Title:	Stream Table Investigation	
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Course: **Grade:**	11 – 12	**Duration:** One 45-minute class

Objective:
Students will observe erosional capabilities of moving water as related to earth surface components and relate those to water quality at oil and natural gas drill sites.

Summary of Lesson:
Students will model a stream and show movement and changes in the surface due to changes in stream flow. Following this activity students, will conduct research on EPA regulations and Arkansas Best Management Practices for water quality at oil and natural gas drill sites.

Arkansas Standards:

CODE	GRADE	SLE	STANDARD
ENVIRONMENTAL SCIENCE	**9-12**	**EVS-ESS2-2**	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems
		EVS-ESS2-5	Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes
		EVS1-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants
		EVS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects)
		EVS4-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability

			and aesthetics, as well as possible social, cultural, and environmental impacts.
EARTH SCIENCE	**9-12**	**ES-ESS2-2**	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems
		ES-ESS2-5	Plan and conduct investigations of the properties of water and its effects on EArth materials and surface processes
BIOLOGY	**9-12**	**BI-ESS2-6**	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere
		BI-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
		BI-ESS2-4	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate
		BI-ESS2-5	Plan and conduct investigation of the properties of water and its effects on Earth materials and surface processes
		BI-ESS3-1	Construct and explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
		BI-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems
PHYSICAL SCIENCE	**9-12**	**PSI-PS3-2**	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles and energy associated with the relative position of particles
		PSI-ESS3-2	Evaluate competing design solutions for developing managing, and utilizing energy and mineral resources based on cost-benefit ratios
		PSI6-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and

			tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural and environmental impacts.
ECONOMICS	**9-12**	**EM.3.E.3**	Evaluate intended and unintended consequences of government policies created to improve market outcomes (e.g., regulatory, participatory, supervisory)
LANGUAGE ARTS	**9-12**	**W.9-10.2** **W.11-12.2**	Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
		W.9-10.2.A **W.11-12.2.A**	Introduce a topic; organize complex ideas, concepts, and information to make important connections and distinctions; include appropriate text features (e.g., captions, headings), graphics (e.g., figures, tables), and/or multimedia.

Teacher Excellence Support System (TESS):
Domain 1b: Teacher Knowledge of students. (Learning types)
Domain 1d: Demonstrating knowledge of resources. (Use what is available)
Domain 3c: Engaging students in learning. (Get them involved)

Instructional Strategies and Practices:
Independent research, Simulation, Conducting experiments

Bloom's Level: Highest Level Only
Understanding

Materials and Resources:

- Stream tables or wallpaper trays.
- Sand
- Water source such as a watering can with small holes in the spout
- Rocks, sticks, leave, etc. (to create debris, blockages, dams, etc.)
- Websites for research:
    - http://www.veilenvironmental.com/publications/pw/Water_Mgmt_in_Fayetteville_Shale.pdf
    - http://www.api.org/environment-health-and-safety/clean-water/surface-water-quality/surface-water-quality

If these websites are no longer available explore the internet using key phrase: “mandatory and voluntary practices used by the oil and gas industry in Arkansas to protect water quality.”

Formative Assessment:
Student group lab activity written report of results.
Teacher made rubric for assessing oral report

Notes to Teacher:

The following statement was taken from: http://www.oilandgasbmps.org/resources/water_quality.php. Use it to introduce the stream table activity and explain why water quality issues are so important to the oil and natural gas industry.

> *“Improved technological developments in directional drilling and hydraulic fracturing, more commonly known as “fracking,” have resulted in an oil and gas production boom nationwide. In October 2013, the U.S. Energy Information Administration announced that the United States would surpass Russia and Saudi Arabia as the world’s largest producer of oil and natural gas by the end of the year. The boom has resulted in oil and gas development in regions unaccustomed to the industry as well as in regions that have a century-long relationship with oil and gas extraction. However, wastewater discharges, hydraulic fracturing fluid releases, improper casing/cementing, and other accidental spills pose potential water quality risks in areas where directional drilling and hydraulic fracturing technologies are utilized. Rapid development of oil and gas wells, particularly in urban and suburban areas, coupled with the practice of hydraulic fracturing, has sparked concern for water quality and an interest in laws designed to protect water quality”*

Student Activity

1. Students set up stream table and fill tray/table with sand to indicated level. Spray the sand with water and stir the sand around until it is evenly moistened. This will help hold the sand inside the tray when it is propped on an incline.

2. Students gently pour water over stream table to simulate rain. Monitor water flow through sand and observe changes in particles, movement, and erosional properties of water.

3. Students add items from those provided to see how erosion changes due to obstructions to water flow.

4. SUMMARY: Students learn basics of water flow and erosion properties of water. This activity allows them to see how different "objects" can affect the flow of water in a stream system, and thus how natural and man-made items can affect the movement of Earth's surface materials. Trees, pylons, rocks, piers, docks, etc., all play a role in how water erodes the Earth's surface.

5. Discuss how the activity relates to water quality on and around oil and natural gas drilling sites.

6. Allow students to self-select research groups of 3 to 4.

7. Each group will explore the mandatory and voluntary practices used by the oil and gas industry in Arkansas to protect water quality on and around well sites. A final report will be presented orally and will include visuals of typical methods used to safeguard the water supply. Encourage students to be creative in developing their report.

8. Provide the following list of websites:

    - http://www.veilenvironmental.com/publications/pw/Water_Mgmt_in_Fayetteville_Shale.pdf
    - http://www.api.org/environment-health-and-safety/clean-water/surface-water-quality/surface-water-quality

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9. Evaluate the reports and visuals with a teacher made rubric.