GROUNDWATER ??

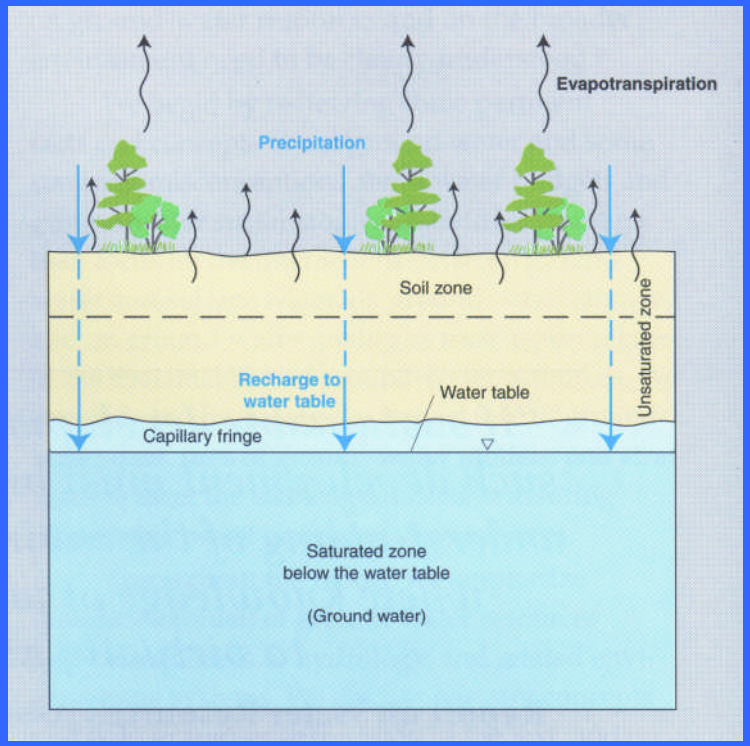
OUTLINE OF PRESENTATION

- What is groundwater?
- Geologic investigation
- Definitions: aquifer and aquitard, unconfined and semi-confined
- Water level and interpretation of water level data
- Well yield
- Hydraulic properties: storage coefficient, hydraulic conductivity transmissivity

DEFINITIONS

What is groundwater?:

Groundwater is the water below the surface of the ground where the sediments are saturated.



(USGS Circular 1186, 1999. Figure 4)

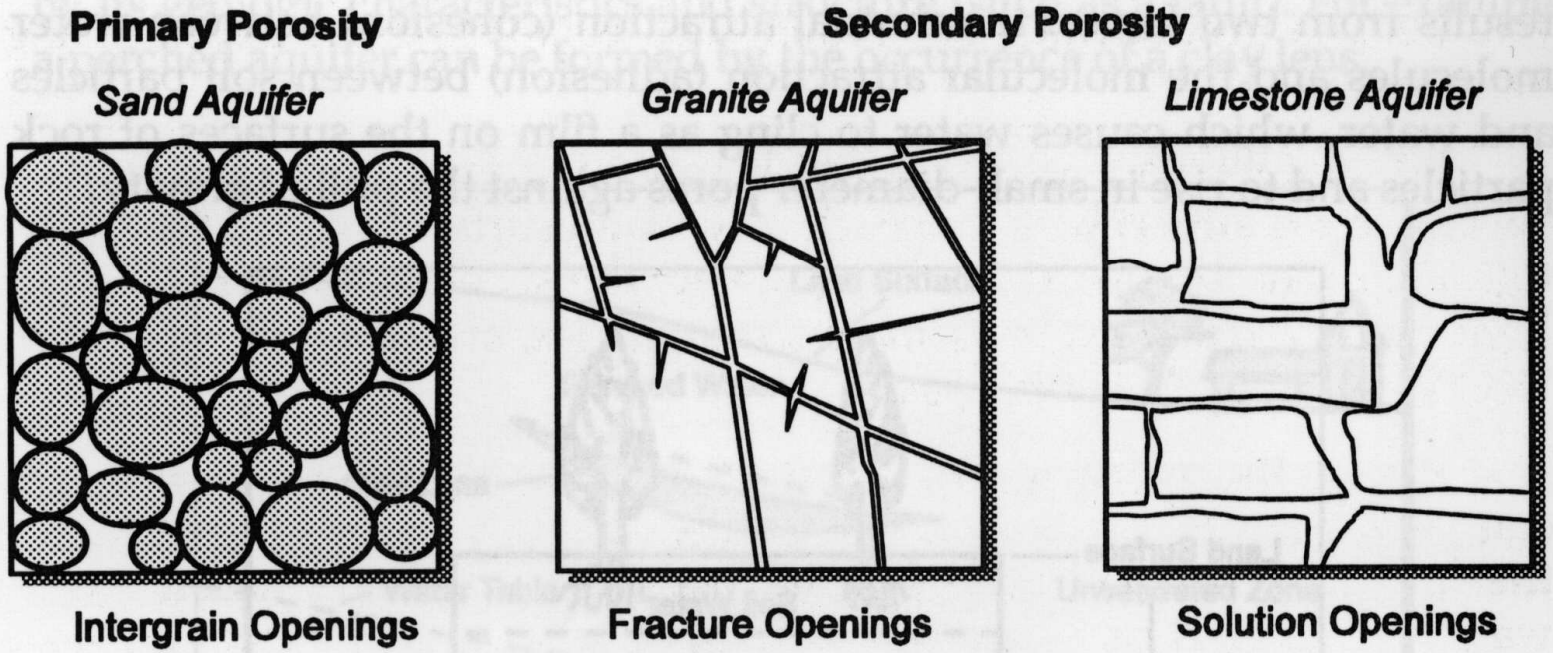


Figure 2. Groundwater is contained in interconnected pore spaces between rock particles or in fractures and fissures (Modified from Meinzer, 1923)

[Source: Moore et al. Groundwater a primer. AGI, IAH, 1995]

