LESSON 1

Jigsaw - Why is Stormwater a Problem?

Problem Statement: How can I apply the practices of engineering design to recommend the best green stormwater infrastructure (GSI) applications for a high priority site in my neighborhood?

Subject: Human Geography, Science, Engineering, Math, Civics, Common Core
Grade Level: Middle School or High School

BACKGROUND

Actually, stormwater is **not a problem for Nature.** Our Pacific Northwest forests thrive because of how they have evolved and adapted to the amount of rain we get.

The "**natural engineering design**" of leaves, needles, twigs, limbs and tree bark intercepts the rain, slows it down, and takes it in. Sometimes the rain, absorbed by leaves and needles, never even reaches the ground.

Centuries of fallen and slowly decaying organic material builds a spongy forest floor with an incredibly intricate soil food web teaming with microbial life, nutrients, and water. The forest floor can absorb a lot of water.

Percolating through layers of humus, soil, sand, clay, and gravel, stormwater becomes groundwater. As it infiltrates, the water is filtered and cleaned right there without running off. Tree roots stabilize the soil preventing erosion while pulling water back up into the biomass of the trunk, limbs, and leaves. The leaves use water molecules in their chemical equation for photosynthesis.

Nature has engineered what we might call **"green infrastructure"** to take full advantage of whatever amount of precipitation falls on its land area.

In our cities we have developed a lot of **"gray infrastructure"** made from cement, steel, aluminum, and asphalt, to capture and remove stormwater so that our roads and parking lots are not flooded. We have pavement, sidewalks, curbs, gutters, storm drains and underground pipes to take the water that falls on our **impervious** surfaces and redirect it somewhere else. Sometimes this goes straight into the nearest stream or lake carrying pollution along with it.

DESCRIPTION

Students practice breaking down the problem statement and gain basic knowledge of the issues through a jigsaw exploration of selected infographics, videos, maps, and text.

ACTIVITY 1

Breaking Down the Problem Statement

You may choose to use this activity as an entry event, or as an iterative exercise over several stages throughout subsequent lessons. The sub-questions provided here should be used primarily as a teacher's guide for facilitating the inquiry process, not as a student handout. Giving them a completed handout prevents them from exploring their own voice, their own mental models, their own understandings and assumptions. The goal is to support students' own ability to thoroughly analyze a worthy problem statement. Get the BLANK WORKSHEET

A strong problem statement includes some or all of these elements.

- Embedded academic concepts or needed skills
- Intriguing phenomena
- Demands to be broken into smaller inquiries (a good discipline to practice!)
- Invites a diversity of entry points for student curiosity, agency, and lived experience
- Centers on the individual self as the agent of change
- Focuses on local action to ensure relevance and shared responsibility

Ideas for Facilitating Inquiry...

1. **Take a look at the problem statement with your students.** You can project it as a shared digital document, print it out as an individual worksheet, or ask students to take a out a blank sheet of paper and write the problem statement in the middle of the page, centered, and broken into phrases with space between the lines so that there is plenty of room for developing a mind map from each of the key concepts.

2. Ask several students to **read it outloud.** Playing with the vocal dynamics of the spoken word and engaging different student voices, allows time for all listeners to inhabit the depth of the question in their own way. This practice shifts the problem statement from being an academic question contrived by the teacher, to being an intriguing set of sub inquiries worth pursuing.

3. Invite a range of outloud readings in different **theatrical styles** such as...

    - Read it like a newscast or a political speech.
    - Read it mad, with righteous indignation
    - Read it crazy fast but with perfect diction without making a single hiccup.
    - Read it slow as a sloth with great emphasis and solemnity.
    - Read it with emphatic phrasing and emphasis.
    - Read it translated into your native language.
    - Read it backwards with emphatic phrasing and emphasis.
    - Would someone like to try and recite it from memory?

4. Ask students to take 5-10 minutes of **personal reflection time** to do one or more of the following:

    - Identify what you think are **all of the most important concepts** in our problem statement. Make a list of words or phrases, or you can circle them in the sentence. Make a few notes about why you think these are the most essential.

    - Identify what you think is the **single most important concept** or idea in our problem statement. Write out your thoughts to justify the choice you made. It may be different for other students. The debate will be insightful because there may not be a right answer.

    - Make a list of ideas or **solutions** you are already thinking about in relation to our problem statement. How would you actually answer the question or solve the problem? What would you want to do?

    - What have you **already done** in your personal life that seems like part of the solution to this problem?

    - Are you noticing potential **issues of culture, gender, race, or privilege** associated with one or more concepts in our problem statement?

