CE 3354 ENGINEERING HYDROLOGY

LECTURE 2: WATER BUDGET EXAMPLE; AQUIFERS

OUTLINE

- Water Budget
- Aquifers

WHAT IS HYDROLOGY?

- Study of the occurrence, circulation, storage, and distribution of surface and groundwater on the Earth.
- Engineering hydrology is the quantification of amounts of water at various locations (spatially) as a function of time (temporally) for surface water applications.

WHAT IS A WATERSHED?

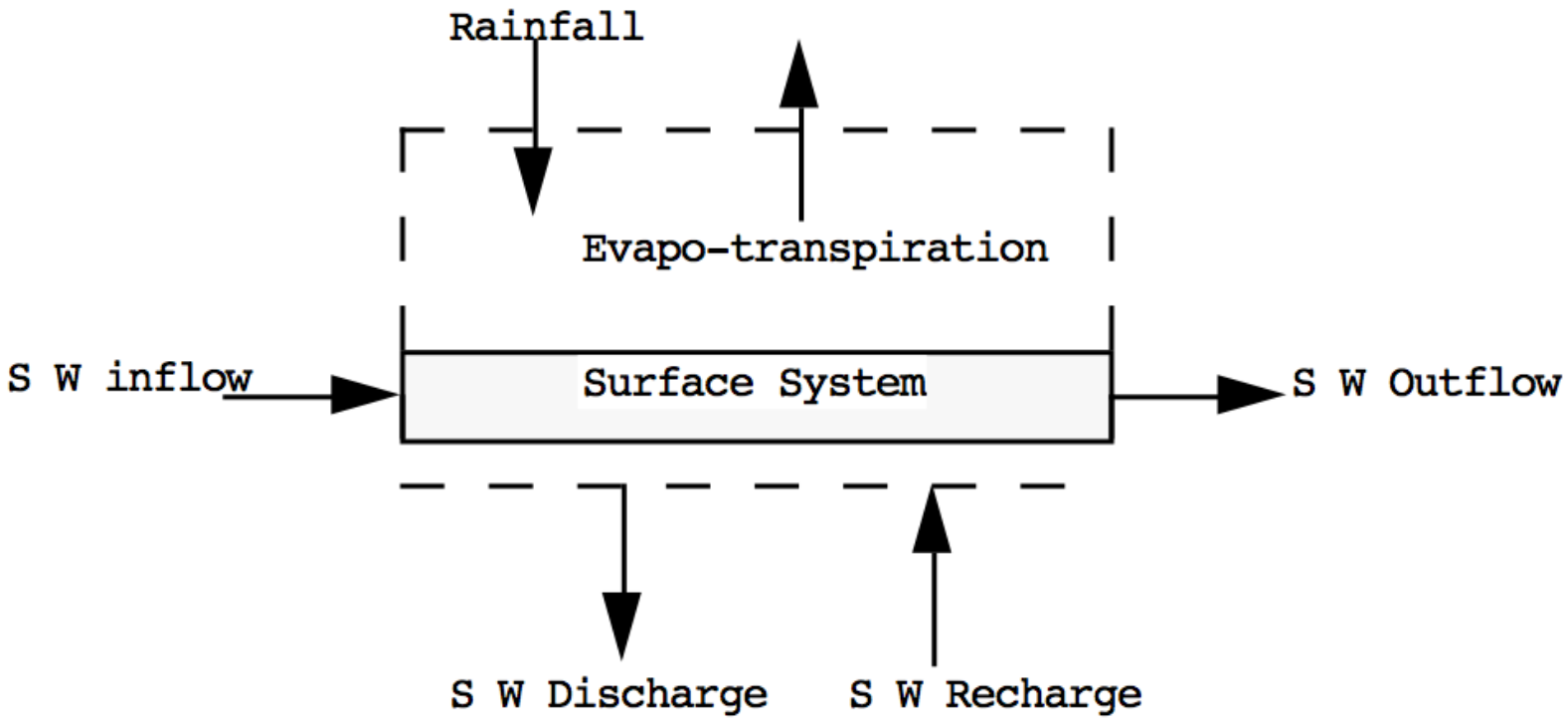
- Topographic area that collects and discharges surface streamflow through one outlet or mouth (pour point)
- The area on the surface of the Earth that drains to a specific location
- In groundwater a similar concept is called a groundwater basin – only the boundaries can move depending on relative rates of recharge and discharge

WATER BUDGET

- The water budget, or hydrologic balance is simply the expression of the conservation of mass in hydrologic terms for a hydrologic system.
- Generally it is expressed as a rate (or volume) balance.
- The hydrologic equation is the fundamental tool in hydrology to describe amounts of water in storage in different compartments at different scales. The equation expressed in "words" is

Rate of inflow - Rate of outflow = Rate of change of storage + Rate of internal mass generation.

