Geoscape Southern Saskatchewan: Geoscience for Prairie Communities.

Groundwater: Vital But Vulnerable
The Flow Below

Subject/Grade: Science 8 & 11 **Lesson Title:** Groundwater: The Flow Below

Stage 1: Identify Desired Results

Outcome(s)/Indicator(s)

Grade 8 Water Systems

WS8.1 Analyze the impact of natural and human-induced changes to the characteristics and distribution of water in local, regional, and natural ecosystems. [CP, DM]

a) Construct visual representations of the world distribution of water, and the distribution of water in Saskatchewan, including watersheds, lakes, rivers, streams, river systems, wetlands, groundwater, saline lakes, and riparian areas.

f) Identify possible personal, societal, economic, and environmental consequences of natural changes and humans practices and technologies that pose threats to surface and/or groundwater systems in Saskatchewan (eg. vegetation removal, water and sewage treatment plants, timber harvesting, over-application of fertilizers, agricultural and urban irrigation, impervious groundcover, land alterations, mining, introduction of invasive species, shoreline erosion, fluctuating lake levels, flooding, draining and/or channeling of surface water features and damming of rivers).

g) Research a specific human practice or technology that may pose a threat to surface and/or groundwater systems in Saskatchewan and explain how different groups in society (e.g., landowner, consumer, business owner, recreational user, fishing, government official, and farmer) may have conflicting needs and desires in relation to the practice or technology and how those decisions or actions of different stakeholders may or may not be addressed by scientific or technological knowledge.

Environmental Science 20

ES20-AS2: Assess the importance of maintaining healthy water for humans and the environment.

a) Analyze emerging health challenges such as the spread of disease, mercury in fish, blue-green algae and E. coli in drinking water that result from changes to the condition of aquatic systems. (STSE, K)

f) Analyze the impacts of point source and nonpoint source pollution on humans and aquatic systems. (STSE, K, A)

g) Research the sources, effects, and management and mitigation strategies of contaminants such as pathogens, organic matter, heavy metals, sediment, heat, petrochemicals and inorganic chemicals such as pesticides in aquatic and/or marine ecosystems. (STSE, A)

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j) Research advances in technologies such as desalination plants, water treatment plants and home water filtration systems, which are designed to maintain and improve water quality. (K, STSE, A)

Key Understandings: ('I Can' statements)	**Essential Questions:**
I can…create a visual representation of groundwater and compare it to an actual groundwater aquifer. I can…explain what causes groundwater pollution and the impacts that it has on humans, animals, and plants.	● What is groundwater? ● How can the water table be lowered or raised? ● What are some sources of groundwater pollution? ● How does groundwater pollution impact humans, animals and plants?

Teacher Background

Groundwater meets the needs of about 75% of all communities and most of the farms and ranches in southern Saskatchewan. Much of this groundwater comes from aquifers composed of sand and gravel deposits that lie tens to hundreds of metres below the surface. The freshest (lowest salinity) groundwater tends to be at shallow depths. Deeper groundwater is generally more saline and therefore less useful, although some towns, such as Melville, Rosetown, and Wawota, de-salinize groundwater to make it potable. If not properly managed, the amount of available water stored underground can be reduced by withdrawal of groundwater at rates that exceed the rate of natural recharge. Such depletion lowers the water table, increases the pumping cost, and ultimately can exhaust water supplies and damage aquifers.

