Water Science School

Aquifers and Groundwater

A huge amount of water exists in the ground below your feet, and people all over the world make great use of it. But it is only found in usable quantities in certain places underground — aquifers. Read on to understand the concepts of aquifers and how water exists in the ground.

• Water Science School HOME • Groundwater topics •

Groundwater and aquifers

I hope you appreciate my spending an hour in the blazing sun to dig this hole at the beach. It is a great way to illustrate the concept of how, below a certain depth, the ground, if it is permeable enough to hold water, is saturated with water. The upper surface of this zone of saturation is called the water table. The saturated zone beneath the water table is called an aquifer, and aquifers are huge storehouses of water. What you are looking at in this picture is a "well" that exposes the water table, with an aquifer beneath it. Of course, I am cheating here, as at the beach, the level of the water table is always at the same level as the ocean, which is

A hole dug at the beach is a great way to illustrate the concept of how, below a certain depth, the ground, if it is permeable enough to hold water, is saturated with water. The upper surface of this zone of saturation is called the water table. (Credit: Howard Perlman, USGS)

Status - Completed

Contacts

Ask USGS

https://answers.usgs.gov

Explore More Science

water table
aquifer
artesian
ground water
groundwater
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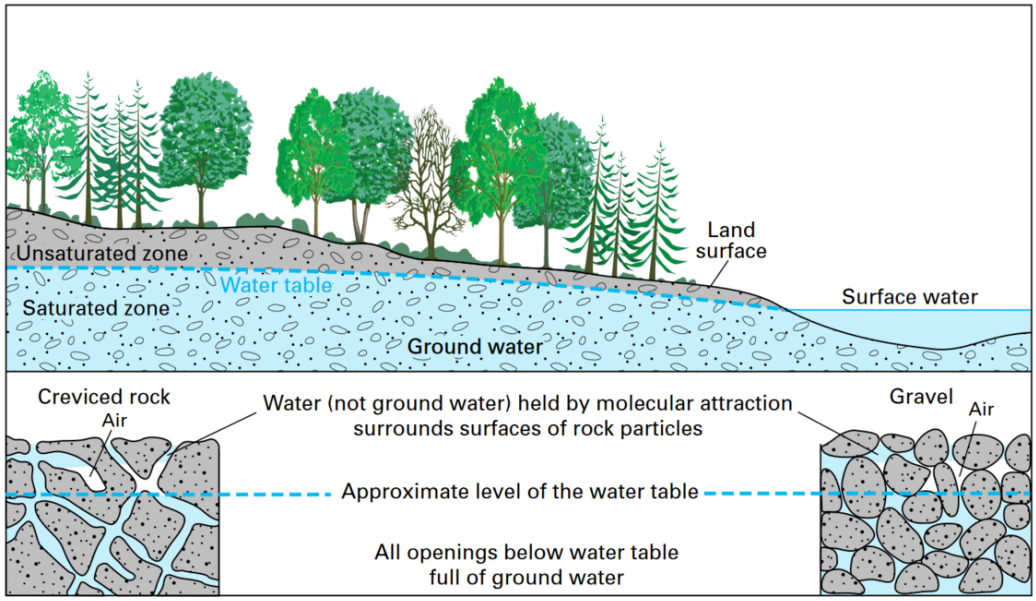
just below the surface of the beach.

Groundwater is one of our most valuable resources—even though you probably never see it or even realize it is there. As you may have read, most of the void spaces in the rocks below the water table are filled with water. These rocks have different porosity and permeability characteristics, which means that water does not move around the same way in all rocks below ground.

When a water-bearing rock readily transmits water to wells and springs, it is called an aquifer. **Wells** can be drilled into the aquifers and water can be pumped out. **Precipitation** eventually adds water (recharge) into the porous rock of the aquifer. The rate of recharge is not the same for all aquifers, though, and that must be considered when pumping water from a well. Pumping too much water too fast draws down the water in the aquifer and eventually causes a well to yield less and less water and even run dry. In fact, pumping your well too much can even cause your neighbor's well to run dry if you both are pumping from the same aquifer.

Visualizing groundwater

In the diagram below, you can see how the ground below the water table (the blue area) is saturated with water. The "unsaturated zone" above the water table (the gray area) still contains water (after all, plants' roots live in this area), but it is not totally saturated with water. You can see this in the two drawings at the bottom of the diagram, which show a close-up of how water is stored in between underground rock particles.



How ground water occurs in rocks.

