How Healthy is the Sakai Stream for Salmon?

A 5th Grade Citizen Science Unit

Sakai Intermediate School
IslandWod/Homewaters

Fall 2013

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Introduction

Unit Description

Beginning in the fall of 2013, all 275 5th graders at Sakai Intermediate School will become citizen scientists, tasked with investigating the condition of the creek behind their school. Through a five-week science unit, students will visit the stream nine times to assess its health. Annually, students raise and release salmon fry into Sakai Stream, which is located directly behind the school. However, a recent report from the City of Bainbridge Island revealed that the Murden Cove watershed, which encompasses the Sakai Stream, is not healthy. The city has selected testing sites throughout the watershed to pinpoint the problem areas. One of those sites is in the Sakai Stream.

Throughout the year, the 5th grade students will be monitoring the stream while gathering and analyzing important water quality data like temperature, dissolved oxygen levels, and pH. They will also note the condition of the surrounding vegetation, overall appearance of the water, and analyze nutrient and bacteria levels from stream samples taken monthly. To support their data collection students will use a range of equipment from simple stream equipment like pH strips and turbidity tubes to more complex technology such as the Quanta probe, an industry-grade water testing instrument. Students will regularly submit their information to the City of Bainbridge Island to help monitor the health of the greater Murden Cove watershed.

Student Goals

As a result of this rich outdoor learning, students will benefit from this outdoor science unit in these ways:

- Throughout their investigation of the stream, students will develop key science practices that will help them develop as citizen scientists who work to answer a real-world question.
- As students test the water, they will learn about the stream's ecology. They will understand why it is important to test the water for properties like dissolved oxygen and pH. They will also learn what factors in the community might affect the water, both negatively and positively.
- To culminate their research and to look towards a healthier stream, students will apply their knowledge and findings to develop a potential solution that will improve the health of the stream. They will share these ideas with the greater Sakai community, which includes the City of Bainbridge Island, the Bainbridge Island School District, families of Sakai, and citizens living in the surrounding area.

Culminating Project

After students investigate the health of the stream by gathering and analyzing data, they will engage in an engineering project. Based on the data they collect, students will define one problem to design a feasible solution for. They will share their data and this solution with the greater Murden Cove community.

Unit Overview

Unit Length

<u>5 weeks:</u> There are 15 science lessons in the unit, each 1 hour in length. After these 15 lessons, students will create a culminating engineering project. This final project will take approximately 8-10 science periods.

Integration with FOSS Environments

This unit is designed to be taught as part of the FOSS Environments curriculum. In the FOSS investigations, common themes are habitat needs for living organisms and determining optimal conditions for living organisms. This stream unit integrates these ideas in a hands-on, real world application.

Partnership

This unit is the result of collaboration between: Sakai Intermediate School, City of Bainbridge Island, IslandWood, Bainbridge Island School District, and 3M. Through funding by 3M, IslandWood and Sakai have created hands-on lessons to help students become citizen scientists in Sakai's backyard. Through water quality training from the City of Bainbridge Island, students will test the stream using a high-tech probe.

Next Generation Science Standards
All lessons in this unit are aligned to the Next Generation Science Standards. At a glance, below are the standards that this unit focuses on. A more detailed list is located at the end of this curriculum.

Science and Engineering Practices
Planning and Carrying Out Investigations Analyzing and Interpreting Data Construction Explanations and Designing Solutions Engaging in Argument from Evidence
Disciplinary Core Ideas
ESS3.C: Human Impacts on Earth LS1.B: Growth and Development of Organisms LS4.C: Adaptation LS4.D: Biodiversity and Humans
Crosscutting Concepts
Cause and Effect Patterns Systems and System Models

Throughout the unit, the applicable standards are located at the top of each lesson. Because this unit teaches students important science practices, within the lessons key student actions directly related to these practices are highlighted in **blue**. This will be helpful at the end of each lesson, when teachers and students will review the practices they used during the lesson, as well as the content they learned.

End of Lesson Reflections
At the end of each lesson, students will reflect on what content ideas they learned, new words they used, and what science and/or engineering practices they used. To help keep track of these reflections, set up chart paper lists in the classroom to refer to and add on. Adding reflection with students throughout the lessons will help them become more aware of their own development as a scientist.

IslandWood Support
For three outdoor lessons, each teacher will have the support of an IslandWood educator. This educator will:

- Co-teach lessons 6, 7, and 10 with the teacher
- Hold a planning session with the teacher to plan the co-teaching

Additionally, Clair Durkes, IslandWood Lead Educator, will continue to be your source of support throughout the unit: clair[d@islandwood.org](mailto:claird@islandwood.org)

Assessment
To help provide valuable assessment data to improve the unit, document student and teacher learning, and report our successes to 3M, our funder, it will be very helpful if teachers can support accurate assessment of the unit in these ways:

- Gather student notebook samples to be assessed by IslandWood
- Give the pre- and post-test of science content to all students and provide IslandWood with the results
- Give weekly “exit tickets” to students and provide IslandWood with copies
- Attend a focus group after teaching the unit to share reflections, suggestions, and thoughts

Safety
After each lesson that involves students touching the stream water, it is necessary for them to wash their hands. This is needed because of possible fecal coliform on the water (can transmit pathogens). This will add time, but this extra time commitment will be minimized as students develop a routine. Gloves will also be available in the outdoor classroom bin for these lessons in case anyone has open cuts or wounds on their hands. Goggles will be

available for any student who is handling chemicals during water quality testing. Also, when taking students to the stream, the outdoor classroom bin has basic first aid tools (band aids, ice packs).

Vocabulary

Vocabulary Embedded in Lessons

Vocabulary words that accompany this unit are embedded in the lessons. When they are first introduced, the vocabulary words are underlined. Below is a chart with words, definitions, and lessons in which they are introduced.

Lesson	Words and Definitions
1	**ecosystem:** a community of living things together with non-living parts, functioning as a unit
2	**watershed:** all the land area that drains into a particular body of water
3	**alevin:** a newly hatched salmon that feeds from yolk sac for nourishment **fry:** a small salmon that no longer uses yolk sac for food; eats tiny invertebrates **smolt:** salmon that have undergone physiological changes to allow them to live in the ocean **redd:** a gravel depression made by adult salmon to lay eggs in (nest) **anadromous:** describes organisms that are born in fresh water, live most of their lives in salt water, and return to fresh water to spawn
5	**turbidity:** the level of cloudiness of water caused by individual particles (suspended solids) **riparian zone:** the area of land that borders water **tree canopy:** a layer of leaves and branches from trees that covers the ground **vegetation:** plant life
6	**pH:** a chemical test that measures the concentration of hydrogen ions in a substance **dissolved oxygen:** the amount of oxygen in water (not part of H_20)
7	**probe:** a testing instrument **in situ:** Latin for “in position” **physiochemical parameters:** parameters that measure the physical chemistry of water
10	**macroinvertebrates:** organisms with no back bone that are big enough to be seen with the naked eye
13	**database:** an organized collection of data
14	**fecal coliform:** bacteria that live in the digestive tracts of warm-blooded animals; can carry disease **ammonia:** naturally occurring by-product of decomposition; can be dissolved in water **phosphorous:** an element naturally present in rocks, soil, and other organic matter; essential to photosynthesis; can occur in fertilizer, pesticides, and other human-made substances **nitrogen:** a necessary elements for all living organisms; often found also in fertilizers
Culminating Project	**engineering:** any engagement in a systematic practice of design to achieve solutions to particular human problems (from NGSS)

Materials

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

Lesson	Provided Materials (in kit)	Materials Needed (from classroom)
1	Outdoor classroom bin: whiteboard, dry erase markers, eraser, 1st aid kit, gloves, extra pencils	Clipboards Chart paper
2	Spray bottles	Magic markers Chart paper
3	Poker chips Flash drive: salmon video Safety cones Salmon signs	
4	Flash drive: salmon PowerPoint Outdoor Classroom Bin	clipboards
5	Outdoor Classroom Bin Thermometer and pH Testing bin Turbidity tubes (3) Cups (3) Buckets (5)	clipboards
6	Outdoor Classroom Bin Thermometer and pH Testing Bin DO Testing Bin Macroinvertebrate Outdoor Bin Buckets Household liquids (jars) Quanta probe in backpack	clipboards
7, 8, 9	Outdoor Classroom Bin Thermometer and pH Testing Bin DO Testing Bin Macroinvertebrate Outdoor Bin Buckets Household liquids (jars) Quanta probe in backpack	clipboards
10	Pink basins for macros Ice cube trays Macro field guides Petri dishes Hand lenses Macro tools (5 sets) Buckets	clipboards
11	Quanta probe in backpack Outdoor Classroom Bin Stream dye and spoon Role play cards	clipboards
12	Quanta probe in backpack Outdoor Classroom Bin Tupperware with holes Trowel	clipboards

	Cups Pink basins (for macro lesson 10)	
13		Computers Access to online database
14	Flash drive: Bacteria and nutrient slideshow Flash drive: YouTube fecal coliform video	Computer s Access to online database
15	Flash drive: map of Murden Cove project	Computers Access to online database
Culminating Project	Flash drive: TED Talk examples	Computers Access to online database Presentation materials

Lessons

Lesson 1: Exploring the Stream

Time: 60 minutes
Location: Classroom and stream

Lesson Summary
In this hour lesson, students will travel to the stream for their first outdoor lesson. They will be introduced to the overarching essential question for the unit: How healthy is this part of the stream for salmon? During this trip to gather initial observations, make a prediction about its health, and establish routines for visiting the stream.

Next Generation Science Standards

SP	**Planning and Carrying out Investigations:** Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments.
CC	**Cause and Effect**

Objective
Using initial observations of the stream, students will be able to make a prediction to answer this overarching question: How healthy is this part of the stream for salmon? Students will record predictions, along with evidence to support their thinking, in their science field notebooks.

Assessment
Students will make and record their observations and predictions in their science field notebooks.

Materials
- Qualitative Stream Data Student Notebook page
- Pencils
- Clipboards
- Teacher outdoor classroom bin
- Chart paper

Important Notes
This is the first lesson of the unit and the first trip to the stream. It will be very important to establish a set of classroom norms for using the "outdoor classroom" during this lesson. These norms will be helpful to refer back to for subsequent trips to the stream.

Part 1: Unit Kickoff!
1) To get students introduced to the purpose of the unit, and to get them excited about it, show them the website that last year's 5th graders worked on.
   http://www.bisd303.org/site/Default.aspx?PageID=7253
2) Either as a class or in smaller teams, peruse the information and tell your class that they will be continuing this important research. Through sharing the website and viewing the videos, make sure that students understand:
   - Why the Murden Cove watershed is being studied: This doesn't have to be all negative, but they should know there are elements of the water that might be unhealthy based on past research.
   - What their role will be: To study the watershed behind Sakai!
   - That they can help have a positive impact on the watershed as they learn more about it. The students from last year helped by creating videos to share with everyone.
3) As scientists, the students' first task will be to gather some initial observations about the stream ecosystem. Today will be their first trip of many to the stream. Each student will need a clipboard, field notebook, and pencil. Explain to the scientists that they will **predict** the health of the ecosystem based on observations of the ecosystem. They will **observe and gather data to use as evidence in explaining their thoughts** about the health of the ecosystem. Predicting is helpful to:
   - Formulate thoughts based on evidence

- Determine testing parameters
- Engage the scientists by prompting them to make connections based on what they already know

Part 2: Using the Outdoor Classroom

1) Now that students know about the next unit they will study, why it's important, and what their first task is, it might be helpful to set a few classroom norms for using the "outdoor classroom." While students may have visited the salmon stream and amphitheater previously during school, the class will be using this "outdoor classroom" many times during this unit to investigate the watershed's health. Before venturing outside, set up a group of classroom norms for being scientists outside. Some examples:
   - Be respectful of living things: let them grow.
   - Tread lightly: keep on the trails and paths.
   - Be prepared with outdoor layers and shoes that can get muddy (leave a pair at school?).
   - Establish attention getters for the outdoor classroom.

Part 3: Observing the Ecosystem (Stream)

1) Once the group is outside and headed down to the salmon stream, stop for a few minutes to give the group their first task: gathering observations about the stream ecosystem. Explain that it in order to make an informed prediction about the health of the stream, they will first **make observations and gather data** about what they see, smell, and hear around them. Model this for students:
   - The air smells really fresh. I don't detect bad smells, so this could be a sign the stream is healthy.
2) Keep walking down to the stream, moving slowly to allow everyone a chance to write down observations.
3) Note that one of the observations scientists make is about the weather. Ask the group why the weather is important to observe and record when conducting fieldwork.
4) Once down at the amphitheater, allow more time to observe and make a few more observations.

