GROUND WATER AND HYDROGEOLOGY- AN INTRODUCTION.

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PREFACE.

- Water preceded all forms of life on Earth & is believed to be the very origin of all organic like forms.
- Water is a natural resource, very much essential for the human & organisms.
- Agriculture is the greatest user of water accounting for 80% of all consumptions.
- An adequate supply of water is one of the pre-requisites for development and industrial growth.

FACTS ABOUT WATER

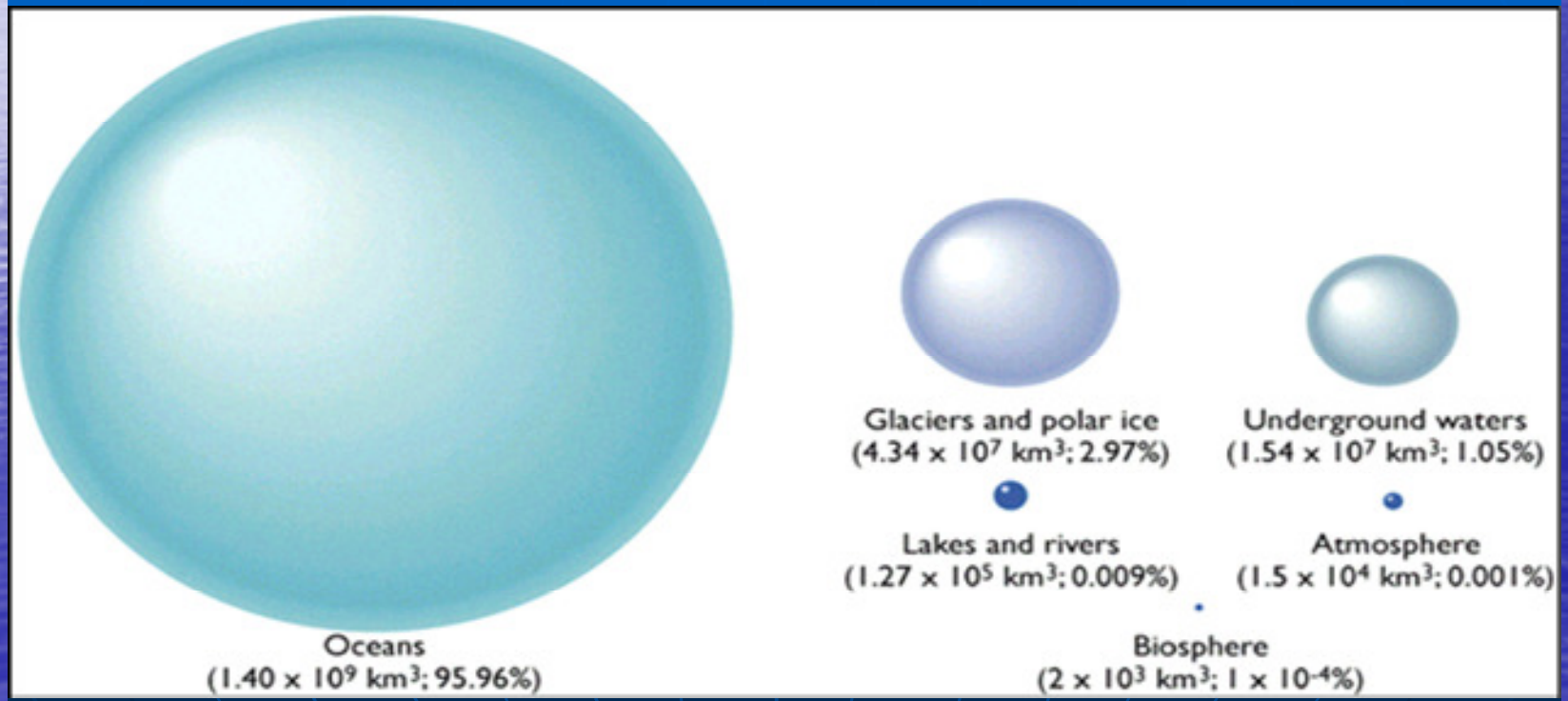
- Water (H2O) is the only visible substance to occur naturally in solid, liquid and gas states.
- Pure water is pH neutral (7.0).
- Water is a universal solvent, dissolving more substances (including contaminants!) than any other liquid.
- A gallon of water weighs 8.34 lbs @ 40 C Ice weighs about 91.7% of water.

FRESH WATER IS RARE!

- Only 3% of water is fresh (< 500 ppm TDS)
- 25% is ground water, 75% is in ice!
- Less than 1% is in streams and lakes.
- Water is water. It's the stuff in the water that makes a difference to quality.
- Almost any water can be made drinkable.
- Desalination is increasing in use.

GLOBAL WATER RESOURCES.

Distribution of Water



Freshwater Year 2003
Ministry of Water Resources
Government of India

Freshwater resources

Ice and permanent snow cover

Useable freshwater

Underground resources, soil moisture

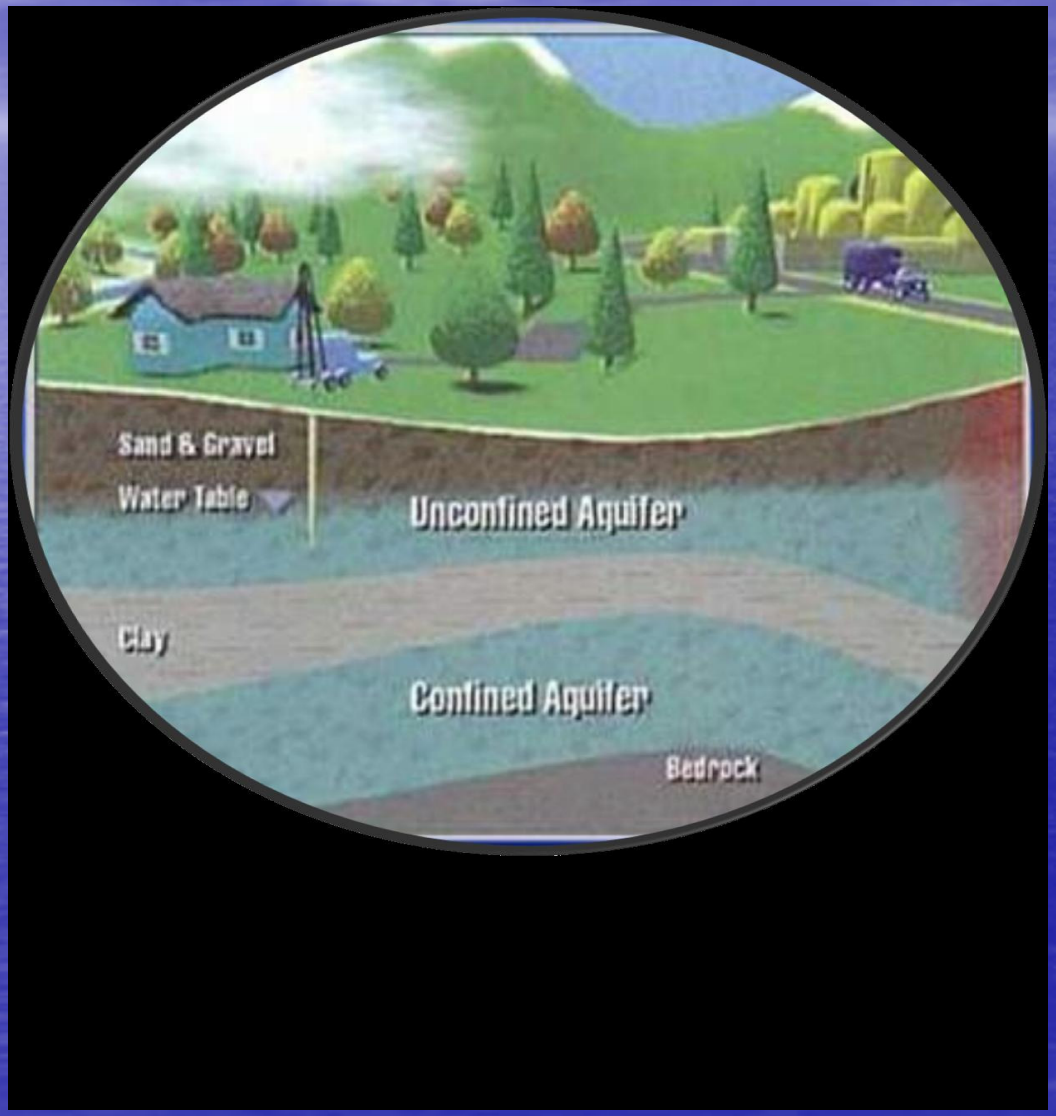
69%

1%

30%

Graphics/N.V. JOSE

BASICS OF HYDROGEOLOGY.

