Classifying Rivers - Three Stages of River Development

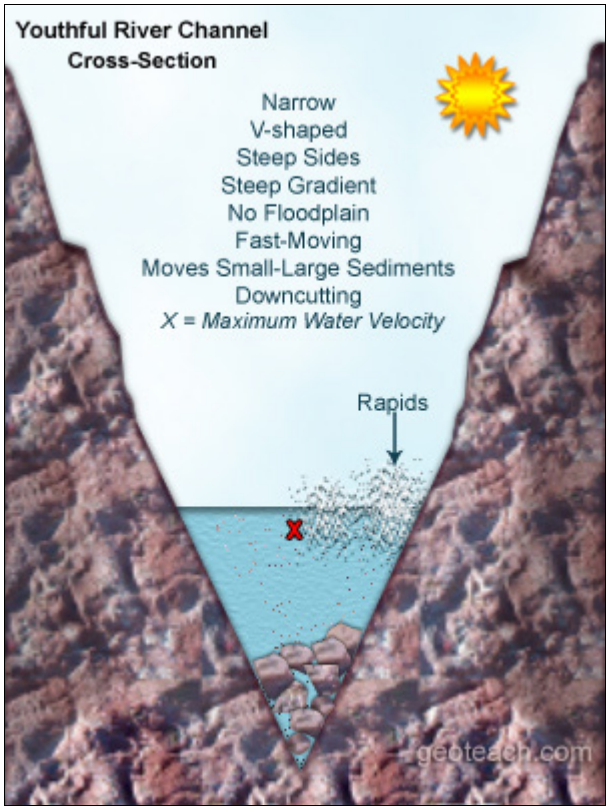
River Characteristics - Sediment Transport - River Velocity - Terminology

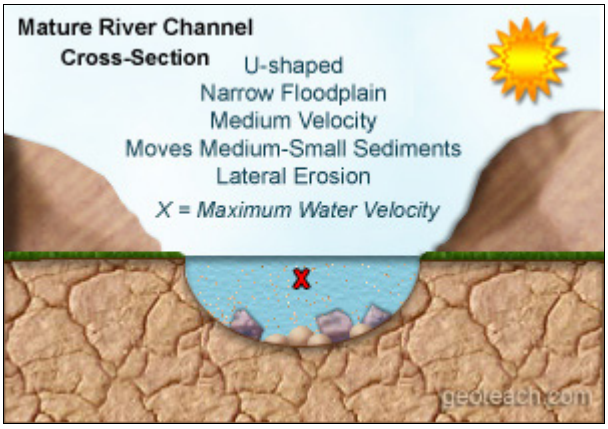
The illustrations below represent the 3 general classifications into which rivers are placed according to specific characteristics.
These categories are: Youthful, Mature and Old Age. A Rejuvenated River, one with a gradient that is raised by the earth's movement, can be an old age river that returns to a Youthful State, and which repeats the cycle of stages once again.

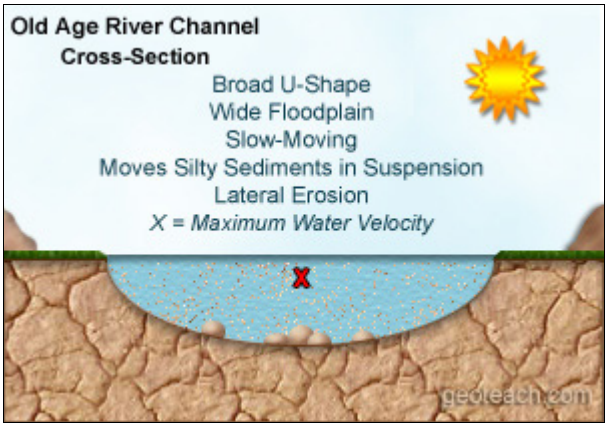
A brief overview of each stage of river development begins after the images.

