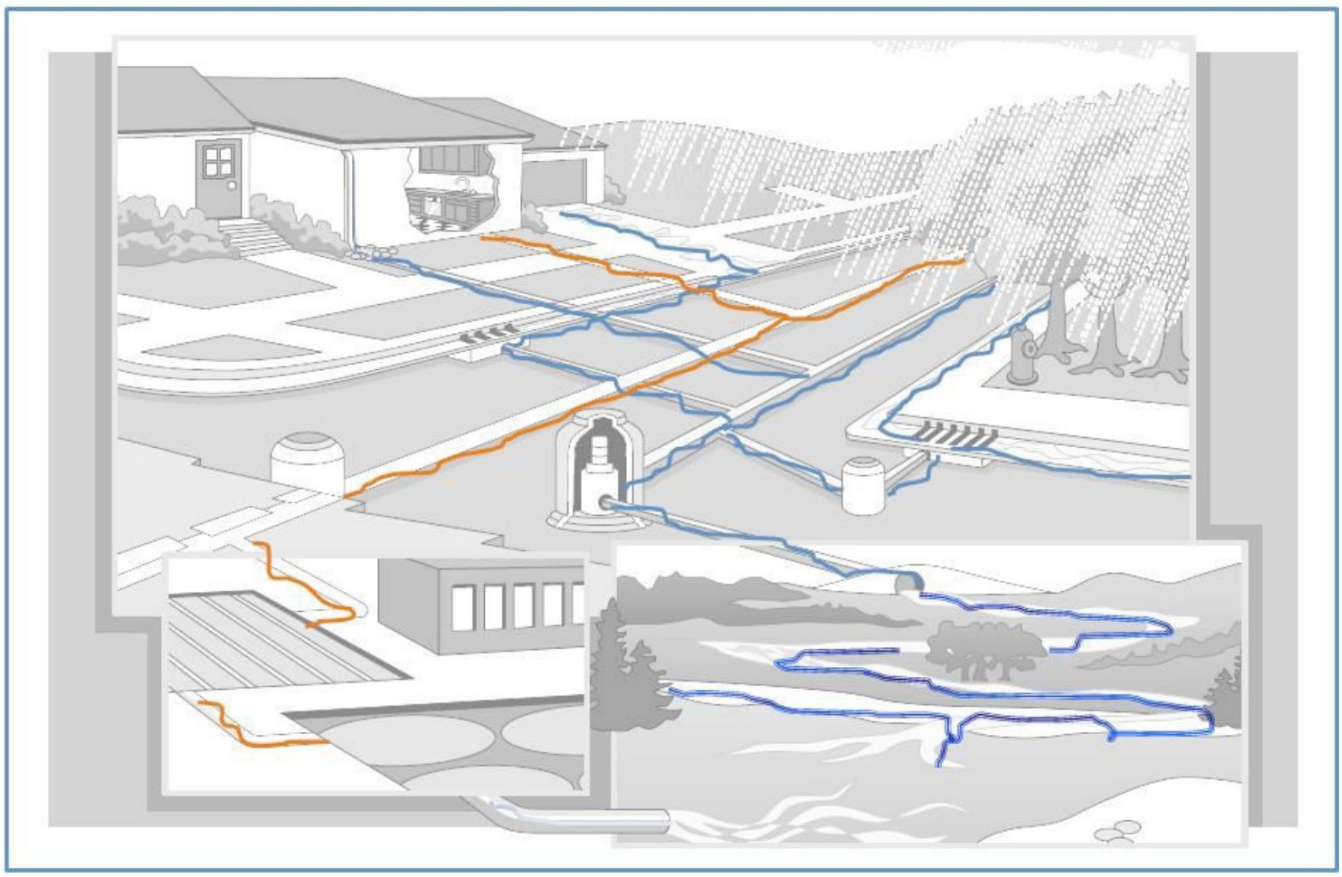
- Answer the Investigation Question.
- Include supporting evidence from the Then and Now Region Analysis table.
- Explain reasons why the vegetable cover has changed.

Investigation Question: "Which year has a higher percentage of vegetative cover (pervious surfaces)_____ or _____?"
Claim:
Evidence:
Reasoning:

Mill Creek Area 2010

Mill Creek Area 1978

Where does the Water go?



From Seattle Public Utilities
www.seattle.gov/util/

LESSON 1

What is the role of a Stormwater Engineer?

Puget Sound Starts Here

Overview

Students are introduced to the problem of stormwater pollution and how stormwater engineers work to solve this problem.

Objectives

Students describe the role of the stormwater engineer by responding to research questions and by writing an informational essay using best practices for writing.

Evaluation

Score the performance task using the three research rubrics and the Informational/Explanatory Writing Unit.

(Rubrics and scoring notes are included with this lesson.)

Activities

Day One:

1. Share with the students that they are about to begin a new unit where they will work like a stormwater engineer, using a problem based learning model, to investigate stormwater solutions on their school sites. They will follow a number of steps as they investigate the problems of stormwater pollution, understand stakeholders, evaluate options, and develop and propose a plan for improving stormwater runoff on the school site. The plan will be submitted to district administration for possible implementation. Share the essential questions for the unit. Use the list provided. Post the questions so that you can revisit these during the unit.

Science
Grades Secondary
Lesson #1 (Two Class Periods)

Materials

- Essential Questions List
- Computers for Internet Access
- Stormwater Engineers Performance Task Parts 1 and 2 Student Directions
- Stormwater Engineers Performance Task Teacher Directions and Scoring Rubrics
- "Stormwater 101" video http://www.youtube.com/watch?v=eozVMJCYHCM
- "Water Resource Engineer" video http://www.youtube.com/watch?v=_jJGblbKm5U
- Job Posting Reading

What is the role of a Stormwater Engineer?

2. Today, students will investigate the role of a Stormwater Engineer in designing many solutions to stormwater management. They will do this by reading an actual job description from a local City (Happyville) and watching videos. The students will answer three research questions today and then compose an essay tomorrow explaining what a stormwater engineer does and why this work is important to our environment. Reinforce the learning target: *I can describe the role of the stormwater engineer by responding to research questions and by writing an informational essay using best practices for writing.*

3. Distribute the performance task assessment or take the students to an online site for conducting the assessment. Students should have an entire class period to view, read, take notes, and respond to the three questions. A note taking template is provided.

4. Collect the student responses for scoring using there search rubrics provided.

Day Two:

5. Review the scenario with the students: *You have been asked by the City Happyville to create an advertisement for hiring a stormwater engineer. Your ad will be in the form of an essay where you explain what a stormwater engineer does and why this job is important to the wellbeing of our environment.*

6. Create your advertisement by writing an essay that includes the following:

    - The problems we face with stormwater
    - The role of the engineer in solving these problems
    - The qualities a stormwater engineer needs to be successful in the job

7. Provide time for the students to write their essays. Students may use their notes from the previous day and refer back to the videos and the reading.

Teacher Note: Teacher directions, start on page XX. Career cards are available on the page and sound starts here website: pugetsoundstartshere.org/drain rangers

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Science
Grades 6-12
Lesson #1 (Two Class Periods)

Common Core ELA Standards

- W #2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- W #4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
- W #7: Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- W #8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- W #9: Draw Evidence from literary or informational texts to support analysis, reflection, and research.

Essential Questions:

1. What is the role of the Stormwater Engineer and how do they solve problems?

2. What issues do we face as both a school and local community with stormwater runoff and pollution?

3. Who are the stakeholders in managing stormwater runoff and pollution and what are their interests?

4. What are solutions for managing stormwater runoff and pollution including pluses and minuses?

5. What plan will we propose to address stormwater runoff and pollution on our school campus?

6. How might the implementation of our plan be monitored and evaluated over time?

Task: Stormwater Engineers

Puget Sound Starts Here

Part 1 (60 minutes)
Student Directions

Your assignment:

Engineers are a key to problem solving in our environment. You will watch two informational videos about stormwater management and read the job description for a stormwater engineer, taking notes on these sources. Then you will respond to three research questions and write an article explaining the important work of a stormwater engineer.

Steps you will be following:

In order to plan and write your essay, you will do all of the following:

1. Watch two videos and read a job description for a stormwater engineer.
2. Answer three questions about thes ources.
3. Plan and write your article.

Directions for beginning:

You will now watch two video and read a job description, taking notes from these three sources. You may use these note in responding to the three questions and in writing your article. You can refer back to any of the sources as often as you like.

Source Information:

Source #1: Stormwater Runoff 101 (3 min. 7 sec.)
Video #1 Stormwater Runoff 101 (3 min. 7 sec.) http://www.youtube.com/watch?v=eozVMJCYHCM

Source #2: Water Resources Engineer (4 min. 51 sec.)
Video #2 http://www.youtube.com/watch?v=_jJGblbKm5U

Source #3: City of Happyville Stormwater Engineer Job Posting
Reading

Task: Stormwater Engineers

Puget Sound Starts Here

	What stormwater is	Why stormwater pollution is a problem	Ways to manage stormwater pollution
Video #1: Stormwater 101			
	What a Stormwater Engineer does	**Why this job is important**	**Key Qualifications**
Video #2 Water Resource Enginner			
Reading #1 Job Posting			

Job Posting: Stormwater Engineer

Department: Public Works, City of Happyville, USA

Start Date: Immediately AfterHiring

Salary Range: $64,776 to $85,356

Job Description:

The stormwater engineer is responsible for designing solutions to complex stormwater management problems. This person will provide leadership for managing surface water runoff including designing gray and green stormwater solutions. The stormwater engineer will manage all projects within the local watershed including watershed planning and stream restoration.

Qualifications:

Candidates must have knowledge of the following:

- Stormwaterdrainagesystemsanderosioncontrol
- Gray and Green stormwater solutions
- Federal, state and local laws and codes related to stormwater management including water quality standards and the Endangered Species Act
- Water quality testing methods
- Best Management Practices (BMP's) for maintaining a clean and healthy environment
- Computer programs including computer aided drafting and design software and Geographic Information Systems (GIS)
- Principles of environmental science
- Office software programs such as Outlook, Word, Excel and Powerpoint

Skills and Abilities:

- The ability to analyze problems and come up with creative solutions (Complex Thinker)
- Exceptional communication and interpersonal skills, both written and verbal (Effective Communicator)
- The ability to read and interpret civil engineering plans and designs
- The ability to work as a member of ateam(Collaborative Worker)

Education and Experience:

- Bachelor's Degree in Civil Engineering or Environmental Science or other education and training that results in the ability to demonstrate the knowledge and skills outlined in this job description
- Two years prior experience working in a public works or stormwater environmental department

Task: Stormwater Engineers

Puget Sound Starts Here

Questions

Use the remaining time to answer the questions below. Your answers to these questions will be scored. Also, they will help you think about the sources you have read and viewed. You may refer back to the sources or your notes when you think it would be helpful. Answer the questions in the spaces provided below them.

1. Explain the importance of stormwater management. Use details from at least two of the three sources to support your answer. Cite your sources. **(Claim 4, Target 2)**

Task: Stormwater Engineers

Puget Sound Starts Here

2. Evaluate which source, the job description or the water resources engineer video, best explains what a stormwater engineer does. Use details from the two sources to support your answer. Cite your sources. **(Claim 4, Target 3)**

Task: Stormwater Engineers

Puget Sound Starts Here

3. Would you consider a career as a stormwater engineer? Use information from the videos and the job posting in your response. Include three reasons to support your choice. Cite your sources. **(Claim 4, Target 4)**

Task: Stormwater Engineers

Puget Sound Starts Here

Your assignment:

You have been asked by the City of Happyville to write an article for hiring a stormwater engineer. Your article should explain what a stormwater engineer does and why this job is important to the wellbeing of the environment. Include the following information:

- Problems we face from stormwater
- Role of the engineer in solving these problems (stormwater solutions)
- Important qualities a stormwater engineer needs to be successful in the job

You have 70 minutes to review your notes and sources, and plan, draft, and revise your article. You may also refer to the answers you wrote to the questions in part 1 but you cannot change those answers. Now read your assignment and the information about how your essay will be scored.

Essay Scoring

How your essay will be scored:

The people scoring your essay will be assigning scores for:

1. **Statement of Purpose/Focus** – how well you clearly state and maintain your controlling idea or main idea
2. **Organization** – how well the ideas progress from the introduction to the conclusion using effective transitions and how well you stay on topic throughout the essay
3. **Elaboration of Evidence** – how well you provide evidence from sources about your topic and elaborate with specific information
4. **Language and Vocabulary** – how well you effectively express ideas using precise language that is appropriate for your audience and purpose
5. **Conventions** – how well you follow the rules of usage, punctuation, capitalization, and spelling

Word-processing tools and spell check are available to you.

Now begin work on your essay.

Manage your time carefully so that you can:

- plan your essay
- write your essay
- revise and edit for a final draft

PLANNING MY ESSAY

Introduction—Statement of Purpose:
Problems we face from stormwater pollution:
Role of the engineer in solving these problems (stormwater solutions):
The most important qualities a stormwater engineer needs to be successful in the job:
Conclusion:

Task Overview:
Stormwater Engineer

GRADE (Two 60-90 minute testing periods)

Part 1 (60-90 minutes)

Students research from three sources; two videos and a job description and take notes on these sources. They then respond to three questions about the sources.

Part 2 (60-90 minutes)

Students compose full-length informational essays on the important work of the stormwater engineer. Pre-writing, drafting, and revising will be involved.

Scorable Products: Student responses to the constructed-response questions and the essay will be scored.

Teacher Directions: Students are given the texts, research, and any additional information about the essay.

Part 1 (60-90 minutes)

- Initiate the testing session. Review the task and note taking template.
- Show each video twice while students take notes. Then instruct students to read the job description and take notes.
- Alert students when there are10 minutes remaining in part 1.

Stretch Break (Or overnight break)

Part 2 (60-90 minutes)

- Initiate the testing part 2: Review the task and the essay planning template.
- Allow students to access the sources and their answers to the constructed response questions presented in part 1.They will not be allowed to change their answers.
- Alert the students when 15 minutes remain in the testing session and suggest they begin revising their essays.
- Alert the students when there are 5 minutes remaining in the session.
- Close the testing session.

Task Overview:
Stormwater Engineer

Scoring Rubrics:

Question #1	Claim 4, Target 2
Question #2	Claim 4, Target 3
Question #3	Claim 4, Target 4
Essay	Explanatory Writing Rubric (Grades 6-11)

Informational Essay Traits and Scoring Guide:

4 – Points	Statement of Purpose/Focus; Organization
4 – Points	Language and Elaboration
2 – Points	Conventions

FIVE TRAIT VERSION

Informative/Explanatory Writing Rubric (Grades 6-11)

Score	4	3	2	1
Statement of Purpose/Focus	**The response is fully sustained and consistently and purposely focused:** • controlling or main idea of topic is clearly communicated, and the focus is strongly maintained for the purpose, audience, and task	**The response is adequately sustained and generally focused:** • controlling or main idea of a topic is clear, and the focus is mostly maintained for the purpose, audience, and task	**The response is somewhat sustained and may have a minor drift in focus:** • controlling or main idea of a topic may be somewhat unclear or the focus may be insufficiently sustained for the purpose, audience, and task	**The response may be related to the topic but may provide little or no focus:** • controlling or main idea may be confusing or ambiguous; response may be too brief or the focus may drift from the purpose, audience, or task
Organization	**The response has a clear and effective organizational structure, creating a sense of unity and completeness:** • consistent use of a variety of transitional strategies to clarify the relationships between and among ideas • effective introduction and conclusion • logical progression of ideas from beginning to end; strong connections between and among ideas with some syntactic variety	**The response has an evident organizational structure and a sense of completeness, though there may be minor flaws and some ideas may be loosely connected:** • adequate use of transitional strategies with some variety to clarify the relationships between and among ideas • adequate introduction and conclusion • adequate progression of ideas from beginning to end; adequate connections between and among ideas	**The response has an inconsistent organizational structure, and flaws are evident:** • inconsistent use of transitional strategies and/or little variety • introduction or conclusion if present may be weak • uneven progression of ideas from beginning to end; and/or formulaic; inconsistent or unclear connections among ideas	**The response has little or no discernible organizational structure:** • few or no transitional strategies are evident • introduction and/or conclusion may be missing • frequent extraneous ideas may be evident; ideas may be randomly ordered or have an unclear progression
Elaboration of Evidence	**The response provides thorough and convincing support/evidence for the controlling idea and supporting idea(s) that includes the effective use of sources (facts, and details).** • comprehensive evidence from sources is integrated; references are relevant and specific • effective use of a variety of elaborative techniques (may include personal experiences)	**The response provides adequate support/evidence for the controlling idea and supporting idea(s) and claim that includes the use of sources (facts, and details).** • adequate evidence from sources is integrated; some references may be general • adequate use of some elaborative techniques (may include personal experiences)	**The response provides uneven, cursory support/evidence for the controlling idea and supporting idea(s) that includes uneven or limited use of sources (facts, and details).** • some evidence from sources may be weakly integrated, imprecise, or repetitive; references may be vague • weak or uneven use of elaborative techniques • development may consist primarily of source summary (may include personal experiences)	**The response provides minimal support/evidence for the controlling idea and supporting idea(s) and claim that includes little or no use of sources (facts, and details):** • evidence from the source material is minimal or irrelevant; references may be absent or incorrectly used • minimal, if any use of elaborative techniques (may include personal experiences)
Language	**The response clearly and effectively elaborates ideas, using precise language:** • vocabulary is clearly appropriate for the audience and purpose • effective, appropriate style enhances content	**The response adequately elaborates ideas, employing a mix of precise with more general language:** • vocabulary is generally appropriate for the audience and purpose • generally appropriate style is evident	**The response elaborates ideas unevenly, using simplistic language:** • vocabulary use is uneven or somewhat ineffective for the audience and purpose • inconsistent or weak attempt to create appropriate style	**The response's vague, lacks clarity, or is confusing:** • vocabulary is limited or ineffective for the audience and purpose • little or no evidence of appropriate style

Score	2	1	0
Conventions	The response demonstrates an adequate command of conventions: • adequate use of correct sentence formation, punctuation, capitalization, grammar usage, and spelling	The response demonstrates a partial command of conventions: • limited use of correct sentence formation, punctuation, capitalization, grammar usage, and spelling	The response demonstrates little or no command of conventions: • infrequent use of correct sentence formation, punctuation, capitalization, grammar usage, and spelling

• Unintelligible • Insufficient (includes copied text) • In a language other than English • Off-topic • Off-purpose

Stormwater Engineer?

1. Explain the importance of stormwater management. Use details from at least two of the sources to support your answer. Cite your sources. **(Claim 4, Target2)**

	Analyze/Integrate Information Rubric (Claim 4, Target 2)
2	• The response gives sufficient evidence of the ability to gather, analyze, and integrate information within and among multiple sources of information.
1	• The response gives limited evidence of the ability to gather, analyze, and integrate information within and among multiple sources of information.
0	A response gets no credit if it provides no evidence of the ability to gather, analyze, and integrate information within and among multiple sources of information.

Scoring

- **Video #1:** Stormwater management helps to prevent pollution in the waters, keeping people healthy and the economy strong. It also leads to creating ways to collect the water before it becomes polluted like rain barrels and permeable concrete.
- **Video #2**: Stormwater management helps to prevent urban flooding. Stormwater management also keeps our environment healthy for the future. Tools used help to monitor the water quality.
- **Job Description**: Stormwater management keeps our water safe, helps to control erosion, and protects the environment from pollution. The stormwater manager also designs solutions for stormwater runoff. (Other possibilities on job description)

2 Points:

- Provides two specific details that explain the importance of stormwater management.
- References two of the three sources.
- Names the sources.

1 Point:

- Provides one detail from one or two of the sources that explains the importance of stormwater management.
- May or may not name the source.

0 Points:

- No connection is made to stormwater management
- No relevant details are provided.
- Off topic response

Stormwater Engineer?

Sample student responses represent the work of grade five students.

Sample 2 Point Responses:

Example #1: From video #1 it says that stormwater management is important because it tries to stop the rain from getting polluted and makes things like concrete that absorbs water and putting barrels underneath gutters so that they collect the water. From the text, it says that the stormwater management is responsible for designing solutions to complex stormwater problems. This includes water runoff. From video #2, it says that stormwater management is suppose to make the water clean and healthy using tools like the turbidity tool for monitoring and make it so the water doesn't overflow the streams.

Example #2: Stormwater management is important to our community. In Video #1, rainwater hits our pavements and gets into our storm drains and picks up litter such as car oil, trash, water bottles, and paper. All that litter gets into our storm drains. In Video #2, GIS software and computers also help very much to test water. Turbidity meters that use light check the clarity of the water. All these tools help to monitor the water so we can drink it.

Example #3: Stormwater management is important for many reasons. In video #1, it says you can get sick form stormwater runoff. In video #2, it says everyone needs water to live. So I personally think we need stormwater management to stay healthy and be able to drink the water.

Sample 1 Point Responses:

Example #1: If we did not do stormwater management the runoff would pick up pollutants such as trash and car oil. That would then flow into oceans and if we swim we can get sick. **(Provides only one detail. Does not name the sources.)**

Example #2: Stormwater management is important because stormwater is polluted water that affects water bodies. And if we don't stop stormwater we won't have any clean water. And if we don't have clean water or any water we won't live right. Permeable pavement and rain barrels will help with stormwater management. In Water Resources Engineering video, they use a turbidimeter and transparency tube to measure water clarity. **(Only one source is referenced.)**

Sample 0 Point Responses:

Example #1: There are many problems we face with stormwater runoff. Car oil gets picked up by runoff and is carried to streams where in turn it kills millions of fish. People can get sick swimming in a polluted beach. **(No connection is made to stormwater management.)**

Example #2: Pollution and stormwater because pollution kills and stormwater takes pollution with it. Then the pollution kills fish. Also then you can't swim at beaches. **(No connection is made to stormwater management.)**

Stormwater Engineer?

2. Evaluate which source, the job description or the water resource engineer video, best explains what a stormwater engineer does. Use details from the sources to support your answer. Cite your sources. **(Claim 4, Target3)**

	Use Evidence Rubric (Claim 4, Target 3)
2	The response gives sufficient evidence of the ability to distinguish relevant from irrelevant information such as fact from opinion.
1	The response gives limited evidence of the ability to distinguish relevant from irrelevant information such as fact from opinion.
0	A response gets no credit if it provides no evidence of the ability to distinguish relevant from irrelevant information such as fact from opinion.

