Water Warriors - ABSTRACT

Hydraulic Fracturing – Worth the Cost?

Oil and gas companies use a technique called hydraulic fracturing to extract natural gas from deep wells. The technology is leading to energy independence for America, but not without controversy. The problems addressed in this project are limited to the following issues:

(1) Contamination of aquifers from the wastewater by-product of fracking

(2) The incredible amount of fresh water required to fracture shale

To address these two problems, the Water Warriors developed several tests to determine how flowback affects living organisms. The team developed a way to effectively clean the wastewater for reuse and for cleaner injection into storage wells underground.

To test the danger of flowback water, it was used to germinate seeds, to water plants, and as a habitat for Planaria. In each case, flowback water had negative effects on life. The water itself was tested and found to contain higher than expected levels of many dangerous chemicals.

The team designed four types of distillation units to be adapted for use in the oilfield. Fracking water was distilled in the lab and the most effective unit reclaimed 90% of the water for reuse.

In the future, the team will work with the oil companies to develop a cost-effective way to conserve our most important natural resource, water. Our information has been well received by conservation groups. The team is building a prototype of a distillation unit that would be used on-site by the oil industry, making fossil fuels greener at last.

Mission Folder: View Mission for 'Water Warriors'

State
Texas
Grade
6th
Mission Challenge
Environment
Method
Scientific Inquiry using Scientific Practices
Students

ozark259trail
thesilverleafdinosaur
silverleaf5899
homerunqueen

Team Collaboration

Uploaded Files:

- [View] **Landowner Interview** (By: ozark259trail, 02/28/2015, .pdf)

  After reading a feature story in the Lubbock Avalanche-Journal newspaper, the Water Warriors contacted landowner Russell Ray wh well became contaminated after a hydraulic fracturing unit was placed on nearby land. This file shares his story and shows how the t its research phase of the project.

- [View] **Timeline: Water Warriors accomplishments from April 2014 to May 2015** (By: ozark259trail, 02/ .pdf)

  The file is a timeline of team Water Warriors showing major events that occurred monthly from April 2014 to May 2015.

- [View] **Team Responsibilities and Roles** (By: ozark259trail, 02/28/2015, .pdf)

  A chart that shows the roles, strengths, and major contributions of each team member is provided in this document.

- [View] **Team Action Plan** (By: homerunqueen, 02/28/2015, .pdf)

  A graphic organizer is used in this one page document to show the relationships between the community problem, hypotheses, expe and solutions.

- [View] **Idea for the Project** (By: thesilverleafdinosaur, 02/28/2015, .pdf)

  A newspaper article about hydraulic fracturing of shale layers in order to extract natural gas and oil is common on the front page of th Avalanche-Journal. Earthquakes, water use, contamination of aquifers, and air quality are just a few of the concerns across the coun especially in areas where oil

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.
Please see attached files – Team Responsibilities and Roles, Timeline: Experiment Schedule of Water Warriors April 2014 to May 2015, Idea for the Project, Landowner Interview, and Team Action Plan. These files enrich the Mission Folder answers.

In an area that relies on oil, natural gas, and the petroleum industry, hydraulic fracturing is a major issue and a topic of discussion throughout our community. The concerns do not stop here. Across our state and across the country, headlines frequently question the cost of 'clean, inexpensive, abundant natural gas' that comes at a high cost. We identified the contamination of the environment and the decline of major freshwater aquifers due to hydraulic fracturing as a community problem that can be solved using the STEM fields of science, technology, engineering, and mathematics.

"Water Warriors" is a team of sixth graders from a small, rural community. Our team came together in April 2014 and we were a group who wanted to make hydraulic fracturing more environmentally friendly for citizens and the petroleum industry. The problem-solving task began by ensuring that jobs were done correctly and deadlines were met. This happened by choosing the right members for this project. We formed a team because we are friends who work well together, we have a good work ethic, and we are strong students. We also considered the abilities of each to be organized, having the time to work for eight months, and the dedication to see the project through. The use of email, Facebook, text reminders, and personal communication at school kept all of us on track. Completing assignments at home and school, staying on task, and feeling free to give our opinions was also important.

One of the most important traits we looked for in each other was the ability to encourage the team. By choosing members we had worked with before and knew as friends, a good choice was made. When the work was hard and school was busy, we made sure to encourage each other to stick together and be the best scientists possible. Dwayne always kept us laughing and encouraged, and he brought terrific snacks to the meetings! It's hard to get discouraged with a corndog in your hand!

We met from 4:00 - 6:00 on Monday and Wednesday each week from August to February, balancing STEM with basketball, music lessons, and busy schedules from the middle school we attend. We spent many weekends focused on this project. Responsibilities were assigned based on each other's strengths and areas we wanted to improve. We made a list of assignments and completed them during team meetings. We kept a 3-ring binder with hard copies of our assignment book and objectives listed. The school computer network had a place for all the electronic files for our team, including a timeline, goals, experiments, dates, and next steps.

All team members were involved in brainstorming ways to make hydraulic fracturing greener and thinking of possible experts who could help us. Finding solutions that were testable and measurable, and supporting one another also took everyone's contribution. We supported goals set by the team and when we needed to, we compromised. We learned to listen to other opinions, and respected the ideas and gifts of each member. We brought unique talents to this team and each played a role, as described below.

Elizabeth is excellent in the areas of complex thinking, organization, and writing, as well as having the ability to speak two languages. Since our community has a large Hispanic population, it was useful to have a team member who could communicate well with different populations. She also kept track of the team binder, prepared presentations, and led the study on water quality.

Kaleb is talented in research and analysis, as well as having a sharp memory for details. During presentations, he took the lead answering questions. Kaleb was the webmaster for the team and kept the website updated as solutions were developed. He also worked with Kaden on public poster presentations of the team's findings, and developed the data tables and graphs.

Dwayne is a creative thinker who saw many sides of an idea. He was good at seeing problems during engineering before they even arose. His knowledge of the hydraulic fracturing process and the environment was very helpful to the team. Dwayne led the engineering side of the project and the testing of different distillation units.

Kaden is very efficient, takes charge of completing tasks within the time limit of meetings, and records lab reports for the team. If there is ever a question about any lab work that was done, he found the answer in the binder and online. Kaden developed a poster presentation for public awareness along with Kaleb, and together they taught others about the issues surrounding hydraulic fracturing.

All students shared the responsibility for answering the Mission Folder questions, and individual tasks were chosen based on strengths of the individual. An action plan was developed early in the project and reviewed monthly to be sure the project stayed on track. Every team member followed the action plan that we kept in our binder and the notes we made kept everyone on track with deadlines and assignments.

Scientific Inquiry

Uploaded Files:

- [**View**] **Seed Germination Lab Report** (By: thesilverleafdinosaur, 02/28/2015, .pdf)

  The file is a complete lab report telling the use of scientific inquiry and scientific practices of the team. It is written about the effect o waste water from the hydraulic fracturing process on seed germination. Photos, data spreadsheets, graphs, scientific processes, re conclusions, and next steps in experimentation are all included in this report.

- [**View**] **Living Organisms Lab Report** (By: thesilverleafdinosaur, 02/28/2015, .pdf)

  *The file is a complete lab report written about the effect of flowback waste water from the hydraulic fracturing process on the living Planaria vulgaris. Photos, drawings, data spreadsheets, scientific processes, results, conclusions, and next steps in experimentati included in this report. **Invertebrates were used for testing, therefore no IRB paperwork was required.*

- [**View**] **Plant Growth Lab Report** (By: homerunqueen, 02/28/2015, .pdf)

  The Effect of Hydraulic Fracturing on Plant Growth: The file is a complete lab report written about the effect of flowback waste wate hydraulic fracturing process on plant growth. Photos, data, graphs, scientific processes, results, conclusions, and next steps in experimentation are included in this report. The data spreadsheets and explanations of the data are included in the separate ExCe uploaded below this document.

- [View] **Plant Growth - Stem Data** (By: homerunqueen, 02/28/2015, .xlsx)

  An ExCel spreadsheet shows the data collected for stem measurements taken during the lab experiment on plant growth. The lab "Plant Growth Lab" is attached separately.

- [View] **Plant Growth - Roots Data** (By: homerunqueen, 02/28/2015, .xlsx)

  This ExCel file shows the data collected during the Plant Growth lab. Roots were measured throughout the growing period and diff were seen between the types of water used and overall growth.

- [View] **Water Quality Lab Report** (By: homerunqueen, 02/28/2015, .pdf)

  Water quality is measured for drinking water and tests for chemicals such as chlorine, sulfates, nitrites, pH, and iron were used on water from the fracking process. This report outlines the scientific method conducted and includes data, photos, results, analysis.

- [View] **Photo Essay for Water Warriors** (By: thesilverleafdinosaur, 03/02/2015, .pdf)

  This photo essay shows the Water Warriors team in action. Please view a summary of our research and experimentation through t of photographs and headings.

- [View] **Lab Report on Water Distillation Units** (By: thesilverleafdinosaur, 03/02/2015, .pdf)

  The lab report includes data, procedures, photos of the units, results, and a comparison of the four distillation units build by the tea

- [View] **Bibliography** (By: thesilverleafdinosaur, 03/02/2015, .docx)

  Bibliography - We add to this weekly because of our ongoing project but this is the most recent list of works sited at the time of sub

- [View] **Contact List** (By: homerunqueen, 03/02/2015, .docx)

  A list of our major supporters and mentors this year

Problem Statement

(1) What problem in your community did your team try to solve? Why is this problem important to your community?

The need for the United States to achieve energy independence is crucial. The latest technology in horizontal drilling and the use of water to release gas and oil from the Earth has led to an abundance of natural gas and its slogan of clean, inexpensive fuel for America. The issue of fossil fuel extraction through horizontal wells has become very controversial, pitting environmentalists and “big oil” against one another and forcing many Americans to take sides.

The Water Warriors team set a goal of being open-minded and learning all we could this year about the process used to extract natural gas from the oil fields that lie literally beneath our community. Hydraulic fracturing is a way of life in West Texas. “Fracking” is the oil field process of drilling and injecting fluid into the ground at a high pressure in order to fracture shale rock layers and release oil and natural gas from inside the rock. In order to release this energy, the price to the environment and to human health must be measured. How safe is this process? Does the need for American energy independence and the abundance of natural gas in shale offset the possible negative effects of fracturing?

The issue is important to our community because this nation relies on oil and agriculture from the region – both of which could suffer negative effects from the hydraulic fracturing industry. Can a solution be found to balance the need for domestic energy while creating a greener aspect to hydraulic fracturing? A problem statement was developed to answer that question and it is testable, repeatable, and measurable.

Problem Statement –

What effect does hydraulic fracturing wastewater have on living things?

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter exp

Please see complete works cited in the attached files – Bibliography and Contact List

Our community was in need of some answers to the issue of balance within the agricultural and oil industries. Research began by finding community leaders, subject matter experts, and institutions near our town that would become the foundation for our research. Our information came from newspapers, interviews, online podcasts, websites, professional journals, emails, and newsletters. With the controversial topic of ‘fracking’, many websites were one-sided; therefore, we avoided relying on any one source, trusting multiple government agencies and university sites instead. Our hypothesis and experiments would be based on what we learned from varied sources and would lead to a STEM solution for the hydraulic fracturing industry.

Websites –

“Dangers of Fracking,” (http://dangersoffracking.com/) Hydraulic Fracturing 101, Energy from Shale. Org. Courtesy of Gasland: The Movie.com, 5 Oct. 2014

"How the Texas Congressmen Feel," (http://dirtyenergymoney.com/) Oil Change International. 113th Congress, 2013-2014

Dunne, Joseph. "Fracking Folly: Regulatory Alternatives to a High-Stakes Race to the Bottom," http://www.kansas.com/news/state/article7540583.html

"Earthquake Hazard Map." (http:earthquake.usgs.gov/hazards/products/graphic2pct.50pdf)

Periodicals –

Peggy Heinkel-Wolfe and Lowell Brown, "Stuck in the Middle," (http://www.detonrc.com/local-news/local-news-headlines/20120211) /Denton Record Chronicle, 11 Feb. 2012.

Jennifer Hiller. "South Texas Hydraulic Fracturing Turns Water Into Gold". Lubbock Avalanche Journal. 22 Dec. 2013

Subject Matter Experts –

Mr. Jon Townsend, MS
Chemistry Teacher
Howard Payne University

Dr. David Klein PhD
Environmental Chemist
Texas Tech Institute of Environmental and Human Health

Mr. Landon Kerby
Natural Resource Conservation Service
Morton, Texas

Mr. Jude Smith
Refuge Manager
Muleshoe National Wildlife Refuge
Muleshoe, Texas

Mr. Danny Farr
Manager, Sundown Operation
Apache Oil Corporation
Sundown, Texas

Professional Journals –

Fairley, Peter "Solar without the Panels," MIT Technology Review, V1.13.05.10. 29 Feb. 2008

Kahl, AlandraDanita Heller, and Kim Ogden. "Constructing a Simple Apparatus to Purify Seawater." (pubs.acs.org/doi/abs/10.1021/ed400262v-) Journal of Chemical Education 27 Jan. 2014. Print.

Online Podcasts –

Biello, David. "Fracking to Free Natural Gas" Scientific American. February 28, 2010

Giovanetti, Tom. Institute for Policy Innovation. "Fracking Bans - But What About Property Rights?" August 22, 2014

Interviews –

Mr. Russell Ray
Landowner, Rancher
Idalou, Texas

Newsletters and Magazines –

"Air Quality – Barnett Shale," (http://www.tceq.state.tx.us/airquality/barnetteshale). Publication of Texas Commission On Environmental Quality.

Ashworth, John B. Geologist and Janie Hopkins, Geologist. "Aquifers of Texas". Texas Water Development Board Report 345. Nov. 1995

McGraw,Seamus. “is Fracking Safe? The Top 10 Controversial Claims About Natural Gas Drilling.” Popular Mechanics.

Mandel, Erik. "World Water Day 2012: Two Innovations for Purifying Water." (www.csmonitor.com/World/Making-a-difference/change-agent/2012) Christian Science Monitor 22 Mar. 2012.

“Top 50 Current Highest Total Well Counts In Permian Basin Fields,” (http://www.rrc.state.tx.us/permianbasin) Publication by Texas Railroad Commission. Mar. 2013

(3) Describe what you learned in your research.

To learn ways to address the issue of responsible hydraulic fracturing, we interviewed professionals in the fields of conservation (Mr. Jude Smith, US Fish and Wildlife Service) and petroleum (Mr. Danny Farr, Apache Oil Corporation). We talked with farmers, conservationists, Western Farm Press representatives, and the Texas Commission on Environmental Quality. The High Plains Underground Water Conservation District offered advice on protecting the largest aquifer in North America called the Ogallala Aquifer.

What is in Fracking Fluid?

Each hydraulic fracturing well site requires 400 tanker trucks of water and chemicals to be hauled to that well. An average of 4 million gallons of fresh drinking water is used for each hydraulic fracturing site. The water is mixed with acids, salts, and chemicals including volatile organic compounds (VOCs) such as benzene, toluene, ethylbenzene and xylene. The Chemical Disclosure Registry called “FracFocus” lists many chemicals and their specific uses in the hydraulic fracturing process. Among these are hydrochloric acid to dissolve minerals and begin cracks in the rock; ammonium chloride to eliminate bacteria in the water that produces corrosion; and ethylene glycol as a stabilizer.

The Fracking Process

The water is pumped down a well shaft, continuing through a horizontal line, and hydraulic pressure then cracks the shale rock formation and pushes out oil and natural gas. After the fracking is completed, the used water (known as ‘flowback’) is pumped back to the surface, put in evaporative pits lined with tarps, then pumped underground for permanent storage in wells. The well shafts that lead to the storage areas underground are lined with concrete to prevent leakage.

Leaking Well Shafts

Sources including The Sierra Club and Food and Water Watch claim these casings leak 50% of the time. Other sources such as the Groundwater Protection Council cite data that reports a smaller failure rate of twelve incidences of leaks in the state of Ohio. Some of the research associated with this issue sounded like “he said” and “she said”, therefore a large number of sites from government and university studies were consulted. Even then, there was no straightforward answer to some of our questions. According to Dr. David Klein, an environmental chemist who testifies in court when contaminants from oil fields enter water supplies, says that concrete casings do prevent some leakage but they are not foolproof and have a ‘life’ of less than 20 years before failure.

Amount of Water Used for Fracking

The amount of water used for the fracking process is extreme and critically important. The same water used for fracking is the only source of drinking water on the South Plains – the Ogallala Aquifer. It is essential for drinking, living, livestock, and crops, yet it is in serious decline at a rate of one foot per year, reports the High Plains Underground Water Conservation District. Within 75 years, this major aquifer will be depleted unless conservation methods are taken. The Ogallala aquifer is located under 8 states throughout the Great Plains and is one of the world’s largest aquifers. It covers 174,000 square miles and the nation depends on it for watering the Breadbasket of the World. At the rate of its depletion, is there enough water for agriculture, communities and the petroleum industry to share?

Contaminants used in the Water for Fracking

Only 50% of the contaminated fluids used during drilling are recovered. This amount is left to evaporate in open pits where over 476 toxic chemicals are released, according to the Environmental Protection Agency. Our groundwater may be at risk for contamination through the leaching of the toxins. Fresh water wells near fracking sites are more likely to contain carcinogens than those in non-oil affected areas, reports The Washington Post in September 2014. The research indicates flowback water contains chemicals but is it dangerous? There are rare inspections made of these fracking sites and the fines to energy companies are negligible.

Research Summary

Hydraulic fracturing is the process of drilling and using water pressure to break the impermeable rock layers to extract oil and natural gas from deposits in the Earth’s crust. Each gas deposit site requires approximately 400 tank trucks to carry water, chemicals, and other supplies to the fracturing site. It takes one to eight million gallons of clean water to complete a single fracture job. The water brought in to the site is usually treated with sand and chemicals to create the water that is sent down to fracture the rocks.

An estimated 40,000 gallons of chemicals are used in one fracture. Up to 600 known chemicals are used in the fracturing water, including toxins and carcinogens such as Lead, Radium, Uranium, Methanol, Mercury, Ethylene Glycol, Hydrochloric Acid, and Formaldehyde. There are 500,000 active gas wells, up and running in the U.S. There are 8 million gallons of water used in a single fracturing. There is a limit of eighteen times a well can be used to fracture. Altogether, that is 72 trillion gallons of water that comes from our only potable aquifer, the Ogallala Aquifer, and 360 billion gallons of chemicals to run and operate our current hydraulic fracturing wells in the U.S.

During this fracturing process toxic chemicals and methane gas can contaminate the nearby groundwater. Methane concentrations can be found in groundwater seventeen times higher in the fracturing site wells than in normal drinking water wells. The contaminated drinking water is then produced for nearby towns. There have been over 1,000 cases of drinking water contamination by gas drilling that involves cases of sensory, respiratory, and neurological damage due to the ingestion of contaminated water.

Only about 30-50% of the fracturing fluid is recovered during the hydraulic fracturing process. The rest of the dangerous and toxic fluid is left in the ground and is not biodegradable. The toxic water is left in open air pits to evaporate. These gases or harmful VOC'S (Volatile Organic Compounds) get released into the atmosphere creating acid rain, pollution, and ground level ozone which can escape and cause health problems. The hydraulic fracturing process produces 300,000 barrels of natural gas a day, but at the cost of health issues and contamination, according to many sources.

We contacted and met with many officials in our community and in our region that are focused on hydraulic fracturing. We met with a local environmental safety official, Danny Far of the Apache Oil Corporation and one of the largest global oil companies. They are interested in the ideas our team is developing for making hydraulic fracturing greener.

We met with Dr. David Klein, a professor at Texas Tech University and a chemist with experience in clinical and environmental chemistry. He had many answers to questions about open contaminated water pits. Our idea was to design a solar distillation unit that would clean the flowback water. He gave us advice about how to make that idea work.

We met with Congressman Randy Neugebauer. who represents our district and serves on the House Committee on Science, Space, and Technology with the environment being a primary initiative. Based on our initial research, our suggestion to stop using the Ogallala aquifer for fracking water and begin using salt water aquifers that are non-potable was discussed with the Congressman.

Throughout the research period, the team met many interesting people with different opinions, subject matter experts who could be trusted, and workers in the oil fields on the South Plains. The team began to form a hypothesis.

Hypothesis

(4) State your hypothesis. Describe how your hypothesis could help solve your problem.

