THE STORY OF LIFE AS TOLD BY WATER

6th Grade - "Raindrop to Sea"

cascade head
UNESCO BIOSPHERE RESERVE

OREGON COAST AQUARIUM

LINCOLN COUNTY SCHOOL DISTRICT

Funded by NOAA's Bay and Watershed Education and Training (B-WET) Program

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

TABLE OF CONTENTS (click to go!)

Background and Program Goals (pg. 2)

Education Standards (pg. 2)

Learning Units (pg. 4)

INTRODUCTORY UNIT (pg. 5)

LEARNING CIRCLE 1 (pg. 9)

LEARNING CIRCLE 2 (pg. 14)

LEARNING CIRCLE 3 (pg. 17)

LEARNING CIRCLE 4 (pg. 21)

LEARNING CIRCLE 5 (pg. 24)

LEARNING CIRCLE 6 (pg. 27)

LEARNING CIRCLE 7 (pg. 30)

LEARNING CIRCLE 8 (pg. 33)

Final Project (pg. 34)

Reflection Activities (pg. 37)

Extension Activities by Learning Circle (pg. 37)

Teacher Resources (pg. 44)

Glossary (pg. 45)

Introduction

The Story of Life as Told by Water is a place-based educational curriculum developed by the Cascade Head Biosphere Reserve, Oregon Coast Aquarium, and the Lincoln County School District. The "*Raindrop to Sea*" component for 6th graders explores the inner workings of the water cycle, providing students insight into weather, watersheds, and life on Earth. Resources within the program include nine videos which guide students through a small watershed in the awe-inspiring Cascade Head Biosphere Reserve on the Central Oregon Coast. Led by two engaging Youth Correspondents as hosts, students will be immersed in the landscape, traversing through forests, wetlands, ultimately out to sea as they track a raindrop through the never-ending water cycle. This video series is a learning journey paired with interactive activities, providing the tools needed for a complete lesson plan. This program will provide hands-on opportunities for learning and exploration about the water cycle, human-environment interactions, ecosystem interconnectedness, and more. Activities will invite students to use critical thinking and collaborative group work to answer real questions and generate ideas.

Background and Program Goals

The focus area for this program is the UNESCO-designated Cascade Head Biosphere Reserve (cascadehead.org). This extraordinary place and its adjacent marine reserve (oregonmarinereserves.com) are a rare example of a protected and contiguous land/sea connection. It is comprised of 102,110 acres located on the Central Oregon Coast, in a unique convergence of physical components including: six miles of protected Pacific Ocean coastline with marine reserve and marine protected areas; a littoral sand spit, dune and beach pine complex; the Salmon River and its recently restored estuary; and forested uplands. The Cascade Head Biosphere Reserve is one of 714 such biosphere reserves around the globe, and is a one of 61 members of the UNESCO World Network of Island and Coastal Biosphere Reserves. The Salmon River and its estuary, coupled with the marine reserve and marine protected areas, make the location of our project a premium spot to relate the interconnectedness of the watershed and the ocean.

Through the *Raindrop to Sea* program and its accompanying 3rd Grade *Secret Life of Salmon* curriculum, *The Story of Life as Told by Water* provides meaningful watershed educational experiences for students. Specifically, we seek to do the following:

- Increase teachers' confidence instructing students about watersheds, and the water cycle, including the basics of environmental change and human impacts.
- Provide meaningful resources to experience the inner workings of the water cycle, how it generates weather systems, creates watersheds and supports the life cycle of wild salmon.
- Utilize a balance of art and science to create "Whole Systems" education that meets Next Generation Science Standards and delivers Meaningful Watershed Educational Experiences.

Education Standards

Next Generation Science Standards

• LS 1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. *(Learning Circle 5)*

• ESS 2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *(Learning Circles 1 & 2)*

• ESS 3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. *(Learning Circle 8 / Final Project)*

• ESS 3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. *(Learning Circles 6 & 7)*

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. *(Learning Circle 2)*

• MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. *(Learning Circle 3)*

• MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. *(Learning Circles 3 & 4)*

• MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. *(Learning Circle 3)*

• MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. *(Learning Circle 4)*

Oregon Social Sciences - Grade 6

Geography
6.12. Collect and analyze data to describe regions of the Western Hemisphere.
6.13. Classify and analyze the types of connections between places in the Western Hemisphere.

Social Science Analysis
6.21. Clarify key aspects of an event, issue, or problem through inquiry and research.

Coast Connections Education Project:

Essential Questions:

- What is the water cycle & how is water distributed on earth?
- What is a watershed and why are they important?
- How can we monitor and take care of our watershed?

Essential Concepts:

- Water cycles through Earth's systems, driven by energy from the sun and gravity
- Characteristic animal behaviors and specialized plant structures affect the probability of successful survival and reproduction
- We can apply scientific principles to monitor and mitigate human impact on the environment.

Reach for Reading - Grade 6

Unit 2: Survival (FALL)

- Big Question: What does it take to survive?
- Themes: Adaptation and survival

Unit 4: Ecosystems and Conservation (SPRING)

- Big Question: Is diversity valuable?
- Themes: Ecosystems; Endangered Species; Conservation

STEM Scopes: Bundle 3 – Causes and Effects of Regional Climates; Bundle 4 – Effects of Global Warming on Living Systems (human impacts)

Learning Units

Videos

Each Learning Circle has one video that provides context and introduces concepts. Each video is about 5 minutes long. Before sharing each video with students, take the time to view it yourself so you know what to expect. Then, before each video, share a brief introduction of the content with your students, using the summaries provided. Write the journal prompt on the board and remind students to be watching for the answers in the videos. We recommend that you show each video twice: the first time just to familiarize with concepts, and the second time to respond to journal prompts and note vocabulary. Save time after each video to talk about the provided discussion questions. We recommend using videos before their associated activities to introduce concepts to students; however, you may choose to use some of the activities as introductions, and share videos in the middle or at the end of units. This program is designed to be flexible and adaptable to you and your students.

Videos can be found at:
https://www.youtube.com/playlist?list=PLt_R8GzbuH2Ad4O-z8K3XB8X0C6yHpo8m (search YouTube for *Raindrop To Sea Video Series* by Cascade Head Biosphere Reserve)

Student Journals

The purpose of the student journal is to provide a place for students to record thoughts and reflections about the program, and to show evidence for knowledge gained. Prompts for students to respond to will be provided throughout the program, but students should also be encouraged to use their journals to record impromptu thoughts, questions, and sketches along the way. You'll see below that setting up the journal is the first activity listed in the Introductory unit; be sure to do that first so students will have their journals for the rest of the activities. Use the journals at the end of the unit to assess how students may have gained knowledge, changed perspectives, and generated ideas as a result of the program.

Activities

The provided activities are designed to accompany the videos chronologically. Two activities are provided per Learning Circle. However, based on your time availability and student interest, you are encouraged to use these materials in whatever way works best for you. For example, you may choose to do one of the activities before its accompanying video and one after, all activities after, one of the activities later in the unit, etc. Materials needed for each activity are also listed. In addition to the activities listed for each video, there are also a number of Extension Activities provided at the end of this guide - one per Learning Circle.

INTRODUCTORY UNIT

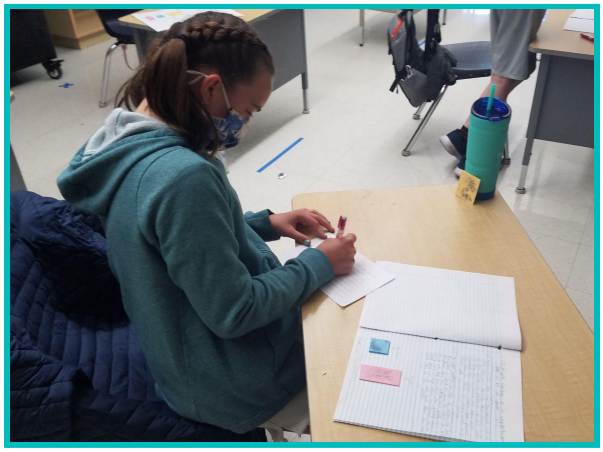
Vocabulary

Watershed - an area of land that channels rainfall and snowmelt through streams and rivers, back to the ocean.

Water Cycle - the continuous cycling of water within the Earth and atmosphere.

Atmosphere - the envelope of gas surrounding the Earth; the air.

Intro Activity A: Creating your "Raindrop To Sea" Journal



Purpose: Students will become familiar with creating a journal for systematically collecting data, recording observations, making notations, doing sketches, and establishing a glossary of terms for their exploration of the UNESCO Cascade Head Biosphere Reserve.

Time needed: 10-15 minutes

Materials needed (for each student): Journal, Pencil, Permanent Marker, Colored Pencils

Instructions: Throughout this video series, students will be taking and recording measurements, logging observations, and making art. As a first step to recording their observations in an orderly manner, they will need to set up their Journals. Guide your students through the following steps to set up their journals:

- Step 1) Create a title page complete with the following: Your Name, Class, Teacher, and Project name - "Raindrop to Sea".
- Step 2) On Page 2, create a Table of Contents. Start a list which will include each of the Learning Circles, 1-8. Each will include the title of that unit's video, and the names of the activities you do. Be sure to leave a couple extra lines of space between each of the eight Learning Circles for any additional notes you may take.
- Step 3) Then on Page 3, start a new section for Activities that you will be completing. For each activity start a new page, and at the top of each section record the Learning Circle number, date, and title of the Activity. In the main body, you will record any notes, observations, and/or place any art you may have made or figures or maps you add. With each activity you will become more familiar with how to best use your journal.
- Step 4) Now turn to the end of the journal, and on the second-to-last page, start a Glossary. In each video you will come across new vocabulary terms - record the words and their definitions in this section.

- Step 5) Ask students: *what do you think of when you hear the phrase "raindrop to sea"?* Provide students a few minutes to create a sketch on their title page depicting their vision of what that phrase means.

Video: Introduction to Cascade Head

Summary: Our two Youth Correspondents (YC's) walk through the Cascade Head Biosphere Reserve dunes. They introduce themselves and the Reserve ecosystems, and introduce key concepts including what a watershed is, how the water cycle works, and what they will be seeing and doing over the course of these videos.

Video journal prompt: What are the different forms of water?

Post-video discussion question: If you were a bird flying over **our** watershed and looking down, what would you see? (NOTE: you may want to conclude this discussion by sharing an aerial photograph of the area around your school. Google Maps and Google Earth are great resources for this.)

Intro Activity B: Mapping Our Way

Purpose: Students will explore their geographic relationship to the Cascade Head Biosphere Reserve, to build their sense of connection with their immediate environment and that of the Cascade Head study site. They will also become familiar with reading maps and using maps to establish locations.

Time needed: 30-40 mins

Materials needed: Raindrop to Sea Watershed Trail Map, maps of the UNESCO Cascade Head Biosphere Reserve and Lincoln County, glue, internet access, tablets/computers for students.

Instructions:

- **ENGAGE:** Tell students that they will be using maps to explore both their surroundings at school and the Cascade Head Biosphere Reserve, and to learn where their school is in relation to Cascade Head.
- **EXPLORE**: After each of the following steps, pause to allow students to share their observations aloud.
    - Step 1) Study the UNESCO Cascade Head Biosphere Reserve Map, the *Raindrop to Sea* Watershed Trail Map with the 8 Learning Circles, and the Lincoln County Map.
    - Step 2) Investigate the UNESCO Cascade Head Biosphere Reserve Map, noting its placement in Oregon and the United States.
    - Step 3) Make note of the color coded legend. Referring to the Legend, note in your journal the total size of the Biosphere Reserve as well as the size of the three areas

within the Biosphere Reserve (Core Protected Area, Area of Managed Use, and Area of Cooperation and Partnership) which make up this unique place in Oregon.

    - Step 4) Review the Watershed Trail Map, noting each of the 8 Learning Circles. This map shows us the path we will be following along with the Youth Correspondents in each video. Can you find each of these Learning Circles on the Cascade Head Biosphere Reserve map?
    - Step 5) Review the Lincoln County Map. Using your knowledge gained from the previous maps, determine where Cascade Head is located, and mark and label this spot. Then, determine where your school is, and mark and label that as well. Using the scale, determine how far away your school is from Cascade Head, and in what direction. Note these in your Journal.
    - Step 6) Glue or staple the three maps into your journal; allow sufficient time for each map to dry.
    - Step 7) On your tablet or computer, go to maps.google.com. In Google Maps, zoom in on the Cascade Head and the surrounding area. In your journal describe some of the features of this area, including the coast, and any rivers, roads, and towns that you can find. Explore with the Satellite view setting as well to see details on the landscape and out to sea.
    - Step 8) In Google Maps, navigate to your school site. Compare and contrast the features you see there with the things you observed at Cascade Head.

