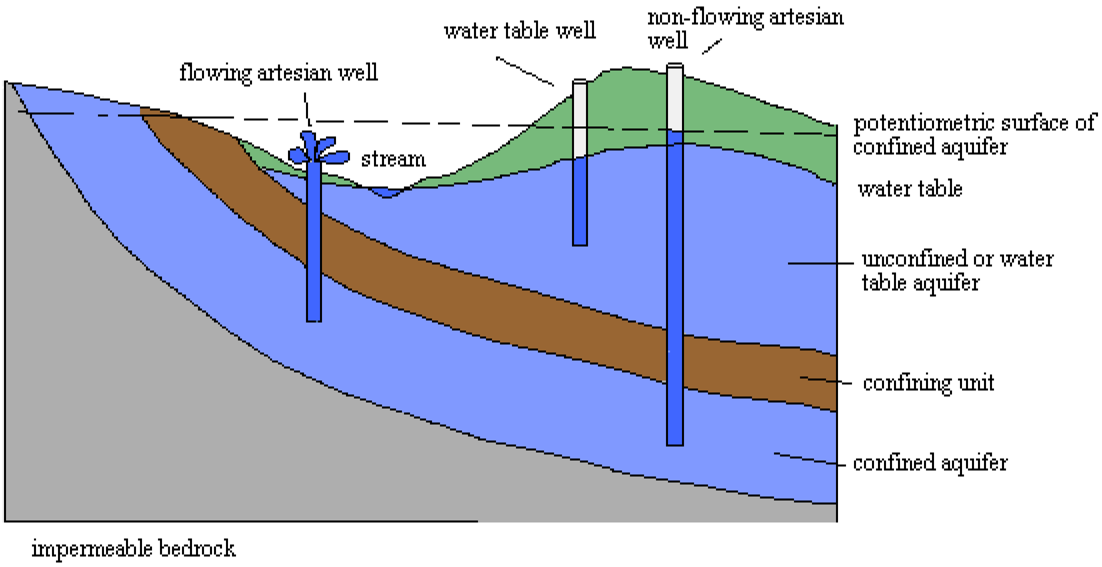
# AQUIFERS AND THEIR CHARACTERISTICS



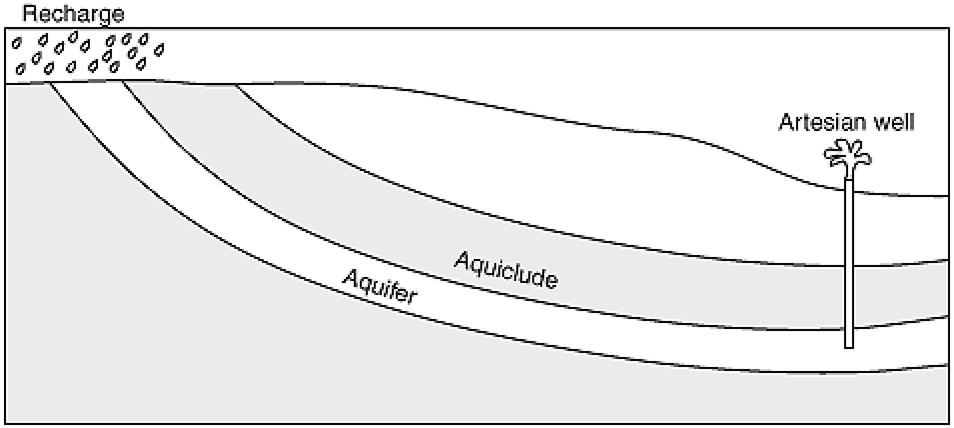
I. General Groups

A. Aquifer

B. Aquiclude

# I. General Groups

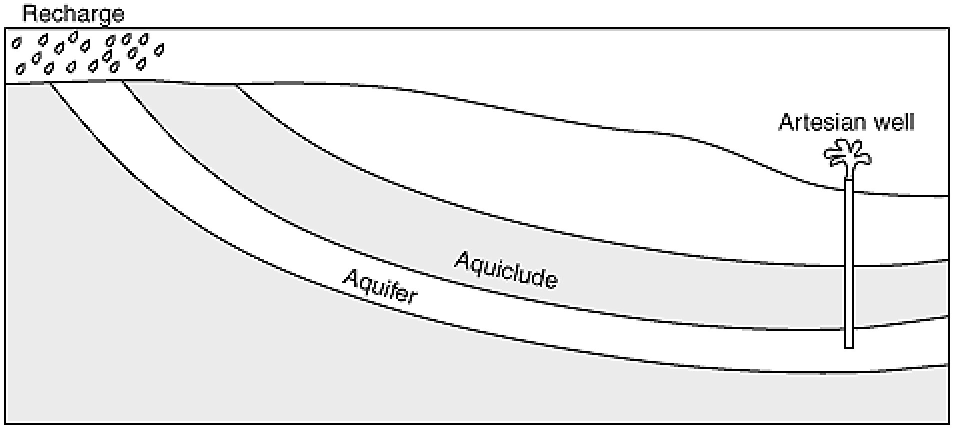
## A. Aquifer *(def) A saturated, permeable, geologic unit that can transmit a significant amount of groundwater under an ordinary gradient.*



# I. General Groups

# A. Aquifer

# B. Aquiclude *(def) A saturated geologic unit which does not transmit a significant quantity of groundwater under ordinary gradients.*