Based on months of research and meetings with experts, the team formed a three-part hypothesis. Each solves a different aspect of the problem of environmental threats due to hydraulic fracturing. Part One determines the level of contamination hydraulic fracturing poses to local residents and wildlife. Part Two addresses the volumes of fresh water being used in the hydraulic fracturing process. Part Three involves methods of reducing contaminants in the flowback water that will be injected into deep wells for permanent storage. Together, these three hypotheses if supported by data would reduce the amount of fresh water needed for fracking; would allow water to be reused rather than disposed of after a single use; and would prevent contamination of fresh water aquifers near deep well injection sites.

1) If the flowback water from hydraulic fracturing has a negative effect on plant and animal life, then it should be considered a threat to our environment. Finding a way to reduce that threat would lead to a solution for this issue.

2) If flowback water can be reclaimed through a distillation process on site, then water could be reused, reducing the demand for fresh water from an aquifer. The key will lie in whether or not distillation can be accomplished without too great a cost, whether oil companies would adopt the practice, and whether greater than 20% of the water can be reclaimed, making it feasible.

3) If we can find a distillation process that promises more than a 20% return, and is economically feasible, then cleaner flowback water will be re-injected into the deep wells. Even if oil companies are unwilling to reuse flowback, the quality of the aquifer could still be maintained by producing cleaner wastewater for underground storage. The key will lie in our ability to evaporate the water, condense it, and collect it efficiently.

To test, retest, and measure the outcomes of each hypothesis, a series of lab experiments would be conducted. Each individual experiment had its own hypothesis recorded below:

Test 1 - Determine the Effect of Flowback Water on Seed Germination

If the flowback water is used on seeds during a germination test, then they will germinate more slowly than seeds with spring water, aquifer water, pre-use frack water, or distilled water. Our test will be proven valid if the germination rate is 25% than that of the other groups.

Test 2 – Determine the Effect of Flowback Water on Plant Growth

If the flowback water is used to water plants, then they will grow more slowly than plants with spring water, aquifer water, pre-use frack water, or distilled water. Our tests will be proven valid if the plant growth rate is 50% that of the control groups.

Test 3 – Determine the Effect of Flowback Water on Living Organisms

If flowback water is applied to living organisms (Planaria vulgaris), then a negative effect will occur to these invertebrates. If the behavior is altered significantly or if the pollutants prove to be fatal, then our tests will be considered valid.

Test 4 – Determine the Quality & Quantity of Water Resulting from Hydraulic Fracturing

If the flowback water indicates a poor quality during chemical testing, then the need for distillation of wastewater would be confirmed. If the amount of flowback water produced by fracking sites is large, then a calculation will be made as to the amount of water that could potentially be conserved by adopting on-site conservation measures and identifying an alternative source of water.

Test 5 – Determine a Method of Desalination/Distillation for Flowback Water

If the flowback water can be distilled, then the water can be reused in the hydraulic fracturing process, saving our precious fresh water needed for drinking, crops, and livestock. The amount of water distilled for our hypothesis to be proven valid is 30%.

(5) Identify the independent variables and the dependent variables in your hypothesis.
Test 1 - Determining the Effect of Flowback Water on Seed Germination

Independent Variable:
The kind of water being used for germination is the independent variable in this experiment.

Dependent Variable:
The time it takes for the seeds to germinate is the dependent variable in this experiment.

Test 2 – Determining the Effect of Flowback Water on Plant Growth

Independent Variable:
The kind of water being used to water the plants is the independent variable.

Dependent Variable:
The length of the stem and leaf of each plant following germination is the dependent variable.

Test 3 – Determine the Effect of Flowback Water on Living Organisms

Independent Variable:
The type of water used as a habitat is the independent variable.

Dependent Variable:

The behavior of the Planaria vulgaris and the time it takes for a negative behavior to be seen are the dependent variables.

Test 4 – Determine the Quality & Quantity of the Water from Hydraulic Fracturing

Independent Variable:
The type of water used in testing will be the independent variable for quality of water.
The number of gallons of water needed per fracking site will be the independent variable for quantity of water.

Dependent Variable:
The levels of nitrates, sulfides, pH, copper, iron, and sulfates will be the dependent variables in this experiment.

Test 5 – Determining a Method of Desalination/Distillation for Post-use Frack Water

Independent Variable: The method of distillation as applied to post-use frack water is the independent variable. (saucepan, slanted roof, heat lamp, pressure cooker)

Dependent Variable:
The percent of clean water reclaimed through the distillation process is the dependent variable.

(6) How did you measure the validity of your hypothesis? (In other words, how did you determine that your hypothesis measures what it is SUPPOSED to measure?)
Test 1 - Determine the Effect of Flowback Water on Seed Germination

Our hypothesis will be proven valid if the germination rate of seeds using flowback water is only 25% that of the other groups. If this is the case, it can be said that flowback water has a negative effect on germination.

Test 2 – Determine the Effect of Flowback Water on Plant Growth

Our hypothesis will be proven valid if the plant growth rate is 50% that of the control groups. If this occurs, then it can be said that flowback water has a negative effect on plant growth.

Test 3 – Determine the Effect of Flowback Water on Living Organisms

If the Planaria vulgaris behavior is altered significantly from what is seen in spring water, or if the pollutants prove to be fatal to the Planaria, then our hypothesis will be considered valid. It would be determined that flowback water has a negative effect on living organisms.

Test 4 – Determine the Quality & Quantity of Water Resulting from Hydraulic Fracturing

If the flowback water tests poor quality using chemical testing kits and qualitative measurements, then our hypothesis will be proven valid. If the amount of water used for fracking a single site exceeds that of domestic or agricultural use on the same amount of land, then it will be considered excessive and our hypothesis proven valid.

Test 5 – Determine a Method of Desalination/Distillation for Flowback Water

If the flowback water can be distilled and the resulting amount of fresh water collected is 30% or higher, then our hypothesis will be proven valid and on-site distillation would be a viable option for the oil companies.

Experimental Design

(7) List the materials you used in your experiment. Include technologies you used (e.g., scientific equipment, internet resources, computer programs, multimedia, etc.).

Test 1 and Test 2 – Determine the Effect of Flowback Water on Seed Germination and Plant Growth

Materials Needed:

Glass jar for collection of flowback water
Oil company employee to collect the flowback water
Field and lab data forms and labels
Gloves
Goggles
Petri dishes
Cups
Potting soil
Pipet
Graduated cylinders
Beakers
Metric measuring spoons
Distilled water
Calculator
Spring water
Aquifer water
Fresh frack water from an oilfield truck
Radish Seeds, Bean seeds, Corn seeds, Wheat seeds
Camera
Heat and plant lights
Paper towels
Ziplock bags
ExCel spreadsheet for recording data

Test 3 – Determine the Effect of Flowback Water on Living Organisms

Glass jar for collection of flowback water
Oil company employee to collect the flowback water
Field and lab data forms and labels
Gloves
Goggles
Petri dishes
Planaria vulgaris invertebrates

Pipet
Graduated cylinders
Microscope
Hand Lens
Metric measuring spoons
Distilled water
Calculator
Spring water
Aquifer water
Fresh frack water from an oilfield truck
Camera
Timing device
Drawing paper and pencil

Test 4 – Determine the Quality & Quantity of Water Resulting from Hydraulic Fracturing

Water quality test kits from Carolina Scientific
pH meter and computer interface
Spring Water
Flowback water
Goggles
Gloves
Agitator to stir the water for pH testing
Indicator strips

Test 5 – Determine a Method of Desalination/Distillation for Flowback Water

Heat Lamp Method: 4 quart plastic bowl, black plastic, small plastic cup, saran wrap, pebbles, heat lamp, post-frack water

Slant Roof Method: 4 quart saucepan, standard cookie sheet, measuring cop, aluminum foil, salt water with food coloring

Saucepan Method: 4 quart saucepan, tight-fitting lid,
Metal bowl, zip lock bag full of ice, salt water, food coloring, heat source

Pressure Cooker Method: Standard kitchen pressure cooker, funnell, gasket sea, plastic tube, zip-lock bag full of ice, water bottle, heat source, salt water and food coloring

(8) Identify the control group and the constants in your experiment.
Test 1 - Determine the Effect of Flowback Water on Seed Germination

Control –

A control of seeds being germinated using distilled water was used as the comparison

Constants –

Follow the written procedures carefully every time we measured germination during the lab.
Keep all measurements, temperature, and timing the same for every sample.

Test 2 – Determine the Effect of Flowback Water on Plant Growth

Control –

A control of seeds being watered using distilled water was used as the comparison

Constants -

The amount of water used on each plant.
Measuring accurately each time.
Identifying the correct plant for measuring roots and stems.
Providing the same amount of light, at the same temperature.

Test 3 – Determine the Effect of Flowback Water on Living Organisms

Control –
The control group was the planaria living in the spring water

Constants –
Use the same species of Planaria vulgaris, of the same age, and same shipment
Expose the planaria to the aquatic habitats for the same amount of time and at the same temperature
Accurately time each behavior and effect for both the control group and experimental group

Test 4 – Determine the Quality & Quantity of Water Resulting from Hydraulic Fracturing

Control –
The control is the testing of the distilled water

Constants –
Following the correct procedure exactly as stated on the Carolina Scientific testing kit.
Using the same amount of water for each test.
Exposing the indicator strip to the water for the same amount of time.

Test 5 – Determine a Method of Desalination/Distillation for Flowback Water

Control - When testing prototypes against one another, the control is the resulting percentages of water reclaimed from one prototype compared to the others.

Constants –
Using the same initial amount of water in each prototype.
Keeping the initial temperatures the same for the water.
Allowing the prototype to operate for the same amount of time.
Collecting the water in the same, careful manner each time.

Accurately identifies the control group, and constants 20 20 Gabriel Jones (Student Virtual Judge)

(9) What was your experimental process? Include each of the steps in your experiment.
Please see our multiple attachments for the experimental process and each step of the experiments conducted. These attachments include the titles of 'Lab Reports' and 'Photo Essays' and contain detailed procedures, processes, and protocols in each of our attached lab reports. Complete details are given in those attachments. There is a lab report uploaded for every investigation.

SAFETY PRECAUTIONS - When working with flowback water that contains acids, salts, and many other chemicals, we wore gloves and goggles and were very, very careful when handling this water. We consulted experts in the field prior to experimentation to be certain this project was appropriate for sixth graders.

Abbreviated Procedure for Seed Germination Experiment:

1. Place seeds and thick paper toweling in plastic bags.
2. Add the same amount of water for each bag – spring water, aquifer water, fresh frack water, flowback water, and distilled water as the control.
3. Record the length of the root on sprouting seeds as they germinate.

Abbreviated Procedure for Plant Growth Experiment:

1. Continue measuring the length of roots and stems on growing plants while providing various types of water to the plants.
2. Add the same amount of water– spring water, aquifer water, fresh frack water, flowback water, and distilled water as the control.
3. Record the length of the root and the length of the stem for every seed (5 of each type)

Abbreviated Procedure for Living Organism Experment:

1. Place planaria vulgaris flatworms in spring water.
2. Record its behavior and the time in which it lives.
3. Place planaria vulgaris in flowback water.
4. Record its behavior and the time in which it lives.

Abbreviated Procedure for Water Quality Experiment:

1. Use commercial testing kits to determine drinking water quality of flowback water.
2. Use a drop of water on an indicator strip and compare the color change to a standard.
3. Record the amounts found of iron, chlorine, nitrites, and sulfides in parts per million.

Abbreviated Procedure for Distillation Experiments:

1. Build 4 different distillation models to determine which would best reclaim contaminated water.
2. Follow procedures for building, heating, condensing, and collecting water from each unit.
3. Calculate the percent of water reclaimed from each distillation unit.
4. Compare the effectiveness of each type of unit to distill contaminated water.

Data Collection and Analysis

(10) Describe the data you collected and observed in your experiment. The use of data tables, charts, and/or graphs are encouraged.

Please see attachments – Lab Reports and Data Tables/Charts/Graphs

The complete descriptions of the quantitative and qualitative data collected can be found in each of the attached lab reports, including spreadsheets, data tables, charts and graphs. It was important that all three ways of graphically showing data were made for this project - graphs, charts, and tables. ExCel files are also attached for your convenience. The lab reports also contain protocols, results, conclusions, and photos of the experiment being conducted.

The tests were repeated three to five times for accuracy for germination, plant growth, water quality, distillation units, and effects on living organisms.

Test 1 – Determine the Effect of Flowback Water on Seed Germination

We attempted to germinate seeds including radish, corn, bean, and wheat. All except the corn, which was suspected of being old, germinated with other types of water tested including distilled water, fresh well water, aquifer water, and spring drinking water. None of the seeds germinated with the flowback water.

Test 2 – Determine the Effect of Flowback Water on Plant Growth

We measured the stem, leaf, and root length of the seeds that germinated for 10 days. Since there was no germination in the seeds that we watered with flowback water, then there was no plant growth to measure.

Test 3 – Determine the Effect of Flowback Water on Living Organisms

We used planarium to test the results on. We applied other types of water to the planaria and observed them to behave in much the same way as they were doing before adding the water. The water tested included spring drinking water, distilled water, fresh well water, and treated city water. However when the flowback water was added to the planarium, the organisms died almost immediately.

Test 4 – Determine the Quality and Quantity of Water Resulting from Hydraulic Fracturing

We did a water quality test on the flowback water and found it to have higher than expected levels of many harmful/dangerous chemicals. The water appearance was sometimes cloudy with sediments on the bottom and sometimes black. It would turn black and then clear up, apparently from some sort of chemical reactions going on. The odor was incredible, such that we had to use masks to handle the experiments. This was after the water was supposedly treated by the oil company and ready to re-inject.

Test 4 – Determine a Method of Desalination/Distillation for Flowback Water

We tried several different methods of distillation including heat lamp, pressure cooker, slant-roof, and saucepan. Our results show that the saucepan method was preferable because it reclaimed the most water, but for use in the field, the slant roof model has the greatest appeal. We would need to develop a prototype to show how the open pits where the flowback water is stored and treated could become an enclosed distillation unit with a slant roof and solar panels.

(11) Analyze the data you collected and observed in your experiment. Does your data support or refute your hypothesis? Do not answer with a yes or no. Explain your answer using one of the following prompts: 'Our data supports/refutes the hypothesis because...'

Please see attachments – Lab Reports for the complete answer to this question. The attached lab reports include an analysis of the data we collected for each experiment, whether our hypothesis was supported or refuted, and what we are going to do about it! It also describes its application to the environmentalists and the oil companies.

Abbreviated answers below:

Test 1 - Determine the Effect of Flowback Water on Seed Germination

The data collected showed a negative effect of flowback water on seed germination – supporting our hypothesis that fracking water would have less than 25% germination rates of other types of water. The flowback water had 100% fewer seeds germinate than that of

every other kind of water tested.

Test 2 – Determine the Effect of Flowback Water on Plant Growth

The data collected showed a negative effect of flowback water on plant growth – supporting our hypothesis that fracking water would have less than 50% plant growth compared to other types of water. The flowback water had 100% fewer plants grow than that of every other kind of water tested.

Test 3 – Determine the Effect of Flowback Water on Living Organisms

The data collected showed that flowback water is fatal for Planaria vulgaris – supporting our hypothesis that fracking water would have a negative effect on invertebrates. The flowback water resulted in altered behavior of the Planaria and resulted in death within minutes.

Test 4 – Determine the Quality & Quantity of Water Resulting from Hydraulic Fracturing
The data collected for the tests of iron, chlorine, nitrites, and sulfides showed no levels of these common indicators of poor water quality in flowback water. These results refuted our hypothesis that flowback would show high levels of these chemicals. The pH level showed acidic levels and the qualitative data collected showed very poor quality and contamination. The color, clarity, and odor of the water would make it non-potable. The qualitative data supported our hypothesis that flowback water is contaminated.

Test 5 – Determine a Method of Desalination/Distillation for Flowback Water

The data collected for the distillation units tested showed different amounts of clean water collected, supporting some of our predictions and refuting others. The Slanted Roof Model which we thought would be effective, reclaimed only 1% of the water – refuting our hypothesis. The Pressure Cooker Method and the Heat Lamp Method reclaimed 18% and 12% of the water, refuting our hypothesis of 30% reclamation. The Sauce Pan Method reclaimed 90% of the water, supporting our hypothesis

(12) Explain any sources of error and how these could have affected your results.
Every experiment has sources of error and although good scientists try to keep these to a minimum, they do affect results. During the seed germination experiment, constants were maintained and a control was included for comparison with the experimental groups. Despite using five seeds in each of three trials, the results may contain some errors. The corn seed did not germinate under any conditions. Since corn is a primary crop in this area, retesting this kind of seed in the future would be best. This could have affected our results since corn was the only kind of monocot tested that was GMO.

The collection of post-frack water called “flowback water” was originally collected in a plastic water bottle and transferred within 24 hours to a glass container. When using water samples for testing, it is recommended that collection take place in glass only for the tests to be valid. We consulted a geoscientist, Dr. Melanie Barnes, before testing to be sure that the time in the plastic bottle would not affect results. She assured us that the water quality would be retained and results could be trusted for flowback water collected and stored in this manner.

Collecting water from many different flowback water pits would have given the team more sources for testing, and possibly different results; however, we were unable to collect on our own. The flowback pits are on oil company property and the employees were the only ones who could bring us samples. Upon giving us the first sample, the employee told us that it was the only sample he would bring because his job was in jeopardy. The chemical compounds in fracking water are a trade secret and two different supervisors told him that water samples from their company would not be given to anyone. A third supervisor felt like this project was important and helped him collect the sample for the team, anonymously. Sometimes science is more important than keeping secrets.

<u>Drawing Conclusions</u>
(13) Interpret and evaluate your results and write a conclusion statement that includes the following: Describe what you would do if you wanted to retest or further test your hypothesis. Evaluate the usefulness of the data your team collected. What changes would you make to your hypothesis and/or experimental design in the future, if any?
Please see attachments for lab reports that also contain detailed conclusions about each experiment and the next steps in experimentation.

The experiment results of Water Warriors support the hypothesis that flowback water, which is wastewater from the hydraulic fracturing process, has a negative effect on living things. Plants and invertebrates both experienced extreme effects when flowback water was applied. The fact that this water is set in open air pits to evaporate is alarming, considering the results we have seen. The tarps may not completely protect the soil and aquifers underground from leakage of this contaminated water. After a period of time, the water and resulting sediment sludge is then pumped down concrete-lined well shafts for permanent storage. Leakage of these shafts has been well-documented and based on our results, the effects on plants and living organisms from contaminated flowback water that could enter an aquifer would be devastating.

Retest and Further Test our Hypothesis

One way we would retest our hypothesis that says, "If flowback water is found to be of poor quality, then it could be considered dangerous to the environment", would be to have the water tested by a spectrophotometer at Texas Tech University's chemistry department. Our procedure would be to collect flowback water in a glass container and within 24 hours, have that water tested and a chemical analysis run. In this way, better results could be obtained.

New Hypothesis and Experimental Design

In order to retest and further experiment on water contamination, our team would like to collect more samples of flowback water from different companies and test these samples in a university laboratory with sophisticated equipment. We contacted Dr. Melanie Barnes of the Department of Geosciences at Texas Tech University and she has offered her assistance in further testing. Partnering with teachers in New Jersey and Pennsylvania, students there could conduct our experiments using flowback water from their fracking sites. It would be interesting to see if they collected similar results.

The purpose of retesting or further testing hypotheses is always to confirm your own results and find better solutions to community problems.

Conclusion Statement –

Due to the benefits of energy independence and the large supply of natural gas found in shale layers of rock, we do not believe that hydraulic fracturing is going away any time soon. Due to the economic benefits worth billions of dollars in the state of Texas alone, not even counting the fields in North Dakota and the Pennsylvania and northeast oil fields, we do not believe hydraulic fracturing is going away. As a team, what can we conclude? The flowback wastewater from hydraulic fracturing is dangerous. Oil companies should take responsibility for making this water cleaner by using distillation units to purify water and then reusing it. If there is water left after distillation as seen in our experiments, that water should be treated before disposal. The data our team collected is useful because it gives others a way to deal with contaminated water from fracking and make the oil industry greener and more environmentally friendly. We do believe that environmentalists and oil companies can cooperate in a spirit of community service to protect aquifers.

Community Benefit

Uploaded Files:

- [**View**] **Political Initiative: Meeting with Congressman Neugebauer** (By: thesilverleafdinosaur, 02/28/2015, .p

  The file describes a meeting between the team and U.S. Congressman Randy Neugebauer in which we discuss our concerns a use of the Ogallala Aquifer in the fracking process. A photograph and newspaper article are included within this file.

