

Storage and Flow of Groundwater



Aquifer

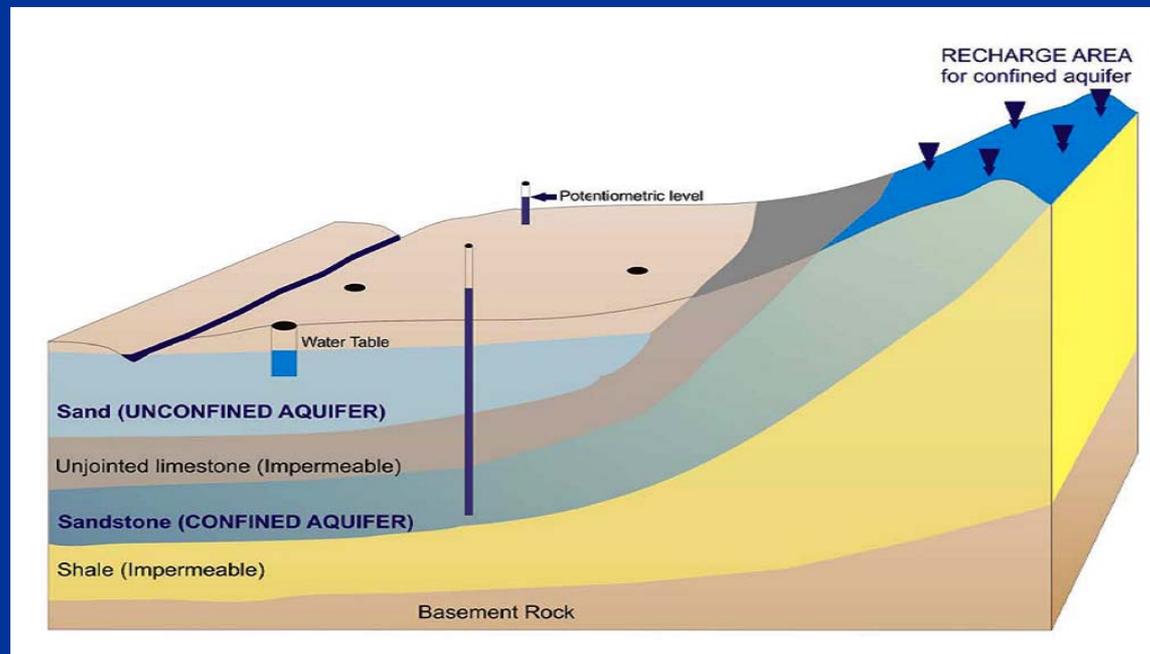
AQUIFER (in Greek)= AQUA (water) + FERRE (to bear)

Aquifer- “a saturated geological formation which will yield sufficient quantity of water to wells and springs”