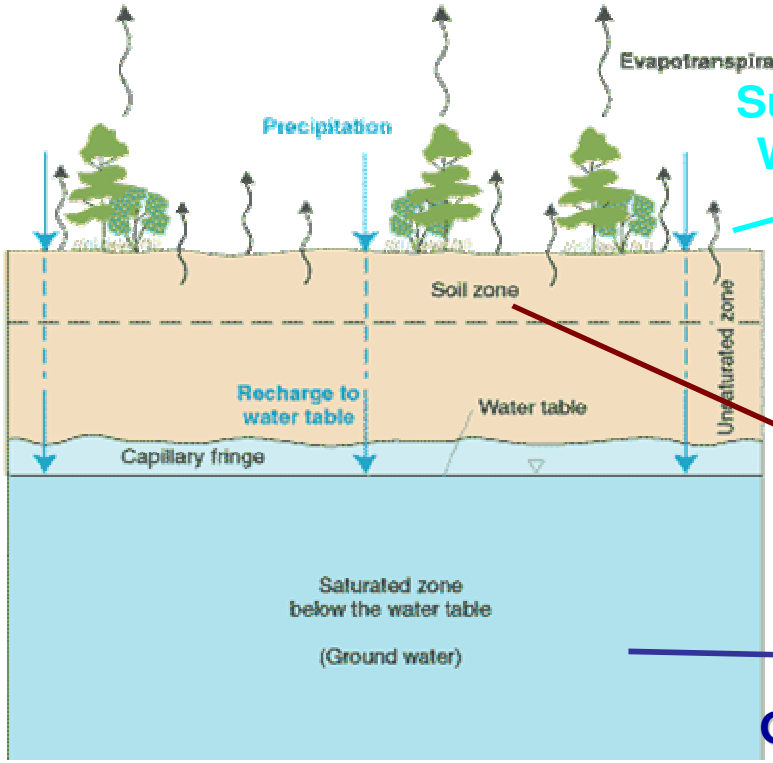


HYDROGEOLOGY.

- The branch of Geology dealing with surface & subsurface water [ground water].
- The science of hydrogeology is defined as hydrology with emphasis on geology.

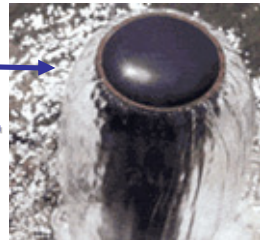
TYPES OF TERRESTIAL WATER.

Types of Terrestrial Water



Surface Water

Soil Moisture



Ground water

WATER SOURCES.

Water Sources

- Surface Water
  - Streams
  - Lakes
  - Runoff
- Ground Water
  - Wells
  - Springs
  - Ganats
- Rain Harvesting

GROUND WATER.

- **Ground water :** All the water contained in the void spaces within rocks.
- Merriam-Webster dictionary: Water within the earth, especially water that supplies wells and springs.
- EPA's drinking water glossary: The water that systems pump and treat from aquifers (natural reservoirs below the earth's surface).
- More inclusively, it includes soil moisture, permafrost, water in tight formations, saline waters, etc..

ORGIN OF GROUND WATER.

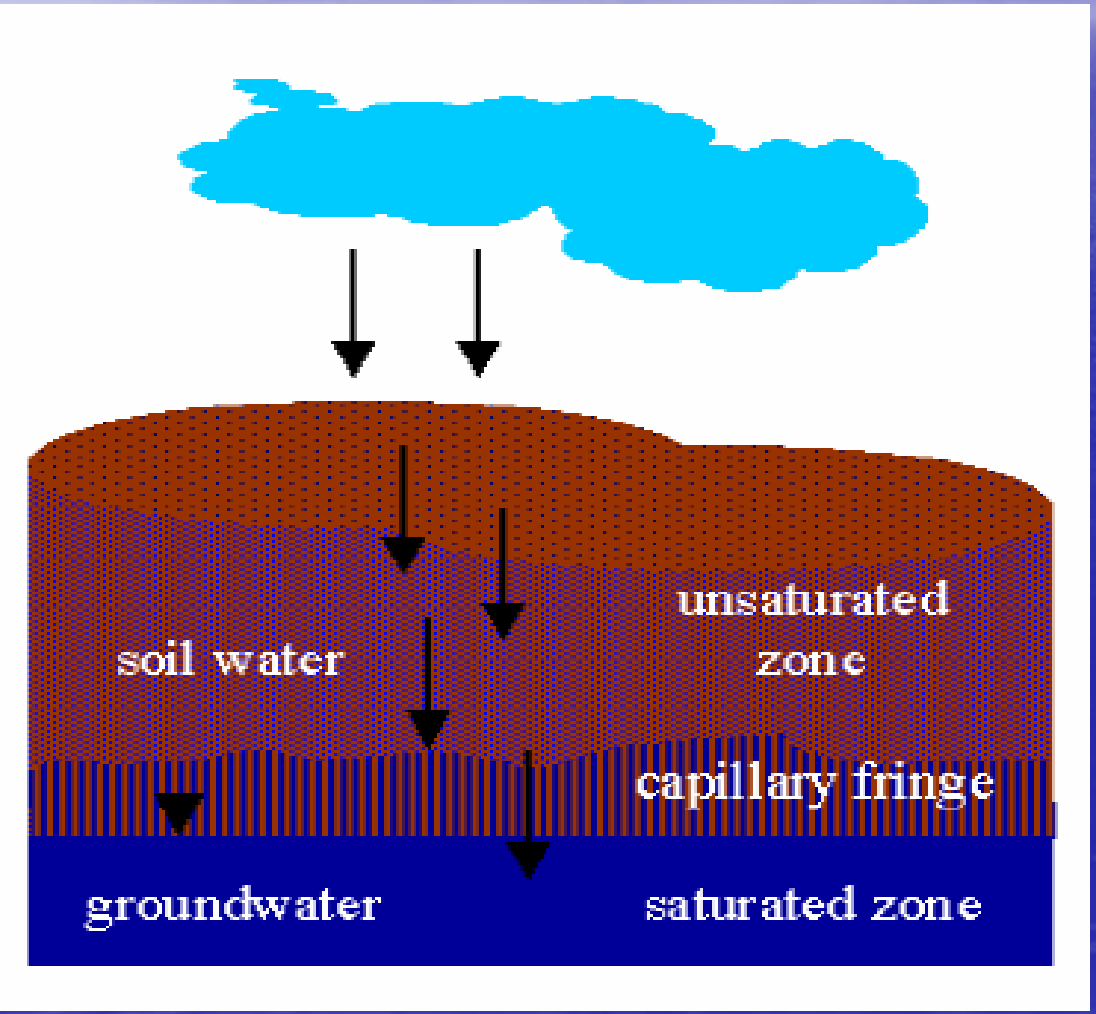
Origin of Ground Water

- When precipitation falls on the land surface, what happens to it?
  - Evaporates and/or is transpired back to atmosphere
  - runs over land surface
  - infiltrates the land surface
    and
  - percolates downward
    and
  - becomes ground water

ORGIN OF GROUND WATER.

- Some of precipitation ie, rain water soaks into the land surface by the process of infiltration and percolates down to the water table to become ground water.
- Water becomes ground water- by infiltrating through soil
- Infiltrating through faults or fractures flowing directly into karst sinkholes or caverns

ORGIN OF GROUND WATER.