Scoring Notes:

- Students must select either the job description or the Water Resource Engineer video and not both.
- Arguments for the video may include the following:
  - The video shows us what a stormwater engineer does rather than just telling us as in the job description. We see things like water testing and using technology on the job.
- Arguments for the job description may include the following:
  - The job description provides lots of details regarding what a stormwater engineer does. For example, we learn that a stormwater engineer has to solve complex problems, work with city government, manage stormwater runoff, design gray and green infrastructures, do watershed planning, and stream restoration maintenance.

2 Points:

- Selects either the job description or the video.
- Provides a general statement arguing for the resource selected.
- Includes at least one specific example from that source.
- References the other source in comparison.
- References the sources.

1 Point:

- Selects one of the sources.
- Does not compare the source selected to the other source.
- Provides a general statement with no specific example from the source selected.
- May or may not reference the sources.

0 Point:

- Unclear which source is selected or a source is selected with no rationale.
- Off topic response

Stormwater Engineer?

Sample 2 point responses:

Example #1: I think video #2 or Water Resource Engineer video explains it best because it shows you what you need to do or have to be able to be a stormwater engineer. The job description lists qualifications but doesn't show what it looks like to do the job. In the video, the engineer uses GIS (Geographic Information Software). She also uses a transparency tube which allows you to see how clear the water is and a turbidameter which is a small machine that uses light to also measure water clarity.

Example #2: I think video 2 is the best source. I think video 2 is best because it's coming from an actual stormwater engineer and we see what she does. The job description says stormwater engineers design solutions to complex stormwater management problems. But video 2 says two things about what a stormwater engineer does. #1: They locate bad or polluted waters. #2: They fix the stormwater problems. I hope you understand that video 2 is the best resource to understand what a stormwater engineer does.

Example #3: I think the job description best explains what a stormwater engineer does because it just explains exactly what the job responsibilities are. In the video 2 it says a lot of what most stormwater engineers do but it also says a lot of what she does like she said "I use a computer everyday." And maybe not all stormwater engineers use a computer every day. The job description, on the other hand, is very detailed and specific.

Sample 1 point responses:

Example #1: I think it was video 2 because she was an engineer herself. And what I learned from it was that she used a thing to see how clear the water was, and she used another thing where you put water in it and it uses light to check the water. **(Provides a reasonable rationale for selecting video 2 (she was an engineer herself) but does not reference the job description.)**

Example #2: The article best explains what a stormwater engineer does. It says a stormwater engineer designs solutions to stormwater management problems and will review and assure the quality of the problems. **(Does not reference the other source in comparison.)**

Sample 0 point responses:

Example #1: A stormwater engineer is responsible for designing solutions to complex stormwater management problems. A stormwater engineer will engineer, review, and assure the quality of project designs for county stormwater management. **(Off topic response. Does not select one of the sources as best explaining what a stormwater engineer does. Lists information in a source but does not answer the question.)**

Example #2: In Video 2, it says stormwater engineers work on water quality in other states. Readings. Also it says that stormwater engineers design solutions to complex stormwater management problems. And quality control on all storm water management. **(Does not select one source as better than the other with reasons.)**

Stormwater Engineer?

3. Would you consider a career as a stormwater engineer? Use information from the videos and the job posting in your response. Include three reasons to support your choice. Cite your sources. **(Claim 4, Target 4)**

	Use Evidence Rubric (Claim 4, Target 3)
2	The response gives sufficient evidence of the ability to distinguish relevant from irrelevant information such as fact from opinion.
1	The response gives limited evidence of the ability to distinguish relevant from irrelevant information such as fact from opinion.
0	A response gets no credit if it provides no evidence of the ability to distinguish relevant from irrelevant information such as fact from opinion.

Scoring Notes:

- States a position: "Yes, I would consider a career as a stormwater engineer" or "No, I would not consider a career as a stormwater engineer." Or "I don't know because…."
- Provides at least three specific reasons for the position stated.
- Uses information from at least one of the videos and the job posting in the response.
- References the sources

2 Points:

- Includes all of the above

1 Point:

- States a position
- Provides one or two specific reasons for the position stated.
- Uses information from only one source.
- May or may not reference the sources.

0 Points:

- No clear position is stated or a position is stated with no specific evidence to support it.
- Sources are not referenced.
- Off topic.

Sample 2 point responses:

Example #1: Yes! Yes! Yes! I would love to be a stormwater engineer. I love to do STEM-science, technology, engineering and math - and all of these are included in being a stormwater engineer. I would get to use technology on the job. Also, the posting states you need skills and have the responsibility for the design and testing of projects. I like design work. When video two told me that the engineers have to work hard, I still wanted the job!

Example #2: I would consider it as a career because I like to solve problems. In the article, they said that stormwater engineers are always responsible for stormwater problems. They also manage surface water runoff designing green and gray infrastructures. In video #1, they said that this awesome pavement can really soak in water so this polluted water will soak in the water and if they plant more grass they can improve the environment. I like improving the environment. In video #2, they explained that they try to monitor water even close to a ¼ of an inch. Also a lot of people get their masters degree and I would like to get a masters degree. Another example form video #2 is that they use a lot of technology to test the water quality and I like using technology.

Example #3: I would not consider a career as a stormwater engineer. The article says that you need to know the stormwater engineering principles and it's kind of hard for me to remember things. I understand that this job is very important, as both the article and video 2 states. But both the article and video 2 also state that you need experience or training and I don't know where I would get it. This job just does not interest me.

Sample 1 point responses:

Example #1: No because it involves getting dirty and because you have to be good at math which I am not. You also need to be able to communicate with people you work with and the people you work for. I can't communicate well with others. *(Three reasons but does not reference the sources.)*

Example #2: I don't really know. I kind of would but I kind of don't because you have to know a whole lot of things like surface water design, computer application for stormwater and much more. But why I think it would be a good job because you get paid a lot of money. *(States a position ("I really don't know.") with two reasons, not three. Fails to reference the sources.)*

Example #3: I don't think I would want to be a stormwater engineer. I don't want to be a stormwater engineer because it's dirty. I am not the kind of person who likes to get mud all over them. I'm not saying I'm a girly-girl but I just don't. I'll also have to deal with pollution. I'm just going to say this. I'm paranoid to those kinds of things. It also says I have to have the ability to creatively problem solve. I can't do that. So if you're someone like me, I don't recommend it. *(Has three reasons but fails to reference sources.)*

Sample 0 point responses:

Example #1: No because If you really like math and science, I think stormwater engineering would be a really good fit to work at. I think some stormwater engineers use a GIS (Geographic Information Software) and I think I really would be good at using that because I have a stream next to my house and I test is with my dad often.*(Position is unclear. Sources are not referenced.)*

Example #2: No. No is my answer because the job seems a little too hard but if someone else wants the job, then fine by me! I just want to be something else and that something else is a Pop Star! But if someone else wants to be an engineer that's OK. *(Position is stated with no specific evidence from the sources to support it.)*

LESSON 2

Defining the Problem: Stormwater Pollution

Puget Sound Starts Here

Overview

Students continue to explore the problems we face from polluted and too much stormwater runoff, are asked to describe the situation confronting us, and build domain specific vocabulary.

Objectives

Students define the problems we face from too much (quantity) and polluted (quality) stormwater runoff.

Evaluation

Collect the students' problem statements and summary of the situation with stormwater pollution. Note discrepancies that should be addressed in class the next day.

Activities

1. Invite students to share their insights into what a stormwater engineer does. What skills do they believe that a person must have to be a stormwater engineer? Is this a career that might interest them? Why or why not? Link the skills of the stormwater engineer problem solving.
2. Share that they will have the opportunity to practice the skills of a stormwater engineer in this unit! They will define the problems that exist with stormwater on their school campus, explore various solutions, analyze the solutions, and select one to recommend for implementation. They will learn the importance of stakeholders and consider strengths and weaknesses of each stormwater solution. They will also look at what regional stormwater managers advocate for personal behaviors called Best Management Practices (BMP's) and consider application in their home environment.
3. Share today's specific learning target: I can define the problems we face from too much and polluted stormwater runoff.
4. Today, students will view videos that describe stormwater runoff pollution. They will practice their note taking and summarizing skills by taking notes and then writing a summary statement with supporting evidence. Their focus is on understanding stormwater pollution, including the greatest polluters. Provide students with the note-taking template included with this lesson. After viewing each video, students should work as a table group comparing their notes and adding ideas.

Science
Secondary
Lesson #2 (60 minutes)

Materials

- Videos 1-4 of Drain Rangers channel: https://www.youtube.com/channel/UC4MI0TNPRaFJz7m11e7bDAg
- Watershed Report: Stormwater Pollution https://vimeo.com/32998265

  Stormwater Runoff: Florida http://www.youtube.com/watch?v=cbsWXIphewE

  Lost and (Puget) Sound: Seattle https://www.youtube.com/watch?v=o9hF2sQ5_9s
- Department of Ecology Storm Water Placemat

  https:// fortress.wa.gov/ecy/publications/documents/0710058.pdf
- Engineering is Everywhere: Stormwater Runoff Special Report

  http://www.eie.org/engineering-everywhere/curriculum-units/dont-runoff
- Note Taking template
- Vocabulary List with Definitions
- Cognitive Content Dictionary Template
- Discussion Skills
- Engineering Design
- Engineering Design Problem Solving graphic organizer

Defining the Problem: Stormwater Pollution

5. Next, share the placemat reading (make placemats from the link, not this lesson, for clearer details) with the students on stormwater pollution. Preview the reading by looking at text features. Set a purpose for the reading by referring back to the note-taking template. Provide time for students to read and then to discuss again in their small groups. Remind students to practice good discussion skills. See the protocol provided with this lesson.
6. Summarize the major vocabulary that the students have encountered and discuss the meanings of the terms. Vocabulary includes the following: stormwater; surface water; runoff; pollution; stormwater engineer; ground water; surface water. Direct students to record these terms in their journals. They will continue to add vocabulary throughout this unit. Keep a wall chart of the new vocabulary as well, adding terms that appear in the readings and videos.
7. Distribute the Engineering Design steps page. Review the engineering design steps, by asking the students to explain the steps and discuss how the steps are not necessarily linear. Note the video gives different names to the steps. A problem is a situation that needs to be fixed or resolved. The problem the students will help to solve is the problem of stormwater pollution. During this unit, the students will explore alternatives, evaluate these alternatives and propose a solution with rationale. They will replicate the thinking process that a stormwater engineer would use to design solutions and implement a plan (Engineering Design).
8. Direct the students to record the problem. Guide students to write the problem statement as a question in their notebooks. For example: What alternatives can we identify to improve the quality of stormwater runoff and decrease pollution flowing into our rivers, lakes and Puget Sound?
9. Optional graphic organizer for classes not planning on implementing a plan. Use this Engineering Design graphic organizer if you are not going to go through the entire process but want to build engineering design skills.

Science
Secondary
Lesson #2 (60 minutes)

Common Core ELA Standards

- R #4: Determine the meaning of general academic and domainspecific words and phrases in a text relevant to a topic or subject area.
- W #9: Draw Evidence from literary or informational texts to support analysis, reflection, and research.
- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on various topics and texts, building on others' ideas and expressing their own clearly.
- S/L #2: Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

What is Stormwater Pollution?

Define theProblem _____

_____

Source	Sources of Stormwater Pollution	Consequences	Solutions
Video #1			
Video #2			
Reading: Department of Ecology Stormwater Placemat			

Discussion Protocol

1. Come to discussions prepared with assigned reading and/or research completed.

2. Follow agreed upon rules for discussions:
   - Listen respectfully
   - Take turns
   - Invite all voices to share

3. Ask clarifying questions.

4. Build on others' ideas.

5. Summarize key ideas expressed.

Based on the Common Core Speaking and Listening Standards

Vocabulary

Best Management Practices (BMPs): A Best Management Practice is a behavior or action that a person performs that protects the health of the environment.

Groundwater: Water that exists underground in the cracks and spaces in soil, sand, and rock. Groundwater is stored in aquifers.

Stormwater: Water from rainfall that flows into surface water including drainage facilities, rivers, streams, lakes, or Puget Sound.

Stormwater Pollution: Anything in our stormwater that makes it unclean.

Stormwater Runoff: Water that runs off our roofs, streets and lawns; finds its way directly into waterways or storm drains and then enters our streams, rivers, lakes and Puget Sound.

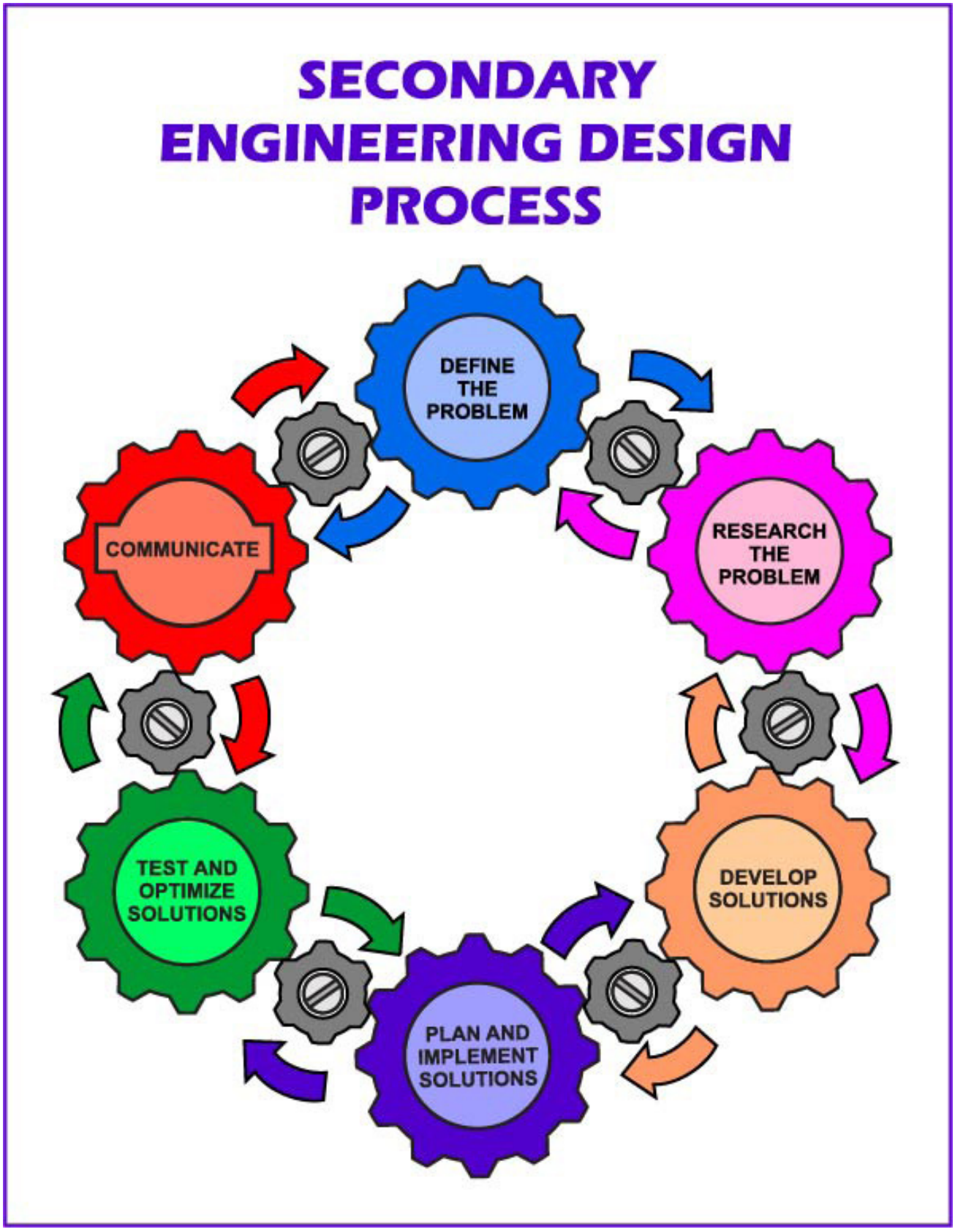
Stormwater Engineer: A person who designs solutions for problems created by surface water runoff and pollution.

Surface Water: Lakes, streams, rivers, oceans- water that exists on the surface of the planet.

Engineering Design - Problem Solving

Puget Sound Starts Here

Situation:				
Define the Problem	Problem:			
	Criteria and Constraints:			
	Possible Solutions	Solution 1	Solution 2	Solution 3
Compare Different Solutions	**Strengths:**			
	Weaknesses:			
Implement the Plan	**Proposed Solution and Plan:**			
	Reasons:			
	Optimizing Plan:			


SECONDARY
ENGINEERING DESIGN
PROCESS
DEFINE THE PROBLEM
RESEARCH THE PROBLEM
DEVELOP SOLUTIONS
PLAN AND IMPLEMENT SOLUTIONS
TEST AND OPTIMIZE SOLUTIONS
COMMUNICATE

Environment Education Guide

Protecting Washington's waters from stormwater pollution

Stormwater runoff is damaging salmon habitat. It's the Number 1 water pollution problem in the urban areas of our state, and it causes and contributes to flooding.

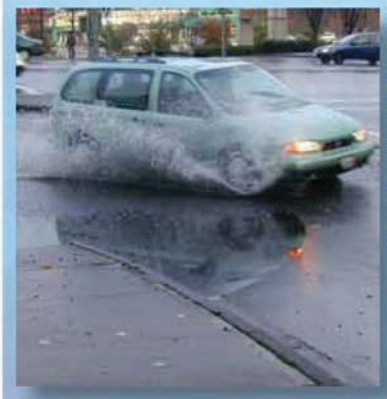


Photo: Toni Weyman Droscher

Did you know Washington has a stormwater runoff problem?

Stormwater runoff is damaging salmon habitat. It's the Number 1 water pollution problem in the urban areas of our state, and it causes and contributes to flooding.

Chances are pretty good you've seen stormwater runoff. It's the water from rain or snow that runs off yards, roofs and roadways. As gravity pulls it downhill into low spots, ditches and storm drains, the water picks up soil, chemicals and other pollutants and carries them into our lakes, rivers and marine waters.

Our waters and salmon as well as other fish and wildlife species aren't the only things at risk. Stormwater problems also affect the health and safety of people.

As we develop land to accommodate Washington's growing population, our state's stormwater problem grows, too. The good news is we can do something about it—all of us.

In Washington, the state Department of Ecology, the U.S. Environmental Protection Agency and local governments all work together to regulate stormwater.

The key to solving the problem isn't really in the rules and permits. It's in people—how we live on the land and the everyday choices each of us makes.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

From rain to runoff — what comes down must go somewhere...

If you want to understand stormwater, watch what happens the next time it rains. Pay attention to how shapes and surfaces determine what happens to the water.

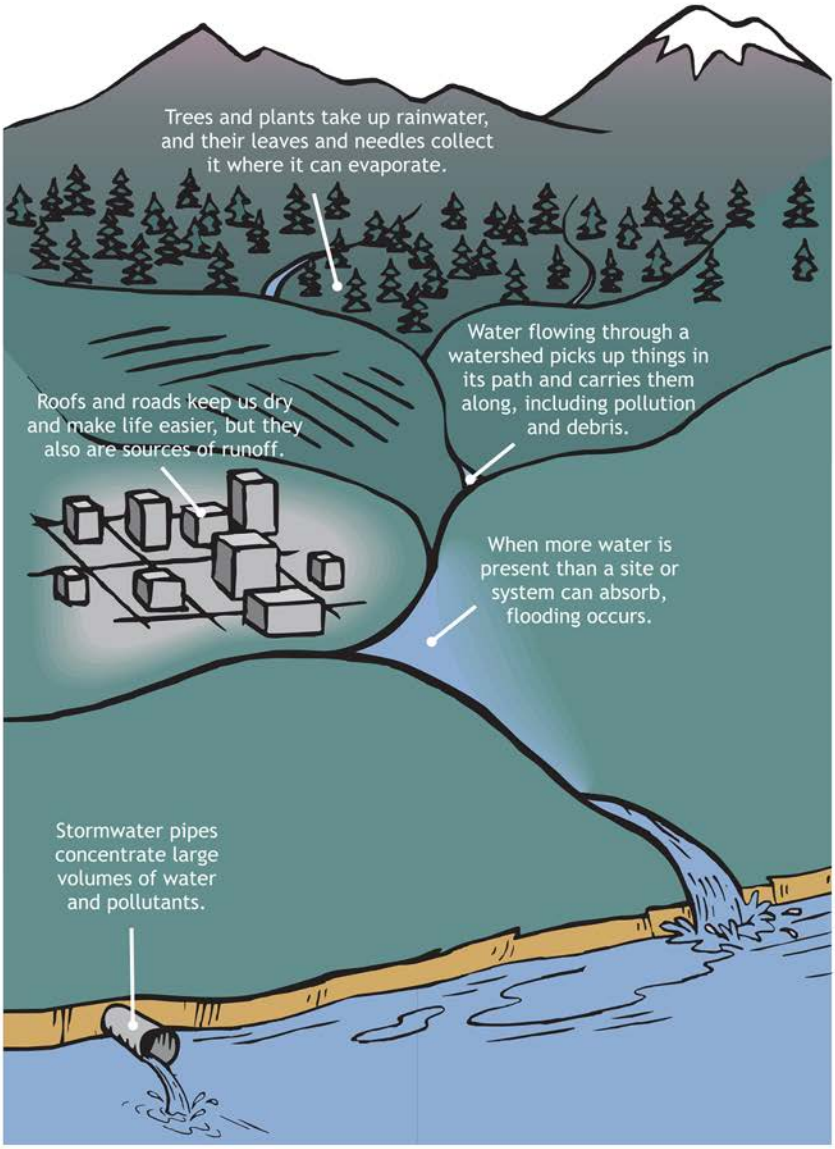
Watch how rainwater flows downhill and collects in low places. See how quickly it starts running down a downspout or into a gutter. Feel how pavement stays hard but soil gets soft. Pay attention to what the water sweeps along in the gutter and where there's an oily sheen on a puddle. Notice what happens to streams and rivers. Notice how runoff seems to be everywhere in the city and is harder to find in the forest.