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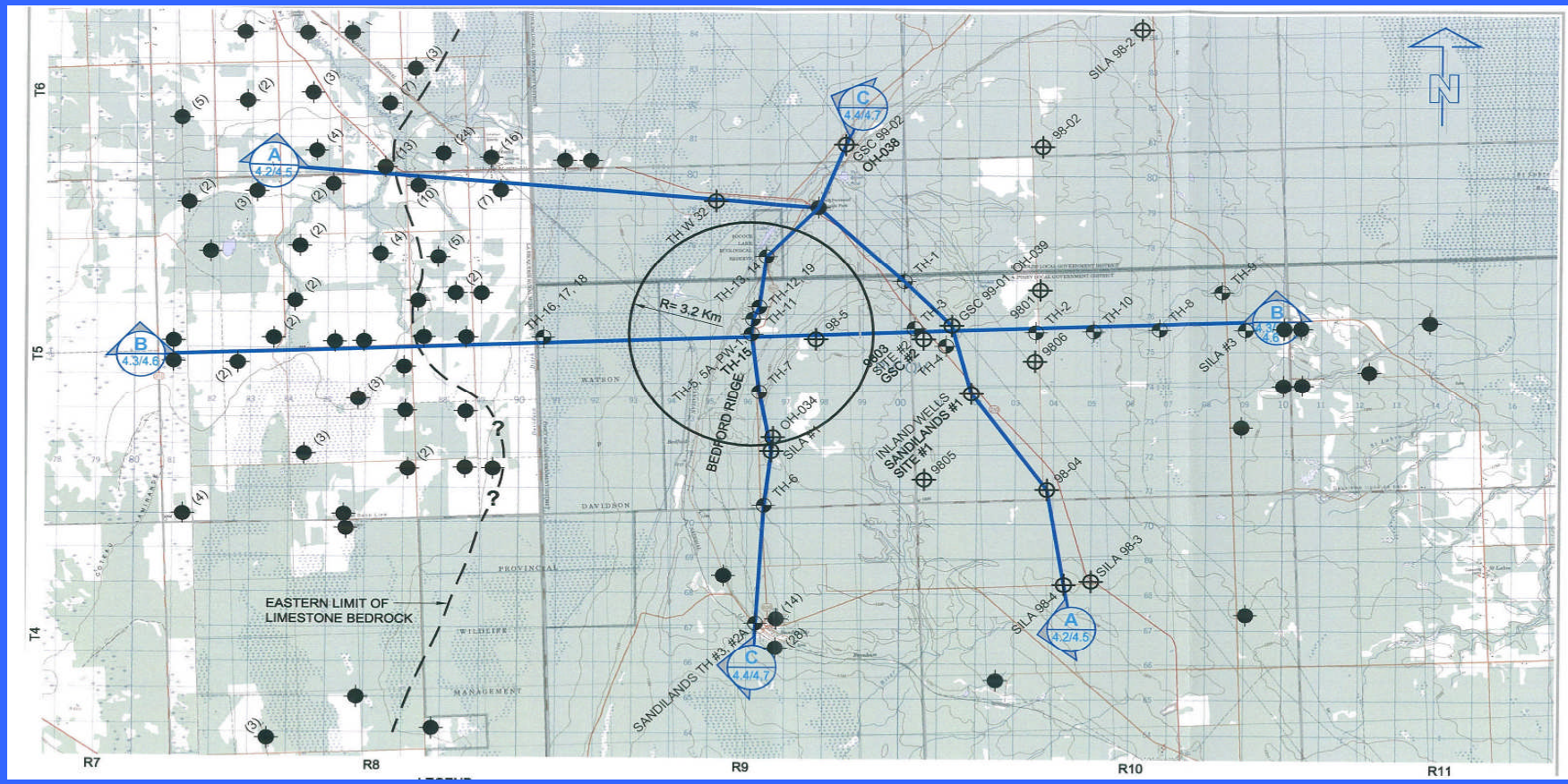
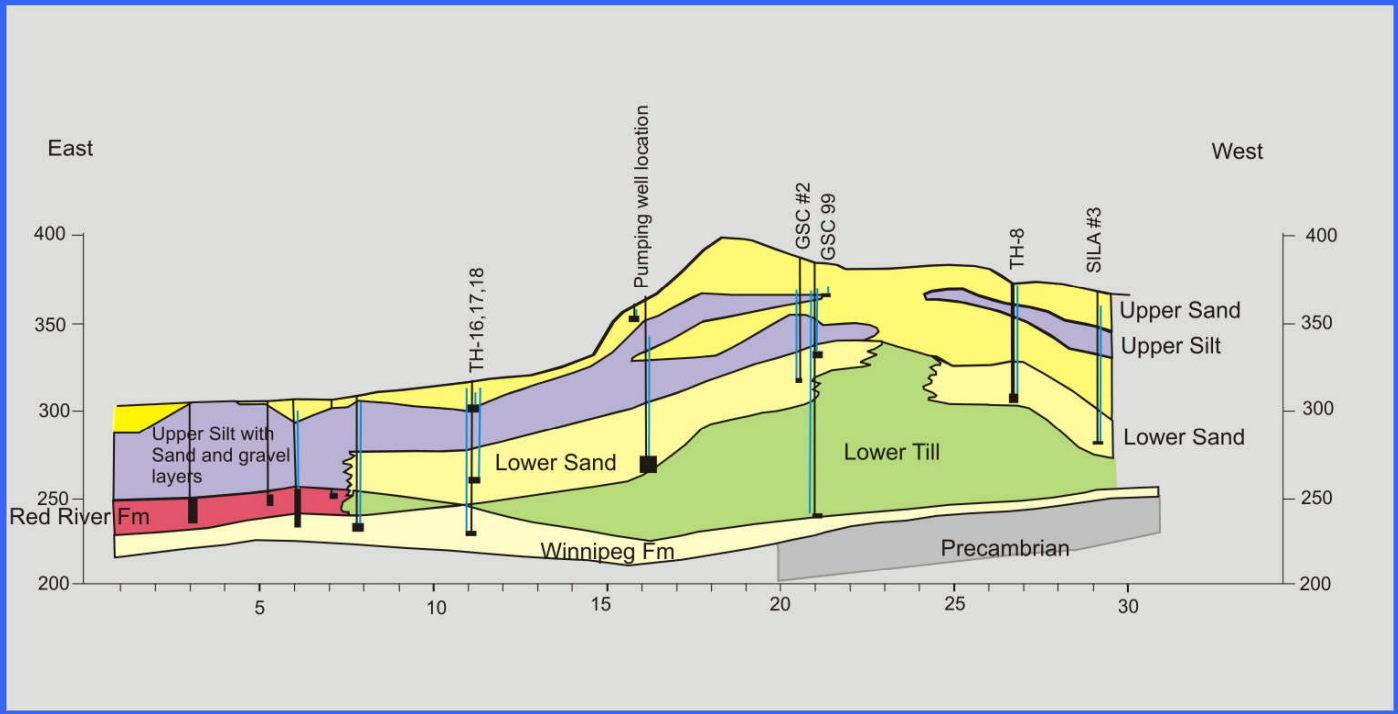
Testhole drilling to establish the geological setting



Construction of cross sections to establish the geological framework



Geological cross section

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DEFINITIONS: AQUIFER AND AQUITARD

Aquifer:

An aquifer is a saturated geologic unit that is permeable enough to yield economic quantities of water to wells.
An aquifer can be part of a geological formation, the entire formation or group of formations.

Aquifers: sand and gravels, sandstone, fractured rock

Aquitard:

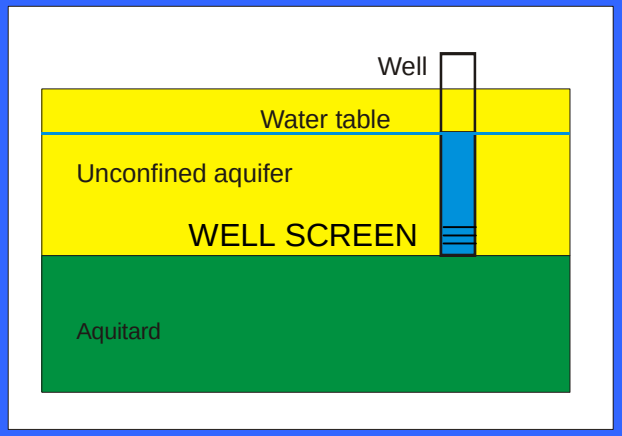
An aquitard is a saturated geologic unit which is permeable enough to transmit water in significant quantities over large areas and long periods, but does not yield economic quantities of water to wells.

Aquitards: clay tills, silts, clays, shales, unfractured rock

DEFINITIONS: UNCONFINED AND SEMI-CONFINED AQUIFER

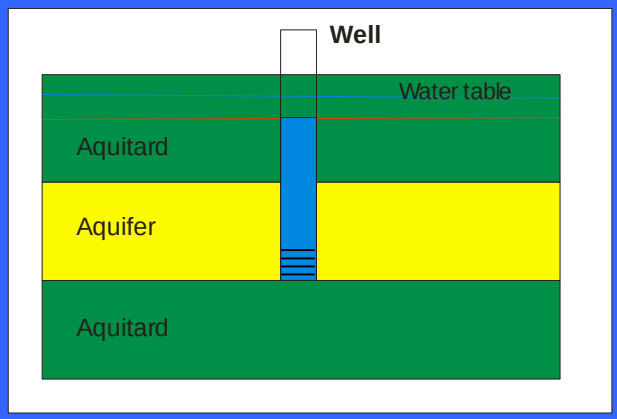
Unconfined aquifer:

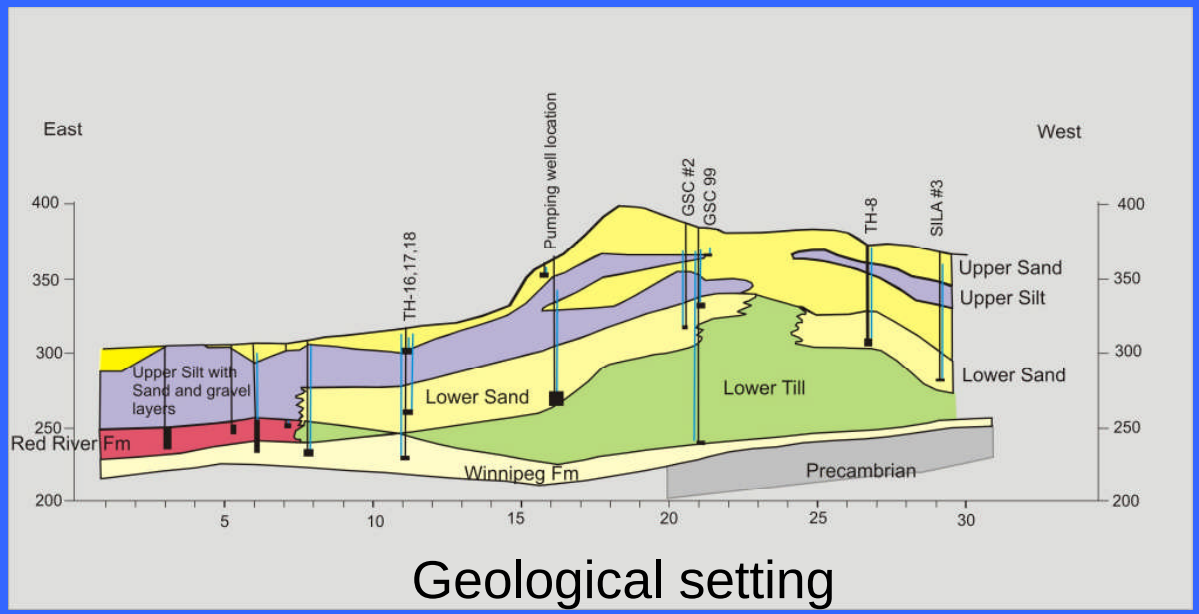
An unconfined aquifer, or water-table aquifer, is an aquifer bounded at the bottom by an aquitard and at the top by the water table.



