Geol 220: GROUNDWATER HYDROLOGY

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Lecture 1- Introduction to Hydrology
Jan 28 , 2002

Outline

- Introductions- Lecturers ⟷ Students

- Agreement on Class Schedule

- Course Syllabus

- Introductory Lecture and Definitions (Dave)

- Continuum Equation and Soil Water Flow Equation (Richard)

Introduction to Groundwater Hydrology

- What is groundwater hydrology?

- Why study groundwater hydrology?

- The Hydrologic Cycle

- Some definitions related to groundwater hydrology

- Darcy's Law

Groundwater Hydrology

- The subdivision of the science of hydrology that deals with the <u>occurrence</u>, <u>movement</u> and <u>quality</u> of water beneath the Earth's surface

- Interdisciplinary scope involves physical, chemical, biological and mathematical sciences

  - Contrary to impressions of rapid movement observed for streams in caves, the movement of most ground water is exceedingly slow.

SURFACE WATER

NOW

THEN
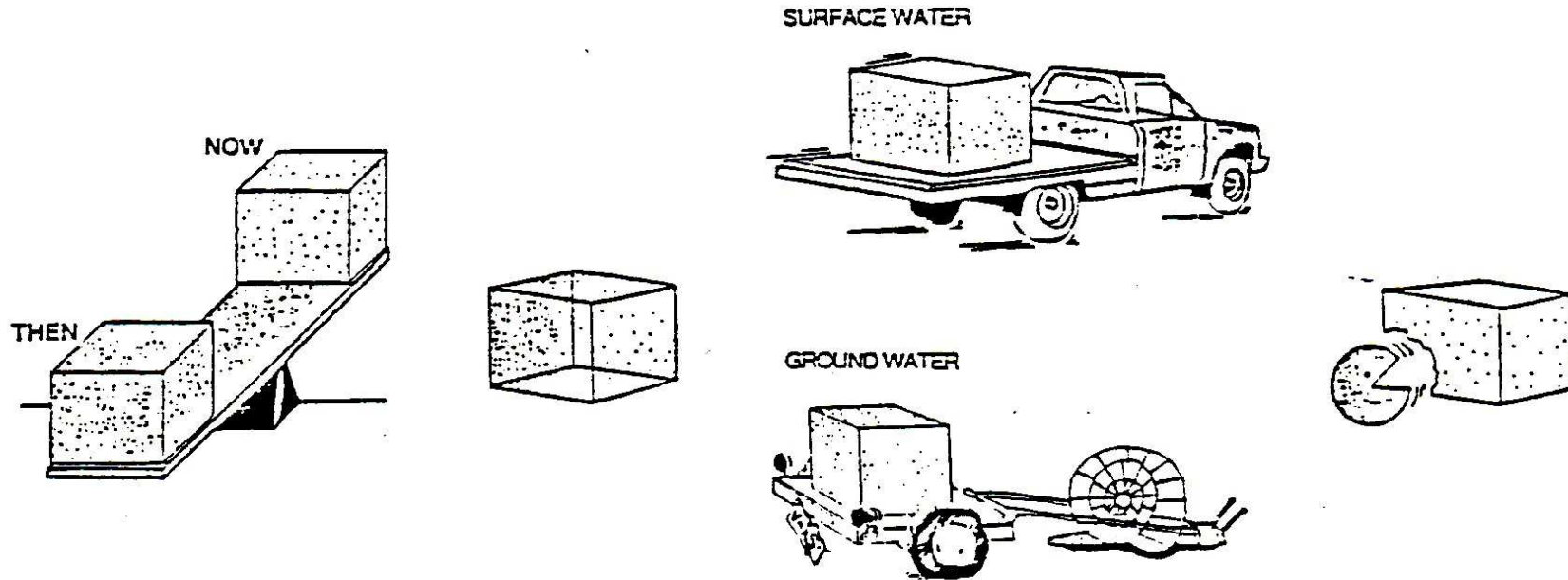
GROUND WATER

1.

velocities in surface waters, e.g., rivers can be a million times larger than those (seepage velocities) in groundwater systems (e.g., compare typical velocities of about 0.5 m/sec for rivers with groundwater seepage velocities of about 10 m/yr).

