Watersheds and Stormwater

Students build a watershed model to define what a watershed is, identify the different parts within a watershed, and discover how water moves within a watershed. After learning Best Management Practices and mitigation techniques, students rebuild their models.

Subject: Earth Systems and Human Activity

Objectives are focused on HS- ESS3:

The students will be able to:

* Define a watershed as, "an area of land that drains to a particular body of water,” and identify the natural and human components of a typical watershed.
* Students construct a model of a watershed.
* Understand how human land use impacts the health of the Southern Resident Orcas

Materials:

* Materials x # of groups (8-10 students in a group):
* Bag of newspaper
* 1 – 8x10 tarp
* Watershed features laminated cards
* Rain: 3 spray bottles (filled with water)
* Natural water slowing features representing lakes, wetlands, forests (sponges)
* Human impact:
	+ 5 green houses, 2 blue apartments, 1 - 2 red or white industry buildings
	+ 4 farm animals
	+ 3 - 4 plants (representing crops)
	+ 3 vehicles
* Pollution:
	+ food coloring (represents oil, fuel, fertilizer, grease, anti-freeze, etc.)
	+ chocolate sprinkles (represents poop)
	+ litter (hole punch chards)
* Mitigation tools: riparian zones (in sponges), rain gardens (in sponges), manure lagoon (lids)

Number of Participants:

1 - 25 students

Setting:

Outside

Duration:

1.5 hours - but can be varied based on student knowledge

Background Information:

The watershed consists of surface water—lakes, streams, reservoirs, and wetlands--and all the underlying groundwater. Larger watersheds contain many smaller watersheds. It all depends on the outflow point; all of the land that drains water to the outflow point is the watershed for that outflow location. Watersheds are important because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point. There are many factors that determine how much water flows in a stream (these factors are universal in nature and not particular to a single stream):

* **Precipitation:** The greatest factor controlling streamflow, by far, is the amount of precipitation that falls in the watershed as rain or snow. However, not all precipitation that falls in a watershed flows out, and a stream will often continue to flow where there is no direct runoff from recent precipitation.
* **Infiltration:** When rain falls on dry ground, some of the water soaks in, or infiltrates the soil. Some water that infiltrates will remain in the shallow soil layer, where it will gradually move downhill, through the soil, and eventually enters the stream by seepage into the stream bank. Some of the water may infiltrate much deeper, recharging groundwater aquifers. Water may travel long distances or remain in storage for long periods before returning to the surface. The amount of water that will soak in overtime depends on several characteristics of the watershed:
	+ **Soil saturation:** Like a wet sponge, soil already saturated from previous rainfall can't absorb much more ... thus more rainfall will become surface runoff.
	+ **Soil characteristics:** Different soil characteristics can either help or hinder infiltration. For example, sandstone does relatively well at allowing water to percolate through, but clays and cements do not.
	+ **Land cover:** Some land covers have a great impact on infiltration and rainfall runoff. Impervious surfaces, such as parking lots, roads, and developments, act as a "fast lane" for rainfall - right into storm drains that drain directly into streams. [Flooding becomes more prevalent](http://water.usgs.gov/edu/impervious.html) as the area of impervious surfaces increase.

Vegetation such as grasses, trees and shrubs that you find beside lakes, rivers and streams and in wetlands is important to reduce soil erosion, filter out contaminants, provide habitat for wildlife and contribute to the water quality and thermal requirements that fish need to live. Plant life found in bodies of water, especially wetlands, provide important habitat for fish and other aquatic species. ([http://watersheds101.ca/learn-about-watersheds/what-is-a-watershed)](http://watersheds101.ca/learn-about-watersheds/what-is-a-watershed%29)

Wetlands help protect the quality and supply of our groundwater by acting as a natural filter for toxic substances, providing a groundwater recharge area, preventing soil erosion and storing floodwaters. Wetlands are also sources of food and habitat for many plants, fish, birds and other wildlife. Wetlands improve water quality, store water and reduce the impacts of floods. Globally, human activity has eliminated 30% of all wetlands (http://watersheds101.ca/learn-about-watersheds/what-is-a-watershed)

* + **Slope of the land:** Water falling on steeply-sloped land runs off more quickly than water falling on flat land.

The shape and type of land formed by geology and weather greatly influences how water moves through watersheds creating runoff, erosion, drainage and wetlands. Think about stormwater running over a steep mound of bedrock, compared to running across a grassy field. The topography and characteristics of an area dictate how quickly water moves through and over a landscape and what it picks up along the way. [(http://watersheds101.ca/learn-about-watersheds/what-is-a-watershed)](http://watersheds101.ca/learn-about-watersheds/what-is-a-watershed%29)

* [**Evaporation**](http://water.usgs.gov/edu/watercycleevaporation.html)**:** Water from rainfall returns to the atmosphere largely through evaporation. The amount of evaporation depends on temperature, solar radiation, wind, atmospheric pressure, and other factors.
* [**Transpiration**](http://water.usgs.gov/edu/watercycletranspiration.html)**:** The root systems of plants absorb water from the surrounding soil in various amounts. Most of this water moves through the plant and escapes into the atmosphere through the leaves. Transpiration is controlled by the same factors as evaporation, and by the characteristics and density of the vegetation. Vegetation slows runoff and allows water to seep into the ground.