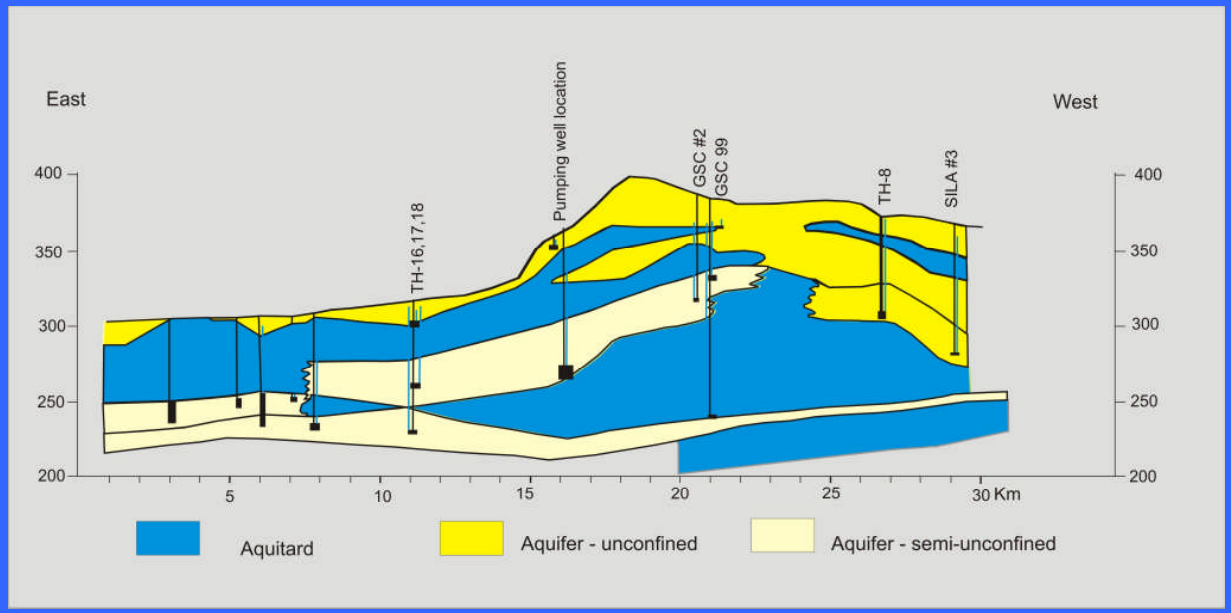
Semi-confined aquifer:

A semi-confined, or leaky aquifer, is an aquifer bounded at the top and bottom by aquitards.



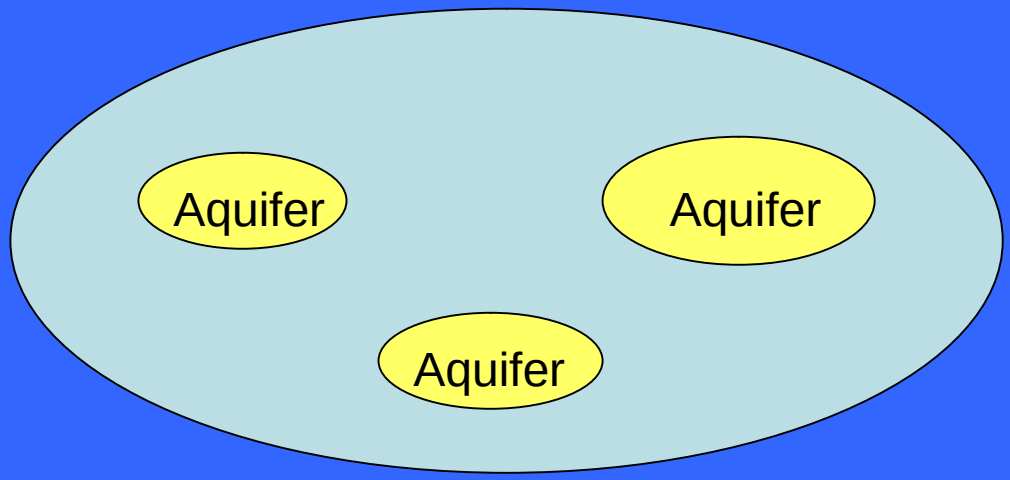


Geological setting

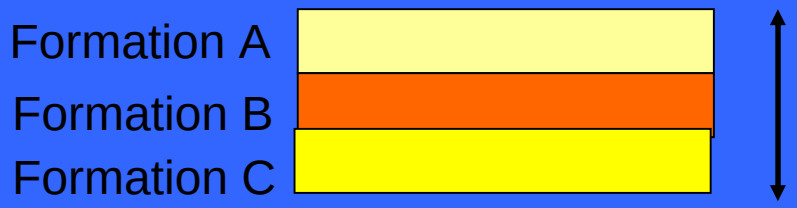


Hydrogeological setting

Geological settings and therefore, hydrogeological settings, are often complex.



Single geological unit but several hydrogeological units



Several geological unit can form a single hydrogeological unit

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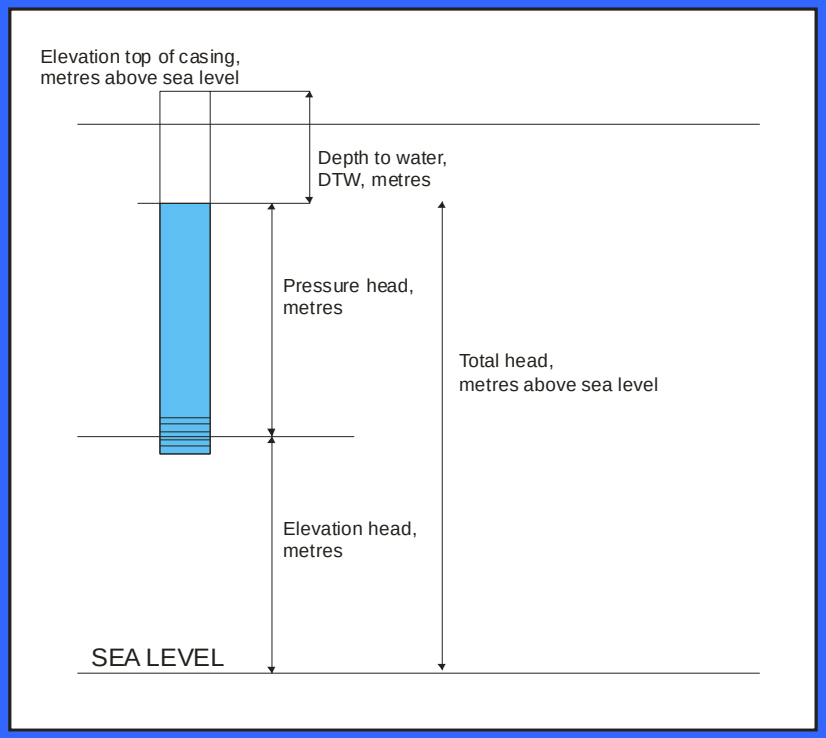
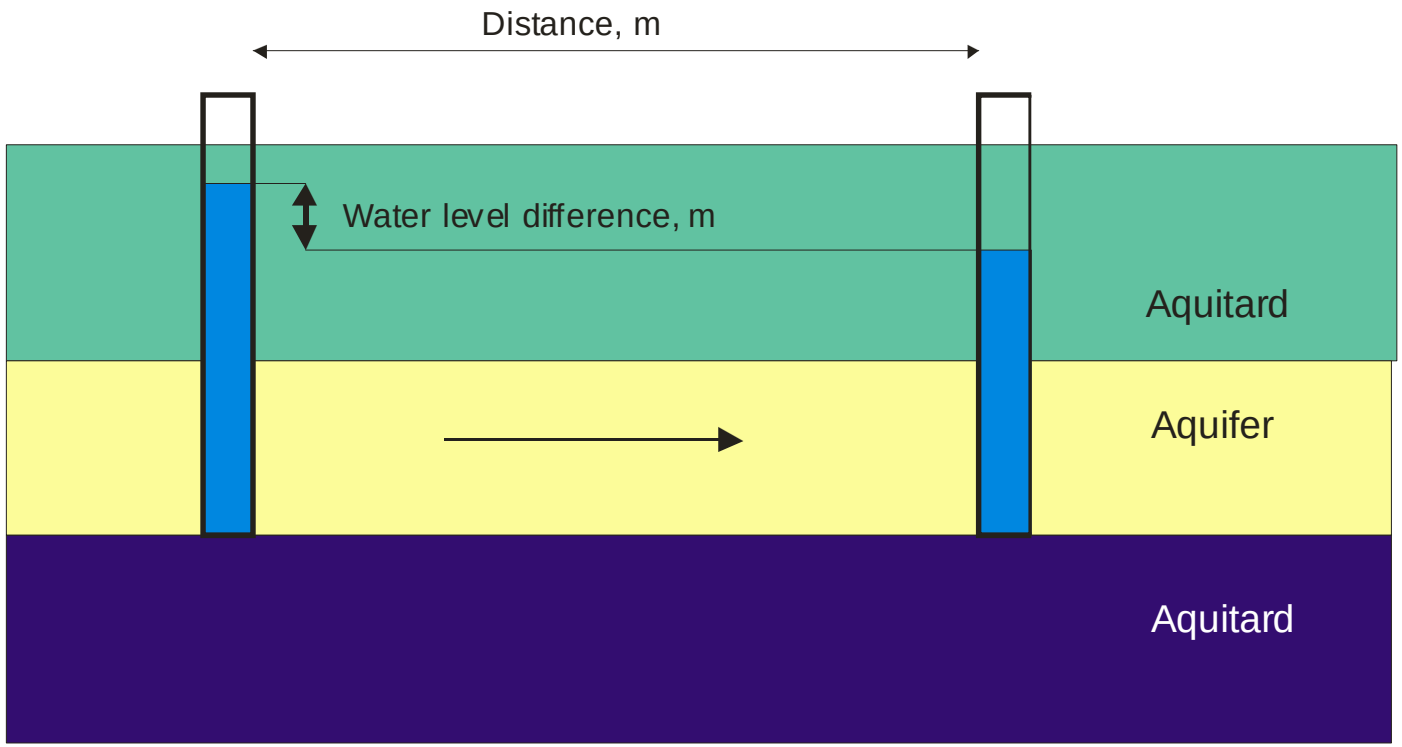
DEFINITION:
WATER LEVEL