I. General Groups

A. Aquifer

B. Aquiclude

1. Aquitard
2. Aquifuge

# II. Aquifer Types

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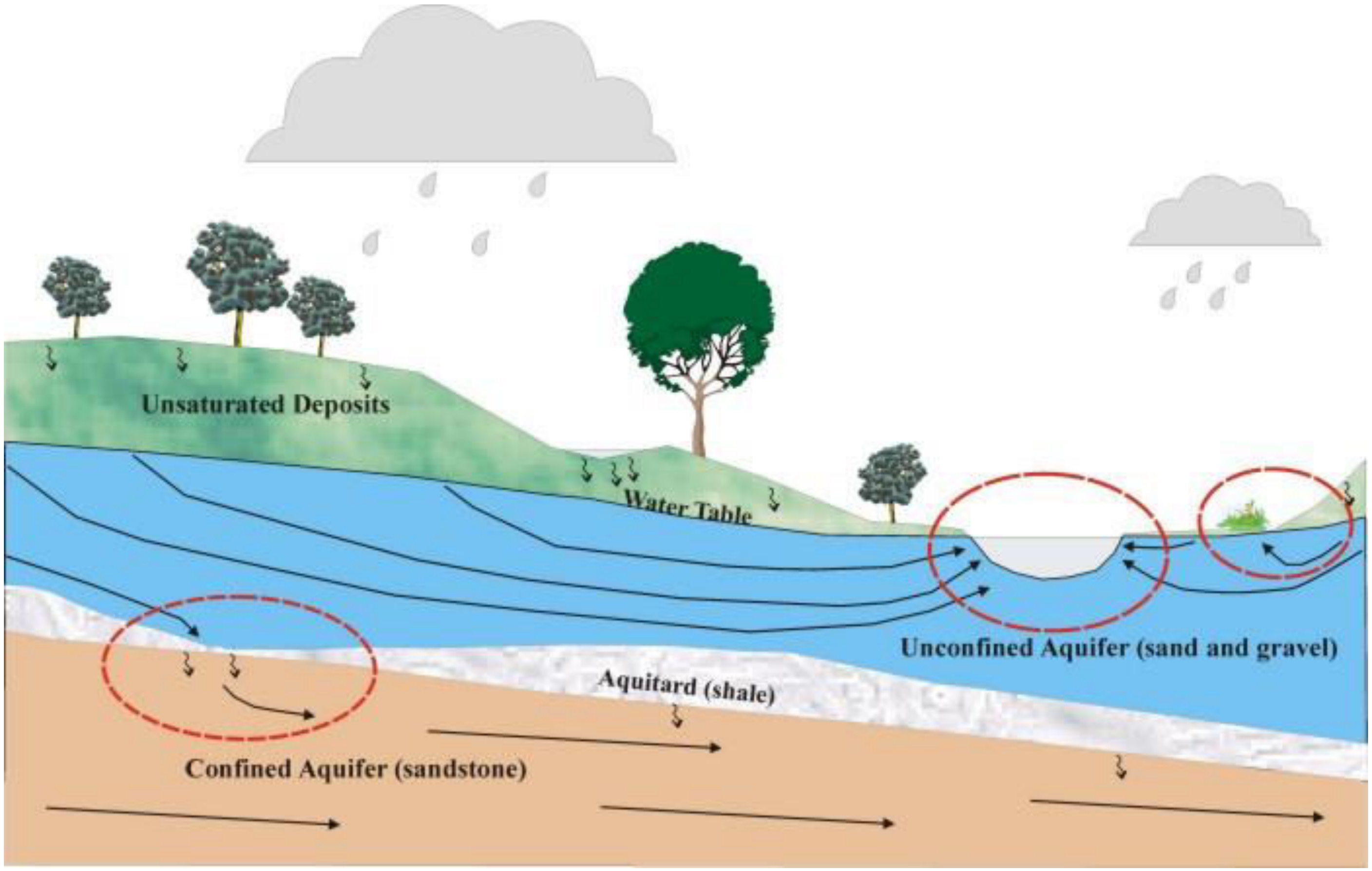
## A. Unconfined



