Community Waters

Engineering Stormwater Solutions with Plants

Created by IslandWood in collaboration
with Seattle Public Schools and Seattle Public Utilities.

PROTECT OUR WATERS
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SEATTLE PUBLIC SCHOOLS

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Overview

Summary

This unit includes 9 lessons with possible extensions; most are designed to take an hour. Lesson 3 will probably take two hours and can be divided into two days. Parts of some lessons can be taught during ELA and math time.

This set of lessons supports Next Generation Science Standards in an active, hands-on exploration of plants and water in our urban areas. Students will learn about watersheds, runoff, and stormwater by conducting investigations of their schoolyard and neighborhood. Students will then developing an engineering solution to a neighborhood runoff problem. Students will use a variety of tools to investigate and communicate the problems and solutions, including models, field studies, diagrams, readings, online maps, and videos. Science notebooks and included worksheets will be used to capture student notes, thinking, and learning. The unit will conclude with students sharing their proposed stormwater solutions with their classmates. If there is time, students can possibly build, test and optimize solutions.

Goals

- Engage teachers and students with NGSS Disciplinary Core Ideas and Practices, including Engineering Design Practices
- Actively engage students in developing engineering solutions to environmental challenges
- Increase students' skills in investigations of local environmental issues and solutions, particularly in relation to stormwater

Next Generation Science Standards in this Unit

All lessons in this unit are aligned to the Next Generation Science Standards ("Washington State 2013 Science Learning Standards"). The quick list of standards below is described in more detail at the end of this curriculum. The applicable standards are also listed at the start of each lesson. When a practice is introduced in a lesson it will be **highlighted in blue**.

4th Grade Disciplinary Core Ideas
LS1.A Structure and Function **ESS2.A Earth Materials and Systems** **ESS2.E Biogeology** **ESS3.B Natural Hazards** **ETS1.A Defining and Delimiting Engineering Problems** **ETS1.B Designing Solutions to Engineering Problems**
Science and Engineering Practices
Asking Questions and Defining Problems **Developing and Using Models** **Planning and Carrying Out Investigations** **Analyzing and Interpreting Data** **Using Mathematical and Computational Thinking** **Construction Explanations and Designing Solutions** **Engaging in Argument from Evidence** **Obtaining, Evaluating, and Communicating Information**
Crosscutting Concepts
Cause and Effect **Systems and System Models** **Structure and Function** **Influence of Engineering, Technology, and Science and the Natural World (Engineering)**

Lesson Overviews

For complete definitions of the vocabulary words, please refer to the Glossary at the end of the document.

Lesson 1: Activating Prior Knowledge	
Summary	As a hook to introduce the unit, students will view a video showing stormwater emptying into Puget Sound. Students will share their knowledge about stormwater and engineering for a KWELs chart.
Focus Questions	● *What do you think you already know about engineering?* ● *What do you think you know about rain water and where it goes in your neighborhood?*
Vocabulary	student generated
Learning Targets	We will identify what we know about engineering and rain water.
Assessment Options	● Explain why we should care about the rain and water that pass through our neighborhood.

Lesson 2: Watersheds and Runoff	
Summary	Using paper models, students first explore what a watershed is and how water and pollution can travel downstream. Students will understand that pollutants can cause water quality problems and heavy runoff can cause flooding within a watershed. These things can be worse in urban watersheds where there is more pavement.
Focus Questions	● *What is a watershed?* ● *How does water flow in a watershed?* ● *What happens to rain that passes through an urban area?*
Vocabulary	watershed, runoff, pollution
Learning Targets	We will make a model of a watershed to show what happens to pollution in our neighborhood.
Assessment Options	● Design a sign for the neighborhood on what families need to know about what happens to water that flows into a storm drain.

Lesson 3: Community-Based Watershed Assessment (Field Experience)	
Summary	Students explore their school or neighborhood with a list of things that might increase or reduce runoff. On a map, they record locations of features they find and identify areas where flooding could be a concern (e.g. a basketball court in their schoolyard, or a nearby stream). Students learn about pervious and impervious surfaces as features that affect runoff.
Focus Questions	● *What features around our school (and neighborhood) affect the flow of surface water runoff during rainy days?* ● *What areas on our school grounds are concerns for flooding?*
Vocabulary	pervious, impervious, stormwater, erosion
Learning Targets	We will examine where water flows in our school yard to show where flooding may be a problem.
Assessment Options	● Set criteria for "useful" and "not useful" information on our survey; assess how we did. ● Explain why some features may be a problem. ● How did we do as an investigative team? What will we do to be able to be a stronger group of scientists? ● Post-test on key vocabulary ● Integrate with math objectives to predict what would happen in the event of heavy rains or snows over 2, 3, 5 days. ● Develop 3 questions to ask a school facilities or grounds administrator to learn about our school grounds.

Lesson 4: Stormwater Engineering, Part 1 - Defining the Problem	
Summary	Students are introduced to Engineering practices. Students choose a site they would like to design a green engineering solution for and consider the constraints and criteria at that site.
Focus Questions	● *What should we consider when designing an engineering solution?*
Vocabulary	engineering, design, constraint, criteria

<table>
<tr><td>Learning Targets</td><td>We will define a problem in our neighborhood that we may be able to help solve.</td></tr>
<tr><td>Assessment Options</td><td>

Define the criteria of a successful solution.
Compare two possible solutions using both drawing and explanation.
Compare solutions using a table

<table>
<tr><td></td><td>Advantages</td><td>Constraints</td></tr>
<tr><td>Solution 1</td><td></td><td></td></tr>
<tr><td>Solution 2</td><td></td><td></td></tr>
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<table>
<tr><th colspan="2">Lesson 5: Water Runoff Field Investigation (Field Experience)</th></tr>
<tr><td>Summary</td><td>Student teams conduct rainwater run-off experiments on various surfaces, ground cover, and/or canopy cover around their school or nearby park.</td></tr>
<tr><td>Focus Questions</td><td>How does the surface of the land affect the speed water travels?</td></tr>
<tr><td>Vocabulary</td><td>controlled variable, changed variable, measured variable</td></tr>
<tr><td>Learning Targets</td><td>As a team, we will conduct a scientific investigation.</td></tr>
<tr><td>Assessment Options</td><td>
How did we do as an investigative team? How did I do as a team scientist?
Identify 3 examples of changed and measured variables we can see in our classroom.
Write/draw an explanation of the relationship between the surface and the rate of water flow.
Find examples in the greater Puget Sound area of fast and slow moving water to support the above explanation. (pictures, topo map, web)
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<table>
<tr><th colspan="2">Lesson 6: RainWise Home Connection</th></tr>
<tr><td>Summary</td><td>Students view the online RainWise map of their neighborhood and discuss how different solutions might impact water flow and pollution. They search for things that could slow down or collect the stormwater in their home neighborhoods and find a problem area to investigate in a later lesson.</td></tr>
<tr><td>Focus Questions</td><td>What things around my neighborhood affect the health of the watershed?
What are some solutions to stop stormwater pollution and flooding in my neighborhood?</td></tr>
<tr><td>Vocabulary</td><td>feature, solution, rain garden</td></tr>
<tr><td>Learning Targets</td><td>We will use our investigative strategies to evaluate features in our neighborhood that may affect water flow and flooding.</td></tr>
<tr><td>Assessment Options</td><td>
Make or collaborate on a list of criteria for positive watershed features. Identify 5 features and evaluate for whether they help or hinder.
Create a sign for our neighborhood on what families need to know and could do to protect the watershed.
Monitor and write about a feature of concern through days/weeks of weather changes.
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Lesson 7: Plant Structures and Functions	
Summary	Students consider how differences in plant structures affect the plant's needs for survival, but also can affect the impact the plant has on water filtering and flooding.
Focus Questions	● *How does the structure and function of plants help with problems of flooding and water pollution in our city?*
Vocabulary	structure, function, system
Learning Targets	We will be able to identify how we might use plants to help our community with filtering pollution and prevention of flooding.
Assessment Options	● Using the legend from the earlier map lesson draw an explanation of how plants can impact filtering and flooding. ● Draw and explain how plant structures impact filtering and water flow.

Lesson 8: Stormwater Engineering, Part 2 – Developing a Solution	
Summary	Students research rain gardens and planting trees to decide which solution would work best in the area of concern that they have chosen in lesson 5.
Focus Questions	● *What types of plants are best able to solve the problems of stormwater runoff when using a rain garden or planting trees?* ● *What would your green stormwater solution look like?*
Vocabulary	No new
Learning Targets	As engineers we will design "green" solutions that could make a difference in our neighborhood.
Assessment Options	● Write a proposal for a solution. ● Compare several solutions using a chart, constraints, and established criteria. ● Build class rubric defining criteria for effective presentation and solution – could include criteria for investigating (scientists), defining the problem, working as a team, organization, etc. Consider integrating objectives in content areas of math and language arts.

Lesson 9: Stormwater Engineering, Part 3 – Communicate	
Summary	Student teams present their solutions to the class and the class discusses how the solutions meet criteria for success.
Focus Questions	● *What would your stormwater solution look like, and how will it work?*
Vocabulary	No new
Learning Targets	We will use our science and engineering skills to be convincing advocates for our green solution.
Assessment Options	● Use class-designed rubric to evaluate projects. ● Present proposals to members of the community (parents, school, etc.).

Advance Planning

This unit integrates many ways to connect students to their neighborhood, school grounds and community. Are there parents of students that are engineers? Are there parents who are interested in local environmental issues? Consider inviting their support!

Outdoor components on school grounds – Lessons 3 and 5

Familiarize with school grounds and where water goes

Need chaperones for taking students outside

ELA Performance Task – Lesson 7

What skills are students working on? What scaffolding will they need?

[Plan to reformat with timeline: 1 month in advance, one week in advance, etc.]

Prior to Lesson 1

View video

Prepare KWELs chart on wall

Prior to Lesson 2

Prior to Lesson 3

Walk around the school grounds to assess the features students will come across during their investigation and note features on a map of the school that you will want to make sure the class sees (e.g. storm drains, gardens, gutters, cisterns, trees, steep slopes, impervious services, etc).

If the school has bordering neighborhood streets that are accessible for the class, walk around the school neighborhood and mark features in advance here as well. Of particular interest would be nearby creeks or streams, which the storm drains lead into.

Consider how to manage students outside. Depending on students and the area, establish physical boundaries to let students explore the campus at their own pace as they search for water features. Students can work alone, in pairs or small groups. Alternatively, flag particular features in advance and lead students altogether in a simple tour.

<u>Secure at least one other adult</u> to act as support for the walk around the school grounds.

Gather materials for pervious/impervious surface demonstration

- Two .5 liter bottles filled with water – these are your two “rain” events
- Plastic container with sloped sod/grass*; slope covered with tin foil; drainage hole in “downstream” end – the tinfoil represents **impervious surfaces** like concrete and roads and the grass represents **pervious surfaces** covered with plants
- Plastic container or bowl to catch water

* Sod can be dug up from existing lawn (only need ~5”x10”), or planted a few weeks in advance.

Unit Materials

For each lesson, students will need their **science notebooks** and a pencil in addition to the materials below:

Lesson	Provided Materials	Materials Needed (from classroom)
1 - Activating Prior Knowledge		Butcher paper for KLEWS chart Post-it notes Computer with internet connection & projection *Rosie Revere, Engineer* by Andrea Beaty (from library)
2 – Watersheds and Runoff		Supplies for watershed model activity: ● 8.5"x11" paper (1 piece for each pair of students) ● Water-based (Crayola OR Vis-a-Vis wet erase, for example) markers – blue and red (1 of each per pair) ● Spray bottles with water (at least 2 per class) ● Towels for clean up ● Local watershed map from website provided (print or project)
3 – Community-Based Watershed Assessment	Stormwater Legend (1 per pair) Stormwater Features Diagram (projected or 1 per group of 3-4 students) Surface Types Diagram (1 per group of 3-4 students) Before & After poster	Map of school grounds (1 per student) Clipboards for each student Supplies for Pervious/impervious surfaces demonstration: ● .5 liter bottles (2) ● Plastic container (1 6 qt. size minimum) with sod/grass (at a slope); drainage hole in "downstream" corner ● Tinfoil rectangle the same size as the sod/grass (this will start out covering the grass) ● Plastic container or bowl
4 – Stormwater Engineering, Part 1	Lesson Worksheet (1 per student)	Computer with internet connection
5 – Water Runoff Field Investigation	Lesson Worksheet (1 per student)	20 oz. plastic water bottles (1 per student) Stopwatch (1 per group OR one for teacher) Measuring tape (1 per group) from math kit popsicle sticks (optional)
6 – RainWise Home Connection	Lesson Homework (1 per student) Stormwater Features Diagram (for pairs)	Computer with internet connection & projection
7 – Plant Structures and Functions	Lesson Worksheet (1 per student) Stormwater Game Board & Rules (6 copies, 1 for each group of 3-5 students) Stormwater Game Die Roll Results table (6 copies or project)	Clipboards for each student 30 pennies (5 for each group of 3-5 students) 6 six-sided dice (1 for each group of 3-5 students)
8 – Stormwater Engineering, Part 2	Lesson Worksheet (1 per student) Research References	Poster-size drawing paper Colored pencils and/or markers Pens

Lesson 1: Activating Prior Knowledge

Time: 60min
Location: Classroom

Next Generation Science Standards

DCI	**ESS3.B Natural Hazards**
SP	**Developing and Using Models**
CC	**Cause and Effect; Systems and System Models**

Lesson Purpose: Activating students' prior knowledge around engineering and stormwater runoff.