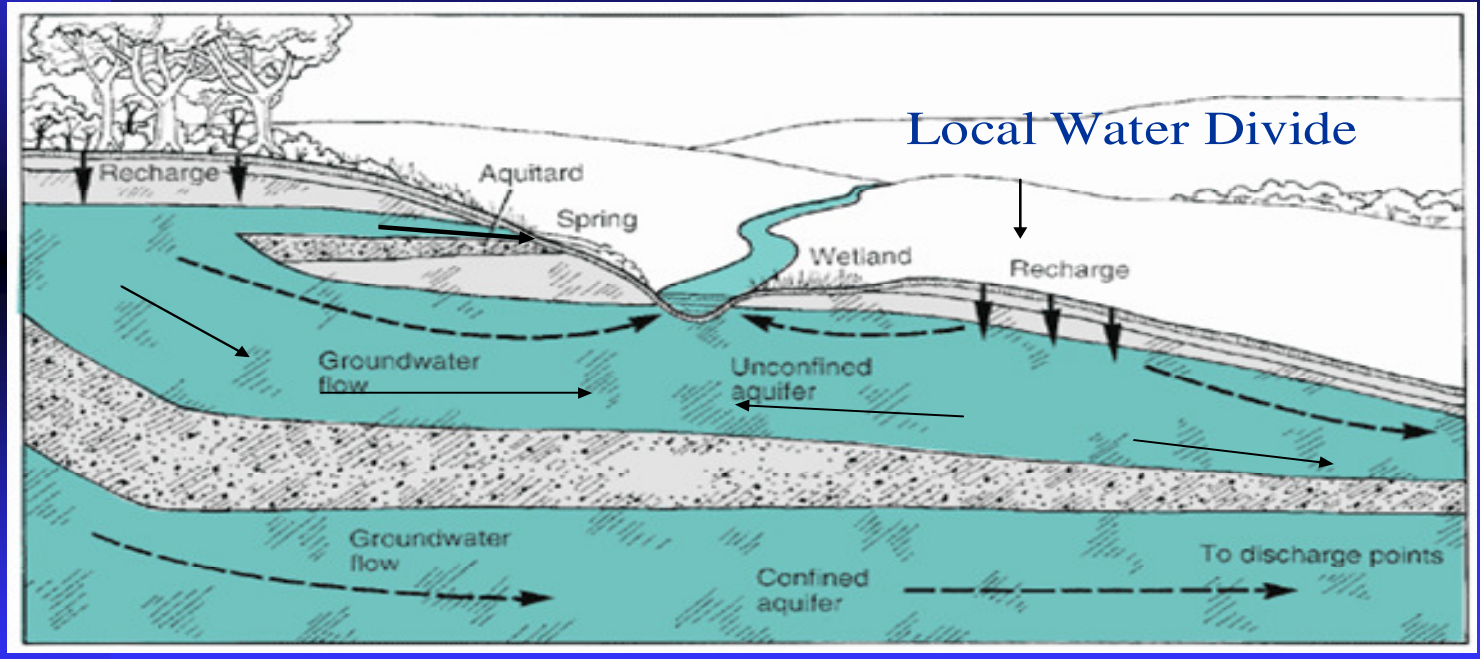
PRECIPITATION.

INFILTRATION

SURFACE WATER & GROUND WATER INTER RELATED.

Surfacewater & Groundwater

They Are Related and Connected !



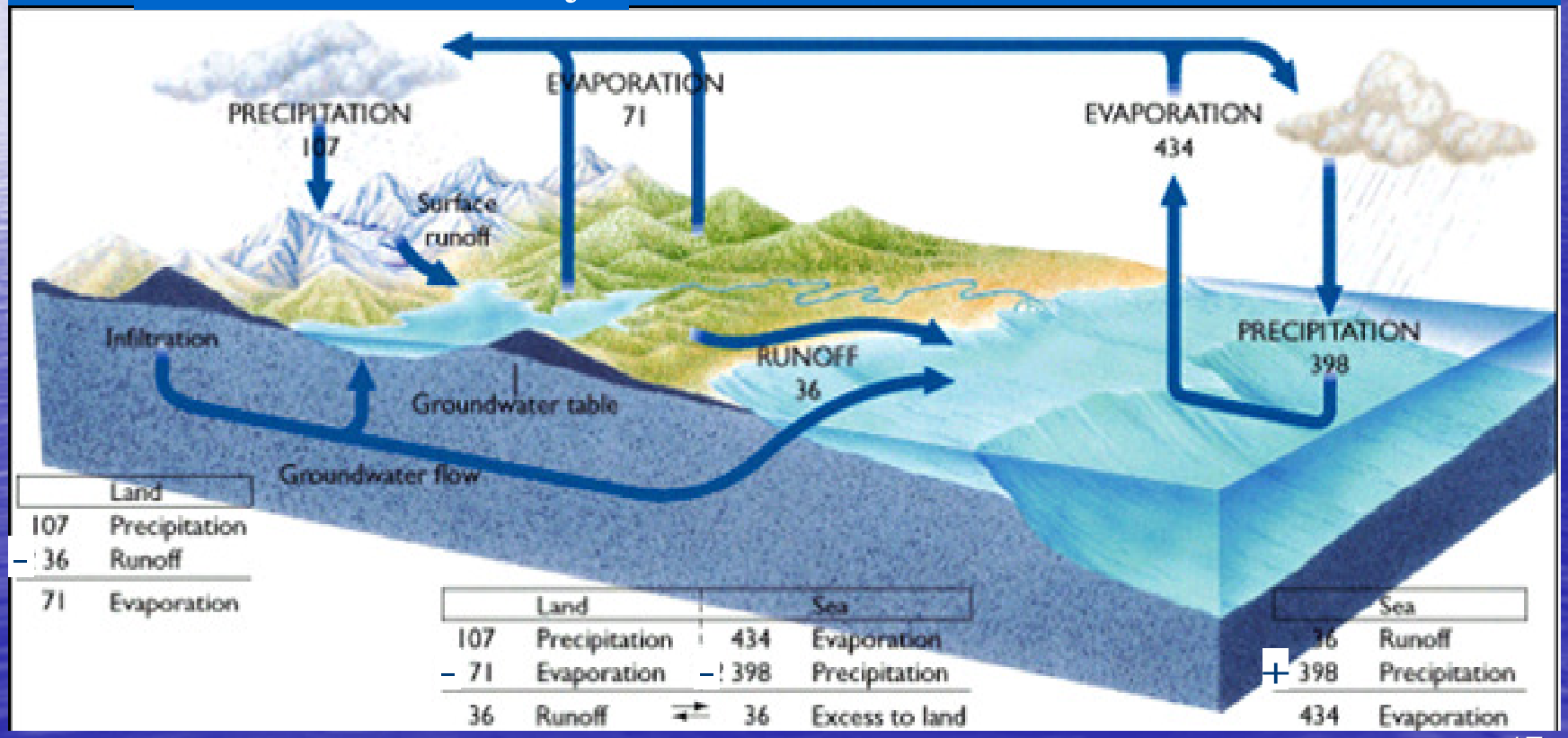
GROUND WATER IN HYDROLOGIC CYCLE.

Groundwater in Hydrologic Cycle

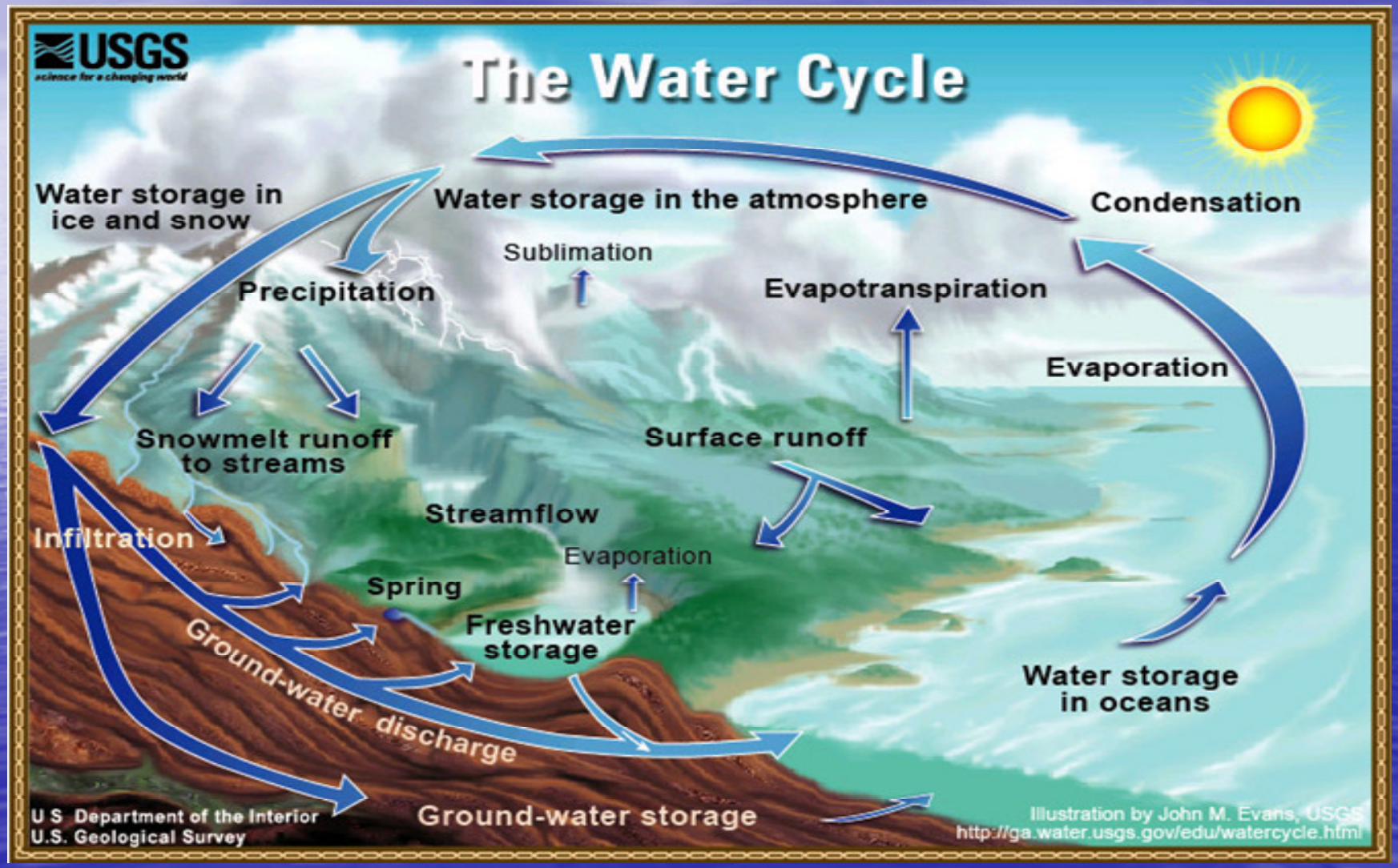
HYDROLOGIC CYCLE.