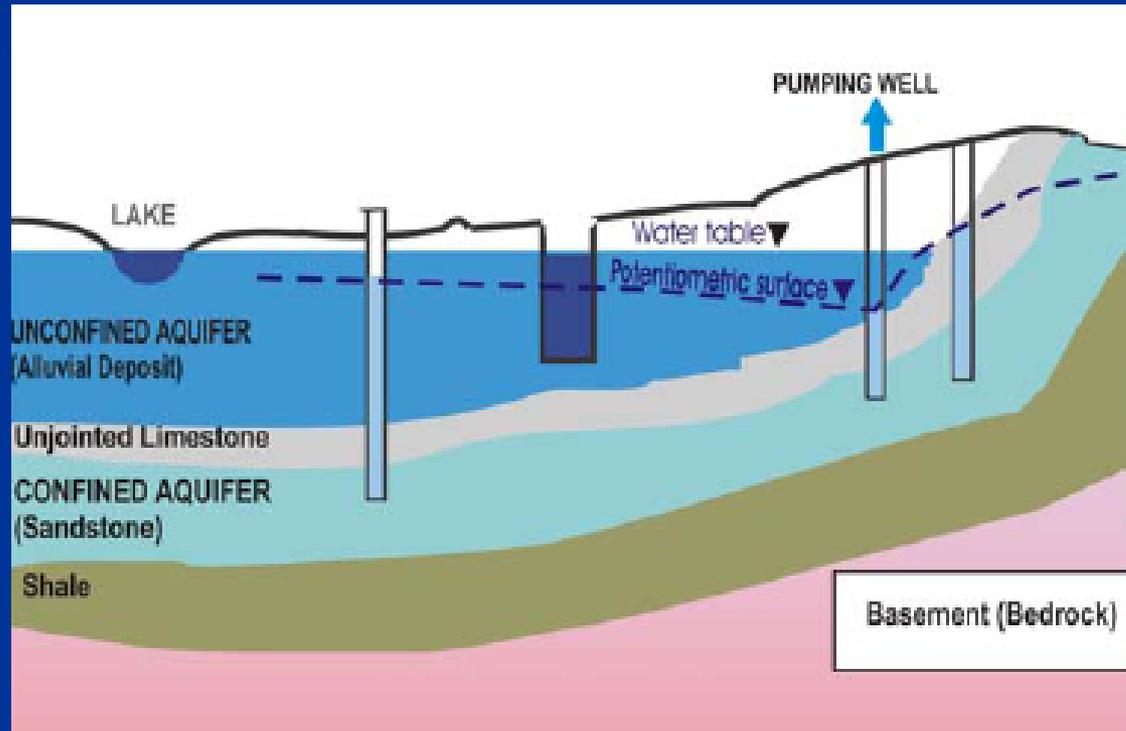
- **Underground storage reservoirs**
- **The *zone of saturation in the rock* is termed as an **AQUIFER.****

Types of Aquifers

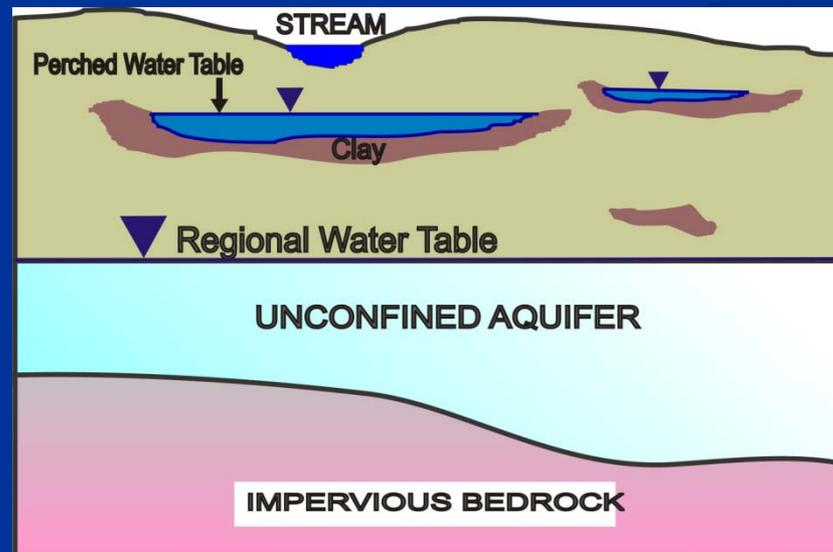
- Unconfined- water table is exposed to the atmosphere through openings in the overlying regolith.



