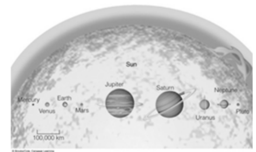
Chapter 12

Running Water

Introduction

- *Mercury, Venus, Earth and Mars share a similar history, but Earth is the only terrestrial planet with abundant water !*
  - Mercury is too small and hot
  - Venus has a runaway green-house effect so it is too hot
  - Mars is too small and too cold, although it had surface water during its earlier history.



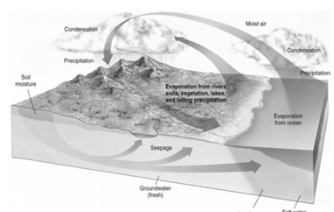
Water on Earth

- Most of Earth's water is in the Oceans

96.5% in Oceans
1.74% in Ice caps and glaciers
1.69% in groundwater and soil moisture
<<<1% in atmosphere, lakes and streams

Water on Earth

The Hydrologic Cycle



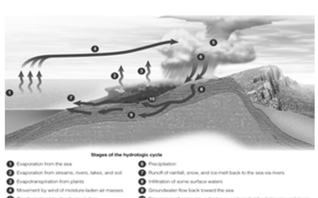
- This cycle is important because it is the source of all freshwater on land.

Water on Earth

The Hydrologic Cycle

- 85% of all water that enters the atmosphere comes from the oceans, and 80% of all precipitation falls there. For the remaining 20%, the cycle is:

Evaporation → Condensation → transport over land → Precipitation → Runoff and Infiltration



Water on Earth

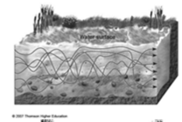
- ***Fluid Flow***
  - Runoff occurs when rainfall intensity exceeds the infiltration capacity (ability to absorb water) of the soil.
  - The infiltration capacity is affected by the intensity and duration of rainfall, and the type of soil and its makeup.
  - Once the ground is saturated and cannot absorb any more water, runoff begins.

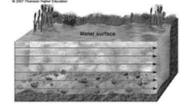
Running Water

- ***Sheet Flow and Channel Flow*** – two ways to describe the path the water takes as it moves downslope.
  - In sheet flow, the water moves as a continuous film of water flowing over the surface.
  - In channel flow, the surface runoff is confined in a channel, which is a trough-like depression.

Water on Earth

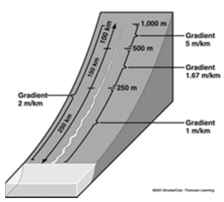
- ***Fluid Flow*** - Almost all surface flow is fully turbulent, which is more capable of erosion and sediment transport
  - In turbulent flow the lines of flow are complexly intertwined
  - In laminar flow little mixing takes place between adjacent flow lines within the fluid.





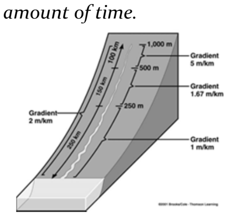
Running Water

- ***Gradient, Velocity, and Discharge***
  - *Water flows downhill over a slope known as its gradient (m/km, feet/mile).*



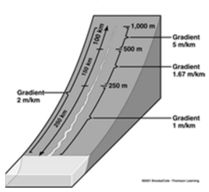
Running Water

- ***Gradient, Velocity, and Discharge***
  - *The velocity of running water is a measure of the distance water travels in a given amount of time.*
  - Flow velocity (m/s, ft/s) varies downstream as well as along a cross-section of a stream in response to changes in channel roughness, shape, slope and discharge.



Running Water

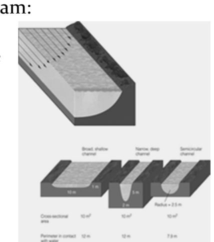
- ***Gradient, Velocity, and Discharge***
  - *The discharge is the volume of water that passes a given point in a given amount of time (m^3/s).*
  - Discharge generally increases downstream due to tributary inputs of water.



