

Karst Watershed Simulation Activity: Point and Nonpoint Source Water Pollution Causes and Prevention

Lesson Summary (Grades 8-12): In this simulation activity, students are introduced to how various land uses and practices can impact water quality. Students receive a “land lot,” (resembles a map of a small piece of land), which represents a segment of a hypothetical watershed in a karst region. Students are then provided corresponding background information about their land lot, including specifics about how the land is used and potential water pollution sources (point and nonpoint) that may be generated by that use. The students draw symbols on their land lot map to represent these occurrences. Then all the segments are assembled side-by-side into a rectangular map of the larger watershed, so the class can visualize the water quality impacts on those downstream. In addition, the karst features on the watershed map provide insight into possible groundwater threats from various land uses.

Missouri Earth System and Human Activity Standards:

6-8.ESS3.C.2 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

9-12.ESS3.C.2 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and/or biodiversity of the ecosystem as well as prevent their reoccurrences.

9-12.ESS3.D.2 Predict how human activity affects the relationships between Earth systems in both positive and negative ways.

Related Vocabulary:

Watershed	Non-Point Source Water Pollution (NPS)	Best Management Practices (BMPs)	Erosion
Karst	Point Source Water Pollution (PS)		Runoff
Impermeable			Sediments

Time Requirements: For preparation, the teacher needs to read the lesson and the LAND LOT TASK SHEETS. PDFs need to be printed and supplies gathered. Time required for the activity will be 1-2 class periods, depending on how much in-depth discussion occurs.

Background Information for the Teacher:

Watershed Definition: The land that water flows across or under on its way to a stream, river, or lake.

Karst Description: Karst is a geological area composed of features such as sinkholes, losing streams (water goes underground and returns elsewhere), springs and caves. Karst features result from groundwater slowly dissolving carbonate rocks. The Missouri Ozarks has karst terrain.

Watershed & Karst Relevance: The water quality in a watershed is mainly the result of land use practices in a given watershed. Missouri’s land is 93% privately owned. Therefore, private individuals and their activities do have an impact of the water quality of their watershed and

groundwater. Since the Missouri Ozarks is composed of karst features, the surface waters (streams and rivers) are often connected with groundwater. Wells are the main source of domestic water for homes and businesses in the Missouri Ozarks. Therefore, activities on the surface may expose groundwater to surface water pollution.

Water Pollution: There are two main types, point source (**PS**) and nonpoint source (**NPS**).

Point Source Water Pollution Definition from Clean Water Act section 502(14): *The term “point source” means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.*

Note: Point source water pollution is regulated to minimize the harmful health effects on life and the environment. It is regulated through the National Pollution Elimination Discharge System (NPDES) and conducted by state resource regulatory agencies.

Nonpoint Source Water Pollution: Nonpoint source water pollution runoff results when rain and snow melts carry natural and human-made pollutions and sediments from land to waterways. Deposition of air pollution particles (air pollution particles settled in waterways) is also a source of nonpoint water pollution. These pollutants in excessive amounts cause health problems for humans and wildlife. **Best Management Practices (BMPs)** are methods that have been determined to be the most effective and practical methods for preventing and reducing nonpoint water pollution.

Significance: Nonpoint source water pollution is a leading cause of water quality problems today. Sources are varied and complex this lesson covers the major categories. NPS water pollution can have harmful effects on drinking water supplies, recreation, fisheries, and wildlife. Excessive nutrients and sediments are nonpoint source of water pollution that are especially problematic.

Related Web Links / Background Information:

[Watersheds - PUB0243 | Missouri Department of Natural Resources \(mo.gov\)](#)

[Polluted Runoff: Nonpoint Source \(NPS\) Pollution | US EPA](#)

[All NPDES Program Areas | US EPA](#)

[How's My Waterway - Home \(epa.gov\)](#)

Required Materials:

1. Print out the **Karst Watershed Pattern PDF file**. There are 20 different Land Lot sheets that compose the watershed pattern so there are 20 pages.
2. Print out the **LAND LOT TASK SHEET PDF file**. There is a task sheet for each land lot that corresponds with the lot number. These can be saved and reused.
3. Students will need **scissors** to cut out along the black border of their LAND LOT and **rulers** to measure dot sizes (.5 cm so they can be seen from a distance).
4. **Colored markers** are needed to draw on colored symbols on lots: *green, blue, brown, purple, yellow and gray*. See the following page **Karst Watershed Simulation: Colored Symbol Key** for specific-colored symbols that will be added to lots.

5. The watershed map will need to be put together in an area where students can gather around or see from a distance. *When constructed the watershed map is 37" in height and 26.5" in width.* If available, lay out on a table, or if not, tape it on wall or classroom white board.
6. Have a **laser pointer** to point out downstream effects once the pattern is put together.
7. *Optional:* Provide students the **Karst Watershed Simulation: Land Lot Tracker PDF** for them to follow along as students share information about their lots. They could do this in pairs as well. The tracker is a table listing each lot which gives each land use and the karst features. Student fill a column Yes or No for whether or not the lot is in compliance with permits or following Best Management Practices to prevent or reduce nonpoint source water pollution.
8. *Optional:* Display on the board the different colored symbols for the various lots. See table below or provide them this table.