Part 4: Making Predictions (Stream)

1) While the group is sitting down on the benches in the amphitheater, allow time for students to make their predictions, answering this question: Do you think this part of the creek a healthy habitat for salmon? Prompt them to think of a **detailed rationale to explain their thinking**. Before writing, ask students to share their thoughts with a partner or small group. Then, they will write their thoughts. This prediction will serve as a formative assessment: what students think about the health of the stream and *why* will illustrate what they think is important in measuring stream health.

Part 5: Planning the Investigation

1) The next part of the students' jobs as scientists during this unit will be to conduct investigations into the health of the stream. Ask students to help **plan what information we need to gather** to determine the health of the stream. Begin to head back to class.
2) Back inside, ask students: what information de we need for this investigation? What data should we gather? How should we do it? Generate a list on chart paper. Explain that we work through this list and gather data, adding to it if necessary. Examples: temperature, pollution (chemicals), food, bacteria.
3) Ask students to also think about any additional information they need to understand what salmon need in a stream. Things to add to include: knowing the salmon life cycle, finding out when in their lives they need the stream and why (specific habitat needs).

Part 6: Wrap Up

1) Reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 2: What is a Watershed?

Time: 60 minutes
Location: Classroom and outside (playground)

Lesson Summary

To be able to conceptualize where the water in the stream comes from, students will create watershed models to observe where water and ground surface pollution travels. Using a map of the island, students will locate which watershed they are part of on Bainbridge Island and discover where the water flows.

Next Generation Science Standards

SP	**Obtaining, Evaluating, and Communicating Information:** Obtain and combine information from books and/or other media to explain phenomena **Developing and Using Models:** Develop and/or use models to describe and/or predict phenomena.
DCI	**ESS2.A. Earth Materials and Systems:** Four major Earth systems interact. Rainfall helps to share the land and affects the types of living things found in a region.
CC	**Systems and System Models**

Objective

By making a model watershed, students will be able to explain how water travels over land and how ground surface pollution affects local bodies of water (stream, lake, ocean). They will also be able to identify what watershed Sakai is in and brainstorm 2-4 possible threats to the stream ecosystem based on knowledge of how water flows within this watershed.

Assessment

Students will explain in writing at least two ways the surrounding land can affect the Sakai stream.

Materials

- Question/Answer Student Notebook page
- Scratch paper for making watershed models
- Spray bottles
- Magic markers (not permanent)
- Chart paper

Important Notes

For the watershed models, it is crucial to use markers that will "bleed" when wet. Test markers ahead of time! This lesson was adapted from a University of California 4H Agua Pura Project curriculum.

Part 1: What is a Watershed?

1) Revisit the class list from Lesson 1 detailing the information students need to learn to fully investigate the health of the stream. Today, students will learn about the Murden Cove watershed. As scientists, it is important to **obtain information to understand phenomena being studied.**
2) To help students start thinking about a watershed, start by asking: How do you think water ends up in our stream? Possible student answers include rain, water from other streams, or water from lawns running downhill to the stream.
3) As students think about water running down into the stream, help define the land surrounding the stream as a watershed:
    - An area of land that "sheds" water into a body of water
    - Watersheds are defined by their ridges, or the highest points surrounding a body of water
    - Rainwater can wash pollution and other substances on the ground into a body of water within a watershed. Bodies of water are heavily affected by the land surrounding them.
4) Ask students: What do you think might affect the stream water in this area (around Sakai)? Would those factors help or hurt the stream? Give time to discuss thoughts.

Part 2: A Watershed Model

1) After discussing the concept of a watershed, students will **build a model** to describe how the stream's health might be affected by the surrounding land (and brainstorm specific factors that might affect the stream).
2) Demo the watershed model for students:
   - Crumple a piece of paper up and loosely unfold it.
   - With a **blue** marker, color areas where you think water would collect (in valleys and crevices).
   - With a **black** marker, outline the ridges of the watershed: the highest parts that define the boundaries. This will help students understand the watershed boundaries.
   - With a **brown** marker, color places that might have exposed soil that could be washed away in the rain (not held in place by any vegetation).
   - With a **red** marker, color any pollution. Think through: where cars might leave oil, where dog poop might be, where chemicals might be, where houses might be and what pollutants come from houses.
   - Spray the model gently with water (just pantomime this; let students do this for the first time on their own). This symbolizes rain over the land. Model a light rain and a heavier rain. Ask students to predict what will happen in their models. How might amount of water affect the stream?
3) After the demo, give students materials directions for them to do this on their own. Questions to ask as they work: What is happening to your soil and pollutants? In what ways do you think the stream will be affected?

Part 3: Sakai's Watershed (Playground)

1) Connect the watershed models to the Sakai stream investigation by asking: Thinking about this watershed, what might affect the stream here? To help think about this, if there is time take a quick trip outside to see the slope of the land around Sakai. Walk out to the playground and ask students to locate the direction that water would flow over this land. Ask: what could get carried into the stream from our playground that might affect the stream?
2) Back in the classroom, connect the Sakai stream and the watershed models with the greater Murden Cove watershed by pulling up a Google map of the area and/or showing the Murden Cove map (on flash drive). Find Sakai and identify this watershed as the Murden Cove watershed, because all the water eventually flows out into Murden Cove.
3) Introduce students to the greater Murden Cove watershed project that we are part of. Highlight that multiple sites in the watershed are being tested; we are one of them and will be contributing our data to the water resource manager at the City of Bainbridge Island.
4) To conclude, ask students to think about and write thoughts to these questions:
   - Thinking about our watershed, what factors do you think could affect the health of our stream? How would those things end up in the stream? What effect do you think they would have on the stream's health?

Part 5: Wrap Up

1) Reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 3: The Salmon Life Cycle

Time: 60 minutes
Location: Classroom and playground

Lesson Summary
As scientists investigating the health of the salmon stream, students need to understand why salmon are important to the ecosystem. During this lesson, students will learn the life cycle of a salmon, including their journey to the sea and back. This will be done through short videos and a salmon game.

Next Generation Science Standards

SP	**Obtaining, Evaluating, and Communicating Information:** Obtain and combine information from books and/or other media to explain phenomena **Developing and Using Models:** Develop and/or use models to describe and/or predict phenomena.
DCI	**LS1.B. Growth and Development of Organisms:** Reproduction is essential to every kind of organisms. Organisms have unique and diverse life cycles.
CC	**Systems and System Models**

Objective
Through watching a short video about the salmon life cycle and playing the game "Salmon Journey," students will be able to retell the life cycle of a Pacific salmon, including the journey they make out to the ocean and back to the home stream to spawn. They will also be able to name 2-3 threats salmon face to their survival.

Assessment
In their science notebooks, students will write the journey of a Pacific salmon and name 2-3 threats to salmon.

Materials
- Question/Answer Student Notebook page
- Video on the salmon life cycle (flash drive)
- Poker chips
- 6 cones
- Rope to create boundaries

Important Notes
This game in this lesson needs a large space: the playground blacktop or indoor gym space are great locations. This game was adapted from a Project WILD Aquatic lesson.

Part 1: Salmon Life Cycle
1) Review the class list students made of what information they need in order to fully investigate the stream. To continue to gather information about what salmon need, scientists today are going to **obtain information** about the salmon life cycle by watching a video. They will play a salmon game, **using this as a model,** to describe the salmon journey from the stream to the ocean and back.
2) When you teach this lesson, if the salmon tank is set up with salmon, begin your lesson out in the hall by looking at the salmon and observing what stage the salmon are in (egg, alevin, or fry).
3) Back in the classroom (or start with this if there are no salmon yet), show a short video on the salmon life cycle. Together, draw/show a model of the salmon life cycle: egg, alevin, fry, smolt, adult.
4) Ask students to identify at what times during salmon lives they need the stream (eggs are laid in the stream, alevin and fry live in stream, adults return to the stream to lay eggs).
    - Salmon are anadromous: born in freshwater, spend lives in saltwater, return to freshwater.

Part 2: Salmon Journey Model Set Up (Playground)
1) To help conceptualize the salmon journey, students are going to **model the salmon journey** outside. This is a game, and make sure to **tell students that today the game is also a model**. By playing "Salmon Journey," students will be salmon with the object to make it out to the ocean as an adult salmon and return to the home stream to spawn. Along the way, there may be barriers prohibiting their success.

2) To play the game, in a large space (playground or gym):
    - Identify the “home stream,” where all the salmon will start, and the “open ocean.” Use rope to define boundaries. Most of the students will start out as salmon in the stream, ready to head out to the ocean. Explain that the salmon in the stream were born there: they grew from eggs, to alevin, to fry, now smolts. This took many months and the young salmon now need to go out to the ocean to grow. Establish the path that all salmon must try to take: go to the ocean and return to the home stream.
    - Along the way, the salmon might meet some threats to their survival. Introduce the first threat: predators in the stream, like blue herons, eagles, and otters. If a predator tags you with two hands, you are caught. Choose two students to be predators.
    - The next threat is fishers in the ocean. Choose two students to be fishers. Salmon face fishers in the ocean. If a fisher tags you with two hands, you are caught.
    - Once in the ocean, salmon must survive for approximately four years. In the “ocean” area, play two piles of poker chips. Salmon must collect these chips one at a time by retrieving them from alternating ends of the ocean. Once a salmon has four chips, he/she can migrate back home.
    - The home stretch is physically challenging: salmon must swim upstream to get back to the place to spawn (in the stream where they were born). Any surviving salmon must jump over the waterfalls in the stream, represented by cones. Salmon must jump from cone to cone until they are back in their stream. Sometimes streams have fish ladders to help the salmon swim upstream.
    - After salmon make it up the waterfalls, they potentially face one last set of predators before spawning. In some geographic areas, bears prey on these adult salmon. Other predators could be birds or otters. Choose one or two students to be this last set of predators, ready to “catch” salmon after they make it up the waterfalls.

Part 3: Playing the Game (Playground)

1) Once the boundaries and rules have been explained, the class is almost ready to play! Once students are “caught,” they wait by the side of the stream for the next round.
2) To help students conceptualize growing from egg to fry, have all salmon start as eggs in the stream. Tell them a story of hatching, becoming alevin and relying on their egg sacs, and becoming fry once the egg sac nutrients are used up. Have students act this out as you go.
3) If it appears that predators are tagging everyone and NO salmon are making it through, you can add limitations to the predators. Or, you can use this as a teaching moment to highlight how few salmon actually survive.
        - Examples of limitations: birds must hop, bears must stay stationary, predators must walk their “prey” out of bounds and return to their starting position before hunting again.
4) If you have students who don’t want to run and jump, add students to the waterfall section to monitor if the salmon make it up to the stream again.

Part 4: Adding in Human Impacts

1) To help students understand how human changes impact salmon, you can add in extra challenges to simulate this. Some examples:
    - Salmon have to crawl to the ocean because the water flow is so strong it slows them down. Water flow = strong when more water gets into the stream. This happens if there are few plants along the stream to soak up rain water (so rain goes straight into the stream).

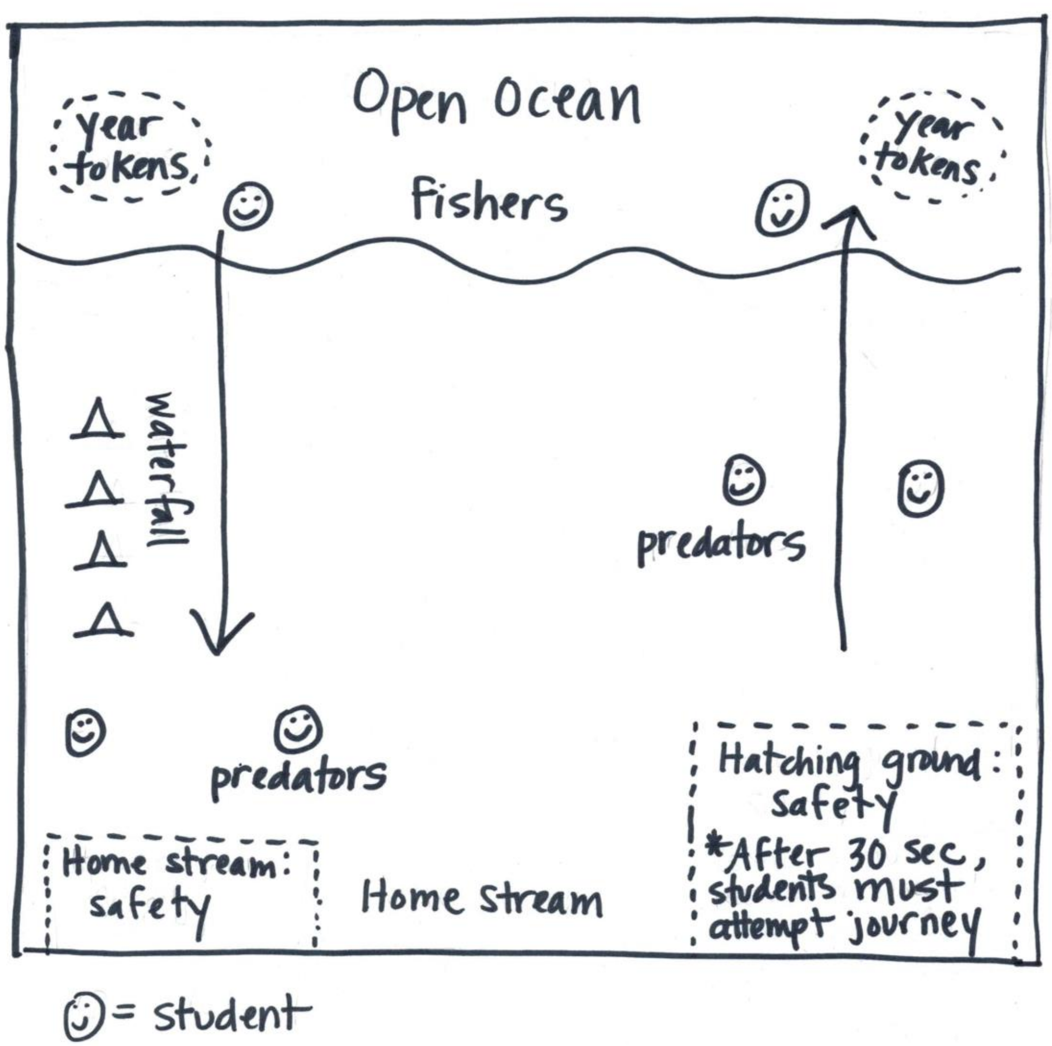
- The water is so turbid (cloudy) that salmon get disoriented easily. All salmon have to spin in place 5 times before attempting their journey.