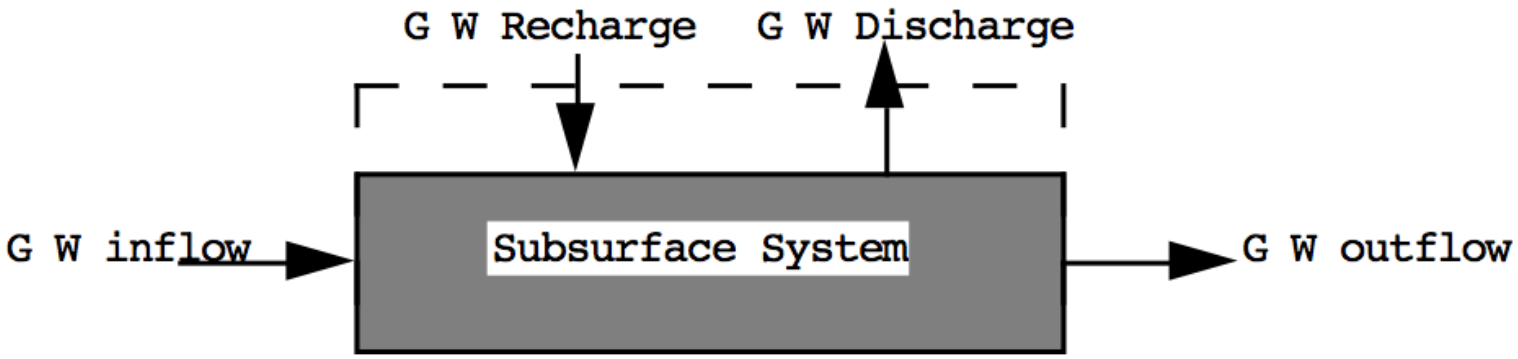
SURFACE WATER SYSTEMS



SURFACE WATER BUDGET

- From the surface water system diagram, an appropriate budget would be
  - Inflows: Rainfall; Surface water from outside boundary, recharge from Groundwater.
  - Outflows: Evapotranspiration; Surface water leaving boundary; Infiltration to groundwater.
  - Storage: Water levels in lakes, rivers, ponds within the boundary; water stored on leaves and other surfaces.

