# Engineering Geology

Lecture-10

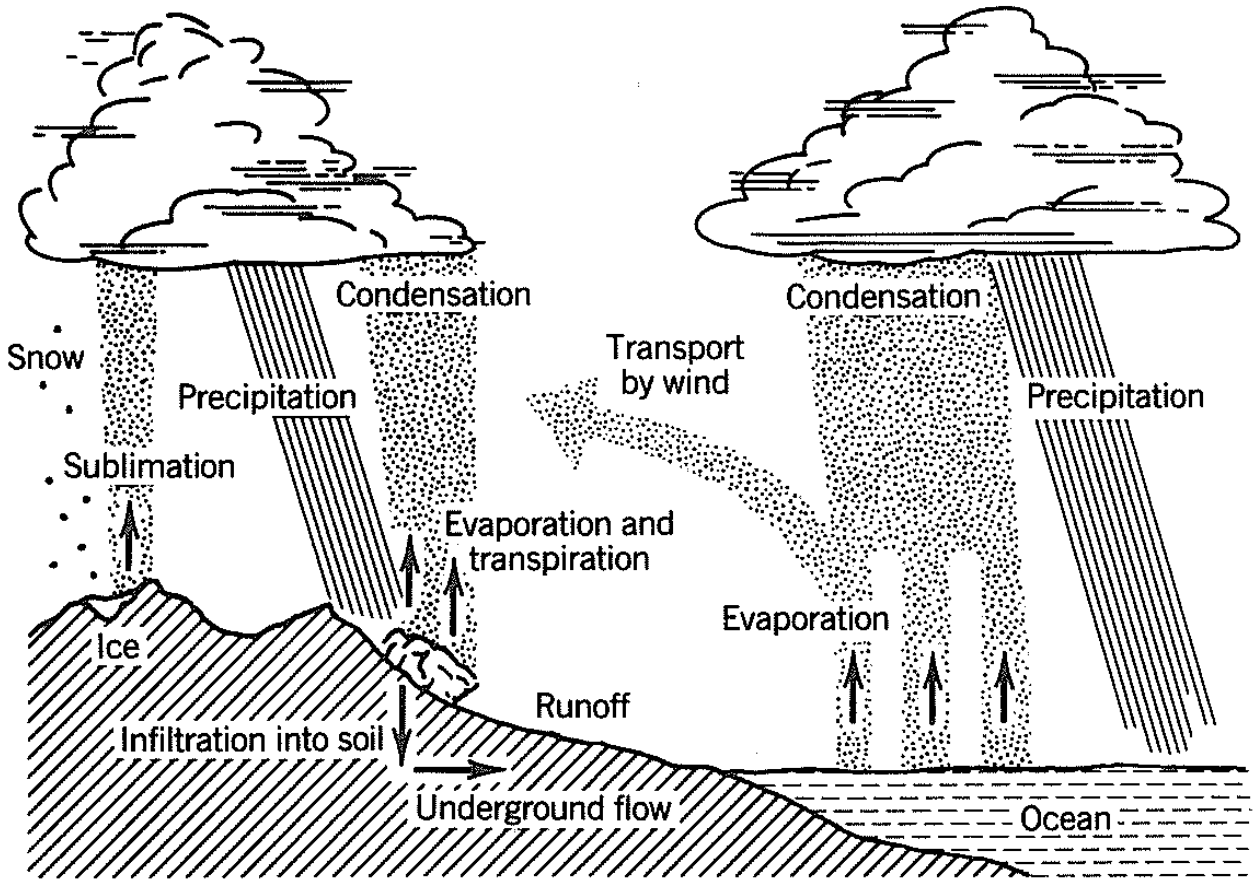
# Hydrogeology

- Hydrogeology examines the relationships of geologic materials and flowing water