Part 4: Debriefing the Game

1) After playing the game, head back into the classroom to debrief the game. Questions to ask:
   - How many salmon (students) ended up making it through for each round? Most likely, few did.
   - Out of 4,000 eggs laid in a redd (nest), how many do you think end up making it back to their home stream? The reality is very few: about 2 adults will be successful.
   - What seemed realistic about this game, as compared to the salmon life cycle and journey? What didn't seem realistic?
   - How did this **model of the salmon journey** help us **obtain important information** about salmon to help with our stream investigation (determining the health of the stream)?

Part 5: Wrap Up

1) To conclude the lesson, have students write about what they learned about the salmon life cycle, the journey salmon make, and 2-3 threats that face salmon throughout their lives. Also, have them reflect on how this information will help them, as scientists, investigate the health of the stream.
2) Reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.



Lesson 4: Assessing the Salmon Habitat

Time: 60 minutes
Location: Classroom and stream

Lesson Summary

This lesson includes students' second visit to the stream. After a brief time spent in the classroom viewing photos about salmon habitat needs, students will assess the stream ecosystem for these needs.

Next Generation Science Standards

SP	**Obtaining, Evaluating, and Communicating Information:** Obtain and combine information from books and/or other media to explain phenomena **Planning and Carrying Out Investigations:** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. **Analyzing and Interpreting Data:** Analyze and interpret data to make sense of phenomena using logical reasoning.
DCI	**LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Cause and Effect**

Objective

Through a visit to the stream, students will assess the physical habitat for salmon and determine if the stream has the necessary habitat features for salmon survival by drawing detailed maps and recording observations and notes in science field notebooks.

Assessment

In their science notebooks, students will record their observations and conclusions.

Materials

- Salmon Habitat Needs Student Notebook page
- Clipboards
- Pencils
- Salmon PowerPoint (flash drive)
- Teacher outdoor classroom bin

Part 1: Salmon Habitat Needs

1) In the previous lesson, students learned about life cycle of a salmon and modeled their journey to the sea and back. During today's visit to the stream, they will be **making observations** of the stream**, gathering data** to assess the stream's habitat for salmon. First, they need to **obtain information** about the different needs of salmon. Activate students' prior knowledge by asking: what stages of life do salmon need the stream? What do you think salmon need from the stream habitat?
2) Use the salmon PowerPoint slideshow to show students what habitat features salmon need throughout their lives. Students will **take notes** as you click through and explain the pictures. Students will need these notes when they head to the stream. The notes will help them determine what to look for.
3) In the presentation notes section for each slide, there is the information students will need. For each slide, ask students: what do you think the salmon need at this life stage? Help them by filling in gaps in their information.
    - Eggs: Adult salmon lay their eggs in gravel. It is important that the gravel bed be free of silt and finer sediment; these can smother the eggs and kill them (they won't get oxygen if covered).
    - Alevin: The alevin grow in the gravel and feed on their yolk sacs. It important that the water be clear and free of sediment. They need oxygen in the water, which happens when fast water moves over sticks and rocks, creating bubbles.

- Fry: Fry need to find their own food. They eat aquatic organisms that live in the water and in the surrounding plants. Fry need oxygen in the water, as well as hiding places from predators. They spend a few months in the stream before heading out to the ocean.
- Smolts: Smolts are ready to journey out into the ocean. They need to be able to hide from predators, breathe, and eat.
- Adult Salmon: After spending 2-5 years in the ocean, salmon are ready to return to their stream to spawn. Since they are making the journey upstream, adult salmon will need resting pools, where they won't get swept back downstream. Once they arrive in the stream, they need gravel to lay their eggs.

Part 2: Visit to the Stream (Stream)

1) After students have detailed notes on salmon needs, head down to the stream with student notebooks, clipboards, and pencils. Settle at the amphitheater.
2) Give students the instructions for the next part of the lesson: gather data by mapping the stream and noting different salmon needs. Make sure to reference the list made in the classroom: these features are salmon need in the stream. Show them the example of a birds' eye view map and go over the map key.
3) Model making a map if needed, starting with drawing the outline of the stream first and using the map key for helpful symbols.
4) Have the class start making their maps in the amphitheater, where they have a good birds' eye view of the stream. After a few minutes, have the class walk down to the stream, one at a time, for a closer look at the stream. Make sure students use the rope while walking down.

Part 3: Reviewing the Data

1) Back at the amphitheater, students will **analyze their data**: use their maps and their lists of salmon needs to determine if the stream has all salmon habitat needs (at least from today's data). Give time for students to look over their maps and check their lists.
2) Open a brief discussion about the condition of the habitat, asking: How well do you think this habitat provides for salmon needs at every stage of life? Are there any features of the stream that don't seem healthy? That do seem healthy? What other information might we need?
3) After some time to share thoughts, give students time to record their thoughts on how well they think the stream provides a healthy physical habitat. Prompt them to **use evidence to support explanations.**
   - Model writing a conclusion using evidence if needed: State the claim and back it up with rationale from the data, using today's observations as data.

Part 4: Wrap Up

1) Back in the classroom, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 5: Temperature, pH, and Turbidity Testing

Time: 60 minutes
Location: Stream

Important Notes

For this lesson, students will test the turbidity, pH, and temperature of the stream water. Put the class in four "stream teams." They will need these same teams for the rest of the stream sampling in the unit. You will need another adult to help with this lesson. It takes place at the stream.

Next Generation Science Standards

SP	**Planning and Carrying Out Investigations:** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon **Developing and Using Models:** Develop and/or use models to describe and/or predict phenomena.
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments. **LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Cause and Effect; Patterns**

Objective

Through the use of observational skills and stream sampling equipment, students will be able to assess the health through testing for turbidity, pH, and temperature.

Assessment

Students will record data and thoughts in their science notebooks. They will also participate in a final discussion to determine how healthy plants around the stream contribute to a healthy habitat for salmon.

Materials

- Stream Data Student Notebook page
- Clipboards
- Turbidity procedure sheets
- Turbidity tubes and cups
- Buckets
- Teacher Outdoor Classroom bin
- pH and Temperature bin

Part 1: Stream Observations

1) Informally review the data students have gathered this far about the stream's health by asking them to share what we have found. Review the class list from Lesson 1 about what information we need to gather. Explain that to keep gathering important data about the stream, today students will **gather data** through **observation**, with **testing equipment**, and **collaboratively in stream teams**.
2) Before heading out to the stream, put students into their stream teams (there should four teams total).
3) Students will head out to the stream with their clipboards and science notebooks. The first thing they will do is to assess the stream since the last time they visited, thinking about what looks new and/or what changes have taken place. At the amphitheater, probe students to think about the rationale behind this: why would it be a good idea to observe the stream again?
4) Since an important part of assessing the health of an ecosystem is to gather data over time, students will take note of any observations: smell, presence of foam (and description if present), sounds, etc.

Part 2: Turbidity, pH, and Temperature Demo

1) Ask your adult helper or a few students to head to the stream and fill four buckets halfway with water (or two full buckets that can be split into four buckets).
2) Ask students to think about why kind of water is best for salmon? Activate their prior knowledge here by prompting them to think of what they learned in the salmon PowerPoint (clean, clear, cool water).

3) Tell students that they are going to test the water today and see if it's healthy for salmon. Demo the tests using the water that was brought up by the adult or students. Use the procedure cards to **follow testing procedures** (have a student read the card). As you demo and explain the tests, have the students note the healthy ranges for these tests in their "notes" section.

Temperature

- Salmon need a temperature between 5^o and 15^oC (41-59^oF).
- Cooler water also holds more dissolved oxygen, which is important for salmon.

pH

- pH is a chemical test of the water to measure the concentration of hydrogen ions. pH stands for "power of hydrogen." You can test the pH of many things: food, soil, liquids.
- Some substances that end up in the stream can affect the pH negatively (bleach, soaps).
- Show the laminated scale and explain we measure pH on a scale from 0-14: 14 is basic, 0 is acidic, and 7 is neutral. Salmon need a very specific range of pH: 6.5-8.0.

Turbidity

- This measures the clarity of the water (cloudy or not cloudy).
- We want a turbidity reading of < 27 NTU for this stream.
- Turbidity standards for salmon-bearing streams in Washington are determined using the "background" level of turbidity in a stream, or baseline standard for a natural amount of turbidity. If the background is less than 50 NTU, the standard is that the turbidity should not exceed the background + 10 NTU. In our case the background for the stream is 17 NTU, so the turbidity should be below 27 NTU.

Part 3: The Tests

After the test demos, **students will carry out these tests**. Keep two stream teams at the amphitheater and send two to the adult (over by the steps or up on the trail).

Teacher

With two groups and two buckets, help stream teams run the turbidity test. Make sure they read the procedures and everyone has a job.

Adult

With two groups and two buckets, help stream teams run the temperature and pH tests. Make sure they read the procedures and everyone has a job.

After the groups are done, have them switch (turbidity go test temperature/pH and vice versa).

Part 4: Discuss Results

After the tests are complete, gather everyone at the amphitheater for a debrief. While you are debriefing, ask your adult helper to clean up the supplies.

1) Ask students: what does your group's data tell you about the health of the stream today? Invite group discussion or think-pair-share.
2) Highlight that there were four teams gathering data so there are four sets of data. Give this a little thought by asking students: How could it be helpful to have **multiple trials of the same test**? What, if anything, should we do with our different data to get the most accurate levels for temperature and turbidity for today? Do we have outliers? What could have caused those?
3) Help determine one class value of the data using mean, median, or a combination.
4) After the data has been analyzed, students will **write conclusions citing data** from today about the health of the stream.

    - Model writing a conclusion using evidence if needed: State the claim and back it up with rationale from the data. Today's data: observations.
5) Prompt students to think about what contributes to healthy pH, temperature, and turbidity of a stream:

    <u>Temperature</u>
    - Water shaded by trees
    - Seasonal changes also occur.

    <u>pH</u>
    - Some substances that end up in the stream can affect the pH negatively (bleach, soaps).

    <u>Turbidity</u>
    - Erosion along and near the stream makes water cloudy with dirt. Plants and trees can help hold the earth into place.

Part 5: Wrap Up

1) Before leaving the stream, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts in classroom. Write any new words learned on the "Words" chart.

Lessons 6 and 7: Water Testing with a Homewaters Educator

Time: 60 minutes
Location: Stream

Important Notes
You will have a Homewaters educator with your for lessons 6 and 7. Students will conduct turbidity, temperature, and pH tests, as well as learn to test for dissolved oxygen, macroinvertebrates, and use the Quanta probe. Over the next two lessons, all four stream teams will be able to test all parameters.

Next Generation Science Standards

SP	**Planning and Carrying Out Investigations:** Conduct an investigation collaboratively to produce data to serve as the basis for evidence. **Asking Questions and Defining Problems:** Predict reasonable outcomes based on patterns such as cause and effect relationships. **Constructing Explanations and Designing Solutions:** Use evidence to construct or support an explanation.
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments. **LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Cause and Effect; Patterns**

Objective
Students will be able to assess the health of the stream by testing the levels of dissolved oxygen, pH, temperature, and turbidity.

Assessment
Students will record test data and their conclusions about the stream's health in their student field notebooks.

