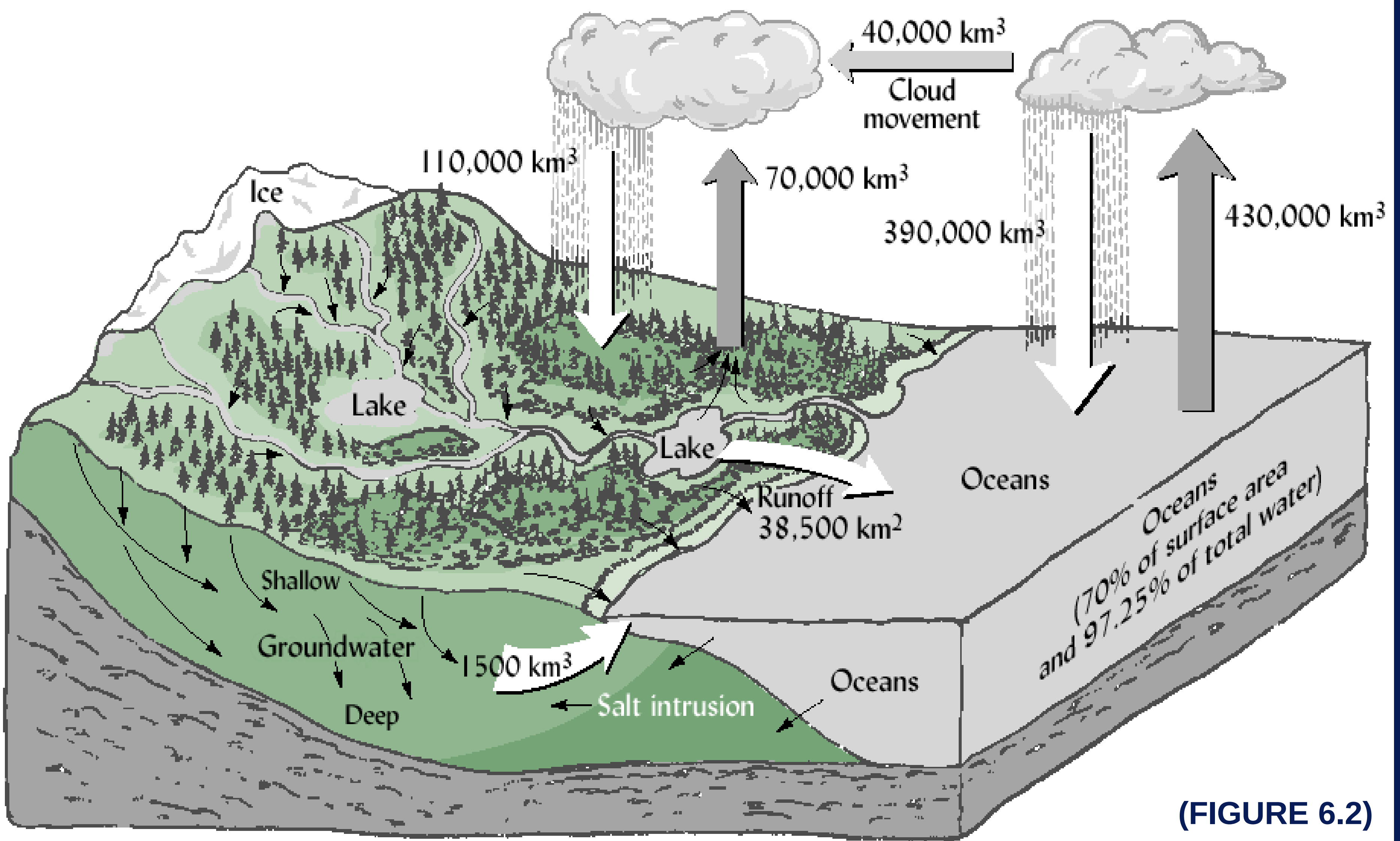
GEOLOGY 408/508

SOIL AND THE HYDROLOGIC CYCLE

CHAPTER 6

Brady & Weil, Rev. 14th ed.

THE HYDROLOGIC CYCLE



(FIGURE 6.2)

WATER BALANCE EQUATION

Watershed - an area of land drained by a single stream system and is separated from adjacent areas by ridges

- An important ecological concept; activities in one area may affect entire watershed
- Water-balance equation:

$$P = ET + SS + D$$

P = precipitation

ET - evapotranspiration

SS - soil storage

D - discharge

FATE OF PRECIPITATION & IRRIGATION WATER

- **Interception - catchment of precipitation by canopy vegetation**

  - may prevent 30-50% rainfall from reaching soil

- **Water impacting soil:**
  - **- infiltration**
    - **- soil storage**
    - **- drainage from profile**
  - **- surface runoff**
    - **- may cause erosion**

FATE OF PRECIPITATION & IRRIGATION WATER

Effects of Vegetation & Soil Properties on Infiltration

- Type of vegetation
  - grasslands - dense vs sparse cover
  - forests - dense vs sparse cover
- Stem flow
  - slows and captures rainfall
  - varies with vegetation type
- Soil management
  - enhance surface retention in cultivated fields
  - cover crops
- Soil porosity
  - loose & open vs. tightly packed

Two methods of increasing infiltration and slowing runoff in urbanized watersheds

