Create-A-Watershed

Students orient themselves to the Great Lakes using maps and learn about watershed management and water pollution

OBJECTIVES

- Identify the Great Lakes watershed on a map
- Describe a watershed
- Locate local watershed(s) on a map
- Research point and nonpoint source pollution in the local watershed

SUBJECT
Geography, Ecology

PREREQUISITE
#2: A Sense of Place
#5: Getting to the Bottom of the Great Lakes

VOCABULARY
acid mine drainage
algal bloom
aquifer
groundwater
hydrologic cycle
infiltration
impervious surface
land cover
nonpoint source pollution
point source pollution
pH
sediments
stakeholder
surface runoff
transpiration
tributary

MATERIALS
computers with internet access and Google Earth installed, or one computer with a projector.

For each group of four students:
- two spray bottles
- five toothpicks with flags
- food coloring, cocoa powder (optional: chocolate chips or candies)
- 9" by 13" glass baking dish (or clear plastic container of a similar size)
- pencils
- sand
- maps: world map, Great Lakes watershed map (one for each student plus one for the classroom), local watershed map (one for each student)

TIME/DURATION
90-120 minutes

SETTING
Indoors

This Great Lakes in My World 9-12 activity is aligned to the Common Core State Standards (as available). This alignment is available on your Great Lakes in My World 9-12 USB flash drive in the "Standards" folder and on-line at http://www.greatlakes.org/GLiMWstandards.

BACKGROUND

A watershed is an area of land drained by a body of water. For example, all of the water that falls in the Great Lakes Basin eventually drains into one of the Great Lakes. All land is a part of a watershed. Watersheds are nested within each other. The Great Lakes Basin is the land that makes up the Great Lakes watershed. Within the Basin, each lake has its own watershed (see map). Within the lake, watersheds are smaller watersheds of land that drain into rivers. However, as watersheds become more developed and have an increased number of impervious surfaces (rooftops, parking lots, and roads), more water is blocked from soaking into the ground. As stormwater runs across the land, it picks up and transports pollutants to our lakes, rivers and streams. These pollutants can degrade biotic communities, prevent recreational uses and contaminate water supplies.
See student pages for additional background information.

PROCEDURE

1. Students read the background information and respond to the questions on the student pages.

2. Ask students to describe three large landforms that determine where water ends up in North America. Remind them that water always flows downhill, which is why topography is important. *1. The Rocky Mountains (water flows to the Pacific); 2. The Appalachians (water flows into the Atlantic), and in between the Appalachians and the Rockies, the water flows into the Gulf of Mexico; 3. The Great Lakes (water flows into the north Atlantic).* This is a simplistic explanation, but it will spark a discussion about watersheds.

PART ONE: CAUSE AND EFFECT -- *THE INTERCONNECTEDNESS OF A WATERSHED*

3. Use the "Cause and Effect Cards" that are part of this activity. Hand out "effects" to half of the class, so that several students are assigned each effect. Give the other half of the class the "causes" of these problems. Each student should find a partner in order to match the causes and effects. Give each student two copies of the cause or the effect, so that they can give one copy to their partner. Each student should have a complete set. Cause cards are numbered 1-7 and effect cards lettered A-G. Cards match-up accordingly: 1F, 2C, 3B, 4E, 5A, 6G, and 7D.

4. Make several groups so that each cause-effect or watershed problem is represented in each group. Have each student group put these problems in order of most to least important if these issues were to arise in their community's watershed. Which cause-effect watershed problems would affect you and your family? The school?

5. As a class, discuss the various causes and effects. Have groups report out their most important and least important cause-effect relationships and describe why they place more or less importance on different issues.

PART TWO: LAB ACTIVITY -- *A MODEL WATERSHED*

6. At lab tables or in small groups, have students fill a glass baking dish with sand (a similarly shaped, transparent plastic container can also be used). Allow students to form a "landscape." The landscape should include a lot of variety, with hills, ridges, plains and/or depressions.

7. Students draw a sketch of their watershed model. This should include the key elements of a map, as learned in "A Sense of Place" (title, key/legend, cardinal directions or north arrow, scale and labels).