# II. Aquifer Types

## B. Confined

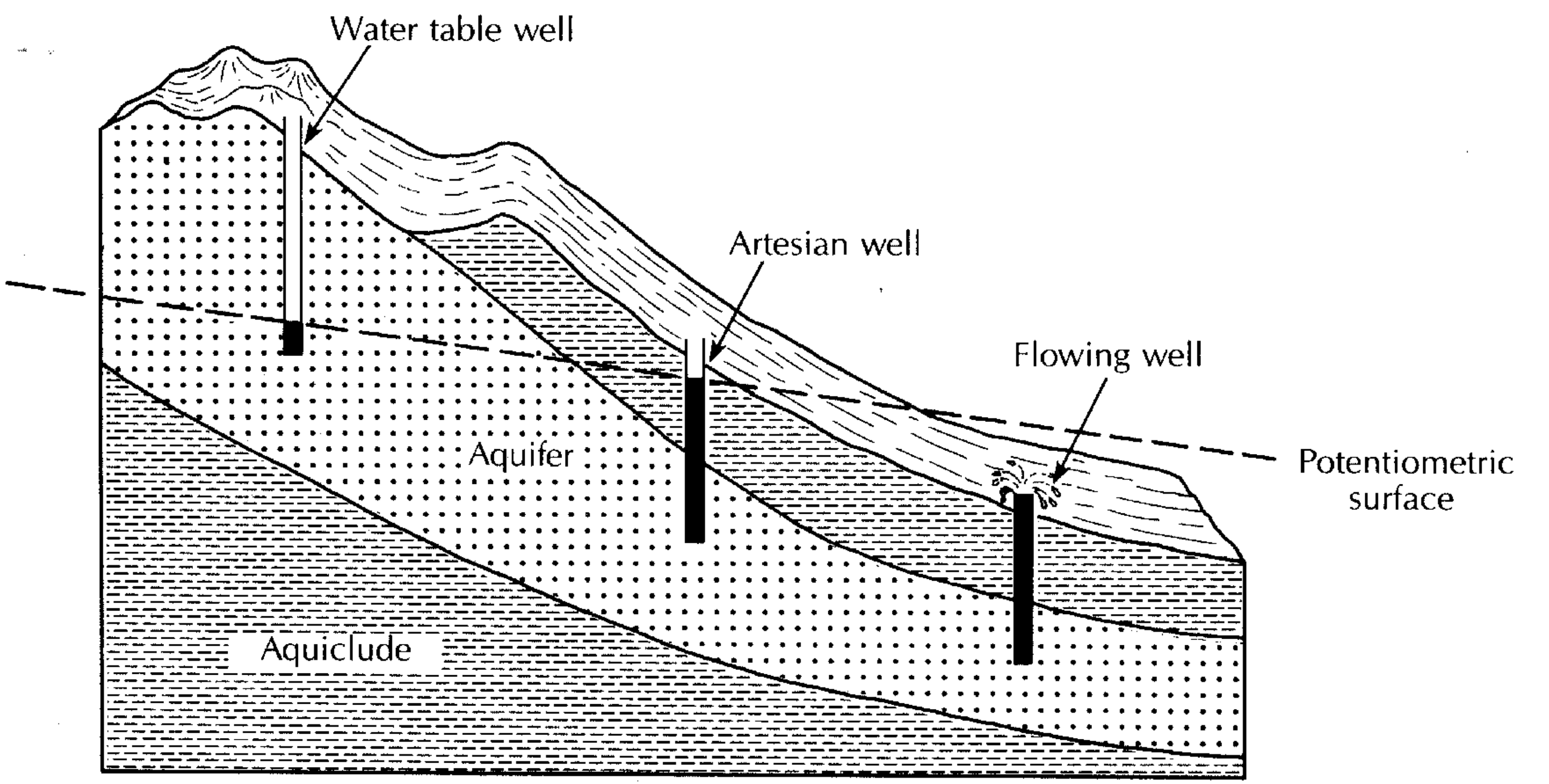


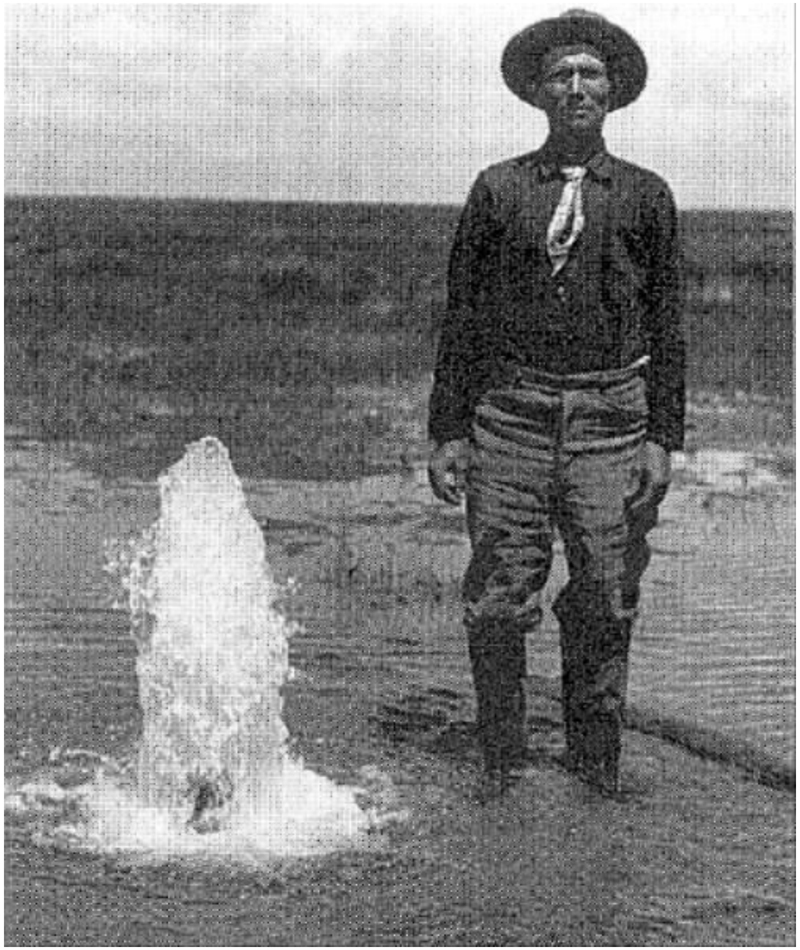

**FIGURE 4.21** Artesian and flowing well in confined aquifer.

II. Aquifer Types

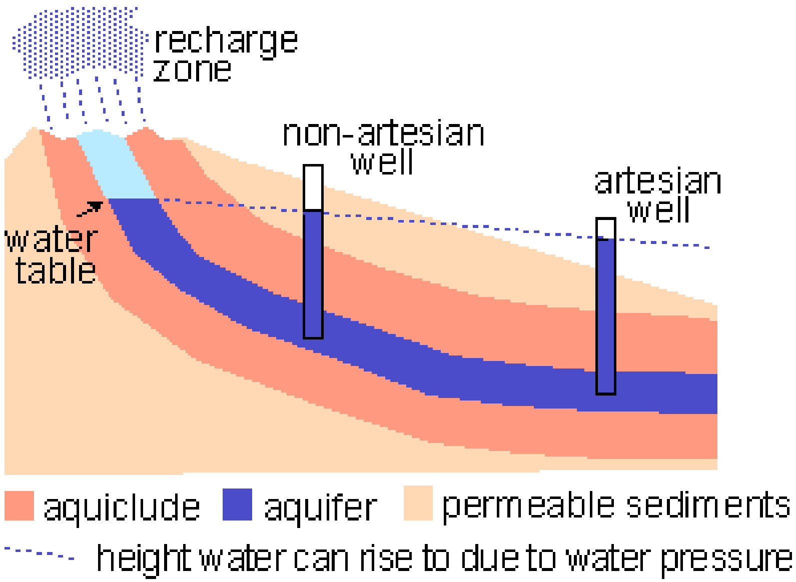
A. Unconfined

B. Confined

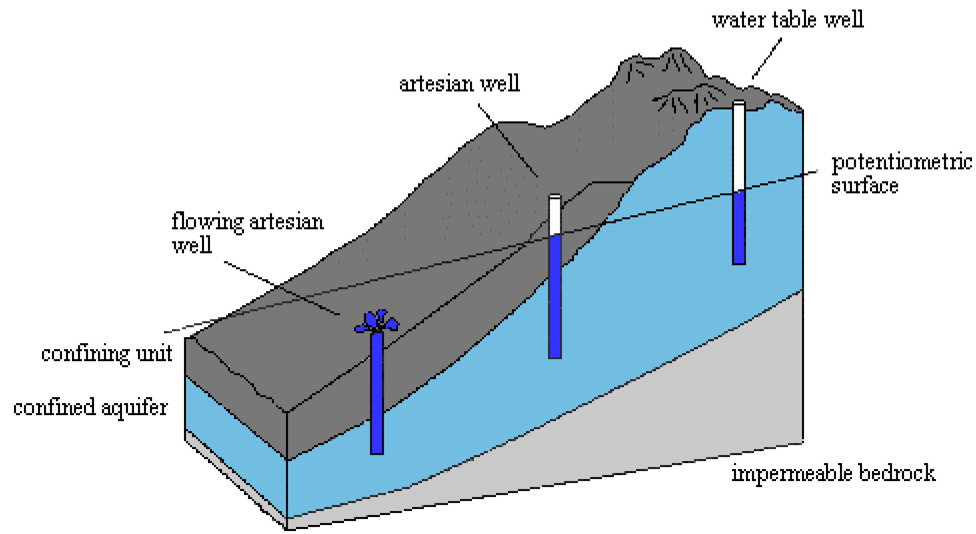
C. Artesian



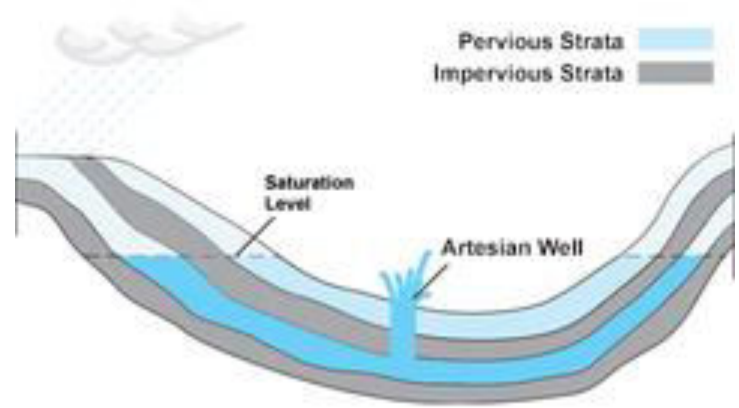
# C. Artesian



recharge zone
non-artesian well
artesian well
water table
aquiclude
aquifer
permeable sediments
height water can rise to due to water pressure

water table well
artesian well
potentiometric surface
flowing artesian well
confining unit
confined aquifer
impermeable bedrock

