ES 105 Streams and Floods

I. Hydrologic cycle
  A. Distribution
    1. +97% in oceans
    2. >3% surface water
      a. +99% surface water in glaciers
      b. >1/3% liquid, fresh water in streams and lakes~1/10,000 of water
  B. Cycle
    1. evaporates
      a. 84% from sea surface
      b. Transpiration is
        1) plants releasing moisture to atmosphere
        2) “Evapotranspiration” is combined effect
      c. Becomes atmospheric moisture moved by winds
    2. condensation into clouds allows precipitation
      a. 75% over sea, 25% over land
      b. Concentrated in tropical and midlatitudes
      c. Much falls as snowfall,
        1) ‘storage’ of solid water on land surfaces
        2) Glaciers hold over 2% of Earth’s water
          a) Most of fresh water on land
          b) If it melted, sea level would rise 75 meters+/-
    3. runoff, infiltration
      a. back to the sea—about 1/3 of land precipitation runs off
      b. (most of the other 2/3 of land precipitation is returned to atmosphere by evapotranspiration)
      c. Groundwater: storage of water from cycle for long times

II. Running water
  A. Runoff is only 0.00005% of total water on Earth, but vital to civilization
  B. Understanding source of runoff to be rainfall realized in 1500s
  C. Drainage basin
    1. land that contributes water to stream
    2. basins separated by divides
  D. River systems
    1. erode channels in which they flow
      a. most erosion is in headwater area of stream
      b. variety of erosional landforms including V-shaped valleys
    2. transport sediment delivered to them by mass wasting
      a. solid particles transported in suspension, and as bedload
      b. dissolved material, released by weathering, important component of stream transportation
    3. deposit material in temporary sites on the way to the sea

III. Streamflow
- A. Types of streamflow
  1. Laminar flow in smooth, straight-line paths at consistent velocity
  2. Turbulent flow is erratic
     a. differing directions lead to localized areas of greater velocity
     b. lifts material from streambed—enhances erosion
- B. ability to erode and transport controlled by velocity of flow
  1. Channel characteristics
     a. gradient
     b. channel roughness, shape and size
  2. amount of water in channel (discharge)
- C. channel characteristics
  1. gradient—drop in feet, meters or centimeters divided by distance of stream channel in miles or kilometers
     a. lower Mississippi River < 10 cm/km
     b. Columbia River
        1) elevation 10 ft @ Portland
        2) 100 miles to the sea
        3) 0.1 ft.mile = 1.9 cm/km
  2. shape, roughness contribute to frictional drag of channel on water
     a. large channels
        1) have less surface area per volume of water
        2) more efficient because there is less drag
     b. channel roughness
        1) smooth channels have less obstacles promotes smooth laminar flow
        2) rough channels prone to turbulent flow
           a) slowed
           b) more erosive
  3. discharge—the amount of water flowing in the stream
     a. cross sectional area x velocity of water flowing
     b. cubic meters per second
     c. Willamette discharge—
        1) About 1700 m^3/s Feb 2, 2008
        2) About 510 m^3/s Mar 1, 2008
        3) Website--http://waterdata.usgs.gov/or/nwis/uv?format=gif&period=31&site_no=14191000
     d. Most rivers have seasonal fluctuations of discharge
        1) High flow during snowmelt or rainy season
        2) Some are ‘intermittent’ or ‘ephemeral’

e. Floods
    1) Discharge is greater than bank-full level
        a) Measured in feet above flood stage
        b) Reported as cubic feet per second or cubic meters per second
        c) Recurrence interval
            i. X year flood
                a. 10 year flood—10% chance of occurring in any given year
                b. 25 year flood—4% chance
                c. 100 year flood—1% chance
                d. 500 year flood—0.02% chance
            ii. Not an absolute event.
                a. Not ‘will occur only every 500 years’
                b. Probability based on sedimentary records
    2) Types of floods
        a) Riverine
            i. Slow due to protracted rainfall
            ii. Flash due to sudden rainfall
        b) Coastal
            i. Storm surge
            ii. High tide
            iii. Cyclonic storm rainfall
        c) Catastrophic
            i. Landslide or lava flow damming river
            ii. Washout of dam—natural or manmade
    3) Flood Effects
        a) Infrastructure damage
            i. buildings
            ii. Utilities
            iii. Transportation systems
        b) Disease and pollution
        c) Crop and food supply
        d) Natural vegetation
        e) Renewal of nutrients in farmland
    4) Flood control
        a) Containment levees and reservoirs
        b) Water management in reservoirs and sacrificial areas
        c) Flood-plain development restrictions