Permeable pavers

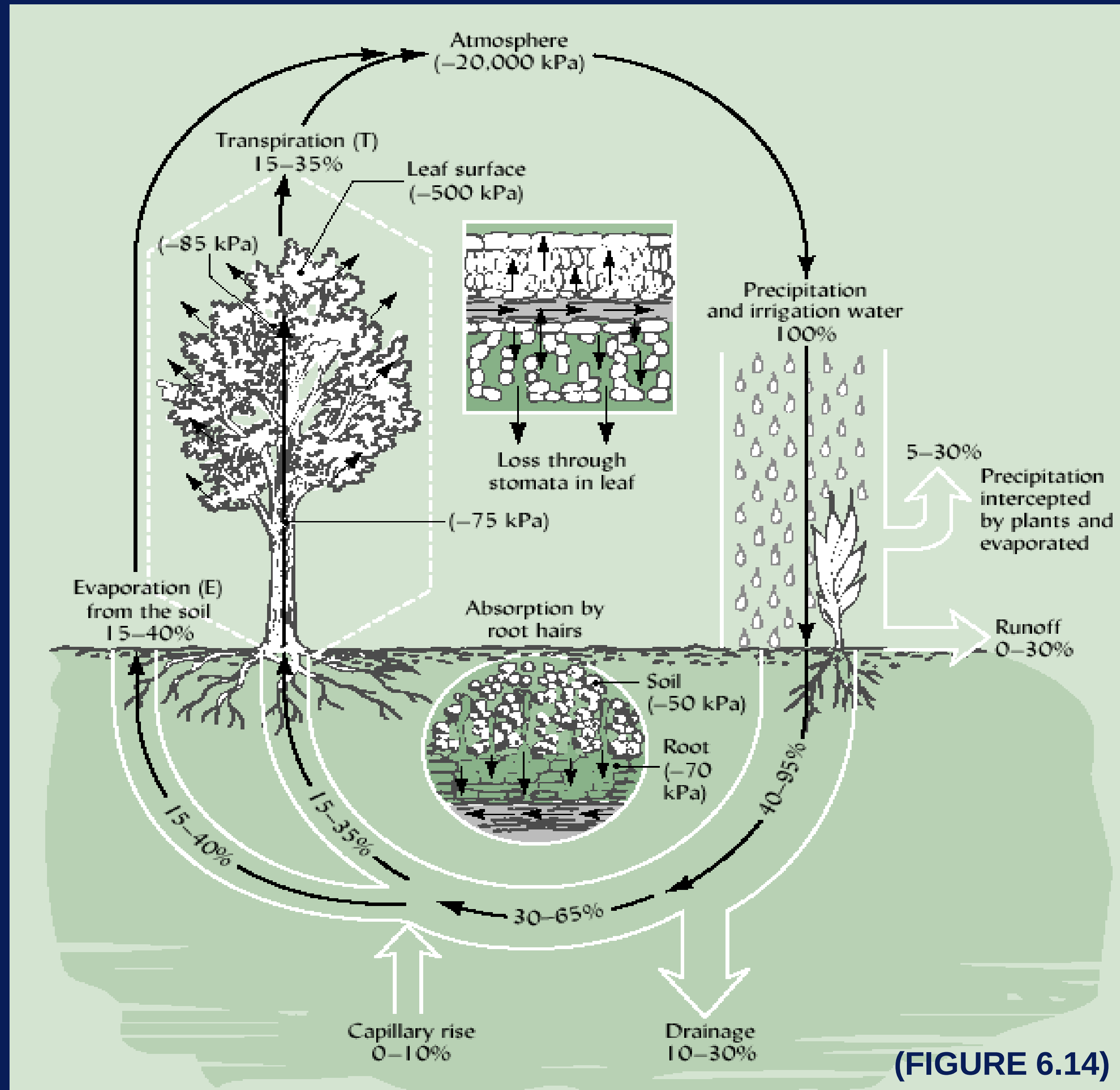
Inlet to a small rain garden

FIGURE 6.11a,b

SOIL-PLANT-ATMOSPHERE CONTINUUM

(SPAC)

Water movement through various media



(FIGURE 6.14)

WATER BALANCE

SPAC = Soil - Plant - Atmosphere Continuum

-major component of hydrologic cycle

Water movement - two major points of resistance:

- root-soil water interface
- leaf cell - atmosphere interface

Component	Moisture potential
Atmosphere	-20,000 kPa
Leaf surface	-500 kPa
Upper plant (internal)	-85 kPa
Lower plant (internal)	-75 kPa
Soil water	-50 kPa

SOIL-PLANT-ATMOSPHERE CONTINUUM

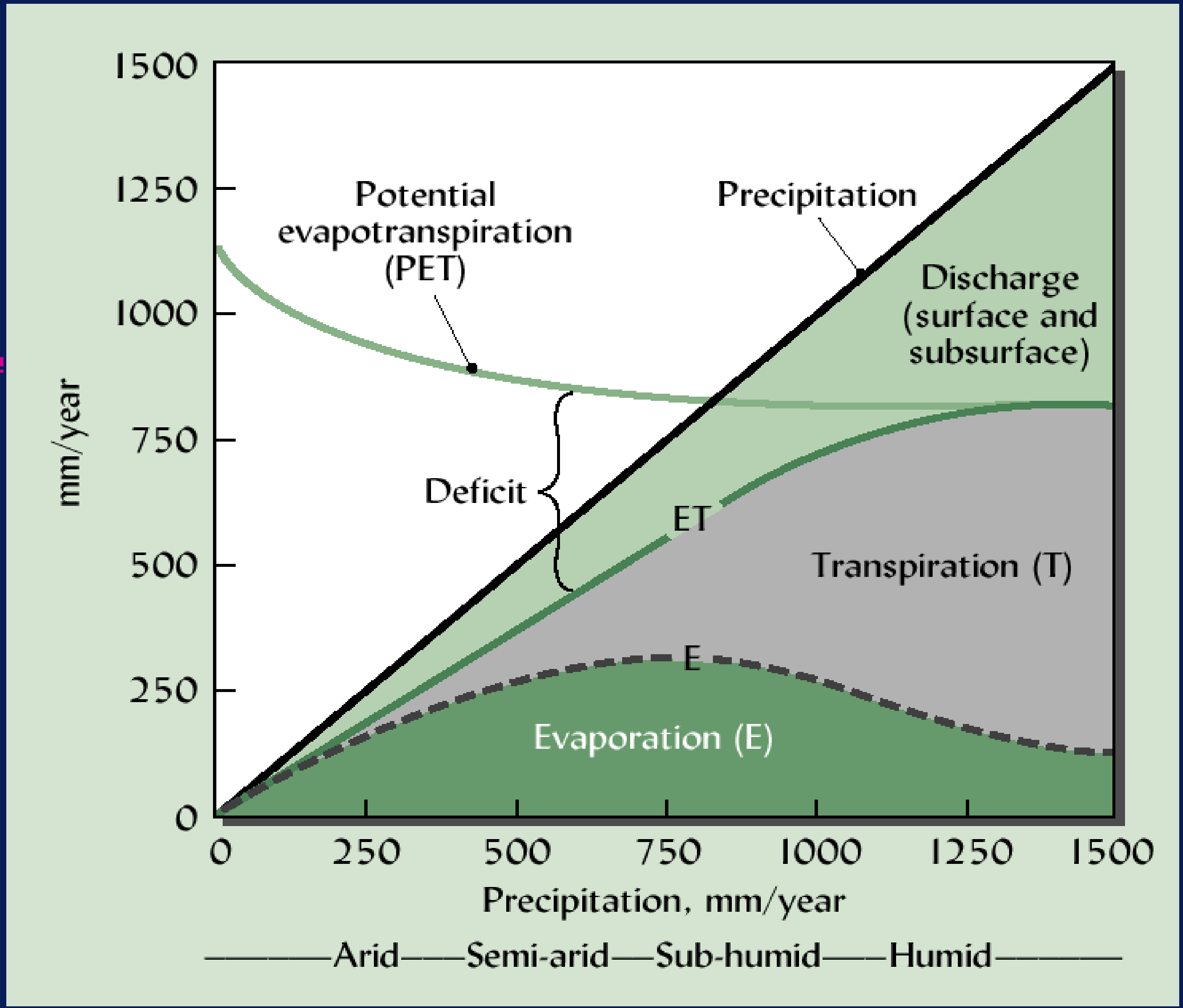
- Evaporation (E) - loss of water from soil surface
- Transpiration (T) - loss of water from plant leaves
- Evapotranspiration (ET) - combined loss of water
  - most commonly measured
- Potential evapotranspiration (PET) - useful info
- Water deficit = (PET) - (ET)
- ET losses vary greatly with plant type