- Confined- isolated from atmosphere and extends between two impermeable layers



- Perched- Impervious stratum within the zone of aeration interrupts percolation and causes ground water to accumulate in a limited area above the stratum



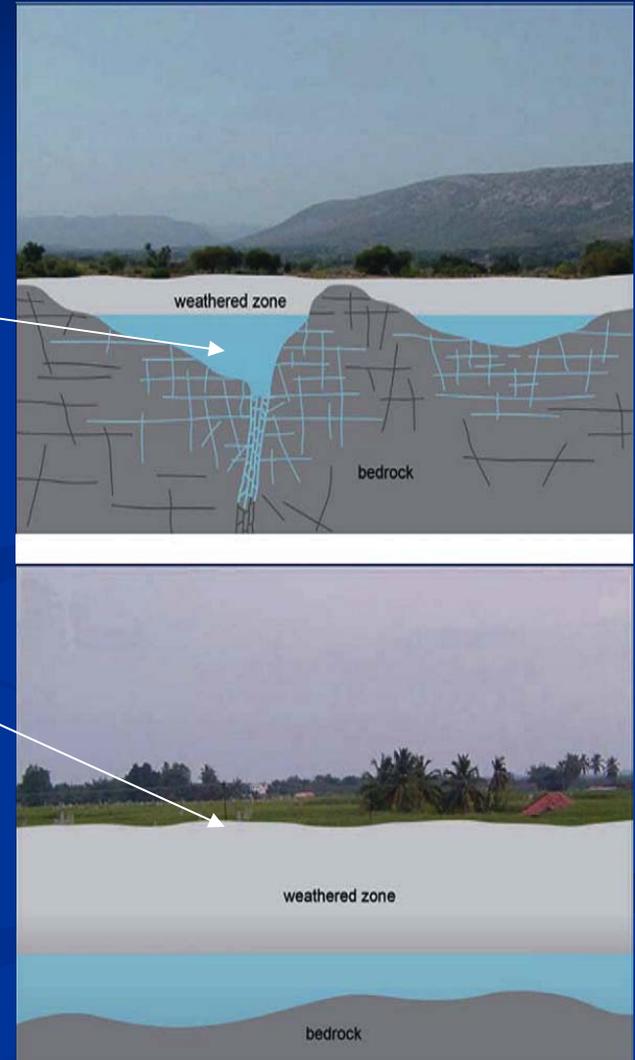
FUNCTION

Aquifer may be

1. Local

2. Regional

- An aquifer on its regional scale performs two functions
 - **Storing the water** (storage)
 - **Transmission of water** (flow)