Focus Questions: What do you think you already know about engineering? What do you already think you know about rain water and where it goes in your neighborhood?

Advance Preparation

- **Prepare KLEWS chart poster** (large enough for whole class to add post-its) to be used throughout the unit, adding evidence and new knowledge as the unit progresses.

Know (What I think I know)	**L**earnings	**E**vidence	**W**onderings	**S**cientific Principles
Stormwater	Stormwater	Stormwater		Stormwater
Engineering	Engineering	Engineering		Engineering

- **Prepare stormwater runoff video**: https://vimeo.com/51456008 (make sure your LCD projector does not show the description piece at the bottom.
- **Check out from the library:** *Rosie Revere, Engineer* by Andrea Beaty

Engage and Encounter

1. **Activate** students' prior experiences by asking:
   - What do you think you already know about engineering?
   - What do you already think you know about rain water and where it goes in your neighborhood?
2. Have **students write their answers on post-its** and place under the **K**(now) section of the KLEWS chart for engineering and stormwater. Review some of their answers with the class.

3. **Cue up video** (be sure to not let them see the "Stormwater runoff" title. Ask students to watch the time lapse video (3 min.) trying to answer the questions: "What is this and where might this be?" After, have them turn and talk to share with each other their ideas and discuss as a class.
4. After the discussion **TELL them**: *"This is an outlet from where the rain drains from the streets and directly into Puget Sound. This particular stormwater drain is off of Alki Beach in West Seattle. In this unit, we are going to investigate our schoolyard and neighborhood as scientists and engineers. As scientists we are going to investigate where the rainwater is going in our neighborhood, what in our neighborhood has an effect on it, and how it might be affecting us. As engineers, we are going to focus on a particular problem and design a solution for that problem*."
5. **Ask:** "*What is an engineer? What are examples of different kinds of engineers?"* Engineers are people that work on solutions to human problems, including stormwater.
6. **Read to the whole class**: *Rosie Revere, Engineer* by Andrea Beaty. This picture book illustrates how engineers design, test, redesign and test again, over and over again.
7. **Discuss with class**: *How is an engineer different than a scientist? How are they the same? Can you think of any examples of when you've had to solve a problem? What did you do, how did you do it?*
8. Introduce the next lesson: Next time, we'll start our scientific investigations and learn more about stormwater by learning about what a watershed is, and how water moves through a watershed.

Lesson 2: Watersheds and Runoff

(Adapted from Sound Salmon Solutions Restoration Ecology for Young Stewards *'Watersheds'* lesson)

Time: 60min
Location: Classroom

Next Generation Science Standards

DCI	**ESS3.B Natural Hazards**
SP	**Developing and Using Models**
CC	**Cause and Effect; Systems and System Models**

Lesson Concepts: Water flows through a watershed and can carry pollutants with it into bodies of water. We all live in a watershed.

Focus Questions: What is a watershed, and how does water flow in a watershed? What happens to rain that passes through an urban area?

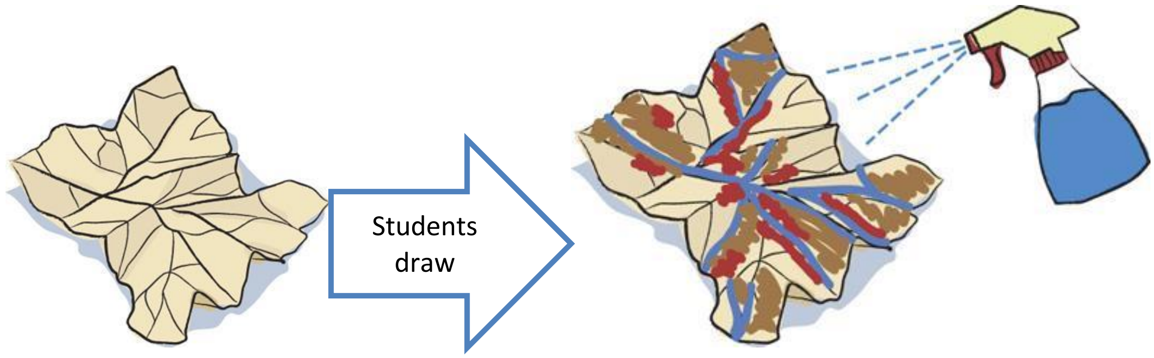
Scientific Terms: **watersheds** **runoff** **pollution**

Advance Preparation

- Decide if students will work in pairs or individually to create watershed models.
- Gather materials for watershed models
    - 8.5"x11" paper (1 piece for each model)
    - Water-based markers (Crayola, for example) – blue and red
    - Spray bottles with water
    - Towels for clean-up

Explore and Investigate:

9. *"In order to start our investigation, we have to know a little bit about how water moves through our city and over the ground. The place we are going to start is with something called a watershed."* **Ask** if students have ever heard of a watershed and if so, how would they describe one. Gather descriptions from students and focus in on answers that relate to land, drainage areas, descriptions of hills and valleys. If students are unfamiliar with the term give a brief description and let the students know that they will be making a watershed so they can see what one is.
10. **Define a watershed** as "all of the land that surrounds and drains to a creek, river, lake or other water body."
    a. Have students cup their hands to model the overall shape of a watershed.
    b. OPTIONAL - Create another model of a watershed, using two students facing each other and holding hands. Students are "mountains," their hands are where the "river" flows, and the watershed boundaries are at the tops of students' heads.
    c. Have students record the definition for a watershed in their science notebook.
11. **Pass out paper** - one 8½" x 11" sheet to each student. Have **students crumple** their paper loosely, then open it up again, but do not smooth it out. The finished outer dimension of the paper should be ~ 6x6".



Source: http://sns.ucdavis.edu/index.php/activity_6_defining_our_w

12. **Students should use** the water-soluble **blue marker** and a solid line to highlight the tallest or most obvious ridgelines (top creases, sticking up). Next, have **students** predict where river and lakes may form and **use the blue marker** to make “X”s to mark the low spots or valleys between the ridgelines. These marks are blue to represent clean water, both high up in the watershed and at the bottom.
13. Have students use **red water-soluble markers** to draw in houses, roads, and farms on one side (half) of their watershed model (carefully so they don’t flatten the paper). **Leaving half the model empty** of houses, roads, and farms will let them compare what happens on each side when they add “rain”.
14. **Explain** to students that a spray bottle will be used to “rain” on the model and they will be observing where the water goes and what happens to it.
15. **Use spray bottles** to represent rain clouds and “rain” on models (from the top, just enough to have water drip down the paper) and observe.

Reflect and Explain

16. **Discuss observations** as a class, especially how water that passed by houses, roads, and farms turned red and maybe purple (if the blue from above mixed with the red). Discuss how this colored water travelled downstream in the watershed. Tie this in with possible pollution (fertilizer, oil, soap, pesticide), and how it can spread downstream.

Apply and Extend

17. **Project a map** (from one of the resources above) of the local watershed for the class to see. Looking at the map, ask students if they can identify where their school is in the watershed. Have students locate the school and circle the area. Follow along on the map and ask students what they think happens to water in our watershed: where does it begin, where does it end up?
18. **Explain** that people are thinking about how to solve the problem of flooding and runoff pollution by allowing water to soak into the ground instead of run right off into nearby creeks and other water.

Next time, we will be using maps and investigating our school grounds to see where rainwater goes and what features around the school affect the flow of water runoff.

Lesson 3: Community-Based Watershed Assessment

(Adapted from Project WET's *'Rainy-Day Hike'*)

Time: *TWO 60 minute sessions – see "Important Note" below*
Location: Classroom and school grounds

Important Note: There are three parts to this lesson. Plan for Part 1 and Part 2 to be done together in one hour class, and Part 3 done the next hour class.

Next Generation Science Standards

DCI	ESS2.A Earth Materials and Systems
SP	Asking Questions and Defining Problems Developing and Using Models Planning and Carrying out Investigations
CC	Systems and Systems Models Cause and Effect

Lesson Concepts: Different features around schools (and neighborhoods) can increase or decrease the rate of surface water runoff that eventually empties into the Puget Sound. Depending on the location of different areas in the watershed, some areas are more at risk for flooding and water pollution than others.
Focus Questions: What features around our school (and neighborhood) affect the flow of surface water runoff during rainy days? What areas on our school grounds are concerns for flooding?
Scientific Terms: **stormwater** **pervious** **impervious** **erosion**

Advance Preparation

- Pre-Planning
  - Walk around the school grounds to assess the features students will come across during their investigation and note features on a map of the school that you will want to make sure the class sees (e.g. storm drains, gardens, gutters, cisterns, trees, steep slopes, impervious services, etc.)
  - If the school has bordering neighborhood streets that are accessible for the class, walk around the school neighborhood and mark features in advance here as well. Of particular interest would be nearby creeks or streams, which the storm drains lead into.
  - Consider how to manage students outside. Depending on students and the area, establish physical boundaries to let students explore the campus at their own pace as they search for water features. Students can work alone, in pairs or small groups. Alternatively, flag particular features in advance and lead students altogether in a simple tour.
  - Secure at least one other adult to act as support for the walk around the school grounds.
- Gather materials for pervious/impervious surface demonstration
  - Two .5 liter bottles filled with water – these are your two "rain" events
  - Plastic container with sloped sod/grass*; slope covered with tin foil; drainage hole in "downstream" end – the tinfoil represents **impervious surfaces** like concrete and roads and the grass represents **pervious surfaces** covered with plants

* Sod can be dug up from existing lawn (only need ~5"x10"), or planted a few weeks in advance.

- Plastic container or bowl to catch water

- Materials for class (for each group of 3-4 students – found **Student Worksheets and Handouts**)
  - Stormwater Features Diagram (can be projected for class or printed for groups of 3-4). Source, for full content with diagram: http://www.seattle.gov/util/groups/public/@spu/@usm/documents/webcontent/spu01_006289.pdf
  - Surface Types Diagram. Source: http://2.bp.blogspot.com/-LRuYBmc8LJU/VAnq6G1KodI/AAAAAAAAAZE/GbMzmJlefNM/s1600/LID.png
  - Before & After Poster

- Materials for each group of 2
  - Stormwater Legend
  - School map from school website or www.google.com/maps
  - Clipboard or cardboard with rubber band to hold the paper in place
  - Pencils

Engage and Encounter:

1. **Review** the definition of a watershed as "all of the land that surrounds and drains to a creek, river, lake or other water body." Remind students that they got to explore how watersheds work last time, and they used models to do so.
   - *"What happened to the water in their watershed models last time?"*

2. **Share** favorite places on school grounds (e.g. basketball court, playground, garden, etc.). **Imagine or remember** the place on a rainy day: what happens to the school grounds? the place on a rainy day: are students' favorite places at risk for flooding? Why or why not? In a think-pair-share, have students discuss:
   - *"What could be on the surfaces of these locations (e.g. on the basketball court) that could get washed away by the rain?"*
   - *"Where does the moving water go?"*

PART 1 – Pervious and Impervious surfaces and fast-moving water

3. **Ask** students to think about what might increase the speed and amount of the water flowing downhill. If they come up with human changes, prompt them to think about natural processes, too. Discuss ideas and conclude with the students that more water in the creek would make it go faster, among other things. Discuss with students:
   - *"How more water flowing faster might affect the land, water, and people?"*
   - "*How might more water end up in the creeks or rivers?*"

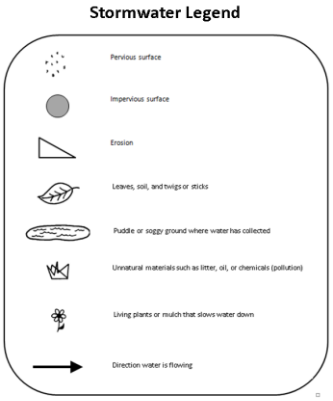
4. **Show** students the pervious/impervious surfaces diagrams ("Surface Types Diagram" and "Before & After Poster"), giving them time to look it over and read the text. Ask: "*What do you notice about the difference between the impervious area and pervious area? What do you think the words 'pervious' and 'impervious might mean?"* Ensure students understand that "pervious surface" means water can pass through and "impervious surface" means water cannot pass through.