Pervious Strata
Impervious Strata
Saturation Level
Artesian Well

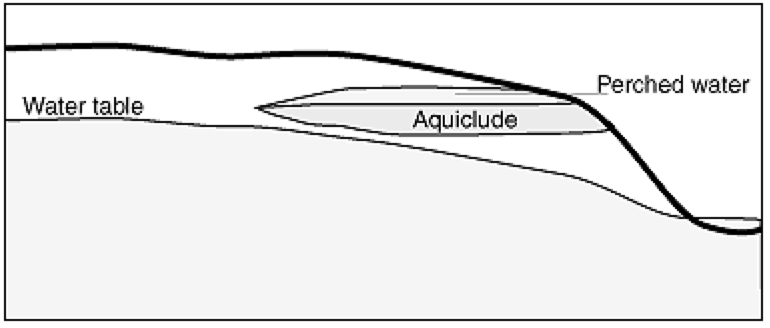
# II. Aquifer Types

A. Unconfined

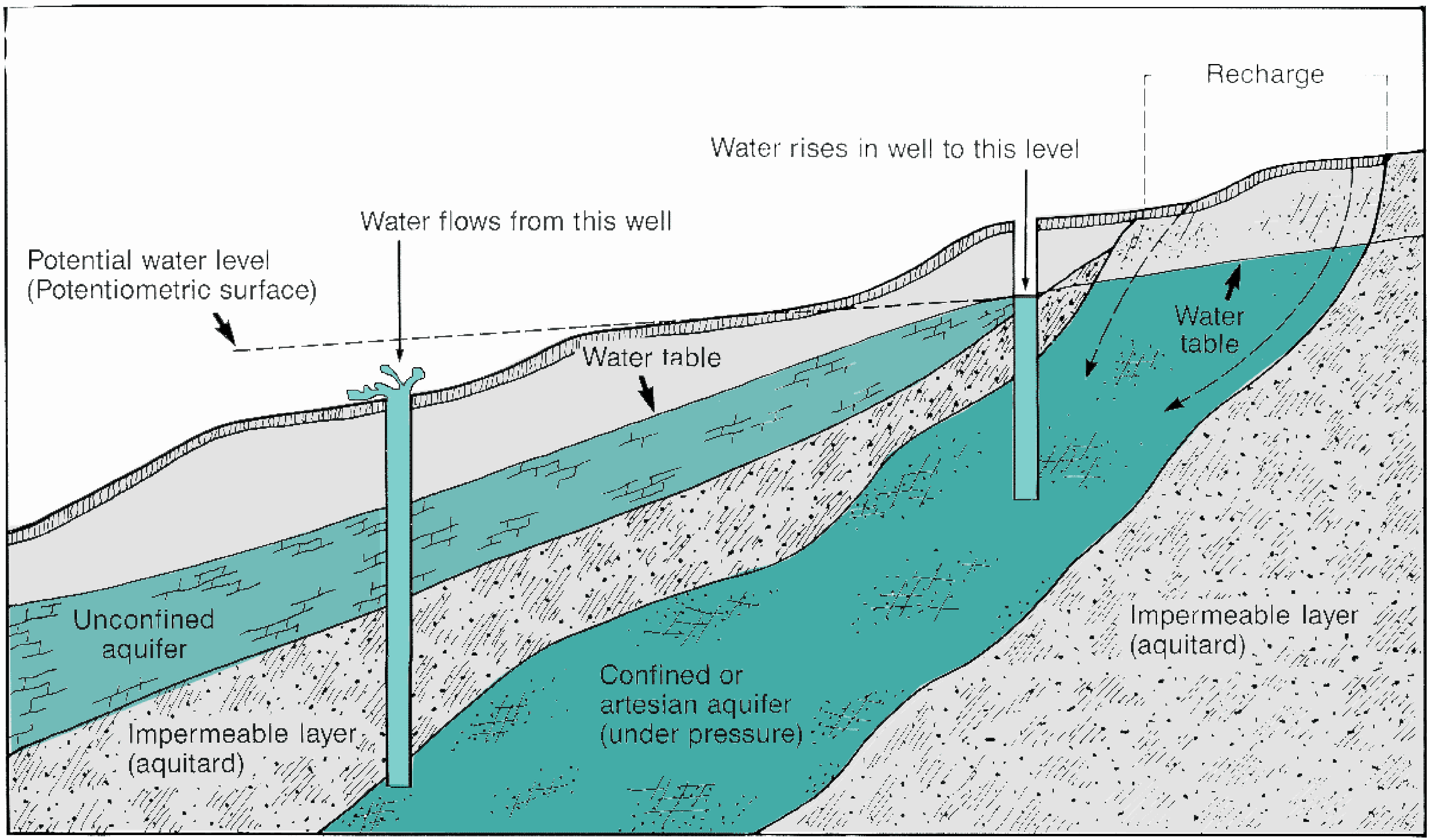
B. Confined

C. Artesian

D. Perched



# E. Potentiometric Surface and Water Table



# III. Aquifer Characteristics

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### A. Transmissivity

- ***measures the amount of water that can be transmitted horizontally by a full saturated thickness of aquifer.***

**T**

# B. Storativity (storage coefficient)

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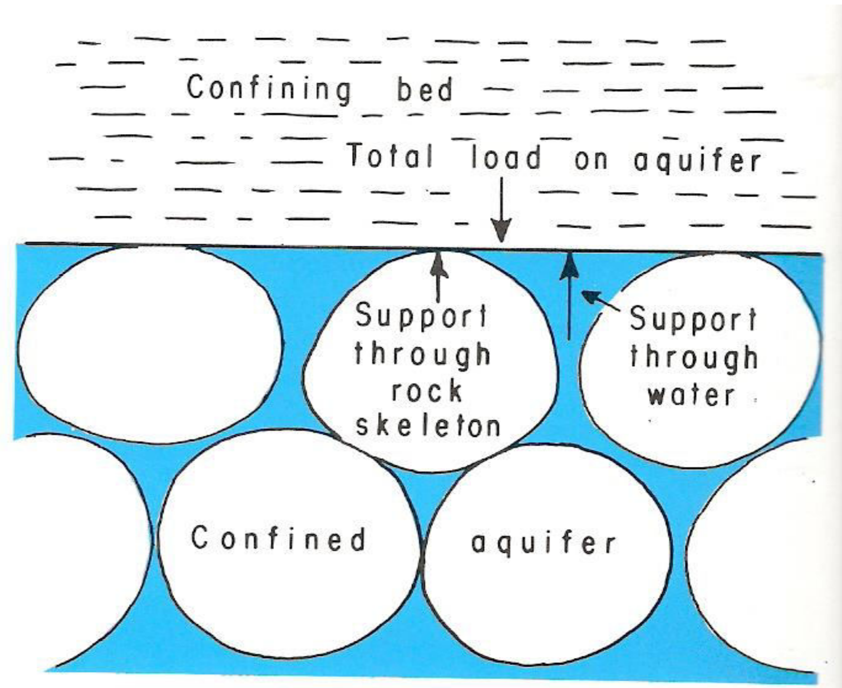
***Water is released from storage via:***