- **EXPLAIN**: Discuss with students all of the ways that maps like these can be used to learn about a place. Ask them to share what they learned from these maps; then, brainstorm other ways that maps can be used, such as understanding topography (the rise and fall and shapes of the land), discovering boundaries (natural or human-made), or even environmental qualities like weather, vegetation, etc.
- **EXPAND:** In their journals, students should add any experiences they may have had or stories they may know of from this area. If they are unfamiliar with the area entirely, ask them to write a question that they have or would like to learn about this area.
- **EVALUATE:** Can students describe the geographic features of the Cascade Head Biosphere Reserve and how they are connected?
- **EXTENSION:** Return to these maps regularly throughout this program to reorient students, answer questions, find places, etc.

Intro Activity C: Create a mini water cycle

Purpose: This demonstration uses simple materials to create a living example of the water cycle, so students can observe the ways that water and the sun interact to drive the movement of water around our planet.

Time needed: 15-20 mins

Materials: a large bowl, a pitcher or bucket, a sheet of clear plastic wrap, a large rubber band or string, water, dry ceramic coffee mug or heavy cup, ice cube

Instructions:

- **ENGAGE**: Briefly review the steps of the water cycle with your students (precipitation, evaporation, etc.). Then, tell them we're going to create a model of the water cycle right here at school.
- **EXPLORE:**
    - Step 1) Put the bowl in a sunny place outside. (NOTE: If you don't have sunny weather, you can also do this experiment inside using a heat lamp.)
    - Step 2) Using the pitcher or bucket, pour water into the bowl until it is about ¼ full. Tell students that this bowl full of water represents the ocean.
    - Step 3) Place the mug in the center of the bowl. Be careful not to splash any water into it. Tell students that this mug represents a lake.
    - Step 4) Cover the top of the bowl tightly with the plastic wrap. Place an ice cube on top. The plastic wrap will represent the atmosphere and the ice cube represents cold, gathered molecules - clouds!
    - Step 5) Put the rubber band or string around the top of the bowl to hold the plastic wrap in place.
    - Watch the bowl for 3-5 minutes to see what happens. (The length of time this takes will depend on the brightness of the sun/heat lamp on the bowl.)
- **EXPLAIN:**
    - The condensation that forms on the inside of the plastic wrap will slowly become larger drops of water that will begin to drip. (You can speed up the dripping by carefully moving the bowl – don't splash! – into the shade.) Explain to students that the droplets on the plastic wrap represent the water that precipitates from the clouds as rain.
    - Carefully peel back the plastic. Is the coffee mug still empty? Water from the "ocean" of water in the bowl evaporated. It condensed to form misty "clouds" on the plastic wrap. When the clouds became saturated it "rained" into the mug (lake), representing precipitation.
- **EXPAND:** Ask students to record, in their Journals, a sketch of this experiment. Instruct them to include all of the main elements (bowl, water, mug, plastic, sun) and to use arrows and notations to show what happened and what steps of the water cycle it represented.
- **EVALUATE**: Can students name the parts of the water cycle and describe where they occur and how they connect to each other?

LEARNING CIRCLE 1

Vocabulary

Evaporation - the process of turning from liquid into vapor.

Condensation - the conversion of a vapor or gas to a liquid.

Precipitation - rain, snow, sleet, or hail that falls to the ground.

Infiltration - permeation of a liquid into something by filtration.

Percolation - the movement of water through the soil.

Transpiration - the process of water movement through a plant and its evaporation through its leaves, stems and flowers.

Video: The High Meadow

Summary: After climbing to the top of the watershed, the YC's share more information about how humans relate to watersheds and the details of the water cycle. They discuss how water travels through Cascade Head, and the role of plants in this process.

Video journal prompt: Name the parts of the water cycle that involve the ground.

Post-video discussion question: How can a desert be part of a watershed?

LC1 Activity A: Watershed Model

Purpose: This activity, which can be done as a group or as a teacher demonstration, involves building a simple model of a landscape to see how water droplets flow and how the shape of the land helps collect water. By adding materials such as food coloring or beads to their landscapes, students will observe how water carries pollutants through the land and sea.

Time needed: 45-50 mins

Materials (per pair of students): 1 tray (lid of a plastic storage container, or alternatively lunch tray, etc),1 sheet of clear or light-colored plastic (e.g., shower curtain, or cut-open shopping bag), 2 spray bottles, 2 small squeeze bottles of food coloring, 1 squeeze bottle of cooking oil, dried spices, towels for cleaning up spills, 4-6 various sized containers (e.g., 12-oz. cups or soda bottles, coffee can, soup or soda can, paper cup, yogurt container, etc.) cake sprinkles, pieces of confetti/beads or other small objects.

Instructions: Be sure to save these models - you will use them again later!

- **ENGAGE**: Ask students to describe, in their own words, what they think a watershed is. Then tell them that they are going to create their own models of a watershed to help understand how it works.
- **EXPLORE**:
    - Step 1) Hand out the materials listed, **except for** the cooking oil, food coloring, spices, cake sprinkles and spray bottles.
    - Step 2) Have students build their own watershed using the tray to build on, and the containers to represent mountains and hills; the flat areas are the valleys, lakes, and rivers in between. Be sure they include a "land" section and flat "ocean" section adjoining the land.
    - Step 3) Instruct students to lay the plastic sheet over their landscape, gently pressing it down between the "mountains" to create low spaces in the "valleys" and "rivers".
    - Step 4) Ask students to make predictions about where rainwater would collect and flow in their watershed. Have them note their predictions in their journals, and share them aloud.
    - Step 5) Hand out spray bottles, and tell kids to take turns being "clouds" and observers. Use the spray bottles to make it "rain" on their watersheds.
    - Step 6) Circulate as students spray, asking each group to explain what the water is doing and show you the lakes and rivers in their model.
    - Step 7) Next, students will experiment with how pollutants might travel through their watersheds. Ask them to brainstorm what kinds of pollutants we might find in the environment, and write these on the board. Then show them the bottles of cooking oil, food coloring, glitter, and other materials, and explain how these will represent pollutants in the environment such as motor oil, chemicals, plastics, etc. Be sure students understand they should place the materials all over their models.
    - Step 8) Distribute the bottles of oil (1 per group). Tell students to SLOWLY AND CAREFULLY squeeze a few drops of oil on different areas of the watershed, including the mountains and valleys; this represents motor oil that can leak out of cars.

    - Step 9) Distribute the bottles of food coloring (1 per group). Tell students to again SLOWLY AND CAREFULLY squeeze a few drops of food coloring on different areas of the landscape, including the mountains and valleys; this represents toxic chemicals that could escape from factories, houses, etc.
    - Step 10) Distribute the "pollutant" materials (plastic wrappers, bottle caps, soda bottles, etc.) Have students again sprinkle these across their watershed.
    - Step 11) Tell students that now they will again make it rain to observe how these pollutants travel in

their watershed. Have students use the spray bottles to liberally "rain" across their watershed.

- **EXPLAIN:** Ask students to share where and how the pollutants traveled in their landscape. They should conclude that both the water and the pollutants tend to flow from the highest to the lowest points on the watershed, and collect in the valleys, lakes and rivers, eventually making their way to the ocean.
- **EXPAND:** Ask students to sketch a representation of their watershed model in their journals, including the mountains, valleys, and sea, and use arrows to show how and where the water and pollutants traveled. Then, in their journals, ask them to write a response to the question: *What do you think this activity has to do with the water you drink?* If time allows, discuss these responses: The water you drink comes from a watershed - this is why it is important that we try not to pollute either the water or the land. Anything that pollutes the land will eventually wind up in the water!
- **EVALUATE:** Can students explain what a watershed is, including the various parts such as land, water, rainfall, and pollutants?
- **EXTENSION:** If you have the space to keep these models in your classroom throughout this unit, you can return to them during subsequent activities! Use the models again to demonstrate estuary water quality, how beaver dams impact flow, etc.

ALTERNATIVE METHOD! This may be a good option for larger classes, or with students who may need a less complex activity:

- Follow the above procedures with only one watershed model at the front of the class, using it as a demo for students, with the teacher applying the rain and pollutants (or enlisting student volunteers).
- Distribute one piece of paper per student. This can be either a standard size sheet, or you may choose to use poster paper and do this activity outside.
- Instruct students to crumple up their paper into a ball, then stretch it out again almost fully. This represents an area of land, or watershed. The ridges and creases that form represent mountains and valleys.
- Distribute blue water-soluble markers and allow students to trace the creases, representing rivers, streams and creeks. (If doing this outside with large poster paper, you can also allow students to add rocks, sticks, etc to represent various landforms.)
- Distribute spray bottles. Tell students to make it rain on their models and watch what happens - the blue ink will spread, showing the way that the water moves through the watershed..
- Next, distribute red markers. This color represents pollutants such as oil, chemicals, plastic, etc. Ask students to draw dots or x's on their model in places where they might find pollutants.
- Repeat the experiment with the spray bottles, watching where and how the pollutants spread.
- Note that in many cases, the blue and red ink combined (making purple). This is because pollutants often get washed into rivers and streams by the rain.

LC1 Activity B: Counting Raindrops

Purpose: Students will make their own rain gauges to collect and record daily rainfall, gaining a sense of the patterns in weather and the water cycle where they live.

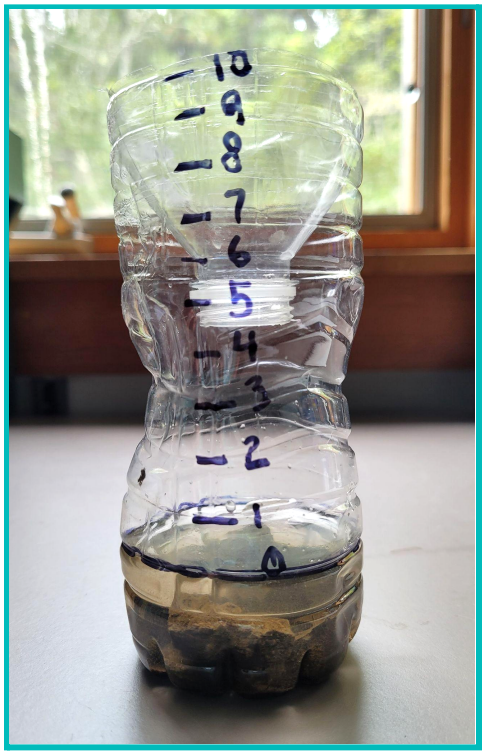
Time needed: 15-20 mins during first class period, 10-15 mins during second class period one week later, plus 5 mins each day at home for 7 days in between.

Materials (one per student): ruler in centimeters, permanent marker, journal, clear plastic bottle, scissors, small pebbles and/or gravel, pitcher or cups of water.

Prior preparation: Make your own rain gauge using the instructions below. This can be used as an example while students build theirs. After, it should be placed on the school grounds to add to the group data, and to provide data to students who may not be able to place a rain gauge where they live.