Materials
- Stream Data Student Notebook page
- Clipboards
- Turbidity testing materials (tubes, cups)
- DO Testing bin
- Temperature and pH Testing bin
- Household liquids in jars with regular pH strips
- Buckets
- Macroinvertebrate Testing bin
- Teacher Outdoor Classroom bin

Part 1: Welcome at the Amphitheater
Gather at the amphitheater and introduce the Homewaters Educator. Explain the plan for today: to continue stream testing in order to determine if the stream is healthy for salmon. Send two stream teams down to the stream with the Homewaters Educator. Keep two teams at the amphitheater.

Part 2: Stream Tests
In stream teams, students will **students will carry out tests to gather stream data.**

<u>**Teacher:**</u> **pH/Temperature and Turbidity Tests at Amphitheater**
With two stream teams at the amphitheater, one will test the turbidity and one will test the pH and temperature. Then the groups will switch. Send two students down to the stream right away to get buckets full of water.

1) Start by activating students' prior knowledge: ask what they remember about these tests from the previous day. Why should we run these tests again? What are the optimal conditions for these tests?
2) Give them all a moment to write down the optimal levels in the notes section, and write notes about the weather, date, and purpose of today.
3) Send one team with a bucket and the Temperature and pH Testing bin to the open area by the stairs. They can start the test.

4) Keep the other team by the amphitheater and have them start on the turbidity test. Since there are three tubes, the group can split up to run more trials of the test.
5) When the teams are done with the first test, have them switch.
6) When everyone is done running both tests, gather together to **discuss results**:
    - Share data.
    - Determine if there are outliers and what might have caused this.
    - Use mean, median, or combination to determine one value of each test for the group.
    - Allow time for students to discuss and **write a conclusion** about the health of the stream **based on this evidence.**
7) If there is time, ask students what might affect the pH of the stream (substances, chemicals running into it). Test some solutions (in containers) with regular pH strips to discover how chemicals, bleach, and cleaners could affect the stream. Discuss how these might end up in the stream.

<u>HW Educator:</u> DO, Macros, and Quanta at the Stream

1) Before stream teams separate into their groups, introduce the Quanta. Have a brief discussion about how this technology might help us monitor the stream. Touch on pros/cons of using a hi-tech instrument (calibration, expensive, fast, easy to use). Set the Quanta in the stream (upstream from where the kids will be searching for macros) and leave it for a while. Wear gloves when handling the Quanta.
2) With the whole group, introduce the two other tests they will be doing at the stream: looking for macros as indicators of a healthy habitat and testing the oxygen level. Give a minute to have students jot down the purpose, date, and weather in their notebooks.
3) Demo collecting macros: using nets, treading lightly, returning to the bucket to put macros in. Send the macro group off.
4) Intro the DO test. Make sure to define DO, ask students why it's important for salmon, and where DO comes from (bubbles, faster water). Note that DO is different than the oxygen in H_20. Have them note the optimal level in notebook: <u>9.0 mg/L or more</u>.
5) Have the stream team **conduct the test** using the procedure cards. Monitor this closely.
6) After they have completed this test, have the macro and DO groups switch.
8) When everyone is done running both tests, gather together to **discuss results**:
    - Check on the Quanta: what does it say?
    - Share data: What did we find out about DO? What did you discover when searching for macros?
    - Determine if there are outliers and what might have caused this.
    - Use mean, median, or combination to determine one value of each test for the group.
    - Allow time for students to discuss and **write a conclusion** about the health of the stream **based on this evidence.**
7) Discuss what affects the DO in a stream:
    - Cooler water holds more oxygen.
    - If there are excess nutrients (fertilizer), this can cause an algae bloom. When algae decompose, the bacteria that help decompose them require oxygen. This can lower the DO.

Part 4: Wrap Up

1) Back in the classroom or at amphitheater as a whole class, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lessons 8 and 9: Water Testing in Stream Teams (No HW Help)

Time: 60 minutes
Location: Stream

Important Notes
These two lessons are the same as Lessons 6 and 7. The only difference is that there is no Homewaters educator. Instead, you will need an adult to help. By these lessons, students will know the routines and how to conduct the tests on their own. The teacher and adult will be there for support and supervision. The teacher should monitor the DO, Quanta, and macros at the stream, while the other adult monitors the pH, temperature, and turbidity.

Next Generation Science Standards

SP	**Planning and Carrying Out Investigations:** Conduct an investigation collaboratively to produce data to serve as the basis for evidence. **Asking Questions and Defining Problems:** Predict reasonable outcomes based on patterns such as cause and effect relationships. **Constructing Explanations and Designing Solutions:** Use evidence to construct or support an explanation.
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments. **LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Cause and Effect; Patterns**

Objective
Students will be able to assess the health of the stream by testing the DO, pH, temperature, and turbidity.

Assessment
Students will record test data and their conclusions about the stream's health in their student field notebooks.

Materials
- Stream Data Student Notebook page
- Clipboards
- Turbidity testing materials (tubes, cups)
- DO Testing bin
- Temperature and pH Testing bin
- Household liquids in jars with regular pH strips
- Buckets
- Macroinvertebrate Testing bin
- Teacher Outdoor Classroom bin

Part 1: Welcome at the Amphitheater
Gather at the amphitheater and introduce the Homewaters Educator. Explain the plan for today: to continue stream testing in order to determine if the stream is healthy for salmon. Send two stream teams down to the stream with the Homewaters Educator. Keep two teams at the amphitheater.

Part 2: Stream Tests
In stream teams, students will **students will carry out tests to gather stream data.**

<u>Adult:</u> pH/Temperature and Turbidity Tests at Amphitheater
With two stream teams at the amphitheater, one will test the turbidity and one will test the pH and temperature. Then the groups will switch. Send two students down to the stream right away to get buckets full of water.

1) Start by activating students' prior knowledge: ask what they remember about these tests from the previous day. Why should we run these tests again? What are the optimal conditions for these tests?
2) Give them all a moment to write down the optimal levels in the notes section, and write notes about the weather, date, and purpose of today.
3) Send one team with a bucket and the Temperature and pH Testing bin to the open area by the stairs. They can start the test.

4) Keep the other team by the amphitheater and have them start on the turbidity test. Since there are three tubes, the group can split up to run more trials of the test.
5) When the teams are done with the first test, have them switch.
6) When everyone is done running both tests, gather together to **discuss results**:
   - Share data.
   - Determine if there are outliers and what might have caused this.
   - Use mean, median, or combination to determine one value of each test for the group.
   - Allow time for students to discuss and **write a conclusion** about the health of the stream **based on this evidence.**
7) If there is time, ask students what might affect the pH of the stream (substances, chemicals running into it). Test some solutions (in containers) with regular pH strips to discover how chemicals, bleach, and cleaners could affect the stream. Discuss how these might end up in the stream.

<u>Teacher:</u> DO, Macros, and Quanta at the Stream

1) Before stream teams separate into their groups, introduce the Quanta. Have a brief discussion about how this technology might help us monitor the stream. Touch on pros/cons of using a hi-tech instrument (calibration, expensive, fast, easy to use). Set the Quanta in the stream (upstream from where the kids will be searching for macros) and leave it for a while. Wear gloves when handling the Quanta.
2) With the whole group, introduce the two other tests they will be doing at the stream: looking for macros as indicators of a healthy habitat and testing the oxygen level. Give a minute to have students jot down the purpose, date, and weather in their notebooks.
3) Demo collecting macros: using nets, treading lightly, returning to the bucket to put macros in. Send the macro group off.
4) Intro the DO test. Make sure to define DO, ask students why it's important for salmon, and where DO comes from (bubbles, faster water). Note that DO is different than the oxygen in H_20. Have them note the optimal level in notebook: <u>9.0 mg/L or more</u>.
5) Have the stream team **conduct the test** using the procedure cards. Monitor this closely.
6) After they have completed this test, have the macro and DO groups switch.
7) When everyone is done running both tests, gather together to **discuss results**:
   - Check on the Quanta: what does it say?
   - Share data: What did we find out about DO? What did you discover when searching for macros?
   - Determine if there are outliers and what might have caused this.
   - Use mean, median, or combination to determine one value of each test for the group.
   - Allow time for students to discuss and **write a conclusion** about the health of the stream **based on this evidence.**
8) Discuss what affects the DO in a stream:
   - Cooler water holds more oxygen.
   - If there are excess nutrients (fertilizer), this can cause an algae bloom. When algae decompose, the bacteria that help decompose them require oxygen. This can lower the DO.

Part 4: Wrap Up

1) Back in the classroom or at amphitheater as a whole class, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 10: Studying Macroinvertebrates

Time: 60 minutes
Location: Classroom

Lesson Summary
During this lesson, students will examine the macroinvertebrates from the stream to help determine the stream health. They will look at the stream samples in the classroom and use guides to identify the macroinvertebrates in the water. Using information about the pollution tolerance levels of the macroinvertebrates, students will determine if the organisms found indicate healthy or unhealthy water.

Next Generation Science Standards

SP	**Planning and Carrying Out Investigations:** Conduct an investigation collaboratively to produce data to serve as the basis for evidence. **Constructing Explanations and Designing Solutions:** Use evidence to construct or support an explanation.
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments. **LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Cause and Effect**

Objective
In teams of scientists, students will determine the health of the stream through examining macroinvertebrates found in water samples. They will do this by using microscopes and/or hand lenses and field guides to identify the invertebrates and determine their pollution tolerance levels.

Assessment
Students will record today's data and their conclusions on the stream's health in their student field notebooks.

Materials
- Macroinvertebrate Student Notebook page
- Clipboards
- Pencils
- Macroinvertebrates (IW educator)
- Tubs for macroinvertebrates
- Microscopes and/or hand lenses
- Petri dishes or ice cube trays
- Tools for macro collection in classroom
- Macro field guides
- Buckets to carry macros to/from the stream

Important Notes
This lesson will take place in the classroom, and there will be IslandWood educator support for this lesson. The IslandWood educator will collect the macroinvertebrates before the lesson and bring them to the classroom.

Part 1: Why Macroinvertebrates?
1) Have students gather around a tub with stream <u>macroinvertebrates</u> and ask them what they think these organisms are. Define with them the word by breaking it up into pieces:
   <u>macro</u> = big enough to see with the naked eye
   <u>in</u> = no
   <u>vertebrate</u> = backbone.

   Therefore, these are water organisms that have no backbone and we can see them. Explain where these organisms were collected from (where in the stream and how).
2) Ask: How do you think macroinvertebrates can tell us if the stream is healthy? Some key points:
   - Macroinvertebrates needs similar things as salmon: DO, the right temperature, a healthy pH, and the right turbidity level.
   - Some macroinvertebrates can tolerate more polluted, unhealthy water. Some are very sensitive to polluted, unhealthy water.

Part 2: Identifying the Macroinvertebrates
After you have set a clear purpose for why we are examining the macroinvertebrates in the stream, model the process that students will follow today:

1) Model how to retrieve the macroinvertebrates using the tools (turkey baster, spoon, petri dish). Make sure to review safety precautions: using the right sized tool for each organism, making sure there is always water in the petri dish or ice cube tray, and handling them with care. Let students know that the invertebrates will be returned to the stream when we are done studying them.
2) Show the field identification guides and give some tips on how to use them. When identifying the invertebrates, encourage students to:
    - Look at the structure of the organism: number of legs, number of tails, segments, shape.
    - Examine other characteristics: color, movement, size.
3) In **stream teams students will investigate** the invertebrates by finding and identifying them. Have them record what they find in their field notebooks.

Part 3: Determining the Health of the Water

1) After giving students 15-20 minutes to **observe and identify** the invertebrates, have students put down their tools. At this point, they have macroinvertebrates identified and recorded the data.
2) Pause here to further discuss how the macroinvertebrates can indicate stream health. Show students that their field sheet is divided into two categories:
    - Organisms that need healthy water to survive
    - Organisms that can live in any water, healthy or unhealthy.
    - Have students label these two categories: <u>Healthy</u> and <u>Unhealthy</u>.
3) Ask students to think about these categories: What if we find only invertebrates that can tolerate unhealthy water? What if we find only invertebrates that need healthy water? What do these different results indicate about the stream health? Guide them through thinking about this, making sure to clarify:
    - Invertebrates that need healthy water can only live in healthy water. If you find these, your water is healthy.
    - Invertebrates that can live in unhealthy water can also live in healthy water. Finding healthy invertebrates is key if your water is healthy.
    - If you find a mix of invertebrates that can live in healthy water and unhealthy water, your water is healthy.
4) Before concluding, make sure students return all invertebrates to the tubs and clean all tools.

