What Flows Below: The Science of Watersheds and Pollution

(2-3 Weeks)

Authors

Ramona Singleton

Morgan Terrell

Shannon Varekamp

SUBJECT/GRADE LEVEL

Subject Area: Science

Grade Level: Middle School

Materials

- Computers (Access to Microsoft Excel or Google Sheets)
- Clear Plastic Containers
- Water
- Cleanup tools (spoons, tongs, filters, etc)
- Various Pollutants (Soil, oil, soap, plastic pieces, paper, food coloring, etc.)
- Small empty containers for waste
- Aluminum Foil
- Spray bottle
- Red marker, brown marker, green marker, and blue marker
- Plan for a class of 30 students.

STANDARDS

Next Generation Science Standards

- MS-ESS 3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process

Mathematics Standards | Common Core State Standards

- CCSS.Math.Content.7.RP.A.3: Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

English Language Arts Standards | Common Core State

- CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

LESSON OBJECTIVE(S)

- Students will be able to explain the concept of a watershed and analyze how human activities within a watershed impact water quality.
- Students will be able to identify common types of water pollutants and evaluate methods used to clean up and prevent water pollution.
- Students will be able to interpret water quality data presented in graphs and charts, identify trends and patterns, and construct their own graphs to support data analysis.
- Students will be able to describe how satellites are used to detect and monitor water pollution and interpret satellite imagery related to water quality.

CAREER CONNECTION(S)

Mentor Background: Dr. Lauren Mancewicz

Dr. Mancewicz is a Research Civil Engineer at ERDC. Her research uses groundwater model simulations to investigate groundwater quality and quantity problems. Most of her work uses models to study the impact of long-term extreme weather events on groundwater resiliency. For her PhD research, as well as work at ERDC, she used groundwater model simulations to look at the impact of extreme sea level events on fresh groundwater supply for small islands. Her work at ERDC also involves adapting groundwater modeling tools so that they can be used to solve emerging problems. For one project she is working to couple a geochemical model with a groundwater model to look at arsenic mobilization in Florida. She is also working to couple a surface water model with a groundwater model to better understand flood risks.

STEM Careers:

Structural Engineer, Transportation Engineer, Geotechnical Engineer, Water Resources Engineer, Environmental Engineer, Construction Engineer , Project management, Surveyor Engineer

ENGAGEMENT

Brief Description: Students will be asked about their prior knowledge of watersheds. Students will be

filling out a KWL chart over what they know and what they want to learn about watersheds. At the end of the lesson, students will circle back to fill out what they have learned. Students will use "The National Map Viewer" to identify their local watersheds. Following this, students will create physical models of watersheds with aluminum foil. Finally, students will demonstrate their knowledge by participating in a discussion about watersheds, pollution, and conservation efforts.

Procedures:

Students will be asked about their knowledge of watersheds. Students will be filling out a KWL chart over what they know and what they want to learn about watersheds. Students will come together as a class to share their ideas.

The teacher will ask the students about their knowledge of their local watersheds. Students will be tasked in finding their local watersheds using the National Map Viewer.

Directions for Use:

1. Go to The National Map Viewer
2. Use the green bar above the map, click on the Layers icon which looks like a stack of paper.
3. Click on the box beside "Watershed Boundary Dataset"
4. Zoom in to your area of interest.
5. As you zoom in, click on the arrow beside the watershed boundary box to show smaller watersheds and toggle them off/on.

Students will explore what a watershed is through this website: Watersheds and Drainage Basins | U.S. Geological Survey

While students are exploring, they will be tasked in answering questions in a Mini Worksheet.

Now that students have knowledge about the local watersheds in their area, the teacher will ask the students to create their own watershed.

Teacher: The teacher will lead the students with these directions:

1. The students will take pieces of aluminum foil and crumple it in their hands.
2. The students will open the aluminum foil, but do not flatten it. You want to have some relief
    a. The teacher will ask the students what they think the high spots, the low spots, and the wrinkles represent
        i. The high places are hills, the low spots are the valleys, the wrinkles are streams and rivers
3. With a blue marker, draw on the piece where you think the streams and rivers would be.
4. To check students' work, the teacher will place the paper in a container. The teacher will spray the paper, this will allow "rain" to over in the watershed. The water should be running down the hills.
    a. Tell students that this is how a watershed functions, the water is shed by the land into streams, rivers, and lakes.
5. Students will repeat this activity, during the repeating process. During the second run, students will draw where the streams and rivers are with blue markers. They will use a brown marker along the tops of the hills. They will use a green marker to draw in trees, grass, crops, or pasture land.

Students will use a red marker to draw towns, houses, or businesses.

a. When they repeat this process, students will notice that the colors are running into the streams. If this were a real watershed, the brown could be the dirt from soil, the green could be from grass, and the red could be pollution like oil from leaky cars.