Instructions:

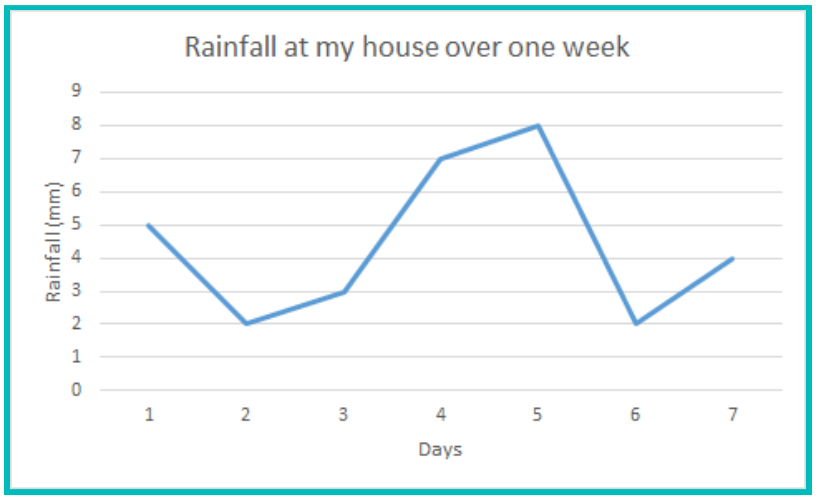
- **ENGAGE:** Tell students they will be creating your own rain gauge to determine the daily rainfall in your area. They'll be recording their data every day for one week (7 days).
- **EXPLORE:**
    - Step 1) Safely cut the top 1/4 of the bottle off. Save it for later as you will use this as a funnel.
    - Step 2) Using a permanent marker draw a line around the outside of the bottle approximately 3 centimeters from the bottom. This will be your "Zero Point". For accuracy in rain collecting, be sure this line is above any uneven portions on the bottom of the bottle and the height of the pebbles you will add later to weigh down the bottle.
    - Step 3) Using your ruler, measure and mark off the bottle every centimeter above your zero point. Label each tick mark sequentially 1 cm, 2 cm, 3 cm, and so forth to 10 cm depending on the size of your bottle. Also mark your "Zero Point" as 0 cm or 0 mm.
    - Step 4) Use a handful of small pebbles or gravel to weigh down your rain gauge. Place the rocks in the bottle. Ensure all the rocks are below the zero point.
    - Step 6) Carefully fill the bottle with water from the pitcher or cup to the "Zero Point". Any rain collected will be measured from above this line.
    - Step 6) Turn the top of the bottle upside down, and insert it into the open top of the bottle so it forms a funnel. The funnel should squeeze down



into the bottle slightly. Use glue to secure this if needed.

- Step 7) Tell students to find an open area in a yard or on a deck where they can place their rain gauges and collect their data. Be sure the area is free from interference from trees or overhanging buildings, and ideally in a protected area out of the wind so it doesn't get knocked over. If possible and practical, students may want to dig a shallow hole in the ground and place the gauge in there to keep it from falling over.
- Step 8) Instruct each student to create a chart in their journal to record the daily rainfall. Include columns for the date, time, and daily accumulation in millimeters. Total accumulation will be tallied at the bottom.
- Step 9) Tell students that they will record accumulated rainfall in their rain gauge each day for 7 days as homework. About 24 hours after they placed the rain gauge, they should record their first data set, then about 24 hours each day after. Tell them to use their ruler to be as accurate as possible to the nearest millimeter and record it in their journal along with the date and time. (You may want to provide an example on the board.)
- Step 10) For each data collection after the first one, students should pour out any accumulated rainfall to bring the water level back down to the Zero Point. That way, new rainfall can be accurately measured each day. Repeat for seven days.
- Step 11) Find somewhere safe on the school grounds to place the group rain gauge that you created. Record daily rainfall from this gauge every day for 7 days just as the students do, and share this data with the class.

- **EXPLAIN:** At the end of the week of data collection, students should add up each amount of rainfall and write the total accumulated rainfall at the bottom of their chart. Tell them that this represents a short glimpse of overall weather patterns at their home.
- **EXPAND:**
  - Instruct students how to create a line chart of their data, with rainfall amounts on the y axis and Day 1, 2, 3, etc. on the x axis. Have them draw their charts in their journals.



  - Ask students to share aloud their observations and the general pattern of their data. Use questions such as the following to spark discussion: *What day was the wettest? What day was the driest? Was it overall a fairly rainy or dry week? Based on this week's pattern, what would you expect the weather to look like next week?*

- **EVALUATE:** Can students describe how they collected their data, what it showed, and how scientists could learn even more about a region's weather?
- **EXTENSION:** Have students write in their journal any issues they had with the rain gauge that may have impacted the data, and make recommendations for improvement of the gauge or the process.

LEARNING CIRCLE 2

Vocabulary

Gravity - the force that pulls all objects downward toward the center of the planet.

Path of Least Resistance - the easiest way to go in response to gravity.

Evergreen - plants that have needles or leaves that usually stay green year round. (also known as *coniferous*)

Deciduous – plants that drop their leaves at the end of the growing season and sprout new leaves in the spring.

Video: The Spring

Summary: The YC's share why water moves a certain way through the watershed, and how water interacts with the ground and plants as it moves downhill. They also point out different types of trees and discuss their roles in the ecosystem and in the water cycle.

Video journal prompt: How does gravity affect watersheds?

Post-video discussion question: How do you think this watershed would be different without trees?

LC2 Activity A: Bottle Ecosystems

Purpose: This activity demonstrates the relationship between precipitation and soil loss, allowing students to observe water erosion in action and guiding them to understand the need to protect waterways and vegetation.

Time needed: 20-30 mins to prepare bottles; 1-2 days to see results

Materials: Three large identical plastic bottles, such as 1 liter soda bottles; small gardening trowel; string; hole puncher; three clear plastic cups, strong scissors, adhesive glue, pan or bucket; large

measuring cup; flat surface to glue experiment onto, such as a large piece of cardboard or plywood.

Prior preparation: Make sure bottles are emptied and cleaned. Lay each bottle down on its side. Cut the top half of the bottle off, horizontally. Attach them to a flat surface using glue with the top ends protruding a few inches off. Then, punch two holes in the sides of each plastic cup towards the top. Attach these with string to the tops of each bottle so they are hanging below the opening. Visit https://www.lifeisagarden.co.za/soil-erosion-experiment/ for some excellent pictures and further explanation of this process.

Instructions:

- **ENGAGE:** Explain how these bottles are going to represent different parts of a watershed. We are going to place different types of soil into each bottle, add water representing rainfall, and then see which type of soil holds the most water.
- **EXPLORE:**
    - Step 1) Go out to the schoolyard and use your trowel to collect three samples, each of a size and shape that will fit in the bottles: 1. A patch of grass, including the grass, soil, and roots; 2. A patch of soil containing dead plant matter such as twigs and leaves; 3. A patch of dirt without any plant matter, such as clay.
    - Step 2) Back in the classroom, place each of the three samples into the bottles, packing them tightly into the bottle. Tell students: these represent a place with lots of living vegetation; a place with some vegetation; and a place with no plant life.
    - Step 3) Fill the measuring cup with water and pour into the first bottle over the vegetation/dirt - just enough so that it begins to run out of the dirt. Repeat with the same amount of water for the other two bottles. This represents rainfall.

    - Step 4) Now we wait! Tell students our mini ecosystems need some time to absorb the rain and we'll check back tomorrow.

- **EXPLAIN:** The next day, observe the plastic cups that have collected water runoff from each bottle. You should find that the bottle with the grass has lost the least water, while the bottle with no vegetation has lost the most. Explain the concept of *runoff* and ask students why they think this has occurred? The roots of the grass work to hold in more water, and the dead vegetation does the same to the lesser extent. The dirt with no plant life cannot hold much water and so it runs off, causing a lot more *erosion.*
- **EXPAND:** Ask students what they think would have happened if they'd had a bottle with just sand in it. Would it have washed away more or less quickly than the other bottles? Remind them that this is what happens on sandy beaches all day every day: sand is constantly being moved back and forth by the ocean waves.

- **EVALUATE:** Can students describe this experiment, the results, and what it taught them about the relationship between vegetation and erosion?

LC2 Activity B: Art Illuminating Science

Purpose: Students will create prints of plant samples in their journals to practice an artistic technique and to learn about the characteristics of both deciduous and coniferous plants.

Time needed: 15-20 mins

Materials: Ink pad, Journals, 2 small plastic baggies per student, glue, magnifying loupes or hand lenses, small plant samples from two types of plants selected from your local area (one deciduous, one evergreen - see *Prior Preparation* below), scrap paper.

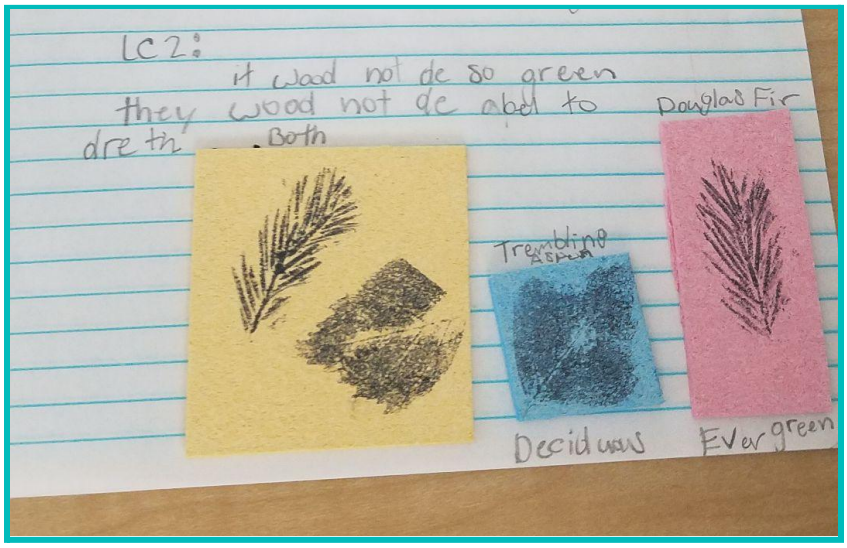
Prior preparation: Find a deciduous tree and collect enough leaves to have two leaves per student in your class. Do the same with a coniferous (evergreen) tree. Make sure all leaves are clean and dry. You should be able to find each of these types of trees in your neighborhood or even your own backyard. Use the iNaturalist app to identify what types of trees you used. Alternatively, take your students on a short field trip out to the school yard and have them collect their own leaves! In this case, be sure that students collect both their deciduous leaves from the same tree, and the same for their coniferous samples. This ensures each of the two sample types will be from the same species.

Instructions:

- **ENGAGE:** Tell students that there are many ways scientists record and learn about plants and animals, including something known as "prints" - copying the shape and texture of a plant or animal onto paper using ink. This can be done with leaves, flowers, insects, fish - all kinds of things! Next, review the basic characteristics of deciduous vs. coniferous (evergreen) plants as described in the video: deciduous trees lose their leaves in the winter and regrow them in the Spring, while conifers keep most of their needles year-round. Deciduous plants tend to have larger, broader leaves, while evergreens often have short, narrow, spiky needles.
- **EXPLORE:** Guide students through the following steps to create nature prints in their journals.
    - Step 1) Select a part of the deciduous plant that is slightly smaller than the ink pad.
    - Step 2) Lay one of the leaves from your deciduous plant on the ink pad.
    - Step 3) With your hand inside a plastic baggie, press your fingers firmly on the plant so the bottom of the plant gets well inked.
    - Step 4) Lift the plant off of the ink pad, grasping the stem of the plant with your fingers still inside of the plastic baggie.
    - Step 5) Quickly and carefully, lay the plant - ink sided down - onto a blank page of your journal.

- Step 6) Take a clean scrap of paper and place it over the plant and firmly press the plant down against the paper.
- Step 7) After a moment, carefully lift the scrap paper and plant off of the page. If desired, use the extra pieces of paper to practice your nature printing skills, choosing your best print for your Journal.
- Step 8) Dispose of the used scrap paper and the inked leaf, using the baggie.
- Step 9) After the ink has dried sufficiently, glue your print into your Journal.
- Step 10) Repeat steps 1-9 above with one of the coniferous plant leaves.
- Step 11) Using your loupe or hand lens, carefully examine both of your tree samples (the non-inked samples). What do you notice? What is strange or surprising?
- Step 12) Choose one particularly interesting area for each plant sample, and sketch what you see in your Journal next to each print. Use arrows to indicate which part of each plant your sketches were drawn from. Mark these sketches with "5X" to indicate the magnification used.

- **EXPLAIN:** Tell students what types of trees or plants these leaves were from, and have them label their prints with both the common and scientific names of each plant. Ask them to share aloud their observations about how the two types of leaves are different.
- **EXPAND:** Show students pictures of these trees. Discuss ways they could identify these trees out in nature.
- **EVALUATE**: Can students explain the differences between deciduous and coniferous plants, and explain why they're both important in an ecosystem?



LEARNING CIRCLE 3

Vocabulary

Ecosystem - A geographic area where plants, animals and other organisms, as well as weather and landscape, work together to form a web of life containing biotic (living) parts and abiotic (nonliving) parts.

Video: Lost Lake

Summary: The YC's dive deeper into what an ecosystem is and how all of its living and nonliving parts interact, including humans. They discuss how features such as lakes and streams are formed. The role of beavers in changing the landscape is also shown.

Video journal prompt: What forces created Lost Lake?

Post-video discussion question: Why do the hosts describe an ecosystem as a "web"?

LC 3 Activity A: Nature's Engineer vs Human Engineers

Purpose: Students will research and describe the impacts beavers have on the environment, exploring how living and nonliving elements of an ecosystem interact and affect each other. They will then compare this to the impacts that humans have on rivers.

