Water Use in Hydraulic Fracturing

AirWaterGas

Students will find information about water usage by hydraulic fracturing sites in their communities using the FracFocus website. They will then this water use information into a scale model to compare personal usage amounts to water use at local hydraulic fracturing sites.

CREDITS: Activity developed by UCAR AirWaterGas Teacher-in-Residence Shelly Grandell with the assistance of AirWaterGas science advisor Gregory Lackey.[1] Updated by Tiffany Kapler, independent science curriculum consultant. This version was made possible by collaboration between Inside Energy and AirWaterGas, a Sustainability Research Network funded by the National Science Foundation.

GRADE LEVEL: 6-8

LESSON FORMAT (CONTENT): Data calculations, data collection (online resources), team design challenge.

TIME REQUIRED:
Teacher prep time: 30 minutes to gather materials and print student sheets
Class Time: 2 block periods (more if you plan to use CAD for 2D/3D modeling)

LEARNING GOALS: Students will collect data to understand how much water is required for hydraulic fracturing. Students will apply data collected to construct a scale model that demonstrates the comparisons of various kinds of water usage to hydraulic fracturing water usage.

MULTIMEDIA RESOURCES
This activity can be paired with the Inside Energy video, "Water Use In Hydraulic Fracturing" to aid in comprehension and provide additional discussion points. The video can be used before the activity as an introduction, or after the activity to promote sense-making.

[1] https://www.airwatergas.org/resources/curriculum/water-use-in-hydraulic-fracturing-lesson/

MATERIALS

- Water Use in Hydraulic Fracturing Student Guide
- Water Use Data Sheet
- Student group access to internet
- Calculators
- Materials for student design project
    - Small, physical objects, ie. adding machine tape, beads, cardboard, paper, anything they can potentially model up to 500 million gallons with. Keep the space in your room in mind. To limit the impact on space in the classroom, consider suspending some of the models from the ceiling after construction, or perhaps down a hallway.
    - You can also have students use technology to design the model. Free websites such as Scratch or Alice can allow student to write a 2D or 3D program to model the water amounts. These projects would take another 2-3 periods for students to learn how to use them, but are relatively simple.
- Water Resources Risk Reading (optional)

STANDARDS

Next Generation Science Standards

- ***ESS3.A Natural Resources*** *Humans depend on Earth's land, ocean, atmosphere and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.*

Colorado Academic Standards – Science

- ***SC09-GR.6-S.3-GLE.2 .*** *Water on Earth is distributed and circulated through oceans, glaciers, rivers, ground water, and the atmosphere.*
- ***SC09-GR.6-S.3-GLE.3 .*** *Earth's natural resources provide the foundation for human society's physical needs. Many natural resources are nonrenewable on human timescales, while others can be renewed or recycled.*

PREPARATION – 30 MINUTES

1. Print out Water Use in Hydraulic Fracturing Student Guide and Water Use Data Sheet
2. Gather materials for students to engineer their scale models with ahead of time, and have materials ready to go for a day or two.

DIRECTIONS

Day 1 — Indirect Water Use and Hydraulic Fracturing Water Volume Data Collection

1. Introduction: Project a picture or graphic of a food item such as a sandwich or burger. As students come in, ask them to complete the bell starter in their journals.
2. Bell starter/warm up: Have students write in their journals (or sticky notes) all of the ways water is needed to make that one food item. When they are done, have them share out. Here is an example:

3. Give students a few minutes to write down their thoughts and then ask them to share out with the class. Students may identify things like:
    - Water to grow the lettuce
    - Water to grow the tomatoes
    - Water to grow wheat for the bun
    - Water to mix with flour for bread

    Some items they MAY think of:
    - Water for the cow (beef)
    - Water for the cow (cheese)
    - Water for the sesame seeds
    - If there is ketchup etc…water for those

    Some items they may not have thought of:
    - Water to make the steel for the equipment needed to harvest/produce various components
    - Water to extract the oil/natural gas needed for: Tractors to plant/harvest (fuel and steel), Jet fuel (transport products), Plastics (containers and prep materials), Fuel for

food delivery/transportation, Steel, wood (production), plastics for restaurant and prep equipment

4. At this point, lead the class into a brief discussion about water use and hydraulic fracturing. Ask them how much water they think they use in a year and how that compares to the amount of water used to frack one well. Have them throw out some numbers, and record their brainstorm on the board to reference later when they have done the research and KNOW the actual comparison.

5. Pass out the Student Guide.

6. Make sure all students have access to the internet for this part (NOTE: FracFocus website works best with Google Chrome!).

7. Have students access the FracFocus (www.fracfocus.org) website for collecting water data for 14 oil and gas well sites around Colorado.

8. Use pages 1 and 2 of the Student Guide to walk them through navigating the map search tool. The guide takes students through the site step by step to access the PDF files for each site. Once students have familiarized themselves with the site, they should collect data. Remind them as they go to work independently, that they need to make sure 4 of the 14 wells are near their school (if this applies to your location). Students should also calculate an *average* water use for the 14 wells.

9. Have students share out the various volumes they collected. The number will vary, some are as large as 12 million gallons, other wells use as little as 30,000 gallons. Averages may vary, as well.

10. If there is time, pass out the Water Use Data Sheet, at let students compare the water use of hydraulic fracturing to other water uses.