- [**View**] **Website and Public Awareness** (By: thesilverleafdinosaur, 02/28/2015, .pdf)

  The link to our website and QR code for access to information about hydraulic fracturing is located in this document. Full versio the lab reports, photographs, movie clips, works cited, and updated information can be viewed online at http://water-warriors.w Many documents were not included here due to the size restrictions of the Mission Folder, but are available on the website.

- [**View**] **Community Awareness and Outreach** (By: thesilverleafdinosaur, 03/02/2015, .pdf)

  Water Warriors conducted community awareness classes to teach others the importance of protecting our aquifer. The High Pl Underground Water Conservation District awarded the team an environmental certificate for our work in helping the community understand water issues. This is one poster advertising a session on conservation.

- [**View**] **Presentation to Texas Tech University** (By: thesilverleafdinosaur, 03/02/2015, .pptx)

  A poster presentation was prepared from these slides and then Kaleb and Kaden spoke to 50 people about the Water Warriors objectives, goals, and milestones. The project won the Top Water Conservation Award and also the Top Environmental Project Middle School. Most importantly, the project brought regional attention to the issue of hydraulic fracturing and what can be don this industry greener.

- [**View**] **Hydraulic Fracturing: Worth the Cost?** (By: homerunqueen, 03/02/2015, .pdf)

  This presentation is used to teach students about hydraulic fracturing and the impact it can have on the environment. Elizabeth the slide show as a way to distribute basic information with graphics and photos to help tell the story.

(1) How could your experiments and data help solve your problem and benefit your community? Describe next steps for further research/experimentation and how you have or how you could implement your solution in the future.
Please see attachments: Website Link, Brochure, Poster, Political Initiatives

"It is not necessary that we change. Survival, after all, is not mandatory." -- Steve Williams

In order to benefit our community and solve the problem of contaminated flowback water produced by hydraulic fracturing, oil companies were contacted and we discussed our experimental data with them. There were positive signs that the use of a distillation unit similar to the one we are designing could be implemented on-site. The cost of solar distillation has decreased steadily over the last decade, making this solution feasible for many large oil corporations. Meeting with Apache Oil Corporation, we learned of the potential for utilizing salt water aquifers in the Midland/Odessa oilfields. This technology that allows drillers to extract brine water could also be used on our community's nearby oil fields.

Outreach opportunities are growing for our team through the use of brochures that educate others about the need for protecting the aquifer from flowback water contamination. When citizens understand an issue and get the facts to back up their ideas, change can happen. The High Plains Underground Water Conservation District has contacted our team and our information will be included in their newsletters that reach thousands of people. The Lubbock Avalanche-Journal newspaper has a large circulation as well and we are actually meeting with them on March 3 for a leading article concerning our results. Through conservation non-profit organizations, we have the chance to influence many more people who are in the position of making decisions at a high level. With time, we hope to see the fracking industry lead the way for green fossil fuels. We know that may sound like an oxymoron, but there are practical solutions available for oil companies to utilize.

Please visit our website http://water-warriors.weebly.com to learn more about the implementation of our solution in the community and our ongoing work on this issue.

Our generation must take responsibility for the stewardship of the land and water. We cannot look to others for answers, but we must seek answers ourselves. Conserving a precious water source like the Ogallala Aquifer means our great-great grandchildren will be affected and that is critical, as is the ability of America to provide its own clean energy. Balance must be achieved between a healthy environment, alternative energy, and today's fossil fuels. Hydraulic fracturing has definitely impacted this nation. It's your turn to answer the question ..... Is it worth the cost?

"Never forget that the water cycle and the LIFE cycle are one." Jacques Cousteau

Mission Verification

(1) Does your Mission Folder project involve vertebrate testing, defined as animals with backbones and spinal columns (which includes humans)? If yes, team must complete and attach an IRB.
No
(2) Did your team use a survey for any part of your project? If yes, team must complete and attach a survey approval form.
No
(3) You will need to include an abstract of 250 words or less. As part of the abstract you will need to describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community
Hydraulic Fracturing – Worth the Cost?

Oil and gas companies use a technique called hydraulic fracturing to extract natural gas from deep wells. The technology is leading to energy independence for America, but not without controversy. The problems addressed in this project are limited to the following issues:

(1) Contamination of aquifers from the wastewater by-product of fracking

(2) The incredible amount of fresh water required to fracture shale

To address these two problems, the Water Warriors developed several tests to determine how flowback affects living organisms. The team developed a way to effectively clean the wastewater for reuse and for cleaner injection into storage wells underground.

To test the danger of flowback water, it was used to germinate seeds, to water plants, and as a habitat for Planaria. In each case, flowback water had negative effects on life. The water itself was tested and found to contain higher than expected levels of many dangerous chemicals.

The team designed four types of distillation units to be adapted for use in the oilfield. Fracking water was distilled in the lab and the most effective unit reclaimed 90% of the water for reuse.

In the future, the team will work with the oil companies to develop a cost-effective way to conserve our most important natural resource, water. Our information has been well received by conservation groups. The team is building a prototype of a distillation unit that would be used on-site by the oil industry, making fossil fuels greener at last.

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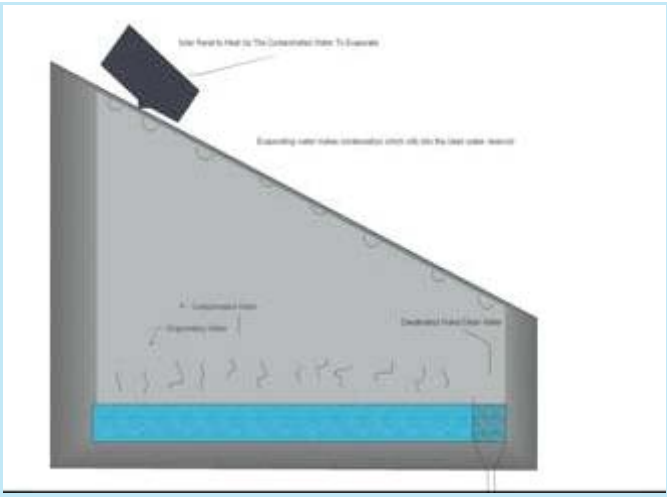
We are making hydraulic fracturing greener and more environmentally friendly



The team has been engineering distillation units to clean the water.

Help Make Fracking worth the Cost!
Come learn how you can help!
Friday, February 6
2:30 p.m.
Elementary Auditorium

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Thank you to the following major supporters
and mentors of the *Water Warriors* team

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*Mr. Danny Farr
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Sundown, Texas

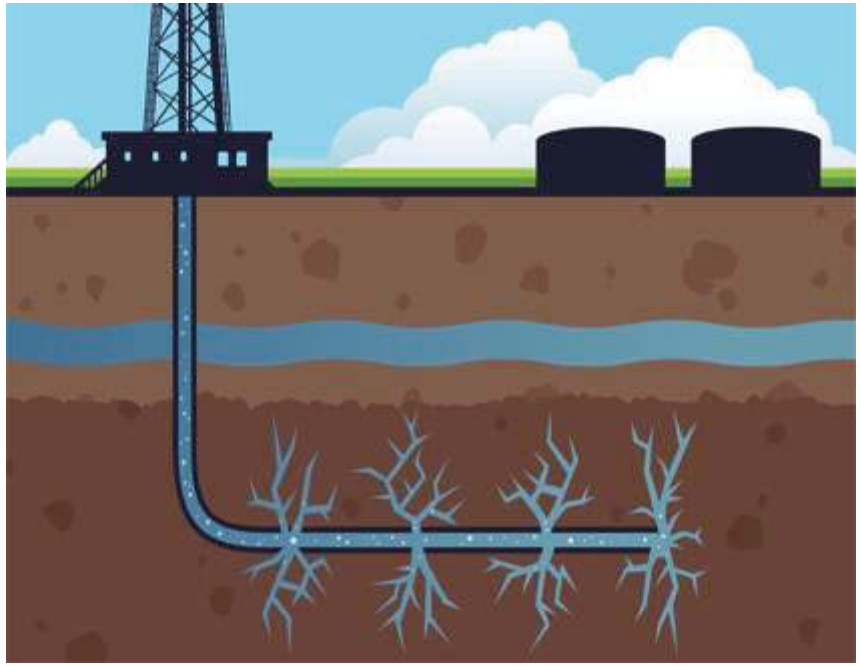
* Thank you to our most loyal mentors

Water Warriors

Hydraulic Fracturing:
Making it Greener and More Environmentally Friendly

Problem

Hydraulic Fracturing otherwise known as fracking is a drilling process in which oil companies drill holes in the ground in order to send fracking fluid down into the Earth's surface to break shale rocks. Once the rocks are broken the companies are able to pump out the gas.



Fracking Diagram

Hydraulic fracturing takes 5 million gallons of water for each frack site – water that comes directly from the Ogallala aquifer and used for drinking, livestock, and crops. Our aquifer is in decline – we can't afford to lose that much water.

Once the water has successfully broken through the rocks, the natural gas and oil is pumped to the surface. The water used in this process is also pumped and put into open pits for treatment and evaporation. Then, the water and sludge is injected deep into wells for storage underground permanently. Any leaks mean the contaminated water has no where to go but to the Ogallala Aquifer. Our source of water would then be contaminated with fracking fluid.

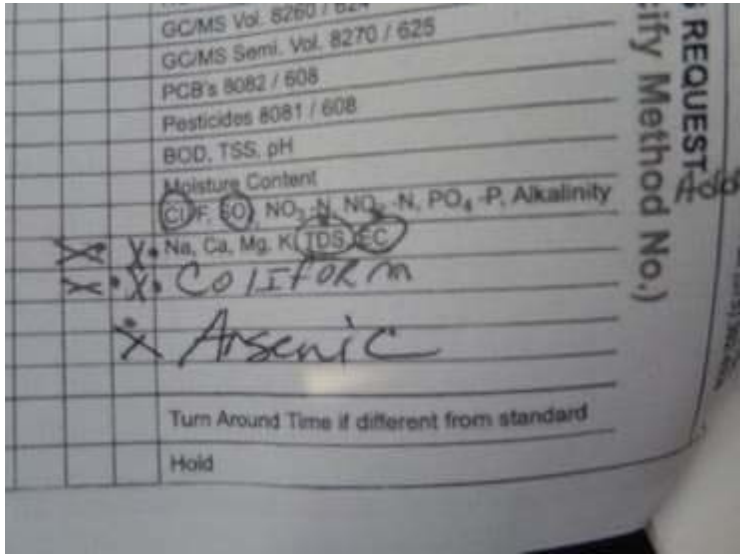
The Ogallala Aquifer

Oil companies receive complaints from all over Texas of their animals mysteriously dying soon after a well has been fracked. Oil companies deny responsibility because it is costly to prove that they're the cause of the negative effects on living organisms.

Fracking wells in Texas

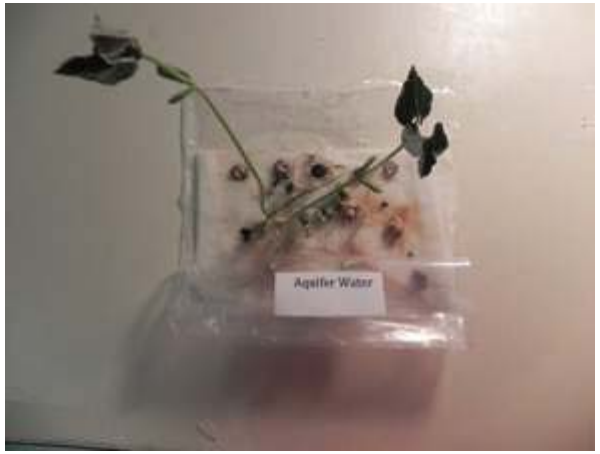
We met with Randy Neugebeaur (US Congressman) and discussed the problem of fracking. He agreed with us that the idea of using salt water aquifers instead of fresh water aquifers was smart.

We interviewed Russell Ray – a victim of fracking. He stated that a well near his house had been fracked and later found a few of his animals dead. He tested the water and found methane and arsenic. His water quality became so bad, the water to his home was no longer potable.



We met with Dr. David Klein, an environmental chemist at Texas Tech. He told us that we could use the process of solar distillation for every open pit of fracking water. He gave a lot of his time over Christmas break to help the team refine our ideas. He also said if we wanted graduate school paid for, we should all major in chemistry and go for a PhD!

Result after 10 days



Aquifer Water

Spring Water

Fresh Frack Water

Distilled Water(control)

Post Frack Water

Conclusion : Post Frack Water does not allow seeds to germinate.

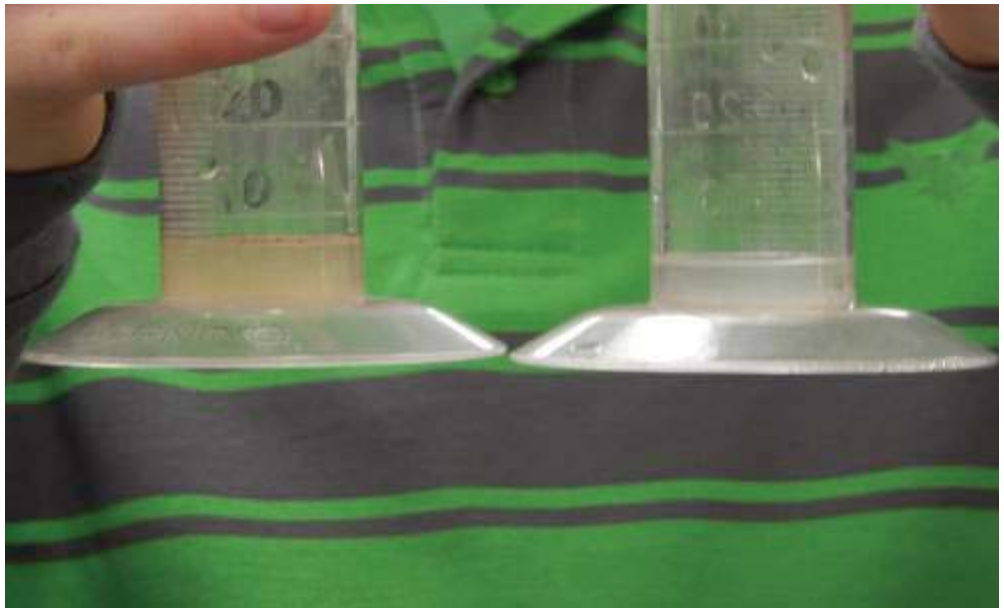
Using an anonymous source of post frack water we tested how it would affect plant life compared to other types of water.

Our next experiment was to see what affect post frack water has on a living organism. Using planaria we were able to conclude that post frack water has a negative effect on living organisms.

Post Frack Water

Solution

We decided to use a solar distillation unit which is the process in which dirty water is set in a concealed container and the water evaporates into water vapor and the waste and chemicals are removed from the water. This could be used on site to clean up post frack water for reuse.



Post Frack Water

Distilled Water

We tried using ice hoping the ice would make the water condensate and make it easier to collect the water. Unfortunately our first model didn't work collecting only 17% of our original amount.

We designed different models of solar distillation units hoping to collect more water. The first three models collected between 1% and 17% of reclaimed clean water. That was not enough to support our hypothesis for onsite distillation by oil companies.

Our last model was a success, collecting 90% of the original amount of water in the system. That water was clean and purified. It could be reused for fracking or disposed of without worry of contamination

Local Newspaper features Hydraulic Fracturing

South Texas hydraulic fracturing turns water into gold

BY JENNIFER HILLER
SAN ANTONIO EXPRESS-NEWS

SAN ANTONIO — In the heart of South Texas, where the muted grayish green of live oak and the slender leaves of the thorny mesquite dominate a landscape burdened by drought, hydraulic fracturing used more than 14 billion gallons of water last year.

The number far outpaces estimates of what water use in the Eagle Ford Shale might have peaked at some time in the next decade, and represents one more way in which the meteoric development of the oil field has blown past expectations.

A widely cited University of Texas at Austin study, funded by the oil and gas industry, had predicted hydraulic fracturing in the Eagle Ford would use a maximum of around 35,000 acre-feet of water annually.

But the San Antonio Express-News looked at more than 23,000 Texas wells drilled from 2011 to 2013, including more than 6,100 in the Eagle Ford, and found that the oil field already is swallowing more water.

Operators reported using around 43,770 acre-feet last year in 3,522 Eagle Ford wells, the approximate annual usage for 153,000 San Antonio households.

"The oil and gas boom is requiring more water than we have," said Hugh Fitzsimons, a Dimmit County rancher and a director of the Wintergarden Groundwater Conservation District. "Period."

Water always has been needed for oil and gas drilling, but not in this quantity. The relatively new ability to combine horizontal drilling with hydraulic fracturing has made it possible to drill in tight rock such as shale, which stores oil

to break the shale. Then sand is added to the fluid in increasing amounts to hold open the fissures, letting oil and gas flow up the well to the surface.

Cleaning and recycling water so it can be used in multiple wells is on the rise in the region, but it's not standard practice.

Some portion of those 14 billion Eagle Ford gallons used for fracturing — likely around 21 percent, according to the UT study — would have come from nonfresh-water sources: brackish aquifers that can't be used for drinking, agriculture or livestock, or water that was recycled.

Fracturing each Eagle Ford well took around 3.8 million gallons of water this year, down from 4 million gallons in 2012.

But eight dozen wells used more than 10 million gallons of water — enough in each well to fill 15 Olympic-size swimming pools.

Water, though, is a complex issue.

Irrigation takes the lion's share of the state's water — about 61 percent of the state's water demand, according to the Texas Water Development Board.

By comparison, water use for mining operations, including hydraulic fracturing, is a small slice of the state's water use — around 1 percent, less than is used to keep yards green.

"A study released earlier this year showed that Texans use about 18 times as much fresh water watering their lawns as the highest estimates of the volumes of water used by the oil and gas industry in the state," industry spokesman David Blackmon said.

And there are riches in selling fresh water.

"Water for sale" signs are commonplace in South Texas, along with reports of landowners who have be-

ASSOCIATED PRESS

Water retention ponds behind a gas flare, also known as a flare stack, at the the Eagle Ford Shale region on D. 13.

oil and gas leases requ that operators purc water from the rancher

The Express-News lo at data from the nonp Sky-Truth, which comp reports from FracFo the national registry w oil and gas operators re the chemicals and w used in every well hyd

lically fractured in the U.S.

The data is not perfect. It's likely incomplete, and there's a lag between the time when a well is fractured and when the data gets reported.

However, it's the best set of publicly available information about water use for hydraulic fracturing,

and gives some insight into the shale drilling boom. (Because of changes to the FracFocus website, Sky-Truth has not been able to scrape data since May.) No state agency tallies the well-by-well amount of water used in oil and gas operations.

The UT paper noted the Eagle Ford was a particularly difficult field to predict, and its lead author, Jean-Philippe Nicot, a research scientist at UT's Bureau of Economic Geology, said he now thinks the actual use in the Eagle Ford is around 40,000 acre-feet annually.

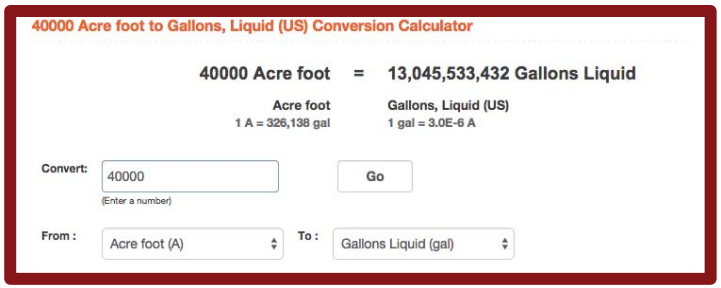
He's working on a paper that will be peer-reviewed and looks specifically at South Texas, but said the proximity to Gulf Coast refineries and oil prices staying near $100 a barrel have accelerated the field's development.

It's barely five years from discovery, but the Eagle Ford is expected to cross the 1 million-barrel-per-day mark for crude oil production sometime next year.

Three Eagle Ford counties — Karnes, La Salle and Gonzales — are the top crude oil producers in Texas. And the jobs and wealth added to the region have been unprecedented, even for a region already familiar with the booms-and-bust cycle of oil and gas.

- Enormous amounts of water are used in fracking for oil and natural gas
- The amount of oil and gas extracted through hydraulic fracturing is 1 million barrels per day
- The jobs and wealth added to our region has been unprecedented, according to the Associated Press.
- Water retention ponds for flowback water can be seen in the photograph.
- The Eagle Ford oil field in Texas uses 40,000 acre feet of water annually, which is equal to 13 billion gallons of water for this one oilfield.