***1. decrease in fluid pressure***

***2. increase in pressure from overburden***

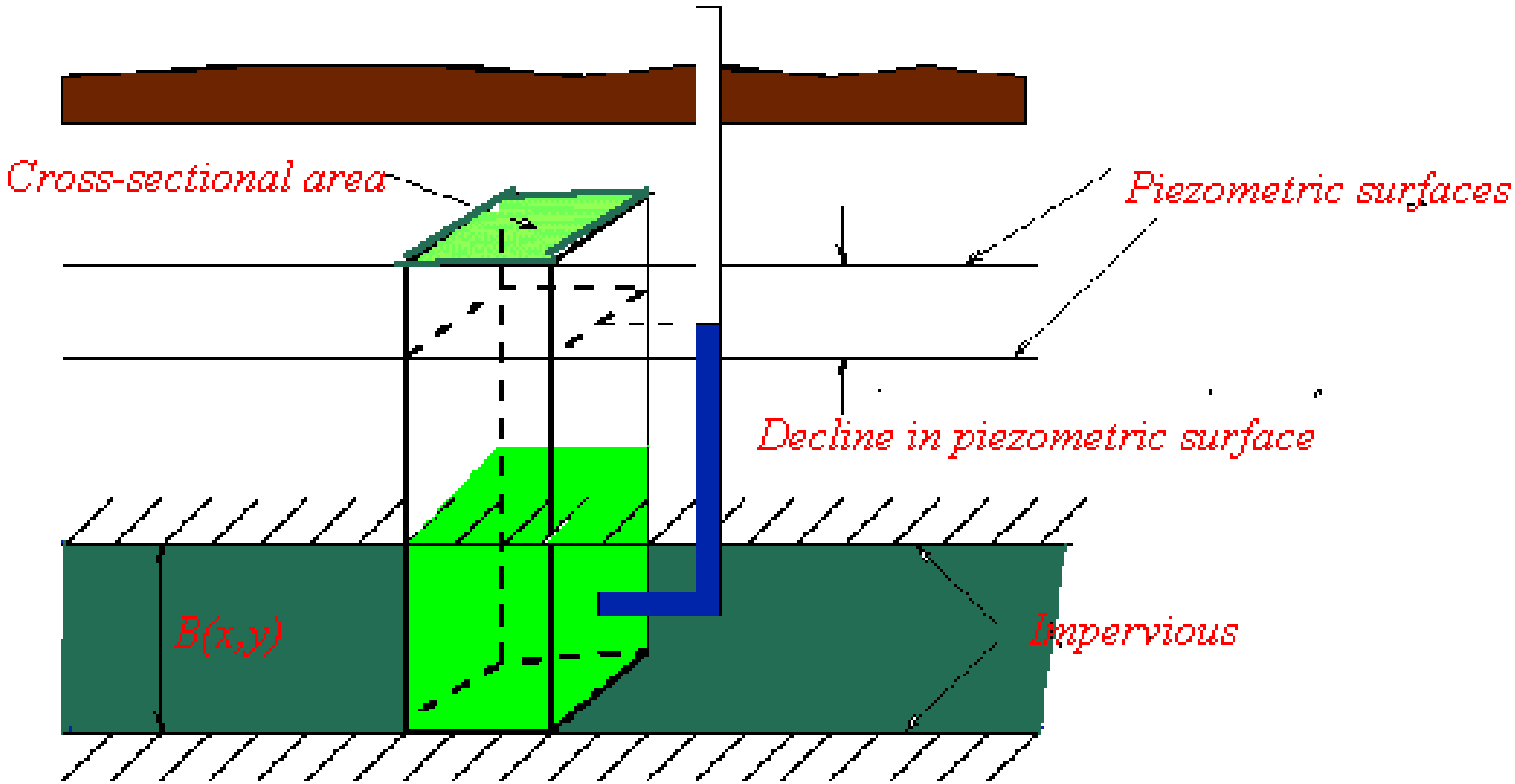

(2)

## B. Storativity (storage coefficient)

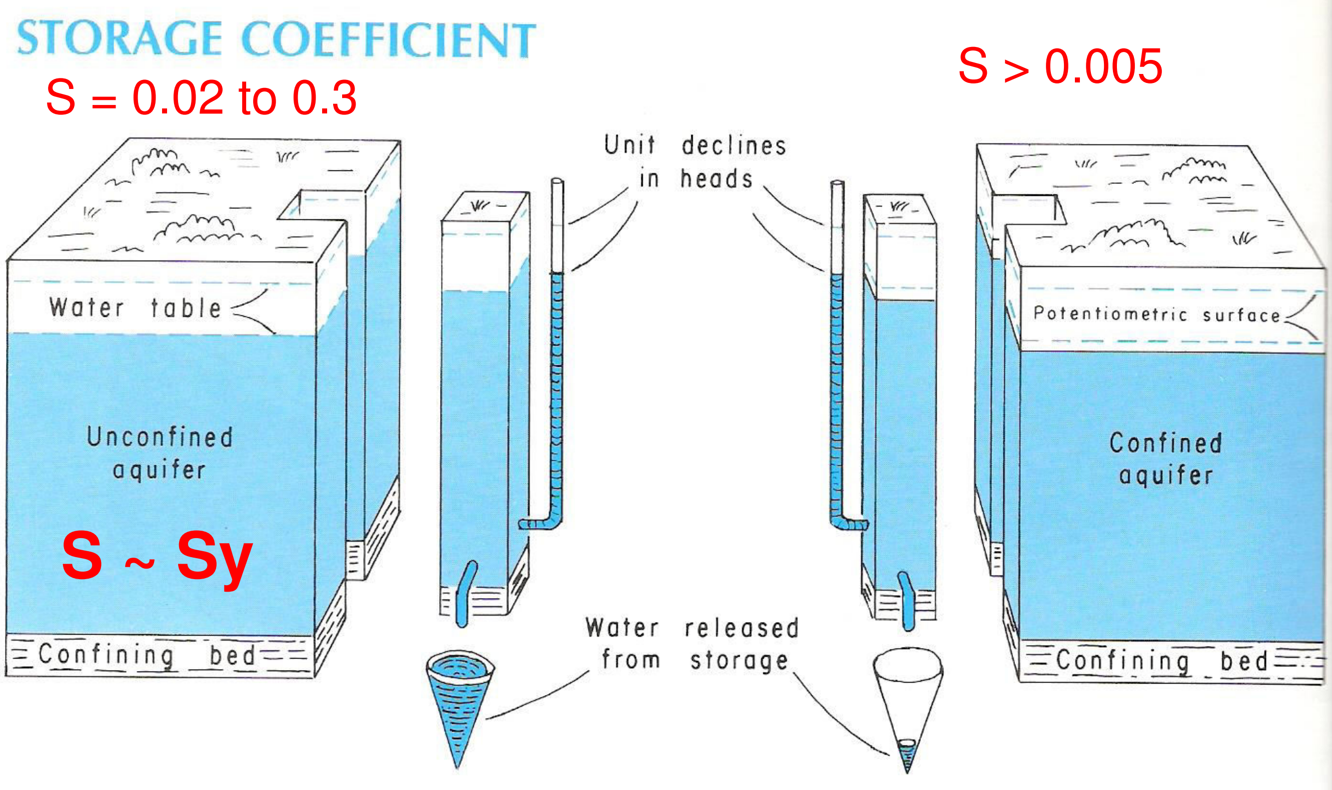
*(def): The volume of water that a permeable unit will absorb or expel from storage per unit surface area per unit change in hydraulic head*

