

WATER RESOURCES

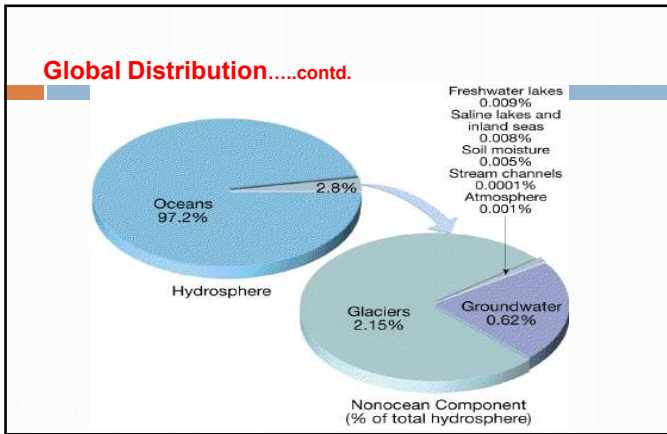
Global Distribution

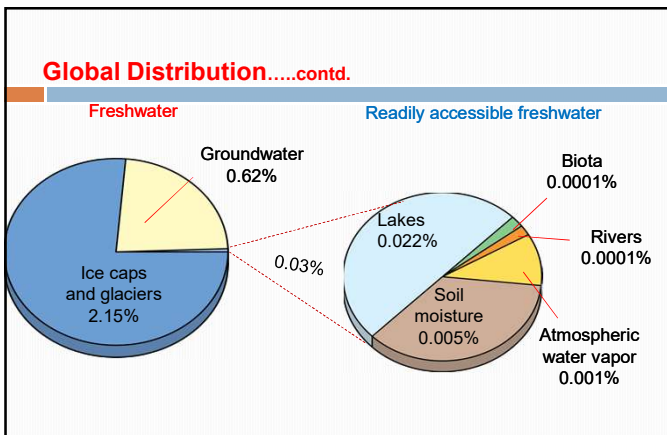
- Over two thirds of the earth's surface is covered with water, 97.2% of which are contained in the five oceans.
- Thus, only 2.8% of global water constitute freshwater.
- Of this freshwater, 2.15% are locked-up in ice caps and glaciers.
- As such, less than 0.7% are available for human use

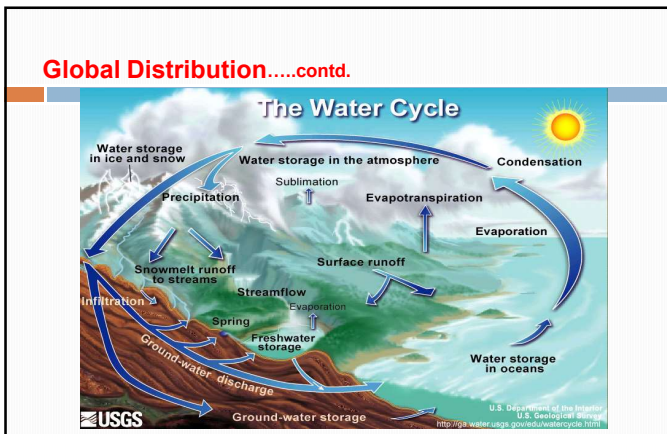
Global Distribution.....contd.

67% of Earth's surface covered by water.









Surface Water

Forms from

- 1. **Runoff** – that part of the precipitated moisture that moves across the land surface.



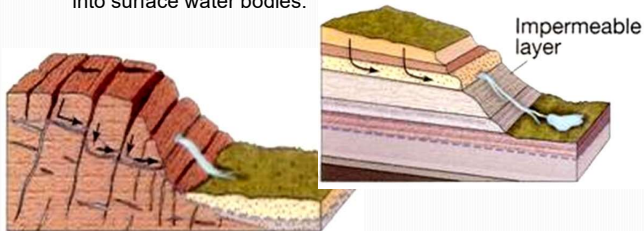
Surface Water.....contd.

- 1. **Runoff.....(contd.)**



Surface Water.....contd.

