The Great Groundwater Debate

"Anyone who can solve the problems of water will be worthy of two Nobel prizes-one for peace and one for science." – John F. Kennedy

Background Information:

Bin Information

This is the third lesson in a series of lessons all about water. In the first lesson, Water Cycle Whirl, students act as a water droplet as they make their way through the water cycle. In the second lesson, Water(sheds), Water(sheds) Everywhere, students learn more about how water is interconnected.

The purpose of this lesson is for students to learn more about groundwater and examine critically the ways that we use water.

Information for Instructors

For more background information on aquifers and groundwater, instructors can read the information by USGS found here.

In 2019, a Lakeville-based company called Empire Builder Investments proposed a plan to pump groundwater from the Mount Simon-Hinckley Aquifer, one of the oldest aquifers in Minnesota. The company hoped to ship 500 million gallons of groundwater a year to drought affected states. The Minnesota Department of Natural Resources denied the request, especially considering specific protections and restrictions already surrounding the Mt. Simon-Hinckley aquifer.

There have been many proposals to ship water out of Minnesota and into other states, but none have yet been approved. Dakota county may face its own water shortages in the next 10-20 years. However, as water becomes an ever increasingly valuable resource, requests will continue to come.

Vocabulary

Definitions are taken from groundwater.org

- **Groundwater:** Water contained under the ground's surface, located in the spaces between soil particles and in the cracks of sand, gravel, and rock; a natural resource and source of water for drinking, irrigation, recreation, and industry.
- **Aquifer**: An underground geological formation of sand, soil, gravel and rock able to store and yield water.

Author:

Dominique Menard

Themes:

Social Action, Aquifers, Groundwater, Debate, Research

Estimated Duration:

Two 50 minute lesson periods

Audience Identified:

6th-12th grade

Location:

Classroom

Goal:

Students will learn more about local groundwater in order to discuss the future of Minnesota's water from different perspectives.

Objectives:

Students will be able to match vocabulary words related to aquifers to their definitions.

Students will be able to critically read and evaluate sources about groundwater.

Students will synthesis information learned to defend a stance on shipping water.

Students will engage civilly in a discussion with many different viewpoints.

    - **Confined or Artesian Aquifer:** an aquifer that exists where the groundwater is bonded between layers of impermeable substances like clay or dense rock. When tapped by a well, water in confined aquifers is forced up, sometimes above the soil surface. This is how a flowing artesian well is formed. Also known as a pressure aquifer.
    - **Unconfined or Water Table Aquifer:** An aquifer in which the water table is at or near atmosphere pressure and is the upper boundary of the aquifer. Because the aquifer is not under pressure the water level in a well is the same as the water table outside the well.
- **Unsaturated Zone/Aeration Zone:** The zone immediately below the land surface where the pores contain both water and air, but are not totally saturated with water. Plant roots can capture the moisture passing through this zone, but it cannot provide water for wells.
- **Saturated Zone**: The portion below the earth's surface that is saturated with water. The upper surface of this zone, open to atmospheric pressure, is known as the water table.
- **Recharge**: Water added to a groundwater aquifer. For example, when rainwater seeps into the ground. Recharge may occur naturally through precipitation or surface water or artificially through injection wells or by spreading water over groundwater reservoirs.

Materials and Set-Up:

This kit includes:

- Stakeholder role cards
- Gravel
- Sand
- Clay
- Sieves (3)
- Magnifying glass
- Tray
- Groundwater vocab flash cards (5 sets)
- Aquifer poster
- Master copies of articles

You will need:

- Pen and paper for each student
- Clear containers or jars (3)

Set-Up:

- Gather all the materials so that they are accessible, including water
- Make photocopies of articles (optional)
- Make sure that sieves are clean

Introduction:

Estimated Duration: 5 minutes

Warm Up

Start this lesson with an assessment of prior knowledge on the world's water. In a notebook, or on a scrap piece of paper, have students draw two circles for pie graphs.

