Introduction to Hydrology
Part A

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أَوَلَمْ يَرَ الَّذِينَ كَفَرُوا أَنَّ السَّمَاوَاتِ وَالْأَرْضَ كَانَتَا رَتْقًا فَفَتَقْنَاهُمَا **وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ** أَفَلَا يُؤْمِنُونَ (سورة الأنبياء-30)

Have not those who disbelieve known that the heavens and the earth were joined together as one united piece, then We parted them! **And We have made from water every living thing**. Will they not then believe

الَّذِي جَعَلَ لَكُمُ الأَرْضَ فِرَاشاً وَالسَّمَاء بِنَاء **وَأَنزَلَ مِنَ السَّمَاء مَاء فَأَخْرَجَ بِهِ مِنَ الثَّمَرَاتِ رِزْقاً لَّكُمْ** فَلاَ تَجْعَلُواْ لِلّهِ أَندَاداً وَأَنتُمْ تَعْلَمُونَ . (سورة البقرة-22)

Who has made the earth a resting place for you, and the sky as a canopy, **and sent down water (rain) from the sky and brought forth therewith fruits as a provision for you.** Then do not set up rivals unto Allah (in worship) while you know (that He alone has the right to be worshipped).

وَهُوَ الَّذِي يُرْسِلُ الرِّيَاحَ بُشْرًا بَيْنَ يَدَيْ رَحْمَتِهِ حَتَّى إِذَا أَقَلَّتْ سَحَابًا ثِقَالاً سُقْنَاهُ لِبَلَدٍ مَّيِّتٍ فَأَنزَلْنَا بِهِ الْمَاءَ فَأَخْرَجْنَا بِهِ مِن كُلِّ الثَّمَرَاتِ كَذَلِكَ نُخْرِجُ الْمَوْتَى لَعَلَّكُمْ تَذَكَّرُونَ (سورة الأعراف-57)

And it is He Who sends the winds as heralds of glad tidings, going before His mercy. Till when they have carried a heavy-laden cloud, We drive it to a land that is dead, then We cause water (rain) to descend thereon. Then We produce every kind of fruit therewith. Similarly, We shall raise up the dead, so that you may remember or take heed.

وَأَرْسَلْنَا الرِّيَاحَ لَوَاقِحَ فَأَنزَلْنَا مِنَ السَّمَاءِ مَاءً فَأَسْقَيْنَاكُمُوهُ وَمَا أَنتُمْ لَهُ بِخَازِنِينَ (سورة الحجر-22)

And We send the winds fertilizing, then We cause the water to descend from the sky, and We give it to you to drink, and it is not you who are the owners of its supply.

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Earth or Water?

75% of the surface of Earth is water

Don't you think the name EARTH should be replaced by WATER???

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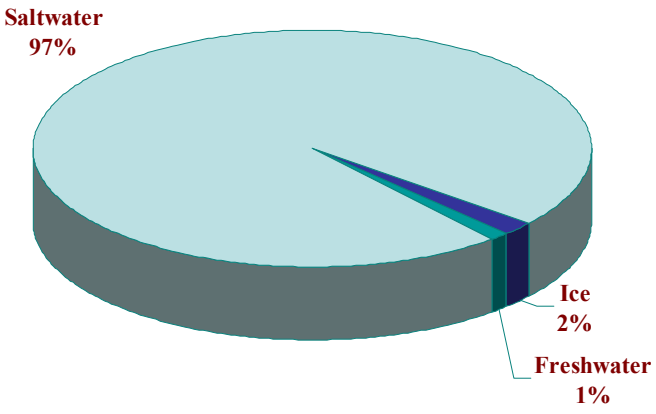
Water on Earth



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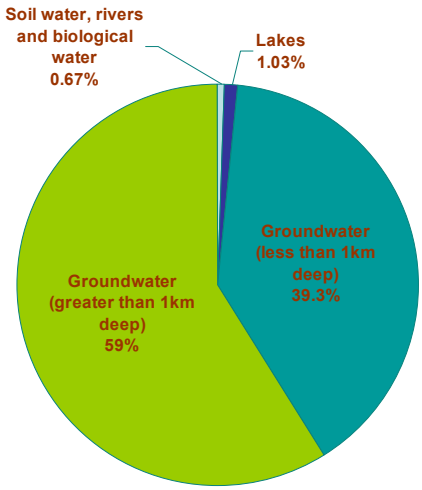
Fresh water



If all the world's water were fit into a gallon (3.785 liter) jug, the fresh water available for us to use would equal only about one tablespoon.