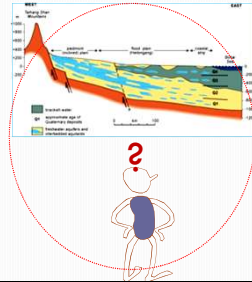
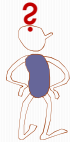
- 2. **Interflow** – water that infiltrates the ground, moves through the ground, and flows out of the ground again into surface water bodies.



Groundwater

What is it? Different Perspectives of what groundwater is.....

Water on the ground?



Modified from Turnhoff, 2009

Groundwater.....contd.

Groundwater:

- Is a *mineral* that occurs in the subsurface within sediments, rocks, desert sands, etc.
- Gets replenished from precipitation.
- Is most widely distributed precious resource of the Earth.
- forms an **invisible** component of the water system.

Groundwater.....contd.

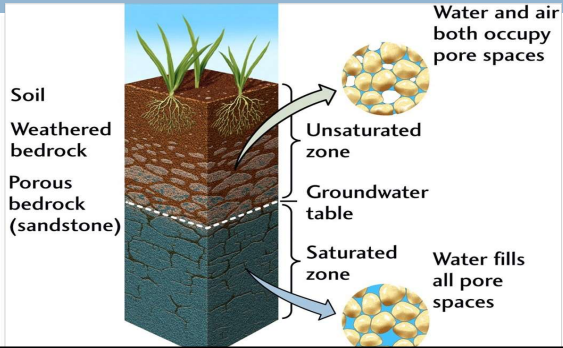
- Accumulation of water from infiltrating precipitation in the subsurface.
- Occurs below surface in *voids, spaces and cracks between particles of soil and rock.*
- Forms from ppt. that percolates downwards to the **water table.**

Groundwater.....contd.

Composed of:

- **Vadose (unsaturated) Zone** – where not all pore-spaces are filled with water.
- **Water Table:**
 - top of **saturated zone**
 - Level @ which pore water is @ atmospheric pressure.

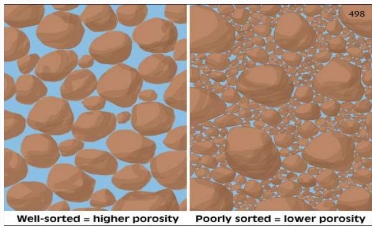
Groundwater.....contd.



How water flows through the ground

Porosity and Permeability

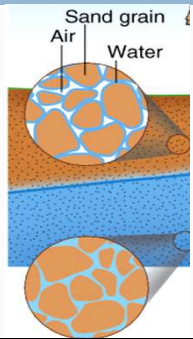
- **Porosity** – percent of total volume of rock/ sediment consisting of open spaces (pores).



Pores are not empty though, but contain gases or fluids.

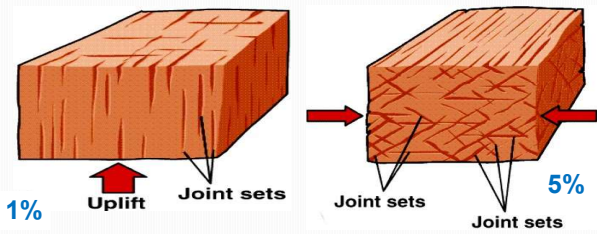
How water flows through the ground.....contd.

> **Sediment:** Determined by how tightly packed and how clean (silt and clay), (usually between 20 & 40%)



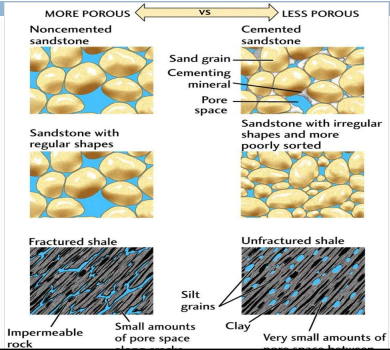
How water flows through the ground.....contd.

> **Rock:** Determined by size and number of fractures (most often very low, <5%).



How water flows through the ground.....contd.

Porosity determines quantity of groundwater that can be stored in geologic material.

