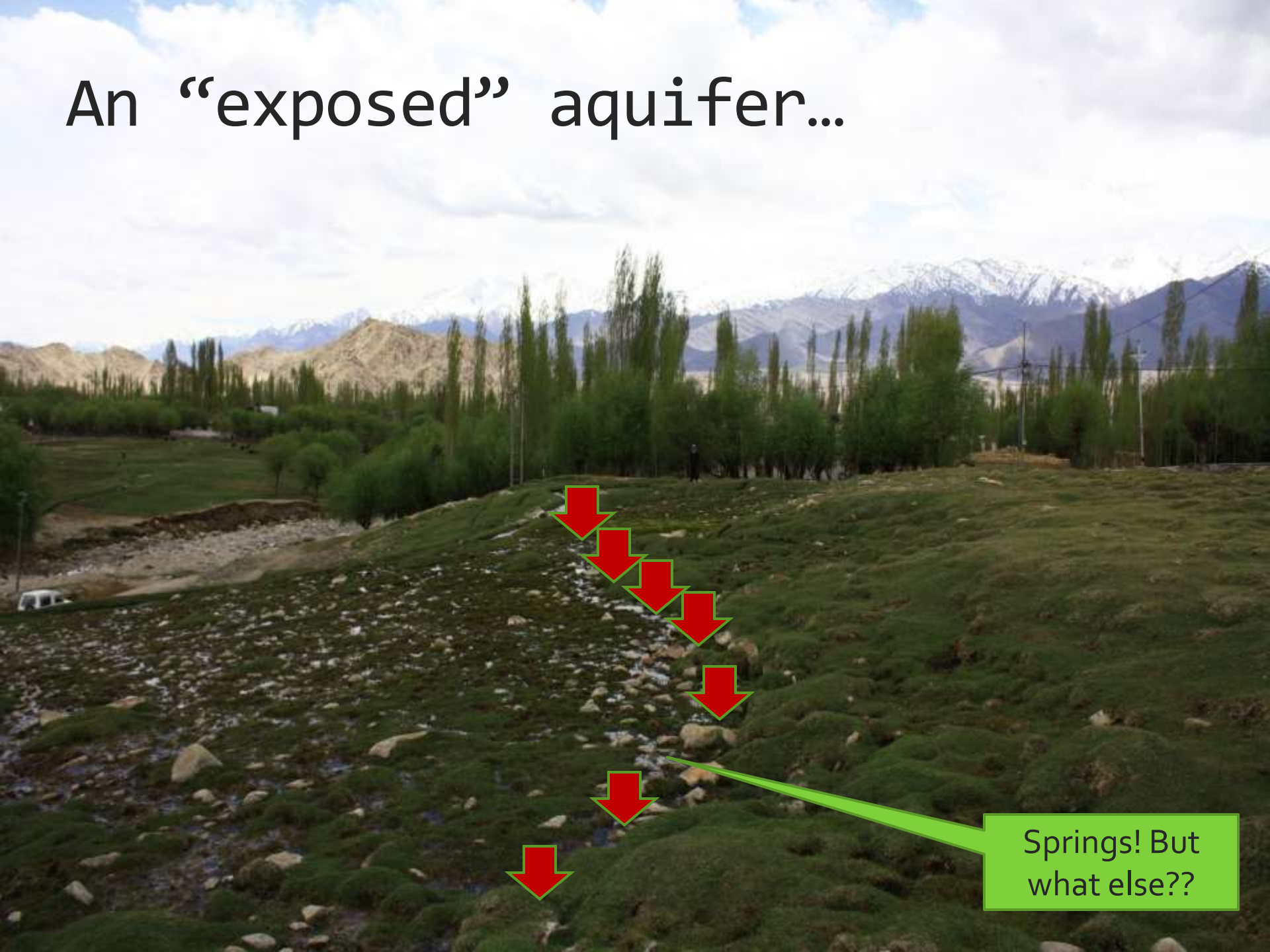
AQUIFERS & THEIR CHARACTERISTICS

An “exposed” aquifer…

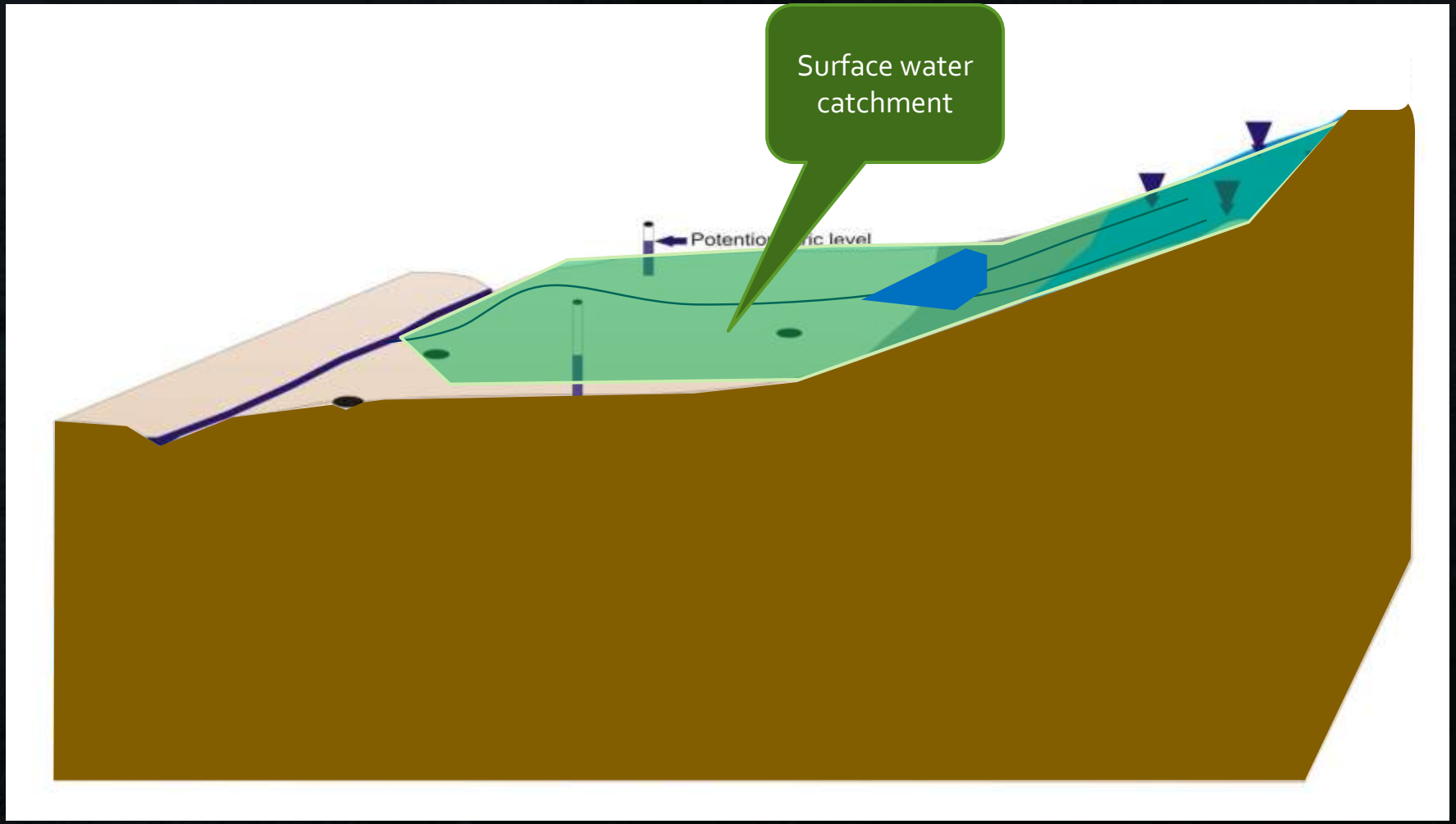


The aquifer feeding the springs

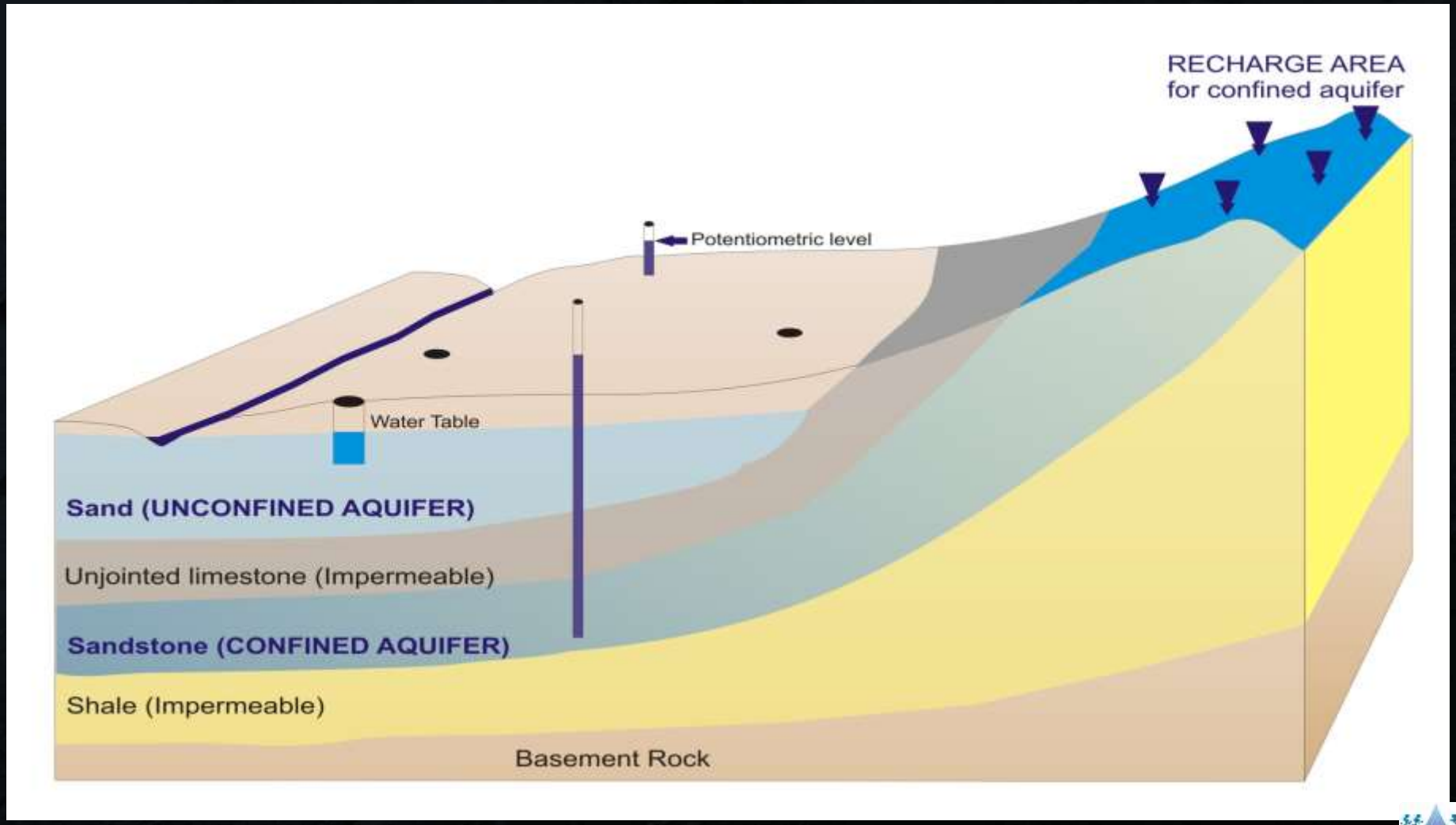
Why does a well produce water…?

- The permeability or hydraulic conductivity of the aquifer…allows water to flow towards the well.

- The storage of groundwater in the aquifer due to the porosity of the rocks/rock material provides storage of water to feed the well through permeable zones.