8. Explain to the student that the food coloring will represent pollution.

9. Students are to place five drops of food coloring or cake dye in the following locations:

a. At three places buried in the sand (in the groundwater)

b. At three places on the sand (on the surface or ground level)

10. Choose three places in the landscape to spray water, simulating rain. Mark them with toothpicks with flags. Caution the students not to use the spray bottle until they are directed to do so. Ask students to guess where the water will go when sprinkled on the landscape. Have them point out the toothpick or draw arrows in the sand to mark the water flow. At each of the marked locations, students will use spray bottles to distribute water, or will gently pour water, over the landscape. They should watch carefully to see where the water goes. Did it follow their flags or arrows? Why did the water flow the way it did? (*Water will flow down hills and collect in the basins. If you choose to use sand, some of the water will sink in. This mimics water flow in the natural world. Gravity is the force affecting this flow.*)

Have students point out the bodies of water and the rivers that formed. Explain that an area drained by a body of water is called a watershed. Have students find the watershed for the larger bodies of water in their landscape. Ask them if they notice anything about the water poured over the tops of their hills or ridges. *Water poured over the top of a point will probably flow in both directions, into different watersheds.* These points mark the boundaries between watersheds. Consider using cocoa powder instead of colored water or food that will melt or that has colors that will run (chocolate chips, or other candy) to place in the landscape and simulate pollution (have students think of what pollution they want to represent in their watersheds) and animal waste in the ecosystem. You can also make marks with dots of another color to indicate pesticides and insecticides. Re-spray the landscape and have the students observe and discuss what happens. *Remind students that water flows downhill and eventually ends up in the sea. You can see where water goes by using topography.*

PART THREE: POLLUTION WITHIN A WATERSHED -- *POINT AND NONPOINT*

11. On student page ##, tell students to draw a picture of the watershed model that they created in small groups. Using their watershed model as a visual example, ask students to brainstorm real-life pollution sources. They should answer the questions individually.

12. In small groups or as a whole class, students discuss what problems communities might face in identifying pollution sources. What makes it more difficult to identify nonpoint source pollution in a watershed?

WRAP-UP QUESTIONS

13. Ask students to think of watersheds in the natural landscape. What body of water is nearby? What land do they think is a part of its watershed? Are they standing in a watershed now? *(Every place is in a watershed!)* Tell students that they will look at maps to find their watersheds. If desired, have students sketch the landscape that they've created.

14. How does pollution in your watershed impact the people living in your watershed? How does it impact the ecosystem and the species living within this watershed?

15. If you were to discover a pollution source or other problem within your watershed, what would you do as a community? If you were to organize a meeting to discuss this issue, what stakeholders would you invite? How would you structure the discussion to reach a solution to this problem?

EXTENSION

A. You may do this research in advance or with the class. Go to: http://cfpub.epa.gov/surf/locate/index.cfm or another Web site from the resource list to locate your watershed and find out information about it.

a. To find out more about your watershed, click on: *Environmental Websites Involving This Watershed*. Scroll through the list of web sites and look for a general site about your watershed. Click on the link. The screen will say: *You are now exiting the EPA web server*. Click on the blue link. If you do not find a general web site about your watershed, try http://www.great-lakes.net.

B. Have students mark their watershed on a Great Lakes map with a highlighter. These maps are not very detailed, so you may wish to use them in conjunction with more detailed maps of your area. Comparing the two maps, have students find their watershed on the more detailed map. This will give them a better orientation. They can look for their school and homes on the map, as well.

ASSESSMENT

See rubric on page 88.

RESOURCES

Please see Resource List for additional information related to watersheds and more.

CAUSE-AND-EFFECT: POLLUTION IN OUR WATERSHED

CAUSE - 1

As power plants produce electrical energy, the pressure and temperature within and surrounding their generators increase. Power plants are often developed near a body of water, such as a river or lake. To reduce the heat and pressure, water is used for cooling purposes. This water is taken in from a nearby body of water, such as a river or lake. After the water is used, it is discharged into the lake. Excess heat is discharged and thermal, or heat, pollution often results.

CAUSE - 3

Areas dense in agricultural activities often see increased amounts of nutrients, phosphorus and nitrogen, in the local watershed. This is because some farmers use mass amounts of fertilizer containing phosphorus and nitrogen and during precipitation events, like storms, this fertilizer runs off into local streams and lakes.

CAUSE - 2

Groundwater and surface water can be considered a single resource, because they are connected. Although gasoline on the surface of pavements, such as driveways, parking lots and roads appears to just sit there, this gasoline can be washed away with the rain into permeable surfaces, or into our stormwater drains or local waterways. This is an example of nonpoint source pollution. On the other hand, a leak from an underground gasoline tank would be considered point source pollution. Underground storage tanks (USTs) are prone to corrosion and leaks and are therefore a risky process. The petroleum or hazardous substances stored in these USTs have a chance of leaking into the surrounding groundwater and polluting this precious resource used for drinking water. Groundwater pollution is a huge concern because the majority of many communities' drinking water comes from groundwater, and it takes an extreme amount of time and money to clean out the contaminants from polluted groundwater.

