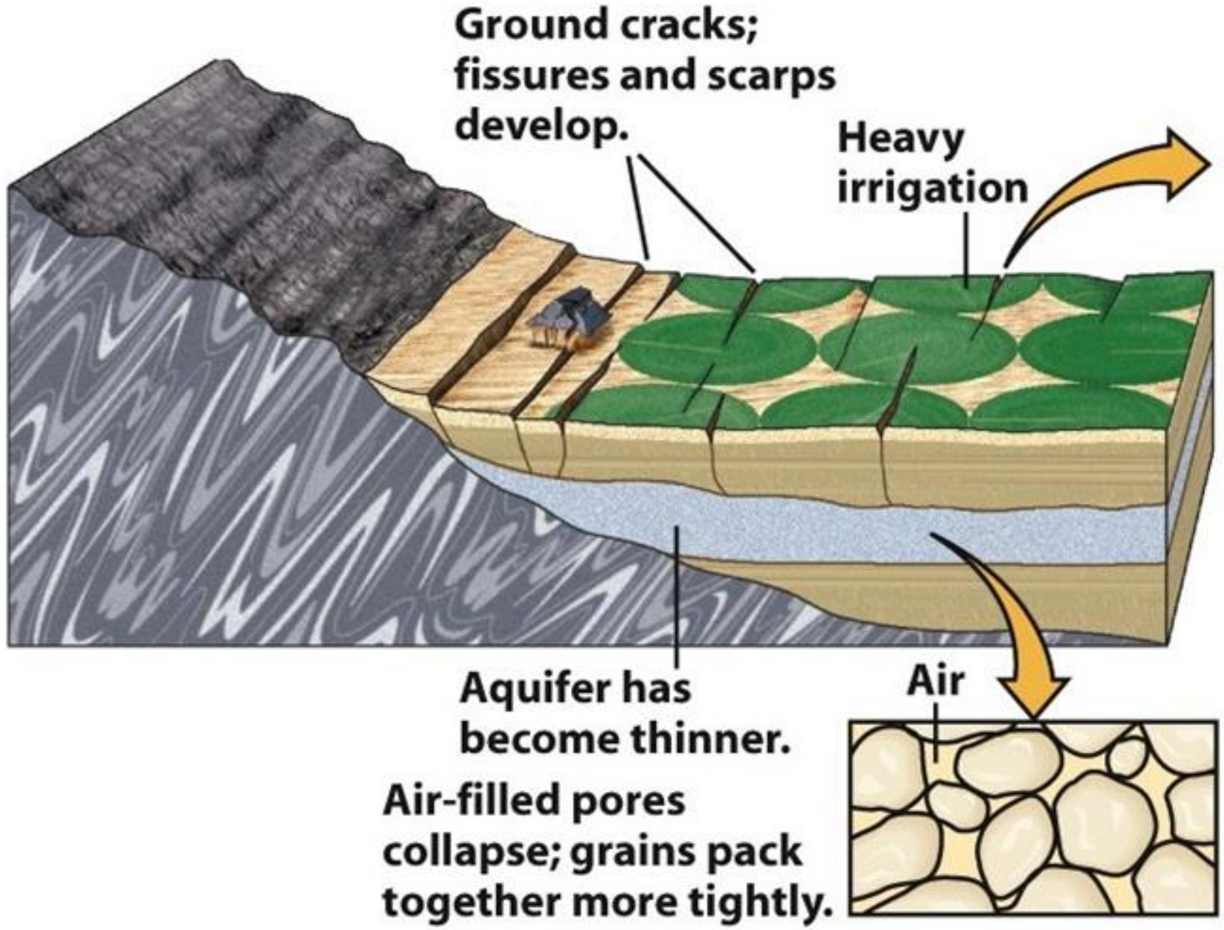


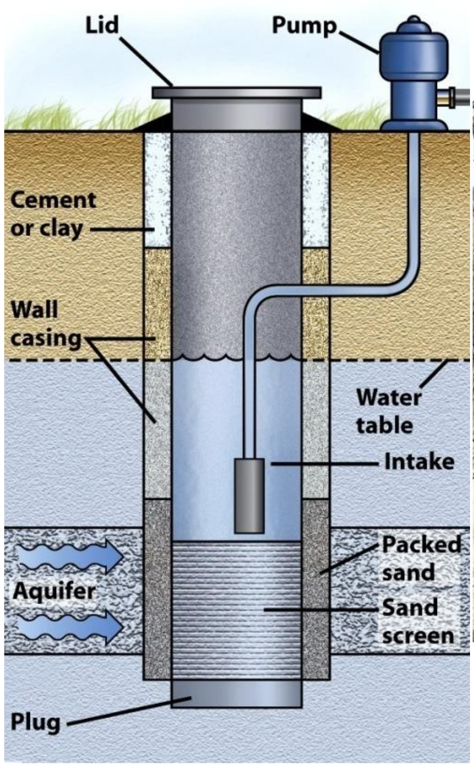
Lecture 14a – Sustainable groundwater use

Learning Outcomes

- Be to explain/describe how humans are causing problems with groundwater:
  - **Drawdown of the water table**
    - Be able to draw/describe and carry out simple calculations related to cones of depression
    - Be able to explain the consequences of drawdown
  - **Compaction and subsidence**
  - **Contamination of groundwater**
    - Be able to describe sources of contamination and challenges of prevention/clean up
    - Be able to describe/explain how groundwater overuse can cause saltwater intrusion near the coast and pollutant plume capture
- Be aware of the laws/regulation around groundwater