How Groundwater Occurs

Credit:USGS, Public domain

Sometimes the porous rock layers become tilted in the earth. There might be a confining layer of less porous rock both above and below the porous layer. This is an

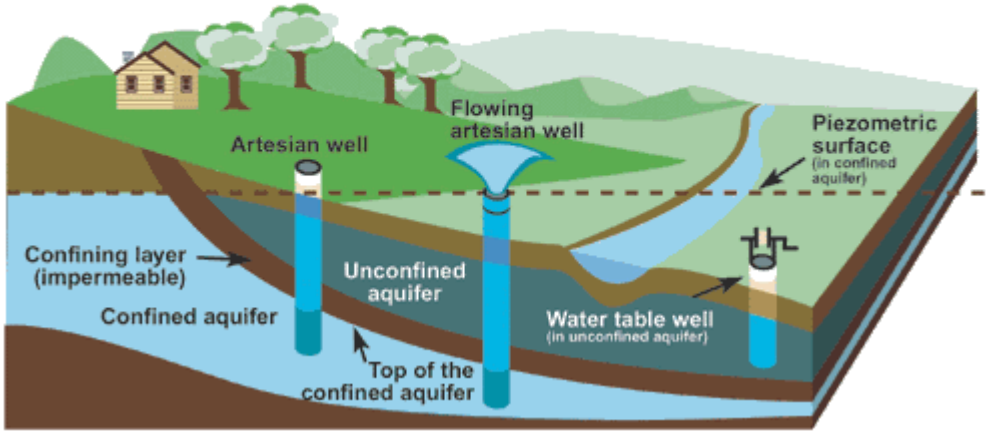
example of a confined aquifer. In this case, the rocks surrounding the aquifer confines the pressure in the porous rock and its water. If a well is drilled into this "pressurized" aquifer, the internal pressure might (depending on the ability of the rock to transport water) be enough to push the water up the well and up to the surface without the aid of a pump, sometimes completely out of the well. This type of well is called artesian. The pressure of water from an **artesian well** can be quite dramatic.

Learn the basics about water using our Water Primers!

- A Primer on Water (PDF)
- A Primer on Ground Water (PDF)
- Ground water and the Rural Homeowner

A relationship does not necessarily exist between the water-bearing capacity of rocks and the depth at which they are found. A very dense granite that will yield little or no water to a well may be exposed at the land surface. Conversely, a porous sandstone may lie hundreds or thousands of feet below the land surface and may yield hundreds of gallons per minute of water. Rocks that yield freshwater have been found at depths of more than 6,000 feet, and salty water has come from oil wells at depths of more than 30,000 feet. On the average, however, the porosity and permeability of rocks decrease as their depth below land surface increases; the pores and cracks in rocks at great depths are closed or greatly reduced in size because of the weight of overlying rocks.

Aquifers and wells



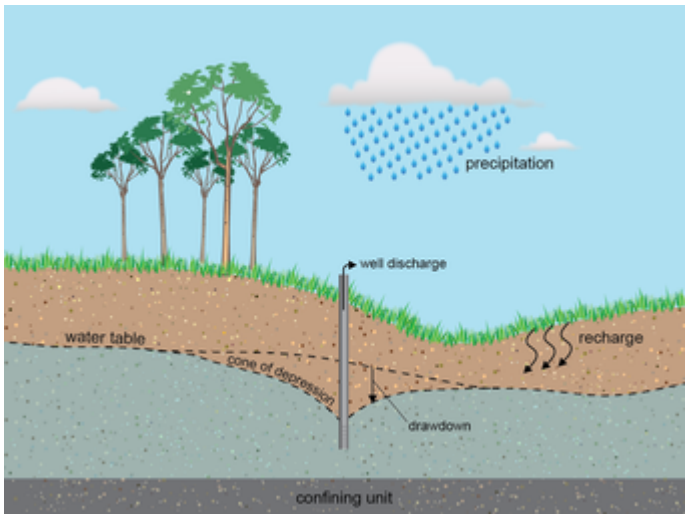
The illustration shows an artesian well and a flowing artesian well, which are drilled into a confined aquifer, and a water table well, which is drilled into an unconfined aquifer. Also shown are the Piezometric surface in the confined aquifer and the impermeable, confining layer between the confined and unconfined aquifer. (Credit: Environment and Climate Change Canada)

Pumping can affect the level of the water table

Groundwater occurs in the saturated soil and rock below the water table. If the aquifer is shallow enough and permeable enough to allow water to move through it at a rapid-enough rate, then people can drill wells into it and withdraw water. The level of the water table can naturally change over time due to changes in weather cycles and precipitation patterns, streamflow and geologic changes, and even human-induced changes, such as the increase in impervious surfaces on the landscape.