Students will answer discussion questions that correlate to the activity:

- What are some examples of small watersheds
- in your neighborhood?
- What stream, river, or lake does the runoff water from your neighborhood empty into?
- Why do pollution problems tend to get worse farther down the stream?
- What is the name of the watershed you live in?
- What are some ways you can help keep your own watershed clean and help watersheds downstream?

At the end of the lesson, the students will circle back to their KWL chart to fill out what they have learned. Their KWL chart will be turned in as an exit ticket.

EXPLORATION

Brief Description: Students will go on a scavenger hunt to find a variety of items. After the scavenger hunt, students will be introduced to watersheds and pollution via Youtube videos.

Procedures:
Students will be placed in groups of 3-4. Students will be tasked in finding a variety of listed items.

Toxic Scavenger Hunt

Prep work: Students will be given a list of items to find.

- Something that can soak up water
- Something that floats on water
- Something that sinks in water
- Something that changes the color of the water

Teacher will show videos below:

Video 1- Water Pollutants

Video 2: Water Sheds and Pollution

Brief Description:
This activity guides students through a hands-on simulation of water pollution and cleanup. Using a clear container of "clean water," students will observe the impact of various "pollutants" as they are added, understanding how these substances enter real aquatic ecosystems. Following a discussion on the effects of pollution, students will attempt to clean the water using simple tools, experiencing firsthand the challenges and limitations of environmental remediation. The activity concludes with a reflection on the importance of pollution prevention.

Procedures:
After the students have found the items, the teacher will fill a clear container of water. The container will represent a clean body of water. Have students discuss what kinds of bodies of water that this represents. Examples: Oceans, Rivers, Streams, Lakes, etc. Have students insert their items into the container. Students will place their items into the water. For each item that is placed in the water, tell a brief story about how it may enter a real body of water.

Examples:

- Soil- Runoff
- Oil- Someone had an oil leak
- Soap: Washing car and water drained down a storm drain
- Plastic Pieces: Litter from a car has blown down to a lake
- Food Coloring: A factory accidentally released dye into the river
- Garbage or debris off of boats
- Or other pollutants that your local water shed is dealing with
    - Example: PCBs, copper, paint dumped into the river from factories (again, GE and GM plants along the Hudson)
- Failing infrastructure causes more overflows into watershed

As each pollutant is added, have students describe what they are seeing happening to the water.

Clean Up Activity: Give students clean up tools (spoons, tongs, coffee filters). Challenge students to clean up the polluted water and make it safe again. What are some tools to work best at cleaning different pollutants?

After the cleanup attempt, bring the class together for a whole class discussion.

"Even with our tools, could we make the water as clean as it was at the beginning?"

Water Pollution Mini Lab

EXPLANATION

Brief Description: Think-Pair-Share and Curipod. Students will explain what they have learned through a think-pair share. Curipod is a resource for students to explain how people can cause pollution, trace it through a watershed, and judge its effects on water, wildlife, and humans.

Procedures:.

Discuss: The teacher will lead the class in a think pair share of each question. The teacher will correlate the activity in the exploration section. The teacher and students should be thinking back to the water that they have previously contaminated.

"Would you want to drink this water now?" Why or why not?

"Would you want to swim in this water?" Why or Why not?

"What might happen to the fish, plants, and other animals that live in this water?"

The teacher will give students 5 minutes to think about these questions individually. They will jot down their answers. After 5 minutes, the teacher will give students 10 minutes to discuss the questions and their individual answers. Lastly, the teacher will have the whole class discuss their answers.

The teacher can use this Curipod as an extension for students to explain how people cause water pollution, trace pollution through a watershed, and judge its effects on water, wildlife, and us.

Curipod:

ELABORATE

Brief Description: Students will learn about how satellites are one of the methods used to collect data on pollution. They will learn how to retrieve and analyze data from the HydroClimate Model.

Procedures:

Teacher Action on Satellites:

The teacher will introduce different types of satellites that observe water with the following videos:

Video 1 - This NASA satellite monitors Earth's water from space

Video 2 - How do satellites help us study Earth from space

The teacher will provide examples of different images taken by satellites on different types of polluted waters.The examples will include the following:

- Harmful algal blooms in lakes and oceans.
- Sediment runoff
- Oil spills

Student Action on Satellites:

In small groups, ask students to analyze the images and websites and describe what they see and what they learn. Evaluate and describe your learnings on the attached worksheet

- What do you see in the water?
- Does the water look clean or polluted? Why?
- What might be causing the pollution?

Groups will share their findings with the class.

Teacher Action on Data Collection:

The teacher will introduce the **Oak Ridge National Laboratory (ORNL)** by showing a brief introductory video. This video will provide students with background information on the lab's purpose, focus areas, and contributions to scientific research, particularly in climate and environmental sciences.

Following the video, the teacher will discuss the **HydroClimate Model**, an online tool provided by ORNL that will be used for the class's data retrieval task. The teacher will explain the importance of the model and how it supports climate research through long-term environmental data collection.