    - Make a **bunch of mind mapping notes** on the worksheet, branching out to either small and big ideas, or questions, and then keep mapping additional ideas or new questions stemming from those. Write as many ideas, insights, sub-questions as possible, challenging yourself to leave no assumptions unexamined.

    - What is your **cultural bias** in responding to this question? Could someone who identifies differently than you have a different window into the nature of this question? How does your lived experience impact where we start in solving this problem?

5. Organize students in **self-facilitated small groups** for 10-15 minutes to share their responses (so far) on the depth of the problem statement and their initial stake in it, including unique perspectives that may arise through different cultural lenses. Encourage students to add notes to their own mind-map as they pick up new connections through discussion with their peers. Note that this is an interactive process that you can return to as the project design and implementation phases unfold in your classroom.

6. **Facilitate a full class discussion** on all of the ways we can break down the problem statement. Find creative ways to refine and visualize the individual, team, or classroom responses to the problem statement. This could be a large poster for the wall, or a digitally recorded brainstorm, or a mind map file for the class, or even an organized spreadsheet shared digitally.

7. **Launch problem solving.** Taking the time to thoroughly break down the problem statement, will naturally turn up several choice points where teams, individuals, or the entire class can decide to engage in further research and apply it to one or more stewardship actions that benefit both people and salmon.

ACTIVITY 2

Analyzing Infographics: Why is Stormwater a Problem?

See if you can develop a well-rounded answer to the question ***"Why is stormwater a problem?"*** by analyzing how different graphic artists have designed the infographics shared below to help people understand the problem and take action.

Here are some suggested prompts…

- What grabs your attention first on this infographic? Why?
- What grabs your attention second, third, or fourth, and what graphic design strategies were used to guide your eye around and through the infographic?
- How would you describe the color scheme for this infographic? Does it help unify, group, or compare main ideas?
- How are shapes used to help organize and feature critical information? Does the size, color, and placement of shapes guide your eye around the infographic?
- How does the size, font, and placement of text support the main ideas without being "too much reading?"

- How is data displayed? How does the color, size, and placement of numbers help you understand what's quantifiable and measurable?
- Are icons used to help symbolize key concepts?

Explore these infographics. Which design is the most successful do you think? Defend your answer.

1. **INFOGRAPHIC - Orcas Love Rain Gardens**
2. **INFOGRAPHIC - Bioaccumulation of Toxins in Puget Sound**
3. **INFOGRAPHIC - Comparing Before and After Urban Development**
4. **INFOGRAPHIC - Preventing Pollution, Protecting our Waters**
5. **INFOGRAPHIC - Stormwater Pollution, the Big Picture**
6. **INFOGRAPHIC - Redesigning Cities to Function Like Forests**
7. **INFOGRAPHIC - Puget Soundkeeper Stormwater Runoff**
8. **INFOGRAPHIC - Series of Stormwater Management Strategies**
9. **INFOGRAPHIC - Trees Tame Stormwater**
10. **Google search for more "Stormwater Infographics,"** Select one or two more infographics that you think are particularly effective at answering our question, *"Why is stormwater a problem?"*

ACTIVITY 3

Analyzing Videos: Why is Stormwater a Problem?

View and analyze these different videos to **unpack the basic storyboard** that you think was used to produce each one.

- What are the main ideas and how are they sequenced?
- How does the storyteller hook you at the beginning and what kind of a conclusion do they leave you with?
- Do these videos help you answer the question, **"Why is Stormwater a Problem?"**

VIDEO: Stormwater 101, Youth-Voiced Expert Topic Series. Watch VIDEO [11:36] This is a recorded slideshow voiced by 10th grader Anshika Rath with great images and clear descriptions of why stormwater is a problem in our bioregion.

VIDEO: Drained: Urban Stormwater Pollution Watch VIDEO [8:30] EarthFix Producer Katie Campbell teams up with local underwater filmmaker Laura James to swim up close to a stormwater outfall spewing sludge from our streets and parking lots into Puget Sound.

VIDEO: Why are Salmon Dying Before They Can Spawn? Watch VIDEO [7:41] When it comes time to spawn, salmon swim upstream back to where it all began to lay their eggs and die. Many salmon are dying before they can complete this spawning phase of their lifecycle. Kathryn Davis, Stewardship Manager for Puget Soundkeeper walks us through how human development and infrastructure is driving salmon pre-spawn mortality.

VIDEO: Toxics in Stormwater Pollution Watch VIDEO [11:00] Jenifer McIntyre, Research Scientist with the WSU Stormwater Center, describes the current science on the toxic chemicals entering Puget Sound from polluted storm water runoff with a focus on how it impacts salmon. Current research on rain garden soil filtration points to solutions for reducing these toxics, leaving cleaner water with less impact on fish.