5. **Show** students land container with tinfoil. Explain that this is a concrete slope, like a road. Hold the empty plastic container at the drainage hole and explain that this is the "creek", right next to the concrete slope.

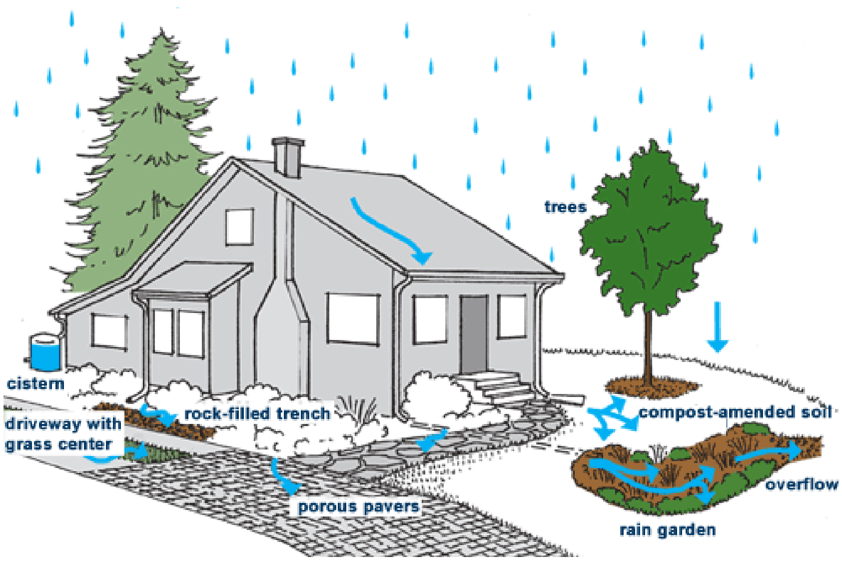
6. **Ask** the group to estimate how much "rain" will end up in the creek.

7. **Pour the water** over the **concrete slope** (container/bin with tinfoil), catching the "rain" in the creek and pouring this back into the bottle to see how much water ended up into the creek. Ask everyone to think why this happened.
8. **Repeat** the demo with **tinfoil removed and exposed grass/sod**. Ask students to brainstorm what the grass might represent (meadow, forest, trees, etc.).
9. Note the **amount** of water that ends up in the "creek." There should be quite a bit less with the grass than the tinfoil block. Pour it back into the bottle and compare to the amount in the container from the tinfoil land.

PART 2 – Introduce legend and diagram



10. **Display** the Stormwater Legend. Review each item in the legend (the things students will be looking for), spending extra time, if necessary, on the scientific terms of the legend: pervious and impervious surface, and erosion. Explain that pervious surfaces can be a solution to runoff problems: some pervious surfaces are special asphalt and concrete with holes that allow water to drain through, but "green" pervious surfaces are simply soil and plants.
11. If students have not used a legend before, be sure they understand that they use the symbols instead of writing out words. Optional: have students create their own legend, or add space for them to include their own symbol and its meaning.
12. Have **students match up items** from the legend with the things they find in the Stormwater Features Diagram and make predictions about what purposes the elements in the picture serve.



The **Stormwater Features Diagram** shows solutions people might use to help with stormwater problems. Some solutions involve plants and soil (trees, rain garden, compost-amended soil, driveway with grass center) and others do not (rock-filled trench, porous pavement, cistern). All are intended to slow down, spread out, and filter rain water so that it does not cause flooding.

13. **Introduce** next part of the lesson (the investigation): "*We are going to use the legend to survey our school grounds, looking for the things in the legend and adding them to a map.*"

Part 3 – School grounds survey

Explore and Investigate:

14. **Setting up the survey (investigation), tell students that they will be doing a survey of their school's watershed**. This survey can be adjusted depending on whether it is a dry day or a rainy day.
    - On a **DRY day**, each group will **search for features** using the Stormwater Legend. Students will **<u>predict or remember</u>** the direction of water flow, and how each feature affects the rate of water flow and pollution. Students will mark each item they visit using the legend and use science notebooks to record predictions and observations.
    - On a **RAINY day**, each group will **search for features** using the Stormwater Legend. Students will **record their observations** about the direction of water flow, any pollution they see in the water, and any areas of flooding. Students could keep maps under covered areas and write on them after exploring <u>OR</u> use a plastic bag to cover the map while writing; observations should be recorded in science notebooks.

Reflect and Explain:

15. **Back in the classroom**, give students several minutes to look over their maps and discuss their findings. In a think-pair-share, ask students :
    - *Where did you predict the direction of water flow would start and end?*
    - *Where did you observe it starting and ending?*
    - *Which features in the watershed slow down the water ("speed bumps")*
    - *Which features increase the speed of the water?*
    - *Did you notice any pollution concerns?*
    - *What surprised you during the investigation?*

Apply and Extend:

16. **Ask** students: *What living things depend on our watershed? What are some ways we can care for our watershed - in particular, preventing flooding and pollution?*
17. If the student survey was completed on a clear day, suggest to students on the next rainy day to visit each feature and compare their observations with their predictions. If class time permits, take the class as a whole to visit each feature on a rainy day to make these observations.
18. In Lesson 3, students will be surveying their own neighborhoods for water features that impact flooding and pollution. Later, they will have a chance to design their own solution that could be implemented in their home or neighborhood.

Lesson 4: Stormwater Engineering, Part 1 – Defining the Problem

(Adapted from Pacific Education Institute's Drain Ranger Curriculum *Lesson 4: Define the Problem* and *Stormwater Pollution)*

Time: 60 min.
Location: Classroom

Next Generation Science Standards

DCI	**ETS1.A: Defining and Delimiting Engineering Problems**
SP	**Asking Questions and Defining Problems**
CC	**Influence of Science, Engineering, and Technology on Society and the Natural World**

Lesson Concepts: In order to develop solutions to problems, engineers must think about the constraints of the problem and criteria for success.

Focus Question: What should we consider when designing an engineering solution?

Scientific Terms: **engineering** **design** **constraint** **criteria** **optimize**

Advance Preparation

- Print **Lesson 4 Worksheet** for students.
- Prepare and review video "**Runoff: Special Report**" (http://vimeo.com/84964332).
- Consider the approach that would work best for your students. The approach below assumes individuals will each work on their own problem and solution. You could decide instead to have the whole class work on the same problem and then compare and discuss the solutions they choose, or work in teams of 2 to 4.

Engage and Encounter:

1. **Overview** the **practices of engineering as defining a problem, developing solutions, and optimizing a solution**. Review what happened in the book *Rosie Revere, Engineer.*
2. **Provide an example** for the students of an engineering challenge and solution. As you describe it highlight where each engineering practice is used (the practices and their components are in **blue** below but are also described in the ETS1 DCIs on Engineering Design). Ideally, the example is one the students feel some connection with. Here is one possible example:
    a. *First, we **define the engineering problem**:*
        i. *"The **problem** is that my classroom gets too hot in spring. This makes it hard for students to concentrate. Further investigation reveals that the heat is coming from sun shining through the classroom windows.*
        ii. *The **criteria for a success** is that any solution must keep it from getting too hot in the room while still letting students look outside.*
        iii. *The school district has said that **constraints** on any solution include it can't cost much and it can't add any ongoing costs.*
    b. *Once we have the problem defined we need to **develop some possible solutions**:*
        i. ***Researching** various approaches people have used before includes planting trees outside the window with leaves that will filter the heat in the spring and summer, putting a*

reflective surface on the glass to reduce the amount of sunlight getting in, using blackout shades to stop light getting in, or installing air conditioning in the room.

ii. ***Considering the solutions in the context of our criteria and constraints,*** *we need to rule out the blackout shades (students wouldn't be able to look outside) and the air conditioning (it would be expensive and add ongoing costs).*

iii. *I then* ***test the different possible solutions*** *by* ***constructing a model of each*** *and seeing how temperature varies when a heat lamp is shining through it. My models show the tree is as effective as the reflective surface so I go with planting trees (since I like trees).*

iv. *Before I start planting trees, I would need to* ***communicate*** *my possible solutions with the school administration to get their feedback on my ideas (and permission to proceed).*

c. *Once I have chosen my solution I can* ***optimize*** *it by experimenting with several different model tree and bush arrangements. After planting the trees I take temperature readings in June to see how well it is working and whether I need to work on it further.*

3. Challenge the students to **think as engineers** as they watch the 10 min video: **Runoff: Special Report** (http://vimeo.com/84964332). *"What is the engineer in the video doing to solve runoff problems in their city?"*

4. After watching the video **discuss** some of the ideas:

   a. *"Why is stormwater runoff a problem in our urban watershed?"* (Parts of the neighborhood can get flooded, or that the water carries trash and pollution with it and ends up in our rivers, lakes and oceans).

   b. "*What could engineers do to help solve the problems associated with stormwater runoff?"* (Examples from the video as well as ideas like rain gardens and planting trees). Record students' solutions on the board and have students explain why they are solutions to the problem.

5. Point out to the students that up to this point they have been scientists, investigating problems. For the rest of the unit they will be engineers focused on designing a solution for a stormwater runoff problem they identified earlier. [Consider referring to them in class as engineers from this point on.]

Explore and Investigate:

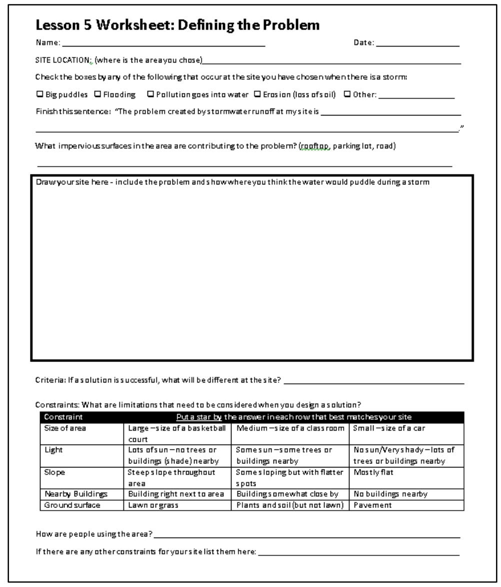
6. Their first step as engineers is to define their problem with the relevant constraints and criteria for success. Later, they will research and develop solutions for the problem they identify today.

7. **Review the lists of problems** created earlier from the Community-Based Watershed Assessment and the Watershed Scavenger Hunt.

   a. Narrow down the list as needed if any of the problems are <u>not</u> caused by stormwater runoff.

   b. **Have students choose a problem site** either from the group list or their homework. If you want to do the same problem site with the whole class, you could have students nominate ideas and vote on which one to address. <u>If doing separate sites, you will want to confirm that each student has chosen something appropriate.</u>

8. Once students have selected their site, **hand out the Lesson 5 worksheet**.
    a. Go over the instructions and the sections. Consider filling in the sheet with an example problem site as you go through it with the class.
    b. Make sure students have a clear sense of the definitions of “constraints” and “criteria” as it pertains to engineering.
    c. Go through the constraints table with the students.
9. Depending on the problem(s) being addressed, you could take the students outside to view the sites or assign the worksheet as homework to fill out when the have the problem site in front of them. Alternatively, you could have the students use their notes from earlier sessions to fill out the sheet while in the classroom.