Narrow diameter monitor well, also called piezometer

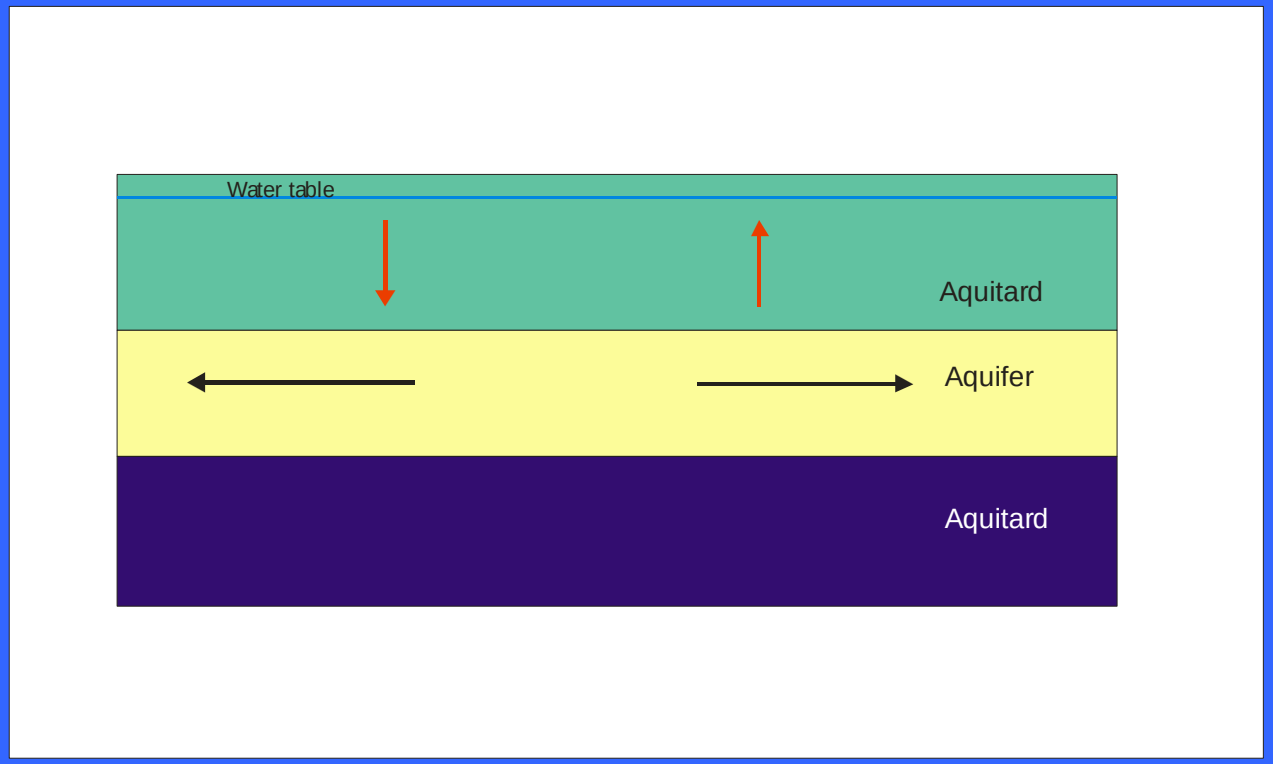
Water level elevation = elevation top of casing - DTW

DEFINITION: Hydraulic Gradient



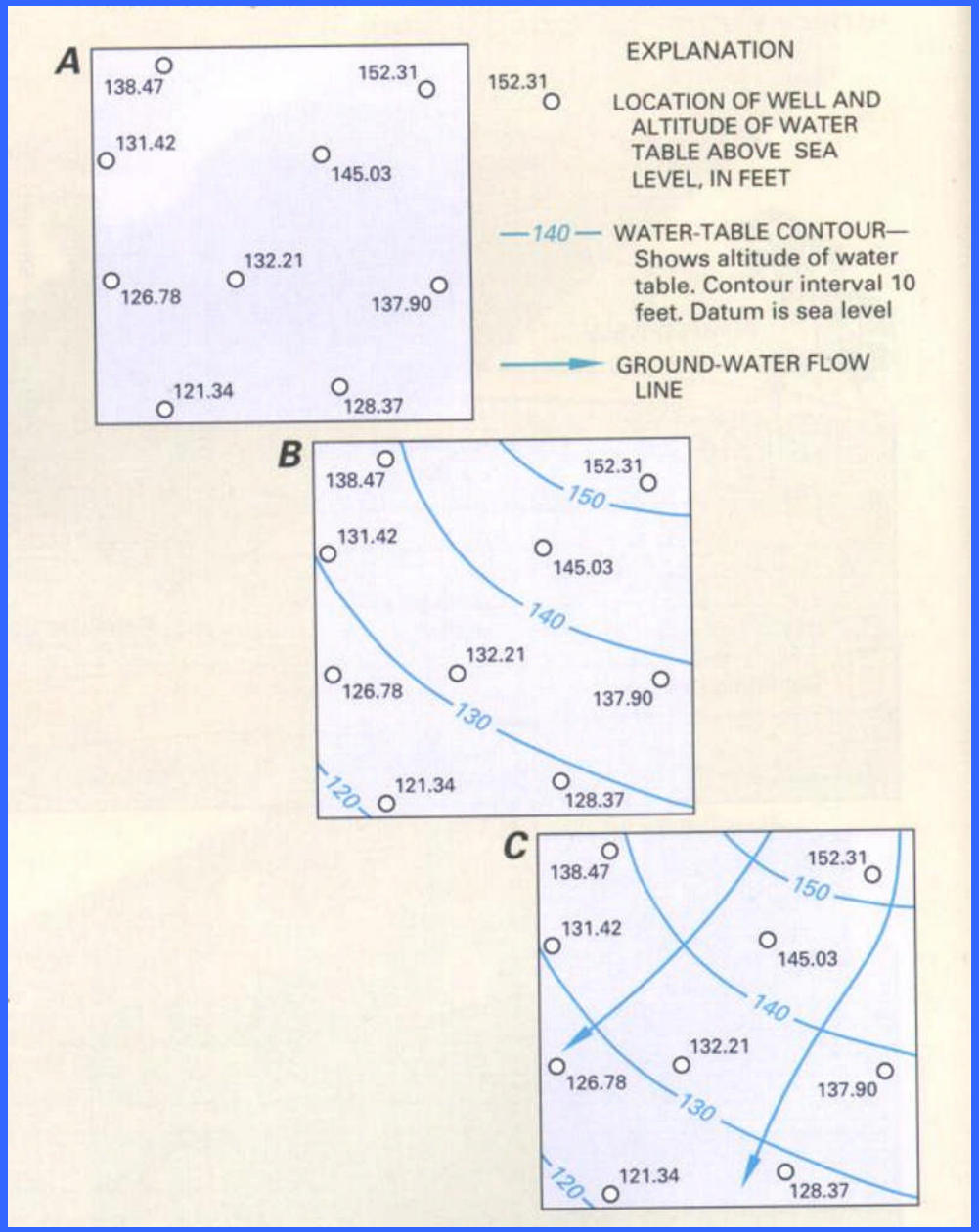
Hydraulic gradient = $\frac{\text{difference in water level}}{\text{difference in distance between wells}}$