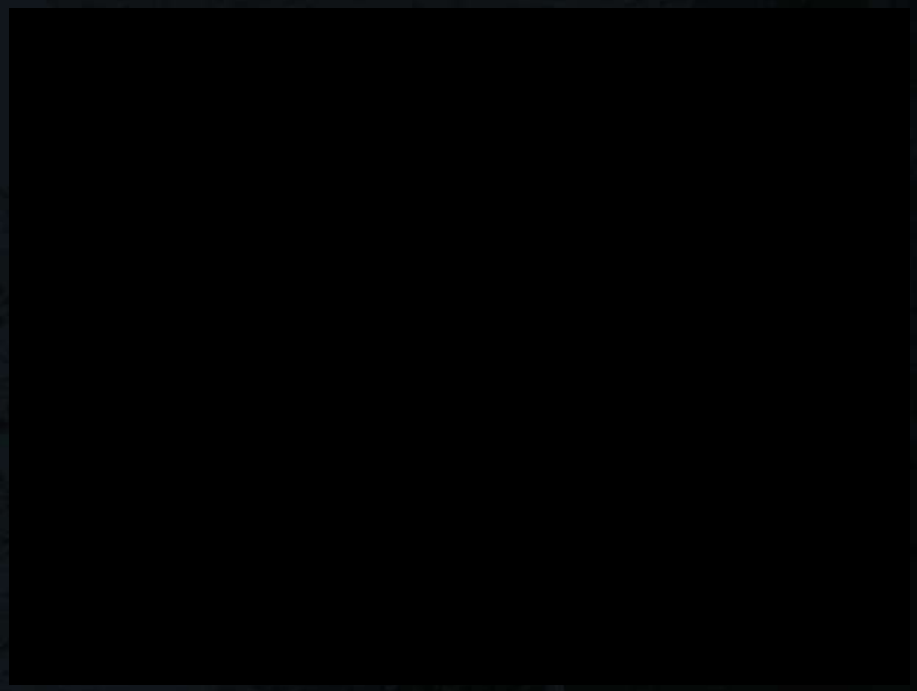

Surface water catchment

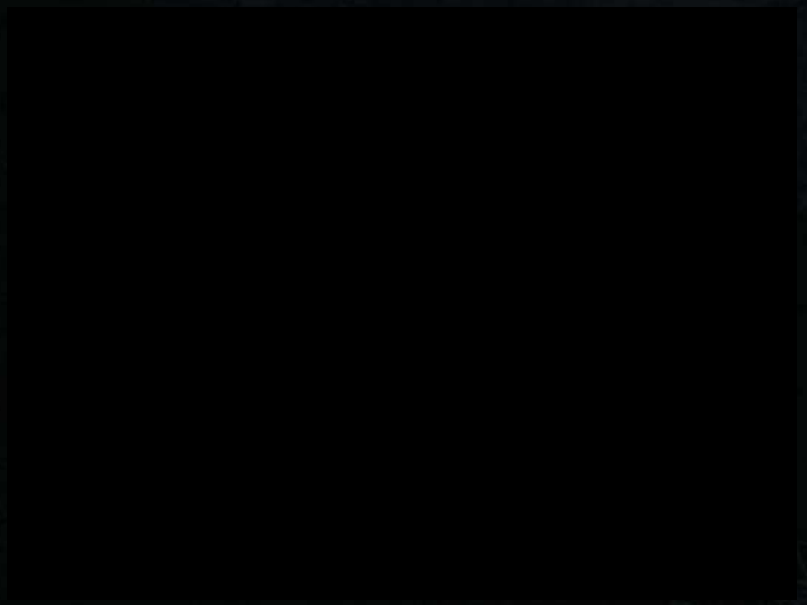
Unconfined & confined aquifers



An aquifer is NOT like an empty vessel…

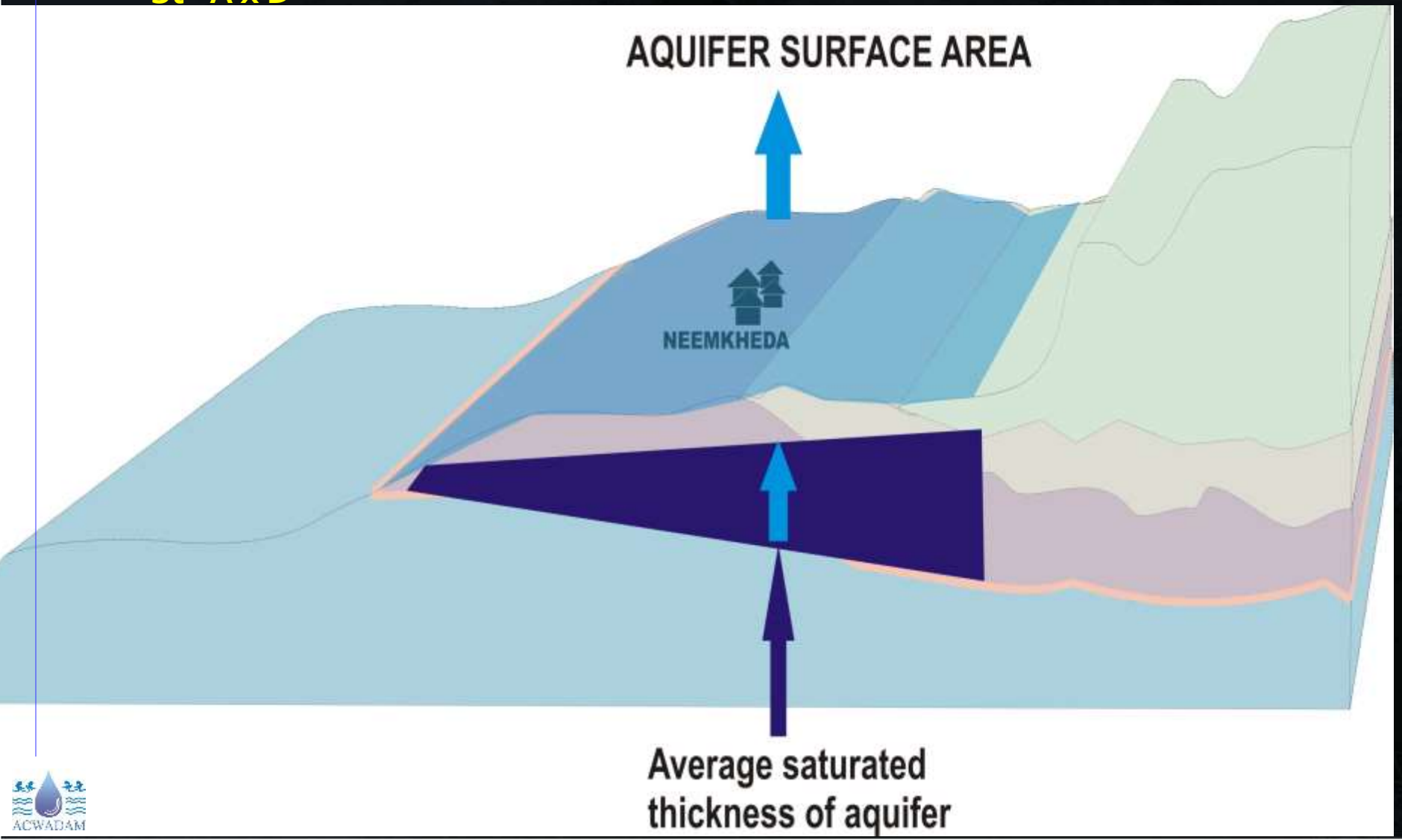
The “filling up” depends upon the aquifer material…