Why Study Groundwater Hydrology?

- Groundwater is the largest, accessible source of freshwater on the planet.

- Groundwater is also the largest source of freshwater available in California.

- California's economy, the seventh largest in the world, relies heavily on groundwater to meet the needs of cities, agriculture, industry and other businesses.

- Groundwater also serves as a freshwater savings account that we rely on during droughts when surface water supplies are reduced.

- **Therefore Groundwater is an important Resource**

Source: www.grac.org

Why Study Groundwater Hydrology?

- **AGRICULTURE**
  - Irrigation
  - Drainage
  - Nutrient uptake
  - Fertilizer Efficiency

- **ENGINEERING**
  - Soil subsidence
  - Drainage
  - Slope stability
  - Geological

    processes

  e.g. earthquakes

- **ENVIRONMENT/HEALTH**
  - Drainage, Flood control
  - Water Storage
  - Groundwater contamination
  - Soil degradation

Ideally, it is not possible to separate reasons for understanding groundwater hydrology in categories as listed, since water links the major components of our ecosystem as part of the:

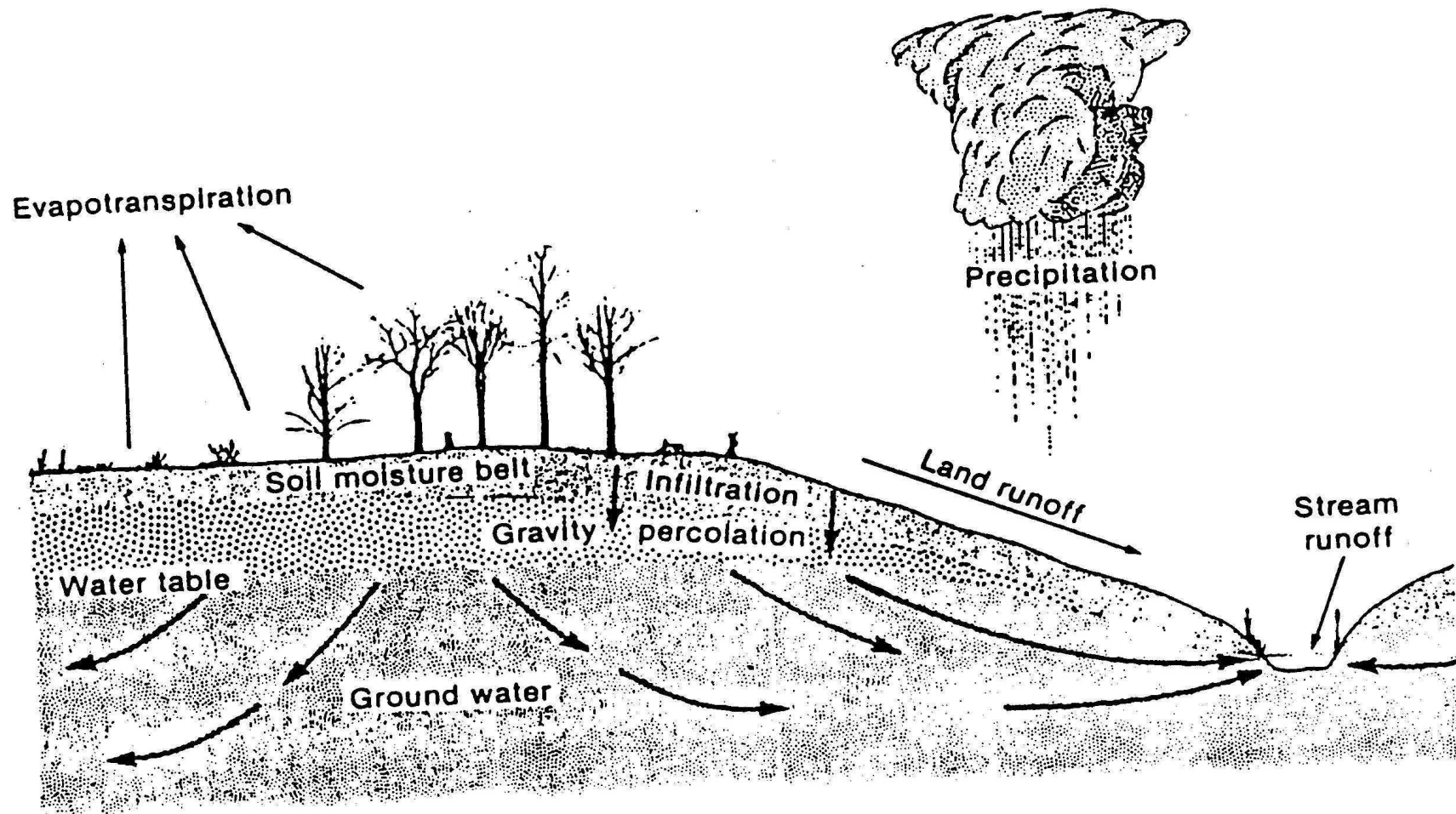## Hydrologic Cycle

Hydrologic Cycle

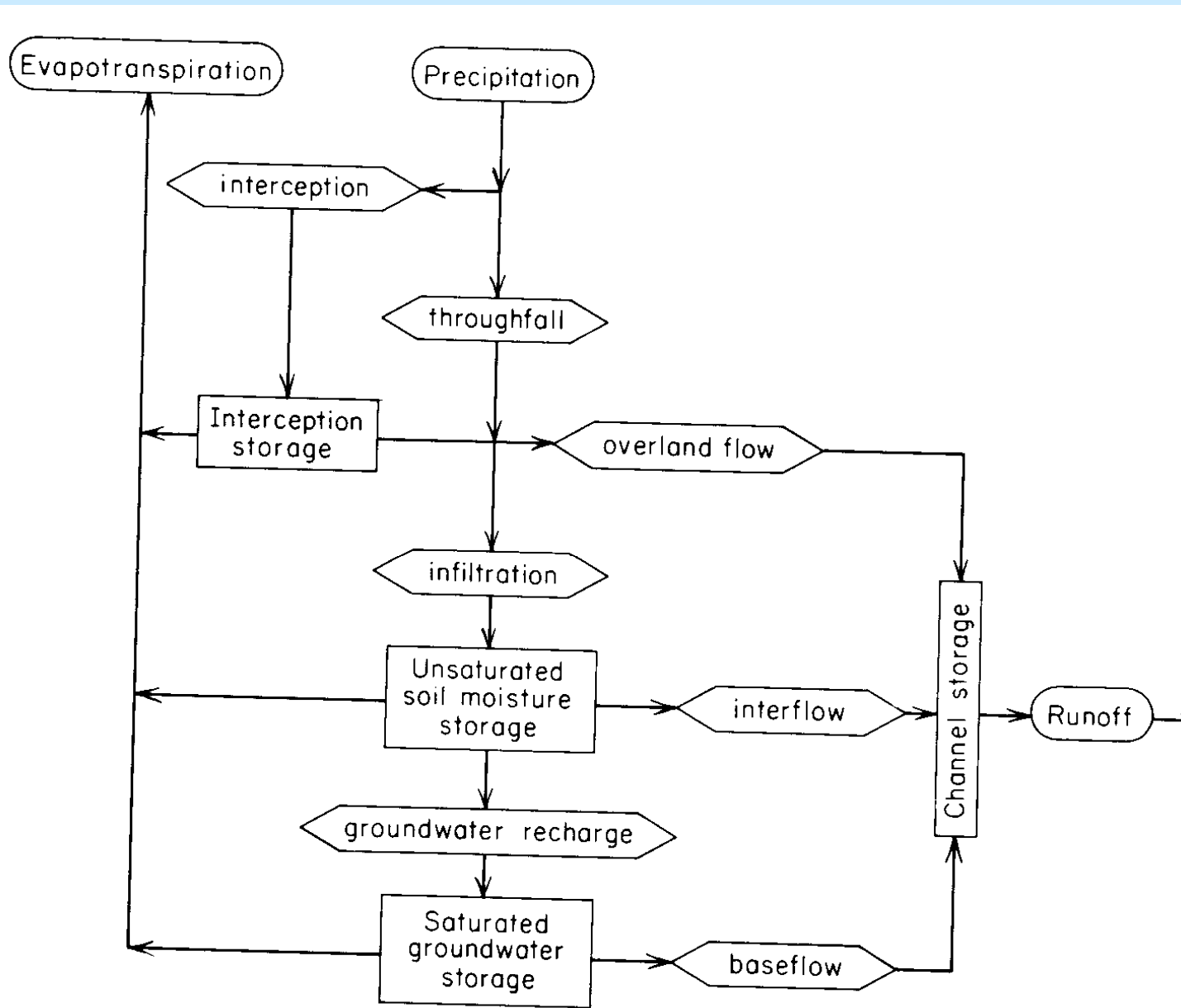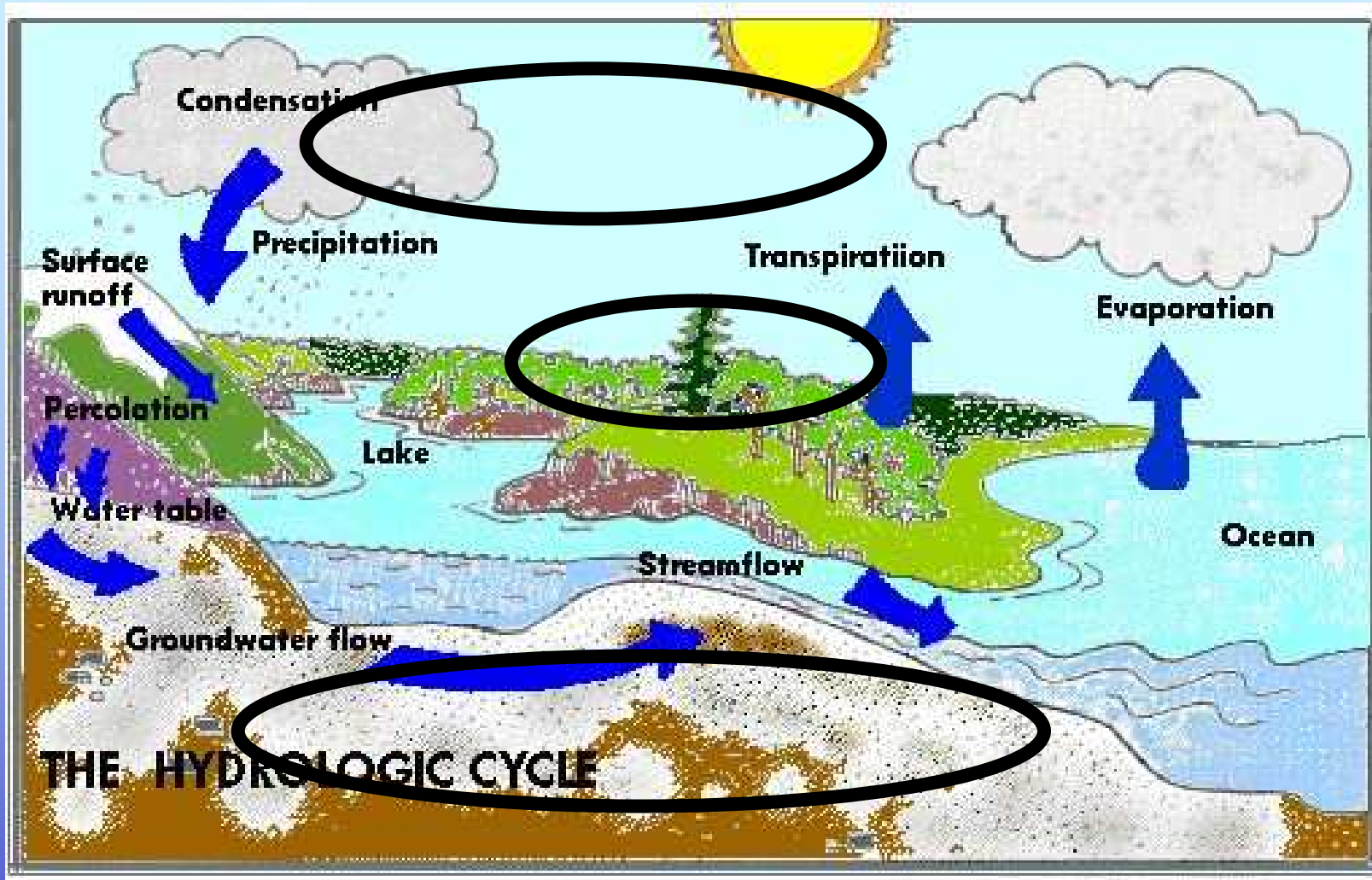Figure 1 Hydrologic processes in the terrestrial ecosystem