Time needed: 35-45 mins

Materials: Journals, pencils, tablets/computers and access to the internet OR printed articles

Prior preparation (optional): If you'd prefer students read copies of the research materials rather than use computers, print a copy of the below linked pages for each student. If using physical copies, students can paste or staple these into their journals at the end of the activity.

Instructions:

- **ENGAGE**: Ask students to think about how one could stop the flow of water if they needed to. The answer is dams! Referencing the video from this unit, remind students that both beavers and humans make different kinds of dams to serve their own purposes. Tell students they'll now be using internet resources to learn about the impacts of both beaver and human dams.
- **EXPLORE:**
    - Step 1) Ask students to access this article about beavers and their dams online OR have them read the printed copies: https://animals.howstuffworks.com/mammals/beaver-dam.htm
    - Step 2) Ask students to list the pros and cons of a beaver dam in their journal. Encourage them to think about other pros and cons that may not have been shared in the article. Then, have them share and discuss these as a group. Pros may include the creation of wetlands which clean water and create biodiversity, while cons may include flooding and impacts on agriculture.
    - Step 3) Ask students to access this article about human dam impacts online OR have them read their printed copy: https://blog.arcadia.com/pros-cons-dams/
    - Step 4) Ask students to list the pros and cons of a human dam in their journal. Encourage them to think about other pros and cons that may not have been shared

in the article. Then, share and discuss these as a group. Pros may include the creation of clean electricity and recreation areas, while cons may include the disruption of salmon runs and poor water quality.

    - Step 5) Ask students to pair up in groups of two. Then, instruct them to work together, referencing the articles and their notes, to discuss the following question: *Which has a greater negative impact on the environment: a beaver dam or human dam?*

- **EXPLAIN:** As a class, ask students to share results from their discussions. Encourage them to cite facts from the articles to defend their statements. At the end of your discussion, synthesize their findings: what are some pros and cons of both beaver and human dams?
- **EXPAND:** Share with students how people are using artificial beaver dams to help restore rivers, using the info and story map from the USDA: https://www.climatehubs.usda.gov/hubs/northwest/topic/incised-stream-restoration-western-us. (Click the "Going with the flow" link to enlarge the story map.) Highlight the Oregon case studies.
- **EVALUATE:** Can students explain how beaver dams and human dams are both alike and different, and the impacts (both positive and negative) of each one?
- **EXTENSION:** The "Hooks and Ladders" activity from Project Wild is a great way to demonstrate the impacts of dams on salmon. You may also wish to return to the watershed models from LC1 Activity A and have students build dams in their model to observe the ways it changes water flow.

LC3 Activity B: River Boxes

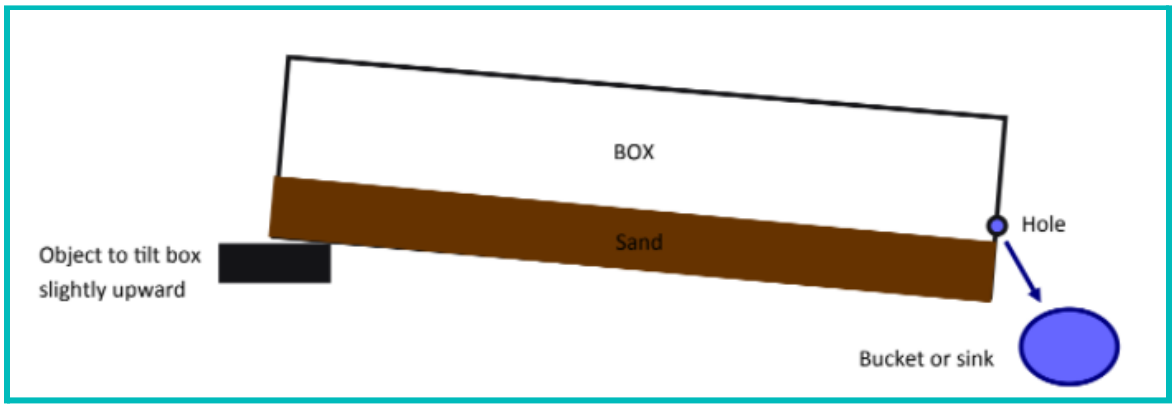
Purpose: Students build models of several different rivers including natural and man-made features, and use these to investigate flow physics and stream dynamics.

Time needed: 45-50 mins

Materials: Plastic or aluminum rectangular box/tray; a book to prop up box; sand, pebbles, small rocks; pitchers with water; bucket; plastic boats, Lego pieces, popsicle sticks, broccoli, etc. to represent boats and branches

Prior preparation: Use plastic or aluminum rectangular, waterproof boxes. The larger the size, the better this activity will work. It does not need to have a top. It should have enough depth to allow room for sand and rocks and for water flow. Punch or cut a hole into one of the short sides of each box. This will be the "downstream" side of the river. The hole should be approximately 2 inches from the bottom of the box, or just above the desired level of sand. It should be about a quarter-inch in size. Place the "downstream" side of the box over a sink, or on the edge of a table above a bucket. This is where the water will drain into, so if you are using a bucket make sure it is large enough. You may need to have students dump it out if it fills during the activity. Fill the bottom of the box with approximately 1.5 inches of sand or small gravel, at least half an inch below the bottom edge of the hole. Be aware that some sand may wash out of the box. Elevate

the “upstream” side of the box (opposite the hole) slightly with a binder, book, or other flat stable object. A couple of inches of elevation should be enough for good water flow.



Instructions: (NOTE: If you are unable to let students work in small groups due to pandemic restrictions, you may do this as a demo.)

- **ENGAGE:** Explain that each group is going to create their own mini-rivers and try to determine how both natural and human-made features impact water flow.
- **EXPLORE:**
  - Step 1) Distribute materials and allow student groups to build their model of a river however they want to start. There is no right or wrong way—the variety of their river models will help to illustrate concepts later. Examples: Add some larger pebbles to represent rocks or boulders. Add rocks and pebbles. Add items such as plastic boats, game pieces, and small sticks if desired. These can represent logs, bridges, dams, etc. Add pieces of broccoli to represent fallen trees. Students can make small floating boats out of Legos.
  - Step 2) Once initial rivers are complete, have students SLOWLY pour a SMALL amount (100-200 ml) of water starting at the furthest point “upstream” (opposite the hole in the box). What happens to the rocks or obstacles they put in their model? How does the water move around these objects? Encourage sharing aloud of observations.
  - Step 3) Tell students their next challenge is to build a river that will flow quickly. The goal is to design a model that allows water to flow as fast as possible. Allow time for students to build, then again pour water down the river. Was the flow as fast as they expected? Why or why not?
  - Step 4) Next, instruct students to build a river that flows very slowly. Repeat the experiment and discuss the results.
  - Step 5) After these experiments, help students identify patterns in their results. Note that straight, clean rivers will flow more quickly than meandering rivers or rivers with many turns or obstacles. Why is this? Have students brainstorm answers. The answer lies in friction: water running against lots of rocks, sand, or curves in the landscape creates a lot of *friction*, which slows down the flow. *Friction* is the resistance that one surface or object encounters when moving against another.

- Step 6) Ask students: Which type of river will be more likely to experience flooding? Ask students to slowly pour about twice as much water as they used before on their model to see what happens. (Answer: meandering, winding rivers will likely accumulate and hold more water rather than quickly routing it downstream.)
- Step 7) Now we will explore another thing that changes the way many rivers operate: dams. First, have students build a river with a few meanders, without too many sharp curves or straight paths—this is representative of most average rivers. Then, give students time to experiment with changing river behavior when they build dams of different types - encourage them to try both tall and short ones, dams made out of softer materials like sticks and harder materials like rocks. Encourage students to record procedures and results in their journals as they go.

- Step 8) Ask and discuss: What happens to the water speed and sediment transportation each time?

- **EXPLAIN:** Discuss how the dams that they built might represent different types of either natural or artificial dams. Which ones were more like beaver dams and which were more like human dams? Which type seemed to more greatly impact the river?
- **EXPAND:** Conclude the activity by asking students to draw both a straight river and a meandering river in their journals, using arrows or other symbols to indicate the speed of water flow for each type.
- **EVALUATE:** Can students look at pictures of different shapes and types of rivers and explain how the water and sediment might move in each one?

LEARNING CIRCLE 4

Vocabulary

Constructive Force - builds up features on the surface of Earth.

Destructive Force - destroys and breaks down features on the surface of Earth.

Weathering - exposure to rain, wind, snow, and ice.

Erosion - the flow of water under the force of gravity.

Earthquakes - break the surface of the Earth.

Adaptation – a characteristic that helps a species survive and reproduce.

Video: The Gorge

Summary: At this dramatic backdrop, the YC's tell us more about how geologic land features are formed and how they are shaped over time by constructive and destructive forces. They also talk about the power of water in shaping the land, and describe what an adaptation is.

Video journal prompt: What is one example of weathering?

Post-video discussion question: How would a powerful water force such as a flood reshape this land we're on now?

LC 4 Activity A: Sand Displacement/Erosion

Purpose: Students will observe how the force of water can displace sand and shape the land, as the Gorge was shaped in the Cascade Head Biosphere Reserve.

Time needed: 20-30 mins

Materials: Two 6-inch plates, approximately 2 cups of wet sand, liquid measuring device (e.g. Beaker / Measuring cup), tape measure, Journal, pencils, space outside (optional)

Instructions: This activity can be done indoors, but due to the potential of messiness, it may be better to do outside.

- **ENGAGE:** After gathering students either in the classroom or outside, tell them that they're going to model how different forces of water move sand. The water will represent rivers, and the sand will represent land, dirt, rocks, etc. Ask them to create a chart in their journals with the following columns: *250ml added water* and *500ml added water*; and the following rows: *Start, End,* and *How much sand lost?*
- **EXPLORE:**
    - Step 1) Place on two 6-inch plates equal amounts (1 cup = 236 ml) of wetted, fully saturated sand, arranged in a mound or pile in the middle of each plate. In the *Start* row in your charts, record this amount (236ml) in both columns to indicate how much sand we started out with.
    - Step 2) Over the first plate, carefully pour 250 ml of water onto the wet sand from a height of four feet. Do this slowly.
    - Step 3) Over the second plate, carefully pour 500 ml of water onto the wet sand from the same height.
    - Step 4) Carefully remove the sand that remains on the first plate after pouring the water over it. Pour the sand into your 1L beaker. Use your best judgement to read

the volume of sand in the beaker in milliliters (ml), and record that quantity in the chart in your Journal (in the *End* row and the *250ml added water* column). Empty the beaker, and then repeat this process for the other plate.

- Step 5) Calculate how much sand was lost from each of the original sand piles. Add this data to your charts in the *How much sand lost?* row.

- **EXPLAIN:** Discuss: Why was more sand washed away by 500ml of water versus 250? The greater the volume of water, the greater its impact. This is also true in nature; the deepest canyons have been carved by big, powerful rivers over thousands of years, much like the gorge in Cascade Head. Smaller rivers and streams will also carve the land, but much more slowly and less dramatically.
- **EXPAND:** Display some aerial photos of different rivers and discuss with students what types of water forces they think may have formed each waterway.
- **EVALUATE:** Can students explain how water erosion shapes the land?

LC 4 Activity B: A World Without Water

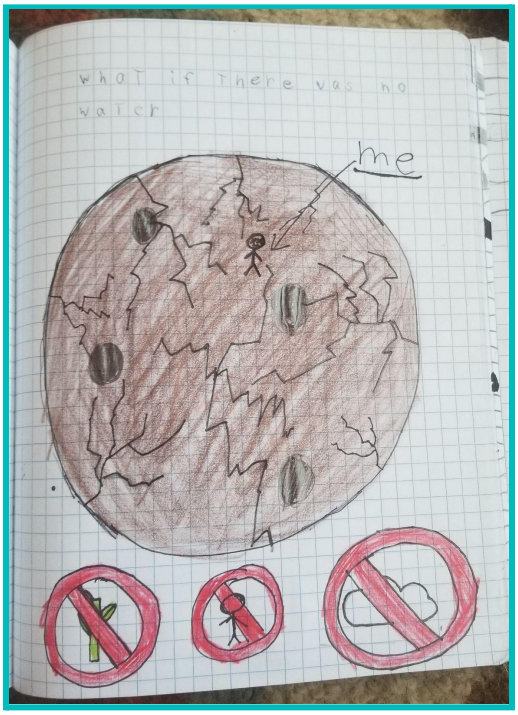
Purpose: Invite students to imagine what the earth might be like without water, identifying all of the ways that water affects their lives, other organisms, and the appearance of our planet.

