Groundwater: 6th Grade Narrative

BIG IDEAS:

- **Groundwater is in the pore spaces between sand grains, gravel and other particles.**
- **Groundwater flows, because gravity works below ground just like it works above ground.**
- **Groundwater is a part of the water cycle.**
- **Groundwater and surface water are connected.**
- **We use groundwater in our homes!**
    - **Our drinking water is groundwater and CAP water from the Colorado River.**

TERMINOLOGY:

Groundwater
Aquifer
Water table
Saturated zone
Unsaturated zone
Pumping wells
Observation wells
CAP water

MATERIALS: For each classroom presentation you need 2 Groundwater Flow Models, and 1 Earth Materials Tube Setup

Groundwater Model

1 Groundwater flow model
1 Hand pump with tubing attached to flask
2 recharge bottles
2 squirt bottles
2 Wooden stands
Food coloring or water bottle full of green water
Expo Marker
Sponge

Earth Materials Tube Setup

1 Earth Materials tube model: including cloth and rubber bands
1 Bag dry sand
1 Bag gravel
1 Stopwatch
2 Cups for capturing water
2 Graduated Cylinders
1 funnel for filling tubes
Bag for wet sand

Bolded Text in the script below denotes items for the presenter to say. The blue text is used for directions and sample participant responses. Highlighted items are the Big Ideas, and *Terminology* is italicized.

Q & A — Introductions/Pre-Assessment – 5 Minutes

Introduce yourself. Introduce Arizona Project WET as a program of the University of Arizona. Introduce Tucson Water as the Sponsor of this program.
Today we are going to start by having you tell us what you know about groundwater.
Hand out worksheets.
Write your name and your teacher's name, school and date on your paper. Look at all the pictures on this worksheet very carefully. Think about what you already know about groundwater and make selections that you think best answer the questions.

This is not a test it is just information that helps us. So just do your best and don't discuss it out loud. It's okay if you don't know. We will learn about all of these things in our lesson today.

Can anyone describe groundwater?
It is water under the ground.
Today we are going to learn about groundwater.

EXPLORATION – Earth Material Tubes -- 5 Minutes

Point to the earth material tube model.
What do you see inside the tubes? Sand and gravel.
Where on Earth do you find sand and gravel? In the ground
What do you think will happen when we pour water into the tubes? Solicit answers. Some students will say that it will stay in the tubes; some will say it will come out.
For those of you that think it will come out, how long do you think it will take for the very first drop to come out of the gravel? Write down their predictions.
How long do you think it will take for the very first drop to come out of the sand? Write down their predictions. *Never* can be an answer.
Experiment
Get two volunteers: a timekeeper and a student to pour water. Teach the student how to use the stopwatch. The timekeeper will tell the other student when to start pouring.
All of the students sitting in the class have a job too! You will say, "Stop" when the very first drop of water comes out of the bottom of the tube. Is everyone ready?
ALWAYS start with the gravel tube. This way you can redo it if the timer experiences operator error. Once the sand is wet, you need new sand.
Ok, The timekeeper will say go and we'll start. Conduct the first experiment.
Now, let's record the time on the board. If the reading on the timer is 5.25 seconds, write it down that way. Don't round the number. (This will eventually teach them about accuracy of the instrument.)
Ok let's look at our prediction for sand. Are you ready to observe the sand tube?
Make sure the timekeeper resets the stopwatch.
Is everyone ready to say, "Stop?" Tell the timekeeper to take over.
Now, let's record the data.
Review Experiment
What causes the water to move through sand and gravel? Gravity.
(If they don't get that right away drop your dry erase marker, ask them, **"What made the marker fall to the ground?"**)

How is the water moving through the gravel and sand? (Give them time to think. If they can't get the answer have them talk about it with their neighbor.) **It moves through the spaces in the gravel and sand.**
These are called "pore spaces." Have the students repeat "pore spaces" together as a class.
Why does the water move faster through the gravel than the sand? The space between the particles is larger between the gravel than it is between sand grains.

ENGAGE — Underground Picture – 3 Minutes

How do we find out what it looks like under the ground? Before you answer, let's take a minute to discuss it with a buddy that sits next to you. Give the students 2 minutes to talk about this. Walk around and monitor to see if they are on task.
OK, who can share an idea they have about how we do this? This gives you an idea of students' prior knowledge.