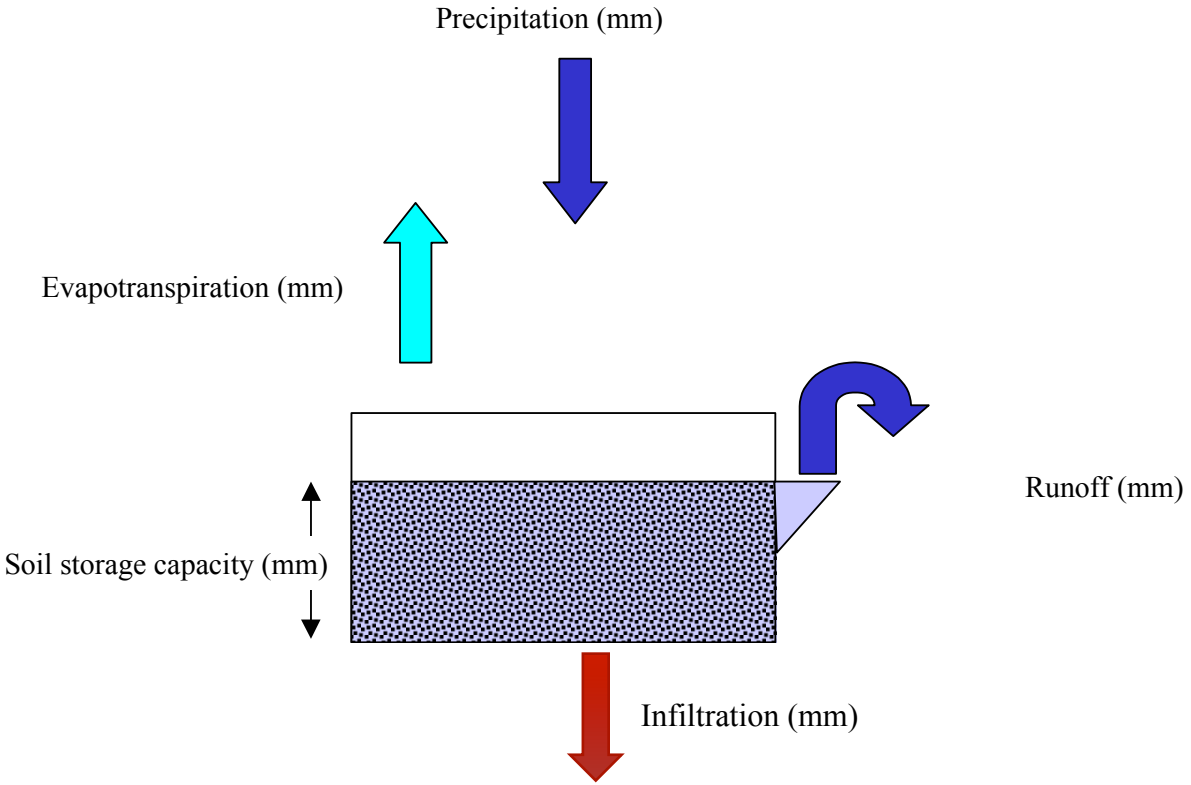
GROUND WATER SYSTEMS



GROUND WATER BUDGET

- From the surface water system diagram, an appropriate budget would be
  - Inflows: Groundwater flow from outside boundary; Recharge from surface system (via infiltration)
  - Outflows: Groundwater flow out of the boundary; Discharge (pumping; springs) to surface system
  - Storage: Water levels in aquifers within the boundary

CONCEPTUAL MODEL OF A WATER BUDGET

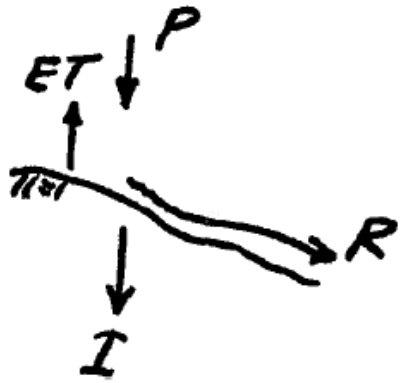


WATER BUDGET EXAMPLE

OVER 2 MONTHS, THE AREA AROUND BETWS-Y-COED IN WALES IS EXPECTED TO RECIEVE 254mm OF RAIN, WITH EXPECTED ET OF 85mm, AND I 20mm. THERE IS NEGLIGIBLE STORAGE IN THE CATCHMENT. WHAT IS THE EXPECTED RAINFALL EXCESS FROM THE CATCHMENT IF THE AREA IS $65 km^2$. EXPRESS THE ANSWER IN m^3 & liters. HOW MANY PEOPLE CAN THE CATCHMENT SUPPLY IF THE DAILY WATER DEMAND IS 160 liters/person?

WATER BUDGET EXAMPLE

SOLUTION



APPLY WATER BALANCE

$$P - ET - I - R \pm \Delta S = 0$$

ΔS → NEGLIGIBLE

"WATERSHED MILLIMETERS"

$$\therefore R = P - ET - I$$

$$= 254 - 85 - 20 = 149\,mm$$

WATER BUDGET EXAMPLE

IN m^3

$$\frac{149\,mm}{1000\,mm/m} \cdot 65\,km^2 \cdot 10^6\,m^2/km^2 = 9.685 \cdot 10^6\,m^3 \times \frac{1000\,L}{m^3} = 9.685 \cdot 10^9\,L$$

USAGE/SUPPLY

$$\frac{160\,L}{person\text{-}day} \cdot \frac{30\,day}{mo} \cdot 2\,mo = 9600\,L/person$$

$$\therefore \quad 9.685 \cdot 10^9\,L / 9600\,L/person = 10^6\,people$$

1 million people, but if better rain!

AQUIFERS

- An aquifer is a geologic formation that stores and transmits water
- Storage is in the interstitial (pore) space between the solid particles that comprise the formation
- Transmission is in the interconnected pore space