**S**

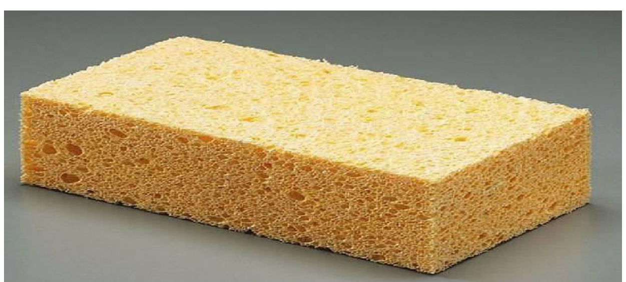
# B.  Storativity (storage coefficient)



# B. Storativity (storage coefficient)




(1)



# B. Storativity (storage coefficient)

**Example Problem**: An unconfined aquifer with a storativity of 0.13 has an area of 123 square miles. The water table drops 5.23 feet during a drought. How much water was lost from storage?

**C. Specific Storage (elastic storage coeff.)**

***(def): The volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head.***

$$S_s$$

## C. Specific Storage (elastic storage coeff.)

***(def): The volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head.***

$$S_s * b = ?$$

**C. Specific Storage (elastic storage coeff.)**

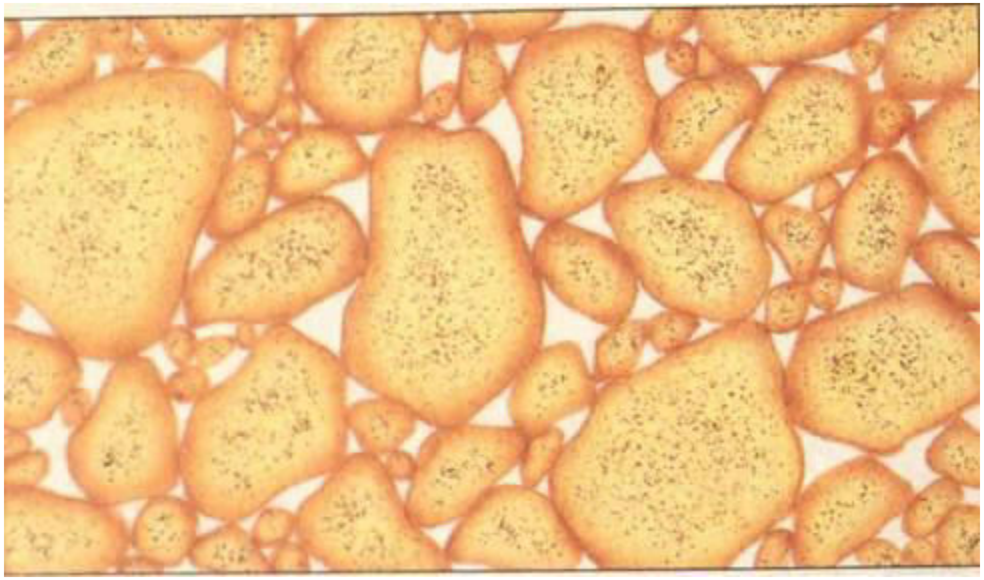
***(def): The volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head.***

$$S_s * b = S$$

# IV. Compressibility and Effective Stress

# A. Compressibility (general)

**"When pressure is applied to the aquifer, a reduction of volume can occur in 3 primary ways"**



# IV. Compressibility and Effective Stress

# A. Compressibility (general)

**“When pressure is applied to the aquifer, a reduction of volume can occur in 3 primary ways”**

- **Compaction of water**
- **Compression of individual sand grains**
- **Rearrangement of sand grains into more closely-packed configuration**

# IV. Compressibility and Effective Stress

# A. Compressibility (general)

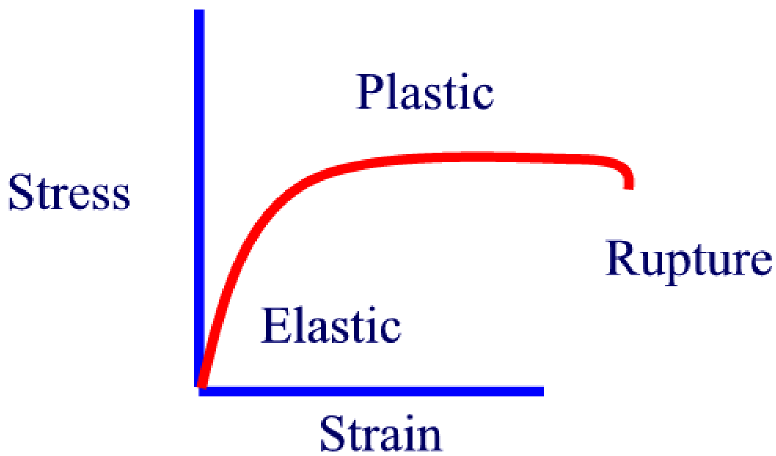
"When pressure is applied to the aquifer, a reduction of volume can occur in 3 primary ways"