Source: COMMAN

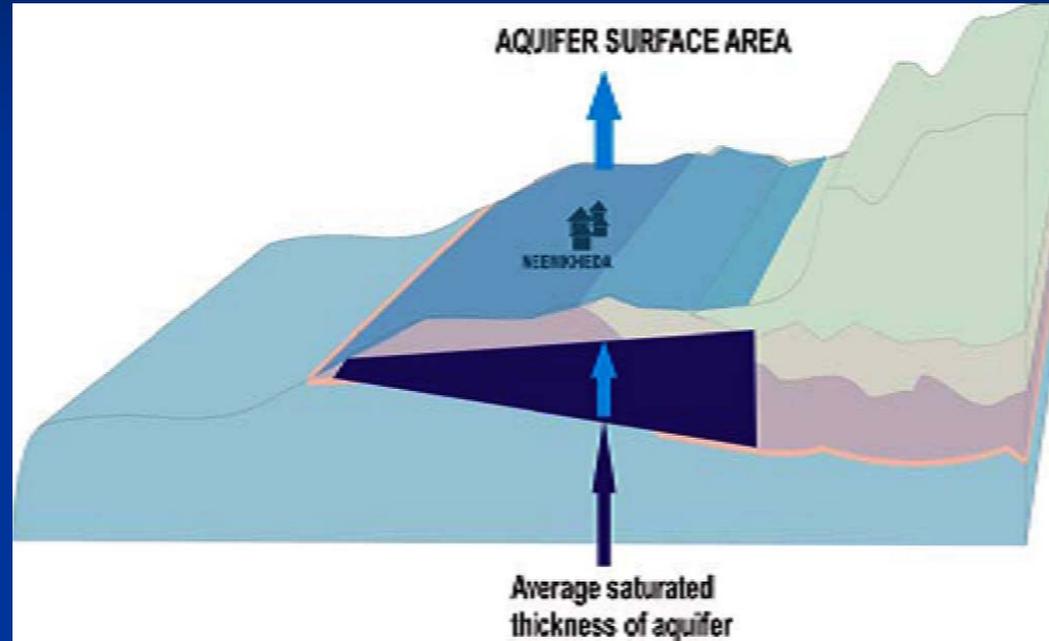
Aquifer Storage

Volume of Aquifer Storage (St)-

- Surface area on which aquifer is exposed (A)
- Saturated thickness of aquifer (D)

$$St = A \times D$$

- Storage capacity depends on POROSITY of the rock
- Storage function related two processes
 - Addition in aquifer storage (Recharge)
 - Reduction in aquifer storage (Discharge)



Changes in aquifer brings about change in potentiometric surface or water table

Storativity and Specific Yield

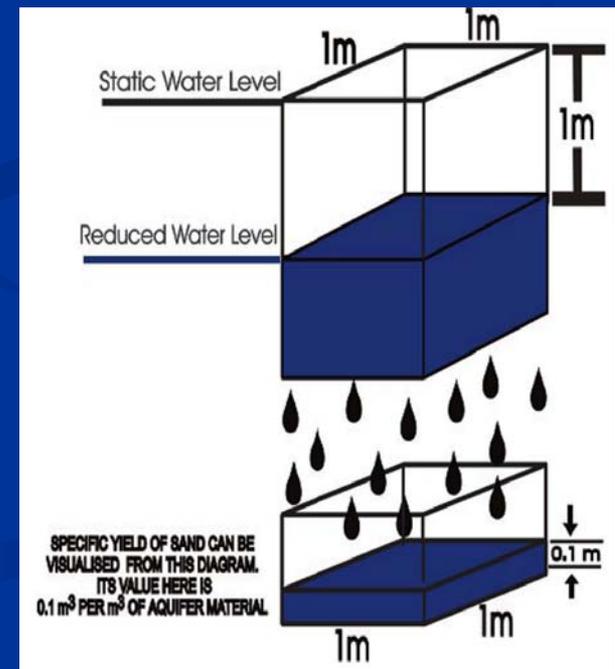
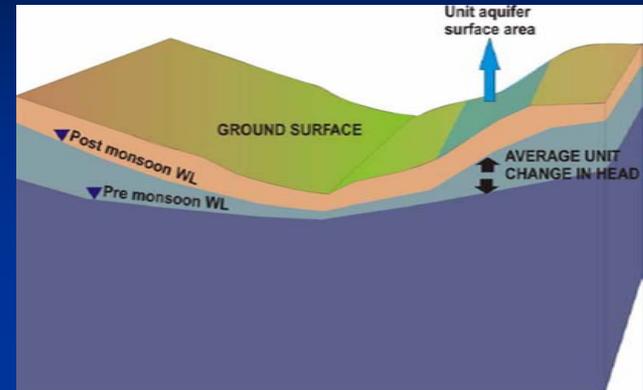
Storativity (S)

Quantity of water taken out of or into an aquifer

Specific quantity of water released by saturated rock under the influence of gravity is **Specific yield (S_y)** of the rock

