Forest Hydrology: Lect. 4

Contents

- The hydrologic balance at a point
- The watershed

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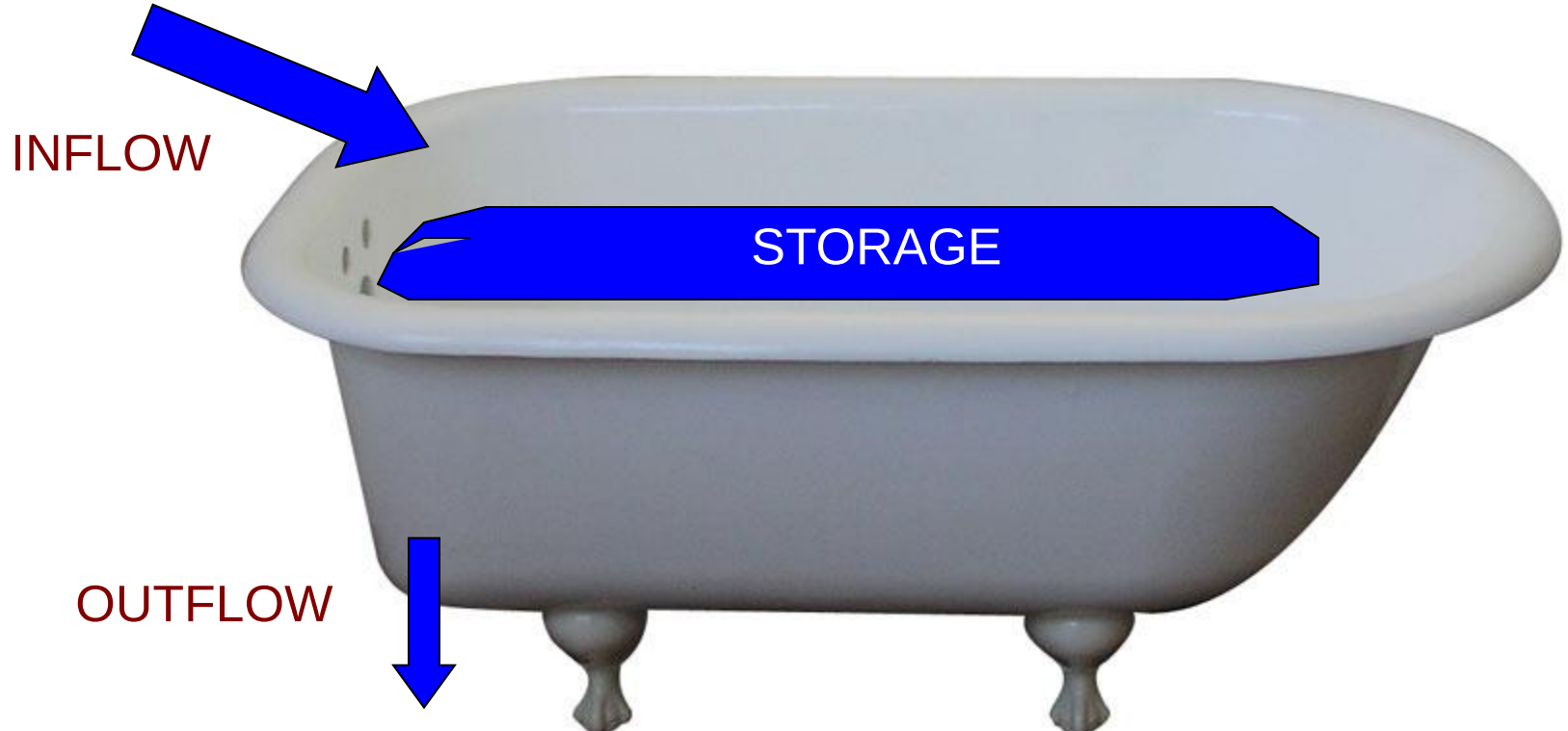
The hydrologic balance - 1