Karst Watershed Simulation: LAND LOT Colored Symbol Key

Important Note: *Instruct students to make dots .5 cm in diameter so they can be seen from a distance when the sheets are put together to make the watershed map.*

Point Source Water Pollution: Permit in Compliance	Point Source Water Pollution: Permit NOT in Compliance	Nonpoint Source Water Pollution Run off	Nonpoint Source Water Pollution Prevented or Reduced by BMPs
<p><i>Note: Even numbers</i></p> <p>LAND LOTS: 4,18</p> <p>A blue outline (appears like a glove) around waterway represents that the point source is in compliance with its permit.</p> <p>Therefore, the waterway is protected according to the permit.</p>	<p><i>Note: odd numbers</i></p> <p>Arrows "point" to the waterways: Point Source Water Pollution!</p> <p>Green Arrow – Excessive Nutrients from point source (lot 1)</p> <p>Red Arrow – Industrial wastewater or thermal pollution from point source (lots 7, 19)</p> <p>Gray Arrow – Polluted stormwater runoff off of an area that requires a stormwater permit (lot 7)</p> <p>Purple Arrow – Chemical (lot 19)</p>	<p><i>Note: odd numbers</i></p> <p>Dots represent how nonpoint water pollution is scattered and spread out over an area.</p> <p>Green Dots (excessive nutrients) (lots 3, 9, 11, 13, 17)</p> <p>Brown Dots (excessive sediments) (lots 3, 5, 9, 11, 13, 15, 17)</p> <p>Black Dots (oils, grease, road sand and salts) (lots 5, 11, 13, 15, 17)</p> <p>Purple Dots (herbicides, pesticides, insecticides, fungicides) (lots 3, 11, 13, 17)</p> <p>Red Dots (household hazard wastes) (lots 11, 13, 17)</p> <p>Yellow Dots (Litter) (lot 15)</p>	<p><i>Note: even numbers</i></p> <p>LAND LOTS: 2, 6, 8, 10, 12, 14, 16, 20</p> <p>A green outline (appears like a glove) surrounding a waterway represents trees and vegetation buffering it from runoff.</p> <p>The blue label "BMPs" represents Best Management Practices being followed to prevent and reduce nonpoint source water pollution.</p>

NOTE: In this simulation all even number lots are in compliance with permits or following Best Management Practices to prevent and reduce water pollution. The odd number lots are NOT in compliance with permits or are NOT following Best Management Practices so they have polluted runoff. *More specific tasks are required with odd number lots. Teachers may want to keep this in mind when passing out the lots to students.*

Lesson Warm Up:

1. Tell students that they are going to participate in a simulation activity. Explain that a simulation is an imitation of a situation. Explain that this simulation is an extremely simplified model of a very complex situation that involves many variables.
2. This simulation is an imitation of a watershed in a karst area and the land use practices that can either possibly help or harm the water quality in that watershed.
3. Discuss definitions of **watershed** and **karst**. Add questioning to prompt participation.
4. Explain that 93% of the land in Missouri is privately owned. However, all residents share surface and subsurface water that travels over and under properties owned by others.
5. Describe the karst features that make up the geology of the Missouri Ozarks. Give examples and ask students to share any they have visited. Include how karst features take surface water runoff underground. In the Missouri Ozarks people depend on groundwater for all domestic and public uses.
6. Introduce the terms **point and nonpoint source water pollution, runoff and Best Management Practices**. Explain that these terms are very relevant to today's lesson.
7. Explain that students will get a **LAND LOT** (one or more depending on class sizes) that is one part of the larger watershed. Explain that they will get a corresponding **LAND LOT TASK SHEET** that will tell them how the land lot is used. It will include the many possible sources of water pollution that may be generated from that lot land use. Once everyone has done the three following steps, they will combine their land lots into a watershed map and see how each one may be helping or harming the water quality of others. *The steps are: a) examine their lot; b) read the background information about the lot; and c) make the necessary-colored markings representing pollutants or prevention measures.*

Karst Watershed Simulation Activity:

1. **Distribute** all the twenty **LAND LOTS** sheets as desired, based on class size. For classes less than 20 students some students will need more than one lot. If so, try to give them lots from the same category. For classes with more than twenty students have students share lots.
2. **Read and discuss the directions and legend at the top of the Land Lot.** The directions and the legend are the same for all 20 lots, however the river patterns and karst features vary on each one.