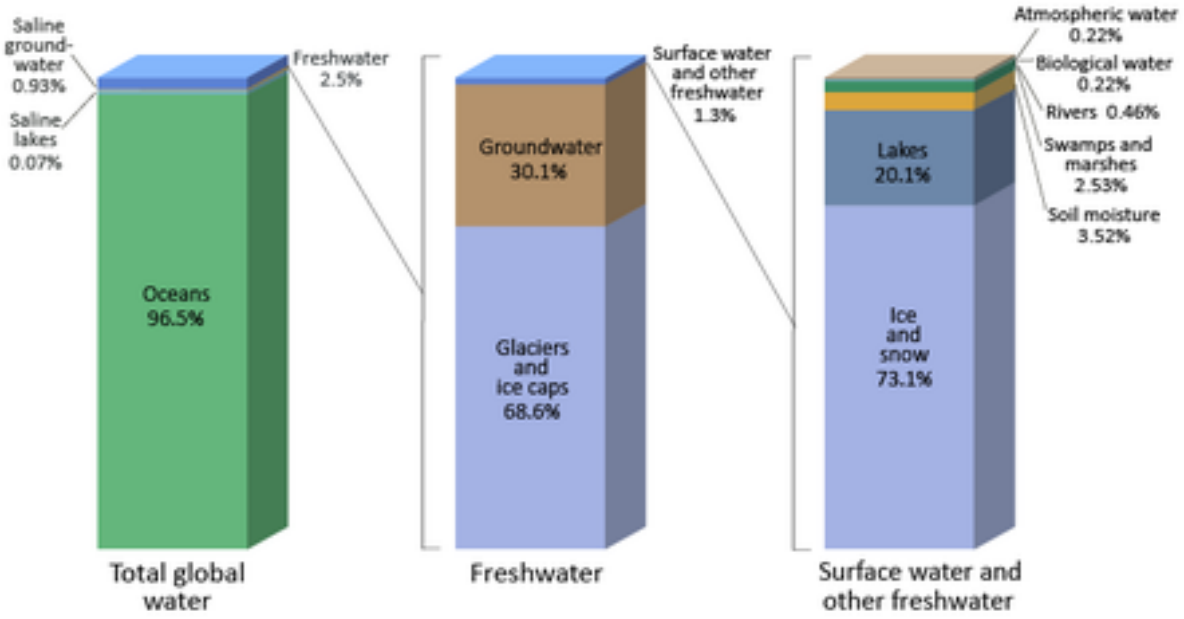
On their own, have them guess and label what percentage of the water in the world is salt water, and what percentage is freshwater. After they have done that, on the second graph have them guess and label of the freshwater what percentage is glaciers or icecaps, what percentage is surface water (rivers, lakes, etc.) and what percentage is groundwater.

Have students all stand up. If they had listed less than 50% of water being saltwater have them sit down. Then if they had listed less than 75% of water as being saltwater, have them sit down. Then if they had listed less than 90% of water as being saltwater, haven them sit down. At this point, depending on how many students remain standing, you may need to adjust the variable of elimination. Exact numbers vary, but less than 3% of the earth's water is freshwater.

Next, have all students stand again. This time designate one area of the room for glaciers and icecaps, one area for groundwater, and one area for surface water. Have students head to the area where they think that most of the earth's freshwater is located. Ask a student from each zone to give a guess as to what percentage of freshwater exists as that designation. When that is done, share the real numbers; about 69% is glaciers and icecaps, about 30% is groundwater, and just under 2% is surface water.