Day 2 – Water use comparison model design and construction

1. Scale models can be helpful in wrapping people's minds around large numbers such as the amounts of water used for hydraulic fracturing. As several points of reference, provide students with the Water Use Data Sheet. Alternatively, have students conduct an internet search to determine some average amounts of water used for various activities. You may want to challenge them to consider both direct and indirect uses as well as common bodies of water that with which they are familiar, such as a swimming pool or a local lake or reservoir.
2. Explain that it is the students' job to help others visualize the amount of water required for hydraulic fracturing by creating a comparison model to demonstrate the volumes of water necessary for various activities. Working in groups or as individuals students will need to plan and create a scale model using the materials provided.
3. To plan their scale model students should complete the Scale Model Planning Sheets portion of the Student Guide. For this step, they will need to choose *one* material to develop a model.

Alternatively, if possible, allow students to choose to develop a 2D or 3D digital model using a free website such as Scratch or Alice. Note that you may need to plan additional time for students to create digital models if they are not already very familiar with these websites.

4. After choosing a material or format for their scale models, students will also need to choose a base unit volume. They should indicate the base unit as well as the volume that their base unit represents in their Student Guide. Encourage students to start with a workable number, such as the individual lifespan use of 3,000,000 gallons or the amount used in one day (37,000 gallons). This will make their model representation more realistic, it will be difficult for them to try and use a 1 gallon representation (remember, they need to model up to 500,000,000 gallons). Students may need additional support in this step.
5. Using their base unit volume, students should calculate how many units they will need to represent the various water uses from the Water Use Data Sheet, including the average annual water use that they calculated hydraulic fracturing during Day 1 of this lesson.
6. Have students sketch their model in the Student Guide.
7. Check student calculations and model design before they begin creating their model.

Once approved, give students their materials and let them build.

ASSESSMENT

Students can be assessed in multiple ways:

- Create a rubric outlining all of the requirements for activity, give points to students based on rubric requirements met. For info/templates for creating rubrics visit: http://rubistar.4teachers.org/index.php
- Have students defend how their model represents the amounts on the data sheet. This can be done in the form of a philosophical chairs activity, Socratic seminar, or board meeting format.
- Have students participate in a gallery walk where other students get to analyze classmate's models. Provide a critique sheet for students to do a peer review.
- Create a digital showcase using Google Classrooms or Weebly. Students can upload pictures and explanations of their models. This is also a great way to have community members, scientists and professionals participate in the assessment process. Instead of them coming into your building, they can access the showcase online, make comments, and leave questions and/or suggestions for the students. Students will also have the ability to comment on peer work.

BACKGROUND INFORMATION

Oil and gas exploration has evolved since the industrial revolution when demand boomed. Since then, many methods of oil and gas extraction have been developed and used throughout the world. Most recently, hydraulic fracturing, or "fracking", has become quite common in the US. Combined with horizontal drilling, this method of using water, sand and other chemicals to fracture the rocks is used to

release the oil and gas trapped within formations thousands of feet below the surface that were previously inaccessible.

The process of fracking is hotly debated across the country for a variety of reasons. The effect of hydraulic fracturing on water quality and the quantity of water usage in the technique is one of the focal points of the debate. The amount of water used for fracking, and what the fracking fluids contain, is not regulated at a federal level. In some cases, individual states have different legislative guidelines for reporting quantities of water used. Colorado does not require oil and gas companies to disclose where they are getting the water used at their sites. However, they do disclose how much water they use via the FracFocus website. The amounts used for fracking can vary from well to well, as students will discover in this activity, but typically average about three to five million gallons per well in Colorado. Some argue that using millions of gallons of water per well is far too big a stress to put on already stressed water systems. On the other hand, according to the USGS, Colorado farmers/ranchers withdraw 500,000,000 gallons of water per hour for agricultural use.

For more information on the fracking process visit the following sites:

- http://education.nationalgeographic.com/media/how-hydraulic-fracturing-works/
- http://science.howstuffworks.com/environmental/energy/hydraulic-fracking.htm
- http://www.fracfocus.org/hydraulic-fracturing-process

For more information about water use in fracking:

- http://pubs.acs.org/doi/abs/10.1021/es405118y
- http://fracfocus.org/water-protection/hydraulic-fracturing-usage
- http://www.usgs.gov/hydraulic_fracturing/
- http://sites.biology.duke.edu/jackson/est2014b.pdf

The Water Resources Risk Reading is a revised version of the article modified for middle school students.

EXTENSIONS

Give students a map of Colorado that had latitude and longitude and have students map water sources near their school and map the well locations using the lat/long info from the FracFocus data sheets.
Ask students to look at water use per well in other states, and compare Colorado's numbers to those.

Students could use CAD to develop a game/model for volume comparison.
Students could work in groups to research why some well use 30,000 gallons and some use 12 million gallons. What possible reasons are there for such a large difference in total water consumption?

Students could look at the US map of oil/gas hydraulic fracturing wells and also look at a map of drought conditions for the US. Using that information, collect total water use for a few sites at different locations and debate as to whether companies should use water for fracking in area that are experiencing water stress. Use the Water Resources Risk Reading for discussion.

Where does the water go? Have students investigate what happens to the water after it is used to frack a well. While some sites recycle portions of the water to use in other fracking operations, the majority of the water has to be disposed of as it contains toxic materials bot that were added and that it picked up from the rock below.

Debate: Have students use this activity, as well as prior knowledge, to debate the pros and cons of water use for hydraulic fracturing.