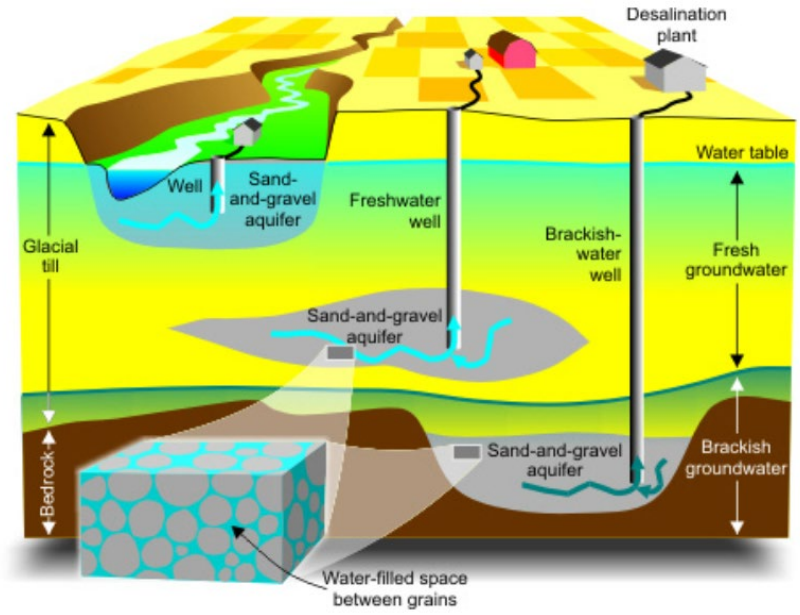

Diagram 1. Groundwater Cross-section

Definitions

Groundwater: water held underground or within the spaces between soil.
Aquifer: an underground layer of rock that has small openings and cracks that allows water to pass through. This is called a permeable layer, a layer of rock that allows water to pass through. For example, sand and gravel are permeable. They have small openings and spaces within the rock that allows water to travel within.
Saline: very salty water. Deeper groundwater is generally more saline and therefore less useful.
Desalinize: is the process by which the salt is removed from saline water so that the water can be safely consumed.
Potable: safe to drink.
Recharge: is the process by which surface water (such as rainwater) moves downward into the ground into an aquifer thus increasing the amount of groundwater in the aquifer.
Water table: is the level below the surface of the ground where water can be found. The soils and rocks are fully saturated with water.
Pollution plume: an area of air, water or soil containing pollutants that traveled from a single source.

Teacher Preparation

1. Prepare the “aquifer”

- Cut away one of the sides of the rectangular bottle as shown in the picture.
- Place a square, double thickness piece of a nylon stocking over the neck of the bottle and secure in place with the rubber band.
- Place the lid back on the bottle.
- Fill the aquifer with the white gravel. It should come above the spout of the bottle, but not reach the very top. Note: darker gravel makes it difficult to track the pollutants.

2. Prepare the "pollutant"
   - Mix 10 mL (2 tsp) dry cocoa with 75 mL (¼ cup) water. Add 5 drops of red food colouring. This will be enough for eight aquifers.
   - Using the small nail, punch a hole in the bottom of each plastic canister. Cover the hole with a piece of tape.
   - Fill each canister about ¾ full of pollutant. Place the lid firmly on the canister, and flip it over to store upside-down.

3. Prepare "rain"
   - Fill 2L pop bottles with water and add 10-15 drops of blue food colouring. Mix well.

4. Make a powerpoint slide of Diagram 1 (Groundwater Cross-section).
5. Print off enough *The Flow Below* Worksheets for each student in the class.

Stage 3: Build Learning Plan

Set (Warm-up, Focusing the Learning): **Time:** 15min

1. Ask students what they think groundwater is, and have them make a quick sketch showing it. This will allow you to access prior knowledge and, more importantly, identify misconceptions which abound when it comes to groundwater.
2. Share the Groundwater Cross-section (Diagram 1) with students and introduce them to the concepts of groundwater and aquifers.
3. Tell students that they will be using a model that represents an aquifer to test how pollutants can travel through this underground environment.

Materials/Equipment:

- Diagram 1: Groundwater Cross-section
- The Flow Below Worksheet
- Bucket (if you do not have a sink)

Per group

- 1 – 1.89 L rectangular plastic bottle (must be flat-sided)
- 1500 mL (6 cups) white aquarium gravel
- Piece of nylon stocking

4. Divide students into groups and give each student a worksheet.
5. Have one student from each group come up and gather the following materials: one aquifer, one canister of pollutant (make sure the lid is on firmly and tape is over hole on the bottom), one pop bottle full of "rain water", two plastic cups, paper towels.

Development: **Time:** 30min

Groundwater Demo

1. The first activity will be a groundwater demonstration. Remind students that they are going to be using coloured water that could stain clothing so to be very careful and roll up their sleeves.
2. Tell students to make sure that their aquifer lid is on tight. They then "charge" their aquifer with rainwater. The water should nearly reach the top of the gravel but not quite. Take this opportunity to talk about the role of porosity in an aquifer, and to show students what the water table is.
3. Ask students how they could make a pond in their aquifer. There will probably be different suggestions but basically they just make a small indentation in the gravel. Talk about how the surface of the pond is level with the underground water table.
4. Explain how their model is going to represent groundwater flowing into a river. The mouth of the bottle, with the nylon covering, will represent the riverbank, where plant cover and roots help filter water coming into the river. The plastic cup is going to represent the river.
5. Ask students if groundwater flows and discuss their answers. Groundwater does flow and they will be demonstrating this process
6. Students set up their groundwater model so that it sits above the "river" (cup). The cup might be held under the edge of a desktop, or the model might be put up on a box with the cup lower. It is up to the teacher's discretion, as long as the cup is lower than the aquifer mouth.
7. One student removes the lid of the aquifer and the group watches as the water flows into the river. When the flow