In case of unconfined aquifer storativity is equivalent to the specific yield

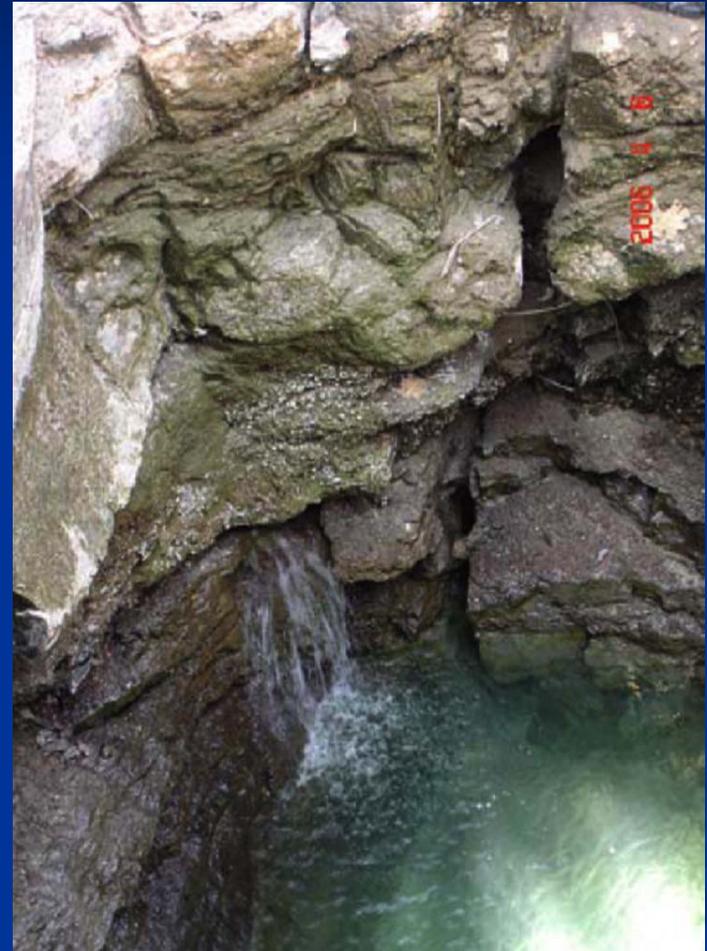
$$S = S_y$$



Hydraulic Conductivity

- Permeability of the rock or rock material
- Ability of rock to allow flow of groundwater through it

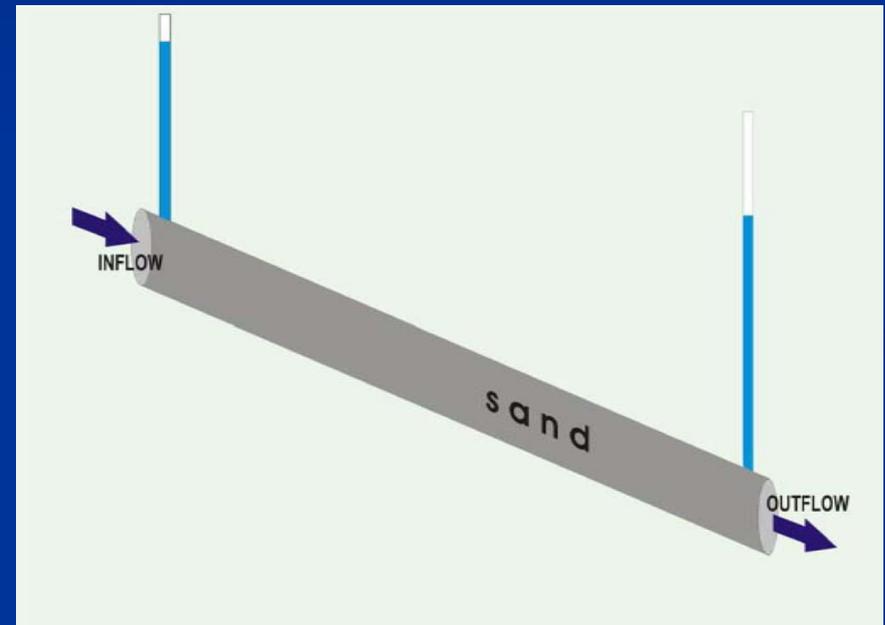
| Hydraulic Conductivity of Rock | Flow of Groundwater |
|--------------------------------|---|
| Good | Easy |
| Poor | Does not allow easy movement of groundwater |