Time needed: 30-40 mins

Materials: large sheets of paper (1 per student), colored pencils, teacher's computer and projector (optional)

Instructions: (NOTE: this could also be assigned as a longer-term project, either in groups or individually. Students could create their depictions with any materials or media they choose.)

- **ENGAGE:** Write the following on the board: *Imagine a world in which there was no water. What would our planet look like?* Ask students to read this and think about it independently and quietly for a few minutes. Ask them to record their thoughts in their journals. Then, divide them into groups of 3-4 students each.
- **EXPLORE:**
  - Step 1) Tell students they are going to work together to create a depiction of what the world would be like without water. Emphasize that this isn't about artistic capability; they can depict their thoughts any way they wish! They may choose to draw pictures, create a word map, write a poem or story together, etc.
  - Step 2) Distribute paper and markers and give students plenty of time to make their creations - about 15-20 mins or more.
  - Step 3) After all of the groups feel done, have students do a "gallery walk" to view everyone else's work: each group should leave their work on the table, then everyone should stand up and walk around to view everyone's products.
- **EXPLAIN:** After students are seated again, discuss all of the ways that the earth would be different without water. Are there any examples in nature of a planet without water? Yes -



Mars! Share pictures and footage from the *Perseverance* Mars expedition, at: https://mars.nasa.gov/mars2020/. Mars is a great example of a place with no water and thus, no life (that we know of) and no water-driven erosion.

- **EXPAND:** Ask students to brainstorm all of the ways they use water every day. Some obvious ones may be drinking, brushing teeth, showering, etc. Remind them of some less obvious, but equally important uses of water including watering the plants and animals we eat, creating electricity, making materials like clothes and plastics, etc. This EPA website has a useful list: https://www.epa.gov/watersense/how-we-use-water
- **EVALUATE:** Can students point out all of the things around them that use water (including people!), explain how it uses water, and describe what the world might look like without it?

LEARNING CIRCLE 5

Vocabulary

Estuary —where freshwater and saltwater mix.

Brackish - a mixture of fresh water draining from the land and salty seawater.

Anadromous – aquatic species born in freshwater that spend most of their lives in saltwater, then return to freshwater to spawn.

Fertile - rich in the nutrients necessary to support life.

Sinuous – having many curves, bends, or turns.

Video: The Estuary

Summary: Continuing their journey through the watershed, the YC's describe what makes an estuary ecosystem and how species are specially adapted to thrive there. They introduce some of the incredible adaptations of salmon and how we as humans can act as stewards to help protect them. The role of estuaries in combating climate change is also discussed.

Video journal prompt: Name a place where you might find brackish water.

Post-video discussion question: Why do estuaries make such great nurseries for juvenile organisms?

LC5 Activity A: Engineer A Fish

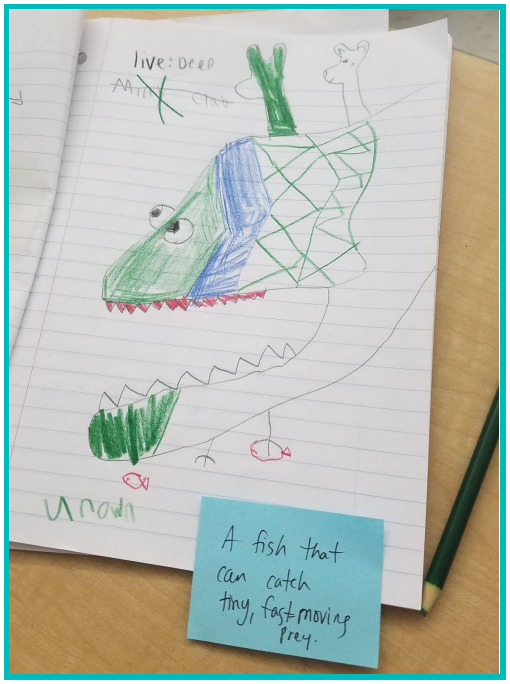
Purpose: Students will become "inventors" to create their own imaginary species of fish, and learn how different species have different adaptations to suit their environments.

Time needed: 20-30 mins

Materials (per group of students, with 4 groups total): large sheet of poster paper, colored pencils, markers

Instructions:

- **ENGAGE:** Walk through the following webpage with students to review the meaning of *adaptation* and provide some examples of fish adaptations: https://www.floridamuseum.ufl.edu/discover-fish/fish/adaptions/. Then, tell them that they are going to design their own fish species, based on a particular environmental need. Remind them that these fish are imaginary, so students can be as creative and crazy as they want! The only requirement is that it has adaptations to match the given environmental need.
- **EXPLORE:** Break students into four groups. Provide each group with one of the following environmental conditions written on a post-it or piece of paper, then give them time to work together to draw their fish:
    - *A fish that can catch tiny, fast-moving prey*
    - *A fish that can hide in the sand*
    - *A fish that can avoid getting eaten by predators*
    - *A fish that can get the attention of a potential mate*



- **EXPLAIN:** Ask each group to present their invented fish. Ask them to point out all of its unique features, and explain how they survive in their environment.
- **EXPAND:** Ask students to name some other environmental conditions a fish might have to adapt to in order to survive. Examples could include: not getting washed away in the waves, hiding in plain sight when there isn't any sand or rocks around, catching large prey or tiny prey, etc.
- **EVALUATE:** Can students explain what an adaptation is and name some examples?

LC5 Activity B: Estuaries as filters

Purpose: Classroom activity or demonstration of watershed model and the effects of having or not having an estuary on the amount of pollution that enters the ocean.

Time needed: 15-20 mins

Materials: watershed models from LC1 Activity A; "pollutants" from LC1 Activity 1 (food dye, oil, spices, etc); spray bottles full of water; scissors; sponges

Instructions:

- **ENGAGE:** Remind students of what they did during LC1 Activity A, where they built watershed models and then explored how pollution traveled through them. Ask: *can you think of anything that could prevent pollutants from getting to the ocean?* One answer is estuaries: nature's filters!
- **EXPLORE:** Tell students they are going to use sponges to represent estuaries in their models.
    - Distribute sponges and scissors and ask each group to cut up the sponges so that they form a solid blockade between the land and the ocean. Make sure the sponge goes tightly all the way to both sides.
    - Distribute "pollutant" materials from LC1 Activity A. Allow a minute or or two for students to arrange these pollutants on the land part of their watershed models ONLY.
    - Distribute spray bottles. Ask students to make it rain on their watershed until the pollutants begin to run down toward the sea.
- **EXPLAIN:** Ask students to explain what happened. Did the pollutants make it into the ocean? Were these results different from the first time we did this exercise without sponges during LC1? Students should observe that this time, the "estuary" sponges prevented most of the pollutants from traveling into the sea. Explain that this is how the vegetation in real estuaries work: they collect many pollutants before they can get to the ocean, acting as natural filters that help improve water quality.
- **EXPAND:** Together or in groups with tablets, explore the following interactive animation from NOAA showing how estuaries filter water: https://coast.noaa.gov/elearning/estuaries/ Note that while estuaries can filter many pollutants, some still escape into the ocean and surrounding watershed, and too many can harm estuary plants and animals. So it's still very important to limit pollutants at the source: on land.
- **EVALUATE:** Can students describe how estuaries work as natural filters and why this is important?

LEARNING CIRCLE 6

Vocabulary

CO_2 – Carbon Dioxide

O_2 - Oxygen

Sedimentary Deposition - The geological process in which sediments, soil and rocks are added to a landform or landmass.

Video: Salmon River

Summary: The YC's provide more detail about how climate change occurs and how it affects ecosystems. They share some fascinating facts about the Salmon River, its range, and how the coastline has changed over time. They also talk about how the river changes every day and across seasons due to tides.

Video journal prompt: Write down some ways that the coastline looked different during the last Ice Age.

Post-video discussion question: What are some causes of excess CO2 that lead to global warming/climate change?

LC 6 Activity A: The Sun, the Moon, and the Tides

Purpose: students play a game using themselves and their bodies to represent how tides work.

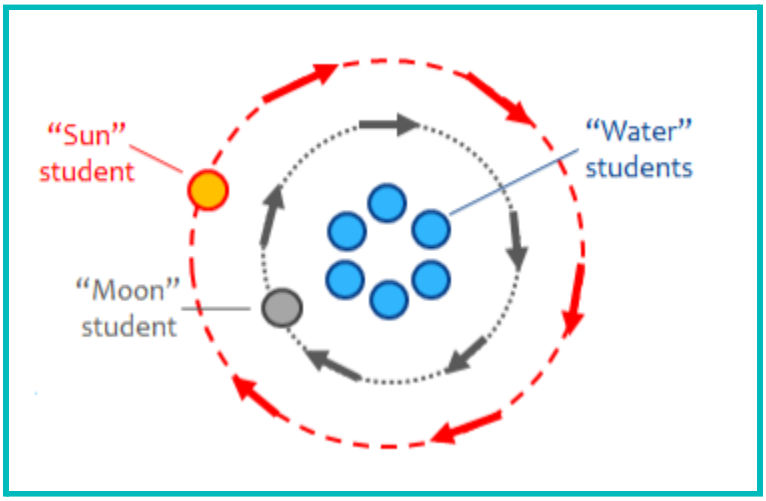
Time needed: 15-20 mins

Materials: animation video at https://www.youtube.com/watch?v=5ohDG7RqQ9I to use as intro (optional), clear space outside or in classroom for students to spread out

Instructions:

- **ENGAGE:** Ask: what is gravity? Revisit this definition. Then, explain that though the Moon is small, it is large enough and close enough to Earth to have a strong gravitational force on Earth's surface. And because Earth, too, is exerting a gravitational force on the Moon, the Moon is trapped in an orbit, circling around the Earth once every month. Our oceans are stretched and pulled towards the Moon as it circles around our planet. This rise and fall of the oceans towards the passing Moon is what causes the rise and fall of water along our shores known as *tides*.
- **EXPLORE:** For the first part of this activity, have students sit on the floor in a tight circle. These students represent the oceans on Earth's surface.

- Select one student to play the Moon and ask him or her to walk slowly around the outside of the circle. Tell students to lean their bodies towards the Moon as it passes; this represents the gravitational pull of the Moon on the oceans, causing the water to rise.
- After one or two revolutions of the Moon, pause and explain that it's a little more complicated than that. The Moon is also pulling on the Earth itself – pulling it AWAY from its oceans on the side opposite the Moon! This causes higher seas on the opposite side of the planet, too.
- Have the Moon walk around the circle again, only this time, have students by the Moon lean towards him or her as they pass, and have students on the opposite side of the circle also lean back, away from the Moon.
- Continue until students can see the pattern of where sea rise occurs relative to the Moon.



- **EXPLAIN:** Tell them that the students who are leaning out – either by the Moon or on the opposite side – represent the areas on Earth where it's high tide. The students not leaning out represent areas of low tide.
- **EXPAND:** Introduce a complication to this pattern: the Sun! The sun is much, much bigger than either the Moon or the Earth, but it is also much further away. Therefore, it exerts a gravitational force on Earth, though a weaker one than the Moon. But it's strong enough that when joined up with the Moon's gravity, it causes a noticeable change in the tides.
    - Pull another student from the circle to play the Sun. Begin by placing the Sun next to the Moon so that all three planets are lined up. Explain that when the planets are lined up this way, there is an extra strong force on Earth's oceans – have the students closest to the Moon and Sun, and on the opposite side, lean ALL the way back to show the increased pull. When the planets are lined up this way, tides are extra high; these are called *Spring Tides.*
    - Next, have the Sun move around the circle so that the Sun and Moon are at a right angle to each other. (Note that the Sun doesn't actually move around the Earth – the Earth moves around the Sun – we are just doing it this way to demonstrate!) Ask students which way they think they should lean when the Sun and Moon are positioned this way. They will probably be torn about whether they ought to lean more towards the Sun or towards the Moon – and they're correct! When the planets are at a right angle like this, the gravity of the Sun and the Moon are competing, and the forces more or less balance each other out. Tell the students to lean towards the area between the Sun and Moon (or away from, on the opposite side), but only a

little. When the planets are arranged this way, there is not much change in water levels even at high and low tides – these are known as *Neap Tides.*

    - Finally, ask both the Moon and the Sun to walk around the circle, and challenge students to lean towards or away from the planets as they pass without your guidance. The Moon should walk more quickly than the Sun to demonstrate that the Moon rotates around Earth much more quickly than the Earth rotates around the Sun (one month versus a year).
- **EVALUATE:** Can students explain what causes tides on Earth and how they work?