During our research, we purposely looked for information that gave us many different opinions on the issue of hydraulic fracturing for natural gas and oil. This article discusses the economic benefits of fracking shale.

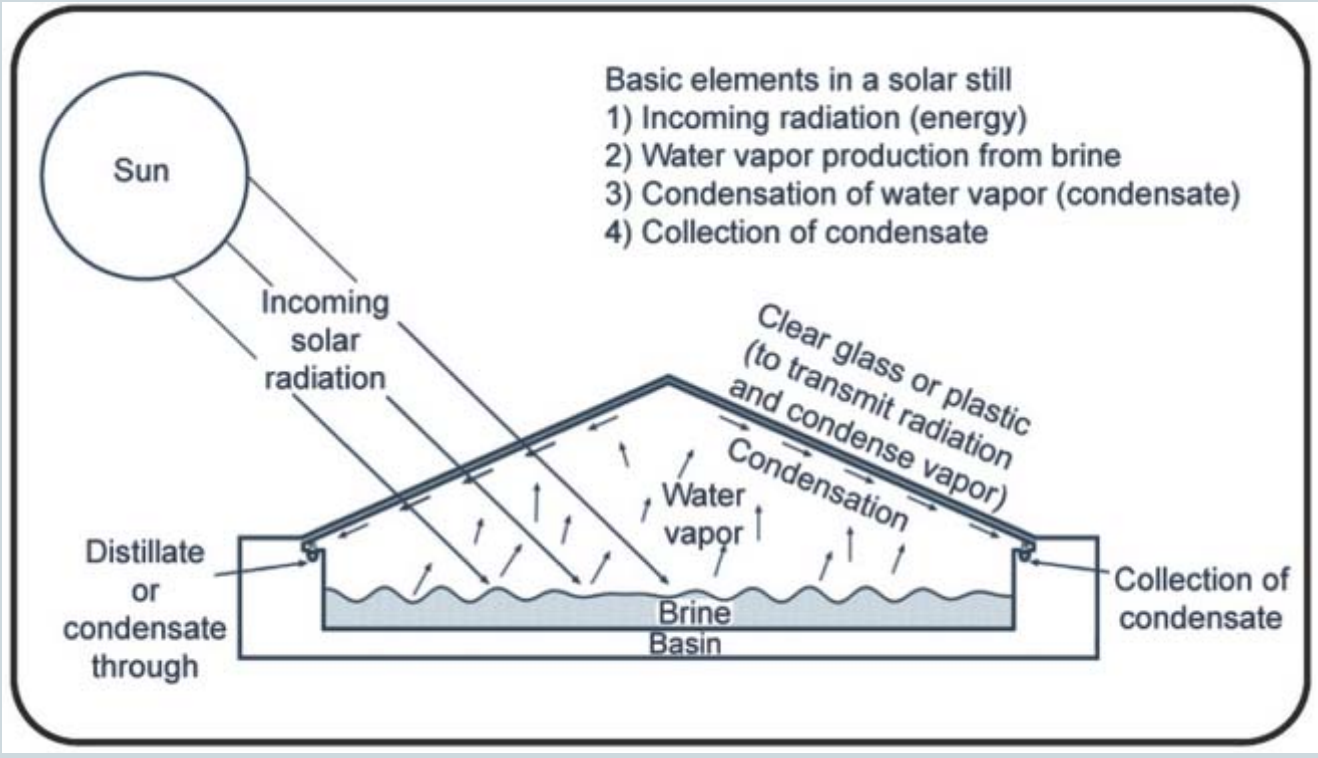


Examine the Use of a Distillation Unit in Decontaminating Flowback Water from Hydraulic Fracturing

Photo courtesy of Permian Trinity

Problem

CAN CONTAMINATED FLOWBACK WATER FROM HYDRAULIC FRACTURING BE RECLAIMED AS FRESH WATER USING A DISTILLATION PROCESS?



Graphic courtesy of Sustainable Sanitation and Water Management

Hypothesis

IF A METHOD CAN BE DEVISED TO DISTILL CONTAMINATED FLOWBACK HYDRAULIC FRACTURING WATER, THEN THE OIL COMPANIES CAN REUSE THE WATER FOR THE FRACTURING PROCESS, RATHER THAN INJECTING CONTAMINATED FLUID UNDERGROUND.

A pit of flowback water from fracturing sits to evaporate before being injected deep underground for permanent storage. The use of fresh water for this process is extreme.

Constants

Heat applied, initial amount of water used, time of distillation process, accuracy applied to each process.

Independent Variable

Type of distillation unit used to clean the post-use hydraulic fracturing water {method of distillation}

Dependent Variable

Percent of water that is reclaimed during the distillation process

Procedures and Materials for Conducting the Distillation Process using the **Heat Lamp Method**

Materials : Heat lamp, bowl, flowback water, Saran Wrap, rocks, and a cup

Procedure

WE CREATED A DISTILLATION UNIT USING A BLACK PLASTIC LINED BOWL WITH A SMALLER BOWL INSIDE. WE POURED SOME OF THE FLOWBACK WATER INTO THE LARGER BOWL AND COVERED ALL WITH CLEAR SARAN WRAP. WE THEN WEIGHTED THE SARAN WRAP IN THE CENTER, OVER THE SMALL BOWL, WITH A FEW PEBBLES. WE THEN PLACED ALL UNDER A HEAT LAMP AND WAITED ABOUT A WEEK. WE WERE ONLY ABLE TO RECLAIM 12% OF THE WATER, BUT IT WAS CLEAR AND CLEAN.

Heat Lamp Method

12%

DISTILLED WATER

Procedures and Materials for Conducting the Distillation Process using the **Pressure Cooker Method**

Materials : Pressure cooker, funnel, tube, empty water bottle, gasket sealant , ice, and salt water.

Procedure

① PUT THE SALT WATER IN THE PRESSURE COOKER.

② WHEN YOU PUT THE LID ON THE PRESSURE COOKER AND MAKE SURE THE LID IS SECURE.

③ THEN STICK THE FUNNEL TO THE LID OF THE PRESSURE COOKER WITH THE GASKET SEALANT.

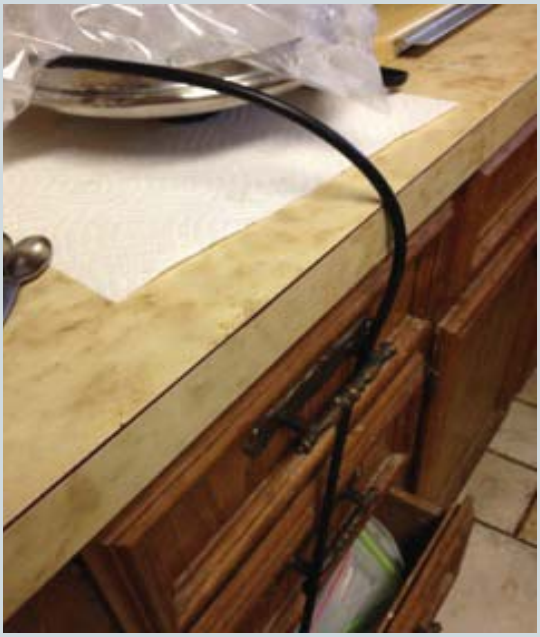
④ STICK THE TUBE IN THE HOLE OF THE FUNNEL.

⑤ STICK THE END OF THE TUBE IN THE EMPTY WATER BOTTLE.

⑥ USE A DIFFERENT LID OF SOME SORT TO PUT UNDER THE TUBE.

⑦ PUT ICE ON THE PART WHERE THE LID IS UNDER THE TUBE.

Pressure Cooker Method



17%

DISTILLED WATER

Procedures and Materials for Conducting the Distillation Process using the **Saucepan Method**

Materials: Saucepan, salt water, ice, lid, food coloring, heat source and a pan

Procedure

OUR NEXT MODEL TO BY TESTED WAS MADE WITH A SAUCE PAN, A METAL BOWL, AND A TIGHT FITTING LIT. WE POURED SOME COLORED SALT WATER INTO THE SAUCE PAN, PLACED THE METAL BOWL INTO THE PAN AND INVERTED THE LIT. WE ALLOWED IT TO COME TO A BOIL AND THEN ADDED ICE TO THE LID. THE CONDENSATION FELL INTO THE METAL BOWL AND WITH THIS METHOD, WE WERE ABLE TO RECLAIM 90% OF THE WATER.

Saucepan Method

THIS METHOD RECOVERED 90% USING HEAT, ICE, FRACK WATER, AND WAS MADE AS A CLOSED SYSTEM. WE PUT A SAUCEPAN INSIDE THE COOKER, AND WHEN WE ADDED HEAT. THE FRACK WATER CONDENSED AND PRECIPITATED INTO THE SAUCE PAN.

90%

DISTILLED WATER

Procedures and Materials for Conducting the Distillation Process using the **Slanted Roof Method**

Materials: cookie sheet, tin foil, saucepan, flowback water, food coloring

Procedure

① PUT THE SAUCEPAN ON THE STOVE WITH 75MM OF SALT WATER.

② PLACE THE COOKIE SHEET ON TOP OF THE SAUCEPAN.

③ SURROUND THE MODEL WITH ALUMINUM FOIL AND BEGIN TO EVAPORATE THE WATER.

④ APPLIED THE HEAT UNDER THE SAUCEPAN TO EVAPORATE THE WATER.

⑤ COLLECT THE WATER THAT WAS DISTILLED.

Slanted Roof Model

WE COLLECTED 1.3%. WITH THIS METHOD WE FOUND THAT YOU CAN NOT USE A SLANTED ROOF MODEL UNLESS YOU CAN PROPERLY SEAL IT.

1%

DISTILLED WATER

Results & Conclusion

90%

17%

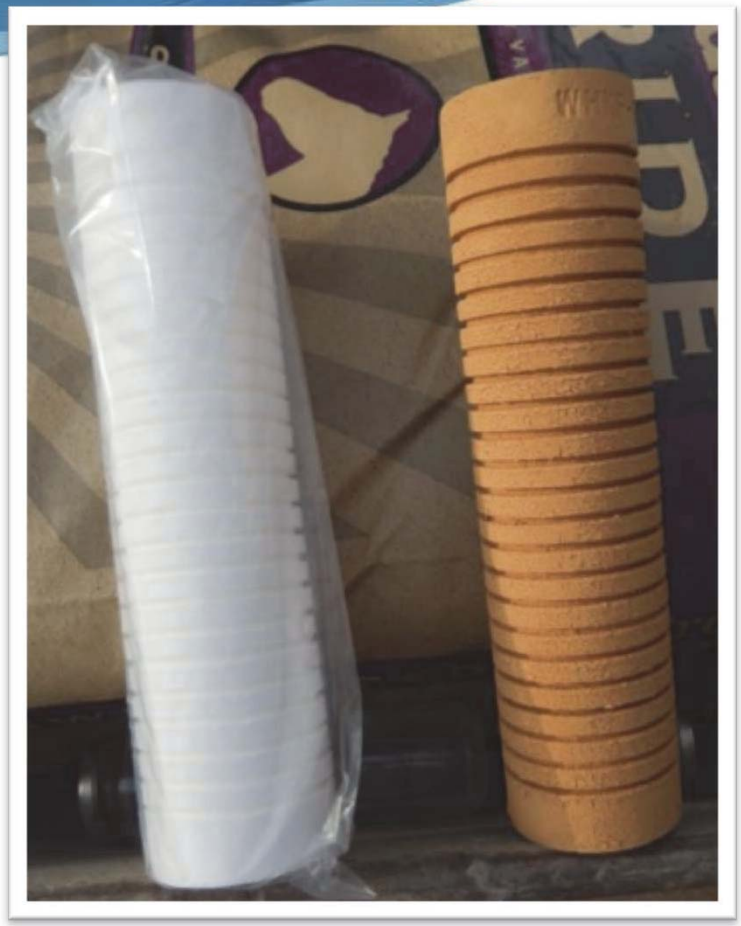
12%

1 %

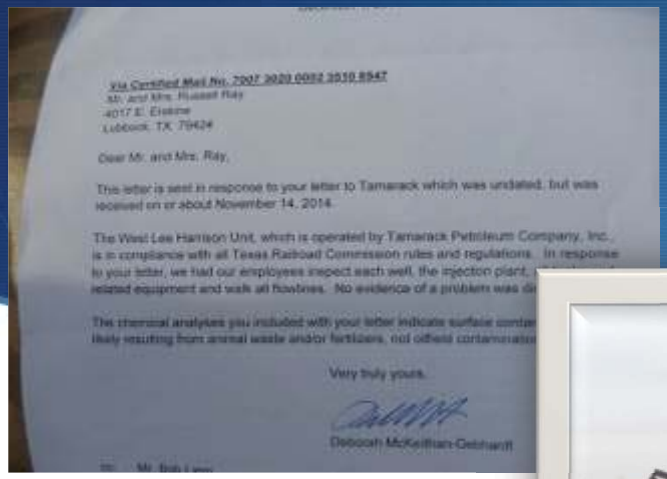
THE SAUCEPAN MODEL RECOVERED THE MOST CLEAN WATER OUT OF ALL FOUR OF THE DISTILLATION UNITS. THE DISTILLATION UNIT THAT SHOULD BE USED BY OIL COMPANIES SHOULD BE SOMETHING SIMILAR TO THE SAUCEPAN METHOD BUT ON A BIGGER SCALE. WE LEARNED THAT IT IS IMPERATIVE TO HAVE A CLOSED UNIT WHEN USING A SOLAR DISTILLATION MODEL TO PREVENT MOST OF THE EVAPORATED WATER AND CONDENSATION FROM ESCAPING THE SYSTEM.

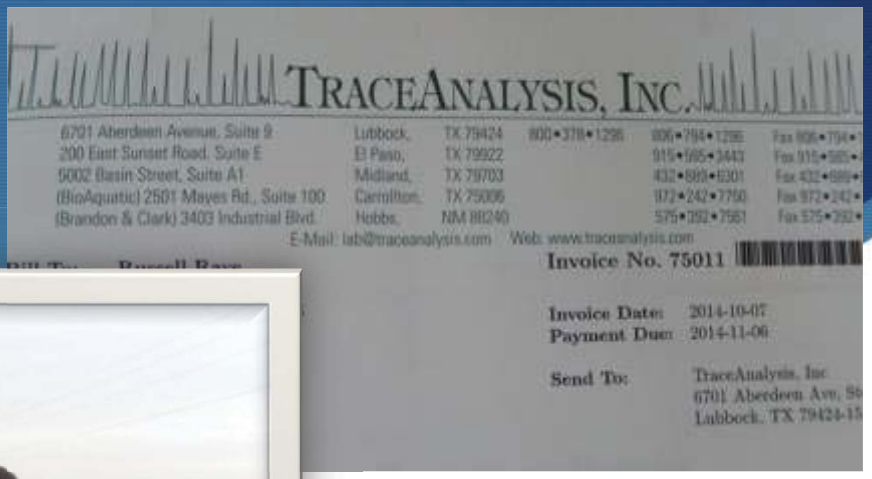
Water Warriors **interview Mr. Russell Ray about his water well's decline in quality since a hydraulic fracturing site was drilled next to his property.**

Water Filter Comparison: New vs. 3 week old Filter



The taste and smell of the water in Russell Ray's home became unbearable.





Trace Analysis, Inc is an independent agency and found toxic chemicals in the water well – including high levels of benzene and arsenic. The water from Mr. Ray's well was tested months before the oil company moved in and again after the decline in water quality. Tamarack Oil Company denies any responsibility from their fracking site, suggesting the high levels of salts found in the water were from cattle. Veterinarian Dr. Jimmy Gleason said that he has never known cattle to excrete salts in their feces.

The chemicals used in the fracking business mirror many of the chemicals in the well.

Oil pump jack 100 yards from Russell Ray's home. Oil fields are common but fracking is new. The injection of contaminants from the hydraulic fracturing process are bringing life back to the oil field economy, cheap natural gas from domestic sources, but at what cost?

Determining whether the cost is worth the benefit is one goal of the *Water Warriors*.

The Effect of Hydraulic Fracturing on Living Organisms

The Use of Biological Assays to Determine the Effects of Flowback Waste Water from the Hydraulic Fracturing Process on Living Organisms

WATER WARRIORS

A Sixth Grade STEM Action Team

- Hydraulic fracturing is known as “fracking” throughout the petroleum industry.
- Hydraulic fracturing is the process used in the petroleum industry to extract oil and natural gas from layers of rock deep beneath the Earth’s surface.
- A chemical gel and water mixture is pumped into rock layers and water pressure is used to split the underground shale rock, allowing the natural gas and oil to be extracted.
- The newest method of extraction is why natural gas is now being labeled as a “clean, inexpensive, abundant” fossil fuel in the U.S.
- It requires an average amount of 4 million gallons of water for each hydraulic fracturing site.
- After the water has been used for extraction, it is then ejected to deep well sites in the Earth for permanent storage of the contaminated fluids. This water is called “flowback” water.
- Considerable amounts of research and independent studies confirm groundwater contamination from the flowback water in the “fracking” industry.
- This water does not fall under regulations in the Safe Drinking Water Act despite being found in groundwater aquifers. This is because of a loophole created to protect oil companies from responsibility of groundwater contamination since “fracking” is not to blame. It is the ***aftermath*** of “fracking” that is the issue.
- This exemption is known as the Halliburton Loophole.

Background Information

Problem

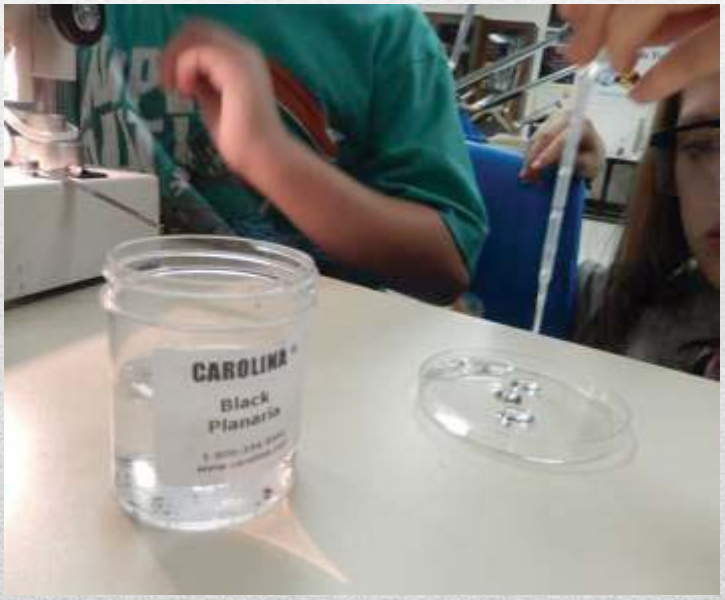
- What is the effect of hydraulic fracturing flowback waste water on living organisms?
- A bioassay experiment using *Planaria vulgaris* was performed because of the high risk of contamination of groundwater via the fracking process. Many living things could be affected by pollutants, including aquifers. A biological assay is a type of experiment conducted to measure the effect of a particular environmental pollutant on a living organism – in this case, flowback waste water from the fracking process used extensively in the petroleum industry.

If hydraulic fracturing flowback waste water has a negative effect on *Planaria vulgaris* it can be measured through qualitative data by observations seen in the behavior of the organism; and, through quantitative data by determining the amount of time it takes for the toxicity to result in the fatality of the planaria. It is believed that a negative effect will be clearly observed because we have seen a dramatically negative effect on seed germination and plant growth during prior experimentation.

Hypothesis

Procedure

- Our team used a Planaria bioassay to investigate what effect flowback hydraulic fracturing water from the oil field has on living organisms.
- Put one Planaria in a spring water-filled Petri dish as the control, and the others in a flowback water-filled Petri dish as the experimental subjects.
- We filled 6 Petri dishes with solutions that had different concentrations of frack water.
- Next we added *Planarians vulgaris* to each dish.
- Team artist Elizabeth made drawings of the Planaria before and after experimentation.
- After 5 minutes, we counted the number of Planaria that died and calculated the percent of Planaria mortality in each dish.
- Remove spring water Planaria from Petri dish. Using a pipette, place it on the slide under the microscope and record observations.
- Record the data in tables and graphs using Microsoft ExCel.
- Next, move on to the Planaria in the flowback water and put it the under the microscope. Record data on mortality on sheet of paper.



Materials

- Planaria vulgaris
- Dissecting microscope
- Dissecting probe
- Spring water
- Flowback water from the hydraulic fracturing process
- Petri dishes
- Pipet
- Graduated cylinder
- Timer
- Microsoft ExCel software
- Digital camera

We used the same type of pipet, the same amount of water, the same species of planarian flatworm, and the same microscopic observations on each test performed in this experiment.