4. longitudinal profile of stream
    a. changes from headwaters to the mouth
    b. constantly decreasing gradient
        1) smooth, concave upward curve over length of stream
        2) some local irregularities present are usually temporary
    c. increases in discharge, width, depth, velocity also downstream

IV. Work of Running Water
A. Most important erosion agent—even in deserts!!
1. Downslope sheetflow of precipitation coalesces into rills and gullies
2. Becomes stream that continues to gain water from tributaries
3. velocity of water can erode banks and channel
    a. hydraulic force of water can cut into bedrock
    b. particles carried by stream enhance its erosive ability
B. transportation of eroded material
1. loads of stream
    a. dissolved load—in solution
    b. suspended load—carried as 'mud'
        1) fine particles in normal flow
        2) sand and pebbles in flood stage
    c. bedload—bounces and rolls along bottom of channel
2. carrying ability—competence vs. capacity
    a. competence—
        1) maximum size of particle that can be moved
        2) determined by velocity of flow
    b. capacity—
        1) amount of material that can be moved
        2) determined by discharge
3. greatest transportation occurs at floodstage
    a. greater discharge
    b. greater velocity
4. transportation will cease—'deposition'—when velocity slows
    a. largest particles deposited first—creates sorting of material
    b. occurs within channels, adjacent to channels, at mouth, etc.

V. Stream Channels
   A. Bedrock channels
      1. where gradient is steep—velocity carries all loose particles away
      2. undulating gradient in headwaters allows local accumulations
   B. alluvial channels
      1. in deposited material—'alluvium': the loose material deposited by streams
      2. streamflow reflected in ability to transport and erode this material
      3. results in numerous characters of channel patterns
         a. meandering channels in fine sediments
            1) transport much material as suspended load
            2) wide sweeping bends eroded on outside curve—cutbank
            3) slower velocity on inside curve—deposition of pointbar
            4) results in migration of the meander loops downstream and side-to-side in valley bottom
            5) can cut off meander loops, leading to oxbow lakes
         b. braided channels where there is oversupply of sediment
            1) occasional periods of great capacity and competence
            2) low discharge results in divided, interwoven channel pattern
VI. Base level and erosion
   A. Lower limit of erosion—base level
      1. Ultimate base level—ocean
      2. Local base level—
         a. Lake level
         b. Resistant rock layers
         c. Discharge into another stream
      3. Affects deposition and erosion of stream
         a. Lower base level—
            1) increase erosion until equilibrium established
            2) accomplished by removal of barrier or uplift of area
            3) can lead to 'incised meanders'
         b. Raise base level—
            1) stop erosion, or increase deposition
            2) accomplished by creating barrier or area subsidence

VII. Shaping stream valleys
- A. Streams cut the channels in which they flow
  1. Running water is the most effective agent of erosion
  2. Removes weathered material to deposition site
- B. Three major directions that streams cut their valleys
  1. Deepening—down to local base level
     a. Velocity of stream controls erosive power
     b. Steep gradients in upper reaches cause stream to downcut into bedrock
  2. Widening—streams erode the sides of their valleys
     a. Material delivered to stream by mass wasting
     b. Stream takes it away, make room for more material
  3. Headward erosion—stream erodes upstream
     a. Erodes into divides that separate it from other drainage basins
     b. Enlarge their drainage basin, even to the point of capture of another stream

VIII. Depositional landforms
- A. Deltas
  1. Another way rivers increase their length
  2. Entering standing water—lose velocity: lose competence
     a. Deposit load in path of flowing water
     b. Eventual blockage leads to new channel location
     c. Cycle continues as long as there is sediment
  3. Distributaries make delta wide and complex
- B. Natural levees
  1. Flow competence depends on velocity
     a. Flood may cause river to leave its channel onto 'floodplain',
     b. it loses velocity
        1) Shallow depth of flow on floodplain
        2) Lack of channel
  2. Loss of competence results in deposition
     a. Largest particles first, near stream bank
     b. Smaller particles become trapped behind the natural levee in the backswamp area after floodwaters recede
        1) Levee prevents water from flowing back into river
        2) Yazoo river, Mississippi
- C. Alluvial fans
  1. Channel lost upon exit from mountain front
  2. Discharge is lost to infiltration of porous fan surfaces
  3. Loses velocity of flow, deposits material in distributaries
  4. Coarser material at head, finer carried to valley