Lesson 5 Worksheet: Defining the Problem

Name: ______________________ Date: ____________

SITE LOCATION: (where is the area you chose)______________________

Check the boxes by any of the following that occur at the site you have chosen when there is a storm:

☐ Big puddles ☐ Flooding ☐ Pollution goes into water ☐ Erosion (loss of soil) ☐ Other: ____________

Finish this sentence: “The problem created by stormwater runoff at my site is ______________________

______________________.”

What impervious surfaces in the area are contributing to the problem? (rooftop, parking lot, road)

____

Draw your site here - include the problem and show where you think the water would puddle during a storm

Criteria: If a solution is successful, what will be different at the site? ______________________

Constraints: What are limitations that need to be considered when you design a solution?

Constraint	Put a star by the answer in each row that best matches your site		
Size of area	Large – size of a basketball court	Medium – size of a classroom	Small – size of a car
Light	Lots of sun – no trees or buildings (shade) nearby	Some sun – some trees or buildings nearby	No sun/Very shady – lots of trees or buildings nearby
Slope	Steep slope throughout area	Some sloping but with flatter spots	Mostly flat
Nearby Buildings	Building right next to area	Building somewhat close by	No buildings nearby
Ground surface	Lawn or grass	Plants and soil (but not lawn)	Pavement

How are people using the area? ______________________

If there are any other constraints for your site list them here: ______________________

Lesson 5: Water Runoff Field Investigation

(Adapted from the Pacific Education Institute's Investigating Wastewater: Solutions & Pollution (SEPUP) Curriculum Workshop, *Activity 10: Does it Soak Right In? A Field Study Investigation)*

Time: 60 min.
Location: Classroom and school grounds

Next Generation Science Standards

DCI	**ESS2.A Earth Materials and Systems** **ESS2.E Biogeology**
SP	**Asking Questions and Defining Problems** **Planning and Carrying out Investigations** **Analyze and Interpret Data** **Using Mathematics and Computational Thinking** **Constructing Explanations**
CC	**Cause and Effect**

Lesson Concepts: Land affects the movement of water. Surfaces increase or reduce the rate of surface water runoff depending on their type. Surface water runoff leads to flooding and pollution of local water bodies.
Focus Question: How does the surface of the land affect the speed water travels?
Scientific Terms: **controlled variable** **measured variable** **changed variable**

Important Notes
This lesson gives students the opportunity to test different surfaces and write a claim, evidence and reasoning statement. Students can be shown the materials available (listed under **Advance Preparation** below), and decide how to use them in order to answer their investigation question. Students can also decide how they work together and what roles they play in each group.

Advance Preparation

- Identify pervious and impervious surfaces that you want students to test, being sure they are at approximately the same slope and that there will be sufficient room for all students in those locations.
- Designate groups of 3-4 students to work together on the investigation
- Materials for each group of 3 to 4 students:
  - One perforated yogurt cup - poke holes in the bottom of the cup from the *inside* of the cup. (Water will not flow out of the cup if the holes are made from the outside).
  - One 20 oz. plastic water bottle per student. Have students collect empty/clean water bottles from their lunches or bring them from home.
  - Stopwatch
  - Measuring tape
  - Pencils
- Materials for the class:
  - Field Study Worksheets

Engage and Encounter:

1. **Introduce investigation**: "*In order to understand why problems might be occurring in our neighborhood and to help us figure out what needs to change when we engineer or create a solution, we need to figure out how different surfaces affect the water speed?"*
2. Tell students they will be simulating a sudden rainstorm outside to see how the surface of the land affects the speed of the rainwater.
3. "*In order to carry out an investigation, we have to ask a question, identify the variables to the investigations and plan the investigation by coming up with a procedure*. *Then we can carry out our investigation, keeping good notes on the data we collect. We will analyze our data and discuss our results, then construct our explanation by writing a conclusion.*"
4. Have students write the **investigation question** in their science notebooks: **How does the surface of the land affect the speed water travels?**
    - o Discuss and underline the changed/manipulated variable (surface of the land)
    - o Discuss and double underline the measured/responding variable (the speed the water travels)
5. Each group will be testing on two different surfaces outside. **Ask students open-ended questions to engage them in forming ideas for the field investigation**:
    - o What kinds of surfaces should they test? (some ideas might be: asphalt, gravel, grass, wood chips)
    - o Where will water travel the fastest and why?
    - o How can they measure this?
    - o What variables are going to need to be **controlled**? (slope, amount of water they use, how quickly the water is poured)
    - o What are variables they can't control since they will be doing this outside (weather, temperature, whether the ground is already wet from recent rainfall). It will be important to record these as a part of their procedure.
    - o How many times should they do their tests on each surface for it to be a fair test? (at least three)

6. **Show students the materials** available to perform the investigation and have the class discuss how they should use them.
7. As a class, **write a procedure** for the field study (example below) or if you are tight on time, give them the procedure. Have students work in groups and decide how they will share the responsibilities.
8. Show students the Field Investigation worksheet that they will use to make predictions and record their observations and data.

Possible Investigation Procedure (your class might come up with a variation on this)**:**

Record Site Information including: location, date, time, weather, and a sketch and description of the two surfaces.

Fill up water bottles and bring investigation materials to the field site

Pour one water bottle into the perforated yogurt cup

Record the time it takes for the surface water to completely stop and mark where the water stopped

Measure the stream distance

Record both the time and distance (measured/responding variables) in the field study worksheet

Record any observed materials that were carried in the surface water-run off in the field notes

Repeat steps 4-7 two more times at first surface (changed/manipulated variable)

Fill up water bottles and move to the second surface site

Repeat steps 3-8.

Explore and Investigate:

9. **Bring the class outside** and point out landmarks on the schoolyard to mark the boundaries of the field investigation. Remind students to select their surfaces (being sure they have the same slope) and record their observations and predictions on their worksheet.
10. **Do the investigation** by following the procedure identified in the classroom.

Reflect and Explain:

11. Back in the classroom: Explain to students how to **find the medians** for each location and record them on their worksheets.
12. **Students analyze and interpret their results in their small groups:** Where did water travel the fastest? Have them explain their conclusions to each other with the support of evidence from their observations.
13. **Students construct an explanation** for their results by writing their conclusions (including evidence) in their science notebooks.
14. **Discuss results** with the whole class.
    - Were they successful at following the procedure and controlling the variables?
    - What surfaces were tested and which were the fastest and slowest?
    - Did the conclusions vary between groups? If so, why might that have happened?
    - How might they do things differently if they were to repeat this investigation?

*Apply and Extend **(THIS WRITING COULD BE DONE DURING YOUR ELA BLOCK):*

15. Start a class discussion with, "*Imagine if scientists collected data and never wrote or talked about their findings. How would our world look different*?" Turn and talk and then share out as a class. Say: "*Today I am going to teach you the way people (scientists included) use evidence and scientific principles to support their claim about a particular question*. *Their writing typically includes a Claim, Evidence and Reasoning (CER)."*

- Use the video and CER template, "My Dad is an Alien" to teach students the format for CER (see student handouts): https://www.youtube.com/watch?v=WQTsue0lKBk
- After using the alien model pass out the blank CER template with the question: "*How does the surface of the land affect the speed water travels?"*
- Have students look at and discuss their data from the field investigation in order to write a claim answering the question: **How does the surface of the land affect the speed water travels**?
- If this is the first time your students have used a CER, guide them through using the template using the key provided in the handouts section. You can also refer to the CER rubric for students to self assess themselves.

16. **Conclude**: *"In Lesson 5, you will begin to think about a specific site and a specific solution, using the Engineering Design Process. We will learn more about the problems associated with stormwater runoff and think about ways to help our watershed by using green solutions to runoff."*

Lesson 4 Worksheet: Water Runoff Field Investigation **Page 1**

Name: ______________________ **School**______________________

Site Information

Location: __________________ **Season:** ☐ Fall ☐ Winter ☐ Spring

Date: __________ **Weather:** ☐ Clear ☐ Cloudy ☐ Rainy

Time: __________ **Ground:** ☐ Dry ☐ Wet ☐ Frozen

Observations

Surface 1 = ______________________________

Surface 2 = ______________________________

Prediction: Which surface will allow the water to travel the fastest? Complete the sentence:

"I think water will travel the fastest on ________________________because ______________

____.

Lesson 4 Worksheet: Water Runoff Field Investigation **Page 2**

Focus Question: *How does the surface of the land affect the speed water travels?*

Gather Data

Run three trials of the surface water speed test following the procedure your class developed.

In the Observations section answer the following:

Does the water carry anything with it in its path?
Are there things on the ground that might slow the water down or speed it up?

Surface 1	**Trial 1**	**Trial 2**	**Trial 3**	**Median**
Distance (inches):				
Time (seconds):				
Speed (=Distance/Time):				

Observations of water on Surface 1:

____

____

____

Surface 2	**Trial 1**	**Trial 2**	**Trial 3**	**Median**
Distance (inches):				
Time (seconds):				
Speed (=Distance/Time):				

Observations of water on Surface 2:

____

____

____

Lesson 6: RainWise Home Connection

Time: 60 minutes; Part 1 – 45 minutes; Part 2 – 30 minutes some days later
Location: Part 1 - Classroom and student neighborhoods; Part 2 - classroom

Next Generation Science Standards

DCI	**ESS3.B Natural Hazards**
SP	**Planning and Carrying Out Investigations** **Obtaining, Evaluating, and Communicating Information**
CC	**Cause and Effect**

Lesson Concepts: Solutions to stormwater pollution and flooding are being implemented in Seattle neighborhoods. People build living (i.e. trees, plants, compost) and non-living (i.e. cistern, porous pavement) solutions to help reduce flooding and water pollution. Living solutions are sometimes called "green" solutions and non-living are sometimes called "gray" solutions. Most of these solutions are examples of engineering.

Field Investigation Questions: What things around my neighborhood affect the health of the watershed? What are some solutions to stormwater pollution and flooding in my neighborhood?

Scientific Terms: **feature** **solution** **rain garden**

Important Notes

This lesson gives students an opportunity to work with an adult in their home to survey their neighborhood for features that could influence the health of their local watershed. Since this assignment asks students to coordinate with an adult's availability, we recommend providing a week of time to complete it. For students who don't have adult help in their home after school, this homework activity can be done by surveying their home/apartment grounds, or surveying what they can see from their window or front door.

PART 1

Location: Classroom and student neighborhoods

Advance Preparation

- Go to the map feature at **RainWise.seattle.gov**:
    1. Locate your school and find out what Seattle Public Utilities recommends to help with run-off.
    2. Zoom out to view the neighborhood and look for raindrop symbols and blue dots – these show actions people have taken to help protect the watershed.
    3. Highlight any actions or features that you will want to show to students.
    4. If you have time this is also a good time to build your background knowledge of various ways to help manage stormwater runoff.
- Consider where students live to decide how best to help the class see where the students have done their surveys. Some possible options:
    - Project a paper map as you mark locations on it with a marker.
    - Use the RainWise website map (above).

- Use the “save” feature in Google maps to set up a map ahead of time.
    - Go to Google maps (https://www.google.com/maps) and login (so you can save locations for later viewing).
    - Enter the address of your school and click on the “save” star next to the address result.
    - Adjust the zoom to display a map of Seattle that includes all of the students’ neighborhoods.
    - Save additional locations the students surveyed on the map by entering address and clicking the “save” star (as above).
    - Alternatively, right click a location on the map and select “What’s here?” Then click on the gray pin marker on the left and click on the “save” star next to the address result.
    - The locations saved will be marked with a star. Click on them to bring the pin back up.

- Materials for each student:
  - Stormwater Features Diagram
  - If students will fill in the scavenger hunt items they come up with themselves, make a copy of the Watershed Scavenger Hunt worksheet for each student ahead of time. Otherwise wait to make the copies until after the hunt items are generated (below).

