

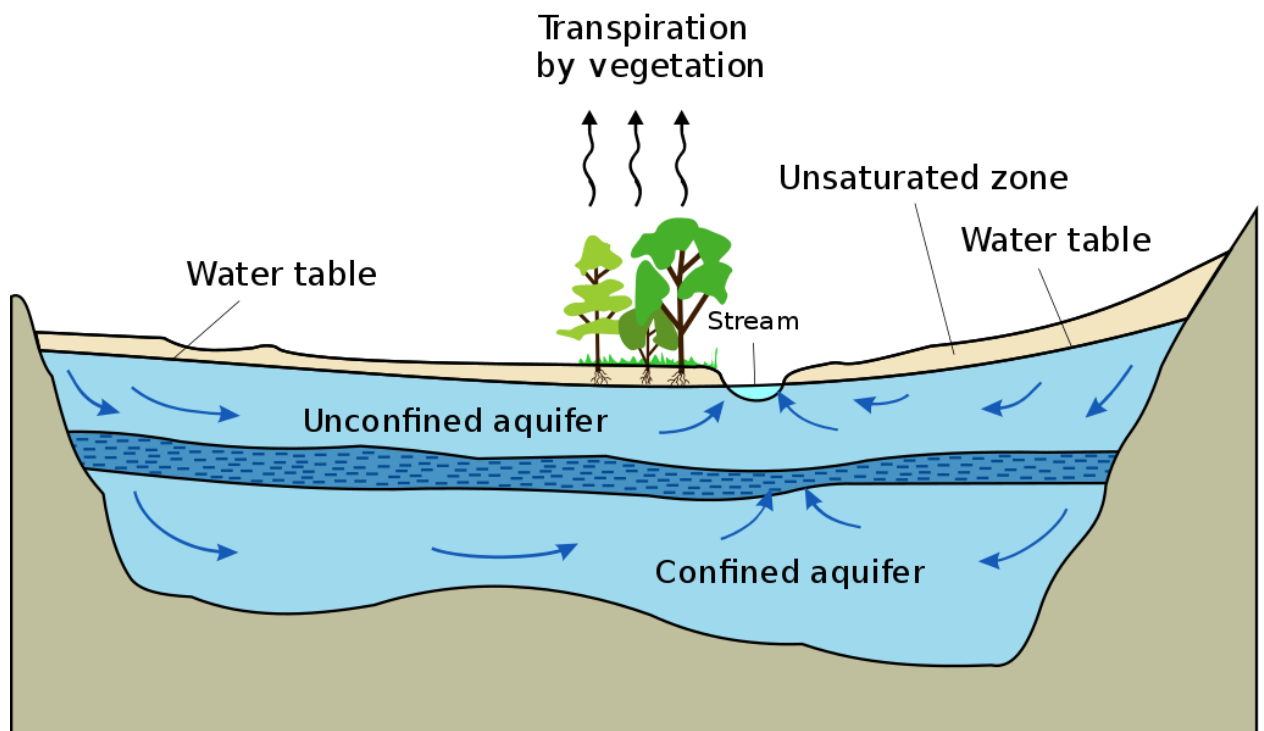
Лекція 3 Ground water. Aquifers

Підземні води. Водоносний горизонт

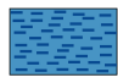
An aquifer is a body of porous rock or sediment saturated with groundwater.

A unconfined aquifer is an aquifer below the land surface that is saturated with water.

Confined aquifers are aquifers that are overlain by a confining layer, often made up of clay



High hydraulic-conductivity aquifer



Low hydraulic-conductivity confining unit



Very low hydraulic-conductivity bedrock



Direction of ground-water flow

Video 1 <https://www.youtube.com/watch?v=zyHtkDCwQUw>

The earth is roughly 70% water however only three percent of this water is **fresh water**. Much of this fresh water is frozen in glaciers. You'll find some of the water in rivers and lakes but almost 30% of this fresh water is groundwater. But what is groundwater?

Groundwater is water that finds its way between the **gaps** of rocks and sediments underground. As the water **seeps** into the ground it may find its way into an aquifer. Aquifers are large underground rock layer saturated with groundwater. An aquifer is not an underground river but large porous layers of rock. For example, the Floridian aquifer covers the entire state of Florida and is over 100 thousand square miles. An aquifer like a huge underground sponge that soaks up the water that falls to the surface of the earth. If you grab the shovel and started digging straight down. You may **strike** water. The first water you strike is called the **water table**. Below the water table the rock may be completely **soaked**. This is called the **saturation zone**. The rocks and minerals above the saturation zone may be dry and is called the **unsaturated zone**. So how does this water end up in ground. When it rains some of the water moves down into the ground. If this water moves deep enough it can stay there for a long time like thousands of years. However not all of the groundwater stays underground. Much of the surface water **comes** from groundwater and aquifers if the ground **dips** below the water table. The ground water will flow to the surface and may create a body of surface water like a lake. Groundwater can also flow out of the water and create a **stream**. This is called a **spring**. However some ground water is so deep that it's difficult to get to these bodies. Groundwater are called confined groundwater. Humans depend on groundwater for drinking water and for growing crops. This groundwater can be reached by digging a **well**. There are thousands and thousands of wells throughout the world that provide drinking water and water for our crops.