Part 3: Conclusion

1) Have stream teams share their data with the rest of the class. Compile all the data together and analyze this information as a class, prompting them to:
    - **Look for patterns in the data**
    - Determine what these data show about the stream's health **citing evidence**
2) After time to **discuss and analyze the data**, students will **write their conclusions citing evidence**.
3) Together, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 11: Pollution as a Threat to Stream Health

Time: 60 minutes
Location: Stream

Important Notes
Bring the Quanta to the stream to test the water today. Students will not be conducting other tests, but the Quanta can help gather data on temperature, pH, turbidity, and DO. The whole class will be staying together throughout the lesson, but it could be helpful to have another adult with you.

The lesson today will involve a harmless dye to simulate pollution entering the stream. The dye will not hurt the stream, but citizens downstream of Sakai might think it's a pollutant. Give Cami Apfelbeck prior notice of this activity (at least one day) by calling or emailing: (206) 780 3779, CApfelbeck@bainbridgewa.gov.

Next Generation Science Standards

SP	**Planning and Carrying Out Investigations:** Conduct an investigation collaboratively to produce data to serve as the basis for evidence. **Constructing Explanations and Designing Solutions:** Use evidence to construct or support an explanation.
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments.
CC	**Cause and Effect**

Objective
At the stream, students will test the water using the Quanta. They will also participate in a pollution model, learning firsthand how little pollution can affect a much larger area of the stream.

Assessment
Students will record test data and their thoughts on the stream's health in their student field notebooks.

Materials
- Quanta
- Stream dye and spoon
- Teacher Outdoor Classroom bin
- Stream Data Student Notebook page

Part 1: Set Purpose
1) At the amphitheater, prompt students to think about how healthy the stream is so far, based on the data they have gathered. Invite a brief group discussion.
2) Explain that the purpose of today is to test the stream, using the Quanta, and to learn about threats to the health of the stream. Have students note this purpose on their data sheets.

Part 2: Pollution as a Threat
1) Walk students down to the stream, making sure to take the Quanta and the stream dye. They can leave clipboards in the amphitheater.
2) At the stream, have some students help place the Quanta in the water (wear gloves). As a class, you will **test the water with the probe** in situ. Leave it to stabilize.
3) As a class, brainstorm potential threats to the health of the stream. Over the past few testing lessons, they have learned about a variety of them. If helpful, prompt them with:
   - What affects the temperature? The turbidity? The pH? The DO?
4) As students brainstorm, make a list on your whiteboard. You can help them determine which pollutants come from a specific source (like a factory) and which come from an indistinguishable source, like from runoff. The two terms for these different types of pollution are point source and nonpoint source.
   - Regardless of the source, the effects of pollution can be widespread. Today's demo will show students how a little "pollution" affects a greater area.

5) Create a scenario in which a pollutant is dumped into the stream (can be point source or nonpoint source). Tell students that you are going to use harmless dye to act as the pollutant in the stream. As you tell the story, "pollute" the stream with 1-2 spoonfuls of dye (use less in lower flow). This is a **model for pollution** that might happen in the real world.
6) Check and note the Quanta levels, then head up to the amphitheater and downstream to watch for the dye (it might take a while, depending on the stream flow). Observe the effects of the "pollutant" on the rest of the stream.
7) Open a discussion with students about how a little pollutant can affect a greater area. Were any of them surprised at the pollutant's effect? What if the dye was a harmful chemical? What other areas of the stream would be affected? What could citizens in a watershed do to prevent harmful pollutant effects?

Part 3: Conclusion

1) After watching the stream pollution model, have students write down their reactions on the back of their stream data sheet.
2) Report out the levels from the Quanta and have them **write their conclusions** about the health of the stream **based on these data** today.

Part 4: Wrap Up

1) Back in the classroom or at the amphitheater, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Optional Follow Up Lesson

To explore this concept of stream pollution from a nearby source, here is an optional follow-up lesson that uses a community meeting role play approach.

Community Meeting Role Play

To help students understand how complex ecological issues can be, engage them in a short role play. This 15-minute activity will task students to take on a role in a fictional community centered around a stream.

- The stream is being polluted by a nearby business which affects the community and its members differently. Students will be in groups of four and will have one of the following roles: citizen scientist, teacher, factory worker, factory worker's family member.
- Hand out a card to each student and have them get into groups according to number on their card.
- Read the scenario and prompt students to think about how they feel about the scenario, according to the role on their card. Allow some time for groups to share their different points of view.
- Come back together to debrief the experience. Is there one clear solution to this problem? How might this community solve the pollution problem while taking care of all of its community members?
- Close out by discussing how sometimes it may seem like there is only one right answer if you consider a problem from one point of view. It's important, especially within a community, to consider others' needs as well when trying to solve problems or improve situations.

Lesson 12: Erosion as a Threat to Stream Health

Time: 60 minutes
Location: Stream

Important Notes
Bring the Quanta to the stream to test the water today. Students will not be conducting other tests, but the Quanta can help gather data on temperature, pH, turbidity, and DO. The whole class will be staying together throughout the lesson, but it could be helpful to have another adult with you.

Next Generation Science Standards

SP	**Planning and Carrying Out Investigations:** Conduct an investigation collaboratively to produce data to serve as the basis for evidence. **Constructing Explanations and Designing Solutions:** Use evidence to construct or support an explanation. **Developing and Using Models:** Develop and/or use models to describe and/or predict phenomena.
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments.
CC	**Cause and Effect**

Objective
At the stream, students will explain how plants and trees around a stream can contribute to healthy levels of turbidity. They will demonstrate this using land models.

Assessment
Students will record test data and their thoughts on the stream's health in their student field notebooks.

Materials
- Tupperware containers with holes
- Quanta probe
- Buckets and cups
- Teacher Outdoor Classroom bin
- Pink basins
- trowels
- Stream Data Student Notebook page

Part 1: Set Purpose
1) At the amphitheater, prompt students to think about how healthy the stream is so far, based on the data they have gathered. Invite a brief group discussion.
2) Explain that the purpose of today is to test the stream, using the Quanta, and to explore one way to keep the level of turbidity healthy in the stream.
3) If you have another adult with you, send them down with a couple of students to set the Quanta (students could use the Quanta procedures). As a class, you will **test the water with the probe** in situ. Leave it to stabilize and have the group come back up.

Part 2: Turbidity Investigation
1) Send a couple of students down to the stream to fill two buckets with water.
2) Job students' memories about turbidity. Have them recall what it is, how we test for it, and why it's an important test at the stream. Brainstorm for a few minutes what might help turbidity stay healthy and what might contribute to unhealthy turbidity (more sediment, erosion).
3) Explain that we are going to **use models of the stream** to investigate how to help our stream's turbidity stay healthy.
4) In groups of 3, challenge students to create a model landform with a slope. Model this: dig up some soil and create a downward slope in a Tupperware. The hole should be at the bottom of the slope.
5) Explain that this model is a Sakai stream model. Place an empty basin under the hole to be the stream.

6) Using a cup of water, make it “rain” on the model. Observe the quality of the water washing over the land and dumping into the stream.
7) Discuss what students are seeing. What is happening in the model? (Erosion, high turbidity)
8) Challenge students to add things (from the ground) to their models to try and prevent high erosion and high turbidity in the model. They can collect leaves and sticks (anything dead, down, and decaying).
9) Let students make it “rain” again in the model. Is there a difference in erosion and water quality?
10) Lead a closing discussion. Assuming students found ways to prevent erosion and improve water quality, ask them to think about what in the real world could do this (plants and trees).

Part 3: Conclusion

1) After making their stream models, lead a closing discussion. Assuming students found ways to prevent erosion and improve water quality, ask them to think about what in the real world could do this (plants and trees).
2) Send the adult and one student to retrieve the Quanta.
3) Report out the levels from the Quanta and have them **write their conclusions** about the health of the stream **based on these data** today.

Part 4: Wrap Up

1) Back in the classroom or at the amphitheater, reflect on what skills students used as scientists today and what information they learned. Write thoughts on the “Practices” and “Ideas” charts together. Write any new words learned on the “Words” chart.

Lesson 13: Using the Online Database

Time: 60 minutes
Location: Classroom

Lesson Summary
This lesson will take place in the classroom and will focus on compiling all of the data students have collected thus far. They will enter the data into an online database found at **http://islandwood.org/sakai**. Through the same website, students will generate graphs based on this data.

Important Notes
It will be important to model how to use the website at the beginning of the lesson. When students are entering data, they can work within their stream teams and take turns entering numbers for each testing parameter. It will be helpful to use a class set of computers for this lesson, or at least make sure there is one computer per team.

The website is pass word protected. The username and password are **sakai**.

Next Generation Science Standards

SP	**Constructing Explanations and Designing Solutions:** Use evidence to construct or support an explanation. **Analyzing and Interpreting Data:** Represent data in tables and graphs to reveal patterns that indicate relationships. Analyze and interpret data to make sense of phenomena, using logical reasoning. **Using Mathematics and Computational Thinking:** Organize simple data sets to reveal patterns that suggest relationships.
CC	**Patterns**

Objective
In teams of scientists, students will upload their stream data to the online database. They will generate graphs of each testing parameter and analyze this data by answering the questions: what patterns do you see? Why do you think those patterns in the data exist? What do these data tell you about the stream health?

Assessment
Students will upload all their data online and will record their thoughts in their field notebooks.

Materials
- Data Analysis Student Notebook page
- Computers: either class set or one computer per stream team

Part 1: Model the Online Database
1) Ask students what they think we should do with our data, now that we have collected several days' worth. Mention, if you haven't already, that while we have been sharing our data internally at the end of each class period, there are other people on Bainbridge Island testing the health of this same stream. Help guide them toward the notion of sharing it, recording it in one place, and being able to access it easily. Also, if applicable, remind them that other classes have also collected data.
2) To help them **compile their data**, we are going to **use an online database** found at: **http://islandwood.org/sakai**. This database is a tool for collecting our information and can display data in graphs and charts.
3) Model using this system for students. Navigate through:
   - Entering the date and time the data was collected.
   - Converting temperature from F to C.
   - Entering notes and group name.
4) Also model how to review saved data. Once students enter their data, they will be able to graph different parameters and retrieve a list of data for specified date ranges.

Part 2: Upload Data

1) After modeling, **students upload their data** in stream teams. Prompt them to look through their entire field notebook and make sure all data is entered. It is okay to enter only one or two pieces of information for one day if that is all the data they have (not all parameters need to be filled out for each day).
2) In teams, students will need to make sure everyone has a turn at entering the data.

Part 3: Analyze the Data

1) Once data entry is complete, regroup and ask students what they think the next step should be, now that we have the data in one place that is easy to access (analyze data, look for trends).
2) To help analyze the data, model how to depict the data in a graph through the online database:
    - This is done through Review Saved Data.
    - Select the desired parameter and click on Show Trends.
3) Looking a list of the data is a good way look for patterns in the data. This is done by:
    - Under Review Saved Data, enter desired date range.
    - Note: this is also where any qualitative data (entered under Notes) will be shown.
4) Before students start to look at the data, ask them to think about these questions:
    - What data points and date ranges do you want to examine?
    - Why have you chosen that data?
5) Once students have a plan about what data to begin to look at, they will return to their computers. As they **generate the graphs and charts of the data**, have students log their thoughts in their student field notebooks as they:
    - Choose what data to look at and why (what parameters, what date ranges)
    - **Look for patterns**
    - Think about the **explanation for those patterns**
    - Determine what these data indicate about stream health
6) Looking for patterns in data might be a new skill for students. If so, draw some sample graphs (or make a graph from data in the database) to model for students how to look for patterns, using these questions as guides:
    - Can you describe what the data is doing?
    - Looking at the data, can you predict what the next outcome would be?
    - Are there any data that don't seem to fit?

Part 4: Conclusion

1) After time to analyze data, bring the class together and share what patterns and trends students are finding. Give time for students to share out and make sure everyone had a chance to **write down their thoughts (citing evidence)** in their notebooks.
2) Reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 14: Analyzing Bacteria and Nutrient Levels

Time: 60 minutes
Location: Classroom

Lesson Summary

In this lesson students will learn about the nutrient and bacteria tests that have been happening monthly, as part of the greater Murden Cove watershed monitoring. These samples are sent to a lab in Seattle and analyzed for levels of nitrogen, phosphorous, ammonia, and fecal coliform. In pairs, students will choose one parameter to look at closely and determine if the levels are healthy.

Next Generation Science Standards

SP	**Analyzing and Interpreting Data:** Represent data in tables and graphs to reveal patterns that indicate relationships. Analyze and interpret data to make sense of phenomena, using logical reasoning. **Using Mathematics and Computational Thinking:** Organize simple data sets to reveal patterns that suggest relationships. **Engaging in Argument from Evidence:** Respectfully provide critiques about a proposed explanation by citing relevant evidence
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments. **LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Cause and Effect; Patterns**

Objective

Students will continue to analyze their data, looking at either nutrients or bacteria. They will generate graphs of chosen testing parameters and analyze these data to help determine the stream health.