The teacher will demonstrate how to retrieve data from the HydroClimate Model website. To guide students effectively, the teacher will use historical data from 2005 to 2025 as an example. Students will observe how to:

- Select relevant parameters (e.g., precipitation, temperature)
- Choose specific date ranges
- Export the data for further analysis

After the data is retrieved, the teacher will show students how to input and visualize the data in Google Sheets (similar to Microsoft Excel). The slide show has an overview of how to make graphs. The data example comes from this Google Sheet. The demonstration will include:

- Entering the data into spreadsheets
- Creating graphs such as line charts and bar graphs
- Labeling axes, adding titles, and interpreting patterns or trends

This foundation will prepare students to independently complete their own data analysis tasks using climate data and Excel tools.

Student Action on Data Collection: Students will apply their understanding of percent change to analyze weather data—specifically average precipitation and temperature changes over the past 20 years. They will organize the data in Microsoft Excel, generate tables, charts, and graphs, and provide a written analysis based on their visualizations.

Data Collection: Students will review data provided by the teacher from the Oak Ridge National Laboratory focusing on:

  - Average annual precipitation
  - Average annual temperature
  - Data should span a 20-year period (e.g., 2005–2025)

Calculation of Percent Change:

- Using Excel, students will calculate the percent change in both precipitation and temperature over the 20-year period.
- Formula to use:
  Percent Change= Projected-Historic/ Historic x 100.

Data Visualization:

- Students will create tables and appropriate visual representations (e.g., line graphs for trends, bar charts for comparison).
- Visuals should clearly reflect changes over time and include proper titles, axis labels, and legends where necessary.

Teacher Demonstration & Video: Students will follow teacher demonstration outlining:

- How to input data in Excel
- How to use formulas for percent change
- How to generate charts and graphs
- Students will also watch a provided instructional video for further guidance.
  Student resource

Written Analysis: Students will write a short analysis (1–2 paragraphs) that:

- Interprets the patterns shown in their graphs
- Discusses possible causes for the changes
- Reflects on the significance of the data in the context of environmental science.

Student Enrichment: After analyzing the data, students will draw conclusions of what may cause these environmental changes. They will study:

  - the process of dredging.
  - Billion Oyster project.
  - Waste Management
  - Environmental Dumping (Illegal Waste Disposal) These laws prohibit the improper disposal of waste materials (e.g., hazardous chemicals, sewage, garbage) into the environment, including land, water, or air.)

Teacher action: Introduce common U.S. laws and penalties concerning environmental dumping.

- **Resource Conservation and Recovery Act (RCRA)** – Regulates the disposal of solid and hazardous waste.
- **Clean Water Act (CWA)** – Prohibits the discharge of pollutants into U.S. waters without a permit.
- **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund)** – Addresses cleanup of sites contaminated with hazardous substances.
  Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act) – Prohibits dumping of material into ocean waters without a permit.

- **Penalties:** Civil fines, criminal charges for willful or repeated offenses, cleanup costs and restitution.

Student Action: Students will make connections with current water pollution clean up efforts such as the billion oyster project and recycling. They will identify ways to aid in pollution clean ups around their school community. Students will create a PSA about water pollution.

EVALUATION

Brief Description: Students will utilize the Oak Ridge National Laboratory (ORNL) Hydro-Climate Model to gather projected weather and temperature data for the upcoming decade (2025–2035). Using this model, they will analyze anticipated changes in temperature and precipitation patterns. The results will then be compared to historical climate data from the previous 20 years (2005–2025) to identify patterns, significant changes and potential long-term climate impacts. This comparative analysis will help students better understand the implications of climate change at both regional and global scales.

Procedures:

Teacher Action: Using the ORNL hydro-climate tool the teacher will instruct students to select the following:

- Area of Interest (**HU6**) They will select the portion of the map near their school.
- Reference Meteorologic Forcing (**Daymet**)
- Climate Models (**ACCESS-CM2 & EC EARTH3**)
- Downscaling Method (**DBCCA**)
- Emission Scenarios (**SSP126 & SSP585**)
- Time Scale (**Annual**)
- Aggregation Method (**Area of Interest**)
- Output File Format (**CSV**)
- Date Range (**2025-2035**)
- Hydrologic Model (**VIC**)
- Hydroclimate Variables (**Daily Max Temperature, Daily Minimum Temperature, & Precipitation**)

Student Action: Students will download and organize data to calculate the percent change and average temperature and precipitation.

REFERENCES

- .https://curipod.com/a09a2bf0-5c95-5d31-9419-67b9dd5fd6ba/lessons/dee5851d-7e5c-40ce-9291-149a90972d72?showpreview=true
- https://www.caryinstitute.org/eco-inquiry/teaching-materials/hudson-river-ecology/natural-history-hudson-river/watersheds
- https://extapps.dec.ny.gov/docs/remediation_hudson_pdf/hrlpwatershedms.pdf
- https://mywaterway.epa.gov/community/10520/overview
- https://hydroclimate.ornl.gov/
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