Mass Balance: fundamental equation in hydrology

Water mass is conserved

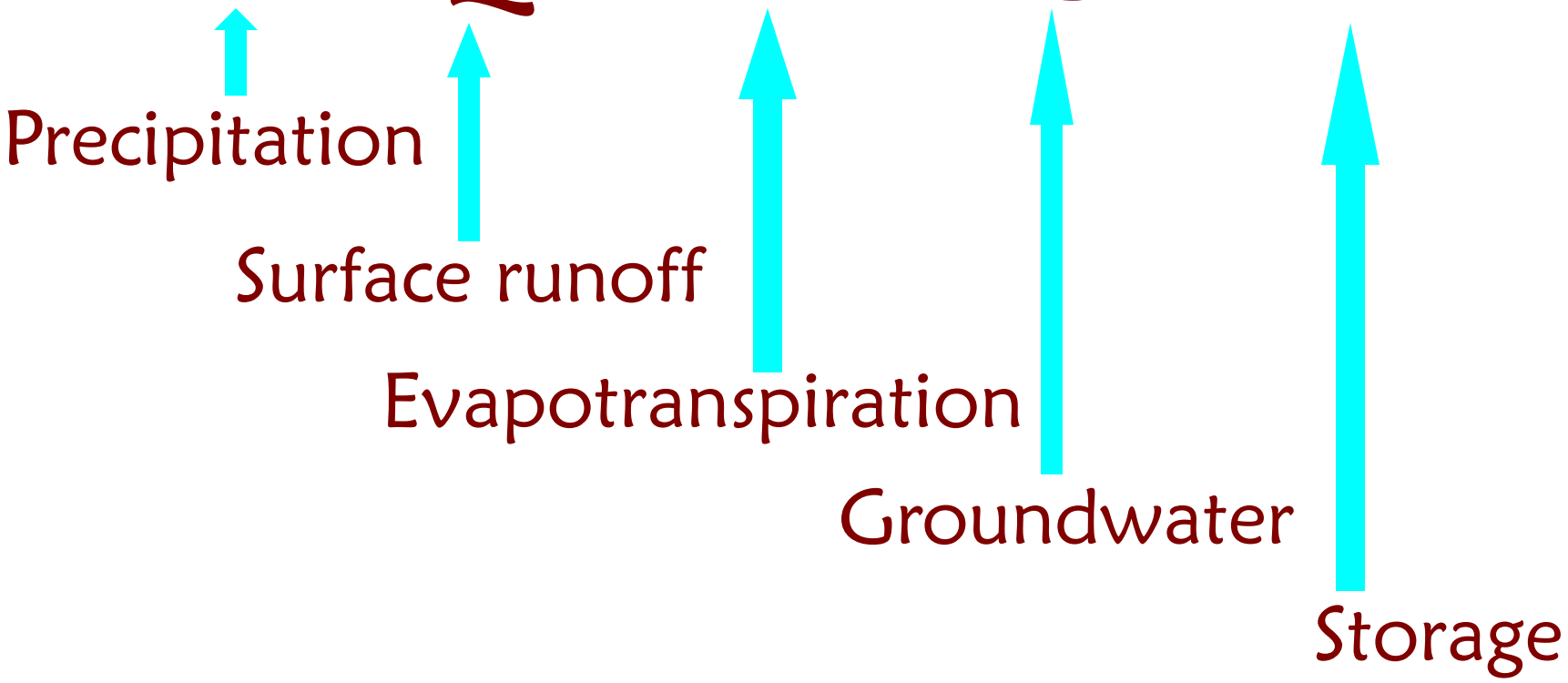
Therefore:

Water In = Water Out + Variation of Storage



The Water Budget at a point

$$P = Q + ET + G + \Delta S$$



Annual Water Budget - Flatwoods

Rainfall (~ 140 cm)

Interception
(~ 30 cm)

Transpiration
(~ 70 cm)

Infiltration to Deep Aquifer
(~20 cm)

Surface Runoff
(~ 20 cm)

Annual Water Budget – Ag Land

Rainfall (~ 140 cm)

Interception
(~ 15 cm)

Evapotranspiration
(~ 80 cm)

Surface
Runoff
(~ 20 cm)

Infiltration to Deep Aquifer
(~25 cm)