Procedure:

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| **Time** | **What** | **NGSS Notes** |
|  | **Intro:**Driving question: Why is the resident orca whale population declining?During this investigation, we will observe how water moves throughout the landscape and eventually affects the marine environment. | Asking questions and developing solutions |
|  | **Step 1. Build a Model with Natural elements*** Topography
	+ Create a mountain and some hills.
	+ Lay the tarp over the elevation you created with the newspaper (this is ground cover).
	+ Shape the tarp and newspaper as needed to ensure a mountain and a valley
* Label the parts:
* Headwater and Outlet
	+ Hand some of the watershed element cards (Salish Sea, Tributary, Spring, River, Glacier) out to students, have them read the cards out loud and then place the card where they think that element is within the watershed.
* How water slows?
	+ Hand remainder of the watershed element cards (Marsh, Swamp, Wetland, Forest, Lake) out to students, have them read the cards out loud and then place the card where they think that element is within the watershed.
	+ Add sponges to the watershed to represent how marshes, wetlands, swamps, forests, and lakes slow down and filter out the water.
* Surface and Groundwater
 | **Systems and System Models:*** Models can be used to simulate systems and interactions - including energy, matter and information flows - within and between systems at different scales
* Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
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|  | **Step 2. Predict, Rain, Observe*****Have students Pair/Share to answer the following questions:**** Where will the water accumulate?
* Where will the water speed up?
* Will the water become discolored?
* What about the sponges?

Have students spray down the watershed representing precipitation. * Were your predictions accurate?

The water that hits the land should flow downhill and collect in rivers, lakes, and the outlet: Salish Sea. * If areas of the watershed were mislabeled, have students move the labels to where the features actually are within their model. (e.g. If water collects in a lake and the lake card is where no water collected, have a student move the label.

***Is this what a watershed looks like? What’s missing? Human impact, wildlife, etc.*** | **Cause and Effect: Mechanism and Prediction*** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system
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|  | **Step 3. Humans Arrive - how do humans impact the landscape?*** FOOD: Add farms - animals and crops
* SHELTER: Add houses, apartments, neighborhoods
* TRANSPORTATION:Add cars
* INDUSTRY: Add white buildings

All this development comes with a cost. Look what is now found at the outlet of the watershed:* Suspended Sediments
* Excess Nutrients
* trash/litter
* Bacteria and Viruses
* Pesticides and Toxic Chemicals
	+ With each pollutant, show visual and ask how it might affect life in the watershed
	+ Have student add the “pollution” - chocolate sprinkles, food coloring, soil.

***Where did this come from??? Have students match the human impact to the pollution on the worksheet*** | Natural Resources:* Resource availability has guided the development of human society
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|  | **Step 4. Predict, Rain, Observe*****Have students Pair/Share to answer the following questions:**** Where will the water accumulate?
* Where will the water speed up?
* Will the water become discolored?
* What about the sponges?

Have students spray down the watershed representing precipitation. * Were your predictions accurate?
	+ Talk about developing in areas that were once wetlands, pervious surfaces. What happens now to the water? You can remove sponges and explain that in order to have housing developments, roads, cities, and farms; humans have logged forests, filled in swamps, and removed marshes to make way. In replacement, we have created an infrastructure of impervious surfaces where water cannot flow through. Instead the water runs off these impervious surfaces and flows directly into our creeks, rivers, and oceans. And moves faster!
	+ Take special note of sponges and the discoloration or pollution that they “hold”
* Any suggestions on how to fix this?
 | **Scale, Proportion and Quantity:*** Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale
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|  | **Step 5. Best Management Practices**Introduce BMP as they fall under these 3 categories:* Source Reduction
	+ Ex. Pick up dog poop, manure lagoon
* Reducing transport of pollution
	+ Ex. Rain garden, riparian zone
* Cleaning pollution out of the water
	+ Beach/ litter cleanups
 | Human Impacts on Earth Systems* scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation
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|  | **Step 6. Create your own**Now you get to create your own watershed.* It must have all the natural elements and all the human impacts but you can plan the placement of where industry, farms, etc. are placed.
* You also can employ the BMPs by using the following:
	+ Riparian zones
	+ Rain gardens
	+ Manure lagoons
* What if there were laws about cars/dogs/etc.?
* After you created it, have a spokesperson share with us the following:
	+ Why you placed human impacts where you did?
	+ Why did you place BMPs where you did?
	+ Any special rules/laws in your watershed?

After each group presents, pollution will be placed and precipitation will be simulated.Observing students will orally give feedback:What did you notice?What worked?What could be improved? | Engaging in argument from evidence* Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence and logical arguments regarding relevant factors.

Constructing explanations and designing solutions.* Design or refine a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria and tradeoff considerations.

Cause and Effect: Mechanism and Prediction* Systems can be designed to cause a desired effect
* Changes in systems may have various causes that may not have equal effects
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|  | **Wrap up model - move to tour**Now we are going to move from the model to the real world. What might work in a model may not work in real world... |  |

**Resources:**

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| Stormwater + land use mapping tool  | <https://www.epa.gov/water-research/national-stormwater-calculator> |
| WA river and stream flow map | <https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Flow-monitoring> |
| Bellingham area utilities, property boundaries, etc. | <https://www.cob.org/services/maps/online-mapping> |
| Nature Conservancy stormwater infographic | <http://www.washingtonnature.org/cities/stormwater/green-infrastructure-infographic> |
| Impervious surface mapping tool | [https://coast.noaa.gov/digitalcoast/tools/isat.htm](https://coast.noaa.gov/digitalcoast/tools/isat.html) |
| Salmon Mapping Tool | <http://apps.wdfw.wa.gov/salmonscape/map.html> |

**Cause Pollutant**

Construction

Brake dust Bacteria and Viruses

Fertilizer on Lawn and Plants

 Suspended Sediments

Unsecured Load

Fuel

 Excess Nutrients

Car washing soap

Livestock

 Litter and Trash

Dog poop

Leaky septic

 Pesticides and Toxic Chemicals

Weed killer