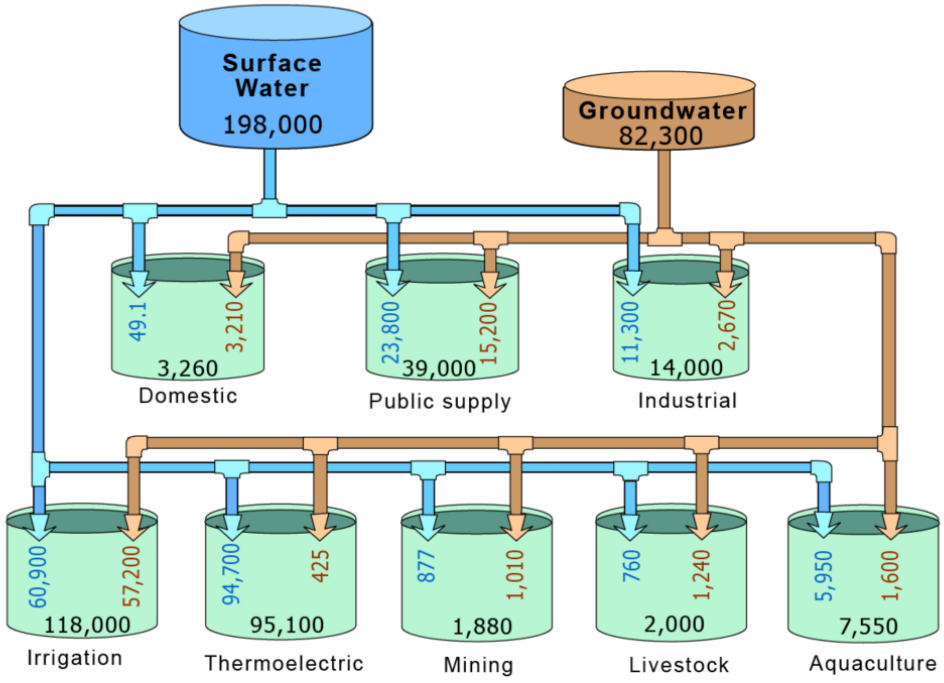
For the last step, have students think guess what source supplies most of the water used by humans. Share the chart below.

Distribution of Earth's Water



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

Source and use of freshwater in the United States, 2015



Explanation

1,234 Surface water
1,234 Groundwater

1,234 Total water use
Data are in million gallons per day and rounded

Content and Methods Part I:

Estimated Duration: 40 minutes

Permeability

Set the sieves on top of the clear containers and fill the sieves with sand, clay and gravel (one material per sieve.) Pass samples of the materials around and give students the opportunity to look carefully at them with a magnifying glass, sharing what they observe. In a larger group, pass around small containers with some of each sample for students to check out and call a few volunteers up to examine with the magnifying glass.

After all three have been observed, ask students which material will drain the fastest. Test the materials one at a time by pouring one cup of water over the top and observing what happens. Discuss the results.

What is an Aquifer?

After the discussion, use the included aquifer poster to give the following information.

- Aquifers are not underground lakes. Rather, they are bodies of saturated rock and sediment that water can move through, like the materials that the students just saw demonstrated. Water from precipitation or irrigation will seep downward from the surface through different layers in a process called saturation.
- Aquifers can be visualized as different layers. On top is the surface of the land. Below that is the unsaturated zone. Below that is the saturated zone that is full of groundwater. The two are separated by the water table line which can rise and fall. That is for an unconfined aquifer. If there is a confining impermeable layer above an aquifer it is a confined aquifer.
- In urban or industrialized areas, often the ground will be made of impervious surfaces. This means that water cannot penetrate and will leave as runoff instead of saturating and replenishing the aquifer.
- If water tables drop too quickly there can be aquifer depletion. This happens when more water is pumped out than can be replaced by rain or snow. This can cause the ground around a well to sink and become depressed.

Evaluation

To evaluate learning for this stage, have students complete the Groundwater Term Game developed by PBS. If students have their own learning devices, they can complete the quiz online as a distance learning option: https://tpt.pbslearningmedia.org/resource/a019b2e6-8c43-4093-915c-9e3082ea3910/the-groundwater-term-game/

In person the evaluation can be run as a game. Divide students into small groups and give them the sets of flashcards and the vocab bank and have them match up the vocab definitions and images. When a group finishes matching, they can call the instructor over to tell them how many they have correct and keep going until they have 100% accuracy.