Engage and Encounter

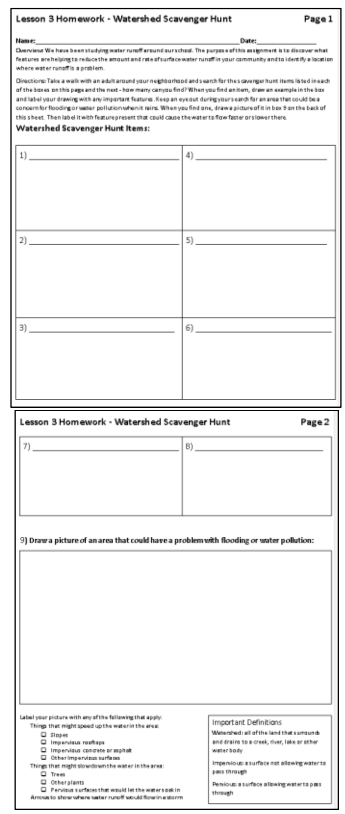
1. **Show students** the Stormwater Features Diagram.
    - Explain that people use living (i.e. trees, plants, compost) and non-living (i.e. cistern, porous pavement) solutions to help reduce flooding and water pollution. Living solutions are sometimes called “green” solutions and non-living are sometimes called “gray” solutions.
    - Take students online to **RainWise.seattle.gov** and type in your school’s address (if the address doesn’t work, you can select a region at the top of the map). The website should provide some recommendations for managing water at school. Zoom out to show the area around the school and if there are water drop markers on the map in your community, click on some of them to see what project has been implemented at that location to reduce run off.
    - Ask students if they have seen any of the solutions you have discussed or seen on the RainWise site. Perhaps some of these solutions are on their school campus or neighborhoods?

- Have them make predictions about what purpose any of the living or non-living solutions could serve. (Pair and share, or write in notebook).

2. Tell students that they are going to **search for things that could slow down or collect the stormwater in their home neighborhoods**. Students should think from the perspective of the water: "*If I were a raindrop, where would I travel to? What would get carried along with me in my current? What would slow me down?*"
3. Using examples from the Stormwater Features Diagram or the list below (in box), narrow the list of living and non-living features that the class came up with to create a list of 8 watershed scavenger hunt items they will search for in their neighborhoods.
4. Have students either write the 8 items in the boxes on their Watershed Scavenger Hunt worksheet or edit the document and print it for them.

> Watershed scavenger hunt ideas:
> - Rain garden*
> - Pond or lake
> - Park
> - Stream or creek or other flowing water
> - Cisterns or rain barrel*
> - Porous pavement or gravel road/driveway*
> - Garden
> - Stormdrain*
>
> *These are engineering solutions

5. **Review** the homework assignment instructions with the students:
   a. Make sure they are prepared to explain it to an adult at home that could walk the neighborhood with them (and/or do the assignment themselves based on what they can see from where they live).
   b. Challenge students to find and draw an example of each of the 8 watershed scavenger hunt items in their neighborhood. Make sure they know that they may not be able to find every feature in their neighborhood. For example, there may not be any rain gardens near where they live.
   c. Explain that they will be drawing a location that could have flooding or pollution problems in the box under #9. They will label things that might slow down or speed up stormwater, and include arrows showing the direction of water flow.
   d. Offer students the option of taking pictures of locations instead of drawing them.



Lesson 3 Homework - Watershed Scavenger Hunt **Page 1**

Name:______________________ **Date:**__________

Overview: We have been studying water runoff around our school. The purpose of this assignment is to discover what features are helping to reduce the amount and rate of surface water runoff in your community and to identify a location where water runoff is a problem.

Directions: Take a walk with an adult around your neighborhood and search for the scavenger hunt items listed in each of the boxes on this page and the next - how many can you find? When you find an item, draw an example in the box and label your drawing with any important features. Keep an eye out during your search for an area that could be a concern for flooding or water pollution when it rains. When you find one, draw a picture of it in box 9 on the back of this sheet. Then label it with feature present that could cause the water to flow faster or slower there.

Watershed Scavenger Hunt Items:

1) ________	4) ________
2) ________	5) ________
3) ________	6) ________

Lesson 3 Homework - Watershed Scavenger Hunt **Page 2**

7) ________	8) ________

9) **Draw a picture of an area that could have a problem with flooding or water pollution:**

Label your picture with any of the following that apply:
Things that might speed up the water in the area:
- ☐ Slopes
- ☐ Impervious rooftops
- ☐ Impervious concrete or asphalt
- ☐ Other impervious surfaces

Things that might slow down the water in the area:
- ☐ Trees
- ☐ Other plants
- ☐ Pervious surfaces that would let the water soak in

Arrows to show where water runoff would flow in a storm

Important Definitions
Watershed: all of the land that surrounds and drains to a creek, river, lake or other water body
Impervious: a surface not allowing water to pass through
Pervious: a surface allowing water to pass through

Explore and Investigate:

(AT HOME) Provide students enough time to arrange to walk with an adult around their neighborhood. If an adult is not present to help, students may also survey from their front yard, front door or even their window.

Students will reveal what they found in Part 2 of this lesson during the next class session.

PART 2 –

Location: Classroom

Reflect and Explain:

6. Use “Watershed Scavenger Hunt Self-Reflection” worksheet to assess student understanding.
7. After students have completed the scavenger hunt, have **students share** what they found in their neighborhoods. If time, have each student share as you mark their investigation area on a map (see mapping options in the advance preparation section above). Questions to discuss and record in science notebooks:
   - *What are some concerns of surface water runoff in the watershed?*
   - *How does the rate of surface water runoff affect the watershed? What happens when the water flows quickly and what happens when it flows slowly?*
   - *What living and nonliving features do people use to help reduce pollution and flooding?* (Examples include plants, trees, cisterns, gravel, pervious surfaces, rain gardens, etc.)
8. **Create a list** of the various problems students identified in their neighborhoods and their suggested solutions. Are there any ideas that were generated that students or their adults would consider actually implementing?

Apply and Extend:

9. If students come from a variety of neighborhoods, this lesson provides the opportunity for a class discussion on how differences in neighborhood composition, such as landscape and resources, impact neighborhoods differently during rainstorms. Encourage students in the scientific process by explaining that, just as the class reported to each other their findings from the scavenger hunts, scientists also make observations of rainy weather and water flow and communicate with each other their findings. This helps people come together to find solutions.

10. OPTIONAL EXTENSION: Exploring property runoff numbers further -
    a. Go to http://rainwise.seattle.gov.
    b. Enter the address of a home or building of interest and click the “Check My Address” button to see a satellite view of the address entered.
    c. Click the “Learn More” button. On the right side of the screen it should show estimates for the property’s water runoff.
    d. Write down the “Forecast Runoff Remaining” gallons per year: “The estimated runoff = ________ gallons per year”.
    e. As a math activity, find out how many gallons would come from the whole class if each student had the same number of gallons of runoff from their home. Show students a gallon jug of water to imagine how much water that would be. Discuss what it means for them and for the watershed if some of that water could get polluted, or some could get absorbed into the ground.

Lesson 7: Structure and Function of Plants

(Adapted from Sound Salmon Solutions lesson *Plants as a System* and Pacific Education Institute lesson *Leaf as a System)*

Time: 60 min.
Location: Classroom and school grounds

Next Generation Science Standards

DCI	LS1.A: Structure and Function ESS2.E Biogeology
SP	Developing and Using Models Obtaining, Evaluating and Communicating Information
CC	Systems and System Models Structure and Function

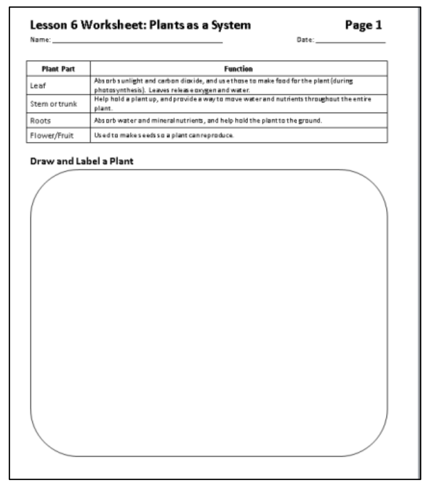
Lesson Concepts: Plants have structures that work as a system to support their survival growth, behavior, and reproduction. Humans use plant systems as solutions to problems of flooding and water pollution in cities.
Focus Question: How does the structure and function of plants help with problems of flooding and water pollution in our city?
Scientific Terms: **system** **structure** **function**

Advance Preparation

- Planning
  - Decide if the students will be working individually or collaboratively
  - Review Teacher Resources and pictures in Teacher Resources section.
  - Prepare a visual example of plant roots. This 46 sec. time-lapse video can be used as an option: https://www.youtube.com/watch?v=d26AhcKeEbE. Or, bring in 3-5 plants that can be easily uprooted from the soil and let students observe and investigate them in groups (if done outdoors, the soil mess will be less difficult to clean up).
  - Research any local volunteer planting projects that you want to share with the class in the optional Apply and Extend step.
- Materials for game (one set for each group of 3-5 students):
  - 5 Pennies
  - 1 six-sided die
  - Game board
  - Game rules & Die Roll Results table
- Materials for the class:
  - *Plant as a System* worksheets (one per student)
  - Clipboards
  - Pencils
  - 3-4 (or more) potted plants
  - (optional) pictures from resources section to show students

Engage and Encounter:

1. **Introduce lesson**: "*Last time, we defined our engineering problem by looking at our site and the constraints we need to consider. We are going to develop a solution to our stormwater problem by using plants. Remember when we did our field investigation and found that water travels slower over ground surfaces that are pervious, or have soil and plants? Why do you think that was true?* (Discuss with students) *Today, we are going to take a closer look at how plants are good at dealing with runoff."*
2. **Show a picture** of a plant either currently growing around the school or one of the potted plants. With assistance from the class, identify the plants parts: leaves, roots, stems, and flowers or fruit/seeds.
3. **Show video** to show roots and plant parts growing.
4. Ask students to make predictions about why plants have each of these parts, or the functions of the parts, and let students discuss their ideas in a think-pair-share.
5. In a group discussion, collect ideas about the functions of each plant part and write student ideas on the board.
6. **Hand out** the ***Lesson 7 Worksheet - Plant as a System*** and have students read the functions of each plant part listed and then compare to the list the classroom generated. Discuss any discrepancies from their lists that students have questions about.



Lesson 6 Worksheet: Plants as a System **Page 1**

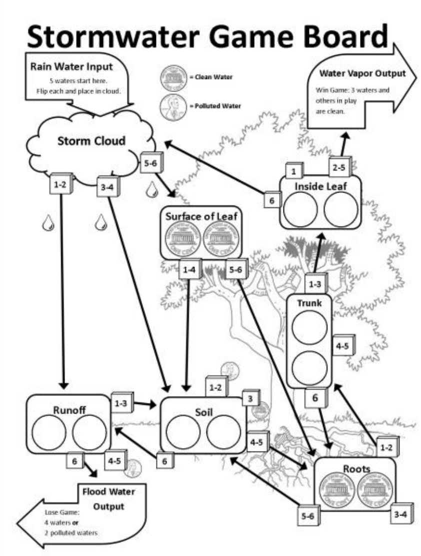
Name: ______________________ Date: ____________

Plant Part	Function
Leaf	Absorb sunlight and carbon dioxide, and use those to make food for the plant (during photosynthesis). Leaves release oxygen and water.
Stem or trunk	Help hold a plant up, and provide a way to move water and nutrients throughout the entire plant.
Roots	Absorb water and mineral nutrients, and help hold the plant to the ground.
Flower/Fruit	Used to make seeds so a plant can reproduce.

Draw and Label a Plant

Explore and Investigate:

7. On the worksheet, have **students draw a plant in the box and label the parts**. Parts of plants may not visible. Roots should be drawn even if not visible, or dig up a plant to observe roots. Options:
   - Put students in groups and give each group a potted plant (brought from home, store, or around school) to draw.
   - Take students outside to draw a plant on the school campus or in the school garden; if in the school garden, it may be possible to pull up some weeds to show their roots.
8. Introduce the **Stormwater Board Game**:
   - In groups of 3-5 students, they will play a cooperative board game that illustrates the inputs and outputs of a plant (tree) and the relationships between plants and water.
   - Students close their eyes and imagine they are rain drops as you read (or paraphrase) the italicized text at the top of the Board Game rules handouts.
   - Handout the "Stormwater Board Game Rules" to each group.
   - Set up a demo game (with board, 5 pennies in the "Rain Water Input" arrow, and a die) under your document camera and project it for the class to watch as you talk about the game.
   - Explain that this is a cooperative game where the whole team is working together to try to progress at least three of their five "water drops" (pennies) through the tree to the "Water Vapor Output" arrow



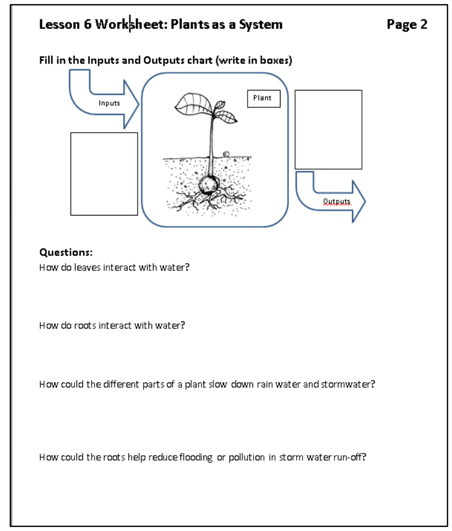
(top right). If three of the pennies end up in the "Flood Water Output" arrow (bottom left) than they lose the game.
  - Demo flipping each penny before placing it in the Storm Cloud. Explain that pennies that are tails up are starting the water as "clean water" and heads up are starting as "polluted water". If water is cleaned or polluted during play they will flip it to the appropriate side. They also lose the game if two polluted waters end up in the "Flood Water Output" arrow.
  - Explain that players will take turns choosing a penny to move (which penny can change from turn to turn)) and rolling a die to determine what happens to it. Demo some of the rolls for the class.
  - Hand out the board, die and pennies to each group and let them play the game!
9. When students are finished playing the game, questions for discussion might include:
  - *Where did your water spend the most time in the game?*
  - *How did the tree affect the water?*
  - *How would the game change if the tree was replaced with something else? Grass? Pavement?*
  - Extension possibility: An interested student could design an alternative board that showed a different type of plant surface (for example, soccer field or wetland or rain garden).