- *Before going on to step 3, have the students identify all the karst features on their Land Lot Sheets using the key on top. The karst features are losing streams, caves, springs, and sinkholes.*
- *Tell them that everyone needs to do the following to help any "karst feature" stand out. Using a red marker, have students make red dashes on any losing streams, and trace any sinkholes, springs, and caves with a red marker as well.*
- *The red markers will help the karst features stand out when the sheets are put together to make the watershed map. Note, not all students will have karst features.*
- *Tell them NOT to make any other markings for now until instructed.*

3. Pass out the **LAND LOT TASK** sheets that correspond with each lot numerically. Point out the topics listed on all sheets.
4. Explain that each lot has these same topics listed, but each one provides different and/or similar information about each lot's land use and practices. **Explain they each need to read the information so they can summarize it briefly to the class once the watershed map is put together later in the activity.** Provide students reading time. Answer questions as needed. *Consider telling student not to write on the LAND LOT TASK SHEETS so you can use them again for other classes and/or keep for future use.*
5. Once students have read and understood the information about their lots, **they need to do the underlined tasks described on their LAND LOT TASK SHEETS to their LAND LOTS.** Have colored markers, scissors, and rulers available for student to use. Assist as required.

Be sure students understand the colored dots need to be .5 cm in diameter so they can be seen at a distance when lots are combined to make the watershed map. Once they measured a few they will know the relative size and do not need to measure each one.

6. Display the watershed as a map by having students put every **LAND LOT** in numerical order by rows so all the pieces and watershed pattern line up. There are 20 lots that make 5 rows of 4 lots each. Use a table large enough to display the entire watershed or tape them to the wall or white board. Have students gather around it to see colored symbols and the entire watershed pattern.
7. Using a **laser pointer**, trace how runoff flows downstream. Mention that the model is only two dimensional. In reality it would have height that would determine where water would flow downhill to the nearest waterway. Discuss the watershed map and point out karst features.
8. **One at a time, have students tell and describe the land use category on their LAND LOT and point out any karst features. Also, have them explain what the colors and symbols represent on the lot. Begin with lot number 1 and go in order to number 20.** Prompt them to use the vocabulary in their summary. Use the laser to point out the lot that is being described so classmates' attention is directed. Also, use the laser to trace the pathway the water will travel from each lot to others downstream. Note all karst features which should stand out in red are conduits to groundwater. Continue this process until all 20 lots are covered.
9. **Ask students to determine how many lots are sending them water pollution. Have students raise their hand if their lot is receiving water pollution.**
10. Remind students that 93% of the land in Missouri is privately owned. Locations that generate point source water pollution are regulated and monitored. Consequences result when noncompliance occurs. Natural resources get degraded, people may get sick, and fines are likely imposed on facilities in noncompliance. Cleaning up waterways is difficult once it occurs. Nonpoint source water pollution is not regulated or monitored. However, natural resources are degraded and it is difficult to hold individuals responsible and to clean up the water pollution. To protect water quality, which is in everyone's interest, individuals need to be aware of their actions and resulting impacts. Being educated on this issue and accessing help can make a **BIG** difference. The collective impact of nonpoint source water pollution is a large problem.
11. For further investigation, point out to student that at the bottom of each **LAND LOT TASK SHEET**, students can find out more information by entering that information in a browser. If correctly done, it should take them to that link.

Lesson Wrap Up:

Summarize the watershed simulation that demonstrated the causes and preventions of point and nonpoint water pollution. Remind students that this is a simulation which is a simplified imitation of a complicated situation. Briefly conduct a discussion how the simulation activity compares and contrasts to reality. Emphasize that all watersheds are part of a river basin which will eventually empty into a sea or ocean. All the water pollutants carried downstream in that basin will eventually accumulate in the seas and oceans.

Modifications:

The lesson difficulty could be decreased by making the following adaptations:

- Rather than have the class do the activity at one time, do one row (four Land Lots) a day over a week. Hang them on the wall so students can see the karst watershed pattern emerge over that time.
- If students need more structure for the lesson, provide them with the **Karst Watershed Simulation: Land Lot Tracker** which provides them a table to follow along and record information on as students talk about the lots 1-20.
- Let students highlight key information on their LAND LOT TASK SHEET to guide them when they briefly explain their LAND LOT use and pollution problems and solutions.

The lesson difficulty could be increased by making the following additions:

- At the bottom of each LAND LOT TASK SHEET there are links that can be typed in a browser. Have students find out more specific information related to the land use.
- Have students research on the EPA website **National Pollution Discharge Elimination Systems** and create a concept map of the types of NPDES outfalls. NPDES are the permits required when wastewater is from a point source.
- Have students use mywaterway.epa.gov to find out what sources of water pollution are being regulated in their own watershed and that of others.

Assessments:

- Have student create a Venn diagram comparing and contrasting point and nonpoint source water pollution.
- Have students describe how karst features can transport surface water pollution underground.
- Have students answer the following question. “What does the phrase “We all live downstream” mean?”
- Have students write a summary paragraph explaining how they can help their own watershed by taking personal responsibility and specific actions around their home and yard.