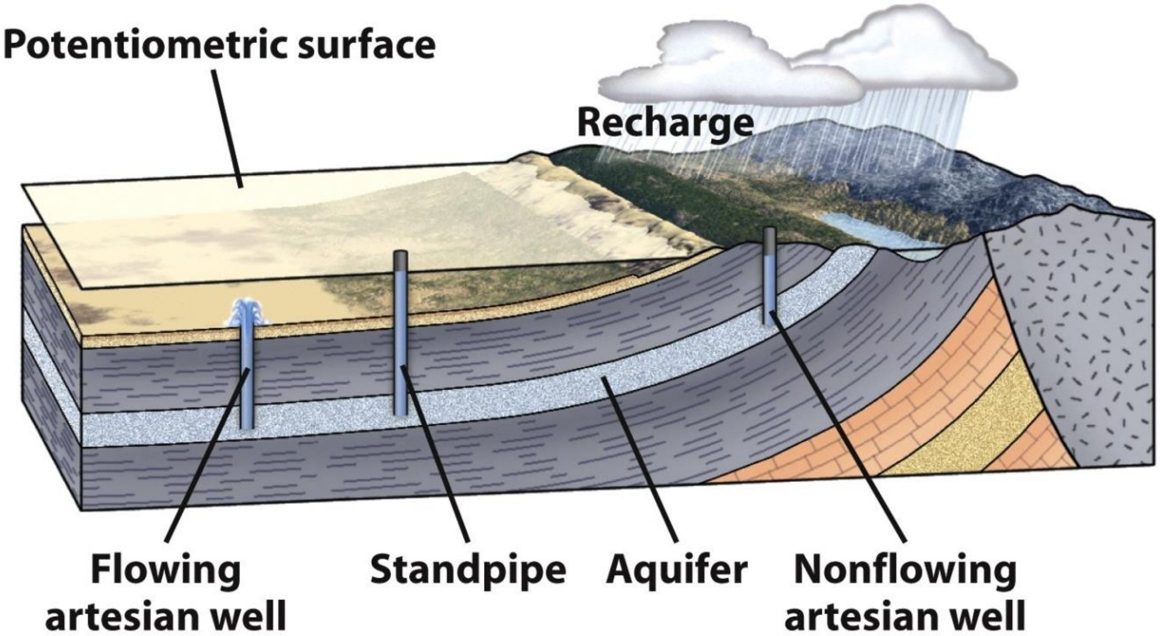
Tapping Groundwater

- Wells are holes drilled or dug into the saturated zone and water extracted

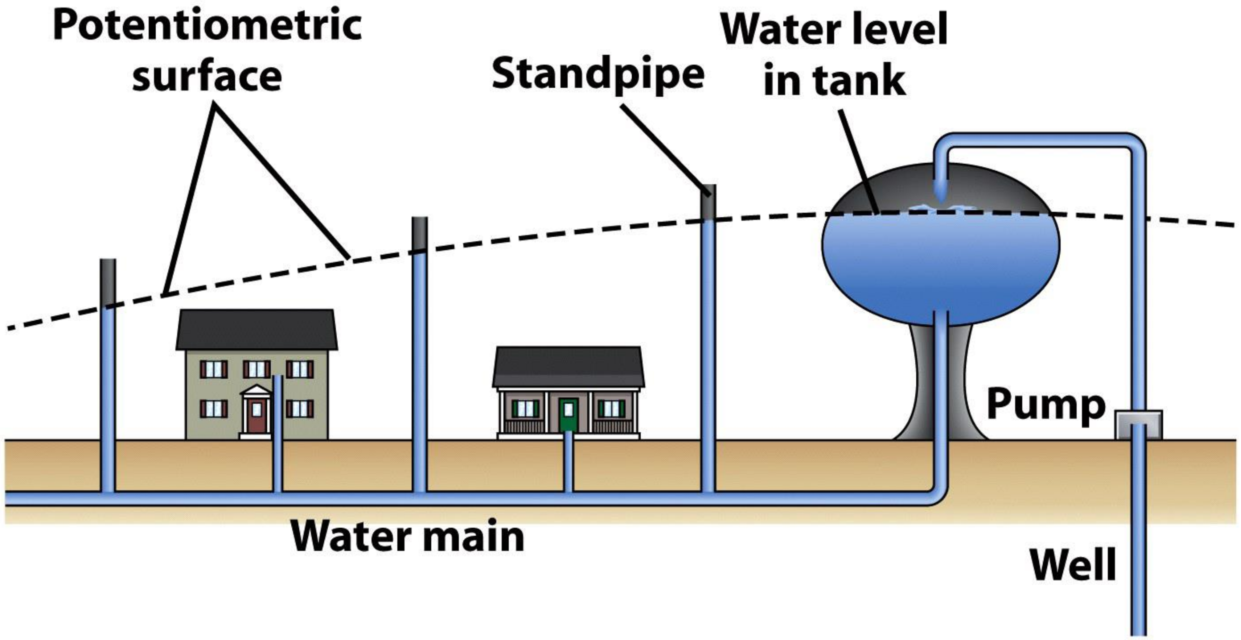


Tapping Groundwater

- Artesian wells tap confined, tilted aquifers
  - Upland recharge pressurizes the aquifer
  - Water rises in artesian wells to the potentiometric surface
  - A well casing below this surface will flow without pumping