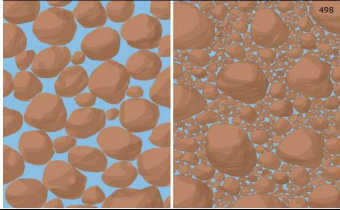


How water flows through the ground.....contd.

2. **Permeability:** Ease with which water flows through a porous material / medium.

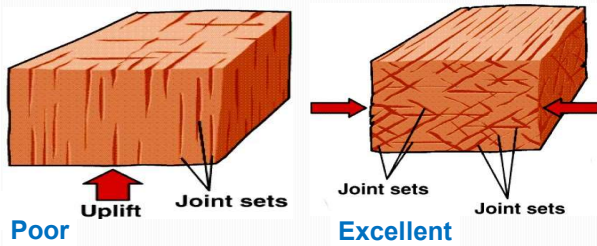
> **Sediment:** Proportional to sediment size

- > Gravel → Excellent
- > Sand → Good
- > Silt → Moderate
- > Clay → Poor



How water flows through the ground.....contd.

> **Rock:** Proportional to fracture size and number. Can be good to excellent.



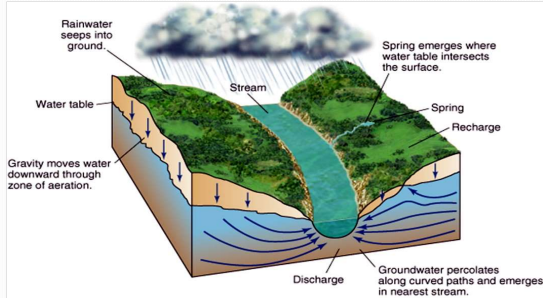
How water flows through the ground.....contd.

Permeability is **not proportional** to porosity:

SEDIMENT	POROSITY (%)	PERMEABILITY
Gravel	25 – 40	Excellent
Sand (clean)	30 – 50	Good to excellent
Silt	35 – 50	Moderate
Clay	35 – 80	Poor
Glacial till	10 – 20	Poor to moderate

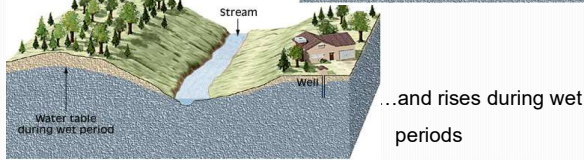
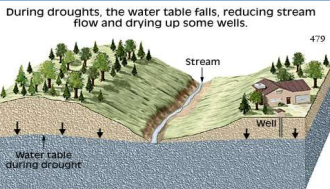
Groundwater Flow

Groundwater percolates down gradient to surface water bodies



Groundwater Flow.....contd.

The height of the water table fluctuates. During droughts, it drops....



Groundwater Flow.....contd.

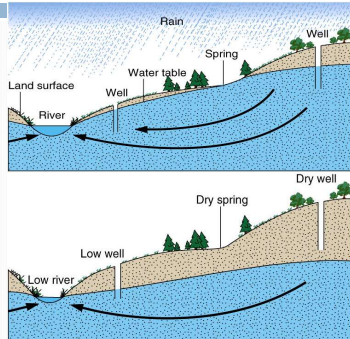
Groundwater Flow velocity

is directly proportional to:

- Permeability
- Slope of water table

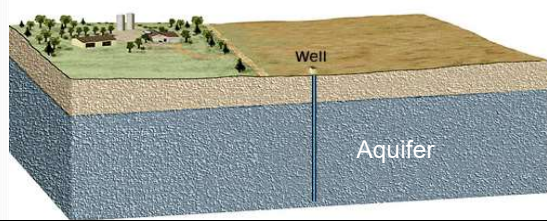
.....and it is Inversely

Proportional to Porosity



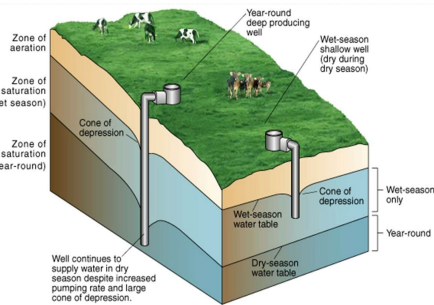
Groundwater Flow.....contd.