# Hydrologic Cycle

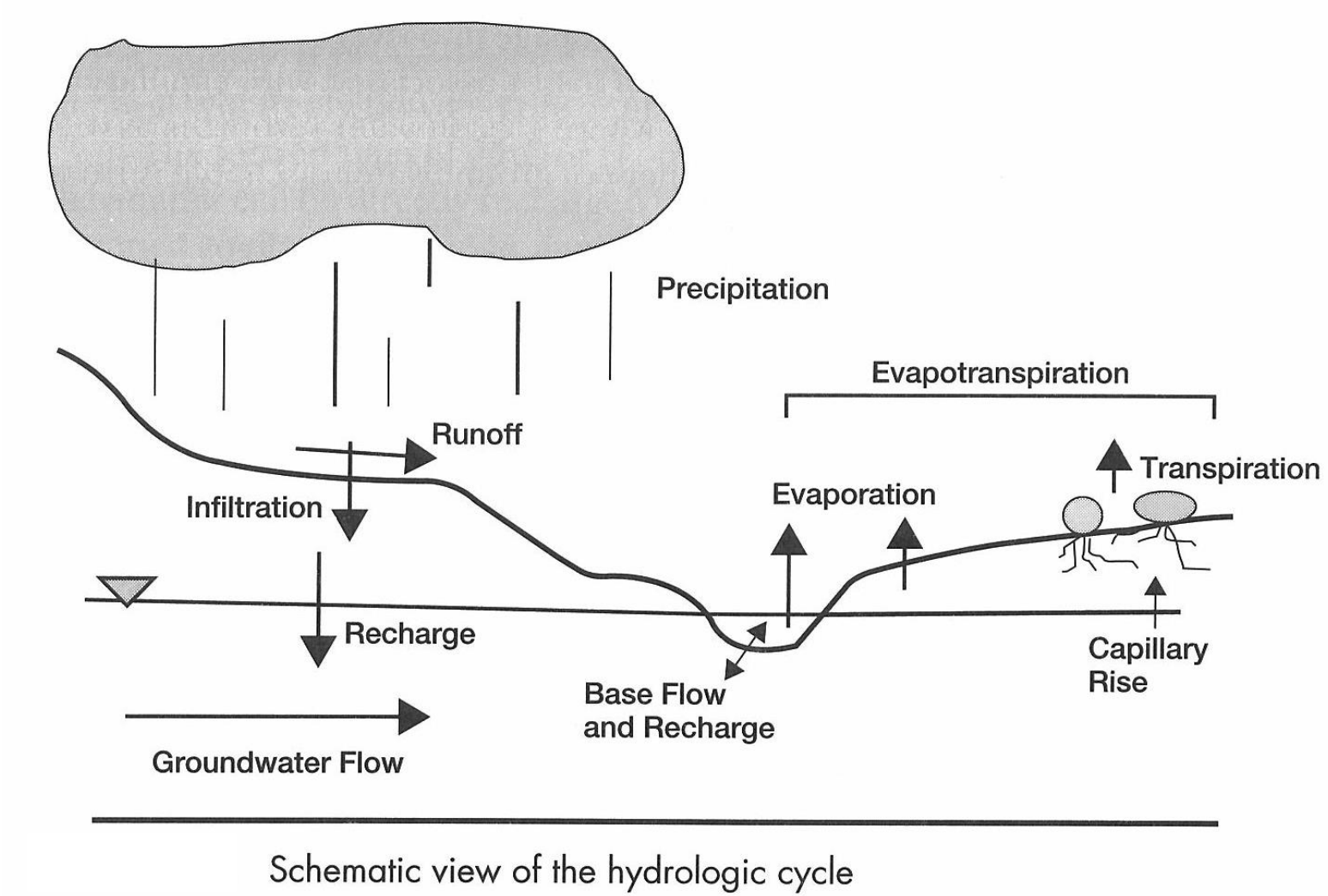
- Hydrologic cycle – circulation of water in the environment
- Surface water evaporates by energy of the sun. The water vapor then forms clouds in the sky. Depending on the temperature and weather conditions, the water vapor condenses and falls to the earth as different types of precipitation (rain, snow, sleet, hail). Some precipitation moves from high areas to low areas on the earth's surface and into surface water bodies. This is known as surface runoff. Other precipitation seeps into the ground and is stored as groundwater.