Hydrologic Cycle

Thousands of km³/yr



THE WATER CYCLE.



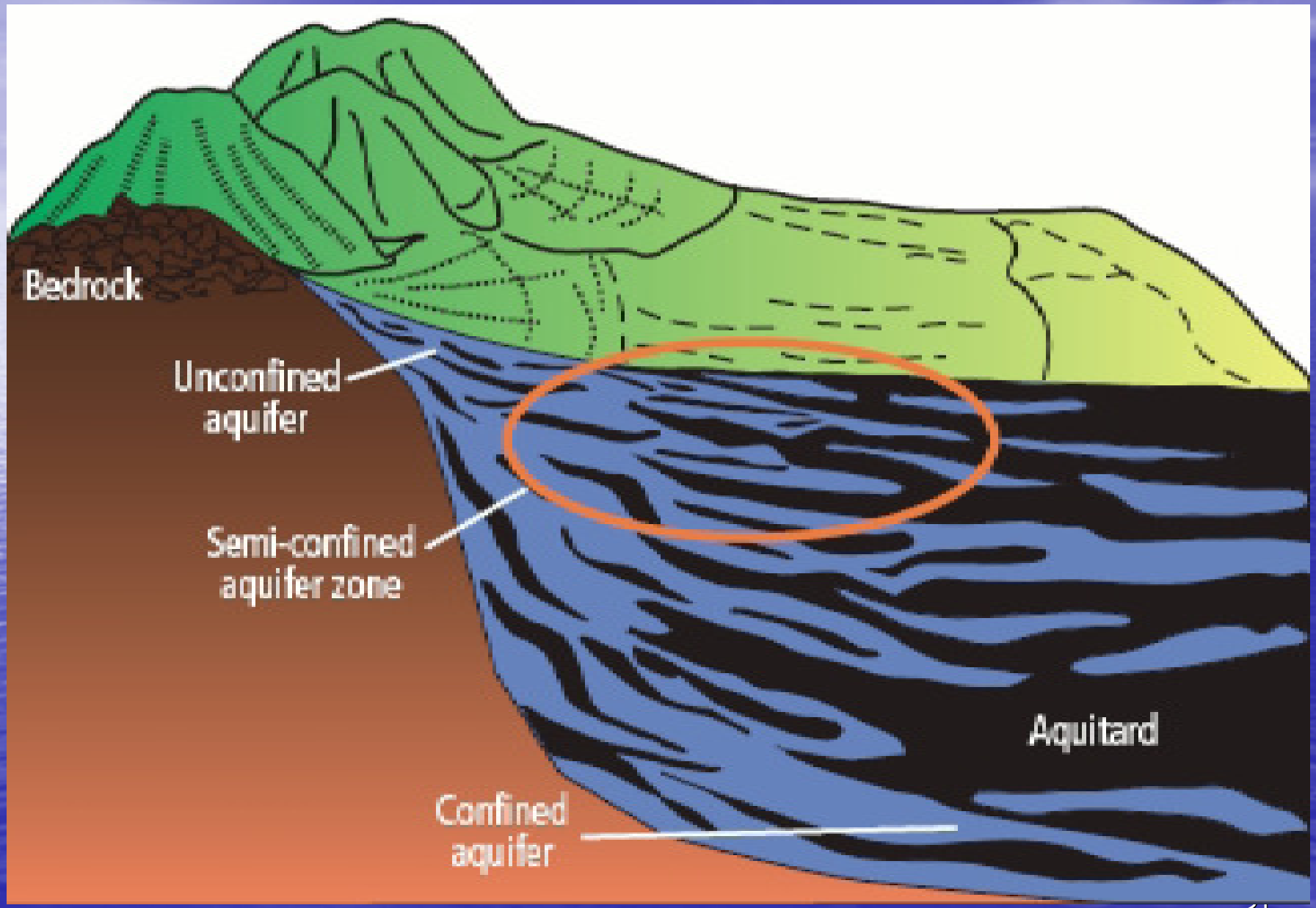
OCCURRENCE OF GROUND WATER.

- Nature does not provide ground water at the place of our choice. It occurs in the subsurface in certain favorable geological formations & structures.
- **Aquifer :** aqui means water; fer means to bear- thus an aquifer bears water from voids- a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradient- eg- sand stone, sand & gravel.

OCCURRENCE OF GROUND WATER.

- **Aquiclude :** a saturated geologic unit that is incapable of transmitting significant quantities of water under ordinary hydraulic gradient- eg- clay lenses & shale.
- **Aquitard :** less permeable beds in a stratigraphic sequence- eg – clay lenses interbedded with sand.
- **Aquifuge :** has too low porosity and neither absorbs nor transmits water- eg- dense basalt, granite.

AQUIFERS


Bedrock
Unconfined aquifer
Semi-confined aquifer zone
Aquitard
Confined aquifer

AQUIFER TYPES.