CAUSE - 4

Acid mine drainage is a huge concern in many places near mining operations. Acidic run-off with a low pH arises when iron or aluminum minerals and water become exposed to oxygen. A low pH level means that little to no life can persist. Because of this, acid mine drainage is a large threat to ecosystem health.

CAUSE - 5

The coastal city in which you live has a combined sewer system, which carries both sanitary sewage and stormwater to a treatment plant. In the event of a heavy rainstorm, the combined system may exceed its holding capacity due to an increased amount of stormwater entering the system, and, as a result, this combined sewage is discharged directly into nearby waters. This is referred to as a combined sewer overflow, or CSO, and can results in sewage discharge with E. coli levels up to 250,000 CFU/ 100 mL.

CAUSE - 7

Monitoring data shows high levels of phosphorus near the lake's shoreline. Phosphorus pollution is associated with the growth of algae, which proliferates during warm weather then washes ashore and decays, sending up foul-smelling odors in the hot summer sun that deter swimmers and others from using the beach. The algae can also harbor potential human pathogens such as Salmonella. Another cause for concern are recent changes in climate. Global climate change occurs naturally with fluctuations in ocean currents, oribital and solar variations, volcanism and plate tectonics. However, carbon emissions resulting from the burning of fossil fuels and changes in land use (i.e deforestation) have accelerated this process. Some areas are experiencing heavy rainfall leading to flooding, while other areas are experiencing extreme droughts. Heat waves are becoming more frequent with these increasing temperatures. Some plants, including algae, are blooming earlier in the year. Algae growth also kills fish and other aquatic organisms by lowering oxygen levels in the water. The nutrients we spread on our lawns, gardens and farmfields to spur healthy plant growth similarly spur algae growth in the lakes when carried there in runoff. Nutrients also reach the lakes via untreated sewage discharges and the use of phosphorus-based detergents at home.

CAUSE - 6

One of the most common ways pharmaceutical compounds enter our watersheds are through our wastewater. Humans and animals alike are given medications, however, their bodies do not fully metabolize or absorb them. The excess drugs are excreted as waste. Another possible cause would be from unused prescription medications that are flushed down the toilet or some other drain by humans. These drugs then enter our wastewater. If effluent isn't treated, these traces of pharmaceuticals may be discharged into our watersheds. Not all wastewater treatment plants can remove these chemicals from the water. The long term effects of pharmaceutical pollution are not known, but there are ways to dispose of pharmaceuticals in a safe way. Pharmacies, nursing homes, hospitals and residents are prompted to bring their unused medications to a "take-back" or safe disposal location.

EFFECT - A

Today, a few of your nearby Great Lakes beaches were closed due to high levels of E. coli in the water. While E. coli is commonly found in low levels most everywhere in the environment, it can cause illness in humans. Humans and most warm-blooded animals carry it in their systems, and excrete it in their fecal matter. The U.S. Environmental Protection Agency recommends that there be no more than 235 CFU ("Colony Forming Units" or cells) per 100 mL in recreational waters. At one of these beaches, you notice a large pipe upstream from where you usually swim at this beach. What may have caused these increased levels of E. coli in the water?

EFFECT - B

The Illinois Department of Natural Resources (IDNR) has identified an algal bloom in a local lake. Algal blooms occur when excessive nutrients from fertilizers allow bacteria and algae to grow beyond the natural level and deplete the oxygen that fish and other wildlife in the ecosystem need to survive. Where do you think extra fertilizer is coming from to destroy the native ecosystem of this lake?

EFFECT - D

It's early spring, but the sun is shining and there is algae growing on the surface of the lake. Lately, the lake has an increase in algae, including some large algal blooms. What could be causing these algal blooms?

EFFECT - C

The United States Geological Survey (USGS) has been assessing the groundwater near underground storage tanks (USTs) filled with petroleum that are located near a gas station in your community. Why do you think the USGS has been carefully monitoring the USTs? Explain.

EFFECT - E

Yesterday, the pH level of a river was measured and it was extremely low, or acidic. The color of the stream was also a bright orange. Geoscientists are exploring where this acidity could have originated from, because the river isn't directly connected to any industry. This river is one of the few remaining functioning rivers in this mining town and the health of the river is crucial to the functioning of the community. Where do you suppose the abnormal acidity is originating from?