# Hydrologic Cycle



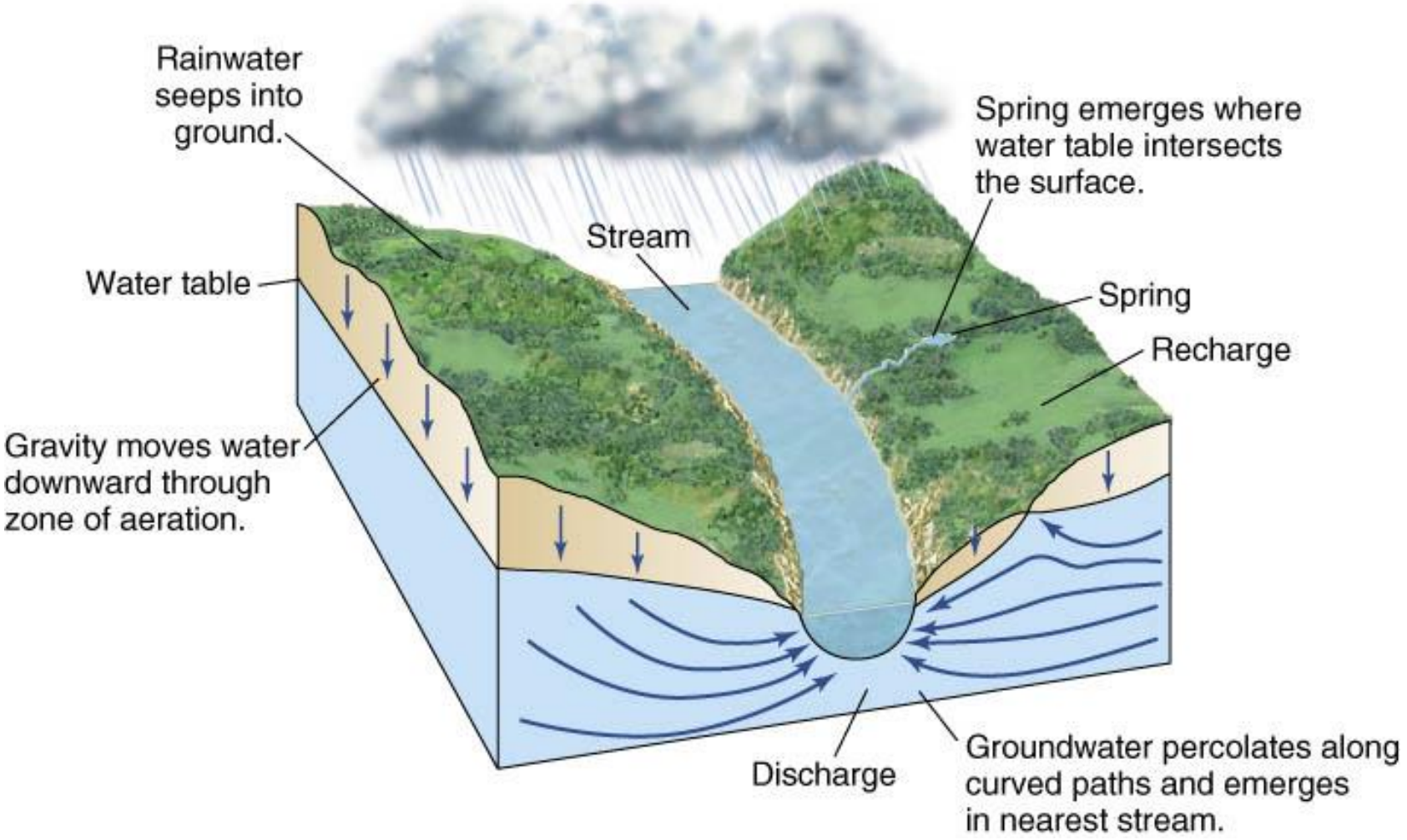

Schematic representation of the hydrologic cycle.