Running Water

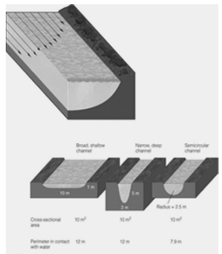
- ***Gradient, Velocity, and Discharge***
  - Calculating Discharge (Q) of a stream:
  - Determine the velocity ~1/3rd of the depth of the stream and in the middle (gives maximum velocity, v)
  - Determine the cross-sectional area (A) of a stream
  - Multiply velocity X area to get discharge:

    Q = v x A in m^3/sec (or ft^3/sec)



Running Water

- ***Gradient, Velocity, and Discharge***
  - Calculating daily discharge:
  - For a stream 148 m wide and 2.6 m deep with a flow velocity of 0.3 m/sec, the discharge is
  - 115.44 m^3/sec
  - What is the discharge per day?
  - 9,974,016 m^3/day



Running Water

- ***Gradient, Velocity, and Discharge***
  - *The velocity of a steam is controlled by:*
    - Gradient (larger gradient = greater velocity)
    - Elevation change (velocity increases due to gravity accelerating the water as it falls)
    - Channel shape (wider, deeper channels = higher velocity)
    - Number of tributaries = more water = greater discharge = higher velocity.

Running Water

- ***Gradient, Velocity, and Discharge***

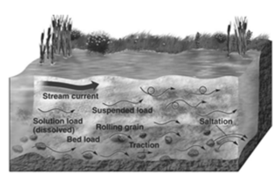
Because of the above factors, velocity generally increases downstream.

How Does Running Water Erode and Transport Sediment?

- Streams and rivers possess potential and kinetic energy to accomplish their task of erosion and transport.
  - Running water carries sand and gravel that wear away any rock surface they move over (abrasion).
  - Hydraulic action is the impact of water, which is quite effective in dislodging loose soil and sediment.

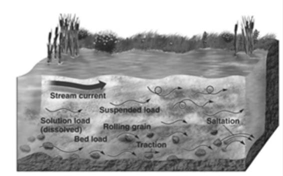
How Does Running Water Erode and Transport Sediment?

- The dislodged loose material is then transported by streams as dissolved, suspended, and bed loads.
  - The dissolved load is invisible because it is composed of ions which are transported in solution.



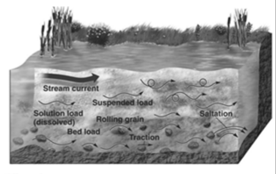
How Does Running Water Erode and Transport Sediment?

- The suspended load is made up of the smallest particles that can be kept in suspension in the water by turbulence.



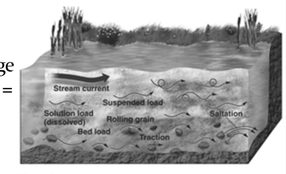
How Does Running Water Erode and Transport Sediment?

- The bed load is composed of sand and gravel that is transported along a stream's bed by saltation and rolling and sliding.



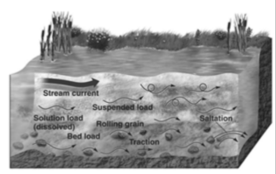
How Does Running Water Erode and Transport Sediment?

- The total load that a stream can carry is called its Capacity.
  - Capacity is a function of discharge – greater discharge = more sediment transport = greater capacity



How Does Running Water Erode and Transport Sediment?

- The maximum sized particle a stream can carry is called its Competence.
  - Competence is a function of velocity – greater velocity = larger particles = greater competence



Deposition by Running Water

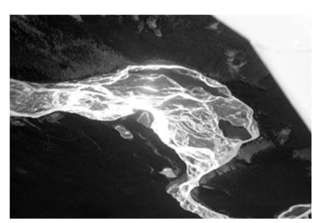
- The products of running water are called alluvium. Alluvium results from sedimentation that occurs during flooding.
- Alluvium is deposited in the continental environment.
- Some of the detrital sediment is not deposited until it reaches the ocean and is found in transitional environments.
- The largest deposits of sediment in the oceans occur on the continental margin in the marine environment and are transported to the oceans by running water.