CONTROL OF EVAPOTRANSPIRATION

In most areas, it is desirable to limit ET:

- limit nutrient supply to plants to limit growth
- decrease plant density (partially effective)
  limits leaf area index
- eliminate undesirable plants (weeds)
- fallow cropping (use in semiarid lands)

LIQUID AND VAPOR LOSSES



Partitioning of liquid water losses (discharge) and vapor losses (evaporation and Transpiration) in regions varying from low (arid) to high (humid) levels of annual precipitation. (FIGURE 6.20)

CONTROL OF SURFACE EVAPORATION

- **Vegetative mulches:**
  sawdust, manure, leaves, straw, crop residue

- **Paper & plastic mulches:**
  - generally use specially prepared material
  - can use newspapers, etc

- **Crop residues & conservation tillage:**
  - leaves a high percentage of previous crop
  - leaves stubble mulch
  - plants next crop without tillage

LIQUID LOSSES OF WATER FROM THE SOIL

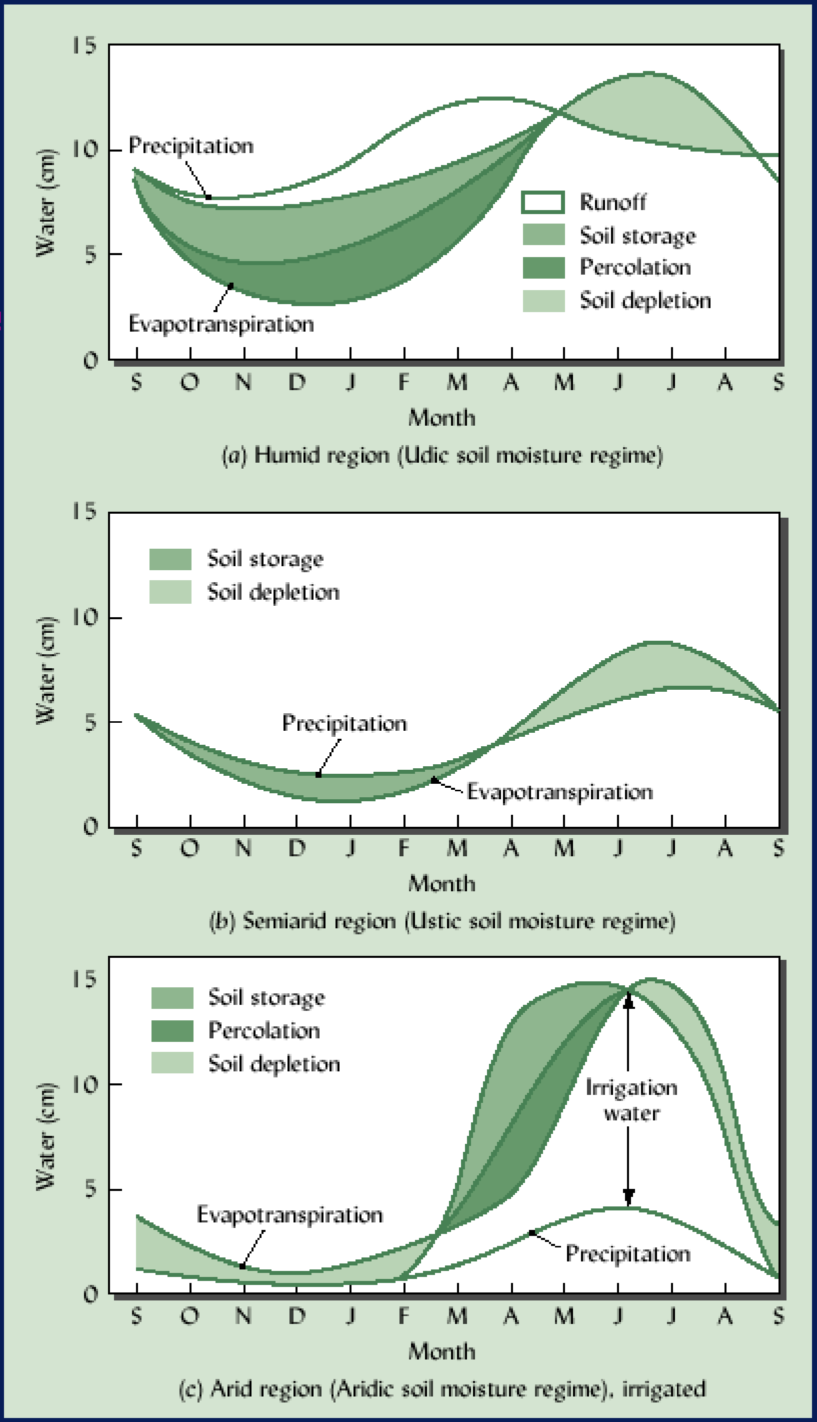
Percolation & leaching:

- Loss of water/chemicals to the groundwater
- Study with tile drains or lysimeters
- High percolation rates give a high potential for leaching losses
- Percolation losses influenced by: amount & distribution of rainfall

LIQUID LOSSES OF WATER FROM THE SOIL

Generalized curves for precipitation & evapotranspiration for three temperate zone regions