POROSITY AND WATER CONTENT

$$n = \frac{V_{voids}}{V_{total}}$$

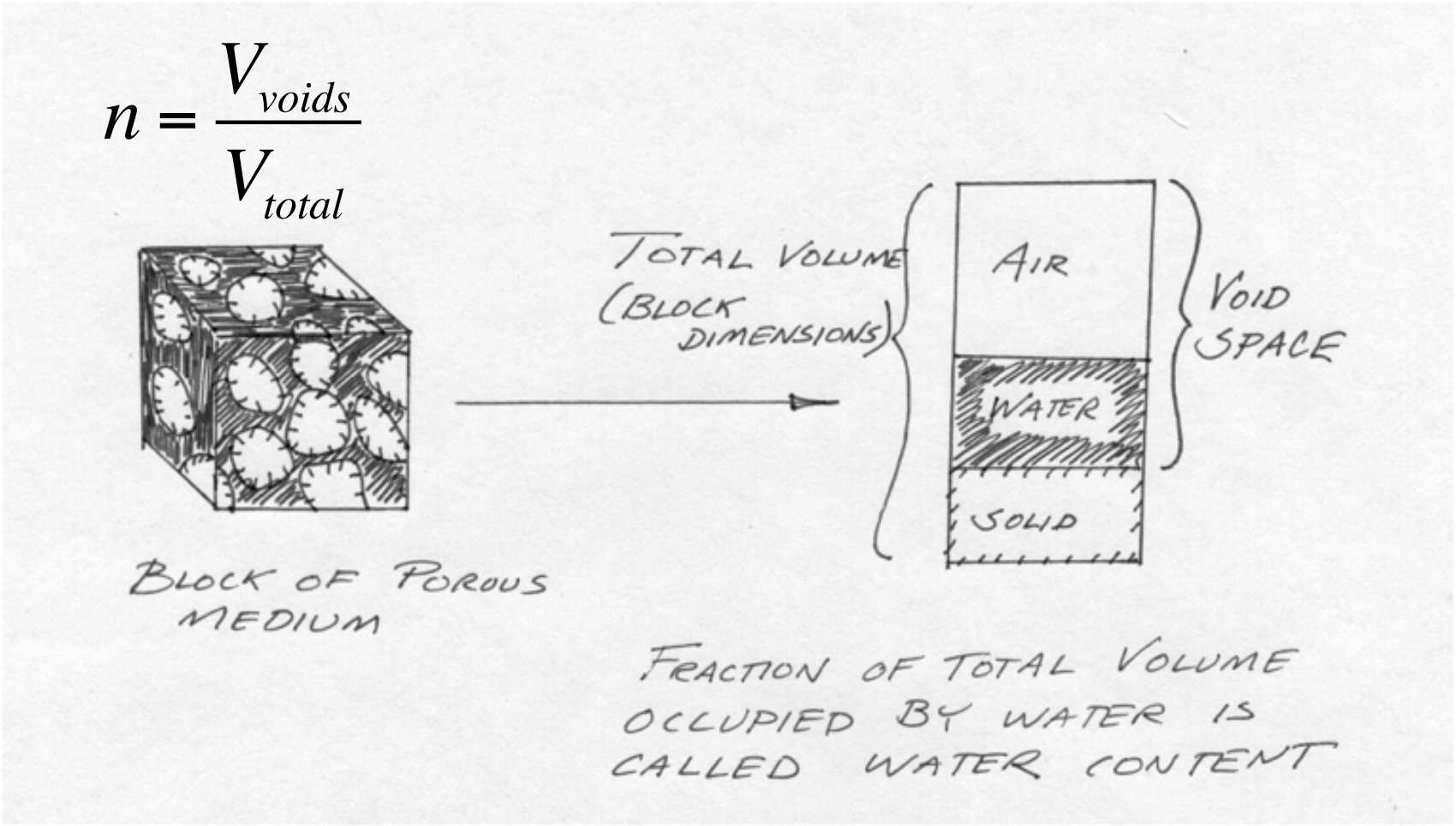


Figure 1.1 Schematic of porous medium and various compartments in the porous medium.

TYPES OF POROUS STRUCTURE

Figure 1.2 Porous materials comprised of spheres.
(From Heath, R.C., 1983. Basic Ground-Water Hydrology, USGS Water Supply Paper 2220)

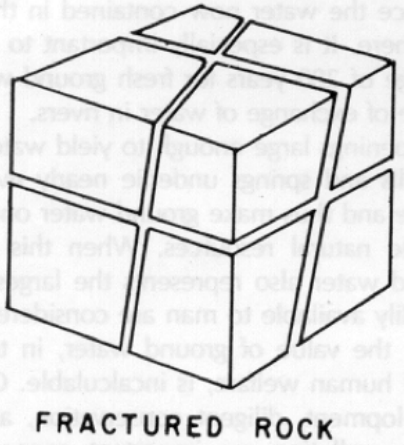


Figure 1.3. Porous material comprised of fractured solids
(From Heath, R.C., 1983. Basic Ground-Water Hydrology, USGS Water Supply Paper 2220)