In Washington's forests, the needles of evergreen trees hold a lot of rain—as much as 40 percent of a low intensity rainfall.

The landscape connection is the key to stormwater runoff

On undeveloped sites, water from rain or snow follows natural patterns of drainage and circulation. Much of the water seeps down into the soil and into underground water supplies. In forests and grasslands, trees and other plants will take up some of this water. Water will also collect on their leaves and needles and evaporate.

Wetlands absorb and hold runoff. In a natural or near-natural setting, the water that does run off directly into streams or other waters is usually filtered and slowed by the web of plants it runs through, a sort of natural purifying system.



A watershed is all the land that drains to the same body of water. A watershed's natural drainage system includes a network of streams and rivers. In a large watershed, many different sources and land uses can contribute to stormwater runoff.

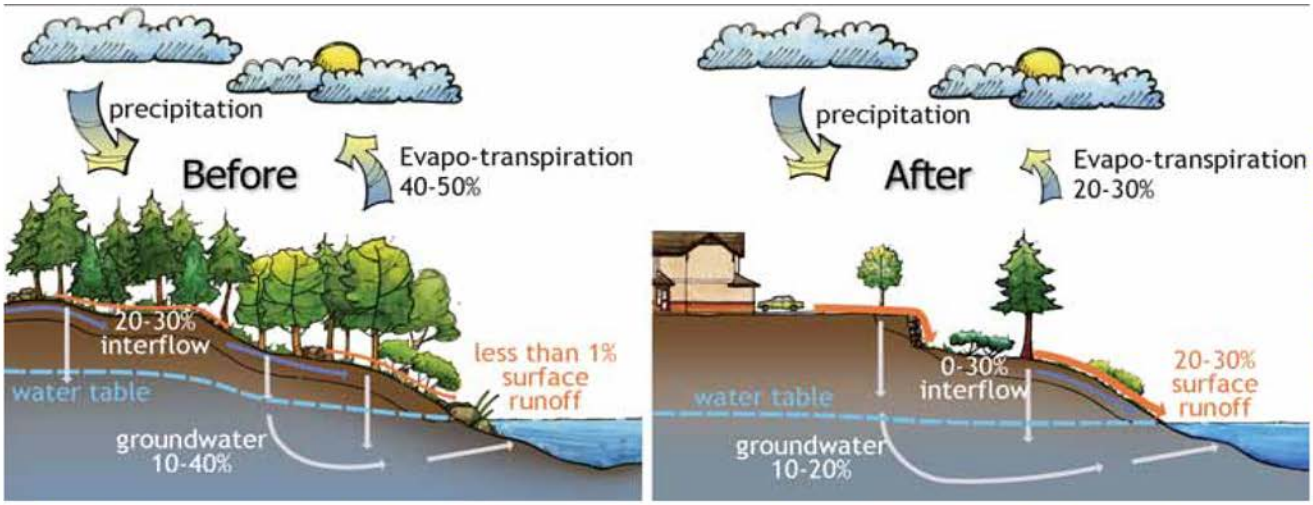


Image courtesy of Puget Sound Partnership

Before *development almost all rainfall is taken up by plants, evaporates or infiltrates through the ground.*
After *conventional development, surface runoff increases significantly while evaporation and infiltration into the ground decrease.*

Developing land typically has meant removing trees or other vegetation, reshaping the land, compacting soil, and creating hard surfaces. These changes alter the natural water patterns, or hydrology, of a site. Much of the water that plants and soil previously would have absorbed now runs off into local waters, either directly or through a system of gutters, ditches, swales, or pipes. These systems collect runoff and concentrate the flow, quickly conveying it into streams or other waters.

Covering as little as 10 percent of a watershed with impervious surfaces can degrade streams, harming salmon, trout and other aquatic life.

The way we use and develop the land changes not only where stormwater goes and how fast it gets there, but also what it meets along the way—parking lots, roads, roofs, farms, ranches, ball fields and more. Whatever stormwater runoff picks up from these places, it carries into Washington's waters.

Water flowing through a watershed picks up things in its path and carries them along, including pollution and debris.

How much stormwater do we make?

POTENTIAL RUNOFF	1,200-square ft. roof	1-acre of pavement
1 inch of rain or snow melt	748 gallons	27,150 gallons
Average annual precipitation		
Seattle (37 in./yr)	27,700 gallons	1 million gallons
Spokane (17 in./yr)	12,700 gallons	0.5 million gallons
Olympia (51 in./yr)	38,100 gallons	1.4 million gallons

Roofs, roads and paved parking lots keep us dry and make life easier, but they are also common sources of runoff. Imagine all the roofs and roads in your area and across the state, and imagine how much runoff they generate.

Precipitation data source: NOAA - Average annual precipitation, 1971-2000. Figures have been rounded.

Washington's growing problem with stormwater runoff

Altered flows — too much, too soon and too little, too late

Stormwater often gets to where it's going faster after an area is developed. Runoff quickly flows into streams and other surface waters instead of seeping into the ground to recharge groundwater and slowly feeding those streams year round.

The results include much higher stream flows and flooding when it rains (especially during heavy rains), and much lower stream flows in the dry season. These extreme high and low flows are bad for salmon, trout and other fish as well as people and communities.

The high-energy, faster, heavier flows erode stream channels and scour streambeds, churning up silt and damaging spawning areas. The energy from high flows also flushes away tiny aquatic life that serve as part of trout and salmon's diets and part of a healthy stream.

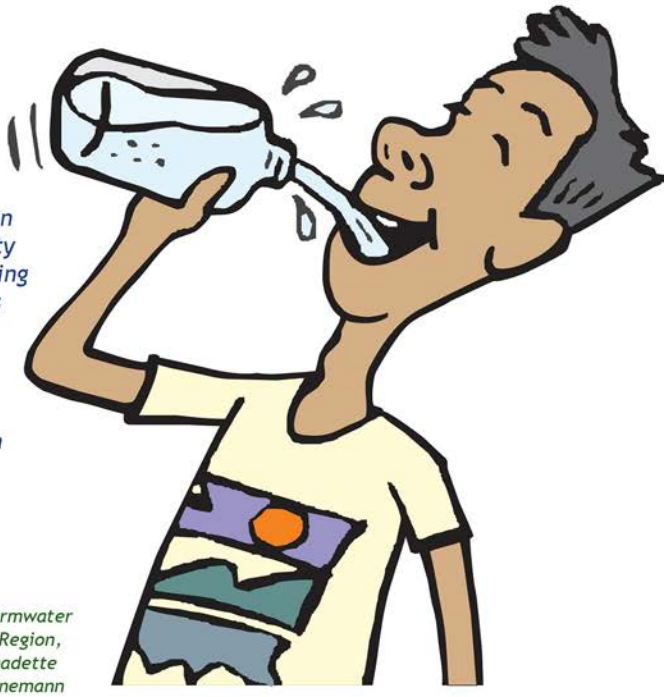
Extreme low flows are also a problem for fish. Some urban streams that used to run year round sometimes dry up in the summer. Others have too little flow to allow salmon to swim up them to spawn. Hardened surfaces contribute to this problem by interrupting the natural water-absorbing process. Rainfall hits these hard surfaces and escapes directly into rivers rather than soaking into the ground to recharge underground water supplies that feed small streams in the summer months.

Did you know...?

- *Economic costs related to stormwater in the Puget Sound region are expected to exceed $1 billion over the next decade.**
- *Even the drier east side of the state has to deal with stormwater, especially in urban areas. If laid end-to-end, Spokane's storm sewers would stretch all the way to Seattle and back.*

There are other flow-related impacts, too. Flooding from extreme high flows can damage private property, public roads and utilities. And when stormwater runs off instead of seeping into groundwater, some wells may go dry.

With high amounts of hardened or paved surfaces, urban areas generate more and faster runoff, increasing the risk of flooding.



Stormwater runoff can affect both the quality and quantity of drinking water supplies. Cities and counties require more stormwater protection in areas near public supply wells to protect them from pollution.

* *Damages and Costs of Stormwater Runoff in the Puget Sound Region, 2006; Derek B. Booth, Bernadette Visitacion and Anne C. Steinemann*

LESSON 3

Researching the Problem:
Best Management Practices

Science
Secondary
Lesson #3 (60 minutes)

Overview

Students explore the Best Management Practices (a behavior or action that a person performs that protects the health of the environment) that guide the work of stormwater engineers and complete a Community Connection where they reflect on actions they can take to improve the health of the environment.

Objectives

Students practice the skills of a stormwater engineer by explaining selected Best Management Practices for stormwater management.

Evaluation

Ask students to complete the exit slip provided:

- Name and define two Best Management Practices important for stormwater management.
- Explain why it is important for people to follow the Best Management Practices.

Activities

1. Share with the students that today they will examine practices that should guide all of us in helping to keep our stormwater free of pollutants. These Best Management Practices must be followed and encouraged by the stormwater engineer. Refer back to the job description to point this out.
2. Review the learning target with the students. *I can practice the skills of a stormwater engineer by explaining selected BMP's for stormwater management.*
3. Explain what a Best Management Practice is. These practices address the issue of stormwater pollution. Note that they are a set of rules to follow so that we can make decisions that preserve and protect the environment. The Best Management Practice descriptions provided by King County (from its Stormwater Pollution Prevention Manual) defines the issue, provide minimum requirements for addressing the issue, and include other options and tips.

Materials

- King County Best Management Practices for Stormwater Management
- Best Management Practices Overview
- Stormwater Problems: Our Role
- Brief Writing Rubric
- Chart paper and pens for jigsaw

Researching the Problem:
Best Management Practices

Science
Secondary
Lesson #3 (60 minutes)

Teacher Note: Explaining what a Best Management Practice is and why these are important would also make a great short write where students are practicing CC ELA skills of reading and responding. If you choose to make this a writing activity verses small group discussions, then score the student responses with the Brief Writing Rubric provided.

4. For practice, ask students to consider what a Best Management Practice might be for bike safety, good nutrition, or safety in the gym. Instruct the students to brainstorm a BMP for one of these topics, including the points listed above: description of the problem, minimum requirements for solving the problem, and other options and tips. For example, students might describe that bike riding is dangerous due to traffic and the potential for accidents and injury. The minimum requirements for bike safety might include wearing a helmet, having bike reflectors, riding on the proper side of the street, etc. Additional tips might include yearly safety inspections for break and tire wear, reflective clothing, etc. Share that by thinking through what works best in a given situation, we can make safer, more effective choices and implement these with knowledge and skill. Engineers must be knowledgeable and thoughtful to recommend and enforce good choices!
5. Invite students to read the overview of Best Management Practices for homeowners along with one management practice such as automobile washing. With a partner or as a table group, ask the students to explain what a Best Management Practice is and why these are important. Students should use examples from the text to support their ideas.
6. Facilitate a jigsaw of selected BMP's from the King County *Stormwater Best Management Practices manual or the Stormwater Problems: Our Role*. These are representative of the whole Puget Sound region. Use the descriptions included with this lesson. The included Best Management Practices are: Residential Automobile and Boat Washing; Residential Storage of Solid and Food Waste; Residential Automobile Repair and Maintenance; Residential Hazardous Waste Use, Storage and Disposal; Residential Gardening and Lawn Care; Residential Maintenance and Repairs: Pet Waste; In my Yard; In my House; in my Car.

Common Core ELA Standards

- R #2: Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.
- W #8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- W #9: Draw Evidence from literary or informational texts to support analysis, reflection, and research.

Researching the Problem:
Best Management Practices

Science
Secondary
Lesson #3 (60 minutes)

7. Group students so that the lower readers have support from more capable readers. Ask students to summarize their assigned BMP's using the following outline:
    - The Issue
    - Minimum Requirements (The rules to follow to address the issue)
    - Other Options and Tips (Additional suggestions to prevent pollution)

    Students should put their summary on a piece of chart paper for posting in the classroom. They are encouraged to illustrate their posters to more effectively communicate the message.
8. Debrief the activity: What would it take to effectively implement and manage these BMP's? What information do people need in order to follow the rules for Best Management Practices? What criteria might we use to see if the BMP's are effective?

Optional: School-Home/Community Connection:

- Students could do a home survey about how much water they use or if they are doing any of the Best Management Practices.
- Students could share the Stormwater Problems: Your Role pamphlet with their families.

Researching the Problem:
Best Management Practices

This chapter consists of a series of information sheets listing the best management practices (BMPs) that are the rules for single family homes in the region to improve the quality and quantity of stormwater runoff. The activity sheets in this chapter target typical household activities that have the potential to pollute stormwater, surface waters, and groundwater.

Stormwater pollution occurs when water runs over the ground, picks up pollutants, and washes the pollutants into surface and ground waters. Street storm drainage systems are designed to prevent local flooding by carrying stormwater runoff to nearby streams and rivers. These drainage systems do not remove pollutants such as motor oil or soap.

Even small amounts of commonly used household products such as motor oil, pesticides, paint waste, and soaps are harmful to aquatic life. Although individual activities may appear insignificant, runoff from urban areas is now a leading cause of water pollution in rivers, lakes, and Puget Sound.

Puget Sound Starts Here's goal is to reduce pollution by educating homeowners and residents to prevent the contamination of stormwater runoff into our streams, rivers, lakes, and groundwater. What might be criteria to see if educating homeowners and residents is working?

Automobile and Boat Washing

Requirements: Activity Sheet R-1

The Issue:

Automobile washing is one of the most common residential activities that pollutes surface water, streams, creeks, lakes, and Puget Sound. In addition to soap and dirt, vehicle wash water carries oil, grease, solvents, nutrients, and metals and to our local water bodies. The soaps and detergents that we use to wash automobiles can be more of a pollution threat than the grime washed off the automobiles. Even soaps that are labeled "biodegradable," "environmentally friendly" or "nontoxic" are harmful to aquatic life and water quality. The "nontoxic" label simply means the soap is less toxic to the user.

Minimum Requirements:

The following BMPs, or equivalent measures, methods or practices are required if you engage in automobile or boat washing at your home.

1. It is acceptable to rinse down the body of a vehicle/boat with just water without doing any washwater BMPs. The wash water is diverted from the storm drain, i.e. wash water will infiltrate.
2. If you wash your automobile or boat using mild detergents (pH neutral) on an area that allows for infiltration of the wash water, such as gravel, grass, or loose soil, it is acceptable to let the wash water infiltrate as long as you only wash the body of the vehicle (i.e. not the undercarriage or engine).
3. If you wash on a paved area such as your driveway and use soaps or other cleansers, you should do ONE of the following:
    - Redirect the wash water to vegetated areas such as landscaping or your lawn. This can be accomplished by using temporary measures such as a berm, boom/socks, or other solid materials like a piece of lumber placed at the low point of where your vehicle is parked. This will direct the flow of water to your lawn or landscaping.
    - Use a wet vacuum to collect the wash water and then dispose of the wash water to your sink or toilet for treatment at your local sewage treatment plant.

Other Options and Tips:

1. Take your vehicle to a commercial car wash where wash water is recycled and discharged to the sanitary sewer. This also reduces the amount of water used for vehicle washing.
2. Use a hose nozzle with a trigger and shut it off when you're not using it to conserve water.
3. Never clean or pressure wash the engine or undercarriage of your automobile at home. The oil, grease, and other pollutants from this activity can contaminate your property, as well as groundwater such as shallow aquifers. This is especially important in areas where wells provide potable water. For this type of cleaning, take the vehicle to a commercial car wash where wash water will be treated appropriately.
4. There are several waterless car wash products on the market. These products are designed to clean and protect your vehicle without using water. Cloths, rags, etc. used with these products should be disposed of as solid waste.

For more information or assistance in implementing these best management practices, contact the King County Department of Natural Resources and Parks Water and Land Resources Division at 206-296-1900.

Storage of Solid and Food Wastes

Requirements: Activity Sheet R-2

The Issue:

Improper storage of household garbage and other wastes can lead to a variety of pollutants in storm water runoff. Waste such as leaking garbage cans, yard waste containers without lids, scrap piles, and junk vehicles and equipment can cause polluted runoff from your property to drain to surface and groundwater. Contaminants such as oils, greases, nutrients, bacteria, pathogens, and suspended solids are carried to our creeks, streams, lakes, rivers, and Puget Sound.

Minimum Requirements:

The following BMPs, or equivalent measures, methods, or practices are required in storage of solid and food wastes at your home.

1. Dispose of unwanted garbage or scrap in your regular garbage service pickup containers, or dispose of garbage and scrap at a landfill or transfer station. Do not let garbage accumulate at your residence. The accumulation of garbage is a surface water concern and a health issue. Accumulated garbage can attract rodents, rats, mosquitoes, and other pests that are also health hazards.
2. Waste stored outside should be kept in covered containers or be covered with a tarp. All waste containers that are outdoors should have lids.

Other Options and Tips:

1. Recycle as much as possible. Someone else may be able to use leftover paints, finishes, cleaning materials, building materials, etc. Contact a neighbor, friend, school, church, or community group to see if your left over materials can be used.

Automobile Repair and Maintenance

Requirements: Activity Sheet R-3

The Issue:

Many people prefer to repair and maintain their vehicles at home. Those that do need to ensure that these activities do not pollute our streams, rivers, and lakes. Automobile maintenance and repair activities can introduce chemicals such as oil, grease, antifreeze, hydraulic and brake fluids, and metals to our surface and groundwater. A recent study estimated that the amount of oil running off our streets and driveways and ultimately flowing into the oceans is equal to an Exxon Valdez oil spill – 10.9 million gallons – every eight months (NRC, 2002).

Minimum Requirements:

The following best management practices (BMPs) or equivalent measures, methods, or practices are required if you engage in automobile repair and maintenance at your home.

1. Collect all used oil, antifreeze, or other vehicle fluids in containers with tight fitting lids. Do not mix these fluids in the same container as this limits your ability to recycle the oil at your local auto parts store or service station.
2. Never dispose of used oil, antifreeze, or other fluids into a storm drain, into a ditch, or onto the ground. Oil should be recycled at an auto parts store or service station. Other fluids can be disposed of at a household hazardous waste collection site.
3. Never clean the engine or undercarriage of your vehicle at home. For this type of cleaning, take the vehicle to a commercial car wash facility.
4. Use drip pans, tarps, or even cardboard and newspaper under the vehicle to capture leaks or spills that may occur during maintenance and repair activities. This ensures spilled fluids won't be washed to the storm drainage system the next time it rains.
5. Clean up spills with rags or absorbent material, such as sand, dirt, or cat litter. Do not wash down or hose down these spills to the curbs, roadway, or storm drains. Sweep up absorbents and dispose of them in your garbage can.
6. Store automotive parts, such as batteries, engines, transmissions, and other parts that may have oily or greasy residue on them, under cover and off the ground to minimize rainwater contact. Rainwater can wash pollutants off these parts and send pollutants to storm drainage systems and groundwater. Tarps are an inexpensive and easy solution to covering parts.

Other Options and Tips:

1. Take your vehicle to a commercial car repair facility where fluids are handled, recycled and disposed of correctly to avoid pollutants being introduced to our local water bodies. The EnviroStars Program certifies businesses for reducing, recycling, and properly managing hazardous waste. See http://www.envirostars.com/ to search for businesses that have earned the EnviroStars rating.

For more information or assistance in implementing these best management practices, contact the King County Department of Natural Resources and Parks Water and Land Resources Division at 206-296-1900.

Hazardous Waste Use, Storage,and Disposal

Requirements: Activity Sheet R-4

The Issue:

There are a variety of hazardous materials routinely used in and around our homes including chemical cleaners, pesticides, paints, solvents, lighter fluid, gasoline, antifreeze, brake fluid and other automotive products, wood preservatives and even batteries from our electronic equipment.

Improper disposal and failure to keep hazardous products from rainwater contact may cause surface and groundwater pollution. With so many hazardous compounds present in thousands of households in King County, the cumulative adverse effects of poor usage, storage and disposal practices are potentially severe to our environmental health.

Minimum Requirements:

The following best management practices (BMPs) or equivalent measures, methods, or practices are required when using or storing hazardous wastes at your home.

1. Store all hazardous materials inside a building or shed or under cover. Do not expose hazardous materials to rainwater that can transport hazardous pollutants to surface and groundwater.
2. Use products only as specified on labeling directions.
3. Dispose of and recycle hazardous wastes through a local Household Hazardous Waste Program or other recycling programs or businesses, or carefully follow disposal directions on containers of chemicals.
4. Never allow hazardous chemicals to be discharged or dumped into storm drainage systems or on to the ground.

Other Options and Tips:

1. Reuse and recycle as much as possible. Someone else may be able to use leftover paints, finishes, cleaning materials, building materials, etc. Contact a neighbor, friend, school, church, or community group to see if your left over materials can be used.
2. Use the least toxic product available. See http://www.govlink.org/hazwaste/house/alternatives for information on finding alternatives to hazardous household products.

Gardening and Lawn Care

Requirements: Activity Sheet R-5

The Issue:

Many pollutants can enter stormwater systems, groundwater, and water bodies as a result of typical lawn and gardening work. Runoff that is contaminated by pesticides and fertilizers can severely degrade receiving waters and result in adverse effects on fish and other aquatic life. Recent studies in the Puget Sound region detected pesticides in urban streams at levels that exceed limits set to protect aquatic life. Some gardening chemicals are also harmful to children and pets.

Fertilizers add nutrients to water bodies causing unwanted algal blooms and other aquatic plant growth. Disposal of grass clippings and other vegetation into storm drains, stormwater ponds, roadside ditches and other water bodies can lead to decreased oxygen levels in stormwater as the vegetation decomposes. Decreased oxygen levels can be lethal to fish and other aquatic life. Several simple practices can be used to prevent these problems, and may result in improved lawn and garden quality. These practices should also be shared with private landscapers that conduct gardening and lawn care on your property.

Note: The term pesticide includes insecticides, herbicides, fungicides, rodenticides, etc.