Max. supply is not generally during max. need



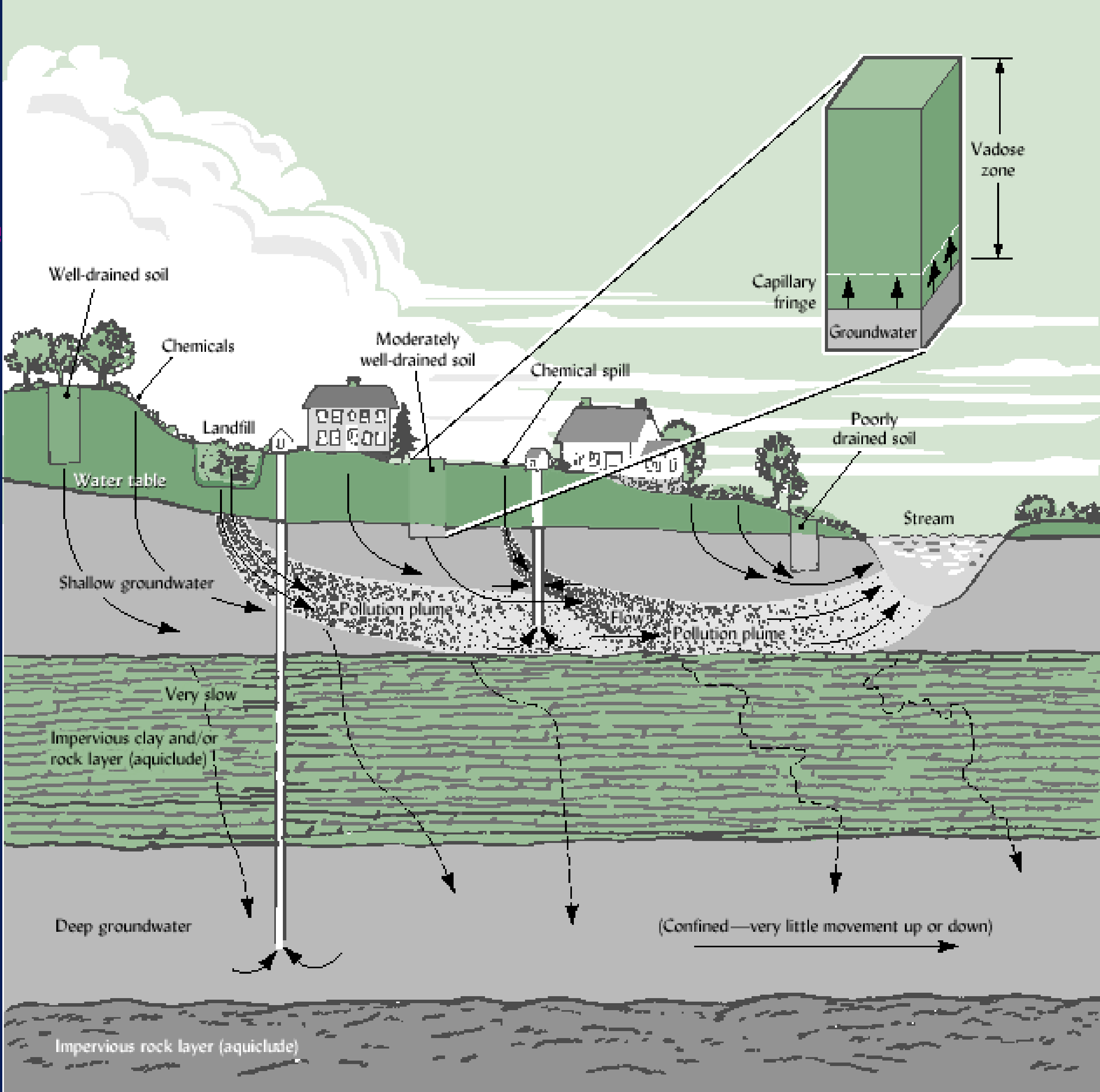
(FIGURE 6.25)

PERCOLATION AND GROUNDWATERS

Groundwater resources:

- Significant water source for domestic, industrial & agricultural uses
- About 50% of people use some groundwater
- Local versus regional aquifers - Ogallala aquifer
- Supply versus withdrawl
- Overpumping aids contaminant influx
- Coastal areas: potential saltwater intrusion

SUBSURFACE WATER MOVEMENT



Relationship of the water table and groundwater to water movement into and out of the soil.

(FIGURE 6.27)

PERCOLATION AND GROUNDWATERS

Shallow groundwater:

- most dynamic portion of groundwater
- may supply growing plants via capillary fringe

Chemicals in drainage water:

- chemicals may leach into groundwater
  - nutrients
    - loss from plant use (lost $$)
    - cause eutrophication (NO_3^-)
  - contaminants
    - pesticides
    - pathogens

PERCOLATION AND GROUNDWATERS

Chemical movement through macropores:

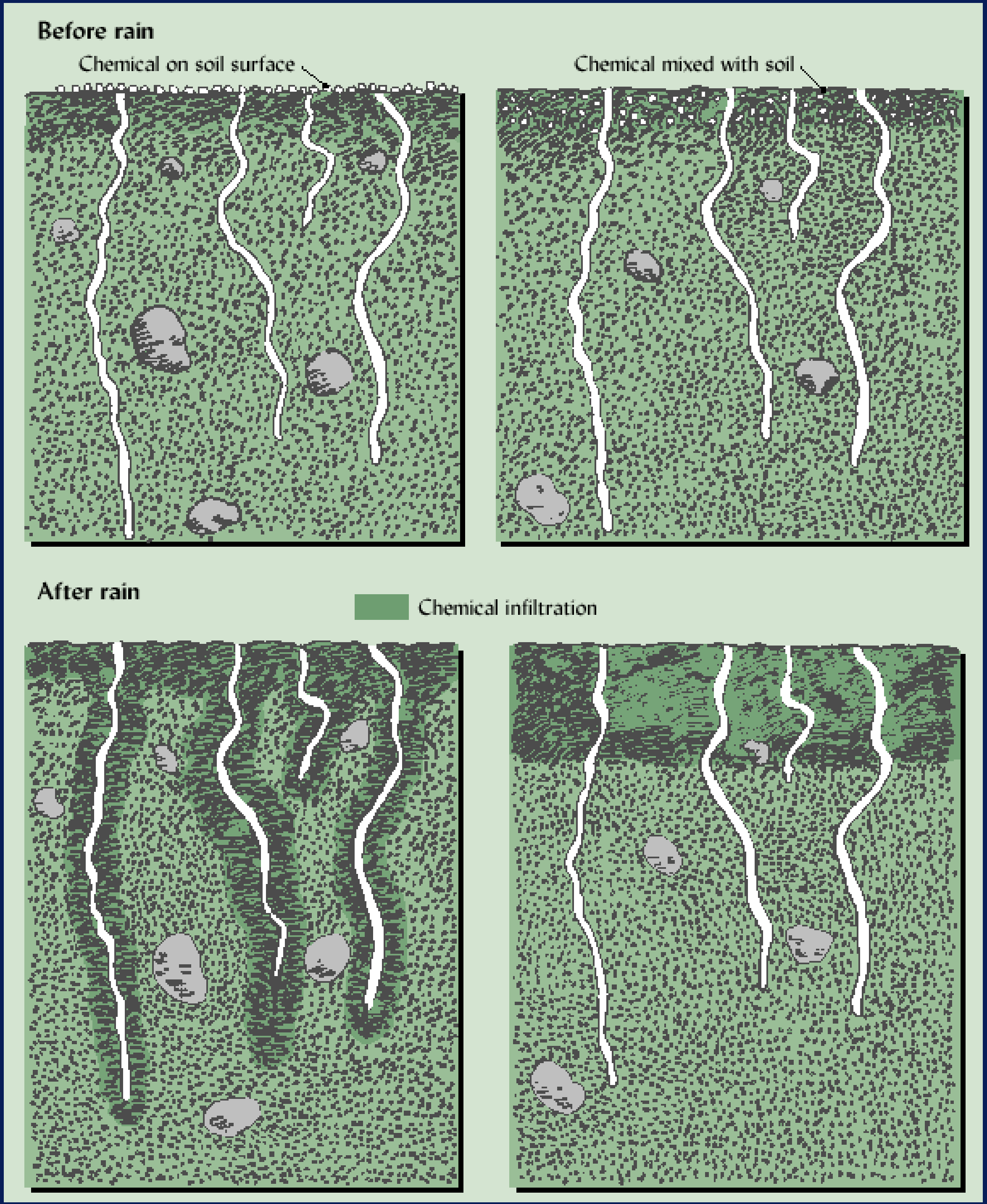
- Preferential or bypass flow - chemicals merely applied to surface do not contact bulk of soil
- High intensity rain or irrigation increases bypass flow
- Need to control irrigation rates and manage soil properties (macropore properties)

BYPASS FLOW IN MACROPORES

Preferential or bypass flow in macropores transports soluble chemicals downward through a soil profile.