Tapping Groundwater

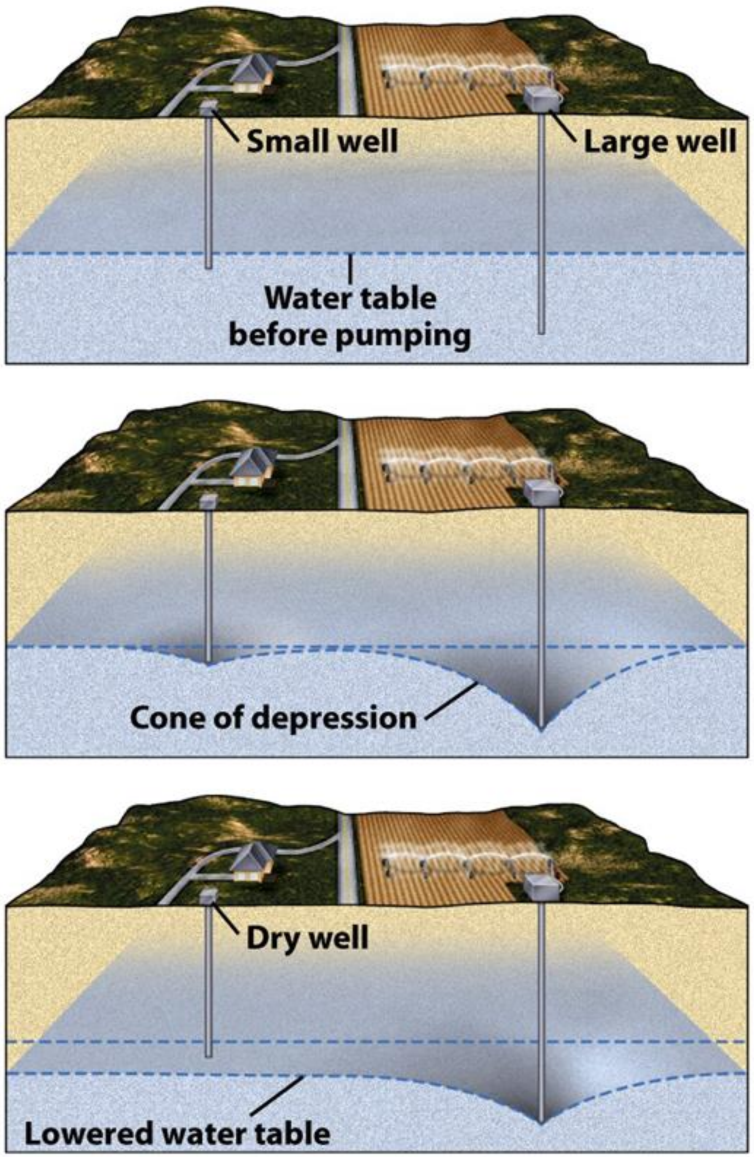


Groundwater Problems

- Groundwater is an important natural resource
  - It accounts for 95% of all the liquid freshwater on Earth
  - It supplies a substantial portion of drinking-water needs
  - Groundwater is threatened by…
    - Mismanagement
    - Overuse
    - Pollution

Groundwater overuse

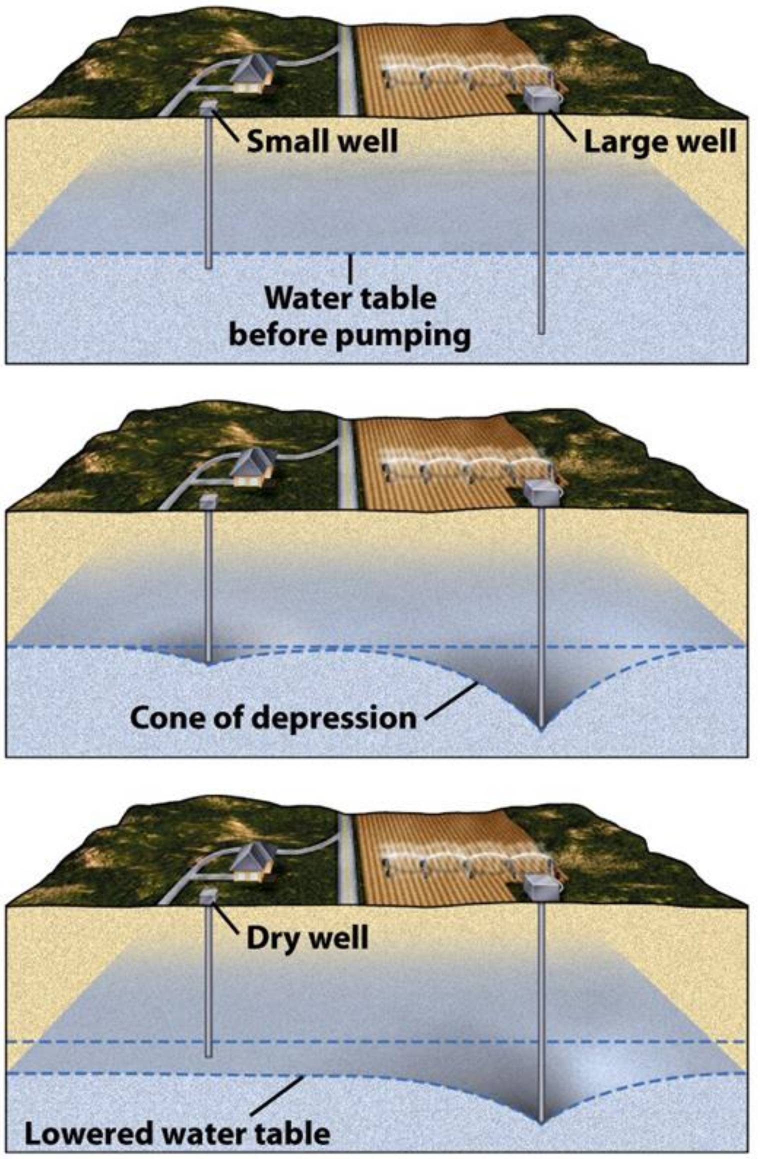
- With drawdown, the water table near the well drops and forms a cone of depression
- Drawdown, from multiple wells in an area, is additive
- Competing users often conflict