EFFECT - F

The Environmental Protection Agency (EPA) has recently discovered increased temperatures in a river populated with several power plants. Where do you think this heat pollution is coming from?

EFFECT - G

Trace amounts of pharmaceutical chemicals were found in the local drinking water supply. Scientists are concerned about the health effects of drinking these low-level concentrations over an extended period of time. The public is notified immediately if certain regulated contaminants are found in the drinking water supply, however there are no requirements to notify if pharmaceuticals are detected. How do you think these pharmaceutical chemicals are getting into our watersheds?

NAME

10
LESSON
STUDENT PAGE

Create-A-Watershed

VOCABULARY

acid mine drainage
algal bloom
aquifer
groundwater
hydrologic cycle
impervious surface
infiltration
land cover
nonpoint source pollution
point source pollution
pH
sediment
stakeholder
surface runoff
transpiration
tributary

BACKGROUND

A watershed is the area of land drained by a body of water. For example, all of the water that falls into the Great Lakes Basin eventually drains into one of the Great Lakes. All of this land is part of a watershed. Watersheds are nested within each other. The United States could be divided into Atlantic and Pacific watersheds, then into smaller watersheds of rivers and lakes and then into even smaller watersheds of the tributaries of rivers. The Great Lakes Basin is the land that makes up the Great Lakes watershed. Within the basin, each lake has its own watershed (see map). Within the lake, watersheds are smaller watersheds of land that drain into rivers. Within the Great Lakes system, water flows from Lake Superior and Lake Michigan to Lake Huron, through Lake St. Clair into Lake Erie, over Niagara Falls and into Lake Ontario before flowing through the St. Lawrence River into the ocean. Rivers and streams transport nutrients, dissolved gases, salts and minerals, sediments and pollutants from watersheds into the Great Lakes.

When precipitation falls on the land, most of it infiltrates the soil, evaporates, is taken up and transpired by plants, or runs across the surface of the land into our waters as surface runoff. Under natural conditions, a relatively small amount of water leaves as surface runoff, while the majority of the water soaks into the ground or is taken up by plants. Soil and plants absorb the water and provide the natural filtration of pollutants. Some water that infiltrates the soil remains near the surface, where it gradually moves downhill, through the soil, and eventually into a nearby stream or water body. Some of the water may infiltrate much deeper, into the aquifers. Water can travel long distances or remain in storage for long periods before returning to the surface. The amount of water that will soak in over time depends on the land cover and soil characteristics and the slope of the lane. In many communities and along many shorelines, more impervious surfaces (rooftops, parking lots, and roads) are being developed within watersheds, and thus more water is blocked from soaking into the ground. Water then remains on the surface and becomes stormwater. Stormwater, either discharging from the end of a pipe or entering a body of water after flowing over the land, is a key threat to water quality. Stormwater may carry a variety of substances as it makes its way to the water: grit, oils and litter from city streets and parking lots; waste from domestic and wild animals; nutrients such as phosphorous from lawns, gardens and farms; yard waste; and sediment and bacteria. All of these substances can harm water quality.

Nonpoint source (or NPS) pollution comes from many different, diffuse sources and is extremely difficult to regulate and control, which makes it a hazard facing the Great Lakes today. NPS pollution is mainly caused by runoff, when rain and snowmelt move over the land, picking up pollutants along the way and eventually dumping the pollutants into rivers and lakes. Some common NPS pollutants include fertilizers and pesticides from agricultural lands and homeowners; oil, grease and salt from highways; sediment from construction sites and eroding shorelines; and animal and human waste.

In contrast, point source pollution is when pollutants enter a waterway though a specific entry point, such as a drainpipe draining directly into a river or lake. Industrial water discharges and sewage treatment plants are the main culprits of this type of pollution. Point source pollutants can include many different organic and inorganic substances, including human waste and toxic metals. Point source pollution can be traced to a specific discharge point and owner; therefore, it has been the easiest source of pollution to control and regulate, although it continues to be a problem.