AQUIFER

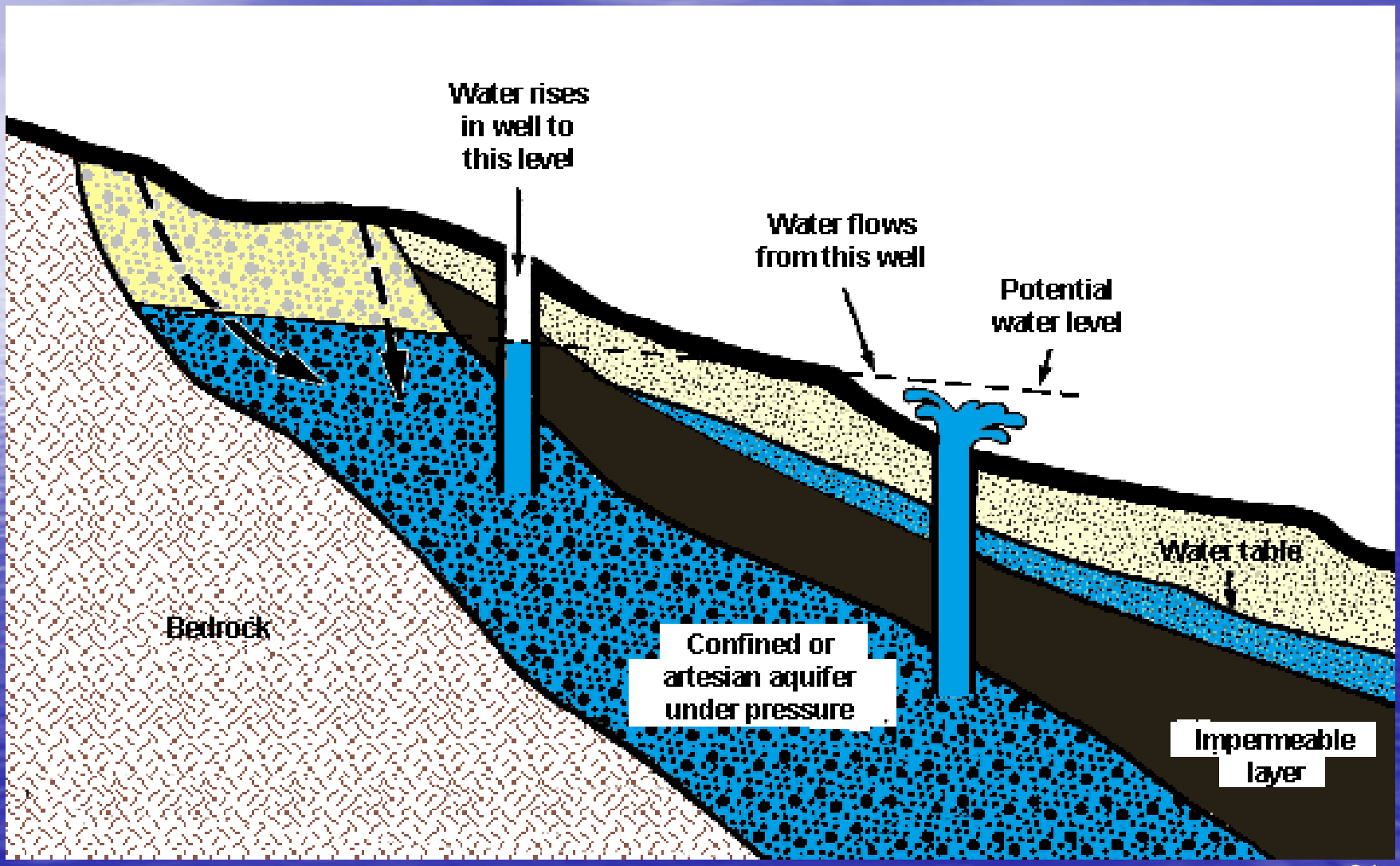
CONFINED AQUIFER

UNCONFINED AQUIFER

CONFINED AQUIFER.

- **Confined aquifer :** Completely saturated aquifer whose upper and lower boundaries are impervious layers. The pressure of water is usually higher than that of atmosphere and the water in the well stands above the top of aquifer.

CONFINED AQUIFER.

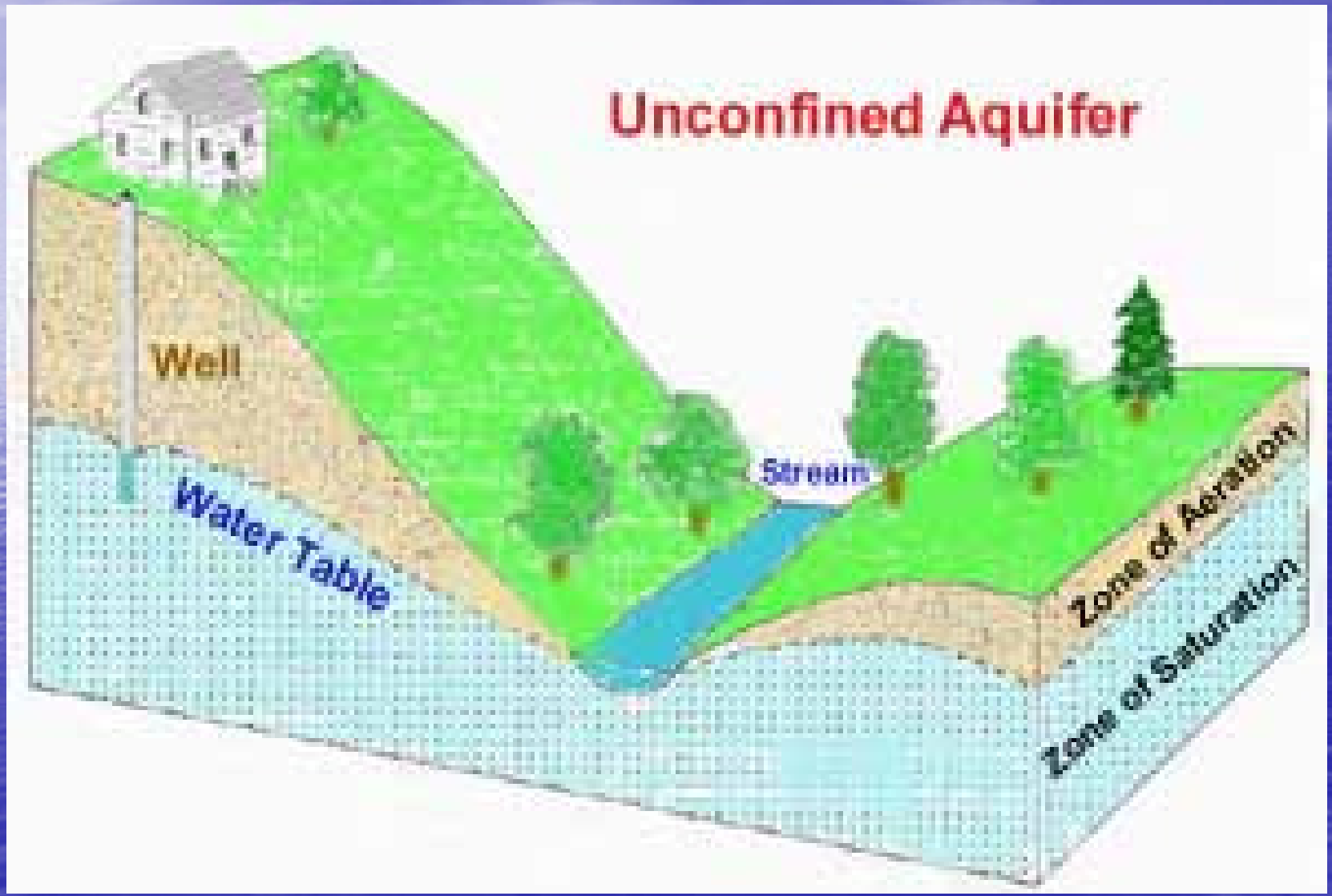


ARTESIAN WELL.

UNCONFINED AQUIFER.

- **Unconfined aquifer :** A permeable formation only partly filled with water and overlying a relatively impervious layer. its upper boundary is formed by a free water table under atmospheric pressure.

UNCONFINED AQUIFER.



CONFINED & UNCONFINED AQUIFERS.

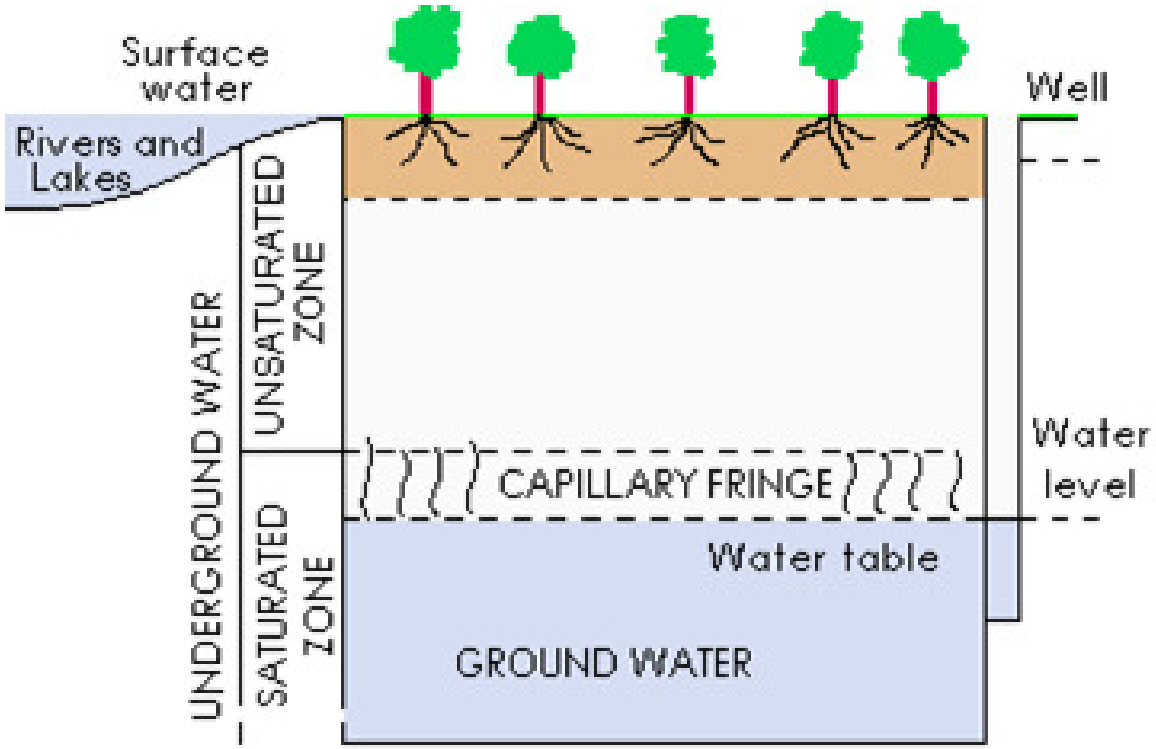
Confined and Unconfined Aquifer

- Unconfined Aquifer: open to atmosphere e.g., overlain by permeable rocks and soils
- Confined aquifer: sandwiched between aquitards
  - Artesian System: Water rises above the level in aquifer because of hydrostatic pressure
- Potentiometric surface: Height to which water pressure would raise the water.