# Hydrologic Cycle

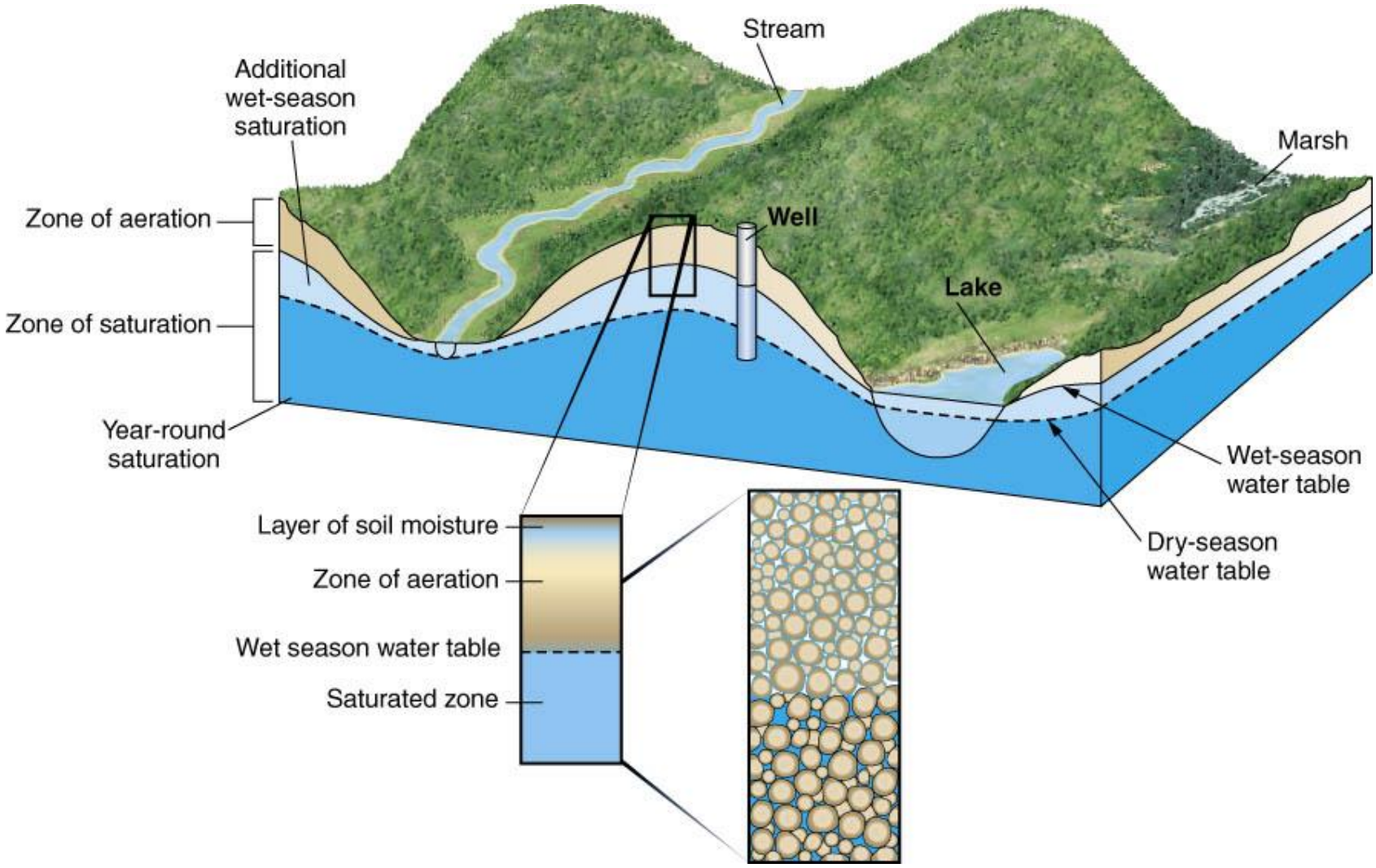



Schematic view of the hydrologic cycle

# Hydrologic Cycle



# Groundwater

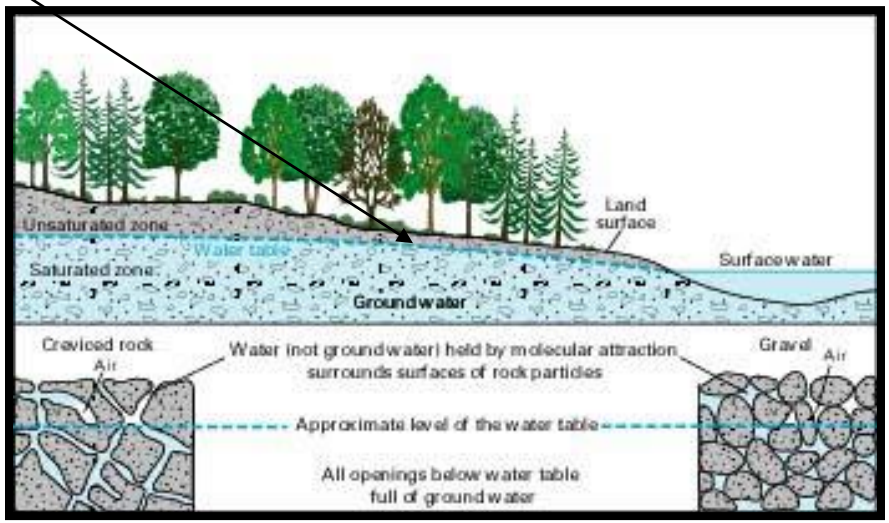


# Groundwater

•**Groundwater** is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers.

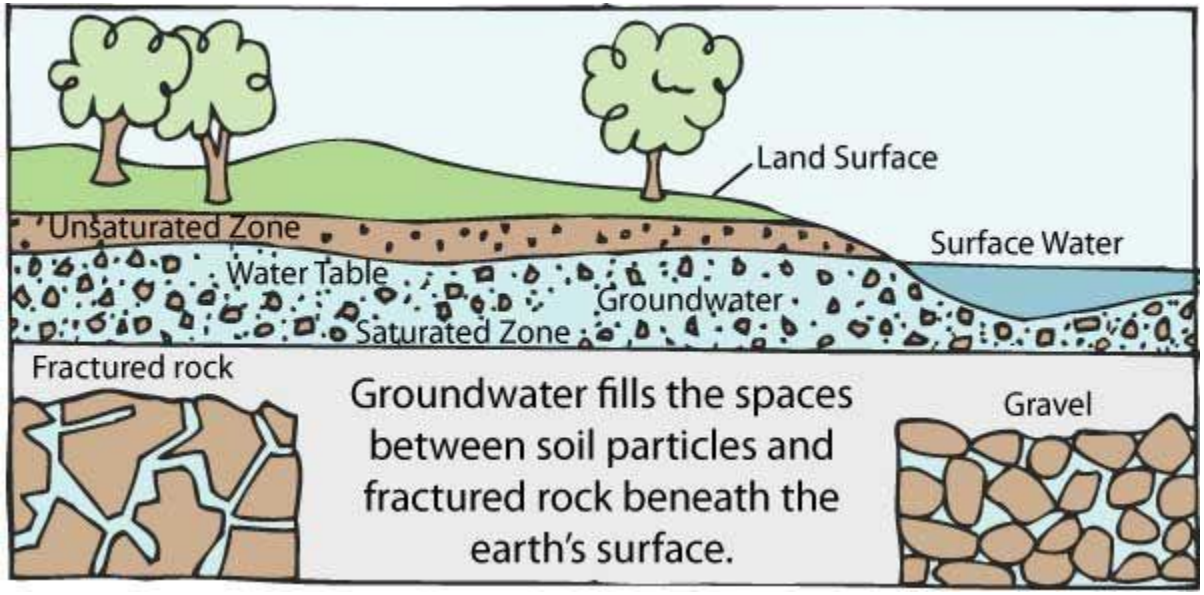
•Ground water occurs when water recharges the subsurface through cracks and pores in soil and rock

- Shallow water level is called the water table



# Groundwater

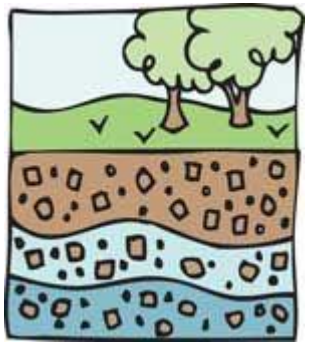
- **Aquifer**: An aquifer is a body of porous rock or sediment saturated with groundwater. Groundwater enters an aquifer as precipitation seeps through the soil. It can move through the aquifer and resurface through springs and wells.
- There are two general types of aquifers: **confined** and **unconfined**. Confined aquifers have a layer of impenetrable rock or clay above them, while unconfined aquifers lie below a permeable layer of soil.
- Many different types of sediments and rocks can form aquifers, including gravel, sandstone, conglomerates, and fractured limestone. Aquifers are sometimes categorized according to the type of rock or sediments of which they are composed.
- The replenishment of aquifers by precipitation is called **recharging**.