Answer: We drill a well and record the sediments that we go through as we drill. As we drill a well, the earth material that we are drilling through comes out of the hole. If the drill bit is at 100 feet below the surface, and coarse-grained sand is coming out of the hole, we know that there is coarse-grained sand 100 feet below the ground surface. This information is used to make a well log. If we put together many well logs across the Tucson basin, we have a picture of what it might look like underground.

EXPLORATION — Groundwater Flow Model – 3 Minutes

Model
What is a model?
A model represents another thing.
Can you give me an example of a model?
See what kinds of examples they can give. A globe is a model of the earth. It is smaller, and may not have all the parts, but it helps us know what the real thing is like.
Our groundwater flow model here represents what it might look like if you were able to look down in the ground 200 feet or so and see across the entire basin. So from one side of the model to the other side represents miles and miles across the Tucson basin. From the ground surface down to the bottom represents hundreds of feet below the surface.

Direct the students to look at the model closest to them.
Parts of Our Groundwater Model
What do you see in this model?
Solicit answers from the students. Explain the things that they see in that order.
There are two groundwater units represented here. Can you tell me what one of them is made of? Gravel.
What about the other groundwater unit? Sand.

ENGAGE — Groundwater Flow Model – 26 Minutes

Where does groundwater come from in the earth system? The ground.
How does it get in to the ground? Rain or precipitation

Where does it rain most often around here? Up in the mountains
Have a student put a recharge bottle up on the left side of model.
This is our mountain rain or mountain front recharge. This is water that travels down through the cracks in the mountains, and at the base of the mountains it moves into the groundwater.
Open the valve on the right side of the model.
Have students study the groundwater flow model to see if anything happens. Watch water bubbling out of the bottle and coming out of the outlet.

Groundwater
Where is the groundwater? (Make them work for this answer, don't volunteer it. Here is more questioning that can help draw it out.) **What color is it?** Clear. **So is it hard to see?** Yes. **Look again where does the groundwater have to be?**

Option 2 - point out:
There are holes in the column on the left side that allow water to go into the model.
Where is the groundwater?
Groundwater is in the pore spaces between sand grains, gravel and other particles.

Option 3 - if that didn't work point to earth material tubes:
Where is the water in the earth material tubes?
Groundwater is in the pore spaces between sand grains, gravel and other particles.

Water Table
Mark the water levels in the observation wells that end in the sand aquifer.
Let's see if we can use our observation wells to see into our upper groundwater unit. We want to look at the water levels in the upper unit (wells B, C D, F and G).
Make sure that students look inside of the observation wells. If they have a hard time seeing it tell them that their head should be about 1 foot away, just above the top of the flow model looking down. You can also point out that the water level is high in the column on the left side and low in the column on the right side, as clues to where the top of the groundwater might be.
Mark the levels to the side of the observation wells. Give them time to do this.

Connect the dots in as smooth a line as possible
When all of the wells in the upper groundwater unit are marked have another student connect those marks with the water levels on the left and the right.
When you draw the line, make a smooth curve to connect them. Just like you would with data points in a graph. What does this line represent? The top surface of the groundwater we call this the water table.
Right now, what is between the grains of sand below this line? Water
What do you think we call this zone? The saturated zone
Right now, what is between the grains of sand above this line? Air
What do you think we call this zone? The unsaturated zone
See Sidebar – Artesian Wells - If a student points out the water in the lake *above* the water table, tell them you will discuss this feature later (the artesian well, and how the lake is actually connected to the confined aquifer (which is a separate system from the unconfined aquifer).

Can a water table change? Yes.

What would cause it to change? Rain, Pumping, Drought.
What do we call water under the ground? Groundwater.
Does anybody know what we call this entire groundwater unit? We call this an aquifer.
What do aquifers do? Store groundwater.