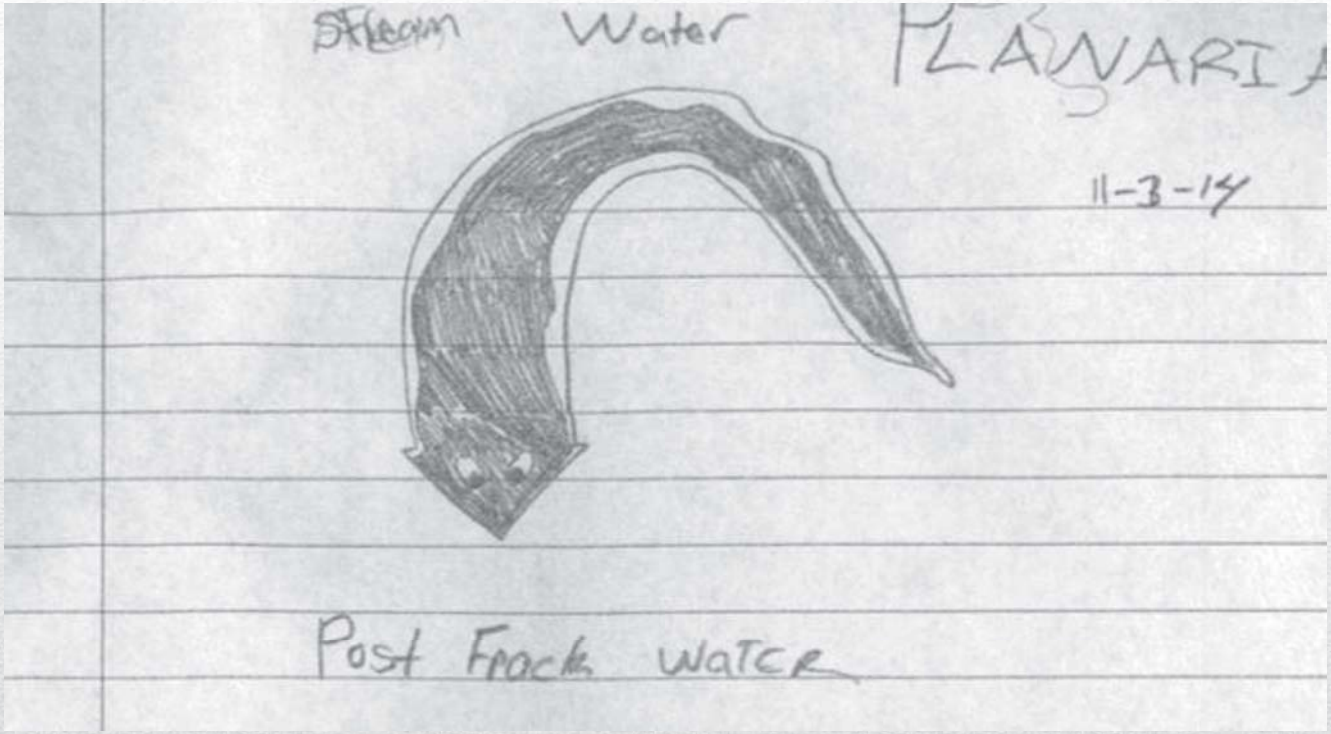
Controls or Constants

The type of water being used in the experiment is the independent variable.

Independent Variable

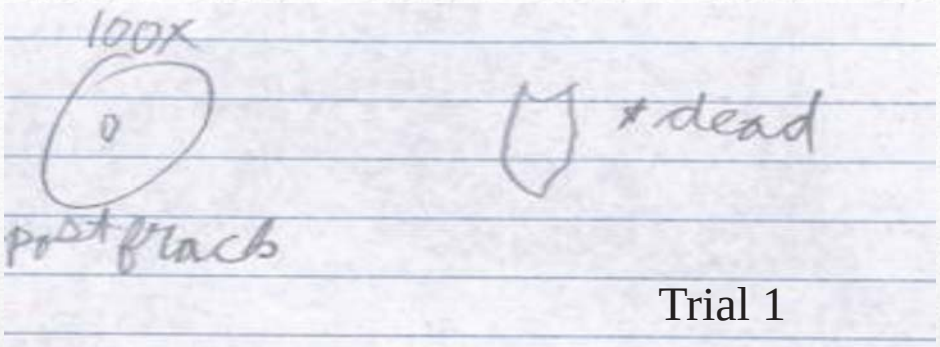
The effect of water on the behavior of the Planaria and the time for mortality to occur will be measured and are the dependent variables.

Dependent Variables



Before Exposure (Drawn by Elizabeth)

Qualitative Data
Observations of Planaria



Trial 1


Trial 2

Trial 3

Qualitative Data: Observations

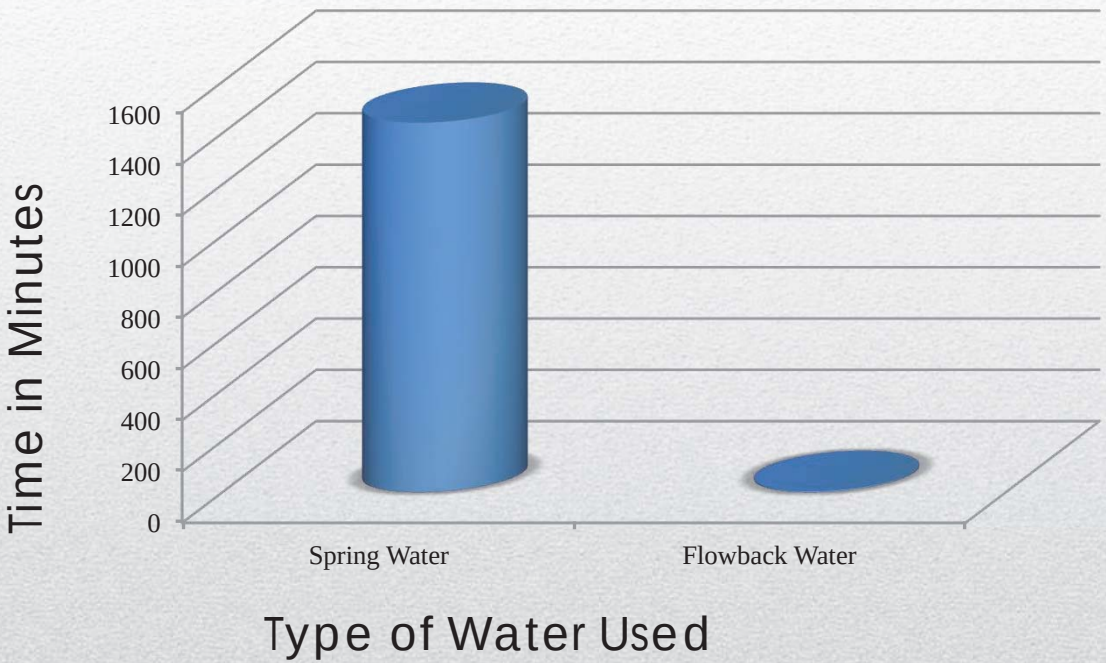
Effect of Flowback Water from Hydraulic Fracturing Processes on Living Organisms

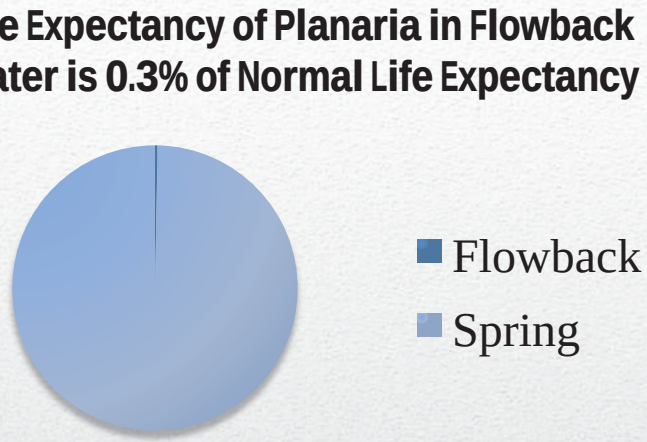
Water Habitat	Time until Mortality Occurs in *Planaria vulgaris* Subjects (seconds)						
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Mean
Spring Water	+24 hours	+24 hours	+24 hours	+24 hours	+24 hours	+24 hours	All planaria thrived in spring water
Flowback Water	4.3	2.7	7.1	2.3	1.8	6.0	**4.0**

Dilute doses of flowback water proved fatal in an average of 4.0 seconds, indicating a strong negative effect of this waste water on living organisms.

Quantitative Data

Quantitative Data





As you can see in the graphs, flowback water led to the death of the Planaria within seconds, severely affecting this invertebrate.

Results

- During our experiment, we noticed a dramatic effect of flowback frack water on Planaria vulgaris. Prior to the introduction of the contaminated water, the planaria were slowly moving, turning about, swimming along the walls of the Petri dish in the spring water. Their behavior was normal for an aquatic invertebrate, as they searched for food (*Daphnia magnus*).
- Following the introduction of the planaria into the flowback frack water, they started slowing down, they stopped moving, they appeared to turn black, and organs were exposed.
- This happened in every test run and averaged 4.0 seconds of exposure as a fatal effect on living organisms.

Conclusion

- Post-use flowback waste water is harmful to the living organism *Planaria vulgaris*. If death occurs to a simple invertebrate, this may also indicate damage/illness/death to vertebrate populations, including humans.
- The contaminated water that is ejected into deep wells lined with concrete which could erode, can make its way to underground aquifers and drinking water.
- Further experimentation would involve engineering a distillation unit or other method of cleaning the water and testing different strengths of concrete and other composite materials that would better contain this waste water.

Water Warriors

A Photo Essay Summary of the Project

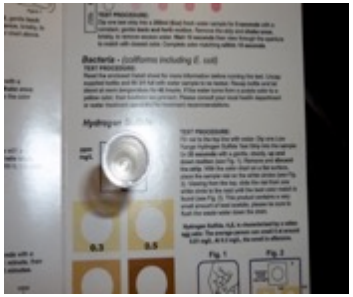
ECYBERMISSION 2015

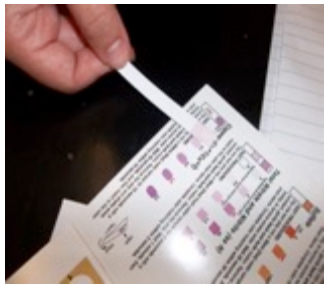
6TH GRADE STEM IN ACTION TEAM

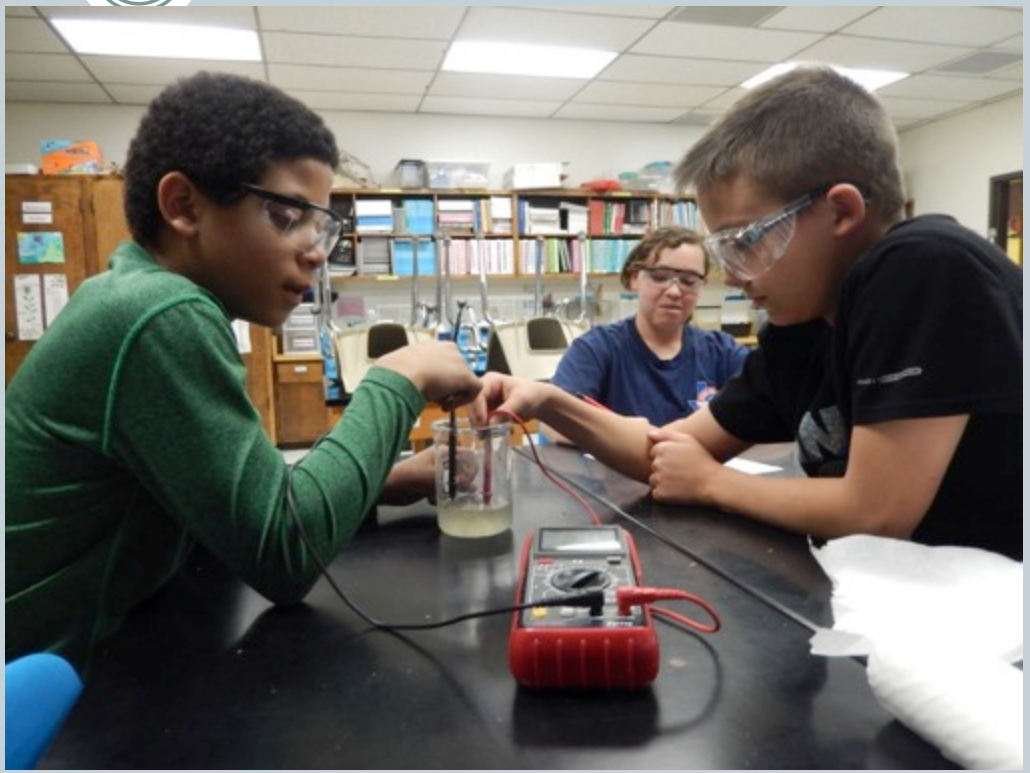
Conducting experiments on the effect of flowback water on seed germination and plant growth

Interviewed local landowners to determine if their water quality was being affected by the hydraulic fracturing process in the oil fields.

Water quality testing and conductivity tests performed on the flowback water from the oil field – is this water safe???

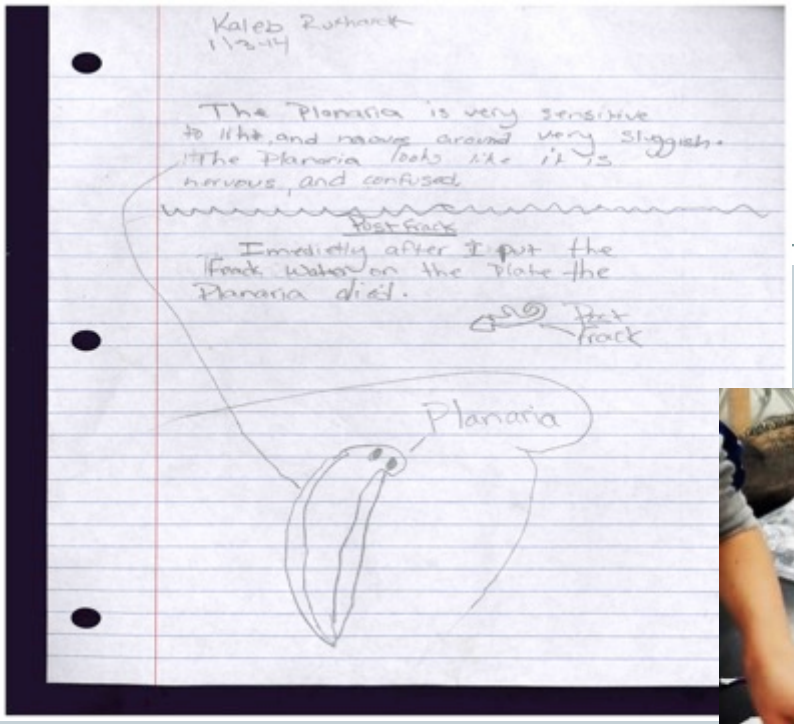


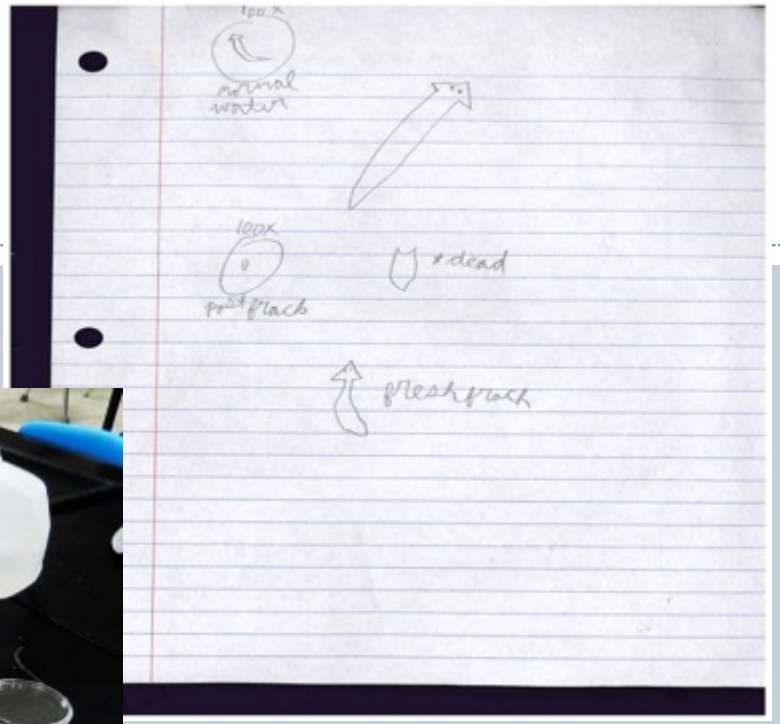




Consulted with biologists and chemists at the Texas Tech Institute of Environmental and Human Health ~ Dr. David Klein

Determining the impact of flowback water on living organisms: *Planaria vulgaris*, invertebrate bioassay studies





Consulting and interviewing U.S. Congressman Randy Neugebauer of the 19th District of Texas. A brainstorming session to make the hydraulic fracturing process greener and environmentally friendly.

MEETING THE CONGRESSMAN - Students from Morton and Whiteface
Randy Neugebauer, who spoke with them and adults during a forum
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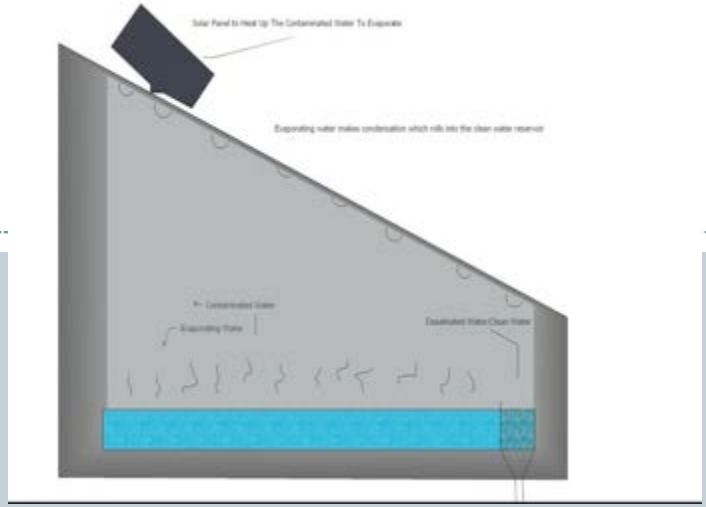
Developing solar distillation models to discover a way of cleaning flowback water, thus saving our aquifer.—Part 1