Direction of groundwater flow in aquifers and aquitards

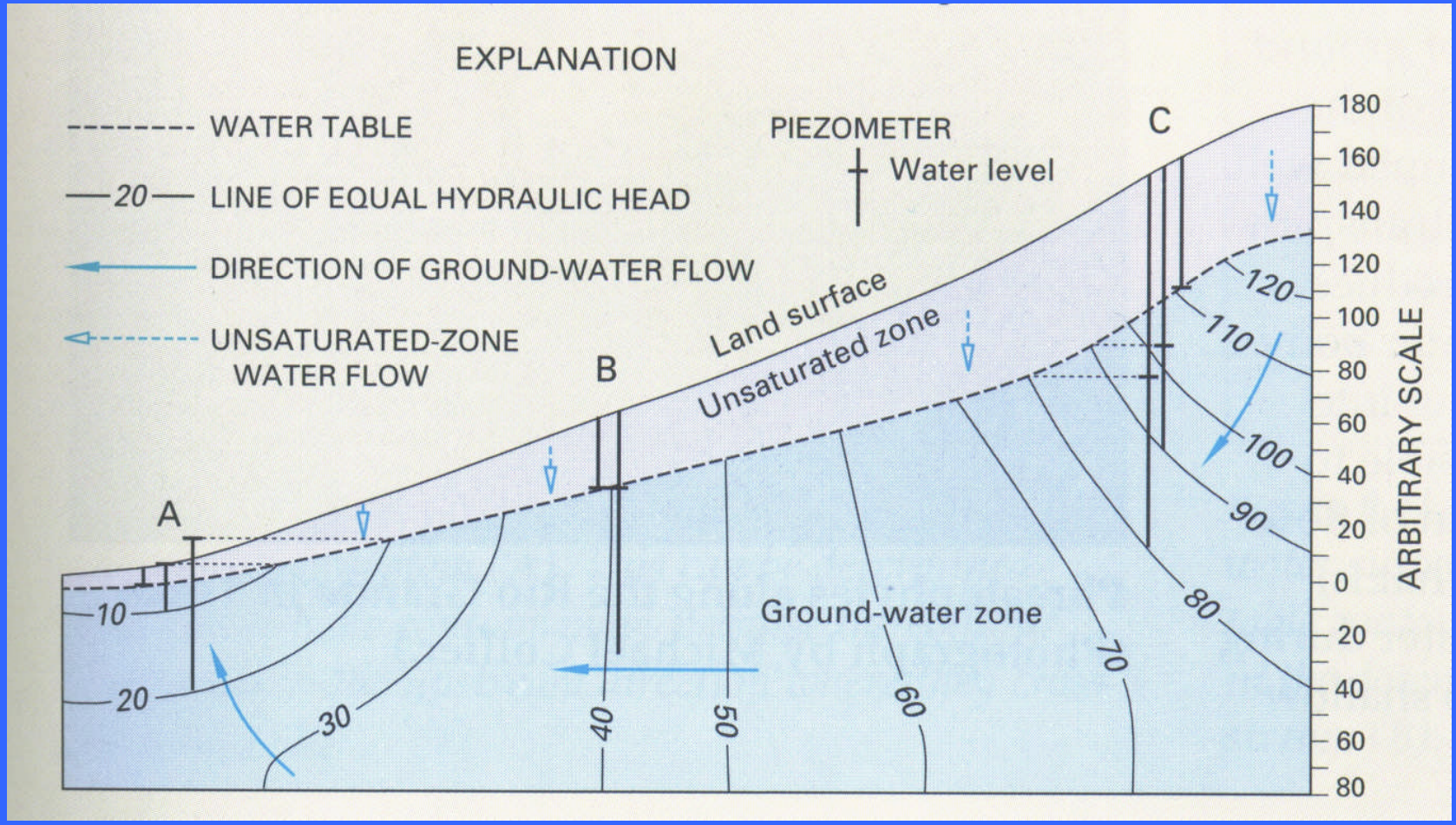


Groundwater flow in aquifers commonly is horizontal

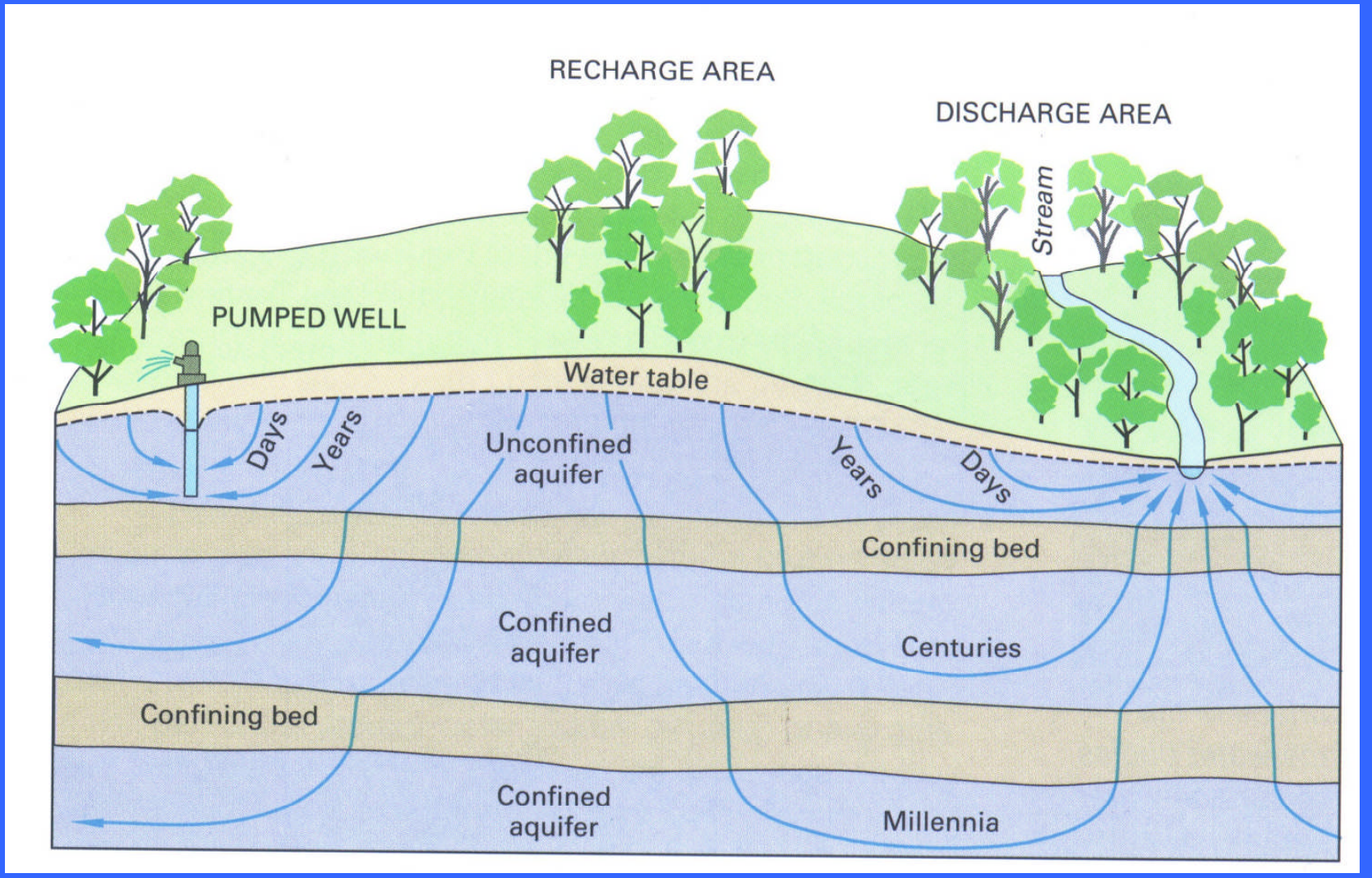
Groundwater flow in aquitards commonly is vertical, upward or downward



Water level measurements are used to draw contour maps and to determine groundwater flow directions
(USGS Circular 1139, 1998)



If the distribution of hydraulic head in vertical sections is known from nested piezometer data, zones of downward, lateral and upward components of groundwater flow can be determined
(USGS Circular 1139, Figure A-3)



Groundwater flow path vary greatly in length, depth and travel time from points of recharge to points of discharge in the groundwater system (USGS Circular 1139, 1998, Figure 3)