- Rubber band
- 2 Clear plastic cups
- Blue food colouring
- Red food colouring
- 1.25 mL (1⁄4tsp) cocoa powder
- 2 L clear plastic pop bottle
- Clear 1.5" diameter plastic canisters

- Small nail
- Water – 2 L
- Lots of paper towels for cleanup

Key Vocabulary:
Groundwater
Aquifer
Saline
Desalinize
Potable
Recharge
Water table
Pollution plume

Safety Considerations:

- The dyed water can stain clothing and skin. Roll up sleeves and be careful not to spill the dyed water on yourself.
- Clean up any water spills right away to avoid people from slipping and falling.

stops, ask students how this might happen in a natural setting (little rain or drought). What would it take to get the aquifer feeding the river again?

Emptying aquifer Charged aquifer

Pollution Plume

1. Now students will have the opportunity to see what happens when pollution enters the groundwater. MAKING SURE THE LID IS BACK ON THE AQUIFER BOTTLE, have them recharge their aquifer by pouring the water collected from step 12 back into the aquifer. They might need to "top it up" with a bit more water from their rainwater bottle.
2. On their worksheet, students draw a labeled diagram of the pre-contaminated aquifer.
3. Talk about the contaminant in the film canister. This could represent fertilizer, sewage, a leaking oil tank, a poorly designed landfill, etc. The source can be well away from the river and still cause problems.
4. Remove the tape from the bottom of the film canister and place it near the back of the aquifer. Place it to one side so that the pollution will be able to easily be seen through the clear plastic. Watch for a while and discuss what is happening to the pollution. Where does it go? What problems could this cause?
5. They are now going to let their groundwater flow again so make sure that the river (cup) is ready to catch the water. One student removes the aquifer lid and students carefully observe the movement of the pollution. At this point, have students note the clarity of the water entering the river. It should be very clean.
6. Another student then makes it rain by adding water from the rain bottle to the back of the aquifer. They should pour just enough to recharge the aquifer and not go above the top of

Possible Adaptations/ Differentiation

- Instead of the activity being done in table groups, the activity could be a classroom demo where the teacher interacts with the students throughout - asking questions to students, students helping with the demo and students recording their observations by writing and drawing on their worksheet.
- If done in table groups print out instructions of the activity for each table group so they can read and also follow along with the teacher's verbal instructions.

the gravel. When the water entering the river begins to cloud up, start collecting it in the second cup and put the first cup aside. When the cup begins to fill, replace the lid on the aquifer.

Plume has moved to river Pollution underneath site

7. Students draw a labeled diagram of the pollution plume on their worksheet and compare the water in the two cups.

8. When finished with the activity, clean up and answer the remaining questions on the worksheet.

The aquifers can be rinsed a few times and reused over and over.

Learning Closure: **Time:** 15min

- Let students work on their worksheets until the end of class time. Have students handin the worksheets.
- Finish off with a class discussion about the demonstration.
- Ask students about what they learned, what they found interesting and if they have any questions.

Stage 4: Determine Evidence for Assessing Learning

- Observe students as they do their activity. Pay particular attention to their engagement with the process, and their willingness to contribute observations and ideas with their group.
- You could also assess the worksheet that the students filled out for the demonstration.

Possible questions (on worksheet)

How is this model like an actual groundwater aquifer and how is it different?
It is similar in that aquifers are more porous zones in the ground such as gravel or sand; it is different in that there is no soil on top of the aquifer, and aquifers are rarely this homogeneous.

Identify three different ways that the water table (top of the groundwater zone) could be lowered.

- Lack of precipitation or droughts (rain and snow)
- Removal of water (for irrigation, urban centers, industry, and changes in land use/construction)
- Over use of a freshwater well (the rate of consumption is higher than the rate of recharge)

Identify three different ways that lowering the water table could negatively affect living things (humans, other animals, and plants).

- Loss of riparian habitat (habitat on the banks of a river)
- People relying on well water running out or having to use deeper, more saline water or water rationing
- Less water in the lakes and streams = shore erosion (could affect the stability of houses built along the shoreline or river banks)

Many environmentally conscious people in Saskatchewan take great care in avoiding dumping contaminant directly into the water. What are two reasons why this does not guarantee a healthy river system?

- Other, less conscientious people will continue to pollute
- Pollutants from sources far away from the river can still reach groundwater

In what direction does groundwater flow?