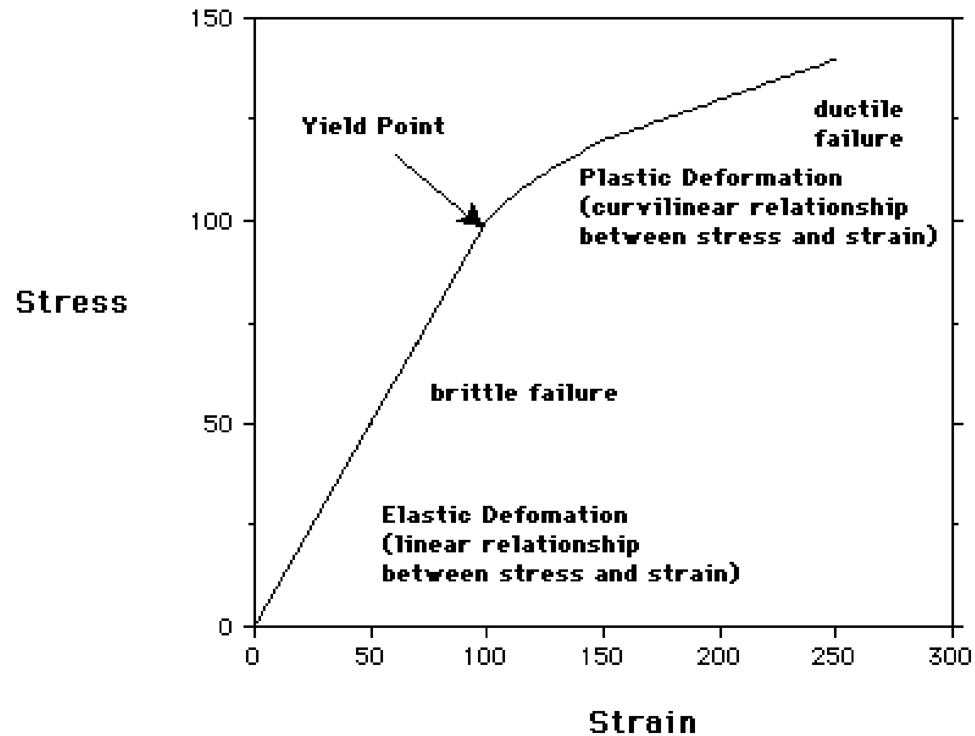
- Compaction of water (β)
- ~~Compression of individual sand grains~~
- Rearrangement of sand grains into more closely-packed configuration (α)

# IV. Compressibility and Effective Stress

# A. Compressibility (general)

$\frac{\text{Stress}}{\text{Strain}}$ = Young's Modulus of Elasticity

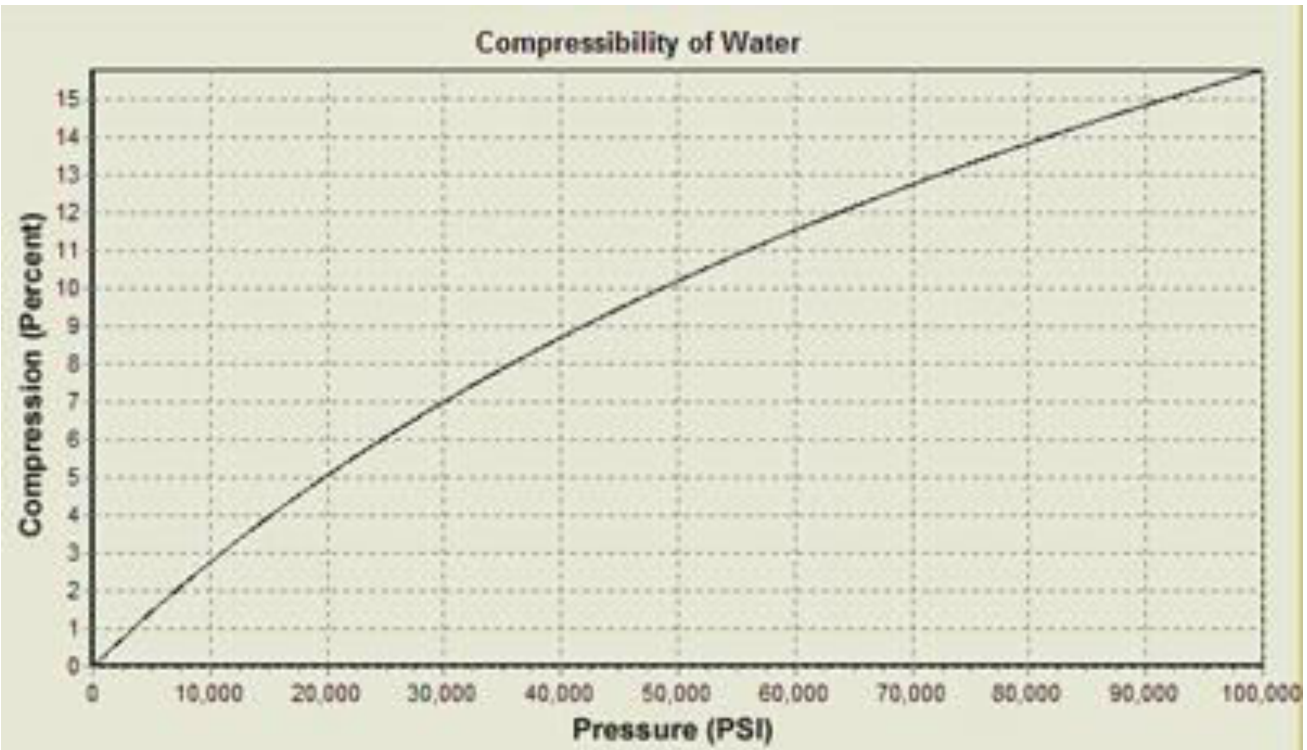


# IV. Compressibility and Effective Stress

# A. Compressibility (general)

$$\frac{\text{Strain}}{\text{Stress}} = \text{Compressibility}$$



# B. Compressibility of Water (β)

$$\frac{\text{Strain}}{\text{Stress}} = \text{Compressibility}$$

$$\beta = \frac{dV_w/V_w}{dP}$$

σ

# B. Compressibility of Water (β)

$$\beta = \frac{dV_w/V_w}{dP}$$

$$\beta = \frac{d\rho_w/\ \rho_w}{dP}$$

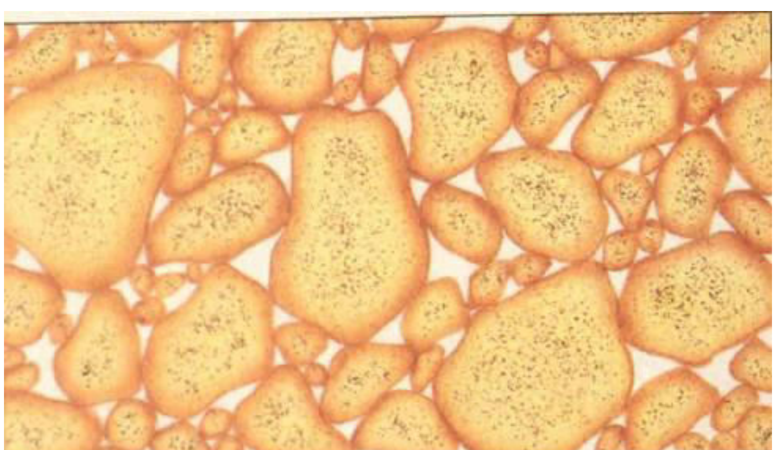
# IV. Compressibility of the Aquifer (α) and Effective Stress