Deposition by Running Water

- ***The Deposits of Braided and Meandering Channels***
  - Braided streams have too much sand and gravel to effectively transport, so the sand and gravel are deposited as bars that divide the main channel into many channels.

Deposition by Running Water

- ***Braided Channels***



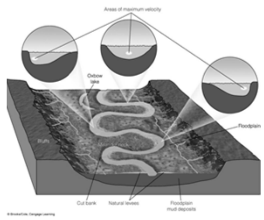
Howse River, Alberta, Canada

From Slide Collection by John Shelton

Deposition by Running Water

- ***The Deposits of Braided and Meandering Channels***

- Meandering streams carry much more suspended load and have a single, sinuous channel.
- Deposits are coarser grained in the channel, and fine-grained in the floodplain.



Deposition by Running Water

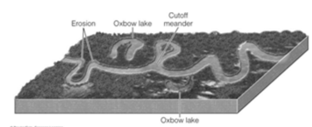
- In meandering channels, flow velocity varies across the channel
- Velocity is fastest on the outside of a meander where erosion occurs. This produces a cut bank.

Deposition by Running Water

- Because velocity on the inner side of the meander is slower, deposition takes place creating a point bar.
- The point bar itself is commonly a body of cross-bedded sand, but in some streams it may be made up of gravel.

Deposition by Running Water

- Oxbow lakes are formed when meander loops are cut off from stream channels. Fine sediment and organic matter accumulates in such lakes.



Deposition by Running Water

- ***Oxbow Lake***

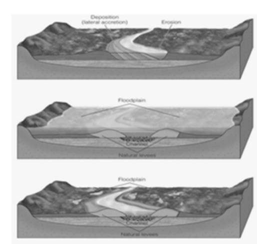
Snake River, Idaho

From Slide Collection by John Shelton

Deposition by Running Water

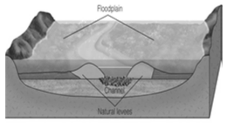
- ***Floodplain Deposits***

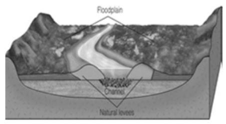
  - Floodplains are the flat lowland areas paralleling streams.
  - Floodplains may be composed of laterally accreted point bars or the vertical accumulation of fine grained flood-borne deposits.



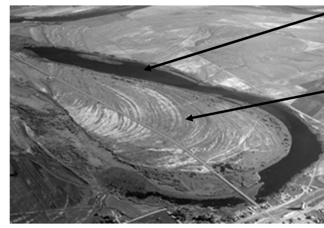
Deposition by Running Water

- When a river or stream receives more water than its channel can hold, it floods.
- The area outside of the channel where flooding occurs is called the floodplain.
- When water goes over the bank of the channel, the velocity of the water decreases as it spreads out on the floodplain, depositing a natural levee on the bank.





Deposition by Running Water

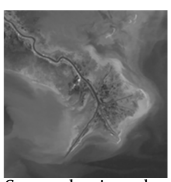


Snake River, Idaho

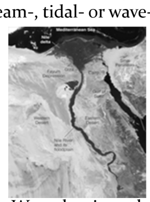
From Slide Collection by John Shelton

Deposition by Running Water

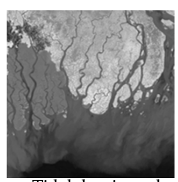
- ***Deltas***
  - Alluvial deposits accumulated at the mouth of a stream are known as deltas.
  - Marine deltas consist of complex geometries of facies, and are either stream-, tidal- or wave-dominated.