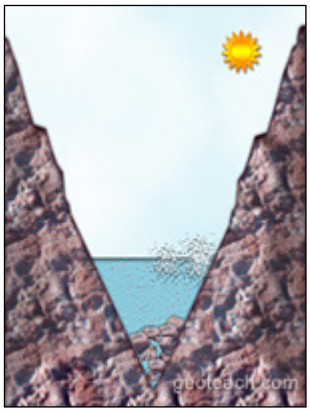
A **list of pertinent vocabulary** appears at the bottom of this document. You may wish to consult it so that you will be aware of terminology used in the descriptive text that follows.

Characteristics found in the 3 Stages of River Development:







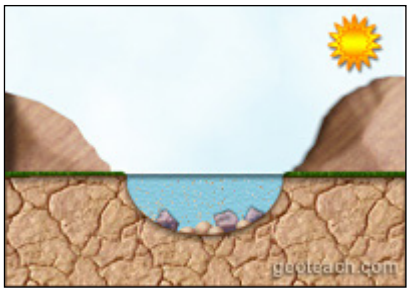


Youthful River:

Perhaps the most dynamic of all rivers is a *Youthful River*. Rafters seeking an exciting ride will surely gravitate towards a young river for their recreational thrills. Characteristically youthful rivers are found at higher elevations, in mountainous areas, where the slope of the land is steeper. Water that flows over such a landscape will flow very fast.
Youthful rivers can be a tributary of a larger and older river, hundreds of miles away and, in fact, they may be close to the headwaters (the beginning) of that larger river.

Upon observation of a Youthful River, here is what one might see:

1. The river flowing down a steep gradient (slope).
2. The channel is deeper than it is wide and V-shaped due to downcutting rather than lateral (side-to-side) erosion.
3. Its velocity is fast and strong and ...
4. Capable of moving all sediment sizes from ions in solution, to silts and clays, also cobbles and boulders.
5. Steep sided cliffs flank the river.
6. A floodplain does not exist. There are no grassy areas beside the river where a person can walk.
7. Rapids may be present due to the water velocity and the presence of boulders in the channel. Waterfalls are also a feature of a young river.
8. Erosion is prominent over deposition.



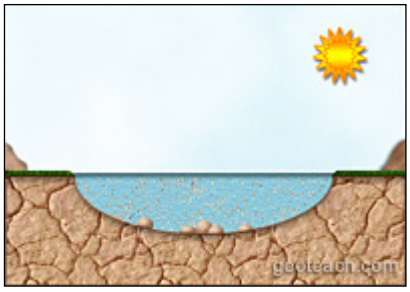
Mature River:

The Mature River is an in-between stage. The river still downcuts though to a much lesser degree than the Youthful River does but it also erodes laterally, though not as extensively, when compared to the Old Age River.
The landscape over which it passes is steep enough that the river's slope enables a velocity capable of moving not only the finer sediments, but also the larger pebbles and cobbles by way of rolling, bouncing and saltation along the river bed. The area through which the river flows may be mountainous but they will not be as high as the Young River's locale. A "hilly" landscape would be a better description for the surrounding area. Rapids are absent and so is the V-shaped channel. The channel of a Mature River is U-shaped but deeper than and not as wide as the Old Age river's channel.

Upon observation of a Mature River, here is what one might see:

1. The river flows down a moderate gradient (slope).
2. The channel is U-shaped and wider than a youthful river yet deeper than an old age channel due to moderate downcutting but also lateral (side-to-side) erosion. In general, the channel is broader with gentler slopes.

3. The velocity is greater than an old age river but less than a youthful one and ...
4. Capable of moving many sediment sizes from ions in solution, to silts and clays, also cobbles, but normally not boulders unless peak flooding occurs.
5. Cliffs may flank the river at a distance, however....
6. A floodplain exists with grassy areas beside the river along which a person can walk.
7. Meanders may be present though they will not be as "curvy" as those found in Old Age Rivers.
8. Erosion is present though deposition of sediments also occurs.
9. There is more water in the stream channel, i.e. the river has a greater discharge than the youthful river. This means the river is capable of carrying more a greater volume of sediment.