PERCHED AQUIFER.

GROUND WATER DISTRIBUTION.

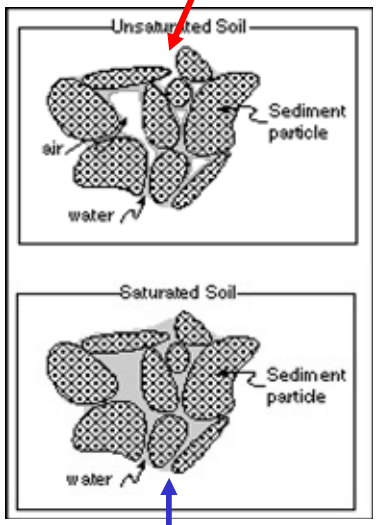
Zones of Aeration and Saturation

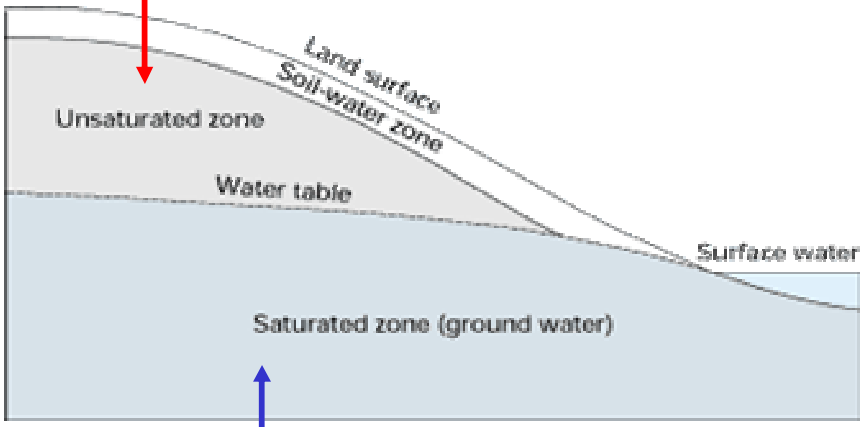


DISTRIBUTION OF GROUND WATER.

Pores Full of Combination of Air and Water

Unsaturated Zone / Zone of Aeration / Vadose (Soil Water)





Zone of Saturation (Ground water)

Pores Full Completely with Water

ZONES OF SUBSURFACE WATER

Zones of Subsurface Water

Zone of Aeration

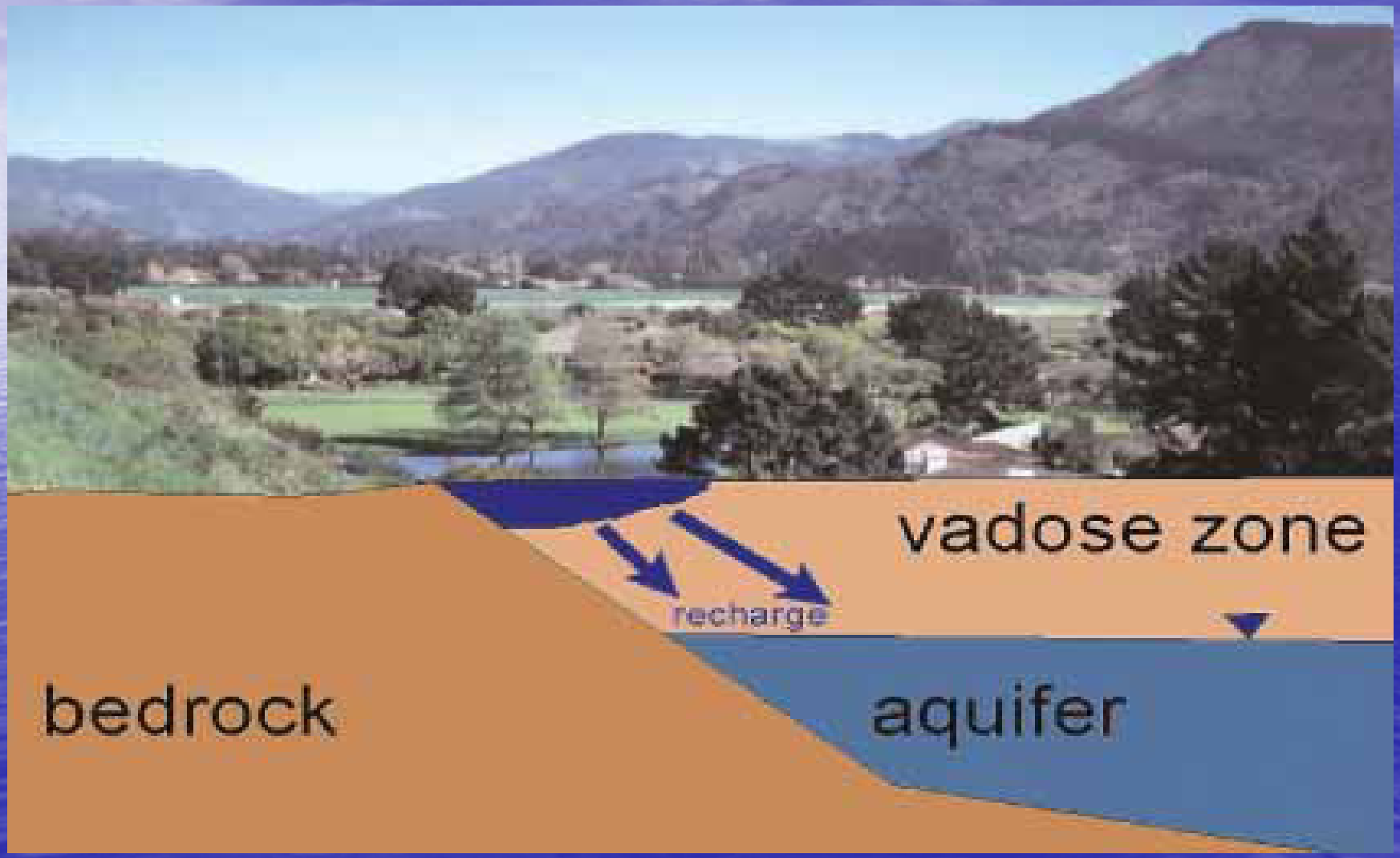
- pores filled with both air and water
- Water held against gravity by surface tension
- Soil water

- Zone of Saturation
  - pores filled only with water
  - Water drained through soil under influence of gravity.
  - Ground Water

ZONE OF AERATION.

- The zone between the ground surface and top of the water table is referred to as vadose zone.
- The zone partly filled up or unfilled with water above the water table is called as zone of aeration.
- The zone of aeration consists of three zones namely soil water zone, the intermediate zone & the capillary zone.
- In the soil water zone, water is trapped in top soil and is used for the growth of trees.

ZONE OF AERATION.