Stream dominated



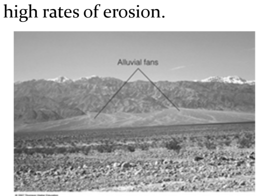
Wave dominated



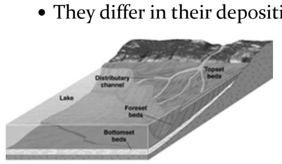
Tidal dominated

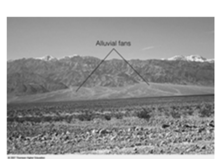
Deposition by Running Water

- ***Alluvial Fans***
  - Lobate deposits of gravel and sand deposited on land are known as alluvial fans. They form most commonly in arid and semiarid regions having high rates of erosion.



- Deltas and Alluvial fans are similar:
  - Both are deposits of alluvium that form where streams and rivers lose their transport capacity (greatly reduced gradient) and sediment accumulates.
  - They differ in their depositional environment.



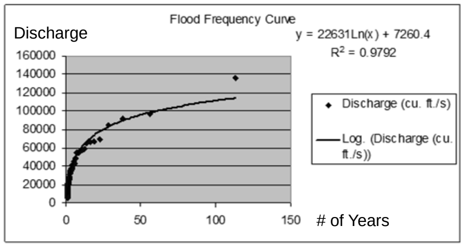


Can Floods Be Predicted and Controlled?

- Prediction of floods depends on an analysis of the flooding history of a particular stream
  - The "100-Year Floodplain" is defined by looking at historical records of flooding for a particular stream and ranking the floods by size.
  - A flood frequency curve is created from this data relating discharge to flood frequency.
  - Discharge is then tied to water height in the channel (or stage) and this information is used to define where the 100-year floodplain is located.

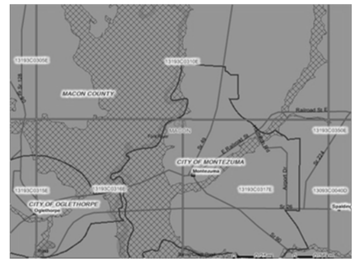
Can Floods Be Predicted and Controlled?

A Flood Frequency Curve for the Flint River, Montezuma, GA



Can Floods Be Predicted and Controlled?

100-Year Flood Plain from FEMA – Montezuma, GA



Can Floods Be Predicted and Controlled?

- What is a 100-year Flood?
- A 100-year flood is one with a 1% chance of occurrence in any single year.
- There could be consecutive years with "100-year floods", or even more than one of these events in one year.

Can Floods Be Predicted and Controlled?

- Why do people live on floodplains?
- Access to water supplies for Industry, recreation, agriculture and domestic supply
- Good soils
- Scenic
- Only flat land
- Ignorance of the risk

Can Floods Be Predicted and Controlled?

- Controlling floods is done mostly through levees and dams.
  - Levees create higher banks restricting the flow of water.
  - Dams effectively prevent flooding in many areas.

Can Floods Be Predicted and Controlled?

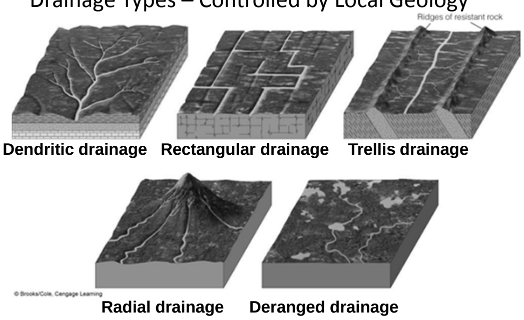
- Controlling floods can also be done using floodways and floodwalls.
  - Floodways are special channels built to divert flood waters.
  - Floodwalls have gates that can be closed to protect communities from flooding

Drainage Systems

- A drainage system is a main stream or river and all its tributaries that carries all the water.
- A drainage basin is a particular geographic area, that is separated from adjacent drainage basins by topographically higher areas called divides.