Note that if the pore is not open to the surface, the bypass flow will NOT occur.

(FIGURE 6.29)



ENHANCING SOIL DRAINAGE

Reasons for enhancing drainage:

- **engineering problems: soil stability for roadbeds, building foundations**
- **plant Production: tillage restrictions, oxygen limitations, low temps in springtime, limited rooting depth in springtime**

Surface drainage systems:

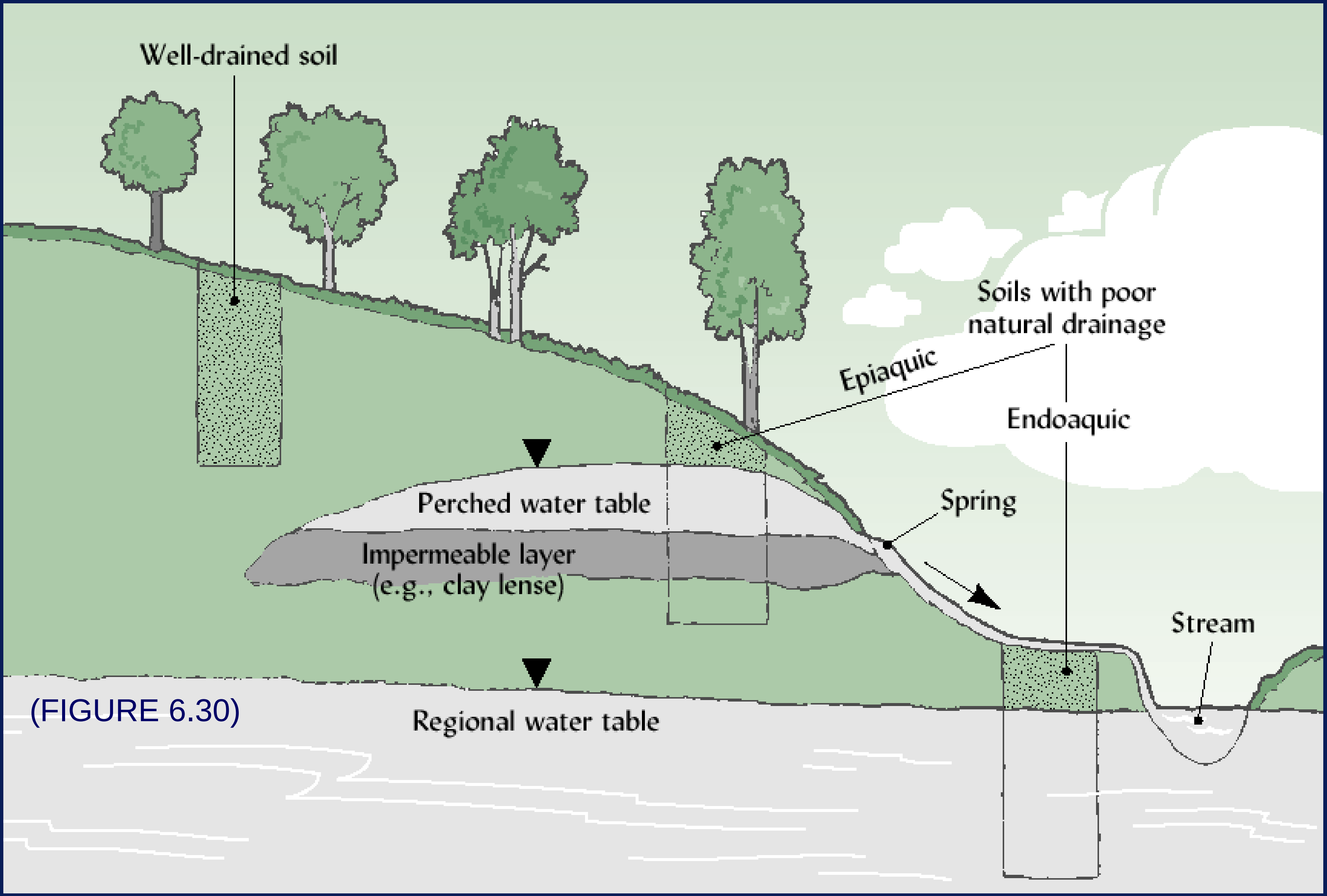
- drainage ditches
- land forming

ENHANCING SOIL DRAINAGE

Subsurface (internal) drainage:

- **deep open-ditch drainage**
  - **- best for coarse textured soils**
  - **- barriers for eqiopment**
- **buried perforated pipes (drain tiles)**
  - **- can last for many years**
  - **- do not disrupt surface operations**
- **building foundation drains**
  - **- Figure 6.32c**
- **mole drainage**
  - **- inexpensive; use in clay soils**

REGIONAL AND PERCHED WATER TABLES



(FIGURE 6.30)