Permeable rocks & sediments that have large enough & *interconnected pore spaces* to transmit groundwater freely are called **AQUIFERS**.



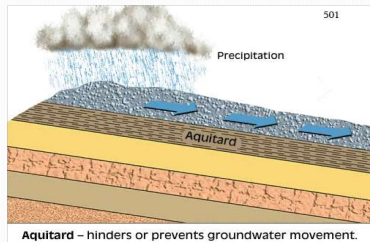
Types of Groundwater Stores – Aquifers

- **Unconfined Aquifer** – an aquifer that is not overlain by any confining layer or **AQUICLUDE / AQUITARD**
- also called **Water Table Aquifer**.



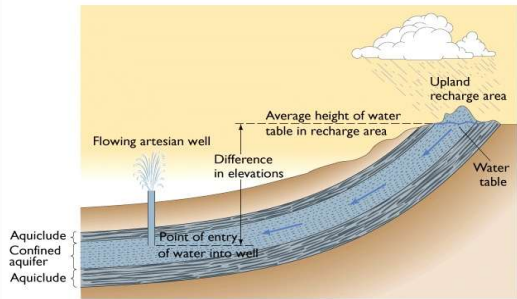
Types of Groundwater Stores – Aquifers.....contd.

- **Aquiclude / Aquitard** – Rock or sediment, e.g. shale & clay, that have so tiny pore spaces that they're nearly impermeable.
- they hinder/prevent groundwater movement.



Types of Groundwater Stores – Aquifers.....contd.

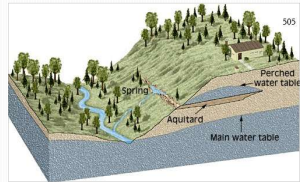
□ **Confined aquifer** is bounded by aquicludes.



Springs



Springs occur when the water table intersects Earth's surface and a natural flow of water occurs.

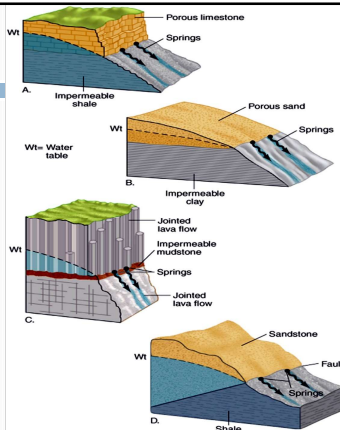


Sometimes springs form when an **Aquitard** is situated above main water table - producing a **perched water table**.

Springs.....contd.

At springs, water table:

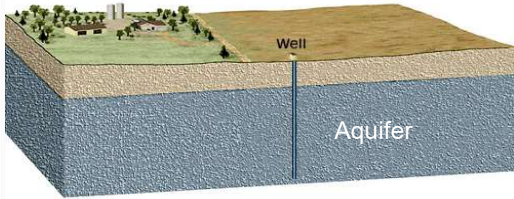
- intersects ground surface.
- gradient slopes toward spring
- is found above an impermeable (or low permeability) zone called **aquiclude**.



Wells

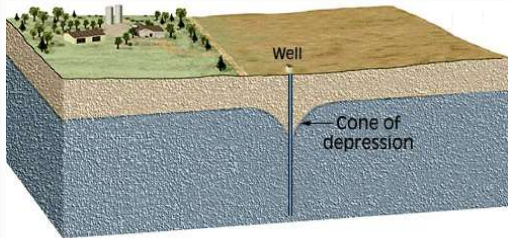
Are:

- holes that penetrate below the water table into the zone of saturation.
- the most common method of obtaining groundwater



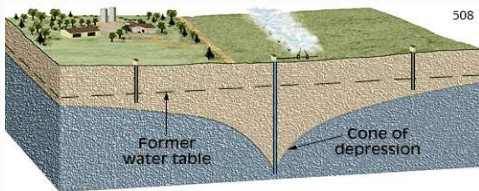
Wells.....contd.