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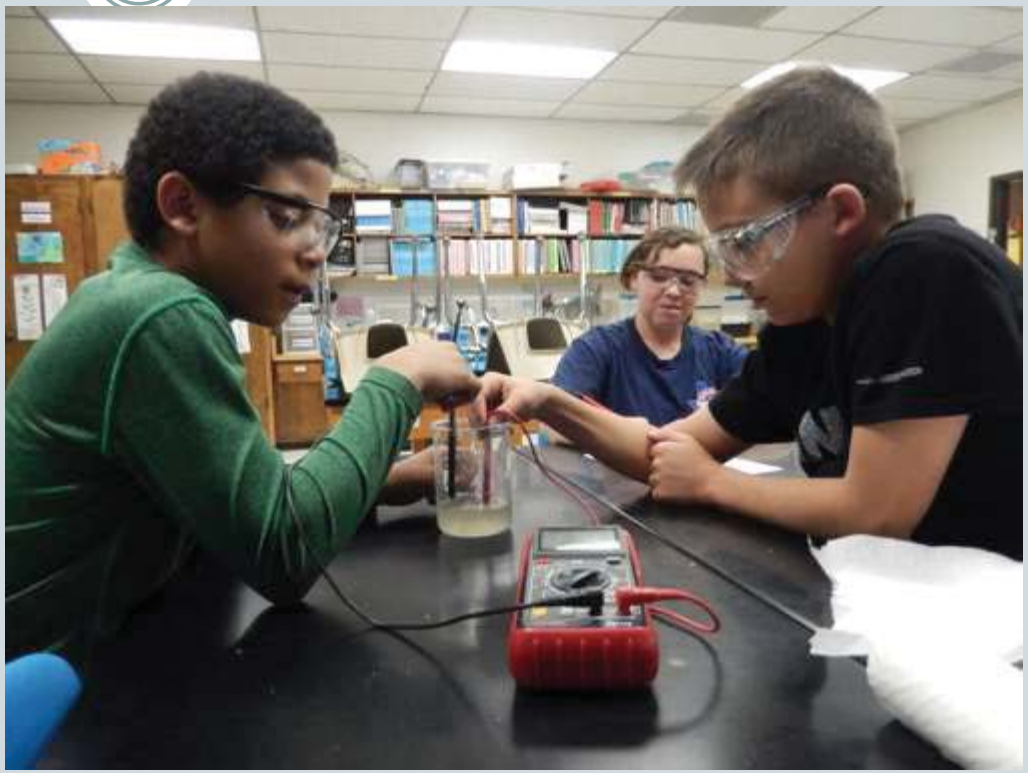
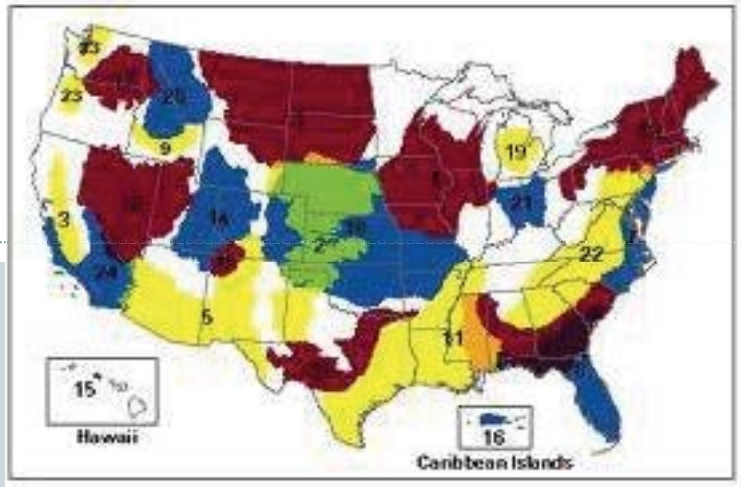
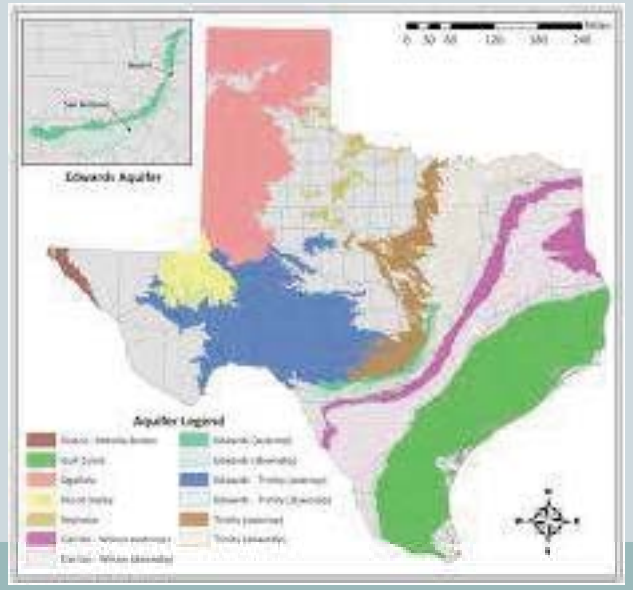
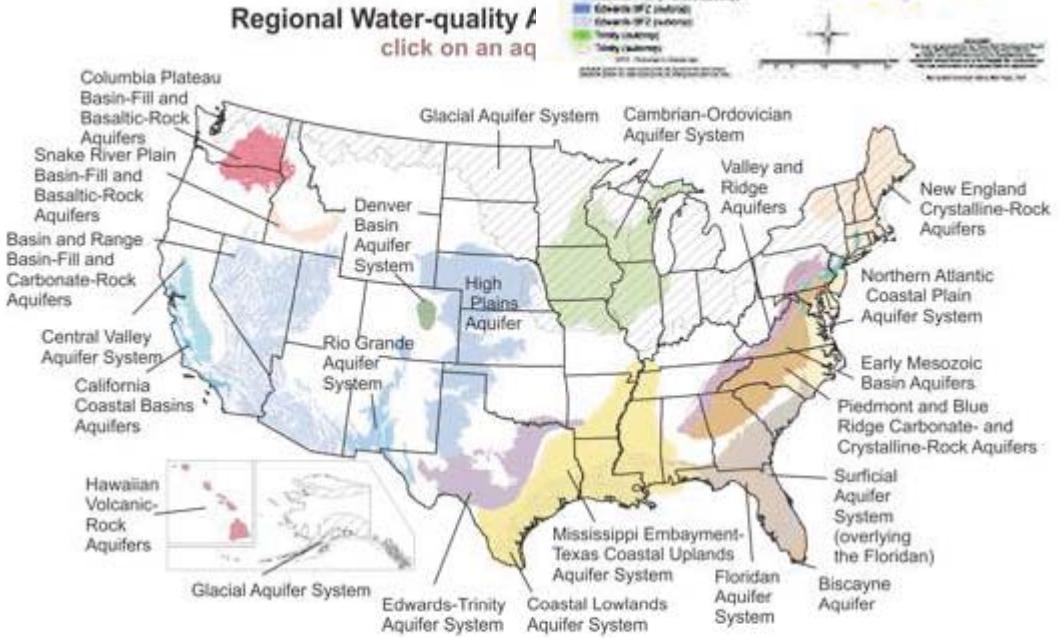


Searching for alternative aquifers for use in hydraulic fracturing in order to conserve the Ogallala aquifer for human use







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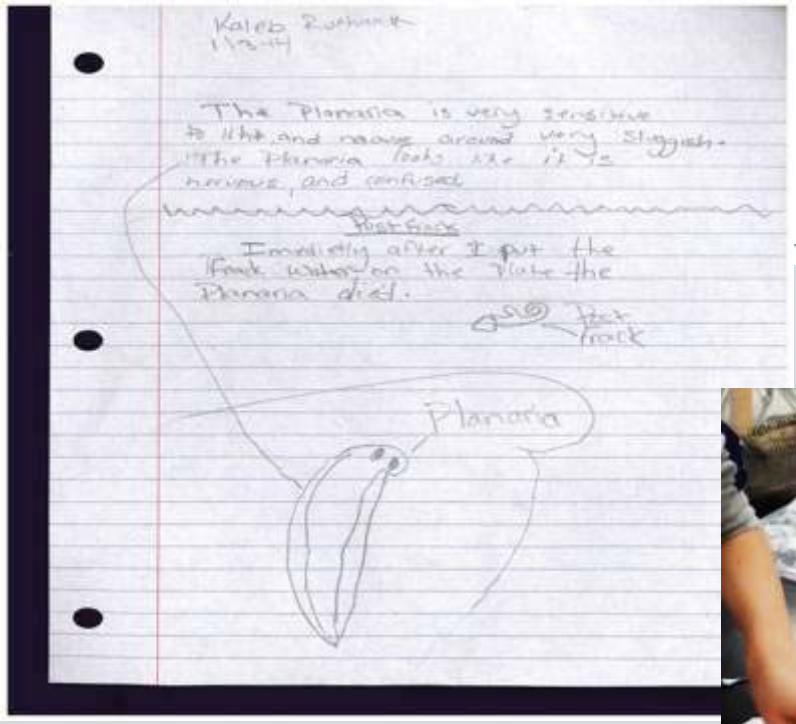

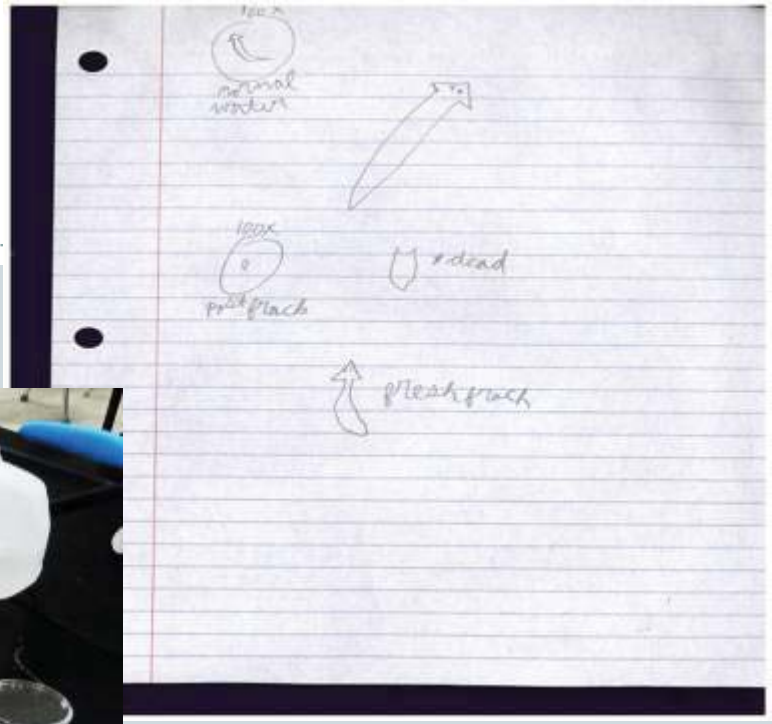

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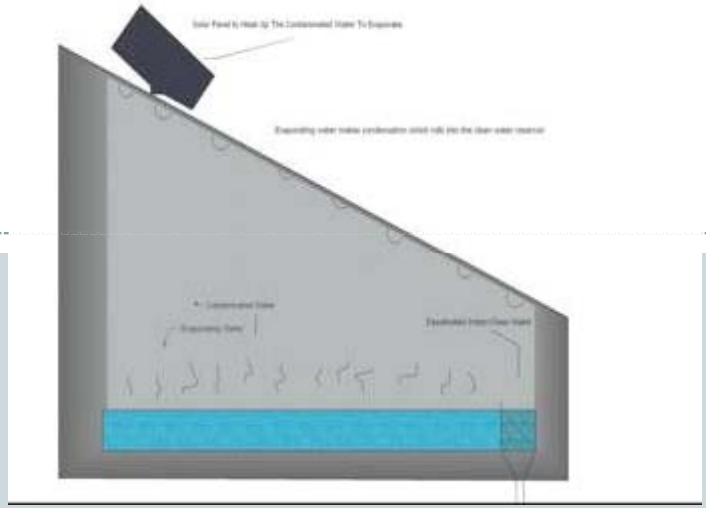


Type of Seed	Root Growth Effected by the Type of Water Used																									
	Distilled					Spring					Aquifer					Fresh Frack					Post Frack				
	Root Length mm					Root Length mm					Root Length mm					Root Length mm					Root Length mm				
	Day 1	Day 3	Day 7	Day 10		Day 1	Day 3	Day 7	Day 10		Day 1	Day 3	Day 7	Day 10		Day 1	Day 3	Day 7	Day 10		Day 1	Day 3	Day 7	Day 10	
	Kaden					Kaleb					Dwayne					Elizabeth					Kaleb				
Radish - 1	0	5	7	17		0	3	14	23		0	5	9	20		0	20	45	55		0	0	0	0	
Radish - 2	0	6	23	34		0	6	10	43		0	5	10	30		0	4	35	45		0	0	0	0	
Radish - 3	0	3	8	17		0	4	10	11		0	6	32	50		0	0	5	7		0	0	0	0	
Radish - 4	0	0	0	0		0	8	12	17		0	13	17	29		0	2	6	15		0	0	0	0	
Radish - 5	0	3	18	18		0	6	13	27		0	4	8	22		0	4	38	47		0	0	0	0	
Wheat - 1	0	5	25	27		0	7	26	28		0	4	8	11		0	9	12	16		0	0	0	0	
Wheat - 2	0	7	26	31		0	9	20	27		0	2	6	10		0	2	2	2		0	0	0	0	
Wheat - 3	0	4	20	28		0	4	4	4		0	2	8	15		0	0	13	20		0	0	0	0	
Wheat - 4	0	0	30	40		0	1	28	61		0	3	15	15		0	12	16	25		0	0	0	0	
Wheat - 5	0	8	30	33		0	12	27	41		0	0	0	0		0	8	22	24		0	0	0	0	
Corn - 1	0	0	0	0		0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	
Corn - 2	0	0	0	0		0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	
Corn - 3	0	0	0	0		0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	
Corn - 4	0	0	0	0		0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	
Corn - 5	0	0	0	0		0	0	0	0		0	0	0	0	0	0	0	0	0		0	0	0	0	
Bean - 1	0	0	0	0		0	0	31	63		0	10	12	26		0	11	58	86		0	0	0	0	
Bean - 2	0	0	14	50		0	0	43	72		0	5	20	85		0	4	39	69		0	0	0	0	
Bean - 3	0	0	19	21		0	0	0	0		0	3	20	50		0	6	22	45		0	0	0	0	
Bean - 4	0	0	21	60		0	0	3	7		0	15	16	60		0	0	8	12		0	0	0	0	
Bean - 5	0	0	3	7		0	0	35	72		0	6	15	20		0	0	8	16		0	0	0	0	

Water Type	Growth
Distilled	363
Spring	496
Aquifer	454
Fresh	484
Flowback	0

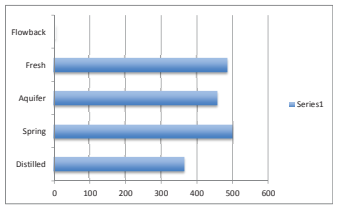
The data spreadsheet shows the amount of growth of the roots of radish, wheat, corn, and bean plants that started from seed. Growth was measured in millimeters on Day 1, 3, 7, and 10. Corn showed almost no growth and it is obvious to us that there was something wrong with the seeds we used. The data from corn is not available for drawing any conclusions, either from stem or root growth.

Overall amounts of root growth across all seed types are shown in the small chart to the left. Spring water and fresh water from a fracking truck (water from the aquifer that will be used to fracture the shale layer underground) led to the greatest root growth, although the difference between those water sources and the aquifer was not great. Flowback water did not allow any root growth at all. Corn did not germinate or grow, indicating the seed was infertile.

Our team's greatest concern is the flowback water injected into deep wells underground for storage. When the concrete barriers on the sides of the well fail - and concrete does fail - that water will leak out and can reach the Ogallala aquifer. This is our region's source of drinking water and it irrigates the world's largest crop of cotton here in West Texas.

Flowback water is disastrous for plants - what happens to our nation's cotton crop if the water for irrigation is contaminated? Worse even - what happens to communities who depend on clean water for consumption?

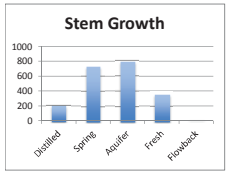
Our experiments on stem growth and root growth of plants under the influence of flowback water indicate a strong negative effect.



Stem Length of Plants Measured as a Result of Exposure to Different Types of Water

Type of Seed	Distilled				Spring				Aquifer				Fresh Frack				Post Frack			
	Stem Length mm				Stem Length mm				Stem Length mm				Stem Length mm				Stem Length mm			
	Day 1	Day 3	Day 7	Day 10	Day 1	Day 3	Day 7	Day 10	Day 1	Day 3	Day 7	Day 10	Day 1	Day 3	Day 7	Day 10	Day 1	Day 3	Day 7	Day 10
	Kaden				Kaleb				Dwayne				Elizabeth				Kaleb			
Radish - 1	0	5	17	17	0	3	7	14	0	9	5	30	0	0	6	11	0	0	0	0
Radish - 2	0	6	5	6	0	6	8	10	0	10	5	40	0	4	5	7	0	0	0	0
Radish - 3	0	3	4	7	0	4	16	21	0	6	12	50	0	0	0	0	0	0	0	0
Radish - 4	0	0	0	0	0	7	8	12	0	13	13	13	0	2	3	4	0	0	0	0
Radish - 5	0	3	0	0	0	6	15	33	0	4	4	4	0	4	7	9	0	0	0	0
Wheat - 1	0	5	60	81	0	7	23	29	0	5	10	11	0	9	36	61	0	0	0	0
Wheat - 2	0	7	0	3	0	9	37	63	0	26	56	110	0	2	21	40	0	0	0	0
Wheat - 3	0	4	3	5	0	0	0	0	0	0	0	15	0	19	34	72	0	0	0	0
Wheat - 4	0	14	30	34	0	1	8	26	0	15	15	15	0	12	27	60	0	0	0	0
Wheat - 5	0	0	1	8	0	1	2	4	0	0	0	0	0	8	8	8	0	0	0	0
Corn - 1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	0	0	0	0
Corn - 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Corn - 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Corn - 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Corn - 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Bean - 1	0	0	0	0	0	13	34	112	0	12	10	180	0	11	14	19	0	0	0	0
Bean - 2	0	0	25	25	0	18	30	165	0	5	20	190	0	4	12	14	0	0	0	0
Bean - 3	0	0	0	0	0	26	120	182	0	3	20	70	0	0	3	6	0	0	0	0
Bean - 4	0	6	8	16	0	6	31	54	0	15	160	70	0	0	5	12	0	0	0	0
Bean - 5	0	0	0	0	0	0	0	0	0	15	155	5	0	0	12	16	0	0	0	0

Water Type	Growth
Distilled	202
Spring	725
Aquifer	786
Fresh	354
Flowback	0



The data spreadsheet shows the amount of growth of the stems of radish, wheat, corn, and bean plants that started from seed. Growth was measured in millimeters on Day 1, 3, 7, and 10. Corn showed almost no growth and it is obvious to us that there was something wrong with the seeds we used. The data from corn is not available for drawing any conclusions.

Some of the wheat seeds began slowly but then showed a lot of growth in the final days. Radish seeds and bean seeds developed overall as expected.

Overall amounts of growth across all seed types are shown in the small chart to the left. Water from our aquifer showed the greatest plant growth overall and flowback water from the fracking process was detrimental to plant growth.

Our team's greatest concern is the flowback water injected into deep wells underground for storage. When the concrete barriers on the sides of the well fail - and concrete does fail - that water will leak out and can reach the Ogallala aquifer. This is our region's source of drinking water and it irrigates the world's largest crop of cotton here in West Texas.

Flowback water is disastrous for plants - what happens to our nation's cotton crop if the water for irrigation is contaminated? Worse even - what happens to communities who depend on clean water for consumption?

Our experiments are leading us to believe the fracking process is having a detrimental effect on life.

THE IMPACT OF FLOWBACK WATER ON PLANT GROWTH

THE RESPONSE OF STEMS AND ROOTS

WATER WARRIORS
SIXTH GRADE ECYBERMISSION TEAM 2015
STEM IN ACTION

HYPOTHESIS

- If flowback fracturing water is polluted to a dangerous level, then it will have a negative effect on living things, including plant growth

VARIABLES

- Independent Variable- We are comparing the types of water: spring, distilled, flowback, fresh frack water, and aquifer water
- Dependent Variable- We measured the plant growth of roots and stems/leaves.

PROCEDURE

① Put germinated radish, wheat, corn, and bean seeds onto a post-use frack water, (10 milliliters), dampened tissue in potting soil for a plant growth experiment.

② Repeat using distilled, spring, aquifer, and pre-use frack water, (fresh water).

③ Record the time it takes for plant growth to occur.

④ Determine the number of plants growing.

⑤ Analyze the different effects on the plants from the different types of water.

⑥ Repeat this every day for 10 days.

