Water Above/ Water Below Lesson

Concept
The relationship between water above ground in a watershed and below ground in an aquifer.

Objective
Students will:
(1) define a watershed, aquifer, surface water, and groundwater
(2) predict the flow of water and pollution in a watershed
(3) predict the flow of water and pollution in an aquifer
(4) draw the cycle of water flowing over a watershed, recharging an aquifer, and discharging at a springs

TEKS Science
5.2 Scientific investigation and reasoning. The student uses scientific methods during laboratory and outdoor investigations. The student is expected to:
(A) describe, plan, and implement simple experimental investigations testing one variable;
(B) ask well-defined questions, formulate testable hypotheses, and select and use appropriate equipment and technology;
(C) collect information by detailed observations…;
(D) analyze and interpret information to construct reasonable explanations from direct (observable) and indirect (inferred) evidence;
(F) communicate valid conclusions…

5.3 Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:
(C) draw or develop a model that represents how something works or looks that cannot be seen…

5.7 Earth and Space. The student knows Earth's surface is constantly changing and consists of useful resources. The student is expected to:
(D) identify fossils as evidence of past living organisms…

5.9 Organisms and Environments. The student knows that there are relationships, systems, and cycles within environments. The student is expected to:
(C) Predict the effects of changes in ecosystems caused by living organisms, including humans…

Vocabulary
aquifer – underground rock layers that store groundwater. They can be made of sand, gravel or limestone. The aquifer under Austin, the Edwards Aquifer, is made of limestone.
groundwater –underground water that flows through soil or fractured rock.
karst – honeycombed limestone; an area of land that has caves, sinkholes, and underground drainage. The Edwards Aquifer is a karst aquifer.
permeability – how easily water can pass through a material (based on how well open spaces are connected).
porosity –the percentage of the total volume of a material (such as sand, soil, or rock) that consists of open spaces. Porosity determines how much water a material can store.
recharge zone – land with caves, sinkholes, cracks, and fractures that rainwater and stream flow drain through to an aquifer.
runoff – water that washes over the land (rather than soaking in).
surface water – water that is on the earth's surface, such as creeks, rivers and lakes.
watershed – an area of land that drains water into a particular creek, river, or lake. Water flows downhill, so hills, ridges, and other high points define the boundary of a watershed.

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Background Information

Watersheds

Everyone lives in a watershed, an area of land that drains water into a particular creek, river, or lake. These bodies of water interconnect to form a larger watershed that drains to the ocean. The watershed of the Colorado River begins above Colorado City and includes all the land that drains into the Colorado River as it travels down to Matagorda Bay and the Gulf of Mexico. The Austin segment of the Colorado River Watershed is composed of 43 smaller watersheds. Urban and natural areas drain water to: (1) creeks, (2) Barton Springs/Edwards Aquifer, and (3) Lake Travis, Lake Austin, and Town Lake. Rainwater travels over all the surfaces in a watershed, so water quality is greatly affected by the condition of the land, streets, building, etc. within the boundary of a watershed.

Gravity forces water downhill, therefore a watershed's boundary is defined by high points such as peaks and ridges that divide two water systems. One of the largest and most famous watershed boundary lines is the North American Continental Divide, which defines the boundary between all the water systems flowing to the Atlantic Ocean and the Pacific Ocean. Topographic maps are used to define a watershed boundary, along with a walk of the area to observe terrain, changes in water flow due to erosion, man-made changes in the landscape, and unusual storm sewer flow routes. Watershed maps are available from the City of Austin.

It is useful for elementary students to define the boundary of the smaller watershed where they live and go to school. The condition of the body of water in their watershed will be an indicator of the environmental problems facing their neighborhood. Students can relate to the effect of their own behavior and choices and focus efforts on cleaning up pollution sources close to home.