Minimum Requirements:

The following BMPs, or equivalent measures, methods, or practices, are required if you are engaged in gardening and lawn care at your home:

1. Never apply herbicides, insecticides, rodenticides, or fungicides along the banks of stream and drainage channels with flowing water, or along the shores of lakes and wetlands. Never apply these chemicals when it is raining.
2. Manually or mechanically remove weeds and other pests rather than using pesticides in areas of running or standing water.
3. Store all bags or piles of fertilizers and containers of pesticides in a covered location such as a garden shed.
4. Do not sweep or dump grass clippings, leaves, or twigs into any street, drainage ditch, or stormwater facility or pond.
5. Store piles of beauty bark and other erodible materials on lawns or other pervious areas. If these materials are stored on impervious areas such as driveways, cover them with a tarp so that rainwater does not wash the materials into storm drains or ditches.

(Turn Over)

Gardening and Lawn Care

Requirements: Activity Sheet R-5 *(Continued)*

Other Options and Tips:

1. Purchase and use the least amount of pesticides necessary and always follow the label directions for application. Try pest control measures that do not require chemicals first.
2. Compost your yard wastes, or use yard waste as mulch in your yard or garden. Contact your local solid waste utility to see if yard waste pickup service is available.
3. Educate yourself about alternatives to chemical pesticides and fertilizers such as integrated pest management techniques..
4. Limit the amount of lawn and garden watering so that surface runoff does not leave your property. Check automatic sprinkler systems to ensure water is dispersed to landscaped areas and not to hard surfaces such as driveways and sidewalks that drain to storm drainage systems.
5. Avoid planting species on the Noxious Weeds list.

For more information or assistance in implementing these best management practices, contact the King County Department of Natural Resources and Parks Water and Land Resources Division at 206-296-1900.

Reader Note: *The above requirements are the minimum required BMPs. If these BMPs fail to prevent discharges to the storm drainage system, you will be asked to take additional measure to correct the continued pollution discharges.*

Maintenance and Repair

Requirements: Activity Sheet R-6

The Issue:

There are a variety of home maintenance and repair activities routinely carried out by homeowners in King County that have the potential to adversely affect our streams, rivers, and lakes. Pollutants generated from these activities can affect whether a lake or water body is swimmable or fishable.

Painting, pressure washing, carpet cleaning, moss control, and concrete repair and maintenance are a few examples of activities homeowners conduct that can result in pollutants being discharged to drainage systems, surface water, and ground water. Wash water from these activities contain chemicals, suspended solids, organic compounds, detergents, solvents, abnormal pH, and other toxins that have a detrimental and toxic effect on fish and other aquatic life.

Minimum Requirements:

The following BMPs, or equivalent measures, methods or practices are required when conducting residential maintenance and repairs at your home.

1. Do not dispose of any wastewater into the street, gutter, storm drain, or drainage ditch, or into a stream, creek, or other body of water.
2. **PAINTING:** Do not dispose of wash water from cleaning brushes, paint rollers, paint buckets, or containers to surface water, storm drains, or ditches. Wash water from latex paints can be disposed of to the sanitary sewer. Empty containers of latex paint can be left open to dry out any residual paint, and then disposed of in your normal garbage or taken to a transfer station for disposal. Residual oil based paint, paint thinners, and solvents must be disposed of as hazardous waste.
3. **PRESSURE WASHING:** Water from pressure washing decks, driveways, roofs, or other hard surfaces may contain suspended solids and other pollutants that should not be directly discharged to drainage systems. Redirect pressure washing wastewater to vegetated areas or areas such as gravel, lawns, landscaping, or bare soil where the water will infiltrate slowly into the ground. If this cannot be accomplished, filter the wash water through filter fabric, or other filtering media to collect the suspended solids before discharging the water to a drainage system. If any chemicals are used during the pressure washing process, the wastewater must be collected and disposed of in a sanitary sewer system or infiltrated on site. If moss control or another chemical treatment is used during pressure washing of roofs, disconnect the downspouts so the chemicals do not discharge to the storm drainage system, and disperse the wash water onto adjacent lawns and landscaping.

Maintenance and Repair

Requirements: Activity Sheet R-6 *(Continued)*

4. **CARPET CLEANING:** Most commercial carpet cleaners have onboard wastewater recycling systems. If you do your own carpet cleaning, the wash water must be discharged to the sanitary sewer or your septic system. Filter the water if it contains lint or other particles to avoid clogging the drains. If you prefer not to discharge the water to your septic system, you may also discharge the water to your lawn or a landscaped area to allow the washwater to infiltrate slowly into the ground. Be aware that detergents and other cleaning chemicals such as solvents can be harmful to vegetation and septic systems. Discharging wash water to the ground may not be allowed if you live in a Critical Aquifer Recharge Area (CARA). Never dispose of carpet cleaning wash water to a storm drain, drainage ditch, or surface water. Carpet cleaning wastewater contains chemicals, detergents, and suspended solids that adversely impact the quality of surface and ground waters.
5. **CEMENT/CONCRETE WORK:** Concrete/cement wash water has a pH level that is toxic to aquatic life. Do not allow wash water from concrete work to discharge into storm drainage systems, including small yard drains or adjacent roadways. This is especially important when installing washed aggregate driveways or patios. Direct the wash water to vegetated areas or dig a hole where the wash water can settle and infiltrate slowly into the ground. The cement residue can be mixed into the soil where the wash water is infiltrated with no detrimental effects, and the pH will be neutralized.

Other Options and Tips:

1. Hire a professional home maintenance and repair company that follows the approved BMPs for home repair and maintenance

   Remember, as a homeowner, you have a responsibility to ensure your contractors follow the required Best Management Practices. As part of your agreement with contractors, require them to follow all codes and regulations.

Best Management Practices (BMPs)

- Name and Define two different BMP's important for stormwater management.
  1. BMP:

     Definition:

  2. BMP:

     Definition:

- Explain why it is important for people to follow the BMPs:

Brief Writing Rubric

	Sample Generic 2-point (Grades 3–11) Brief Writing Rubric
2	The response: • demonstrates sufficient focus on the topic and includes some supporting details • has an adequate organizational pattern, and conveys a sense of wholeness and completeness, although some lapses occur • provides adequate transitions in an attempt to connect ideas • uses adequate language and appropriate word choices for intended audience and purpose • includes sentences, or phrases where appropriate, that are somewhat varied in length and structure
1	The response: • demonstrates little or no focus and few supporting details which may be inconsistent or interfere with the meaning of the text • has little evidence of an organizational pattern or any sense of wholeness and completeness • provides transitions which are poorly utilized, or fails to provides transitions • has limited or inappropriate vocabulary for the intended audience and purpose • has little or no variety in sentence length and structure
0	A response gets no credit if it provides no evidence of the ability to [fill in with key language from the intended target] and includes no relevant information from the text

Stormwater Problems: Your Role

Stormwater Problems: Your Role

Puget Sound Starts Here

Stormwater Runoff

In vegetated areas such as forests, fields, and wetlands, rainwater seeps slowly into the ground. However, when rain falls on paved and other hard surfaces it runs off quickly and is conveyed by pipes and ditches directly to King County lakes, wetlands, and streams. This water that flows across the land is called stormwater runoff. Stormwater runoff, although starting as rain, collects pollutants when it hits the ground and travels. For example, runoff from parking lots picks up oil and grease dripped from cars, asbestos from worn brake linings, and zinc from tires. Pesticides, herbicides, and fertilizers are washed off from landscaped areas, and soils are washed away from construction sites. Any substance found on the ground can contaminate stormwater runoff.

Storm Drains Lead to Lakes and Streams

Storm drainage systems are designed to decrease the chance of flooding in areas that have been developed with homes, businesses, and roads. The rainwater that used to seep into vegetated areas now must be collected and carried elsewhere. The storm drainage system collects this stormwater runoff and carries it to the nearest wetland, lake, stream, or to Puget Sound. In urban areas, the storm drainage system consists of drains and underground pipes. Storm drains are normally located in streets and parking lots. In rural areas, the storm drainage system may be in the form of ditches that carry the stormwater along a roadside or piece of property. These drainage systems are meant to carry only unpolluted stormwater to the nearest natural body of water. Putting oil, antifreeze, detergents, and other material into the storm drainage system is the same as dumping them directly into a lake or stream.

The sanitary sewer system is different. Sanitary sewer drains lead to the sanitary sewer system and end up at a wastewater treatment plant. This system carries household wastewater and some permitted industrial wastewater. The wastewater in this system is treated before being discharged into a natural water body.

Polluting is Against the Law

Keeping pollutants out of the water isn't just a good idea - it's the law. The Washington State Water Pollution Control Law (RCW 90.48) and the King County Water Quality Code (KCC 9.12) prohibit the discharge of pollutants to the storm drainage system, surface water, and groundwater. Polluted stormwater runoff or the direct dumping of pollutants can negatively affect every water body it enters. Pollution can cause algal blooms causing taste and odor problems and impaired recreation and aesthetics; toxins can cause lesions and tumors in fish and other animals; turbidity can cause the destruction of fish spawning areas and other habitat for plants and animals; and all of this can result in a decrease in fishing, swimming, and boating opportunities.

Ways You May Be Polluting

Many people know that it is illegal to dump toxic chemicals or other material down a storm drain. But you are also polluting if you allow pollutants to be washed into a storm drain with stormwater runoff or with wash water. For instance, you may be polluting if you:

- allow water from washing tools and equipment to enter a storm drain;
- spill antifreeze or other material on your site without cleaning it up;
- allow materials or wastes stored outside to leak on the ground; or
- clear land without taking steps to prevent erosion.

Virtually anything on the ground can become a water pollutant. Therefore, it is important to keep a clean site and ensure that polluting material is properly handled and stored.

Pollutants

Any substance that can render water harmful to people, fish, or wildlife or impair recreation or other beneficial uses of water is considered a pollutant. The broad categories of pollutants and their effects on fish and wildlife are described below.

Table 2.1 (located at the end of this chapter) presents a list of the activities addressed in this manual. This table indicates the types of pollutants that may be generated by those activities as well as the types of receiving water bodies that may be affected by stormwater runoff from the activity sites.

Oils, Greases, and Fuels

Oils and greases are a common component of stormwater runoff pollutants, primarily because there are so many common sources: driveways, streets and highways, parking lots, food waste storage areas, heavy equipment and machinery storage areas, and areas where pesticides have been applied. The familiar sight of a rainbow-colored puddle or trickling stream of water in parking lots, driveways, and street gutters is a

reminder of the presence of oils and greases in stormwater runoff. Oils and greases can be petroleum-based or food related (such as cooking oils). No type of oil or grease belongs in surface water. Oil and grease are known to be toxic to aquatic organisms at relatively low concentrations. They can coat fish gills, prevent oxygen from entering the water, and clog drainage facilities (leading to increased maintenance costs and potential flooding problems).

Metals

Many metals, including lead, copper, zinc and cadmium, are commonly found in urban runoff. Metals can contaminate surface and groundwater, and concentrate in bottom sediments, presenting health problems for fish and animals that eat from the bottom of lakes, streams, and Puget Sound. Reproductive cycles of bottom-dwelling species can be severely reduced, and fish inhabiting such metal-contaminated locations often exhibit lesions and tumors. Metals can also contaminate drinking water supplies.

Industrial areas, scrap yards, paints, pesticides, and fallout from automobile emissions are typical sources of metals in runoff.

Sediments

Sediment, often originating as topsoil, sand, and clay, is the most common pollutant in stormwater runoff by volume and weight. Sediments readily wash off paved surfaces and exposed earth during storms. Sediment may seem harmless enough, but it poses serious problems in the water. Excess sediment concentrations turn stream and lake water cloudy, making them less suitable for recreation, fish life, and plant growth.

Sediment is of particular concern in fish bearing streams where it can smother trout and salmon eggs, destroy habitat for insects (a food source for fish), and cover prime spawning areas. Uncontrolled sediment can also clog storm drains, leading to increased private and public maintenance costs and flooding problems.

Sediment is also of concern because many other pollutants including oils, metals, bacteria, and nutrients tend to attach to soil particles. Therefore, when sediments enter water, they usually carry other pollutants with them.

Cleared construction sites and exposed earth are generally the greatest contributors of soil particles in surface waters. Other sources include erosion from agricultural lands, application of sand and salts to icy roads, fallout from pressure washing and sandblasting operations, dirt from equipment and vehicles, and dirt and grit from parking lots, driveways, and sidewalks.

Oxygen-Demanding Substances

Plant debris, yard waste, food waste, and some chemical wastes fall into a category of water pollutants known as oxygen-demanding substances. Such substances use dissolved oxygen in water when they decay or chemically react. If dissolved oxygen levels in water become too low, aquatic animals become stressed or die. Salmon and trout are particularly at risk because they need high dissolved oxygen levels to live.

Animal wastes, food wastes, leaves and twigs, and other miscellaneous organic matter carried by stormwater runoff into surface water can lead to reduced oxygen levels.

Slow moving waters are particularly susceptible to oxygen depletion because aeration of the water by turbulence is lacking. Therefore, oxygen that is depleted in slow- moving waters due to the presence of excess organic matter or unnatural chemical compounds is not replaced. Reduced oxygen levels in these waters are often particularly severe after a storm.

Nutrients

Nutrients such as phosphorus and nitrogen are needed by plants to grow, but high levels can be harmful to water quality. Excess nutrient levels can over-stimulate the growth of algae and other aquatic plants, resulting in unpleasant odors, unsightly surface scum, and lowered dissolved oxygen levels from plant decay. Nutrients are most likely to pose a problem in slow moving water such as lakes or sluggish streams.

Some forms of algae are toxic to fish and other aquatic organisms and may even cause death in animals that drink affected water. Algae can also cause taste and odor problems in drinking water, foul-smelling odor in ponds and lakes, and problems with clogged water intakes, drains, and pipes. Heavy loading of nutrients into slow-moving waters can adversely affect many beneficial uses of the water. Forms of nitrogen (ammonium), in combination with pH and temperature variations, can cause water quality problems and be toxic to fish. This process consumes large amounts of oxygen in the water and subsequently stresses or kills fish and other aquatic organisms when oxygen levels are reduced.

Ammonia can harm fish and other aquatic organisms.

Fertilizers, animal wastes, failing septic systems, detergents, road deicing salts, automobile emissions, eroded soils, and organic matter such as lawn clippings and leaves are all contributors to excessive nutrient levels in urban/rural and agricultural stormwater runoff.

Toxic Organic Compounds

Toxic organic compounds such as pesticides are particularly dangerous in the aquatic environment. Excessive application of insecticides, herbicides, fungicides, and rodenticides, or application of any of these shortly before a storm, can result in toxic pesticide chemicals being carried from agricultural lands, construction sites, parks, golf courses, and residential lawns and gardens to receiving waters. Many pesticide compounds are extremely toxic to aquatic organisms and can cause fish kills.

Many other toxic organic compounds can also affect receiving waters. These toxic compounds include phenols, glycol ethers, esters, nitrosamines, and other nitrogen compounds. Common sources of these compounds include wood preservatives, antifreeze, dry cleaning chemicals, cleansers, and a variety of other chemical products. Like pesticides these other toxic organic compounds can be lethal to aquatic organisms.

Fecal Coliform Bacteria

Fecal coliform bacteria in water may indicate the presence of pathogenic (disease- causing) bacteria and viruses. Pet and other animal wastes, failing septic systems, livestock waste in agricultural areas and on hobby farms, and fertilizers can all contribute fecal coliform bacteria. This can limit the recreational use of a water body. Bacterial contamination has led to closures of numerous shellfish harvesting areas and swimming beaches in the Puget Sound region.

*p*H

The pH value of water is an indication of its relative acidity. The pH value can range from 0 to 14, with a range of 6 to 8 being desirable for most bodies of water. A pH level outside this range will adversely affect plant and animal life. Waters with very high (basic) or very low (acidic) pH are corrosive to metal surfaces. There are several sources that can contribute to change of pH in runoff, including industrial processes that discharge acidic wastewater, solutions used in metal plating operations, acidic chemicals used in printing and graphic art businesses, cement used in concrete products and concrete pavement, and chemical cleaners used in homes and businesses.

How can I help...around my Dog?

Scoop the poop, bag it and throw it in the trash (not in the yard waste bin). 87% of dog poop in Puget Sound lands in our own backyards. 48% of the people in King County say they don't always properly dispose of pet waste at home.

Backyard poop is a big problem. Keep your yard clean of pet waste by scooping at least weekly if possible. Always carry plastic bags when walking your pet. After you've picked it up and bagged it, throw the poop in the garbage and be sure to wash your hands. It's that simple and your garbage hauler won't mind (plus, not pickup up your dog's poop is illegal). Just remember to keep the poop out of the yard waste container.

The Issue

Pet waste is raw sewage. It contains hazardous organisms that cause bacterial contamination in local streams, rivers, and lakes. When it rains, bacteria in dog poop is carried by stormwater runoff to storm drains, ditches, and streams that feed our rivers, lakes, and Puget Sound. Dog waste contains fecal coliform bacteria and other disease-causing organisms such as salmonella, roundworms, and giardia. These bacteria can make water unsafe to drink or swim in. These bacteria also end up in shellfish, and can make the people who eat them very sick.

Facts: We have more than 125,000 dogs and 60,000 outdoor cats in Seattle! That amounts to about 50,000 pounds of bet waste every day. In one gram of dog poop, a piece about the size of a round green pea, there are 23 million fecal coliform bacteria.

Left on streets, curb strips, and in yards and parks, pet waste can be carried by rainwater to storm drains and into our creeks, lakes, and Puget Sound without treatment, it is one of the leading causes of bacterial contamination in our streams and causes other water quality problems just like livestock manure and fertilizer.

Get Involved

- Purchase a pet waste baggie dispense and bags for your street. Available online or in pet supply stores these are not supplied or maintained by the City).
- Spread the word about the importance of picking up pet waste. Print an I Poop Poster from the Puget Sound Starts Here website and ask a local business to post it.

What if pet waste isn't picked up?

It's bad for your health, our waterways, and potentially your pocketbook! There are laws in Seattle to protect our health and our environment which require pet waste to be picked up and disposed of properly.

SMC 9.25.082

(A) Allowing the accumulation of feces (civil infraction, $109.00 fine)

(B) Not removing feces from another's property (civil infraction, $54.00 fine)

(C) Not having equipment to remove feces (civil infraction, $54.00 fine)

How can I help...in my Yard?

Use fertilizers and pesticides sparingly, or just use compost.

Go Green with Less

It's okay to want green lawns and gorgeous flowers. But too much fertilizer or too many bug killers are not necessary. It doesn't take much of the right product to achieve the desired result. In fact, there are many non-chemical choices for preventing weeds and bugs. One choice is to try compost instead of a fertilizer or herbicide.

The Issue – 96% of the insects in a yard are good bugs

Scientists have found 23 pesticides in Puget Sound streams, many at levels that can harm salmon and other wildlife. When stormwater flows over our yards and gardens it picks up pesticides, herbicides, and fertilizers and carries them into streams, rivers, lakes, and Puget Sound. These chemicals poison wildlife and absorb oxygen in water, contributing to dead zones.

Yard Care Tips

If you already follow the directions on your fertilizer or pesticide, try something new and easy:

Go Natural: Use compost to augment your soil and fertilize your plants. There are many types of compost available and some cities or counties offer their own products. If you must, use slow release organic fertilizer in late September and/or early May.

Plant a Tree: Increase the number of trees to help intercept rainwater.

Let the Rain Soak In: Slow stormwater runoff by directing downspouts into lawns, beds, or rain gardens.

Build Healthy Soil: Supplement your soil with mulch, compost and other all-natural soil amendments. Healthy soils lead to robust plants that are more resistant to disease and insect problems, which means you'll reduce the need for herbicides and pesticides.

Clean Up Troublemakers: Remove diseased plants and compost the dead ones.

Minimize Spray: Try traps, barriers, fabric row covers and repellents before turning to pesticides.

Plant Right for Your Site: Select pest-resistant plants and put them in soil mixture and sun conditions they like. Consult a garden expert for advice on the right plant for your conditions.

Water Smart: Water deeply and infrequently. Most plants do best if the soil partially dries out between watering. One **inch a week is the rule of thumb.**

Test Automatics: Test, repair, and adjust your sprinklers annually, and install a rain shut-off device.

How can I help...in my House?

Use less hazardous cleaning solutions.

Household Cleaning

Even though most home cleaning products are processed through sewage treatment plants or septic systems, many of the harmful chemicals they contain still end up in our waterways. This also happens when some sewer systems overflow during big storms and heavy rains. Whenever possible, use natural cleaning products to tidy up your home. This includes detergents for dish and clothes washing that do not contain phosphorus. For other cleaning needs, avoid products that say "Poison" or "Danger." And, create a low-cost household cleaning kit with white vinegar, baking soda, borax, castile soap, and a spray bottle. Recipes are available online: http://www.pugetsoundstartshere.org/at-home-and more/household-cleaning/.

How can I help...in my Car?

Use a commercial car wash and have fluid leaks repaired.

Use a commercial car wash. Market research from the International Carwash Association shows that 38% of the public wash their cars at home.

Washing your car at home is a dirty business. Oil, brake pad and tire dust and other chemical residue build-up – along with soap – wash straight down the storm drain and flow, untreated, into nearby streams, rivers, and Puget Sound when you wash your car in the driveway or street. The water from commercial car washes flows into the sanitary sewer system and is treated by wastewater treatment plants before it enters local waterways.

The Issue

The water from car washing contains oil, zinc, lead, copper, solvents and antifreeze. All of these enter the Sound – or bodies of water that lead to the sound – when we wash our cars on the street, in our driveways or in a parking lot. Sops are a significant problem and are harmful to fish and the aquatic insects they eat. Soaps contain surfactants, which are chemicals designed to coat dirt and grime so they don't settle back onto your car. Surfactants also coat fish gills and prevent fish and aquatic insects from getting the oxygen they need.

Fix your car's oil drips

Motor oil is a pollution problem in our streams, rivers, and lakes. Oil doesn't dissolve in water, which means it sticks around for a long time. It's toxic to people, wildlife, and plants. Contain oil leaks that you know about until you can get your car fixed.

Car Care Tips

Dispose of Fluids Properly. Never pour anything but clean water down a storm drain, since most drains empty directly into streams or rivers. Recycle oil at registered collection centers throughout the region.