MATERIALS

- Potting Soil
- Wheat, Radish, Corn, and Bean seeds
- Flowback water, Pre-use water, Distilled Water, Aquifer Water, and Spring Water
- Metric Ruler
- Digital Camera
- Plant Light
- Graduated Cylinder
- Pot/Cup

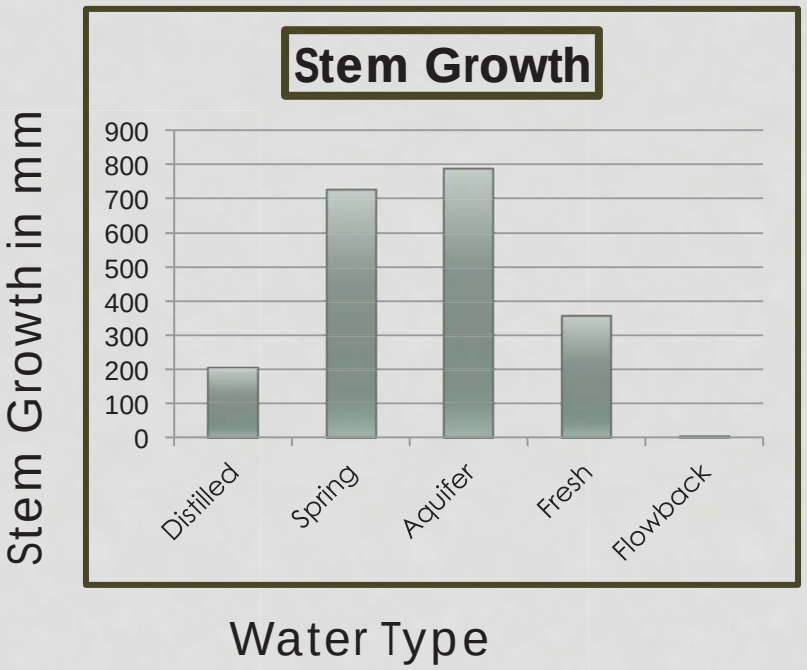
QUALITATIVE DATA: PLANT HEALTH

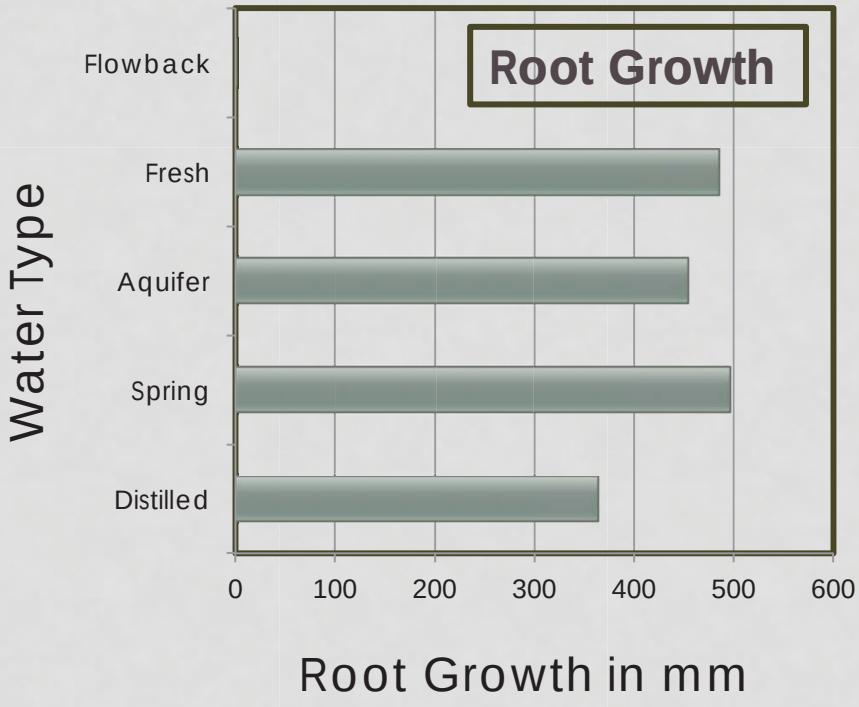
Seeds responded to different types of water and then were placed into cups of soil for the plant growth experiment to continue.

Flowback water showed no germination and no plant growth.

QUANTITATIVE DATA –
COMPLETE SPREADSHEET IS ATTACHED AS A SEPARATE FILE

Water Type Impacts Stem Growth in Plants





QUANTITATIVE DATA: PLANT GROWTH IN CENTIMETERS

Please see our attached ExCel file, "Plant Growth Spreadsheet" showing data and a discussion about its meaning.

CONCLUSION

Of the plant growth tests we conducted, the flowback hydraulic fracturing water did not produce growth In the seeds and plants. Post-use water is the aftermath of the hydraulic fracturing process. Based on the components found in flowback water and the lack of germination or plant growth, we concluded that this water damages living things.

OBSERVATIONS FROM DATA

THE DATA SPREADSHEET SHOWS THE AMOUNT OF GROWTH OF THE STEMS OF RADISH, WHEAT, CORN, AND BEAN PLANTS THAT STARTED FROM SEED. GROWTH WAS MEASURED IN MILLIMETERS ON DAY 1, 3, 7, AND 10. CORN SHOWED ALMOST NO GROWTH AND IT IS OBVIOUS TO US THAT THERE WAS SOMETHING WRONG WITH THE SEEDS WE USED. THE DATA FROM CORN IS NOT AVAILABLE FOR DRAWING ANY CONCLUSIONS.

SOME OF THE WHEAT SEEDS BEGAN SLOWLY BUT THEN SHOWED A LOT OF GROWTH IN THE FINAL DAYS. RADISH SEEDS AND BEAN SEEDS DEVELOPED OVERALL AS EXPECTED.

OVERALL AMOUNTS OF GROWTH ACROSS ALL SEED TYPES ARE SHOWN IN THE SMALL CHART TO THE LEFT. WATER FROM OUR AQUIFER SHOWED THE GREATEST PLANT GROWTH OVERALL AND FLOWBACK WATER FROM THE FRACKING PROCESS WAS DETRIMENTAL TO PLANT GROWTH.

OUR TEAM'S GREATEST CONCERN IS THE FLOWBACK WATER INJECTED INTO DEEP WELLS UNDERGROUND FOR STORAGE. WHEN THE CONCRETE BARRIERS ON THE SIDES OF THE WELL FAIL - AND CONCRETE DOES FAIL - THAT WATER WILL LEAK OUT AND CAN REACH THE OGALLALA AQUIFER. THIS IS OUR REGION'S SOURCE OF DRINKING WATER AND IT IRRIGATES THE WORLD'S LARGEST CROP OF COTTON HERE IN WEST TEXAS.

FLOWBACK WATER IS DISASTROUS FOR PLANTS - WHAT HAPPENS TO OUR NATION'S COTTON CROP IF THE WATER FOR IRRIGATION IS CONTAMINATED? WORSE EVEN - WHAT HAPPENS TO COMMUNITIES WHO DEPEND ON CLEAN WATER FOR CONSUMPTION?

OUR EXPERIMENTS ARE LEADING US TO BELIEVE THE FRACKING PROCESS IS HAVING A DETRIMENTAL EFFECT ON LIFE.

Water Warriors Meeting with Congressman Randy Neugebauer

The Water Warriors met with Congressman Neugebauer in October 2014 to talk about making hydraulic fracturing more environmentally friendly by not using our precious aquifer water. The Ogallala Aquifer, which only has about 75 more years of use, is being depleted. We wanted to discuss with our Congressman the idea to use the saline aquifer under the fresh water Ogallala aquifer, for the fracking process; thus, saving our fresh water for consumption and agriculture.

MEETING THE CONGRESSMAN - Students from Morton and Whiteface are pictured with U.S. Rep. Randy Neugebauer, who spoke with them and adults during a forum Wednesday in Morton. The congressman addressed some of the issues currently facing the country and took questions from students and other county residents. (Staff Photo)

The Water Warriors (front and left) joined area residents and National Honor Society members at a community forum after contacting Congressman Neugebauer about our concerns with the amount of water needed for hydraulic fracturing.

Congressman Neugebauer addresses issues at forum

The Ebola virus, radical Islamic fighters and border security are among the pressing issues for this country, U.S. Rep. Randy Neugebauer, R-Lubbock, said Wednesday.

Neugebauer addressed those issues and other challenges during a forum at the Cochran County Senior Citizens Center in Morton.

The presence of the Ebola virus in this country is a serious issue, but it is being handled effectively, said the lawmaker.

"We're monitoring four (major) airports. We are now screening people coming into this country," he said. "I think we are on top of it."

The situation in Iraq and Syria in which ISIS fighters are killing and beheading people is "a mess and chaos."

The United States invested a lot in Iraq to defend liberty and freedom, only to see people put down their arms after we left that country.

"It's not just a one-shot deal," he said. "We may have left too quickly."

The situation in Iraq and Syria means that someone will have to eventually control the situation on the ground.

But the congressman said he is not yet ready to commit ground troops at this time.

This country must first determine what the mission is and what can be accomplished before it puts troops on the ground, Neugebauer said.

The United States must have a secure border, he said, adding that it should enforce existing laws before putting in additional ones.

"We've got to do a better job of enforcing the border," he said.

Speaking to Morton and Whiteface students who attended the forum, he told them that the "pursuit of happiness" and opportunity in this country is threatened by reckless government spending.

The national debt now exceeds $17 trillion. He told the students that counting to one trillion would take a person 29,000 years.

"That's what the U.S. government has done; we're charging it to our children," he said. "We cannot be the generation that used up all the opportunity in Texas."

A woman asked the solon about the new farm bill.

Neugebauer said problems have developed in implementing parts of the bill.

See FORUM Page 2

FORUM *continued from page 1*

One problem has surfaced on the issue of production history, which can hurt growers who have been through some poor harvests in the ongoing drought.

Another issue is crop insurance, which is also a problem for lenders, he said.

J. Collier Adams said the federal listing of the prairie chicken as a threatened species is an attempt to take away his land use rights.

"I never thought they could apply that to private property," Adams said. He added that land patents state that a person's rights as a landowner are protected forever.

"I'm on your side," replied Neugebauer. "The two things that concern me are this big federalism and a huge expansion of powers. Now we've got the government telling you what kind of activity you can do."

He said the EPA and other federal agencies have implemented rules that are "snuffing out a lot of economic opportunity."

A Whiteface student asked the congressman what he thinks about the use of hydraulic fracking in this county.

Neugebauer said fracking has helped the United States to reach a point where it is now producing more crude oil than it is importing.

He noted that concerns have surfaced about the use of fresh water in oilfield operations. The oil industry has responded by re-processing fresh water and cleaning it up. There is also salt water in a deep aquifer under the Ogallala Aquifer that could potentially be used.

One woman asked about a recent ruling by a federal judge on the issue of gay marriage.

Neugebauer said some judges have ruled that states which do not recognize gay marriages as legal are violating the law.

"What I'm concerned about is the states' right to make those determination," he said. "I'm afraid we have some judges trying to inject their own personal feelings into it."

Asked about teachers carrying concealed handguns, Neugebauer said he supports the rights of school districts to allow such measures.

"You need to have firearms in the hands of people who are responsible," he said. "Government should not preclude the option of local school district."

Neugebauer told one student that he has supported legislation that addresses the issue of declining bee populations in the United States.

On the question of oil, he said producers are drilling as much as they can under the Obama administration.

"What we need is for the Administration to free up and allow more drilling," he said. "I think oil independence is a national security issue."

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See our discussion with Congressman Neugebauer in paragraphs seven through nine on page 2 of the article.

Objective

To determine the effect of post-use water from hydraulic fracturing on living organisms.

Hypothesis

If post-use hydraulic fracturing water is polluted to a dangerous level, then it will have a negative effect on living organisms.

Procedure

① Put radish, wheat, corn, and bean seeds onto a post-use frack water, (10 milliliters), dampened tissue in a plastic bag for a germination experiment.

② Repeat using distilled, spring, aquifer, and pre-use frack water, (fresh water).

③ Record the plant germination, stem length, and leaf growth for 21 days.

④ Analyze the different effects on the seedlings from the different types of water.

⑤ After this process, remove the seedlings and implant them into a soil filled styrofoam cup. Repeat this process with the growing plants.

⑥ Repeat these experiments on planaria.

Materials

- Styrofoam Cup
- Potting Soil
- Wheat, Radish, Corn, and Bean seeds
- Post-use water, Pre-use water, Distilled Water, Aquifer Water, and Spring Water
- Metric Ruler
- Digital Camera
- Plant Light
- Graduated Cylinder

Variables

- Independent Variable- We are changing the types of water used for seed germination: Spring, Distilled, Post-Frack, Pre-use frack water, and aquifer water

- Dependent Variable- Measuring the germination and plant growth in centimeters over time

Results- (Average)

- Spring Water- Radish: Root Length- 18.6 mm Leaf Length- 18 mm
- Spring Water- Wheat: Root Length- 14.8 mm Leaf Length- 18.8 mm
- Spring Water- Bean: Root Length- 16.8 mm Leaf Length- 91.8 mm
- Fresh Frack Water- Radish: Root Length- 30.8 mm Leaf Length- 5.4 mm
- Fresh Frack Water- Wheat: Root Length- 41.8 mm Leaf Length- 12.6 mm
- Fresh Frack Water- Bean: Root Length- 40 mm Leaf Length- 6.6 mm
- Post Frack Water- Bean: 0 mm, Wheat: 0 mm, Radish: 0 mm
- Distilled Water- Radish: Root Length- 11.2 mm Leaf Length- 8 mm
- Distilled Water- Wheat: Root Length- 27.8 mm Leaf Length- 24.8 mm
- Distilled Water- Bean: Root Length- 11.4 mm Leaf Length- 7.4 mm

Radish Seeds

Water	Day 1	Day 3	Day 7	Day 10
Distilled	0	5	7	17
Fresh Frack	0	2	7	45
Spring	0	3	6	23
Aquifer	0	5	9	20
Post-Frack	0	0	0	0

Wheat Seeds

Water	Day 1	Day 3	Day 7	Day 10
Distilled	0	5	25	27
Fresh Frack	0	2	12	25
Spring	0	7	27	41
Aquifer	0	0	15	110
Post-Frack	0	0	0	0

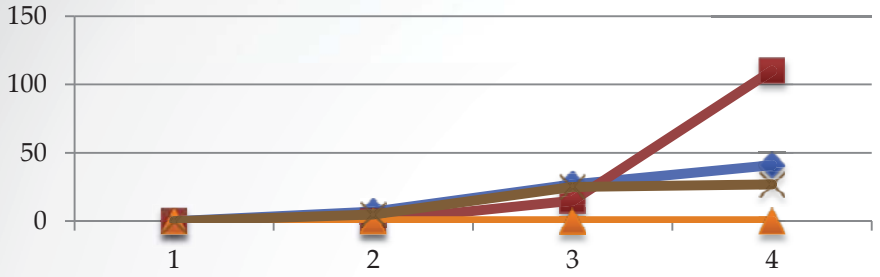
Bean Seeds

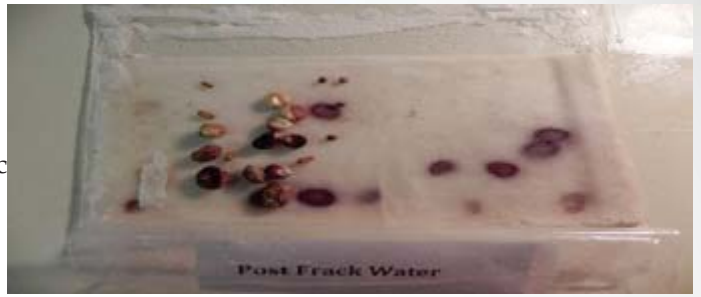
Water	Day 1	Day 3	Day 7	Day 10
Distilled	0	0	19	21
Fresh Frack	0	11	45	86
Spring	0	0	31	72
Aquifer	0	5	20	160
Post-Frack	0	0	0	0

The data presented in these tables represent the average growth of radish, wheat, and bean seeds when exposed to five types of water. 5 seeds of each species were measured and analyzed, with the experiment repeated for accuracy. The raw data shows the lengths of roots and leaves for every seedling over a 2 week period and can be seen in our binder.

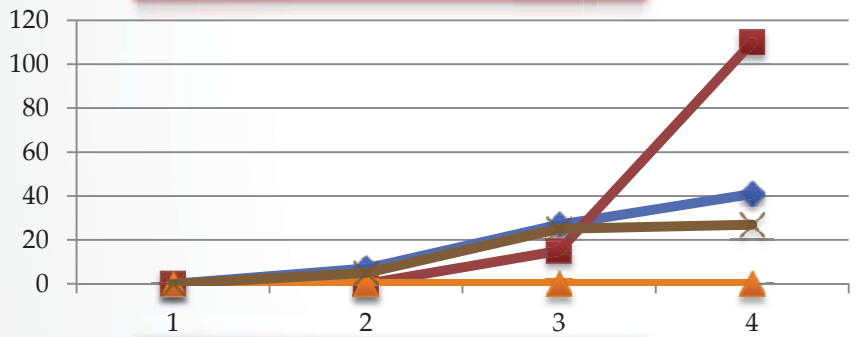
Seed Germination Data

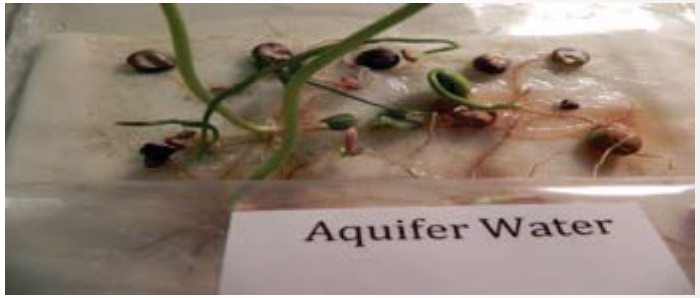
Radish Seeds



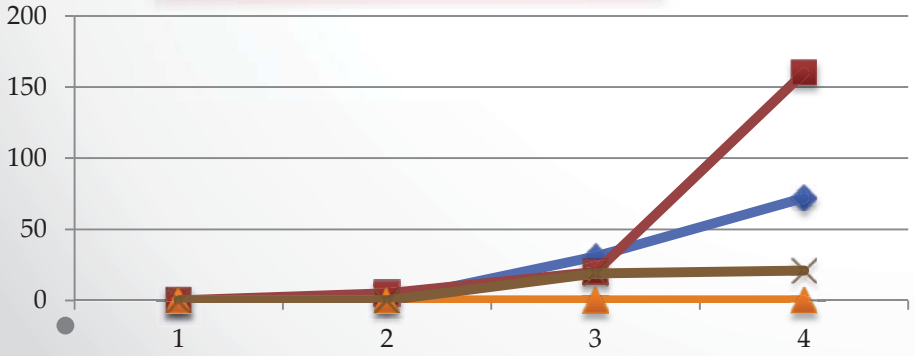


Wheat Seeds





Bean Seeds



Conclusion

Of the germination tests that we conducted, the post-use water did not germinate any of the seeds. The variables were 0.0 on all of the tests. Post-use water is the aftermath of the hydraulic fracturing process. The post-use water contains an oil base that is harmful to the environment. It also contains a small percentage of saline. The water has a pH of 6.35ppm. Our impact on the nation with this project is to not end Hydraulic Fracturing, but to make it safer, and more environmentally friendly for the nation.

Professional Collaborations

- Dr. David Klein Texas Tech University, The Institute of Environmental and Human Health, (TIEHH)
- Russell Ray- Land owner experiencing negative effects of the fracking process
- Dr. Melanie Barnes- Geosciences, TTU
- Randy Neugebauer- U.S. Congressman, District 19

Congressman Randy Neugebauer

Dr. David Klein

Russell Ray

Solution

Our solution is to distill the water that is reserved in the open frack water pits. We could build a slanted closed solar distillation unit to desalinate and clean the water. After this process we could input a bacteria that eats chemicals into the pits so that any water stored underground is safe..

Award Winning Project for Excellence in Environmental Science
Top Water Conservation Project in the Texas Panhandle

The Effect of Flowback Waste Water from Hydraulic Fracturing on Seed Germination

Water Warriors

A Sixth Grade STEM Action Team

Photo used with permission:
www.ucsusa.org

Objective

- To determine the effect of flowback waste water from the hydraulic fracturing process on seed germination
- To determine if flowback water presents a concern for the agricultural industry because of the risk of this contaminated water entering the Ogallala Aquifer

Hypothesis

- If flowback waste water from fracturing is polluted to a dangerous level, then it will have a negative effect on seed germination.
- If seed germination success and germination rate is decreased when exposed to flowback water, then there is concern for the agriculture industry when this water reaches the Ogallala Aquifer.
- If flowback water is a danger to agriculture, then the water must be purified before deep well injection or the concrete barriers used to contain the water must be engineered to prevent leakage from occurring.

Procedure

1. Put radish, wheat, corn, and bean seeds onto a flowback frack water, (10 milliliters) dampened tissue in a plastic bag for a germination experiment.
2. Repeat using distilled, spring, aquifer, and aquifer water (fresh water).
3. Place bags under plant lights and monitor temperature using thermometers to assure that all seeds are receiving the same amount of heat.
4. Record the time it takes for seed germination to occur
5. Determine the number of seeds germinated
6. Analyze the different effects on the seedlings from the different types of water.
7. Repeat observations for 10 days.