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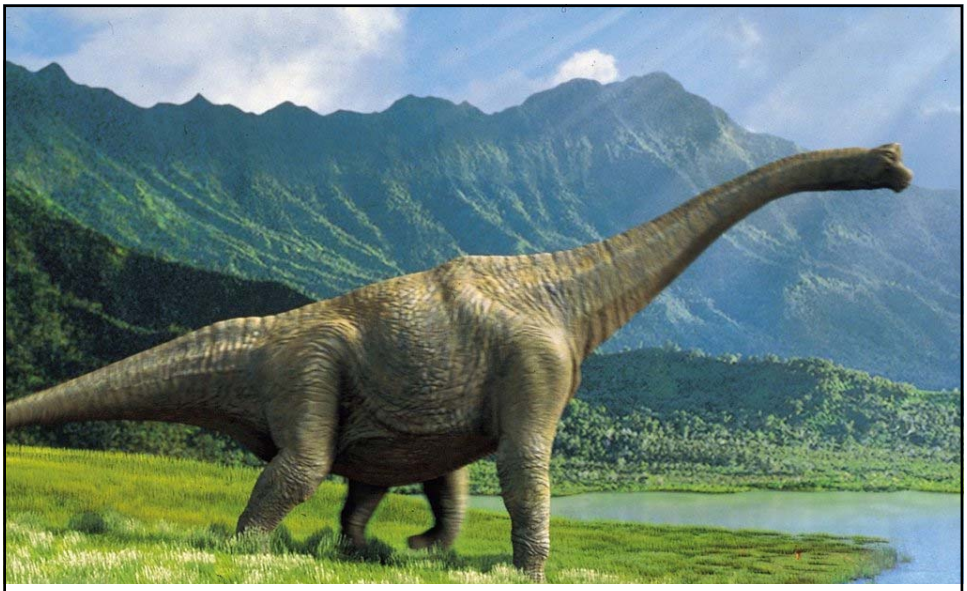

There is the same amount of water on Earth as there was when the Earth was formed. The water from your faucet could contain molecules that dinosaurs drank.

Water and life

- Water regulates the Earth's temperature. It also regulates the temperature of the human body, carries nutrients and oxygen to cells, cushions joints, protects organs and tissues, and removes wastes.
- 75% of a living tree is water.
- Human brains are 75% water.
- Human bones are 25% water.
- Human blood is 83% water.
- A person can live about a month without food, but only about a week without water.