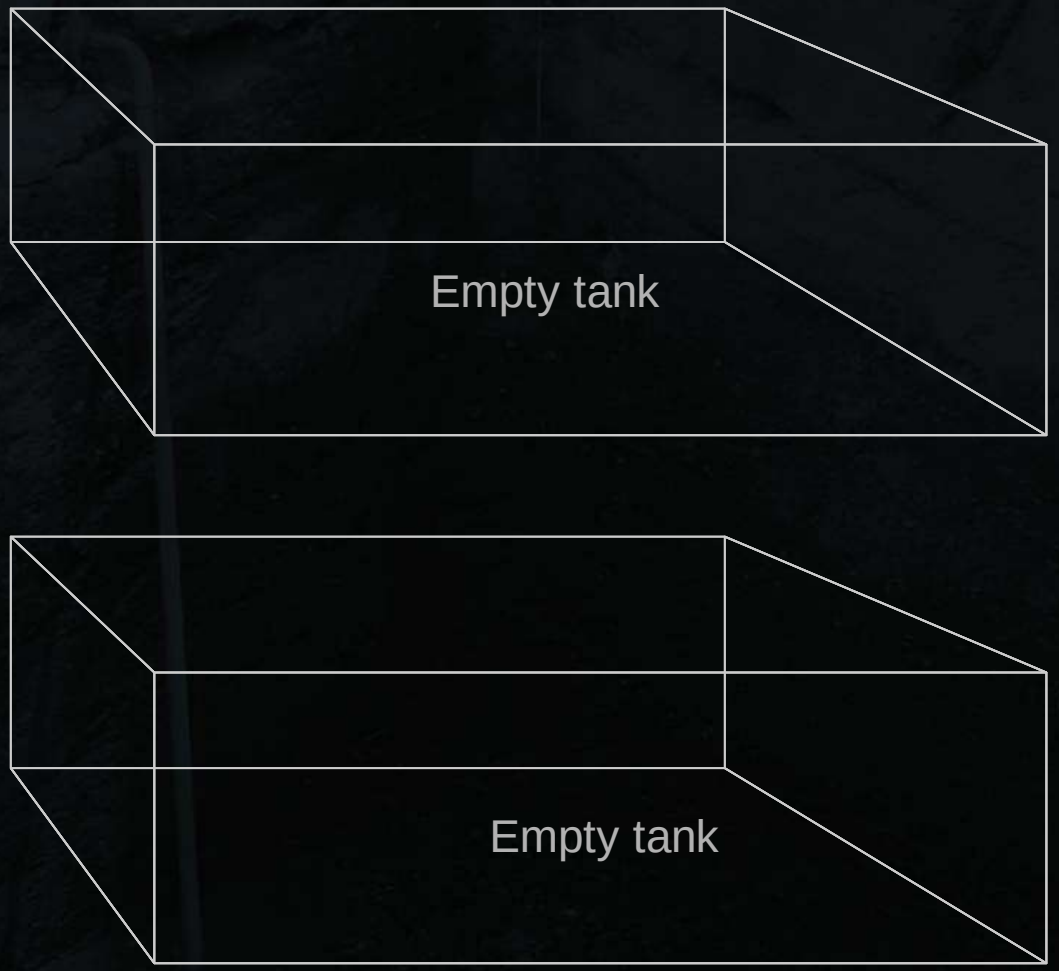


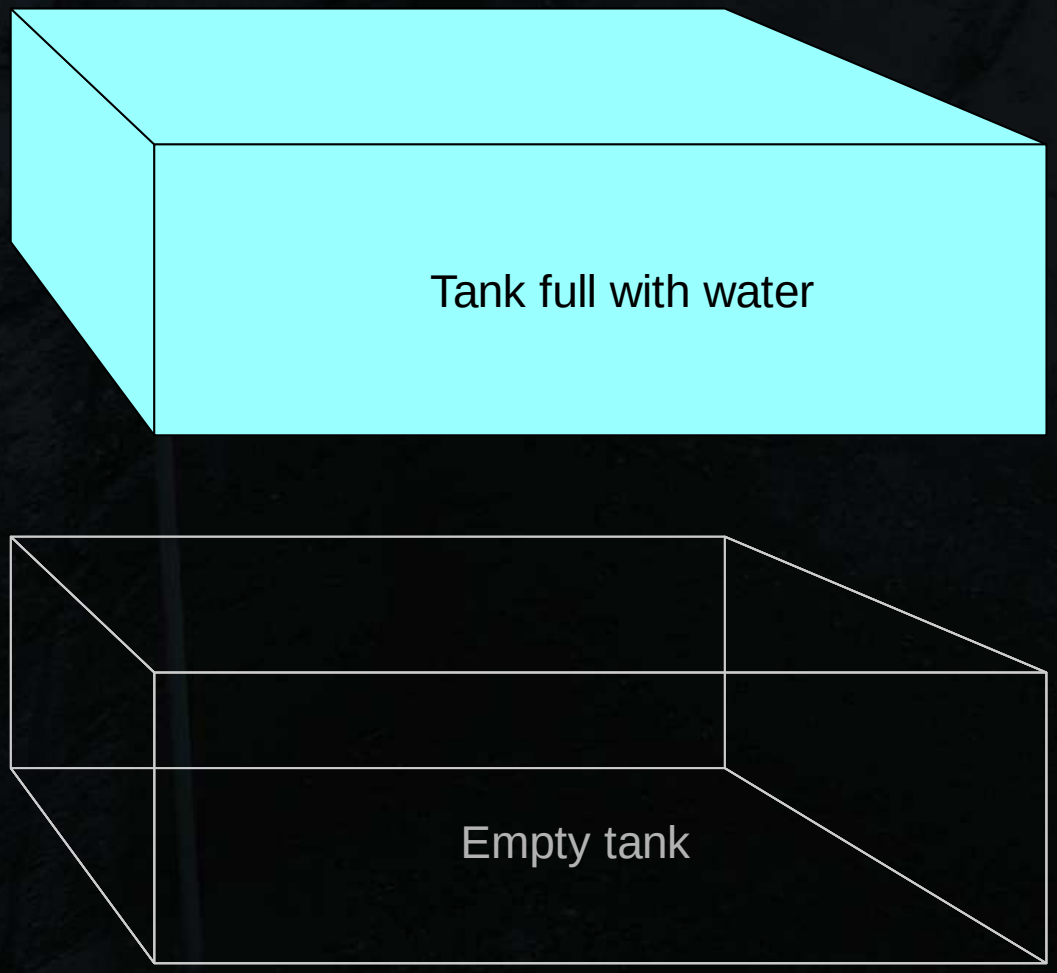


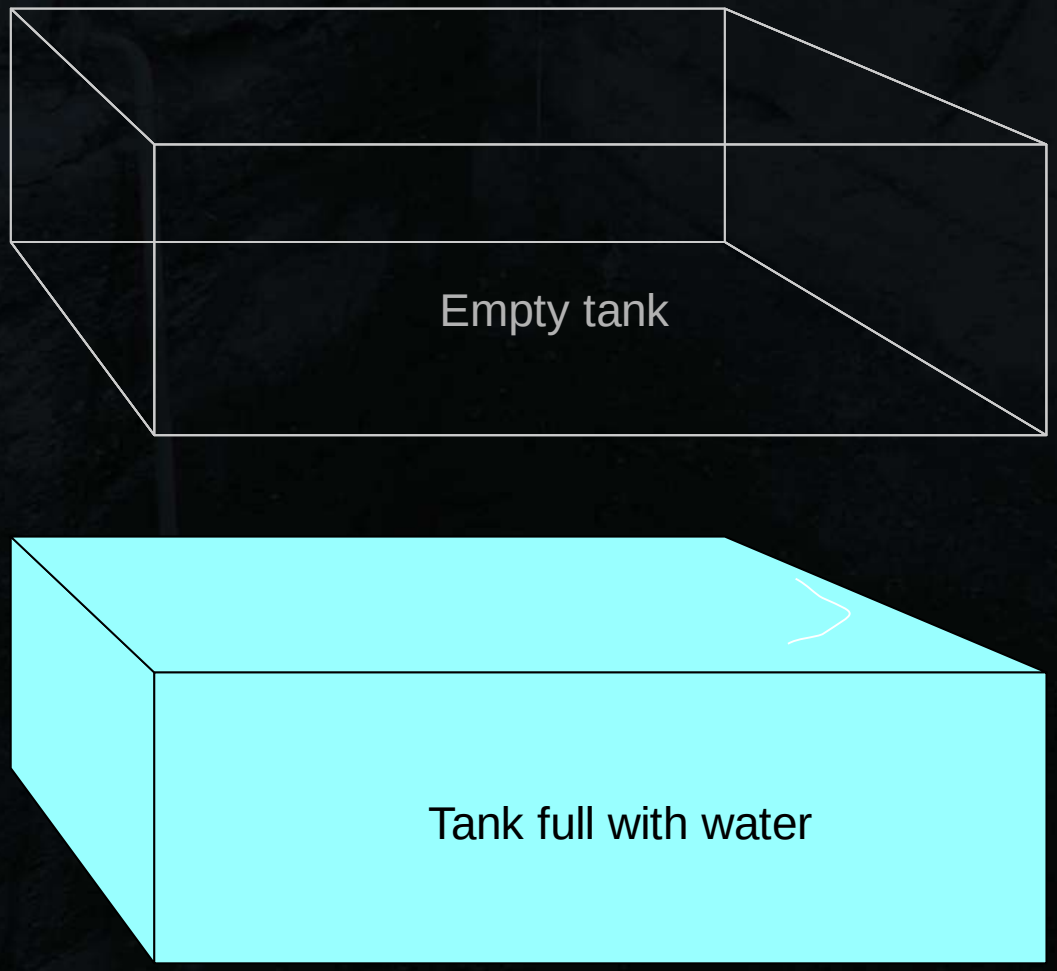
Aquifer storage

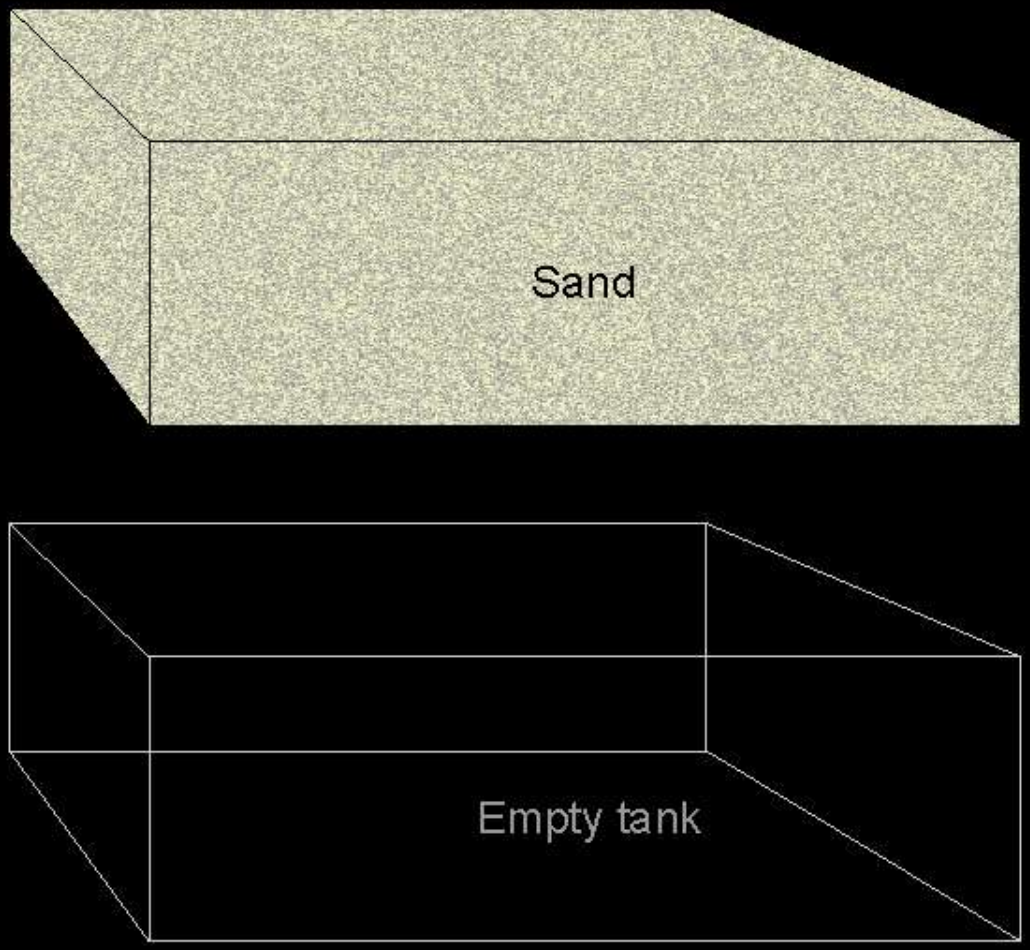
- The volume of aquifer storage can be simply estimated using the relation:
  St= A x D x ?