Darcy's Apparatus

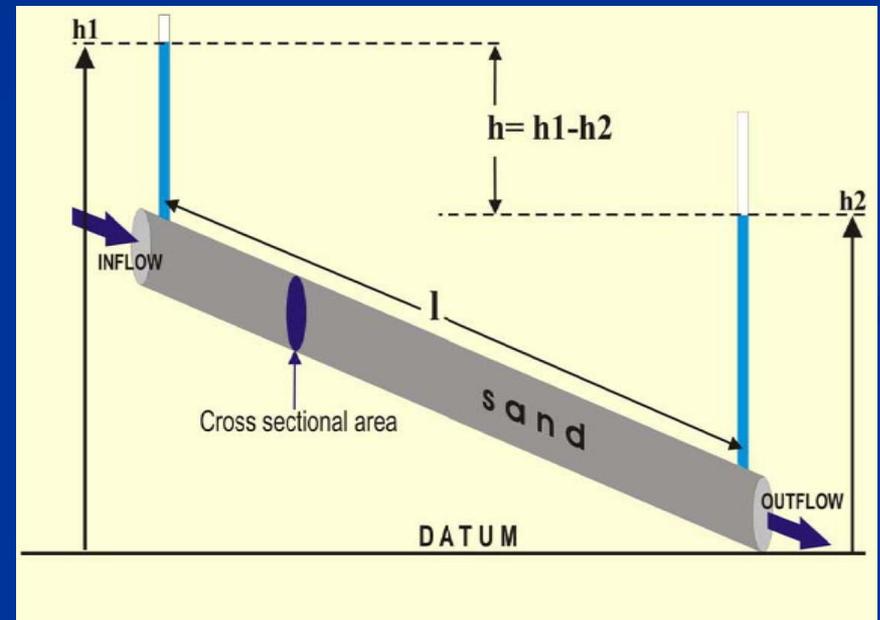
Henry Darcy (French Engineer, 1856)

- Glass cylinder filled with sand
- Glass cylinder had inlet and outlet for inflow and outflow of water
- Two vertical glass tubes were fitted at fixed distance to measure the level of water in each tube



Darcy's Experiment

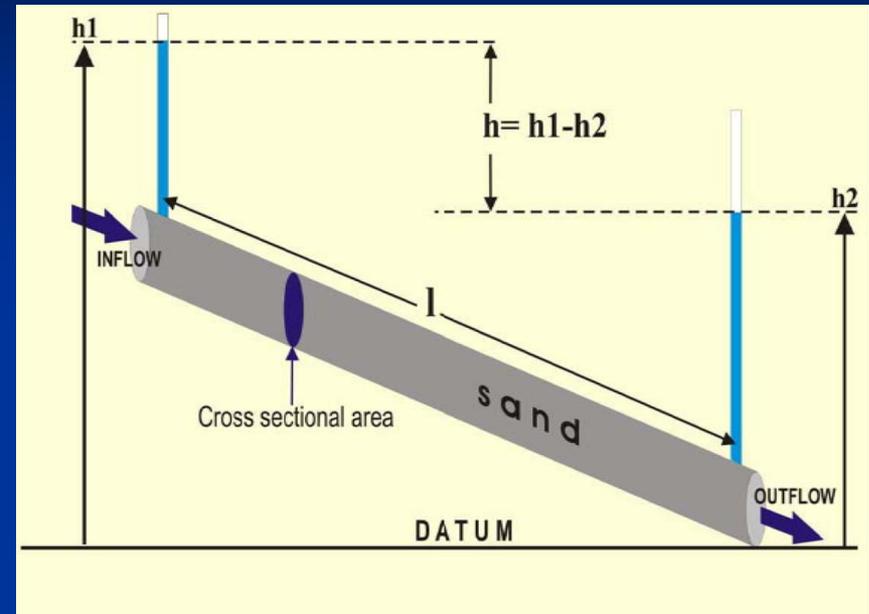
- After the water is passed through the inflow into the sand bed-
 - Water level (Hydraulic Head) rises in the vertical glass tubes.
 - The difference water levels is “h”.
 - Distance between the two points is “l”.