*The area where water fills the aquifer is called the saturated zone (or saturation zone). The top of this zone is called the water table. The water table may be located only a foot below the ground's surface or it can sit hundreds of feet down.*

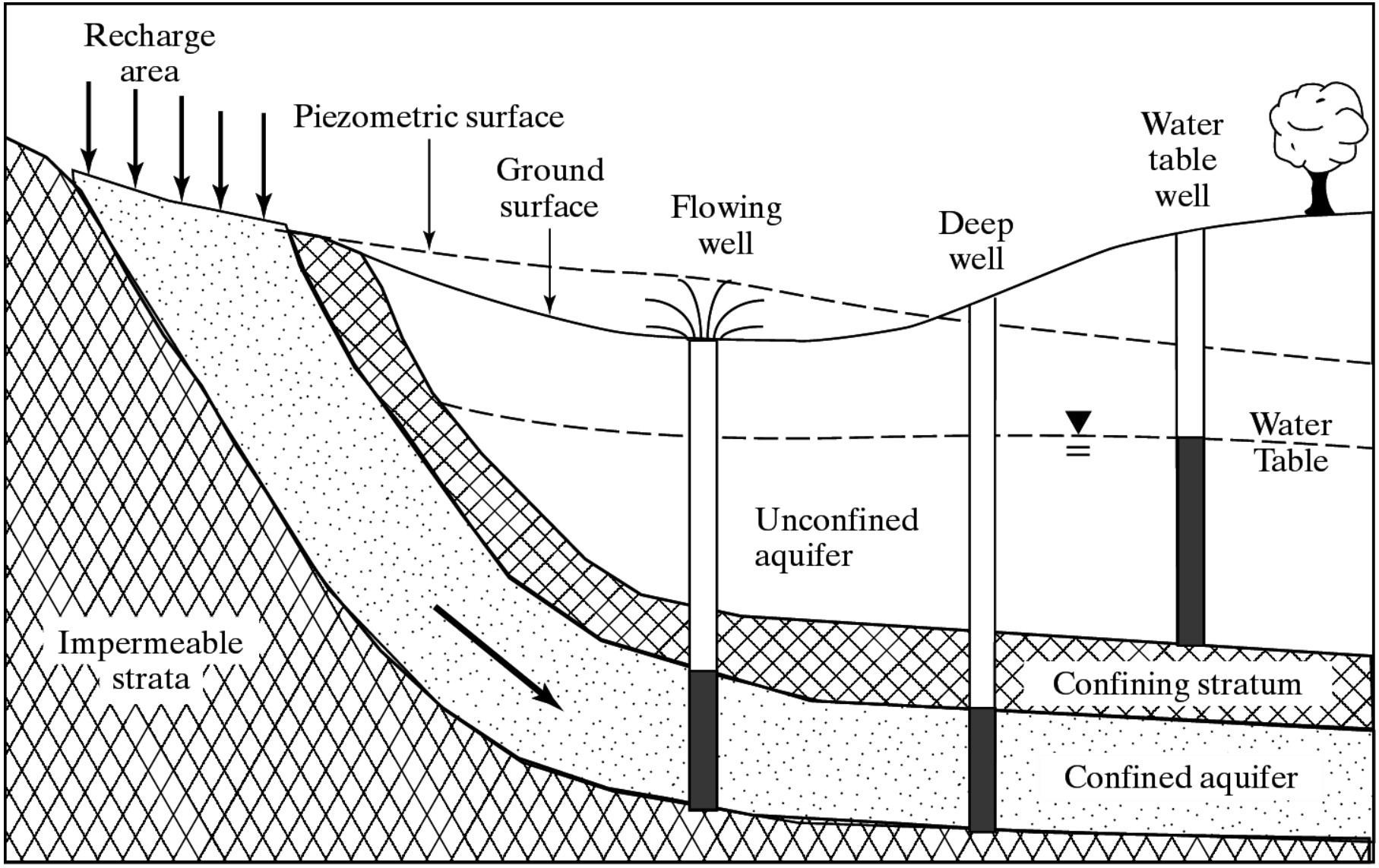
Aquifers are typically made up of gravel, sand, sandstone, or fractured rock, like limestone. Water can move through these materials because they have large connected spaces that make them permeable. The speed at which groundwater flows depends on the size of the spaces in the soil or rock and how well the spaces are connected.