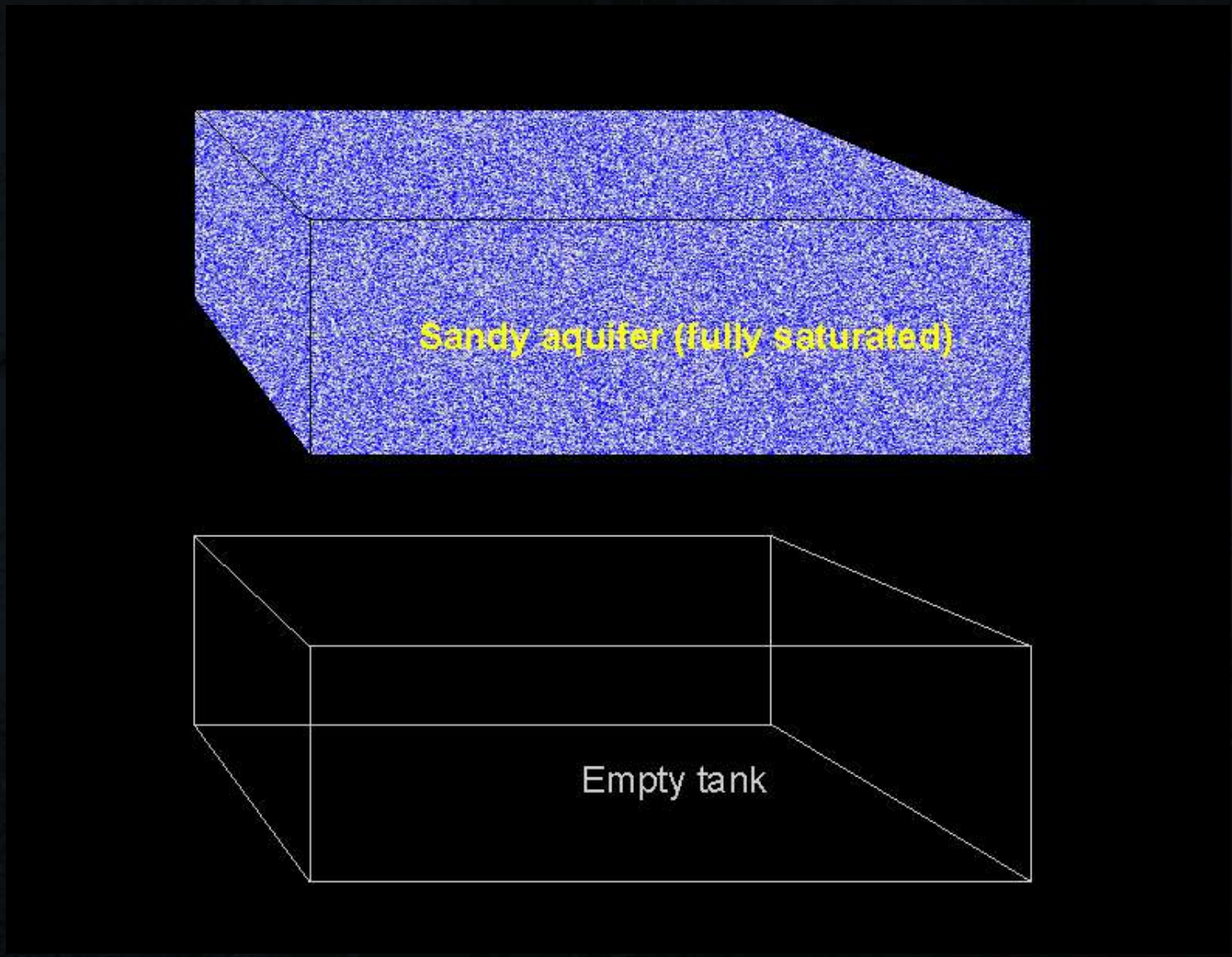


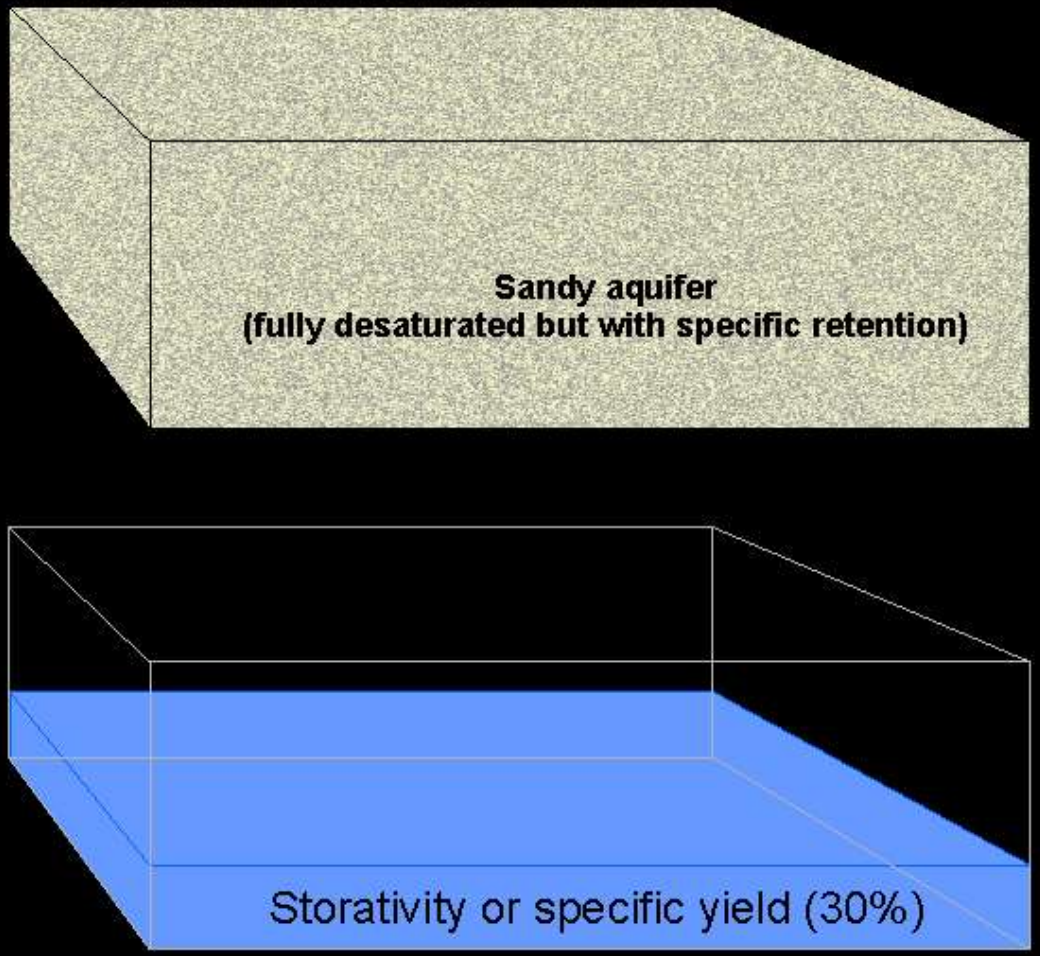

Empty tank
Empty tank

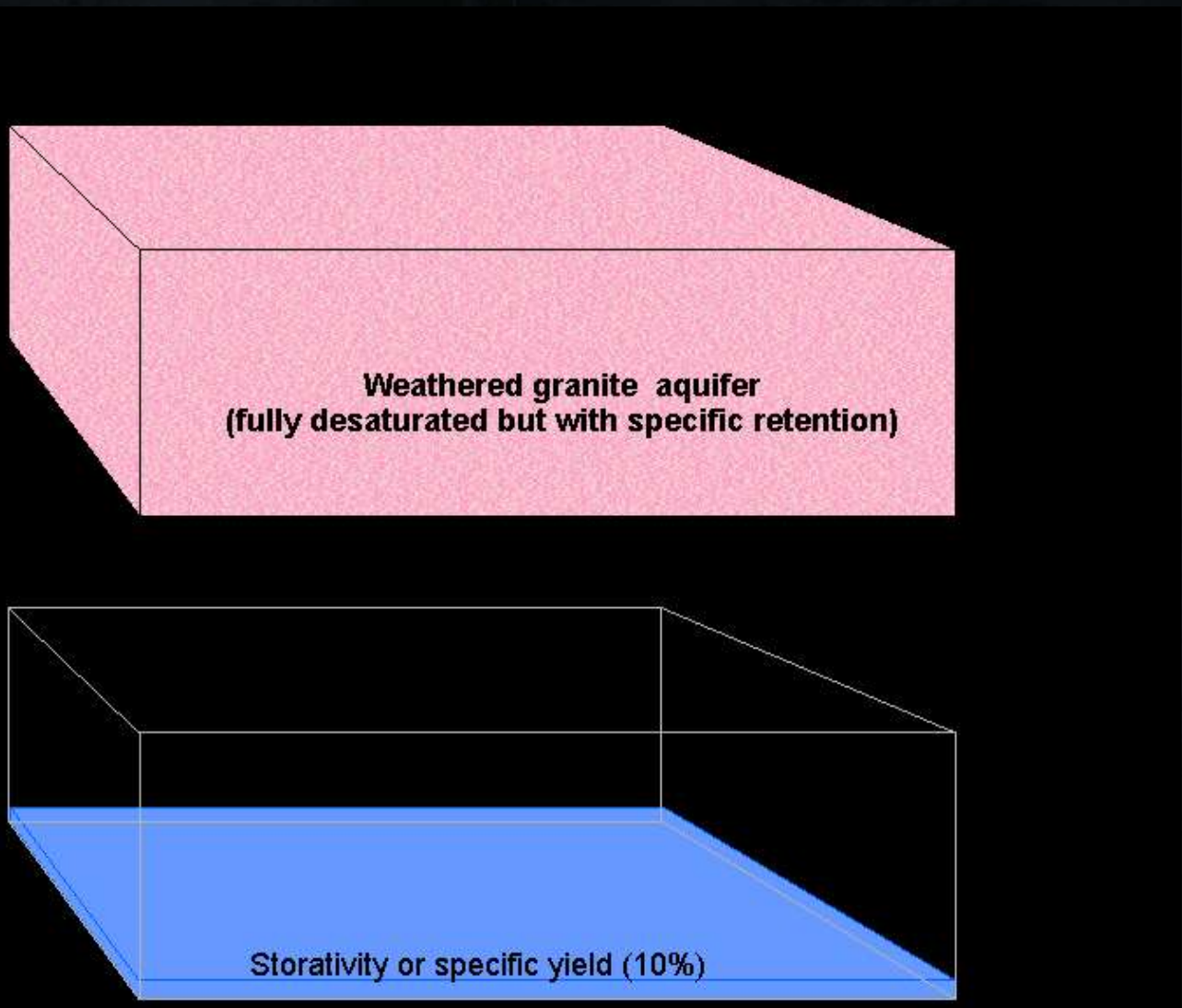

Tank full with water
Empty tank


Empty tank
Tank full with water


Sand
Empty tank

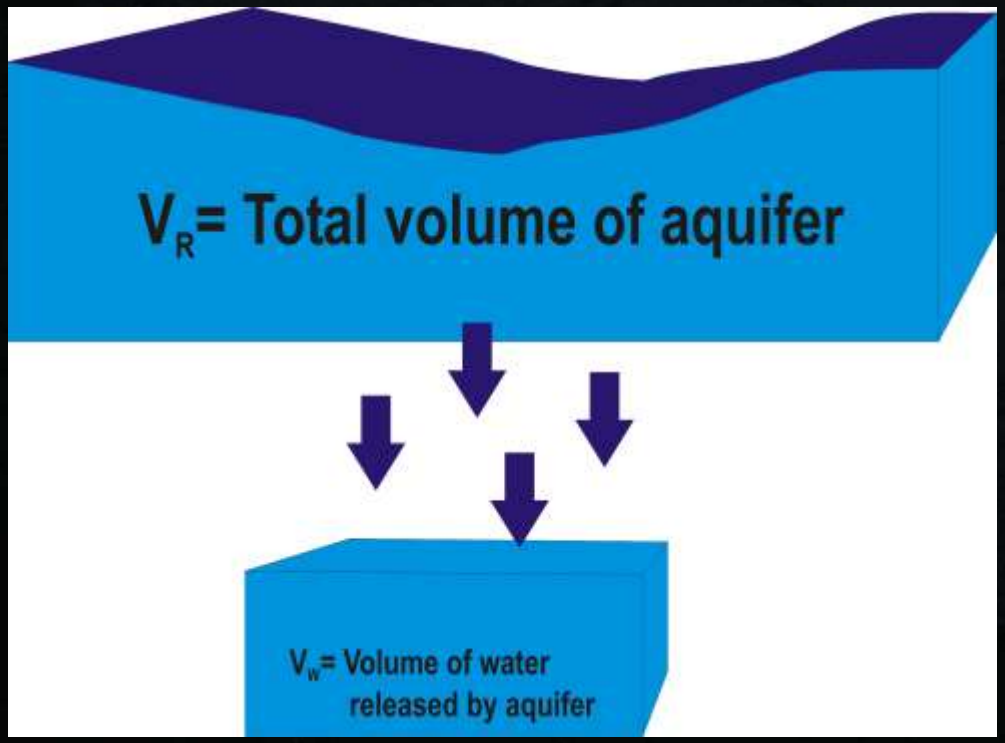

Sandy aquifer (fully saturated)
Empty tank


Sandy aquifer
(fully desaturated but with specific retention)
Storativity or specific yield (30%)


Weathered granite aquifer
(fully desaturated but with specific retention)
Storativity or specific yield (10%)

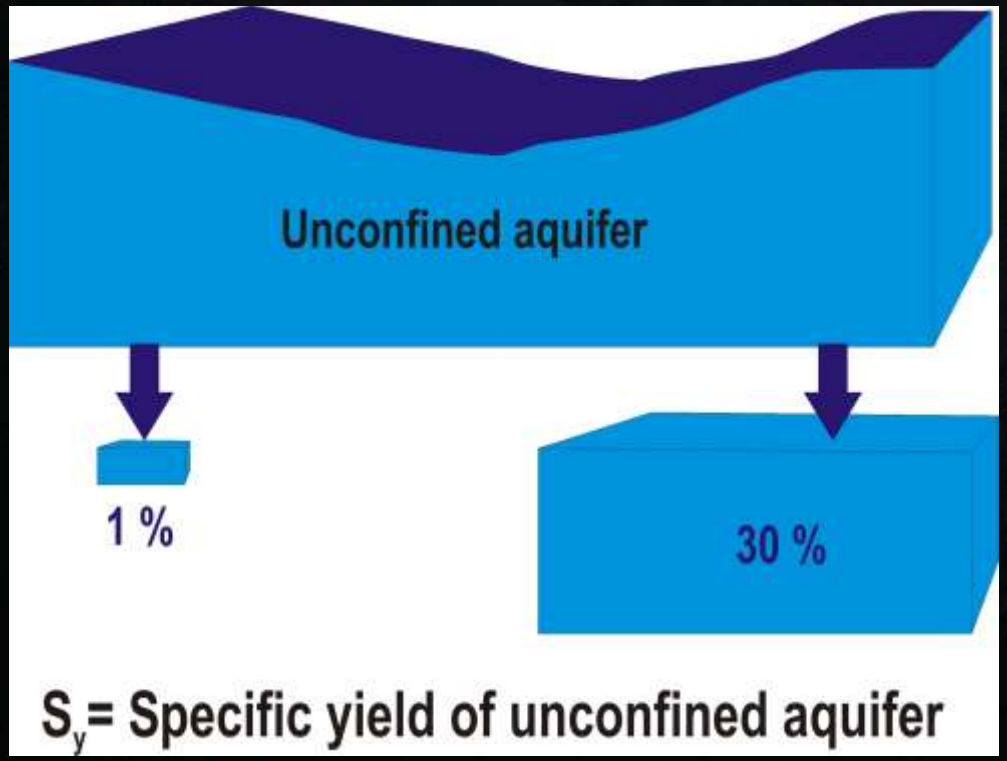
Measurement of storativity

- When we pump out the water from an unconfined aquifer, the water level declines.
- A specific quantity of water is released from a unit volume of aquifer under the influence of gravity.
- If V_R is volume of aquifer releasing V_w volume of water under gravity then $\mathbf{V_W \propto V_R}$
- $V_W = S \times V_R$
- $\mathbf{S = V_W / V_R}$ where S is Storativity



Specific yield – unconfined aquifer

- Generally specific yield for an unconfined aquifer ranges between 1 to 30% or 0.01 to 0.3
- Specific yield values are useful in estimating the aquifer storage and the changes therein (±Δs) for an unconfined aquifer.



Example for calculating recharge using specific yield

Recharge (over a specific time) is indicated by a positive change (addition) in the aquifer storage (**+ Δs**)

Hence,

$+ \Delta s = A \times (+wl) \times (S_y)$

Example

The water table rises by 3 m over an area of 1000 m^2, with an aquifer specific yield of 0.025.