Darcy, Law

- Rate of flow of water through the porous sand is directly proportional to the difference in hydraulic head between the two points and inversely proportional to the distance between the two points.

$$v \propto h/l$$



Therefore the equation is

$$v = k(h/l)$$

v = velocity

h = hydraulic head difference
between the two points

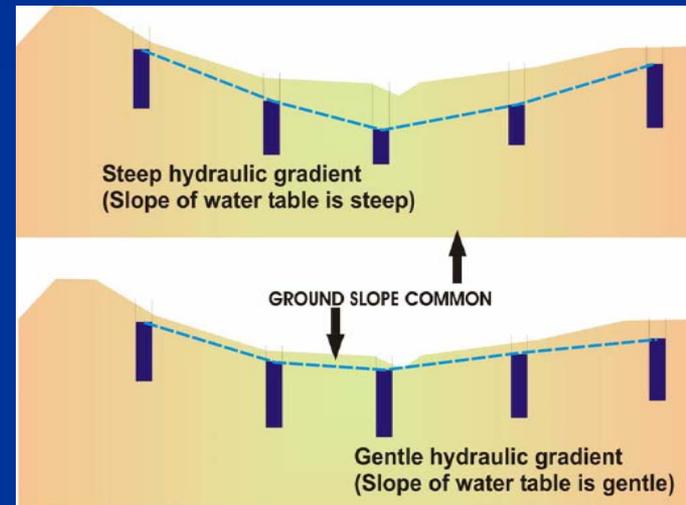
l = distance between the two points

k = coefficient of permeability or
HYDRAULIC CONDUCTIVITY

Hydraulic Gradient (i)

- **Hydraulic gradient (i)**— Slope of water level surface *HYDRAULIC GRADIENT*
- *The difference of hydraulic head “h” over the distance “l” is the slope of the imaginary line joining the heads in the tubes*