LC6 Activity B: River Watch

Purpose: Students will explore online resources to gather data for river flow and elevation, and learn how scientists study and predict floods.

Time needed: 30-40 mins

Materials: access to the internet, Journals, colored Pencils.

Instructions:

- **ENGAGE:** Ask students how they know if there will be a flood in the area? Usually they, or their parents will see alerts on TV and online warning them about potential floods. But where does that information come from? Explain that scientists must research river elevations and flow data to determine when there might be a flood and warn the public. Students will look at data for the Salmon River which flows through the Cascade Head Biosphere Reserve to understand flow patterns.
- **EXPLORE:** Guide students through the following steps using their tablets or computers.
    - Step 1) Navigate online to the Northwest River Forecast Center [https://www.nwrfc.noaa.gov/rfc/]. Using your mouse, familiarize yourself with the home page, including the various tabs and menu items. Hover over specific dots on the map to see pop up displays of various rivers in the Pacific Northwest. The pop-up displays show past, current, and forecasted river levels. If you click on one of the dots the river gauging station's web page opens up as part of the display. NOTE: you have to be very precise with your mouse when working on this website.
    - Step 2) Using the Dropdown menu on the right hand side of the screen labeled "SELECT RIVER", scroll through the list to find and highlight SALMON RVR. Be sure to include the "RVR" as there are many rivers with Salmon in their name. You will know you have the right one if the ID shows as "SRRO3" and the Description shows "SALMON RVR - BLW SLICK ROCK CRK AT ROSE LODGE" which stands for the Salmon River below Slick Rock Creek at Rose Lodge. Alternatively, start typing Salmon RVR in “Get Station”. Select that station from the list and then press GO.
    - Step 3) From the newly open SALMON RVR web page, click on the hyperlink of the Gauge ID "SRRO3" to open the *hydrograph* (highlight this term with students - a

graph displaying water levels over time). If using Alternate method in Step 2 this hydrograph page opens automatically.

- Step 4) Ask students to study the hydrograph, noting what is on the x axis (days of the month for the last 10 days) and y axis (water levels in feet).
- Step 4) In your Journal record the name of the station, including its ID, latitude and longitude, and elevation. Then sketch a copy of the graph, noting that it only shows the past and current data, not a predicted level.

- **EXPLAIN:** Ask students to share what they learned. Ask them to describe the pattern they observed in river levels. Was it increasing, decreasing, or staying generally the same?
- **EXPAND:** Based on the graph, write a short entry in your Journal with your prediction for the river level for the Salmon River over the week. Discuss what you think the river level will do if it rains, and how fast it might rise or drop. Then, again using their tablets, ask students to use the forecasted river levels pop-up on the NWRFC homepage to see if it matches their predictions. Write these results in their journals.
- **EVALUATE:** Can students interpret a hydrograph from a different river, explaining what is on the x and y axes, and what the data tell you?

LEARNING CIRCLE 7

Vocabulary

Spit - a narrow coastal land formation that is tied to the coast at one end.

Seine Net - a device used by scientists to catch aquatic organisms for observation or research.

Video: The Spit

Summary: Now at the beach, the YC's talk about the interactions of sand, ocean, river, and weather that shape the land. They also describe how scientists capture and study aquatic organisms, and show evidence for how climate change has affected Cascade Head ecosystems.

Video journal prompt: What are some types of ocean animals that come into the Salmon River?

Post-video discussion question: How would you describe a watershed to a friend?

LC 7 Activity A: Tree Rings through Time

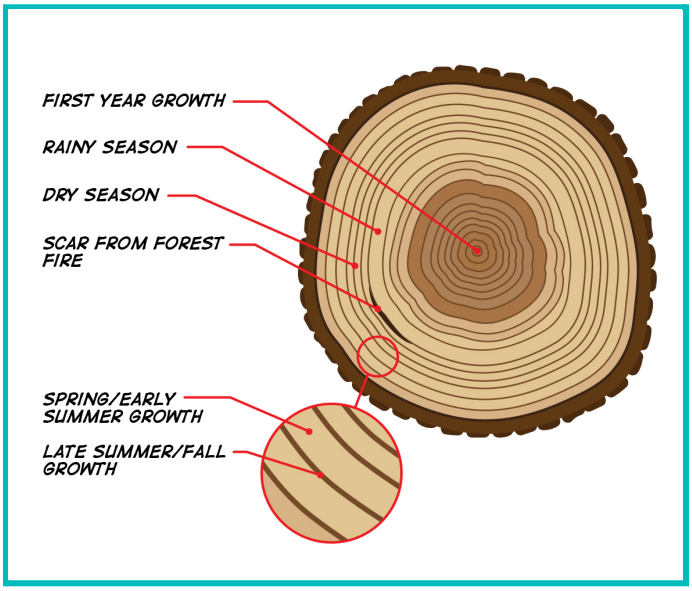
Purpose: Students will create artwork and study images to learn about dendrochronology - the study of trees to learn about past climate and environmental conditions.

Time needed: 20-30 mins

Materials: teacher computer, projector, journals; for optional Extension activity: cross-cut sections of tree branches, ink pads (see below)

Instructions:

- **ENGAGE**: Ask students how they think somebody could learn about the history of an area. Answers may include looking at historical documents, conducting interviews, looking at past and current data, etc. These are all great ideas! Then, tell students that one way people learn about past weather and climate is called *dendrochronology* - the study of tree rings to learn about environmental conditions in the past. Did they know that you can actually tell what the climate was like hundreds of years ago just by looking inside a tree's trunk?



- **EXPLORE:** Bring up the website https://climatekids.nasa.gov/tree-rings/ on the projector and read through this page with students. Observe that narrow rings generally mean slow growth during a dry period, while wider space between rings means faster growth during a wet period of time.
    - Bring up https://archive.epa.gov/climatechange/kids/documents/tree-rings.pdf on the projector (or print copies of this document) and go to page 10, where you'll see a cartoon image of a tree cross-section. Using what they just learned, ask students to narrate aloud this tree's history, pointing out where they think it was very rainy, where there might have been drought, and any other features.
    - Randomly distribute copies of the other three trees from the above link, one image per student. Ask students to study their image, and then write the story of their tree's life in their journals. Encourage creativity - students can choose to write this as a poem, a first-person account, illustrated children's story, etc.
- **EXPLAIN:** Ask students how they think scientists could use this information to learn about climate change. Remind them that *weather* (a short-term pattern in rainfall, temperature, etc) is different from *climate* (the pattern of changes that occur over a long time). Each individual tree can show both: the weather that occurred each year of the tree's life, and the climate over time that all of the rings put together reveal. And when you put many dozens or hundreds of trees' data together, all of that combined data can provide a really clear view of past climates.
- **EXPAND:** Ask students to brainstorm what other environmental factors, besides rainfall, could impact tree growth from year to year. Then, share that fish have a special bone in their ear called an *otolith* that also grows in rings. Scientists can use these to determine not

just that fish's age, but also environmental conditions during that fish's life - much like tree rings.

- **EVALUATE:** Can students look at a real tree cross-section (either real wood or printed images, not illustrations) and describe climate conditions throughout that tree's life?
- **EXTENSION:** Bring in some cross-sections of tree branches and allow students to use ink pads to create prints of these in their journals. Have them study the rings and note what they tell them about that tree's life.

LC7 Activity B: What does it take to be a scientist?

Purpose: Students will explore careers in ocean science and the paths of various marine scientists to learn about life as an ocean explorer, and consider careers they may want to pursue themselves.

Materials: computers or tablets with internet access, journals

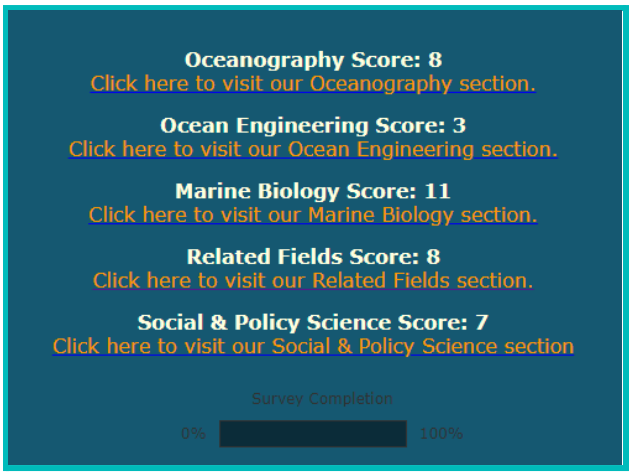
Time needed: 45-50 mins

Instructions: (NOTE: this could also be assigned as homework.)

- **ENGAGE:** Remind students of the discussion of how scientists capture aquatic organisms for study in the video. This field of study is just one of many, many careers you could have in marine or environmental science! Tell students they'll be getting to know some ocean scientists and learning how they became scientists.
- **EXPLORE:** Have students log onto their tablets or computers, then guide them through the following:
    - Step 1) Go to www.marinecareers.net. This resource was developed by Sea Grant, a NOAA program.
    - Step 2) In the bottom right corner, students should see a box titled "Which marine career is right for you?" Instruct students to click on "Get Started" to complete the quiz. This should take about 5 minutes. Encourage students to answer honestly; there are no right or wrong answers!
    - Step 3) Students will be provided a numerical aptitude score for each of the five following areas: Oceanography, Ocean Engineering, Marine Biology, Social & Policy Science, and Related Fields. Ask students to note their top 3 highest-scoring areas of study in their journals.
    - Step 4) Instruct students to return to marinecareers.net. Using the tabs at the top of the page, students should explore their 3 top marine careers. When they click on each tab, a description of that field will display, along with pictures and profiles for several scientists in that field. They can click on the link below the pictures to see all available scientist profiles. For each of their top 3 fields, students should pick ONE scientist who seems the most interesting to them.

- Step 5) For each of their 3 chosen scientist profiles, instruct students to write in their journals one thing from that scientist's profile that was memorable - something that surprised them, interested them, or made them wonder.
- Step 6) After exploring their top 3 fields, ask students to pick their first choice for a career in ocean sciences. Then, designate one place in your classroom (or outside if the weather allows) for each of the five fields. Send students to the place they designated for their top choice career.
- Step 7) Once students have gathered in groups, ask them to share their thoughts amongst themselves. Have them share if their quiz results surprised them, if they think they would actually pursue this career (and why or why not!), and any other thoughts or reactions.

- **EXPLAIN:** After students have retaken their seats, ask them to share their responses with the whole class. Remind students that even if they're not specifically interested in marine careers, the jobs that they learned about could easily translate to other sciences, or even other fields.



- **EXPAND:** Ask students to share their thoughts about how some of the experiences and skills they learned about could transfer to other, non-science jobs. Encourage students to ask their parents or other family members about their careers, why they chose them, and how they prepared for them.
- **EVALUATE:** Can students describe a few different marine careers, what they involve, and how somebody might pursue that career?

LEARNING CIRCLE 8

Vocabulary

Stewardship - the responsible use and protection of the natural environment through conservation and sustainable practices.

Video: The Sea

Summary: At the end of our journey, the YC's review the path that they and our raindrop have traveled through the watershed. They discuss all of the ways that humans are connected to, and dependent upon, water and healthy watersheds. They share ideas for ways that students can help take care of, and build a relationship with, their own watersheds.

Video journal prompt: Write down one way that you could start taking care of your watershed today.

Post-video discussion question: What are some other ways (besides the ones discussed in the video) that you rely on water in your everyday life?

Final Project

There are no set topics for students' final projects; rather, they should be based on students' creativity and interests to reflect what they learned about watersheds. You may choose to have students work individually or in groups. The National Oceanic and Atmospheric Administration (NOAA), the funder of this program, defines a successful final project as including these distinct *stewardship actions:*

> Students identify and implement a stewardship action as a solution that directly addresses the defined issue or phenomenon within their school, town, neighborhood, or community. Students are actively engaged and, to the extent possible, drive the decision-making, planning, and implementation of the stewardship action while teachers play a facilitation role by forming groups, moderating, and answering questions. Students reflect on the action and determine the extent to which the action successfully addressed the issue or phenomenon.
>
> This element allows students to understand that they personally have the power to bring about change to environmental issues, take action to address these issues at the personal or societal level, and understand the value of that action. This can instill confidence in students and can contribute to students becoming environmental stewards in their communities.
>
> Stewardship actions can take many forms and may fall into the following categories:

- **Watershed Restoration or Protection**: actions that assist in the recovery or preservation of a watershed or related ecosystem that has been degraded, damaged, or destroyed (e.g., plant or restore protective vegetation/trees; restore a local habitat; remove invasive plants; clean up litter at local beaches, parks, or school grounds; develop a school garden, natural history area, community garden, or other sustainable green space; install rain gardens to help manage stormwater).