Groundwater overuse

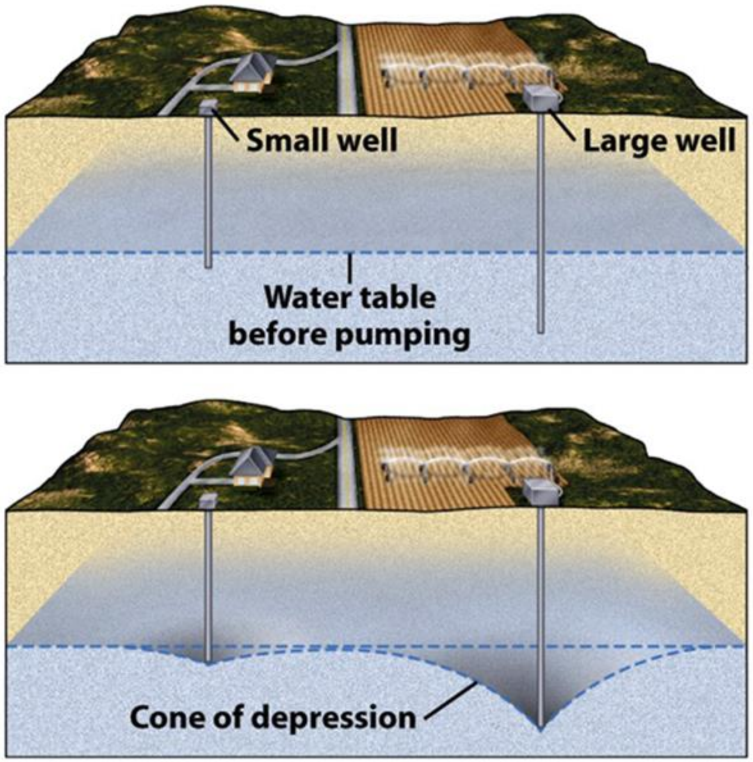
- What might happen to nearby streams?

- What would happen to the amount of discharge of groundwater close to the well?
  a) Discharge would increase
  b) Discharge would decrease
  c) No change



Calculating drawdown

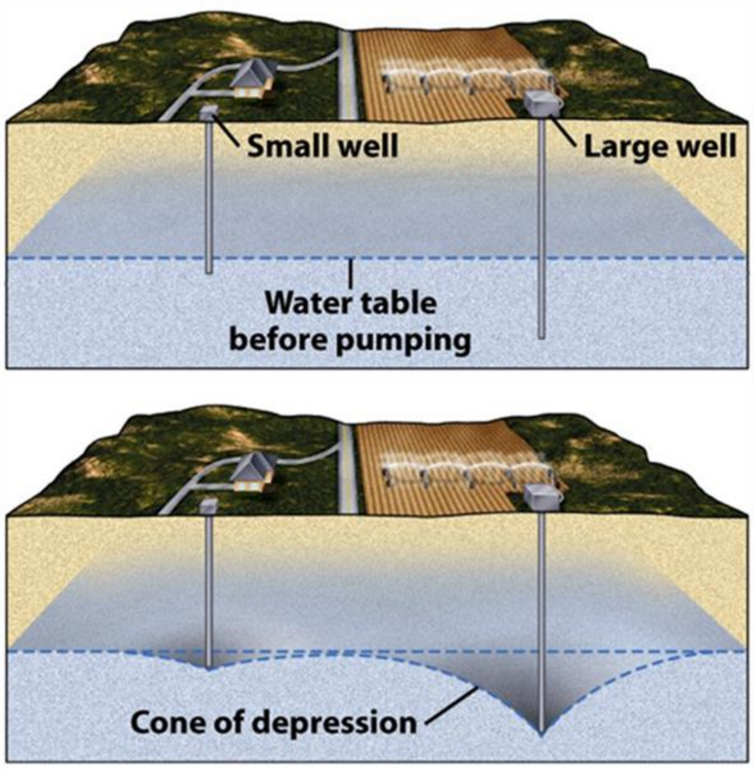
- What factors do you think will affect the amount of drawdown?



Calculating drawdown

How would the shape of the cone of depression change if the same volume of water was extracted with a higher pumping rate?