Annual Water Budget – Urban Land

Rainfall (~ 140 cm)

Interception
(~ 20 cm)

Evapotranspiration
(~ 50 cm)

Surface
Runoff
(~ 60 cm)

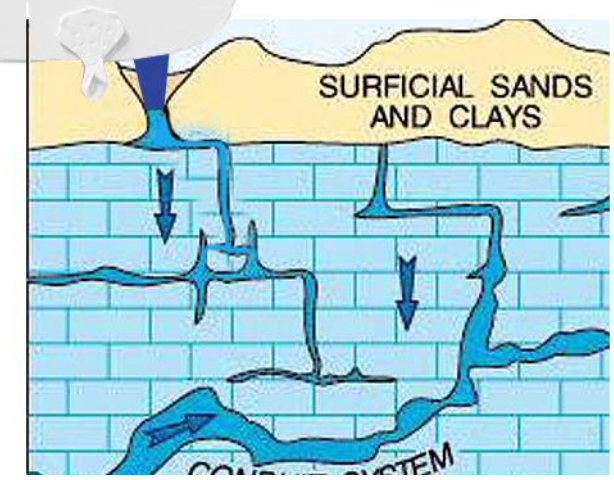
Infiltration to Deep Aquifer
(~ 7 cm)

$\Delta S_{storage}$ = Inputs - Outputs

In > Out ?

Out > in ?

In = Out ?



What if $In_{measured} > Out_{measured}$

AND water level is falling?

Water balance terms must be in common units (usually mm depth over the watershed area).

Precipitation, ET, runoff are measured in depth over the area (mm/yr)

What to do about units?

- Rainfall is expressed in mm.
- Stream flow is expressed in cubic meter per second
- Evapotranspiration is expressed in mm
- Soil water storage in mm.
- How can we make a mass balance with different units?
- Conversion

Conversion

- We have to use the same units; thus we have to remove the area from our calculation

- We need to convert volume into unit depth; thus what's water depth:

Water depth (d) = Volume of water (V) / Surface of the field (A)

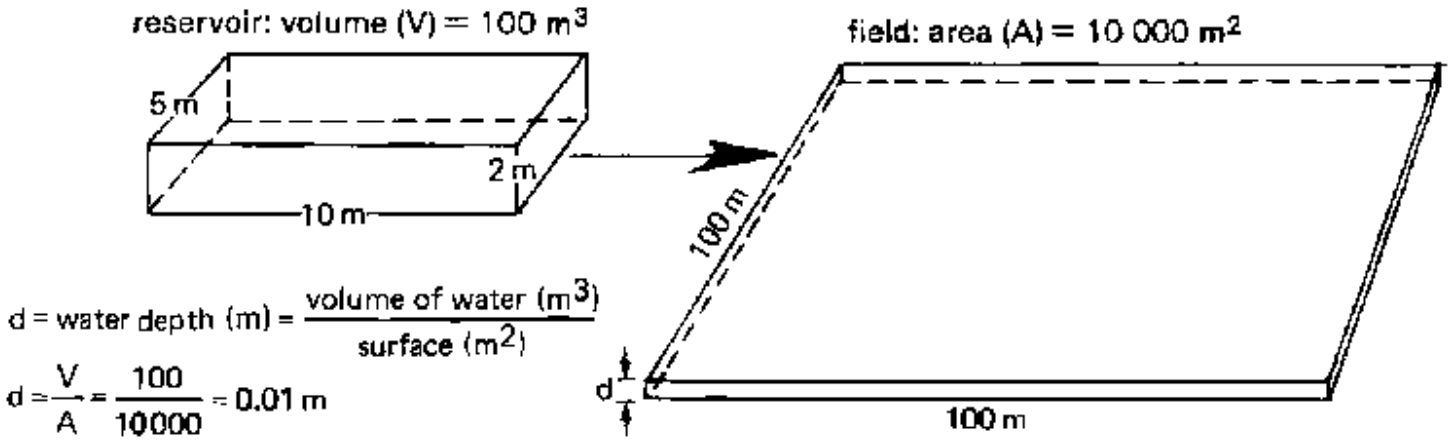
Problem 1

- Suppose there is a reservoir, filled with water, with a length of 5 m, a width of 10 m and a depth of 2 m. All the water from the reservoir is spread over a field of 1 hectare. Calculate the water depth (which is the thickness of the water layer) on the field.