Use Cardboard. If you have an older car that leaks a little oil, put a piece of cardboard under the leak when the car is parked. Periodically dispose f the cardboard at registered collection centers, not in the trash.

Skip Driving Alone. Leave the car at home and take an alternative form of transportation, or carpool with other people in your neighborhood.

LESSON 4

Understanding Stakeholders

Science
Secondary
Lesson #4 (60 minutes)

Overview

Students identify the major stakeholders in designing stormwater solutions for their school campus, describing the stakeholders' responsibilities, interests, and possible impact resulting from change.

Objectives

Students identify the stakeholders affected by various solutions to polluted stormwater runoff and summarize their interest when making changes to the school site.

Evaluation

Collect the students' completed charts to review for completeness and accuracy.

Ask students to reflect on an exit slip: Which stakeholder's position may be most important? Least important? What makes the students think this? Collect student responses.

Activities

1. Share with students that today they will consider stakeholders that may have an interest in solutions for the stormwater pollution problems on their school campus. Ask: What is a stakeholder and why might stakeholders be important when solving problems?
2. Check student ideas. Then share a definition of a stakeholder: Individuals or groups with interests related to an issue or outcome. Ask: Who might be the stakeholders when we make improvements on our campus and how might these stakeholders be affected?
3. Share the learning target with the students: *I can describe the stakeholders affected by various solutions to stormwater runoff and summarize their interest when* making changes to the school site.
4. Distribute the Stakeholder Matrix for student note taking. Point out that the students are practicing the thinking skill of point of view when they consider the interests of stakeholders. These interests will influence point of view toward the potential solutions to stormwater runoff on the school campus.

Materials

- Template for recording stakeholder information
- Discussion Protocol

Understanding Stakeholders

5. Ask students to name the stakeholders they believe might be affected by improvements to their campus site. Guide the students to name many the following:

    - The Maintenance Department
    - Grounds crew
    - Custodian
    - The Finance Office
    - The Principal
    - Local Government (City/County)
    - Students
    - Parents
    - Developers
    - Local environmental groups
    - Teachers
    - Neighbors

6. Direct the students to choose 5-6 of these stakeholders and record on the chart. In groups, instruct students to complete the sections of the chart that include describing the stakeholder and identifying the stakeholder's possible interests in making changes on the school campus. Provide a model for the class as a shared think aloud prior to instructing the students to work independently. Students must think flexibly and as they try to see the issue of stormwater solutions from the points of view of others who might be affected by any proposed change to the school campus. Revisit the Discussion Protocol with the students.

    Possible impacts are recorded below. There is also a key provided with this lesson.

    - **Maintenance Department:** Changes may create more work for this department. For example, who will weed and maintain a rain garden?
    - **Finance Office:** What will the cost be for the proposed solution? Can the district budget support the cost?
    - **The Principal:** Will the proposed change affect the school childrens' play area? Will the change help the children to learn about the importance of stormwater management?
    - **Local Government:** Will the change be consistent with city/county plans for stormwater management and rules for the installation of proposed solutions?

Science
Secondary
Lesson #4 (60 minutes)

Common Core ELA Standards

- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on various topics and texts, building on others' ideas and expressing their own clearly.
- S/L #2: Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

- **Local Businesses:** Which local business be the one selected to do contract work related to the proposed stormwater solution?
- **Students:** How will the solution change the school campus? Will our play areas be affected? Which solution will add the most to our learning about stormwater runoff?

7. Share that the stakeholders' considerations will be important when evaluating options for site improvements. Have students identify possible criteria for evaluating those options, based on the Possible Interests for each stakeholder. These include impact on stormwater quality and quantity, upkeep, appearance, cost, safety, compliance with rules, educational value, impact on play areas. Students will look at possible solutions to the stormwater problems and evaluate these through the eyes of the stakeholders.
8. Have students reflect on an exit slip:
   - Which stakeholders' position may be most important?
   - Least important?

   Collect student responses.

Selecting Stormwater Solutions for Our School Campus

Choose 5-6 stakeholders to examine

Stakeholder	Description	Possible Interests	Impact

Selecting Stormwater Solutions for Our School Campus

Possible Key

Stakeholder	Description	Possible Interests	Impact
Maintenance Department	These people are responsible for taking care of the grounds.	• Upkeep • Could improve problem areas	The maintenance department has responsible for taking care of the school grounds. If the solution involves on going upkeep, this could be a problem.
Finance Office	These people manage the school district budget.	• Cost	The finance office has knowledge of the district budget. They will want to determine whether or not the cost for the stormwater solution fits into the budget.
School Principal	This person is responsible for the safety and recreational needs of the school yard along with reducing wet areas where students cannot play.	• Safety • Educational Value Clean water Reduced flooding and wet areas on campus	The principal is responsible for the safety and educational value of the school site. He/she may like one solution better than another based on access to play areas and the teaching potential for the stormwater solution.
Local Government	The city has responsibility to ensure stormwater management and compliance with the BMPs. They want to clean up waterways and Puget Sound	• Compliance with laws • Clean water for aquatic life • Decreased erosion problems • Reduced flooding	The City of Maple Valley has oversight responsibility for stormwater management. They will want to ensure that we use BMP's when proposing solutions.
Local Businesses	Local businesses will contract for installation of stormwater solutions.	• Income • Publicity	Local businesses will contract for installation of stormwater solutions.
Students	The students use the school campus on a daily basis and will want to have good play spaces and learning opportunities along with benefiting aquatic organisms and reducing flooding.	• Good play areas • New learning opportunities • Clean water • Decreased erosion • Reduced wet areas and flooding	Students will want to maintain or improve campus play areas and learning spaces.

Discussion Protocol

1. Come to discussions prepared with assigned readingand/or research completed.

2. Follow agreed upon rules for discussions:
   - Listen respectfully
   - Take turns
   - Invite all voices to share

3. Ask clarifying questions.

4. Build on others' ideas.

5. Summarize key ideas expressed.

Based on the Common Core Speaking and Listening Standards

EXIT TICKET:

- Which stakeholder's position may be most important and why?
- Which stakeholder's position may be least important and why?

EXIT TICKET:

- Which stakeholder's position may be most important and why?
- Which stakeholder's position may be least important and why?

LESSON 5

Exploring Possible Solutions

Puget Sound Starts Here

Overview

Students explore multiple possible engineering solutions to address the problem of too much (quantity) and polluted (quality) stormwater runoff in their community and particularly solutions for their schoolyard.

Objectives

- Students research various engineering solutions to address pollution of stormwater runoff and the amount of stormwater runoff in their schoolyard.
- Students work collaboratively to deliver a short presentation on their solution.

Evaluation

Score the presentations on the following criteria:

1. Completeness: The students described the proposed solution, used a picture to illustrate the solution, indicated where on the school grounds the solution would be implemented (e.g. parking lot, play field, etc.) and shared how the stakeholders would be affected
2. Citing Sources: The students cite the sources for finding their
3. Presentation: The students speak clearly, use visuals, and have effective eye contact.

Activities

Day One:

1. Share today's learning target:

   I can explore multiple possible engineering solutions to address the problem of too much (quantity) and polluted (quality) stormwater runoff in my community and particularly solutions for my schoolyard.

   Share with students that today, they will research different engineering solutions to the problem of quality and quantity of stormwater runoff. These solutions include various alternatives.

2. Use the Power Point provided to share examples of engineering solutions that address stormwater runoff problems in urban areas.

Science
Secondary
Lesson #5
(Two Classes Periods)

Materials

- Internet access
- Stormwater Runoff Solution Template
- Stakeholder impact template
- Stormwater Solutions Power Point
- Seattle Utility Rainwise Program

  http://www.seattle.gov/util/EnvironmentConservation/Projects/GreenStormwaterInfrastructure/RainWise/index.htm
- Bothell Managing Rainwater Guide

  http://www.ci.bothell.wa.us/DocumentCenter/Home/View/1287
- Solutions Library from Sustainability Ambassadors

  http://www.sustainabilityambassadors.org/lid-manual-for-schools
- Drain Rangers BMP Pages of Solutions

Exploring Possible Solutions

3. Review with the students the list of possible site improvements that will help to reduce stormwater pollution. The list should include some of the following:
    - Rain gardens
    - Planting trees/native plants
    - Mulching and improving soils
    - Bioswales/curbcuts
    - Detention ponds
    - Green roofs/walls
    - Rock- filled trenches
    - Rain barrels/Cisterns
    - Reducing pavement (impervious surfaces)
    - Installation of pervious surfaces (pavers, concrete, asphalt)
4. Provide the students with the website links for them to use initially in their research of the various solutions. Or alternatively you could print these out for students. The web links are:
    - Seattle Utility Rainwise Program –Information on right hand sidebar –each solution separate http://www.seattle.gov/util/EnvironmentConservation/Projects/GreenStormwaterInfrastructure/RainWise/index.htm
    - Bothell Managing Rainwater Guide http://www.ci.bothell.wa.us/Site/Content/Public%20Works/Surface%20Water%20Mgmt/Managing%20Rainwater_rev2.pdf
    - Solutions Library from Sustainability Ambassadors http://www.sustainabilityambassadors.org/lid-manual-for- schools
    - Drain Rangers schoolyard solution pages
5. Assign students the task of researching one of these possible solutions including finding out the following information:
    - Describe the solution and its benefits
    - Provide a picture of the solution
    - List 1-3 criteria for success
    - List 1-3 constraints to the solution
    - Name the stakeholders that would most likely be affected and how
6. Students should work with a partner or in a trio to research their assigned solution and complete the two templates provided. They will need access to the internet to complete their research.

Science
Secondary
Lesson #5
(Two Classes Periods)

Common Core ELA Standards

- W #7: Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- W #8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on various topics and texts, building on others' ideas and expressing their own clearly.
- S/L #2: Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
- S/L #4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

Day Two:

7. Instruct the students to share their solution in a brief class presentation (3-5 minutes).

Teacher Note: Consider asking students to develop Power Point slides to present their solution:

Slide #1: Name and describe the solution

Slide #2: A picture of the solution

Slide #3: Benefits (advantages) of the solution

Slide #4: Drawbacks (disadvantages)

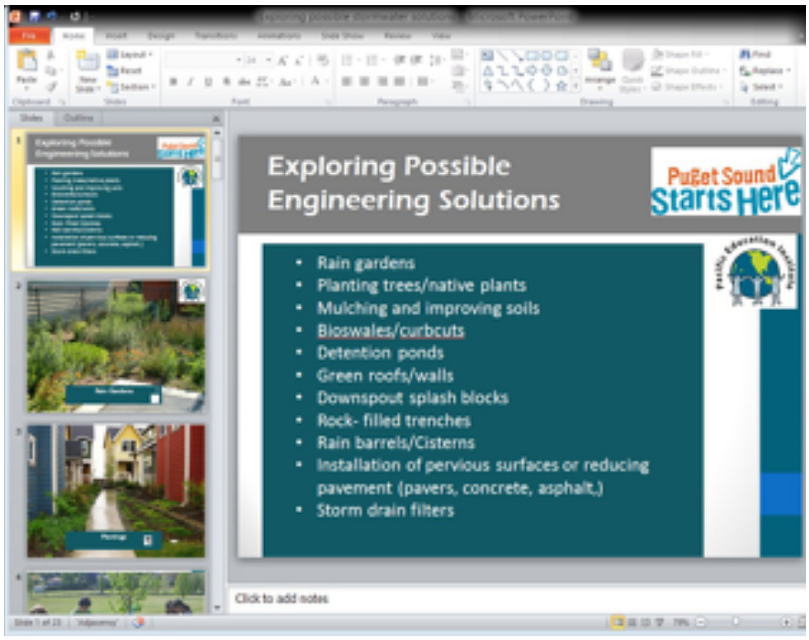
Slide #5: List 2-3 criteria for measuring success of such a solution

Slide #6: List any constraints or disadvantages of the solution

Slide #7: Stakeholders and impact

Exploring Possible Solutions:

Use the Exploring Possible Engineering Solutions Power Point to share an overview of possible solutions



Stormwater Runoff Solution

Problem:
Proposed Solution:
Description
Benefits (Strengths)
Drawbacks (Weaknesses)
Criteria for Success
Constraints (money, time, material, people)
Source(s):

Stormwater Runoff Solution

Choose 3-5 stakeholders to summarize the potential impact on each stakeholder

Stakeholder	Potential Impact

LESSON 6

Exploring Possible Solutions:
Mapping Our Campus

Science
Secondary
Lesson #6 (One Class Period)

Overview

Students use engineering symbols to map their school campus solutions and begin to consider where additional solutions might improve runoff.

Objectives

Students identify the application of stormwater engineering solutions on the campus, recognize problem areas, and use symbols to create an accurate map of their schoolyard.

Evaluation

Collect the student maps to check for accuracy, completeness and clarity.

Activities

1. Share today's learning target:

   I can identify the application of stormwater engineering solutions on my campus, recognize problem areas, and use symbols to create an accurate map of my schoolyard.

   Ask students: What will they need to know or do to accomplish this learning goal?

   Tell the students that they are researching solutions for the stormwater runoff pollution problem. Today they are doing that by mapping the school campus. Engineers often start by gathering data to better understand a complex problem like polluted stormwater runoff. This is an important step in the process of engineering solutions.

2. Review with the students the engineering solutions for stormwater management that they researched. Solutions refer to site modifications that improve stormwater runoff quality and reduce runoff quantity. Remind students that they didn't research storm drains and storm pipes which are solutions the community uses to manage stormwater runoff, but are not solutions they can implement on their campus. They will still locate these solutions on their campus.

3. Review the power point slide presentation that depicts each of these solutions. Share that students will look for evidence of these engineering solutions first on their school campus and then in their local neighborhood.

Materials

- Campus maps from district or google
- Digital cameras (optional)
- Home-School Connections
- Power Point slides: engineering solutions
- Engineering Map Symbols
- Protocol for Outdoor Learning

Exploring Possible Solutions:
Mapping Our Campus

4. Invite the students to talk with each other about what stormwater engineering solutions they expect to find on their school campuses and where they think they will find them. For example, a rain garden is an example stormwater engineering solution. Ask students to record their predictions so that they can see how closely their predictions match what they actually discover.
5. Distribute campus maps that the students will use and discuss the surveying activity that will follow. Students will use special symbols on their maps to record what they find on their school campuses. Distribute the engineering symbols and review what each means. Students will mark existing stormwater solutions and note places where additional improvements would improve the quality or quantity of stormwater runoff.
6. Remind the students that they are working like engineers when they evaluate the current state of the schoolyard.
7. Review the protocol for outdoor learning. Take the students out to the campus and ask them to proceed with the mapping. They could take photos of each practice as well as recording the practices on their maps.
8. Upon return to class, debrief with the students:
    - Were their predictions accurate?
    - Were they surprised by anything they saw?
    - What did they notice that needs improvement on the campus? Share that the next step in this engineering process is to evaluate the options for site improvement and their potential impact on stakeholders. Engineers first must define the problem, review the current state, and then begin to think about the best options for improvement (optimization).

Teacher Notes: Students are documenting solutions that are already in place so they are now improving or optimizing those solutions. This is an opportunity for Claims, Evidence and Reasoning short write up.

Home-School-Community Connection: Tell students to go on a scavenger hunt in their neighborhood. Which stormwater solutions can they identify? Ask the students to take pictures of the stormwater solutions they find and to incorporate these into a document that shows stormwater solutions in their neighborhood. The document can be in the form of labeled photos, a labeled street map or other way to show neighborhood efforts to manage stormwater runoff and pollution. Create a bulletin board display to show the various neighborhoods and the stormwater solutions.

Science
Secondary
Lesson #6 (Two Class Periods)

Common Core ELA Standards

- RI #7: Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve problem efficiently.

Protocol for Outdoor Learning

1. **Gather Data Through Your Senses**: Watch, Listen, Smell, Touch

2. **Strive for Accuracy and Precision**: Use your journals, maps, or other documents to carefully record what you observe.

3. **Think Interdependently**: Work with your partner as an equal member of a team by discussing what you observe.

4. **Question and Problem Pose**: Be curious and inquisitive as you make your observations. Capture questions for follow up in the classroom.

5. **Manage Your Impulsivity**: Stay focused on the purpose for the outdoor learning

6. **Demonstrate Empathy**: Leave the observation site the same or better than prior to your visit

MAP LEGEND - ENGINEERING SOLUTIONS

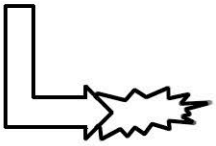
Rain Garden

Storm Drain

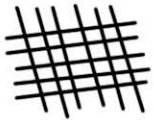
Plantings

Storm Pipe

Trees



Downspout splash



Mulch

Rain barrel or cistern

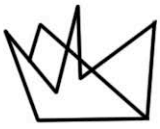
Rentention Pond and Bioswales

Previous concrete or asphalt

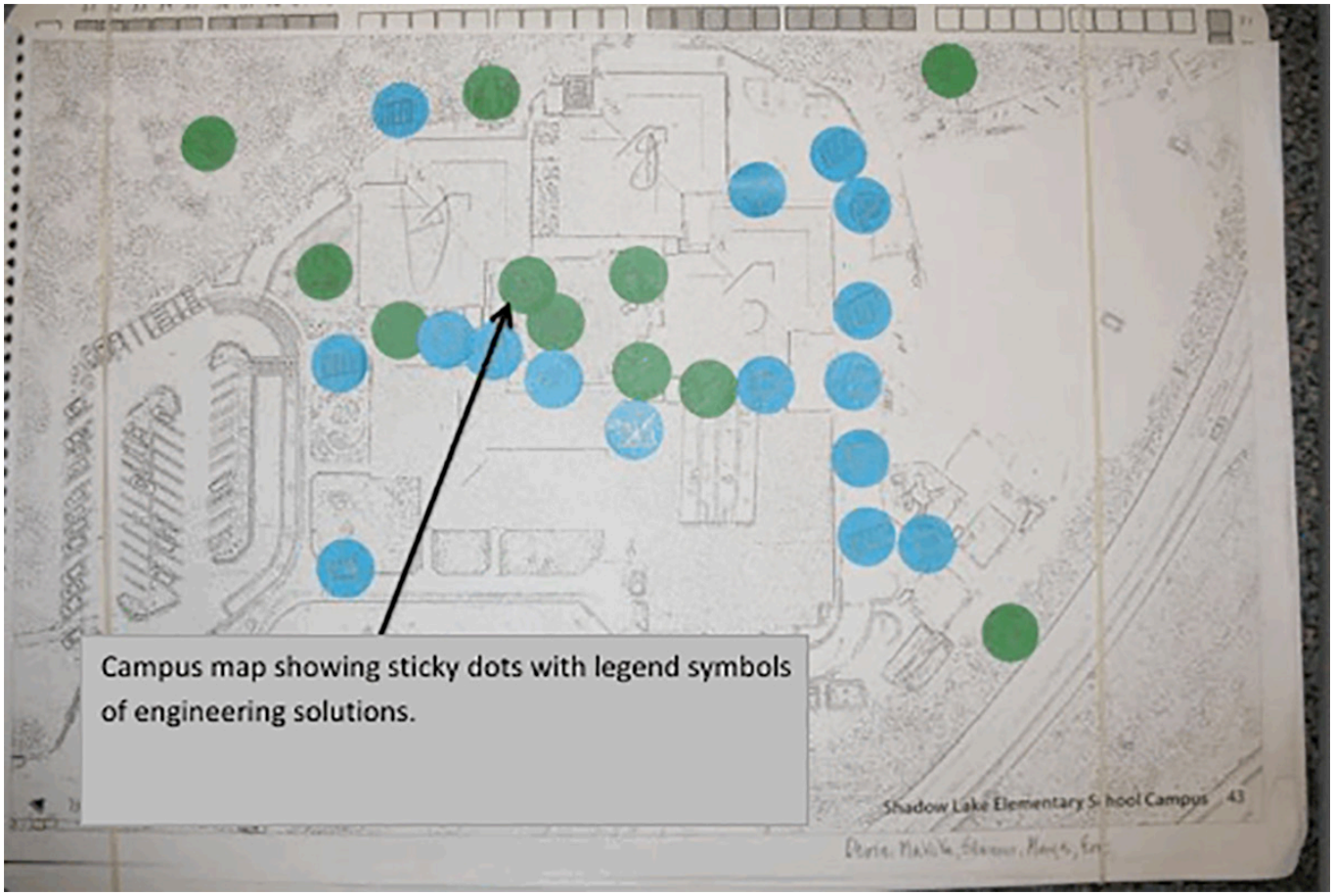
Green Wall/Roof

Curbcut

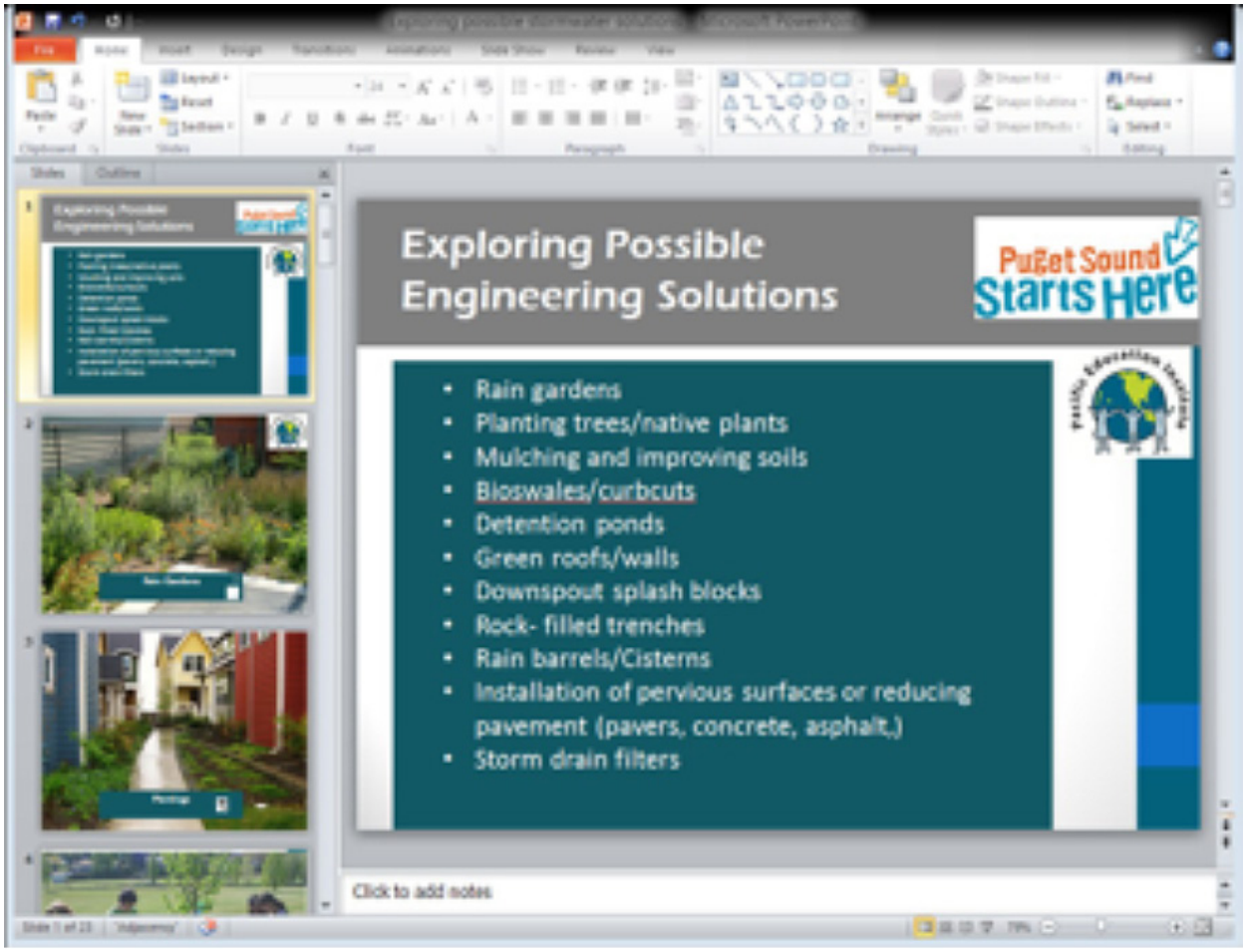
Problem Areas



Example of a campus map with symbols of solutions



Use the Exploring Possible Engineering Solutions Powerpoint if you need to review



LESSON 7

Evaluating Possible Solutions

Puget Sound Starts Here

Overview

Students use criteria to evaluate stormwater solutions, thinking about feasibility and constraints.