Groundwater Moves through the Ground

Get a student volunteer(s) to help you.
We are going to add dye into our groundwater. I want you to put the bottle nozzle nice and snug into our observation well and squeeze until a blob comes out in the sand.
Mark wells B, C, and D so students know which ones to squeeze it into. Make sure the recharge bottle is still flowing and that the valve is still open.
Have students again study the groundwater flow model to see what happens. You can use a dry-erase marker to circle the blob of dye in ground to see how it changes.
What is happening to the dye? It's spreading (they usually say).
Is it spreading in one direction more than the other? It's moving to the right.
Why? Because the water is moving.
Wow! Groundwater moves underground? Yes.
What would make it move? If they can't get it show them the recharge up high and the outlet down low. Gravity works!
Water flows from up high to low and in our model from left to right.
So what did we learn?
Groundwater flows, because gravity works below ground just like it works above ground.

Groundwater and Surface Water are Connected

Remember that the recharge bottle represents the rain that moves down through the cracks in the mountain rock- it enters the groundwater here. So in the natural world, what does the water on the right side of the model represent? Allow time for them to think about this.
Where did this water come from? Inside the model.
What kind of water was inside the model? Groundwater.
Is this water on the right between grains of sand and gravel? No.
What must this water represent in a natural system? Surface water.
In this case it looks like the surface water is in a big canyon.
Take your finger and follow the water table from left to right on the model. Now talk with your neighbor about what you think happens when the water table crosses the land surface. There is surface water.
Do we have surface water in our rivers most of the time? No.
They do on the east side of the country and in other wetter areas. In Tucson, what do you think has happened?
Use your arm as the water table and bring it to the level that you drew on your model. Demonstrate what you think happened to the water table.
The water table has dropped so that it no longer crosses the surface. In some areas it is hundreds of feet down.

Can water do the opposite and move from the surface water to groundwater?
Put dye and/or water into the recharge basin/wetland. Dye should move into the groundwater. If you don't use dye, mark the level with a marker. Yes it can.

Describe what happened to the surface water.
Water moved down in to the groundwater.
The vertical movement of water through the ground is called percolation. Repeat after me.
Percolation. And what does that mean again? Water moves down through earth materials due to gravity.
So what can you conclude about the relationship between groundwater and surface water?
One can move in to the other. They are connected to one another.
Ground water and surface water are connected.

We've used the model today to study the groundwater system. We've seen water go into the groundwater system. Touch the recharge bottle and recharge basin.
And we've seen water come out of the groundwater system. Touch the right side of the model where surface water is.
So what can we say about the groundwater's connection to the greater earth systems? Tell them to talk to their neighbor about this. This is a big idea.
Groundwater is a part of the water cycle.

We Pump Groundwater for our Homes
Why do we care about groundwater?
We use groundwater in our homes!
How do we get the water out of the ground?
We pump it using a well.
Solicit student volunteers to hold the flask and to pump the pumping well that ends in the sand.
What is going on in the flask?
Water is going in to it.
What is happening to the dye?
It moves into the well. It comes back to the well against gravity from well D.
We see how water moves from all sides in to the well due to pumping. Tucson Water has pumping wells that provide us with all of our water.

Central Arizona Project – Colorado River
If we pump water out of the pore spaces, what is left in those pore spaces?
What's between the grains? Air
So what could happen? The land surface could sink down due to the weight of the earth materials.
We call this *subsidence.* Repeat after me: Subsidence.

Central Tucson had a problem with subsidence. How do you think we fixed that?
Solicit ideas from students. They may say things like we used less water, or we could put water back in those pore spaces.
We have reduced the amount of water each person uses in Tucson, but that wasn't enough to prevent subsidence. The number of people in Tucson keeps increasing.
Does anyone know what the other main source of drinking water for Tucson is? The Colorado River.

We get Colorado River water through the *Central Arizona Project (CAP)* canal. The water from the Colorado River on the western side of our state moves in a canal 336 miles across the state to Tucson. The water from the Colorado River is then recharged in to the ground, (Point to the recharge basin) **and**

then pumped out! Point to the pumping well. **It is stored underground. This helps to keep the ground from subsiding. Right now Tucson is storing a portion of the water we get from the Colorado River underground since everyone does a good job of using water wisely.**

Pump wells until dye is cleaned up. Answer questions that students have about the models or groundwater.

If you have more than 8 minutes left:
Can wells interfere with each other?
Where is the water level in well C now that we've been pumping well 1?
Compare to the original marks they made at well C.
Is the water level in the same place? No, the water that was between the grains is no longer there.
What if a homeowner had a pumping well at D? Could his pumping well affect our pumping well?
Yes his or her well is deeper than ours!
Around each pumped well is a *Cone of Depression*. If your standing body represents the well, put your hands out and spin radially to represent the cone of depression around you. If a lot of wells were drilled in the same area all the cones of depression would result in one large cone of depression.