Figure 1.2 Systems representation of the hydrologic cycle.

The HYDROLOGIC CYCLE maintains the

Earth - Plant - Air continuum.

$V_v = 0.3 \text{ m}^3$

Water

$+$

$V_t = 1.0 \text{ m}^3$

Dry sand

1 m

1 m

Saturated sand

1 m
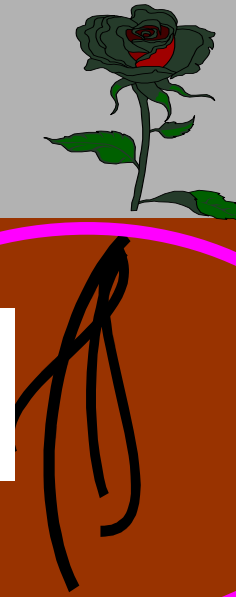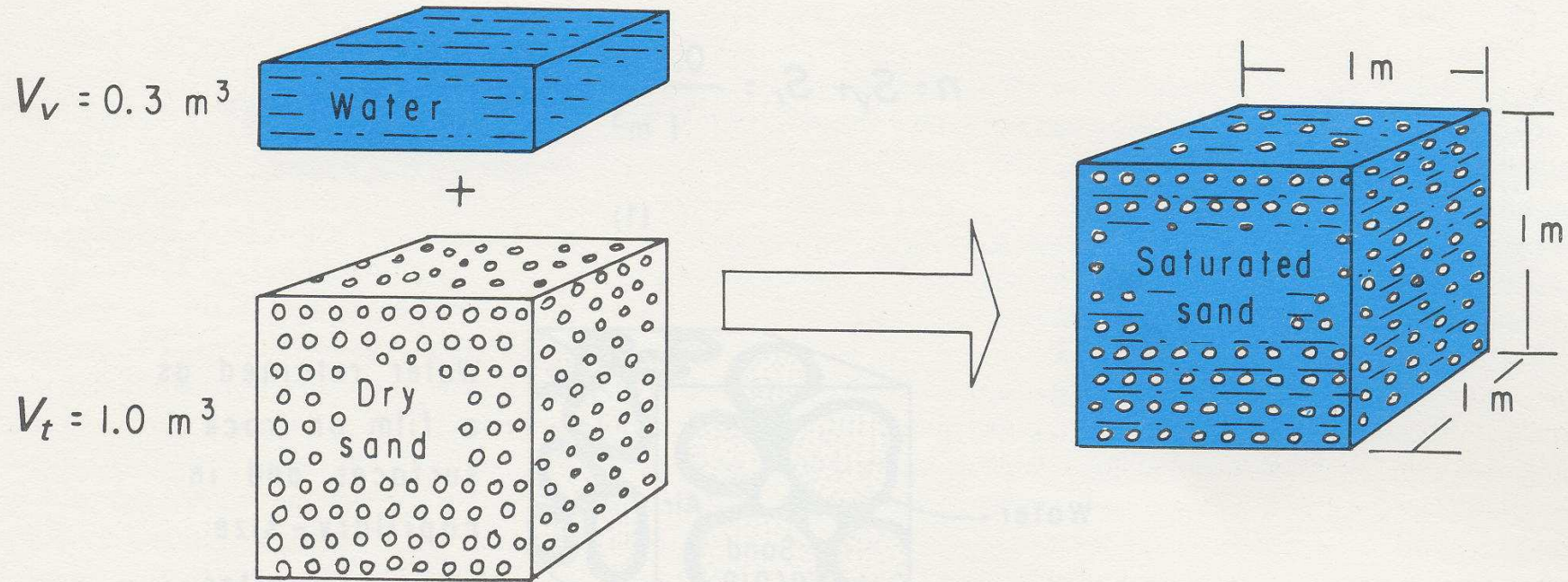
$$\text{Porosity } (n) = \frac{\text{Volume of voids } (V_v)}{\text{Total volume } (V_t)} = \frac{0.3 \text{ m}^3}{1.0 \text{ m}^3} = 0.30$$