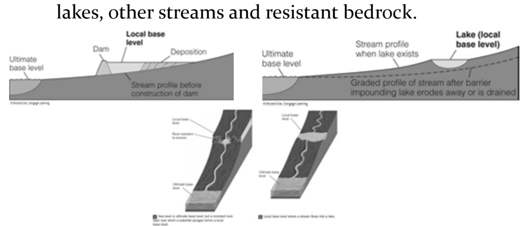
Drainage Basins

Drainage Types – Controlled by Local Geology



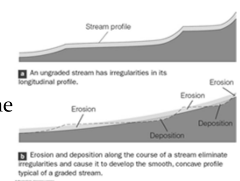
The Significance of Base Level

- The lowest level to which streams can erode is sea level, which is known as ultimate base level.
- Streams commonly have local base levels formed by lakes, other streams and resistant bedrock.



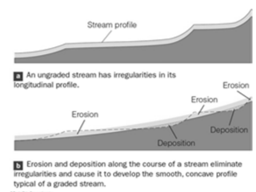
The Significance of Base Level

- ***What is a Graded Stream?***
  - A graded stream has a smooth, concave profile of equilibrium in which all elements are adjusted to one another



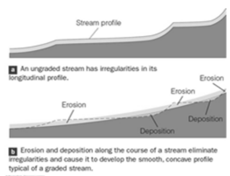
The Significance of Base Level

- ***In a Graded Stream, a delicate balance exists between:***
  - gradient
  - velocity
  - discharge
  - channel shape
  - sediment load



The Significance of Base Level

- Neither significant erosion nor deposition takes place in the graded stream channel.
- The graded condition is an ideal approach by streams, but it is easily upset by changes in base level or climate or increased runoff because of fire.



The Evolution of Valleys

- Low areas on land known as valleys are bounded by higher hills or mountains.
- Most have a river or stream running their length with tributaries draining the nearby highlands.

The Evolution of Valleys

Valleys form as a result of erosion by running water

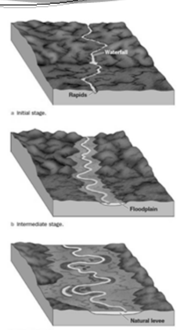
- Steep walled valleys are called canyons
- Very narrow and deep valleys are called gorges
- Small, narrow valleys are called gullies

The Evolution of Valleys

- Stream valleys develop by the combination of processes:
  - Downcutting
  - Lateral and headward erosion
  - Mass wasting
  - Sheetwash

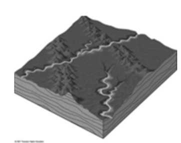
The Evolution of Valleys

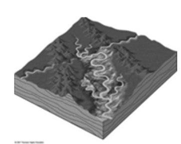
- Downcutting takes place when a stream has excess energy; it uses the excess energy to deepen its valley
- Valley walls are undercut by lateral erosion (spreading), creating unstable slopes which may fail by mass wasting.
- Erosion by sheetwash and tributaries add rock and sediment to the main stream.



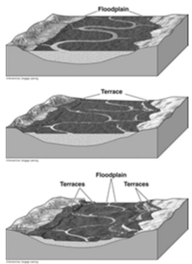
The Evolution of Valleys

- Headward erosion takes place when entering runoff at the upper end of a stream or river valley causes erosion and extension of the upstream portion of the valley.
- Stream piracy occurs if erosion breaches a drainage divide and captures the headwaters of a stream in another drainage basin.





The Evolution of Valleys



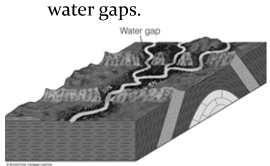
- Stream Terraces
  - Renewed stream downcutting through floodplain deposits commonly results in stream terraces
  - Terraces are the remnants of the older higher elevation stream floodplains.

The Evolution of Valleys

- Incised Meanders
  - Incised meanders occupy deep valleys generally as the result of renewed downcutting by meandering streams.

The Evolution of Valleys

- Superposed streams
  - Superposition takes place when a stream erodes a land surface and encounters resistant rocks below that, when exposed, form ridges.
  - Downcutting slices through the ridges, forming water gaps.



The Evolution of Valleys

- Superposed streams
  - If a water gap is later abandoned by a stream, it is called a wind gap.