Next Steps

Tell students that all that they have learned about groundwater is information that will help them with what they will be doing the next time that they meet. In 2019, a company in Lakeville proposed a plan to pump water from the Mount Simon-Hinckley Aquifer and ship water to be used in the American Southwest. The proposal did not pass, but as water shortages become a more pressing issue, this will not be the only proposal that we see.

For the second part of the lesson, students will use supplied documents in addition to what they learned about groundwater and aquifers to stage a mediation session where each student plays the role of a different stake holder discussing a fictional future proposal to ship Minnesota groundwater to drought afflicted states.

At this point, you can dismiss students or divide into small groups and assign stakeholder roles from the next session so that they can do the reading or additional independent research before the next class.

Content and Methods Part II:

Estimated Duration: 40 minutes

Review

Spend about 5 minutes reviewing the informational covered in the previous session. Ask:

- What are the two types of aquifers? Why are they important?
- How did water move through the different materials that we tested last time?

After the review, if stakeholder roles have already been assigned, and students are prepared with their research, prepare for the mediation. If stakeholder roles have not been assigned yet, then reiterate what the activity is and distribute roles.

Whose Water Is It?

The Scenario

A private company is proposing to ship water from Minnesota aquifers to states that are experiencing drought. Minnesota is a water-rich state but may experience a water shortage in the future if resources are managed poorly. Everyone seems to have different thoughts and concerns about this. Students will discuss whether or not to ship water.

Stakeholders

- **Reinhold Industries:** A new, private company in Lakeville that is proposing a plan to ship groundwater from a Minnesota aquifer and sell to drought affected cities. They are promising to provide jobs.
- **The City of Durham:** One of the places that would be receiving water. They are drought afflicted and do not have enough water to meet their previous levels of consumption. Before the drought, their water usage was similar to that of the city of Lakeville.
- **The Town of Newcomb:** One of the places that would be receiving water. The town is agricultural, but does not have enough water to irrigate all of their crops properly. They ship their crops all over, including Lakeville.
- **Minnesota DNR:** The role of the DNR is to protect Minnesota's natural resources, including groundwater.

- **Minnesota Residents**: This should be the largest group at about three times the size of the other groups and divided into
    - pro-shipping water
    - anti-shipping water
    - neutral or undecided

Assign roles to the students. Depending on the group size, you may have them work independently, or as a part of a team. They should examine the documents provided and structure their main arguments about what to do with Minnesota's groundwater and why they feel that way.

The format of discussion is a mediation session. The goal is to come up with the best decision possible, which may be to ship water, or not ship water, or it may be to ship with restrictions that the group agrees to. This can be prefaced before the beginning, or it can be left to students to discover on their own, with or without instructor help.

There are several ways to run the mediation:

- Require a consensus from the group as a whole.
- Focus on the discussion without requiring any formal decision at the end.
- Lawmaker option: Choose several (3-7 depending on group size) students to be lawmakers. Their role would be to draft a bill that would or would not allow the shipping of groundwater, along with any provisions, and to vote on the bill at the end of the mediation. This extension is an option to also tie into the role of government and to explore that, as well as a possible way to give a leading role to more reserved students. The lawmakers need to balance making their constituents happy with protecting the environment and any of their own convictions. Checks can be provided if necessary by the Minnesota residents to vote lawmakers out if they do not do their job well enough. Lawmakers can be assigned individual stakeholder roles, or act as a neutral party with the only need being to appease their constituents. Before choosing this option, think critically about the dynamics of your group and if having unequal roles will enrich or detract from the learning environment.