Some More Definitions

Vadose Zone: The geologic media between the land surface and the regional water table. Often used as synonymous with the <u>Unsaturated zone</u>

Water Table : Surface in a geologic medium where water pressure equals atmospheric pressure. Often used as the boundary between the Unsaturated and Saturated Zones.

Volumetric water content θ: Volume of water per unit volume of bulk soil. Like porosity n, θ is reported as a decimal or percent. For Saturated zone $\theta = n$, and $\theta < n$ for Unsaturated zone.

Infiltration I : Rate at which water enters the soil from the surface.

If water application rate F is lower than the infiltration the soil I, then water enters into soil and there is no ponding.

If F> I then ponding results; If F>> I, then run off results!

Hydraulic Conductivity K : Rate at which water moves through the soil. Given in cm/s, m/s, cm/day, in/hr or any equivalent units of velocity,

Can vary in the x, y or z directions, as well as in the Unsaturated and Saturated zones.
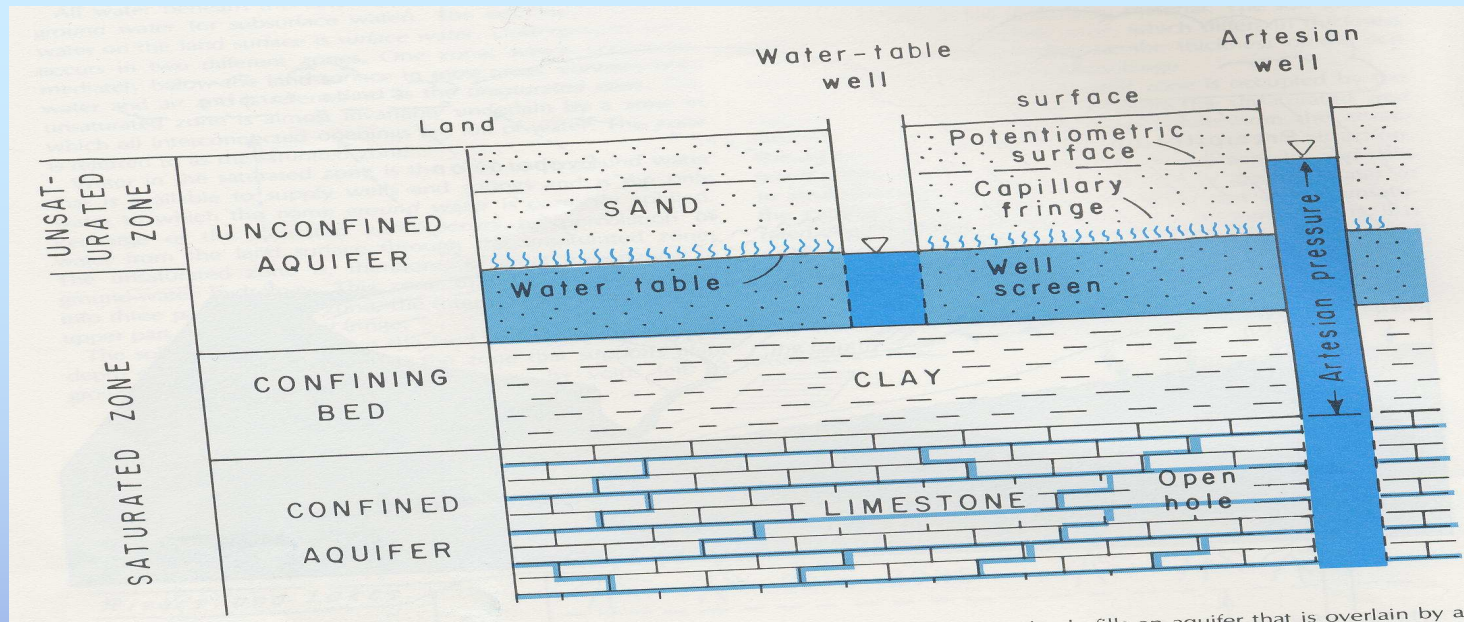
• From a geologic stand point, all rocks that underlie the earth's surface can be classified as **AQUIFERS** or **CONFINING BEDS**