Groundwater can be found almost everywhere. The water table may be deep or shallow; and may rise or fall depending on many factors. Heavy rains or melting snow may cause the water table to rise, or heavy pumping of groundwater supplies may cause the water table to fall.



# Groundwater

- A common misconception about aquifers is that they are underground rivers or lakes. While groundwater can seep into or out of aquifers due to their porous nature, it cannot move fast enough to flow like a river. The rate at which groundwater moves through an aquifer varies depending on the rock's permeability
- Aquifers naturally filter groundwater by forcing it to pass through small pores and between sediments, which helps to remove substances from the water. This natural filtration process, however, may not be enough to remove all of the contaminants
- Much of the water we use for domestic, industrial, or agricultural purposes is **groundwater**. Most groundwater, including a significant amount of our drinking water, comes from aquifers. In order to access this water, a well must be created by drilling a hole that reaches the aquifer. While **wells** are **manmade points of discharge for aquifers**, they also **discharge naturally at springs** and in wetlands.


Recharge area
Piezometric surface
Ground surface
Flowing well
Deep well
Water table well
Water Table
Unconfined aquifer
Impermeable strata
Confining stratum
Confined aquifer

# Wells

Basically, a well is a hole drilled into the ground to access water contained in an aquifer. A pipe and a pump are used to pull water out of the ground, and a screen filters out unwanted particles that could clog the pipe. Wells come in different shapes and sizes, depending on the type of material the well is drilled into and how much water is being pumped out.

# Well Construction

All private well construction is based on establishing the right location for the well, sizing the system correctly and choosing the proper construction techniques. Only professional water well contractors should install wells. They are familiar with the hydrology in an area and all local codes and regulations. Proper well construction is key to operating and maintaining a well.

A well is composed of many components. The most important materials used include:

**Casing** is used to maintain an open access in the earth while not allowing any entrance or leakage into the well from the surrounding formations. The most popular materials used for casing are steel, PVC pipe and concrete pipe.

**Grout** is a sealant that is used to fill in the spaces around the outside of the well. It protects the well against the intrusion of contaminants. A grout mixture can be made of cement, bentonite, or concrete (each used separately).

**Screen** keeps sand and gravel out of the well while allowing groundwater and water from formations to enter into the well. Screen is available in many materials, the most popular being stainless steel and slotted PVC pipe. Screen is used when wells are drilled into unconsolidated materials.

**Gravel pack** is placed around the outside of the screen to prevent sand from entering the well or clogging the screen and to stabilize the well assembly.

# Well Construction

- For understanding of well drilling process using rotary drilling:
- https://www.youtube.com/watch?v=0-KLWEnwiaY

# Types of Wells

Three basic types of wells

**Bored or shallow wells** are usually bored into an unconfined water source, generally found at depths of 100 feet or less.

**Consolidated or rock wells** are drilled into a formation consisting entirely of a natural rock formation that contains no soil and does not collapse. Their average depth is about 250 feet.

**Unconsolidated or sand wells** are drilled into a formation consisting of soil, sand, gravel or clay material that collapses upon itself.

# Springs

A spring is a place where water moving underground finds an opening to the land surface and emerges, sometimes as just a trickle, maybe only after a rain, and sometimes in a continuous flow. Spring water can also emerge from heated rock underground, giving rise to hot springs.