UNDRAINED AND TILE-DRAINED LAND

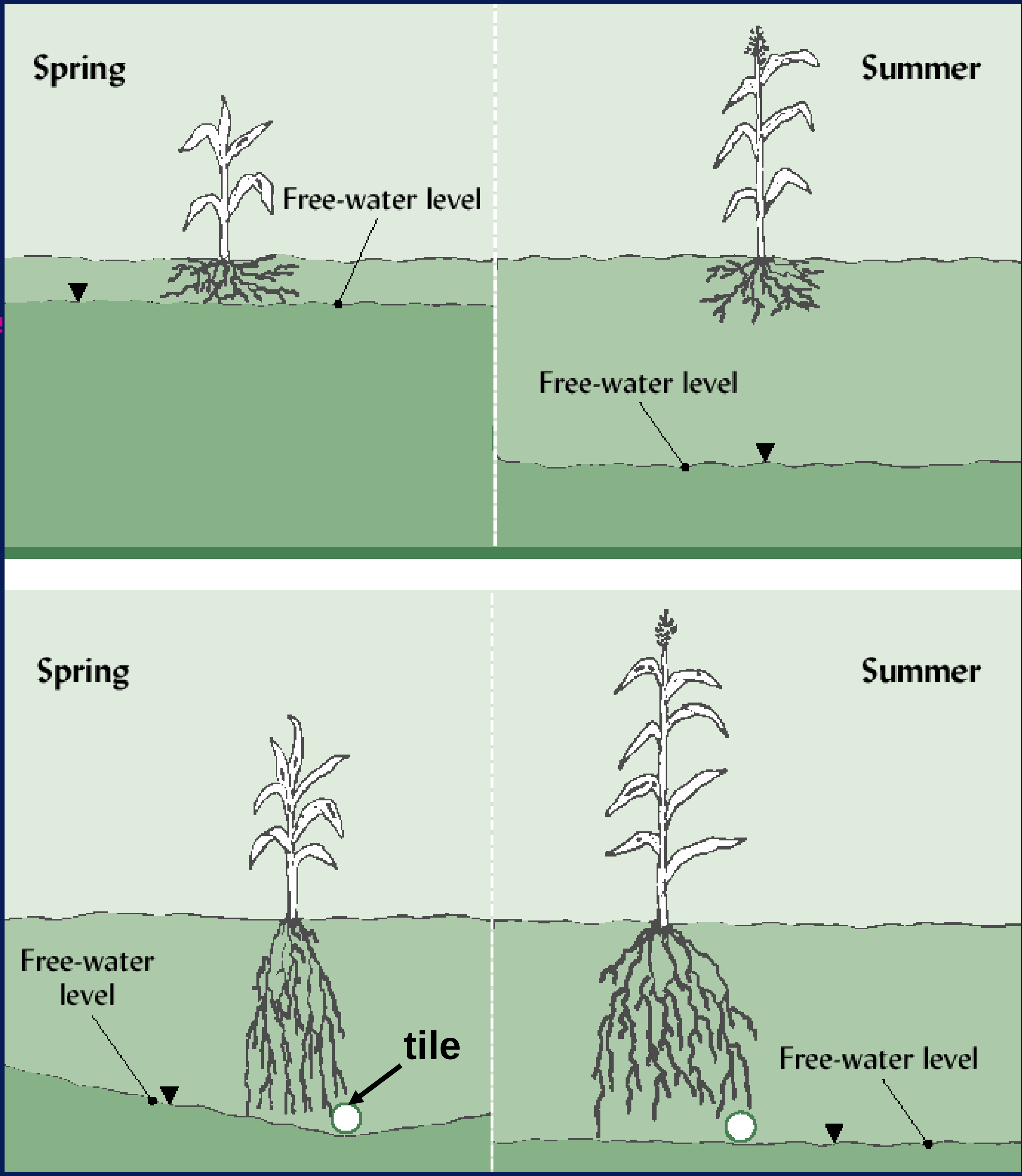
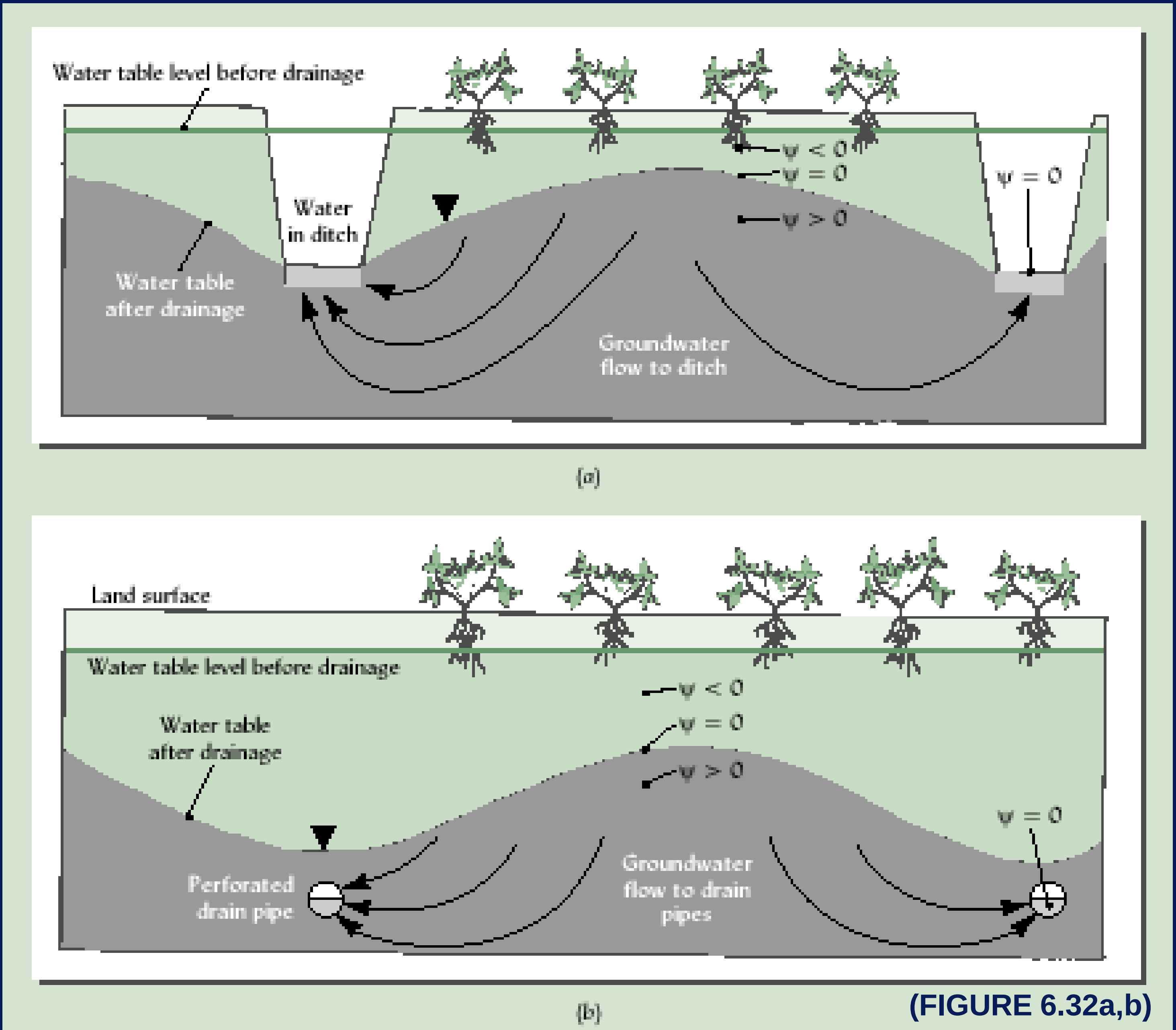


Illustration of water levels of undrained and tile-drained land in the spring and summer.