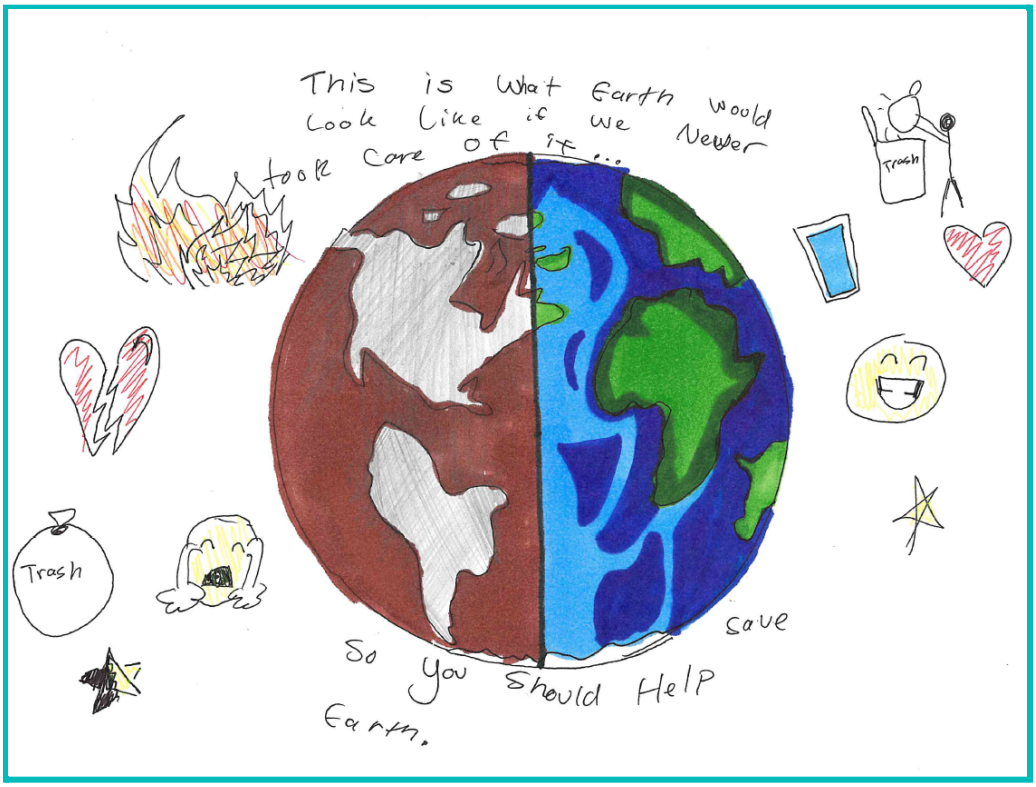
- **Everyday Choices**: actions that reduce human impacts on watersheds and related ecosystems and offer ways to live more sustainably (e.g., reduce/reuse/recycle/upcycle; monitor and save water in the face of potential drought or reduction in water availability; compost food or yard waste; research and implement energy efficient strategies or energy alternatives at school and/or at home).

- **Community Engagement**: actions that inform others about how to address community-level environmental issues (e.g., give presentation to local organizations; organize community events; record or broadcast public service announcements; share information on social media; post flyers in community; share posters at community events/fairs/festivals; mentoring).

- **Civic Action:** actions that identify and address issues of public concern. Students acting alone or together to protect public values or make a change or difference in a student's school, town, neighborhood, or community (e.g., present to school board or school principal; attend, speak, or present at town meetings; write or meet with decision makers/elected officials of a students' school, town, neighborhood, or community).

Source:
https://www.noaa.gov/education/explainers/noaa-meaningful-watershed-educational-experience

An authentic project will engage both minds and hearts to make learning more meaningful.



Raindrop To Sea projects should reflect that students understand how watersheds work, how they interact with wildlife and people, and how they can change over time. Students should demonstrate that they understand how human actions directly affect the watersheds where they live, play and go to school, and the oceans they drain into.

Projects should include one or more of the following elements:

- Listing in detail how their everyday lives at home and at school involve water.
- What actions they can take to conserve and maintain watershed health.
- Creating a map of their own watershed and determining if there are negative human impacts present that could be mitigated by themselves or others.
- Writing a letter to their local newspaper or elected officials advocating for watershed awareness and action in their community.
- Being a watershed advocate at their school.
- Explaining how healthy watersheds help their community.

However, projects are not limited to the above ideas! They should be driven by teacher direction, time availability, resources, local issues and events, and student interest.

Use the following website to generate ideas and share project examples with students. You may even choose to have students pick one or more of these projects to do themselves, if they aren't sure what they'd like to do. This site is maintained by NOAA and a great source of information and inspiration: **https://www.baybackpack.com/action-projects.**

Monterey Bay Aquarium also has an excellent list of projects you can access at: https://www.montereybayaquarium.org/for-educators/teacher-professional-development/project-based-science.

The following is one example of a project students could choose to pursue:

First, create a map or model of where the water flows in your area of choice (can be their school, home, favorite vacation spot, etc).

- This should be open ended and encourage individual creativity. It could be a 3D model, a hand-drawn map, diorama, etc.
- Students should use resources such as https://modelmywatershed.org/, https://www.epa.gov/waterdata/hows-my-waterway, and https://water.usgs.gov/wsc/watershed_finder.html, to create accurate maps and learn about impacts in their watershed.

Then, mark special places in your watershed model. These may include:

- Your home and/or school
- afterschool activities and hobbies
- favorite family spots
- special memories

Finally, tell a story about how the water/watershed interacts with your special places.

- This should also be fairly open-ended. It could be included with labels of places on the map/model, an accompanying story or poem, a play, podcast, etc.
- Encourage students to think about how humans impact the watershed and how the watershed impacts humans.

Reflection Activities

Use the following Journal prompts to help students process and reflect upon all they learned during this program. Provide plenty of time to write; you may even wish to assign one or more of these as an essay for homework so they have adequate time. You may use their writings as assessment tools to determine what and how they learned about watersheds, the water cycle, and environmental stewardship.

- What is your relationship with your watershed?
- What are 5 gifts your watershed has given you? What are 5 gifts you could give back?
- Write a piece or create artwork titled "*the story of life as told by water*".

Extension Activities by Learning Circle

Learning Circle 1: Foggy Glasses

Purpose: Using two drinking glasses, demonstrate how a change in air temperature causes condensation (moisture) to form

Time needed: 15-20 mins

Materials: Once clear drinking glass, access to a freezer or refrigerator

Instructions:

- **ENGAGE:** Tell students that here on the Oregon coast, a big source of water in the water cycle is actually FOG! Fog occurs when the air is very humid - there has to be lots of water vapor in the air. Fog forms when relatively warmer air passes over a cool, moist surface (such as the air just above the ocean). When warm air makes contact with the cooler air, water vapor condenses to create fog. The following experiment will demonstrate this.
- **EXPLORE:**
    - Step 1) Put the glass in the freezer for 10 minutes (or 20 minutes if using a refrigerator) and leave the other one on the kitchen counter.
    - Step 2) After 10 or 20 minutes depending if you used the fridge or the freezer, remove the cold glass and set it next to the other glass on the kitchen counter.
    - Step 3) Notice what happens to the cold glass.
- **EXPLAIN:** The glass was cooled quickly by the freezer, causing water vapor to condense on its surface. Condensation occurs when the water particles in air come in contact with a

cool liquid or solid surface. The water particles slow down and stick together, forming water droplets.

- **EXPAND:** Tell students that engineers are working on ways to collect water from fog. The most effective way has been the development of "fog catchers." Fog catchers are very large screens constructed in arid areas. As fog glides in, water droplets form around the thin screens and drip to the collection pools below. In one day, a single screen can collect more than a hundred gallons of water. The village of Bellavista, Peru, relies on fog catchers. Bellavista is an area that has little access to liquid water—no rivers, lakes, or glaciers are nearby. Wells dry up quickly. Water for irrigation and human consumption is threatened. Every year, however, huge fogs blow in from the Pacific Ocean. In 2006, the community invested in a series of fog catchers outside of town. Now, the residents of Bellavista have enough water to irrigate trees and gardens, as well as provide for their own drinking and hygiene needs. Engineers warn that fog catchers will only work in small areas. Still, engineers and politicians are working on ways to make more powerful fog catchers that will perhaps reduce the need for people to rely so much on groundwater.
- **EVALUATE:** Can students explain how fog is formed?

Learning Circle 2: Soil as a Sponge

Purpose: Students will simulate the absorptive capacity of soil using a piece of sponge and will compare their experimental data with peers.

Time needed: 20-30 mins

Materials: 3 pieces of Pop Up sponge (3 different sizes), 5 ml pipette, Ruler, Journal, Bowls and Cups

Instructions: Each student will be conducting their own experiment on water absorption. Provide each student with the materials above, then guide them through the following steps:

- **ENGAGE:** Ask students what happens when they throw a towel down over a spill. What happens to the liquid? The fabric of the towel absorbs it. In nature, soil acts just like a towel, soaking up the water. Tell students they're now going to experiment with how much water different sizes of sponges can absorb, using this as a model for soil absorption.
- **EXPLORE:**
    - Step 1) Fill your cup with water.
    - Step 2) Take your sponges and measure the length, width, and height of the dry sponge in millimeters. Use your metric ruler, remember that 1 cm = 10 mm. Record these measurements in your Journal. Calculate and record the volume of the sponge by multiplying length times width times height of any side (V=l x w x h).
    - Step 3) Take your largest piece of sponge, place it in your dry bowl.

- Step 4) Take your 5 ml pipette and squeeze the top bulb. Holding it vertically, place the pipette in your cup to draw up water to the 5 ml mark. If you drew up too much water squeeze the bulb to dispense water to the correct level.
- Step 5) Empty the pipette over the sponge.
- Step 6) Repeat filling and emptying your pipette over the sponge until the sponge is fully saturated and begins to leak small amounts of water. Be sure you count each time you empty the pipette.
- Step 7) Record the total volume of water used to reach saturation (number of pipettes used X 5 ml).
- Step 8) Remeasure the sponge's dimensions and calculate and record the new volume of the saturated sponge.
- Step 9) Repeat Steps 3 through 8 for the other two smaller pieces of dry sponge. Be sure to empty and dry the bowl before starting.
- Step 10) Using your sponge data, make a scatter plot of the wetted sponge volumes compared to the amount of water required to get each sponge to saturation.
- Step 11) Draw a best fit line on your scatter plot.

- **EXPLAIN:** Ask students to share their scatter plots and report the pattern they found in their data. They should note that the bigger the sponge, the more water it took to saturate it. Explain that it's the same in nature - ecosystems with more soil can absorb more water. This is really important for ecosystem health and flood prevention!
- **EXPAND**: Describe any observations you have with the experiment, suggesting any improvements that might be made. Consider how the sponges reacted to the water. Also consider how different soils, such as clay, sand, or sandy loam, might also vary in how they absorb rainwater. Write down your thoughts in your Journal.
- **EVALUATE:** Can students explain how soil is related to water absorption?

Learning Circle 3: Five Times (5X) the Fun

Purpose: Students will explore different sizes, shapes, and appearances of sediment, imagining how they came to be.

Time Needed: 15-20 mins

Materials: Magnifying Loupe, Journal, Colored Pencils, a few pinches of sand, soil, sediment etc.