Reflect and Explain:

10. Fill out the inputs/outputs chart on page 2 of the worksheet as a class. Students should also consider "pollution" as a possible input to a plant.

Apply and Extend:

11. Using knowledge gained through the game and the input-output chart, have students answer the questions on page 2 of the worksheet.
12. In a think-pair share, have students use their plant diagram to make an argument about how specific plant structures help reduce flooding or pollution in storm water run-off.


Lesson 6 Worksheet: Plants as a System **Page 2**

Fill in the Inputs and Outputs chart (write in boxes)

Questions:

How do leaves interact with water?

How do roots interact with water?

How could the different parts of a plant slow down rain water and stormwater?

How could the roots help reduce flooding or pollution in storm water run-off?

Optional Additional related lesson ideas:

1. Inform students about local tree planting projects that might be open to volunteers to come and plant trees in a restoration project. Nature Consortium and Mountains to Sound Greenway often host planting projects that are open to youth.
2. "The Role of Plants in Water Filtration" - http://www.marine.usf.edu/pjocean/packets/f00/nwq3.pdf
3. 3rd Grade Unit: "Pollution and Plant Growth", Lesson 3: "Can Plants Clean Pollution out of Water?" - https://www.eugene-or.gov/DocumentCenter/View/13791

Lesson 8: Stormwater Engineering, Part 2 – Develop a Solution

Time: 60 min. plus homework assignment
Location: Classroom

Next Generation Science Standards

DCI	ETS1.B Designing Solutions to Engineering Problems
SP	Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Obtaining and Evaluating Information
CC	Influence of Science, Engineering, and Technology on Society and the Natural World

Lesson Concepts: Engineers design solutions to problems of flooding and water pollution in cities by using plant systems. Engineers must research possible solutions (and take into account constraints) before they propose a solution.

Focus Question: What types of plants are best able to solve the problems of stormwater runoff when using a rain garden or planting trees? What would your green stormwater solution look like?

Advance Preparation

- Planning
  - Print and then divide the materials from **Lesson 7 Research References** into 3 stations. Suggested stations are listed in Explore and Investigate, step 5.
  - Prepare videos for viewing (see links in Lesson 7 Research References)
  - Decide if you would like students to work at their own pace at each station, or rotate every 10 minutes.
- Materials for the class:
  - Lesson 7 Research References
  - Lesson 7 worksheet
  - Lesson 5 worksheet for review
- Materials for homework:
  - Drawing paper (bigger than 8.5x11")
  - Pencils
  - Colored pencils and/or markers
  - Pens

Engage and Encounter:

1. From the previous lesson we know that the structures of plants make them effective tools for dealing with stormwater. In this lesson students will be researching further to compare possible solutions using plants. Which one will work best for the student's problem site?
2. Pair and share to **review the Lesson 5 Worksheet – Developing a Plan**:

a. What is the problem each student identified and what are the criteria for success?

b. Reviewing the drawing of the site, discuss what is causing the problem. Given the site layout, where might plants be added to capture or slow down stormwater? Have students label these areas on their drawing.

3. As a class, go through the table of constraints on the **Lesson 5 worksheet**. How might those constraints have an effect on any efforts to plant in the area?
   i. **Size of Area-** How much space is there in the area that could be used for plants while still letting it serve other desired purposes? Would it fit a few small plants, a tree, or a lot of plants?
   ii. **Light or shade**- How much sunlight would plants get if they were planted there? Would different kinds of plants need different amounts of light?
   iii. **Slope** – would the steepness of the slope be a challenge for your solution?
   iv. **Is the site close to a building?** Would some plants damage a building?
   v. **Ground surface**- What kind of surface would have to be dug up to plant something there?
   vi. **What other constraints** might have to be considered at their sites?

Explore and Investigate:

4. Students will compare possible plant-based engineering solutions to find features that would fit within the constraints of their site.

5. These resources are in 3 stations:

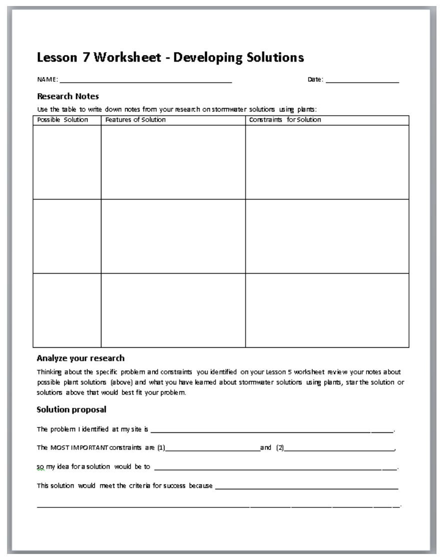
   a. Station 1 - online videos

   b. Station 2 - tree diagrams and readings

   c. Station 3 - rain garden diagrams and readings

6. Students rotate through each station to gather information using the **Lesson 7 worksheet – Developing Solutions**.

7. At each station they will write down one or more possible solutions, the features for that solution, and any constraints of the solution. For example, if they are reading about trees, they could write down some details in the "features" column about ideal tree types and sizes and then write down how much space the trees need in the "constraints" column.



Lesson 7 Worksheet - Developing Solutions

NAME: ______________________ Date: ____________

Research Notes

Use the table to write down notes from your research on stormwater solutions using plants:

Possible Solution	Features of Solution	Constraints for Solution

Analyze your research

Thinking about the specific problem and constraints you identified on your Lesson 5 worksheet review your notes about possible plant solutions (above) and what you have learned about stormwater solutions using plants, star the solution or solutions above that would best fit your problem.

Solution proposal

The problem I identified at my site is ______________________.

The MOST IMPORTANT constraints are (1)____________and (2)____________,

so my idea for a solution would be to ______________________.

This solution would meet the criteria for success because ______________________

______________________.

Reflect and Explain:

8. Students compare the constraints from their site with the constraints on the various solutions they learned about at the stations. Which solutions best fit their site? They could put a star by solutions they are considering incorporating into their solution.

9. Questions to consider:

   a. "Is the solution in consideration feasible given the constraints of the site and needs of the solution?"

   b. "Could the solution actually be implemented at the site?"

10. Students partner up to discuss the solutions they are considering for their site. What will they be incorporating from the plan options they researched? Does the partner have any suggestions or ideas?
11. Students write out a proposal of their solution at the bottom of the Lesson 7 worksheet (see example in box).
12. OPTIONAL EXTENSION: Visit a nearby rain garden with the class. To find rain gardens near the school, use https://rainwise.seattle.gov/city/seattle/map or the 12,000 Rain Gardens website http://www.12000raingardens.org/about-rain-gardens/rain-gardens-near-you/.

Solution proposal example: "The problem I identified is <u>a big puddle in the middle of the grass by the classroom</u>. The most important constraints are <u>the size of the location and amount of sun</u>, so my idea for a solution would be <u>to plant a small rain garden</u>. This solution would meet the criteria for success because <u>it will fit the space and I can plant small plants that like the shade</u>. Those plants will help absorb rain water."

Apply and Extend (HOMEWORK)

13. They will draw the problem area and the imagined solution. They can also incorporate pictures or other images cut and paste onto a poster. Things to include are:
    a. Diagram of current problem area (somewhat like a "before" picture). This could be copied from the drawing they did in the "Defining the Problem" worksheet. It should include:
        i. Surfaces in the area that contribute to the problem.
        ii. Arrows showing where water moves through the site during a storm (e.g. arrows from pervious coming from and where it's causing a problem, source of possible pollutants, etc.
    b. Diagram of Solution (like an "after" picture), showing the proposed solution and its features
    c. Key or legend (if using symbols in drawings)
    d. Constraints of the site that were considered in the solution
    e. Problem and Solution proposal statement from Lesson 7 worksheet
    f. Description of Problem
    g. Description of Solution
14. Students should complete their poster at home and be prepared to share it with their classmates during the next class.

OPTIONAL EXTENSION: invite a stakeholder from the school or community (such as a school facilities person) to discuss the students' proposed solutions.

Lesson 9: Stormwater Engineering, Part 3-Communicate

Time: 60 min.
Location: Classroom

Next Generation Science Standards

DCI	**ETS1.B Designing Solutions to Engineering Problems**
SP	**Designing Solutions** **Engaging in Argument from Evidence** **Obtaining, Evaluating, and Communicating Information**
CC	**Influence of Science, Engineering, and Technology on Society and the Natural World**

Lesson Concepts: Students will share their designs and discuss them with their classmates. Engineers share their design solutions with each other in order to evaluate the solutions based on how well they meet specific criteria or take into account constraints.
Focus Question: What would your stormwater solution look like, and how will it work?
Vocabulary: **optimize**

Advance Planning

- **Room layout**: Where will the posters be displayed and how will people move around the area?
- **Sharing:** What is the best way to have students share their presentations? The approach below has half the students at a time presenting to one other student twice.

Engage and Encounter:

1. **Evaluating and communicating solutions** is an important part of the engineering process. Today's class will provide an opportunity for each student to share their proposed solutions for their site.
2. Student presenters will need to be able to explain:
   a. What the **problem** was at their site and why they chose it
   b. What site **constraints** influenced their solution
   c. What the proposed **solution is and why that solution will work**.
3. Student listeners will write down the person's name, the problem and the proposed, solution. They will share with the presenter something they like about the solution, and ask a question about it. If they have any ideas for improvements that will help **optimize** (improve) the solution they will share them.
4. Pair students off to put up their posters next to each other and practice their explanations.
5. Each pair figures out who will be presenting first.

Explore, Investigate, Reflect, and Explain:

1. Have each pair that worked together stand by the posters they put up. The student presenting first stays with their poster, while the listeners move clockwise to an adjacent presenter.

2. First presentation happens:
    - Each presenter shares their information.
    - The listener then shares something they like and asks a question about the solution.
    - The presenter writes down any ideas for improvements that the listener offers.
3. After 5 minutes the listeners rotate again to see a second solution (and the presenters present a second time).
4. After each presenter has shared twice come back together as a whole class to reflect on the first two presentations:
    - "Listeners, what were some interesting solutions you saw?
    - "Presenters, what ideas did the listeners have for improving your solution?"
5. Listeners and presenters now switch so each student has the opportunity to present twice and listen twice.
6. Bring the whole class together again to reflect and explain interesting solutions and ideas for improvements.
7. Each student writes a list of any revisions they might make to their proposal now that they have seen some other proposals and/or gotten feedback.

Apply and Extend:

8. Engineers will usually **test** their solutions as a part of the engineering process. As an example you could refer back to the example you gave in Lesson 5 of your classroom being too hot. If the trees were planted outside the window, you could take temperature measurements in the spring and observe/interview students on hot days to see if the room is still getting too hot.
    - "What was your criteria for success" (e.g. water not puddling up in the basketball court)
    - "If the project was implemented how could you test whether that criteria was met?" (measure the amount of rainfall and size of any puddle in the basketball court)
    - Each student writes down an idea for how their solution could be tested.
9. Implementing the student's solutions is beyond the scope of this unit, but could happen. Discuss with students, the need for stakeholders to be brought on board to help implement their solutions:
    - If it was at somebodies home, they student would need to talk to their parents (and the property owner if the home is rented).
    - If it is a schoolyard problem, the school district would need to be involved.
    - If the problem was in a park or other public space, Seattle Parks and/or other neighborhood partners would need to be brought on board.