The pumping of wells can have a great deal of **influence on water levels below ground**, especially in the vicinity of the well, as this diagram shows. If water is withdrawn from the ground at a faster rate that it is replenished, either by infiltration from the surface or from streams, then the water table can become lower, resulting in a "cone of depression" around the well. Depending on geologic and hydrologic conditions of the aquifer, the impact on the level of the water table can be short-lived or last for decades, and it can fall a small amount or many hundreds of feet. Excessive pumping can lower the water table so much that the wells no longer supply water—they can "go dry."

Water movement in aquifers



Schematic showing a cone of depression around the well, usually the result of overpumping. (Credit: Tara Gross, USGS)

Water movement in aquifers is highly dependent of the permeability of the aquifer material. Permeable material contains interconnected cracks or spaces that are both numerous enough and large enough to allow water to move freely. In some permeable materials groundwater may move several meters in a day; in other places, it moves only a few centimeters in a century. Groundwater moves very slowly through relatively impermeable materials such as clay and shale. (Source: Environment Canada)

After entering an aquifer, water moves slowly toward lower lying places and eventually is discharged from the aquifer from springs, seeps into streams, or is withdrawn from the ground by wells. Groundwater in aquifers between layers of

poorly permeable rock, such as clay or shale, may be confined under pressure. If such a confined aquifer is tapped by a well, water will rise above the top of the aquifer and may even flow from the well onto the land surface. Water confined in this way is said to be under artesian pressure, and the aquifer is called an **artesian aquifer**.

Visualizing artesian pressure

Here's a little experiment to show you how artesian pressure works. Fill a plastic sandwich baggie with water, put a straw in through the opening, tape the opening around the straw closed, point the straw upward *(but **don't** point the straw towards your teacher or parents!*) and then squeeze the baggie. Artesian water is pushed out through the straw.

Do you think you know about groundwater?
Take our **Groundwater true/false quiz**, part of our **Activity Center**.

Quiz icon made by mynamepong from www.flaticon.com

Below are other science topics related to aquifers and groundwater.

Date published: OCTOBER 9, 2018
Status: Completed

Groundwater Information by Topic

Groundwater is one of our most valuable resources—even though you probably never see it or even realize it is there. There is water somewhere beneath your feet no matter where on Earth you live. Groundwater starts as precipitation, just as surface water does, and once water penetrates the ground, it continues moving, sometimes quickly and sometimes very slowly. Eventually groundwater emerges...

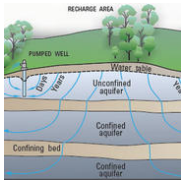
Contacts: Ask USGS

Date published: NOVEMBER 8, 2018
Status: Completed

Groundwater True/False Quiz

How much do you know about the water below your feet? Take our Groundwater True/False Quiz and find out.

Contacts: Ask USGS



Date published: JUNE 18, 2018
Status: Completed

Groundwater Storage and the Water Cycle

The ground stores huge amounts of water and it exists to some degree no matter where on Earth you are. Lucky for people, in many places the water exists in quantities and at depths that wells can be drilled into the water-bearing aquifers and withdrawn to server the many needs people have.

Note: This section of the Water Science School discusses the Earth's "natural" water cycle...

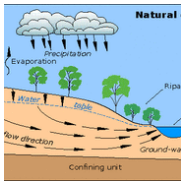
Contacts: Ask USGS

Date published: JUNE 11, 2018
Status: Completed

How Do Hydrologists Locate Groundwater?

As a non-existent proverb states: "*Humans don't live by surface water alone.*" For thousands of years, people have also relied on groundwater to serve their every need. Groundwater is invaluable for many uses, from irrigation to drinking-water supply. But, you can't see groundwater, so how do water scientists know where it is in order to be able to drill wells and pump it out for use...

Contacts: Ask USGS



Date published: JUNE 11, 2018
Status: Completed

Groundwater Flows Underground

Millions of cubic miles of water exists in the ground. You can't see it, but not only is it there, it is always moving around -- mostly downward, but also horizontally. Moving groundwater helps keep rivers full of water and allows for people to draw out water via wells. Moving groundwater is an important part of the water cycle.

Contacts: Ask USGS

Date published: JUNE 6, 2018
Status: Completed

Groundwater Wells

Wells are extremely important to all societies. In many places wells provide a reliable and ample supply of water for home uses, irrigation, and industries. Where surface water is scarce, such as in deserts, people couldn't survive and thrive without groundwater, and people use wells to get at underground water.