Old Age River:

The classic song, "Old Man River", was certainly written about an Old Age River.
The Mississippi is such a river and its slow movement and suspended sediment make it appear, in some locations, more like a river of mud than a river of water. In fact, the Mississippi River can be so muddy that one may think twice before taking a dip.
That does not mean that an Old Age River cannot have its own dynamic behavior. During flood stages, water that overflows the river's banks, pouring over and beyond levees, attains velocities not only capable of moving large boulders, but also large houses! When Old Age Rivers are filled to capacity due to extensive periods of precipitation and the spring snowmelt around its tributaries, flooding makes the newspaper headlines. Extensive property and agricultural damage, as well as loss of life, are the results of hazardous flooding associated with Old Age Rivers.

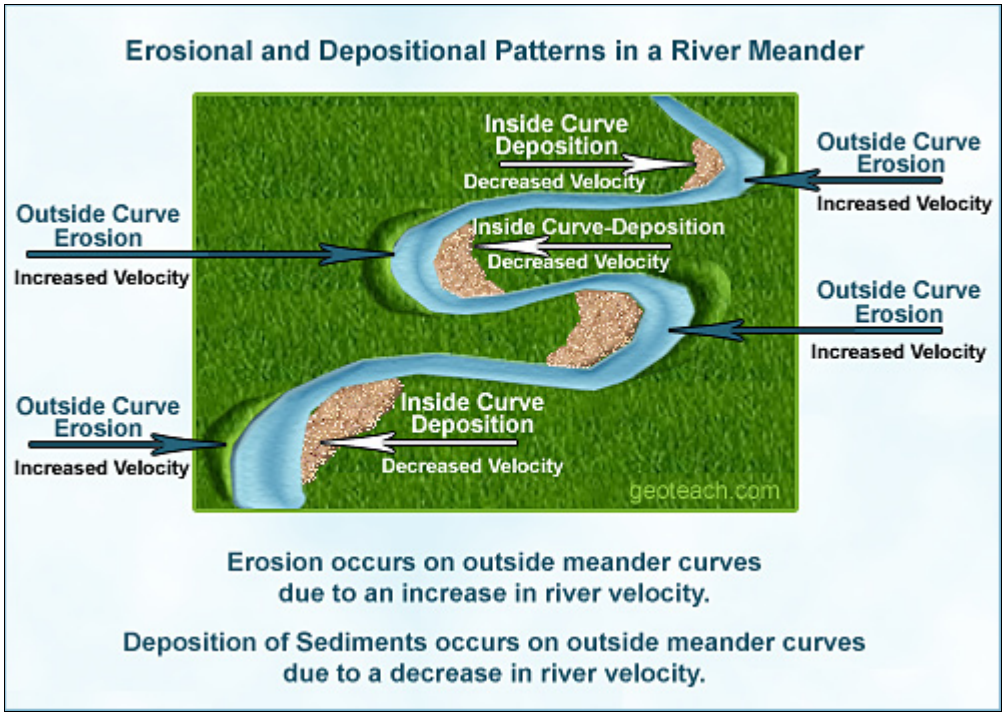
Old Age Rivers actually have more distinguishing features to speak of than the Youthful and Mature Rivers do.
Upon observation of an Old Age River, here is what one might see:

1. The river flows down a very shallow gradient (slope).
2. The channel wider than it is deep with a very broad and U-shape due to extensive lateral (side-to-side) erosion.
3. Its velocity is quite slow and that means the river is...
4. Capable of moving small-sized sediments, i.e. silts and clays. Small sediments are suspended in the slow-moving water giving the river a "muddy" appearance. Dissolved salts and ions are carried in solution.
5. The general landscape surrounding the river is flatter and less steeply sloped. If hilly areas exist, they are further away from the river channel, keep at a distance by the wide floodplain which flanks the river.
6. A wide floodplain characterizes Old Age Rivers. There are grassy areas beside the river along which a person can walk. However, the floodplain is often marshy and swampy due to flooding of the river valley. In places, hip boots would be a good idea.
7. Curvy "S-shaped" *Meanders* are abundant and prominent features of an older river.
8. *Yazoo Streams* run parallel to the main river but do not join it.