Aquifers

Aquifers are underground rock layers that store groundwater. The most common aquifers are made up of sand, gravel, or limestone. The Edwards Aquifer in Austin is formed from layers of limestone. Some layers of the limestone are easily dissolved by water, creating holes, channels and caves. This can create a type of land surface called *karst*. A karst area has many sinkholes, caves and underground channels that can store a lot of water. The limestone that forms a karst area is very porous and appears "honeycombed". Karst aquifers are especially susceptible to pollution because the openings on the surface (sinkholes, caves, openings, cracks, and fractures) can be direct conduits to the aquifer, allowing water to flow into the aquifer without any filtration through the soil.

There are two different ways rain can enter (recharge) the aquifer: (1) Rainfall in a watershed can flow over land into a creek. As the creek flows downstream, it flows over the karst area, where the Edwards Limestone is at the surface of the land. The creek water enters the aquifer when it reaches the holes, channels, cracks, caves, and sinkholes <u>located in the creek bottom of the karst area</u>. Water entering the aquifer is called recharge, and the karst area with the holes, channels, cracks, caves, and sinkholes is called the *recharge zone*. Watersheds with creeks that flow downstream to the recharge zone make up what is called the contributing zone. (2) Rainfall can fall directly on the honeycombed rock of the karst area and soak into the aquifer through the openings before it ever reaches the creek.

The area of land where the Edwards Limestone dips down below the surface in Austin is called the *confined zone*. In this zone the aquifer is capped by a thick layer of clay-type rock that does not allow water to pass through. The confined zone is the lowest segment of the Barton Springs Edwards Aquifer, and is where water from the aquifer resurfaces through fractures and openings in the ground. Barton Springs is located in the confined zone. Water from the Edwards Aquifer is usually crystal clear and cold. However, because water moves quickly through the limestone cavities, there is little filtering to remove pollutants, making the area "environmentally sensitive."

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Introduction (5 minutes)

1. Students are asked if they know what a watershed is. The definition of a watershed is discussed. The students play an echo game ("I say land, you say watershed") and a thumbs up / thumbs down game to help them remember the definition of a watershed.

2. Students look at a large poster showing watersheds, the Colorado River, Barton Springs, the aquifer, and the recharge zone (these terms are discussed). Students will find which watershed their school is in and determine whether or not their school is in the recharge zone. As the aquifer and recharge zone are discussed, students pass around a piece of karstic limestone and look at a poster that features a sinkhole, cave, and spring.

3. Students are asked where their drinking water in Austin comes from. San Antonio and Austin water resources are compared.

Drawing the Cycle (10 minutes)

4. Students are provided with paper, pencils, and blue pencils. Students will use the blue pencil to represent water and the regular pencil for everything else.

   a. They draw a horizontal line across the middle of the paper to separate water above and water below the ground.
   b. Students draw a large, wavy 'W' or a series of 'W's' across the top of the page to simulate the rolling terrain of the hill country. They will connect the 'W' with the word Watershed. Next we will discuss how the water is captured in the low spots of the 'W's'. This could be a stream, river or lake.
   c. We then discuss the meaning and examples of surface water and draw a large 'S' shape like a rivers in the valleys. Students will connect the 'S' of the surface water to the streams and rivers they draw in a 'S' shape.
   d. Students will now draw a line across the center of the page to separate the water above and the water below ground.
   e. Next students draw 'As' below the horizontal line to indicate that the aquifer is underground and 'Gs' between the 'As' to show the groundwater is located in the open spaces of the aquifer. We will discuss and define an aquifer, particularly the karst limestone that makes our Austin water quality easily susceptible to the infiltration of pollution. We will show students a piece of the limestone.
   f. Now, students will write a capital 'R' for recharge zone near the top right corner of the drawing. We will draw and arrow to from above ground going into the aquifer and write the word recharge vertically so that half the word is above ground and half below. This will represent how water infiltrates through the limestone from the surface into the ground.
   g. On the left side of the page we will draw an arrow from underground going up to the surface and write the word discharge vertically to represent water leaving the aquifer. Near the arrow a spring will be drawn.
   h. Students will review the process of the cycle.