Reflect and Explain:

What was the most fun part of the the process? The most challenging? Did you prefer the science learning or the engineering? What other environmental or community problems can you think of that could use engineering solutions?

Next Generation Science Standards

Disciplinary Core Ideas	
LS1.A Structure and Function	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior and reproduction. (4-LS1-1)
ESS2.A Earth Materials and Systems	Roles of water in Earth's surface processes: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils and sediments into smaller particles and move them around. (4-ESS2-1)
ESS2.E Biogeology	Living things affect the physical characteristics of their regions. (4-ESS2-1)
ESS3.B Natural Hazards	A variety of hazards result from natural processes. Humans cannot eliminate the hazards, but can take steps to reduce their impacts. (4-ESS3-2)
ETS1.A Defining and Delimiting Engineering Problems	Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5 ETS1-1)
ETS1.B Designing Solutions to Engineering Problems	Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary to 4-ESS3-2)
Science and Engineering Practices (bulleted practices are specific to this 4th grade performance expectations)	
Asking Questions and Defining Problems	Predict reasonable outcomes based on patterns such as cause and effect relationships. ● **Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, and/or cost. (3-5-ETS1-1)**
Developing and Using Models	Develop and/or use models to describe and/or predict phenomena. Develop a diagram or simple prototype to convey a proposed object, tool, or process. ● **Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)**
Planning and Carrying Out Investigations	Conduct an investigation collaboratively to produce data to serve as the basis for evidence. ● **Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)**
Analyzing and Interpreting Data	Analyze and interpret data to make sense of phenomena using logical reasoning. Represent data in tables and graphs to reveal patterns that indicate relationships.

Using Mathematics and Computational Thinking	Organize simple data sets to reveal patterns that suggest relationships.
Constructing Explanations and Designing Solutions	Use evidence to construct or support explanations. ● **Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2) (3-5-ETS1-2)**
Engaging in Argument from Evidence	Respectfully provide critiques about a proposed explanation by citing relevant evidence. ● **Construct an argument with evidence, data, and/or a model. (4-LS1-1)**
Obtaining, Evaluating, and Communicating Information	Obtain and combine information from books and/or other media to explain phenomena. Communicate scientific information orally and/or in written formats, including tables and charts.
Crosscutting Concepts	
Cause and Effect	● Events that occur together with regularity might or might not be a cause and effect relationship. ● Cause and effect relationships are routinely identified, tested, and used to explain change.
Systems and System Models	● A system can be described in terms of its components and their interactions. ● (A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.)
Influence of Engineering, Technology, and Science on Society and the Natural World	● People's needs and wants change over time, as do their demands for new and improved technologies.

See also APPENDIX I – Engineering Design in the NGSS

Glossary

Changed, measured and controlled variables: All the parts of a system that could be changed are called variables. In an experiment one variable is changed (also called the manipulated variable) and another variable is measured (also called the responding variable). The rest of the variables are kept the same (called "controlled variables"). (From http://www.k12.wa.us/science/pubdocs/Grade5Update2014.pdf)

Constraint*: a limitation to a possible solution, often related to materials and resources

Criteria for success*: desired features of a solution

Engineering*: any engagement in a systematic practice of design to achieve solutions to particular human problems

Erosion: movement of earth materials by processes such as wind, water, ice, and gravity

Function: the normal and specific contribution of a bodily or cellular part to the economy of a living organism.

Impervious: a surface not allowing water to pass through

Optimize*: test solutions in order to determine which of them best solves the problem, given the criteria and the constraints

Pervious: a surface allowing water to pass through

Pollution: the presence or introduction of a harmful substance into the environment (excess of a nonharmful substance can also become harmful; for example: too much noise = noise pollution)

Rain garden: garden which takes advantage of rainfall and stormwater runoff in its design and plant selection; ideally placed close to the source of the runoff; serve to slow the stormwater as it travels downhill, giving the stormwater more time to infiltrate and less opportunity to gain momentum and erosive power (definition from www.lowimpactdevelopment.org)

Rate: a ratio comparing speed over a measured distance; in this unit: speed water travels over a measured distance

Runoff: water that runs off the ground (usually off pervious surfaces) and into storm drains or bodies of water

Solution*: a way (object, tool, process or system) to address or solve a problem; in engineering, solutions take into account constraints and criteria for success

Stormwater: water that falls as rain onto the ground; usually associated with urban areas

Structure: something made up of a number of parts that are held together in a specific way; parts put together to create a whole

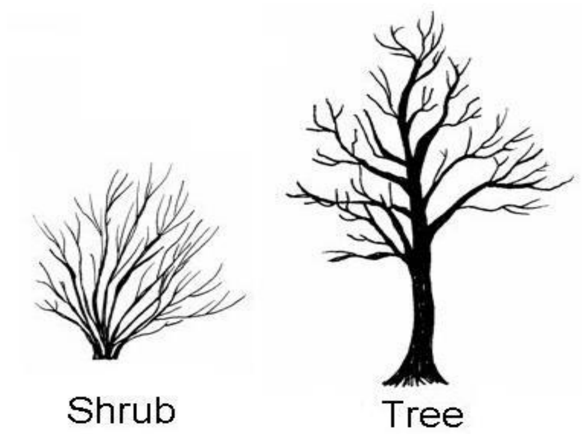
System*: a group of related parts that make up a whole and can carry out functions its individual parts cannot, and can be described in terms of its components and their interactions

Watershed: all of the land that surrounds and drains to a creek, river, lake or other water body

* Definition based on NGSS – 3-5 ETS-1 Engineering Design, APPENDIX G – Crosscutting Concepts, or APPENDIX I – Engineering Design in the NGSS.

Teacher Resources

Lesson 7 – Plant Structures and Functions Resources



Tree or Shrub

- Tree = one trunk (usually), at least three inches diameter at 4 ½ ft., mature height of at least 13 ft.
- Shrub = several woody stems erect or close to ground, less than 13 ft., stems smaller than 3 inches

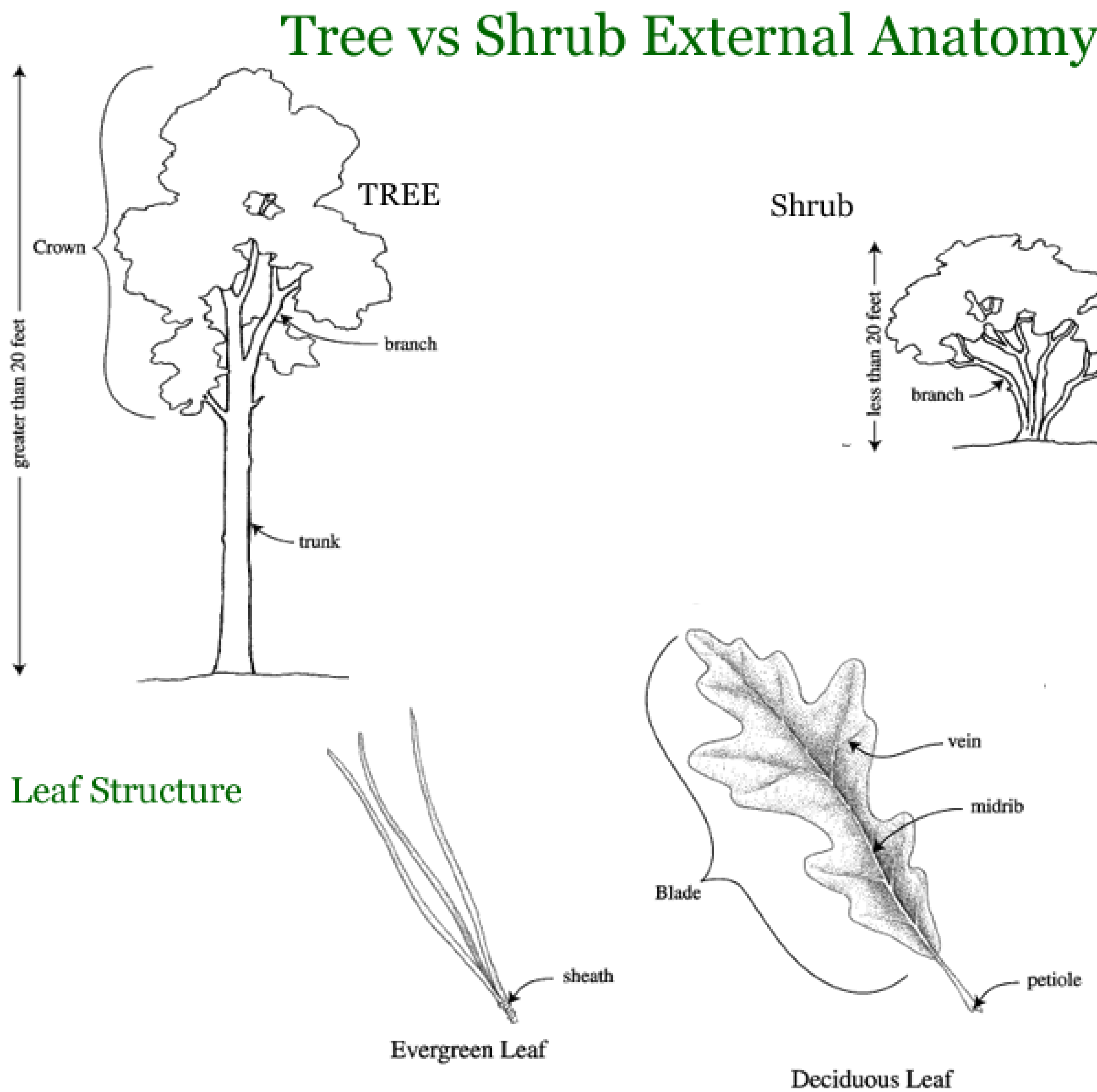
Other types of plants (not trees or shrubs) – grass, ground cover, etc.

- Ground cover = spreads across ground, "carpet like", technically grasses in this category
- Grass = narrow leaves growing from base

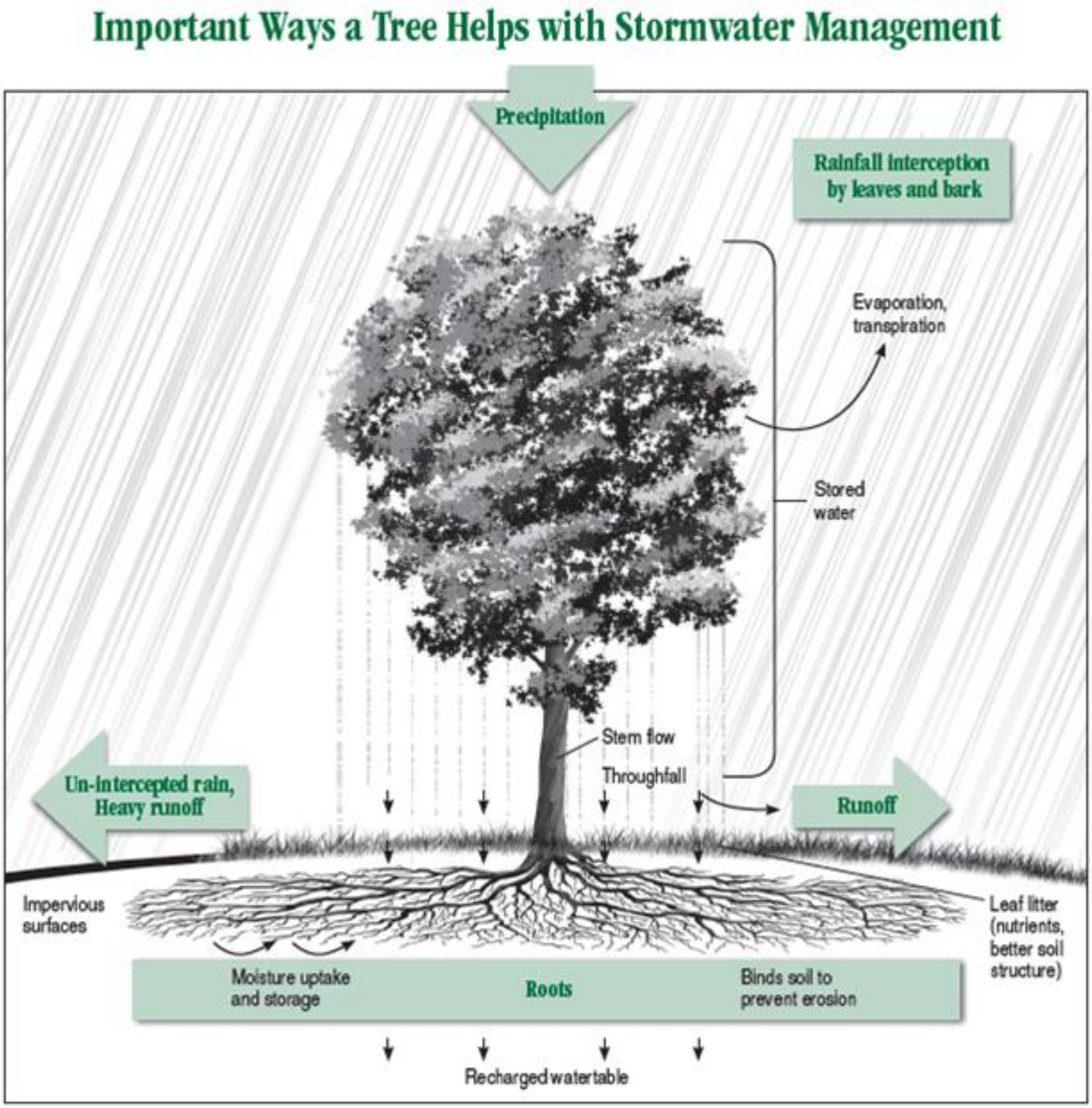
Deciduous or Evergreen

- Evergreen (usually conifers, or cone-bearing trees) = leaves all year round, usually needle-like and thick and waxy
- Deciduous = broad leaves that are usually thinner than evergreen leaves, turn red/yellow/orange in fall then lose leaves