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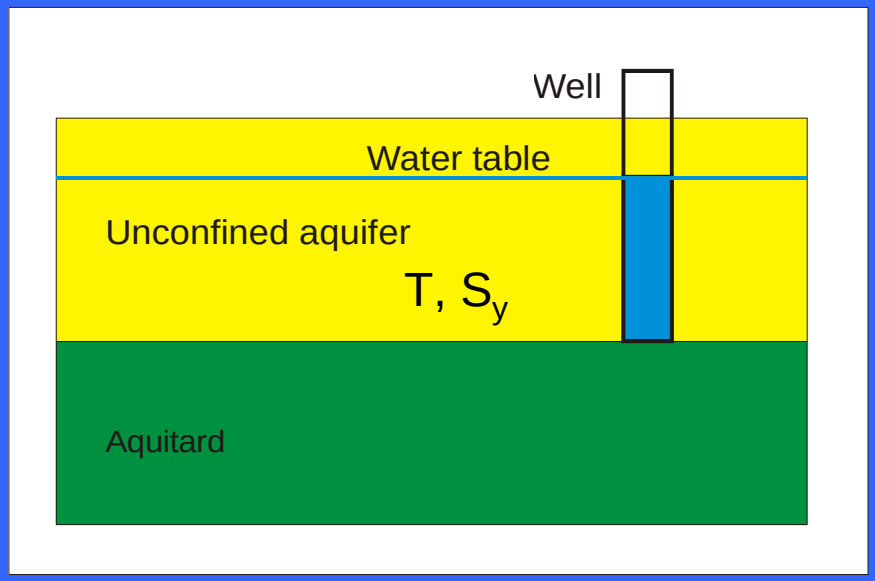
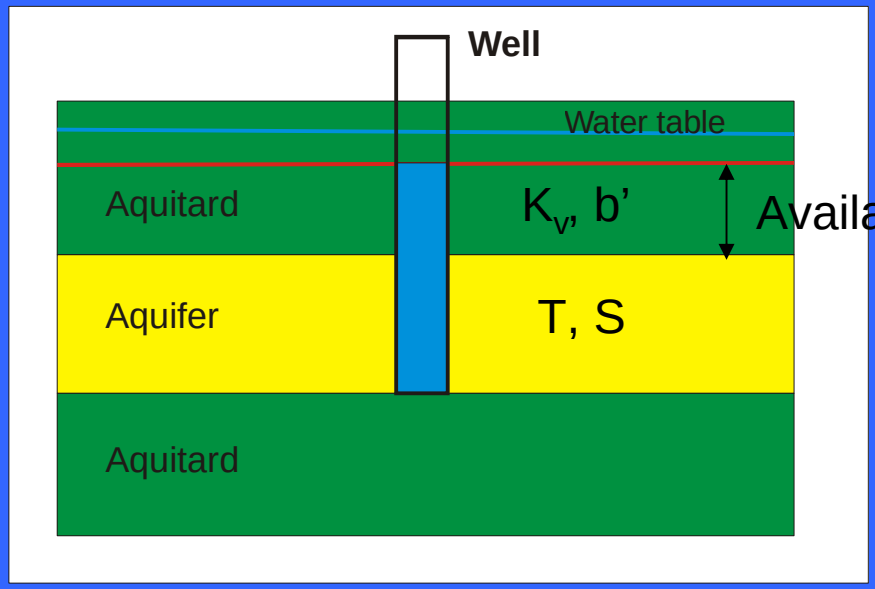




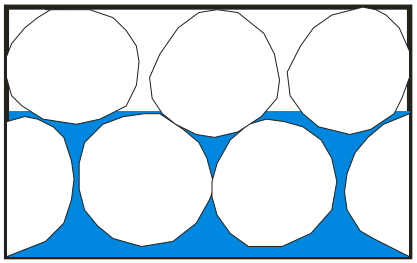
WELL YIELD

The yield of a well depends on transmissivity (T), storage coefficient (S) or specific yield (S_y), aquitard properties (K_v), available drawdown and well/screen diameter.

HYDRAULIC PROPERTIES: STORAGE COEFFICENT (S)

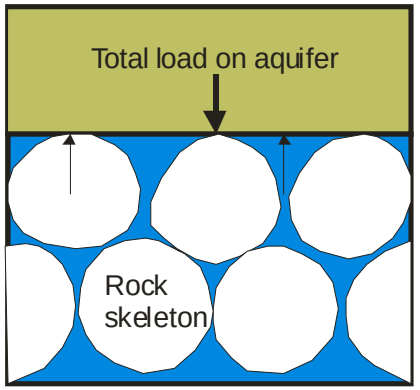
Storage coefficient =volume of water an aquifer releases from or takes into storage, per unit area per unit decline of water level

Unconfined aquifer



Water comes from drainage of pores

Semi-confined aquifer

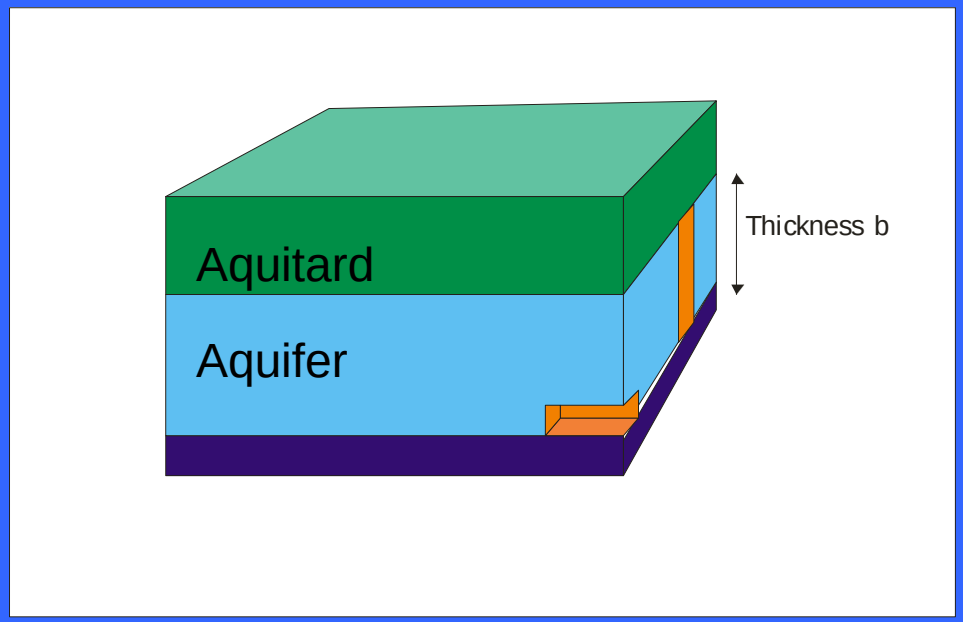


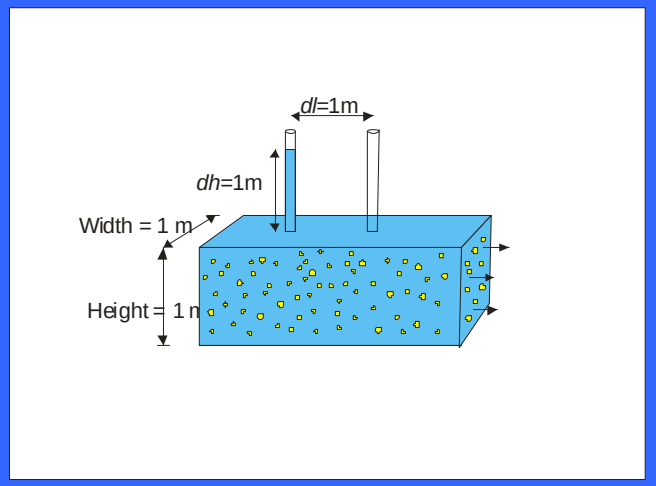
Water comes from expansion of water and compression of aquifer

Unconfined aquifer: 0.1 - 0.25

Semi-confined aquifer: 5×10^{-5} to 5×10^{-3}

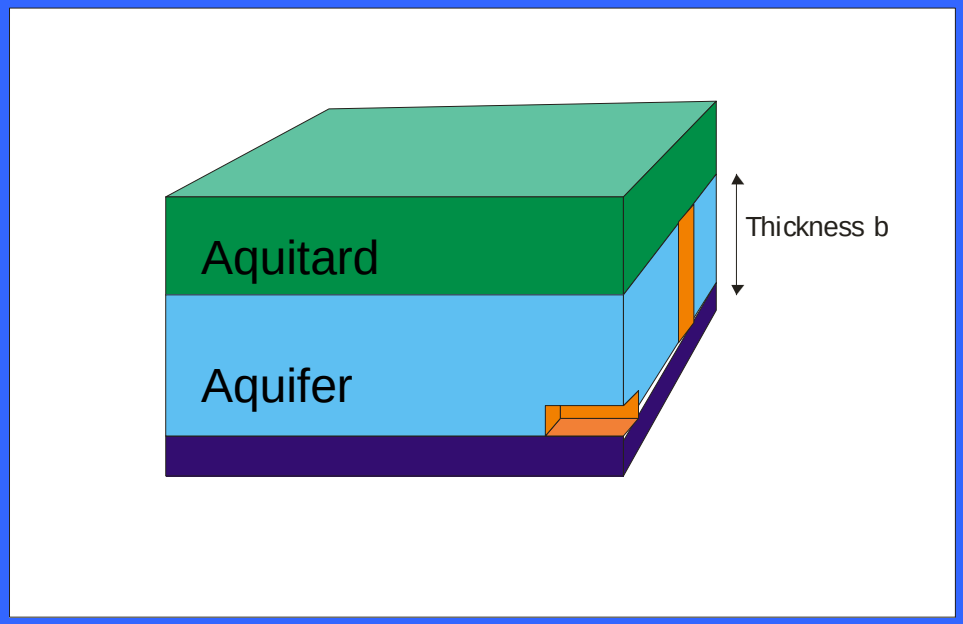
HYDRAULIC PROPERTIES: HYDRAULIC CONDUCTIVITY (K)





Hydraulic conductivity K = volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area (m/day)

HYDRAULIC PROPERTIES: TRANSMISSIVITY (T)



Transmissivity T = rate of flow under a unit hydraulic gradient through a cross section of unit over the thickness of the aquifer

$$T = K \times b \quad (m^2/day)$$

Groundwater Flow: Darcy's Law

$$Q = K\ A\ \Delta h/\Delta l$$

Q: flow (m^3/day)
K: hydraulic conductivity (m/day)
A: area through which flow occurs (m^2)
$\Delta h/\ \Delta l$: hydraulic head gradient (dimensionless)