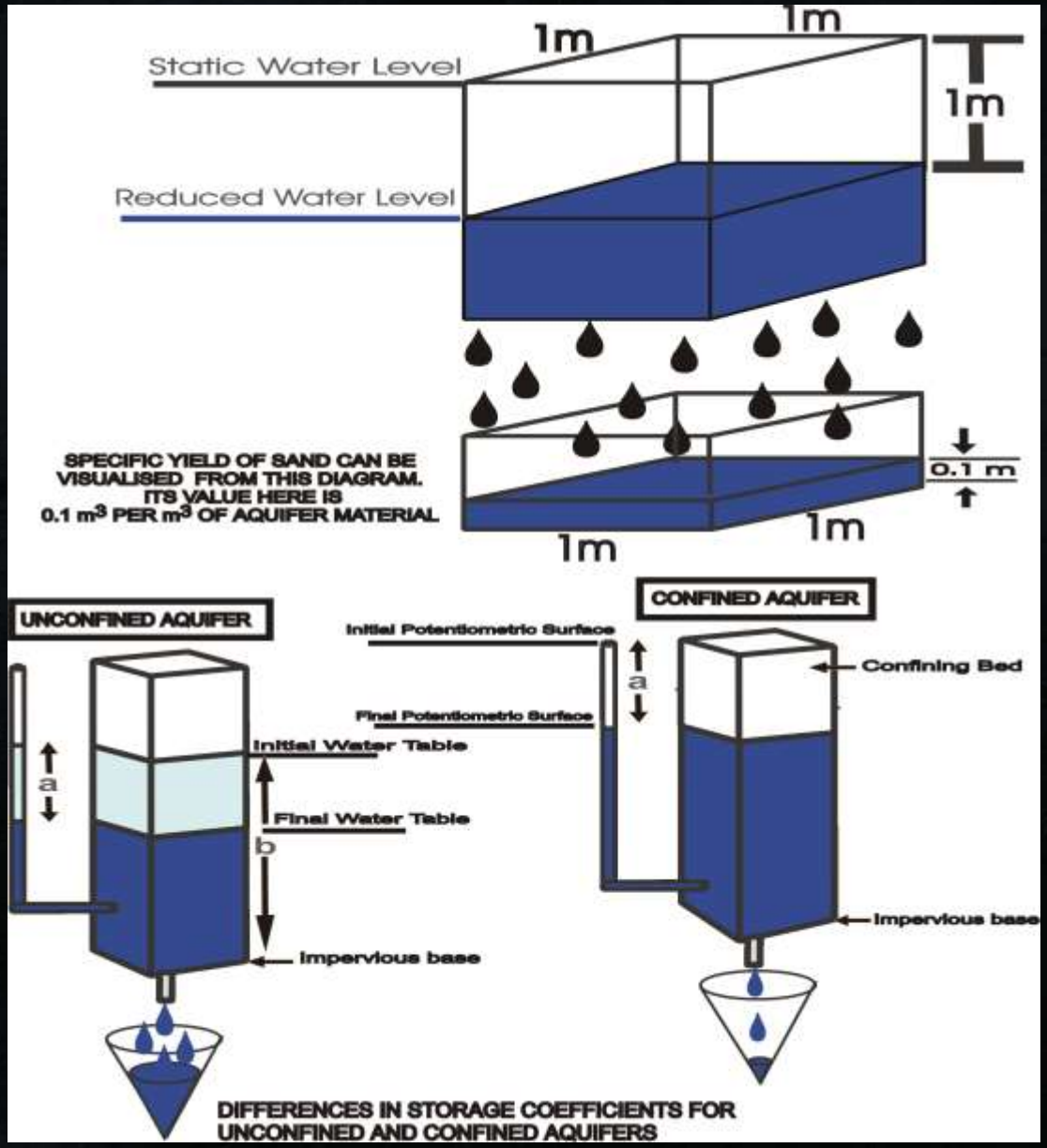
The increase in aquifer storage (as per the equation) is

$+ \Delta s = 1000 \times 3 \times 0.025$

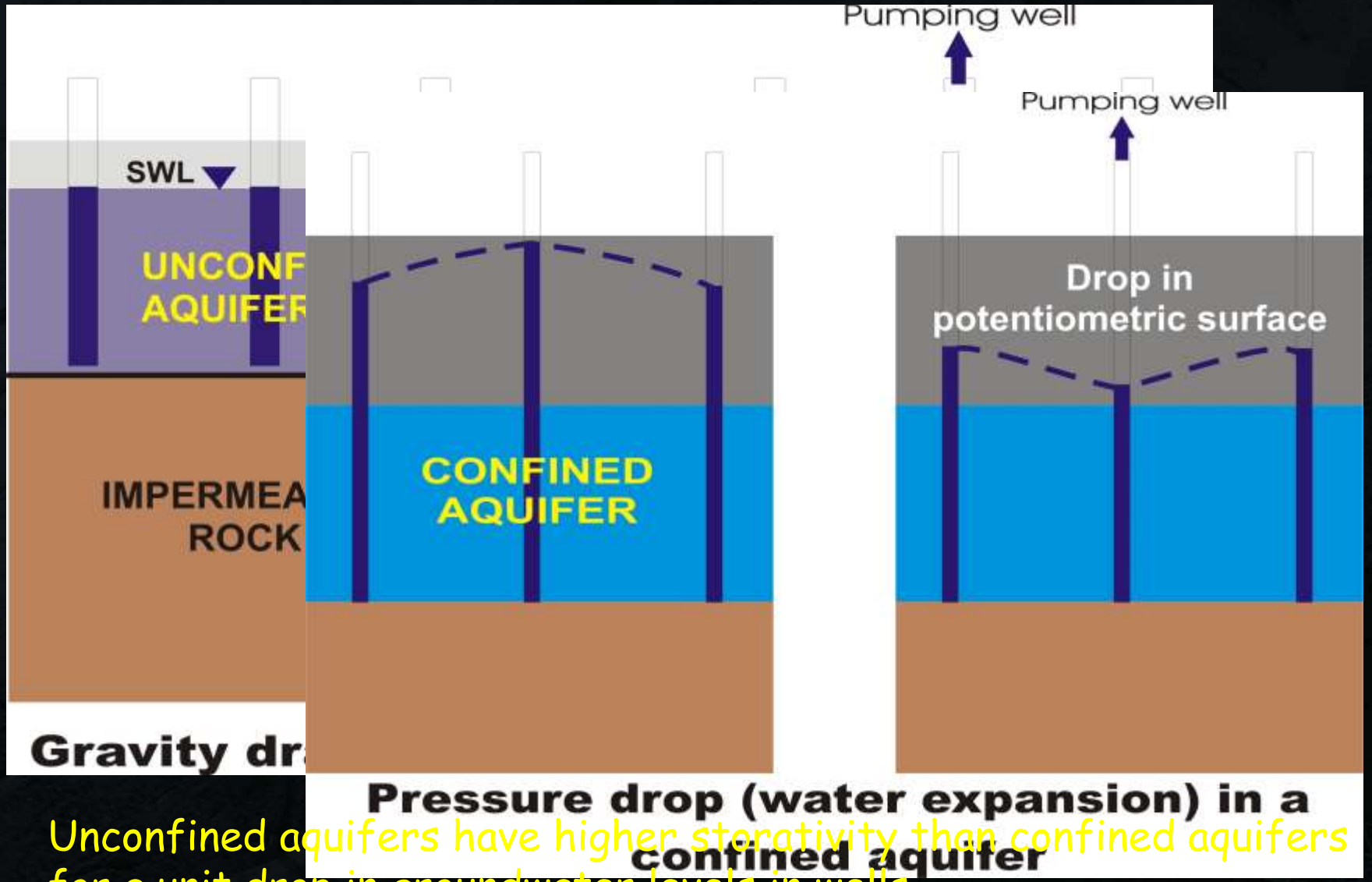
= 75 m^3

Hence, **75 m^3** of water is added to the aquifer

Storage coefficient



Unconfined and confined aquifers: change in storage on pumping



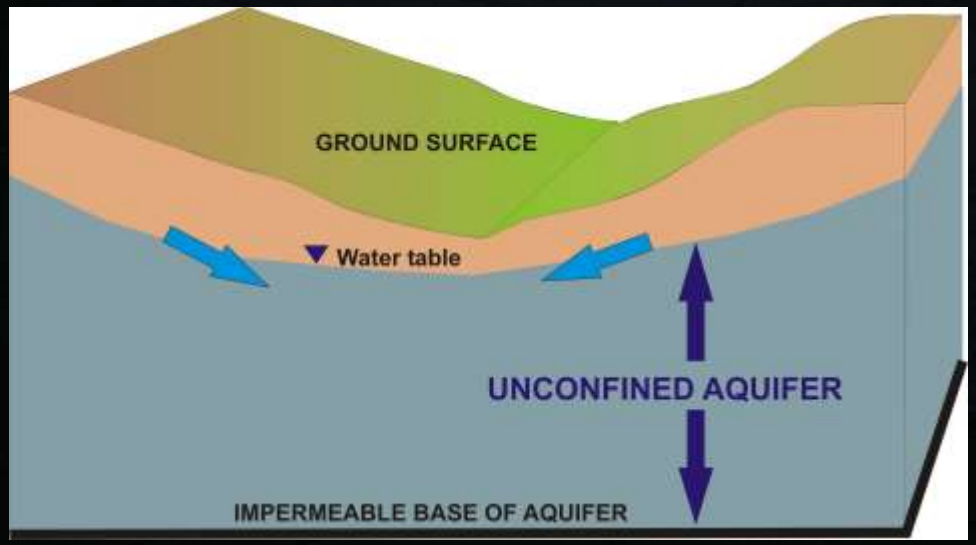
Unconfined aquifers have higher storativity than confined aquifers for a unit drop in groundwater levels in wells