Groundwater Quality
Can human activities at the surface affect groundwater quality?
Yes.
If the dye that we put into the basin was actually pet waste, paint thinner, motor oil, antifreeze or some other substance our own homes, where might that substance end up?
We could pump it into a well.
Do we drink water from wells?
Yes we do. We use groundwater in our homes!
So it is important that we are careful not to pollute or contaminate our groundwater.

EXPLANATION — Review Big Ideas/Post-Assessment – 8 Minutes

Let's repeat what we learned today.

- **Groundwater is in the pore spaces between sand grains, gravel and other soil particles.**
- **Groundwater flows because gravity works below ground just like it works above ground.**
- **Groundwater is a part of the water cycle.**
- **Groundwater and surface water are connected.**
- **We use groundwater in our homes!**
    - **Our drinking water is groundwater and CAP water from the Colorado River.**

Hand out the Post Assessments.
We have already seen these questions and pictures once, but now you know a lot more about groundwater.
Remember to answer Question #1. Look at each picture carefully before choosing the best answer. The order of the pictures is not the same. Pay close attentions to the arrows.
Collect all of the papers.

Visit the University of Arizona! We hope when you're older you'll come learn at the University of Arizona.

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Sidebar – Artesian Wells

Terminology

Impermeable layer
Confined aquifer
Unconfined aquifer
Artesian spring/well
Fracture

Confined Aquifer

Look closely at the layer above the gravel. What do you notice? They notice coarse grains.
There are coarse grains, but also very fine-grained material.
This layer acts as an *impermeable layer* between the sand and the gravel. That means that for the time period that we will study the model, water will not go directly from the sand to the gravel or from the gravel to the sand.
We call the sand layer an *unconfined aquifer*.
Why do you think we call it that? Because there is not an impermeable layer on top of it.
What kind of aquifer do you think we name the gravel aquifer?
Confined.
Why is it called a *confined aquifer*? Because it has an impermeable layer or confining layer on above it.

Artesian Well

Did you notice something strange that happened on your model?
Is there water in the lake that is located above the water table or top surface of the groundwater on your model?
If so, that seems weird. I thought surface water and groundwater were connected, but I see no connection since our water table is lower than the lake!
Well if you thought this you were right! To explain the water in the lake we need to talk about a completely new system.
Did you notice where the observation wells ended that we looked into to determine the water level (wells B, C D, F and G)?
They were all in the upper sand unit or unconfined aquifer. To solve the mystery of the water in the lake we need to look at the *confined aquifer.*
What is the material that you can see in the confined aquifer?
Gravel.
Let's follow the impermeable layer above it all the way to the end. It curves down.
Does any water get out of the model from the gravel unit/confined aquifer then?
No, not if it's truly impermeable.
So what is going to happen to the water in the confined aquifer?
Water has weight so it goes in to the column on the left side and into the gravel layer and in every tube that it can, it's going to go up and equilibrate (or stabilize) at the same level as it did in the left-side column.

There is a secret tube though in the model.
Do you see the tube top that comes out in the lake?
This tube goes down in to the gravel layer. Let's prove that. Let's pump most of the water out of the

lake. Then we'll add green dye to observation well E.
Make sure that your recharge bottle is still full and on the left side of the model and that the nozzle is short enough to allow water to flow out of the tube in the lake.
What happens?
Green dye comes in to the lake.
As long as the water level on the left side of the model is higher than the outlet of the tube in the lake the water will flow.

So what do you think this represents in the real world?
Does anyone recognize the word artesian? Ever seen it on a plastic water bottle? Yes!
What do you think it means?
An *Artesian Spring* is a spring that comes from a confined aquifer that is under pressure.
Hot springs are good examples of artesian springs. The hot water comes from great depths through *fractures* in the rock.
A well could be drilled into a confined aquifer that is under enough pressure, allowing the water to flow at the surface. This is an artesian well.

Note: There are other types of springs. Some springs just flow laterally along an impermeable layer and come out along a mountainside or hillside.
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