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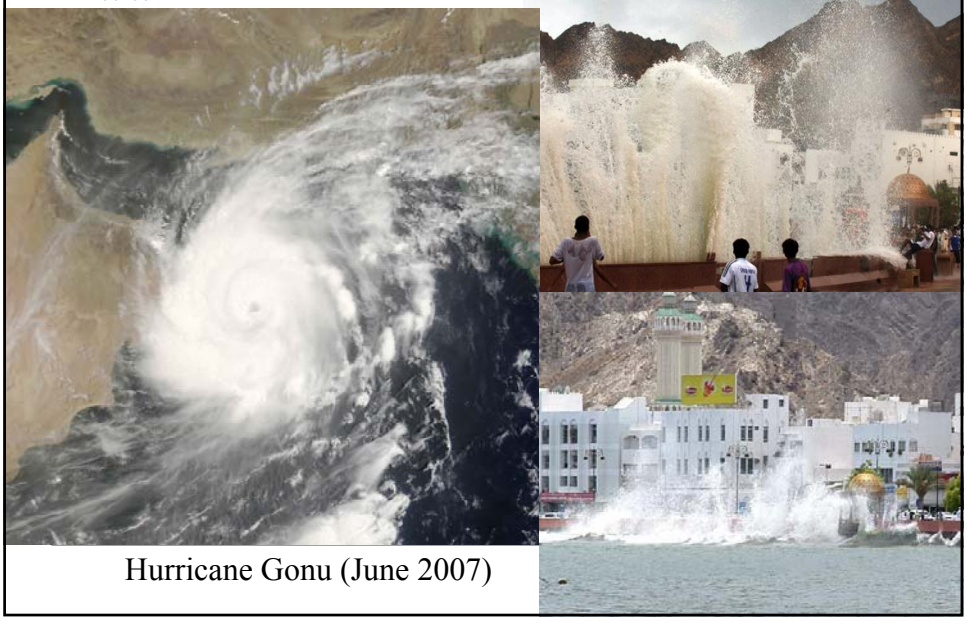
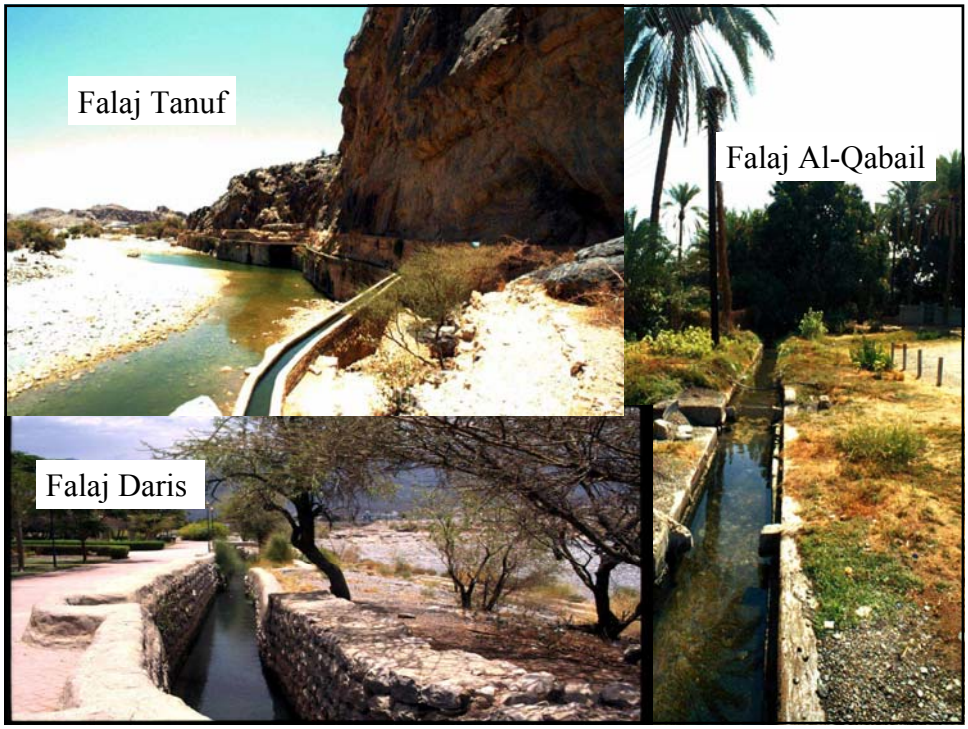
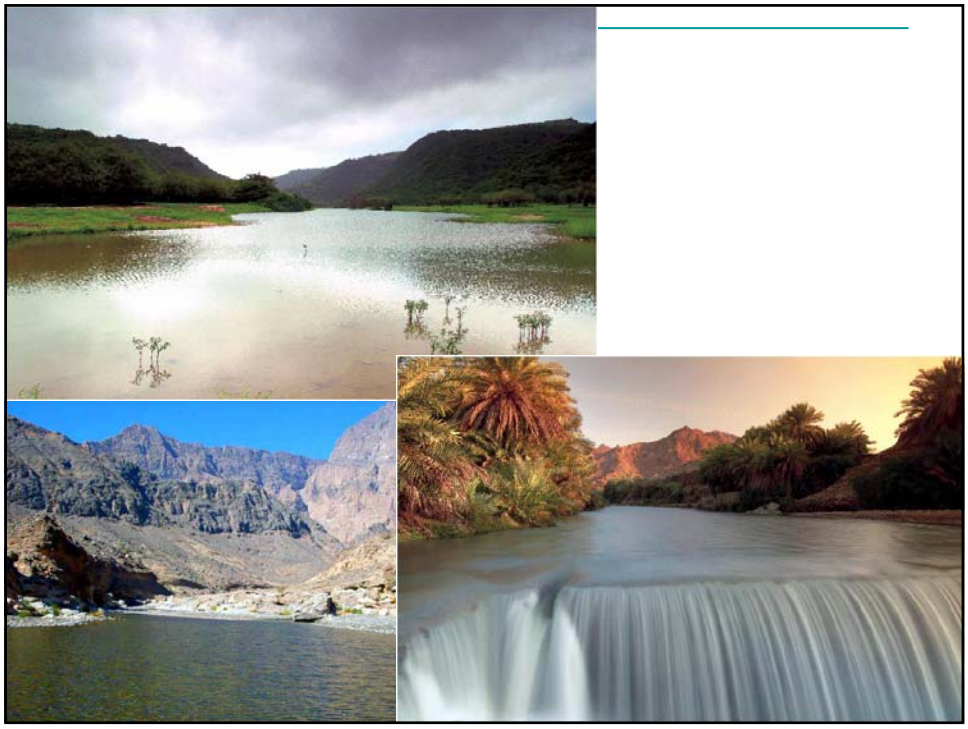
Applications of Hydrology