9. *Oxbow Lakes* exist within the floodplain. Meanders were cut off from the main stream due to extensive erosion and deposition. The meander is now its own lake but, with no water entering to replenish its supply, it will eventually dry up and become a *Meander Scar*.
10. *Natural Levees*, ridges formed by successive floods that deposit sediment over time, flank the outside meander curves.
11. *Point bars* are areas of deposition on the inside curves of a meander. When water velocity decrease on the inside curves, deposition of sediment occurs, filling in the inside curve over time.
12. Fed by many smaller tributaries which join the main river at various locations, the discharge (volume of water), is quite large. This means that, although the river is capable of moving only the finer sediments, it can move large amounts of sediments.
13. Erosion is present on the outside curves of meanders while deposition of sediments occurs on the inside curves.

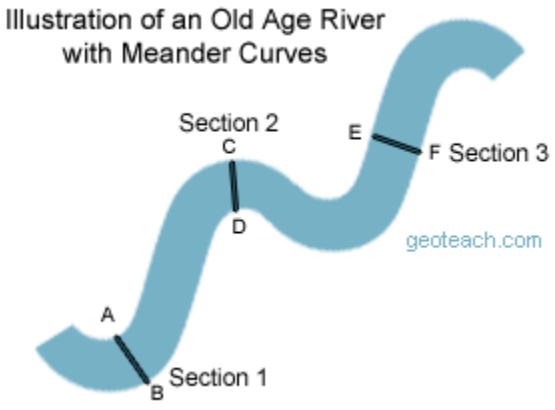
Erosion and Deposition in a Meandering River:

Observe this aerial view of a River and note how erosion and deposition take place with respect to the inside and outside curves:

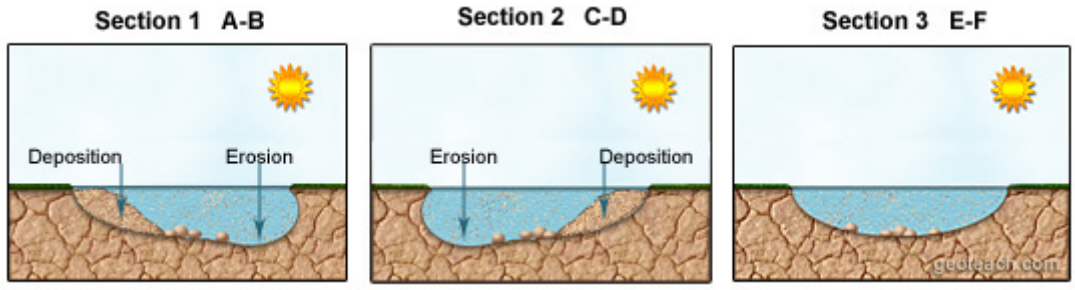


Erosional and Depositional Cross-Sectional Views:

Observe the following illustration to see how the aerial view of the meandering river (above) corresponds to a cross-sections of 3 different locations.
The Illustration shows River Meanders. Lines have been drawn across the river where sections have been lettered for identification.



The following 3 cross sections correspond to each of the 3 sections in the picture above. Notice how the erosional and depositional features change according to the positions of outside and inside curves. The straight section of the river (E-F) is a basic U-shaped channel.



You may want to view: **An Animated Visualization** showing lateral erosion by a meandering old age river: **Observe Changes in the Channel of a Meandering River**.