Objectives

Students evaluate possible solutions to address polluted stormwater runoff and recommend one solution for implementation.

Evaluation

Opinion Essay: Preferred Solution with Rationale

Activities

Day One:

1. *I can evaluate possible solutions to address polluted stormwater runoff and recommend one solution for implementation.*

   Students will practice Engineering Design as they determine a recommendation for improving the quality of stormwater runoff on their school campus. They will apply what they have learned so far in the unit as they consider the various campus improvements, use information from mapping the school campus, and consider the points of view of the various stakeholders.

2. Have students reflect on the fact that their school campus problem and solution is a smaller part of the larger problem of stormwater runoff pollution affecting Puget Sound.

3. Share the evaluation matrix with the students. Students will use this matrix to evaluate options and determine one option to develop a plan and recommend for consideration by the district administration for site improvement. They can use criteria developed from their research or the criteria in the matrix.

Teacher Note: The idea of effectiveness of solutions is, does the solution filter out pollutants and/or how much water does it help soak into the soil to filter out pollutants, or how much stormwater does it divert, or retain, to reduce erosion and flooding. Other problems the solution may solve are: a soaked playfield, water gushing off roofs, drains backing up, etc.

Science
Secondary
Lesson #7 (2-60 minute classes)

Materials

- Evaluation Matrix: Stormwater Solutions
- Colored dots
- Opinion/Argumentative Writing Rubric

Evaluating Possible Solutions

4. Instruct students to work in their small groups, applying the criteria of their solution to the stormwater solution they researched as well as two other proposed solutions of their choosing. They should consider stakeholders' interests and assign a rating of high, medium, or low impact. The alternatives with the highest scores should be the ones considered for recommendation.
5. Tell the students that like engineers, they are evaluating the feasibility of each option! They will need to narrow their choices to one recommendation from the class. You may want to identify the top three options, discuss these further, and use colored dots to select the class choice.
6. Tell the students that tomorrow, they will brainstorm and plan how to test their solutions, and that the day after that they will make a plan for implementing the class' preferred solution. They should think about the possible steps in this plan and success criteria. The plan they create will be presented to the district administration for possible implementation on their school campus.
7. Wrapping up the research, discussions, and evaluation of options: Instruct the students to write a short opinion paper where they share their preferred solution with evidence. Their own proposed solution may be different from the one chosen by the class. Score these essays using the Opinion Writing Rubric.

Teacher Notes:

- The format for this essay could be presented as a Claims, Evidence, and Reasoning Essay to show students how opinion writing and science writing overlap. Reasoning requires students to share the science concepts behind their choice.
- The Claims, Evidence, Reasoning could wait until students create a model to test their solution and then they would have other evidence (data) to back up their claim.

Science
Secondary
Lesson #7
(2-60 minute classes)

Common Core ELA Standards

- W #1: Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
- W #4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
- W #7: Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- W #8: Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.
- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade topics and texts, building on others' ideas and expressing their own clearly.
- S/L #2: Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
- S/L #4: Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

EVALUATION MATRIX:

Improving Stormwater Quality Solutions

Proposed Solution	Proposed Location on School Site	CRITERIA #1 How effective is this solution in reducing pollution in stormwater?	CRITERIA #2 What other problems does this solution help solve?	Constraints: Cost, materials, time, safety	Constraints: Up Keep- ongoing Maintenance	Stakeholders' Interests	Rating 1, 2 or 3

3= This option is feasible to implement
2= This option is somewhat feasible; however there would be impact
1= This option will be challenging to implement; there are definite drawbacks

FIVE TRAIT VERSION

Informative/Explanatory Writing Rubric (Grades 6-11)

Score	4	3	2	1
Statement of Purpose/Focus	**The response is fully sustained and consistently and purposely focused:** • claim is introduced, clearly communicated, and the focus is strongly maintained for the purpose, audience, and task	**The response is adequately sustained and generally focused:** • claim is clear, and the focus is mostly maintained for the purpose, audience, and task	**The response is somewhat sustained and may have a minor drift in focus:** • claim may be somewhat unclear or the focus may be insufficiently sustained for the purpose, audience, and task	**The response may be related to the purpose but may provide little or no focus:** • claim may be confusing or ambiguous; response may be too brief or the focus may drift from the purpose, audience, or task
Organization	**The response has a clear and effective organizational structure, creating a sense of unity and completeness:** • consistent use of a variety of transitional strategies to clarify the relationships between and among ideas • effective introduction and conclusion • logical progression of ideas from beginning to end; strong connections between and among ideas with some syntactic variety • alternative and opposing argument(s) are clearly acknowledged or addressed (begins at Gr 7)	**The response has an evident organizational structure and a sense of completeness, though there may be minor flaws and some ideas may be loosely connected:** • adequate use of transitional strategies with some variety to clarify the relationships between and among ideas • adequate introduction and conclusion • adequate progression of ideas from beginning to end; adequate connections between and among ideas • alternative and opposing argument(s) are adequately acknowledged or addressed	**The response has an inconsistent organizational structure, and flaws are evident:** • inconsistent use of transitional strategies and/or little variety • introduction or conclusion if present may be weak • uneven progression of ideas from beginning to end; and/or formulaic; inconsistent or unclear connections among ideas • alternative and opposing argument(s) may be confusing or not acknowledged	**The response has little or no discernible organizational structure:** • few or no transitional strategies are evident • introduction and/or conclusion may be missing • frequent extraneous ideas may be evident; ideas may be randomly ordered or have an unclear progression • alternative and opposing arguments may not be acknowledged
Elaboration of Evidence	**The response provides thorough and convincing support/evidence for the argument(s) and claim that includes the effective use of sources (facts, and details).** • comprehensive evidence from sources is integrated; references are relevant and specific • effective use of a variety of elaborative techniques (may include personal experiences)	**The response provides adequate support/evidence for the argument(s) and claim that includes the use of sources (facts, and details).** • adequate evidence from sources is integrated; some references may be general • adequate use of some elaborative techniques (may include personal experiences)	**The response provides uneven, cursory support/evidence for the argument(s) and claim that includes partial or uneven use of sources (facts, and details).** • some evidence from sources may be weakly integrated, imprecise, or repetitive; references may be vague • weak or uneven use of elaborative techniques • development may consist primarily of source summary or may rely on emotional appeal (may include personal experiences)	**The response provides minimal support/evidence for the argument(s) and claim that includes little or no use of sources (facts, and details):** • evidence from the source material is minimal or irrelevant; references may be absent or incorrectly used • minimal, if any use of elaborative techniques; emotional appeal may dominate (may include personal experiences)
Language	**The response clearly and effectively expresses ideas, using precise language:** • vocabulary is clearly appropriate for the audience and purpose • effective, appropriate style enhances content	**The response adequately expresses ideas, employing a mix of precise with more general language:** • vocabulary is generally appropriate for the audience and purpose • generally appropriate style is evident	**The response expresses ideas unevenly, using simplistic language:** • vocabulary use is uneven or somewhat ineffective for the audience and purpose • consistent or weak attempt to create appropriate style	**The response's expression of ideas is vague, lacks clarity, or is confusing:** • vocabulary is limited or ineffective for the audience and purpose • little or no evidence of appropriate style

Score	2	1	0
Conventions	The response demonstrates an adequate command of conventions: • adequate use of correct sentence formation, punctuation, capitalization, grammar usage, and spelling	The response demonstrates a partial command of conventions: • limited use of correct sentence formation, punctuation, capitalization, grammar usage, and spelling	The response demonstrates little or no command of conventions: • infrequent use of correct sentence formation, punctuation, capitalization, grammar usage, and spelling

• Unintelligible • Insufficient (includes copied text) • In a language other than English • Off-topic • Off-purpose

LESSON 8

Testing the Solution:
Investigating and Modeling

Science
Secondary
Lesson #8 (2-3 days)

Overview

Before implementing a plan students need to think about and develop how they will measure if their solution "worked". Students test their solution using investigations and/or models.

Objectives

Students collaboratively plan how they will test their solution using investigations and/or models.

Evaluation

Have students construct an explanation about the results of their investigations and/or models and score those.

Activities

1. Share with the students that today, they will continue their work as stormwater engineers, thinking through the development of a project plan for the class' preferred solution to stormwater management and pollution on the school site. Share today's learning target:

   I can collaboratively plan how I will test my solution using investigations and/or models.

2. Remind students of the Engineering Video. How did they know their solutions were working?

3. Review that pollution in stormwater runoff is the major cause of pollution in Puget Sound. Such large problems require multiple solutions just as in the Engineering video citizens across the Puget Sound Region are implementing smaller solutions so that the combined efforts will have an effect.

Materials

- Video-Drained: Urban Stormwater Pollution

  http://vimeo.com/51603152
- Examples of Investigations and Models page
- Model A-Soil Columns: Qualitative
- Model B-Soil Columns: Quantitative
- Model C- King County Rain Garden model

Testing the Solution:
Investigating and Modeling

4. Before implementing their solution inform students that they will need to test their solution to know that their solution to their site problem is successful. Students should have identified criteria for how effective their solution was in reducing pollution and/or quantity of stormwater runoff so have them review those specific criteria from their evaluation matrix. How can they test this?
5. Give students an example. If we want to see if pollution is being reduced we could measure local stream water quality.
6. Have students watch Drained: Urban Stormwater Pollution - http://vimeo.com/51603152.. Ask, "How were these researchers testing rain gardens ability to reduce pollution?" (Using models). Have students brainstorm what models they might use.
7. Below are examples you can share to help students come up with their investigations and models. There are also 2 procedures for using soil column models-one that is qualitative and one that is quantitative.
8. Using all the brainstorm lists for both investigations and models have the class decide on what they think is best for their planned solution.
9. In groups students plan the test of their solution's effectiveness (how their plan worked) using the investigation or model the class decided on.

Science
Secondary
Lesson #8 (2-3 days)

Common Core ELA Standards

- W #7: Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on topics and texts, building on others' ideas and expressing their own clearly.

Evaluating (testing) Engineering Solutions – Examples of Investigations

For solutions that reduce water flowing from the site and/or increase permeability students could do a pre/post-test or with and without test.

Here are some ideas of the investigations they could plan and conduct:

- Test an area for erosion or deposition before and after planting on a slope or compare a non-planted slope to a planted one.
- Sogginess-Footprint test for soil saturation or other before and after
- Puddle sizes before and after solution
- Measure roof's surface area and calculate or measure how much rainwater plantings/rain garden or cistern/rain barrels are intercepting. (or just use area to express improvement-the amount of raining falling on sq. feet is now collected/absorbed)
- If decreasing impervious surfaces make measurements of before and after and calculate the amount of water that now is absorbed that used to flow off the area.
- For Tree plantings. Go to www.treebenefits.com to find out how much water your tree(s) intercepts today and as it grows.
- Observational before and after data such as water flowing over gutters, flooding in surrounding areas, or play fields no longer soggy.
- Soil permeability study- http://www.pltwa.com/soils-as-sponges-fi-and-assessment.html

Evaluating (testing) Engineering Solutions-Examples of Models

Here are some ideas for models for testing solutions:

- Soil columns and how they filter stormwater- Model A: Soil Columns as Models.
- Model soil and plantings by using plastic buckets, putting a pipe in the bottom; layering gravel, rock and mulch; and then putting in some plants.
- Investigating Soil Columns: Finding Solutions to Stormwater Pollution -Model B. Model of soil columns investigating various soil mixtures and removal of Phosphorus and Nitrogen Investigation of soil mixtures similar to WSU research.
- Stream table model or watershed model with and without plantings or with and without larger rocks to show effects on erosion and using plantings or rocks as the solution. Teacher Note: Stream tables may be available in your district or through your local utility. (Need resource list here)
- Designing a model of a green roof from Engineering is Everywhere: http://www.eie.org/engineering-everywhere/curriculum-units/dont-runoff
- Modeling stormwater solutions by building a rain garden and testing their ability to hold and filter water: http://www.pugetsoundstartshere.org/DrainRangers.aspx

Example-Model A - Soil Columns : Qualitative

Natural absorption of polluted stormwater runoff by plants, soils, and rain gardens

Model for testing plantings, soil enhancements, or rain gardens

1. Watch the video http://vimeo.com/51603152 Drained: Urban Stormwater Pollution again if you already watched it. Have students respond to "What did the researchers do to test if rain gardens were working?"
2. Tell students that they will make water filters today to model how water is cleaned when it goes into the ground of native plantings, soil improvements, and rain gardens rather than directly flowing into our rivers and streams.

Materials:

4 clear plastic cups per group
3 cups clean sand
3 cups gravel
1 paper towel sheet per group
Push pins
1 large bucket of water
2 cups soil
Ruler
Sharpies

3. Model how to make a water filter by using clear plastic cups, clean sand and gravel and soil. In the bottom on one of the cups poke holes with the push pins.

Teacher Note: You will probably want to make the cups with the holes for everyone.

4. Lay a circle of paper towel in the bottom of the cup. Add 1 inch of gravel and 1 inch of sand. This is the soil column filter. Explain that this is like the mulch, soil and plant roots that were used to construct that were used in the planting or rain garden. The mulch is the first filter for the water entering the rain garden. Then the water soaks through the soil and in between the plant roots. The water infiltrates this soil, absorbing pollutants in the process.
5. Use another cup as the reservoir and fit the first cup inside. Mix the water and the dirt in one cup. In our model, the dirt represents pollutants like oil, dog poop, and lawn chemicals. Dirt can also be a problem because it can smoother salmon eggs. Pour the dirty water back and forth between the two remaining cups to mix it and to talk about pollutants.
6. Next, pour the water slowly through the filter. Watch the clarity of the water as it comes out of the filter and into the cup. The filter is catching particles of dirt and cleaning the water. Pour the "cleaned" water through the filter several times to see the effect on removing pollutants continues.
7. Now have students make their own soil columns and filter the "dirty" water.
8. Ask students to talk in their groups about how the water was cleaned. Discuss how the soil with the plantings, mulch, or rain garden acts as a filter for pollutants that are in stormwater, pollutants like oil, dog poop, and lawn chemicals. Revisit the learning goal and listen as the students discuss in their groups how nature acts as a filter for cleaning stormwater.

Example-Model B - Soil Columns: Quantitative

Finding Solutions to Stormwater Runoff Pollution

Quantitative Model for testing plantings, soil enhancements, or rain gardens

Overview

- TJ Knappenberger at Washington State University Extension where the research in the video is happening is also studying the ability of various types of soil columns to filter out pollutants in stormwater runoff. Students will test similar soil columns to see how well theirs remove nitrogen and phosphorus.
- Could also watch the video Drained: Urban Stormwater Pollution http://vimeo.com/51603152 OR check out Puget Sound Starts Here Site.

Advanced Preparation

Soil columns -3 per team of 4 students

Vocabulary

Percent

Stormwater

Pollution

mesocosm

Explore and Investigate

Focus Question: Which is the best mixture of soil for a soil filtration system to clean storm water runoff before it enters the streams, lakes, and Puget Sound?

Materials:

Washington State University Polluted Stormwater Runoff reading

Student pages

Premade "polluted water" with known quantities of N and P (making the polluted water acidic is another

option)

Plastic columns or 1 liter plastic bottles - 3 columns for each group

Paper towels

Sand, compost, bark

Measuring beakers

Collecting beakers

LaMotte's or other water testing kits.

Sharpies

Note: This could also be done as a demonstration

1. Tell students that in designing solutions to problems such as Rain gardens for stormwater runoff researchers often need to do investigations just as Jennifer McIntyre did in the video to test that the solution is effective.
2. Have students read about TJ Knappenberger's research at Washington State University in Puyallup, write a summary, and pair share what they read.
3. Tell students that today they will be testing types of soil columns similar to what TJ is doing at WSU (just on a smaller scale) to test which solution to the problem (type of soil column) is best at removing nitrogen and phosphorus pollution. They will be given a solution with a known amount of nitrogen and phosphorus, filter it through their columns, and then test how much nitrates and phosphates are in the filtered water. (do pH if water testing was acidic)
4. Divide students into 9-10 groups (3-4 students in each group). Each group will be doing 1 mixture 3 times. Each group will get to determine a mixture to use in their 3 columns.
5. Instruct students that they have 3 materials: sand, compost, and bark. They get to decide what percent of each material they will use for their 3 columns and whether to mix their substances together or layer them.
6. Have the class decide or you decide how much water they will pour through their columns.
7. Instruct students that they need to put a paper towel at the bottom of their column so that soil doesn't wash into their filtered water. Students draw their columns and write up their procedures. Students must have their column design OK'd by you.
8. Students pour the "synthetic" polluted water through their filters and then analyze the water for nitrates and phosphates using the LaMotte's water testing kits.
9. Students then put their data on the class data charts in their notebooks, write conclusions, and answer the discussion questions. Use Claims, Evidence, and Reasoning structure for writing conclusions.

Focus Question: Which is the best soil mixture for a soil filtration system to clean stormwater runoff before it enters the streams, lakes, and Puget Sound?

Investigation Question: Which type of soil column mixture (different percent of sand, compost, and bark) removes the most nitrates and phosphates?

Soil Column Mixture vs Nitrate in Water				
Soil Column Mixture	**Trial 1**	**Trial 2**	**Trial 3**	**Average Nitrate**

Soil Column Mixture vs Phosphate in Water				
Soil Column Mixture	**Trial 1**	**Trial 2**	**Trial 3**	**Average Nitrate**

Model B - Student Reading

Washington State University Polluted Stormwater Runoff Investigation

Rain Gardens and other green solutions filter stormwater runoff to remove pollutants before the water reaches creeks, streams, and Puget Sound. How to improve the role of soil in these solutions is part of on- going research at Washington State University Extension in Puyallup.

Researcher, T. J. Knappenberger, is testing stormwater runoff pollutant removal of various soil mixes. This study is considered a Mesocosm study because it brings a small part of the natural environment under controlled conditions. In the WSU study there are 5 soil mixes (treatments) being tested with 4 replicates of each. Twenty plastic tanks (2 meters in diameter) serve as large soil columns to test this pollution removal from stormwater runoff.

TJ Knappenberger explaining his soil column research at Washington State University Extension in Puyallup

The various soil mixes are dosed (watered) with stormwater containing known concentrations of pollutants. The 5 treatments contain the following soil mixes (by volume):

1. 60% sandy aggregate and 40% compost.
2. 80% sandy aggregate and 20% compost.
3. 60% sandy aggregate, 30% compost and 10% water treatment residuals.
4. 60% sandy aggregate, 15% compost, 15% shredded bark and 10% water treatment residuals.
5. 60% sandy aggregate, 10% biosolids, 15% shredded bark, 10% water treatment residuals, and 5% sawdust.

All treatments are planted with the same type of plants - slough sedge (carex obnuta), red osier dogwood (cornus sericea) and red switch grass (panicum virgatum).

Soil Column Tank with plantings of slough sedge, red osier dogwood, and red switch grass and tank showing label of 60% sand and 40% compost.

Stormwater is collected from roads and rooftops in a large cistern (approximately 11,356 liters) allowing for the application of stormwater to filter through the soil columns. During storms stormwater is distributed by gravity from the cisterns through pipes at known volumes to the soil column tanks. Water is tested for pollutants before it enters the soil columns and after it has been filtered through the columns.

Between storms the cisterns can be used to mix synthetic stormwater mixtures and dose (water) the soil columns with desired volume and pollutant concentrations. The flexibility built into the collection and delivery system will also allow for the application of various pollutants of concern as scientists and agencies in the region determine research needs.

Previous research suggests that bioretention systems excel at managing most metals, hydrocarbons and sediment, but have shown variable nutrient removal capability. The soil mixtures and water treatment will attempt to show how to improve nutrient management while retaining the excellent removal characteristics for other pollutants. Bacteria capture is also being evaluated in these columns.

Soil tank columns and collection of water after treatment.