TYPES OF POROUS STRUCTURE

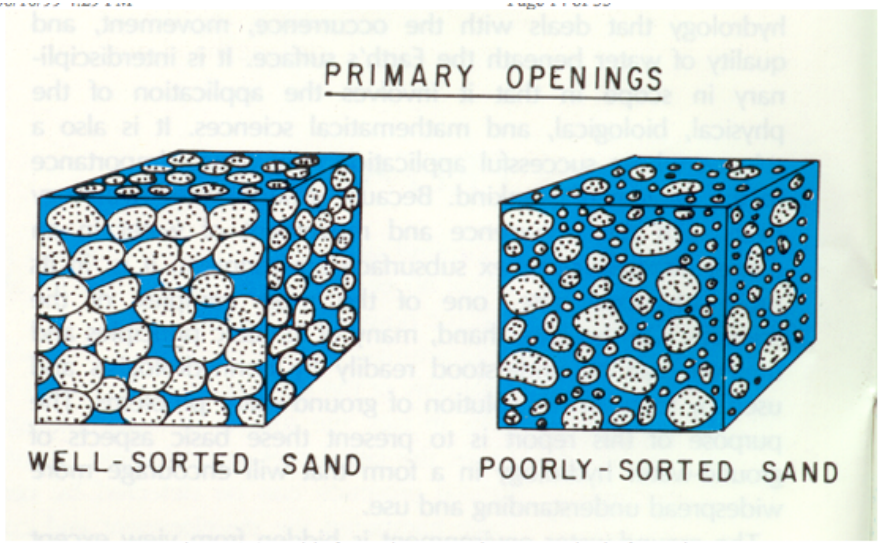


Figure 1.4. Voids formed at same time as geologic formation
(From Heath, R.C., 1983. Basic Ground-Water Hydrology, USGS Water Supply Paper 2220)

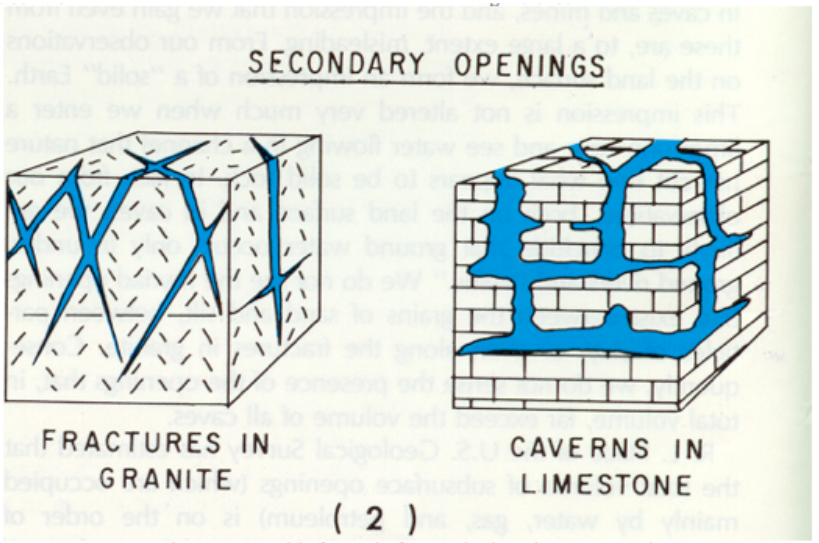


Figure 1.5. Voids formed after geologic unit was created
(From Heath, R.C., 1983. Basic Ground-Water Hydrology, USGS Water Supply Paper 2220)