Assessment

Students will manipulate data online and record thoughts in their field notebooks on what these data show.

Materials

- Data Analysis Student Notebook page
- Computers: either class set or one computer per stream team
- Bacteria and nutrient sampling PowerPoint (flash drive)

Part 1: Bacteria and Nutrient Testing

1) Review what students accomplished during previous lesson. What data did they upload? What did they analyze? What are their thoughts thus far about the health of the stream for salmon?
2) Introduce the bacteria and nutrient testing. Some key points:
   - Monthly samples have been collected starting in April 2013
   - A lab in Seattle runs tests on the samples to determine nutrient and bacteria levels.
   - Samples are analyzed for <u>nitrogen</u>, <u>ammonia</u>, <u>phosphorous</u>, and <u>fecal coliform</u>
   - The water is sampled in the morning, usually between 8 – 9 am
3) Because this sampling happens once a month in the morning most students will not have been involved. Show students the slideshow while narrating the process (slideshow is on the flash drive). Invite students who may have been involved already to help explain what is happening.
4) Open a brief discussion on why it might be important to test for these nutrients and bacteria.
5) To help students picture how the water is tested, show them a short YouTube video on one way to test for fecal coliform: **www.youtube.com/watch?v=iEDazeWs2Ys**
6) Choosing fecal coliform, talk with students more about where fecal coliform bacteria come from and why they are unhealthy in a stream (or other water). Some key points about fecal coliform:

- These bacteria live in the intestines of warm-blooded animals.
- While fecal coliform itself does not carry disease, its presence can indicate possible disease-carrying organisms.
  - These disease-carrying organisms live in the same environments as fecal coliform.

Part 2: Continue Data Analysis

During the next part of this lesson, students will examine bacteria and nutrient levels found in the stream. While as a class you haven't talked about why high levels of nitrogen, phosphorous, and ammonia can be unhealthy, students will be researching this.

1) Remind students of the overall purpose of the stream research: to determine if the stream is healthy or not. In stream teams, decide on what nutrient and bacteria parameters students want to examine today. Within a stream team, students can split into two smaller groups and research in pairs or trios.
2) The data for Sakai will be uploaded to the database and can be accessed like the other data.
3) As they **generate the graphs and charts of the data**, have students log their thoughts in their student field notebooks as they:
   - Choose what nutrient or bacteria parameter to look at
   - Research how those bacteria or nutrients affect stream health and a possible source
   - **Look for patterns** in the data
   - Think about the **explanation for those patterns**
   - Determine what these data indicate about the stream health

Part 3: Sharing Data

1) Because students worked in pairs or trios, have them regroup in stream teams and share their research and conclusions. Encourage students to make sure peers have cited relevant evidence in their conclusions.
2) After sharing, give scientists a minute or two to jot down what they learned from their peers about the nutrient and bacteria levels in the stream.

Part 4: Wrap Up

1) Reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Lesson 15: Connecting to the Murden Cove Watershed

Time: 60 minutes
Location: Classroom

Lesson Summary

After two days of data analysis, students will compile their data with the data from other testing points in the Murden Cove watershed. In this lesson, they will be able to analyze the trends from the whole watershed, look for patterns, and record their thoughts on the health of the greater watershed to contribute to the greater Murden Cove project.

Important Notes

Monthly sampling has been occurring at multiple sites throughout the Murden Cove watershed, one of which is in the Sakai stream. Because students are gathering data and analyzing it to determine the health of the greater watershed, it is necessary for them to examine all of the data. The data from the other sites is uploaded monthly.

It might be most helpful to do this lesson as a class. The point is that students will be able to identify, on their own or with your support, what is happening in the watershed. Do the data show problems? Is it healthy?

Next Generation Science Standards

SP	**Analyzing and Interpreting Data:** Represent data in tables and graphs to reveal patterns that indicate relationships. Analyze and interpret data to make sense of phenomena, using logical reasoning. **Using Mathematics and Computational Thinking:** Organize simple data sets to reveal patterns that suggest relationships. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific information orally and/or in written formats, including tables and charts
DCI	**LS4.C. Adaptation:** Particular organisms can only survive in particular environments. **LS4.D. Biodiversity and Humans:** Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
CC	**Patterns; Systems and System Models**

Objective

In their stream teams, students will choose one other testing site in the Murden Cove watershed to compare their data to. They will analyze data from the 2nd site and use it to draw a conclusion about the health of the greater watershed, citing specific evidence.

Assessment

Students will analyze data from another site in the Murden Cove watershed and record their thoughts on the health of the watershed in light of these new data. They will cite specific evidence to support their thinking.

Materials

- Data Analysis Student Notebook page
- Computers: either class set or one computer per stream team

Part 1: Looking at the Murden Cove Watershed

1) With the class, pull up a Google map satellite image of Sakai and define the Murden Cove watershed again (done previously in lesson 2).
2) Ask teams to **share their current thoughts** about the health of the stream, as evidenced by their data analysis over the past two days.
3) Remind them that we are doing this research to determine the health of the entire Murden Cove watershed. Other groups have been testing the stream but at different sites. We have access to their data and today we are going to look at it. Point out the other sites on the map.

Part 2: Analyze Data from 2nd Site

1) Introduce the team task for today:
    - Teams will choose one other site in the Murden Cove watershed to examine.
    - Each team member will look at one parameter: DO, temperature, turbidity, pH, fecal coliform, or one nutrient.
    - Team members will use the same process of **data analysis** as in previous lessons: access the data, examine the graph of the data, look for patterns, record why they think those patterns exist, and determine what the data indicates about the stream's health.
2) After groups have examined the individual testing parameters for a different site, they will **discuss with team members** what they found out. As a team, the students will:
    - Share their thoughts and listen to what their teammates have found out.
    - Compile their thoughts to paint a larger picture of stream health, according to this one other site.
    - Record their thinking and conclusions, supporting thoughts with evidence.
    - Determine how this information compares with the data they have from the Sakai site. Is it consistent? Are there differences? What might be causing those differences?

Part 3: Compiling Data from Around the Watershed

1) After teams meet to analyze and compile data and thoughts, they will report to the class on:
    - A summary of what the data shows
    - If this data is consistent or inconsistent with data from the Sakai site
    - What the team thinks this data shows about the watershed's health and why
2) As teams report, other teams need this information to help ultimately draw conclusions about the health of the greater watershed.
    - It could be helpful to have a scribe record the thoughts from the teams on chart paper.
3) After teams report out, prompt a class discussion of the data. As **one large team of scientists, students will discuss:**
    - What does this show about the health of the watershed? Why do you think that?
    - What patterns do you see? Why do you think those patterns exist?
4) After the class discussion, students will record their thoughts about the health of the watershed, answering key questions:
    - Based on the data, do you think the watershed is healthy for salmon, or other living organisms? Why or why not? Cite specific evidence.

Part 4: Wrap Up

1) Reflect on what skills students used as scientists today and what information they learned. Write thoughts on the "Practices" and "Ideas" charts together. Write any new words learned on the "Words" chart.

Culminating Project: Engineering a Solution

Time: 8-10 sessions, 60 minutes each
Location: Classroom

Lesson Summary

Over the next two weeks, students will be developing solutions to improving the stream and/or greater watershed's health, based on the data they collected through stream monitoring. Students will prepare and give presentations of their ideas to a community audience.

Next Generation Science Standards

EP	**Defining Problems**: Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, and/or cost. **Developing and Using Models:** Develop a diagram or simple prototype to convey a proposed object, tool, or process. **Designing Solutions:** Use evidence to design a solution to a problem. **Engaging in Argument from Evidence:** Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. **Obtaining, Evaluating, and Communicating Information:** Communicate scientific information orally and/or in written formats, including tables, diagrams, and charts.
DCI	**ETS1.A. Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution. **ETS1.B. Developing Possible Solutions:** Testing a solution involves investigating how well it will perform under a range of likely conditions. Communicating with peers about proposed ideas can lead to improved designs.
CC	**Cause and Effect; Patterns; Systems and System Models**

Objective

In small groups, students will design a solution to improving the stream's health based on the data they collected. They will share their ideas with the greater Murden Cove community in written or oral form.

Assessment

Students will design a solution to improving the health of the Murden Cove watershed and will share this information with the community (see student rubric).

Materials

- Science field notebooks
- Computers
- Presentation materials (poster board, etc)
- Engineering Project Student Rubric

Lesson Structure

There are many important components of a successful final project for this unit. The student rubric will help students formulate their projects, and students should have access to this from the beginning of the project. The mini lessons below match to the project components on the rubric. These mini lessons are designed to last about 10-15 minutes, with the remainder of the class for student work time. To help work through these project components, there are corresponding graphic organizers for students to use (flash drive).

Since students will be working as engineers during these lessons, at the end of each class period reflect on what skills students used as engineers and what information they learned. Use new "Practices" and "Ideas" chart for this purpose, along with a new "Words" chart. This will help students distinguish between the two roles of scientist and engineer.

Define a Problem

Mini Lesson 1: Identify a Problem Based on the Data

1) Now that students have collected and analyzed data from the stream, ask if any of them have ideas on how to improve the health of the stream and/or greater Murden Cove watershed.
2) After allowing for some time to share thoughts, explain that they are thinking like engineers, or problem solvers. Engineers define problems and develop solutions to them.
3) Do a quick Google search and show students some examples of solutions created by engineers. Identify the problem and discuss the solution. Some internet search examples:
   - Bainbridge Island rain gardens
   - Seattle bridges (lift up for boats)
   - Detention ponds (detain water to prevent flooding)
4) Introduce their final project: in small groups or solo, students will define a problem based data from the stream and develop a solution.
5) Prompt students to refer to their student notebooks. Make a class list of problems that are evident based on these data.
6) After talking as a class, students will get in small groups to start on their final projects. Their task for the rest of the class is to define a problem to solve and begin to create a solution:
   - Choose a problem they are interested in solving. Look through field notebook notes to help pinpoint a problem. Create a statement that clearly defines the problem.
     - Problem statement example: Design a solution that lowers the turbidity in the stream.
   - Identify the data that supports this problem. This is the evidence that helps define the problem.
   - Identify at least one possible cause of the problem. For example, if fecal coliform levels are high, why might that be? What factors could lead to this? Students can turn to the internet to help research possible causes.

Create a Solution

Mini Lesson 2: Outlining a Solution

By now, students should have identified the problem they want to solve and at least one possible cause to that problem. Having these items clearly identified will set students up for success as they move forward to create a solution.

1) Given a problem, students will now begin to create a solution and create a clear explanation. To help students with this, model an example or do one together as a class:
   - Problem: High water temperatures in the stream
   - The data shows this. (Cite data).
   - A possible cause: stream does not have adequate canopy cover. I know this is a feasible cause because I have observed fewer tall trees by the stream.
2) The next step would be to think of a solution that solves the problem by tackling the cause of the problem. Think through another example if needed, using a problem that you brainstormed as a class in min lesson 1.
3) As students work through this process, prompt them to clearly outline their solution, including rationale behind their thinking.
4) When they have a solution developed, challenge them to about why that solution might work. Have them think of at least two compelling reasons why the solution might work; engineers want to make sure their solutions are feasible.

Mini Lesson 3: Considering Constraints

1) With a potential solution in mind, brainstorm as a class what is important to consider when designing a solutions. Some key points:

- Cost: Is this a solution that can be implemented with little or no cost? What would it cost? Could the community afford this?
- Time: How long will it take to develop this solution? Is there time involved to maintain the system, tool, or process being proposed?
- Materials: What is needed to implement this solution? Where might those materials come from? Who will build or implement this solution?
- Other things might need to be considered, like space for the project, access to the stream, etc.

2) Ask students why they think it's important to consider these things when engineering (increases likelihood of success of the solution, helps create designs that are within the means of the community, helps define what is needed for the solution to be successful).
3) If you would like to give students constraints for their designs (e.g. a budget or limitations on materials), do so now. Otherwise, have everyone consider the time, materials, and cost and determine what is needed for successful implementation of their solutions. As a designer, being up front with these, and trying to minimize them, may help ensure greater success.

Mini Lesson 4: Creating a Diagram, Prototype, or Model

1) To help think through students' proposed solutions, and to help communicate the ideas clearly to other audiences, it is helpful to create a diagram, prototype, or model (whichever is more appropriate for the solution).
2) To give students ideas, do an internet search for "design prototypes" and show students some of the examples. Diagrams often have:
   - Detailed illustrations
   - Labels
   - Arrows showing movements (if applicable)
   - Explanations
3) Allow students work time to continue progress on their solutions, including the development of a diagram, prototype, or model.

Test Your Ideas

If students have the chance to test an idea, this is great! Most likely, many of them will not have this chance. The testing process is very important in engineering as it helps people improve their designs. So, in lieu of actually testing a solution, all students can invite critique from their peers in order to help improve their designs.