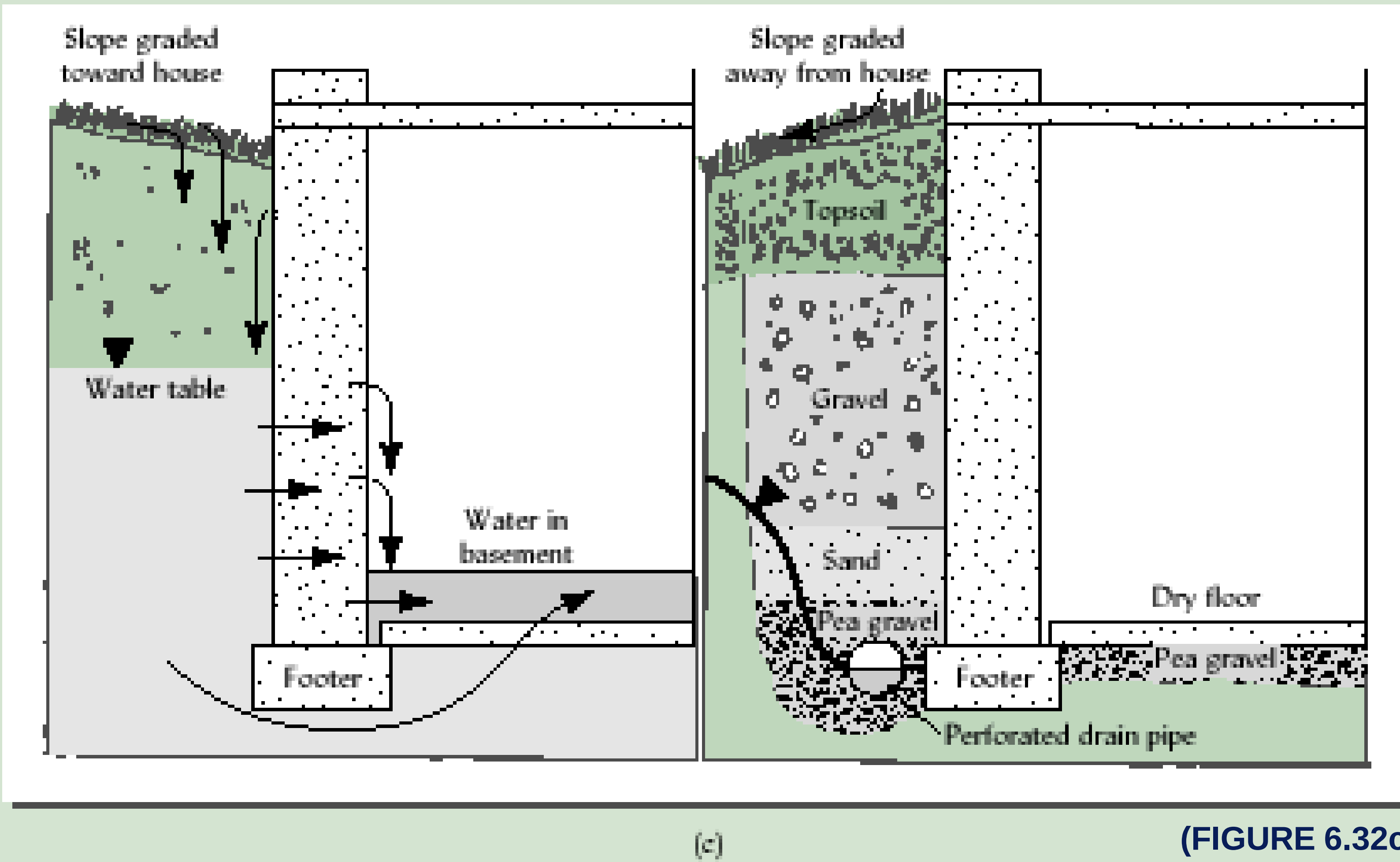
(FIGURE 6.31)

OPEN DITCH & TILE DRAINS IN FIELDS



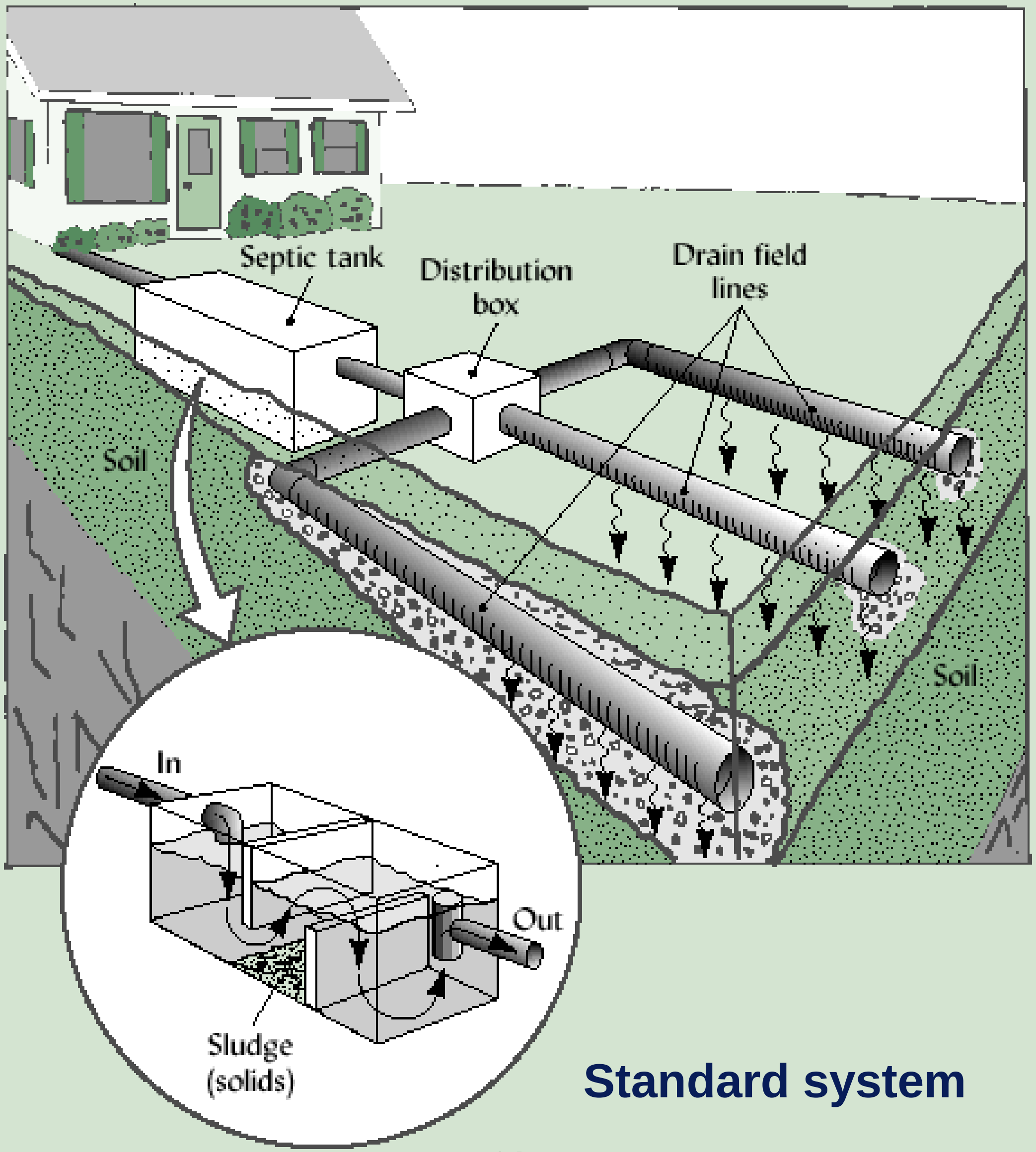
(FIGURE 6.32a,b)