Answer 1

- Surface of the field = 10 000 m2
  Volume of water = 100 m3
- Formula:

d = v/a =100 / 10,000 = 0.01 m = 10 mm



Water Balance for 100 ha land surface

Annual Measurements:

- Rainfall = 1 m (tipping-bucket rain gage)
- Surface outflow (Q) = 100.000 m^3 (weir)
- ET = 0.75 m (evaporation pan)
- Groundwater = 50.000 m^3 (shallow wells)
- Assume $\Delta S=0$

Budget: $P = Q + ET + G + \Delta S$

- Area = 100 ha; 1 ha = 10,000 m^2
- P = 1.0 m
- Q = 100.000 m^3/(100 ha * 10,000 m^2/ha)
  = 0.1 m
- ET = 0.75 m
- G = 50,000 m^3/(100 ha * 10,000 m^2/ha)
  = 0.05 m
- $\Delta S = 0$

- 1.0 = 0.1 + 0.75 + 0.05 + 0 (?!)

Assumptions?

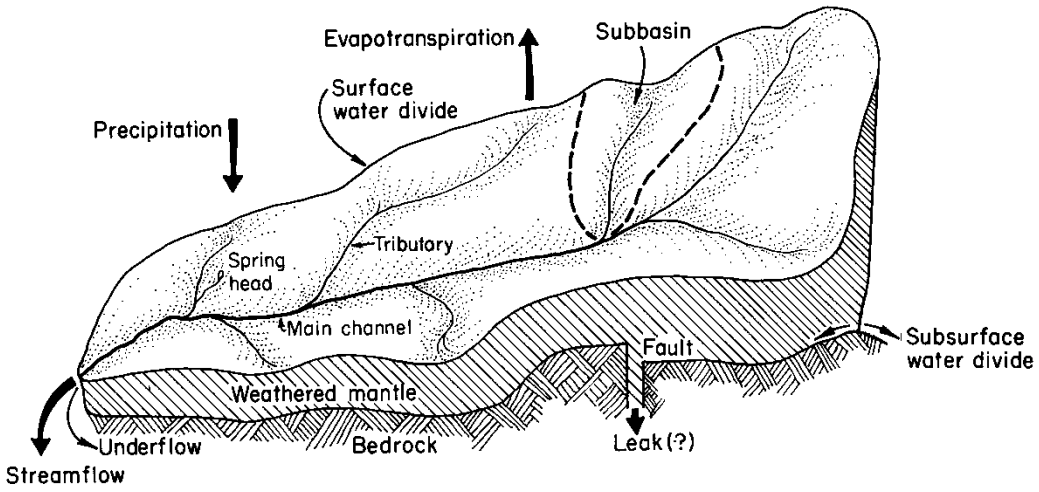
Measurement error?