VIDEO: Stormwater Impact on Pacific Herring Watch VIDEO [9:50] Louisa Harding, Research Scientist with WSU describes the impacts of stormwater runoff on developing herring from Puget Sound. Due to the presence of petroleum hydrocarbons in stormwater, she compares her results to experiments with crude oil exposure conducted by collaborators from the Northwest Fisheries Science Center (NOAA) following the Exxon Valdez oil spill.

VIDEO: Green Solutions to Stormwater Runoff Watch VIDEO [4:07] Easy to follow video that provides a clear overview of the problem with polluted stormwater runoff and then showcases a number of local solutions.

ACTIVITY 4

Analyzing Maps: Why is Stormwater a Problem?

View and analyze these different maps to see how they depict the geographical aspects of the stormwater problem.

- What is the scale of each map?
- Why was the map created?
- Who manages the data for the map?
- Does the map legend help you to understand the story of the data on the map?
- Who are the stakeholders who might be interested in the story this map is telling?
- How do these maps help you answer the question, **"Why is Stormwater a Problem?"**

MAP: 700 Million Gallons - GSI Around You: Visit Webpage
There is great information on this page. Scan it for key ideas and then scroll down about 75% of the way to see a map of where Green Stormwater Infrastructure is already in place. It looks like

a lot. That is until you scroll in, and then scroll in some more. It is actually pretty sparse. What would this map look like if every single building on every single city block had some kind of GSI? It's good to have an interactive map to track it. By the way, why 700 million gallons?

MAP: Puget Sound Stormwater Heat Map Intro Video [2:20] | Website
The stormwater community welcomes a new mapping tool, the Puget Sound Stormwater Heatmap, which can help users identify hotspots where stormwater pollution is generated. This will help stormwater managers decide where pollution interventions should be made to address the most contaminated parts of our landscape.

MAP: Combined Sewer Overflow Status See the CSO Map
This map is active! Check the map at this link to see if a combined sewer overflow, or CSO, is occurring before going swimming, wading, fishing, or boating near a CSO warning sign. These overflows take place within the City of Seattle.

MAP: My Watershed Address Go to Website
Sustainability Ambassadors has developed a cool community impact mapping tool to help people understand all the various geographic conditions and impacts that shape our neighborhoods. Everyone knows their street address. But do you know your watershed address? Click on a bunch of the map layers to see what's here. And then click on the map layer called **Impervious Surface Area**. Zoom into your school or home neighborhood. What do you notice?

MAP: City Maps of Stormwater Pipes
It's pretty fascinating to get a hold of a map that your city maintains to see the actual system of stonewater pipes in the ground and where they flow, sometimes into detention ponds, something right into a stream, river or lake. Check out a few of these examples to practice reading the icons and flow direction, and then ask your city for a digital copy to use in your classroom. You may be able to find it on your own just by searching for “surface water drainage map”, or “stormwater infrastructure map.” When you do access this important map, zoom in on your school or home neighborhood to see what you can learn.

- Kent Drainage Map
- Sammamish Drainage Map
- Bellevue Drainage Map
- Seattle Drainage Map

MAP: Washington Environmental Health Disparities Map See the Map
This is an interactive mapping tool that compares communities across our state for environmental health disparities. The map shows pollution measures such as diesel emissions and ozone, as well as proximity to hazardous waste sites. How does this map overlap with the stormwater pollution maps above?

ACTIVITY 5

Analyzing Text: Why is Stormwater a Problem?

Read and analyze some or all of these excellent resources and work with your team to develop your response to the question, **"Why is Stormwater a Problem?"**

TEXT: Stormwater Pollution - The Big Picture. This beautifully organized King County document mixes text and infographics to tell an excellent story. Visit Website

TEXT: Why Is Green Infrastructure Important? Well written, short but detailed reasons for why stonewater is a problem and why green infrastructure is needed. From the Natural Resource Defence Council. Visit Website

TEXT: The Science of Stormater: This useful resource excerpted from King County discusses the following key ideas. Get Document

- What stormwater is, where it comes from, and why it is important
- How it is polluted, including details on specific pollutants and their sources
- How stormwater pollution is controlled
- What are Stormwater Facilities, and how do they work?
- What businesses need to do to protect stormwater
- What homeowners can do to protect stormwater

TEXT: Puget Sound Vital Signs: This is the dashboard where scientists share information on 23 indicators of ecosystem health. See Toxins in Aquatic Life