Instructions:

- **ENGAGE:** Ask students what they think a single grain of sand looks like under a magnifying glass? Tell them that using their 5X magnifying loupe, they'll inspect sand or soils you can find locally, and draw the various shapes and colors they see in their journal.
- **EXPLORE:**

    - Step 1) Take the Private Eye Loupe out of your kit and place the lanyard (string portion) around your neck so the loupe hangs on your chest.
    - Step) 2 Find a few grains of sand or soil from within your watershed.
    - Step 3) Using a clean hand take the loupe and press the flared open end up to bones around your eye.
    - Step 4) With your other hand take a pinch of sand and hold it about 2 inches from the loupe until it is in focus. Notice any colors and shapes you see.
    - Step 5) Using colored pencils, draw in your journal what you have seen.
    - Step 6) Repeat the investigation five times with other sands or soils you find and record your findings in your journal.
- **EXPLAIN:** Tell students that sand or soil from a distance might look like one continuous color, but under closer inspection a grain of sand or soil might be clear, yellow, red, green, orange, black, or basically any color. This is because grains of sediment are just miniature rocks having been weathered away from bedrock high up in a watershed. Ask students if what they saw matches what they expected to see.
- **EXPAND:** Write a short creative journal entry describing the way the grain of sand or soil particle may have found its way to where you found it. Describe what kind of rock it may have come from, any constructive or destructive forces that it may have experienced, any weathering forces it may have endured, and means of transport it may have taken. Like our raindrop, there is a story behind each grain of sand!
- **EVALUATE:** Can students describe some various shapes and colors of sediment, and describe how they became that way?

Learning Circle 4: Sediment Washing Down the Gorge

Purpose: Students create a "sedimentary rock" and then cut through it with a stream of water, demonstrating how water erodes land, displacing rocks, dirt, and sand.

Time needed: 10-15 mins

Materials: One sheet of paper, a finger full of mud, a 5ml pipette, a cupful of water to fill a pipette, glue

Instructions:

- **ENGAGE:** Tell students they will be observing the effects or erosion using paper and a sediment sample as a model.
- **EXPLORE:**
    - Step 1) Take a piece of paper and smear across the top of the page horizontally from left to right a thin line of mud, one or two fingers thick. Allow it to dry.

    - Step 2) While holding the dried, smeared paper over the sink with one hand (or if it's dry outside or you have a covered area, work outside), take the pipette and squeeze the bulb to allow water to be drawn up into the pipette from the cup of water.
    - Step 3) Slowly dispense water from the pipette from the middle of the top of the paper through the dried mud smudge, so it runs to the bottom.
    - Step 4) Lay the paper flat in a safe place, and leave it to dry overnight.
    - Step 5) Record your observations from your erosion experiment in your Journal.
    - Step 6) Consider and describe the types of rock or soils which might be most vulnerable to erosion.
    - Step 7) On your paper is dry, glue or tape it in your Journal.
- **EXPLAIN:** The water poured onto the paper acted like a stream or river, flowing through the land sediments (dried mud) to form a V-shaped cut or valley.
- **EXPAND:** Ask students how they might have changed this experiment to demonstrate either a flood or a very small stream. Examples may include using more or less water, more or less sediment, different types of sediment, etc.
- **EVALUATE:** Can students explain some ways that water shapes land?

Learning Circle 5: Salmon Stories

Purpose: Students will imagine the life journey of a salmon to illustrate its life cycle and interactions with the ecosystems around it.

Time needed: 30-45 mins

Materials: Journals, pencils

Instructions:

- **ENGAGE:** Ask students to remember some things they learned about the amazing salmon in the video, especially about their unique life cycle - they are born in a freshwater stream, travel to the sea where they live as adults, then finally return to their home stream to mate and lay their eggs. Only a few fish species in the world can do that!
- **EXPLORE:**
    - Step 1) Write the following prompt on the board: *Imagine you are a salmon. Tell your life story, from your birth in a stream, life at sea, to your eventual return to your birth stream.*
    - Step 2) Divide students into small groups of 2-3 people.
    - Step 3) Tell students that each group is going to come up with a story to answer the prompt. Ask them to imagine all of the things that salmon might do or come across during its lifetime in a river and the ocean - prey, predators, people, floods, storms, etc. There are no right or wrong ideas - they should be creative and use their imaginations!

- Step 4) Assign one student in each group to be the recorder, writing down all the main points of their story as they come up with it.
- Step 5) Give students about 15-20 minutes to come up with their salmon stories.
- Step 6) After all the groups have finished their stories, ask each one to share out. They can do this however they wish - they may want to read it aloud, have each person tell a different part of the story, share illustrations, etc.

- **EXPLAIN:** Ask students to identify elements that all or most of their stories shared. They should have all included some mention of being born in a river, swimming out to sea, then returning to their birth river.
- **EXPAND:** If time allows, turn this into a bigger project by having student groups perform a sketch of their story - with costumes, props, and sets, if they wish!
- **EVALUATE:** Can students describe the life cycle of a salmon?

Learning Circle 6: King Tides

Purpose: Using tide charts, students will research the effects of tidal action associated with King Tides, and better understand why people are studying them as an indicator of Sea Level Rise.

Time needed: 45-50 mins

Materials: Internet Access, tablets or computers, Journal, pencils, copies of King Tides Fact Sheet found at www.epa.gov/sites/production/files/2014-04/documents/king_tides_factsheet.pdf

Instructions:

- **ENGAGE:** Predicting tides is fundamentally important whether you are just planning a trip to the beach or have plans of going shellfish harvesting with your family. King Tides, which are extra-large tides that occur rarely during certain times of the year, can serve as a representation of sea level rise resulting from climate change. In this exercise you will determine when and why the highest tides of the year occur on the Oregon coast.
- **EXPLORE:**
  - Step 1) Using the tide tables provided by NOAA at https://tidesandcurrents.noaa.gov/ determine the four highest tides, or King Tides, that will occur during the calendar year of 2021. To navigate the website:
    - a) From the above link, click on your state or enter your local zip code.
    - b) Zoom in or out to view the closest station identified with a pin in the map.
    - c) Select your local station by clicking on the Pin. The most current data should pop up.
    - d) Under the "More Data" drop down menu, select TIDE PREDICTIONS.
    - f) Click the Blue Button that says CLICK HERE FOR ANNUAL PUBLISHED TIDE TABLES to download a PDF of the 2021 tidal predictions for your station.

- Step 2) Record the location of where your tide data are coming from in your Journal. Then, record the dates, times, and tide levels of the four predicted highest tides of the year.
- Step 3) Navigate back to your station's home page. From the "More Data" drop down menu, select SEA LEVEL TRENDS. A graph will appear. Ask students to describe what they see: the general trend since the 1960s, when data collection began, has been a continuous rise in sea level.
- Step 4) Students will see below the graph a statement that says something like "The relative sea level trend is 1.75 millimeters/year with a 95% confidence interval of +/- 0.64 mm/yr based on monthly mean sea level data from 1967 to 2020 which is equivalent to a change of 0.57 feet in 100 years" (the actual data with vary depending on which tide station you used." Help students to interpret each part of this statement:
  - *Relative sea level trend* describes average sea level rise over a period of time,
  - *95% confidence interval* means that the data is 95% accurate (a very high rating in science!)
  - *+/- 0.64 mm/yr* means that the data may vary as much as .064 mm higher or lower than what is given.
  - *Monthly mean sea level data* is the average of data collected at that statement each month,
  - *Equivalent to a change of 0.57 feet in 100 years* means that at this station, the sea level is rising about half a foot every 100 years.
- Step 5) Refer students back to the four highest predicted tides for 2021 that they recorded in their Journals. Ask them to add .5 feet to each of the numbers (for example, a high tide of 8.6 ft would become 9.1 ft). This provides a rough prediction of what the King Tides might be in 100 years.

- **EXPLAIN:** First, ask students to share what time of year their highest recorded tides occurred. They should note that mostly, they are during the winter (November-January). Why is this? It's because of Spring Tides (named for the way the water "springs" up, not the time of year!), or annual extra-high tides when the earth, sun, and moon line up.
- **EXPAND:** Discuss why this data matters. Students may note that it seems like only a small increase in water levels over a long period of time. However, even just a few inches can make a big difference for coastal homes and properties. Explore the photos at https://www.oregonkingtides.net/ to illustrate this idea.
- **EVALUATE:** Can students explain what a King Tide is and how it relates to sea level rise?

Learning Circle 7: DIY Creature Catcher

Purpose: Students craft models of devices that could be used to catch aquatic organisms for scientific study.

Time needed: 20-30 mins

Materials: modeling clay, pipe cleaners, netting, small weights, small pieces of pool noodles or other buoyant items; paperclips; glue

Instructions:

- **ENGAGE:** Tell students: In the video you saw an example of a seine net, which scientists use to capture aquatic animals to study and count them. Now it's your turn to design a device that could be used for that purpose!
- **EXPLORE:** You can choose to have students work individually, in pairs, or in small groups.
    - Step 1) Provide materials to students, and tell them they can use these to invent a creature catching device however they wish. The only requirement is that it must not harm the animals. It's up to students whether they want to make something that catches just one large animal at a time, multiple smaller organisms, fish vs snails, etc. Remind students that it also needs to be able to withstand water and weather.
    - Step 2) Allow students to build freely for 15-20 minutes.
    - Step 3) After time is up, have students share their inventions, explain how it works and what they would use it to catch, and invite the rest of the class to ask questions about it.
- **EXPLAIN:** Scientists and researchers have to use a number of different tools to perform different tasks. Often they have to invent their own tools to complete a very specific task, if none exists, just like you did!
- **EXPAND:** Ask students to imagine that they were the lead scientist at a research facility, studying aquatic organisms. Which model would they select to purchase for their work? Have the class vote, then discuss the winning model - why was it deemed the best?
- **EVALUATE:** Can students explain some aspects of a good scientific tool, specifically one used for studying aquatic species?

Teacher Resources

Teachers On The Estuary:
https://sites.google.com/a/nerra.org/teachers-on-the-estuary-modules/

NOAA Meaningful Watershed Education Experiences (MWEEs):
https://www.noaa.gov/education/explainers/noaa-meaningful-watershed-educational-experience

NOAA Education Resource Collections: https://www.noaa.gov/education/resource-collections

Oregon Watershed Profiles:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/water/resources/?cid=nrcs142p2_045940

Watersheds and Drainage Basins - USGS: https://www.usgs.gov/special-topic/water-science-school/science/watersheds-and-drainage-basins?qt-science_center_objects=0#qt-science_center_objects

The Water Cycle at National Geographic Kids: https://www.natgeokids.com/au/discover/science/nature/water-cycle/

Bay Backpack Teacher Resources: https://www.baybackpack.com/teaching-resources

Watershed 101 - Ways to protect our watersheds: https://www.cwp.org/watershed101/

Empowering Youth to Change Our Planet: https://www.earthecho.org/

Service Learning to engage youth in solving the global water crisis: https://www.h2oforlifeschools.org/

Going Blue: A Teen Guide to Saving Our Oceans, Lakes, Rivers, and Wetlands: https://www.freespirit.com/files/original/going-blue-leaders-guide-1.pdf

---

Glossary

Adaptation – a characteristic that helps a species survive and reproduce.

Anadromous – aquatic species born in freshwater that spend most of their lives in saltwater, then return to freshwater to spawn.

Atmosphere - the envelope of gas surrounding the Earth; the air.

Brackish - a mixture of fresh water draining from the land and salty seawater.

CO_2 – Carbon Dioxide

Condensation - the conversion of a vapor or gas to a liquid.

Constructive Force - builds up features on the surface of Earth.

Deciduous – plants that drop their leaves at the end of the growing season and sprout new leaves in the spring.

Destructive Force - destroys and breaks down features on the surface of Earth.

Earthquakes - break the surface of the Earth.

Ecosystem - A geographic area where plants, animals and other organisms, as well as weather and landscape, work together to form a web of life containing biotic (living) parts and abiotic (nonliving) parts.

Erosion - the flow of water under the force of gravity.

Estuary - where fresh and saltwater mix

Evaporation - the process of turning from liquid into vapor.

Evergreen - plants that have needles or leaves that usually stay green year round. (also known as *coniferous*)

Fertile - rich in the nutrients necessary to support life.

Gravity - the force that pulls all objects downward toward the center of the planet.

Infiltration - permeation of a liquid into something by filtration.

O_2 - Oxygen

Path of Least Resistance - the easiest way to go in response to gravity.

Percolation - the movement of water through the soil.

Precipitation - rain, snow, sleet, or hail that falls to the ground.

Sedimentary Deposition - The geological process in which sediments, soil and rocks are added to a landform or landmass.

Seine Net - a device used by scientists to catch aquatic organisms for observation or research.

Sinuous – having many curves, bends, or turns.

Spit - a narrow coastal land formation that is tied to the coast at one end.

Stewardship - responsible use and protection of the natural environment through conservation and sustainable practices.

Transpiration - the process of water movement through a plant and its evaporation through its leaves, stems and flowers.

Water Cycle - the continuous cycling of water within the Earth and atmosphere.

Watershed - an area of land that channels rainfall and snowmelt through streams and rivers, back to the ocean.

Weathering - exposure to rain, wind, snow, and ice.