Atmospheric pollution (or air deposition), which comes from the sky, is another form of nonpoint source pollution. As water moves through the hydrologic cycle, it falls as rain or snow and then evaporates into the air from land and surface

water. Pollutants emitted into the air, such as through smoke stacks, follow this same path, and can be carried through the atmosphere and deposited into waterways hundreds of miles away from their sources. Acid rain is a well-known form of atmospheric pollution. The major sources of atmospheric pollution include coal-burning energy plants and waste incinerators. The combustion of fossil fuels and waste (such as that from hospitals) produces large amounts of mercury, which travel into the air. Mercury is a toxic chemical that is fatal to humans and animals in large quantities. Phosphorus and polychlorinated biphenyls (PCBs) are also transported to waterways via air deposition.

Because water does not follow our municipal and political boundaries, communities must work together to address nonpoint source pollution and the impacts of land use decisions on our water resources. Watershed management is an effective way to cross traditional boundaries and bring people in different regions together to effectively manage land, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public lands. Watershed management integrates scientific and social considerations to take a holistic approach to protecting and improving a water body. By the end of this lesson, you will understand the issues facing watersheds and you will identify techniques for remediating these issues.

INTRODUCTORY QUESTIONS

1. What are three main features that determine how water flows in North America? (Hint: Think big.)

2. What are two examples of point source pollution? Nonpoint source pollution?

LAB PROCEDURE/QUESTIONS

PART 1: CAUSE AND EFFECT -- POINT AND NONPOINT SOURCE POLLUTION

3. Which cause and effect watershed problems would affect you and your family? The school?

4. What were the most and least important cause-effect relationships? Describe why you placed more or less importance on different issues.

PART 2: LAB ACTIVITY -- A MODEL WATERSHED

5. Form a "landscape" in a glass baking dish using sand. Your landscape should have a lot of variety, such as hills, ridges, plains and depressions.

6. Place five drops of food coloring or cake dye (pollution) in the following locations:
   a. At three places buried in the sand (in the ground water)
   b. At three places at the surface (ground level)

7. Choose three places on the landscape to spray water, simulating rain. Mark them with toothpicks with flags.

8. Either point the toothpick flag or draw arrows in the sand to mark where you think the water will flow.

9. Now, spray water on these surfaces, and observe where the water flows.

PART 3: POLLUTION WITHIN A WATERSHED -- POINT AND NONPOINT SOURCES

10. Sketch a simple map of your watershed model. Include the five key elements of a map: title, key/legend, cardinal directions or north arrow, scale and labels.

11. Draw arrows to show where the water drains.

12. Identify sources of pollution and delineate between point and nonpoint source pollution. Label pollution sources as either P (point source pollution) or N (nonpoint source pollution).

13. What makes it difficult to identify, monitor and address nonpoint source pollution in a watershed?

WRAP-UP QUESTIONS

14. Describe how water flows in a watershed.

15. What are the problems associated with point and nonpoint source pollution?

16. What are impervious surfaces and what is their connection to pollution sources in a watershed?

17. Based on your understanding of watersheds, where would the best location be if you were building a house in this watershed? Where would you build a school or park? Why?

18. What can you do to decrease pollution problems in your watershed?

19. If you were to discover a pollution source or other problem within your watershed, what would you as a community do?

20. If you were to organize a meeting, what stakeholders (people who are interested and/or involved in the topic being discussed) would you invite?

RUBRIC

ELEMENTS	☆☆☆☆	☆☆☆	☆☆	☆
BACKGROUND/QUESTIONS: Student reads background information about watersheds, nonpoint source pollution, and point source pollution and answers introductory questions in the student pages.	Addresses all of the components	Missing one of the components	Missing two components	Missing three or more components
WATERSHED ISSUES: Student identifies cause and effect relationships between issues within a watershed and the effects they have on the watershed. Students work together to discuss these issues and determine how important they are to the community's watershed. Student shares his/her views with the rest of the class.	Addresses all of the components	Missing one of the components	Missing two components	Missing three or more components
MODELING: Student works with a group to construct a model of a landscape consisting of hills, depressions, ridges and plains. Student applies food dye (pollution) at different locations (above and below the ground), and predicts where the water will flow by marking with toothpicks or flags. Student simulates precipitation by using a spray bottle of water in three areas of the model, observing how the water flows through the watershed.	Addresses all of the components	Missing one of the components	Missing two components	Missing three or more components
MAPPING: Student sketches a map of the watershed model. All five key elements of the map are included (title, key, cardinal directions or north arrow, scale and labels), arrows are used to show the water flow direction, and point and nonpoint sources of pollution are labeled. Student uses model and map to answer the wrap-up questions and discuss with the class.	Addresses all of the components	Missing one of the components	Missing two components	Missing three or more components