Greatest Velocity in a River Cross-Section - The Red "X" in all 3 Diagrams:

The red "X" in the first 3 illustrations in this document marks the location where the river water flows the absolute fastest. Despite whatever overall speed a river may be maintaining, in a cross-sectional consideration of river velocity, the water molecules are not all moving at the same speed. This is mainly due to *frictional drag*.
When a moving object comes in direct contact with another object, friction tends to slow down movement, reducing speed.
At all locations where the river water comes in contact with the sides and bottom of the stream channel, there is frictional drag. Also, where the surface of the water comes into contact with the air, there is frictional drag.

The fastest moving water within the channel is located: dead center, just below the surface.
This area is as far away from contact with land surfaces as possible, yet removed from contact with the air.

Remember, we are referring to a cross-section here and not the length of an entire channel. With Old Age Rivers, when an entire river course is considered, there are areas of peak velocities on outside curves of meanders when compared to inside curves, as was already explained in the above section.

How do Rivers Transport their Sediments?

Pebbles, Cobbles and Boulders *(Bedload)**:*** Travel by rolling, sliding and bouncing along the streambed.
Sand-Sized Particles *(Bedload)**:*** Move by *Saltation*. Small grains bounce along the river bottom, as if in a "colliding and jumping" motion.
Silts and Clay *(Suspended Load)**:*** These are carried in *Suspension*.
Salts and Ions *(Dissolved Load)**:*** Are carried in *Solution*.

Sediment Speed:

Sediments *never* travel faster than the river water itself.
Dissolved salts travel at the same speed as the water.
Bedload and suspended sediments always travel slower than the river water.

Velocity, Sediments, Erosion & Deposition - Saying it Simply:

The faster the water velocity, means the more sediments and also the larger sediments a river can transport:

Increased River Velocity = Larger Sediments + Increased Volume of Sediments + Increased Erosion

Decreased River Velocity = Smaller Sediments + Decreased Volume of Sediments + Increased Deposition

For an *excellent animation* showing **Sediment Transport**, visit: **Observe how sediment is transported by flowing water**.

Rivers Modify Landscapes:

All rivers erode the land over which they pass, rendering a more gradual gradient to surrounding areas over time. Rivers carve steep canyons into solid bedrock and erode 3-dimensional landscapes down to flat peneplains.
Sometimes a river which has gone through all 3 stages of its "life" will be uplifted by crustal movement of the area over which it flows. If a river's gradient changes from a shallow to a steep slope, then river velocity will increase, downcutting will begin anew and the river will revert to a more youthful stage with all the characteristics of a young river.

Rejuvenated River:

A *Rejuvenated River* is a course of flowing water with a gradient that is raised by the earth's movement. An example of a river that was old then rejuvenated into one with

abundant rapids and fast-moving water is the Colorado River, famous for downcutting the approximately 1 mile deep Grand Canyon.
The *ancestral Colorado River* began its course when the Rocky Mountains to the east of the Grand Canyon were formed, approximately 60-70 million years ago. The Grand Canyon did not exist at that time. The youthful downcutting and erosive capabilities of the river began about 17 million years ago when the Colorado Plateau began to uplift, raising the area up to 3 miles above sea level. As the land continued to rise the Colorado River, changing its course several times, continued to erode the land, carving the magnificent 277 mile (446 km) long, 5000 feet (1524 m) deep Grand Canyon. While the oldest rocks at the canyon bottom are close to 2 billion years old, the canyon itself, as an erosional feature, formed only in the past five or six million years. Today, Colorado River velocities range from 570 m^3/s in droughts to 28,000 m^3/s in severe floods.