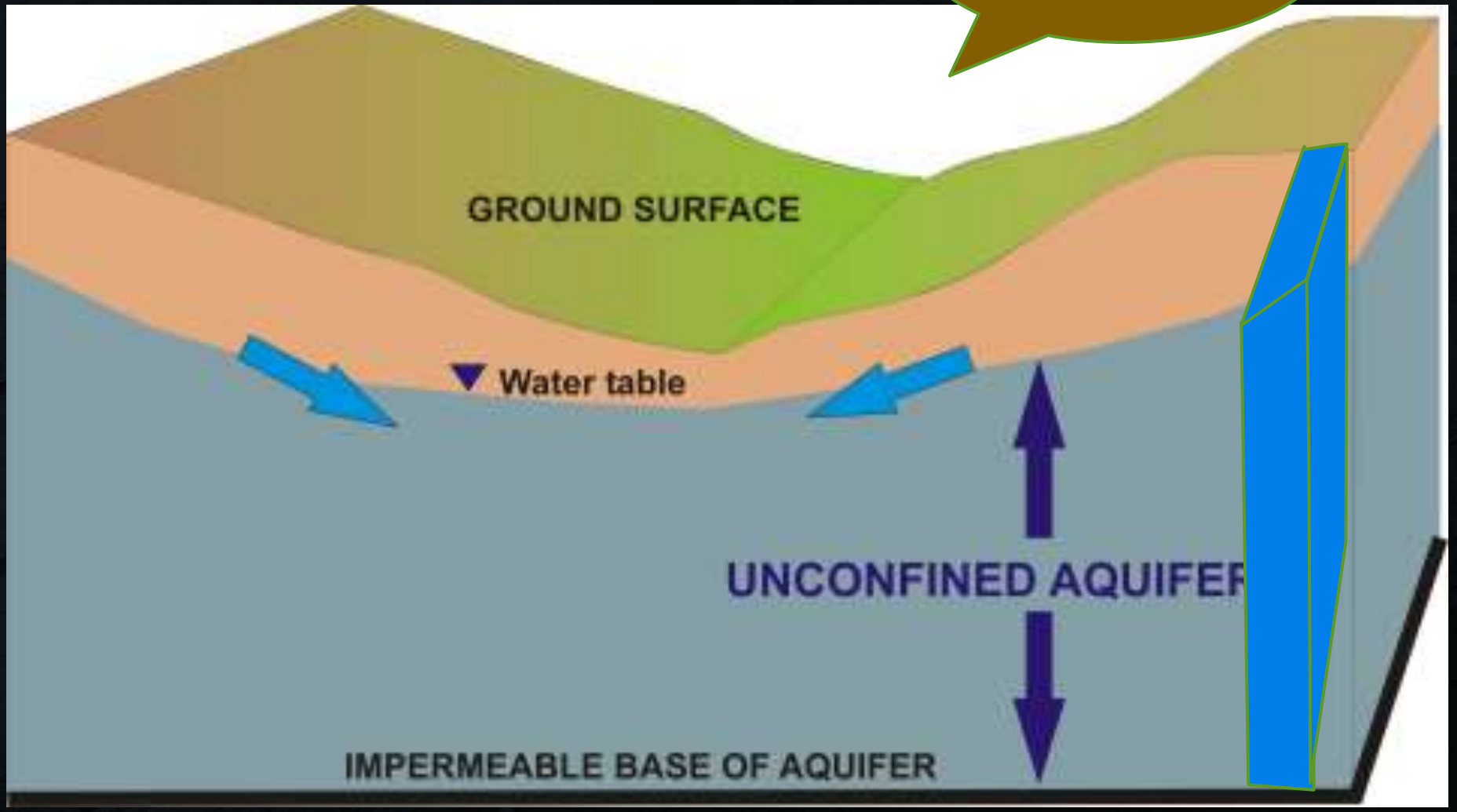
TRANSMISSIVITY

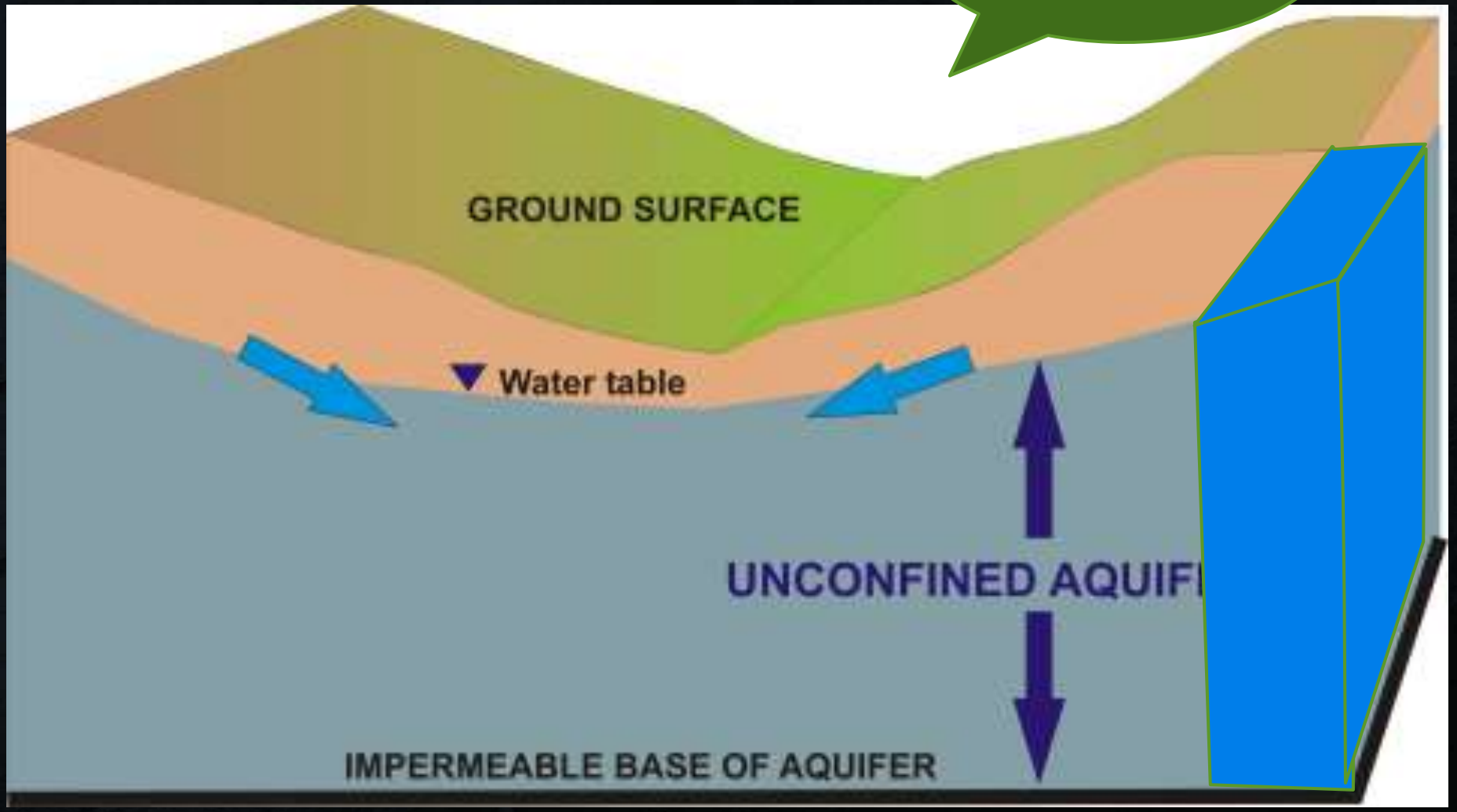
An aquifer performs the function of TRANSMISSION (flow) of groundwater along with that of storage.

Groundwater moves through the porous or fracture network of an aquifer under the influence of hydraulic gradient. This *movement* is called transmission.

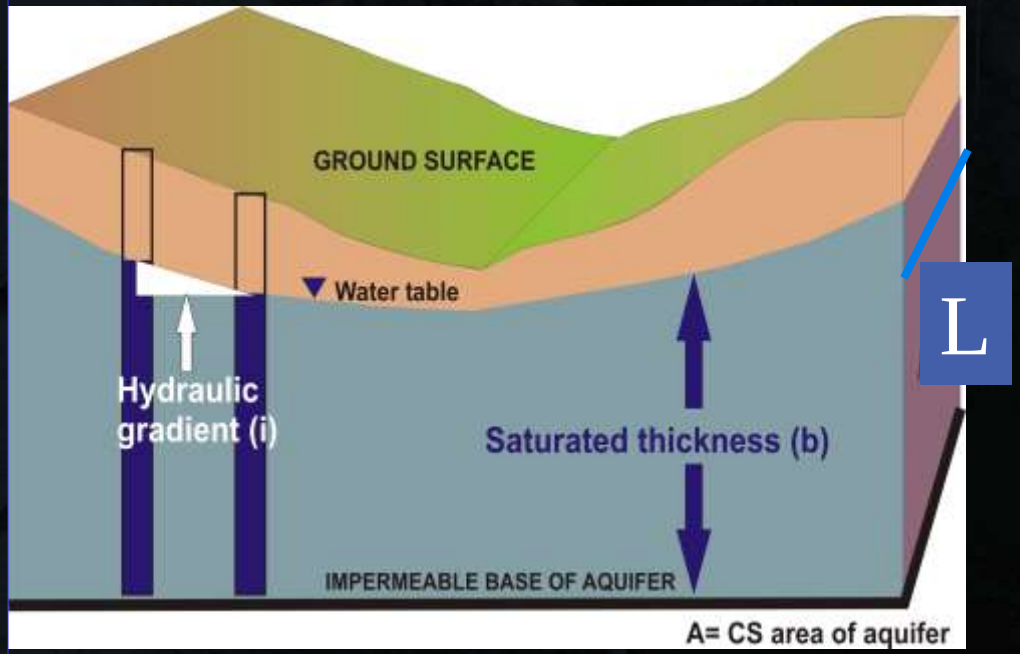
If the aquifer is spread out regionally underground, then the movement of groundwater also takes place on a regional scale.




Low transmissivity
GROUND SURFACE
Water table
UNCONFINED AQUIFER
IMPERMEABLE BASE OF AQUIFER


High transmissivity
GROUND SURFACE
Water table
UNCONFINED AQUIFI
IMPERMEABLE BASE OF AQUIFER

A slight modification to the Darcy's law



- By taking the entire thickness of the aquifer (b) into account one can better visualize the transmission of water through the aquifer.
- By introducing "*b*" into Darcy's law, we have

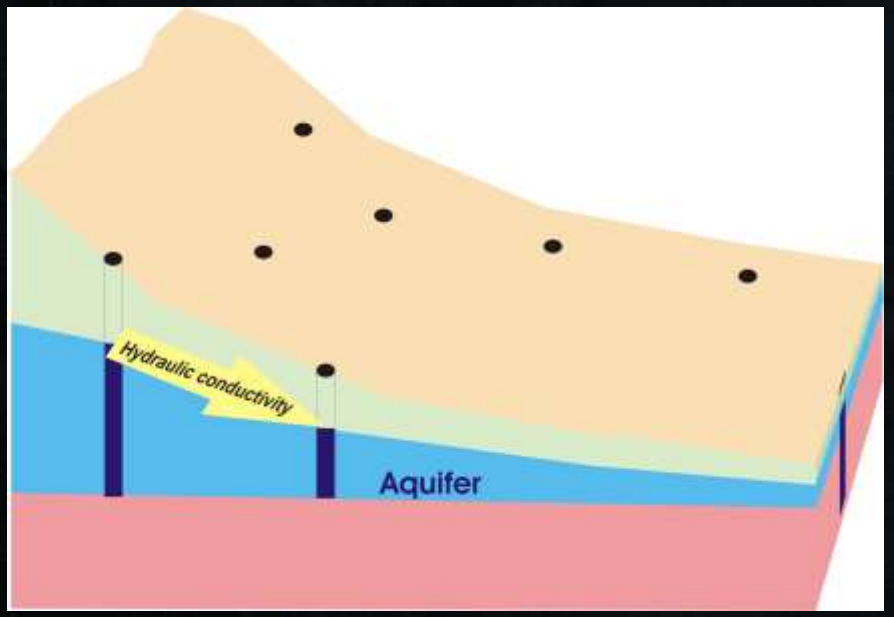
Q = KbiL

i.e. Q = TiL

Hydraulic conductivity and Transmissivity

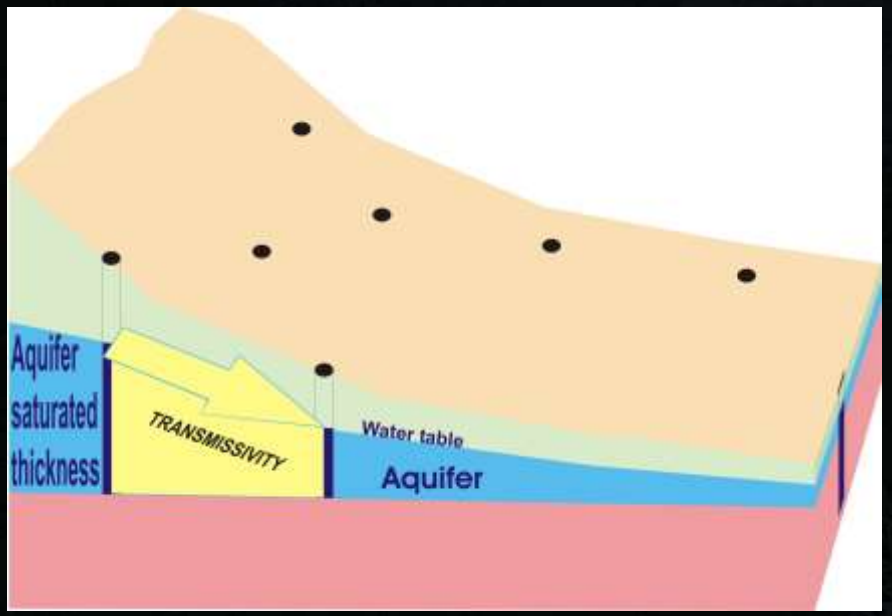
Hydraulic conductivity gives a measure of the rate of groundwater flow in an aquifer

in metres per minute or m/sec or feet/sec etc.



Transmissivity gives a measure of the yield of an aquifer

in m^3/min/m, i.e. m^2/min or m^2/day

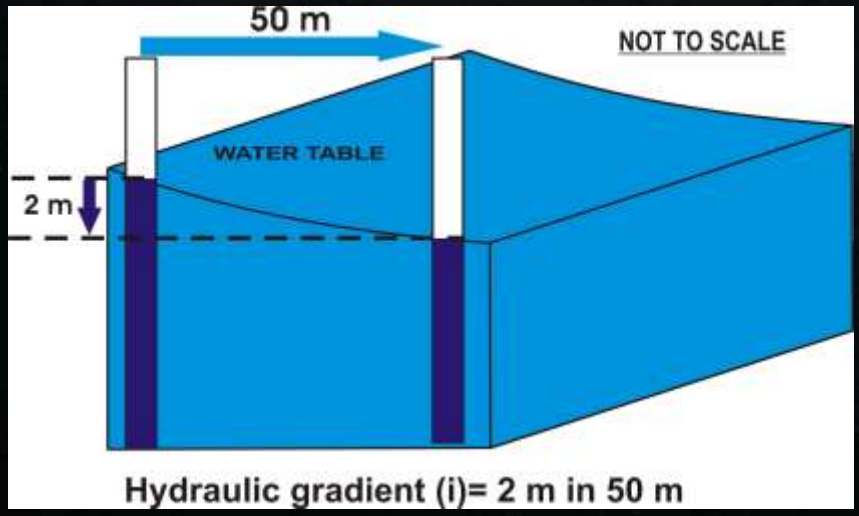


Hydraulic Gradient: slope of the water table / potentiometric surface

- The difference in water table or potentiometric surface between the two wells divided by the distance between those wells in the field is called *HYDRAULIC GRADIENT*.

