29. Groundwater

Water Table

Water that infiltrates into sediment and rocks at the surface becomes groundwater. It is all the water stored below the Earth's surface in spaces within bedrock or regolith.

- e.g. ______________ in sediments
- _______________ in bedrock

Groundwater accounts for ____% of all liquid fresh water and can be found everywhere, even in the driest deserts.

What is the typical depth above which most groundwater occurs? ____________

How deep can water nonetheless be found in the crust? ________________________

At great depths, most water gets taken up in crystal lattices of minerals.

The study of groundwater is called ________________________.

To access groundwater, we must dig deep holes. These fill with water at the bottom to become a ___________. Initially, we dig through dry sediment. The pores in the sediment are filled with air, and maybe a small amount of moisture.

What are the three names used to describe sediment with no water in the pores?

1. ___________________________
2. ___________________________
3. ___________________________

As we dig deeper, we hit sediment that has all the pores filled with water. This zone is called the:

- ________________ or the ________________________

The boundary between air-saturated sediment and water-saturated sediment is called the ________________. Any well that penetrates this boundary will fill up with water to this level.

The water table is not flat but undulates in the same manner as the overlying hills and valleys. So it is ______________ under the hills and ______________ under the valleys.

The natural flow tendency of groundwater is: _______________________________

In such cases, rivers get fed new water ____________________.

During times of drought, the water table drops which is why wells dry up. A river's flow decreases or it dries up because there is no longer a source of water from below when the water table falls to a level just below the bottom of the river valley.
Survivor question (Outwit, Outplay, Outlast!): if you get lost in a desert, where would you dig for water?

Groundwater Transport

Water that infiltrates the ground moves down towards the water table under the influence of gravity. This process is called ________________.

What comes first when rain hits the surface: INFILTRATION or PERCOLATION?

Below the water table, groundwater is constantly on the move, just like channel flow at the surface. What are the water flow rates for:

- groundwater: ______________________
- rivers: ______________________

Groundwater does not flow in open channels but must move through a network of pores and spaces in the rock. The rate that the water moves is dependent on the ________________ and ________________ of the rock.

Porosity and Permeability

Porosity is a measure of the ratio of open space to solid in a sediment or rock. In other words, it is the ______________________.

So porosity measures the amount of water that a rock or sediment is able to hold.

What two factors control the porosity of a sediment?

1) ______________________
2) ______________________

Permeability is a measure of ______________________.

Generally, rocks with high porosities also have high permeabilities, but this is not always the case.

What controls the permeability of sediment? ______________________

What are the narrow pathways between the pores called? ______________________

Recharge and Discharge

Recharge refers to the addition of water to the water table by __________________ that infiltrates at the surface and percolates down through the unsaturated zone.

Discharge is where groundwater leaves the saturated zone and becomes surface water.

Where does groundwater discharge? ______________________
______________________
What is an example of an artificial discharge site? ____________________________

Groundwater moves from points of recharge to points of discharge. This may cause the water to flow upwards, defying gravity. This is because gravity is only one factor that drives flow. The other is pressure. Lithostatic pressure is greater under the hills than under the valleys so the water moves from the high pressure zones to the low pressure zones along a path called the ____________________________.

Analogy: ____________________________ (can squeeze water out the top)

**Rock Dissolution by Groundwater**

Dissolution of limestone by groundwater occurs along fractures and bedding planes in the rock, forming extensive underground openings such as _____________ and ________________ (a system of connected caves).

Underground caves in limestone may result in a sudden collapse of the roof, producing ______________________ at the surface. This may happen numerous times across a region, causing numerous circular, often water-filled basins.

The general appearance of the land containing lots of interconnected sinkholes is called: ____________________________

Often in such regions, surface rivers disappear suddenly into the ground and are called _______________________. They usually reappear somewhere else as springs.

Tall spires of limestone may also occur at the surface in karst topography. These erosional remnants are called ________________________ (e.g. Guilin, China).

**Groundwater Aquifers**

Groundwater is one of our main resources of fresh water to support the consumption needs of society and for agricultural irrigation.

Any type of rock with a high porosity and permeability that is saturated with water below the water table forms a groundwater resource called an ____________________.

What sediment or rocks make good aquifers?

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

What is the largest aquifer in the United States? ____________________________

If an aquifer is in direct contact with the unsaturated zone near the surface, it is called an ______________________________. A well dug into such an aquifer will always fill up to the level of the water table.
In some cases, however, an aquifer may be trapped underground by an overlying impermeable rock layer called an _____________________ (or an aquitard). These types of aquifers are called _____________________.

Any water sitting on top of the aquiclude forms a _____________________________.

The water in a confined aquifer may be under very high pressures because of the weight of the rocks above. If a well is dug into the confined aquifer, the water will rise up inside the well to a level called the _____________________________.

If the Earth’s surface is below the artesian pressure surface of the confined aquifer then the water just rises up and gushes out onto the surface without any pumping necessary.

What do we call this type of well? __________________________

**Overpumping**

If a well is being pumped, the water table drops in a conical shaped region around the well because water is being pumped out faster than groundwater is able to flow to replenish the water table at the well.

What do we call this region of lowered water table around the well? ____________________________

This can be a major problem in agricultural pumping wells, and may cause the entire water table to drop across a wide region. It may take _______________ of years to replenish the groundwater in such cases.

Overpumping can cause the pore spaces in the rock to start to collapse because there is no longer a water pressure inside the pores holding them open.

This effect is called: ____________________________

An aquifer can never recover from compaction. Its porosity and permeability is permanently reduced.

Compaction and overpumping may also cause the land surface to drop down, a process called _______________. This may result in surface flooding and tilting of structures.

Example of where 30 ft of subsidence occurred in 50 yrs: ____________________________

Another problem caused by overpumping in coastal regions is when the groundwater beneath a well taps into saltwater from beneath the ocean floor. This process renders the well useless and is called: ____________________________.

**Groundwater Contamination**

One of the biggest problems facing us today in terms of the management of our aquifers is when the aquifers get contaminated by potentially dangerous toxic chemicals, or contaminants. Potential sources of these contaminants include:

- **untreated sewage** from urban areas and farm animals
• agricultural pesticides and fertilizers
• landfills
• mining and industrial waste
• nuclear waste
• leaking gas storage tanks at gas stations

The study of how contaminants spread through the groundwater system is a major focus of hydrogeologists and environmental scientists. Under a site of contamination, the contaminants spread out along the direction of groundwater flow, forming an ever-growing cloud of contaminants called a ____________________.

Many geologists end up with careers in contaminant remediation, which essentially means trying to clear up the huge mess made by mankind.

**FINAL QUESTION:**

Where is concern over nuclear contaminants a major issue due to the development of a nuclear waste disposal site?

______________________________