Mini Lesson 5: Critiquing Each Other's Work

Engineers rely on their peers to help improve their designs and solutions. Inviting critique from others by being open to their questions and ideas helps devise the best solution possible. Providing constructive critique might be new for many students.

1) Before inviting groups to provide feedback to others, develop some guidelines for doing so. These may include:
   - When listening to a classmate's idea, keep in mind that the goal is to help them improve their design.
   - Ask questions to help classmates improve their design.
   - Remember to also give feedback on aspects of the design that seem successful.
   - When receiving feedback, take notes.
   - After listening, make sure to thank your classmate for their thoughts.
2) If needed, model this process for the class. Perhaps present an idea of your own and ask them to give you feedback.

3) Pair groups to give each other feedback (or have them self select).
4) After students give/receive feedback, allow time to improve their designs based on the questions and ideas from their classmates.

Present Your Ideas

Mini Lesson 6: Choosing an Audience

1) To share students' projects with a greater audience in the Murden Cove watershed, students will all have the chance to present their data ideas. During this lessons, help students choose an appropriate audience. Some examples:
    - Hold a science night and invite parents, scientists from the City of Bainbridge Island, other partners in the Murden Cove watershed monitoring
    - Present at a City Council or school district meeting
    - Present to an environmental science high school class
    - Present to local residents of the Murden Cove watershed
2) After students have decided who they want to present to (and who would best benefit from this knowledge), help them determine if they are going to give an oral presentation (using PowerPoint or other visuals), develop a video, or create a poster board display.
3) From now on, students will continue to work on crafting their solutions and developing a presentation to share their ideas.

Mini Lesson 7: Elements of the Final Project

1) As students continue to work on their solutions, make sure they know what elements they need to include in their final project, regardless of the audience they share it with. As scientists and now engineers, they need to make sure they have:
    - A summary of the problem: what problem are you trying to solve? Do you have evidence to show this problem exists? Why do you think it will work?
    - A clearly explained solution: how will this solution be implemented? What are the costs, time involved, and materials needed?
    - Visual representations of the problem (data) and the solution
    - A reflection on what students have learned. This unit has encompassed science and engineering practices and content, and this final project is a great opportunity for students to reflect and share about:
        - The most important science practice(s) they learned
        - The most important engineering practice(s) they learned

Mini Lesson 8: Ingredients of a Great Oral Presentation

2) As students prepare to give oral presentations to share their data, open a brief discussion about what makes a great presentation (or what doesn't make one!). Start to generate a list. Some key points:
    - Eye contact with audience
    - Use of good visuals
    - Not too much text (especially in PowerPoint slides)
    - Clear speaking voice
    - Information communicated is well-explained
3) Share some examples of effective oral presentations to help brainstorm.
    - http://blog.ted.com/2012/10/17/9-talks-by-impressive-kids/
4) Remind students to practice their presentations!

Next Generation Science Standards

Science and Engineering Practices	
Planning and Carrying Out Investigations	• Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon • Conduct an investigation collaboratively to produce data to serve as the basis for evidence
Obtaining, Evaluating, and Communicating Information	• Obtain and combine information from books and/or other media to explain phenomena • Communicate scientific information orally and/or in written formats, including tables and charts
Developing and Using Models	• Develop and/or use models to describe and/or predict phenomena • Develop a diagram or simple prototype to convey a proposed object, tool, or process •
Analyzing and Interpreting Data	• Analyze and interpret data to make sense of phenomena using logical reasoning • Represent data in tables and graphs to reveal patterns that indicate relationships
Asking Questions and Defining Problems	• Predict reasonable outcomes based on patterns such as cause and effect relationships • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, and/or cost
Constructing Explanations and Designing Solutions	• Use evidence to construct or support an explanations
Use Mathematics and Computational Thinking	• Organize simple data sets to reveal patterns that suggest relationships
Engaging in Argument from Evidence	• Respectfully provide critiques about a proposed explanation by citing relevant evidence
Disciplinary Core Ideas	
ESS3.C. Human Impacts on Earth Systems	Societal activities have had major effects on the land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.
LS1.B. Growth and Development of Organisms	Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.
LS4.C. Adaptation	Particular organisms can only survive in particular environments.
LS4.D. Biodiversity of Humans	Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.
Crosscutting Concepts	
Patterns	• Patterns can be used as evidence to support an explanation • Patterns of change can be used to make predictions
Cause and Effect	• Events that occur together with regularity might or might not be a cause and effect relationship
Systems and System Models	• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot

Murden Cove Watershed Nutrient and Bacteria Reduction Project

This idea for this unit arose from the current state of the Murden Cove watershed and a desire to teach 5th grade students to be citizen scientists in their community, helping monitor the stream behind their school. Below is more info, from: http://www.ci.bainbridge-isl.wa.us/documents/pw/wr_2013/murdencovedetails.pdf.

Murden Cove Watershed

The Murden Cove Watershed is located on the central eastern side of Bainbridge Island in mid Puget Sound (Figure 1). At a size of 2,041 acres, the Murden Cove Watershed is one of the largest watersheds on the Island. The primary stream in the watershed, Murden Creek, is comprised of a mainstem and two significant tributaries (Woodward Creek and Meig's Creek) totaling 3.7 miles. Along with several smaller drainages directly to the shoreline, Murden Creek delivers drainage to Murden Cove which encompasses the entire 3.3-mile shoreline of the watershed.

Figure 1

Land use within this watershed consists of various densities of residential, commercial and light industrial development, schools, and a portion of the Rolling Bay Neighborhood Service Center. The watershed encompasses 2.2 miles of State Highway 305 and 146 acres of parkland. There are agriculture and livestock farms spread throughout the watershed, and, while sanitary sewer services are provided for a small portion of the watershed, most land uses use onsite septic systems.

The Problem

Murden Creek and Murden Cove provide recreational opportunities for humans as well as habitat for numerous aquatic species including shellfish and salmonids, specifically coho, chum, and cutthroat trout. However, Murden Cove's aquatic habitat is listed as impaired by the Washington State Department of Ecology due to low levels of dissolved oxygen and elevated levels of bacteria.

The City's status and trends monitoring in Murden Cove near shore and Murden Creek reveals continued chronic high levels of bacteria and frequent low dissolved oxygen levels since 2007 (Figures 2 and 3). In addition, the cove periodically exceeds pH criteria and frequently fails to meet temperature criteria (Figure 4).

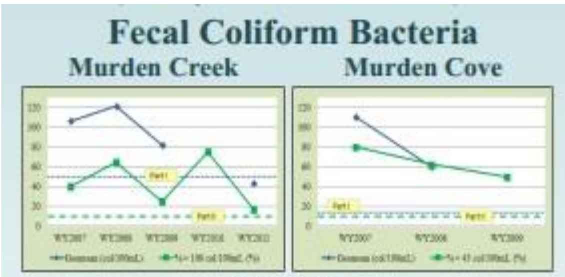


Figure 2

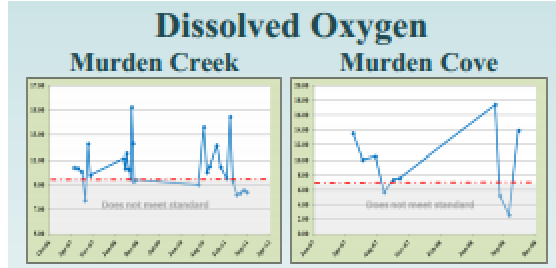


Figure 3

Figure 4

Monitoring during intense rain events in both water bodies in 2009 revealed increased nutrient levels such as phosphorus and nitrogen in both the creek and the cove, as well as ammonia concentrations exceeding chronic criteria (the creek) and acute criteria (the cove).

Murden Creek's benthic macroinvertebrate populations showed a marked decrease in the percentage of pollution intolerant species from 22% in WY2008 to 5% in WY2011 and an increase in the percentage of pollution super tolerant species from 11% to 15%.

The Partnership

Given the numerous apparent water quality issues facing the Murden Cove Watershed, it was clear to many project partners that improving water quality conditions would require a comprehensive multi-agency and community investment. Thus, the Murden Cove Watershed Project Partnership was born.

The partnership includes the City, Kitsap Public Health District (source identification and correction, education and outreach, technical assistance to onsite septic system owners), Sakai Intermediate School/Islandwood (education and outreach, citizen volunteers), the Bainbridge Island Watershed Council (education and outreach, citizen volunteers), Kitsap Conservation District (technical assistance to farmers and horse-owners, education and outreach), and Farbank/Sage (social media and communications support).

In addition to providing funding from both the Water Quality and Flow Monitoring Program and the Illicit Discharge Detection and Elimination Program, the City serves as the project hub by providing monitoring training and oversight, coordination among partners, data compilation and analysis, data sharing, project effectiveness assessment, and project reporting.

The main objectives of this project are to define the severity and extent of the apparent water and habitat quality issues, to identify sources of nutrients and bacteria throughout the Murden Cove Watershed, and to provide educational outreach and technical assistance to watershed residents in order to reduce nutrient and bacteria input to the creek and the cove.

Contact Information

For more information on this project, or to volunteer, contact Cami Apfelbeck, City of Bainbridge Island Water Resources Specialist: capfelbeck@bainbridgewa.gov, (206) 780 3779.

Project Map

Stream Ecosystem Information

Salmon Habitat Needs

Over the course of their life, salmon pass through different ecosystems, needing both fresh and salt water to survive. Salmon begin their lives as embryos in a clean, cool stream. As they grow from egg, to fry, to juveniles, young salmon receive all they need for survival in this home stream. Once they develop into smolts, or young salmon, they make their journey to the salty and fresh water mixture of an estuary. From there, they will move into the greater ocean where they mature into adults. Then, they journey up to 2,000 miles or more back to their home stream to lay eggs.

Salmon have specific needs from the home stream where they begin and end their lives. The stream needs to have clean, cool water at the appropriate temperature for the eggs to develop properly (41-59°F). Vegetation found at the water's edge help prevent stream erosion and keep the water cool. Gravel in the stream is needed for females. They lay eggs in a nest (or redd) buried in gravel at the bottom of the stream. The stream needs appropriate water flow to provide for the growing salmon. At parts, water needs to be fast enough to allow for oxygen to enter the water. At other parts, water needs to be slow enough to allow salmon to seek protection. Additionally, salmonids need food from the stream in the form of plankton and aquatic invertebrates. Salmon prey on organisms found in the water and living in the surrounding vegetation. To stay protected, aside from slow-moving water, woody debris and deep pools of water offer refuge from predators.
http://www.fws.gov/species/species_accounts/bio_salm.html
http://www.nwr.noaa.gov/Salmon-Habitat/

Riparian Zone

According to the Pacific Coast Salmon Fisheries, vegetation in and around the stream is important for salmon survival in four ways.

1. Plants surrounding the stream first help regulate the **temperature of the water** by providing shade. Water that is too warm is harmful to the salmon. Ideal water temperatures are between 41-59° F.
2. A second need for vegetation in and around the stream is **protection**. In the stream, salmon can seek refuge from potential predators among aquatic plants, hiding in plants in the stream to be camouflaged from larger fish and birds. Plants and trees around the stream help protect the salmon as well. Even if predators can spot the salmon in the stream, trees and bigger shrubs might act as obstacles between them and the fish.
3. Vegetation also provides salmon with **adequate food and nutrients**. Growing salmonids feed on plankton, insects, and larvae. The invertebrates especially live among the vegetation. If there is lush vegetation surrounding the stream, greater numbers of insects will fall into the water for the salmon. In addition, salmon benefit from dead vegetation that decays in the water. Nutrients, or detritus, enter the stream system as dead vegetation decomposes via decomposers that break down the matter. These smaller organisms become food for salmon.
4. The fourth way vegetation is necessary for salmon survival is **bank stability**. Plants along the stream, or in the riparian zone, help prevent erosion. This keeps the surrounding vegetation healthy and in place and maintains clear stream water, free of silt.

To protect streams, there are laws that create a **buffer zone** along the stream: An established zone along a stream or river with a margin of perennial grass or other erosion-resistant vegetation helps to filter pollutants and reduce erosion before the run-off enters the water.
http://bcheritage.ca/pacificfisheries/habitat/vegetion.html

Stream Velocity

Stream velocity is an important tool in measuring the health of the watershed. The speed that the water moves in a stream has a direct influence on the health of the stream, including the variety and abundance of aquatic communities of plants and animals. If the water in the stream is moving too fast, organisms could lose their "grip" on or under rocks and other stream bottom material and be carried away. If the water is too slow, there may be insufficient aeration for aquatic organisms which rely on dissolved oxygen (one of the ways oxygen gets into the water is all that splashing and moving) and some species of fish, birds and insects will shy away from stagnated waterways completely. A salmon redd (like a fish "nest"), will get washed away during a rain storm if the velocity is too fast. Rocks and fallen trees help protect the redds as well as providing young salmon shelter from danger. The speed of the water will also determine how well the waterway can transport sediments (salt, silt), chemical and organic debris which have an effect on water temperature.