Hurricane Gonu (June 2007)


McDonald's
ماكدونالدز
CAPITAL COMMERCIAL CENTRE


Falaj Tanuf
Falaj Al-Qabail
Falaj Daris



Problems in Hydrology

- Extreme weather and rainfall variation
- Streamflow and major flood devastation
- River routing and hydraulic conditions
- Overall water supply - local and global scales
- Flow and hydraulics in pipes, streams and channels
- Flood control and drought measures
- Watershed management for urban development

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History of Hydrology - 1800s

- Chezy Channel Formula in the 1780s
- Open channel flow experiments - 1800s
- Darcy and Dupuit laws of ground water - 1850s
- Manning's Eqn - Open Channel Flow - 1889

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History of Hydrology - 1900s

- Penman (1948) - complete theory of evaporation
- Great urban expansion in 1950s and 60s - led to demand for better water supply and prediction (after WW II)

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Major Computer Advances

- Stanford watershed Model of 1966 - first digital code
- USDA and others developed codes in mid 1970s
- US Army Corps of Engineers Hydrologic Engineering Center (HEC) models - 1970s to the present
- HEC-HMS and HEC-RAS (1990s release)
- EPA in 1969 - Storm Water Mgt Model (SWMM)

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Major Hydrologic Processes

- Precipitation (measured by radar or rain gage)
- Evaporation or ET (loss to atmosphere)
- Infiltration (loss to subsurface soils)
- Overland flow (sheet flow toward nearest stream)
- Streamflow (measured flow at stream gage)
- Ground water flow and well mechanics
- Water quality and contaminant transport (S & GW)

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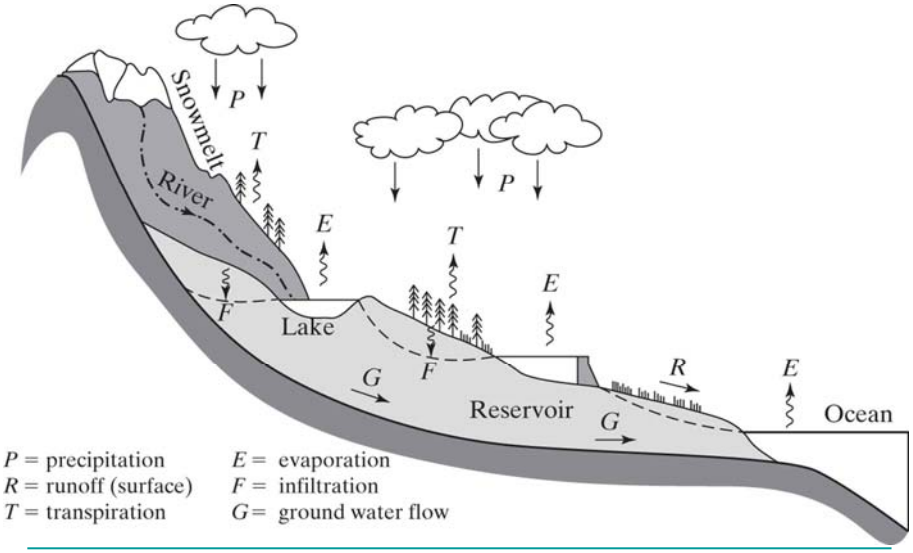
The Hydrologic Cycle