Contacts: Ask USGS
Attribution: Water Resources

Date published: JUNE 6, 2018
Status: Completed

Groundwater Decline and Depletion

Groundwater is a valuable resource both in the United States and throughout the world. Groundwater depletion, a term often defined as long-term water-level declines caused by sustained groundwater pumping, is a key issue associated with groundwater use. Many areas of the United States are experiencing groundwater depletion.

Contacts: Ask USGS

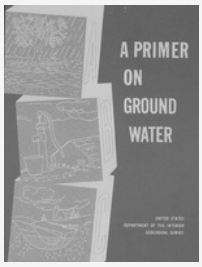
Date published: JUNE 6, 2018
Status: Completed

Drought and Groundwater Levels

Groundwater decline is a real and serious problem in many places of the Nation and the world. When rainfall is less than normal for several weeks, months, or years, the flow of streams and rivers declines, water levels in lakes and reservoirs fall, and the depth to water in wells increases.

Contacts: Ask USGS
Attribution: Water Resources

Below are publications associated with aquifers and groundwater. In addition to those below, Water sources: groundwater by Environment and Climate Change Canada may be of interest.



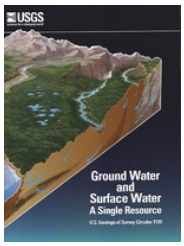
Year Published: 1963

A primer on ground water

Most of us don't have to look for water. We grew up either in big cities where there was a public water supply, or in small towns or on farms where the water came from wells. But there are some people to whom finding a new supply of water is vitally important.

Baldwin, Helene L.; McGuinness, C.L.
Attribution: United States of America

View Citation



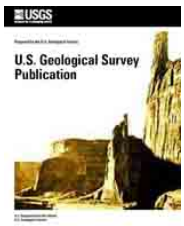
Year Published: 1998

Ground water and surface water: A single resource

The importance of considering ground water and surface water as a single resource has become increasingly evident. Issues related to water supply, water quality, and degradation of aquatic environments are reported on frequently. The interaction of ground water and surface water has been shown to be a significant concern in many of these issues....

Winter, Thomas C.; Harvey, Judson W.; Franke, O. Lehn; Alley, William M.
Attribution: Water, Dakota Water Science Center, Water Resources, Environmental Health, Toxic Substances Hydrology Program, United States of America

View Citation



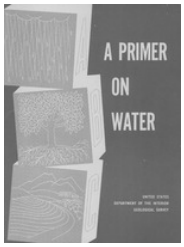
Year Published: 1994

Ground water and the rural homeowner

As the salesmen sang in the musical The Music Man, "You gotta know the territory." This saying is also true when planning to buy or build a house. Learn as much as possible about the land, the water supply, and the septic system of the house before buying or building. Do not just look at the construction aspects or the beauty of the home and...

Waller, Roger M.
Attribution: Water, Water Resources, United States of America, Water Science School

View Citation



Year Published: 1960

A primer on water

When you open the faucet you expect water to flow. And you expect it to flow night or day, summer or winter, whether you want to fill a glass or water the lawn. It should be clean and pure, without any odor.You have seen or read about places where the water doesn't have these qualities. You may have lived in a city where you were allowed to water...

Leopold, Luna Bergere; Langbein, Walter Basil

View Citation

Below are multimedia items associated with aquifers and groundwater.

APRIL 7, 2016

Artesian Water and Artesian Water

Artesian well used for irrigation, Rapid City, South Dakota (January 1956).

AUGUST 21, 2015

Groundwater is accessible through a "well"

Below a certain depth, the ground, if it is permeable enough to hold water, is saturated with water. The upper surface of this zone of saturation is called the water table. The saturated zone beneath the water table is called an aquifer, and aquifers are huge storehouses of water. What you are looking at in this photo is a "well" that exposes the water table, with an

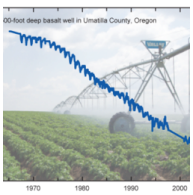
...

FEBRUARY 16, 2013

Water seeping between rock layers

The ground beneath our feet is not just rock, or at least, not just one kind of rock. Many different types of rock exist, and they have very different properties. Often, different types of rocks exist in horizontal layers beneath the land surface. Some layers are more porous than others, and at a certain depth below ground the pores and fractures in these rocks can be

...



Long term pumping can lower the water level of aquifers.

Pumping has removed water from storage in basalt aquifers and caused declines in many areas of the Columbia Plateau.