MOISTURE ZONES

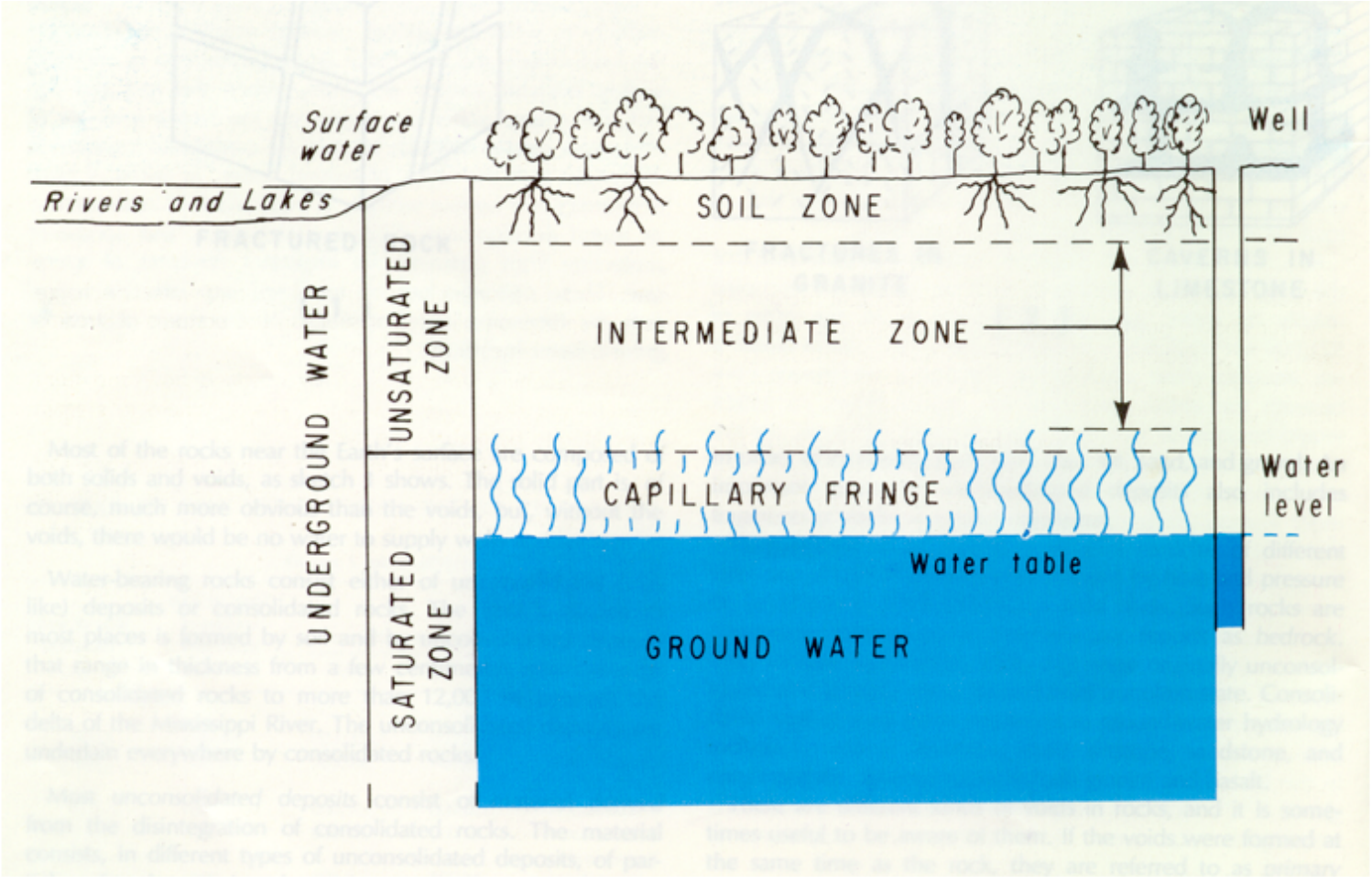
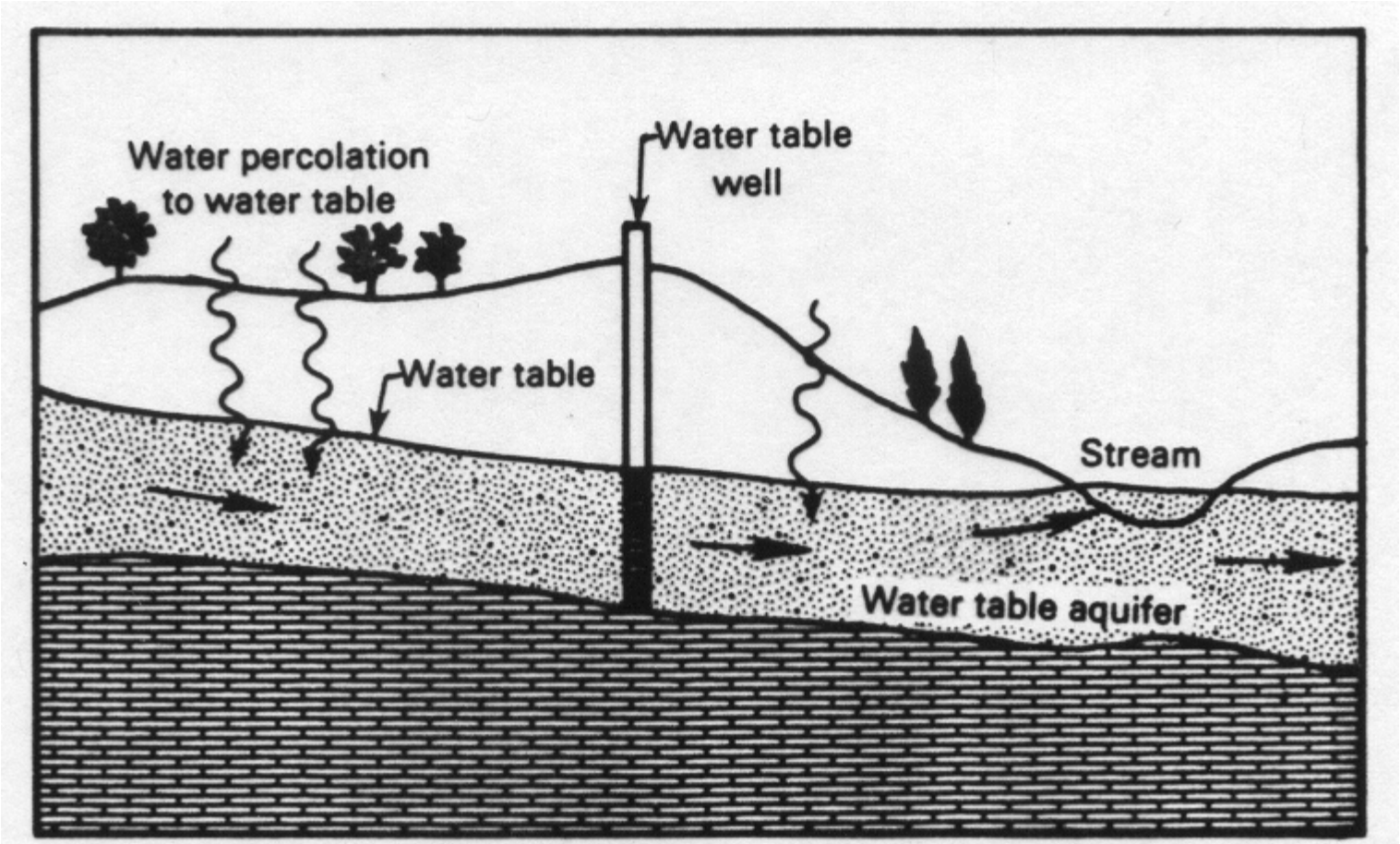