Vocabulary that Relates to Rivers

Bank: as in River Bank: The margins of a channel. Banks are called right or left as viewed facing in the direction of the flow.
Bedload: The larger heavier particles that are being transported by a stream. Instead of being dissolved or suspended, these are being rolled or bounced along, spending at least part of their time in contact with the stream bottom.
Bedrock: Solid rock present beneath any soil, sediment or other surface cover. In some locations it may be exposed at Earth's surface.
Bedrock: Solid rock present beneath any soil, sediment or other surface cover. In some locations it may be exposed at Earth's surface.
Channel (watercourse): An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water.
Delta: A deposit of sediment that forms where a stream enters a standing body of water such as a lake or ocean. The name is derived from the Greek letter “delta” because these deposits typically have a triangular shape in map view.
Deposition: The settling from suspension of transported sediments. Also, the precipitation of chemical sediments from mineral rich waters. In a river system, deposition is found on the inside curves where water velocity is slowest.
Discharge: The volume of water in a flowing stream that passes a given location in a unit of time. Frequently expressed in cubic feet per second or cubic meters per second. Calculated by the formula Q = A x V where Q is the discharge, A is the cross sectional area of the channel and V is the average velocity of the stream.
Downcutting: Refers to river erosion that cuts down into the bedrock below. Such erosion deepens channels, creating a V-shape.
Erosion: A general term applied to the wearing away and movement of earth materials by gravity, wind, water and ice. In a river system, erosion is more active on outside curves where water velocity is fastest.
Flood Plain: An area of alluvium-covered, relatively level land along the banks of a stream that is covered with water when the stream leaves its channel during a time of high flow.
Headwater(s): The upper portions of a drainage basin where the tributaries of a stream first begin flow. The stream's source.
Lateral Erosion: is common to mature and old age rivers where meanders erode the sides of a river's channel, widening the channel while creating an ever-widening floodplain during intermittent periods of flooding.
Levee: A long continuous ridge built by people along the banks of a stream to contain the water during times of high flow. Natural levees can also be built along the banks of a stream. When the flood water decelerates upon leaving the channel, sediments quickly drop out of suspension and build a ridge over time.
Mature River: Characterized by a valley with a wide floor and flaring sides, by advanced headward erosion by tributaries, and by a more smoothly graded bed. Meanders may be present though they are not as pronounced as in Old Age Rivers.
Meander: The bend in a stream.

Meandering Stream: A stream that has many bends (meanders). This type of drainage pattern usually develops on a nearly level landscape and where the banks of the stream are easily eroded.
Mouth: The lower portion of a drainage basin where a river ends and deposits its bedload in a lake or ocean.
Old Age: A stage in the development of a landscape when streams have a low gradient (slope) and meander back and forth across broad floodplains. The landscape is marked by meander scars, oxbow lakes, levees, point bars and swamps. Its course is graded to base level and running through a peneplain, or broad flat area.
Oxbow Lake: A crescent-shaped lake that forms when a meandering stream changes course. Such changes in course frequently occur during flood events when overbank waters erode a new channel.
Peneplain: A nearly flat land surface representing an advanced stage of erosion
Point Bar: A sand bar that develops on the inside curve of a meander bend due to the slowing of river velocity on the inside curves and resulting loss of a portion of bedload (sediments).
Sediment: A loose unconsolidated deposit of weathering debris, chemical precipitates or biological debris that accumulates on Earth's surface.
Swamp: Seasonally flooded land; A lowland region saturated with water.
Streambed: A channel occupied (or formerly occupied) by a stream
Tributary: A stream or river that flows into a larger river.
Yazoo Stream: A tributary that parallels the main channel for a considerable distance. Joining of these streams is normally blocked by a natural levee along the larger stream.
Youthful River: The earliest stage in the development of a landscape. During this stage streams are actively downcutting and flowing straight for long distances with frequent waterfalls and rapids. The valleys are typically steep sided and v-shaped.

Definitions are courtesy of:
Geology Dictionary; Geology and Earth Science Dictionary - copyright 2005 - 2006 - Geology.com
Science in Your Watershed, General Introduction and Hydrologic Definitions, W. B. Langbein and Kathleen T. Iseri, Manual of Hydrology: Part 1. General Surface-Water Techniques, USGS, 1872, 1995
The Free Dictionary.Com
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Grand Canyon National Park Arizona, National Park Service, updated: 01/04/2005

Other Related Pages

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Old Age Meandering Rivers
Student Assignment with Multiple Choice Questions - **Old Age Meandering Rivers**
Young Rivers
Student Worksheet - **Youthful Rivers**