## C. Compressibility of Porous Medium

### 1. "In general"….Terzaghi (1925)

Stress Total
_______________________________________________

Fluid Pressure     Effective Stress



$\sigma$

# IV. Compressibility and Effective Stress

## C. Compressibility of Porous Medium

### 1. “In general”….Terzaghi (1925)

Stress Total

Fluid Pressure + Effective Stress

$\sigma_t$

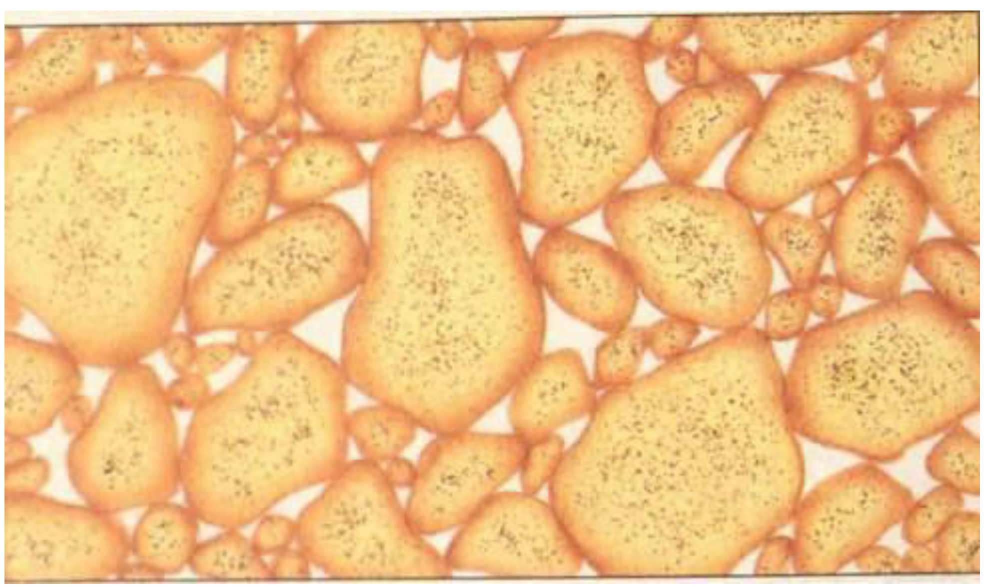
$P + \sigma_e$

σ

# Stress Total

# Fluid Pressure + Effective Stress

$$\sigma_t = P + \sigma_e$$



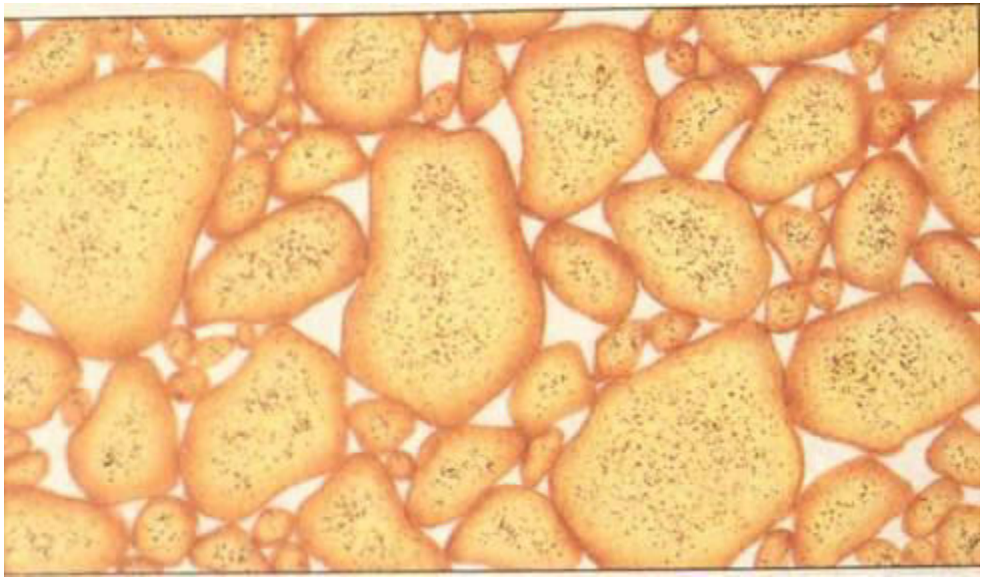
σ

# Stress Total

Fluid Pressure + Effective Stress

$$\sigma_t = P + \sigma_e$$

$$d\sigma_t = dP + d\sigma_e$$



σ

# Stress Total

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# Fluid Pressure + Effective Stress

$$\sigma_t = P + \sigma_e$$

$$d\sigma_t = dP + d\sigma_e$$

$$dP = -d\sigma_e$$

σ

$$\frac{\text{Stress Total}}{\text{Fluid Pressure} \; + \; \text{Effective Stress}}$$

$$\sigma_t = P + \sigma_e$$

$$d\sigma_t = dP + d\sigma_e$$

$$dP = -d\sigma_e$$

$$dP = \rho_w g dh$$

**IV. Compressibility and Effective Stress**

**C. Compressibility of Porous Medium**

$$\alpha = \frac{dV_t/V_t}{dP}$$

# IV. Compressibility and Effective Stress

## C. Compressibility of Porous Medium

$$\alpha = \frac{dV_t/V_t}{dP}$$

$$\alpha = \frac{db/b}{dP}$$

**V. Linking the Parameters of** $\alpha$, $\beta$, $S_s$

**A. Water produced by the compaction of the aquifer**

**B. Water produced from expansion of water**

## V. Linking the Parameters of α, β, Ss

### A. Water produced by the compaction of the aquifer

$$dV_{water} = \rho g \alpha$$

### B. Water produced from expansion of water

$$dV_{water} = \rho g n \beta$$

# V. Linking the Parameters of α, β, Ss

## A. Water produced by the compaction of the aquifer

## B. Water produced from expansion of water

## C. The Link

$dV_{water} = \rho g \alpha$ $dV_{water} = \rho g n \beta$

$$dV_{water\ from\ \alpha} + dV_{water\ from\ \beta} = Ss$$

## V. Linking the Parameters of α, β, Ss

**A. Water produced by the compaction of the aquifer**

**B. Water produced from expansion of water**

## C. The Link

$dV_{water} = \rho g \alpha$ $\quad$ $dV_{water} = \rho g n \beta$

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$\rho g \alpha + \rho g n \beta = Ss$

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$$\rho g \alpha + \rho g n \beta = Ss$$

$$\rho g(\alpha + n\beta) = Ss$$

# V. Linking the Parameters of α, β, Ss

## A. Water produced by the compaction of the aquifer

## B. Water produced from expansion of water

## C. The Link

$dV_{water} = \rho g \alpha$ $dV_{water} = \rho g n \beta$

$$dV_{\text{water from } \alpha} + dV_{\text{water from } \beta} = Ss$$

$$\rho g \alpha + \rho g n \beta = Ss$$

$$S = Ss * ?$$

$$\rho g(\alpha + n\beta) = Ss$$

**V. Linking the Parameters**

**VI. Summary**

***" a problem to work…."***

***A confined aquifer with initial thickness of 45 m compacts by 0.20 m when hydraulic head is lowered by 25m.***

***a) what is the compressibility of the aquifer?***

***b) If the porosity of the aquifer is 12% after compaction, what is the storativity of the aquifer?***