Materials

- Wheat, Radish, and Bean seeds
- Flowback water, Fresh frack water, Distilled Water, Aquifer Water, and Spring Water
- Metric Ruler
- Digital Camera
- Ziplock bags
- Paper towels
- Thermometer
- Plant Light
- Graduated Cylinder
- ExCel data spreadsheet

Set Up

Measuring Distilled Water

Measuring Spring Water

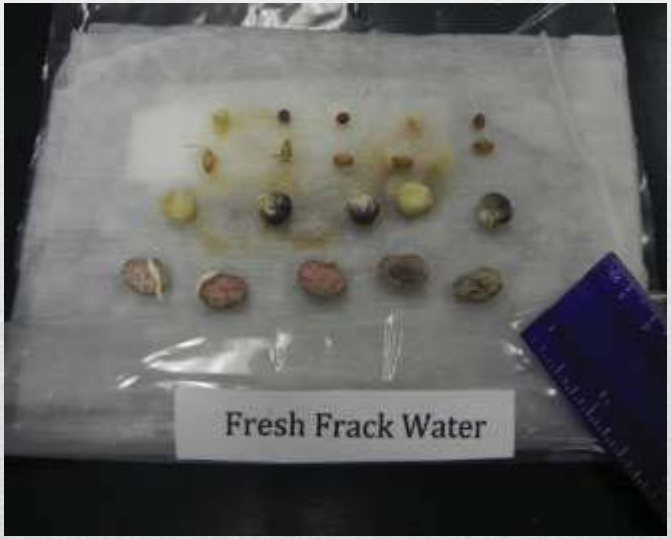
Measuring Flowback Hydraulic Fracturing Water

Adding Water to the Bags

Measuring Faucet/Aquifer Water

Variables

- Independent Variable- We are changing the types of water: Spring, Distilled, Flowback, Fresh frack water, and aquifer water
- Dependent Variable- The time it takes for seed germination to occur in each seed type
- Controlled Variables – temperature, method of germination in bags, number of seeds, amount of water provided



Different Kinds of Water put into the Bags

Germination

- Spring Water- Radish: 5 Days
- Spring Water- Wheat: 4.6 Days
- Spring Water- Bean: 5 Days
- Fresh Frack Water- Radish: 3.8 Days
- Fresh Frack Water- Wheat: 3.4 Days
- Fresh Frack Water- Bean: 3 Days
- Flowback Water- Radish: 0 Days
- Flowback Water – Wheat: 0 Days
- Flowback Water – Bean: 0 Days
- Distilled Water- Radish: 3.4 Days
- Distilled Water- Wheat: 3.4 Days
- Distilled Water- Bean: 5 Days

Results- Average Time for Germination

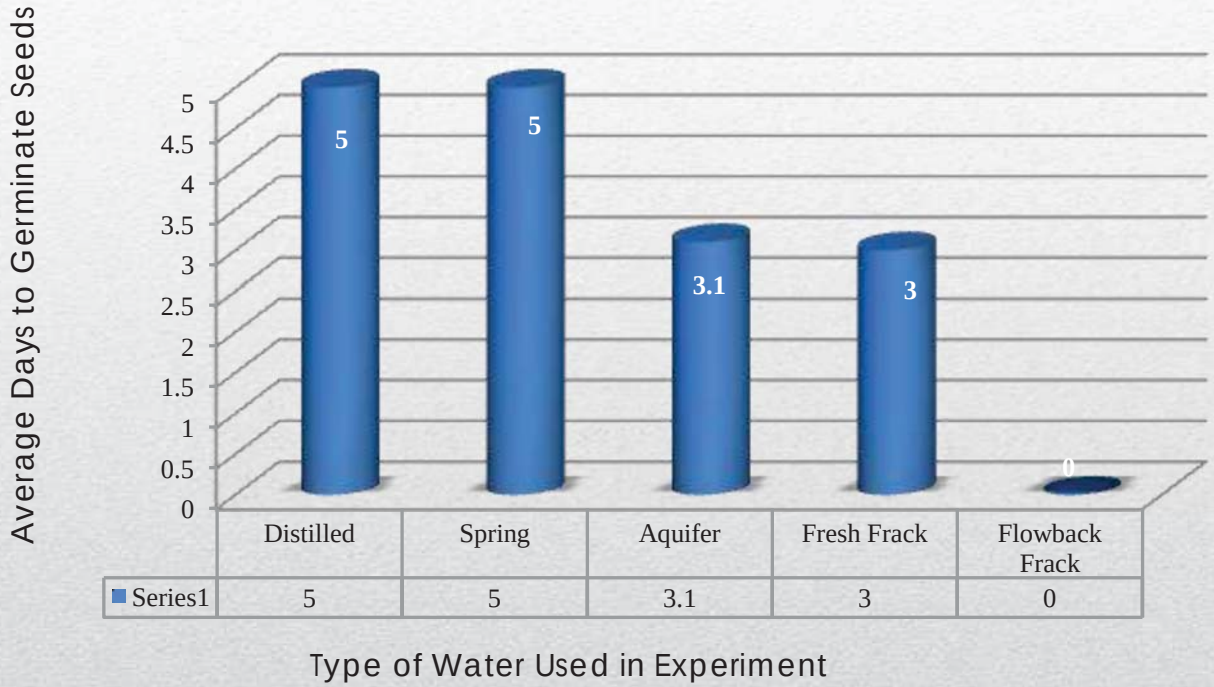
Mean Rate of Seed Germination using Flowback Waste Water from Hydraulic Fracturing

Water Used	Average Time for Seeds to Germinate (days)		
	Radish Seeds	Bean Seeds	Wheat Seeds
Distilled	3.4	5.0	3.4
Spring	5.0	5.0	4.6
Aquifer	3.6	3.1	3.4
Fresh Frack	3.8	3.0	3.4
Flowback Frack	**0.0**	**0.0**	**0.0**

Not only did seed germination times increase when using flowback waste water, NONE of the seeds germinated at all when exposed to flowback water. This was surprising

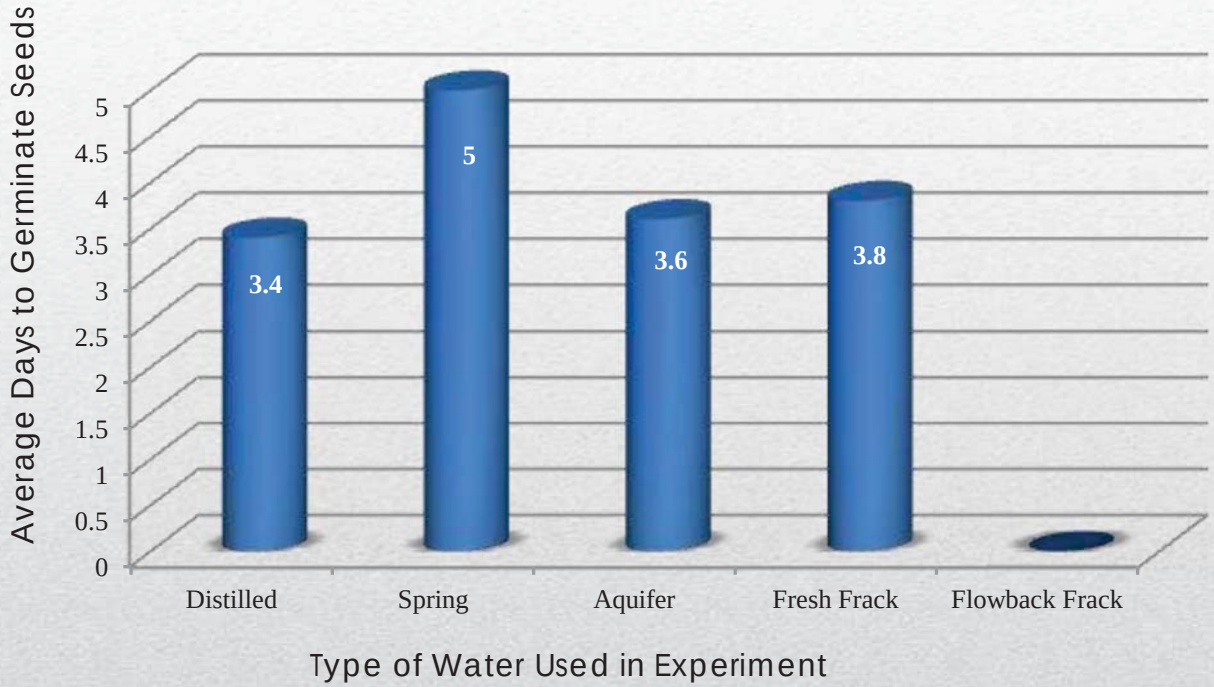
Quantitative Data

Bean Seeds: Rate of Germination



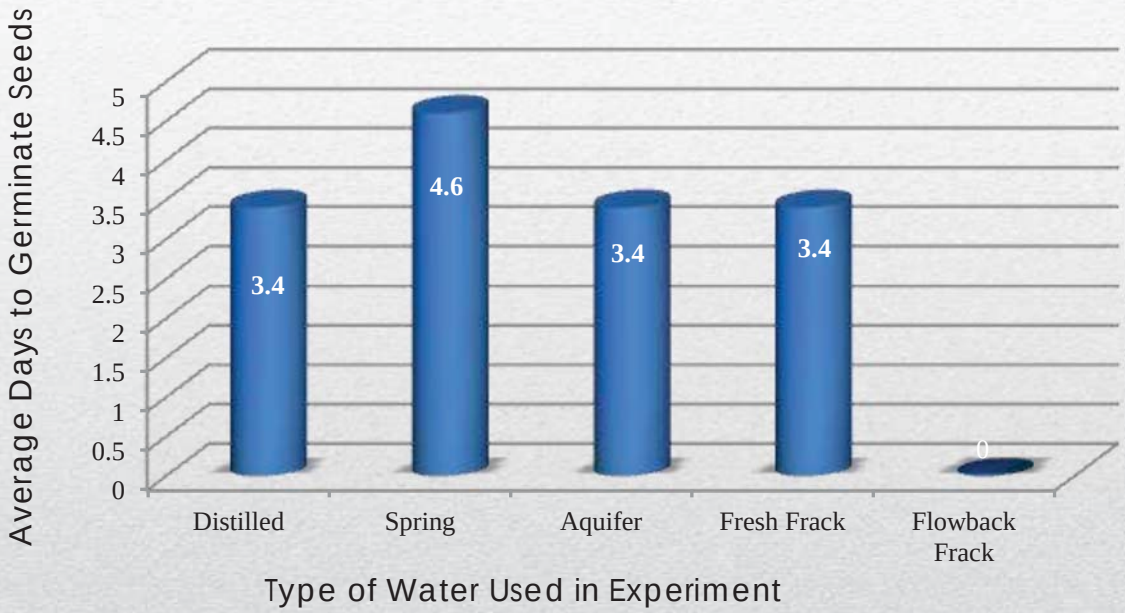
Quantitative Data: Effects of Water Types on Seed Germination

Radish Seeds: Rate of Germination



Quantitative Data: Effects of Water Types on Seed Germination

Wheat Seeds: Rate of Germination



Quantitative Data: Effects of Water Types on Seed Germination

Conclusion

- In the germination tests we conducted, the flowback hydraulic fracturing water did not germinate any of the seeds. Flowback water is the aftermath of the hydraulic fracturing process. This water contains an oil base, salt, and 28 known chemicals and toxins. Based on the components found in flowback frac water, we concluded that this water will not support seed germination or plant life.

- Before this water is injected into deep wells, we believe it should be cleaned better than the current process. If this water leaks into the Ogallala Aquifer and is pumped onto crops, the effect would be disastrous.

Community Problem:
Flowback water from hydraulic fracturing of the shale layers is damaging our environment in several ways

Experiment :
What amount of fresh aquifer water is being used to frack oil in the U.S. and could non-potable water be used instead?

Hypothesis:
If water can be used from non-potable sources to effectively frack oil, then other aquifers could be explored as a source of frack water, leaving the freshwater aquifers available for human consumption and agriculture.

Solution-
Do not use H2O from the Ogallala, but use non-potable water or compressed air for the hydraulic fracturing process.

Experiment :
Can air pressure be as successful in fracturing permeable rock layers as water pressure?

Hypothesis:
If air could be used to permeate rock layers, forcing oil out of the ground, then fresh water would not have to be used for fracking and the rate of aquifer depletion would decrease.

Experiment:
Does flowback water affect living organisms and plant life?

Hypothesis:
If flowback water has a negative effect on the invertebrate Planaria, then it could also be dangerous to other living organisms. If flowback water slows the rate of seed germination and plant growth, then it is proven to have a negative effect on the environment.

Solution-
Reuse distilled flowback water in place of the fresh aquifer water for fracking and reduce the amount of contaminated water that is deep well injected into the ground.

Experiment:
Can flowback water be cleaned effectively?

Hypothesis:
If a distillation unit can be designed to clean flowback water, then the contaminated fluid injected into the ground will be reduced.

Solution:
Add a solar distillation unit for each open pit of fracking waste water to protect the environment from contamination..

Water Warriors

Committed to Responsible Energy for America through a Greener Hydraulic Fracturing Oil Industry

Kaleb	Kaden	Dwayne	Elizabeth
Communication Specialist Leadership Skills	Records Notes during Interviews with Community Experts	Enthusiasm for the Project	Works Together well with Anyone Good Listener
Interviewing Specialist Writes Thank-you notes	Problem Solver/Trouble Shooter	Experimentalist Good Field Skills	Graphs, Charts, Data Generator
Data Collector	Thorough Researcher	Strong Lab Scientist	Time Management Specialist
Public Speaker during Presentations	Idea Generator Studies Paleontology and Geology	Strong Writer Coordinated Distillation Tests	Strong Writing Skills
Sees the Big Picture Easily Family Works in the Oil Industry	Innovator and Creative Mathematician	Coordinates Team Meetings	Prepare Flyers and Brochures Artist
Organized	Bilingual Spanish/English	Design: Website	High Vocabulary in Verbal and Written Communication
Type up notes taken during interviews	Detail Oriented Calculator Skills	Analyzes Data Well Draws Conclusions	Independent Worker Highly Dependable
Encourager to the Team and the most Outgoing Member	Outgoing	Data Collector	Data Coordinator
Good Listener Appreciative of Others Ideas	Prepared Power Points and Presentations	Outgoing Family works in the Oil Industry	Bilingual Spanish/English

Water Warriors

Timeline for eCYBERMISSION Project

Hydraulic Fracturing

Research & topic chosen: the effects of hydraulic fracturing

Ecybermission Registration

Team was completed with members Elizabeth, Kaleb, Kaden, and Dwayne accepting the challenge

Began Experimentation

Seed Germination, Plant Growth, Planaria, and Water Quality Experiments Conducted

Team and Action Plan Development

Research & decisions about the direction of the team and experiments for 6th grade

Team Meetings – Action Plan Developed

Chose a schedule for completion of Mission Folder & Experiments

Consulted Landowners

Interviewed landowners with contaminated wells near fracking sites – Russell Ray

April 2014 ~ May 2015

Water Warriors

Timeline Continued ....

Contacted Other Experts

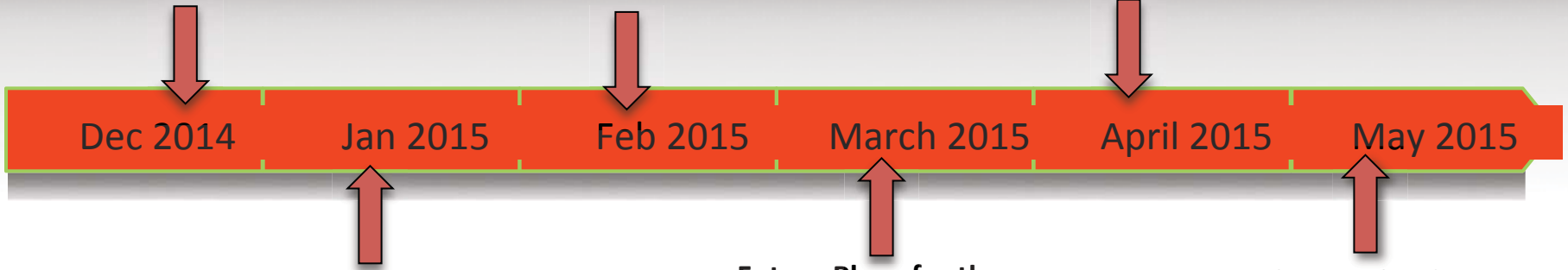
Conducted tests with chemistry teachers and environmental scientists from Texas Tech University

Public Awareness Campaign

Presented poster presentations to Texas Commission on Environmental Quality and Water Conservation Districts

Poster Presentation

Prepare poster for Texas Tech University Graduate School of Geosciences Show Day



Built Distillation Units for Cleaning Flowback

Constructed and tested 4 models for distillation of flowback water in lab

Future Plans for the Project

Plan for field testing a small distillation unit

Graduate School Event

Present project information to the geosciences graduate students of Texas Tech University

Water Quality Testing on Flowback Water

Water Warriors

Sixth Grade eCYBERMISSION Team

STEM in Action

Problem

Does flowback water from hydraulic fracturing contain high levels of the chemicals hydrogen sulfide, copper, nitrite, iron, sulfate, and free chlorine?

Hypothesis

If flowback water is contaminated in a similar way as poor quality drinking water, then the typical tests for chemicals in water will be present in flowback water as well.

Controls

When testing fresh frack water and flowback water for the same chemicals, make sure to follow the procedures exactly and for the same amount of time.

We started the timers at the same time.

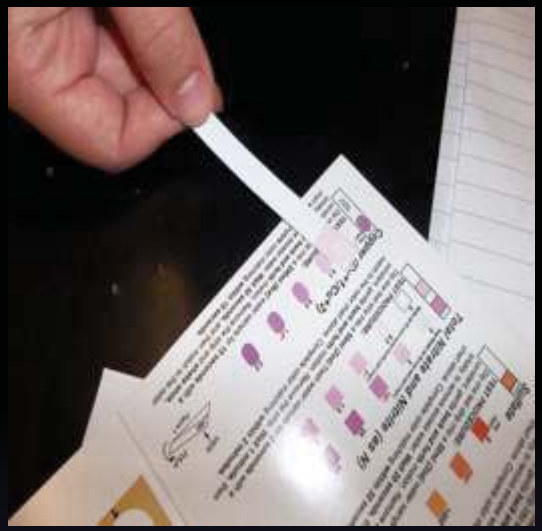
Independent Variable

The type of water is the independent variable: fresh water compared to flowback water from hydraulic fracturing.

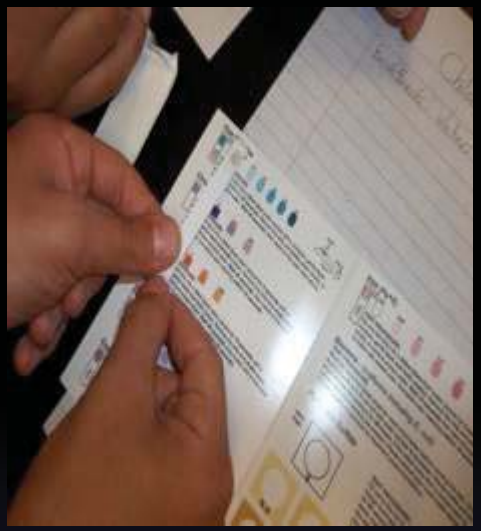
Dependent Variable

We measured Chlorine, Sulfate, Total Nitrate and Nitrate, Copper, Iron, and Hydrogen Sulfide in parts per million for the dependent variable.

Hydrogen Sulfide



Copper



Free Chlorine

Sulfate

Learning to follow procedures and use Indicator Strips Accurately

Iron

We measured the pH level of the flowback water to see how much acid might be in the water. We found that the flowback water has an average pH level of 6.35 even after being treated with neutralizers.

We used a computer interfaced pH meter .

Process

We took the pH meter and placed it in the water for 20 seconds, then took it out and read the pH level on the screen.

Water Quality Data

Type of Water	Hydrogen Sulfide (ppm)	Free Chlorine (ppm)	John's Copper (ppm)	Sulfate (ppm)	Ida's Iron (ppm)	Nitrite (ppm)	Nitrate (ppm)
Fresh Water	0.0 ppm	0.0 ppm	0.0 ppm	500 ppm	0.0 ppm	0.0 ppm	2.0 ppm
Flowback Water	0.3 ppm	0.0 ppm	0.0 ppm	500 ppm	1.0 ppm	0.0 ppm	2.0 ppm

Conclusions

After testing, our hypothesis was refuted. The kinds of contaminants that are present in flowback water are different than fresh frack water. The flowback water does not indicate high levels of most common chemicals that test high in poor quality drinking water. Further chemical testing is needed.

*W*ater *W*arriors

Please visit our website to learn more about:

- Hydraulic fracturing and America's fight for energy independence
- The process of "fracking" for oil and natural gas
- Halliburton Loophole
- The cost of natural gas + the cost to the environment
- Ways to make "fracking" greener for our country
- How to protect fresh water aquifers
- Alternatives to the heavy use of fresh water in the oil field

http://water-warriors.weebly.com

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or
QR code at the top to visit our website