FOOTER DRAIN AROUND FOUNDATION



(FIGURE 6.32c)

SEPTIC TANK AND DRAIN FIELD



(a)

Standard system

(b)

Wastewater stimulation of lawn grass from poorly functioning system

Utility of perc test

(Figure 6.38)

IRRIGATION PRINCIPLES & PRACTICES-1

Importance of irrigation today:

- landscaping
  - use is increasing
  - used to grow non-native species
  - large amounts used in semi-arid regions
- food production
  - agriculture is largest *consumptive* user
  - large amounts used in semi-arid regions
- future prospects
  - demand increasing, supplies decreasing
  - will become global crisis

IRRIGATION PRINCIPLES & PRACTICES-2

Water-use efficiency:

- application efficiency
  - applied vs amount used by plants
  - inefficient, 30-50% used by plants
  - loss from ditches, evaporation
- field water efficiency
  - (transp by crop) ÷ (applied to field) × 100
  - values low, 50-60%
  - much lost via runoff, percolation, evap’n

IRRIGATION PRINCIPLES & PRACTICES-3

Surface irrigation:

- use supply ditches & furrows
- application control difficult
- precise slope control needed
- inexpensive system to install

Sprinkler systems:

- additional losses from evaporation
- plants are cooled by application of water
- plant foliage may stay wet - fungal probs
- more expensive than surface systems
- generally uniform application

CENTER PIVOT IRRIGATION SYSTEMS

(Figure 6.46)

CENTER PIVOT IRRIGATION IN ARID AN CLIMATE

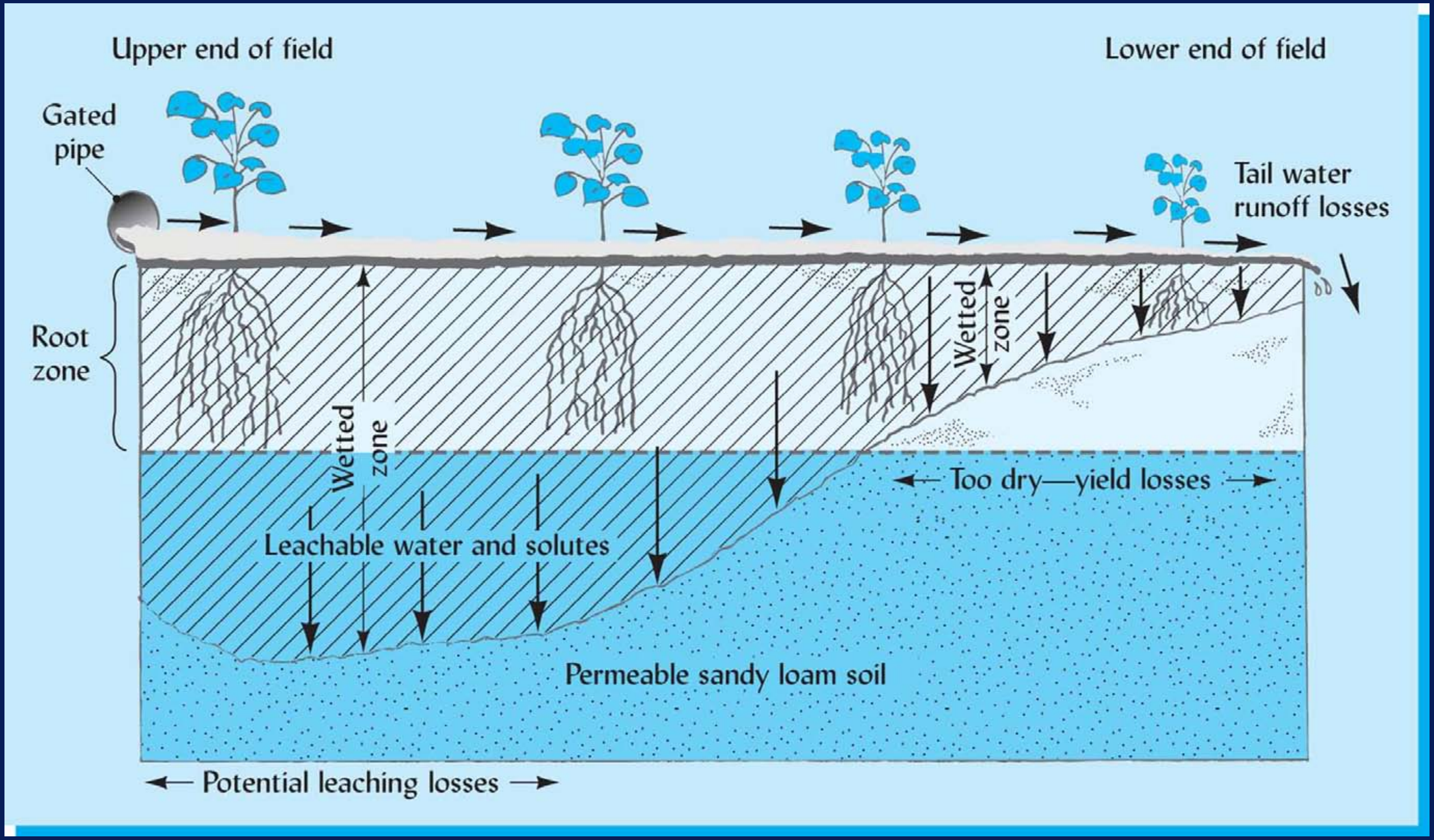
Concrete-lined irrigation ditches and standard sized siphon pipes

TYPICAL IRRIGATION SCENE IN EARLY SPRING IN THE WESTERN US

Water is siphoned from the ditch into miniponds

Delivery of water to a coarse-textured soil under surface irrigation from gated pipe

UNEVEN PENETRATION OF WATER FROM THE USE OF A GATED PIPE



IRRIGATION PRINCIPLES & PRACTICES-4

Microirrigation:

- most efficient systems used today
- drip (trickle), spitters, bubblers
- precise placement and amounts
- may add soluble fertilizer(fertigation)
- capital costs are relatively high
- decreases salinity/waterlogged soils probs
- useful for residential lawns, decks, etc.

Irrigation water management:

- major problem is salinity of soils/water used
- need for increasing water-use efficiency
- need to use water/landscaping more wisely
- reduction of water cost subsidies

DRIP OR TRICKLE IRRIGATION WITH A SINGLE EMITTER FOR EACH SEEDLING

A MICROSPRAYER OR SPITTER IRRIGATING AN INDIVIDUAL TREE IN A HOME GARDEN