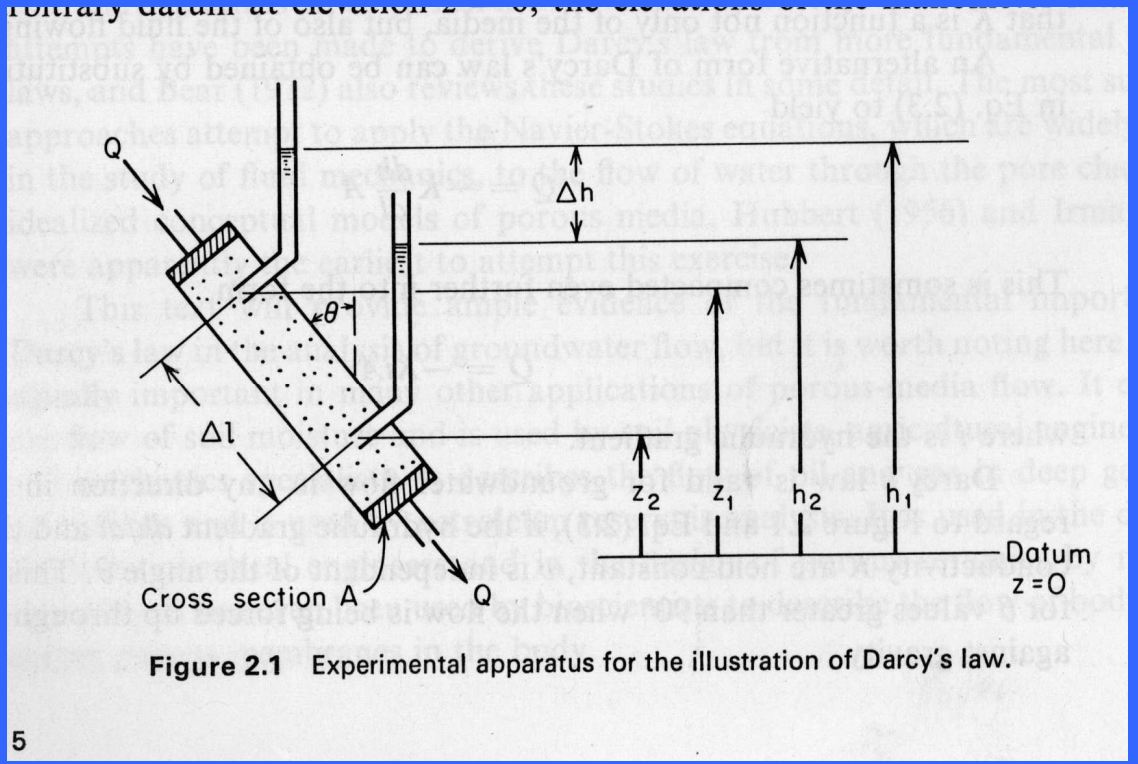


Figure 2.1 Experimental apparatus for the illustration of Darcy's law.

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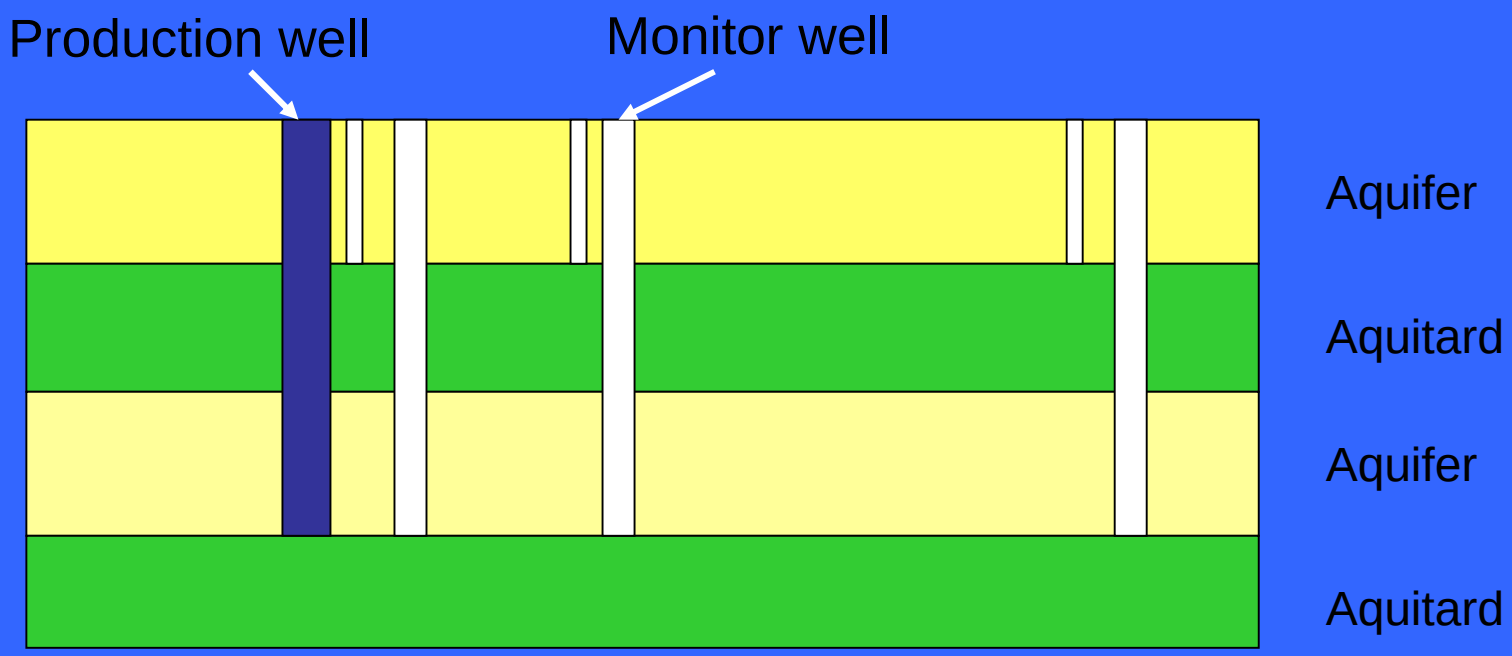
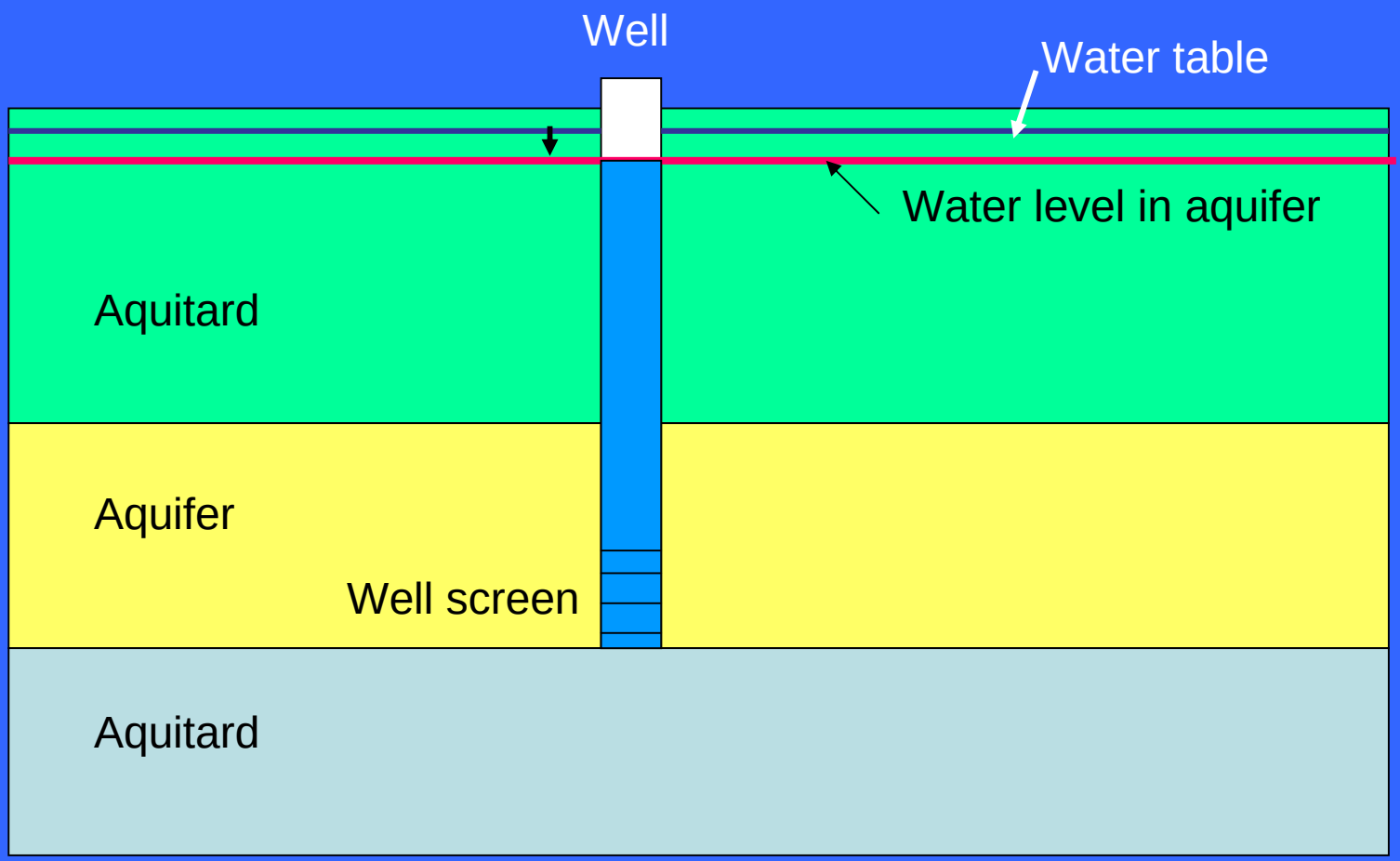
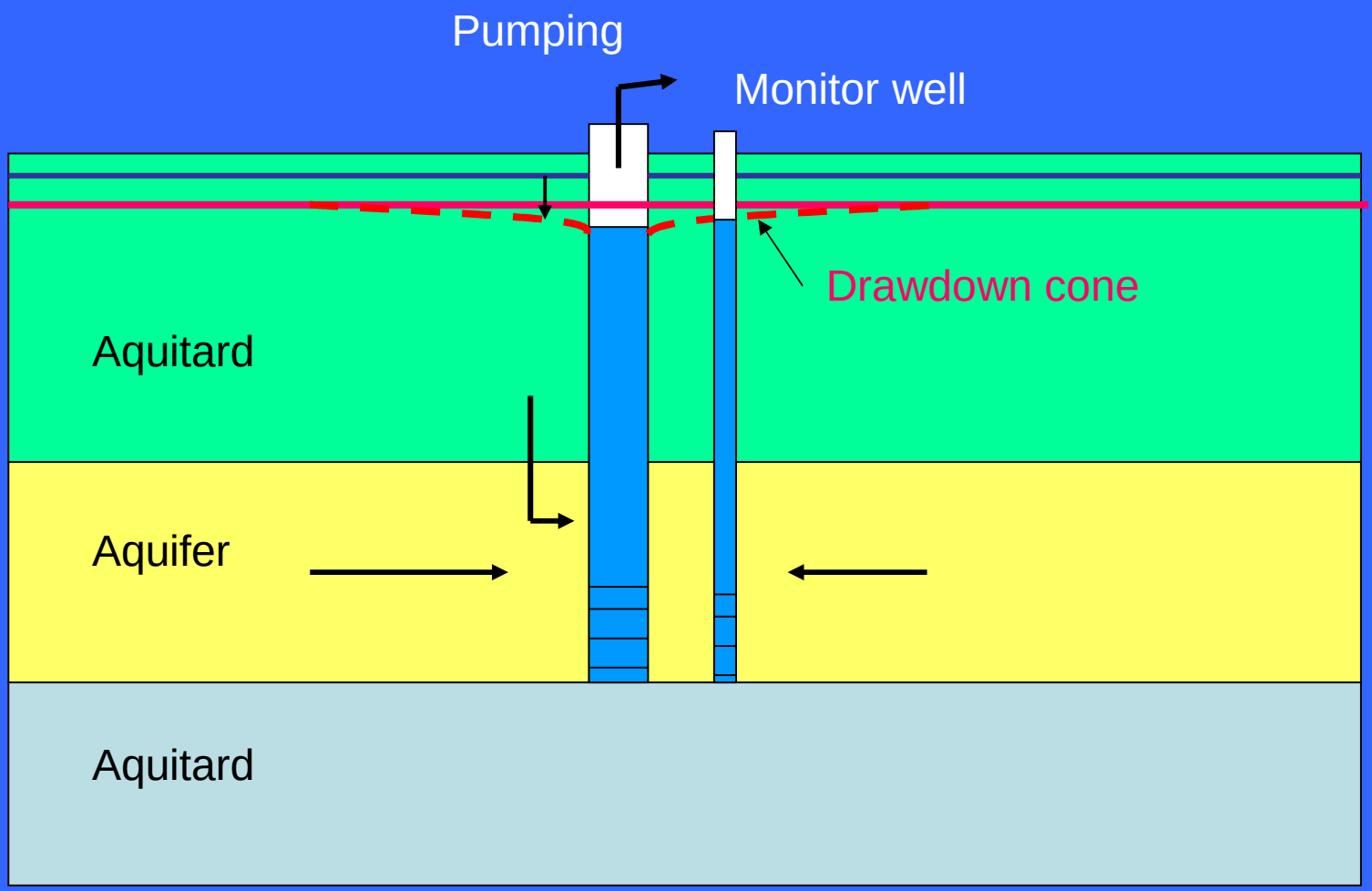
[Groundwater a primer]