Stream velocity can vary greatly depending upon a variety of factors. Seasonal changes such as heavy precipitation, snow melt or drought will affect stream velocity. Human impacts come in the form of increased run-off due to removal of plants and construction of impervious surfaces, dams, the re-routing of water channels, dredging, and the formation of man-made lakes or ponds.

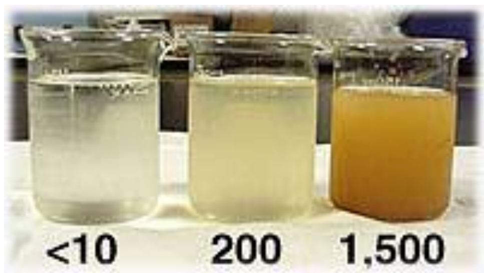
According to NOAA's (National Oceanic and Atmospheric Administration) guidelines for salmonid passage through culverts, a velocity of 6 feet per second (fps) is the maximum speed that adult salmonids can overcome when swimming upstream through a culvert that is less than 60 feet long. We are generalizing this to say that greater than 6 fps is too fast for salmon in a stream.

Beavers also have an impact on stream velocity. Beavers have been redirecting water flow and affecting stream velocity long before humans - just on a beaver-sized scale. Their dams stop the water to create a safe deep water cove for their lodges. While beaver dams can stop fish passage in some circumstance, most do not. On the positive side, beaver dams also slow down streams, and provide habitat for young salmon and the aquatic invertebrates they eat. More effort is now being provided to permit salmon to get past dams without removing them entirely.

Turbidity
In order to properly develop and grow, salmon need clean, clear water. When debris is mixed with water, the level of turbidity, or cloudiness, rises. Turbid water makes it difficult for salmon to breathe and see. Using a turbidity tube, the level of turbidity in water is measured in can be measured in NTU, or Nephelometric Turbidity Units.

Turbidity standards for salmon-bearing streams in Washington are determined using the “background” level of turbidity in a stream, or baseline standard for a natural amount of turbidity. If the background is less than 50 NTU, the standard is that the turbidity should not exceed the background + 10 NTU. In our case the background for the stream is 17 NTU, so the turbidity should be below 27 NTU.

According to the Department of Civil and Environmental Engineering at Michigan Technological Institute, water can become turbid when a number of different substances pollute it. For example, mud, silt, sand, dead plants, living organisms, algae, and chemicals all contribute to the turbidity of water. Often, runoff from agriculture also contributes to higher turbidity levels because chemicals in the runoff promote algae growth, which increases the cloudiness of water.



Sample Turbidities (Howard, 2001)

http://www.cee.mtu.edu/sustainable_engineering/resources/technical/Turbidity-Myre_Shaw.pdf:
http://bcheritage.ca/pacificfisheries/habitat/water.html

Temperature
Water that is too hot or too cold will not allow for proper development. Water between 41-59° F ensures that salmon will achieve their “peak metabolic rate,” able to swim, eat, and grow the best. (9-18°C).
http://bcheritage.ca/pacificfisheries/habitat/water.html

More specifically, for hatching salmon, 48° F is optimal. For adult spawning salmon, 54° F is optimal. For any salmon, temperatures should not exceed 64° F. Warmer water typically causes salmon metabolic rates to increase, which causes them to need more oxygen. Warmer water also holds less dissolved oxygen.

It’s also important to note that water temperature in a stream can vary daily and seasonally. It can also vary within the stream, depending on the sampling location. For a more in depth look at appropriate temperatures for salmon go to: http://www.krisweb.com/stream/temperature.htm.

pH
pH is the measure of concentration of hydrogen ions in water. Measured on a scale from 0 to 14, a pH of 7 means a solution, like water, is “neutral.” Less than 7 means a solution is “acidic” and greater than 7 means “basic.”

Salmon spend part of their lives in freshwater. In order for them to thrive in streams, the pH of the water needs to be between 6.5 and 8.0, the same range that is considered healthy for most freshwater organisms. Small fluctuations in pH can greatly affect salmon causing damage to their gills, fins, and exoskeletons and also causing death. Some small fluctuations in pH are natural, and are due to increased photosynthesis and natural nutrient flow in a stream. However, more and more, external pollutants are causing changes in pH. Pollutants such as fertilizer, pesticides, detergents, manufacturing chemicals, and cement negatively affect the pH of freshwater streams. In King County, many of these pollutants are carried in storm water runoff and travel directly to nearby streams, lakes, and the Puget Sound.
http://stream-team.org/Parameters/pH2.html
http://www.kingcounty.gov/environment/waterandland/stormwater/introduction/science.aspx
http://bcheritage.ca/pacificfisheries/habitat/water.html

Dissolved Oxygen

With gills, fish breathe oxygen from the water for basic survival. While water molecules contain oxygen, fish and other aquatic life breathe oxygen from a different source. This oxygen has been dissolved into the water and is referred to as dissolved oxygen (DO). Fast flowing water that travels over rocks, through waterfalls, and in other non-linear ways allows oxygen to be mixed and dissolved into the water to provide salmon with the necessary levels of DO. For salmon to survive, 9.0- 9.5 mg/L is optimal.
http://www.ecy.wa.gov/programs/wq/links/standards.html#monitoring

Macroinvertebrates

The aquatic organisms we are using to measure stream quality are aquatic “macroinvertebrates,” macro meaning big and invertebrate meaning without a backbone. These organisms are big enough for the naked eye to see (verus “micro”). Some of these aquatic macroinvertebrates spend their entire lives in the water (like clams) and some are insects who spend part of their life in the water (like dragonfly nymphs). These invertebrates live on or under rocks, under logs, in debris, and among aquatic plants. Because they typically dwell at the bottom of the water, they are also called benthic macroinvertebrate, benthic meaning bottom-dwelling.

Like any other organism, each species of macroinvertebrate has its own specific set of environmental conditions that need to be met in order to survive. These include the appropriate temperature, level of dissolved oxygen in the water, the right level of turbidity (clearness of the water), and the presence of food. Because of this, different macroinvertebrates can survive in different water conditions. Some are more sensitive to environmental changes (chemical and physical) than others. Often scientists use the presence or absence of different macroinvertebrates to determine the quality of the water.

There are two general methods for evaluating water quality using macroinvertebrates. The first one uses certain organisms as indicator species and is most closely related to the approach we take in this program. Some invertebrates can only survive in very healthy water, while others can tolerate unhealthier conditions. By looking for organisms that can only survive in healthy water, we can use the presence of these to indicate healthy water. Some pollution intolerant organisms include mayflies, stoneflies, and some caddisflies. Likewise, if we only find organisms that can survive in all water, including poor or unhealthy water, the water is unhealthy. Some pollution tolerant organisms, and therefore very tolerant of unhealthy water, include: worms, leeches, and some midge larva. It is important to keep in mind that pollution tolerant species also like healthy water.

The other method involves examining the diversity of macroinvertebrates within the water. Diversity refers to the number of different kinds of organisms found in the water sample. Greater diversity means more different types of organisms are present. In general, communities with a high diversity tend to be more stable and therefore more healthy. Using macroinvertebrate diversity, scientists take into account the types of organisms found (and their pollution tolerance) in addition to the number of different types of organisms found to determine the quality of the water.
http://www.janegoodall.ca/project-blue/StudyingMacroinvertebrates.html

Fecal Coliform

Fecal coliform bacteria live in the digestive tracts of warm-blooded animals. These bacteria can indicate a possible presence of pathogens, or disease-carrying bacteria, like *e coli*. These pathogens live in the same environment as fecal coliform. Fecal coliform levels are measured in fecal colonies (FC) per 100 ml. Levels in freshwater should not exceed an average count of 100 colonies. Less than 50 FC is optimal. For marine waters, fecal coliform levels should not exceed 14 FC. The health standard for drinking water is zero and for swimming 200 FC.
http://schools.csd509j.net/CVHS/staff/cornelp/APES/Labs/Optimal%20WQ%20Standards.pdf

High levels of fecal coliform can cause other problems as well. Sewage and manure contain nitrogen and phosphorus, which act as fertilizer for algae and other aquatic plants. An overgrowth of plants can deplete oxygen in the water that is needed by fish and other aquatic animals. It can also affect the natural acidic/alkaline (pH) balance of water.
https://fortress.wa.gov/ecy/publications/publications/0210010.pdf

Bacteria and pathogens are mostly a human health concern. However, bacteria can also deplete oxygen in the water when it decomposes, so it may have an indirect (and/or cumulative) impact on aquatic habitat. Additionally, high levels of fecal coliform indicates the presence of sewage and manure, which contain nitrogen and phosphorus. Nitrogen and phosphorous act as fertilizer for algae and other aquatic plants. An overgrowth of plants can deplete oxygen in the water that is needed by fish and other aquatic animals and affect the natural acidic/alkaline (pH) balance of water.

Also, warm water discharges such as from failing septic systems or grey water (sinks, showers, pools) may cause temperature increases beyond aquatic life protection standards. Warmer waters can then result in depleted oxygen and excessive plant and algae growth and bacteria reproduction, starting the cycle of impact all over again.

Nutrients

Nitrogen

Nitrogen is essential for plant growth. Too much nitrogen can stimulate too much growth, oftentimes resulting in algal blooms in water. A rapid increase in growth ultimately lowers DO for other living organisms: as the algae decays the level of oxygen is depleted. This is called **eutrophication** and happens because the organisms that decay the algae and/or other excess plant growth require oxygen themselves. This leaves less oxygen for other organisms in the water, like fish.

Excess nitrogen may come in the form of nitrates, a compound containing nitrogen. Nitrates are found in sewage from septic systems, fertilizers, manure, and waste from garbage dumps. According to the website http://schools.csd509j.net/CVHS/staff/cornelp/APES/Labs/Optimal%20WQ%20Standards.pdf, nitrates levels in unpolluted water bodies should generally be below 1 mg/L.

Phosphorous

Phosphorous is a naturally occurring element and is also essential for all living organisms. It naturally occurs in soil, rocks, sediment, and organic matter. In plants, it is necessary for photosynthesis. Excess phosphorous in streams may come in the form of phosphates, inorganic compounds that contain phosphorous. Common substances that contain phosphates include fertilizer, detergents, pesticides, toothpaste, and oil. Too much phosphorous in freshwater can cause excess algae growth. According to the website http://schools.csd509j.net/CVHS/staff/cornelp/APES/Labs/Optimal%20WQ%20Standards.pdf, phosphates in unpolluted water bodies should generally be below .1 mg/L.

http://www.crwa.org/projects/METwMyRWA/phosedu.html

Ammonia

Ammonia is an unstable form of nitrogen. Ammonia is considered a priority pollutant by the EPA, rather than a nutrient, since it is deadly to both humans and fish. It is naturally produced in soil as a by product of decomposition, but is also found in manure, fertilizers, and cleaning products. The toxicity of ammonia in freshwater depends on the pH, temperature, and DO levels. The higher the temperature and the higher the pH, the more toxic the ammonia is to fish (a smaller amount is necessary to harm fish). Also the lower the DO, the more toxic ammonia is. Ammonia is toxic to most fish between 0.2 – 2.0 mg/L.
http://ohioline.osu.edu/aex-fact/0708.html
http://www.kwiaht.org/downloadfiles/Kwiahtresearchreports/Toxic%20loading%20of%20False%20Bay%20Creek%20fish%20loading%20report.pdf

Water Quality Standards

From COBI State of the Island's Water Report 2012: It is extremely challenging to establish nutrient criteria, as the balance between enough nutrient to feed the ecology and too much nutrient varies significantly from site to site and environment to environment.

Parameter	**COBI Standard**	**Salmon Health**	**Notes**
Temperature	< 16°C (61°F)	5° - 15°C (41-59° F)	Depends on life cycle stage (see temp notes)
Dissolved oxygen	≥ 9.5 mg/L	≥ 9 mg/L	7-8 mg/L is acceptable at times. DO needs of fish depend on life cycle stage and amount of physical activity.
pH	6.5-8.5	6.5-8.5	
Turbidity	< stream "background" plus 10 NTU for fish habitat	< 27 NTU for Sakai Stream	
Ammonia		< 2 mg/L	Ammonia can be toxic to fish between levels of 0.2 – 2 mg/L
Fecal coliform	Part 1: there need to be < 50 col/100 mL Part 2: No more than 10% of samples shall exceed 100 col/100 mL	< 50 col/100 mL	
Nitrogen	< 1-2 mg/L	< 1-2 mg/L	
Phosphorous	< 0.1 mg/L	< 0.1 mg/L	

For more information on surface water quality standards for the State of Washington, visit the Department of Ecology's website: http://www.ecy.wa.gov/programs/wq/swqs/criteria.html.