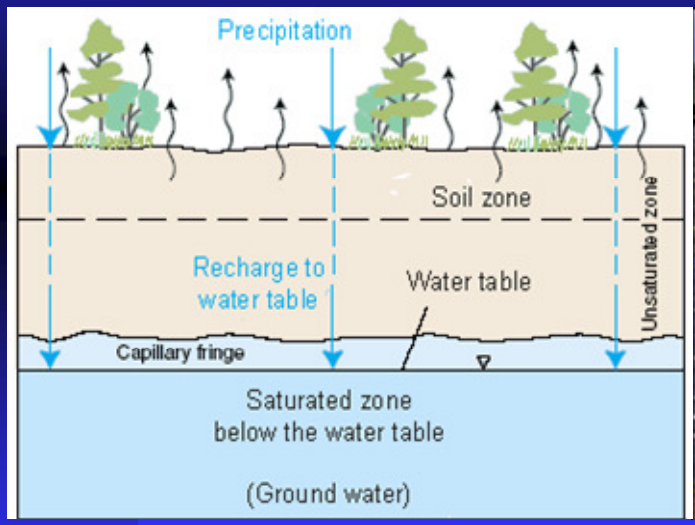


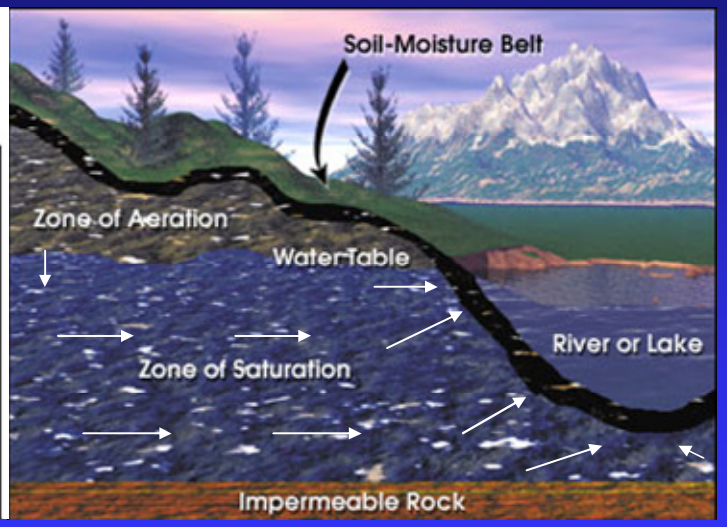
ZONE OF SATURATION.

- The soil or rock zone below the level of water table, where all the voids are saturated with water under pressure greater than that of the atmosphere.
- This zone is separated from the overlying zone of aeration by water table.

ZONE OF SATURATION.

Groundwater
Zone of Saturation

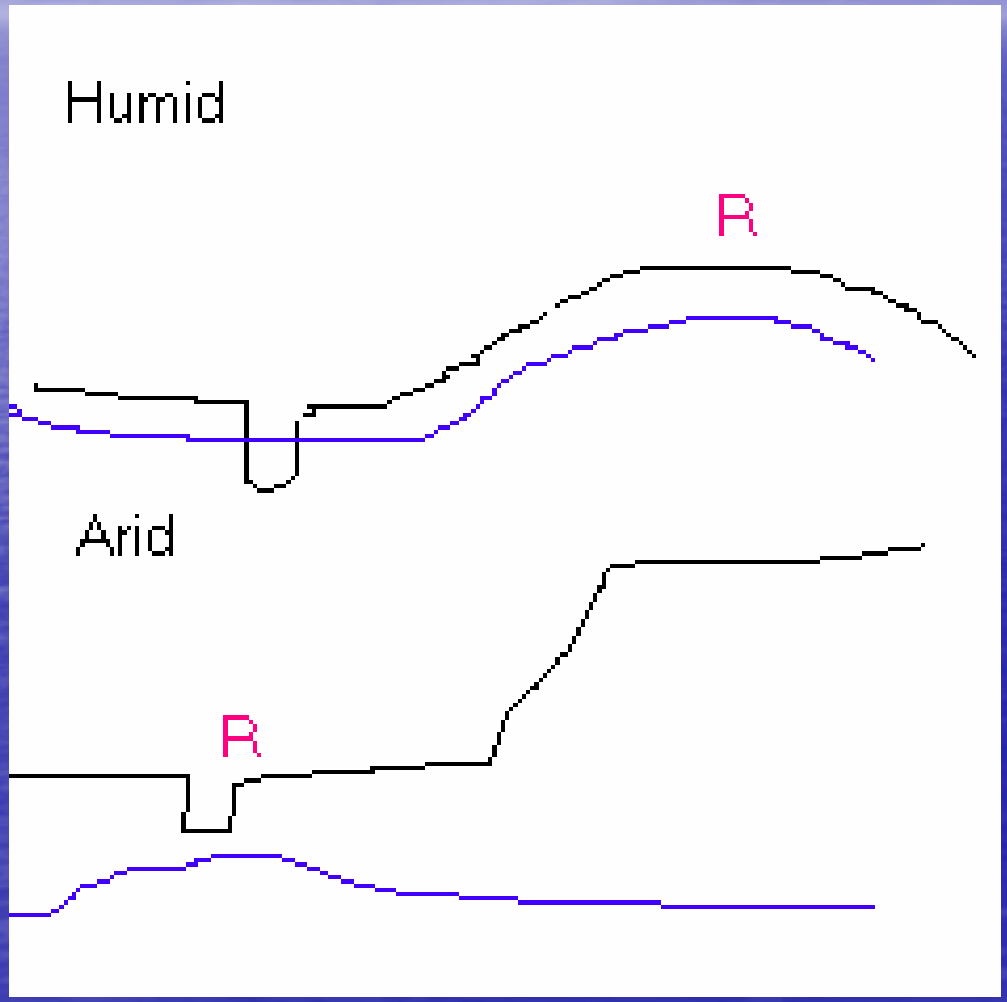




WATER TABLE.

- **Water table :** is defined as the upper surface of ground water.
- It is the phreatic surface dividing the zone of saturation and zone of aeration.
- It is the upper boundary of the zone of saturation where water pressure equals atmospheric pressure, is the water table.
- Depending upon recharge & discharge the water will fluctuate.
- It follows the topography.

CONFIGURATION OF WATER TABLE.



PHYSICAL PROPERTIES OF AQUIFER.

- A water bearing formation primarily performs two important functions- a storage function & a conduit function.
- Porosity and specific yield are the two main storage properties of any water bearing formation.

STORAGE PROPERTIES.

- **POROSITY :** A rock is said to be porous if it posses cavities between the mineral grains- volume of pore space relative to the total volume. porosity n = vo / v- expressed in percentage.

POROSITY IN AQUIFERS.

- Primary porosity is the void spaces between the grains of the rock materials (e.g., sand).
- Secondary porosity is due to fracturing, jointing, weathering, or dissolution of the rock materials.
- Porosity is measured as a percent of volume.
- It can be very low (almost zero), or very high (up to 70%).
- Clays have higher porosities than sands!

POROSITY OF SOME GEOLOGICAL FORMATIONS.

What are some typical values of porosity and permeability?

- **Porosity**

clay	45-55 %
sand	30-40
sandstone	10-20
shale	1-2
limestone	1-10 (or larger)

- Permeability: varies over several orders of magnitude. Expressed as a rate, e.g. ft/day

CONDUIT PROPERTIES.

- The property of a water bearing formation which is related to its conduit function is called its hydraulic conductivity or Permeability.
- <u>Permeability :</u> Represents the velocity of flow or the hydraulic conductivity- measured in darcies or expressed in meters per day.

PERMEABILITY IN AQUIFER.

- Permeability is a measure of how well the aquifer material can transmit water.
- It is not directly related to porosity.
- Permeability depends more on the interconnection of the void spaces than the size of them (but bigger is generally better!).

OTHER IMPORTANT HYDROGEOLOGICAL PARAMETERS.