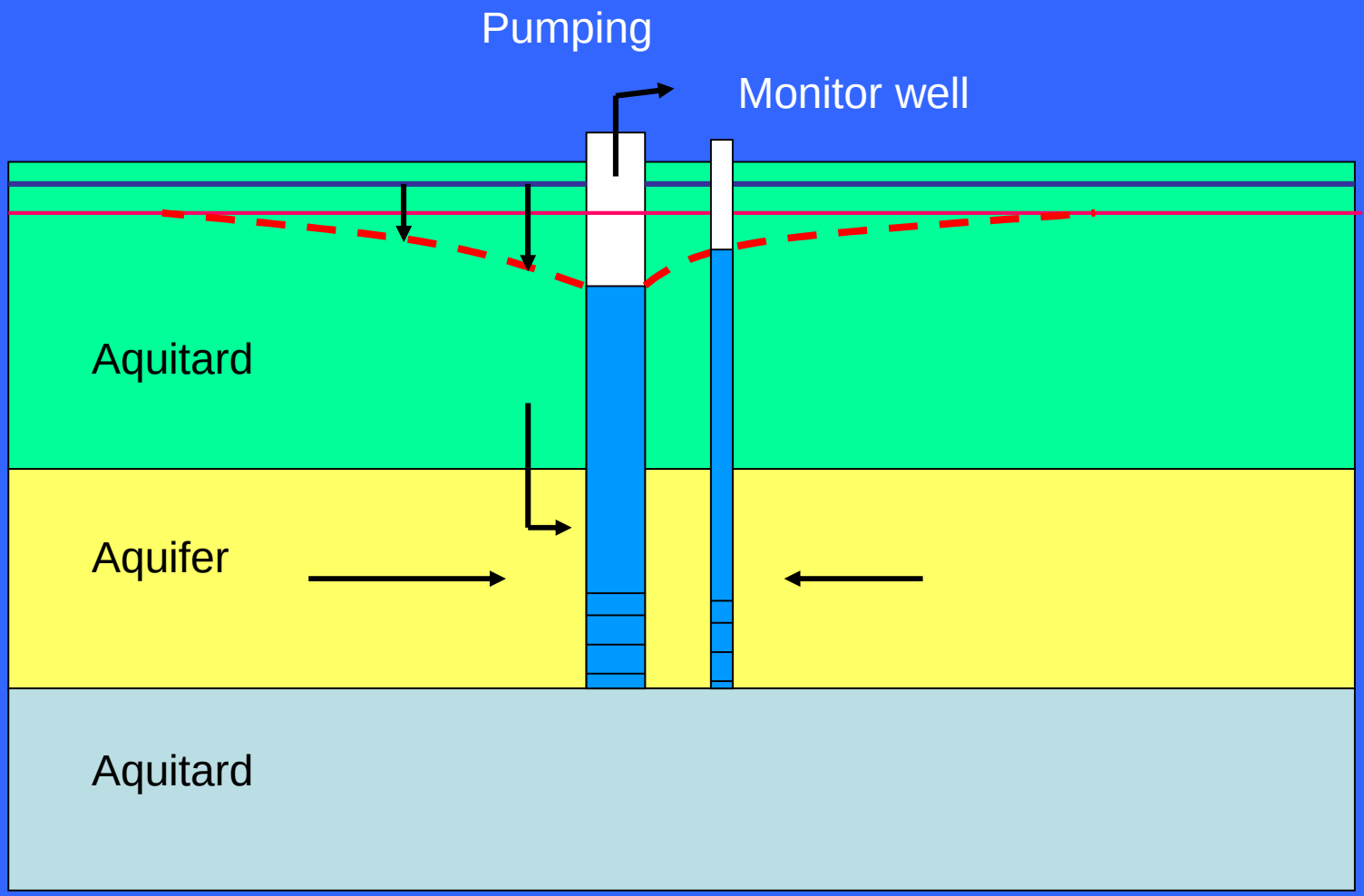
Pumping tests are used to determine aquifer and aquitard properties



Typical pump test setup


Well
Water table
Water level in aquifer
Aquitard
Aquifer
Well screen
Aquitard


Pumping
Monitor well
Drawdown cone
Aquitard
Aquifer
Aquitard


Pumping
Monitor well
Aquitard
Aquifer
Aquitard

Collecting samples for chemical analyses of groundwater