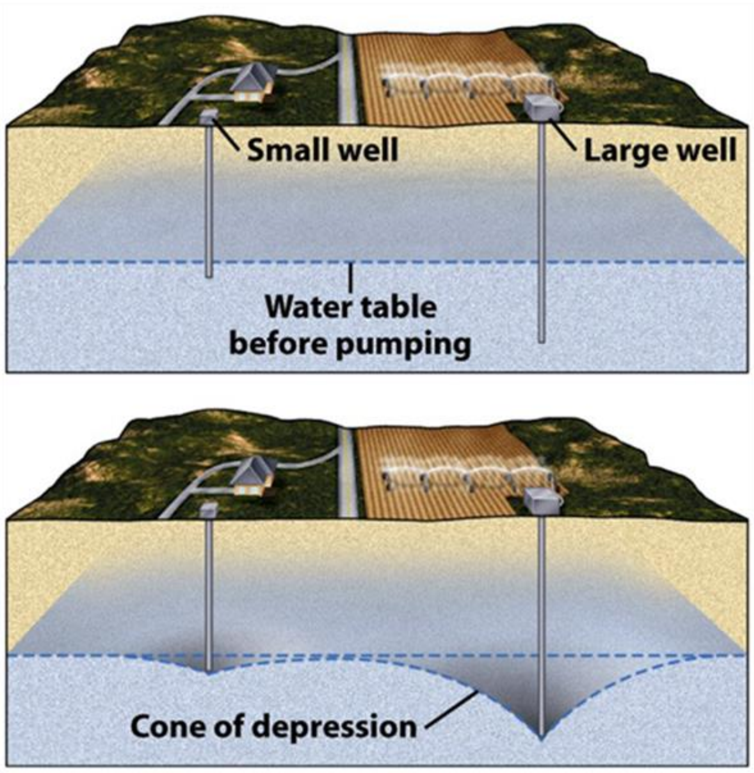
a) Deeper and smaller radius
b) Deeper and wider radius
c) Shallower and smaller radius
d) Shallower and wider radius



Calculating drawdown

How would the shape of the cone of depression change if the same volume was extracted but K_{sat} was greater?

a) Deeper and smaller radius
b) Deeper and wider radius
c) Shallower and smaller radius
d) Shallower and wider radius