- For example, a 2 m drop in head (water level) between two wells situated laterally at a distance of 50 m from each other, indicates a hydraulic gradient of

2 / 50= 0.04 m/m



An example

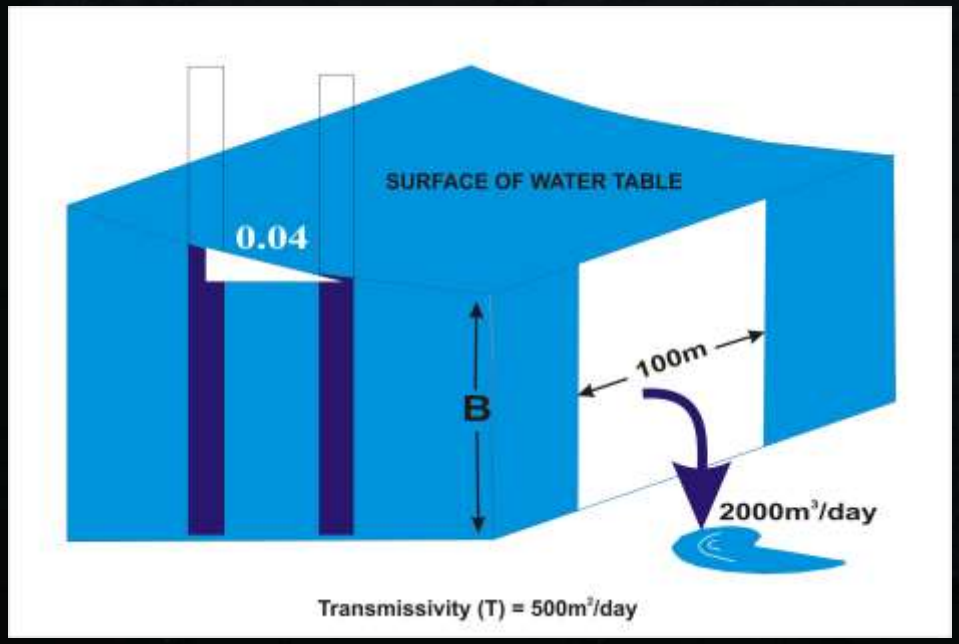
- Discharge rate (Q) = 2000 m^3/day
- Length of aquifer cross section (L)= 100 m
- Hydraulic gradient (i)= 0.04

The volume of the water flowing through that aquifer (Q) based on the equation

Q = TiL

- 20000 = Tx 0.04 x 100m

T = 500 m^2 / day



Transmissivity and storage coefficient - *definitions*

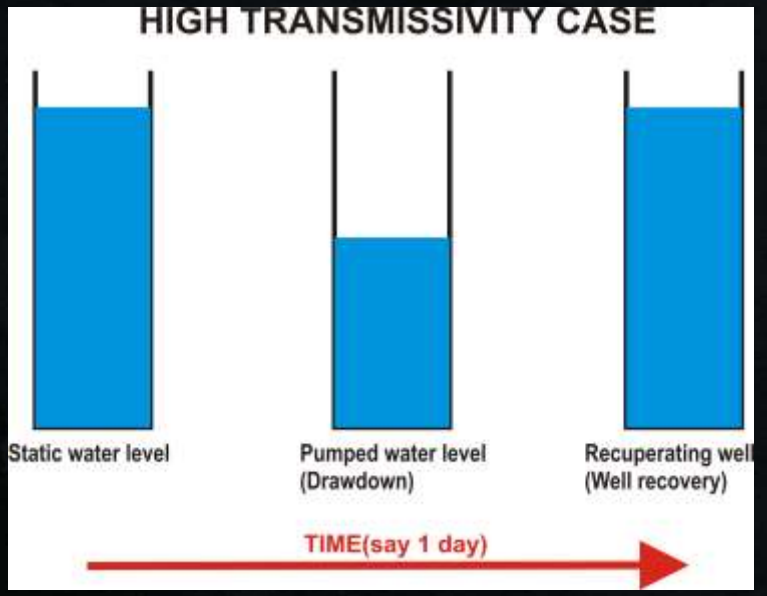
- The capacity of the aquifer to allow flow of groundwater across a unit cross sectional area of the aquifer is called Transmissivity (T).

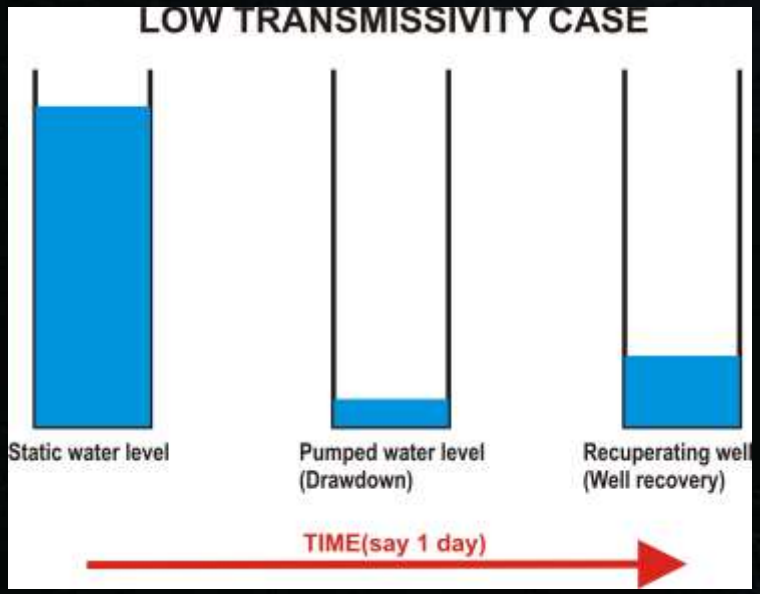
- The capacity of the aquifer to allow a certain volume of groundwater storage within the limits of the aquifer is its storage coefficient or Storativity (S).

T and S are properties of the aquifer,
i.e. the rock / rock material that holds groundwater

How does aquifer trasmissivity affect a well…

- A high T allows a significant quantity of groundwater move quickly towards the well.
- A low T means smaller quantities of water to the well and rather slowly.





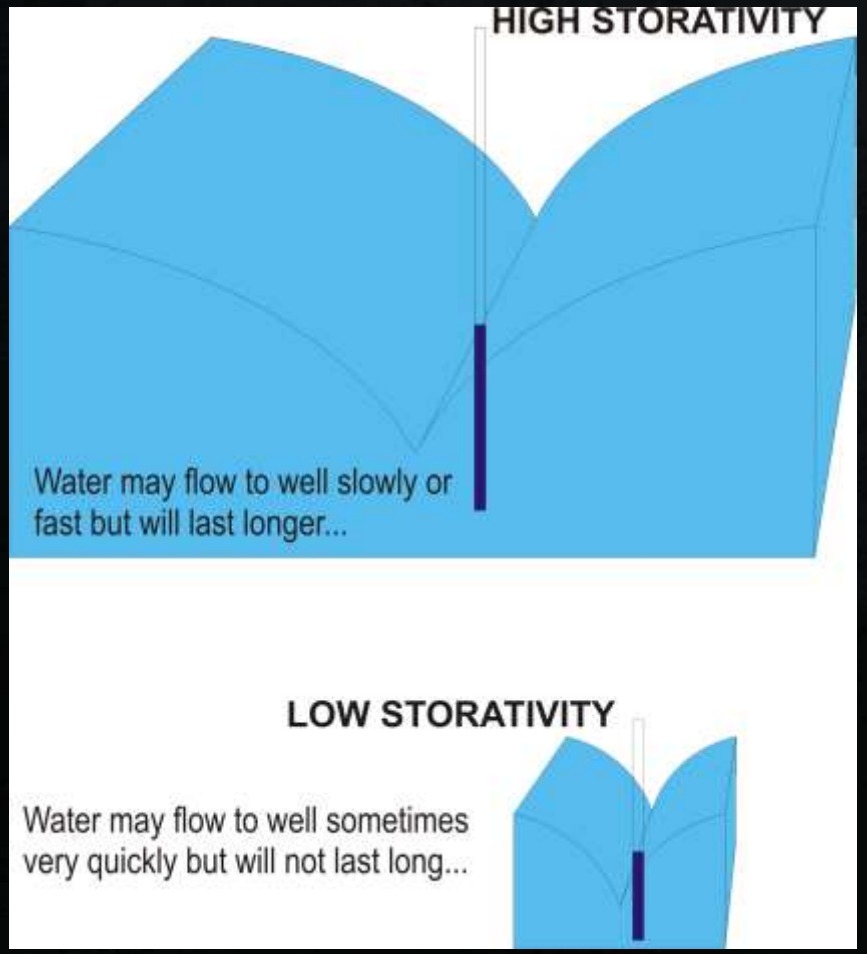
How does aquifer trasmissivity affect a spring…

- High T implies a high-discharge spring

- A low T implies that spring discharge is usually small

How does aquifer storativity affect a well…

- A larger storativity of the aquifer allows water to be available to the well over a longer period of time (throughout the year).
- Limited storativity of the aquifer means the well will groundwater over a shorter period of time (seasonally).



How does aquifer storativity affect a spring…

- A larger storativity of the aquifer implies that the aquifer can discharge to the spring over a long period of the year…*perennial spring*

- Limited storativity of the aquifer implies that the aquifer can discharge to the spring only for a part of the year…*seasonal spring*

What can you say about the aquifers feeding these springs?