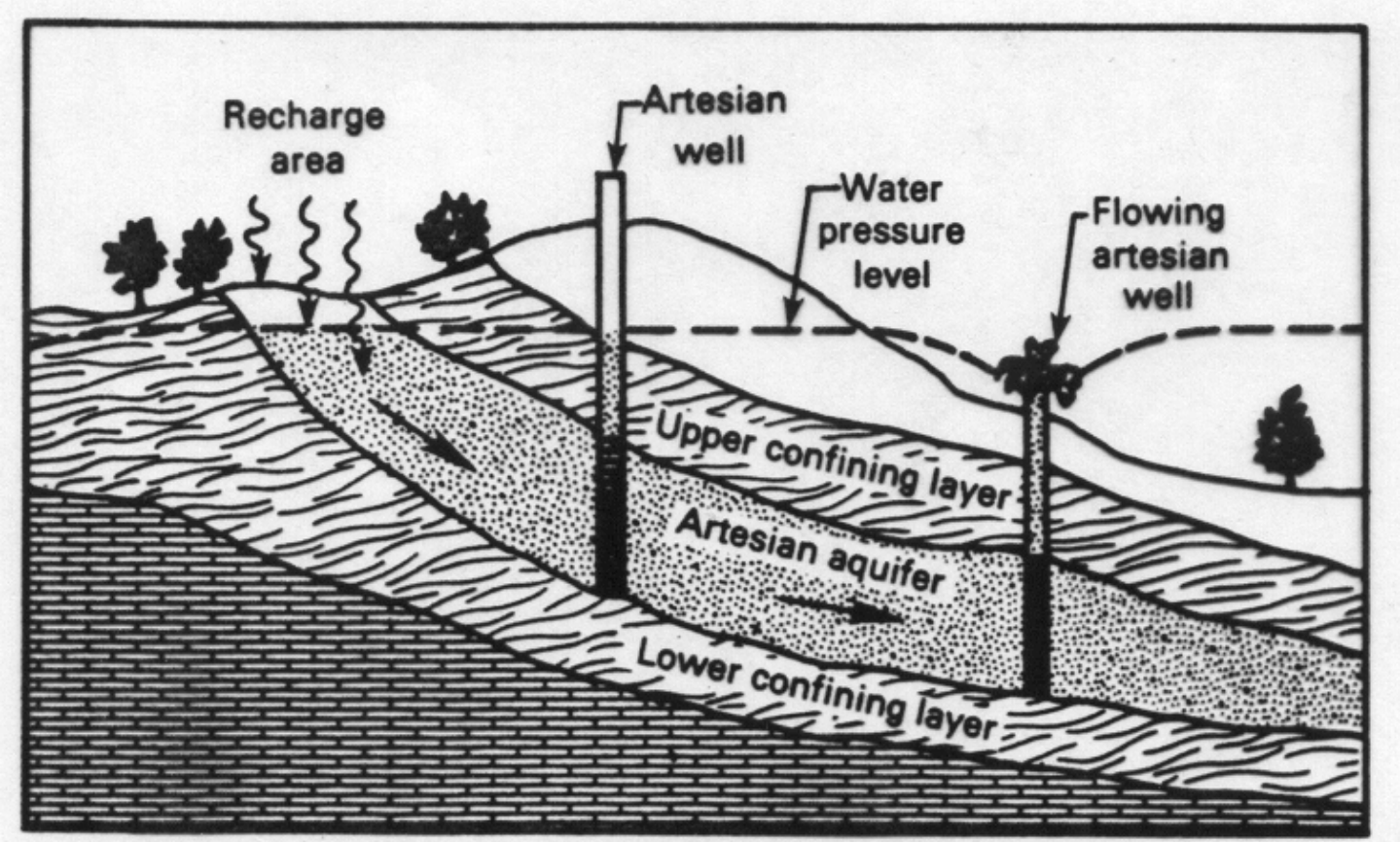
Figure 1.7 Diagram of different moisture zones in the subsurface.
(From Heath, R.C., 1983. Basic Ground-Water Hydrology, USGS Water Supply Paper 2220)