A spring is a water resource formed when the side of a hill, a valley bottom or other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water. A spring is the result of an aquifer being filled to the point that the water overflows onto the land surface. They range in size from intermittent seeps, which flow only after much rain, to huge pools flowing hundreds of millions of gallons daily.

Springs are not limited to the Earth's surface, though. Recently, scientists have discovered hot springs at depths of up to 2.5 kilometers in the oceans, generally along mid-ocean rifts (spreading ridges). The hot water (over 300 degrees Celsius) coming from these springs is also rich in minerals and sulfur, which results in a unique ecosystem where unusual and exotic sea life seems to thrive.

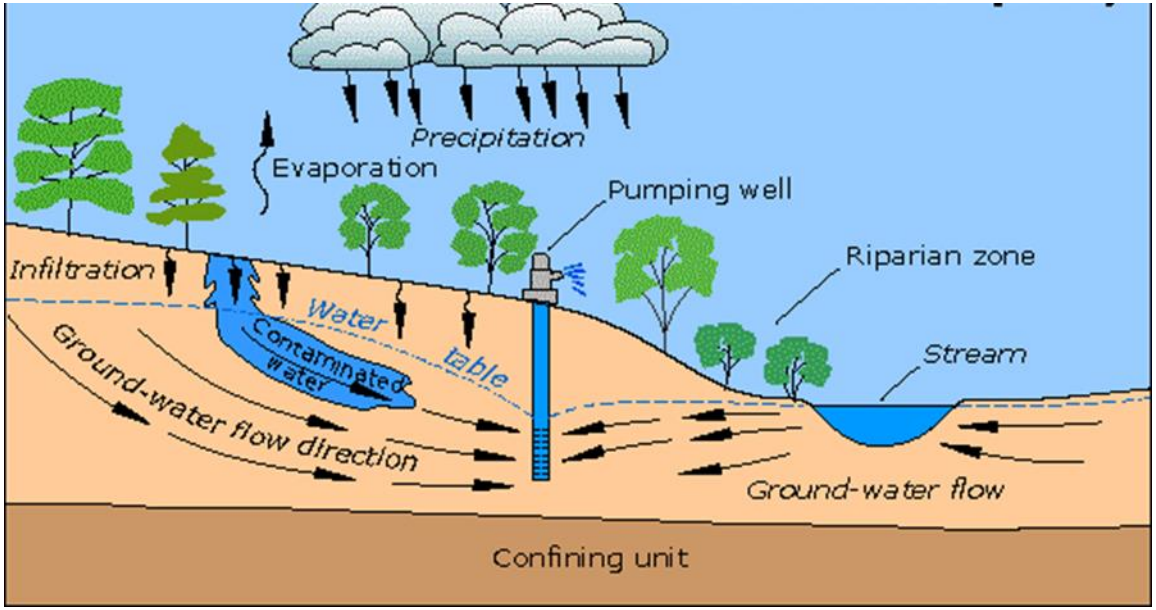
# Streams

A stream is a body of water with surface water flowing within the bed and banks of a channel. The flow of a stream is controlled by three inputs – surface water, subsurface water and groundwater. The surface and subsurface water are highly variable between periods of rainfall. Groundwater, on the other hand, has a relatively constant input and is controlled more by long-term patterns of precipitation.

Depending on its location or certain characteristics, a stream may be referred to by a variety of local or regional names. Long large streams are usually called **rivers**.
Streams are important as conduits in the water cycle, instruments in groundwater recharge, and corridors for fish and wildlife migration. The biological habitat in the immediate vicinity of a stream is called a riparian zone. The study of streams and waterways in general is known as surface hydrology and is a core element of environmental geography.

# Streams

Streams, including those that don't flow all of the time, could be a drizzle of snowmelt that runs down a mountainside crease, a small spring-fed pond, or a depression in the ground that fills with water after every rain and overflows into the creek below. These water sources, which scientists refer to as headwater streams, are often unnamed and rarely appear on maps. Yet the health of small streams is critical to the health of the entire river network and downstream communities. These small streams often appear insignificant, but in fact are very important, as they feed into and create our big rivers.



# Ground Water Conditions