$$v = k(h/l) = ki$$



Therefore,

$$v = ki$$

Quantity of Water flow

- Quantity of water flowing is as follows-

Q = qty. of water flow

A = area through which it flows

v = velocity of water flow

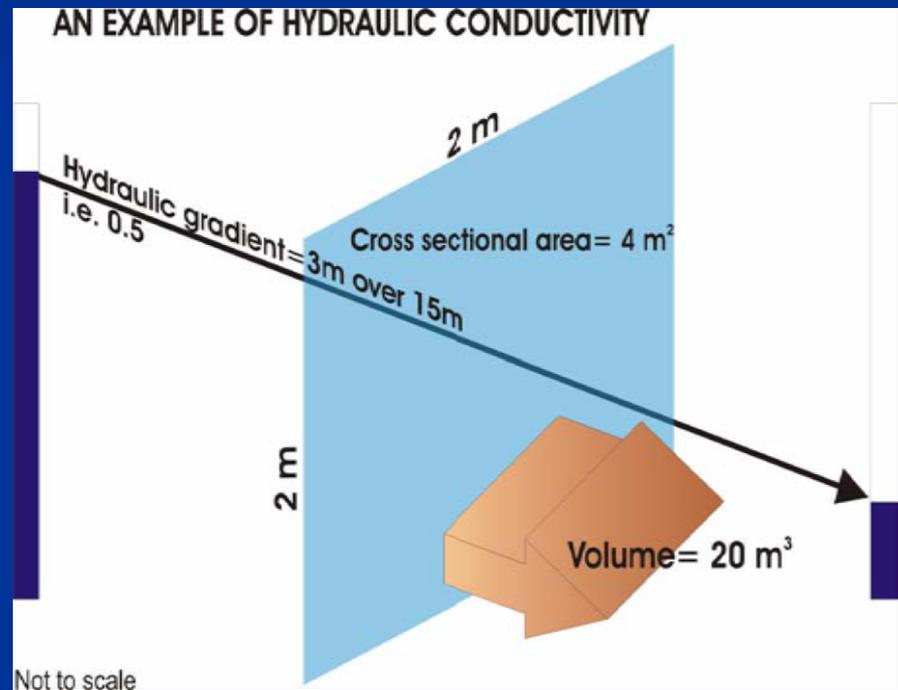
$$Q = A \times v$$

(Since, $v = ki$)

$$Q = kiA$$

Or

$$k = Q/iA$$

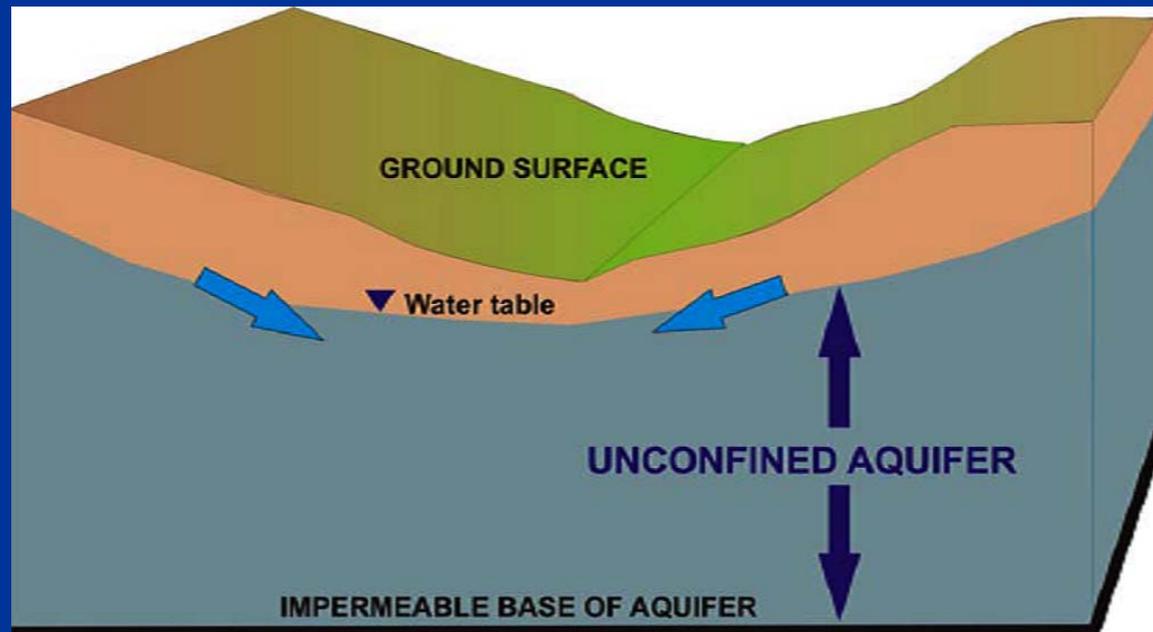


Movement of Groundwater

- Porous material velocity “ v ” is directly proportional to hydraulic gradient
- Here the water moves along hydraulic gradient
- This hydraulic gradient is due to slope of the water table
- Slope is difference in elevation of water table “ h ” in any two wells spaced at a distance “ l ”



Transmission- Movement of groundwater through a porous network of an aquifer under the influence of hydraulic gradient



Lessons

- The status of a rock with regards to *groundwater occurrence and movement* is decided by its *porosity (specific yield, more practically)* and its *hydraulic conductivity*
- These hydrologic properties decide whether a rock can *store and transmit groundwater*.
- In hydrogeology, the *hydrologic properties* of rocks (openings) signify the *status of a rock* to act as a *good or poor aquifer*