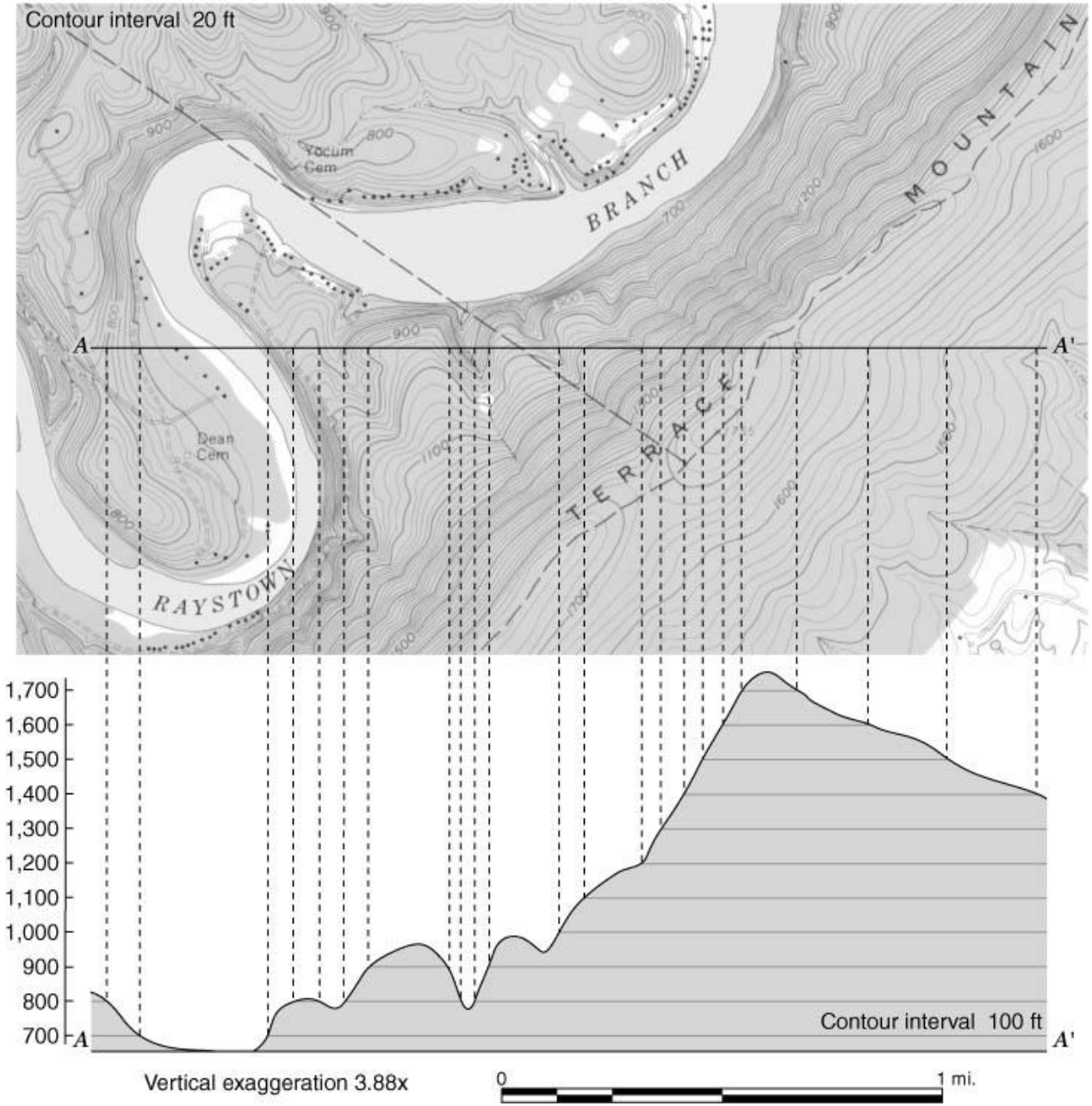
Measurement omissions?

Springs and sinkholes?

Watersheds

- A land area from which all rainfall drains to the same point.
  - The "watershed" is technically the divide between two such areas (called basins)





Hills, valleys, and slopes of a topographic map.

Three Simple Rules

- Ridges are indicated by the highest elevation contour line
- Surface water generally flows at right angles (perpendicular) across contour lines
- Drainages are indicated by flow lines (also called streamlines) that point downstream

- **Topographic Maps:**
  - Used to show slope, elevation, distance, and physical features
- **Scale**:
  - Used to relate the distance on the map to the true distance.
  - 1 map cm = 25.000 true cm = 250 m
- **Contour Line:**
  - Used to show points of similar elevation.
  - 1000 m a.s.l. contour line is a constant elevation above sea level
- **Contour Interval:**
  - The distance between contour lines. A 20 m contour interval has contours every 20 m, i.e., 980, 1000, 1020, etc.
- **Slope:**
  - The steepness of the ground
  - A 1% slope is where the surface drops 1 m every 100 m horizontal.
- **Aspect:**
  - The direction that the slope faces, North, South, East, West, etc.

Delineating Watersheds

1. Identify outlet point
2. Identify high points
3. Link high pts crossing contour lines at right-angles