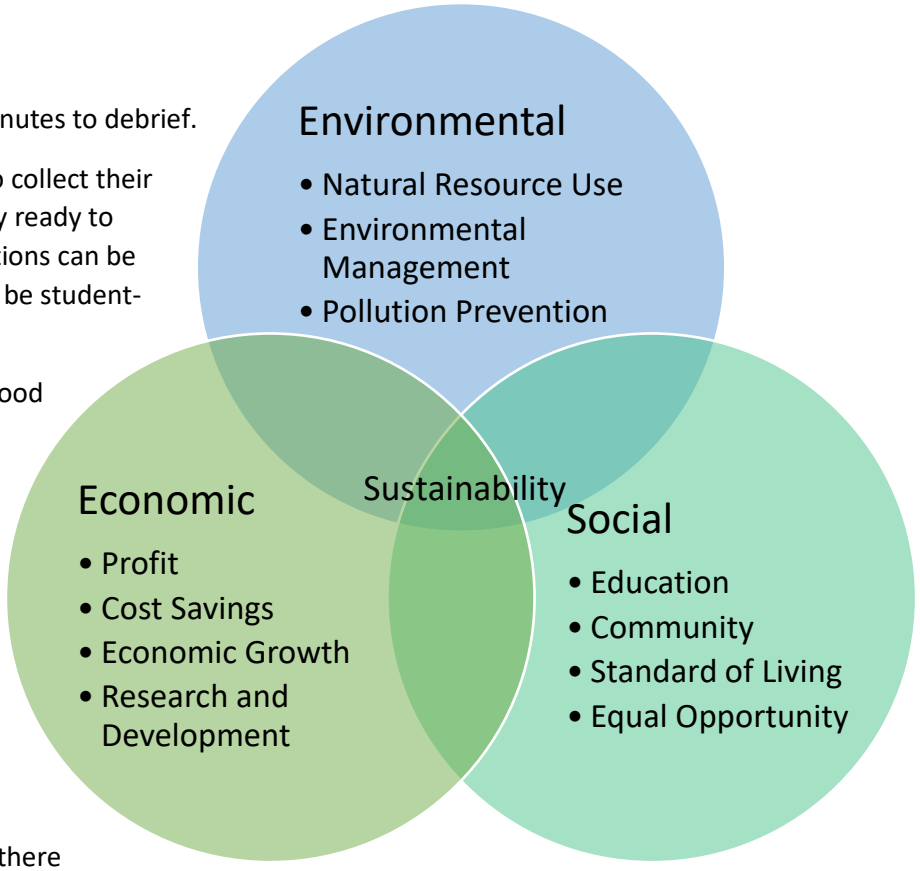
Conclusion:

Estimated Duration: 10 minutes

End the discussion with at least 10 minutes to debrief.

Your group may need a short break to collect their thoughts, or they may be immediately ready to begin debriefing. The following questions can be used to help guide a debrief, or it can be student-led.

- What was something that stood out to you?
- Did your opinion change from the beginning of the activity to the end of it?
- Did you agree with the stakeholder that you were representing? How did that change your experience?
- Were there any parts of the discussion that felt more emotional than rational? Is there anything that you would do differently, or any parts that stood out as being handled very well?



Share the diagram shown on the right. It pictures the three spheres of Sustainability. In order for something to be a truly sustainable option, it must be socially equitable, environmentally responsible, and economically viable. Ask the students:

- Where would your stakeholders fall on the diagram? Did they prioritize any of the spheres over others?
- Did you end the mediation having reached a sustainable option?

Reflection

After students have had a chance to look at the sustainable development triangle have them take a moment to gather their thoughts. Have them step out of the stakeholder roles they have taken on, and take some time to think of what their personal response to this scenario would be. Remind them that this does not need to be their final thoughts on the matter. Give a few minutes for students to each develop a one or two sentence statement to sum up their thoughts on the matter. These can be shared with the group or turned into the teacher.

Evaluation

Evaluation for this lesson takes place during the mediation session. Students will be considered successful if they practice active listening, ask thoughtful questions, and show understanding of the content by tying in information from the reading and activities.