A mesocosm is an experimental tool that brings a small part of the natural environment under controlled conditions. In this way mesocosms provide a link between observational field studies that take place in natural environments, but without replication, and controlled laboratory experiments that may take place under somewhat unnatural conditions.

Example- Model C- Stormwater Solutions Model: Rain Gardens

Quantitative Model for testing the ability of rain gardens to absorb and filter polluted stormwater runoff

Overview

Students build on their knowledge of stormwater solutions by doing a hands-on, small group project. Students construct models of rain gardens. The models are then tested for their effectiveness at filtering and absorbing water.

Objectives

- Review the design and purpose of rain gardens
- Construct models of rain gardens
- Make predictions of how effective the models will be at filtering and absorbing water
- Test the models and analyze the results

Lesson Preparations

This activity, while valuable for hands-on learning, requires a fair amount of preparation and materials-gathering by the instructor(s). Here is a checklist for preparations:

- Acquire/purchase plastic containers for models. I bought plastic storage bins from Target.
- Drill small holes in the bottom of the containers for drainage.
- Make "polluted stormwater runoff" mixture. Students could also do this during the activity.
- Acquire/purchase plants for raingardens. I went to my local nursery, but you could easily dig some up for free!
- Acquire/purchase all materials for making the raingardens, put into buckets and label

Materials (for 5 groups)
10 rain garden containers (5 with holes) (13"x7"x4.5")
5 measuring cups (32 oz)
3-4 hand trowels
Gloves (as needed)
20 oz. Cooking oil (4 oz. per group)
5 tsp glitter (1 tsp per group)
20 plants (4 plants ea)
2 hand pruners
1 bucket compost
1 bucket sand
1 bucket mulch
5 PVC pipe (cut lengthwise)
Rocks or blocks (as needed)

Stormwater Solutions Models

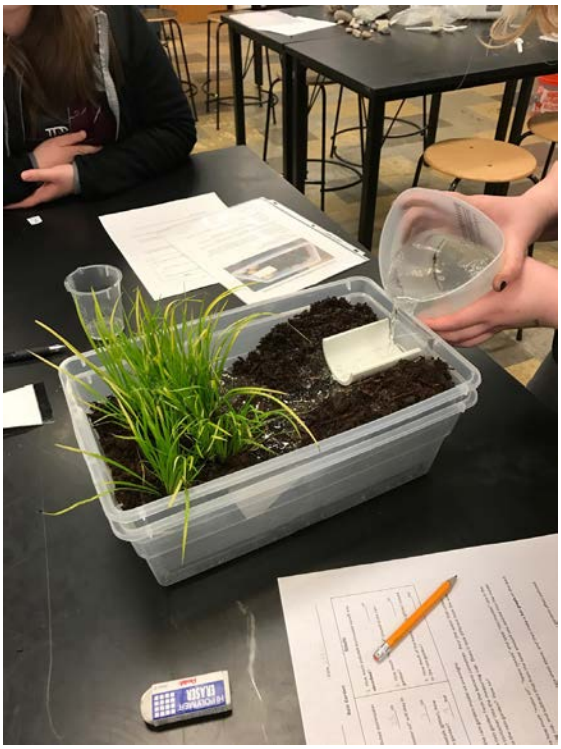
Teacher Note: There are many different ways you can adapt and change this activity to fit your classroom/student needs. This is how we conducted the activity.

Procedure – Model Construction

1. Tell students they are going to be engineers and will be constructing a model of a stormwater solution.
2. Show them the PowerPoint presentation to introduce the activity and teach them details about real-world rain garden construction.
3. Divide the class into small groups. Groups of 3-4 students is ideal.
4. Provide necessary instructions/safety rules for handling materials.
5. Give each group the construction guidelines sheet for them to follow carefully. Every student must help in the construction, so they need to divide up the tasks. Also pass out the data sheet for making predictions.
6. The instructor(s) will walk around and assist as needed.
7. Once the models are completed, have the students write down predictions on the data sheet. Then instruct each group to carefully pour the "polluted stormwater runoff" into their model (be sure they put the model inside the second container to catch the drainage).

Procedure – Model Testing

1. After the models have sat for 1-2 days, they can be tested and analyzed for effectiveness.
2. Give each group their results data sheet from the prior day. Instruct them to follow the directions for measuring the results.
3. Students record their results on the data sheet.
4. Have each group share their results, observations, lessons-learned, etc. with the class.



Name_____ Date_____

Rain Garden

Predictions	Results
1. Out of 30 oz, how much polluted stormwater runoff will be absorbed? _____oz.	1. How much polluted stormwater runoff was **absorbed**? _____oz.
2. Out of 4 oz, how much "motor oil" will stay in the rain garden? _____oz.	2. How much "motor oil" stayed in the rain garden? _____oz.
3. Out of 1 tsp of heavy metals (glitter), how much will stay in the rain garden? _____tsp	3. How much of the heavy metals (glitter) stayed in the rain garden? _____tsp

Day 2: After letting the rain garden model sit overnight -

a. Remove the rain garden from the bottom container. Pour the water that collected in the bottom container into the measuring cup. Does it look different from the water you poured into the rain garden? How so?

b. Measure how much "motor oil", "heavy metals" and total "stormwater" are in the measuring cup, and subtract that from the total amount you poured into the model.

c. Record your answers on the data sheet above, and then make a **bar graph** on the back of this data sheet.

d. What do the results of your test indicate about how rain gardens affect polluted stormwater runoff?

LESSON 9

Developing, Implementing, and Testing Our Preferred Plan

Science
Secondary
Lesson #9 (60 minutes plus project implementation)

Materials

- Computers for Internet Access
- Project Planning Template
- Discussion Protocol
- Materials to implement solution project.
- Materials to implement the test of the solution

Overview

Students work as a member of a design team to create a plan for implementing a preferred stormwater solution including limitations, challenges and success criteria. The class implements one of the plans and tests the effectiveness of that solution.

Objectives

Students collaboratively develop an implementation plan for the proposed solution including action steps, timelines, limitations, and challenges. The class implements one of the solution plans and the tests how well the plan worked.

Evaluation

Collect the students' project proposals and score for completeness. Select the best proposal and share with the class, labeling the criteria for selection.

Activities

1. Share with the students that today, they will continue their work as stormwater engineers, thinking through the development of a project plan for the class' preferred solution to stormwater management and pollution on the school site. Share today's learning target:

   I can collaboratively develop an implementation plan for our proposed solution including action steps, timelines, limitations, challenges, and evaluation (testing).

   Students will work as a member of a team to develop their plan and submit the plan to you for review. One plan from the class will be selected to give to district administration.

2. Provide students with a copy of the Project Planning Template. Instruct the students to work with a partner or in a small group to complete the planning template. Remind students to follow the Discussion Protocol. They will submit their plan to you for review.

3. Review the components of the Project Planning Template:
   - **Purpose:** Summarize the problem that the class is trying to solve.
   - **Proposed Solution:** Summarize the solution selected by the class including why this solution was preferred.

Developing, Implementing, and Testing Our Preferred Plan

- **Projected Cost:** Create a table showing likely expenses and what the cost might be for each.
- **Procedure:** Provide a timeline of the key steps needed to complete the project including people responsible and possible action steps.
- **Limitations and Challenges:** What might interfere with or cause problems during your project? Think about the stakeholders' interests and needs. How might you address the anticipated problems?
- **Evaluation (Testing):** The test planned in the previous lesson.

4. Provide time for students to complete their project proposals. Students will want to research costs for the different alternatives and will need internet access. Share that the most complete proposal, as judged by you, will be submitted to the appropriate district personnel for recommended implementation.
5. Students or the district implement the chosen plan on their school campus or in their community.

Teacher Note: Consider developing criteria for judging the best plan from your class. You may even want to include students in the final judging. Share that engineers will develop proposals for solving problems and the client will review the proposals, selecting one from those that have been submitted. Even though all of the proposals are focused on the same stormwater solution, there will be differences in what the students recommend for an implementation and monitoring plan. What might make one plan better than another? Discuss this with your students.

Teacher Note: The best case scenario is to provide an opportunity for your class to implement their preferred solution for site improvement. Time permitting, consider organizing the class to follow through on the stormwater solution selected including working with stakeholders, monitoring progress, and documenting the success of the project. Teachers may want to collaborate as a grade level to select one class' idea and implement as an entire grade level.

Science
Secondary
Lesson #9 (60 minutes plus project implementation)

Common Core ELA Standards

- W #7: Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on topics and texts, building on others' ideas and expressing their own clearly.

Discussion Protocol

1. Come to discussions prepared with assigned readingand/or research completed.

2. Follow agreed upon rules for discussions:
   - Listen respectfully
   - Take turns
   - Invite all voices to share

3. Ask clarifying questions.

4. Build on others' ideas.

5. Summarize key ideas expressed.

Based on the Common Core Speaking and Listening Standards

Project Planning Template

(Use Digital Version)

- Purpose: Summarize the problem that the class is trying to solve.

- Proposed Solution: Summarize the solution selected by the class including why this solution was preferred.

- Projected Cost: Use a table showing likely expenses and what the cost might be for each.

Expenses	Projected Cost	Source

- Procedure: Provide a timeline of the key steps needed to complete the project including people responsible and possible action steps.

Steps to Complete Project	Person Responsible	Timeline

- Challenges: What might interfere with or cause problems during your project? Think about the stakeholders' interests and needs. How might you address the anticipated problems?

Possible Challenges or Problems	How We Might Address These

- Evaluation (Test): Summarize your "Test" plan developed. Share how you will document the success of your project using observations, data collection, models, photos, interviews, etc.?

Investigation/Model	Data Collection

Materials Needed for Investigation or Model

Team Members Authorization Signatures:

We authorize that this is a well thought out and researched plan meeting the goal of reducing stormwater pollution on our school campus and/or in the local community:

Student Signature_____ Student Signature_____

Student Signature_____ Student Signature_____

LESSON 10

Unit Reflections

Science
Secondary
Lesson #10 (30 minutes)

Overview

Students reflect on their learning during this unit, including actions they will take to reduce pollution and improve the health of our waters.

Objectives

Students reflect on their understanding of the key ideas in this unit and self-evaluate their learning.

Evaluation

Student Self-Evaluation

Activities

1. Share with students that today they will have the opportunity to self-reflect on their work in the stormwater unit. They will write comments regarding the key lessons for them in this unit. The learning goal today is: *I can reflect on my understanding of the key ideas in this unit and self-evaluate my learning.*
2. Revisit the essential questions for this unit:

   What is the role of the Stormwater Engineer and how do they solve problems?

   What issues do we face as both a school and local community with pollution in stormwater runoff?

   Who are the stakeholders in managing polluted stormwater runoff and what are their interests?

   What are solutions for managing polluted stormwater runoff including strengths and weaknesses?

   What plan will we propose to address stormwater runoff and pollution on our school campus?

   How might the implementation of our plan be monitored and evaluated over time?
3. Invite the students to have brief conversations regarding each of the unit questions. What do they recall as they reflect on their learning?

Materials

- Post-Assessment Questions
- Student Self-Reflection

Unit Reflections

4. Instruct students to take the assessment for this unit, including responding to the reflective questions. These include the following:

   - What one action will I take as a result of this unit on Stormwater solutions?
   - What is a new learning for me as I reflect on this unit?
   - What excited me the most about this unit?
   - What challenged me the most during this unit?
   - How do I rate myself as a learner in this unit on a scale of 1-5?

   1 = I did a poor job of learning and 5= I was an outstanding learner in this unit.

   Why did you give yourself this rating? Provide at least one reason.

5. Review the post-assessments and compare the data to the pre- assessments. Summarize the impact of the unit on the students and share this data with your class.

Optional Extension: An Engineering Design Competition!

Engage students in an Engineering Design Competition where the students create their own solutions for stormwater management. They would be given the freedom to invent a new idea, combine ideas from this unit of study, or modify a solution. Their solution could address stormwater problems in their neighborhood or on the school site.

Encourage the students to think like engineers: Analyzing the problem, inventing alternatives, critiquing the alternatives and recommending a proposed solution and plan.

Invite the school's principal, an administrator from the central office or a city engineer to review the student proposals and select ones to recognize for innovation.

Science
Secondary
Lesson #10 (30 minutes)

Common Core ELA Standards

- S/L #1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on topics and texts, building on others' ideas and expressing their own clearly.

Stormwater Solutions Self-Reflection

- What is one action I will take as a result of this unit on Stormwater engineering solutions?

- What is a new learning for me as I reflect on this unit?

- What excited me the most about this unit?

- What challenged me the most during this unit?

- How do I rate myself as a learner in this unit on a scale of 1-5?

  1 2 3 4 5

  Poor Job Outstanding Job

Why did you give yourself this rating? Provide at least one reason.

Glossary of Stormwater Terms

Aquifer: An area where water is stored under the ground, in the soil. When rain water soaks into the ground, it can fill an aquifer. This underground water is called groundwater (see definition below). This water can then be withdrawn for human use through wells and springs.

BMP: This stands for Best Management Practice. A Best Management Practice is a behavior or action that a person performs that protects the health of the environment.

Deposition: The process where sediment, soil, and rocks are moved and collect on another part of the landscape.

Detention pond: A small, man-made pond that collects the rain water that runs off of hard surfaces in developed areas, such as streets and buildings. The detention pond temporarily stores this rain water and releases it gradually back into the environment, usually over a few hours or days.

Erosion: The carrying away or displacement sediment, soil, rock, and other solids, usually by wind, water, or ice by down-slope movement in response to gravity or by living organisms. (OSPI)

Evaporation: The process where water becomes a gas (vapor) from a liquid.

Filtration: A process where water moves slowly through the soil, removing pollutants that are in the water.

Groundwater: the water found underground in the cracks and spaces in soil, sand and rock. Groundwater is found in aquifers. (groundwater.org)

Habitat: An ecological or environmental area that is inhabited by a particular species. It is the natural environment in which an organism lives or the physical environment that surrounds a species population. (OSPI)

Headwaters: The area where a creek, stream, or river begins - the source of that waterway.

Impervious surface: A type of land or ground covering that is hard and prevents rain water from soaking into the soil. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots, buildings, concrete or asphalt paving, gravel roads, and hard-packed dirt.

Infiltration: A process where water moves slowly through the soil.

Model: In science models are used to represent a system. They can be diagrams, physical replicas, mathematical representations, analogies, and computer simulations. (Next Generation Science Standards- Appendices).

Native Plants: Plants that occur naturally in a certain region and are adapted to that climate.

Nonpoint source (NPS) pollution: A type of water pollution which occurs when rain runs off farmland, city streets, construction sites, suburban lawns, roofs, and driveways before entering the waterway. This is pollution that does not come from a single source, or point. Instead, this pollution comes from many different sources, and is collected as rain water runs over the surface of the land.

Optimize: Improving a design to make the design function better, cost less, be more efficient or other criteria. This involves trading off less important features for those that are more important. (Next Generation Science Standards- Appendixes)

Pervious Surface: A type of land surface that allows water to soak in.

Pollutant: A substance introduced into an environment that has undesired, harmful, or destructive effects on organisms and/or resources in the environment. (EPA)

Polluted stormwater runoff: The byproduct of stormwater runoff and the pollutants in the environment through which it runs. Pollution makes the stormwater unclean and harmful to the organisms in the waterway.

Retention: The process of collecting and holding storm water runoff.

Riparian: Describes the area of land directly next to river, lake or other body of water, such a shoreline or river bank.

Rain Garden: A garden with spongy soils and plants used to collect and filter stormwater.

Stakeholder: Individuals or groups with interests related to an issue or outcome.

Storm drain system: The system of gutters, pipes, streams, or ditches used to carry surface and storm water from surrounding lands to rivers, lakes, or the Puget Sound.

Stormwater: is precipitation (rain, snow, or hail) and ice melt. Stormwater can soak into the soil (infiltrate), be held on the surface and evaporate, or runoff and end up in nearby streams, rivers, or other water bodies.

Stormwater Engineer: A person who designs solutions for problems created by too much surface water runoff and pollution in stormwater.

Stormwater Runoff: Water from rain, or other precipitation, that is not absorbed into the ground. Instead, the water runs off the surface of roofs, streets and lawns and enters natural waterbodies, such as rivers, lakes and Puget Sound, either directly or through storm drains. Also see definition of runoff above.

Surface water: Water found about the land, including oceans, estuaries, lakes, rivers, streams, and ponds.

Surface Runoff: Water from rain, or other precipitation, that is not absorbed into the ground. Instead, the water runs off the surface of roofs, streets and lawns and enters natural waterbodies, such as rivers, lakes and Puget Sound, either directly or through storm drains.

Swale: A shallow, line-shaped depression in the ground, like a canal, that can collect water. Swales can be man-made and are usually less than 30 cm deep.

Transpiration: The process by which water evaporates from plant tissues.

Toxic: Poisonous or otherwise directly harmful to life.

Water Filter: A device to remove pollutants or unclean substances from water.

Watershed: The entire land area from which water drains into a particular surface water body.

Wetland: An area covered by shallow water most of the time, where vegetation grows that is adapted to the wet conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Solution Pages to Follow

STORMWATER RUNOFF PROBLEM SOLUTION PAGES

Solution: Install Bioswale

Problem

Rain falling on hard surfaces like roofs, driveways, sidewalks, parking lots, roads, and compacted soils runs off quickly into the nearest storm drain. This drain takes the water in pipes to the nearest lake, stream, or wetland. This fast moving water causes soil erosion in our streams, and higher water temperatures in the summer months. The water also picks up pollution on these surfaces that is harmful to us, our pets, and our environment.

Benefits

Bioswales slow down stormwater runoff reducing the amount of water entering the storm system which helps reduce soil erosion and flooding. The soil and plants act like a filter and remove some of the pollution carried by the stormwater runoff before it reaches local streams. The soil also cools the water as it soaks in, helping to lower stream temperatures, and protecting habitat for salmon and other wildlife.

Considerations

- **Cost**- Costs will vary depending on the size, materials used, site conditions, and whether you hire someone to do the work or do it yourself. Roadside bioswales are generally cheaper than traditional pipe systems.
- **Time needed** - Time will depend on the size, plants, permits, and current conditions of the site.
- **Maintenance** - During the first 2-3 years, the plants will need to be watered during the dry months, mulch will need to be placed around plants, and weeds will need to be removed. Inspections should be conducted seasonally and after large storm events to remove sediment, weeds, and replace plants as necessary.

Solution

A bioswale, also called a vegetated swale, is a shallow ditch that contains soils and plants that act like a sponge to help capture and soak up more stormwater runoff. A bioswale also slows down stormwater runoff, allows some of the water to soak into the soil, and filters out some of the pollution that the water collected along the way.

- **Materials needed** - For installation, you will need equipment to construct the swale like; shovels, rakes, measuring tape, wheelbarrow, stakes, string, plants, mulch, rocks, and seed for the grass portions.
- **Location** - Bioswales perform very well in a variety of locations. Because they are narrow, they are ideal in small areas, along roads, and in parking lots. They should be avoided in areas that are completely flat or very steep because some slope is needed so the water will move, but not too much or the water will pass through too quickly to provide any water quality benefit and possibly cause erosion and flooding.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting **pugetsoundstartshere.org**

STORMWATER RUNOFF PROBLEM SOLUTION PAGES

Solution: Add Compost to Soils

Problem

Poor draining soils do not allow water to pass through which causes ponding, flooding, and allows water to run off rather than soak in. Plants can also drown if the soils do not drain. Unhealthy soils have fewer beneficial living organisms, are often compacted, offer little nutrients to plants.

Benefits

Healthy soil absorbs more water which reduces stormwater runoff. It also acts as a filter and cleans pollutants out of water as it passes through, leaving cleaner water to enter back into our groundwater and streams. Healthy soil cools stormwater as it passes through which provides cooler water for local streams and a healthier environment for the wildlife that live there. Healthy soil provides essential nutrients to plants which improves their health and helps them resist pests and disease.

Solution

Compost is decaying organic material that you can use to fertilze plants. Adding compost to soil helps balance it's pH making it healthy for plants and the beneficial living organisms that live in the soil. It also provides nutrients that plants need to grow. A teaspoon of healthy soil contains about 4 billion living organisms! Compost also creates larger spaces between particles that allow air, water, and plant root growth into the soil.

Considerations

- **Cost** - Purchasing equipment might be necessary to complete this solution. Equipment might include a shovel, wheelbarrow, container, rake, and water hose.
- **Mulching** - Materials from your yard are free, otherwise compost from a store ranges from $5.00 per bag to $25.00 per small pickup truckload.
- **Maintenance** - Experts estimate that mulch and compost should be added each year in either spring or fall so some on-going maintenance will likely be necessary.
- **Time** - The time required depends on the size of your yard .
- **Design** - A day is typically all is necessary to determine where the materials should be placed.
- **Labor** - A few hours to a day will be needed for the initial work.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting **pugetsoundstartshere.org**

STORMWATER RUNOFF PROBLEM: SOLUTION PAGES

Solution: Plant Trees

Problem

When people develop an area of land for homes, buildings, roads, etc. they often cut down most or all of the trees. This drastically changes the way water flows across the land and increases the amount of stormwater runoff. This increased runoff causes local flooding and erosion stream banks.

Benefits

Trees capture stormwater when it rains and slow it down, reducing local stream flooding and erosion of stream banks. Trees planted along a stream provide shade and cool the water temperature which is important for fish. Trees drop leaves and other nutrients into the stream which feed the small underwater insects that fish and other insects eat. They can also provide nutrients for other aquatic animal and plants. Trees eventually fall or drop large branches into streams. These branches or tree trunks create important spots for fish and other wildlife to rest, hide, and hunt. Trees help clean our air and absorb carbon dioxide which help reduce air and water temperatures.

Considerations

- **Cost** - The cost of trees varies greatly depending on the size and species. Seeds are often less than $1.00, small trees can typically range in cost from $2.00 to $25.00, and large trees can range from $25.00 to thousands of dollars.
- **Maintenance** - For the first 2 to 5 years, provide water and nutrients for your new trees. Wood mulch should be placed around the tree annually (being careful not to put it close around the trunk) to slow the growth of weeds and help keep moisture in the soil.
- **Materials needed** - Basic materials include gloves, a shovel, and a tree.
- **Time needed** - It typically takes 5 to 10 minutes to plant a tree. The maintenance will vary depending on the year, seasonal conditions, and number of trees planted.