Perched water - верховодка

Gaps – тріщини

Seep – фільтрувати (просочуватись)

Strike – відкрити родовище

Soaked – змочений

Come – походити

Dips – опускається

Spring - джерело

Stream – потік

Well – свердловина (колодязь)

Video 2 <http://youtube.com/watch?v=83qBb7KRkAE>

Most people get their water from one of two places. City water is usually taken from surface **water resources** treated and piped to your tap. But if you live in an unincorporated area you might be getting your water from a smaller on-site well. This water is from underground aquifers also called **groundwater**.

So what is groundwater? It's water that collects or flows beneath the earth's surface filling the **porous spaces** and soil sediment and rocks. When we say something is **porous** that means it has small spaces or holes in it through which liquid can move. **Porosity** is an indication of how much water a material can hold. When we say something is **permeable** that means it allows liquids to pass through it. **Permeability** is an indication of how easily water can move through a material. Materials like **gravel** and **sand** are permeable and porous. Water flows through them easily and they can hold a lot of it. Materials like **clay** and **shale** are porous and can hold water but their pores are so small that water flows through them very slowly giving them low permeability. With this in mind let's talk about **aquifers**. An aquifer is a saturated area of sediment or rock that groundwater can move through. Groundwater stored in aquifers can be brought to the surface using **wells**. So you can imagine if you think about something like the Grand Canyon and you can see all those different layers. Some of those layers hold water better than other layers and so they're all sandwiched together and interconnected in various different ways. And because it's all underground it's hard to know about how exactly they're interconnected but they're stacked on top of each other. So when you drill a hole in the ground you drill through some geologic formations that aren't holding any water and then you can drill down into one that is we use for all kinds of purposes.

Water that collects underground is held in an upper **unsaturated zone** and a lower **saturated zone**. The unsaturated zone is located directly beneath the land surface and the pore spaces hold both air and water. In the saturated zone all the open spaces are filled with water. The **water table** is the very top of the saturated zone and the bottom of the unsaturated zone. The saturated zone would be all of that soil or whatever the lithology is that at depth that's below that surface water level or we call it the **free water surface** that you would intersect when you drilled the hole. So and you've dropped a float in and you'd see this water standing or like standing water so it's all of the soils or lithology below that free water surface is considered saturated. There's a zone above that called the **capillary fringe** or other names are **seepage face** that's also saturated but held thereby capillarity. So like a **capillary** tube sucks water like a straw. A thin straw out of a beaker the capillary fringe holds water in the saturated. It saturates the soil there or nearly saturates it above it. The soil begins to desaturate associated with the capillary pressures in the water, in the soil water. Until when you come near the surface it's relatively dry. If we're away from you know wet areas.

What does it mean to **recharge** the water table. You can think recharge the ground water table is basically put water into that aquifer. It's like imagine if you had a glass full of sand and you could pour water into that glass even though it's full of sand because there's all the little holes in between the sand bits and so you could pour water in there. and then if you've drilled a hole in the bottom water would just leak out the bottom and so the more you pour water in the top the more your recharging the ground table or filling up that aquifer.

How do surface water and groundwater interact. Some rivers and streams gain flow from groundwater and others lose flow to groundwater. The streams flow across the surface over permeable, some permeable layers and some impermeable layers and so you can end also the streams themselves carry a lot of gravel and sand and so they lay down a bed of permeable sediments and so water can flow down through that ground through that gravel and sand into the groundwater if it's an unconfined aquifer. but if it's a confined aquifer and there's there's a clay layer like that piece of bread on the sandwich that the water can't get through then it doesn't flow down its groundwater. and then also you can have losing and gaining reaches and so some reaches of a stream are leaking water into the groundwater and some the groundwater is pushing up into the stream.

water resources – водні ресурси

capillary fringe - капілярне підняття (капілярна бахрома)

seepage face – поверхня фільтрації

recharge – поповнення

free water surface – вільна поверхня води

shale – сланець

Porosity – пористість

Permeability – водопроникність (фільтрація в насиченому стані)

Video 3 Confined and unconfined Aquifers Part II

<https://www.youtube.com/watch?v=RCu4UWDiiQw>

For our first demonstration, we'll look at an unconfined aquifer composed of gravel and sand. In the model, you can see the aquitard at the base of the unconfined aquifer and open to the surface at the top. We will use dye to show how water flows through the aquifer. On the right side of the tank we have higher elevations and to the left, we have a lake and a river.

As we start to inject the dye where you think it will go? Let's watch. Did you figure it out? The dye flows from high head to low head. Head essentially means the height of the water surface. There is more horizontal movement than vertical movement. You can also see that the low permeability aquitard is restricting the dye from flowing into deeper aquifers. Eventually, groundwater flow paths discharge the dye into the river.