Groundwater flows downward. In some cases this is towards the river which would be the lowest area in the region. In other cases the groundwater may flow downward out of a river to a aquifer below.

Saskatchewan has a great deal of groundwater in many areas, but the deeper the aquifer, the more saline (salty) the water becomes. Based on what you have learned about the groundwater zone, and the fact that deeper water is not potable (drinkable), what are three ways that we could avoid reliance on this deeper water in the future?

- Waste less water in our daily activities
- Do not pollute the groundwater that we have
- Use native plants in your yard that are adapted for your region's climate = less fertilizer and less water
- Water the lawn and plants during the coolest part of the day

Extensions

1. Demonstrate how a wetland system can help keep the environment healthier by placing a small amount of sphagnum moss on the surface of the groundwater model. Repeat the Pollution Plume portion of the activity. Students will observe that the pollution is absorbed into the moss rather than entering the groundwater.

2. Do some research to identify pollution sources within the Saskatchewan river system.

3. Design an experiment that would test how groundwater and contaminants move through different types of soil (sand, clay, glacial till, gravel).

Look at the Digital Geological Highway Map of Saskatchewan (*GeoExplore Saskatchewan*) website for further information and a deeper understanding of the local context:

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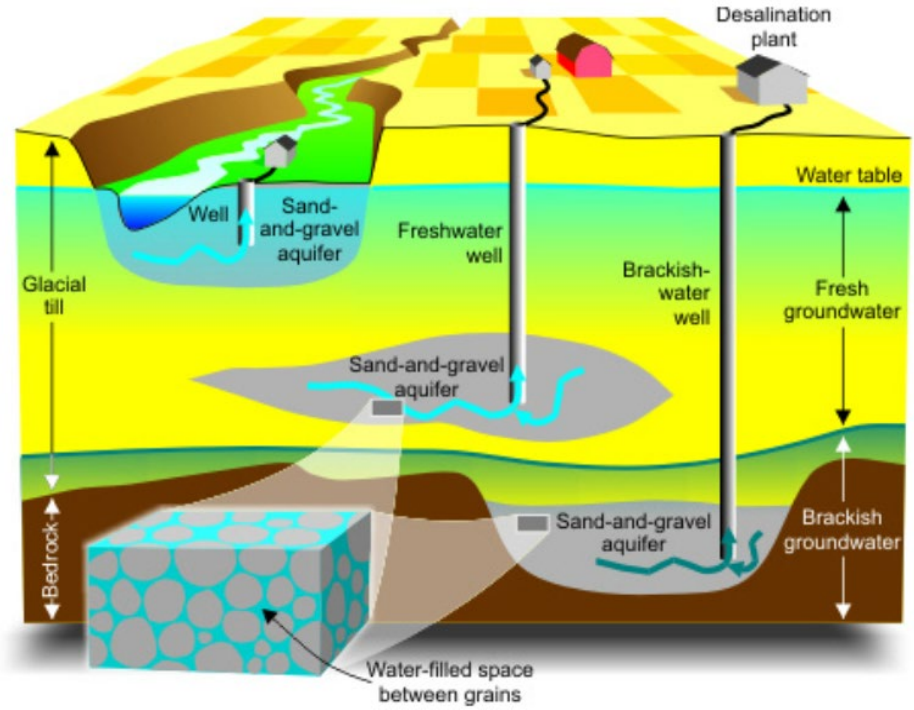
Main Website
https://skgeolhighwaymap.maps.arcgis.com/apps/MapSeries/index.html?appid=a845cbb370f7401597806887318e2676

For more background information related to this lesson check out

- Main tab “Water and Drainage”