From: http://departments.bloomu.edu/biology/ricketts/tree_shrub.jpg



From http://www.kentuckyawake.org/files/external%20anatomy/treeVsShrub-externalAnatomy.png

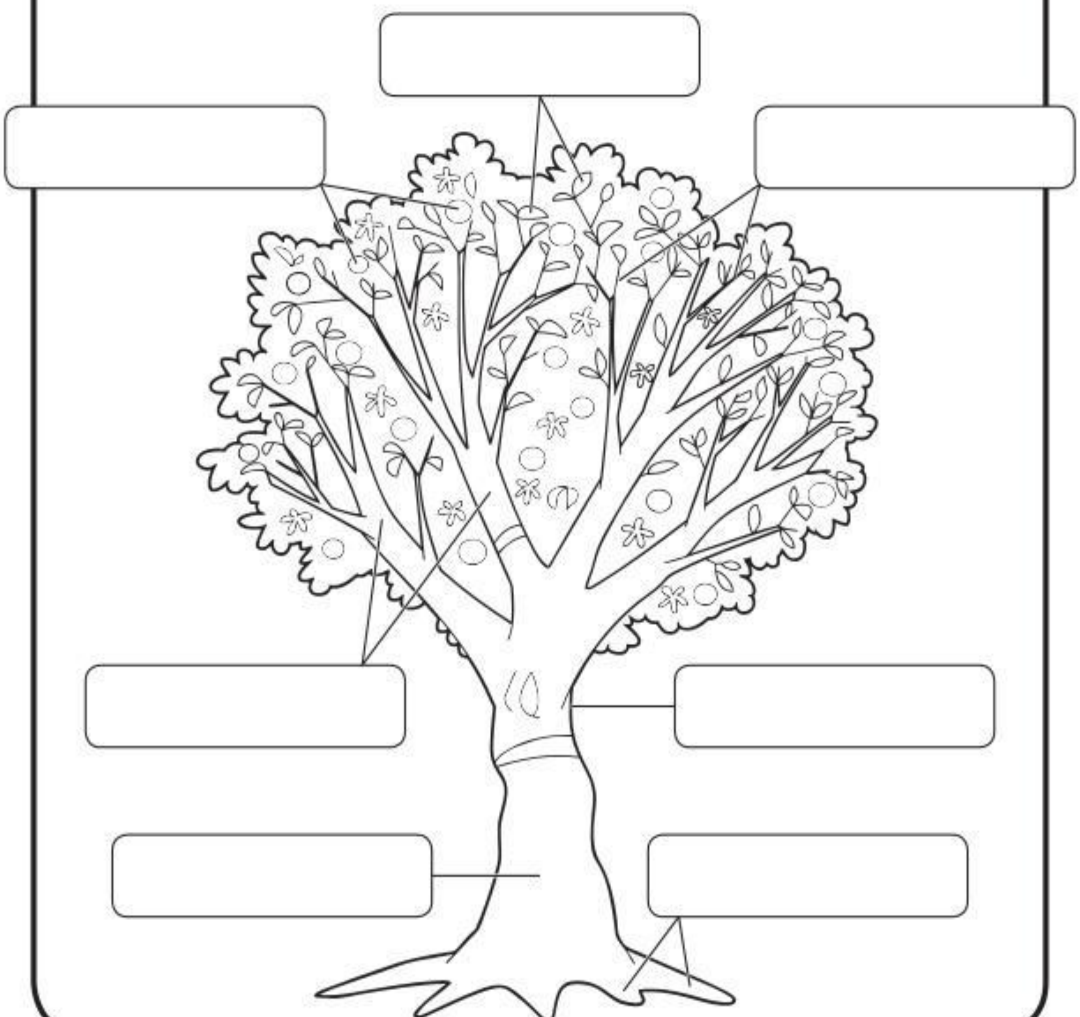


http://blog.arborday.org/wp-content/uploads/2014/05/stormwater-runoff_fazio1.png

Anatomy of a Tree

Read the descriptions below then label the diagram of the tree.

Branches: woody parts of the tree that grow from the trunk.
Twigs: slim woody shoots that grow from a branch or stem of a tree.
Leaves: food processing part of a tree.
Roots: extract food and water from the soil.
Trunk: the main support of the tree.
Bark: protective outer layer of the tree trunk.
Fruit: all trees that are flowering plants produce fruit.



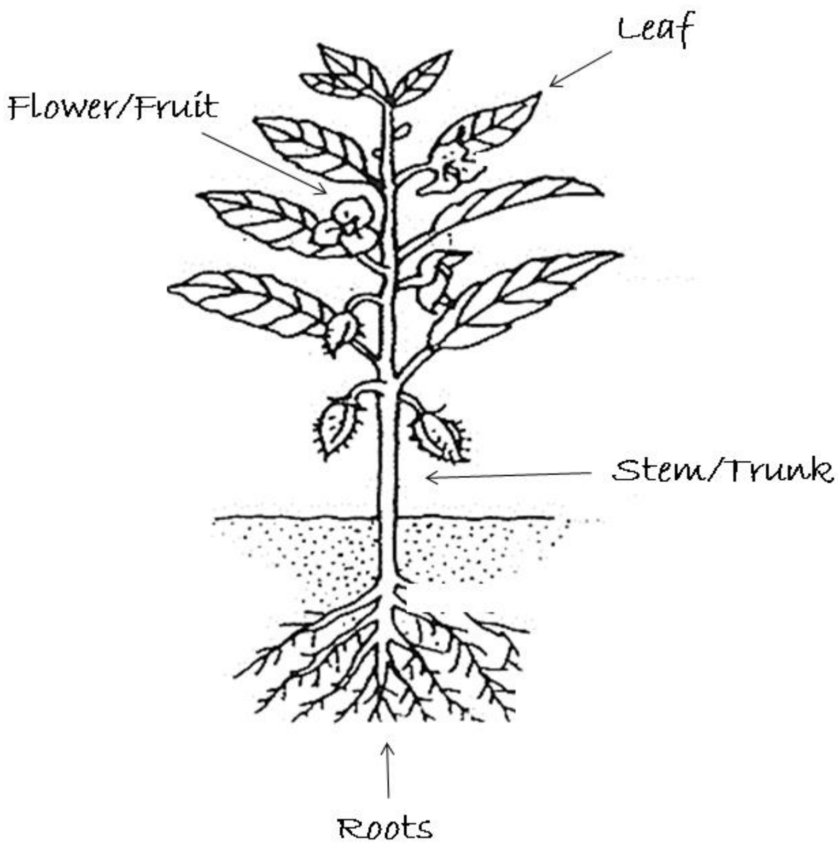
From: http://image.slidesharecdn.com/anatomy-of-tree-121229101046-phpapp01/95/anatomy-oftree-1-638.jpg?cb=1356797523

Plants as a System worksheet – Teacher version

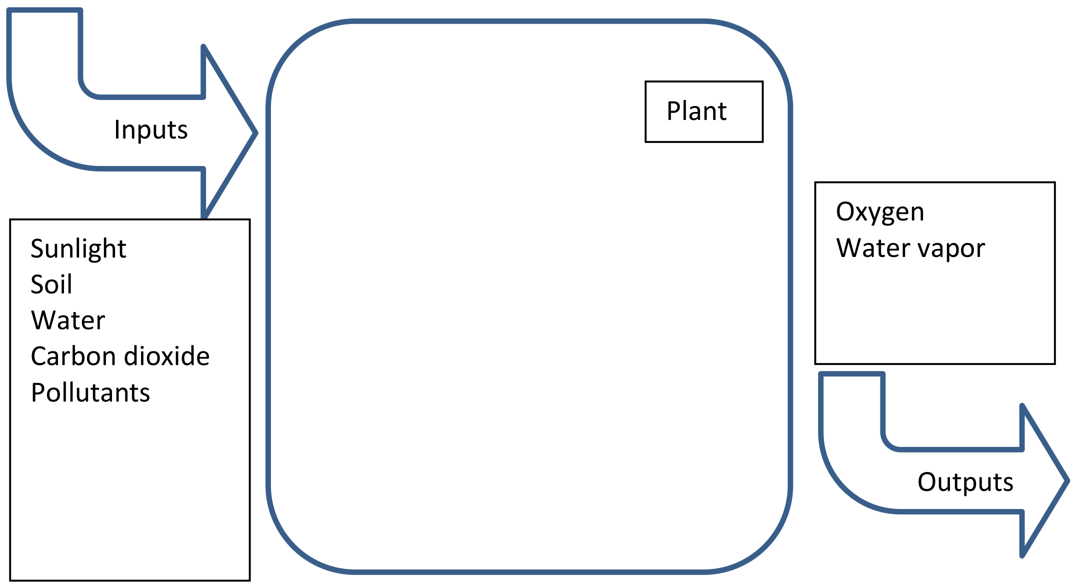
Name: ______________________________

Plant Part	Function
Leaf	Absorb sunlight and carbon dioxide, and use those to make food for the plant (during photosynthesis). Leaves release oxygen and water.
Stem or trunk	Help hold a plant up, and provide a way to move water and nutrients throughout the entire plant.
Roots	Absorb water and mineral nutrients, and help hold the plant to the ground.
Flower/Fruit	Used to make seeds so a plant can reproduce.

Draw and Label the Plant


Leaf
Flower/Fruit
Stem/Trunk
Roots

Fill in the Inputs and Outputs chart (write in boxes)



Questions:

How do leaves interact with water?
(Rainwater hits leaves, which slow the water down before hitting the ground; water evaporates out of the leaves)

How do roots interact with water?
(Roots absorb water from the ground)

How could the different parts of a plant slow down rain water and stormwater?
(Leaves can slow the water down)

How could the roots help reduce flooding or pollution in storm water run-off?
(Roots can soak up water to stop flooding and they soak up pollution in the water)

Lesson 8 – Developing Solutions

Additional resources for rain gardens:

- Plants for Rain Gardens power point and rain garden plant zone photo: http://www.seattle.gov/util/groups/public/@spu/@conservation/documents/webcontent/02_015878.pdf
- Google "rain gardens" for more diagrams, photos, and videos

For this unit, students focus on two possible solutions to stormwater problems. These two solutions are considered "green" solutions, involving plants - rain gardens and planting trees. Here are some considerations for each:

Rain gardens	Planting trees
Good for large and small areas	Depending on the types of trees, good for large and small areas
Can be in places where there is lots of sun or some sun	Different types of trees can be planted in different amounts of sun or shade
These work if buildings are NOT close by	Trees can be planted near buildings
Not a good choice if people use the area	Can be where people are using the area
Must be above soil that can drain (i.e., not clay)	