Solution

Trees catch rainfall on their leaves and needles, slowing it down and allowing much of it to evaporate back into the air. Tree roots also loosen the soil, creating more space for water to soak in, absorb groundwater and transpire it through their leaves or needles back into the air. Trees have other benefits too: cooling our homes and buildings in summer and blocking cold winds in winter, cleaning our air while moving carbon dioxide (a greenhouse gas) from the atmosphere back into the soil, and making our towns and cities pretty while providing homes for birds and other wildlife.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting **pugetsoundstartshere.org**

STORMWATER RUNOFF PROBLEM SOLUTION PAGES

Solution: Disconnect Downspouts

Problem

Rain that falls on a roof is carried through rain gutters to downspouts along the outside of the building. Home and other building downspouts are often connected directly to the stormwater pipes under the street. These pipes take this stormwater from our roofs quickly to the nearest lake, stream, or wetland. In large rain storms, this stormwater runoff can contribute to local flooding and stream bank erosion.

Benefits

Disconnecting downspouts can reduce the amount of stormwater rushing into streams during rainstorms. Reducing the flow of water helps protect streams from erosion and flooding.

Considerations

- **Cost** - Costs for disconnecting a downspout range from $50 to over $1000, based on materials used and size of the area to where the water will flow.
- **Time needed** - Disconnecting the downspouts is fairly simple, but time will vary based on where you decide to direct the water.
- **Maintenance** - During the first year, the downspout should be checked during and after large rainstorms to ensure the diversion is working and water collection is functioning properly. After that, it should be checked twice a year and maintained as necessary.
- **Materials needed** - connection elbow, water diversion path materials (rocks, pipe, etc.), collection unit (rain barrel system or cistern), plants (if needed).
- **Other** - Homeowners should check with their local public works department before disconnecting their downspouts. They must also be able to answer these questions:
  - Can they direct stormwater runoff to a place that can collect and absorb a large amount of water during rainstorms? Can they direct runoff to rain garden, cistern, or large lawn/landscaped area? Can the water get there safely? Is there adequate pipe, splash block, swale, or way to move water away from the house or building to the soil?
  - What happens in a bad storm? Can water overflow safely without flooding neighbors or sidewalks? Are there steep slopes or landslide prone areas in the neighborhood? Does water pool in the yard during winter months?

Solution

Disconnecting downspouts from the stormwater pipes and diverting the water to be collected or absorbed into the soil reduces stormwater runoff. The downspout water can be sent to a cistern for collection or away from the house to a landscaped area that will allow the water to soak into the soil. This landscaped area can be a rain garden, large lawn, or natural vegetated space.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting **pugetsoundstartshere.org**

STORMWATER RUNOFF PROBLEM: SOLUTION PAGES

Solution: Rain Gardens

Problem

Rain falling on hard surfaces like roofs, driveways, sidewalks, parking lots, roads, compacted soils runs off quickly into the nearest storm drain which takes the water in pipes to the nearest lake, stream, or wetland. This fast moving water causes soil erosion in our streams, and higher water temperatures in the summer months. The water also picks up pollution on these surfaces that is harmful to us, our pets, and fish and wildlife.

Benefits

Rain gardens slow down stormwater runoff reducing the amount of water entering the storm system which helps reduce soil erosion and flooding. The soil and plants act like a filter and remove some of the pollution carried by the stormwater runoff before it reaches local streams. The soil also cools the water as it soaks in, helping to lower stream temperatures, and protecting habitat for salmon and other wildlife.

Solution

Rain gardens are shallow bowl shaped gardens that can capture and hold runoff from hard surfaces. They have healthy soils with compost to help soak up more water and allow it to slowly filter through the soil. Rain gardens are landscaped with plants that work best with the amount of sun, soil, and water the garden receives.

Considerations

- **Cost** - Costs will vary based on size, site conditions, and materials. Hiring someone to design and install the garden will increase cost.
- **Location**- rain gardens can only be located where the soil drains well enough to allow the water to filter through.
- **Maintenance needed** - During the first 2-3 years, the plants will need to be watered during the dry months, mulch will need to be placed around plants, and weeds will need to be removed. Inspections should be conducted seasonally and after large storm events to remove sediment, weeds, and replace plants as necessary.
- **Materials needed**- Materials will depend again on the type of garden, but a typical list would include equipment to dig the site, rocks, compost, plants, irrigation or watering hose, and mulch.
- **Permits**- some cities and counties require you to check with them before disconnecting any downspouts. They may need to see the rain garden plans to be sure it can handle the amount of water being directed to it.
- **Time needed** -Time will depend on the size and the types of plants chosen, but an owner should expect to spend a day to a week designing and calculating the rain garden, a few days to a few weeks constructing the rain garden, and couple of hours each month for the first 1 to 3 years of establishment maintaining the site.

MORE INFORMATION:
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STORMWATER RUNOFF PROBLEM SOLUTION PAGES

Solution: Install a Cistern

Problem

Rain or snow that falls on roofs is carried through rain gutters to downspouts along the outside of homes or buildings. These downspouts are often connected directly to the stormwater pipes in the street. These pipes take stormwater quickly to the nearest lake, stream, or wetland causing soil erosion in our streams, and higher water temperatures in the summer months. The water also picks up chemicals and heavy metals from roof materials and deposits them into our streams.

Benefits

Cisterns or a series of rain barrels slow the flow of stormwater by capturing the water for later use. Using cisterns and rain barrels and then releasing the water onto your lawn also allows polluted runoff from roofs to be filtered out by soils on-site before entering streams or lakes.

Considerations

- **Cost** - Cisterns and rain barrels vary greatly in cost depending on the material that they are made of, how big they are, and whether a homeowner installs it themselves or hires someone else, etc. Homeowners need to shop around for materials and plan carefully to find a cistern that meets their space, capacity needs, and site conditions.
- **Maintenance** - Property owners should choose a dark colored tank and place it in a shaded area to limit algae growth. Some tanks can be installed underground, in crawl spaces, or under porches but these are more expensive, harder to install, and harder to repair/ maintain. Once or twice a year, the condition of a cistern and the water in the cistern should be checked. The filter should be cleared of any debris at the beginning and end of the rainy season.
- **Materials needed** - Level location near a downspout, a solid base, a safe place to allow the water to flow from the tank that must be away from homes, buildings, structures, and neighbors.
- **Other** - Some cities have hazard areas that do not allow residents to disconnect their downspouts, so homeowners should check with their local public works department before disconnecting their downspouts and installing a cistern.

Solution

Disconnecting downspouts from stormwater pipes in the street and connecting the downspout to a cistern or multiple rain barrels allows the water to be collected and used or released later to reduce local flooding and stream bank erosion.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting **pugetsoundstartshere.org**

STORMWATER RUNOFF PROBLEM SOLUTION PAGES

Solution: Install Pervious Pavement

Problem

Types of pavement, like asphalt and concrete, are called “impervious surfaces” because they don’t let the rain soak into the soil. Instead rain runs off of these surfaces and into our storm drains. In big storms, stormwater runoff can contribute to local flooding and stream erosion. These impervious surfaces also deposit millions of pounds of pollution into our streams and Puget Sound every year.

Benefits

When water is allowed to soak into the soil, it is slowed down and reaches streams much later than if it were to travel quickly through storm drains. The living organisms in the soil filter the water reducing the amount of pollution reaching local streams. The soil also cools the water and helps lower stream temperatures which is better for salmon and wildlife that live in our streams and Puget Sound.

Considerations

- **Cost** - Cost varies greatly depending on size of area, type of material chosen, use of area you are converting (driveway, patio, sidewalk, road, etc.), and whether you are hiring someone to do the work or doing it yourself.
- **Maintenance** - Porous pavement needs to be cleaned at least annually to prevent spaces from clogging with dirt and debris. Permeable pavers may need to be mowed to keep plants in between them from getting too large.
- **Materials needed** - Porous pavement or pavers, subgrade materials (sand, pebbles, etc. that go underneath the pavement), equipment, and maintenance materials.
- **Time needed** - Design can take days to weeks, construction can take days to weeks and maintenance should take a few hours annually.
- **Site conditions** - the soils need to be able to drain the water fairly quickly to prevent puddles and potential flooding.

Solution

Homeowners can reduce stormwater runoff impacts by choosing pervious pavement options for their driveways, sidewalks, and patios (like porous asphalt, pervious concrete, and permeable pavers) that let the rain soak through into the soil.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting, pugetsoundstartshere.org .

STORMWATER RUNOFF SOLUTION PAGES

COMPARISON SHEET

Before selecting a solution, you must consider the resources available and existing site conditions.

Resources- it is important to review your available resources before selecting the appropriate solution:

- **Cost** - Costs will vary depending on the size, materials used, equipment needed, conditions of the area you are converting, and whether you hire someone to do the work or do it yourself.
- **Installation**- will depend on the size, plants, permits, and current conditions of the site.
- **Maintenance** - During the first two to three years, any plants will need to be watered during the dry months, mulch will need to be placed around plants, and weeds will need to be removed. Inspections should be conducted seasonally and after large storm events to remove sediment, weeds, and replace plants as necessary.

Site conditions- it is important to assess the property for soil type, slope, amount of space available, and proximity to buildings or neighboring properties before selecting the appropriate solution:

- **Slopes-** whether the land is flat or hilly matters when you are installing certain features.
- **Space limitations-** the amount of space you have available will determine what can be placed onsite.
- **Soil conditions-** soil conditions are important when trying to allow the water to soak into the soil.
- **Light conditions**- trees and other vegetation need varying degrees of light throughout the day.

	Bioswale	Compost	Plant Trees	Disconnect Downspouts	Rain Garden	Install Cistern	Porous Pavement
Cost	$	$	$	$	$$	$$	$$-$$$
Installation	Moderate	Easy	Easy	Easy	Moderate	Complex	Complex
Maintenance	Moderate	Low	Low	Low	Moderate	Moderate	Moderate-High
Steep or hilly slopes	Moderate Only	Flat-Steep OK	Flat-Steep OK	Moderate-Steep OK	Flat-Moderate OK	Flat OK	Flat-Moderate OK
Limited space	OK	OK	Sometimes OK	Sometimes OK	Not OK	Not OK	OK
Soil conditions	Well-Moderately Draining	Well-Poor Draining	Depends on species	Well-Moderately Draining	Well-Moderately Draining	N/A	Well-Moderately Draining
Light conditions	Partial sun OK	N/A	Depends on species	N/A	Full sun-shady	N/A	N/A
Water quality benefits	yes	yes	yes	yes	yes	no	yes
Flow control benefits	yes	yes	yes	yes	yes	yes	yes

MORE INFORMATION:
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STORMWATER POLLUTION PROBLEM SOLUTION PAGES

Solution: Use a Commercial Car Wash

Problem

Washing your car in your driveway, on the street, or in a parking lot sends gasoline, oil, heavy metals, solvents, soap and other harmful pollutants into our storm drains. Most storm drains connect directly to our local streams, lakes, and wetlands. Dirty wash water pollutants can cause problems for us, our pets, and our environment. For example, soaps contain solvents that remove the protective coating on fish gills and amphibians which can harm or even kill them. Oil causes heart problems and death in young salmon. Heavy metals in wash water like copper damage the fine sense of smell that salmon need to detect and escape from predators.

Benefits

Millions of gallons of water are used to wash vehicles in our area each year. Commercial car wash facilities use far less water which helps conserve water for streams. Commercial facilites also filter and recycle their dirty wash water and send it to the sewer for treatment. This prevents pollution like soaps, solvents, oils, and heavy metals that are washed off of cars from reaching our streams.

Solution

Commercial car wash facilties use far less water than washing at home and they recycle the water. They use the appropriate cleaners to help maintain your vehicle (dish soap is like washing your car with sand paper), and they capture the harmful wash water and send it to the sewer system for proper treatment and disposal.

Considerations

- **Cost** - Commercial car washes are more expensive than washing your car at home. It can cost from $2.00 to $15.00 for a commercial car wash, depending on whether the owner is using a self-serve or automated facility.
- **Maintenance** - The amount of maintenance needed to keep a car clean depends on whether the driver uses a self-serve or automated car wash, how much the car owner drives, and the road conditions they drive on (gravel/dirt roads create more dirt on vehicles and may require more washing).
- **Materials needed** - For self-serve car wash facilities, owners can use the brushes and soap/wax provided at the facility or they can bring their own supplies. Some car owners prefer to hand dry their vehicles, so towels would be needed.
- **Time needed** - Using a commercial car wash is faster than washing your car at home. This usually takes 10 to 30 minutes for self-serve car washes and 5 to 10 minutes for automated car washes.

MORE INFORMATION:
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STORMWATER POLLUTION PROBLEM SOLUTION PAGES

Solution: Don't Drip and Drive - Fix that Leak

Problem

A few drips of oil or another fluid from your car may not seem like a big deal, but thousands of vehicles are leaking throughout the region. That adds up to a big problem! Fluid leaks like oil, grease, and antifreeze are toxic to people, wildlife, and plants. When it rains, these pollutants are carried by stormwater into our streams, lakes, and wetlands.

Benefits

According to the Washington State Department of Ecology, over 7 million quarts of motor oil and other automotive fluids wash into our streams, lakes, and Puget Sound every year. The Northwest Department of Marine Fisheries (NOAA) has tested the impacts of oil and other petroleum based products on young fish. They found that many of these products caused heart problems and even death in some species. By fixing leaks and removing these toxic products from our streams, we will help to protect and preserve the environment for our fish, wildlife, and ourselves.

Considerations

- **Cost** - The cost of repair depends on the cause of the leak. Costs can range from $5.00 for a new gasket to thousands of dollars for major repairs.
- **Maintenance** - Vehicle owners should have their cars checked and maintained regularly, about once per year. This can be done by the vehicle owner or a mechanic.
- **Materials needed** - Testing for leaks: Vehicle owner can test their cars for leaks using a large sheet of white paper (usually 5 feet square), a color chart of leaks (*www.fixcarleaks.org*), and some rocks to hold the paper down. Repair materials depend on the cause of the leak.
- **Time** - For an owner to check a vehicle themselves, they will need to place the sheet of paper under the vehicle immediately after driving and leave it there for a few hours. If they see a leak, they will need to take the sheet out, check any leaks against the leak color chart and then schedule an appointment with their mechanic to confirm and repair the leak.

Solution

Vehicle leaks are the single largest source of pollution in our streams, so fixing leaks can have a huge impact on the health of our local waters. Even a small leak can have a big impact over time. Leaks also impact the life of a vehicle, so repairing leaks right away will help keep vehicle running longer.

MORE INFORMATION:
Learn more about what you can do to prevent polluted stormwater runoff by visiting **pugetsoundstartshere.org**

STORMWATER POLLUTION PROBLEM SOLUTION PAGES

Solution: Avoid Pesticides

Problem

Some people think they need to use chemical pesticides to keep their lawns and gardens healthy and make them grow faster, but these products are unnecessary and can cause a lot of damage to us, our pets, and our environment. The suffix of pesticide, "-cide" means to kill, so while you may be killing a bug or a plant you don't want in your yard, you are also killing important bugs and plants we need to survive. Plus, when it rains, these toxic chemicals are washed into streams where they can harm or kill fish and wildlife.

Benefits

By keeping pesticides out of our streams, we allow wildlife to thrive. Scientists have found over thirty pesticides in our streams and lakes that cause problems for plants and animals like us. Fish also eat small beneficial macroinvertebrates (stream insects) which can be killed by pesticides when they reach local streams.

Considerations

- **Cost** - Pesticides and fertilizers are more expensive than natural grass seed, compost and mulch. Residents save money by not purchasing chemical products.
- **Maintenance** - Maintaining a lawn and garden without chemicals requires people to mow higher (1-2inches), water deeply and infrequently (1 inch of water a week), pull weeds before they go to seed, overseed once a year, topdress with compost, and occasionally aerate to improve root development and water penetration.
- **Materials needed** - The natural way to maintain a really green healthy lawn is to rake, spread grass seed, spread compost and occasionally thatch (take out small plugs of soil with a machine) your lawn. This requires purchasing compost, grass seed, and occasionally renting a thatching machine.
- **Time needed** - Properly maintaining your lawn requires a few hours in the spring and fall. Pulling weeds is more time consuming than spraying pesticides initially, so more time might be needed to maintain the same look for your lawn initially.

Solution

There are many things you can do before applying harmful chemicals. First, is to select pest-resistant plants and pull weeds in the spring before they go to seed. Second, is to identify any problems before treating because issues could be due to incorrect mowing, pruning, watering, or soil conditions, and that scary insect could actually be a beneficial bug that eats problem pests.

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STORMWATER POLLUTION PROBLEM SOLUTION PAGES

Solution: Scoop the Poop, Bag it, and Place it in the Trash

Problem

Pet waste, like human waste, is raw sewage and contains bacteria and diseases like Ecoli and Giardia that can make animals like us sick. When it rains, pet waste left in our yards and public spaces gets washed into our storm drains and sent directly to the nearest lake, stream, or wetland without treatment. This sends lots of nutrients from our pet waste into our streams and lakes which can cause too much algae to grow. This algae takes oxygen out of the water that fish and other aquatic life need to survive. The harmful bacteria and diseases in pet waste can make the water unhealthy for people and other animals, forcing beaches to close and contaminating shell fish beds, an important source of food and money for Washingtonians.

Benefits

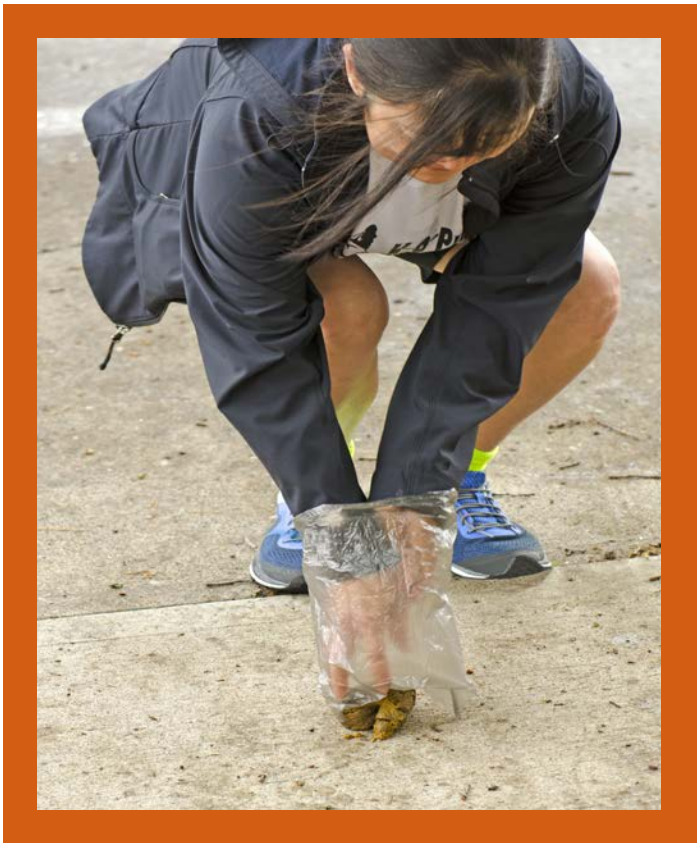
Picking up pet waste protects people and pets from being infected by harmful bacteria and diseases in our homes, yards, and public spaces. Proper disposal also prevents waste from being washed into our streams and lakes when it rains, keeping our beaches and shellfish beds clean and open for everyone to enjoy. Keeping the excess nutrients from pet waste out of the water helps reduce harmful algal blooms which further contaminate our beaches, shellfish, and rob our waterways of the oxygen that fish and other aquatic life need to survive.

Considerations

- **Cost** - Any bags can be used for picking up waste, but many choose to purchase rolled bags for $0.04-$0.50 per bag. Also a one-time cost for a shovel or scoop may be desired.
- **Maintenance** - Scooping waste requires the pet owner to pick up the pet waste and place it in the trash on a regular basis.
- **Materials needed** - Bags to collect and dispose of the waste and sometimes a small scoop or extended shovel are preferred to collect the waste.
- **Time needed** - Scooping pet waste and placing it in the trash may take an extra minute of time.

Solution

The great news is that it's easy to protect ourselves and our local streams, simply scoop the poop, bag it up, and place it in the trash.



MORE INFORMATION:
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STORMWATER RUNOFF PROBLEM: SOLUTION PAGES

Solution: Pick Up Litter

Problem

Litter is what we call trash and dangerous items that are left on land or in water and are not disposed of properly. A large amount of litter is found in parking lots, yards, and along roadways. This litter makes its way into local streams and lakes through storm drains and can impact the environment for years to come. For example, floating pieces of plastic tangle themselves around fish and wildlife, causing harm and even death. Plastic litter can eventually break down into tiny pieces called *microplastics* and float or sink. The floating pieces can be mistaken for food by wildlife and make them sick. Sinking plastic can smother habitat and release toxic chemicals into the water, causing problems for fish and wildlife.

Benefits

Picking up litter helps in a variety of ways. First, picking up a can or bottle may help keep people from thinking it's OK to toss their trash on the ground. Second, people also feel better about themselves and their surroundings when outdoor spaces are clean and free of trash. Finally, proper disposal of trash keeps our streams and lakes clean and healthy for fish, wildlife, and us!

Considerations

- **Cost** - Gloves, a bag, and grabbing tool might be needed to complete this work. Gloves range from $2.00-15.00. Bags costs $.04-.05 per bag. A one-time cost for a grabbing tool may be desired.
- **Maintenance** - Placing trash and recycling can in convenient spots is a great way to encourage people to pick up after themselves. These cans will need to be emptied on a regular basis. Hand collection is also a good idea and should be conducted on a regular basis as well such as weekly, biweekly, or monthly.
- **Materials needed** - Basic materials include trash cans, bags, gloves, and a grabbing tool.
- **Time needed** -Time will depend on the size of the area you are cleaning up and the amount of litter left onsite. Emptying trash cans typically takes a minute or two.

Solution

The great news is that it's easy to protect ourselves and our local streams and lakes by simply picking up litter and placing it in the trash.

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