AQUIFER TYPES



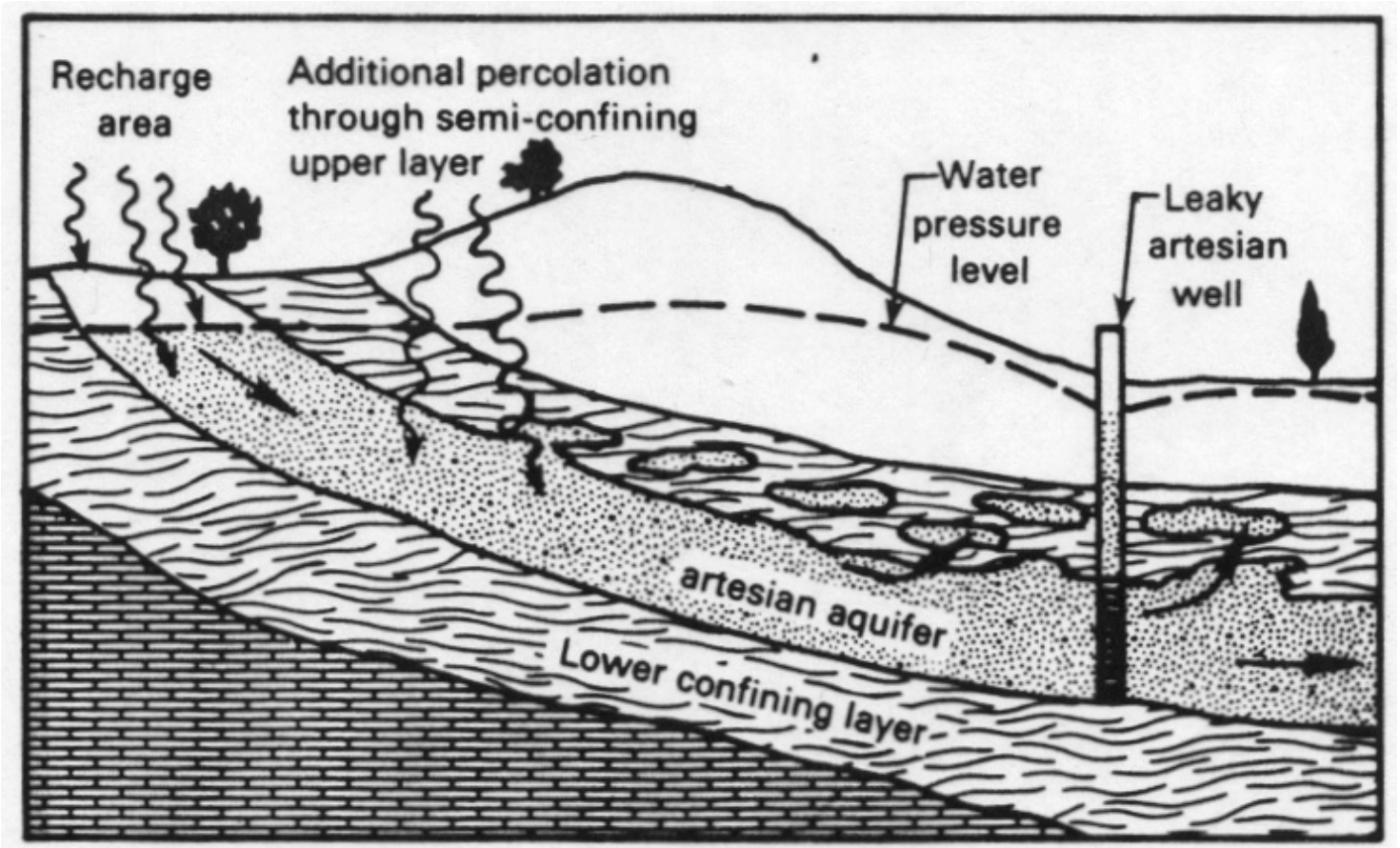
Water table (unconfined) aquifer

AQUIFER TYPES



Artesian (confined) aquifer

AQUIFER TYPES



Leaky Artesian (Gulf Coast) aquifer

NEXT TIME

- Hydrologic Data
- Watershed Delineation