For that confined aquifer, you can see it is kept by an aquitard and an **aquiclude** a type of aquitard that allows no water to flow through. Watch what happens when we inject the dye. The dye follows a similar path of the unconfined aquifer. There is little vertical movement yet lots of horizontal movement. As the dye reaches the artesian wells, the dye flows up and discharges onto the land surface. Again, this is because confined aquifers are under pressure.

In a fractured **bedrock** aquifer a type of confined aquifer commonly called a karst aquifer. The surrounding rock has very low, if any permeability. Thus, it is kept by an aquiclude, a layer of rock which will not transmit water. As we inject

the dye, where do you think it will go? Think about the speed of the water too. Will it flow faster or slower than the other aquifers?

Let's watch.

Look at that! The dye flows only through the **fractures**, not through the rock matrix. And! It flows much more quickly than the other aquifers. Again, once it reaches an artesian well, the dye discharges onto the land surface and flows into the river.

dye - барвник

figure out – здогадатися

head – напір

movement – рух

restrict - обмежувати

aquiclude – водоупор

bedrock – корінні породи

Inaudible - непомітний

Video 1 Aquifers explained Part I

<https://www.youtube.com/watch?v=1HJ5Q2yH5S8>

Geology is the science of planet Earth, its history, and all the processes that act on it. Hydrogeology is the branch of geology which studies how water and rocks interact underground mainly in **aquifers**.

An aquifer is a rock unit that can hold enough water to **supply** water to **wells**. Aquifers can be found in many types of rocks including **sandstone**, **conglomerate**, **unconsolidated sand** and **gravel**, and **fractured rocks** composed of **limestone** or **igneous rocks**. Here at Barton Springs in Austin Texas, we are standing on top of the Edwards aquifer composed mostly of fractured limestone.

Over time, these fractured rocks can **dissolve** to create large **cave** like systems called karst aquifers. So, when you hear the word karst, think cave. Some of these caves are big. Some of them are small. Karst aquifers are different from sedimentary aquifers where water mostly flows through gravel and sand grains similar to a sponge.

Hydrogeologists use two terms when investigating aquifers, **porosity** and **permeability**. Porosity is call the empty pore space inside a rock given in a percent volume. Porosity represents the volume of the water a rock formation can potentially hold. Permeability is how well a fluid can flow within the pore spaces of the rock within the aquifer. For water, we describe this property as **hydraulic**

conductivity. For example, clay and rocks like **pumice** often have high porosity. But because their pores do not connect well with each other, they are often low in permeability. Low permeability materials such as clay and shale, typically act as barriers to ground water flow and may often function as an aquatard in ground water flow systems.

Aquifers that are bounded and the top and bottom by **aquatards** are called **confined aquifers**. In confined aquifers, the ground water is under **pressure**. If **penetrated** by a well, the water level in a confined aquifer will rise above the top of the aquifer. In some cases, the water will reach the surface resulting in a flowing or artesian well. Confined aquifers function differently than unconfined aquifers which have no overlying aquatard.

Unconfined aquifers occur near the Earth's surface. So, they may interact better to the processes that occur near or above land surface. Because unconfined aquifers are exposed to the atmosphere, they may interact with surface water features such as rivers or lakes. If the water level in the aquifer is higher than in the adjacent rivers or lakes, the rivers or lakes gain water. In other words, water from the aquifer flows into the rivers or lakes. If the water level in the aquifer is lower than in the rivers or lakes, then the rivers or lakes lose water. That's saying that water flows from the rivers or lakes into the aquifer.

Rainwater may infiltrate the **shallow soil** and into the aquifer. Plant roots may extend down into the aquifer and use the water to survive. Ground water close to the Earth's surface may also evaporate. Hydrogeologists use the terms **recharge** and **discharge** to describe how water enters and leaves an aquifer.

One way an aquifer can discharge is through a spring. Springs occur when the water table intersects the land's surface. The Barton Springs pool is fed by this spring here. Notice the large fracture which the water flows out of. Here at upper Barton Spring water is flowing out of the ground from a karst aquifer or small caves. To understand better how aquifers work, many hydrogeologists and scientists develop physical models.

aquifers – водоносний горизонт

to supply – постачати

well – колодязь, свердловина

sandstone - пісковик

conglomerate – конгломерат

unconsolidated sand - неконсолідований пісок

gravel - гравій

fractured rock – тріщинувати скеля

limestone - вапняк
igneous rock – магматична порода
dissolve - розчиняти
cave - печера
porosity - пористість
permeability - проникність
hydraulic conductivity - гідравлічна провідність
pumice - пемза
shale – сланець, пустоти
aquatard - водоупор
bounded - обмежений
confined aquifers - (захищені) артезіанські водоносні горизонти
unconfined aquifers – незахищені ґрунтові води
expose - віддавати
adjacent river – сусідня річка
gain – здобувати, отримувати
shallow soil – пустоти ґрунту
recharge - приплив
discharge - витрата
water table – рівень ґрунтових вод
intersect - перетинати
land surface – поверхня землі
fracture – перелом, злам