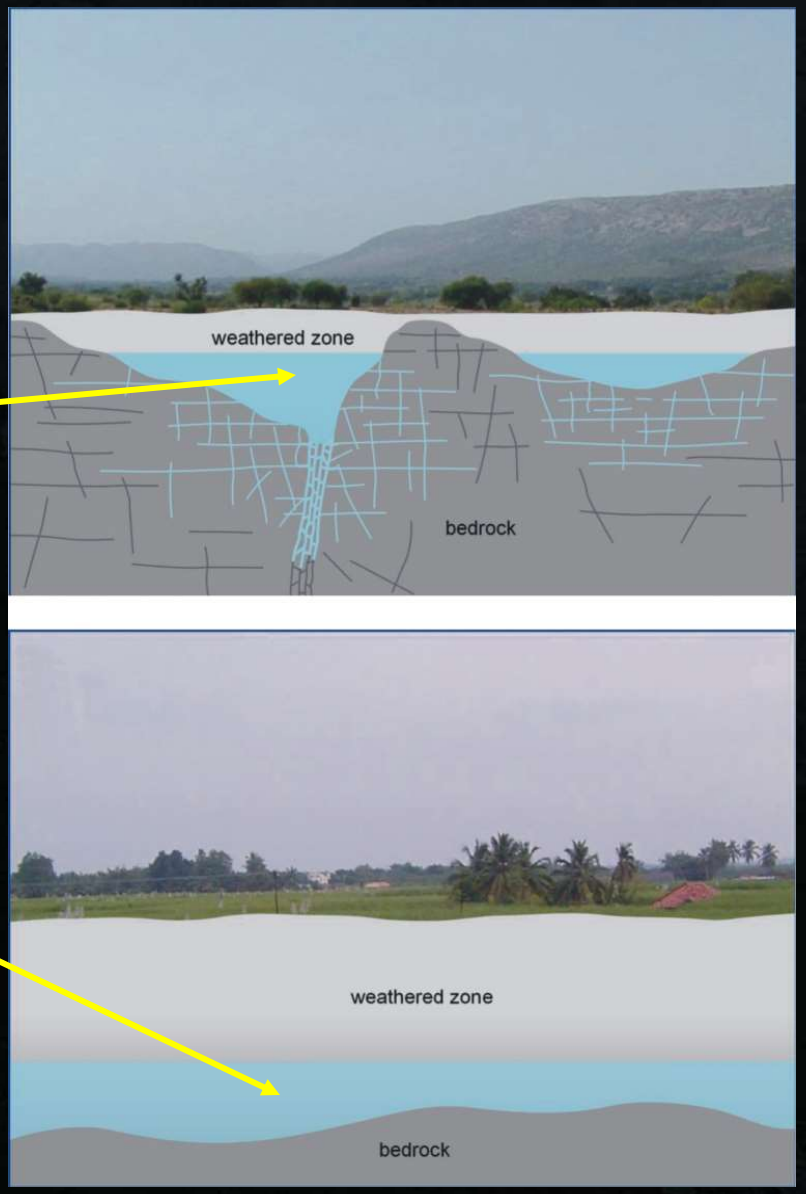
Aquifer material and groundwater

Aquifers filling up…

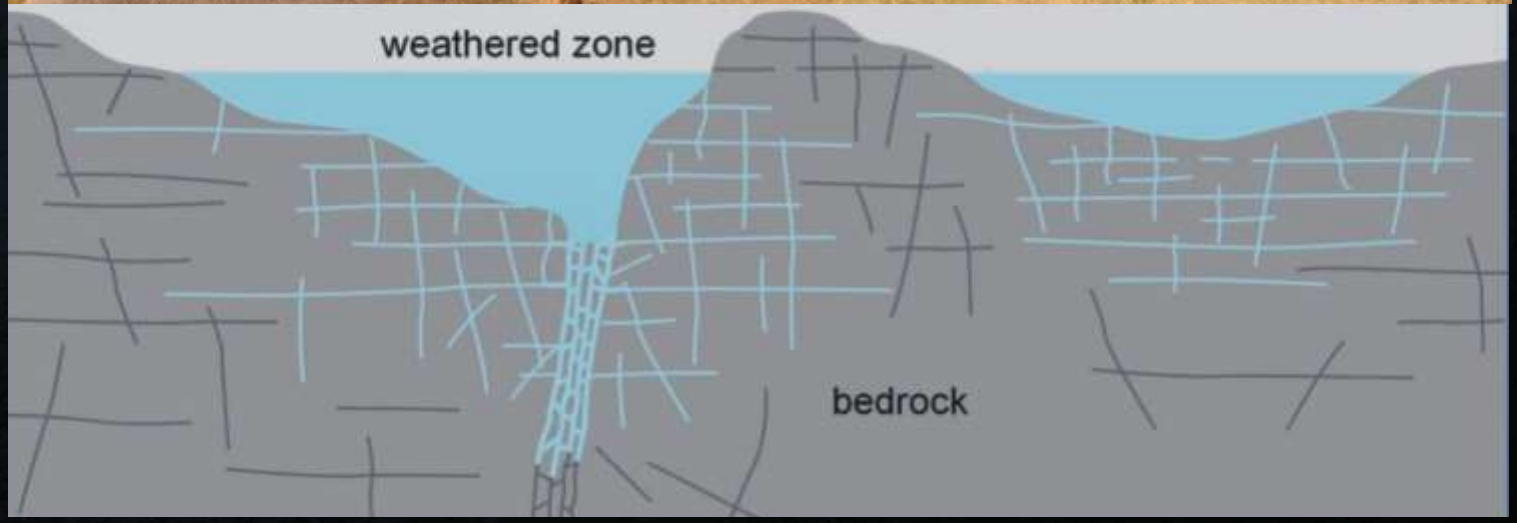
Scale of an aquifer

The rock formation acting as an aquifer may be

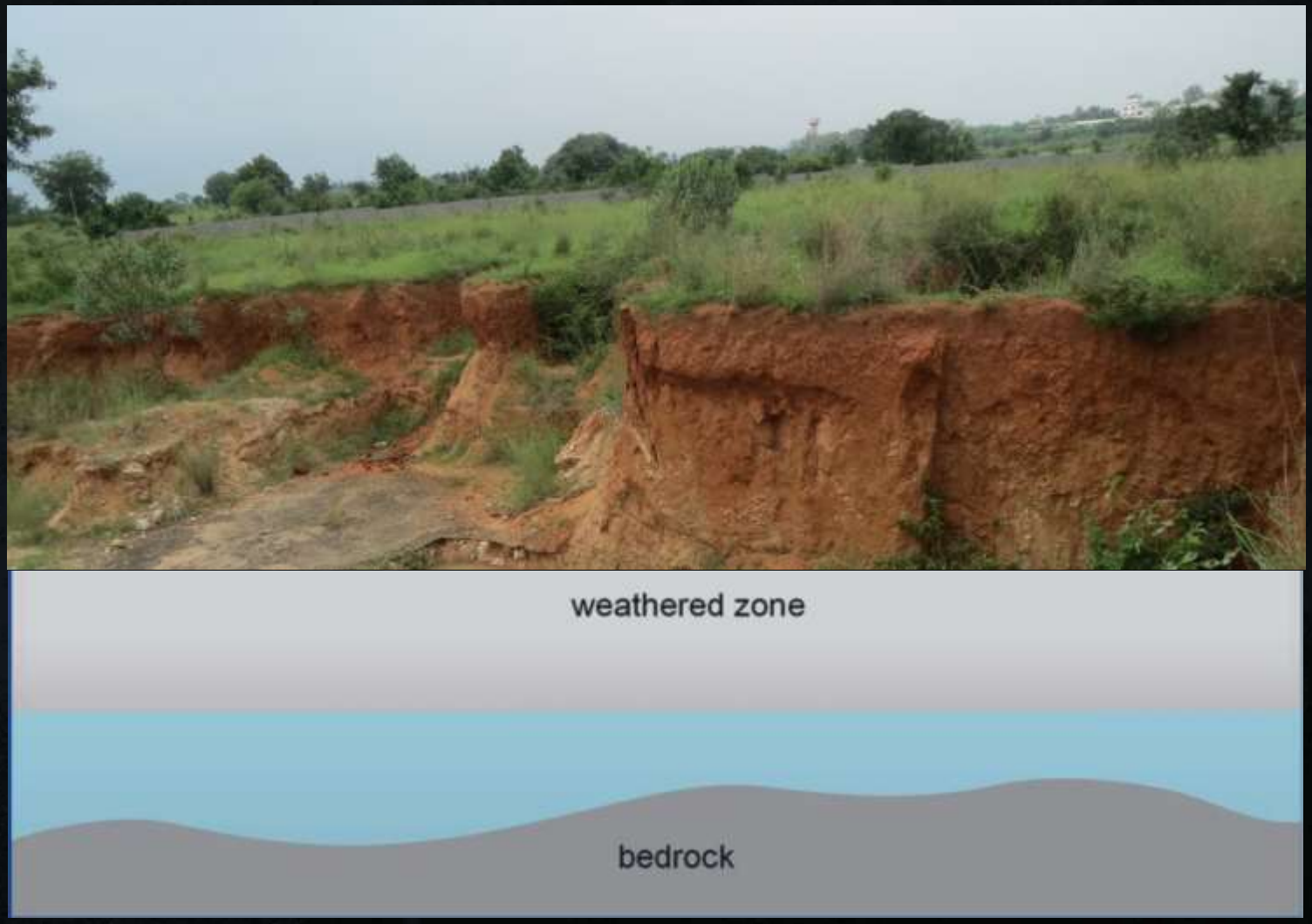
1. quite local or
2. may extend regionally (under a large area)



Local aquifer



Regional aquifer



Functions of an aquifer

An aquifer performs two functions

- Accumulation of water (storage)

- Flow of water (transmission)

The performance of a well depends upon T & S

- **T** determines the pumping rate that a well can sustain. Hence, knowing the T can help decide what is a safe pumping rate for a well.

- **S** governs the sustainability of a well – that is how long will the water in the aquifer be available to a well.


01/01/2005

An exercise...to conclude

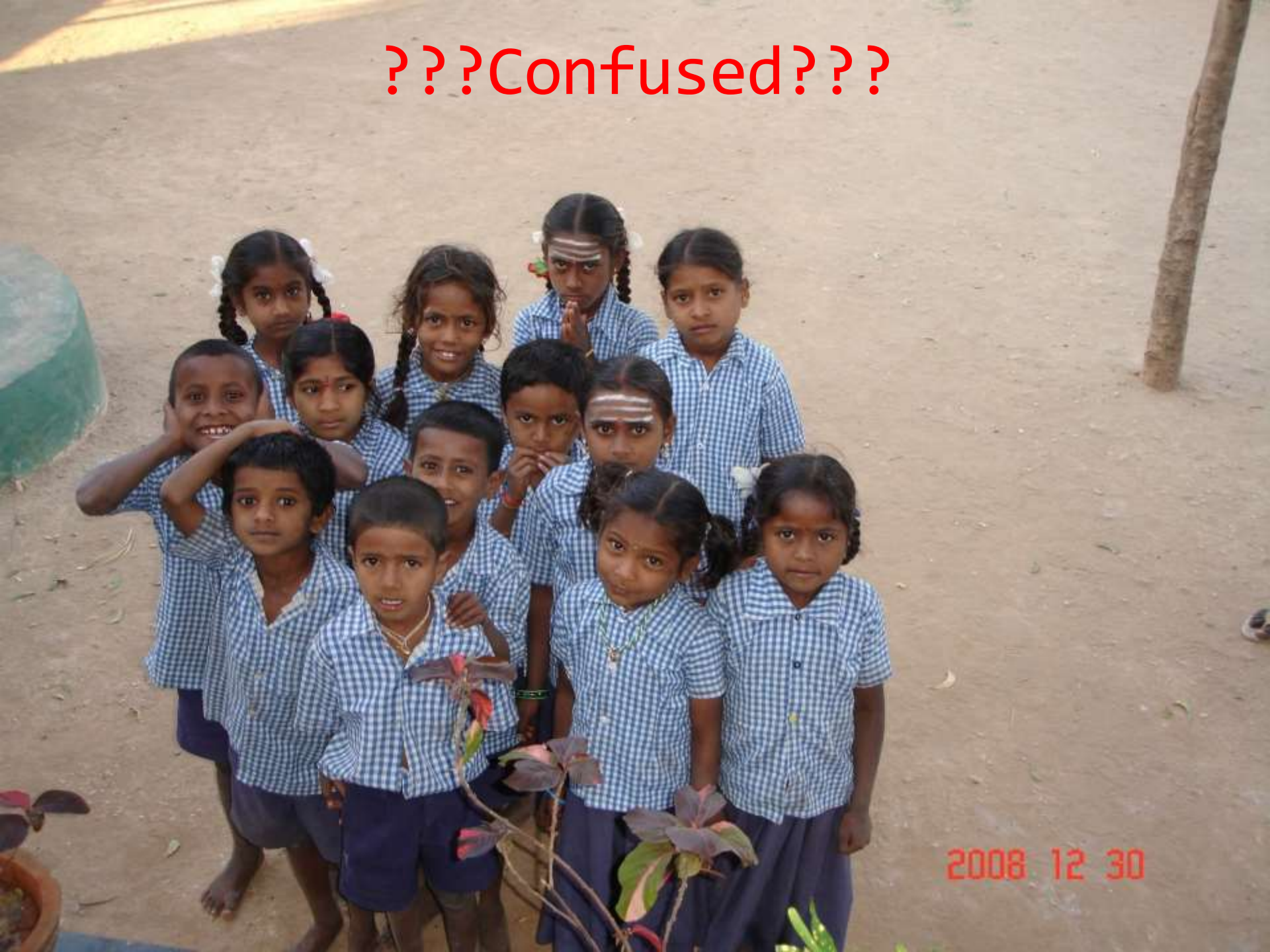
	Storage coefficient	Transmissivity	Aquifer behaviour
Mountain aquifers			
Basalt aquifers / Crystalline aquifers			
Alluvial aquifers			

Water tanker – 5000 litres, i.e. **5 m^3**

An exercise...to conclude

	Storage coefficient	Transmissivity	Aquifer behaviour
Mountain aquifers (Area 50 ha, 5m thick)	0.001	10 to 50 m^2/day	Storage equivalent to 500 TANKERS with 2 to 10 TANKERS moving a distance of 1 m every day
Basalt aquifers / Crystalline aquifers (Area 200 ha, 10m thick)	0.01	5 to 100 m^2/day	Storage equivalent to 40000TANKERS with 1 to 20 TANKERS moving a distance of 1 m every day
Alluvial aquifers (Area 500 ha, 50m thick)	0.1	500 m^2/day and more	Storage equivalent to 50000000 TANKERS with 100 TANKERS moving a distance of 1 m every day

A well being pumped…with a pump


???Confused???
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