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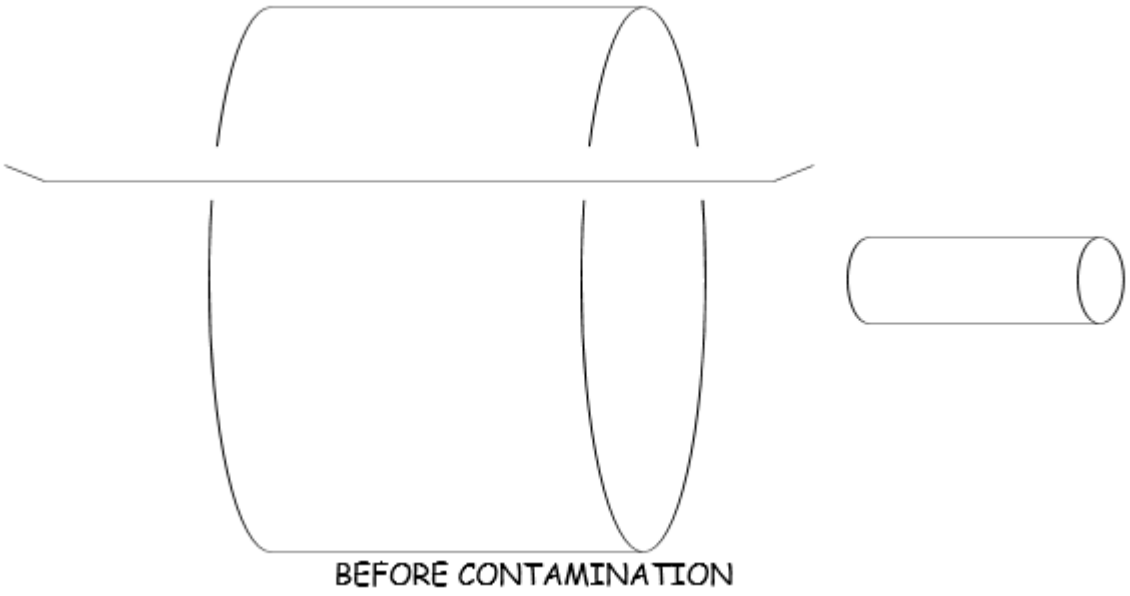
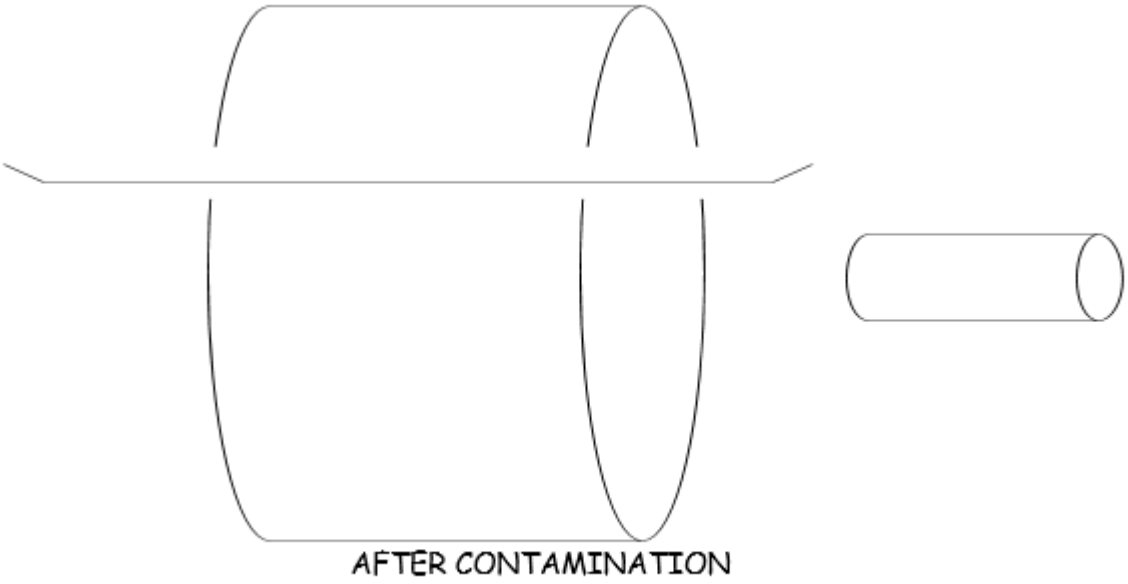
THE FLOW BELOW WORKSHEET

Name: _____ Date: _____

Draw your aquifer before and after contamination has occurred. Label the parts (aquifer, groundwater, water table, pollution plume, direction of groundwater flow, riverbank).



BEFORE CONTAMINATION



AFTER CONTAMINATION

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Questions:

1. How is this model like the actual groundwater and how is it different?

2. Identify three different ways that the water table (top of the groundwater zone) could be lowered.

3. Identify three different ways that lowering the water table could negatively affect living things (humans, other animals, and plants).

4. Many environmentally conscious people in Saskatchewan take great care in avoiding dumping contaminants directly into the water. What are two reasons why this does not guarantee a healthy river system?

5. In what direction does groundwater flow?

6. Saskatchewan has a great deal of groundwater, but the deeper the aquifer, the more saline (salty) the water becomes. Based on what you have learned about the groundwater zone, and the fact that deeper water is not potable (drinkable), what are three ways that we could avoid reliance on this deeper water in the future?