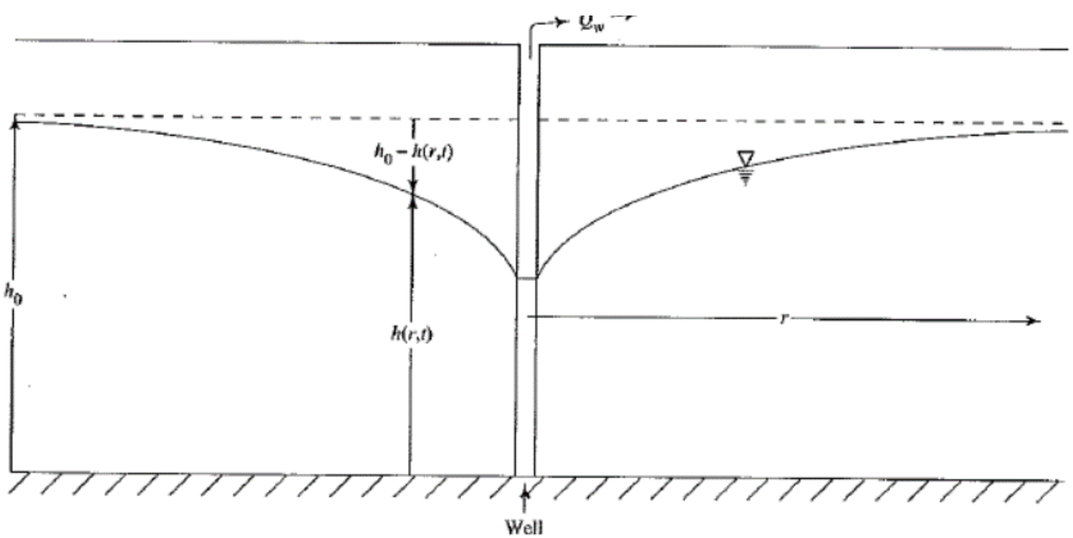


Calculating drawdown

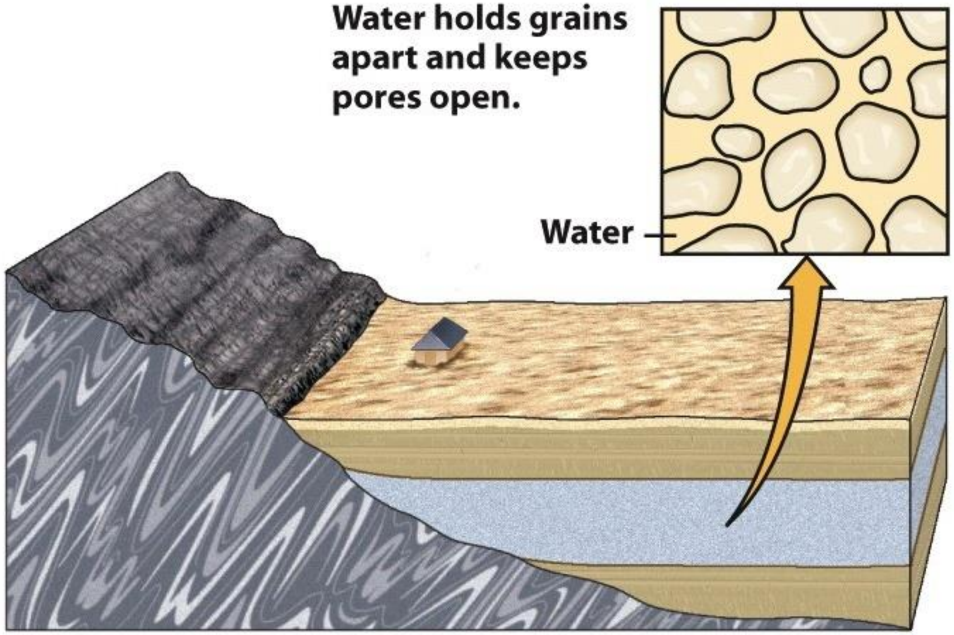
$$S = \frac{Q}{2\pi K_{sat} H_0 (h_2 - h_1)} * \ln(r_2/r_1)$$

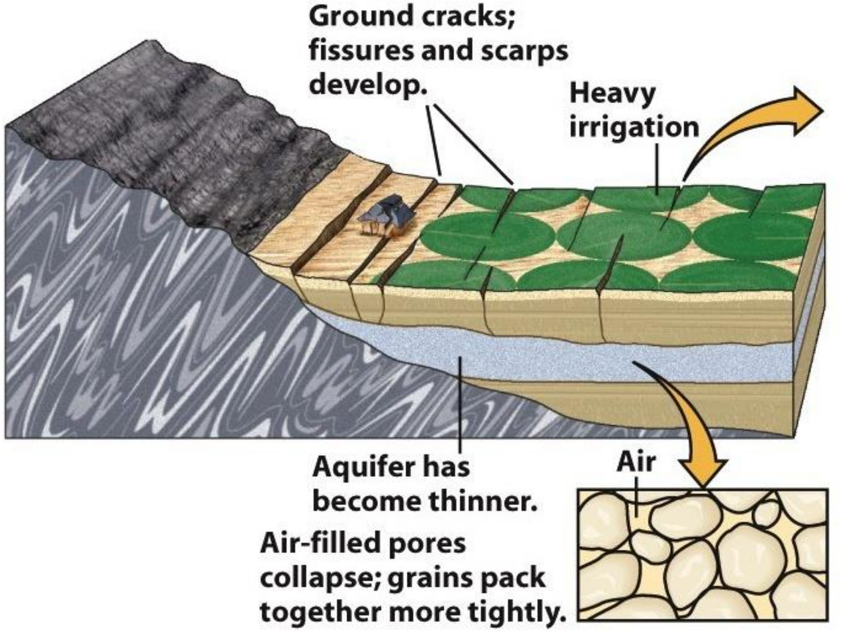
Where S = drawdown (H_0 – H)
H_0 = original height of water table at well
H = current height of water table at well
h_1 = height of water table at the least distant observation well at a distance of r_1
h_2 = height of water table at the most distant observation well at a distance of r_2
Q = pumping rate
K_{sat} = saturated hydraulic conductivity

Note: units don't work out in this equation due to some simplifications and assumptions. Don't worry about units except do make sure that your units for flow (per hour or per day etc) are correct.



Groundwater Depletion





Groundwater Depletion

- Dramatic examples of subsidence are well known
  - The Leaning Tower of Pisa, Italy
  - Sinking buildings in Venice, Italy
  - The San Joaquin Valley, California