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Identifying Pollutants (5 minutes)

5. We discuss types of pollutants that could runoff the land and flow into our drinking water (i.e. fertilizer, herbicide, pesticide, trash, oil, dog poop, etc.) and solutions to pollution (i.e. using compost, which is a mixture, instead of chemical fertilizer, which can easily dissolve into a solution when it rains and runoff of yards and into creeks).

Using Watershed Models (20 minutes)

6. Students use models to observe the flow of water and pollution in a watershed.
   a. The class will be divided into five groups. Each group will receive materials including: watershed model, aquifer tray, watering can, food coloring, and bucket/pitcher.
   b. Within the group, every person is assigned a job by way of a card handed to them. The jobs are: Pollution Manager, Recharge Manager, Colorado River Manager, Rain Manager, and Materials Manager. (If the group has fewer than 5 students, someone will have two jobs.)
   c. The Materials Manager makes sure everything is out of the model and places a clip on the aquifer tray opposite from the Colorado River in order to create a slope toward the Colorado River.
   d. The Colorado River Manager and Recharge Manager plug all of the holes in the watershed model.
   e. Each group is asked to hypothesize which house on the model is polluting "Middle Creek" on the model. They should also predict how the water will flow and what will happen to the pollution. When they have made that decision as a group, the Pollution Manager will place one drop of pollution next to the house that they hypothesized polluted "Middle Creek". The Colorado River Manager will have a sponge ready in case the Colorado River "floods" (water is spilled onto the desk), and the Rain Manager uses the spray bottle to make it rain. Pollution then runs into the creek and eventually into the Colorado River. We discuss where the water went when it rained and what happened to the pollution. Students are asked if their hypothesis was correct and how they determined which house polluted Middle Creek.
   f. The Colorado River Manager and Recharge Manager remove the stoppers from Middle Creek and from the land.
   g. Now we will see what happens when everyone pollutes just a little. The students will take turns adding one drop of pollution to the house that is closest to him/her. The Rain Manager rains water on the model again and students observe what happens. We review the cycle and discuss which water sources were polluted (all of the creeks, the Colorado River, and the aquifer). The Recharge Managers are asked to explain what the holes they unplugged represent and how water traveled into the aquifer.
   h. Teacher assists students with clean up, including pouring water into a sink and drying off models.

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Aquifer Model (10-15 minutes)

7. Students have the opportunity to observe and participate in a visual display of water and pollution moving through the recharge and discharge cycle.
    a. Students sit in a group on the floor (though some students may need to sit in chairs in the back of the group so everyone can see). The Aquifer Model is introduced. The different types of materials that are found underground are discussed and students are asked to hypothesize which material will allow the water and pollution to travel through rapidly and what types of materials might prevent water from passing through.
    b. Blue dye will be placed in the “Recharge Zone” on the model (the first well) so students can see how quickly water can pass through a karst aquifer and discharge at Barton Springs.
    c. Next, a drop of yellow dye will be able to observe the pollution travel underground and pollute the lake.
    d. Next, a drop of green dye will be added to the green lawn by the lake to represent an over-fertilized golf course or a park where people did not scoop their dogs’ poop. Students will observe how the pollution runs off the land and pollutes the lake.
    e. A drop of red dye will be added to an abandoned well to simulate someone dumping trash in an abandoned well, sinkhole, or cave. Students will observe the path of dye.
    f. Students observe how water and pollution can travel across the land, through the aquifer, and upward through artesian wells.
    g. Porosity and permeability will be discussed and students will be asked if they think a sand aquifer or a karst aquifer would be better at filtering pollution and why the Edwards Aquifer is considered environmentally sensitive.

Review (5 minutes)

8. Students will be given stickers for answering questions about what they learned and what they can do to help keep our water clean (if time runs out before all students are given stickers the remaining stickers can be given to the teacher for distribution). The teacher is given the students’ homework (finding which watershed they live on), an aquifer and watershed pollution search, and Earth School evaluations.