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The Watershed or Basin

- Area of land that drains to a single outlet and is separated from other watersheds by a drainage divide.
- Rainfall that falls in a watershed will generate runoff to that watershed outlet.
- Topographic elevation is used to define a watershed boundary (land survey or LIDAR)
- Scale is a big issue for analysis

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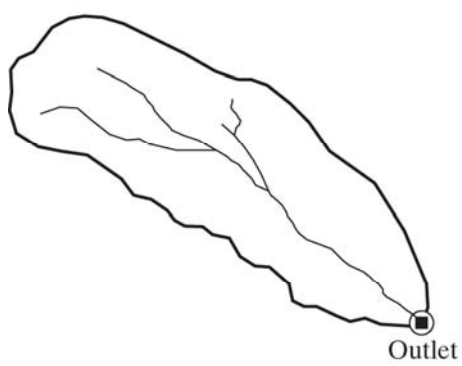
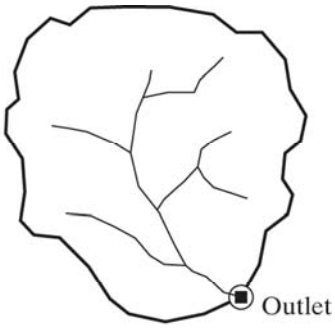


1. Elongated shape



2. Concentrated shape

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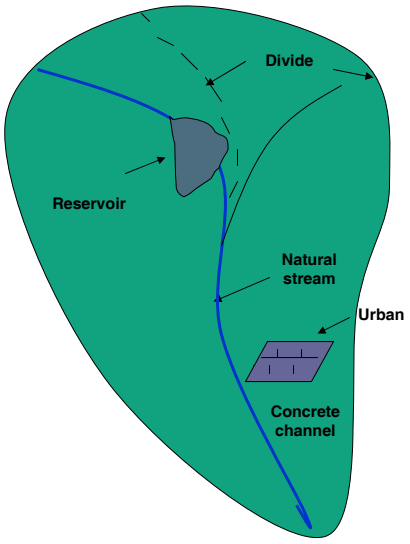
Watershed Characteristics

- Size
- Slope
- Shape
- Soil type
- Storage capacity



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The Watershed Response - Hydrograph

- As rain falls over a watershed area, a certain portion will infiltrate the soil. Some water will evaporate to atmosphere.
- Rainfall that does not infiltrate or evaporate is available as overland flow and runs off to the nearest stream.
- Smaller tributaries or streams then begin to flow and contribute their load to the main channel at confluences.
- As accumulation continues, the streamflow rises to a maximum (peak flow) and a flood wave moves downstream through the main channel.
- The flow eventually recedes or subsides as all areas drain out.

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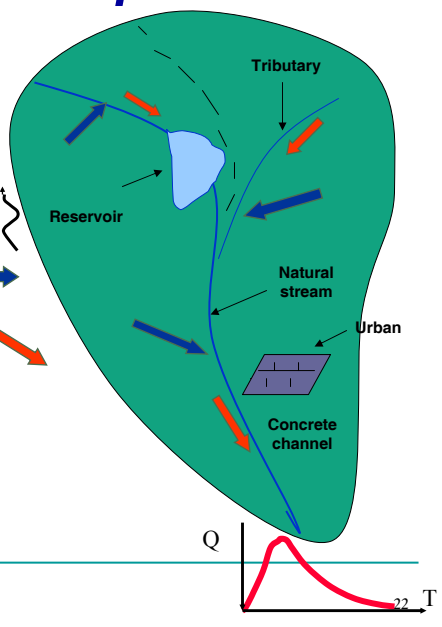
Watershed Response

- Precipitation over the area
- Portion Infiltrates the soil
- Portion Evaporates or ET back
- Remainder - Overland Flow
- Overland flow - Channel flow
- Final Hydrograph at Outlet