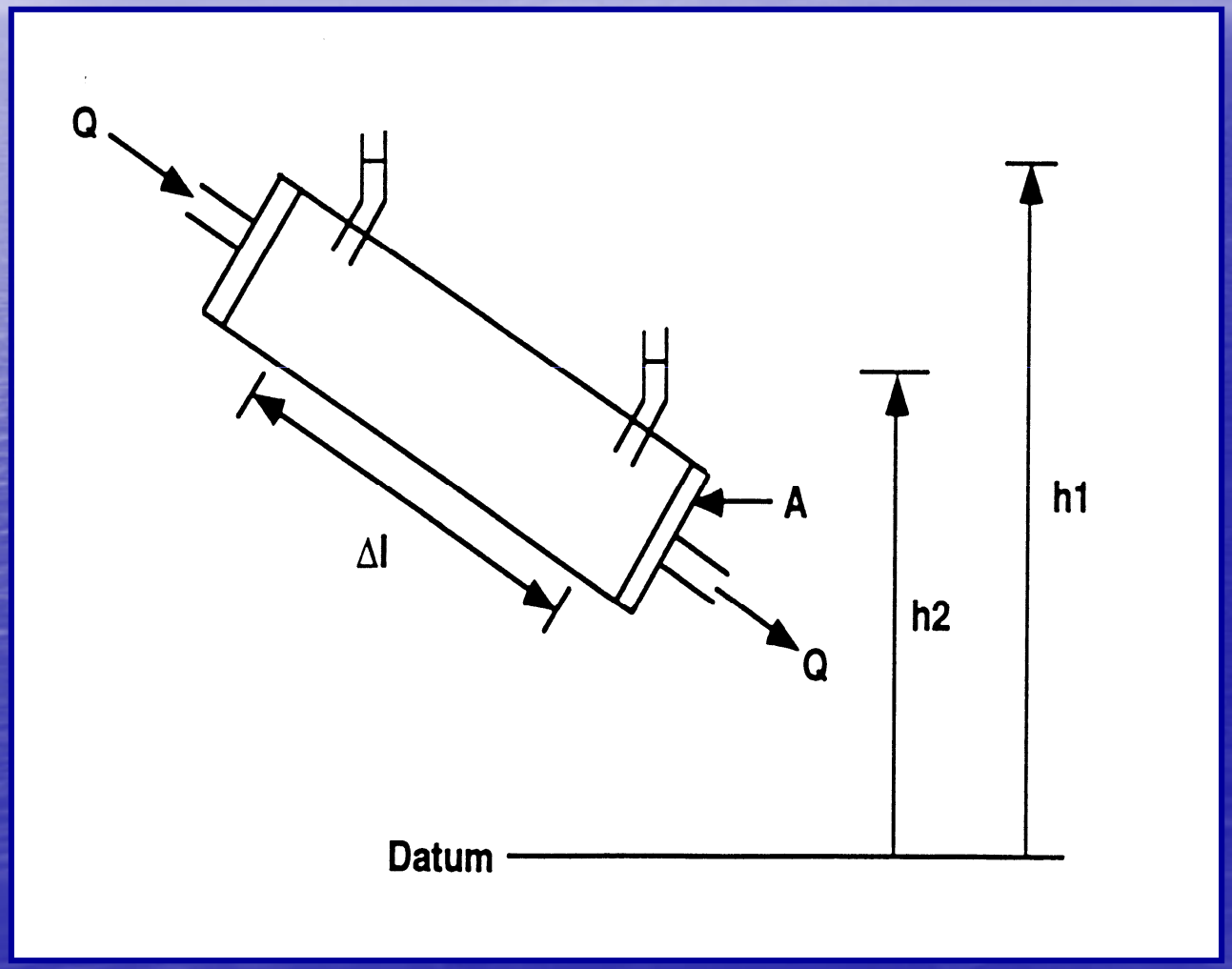
- **Specific yield-** The quantity of water that a unit volume of the material will give up when drained by gravity is called the specific yield and is expressed as ratio.
- **Specific retention-** The quantity that a unit volume retains when subjected to gravity drainage is called its specific retention.
- Both specific yield & specific retention are expressed in percentage and the sum of the two is equal to total porosity.
- **Storage coefficient-** The storage coefficient [Todd 1959] of an aquifer is the volume of water discharged from a unit prism ie, a vertical column of water standing on a unit area- expressed as ratio.
- **Transmissivity-** The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is often expressed as the product of the hydraulic conductivity & the full saturated thickness of the aquifer & has unit of the form of m2/day.

DARCY LAW & GROUND WATER FLOW.

- The ground water movement is based on the principles of Darcy's law.
- In 1856 Henry Darcy studied the movement of water through porous material and he determined an equation that described ground water flow.
- Ground water flow is from high hydraulic head [high water level] to low hydraulic head.
- Darcy is a measure of hydraulic conductivity.
- Darcy's law provides an accurate description of the flow of ground water in almost all hydrogeologic environments.

DARCY'S EXPERIMENT (1856):

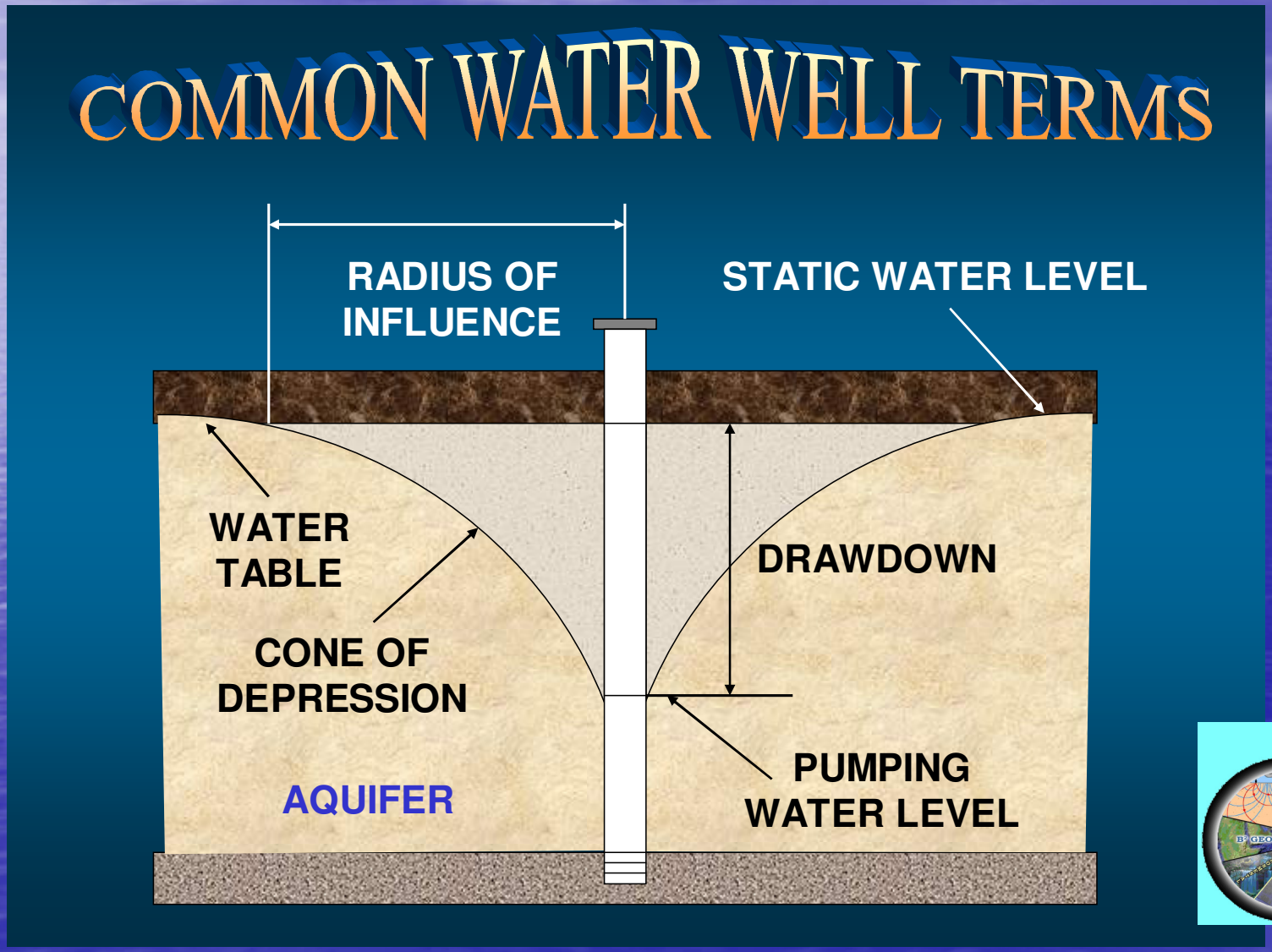
Flow rate determined by Head loss dh = h1 - h2



DARCY'S LAW.

- Darcy's law states that the velocity of flow Q in a porous media is proportional to-
- A = area of cross section filter
- h1 - h2 = difference in water level.
- 1/L = hydraulic gradient.
- Q = K A [h1-h2]/L

COMMON WATER WELL TERMS.



CONCLUSION.

- This is a detailed introduction about ground water and hydrogeology which will guide one to understand the basics of ground water & aquifers.
- Remote Sensing [RS] & Geographic Information System [GIS] are the advanced technologies used in water resources. With these advancements & adapting proper scientific techniques the potential aquifers can be successfully explored & exploited.

THANK YOU.

Water is a precious resource-
let us conserve it.