TEXT: Natures' Scorecard: Stormwater Problems and Impacts in Puget Sound: This easy to read webpage describes how stormwater is the biggest source of toxic pollution impacting Puget Sound. Visit Website

TEXT: Stormwater Impacts on Salmon: Coho are killed by pollution as soon as they hit their natal streams in an estimated 40 percent of their range in Puget Sound especially in overdeveloped urban areas. Seattle Times Article

TEXT: Recent research from the UW and WSU: Tire-related chemical is largely responsible for adult coho salmon deaths in urban streams: UW News

TEXT: All you need to know about Stormwater Runoff: This is an example of excellent journalism, using news to make stories to make people wake up and take action. See Article. The article is part of a series called Curbing Toxic Runoff by Sightline investigative reporter, Lisa Stiffler.

TEXT: Protecting Washington's Waters from Stormwater Pollution: This is a 4-page, well-illustrated overview of the problem with stormwater pollution developed as an environment education guide by the Washington Department of Ecology

TEXT: Stormwater Facts - Encyclopedia of Puget Sound: This is where scientists go to share information for decision makers, the media, and the general public. Visit Website

TEXT: 700 Million Gallons: The City of Seattle has a goal to manage 700 Million Gallons of stormwater a year. This easy to read, well-designed website features a handy list of solutions. Visit Website

TEXT: Traditional Infrastructure Investments to Protect Our Waters: Learn about storage tanks, pipes, and wet weather treatment stations. This site includes several great diagrams. Visit King County Website

TEXT: Natural Drainage Solutions to Protect Our Waters: Learn about green stormwater infrastructure (GSI) solutions that help our urban environment function more like a forest, capturing, filtering, and infiltrating stormwater right where it falls. Includes a great diagram. Visit King County Website

SHOW WHAT YOU KNOW

Okay, so what have you learned about the concepts and issues revealed in the problem statement

> "How can I apply the practices of engineering design to recommend the best green stormwater infrastructure (GSI) applications for a high priority site in my neighborhood?"

Take some time to reflect on your current knowledge. Where does your curiosity take you? What do you want to learn more about? If you are motivated to take some kind of stewardship action at this stage, what might it take to actually begin solving the problem? Who is working on it?

A few ideas…

1. Redesign your original mind map into a **beautifully rendered** team or classroom poster. We can refer to and add to this benchmark as we explore more in the unit.

2. Write a **short reflection** on how your understanding has changed from when we started. Include a reflection on both your intellectual, conceptual knowledge, as well as the emotions or feelings that may have come up for you as you analyzed how salmon and people are thriving or not at your watershed address.

3. Write a short narrative piece, or produce a vlog on the same content, but tell the story of this situation from the **point of view of a salmon**. What is it like to be a salmon in our watershed? What is your day-to-day experience as your travel upriver to spawn? What are you thinking about? What are you feeling? What memories or legends have been passed down to you from the salmon kin who have come before you? What wisdom, dreams, or warnings do you have for the next generation, those who will swim this river after you have spawned and passed away? Or try a different species like Orca, Cedar Tree, Seagull, or Oyster. What's your unique perspective?

4. Host a student panel in front of the class to take turns naming and describing the key insights gained from probing into the problem statement.

5. Produce a series of short, video statements reflecting verbally on the same questions above. How might you edit some of these together with what you think are the most essential images, graphs, or maps to establish a classroom group statement?

6. Use a graphic organizer to brainstorm all of the groups of people you think would be stakeholders in this issue. Who is working on it and what can we learn from them? Who is a stakeholder but doesn't yet know that they have a role to play in solving the problem? How can we best interact with the first group and engage with the second? See the full lesson framework on Engaging Stakeholders, especially the graphic organizers on page 12.

WHAT CAN WE DO?

1. Help plant 3 Million Trees
2. Switch to these strategies for Natural Yard Care (in 15 different languages!)
3. Take personal action at Puget Sound Starts Here
4. Don't Feed the Tox-Ick Monster - 7 Simple Actions
5. See playlist of 20 King County informational videos on Yard Talk
6. Build a Rain Garden at 12,000 Rain Gardens
7. Advocate for Green Stormwater Infrastructure around your school neighborhood
8. Follow the indicators that scientists track on the dashboard Puget Sound Vital Signs

HELP IMPROVE THIS LESSON

1. What advice do you have for making this lesson better?
2. How would you teach parts of this lesson to younger students?
3. Are there broken links that we need to know about?
4. Did you find even better links in your research?
5. Would you like to share examples of your work so that other classrooms can learn by your example?

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