When water is withdrawn from a well, a depression in the water table may develop called a *cone of depression*.



Wells.....contd.

When pumping from a large well is great, cone of depression can be large enough to influence neighbouring wells.



If heavy pumping lowers the water table, the shallow wells may be left dry

Wells.....contd.

Whether a well can produce a useful amount of water depends on the hydrogeology and knowledge of the well installer.

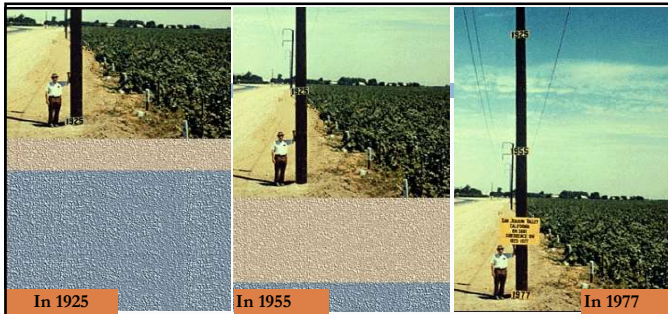
Wells.....contd.

Concentration of boreholes may affect the groundwater table...

Groundwater table behaviour in response to pumpage and drought episodes in two Lusaka boreholes

Wells.....contd.

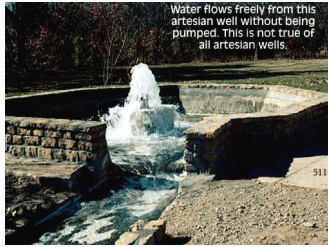
Thus, some places experience *groundwater mining*, i.e. groundwater is being withdrawn far more rapidly than it can be recharged.



When water table is lowered in areas underlain by unconsolidated sediments, **significant ground subsidence may occur**. In this picture, ground subsided almost 9 m between 1925 and 1977 in an area of California, USA.

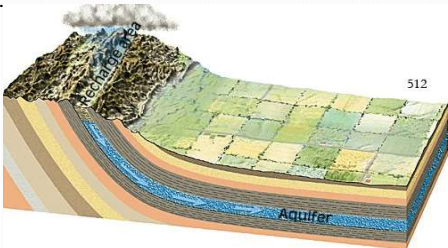
Artesian Wells

Some places have *artesian wells*. Artesian applies to any situation in which groundwater under pressure rises on its own above the level of the aquifer.



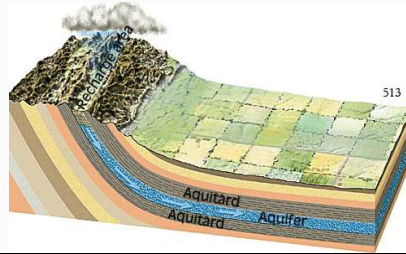
Artesian Wells.....contd.

For an artesian system to exist, water must be confined to an aquifer that is inclined so that one end can receive water...



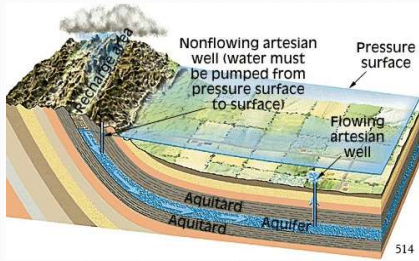
Artesian Wells.....contd.

...and Aquitards must be present above and below the aquifer –
confined aquifer



Artesian Wells.....contd.

When an artesian aquifer is tapped, the pressure created by the weight of water above will cause it to rise.



Summary

- Surface water occurs in surface water bodies – rivers, lakes, oceans, seas, etc.
- Groundwater occurs beneath the ground surface, filling pore space between grains in bodies of sediment and clastic sedimentary rock, and filling cracks and crevices in all types of rock
- source of ground water is mainly rain that falls to the ground, a portion of which percolates down into the ground to become ground water
- groundwater is abstracted through wells & boreholes.

End of Lecture