• An **AQUIFER** is a rock unit that will yield water in a usable quantity to a well or spring

• A **CONFINING BED** is a rock unit having a very low hydraulic conductivity that restricts the movement of groundwater either into or out of adjacent aquifers.

• A **CONFINING BED** is also referred to as as **AQUITARD**

Darcy's Law

Figure .1 Experimental apparatus for the illustration of Darcy's law.
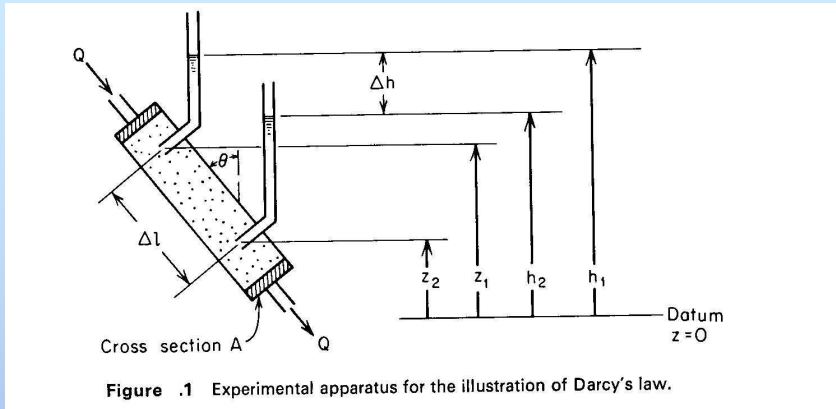
• Assume the cylinder is filled with saturated soil, and water is flowing through it such that rate Q at the inlet is equal to rate Q at the outlet

• Set an arbitrary datum, z = zero

• h1 and h2 are elevations in the manometers

• ΔL is the distance between manometers

• The water flux (specific discharge) is q = Q/A, where A is the cross-sectional area of the cylinder.

• Δh = h2 minus h1. .

$$q = -K \frac{\Delta h}{\Delta l}$$

$$q = -K \frac{\partial h}{\partial l}$$

• where dh/dl is the hydraulic gradient, and K is hydraulic conductivity

Darcy's law: The flow of water through a porous medium is in the direction of, and at a rate proportional to, the driving force (i.e. *the hydraulic gradient*) and also proportional to the ability of the conducting medium to transmit the water (*hydraulic conductivity*).

Using x, y and z coordinates, we can write flux as

$$q_x = -K_x \frac{\partial H}{\partial x}$$

$$q_y = -K_y \frac{\partial H}{\partial y}$$

$$q_z = -K_z \frac{\partial H}{\partial z}$$

Darcy's Equation for Water Flow

- In 1856, Henry Darcy developed the equation for water flux:

$$q = -K \; grad \; H$$

Where q is the flux (m/s), H is the hydraulic head (m), and grad H the gradient of the hydraulic head.

In saturated soils K is defined as the saturated hydraulic conductivity, Ks.

In Unsaturated soils, K is the unsaturated hydraulic conductivity.

Stop here on 01-28-02

☺!?

OR

☹!?