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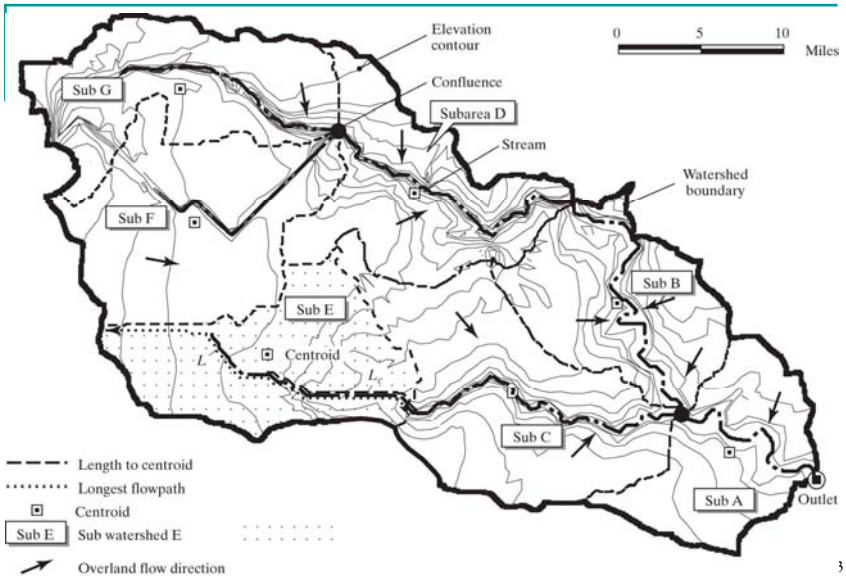
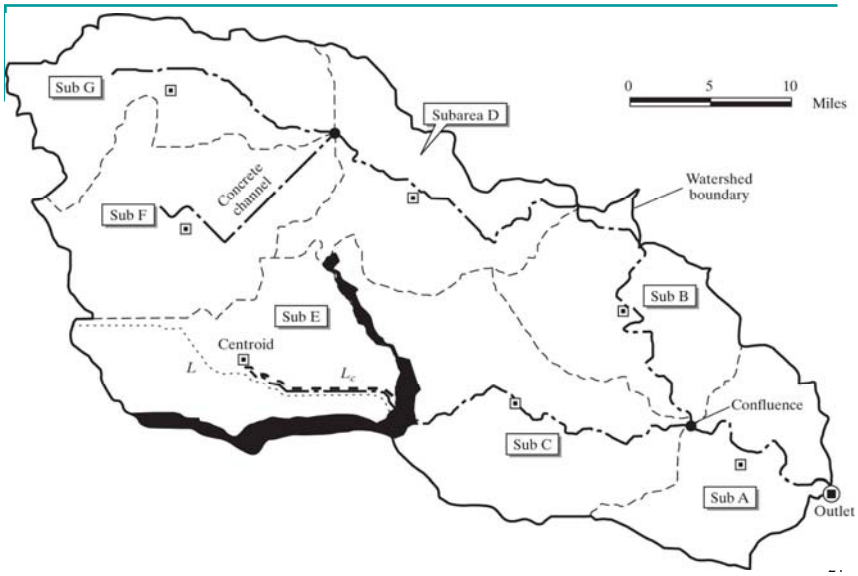
Watershed with contours



Length measures in a watershed



Hydrologic Theory

- One of the principal objectives in hydrology is to transform rainfall that has fallen over a watershed area into flows to be expected in the receiving stream.
- Losses must be considered such as infiltration or evaporation (long-term)
- Watershed characteristics are important

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A Note on Units

- Rainfall volume is normally measured in inches or cm
- Rainfall rate or intensity in inches/hr or cm/hr
- Infiltration is measured in inches/hr or cm/hr
- Evaporation is measured in inches or in/hr (cm/hr)
- Streamflow is measured in cfs or m^3/s
- One acre-ft of volume is 43,560 ft^3 of water
- 1 ac-inch/hr is approx. equal to 1.008 cfs
- Ground water flows are measured as ft^3/day or m^3/day

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The water balance

$$I - Q = \frac{dS}{dt}$$

I = inflow in L^3/T

Q = outflow in L^3/T

dS/dt= Change in storage per unit time in L^3/T

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The water balance

$$P - R - G - E - T = \Delta S$$

P = precipitation

R = surface runoff

G= groundwater flow

E=evaporation

T=transpiration

ΔS=change in storage in a specified time period

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Example 1-1
Example 1-2

Tutorial:
Problem 1.1
Problem 1.2

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