Extensions:

Accessibility and Accommodation

Distance Learning: In place of an in-person demonstration with a physical model, assign Activity 4: Groundwater Movement from High-Adventure Science as listed above. When that is complete, distribute the attached reading materials and stakeholder roles digitally. Students can then create a 3-5 minute video with their stakeholder's view and proposal. The presentations should be shared as a class to lead into an online student-led discussion concerning the different perspectives and possible plans to move forward. With smaller groups it may also be possible to complete the mediation session over a web-conferencing app.

Reading: The second part of this lesson requires reading and comprehension of the attached documents for success. Read over the attached documents before determining if this activity is right for your group. If the reading level is challenging, but not out of reach, consider having time in class where students can go over the documents with the instructor present to give prompts and help answer questions. Some articles may be read aloud as a group as well.

High-Adventure Science

High-Adventure Science is a free educational resource developed by the Concord Consortium in partnership with National Geographic, University of California Santa Cruz, and TERC. It is distributed by the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License by concord.org

Educators can create a class and register students to get reports as they answer questions based off of interactive models. To supplement this lesson, go to has.concord.org and register students for the "Will There Be Enough Fresh Water?" curriculum package, which includes six different activities. The estimated time to complete all of them is 235 minutes.

ELA

This lesson can be used to introduce concepts or enhance skills needed for document-based questions (DBQs) used in many standardized tests. Students must analyze and synthesis information found in the provided documents and use it along with outside information to build their argument.

To further connect to DBQ skills, you may consider the following extensions:

- Have students create a written thesis statement for their stakeholder role.
- Have students create a written outline for their main arguments and discuss how that could also be used to build an essay off.
- Use a similar time allotment for reading and drafting arguments to what students of that grade would be given on a standardized test.
- Debrief at the end how the experience was similar or different to writing a DBQ. What were things that worked well, or things that did not work well. Are there any strategies that students will take with them moving forward?

Reference Materials:

The Concord Consortium. (2019). High-Adventure Science. Retrieved from https://has.concord.org/

National Geographic Society. (2012, October 09). Water Tables and Aquifers. Retrieved from https://www.nationalgeographic.org/encyclopedia/water-tables-and-aquifers/?utm_source=BibblioRCM_Row

University of Nebraska-Lincoln. (2020). Nebraska Real-Time Groundwater Monitoring Network. Retrieved from https://snr.unl.edu/data/water/groundwater/realtime/waterdistribution.aspx

Groundwater Articles

Associated Press. (2020, September 16). Water Shortages in U.S. West Likelier Than Previously Thought. *NBC.* Retrieved from https://www.nbcnews.com/science/science-news/water-shortages-us-west-likelier-previously-thought-rcna120

Atkins, J. & Slavic, M. (2019, December 13). Southwestern States, Keep Your Hands Off Dakota County Water. *StarTribune.* Retrieved from https://www.startribune.com/southwestern-states-keep-your-hands-off-dakota-county-water/566151051/?refresh=true

Marohn, K. (2018, September 4). In Minnesota's Bonanza Valley, DNR Gauges Water Use as Farmers Watch. *MPR News.* Retrieved from https://www.mprnews.org/story/2018/09/04/dnr-gauges-water-use-as-farmers-watch-in-bonanza-valley-minneosta

Reilly, M. (2019, November 1). Railroad Wants to Send Minnesota's Water to Southwest U.S.. *Minneapolis/St. Paul Business Journal.* Retrieved from https://www.bizjournals.com/twincities/news/2019/11/01/railroad-wants-to-send-minnesotas-water-to.html

Strommen, S. (2019, November 1). Statement from DNR Commissioner Sarah Strommen About Proposed Out-of-State Water Transfer. *MNDNR.* Retrieved from https://www.dnr.state.mn.us/news/2019/11/01/statement-dnr-commissioner-sarah-strommen-about-proposed-out-state-water-transfer

Steil, M. (2008, July 29). Deep Aquifers, Deep Questions. *MPR News.* Retrieved from https://www.mprnews.org/story/2008/07/29/deep-aquifers-deep-questions

Water Train. (N.d.). Home. Retrieved from http://www.watertrain.us/