River Processes

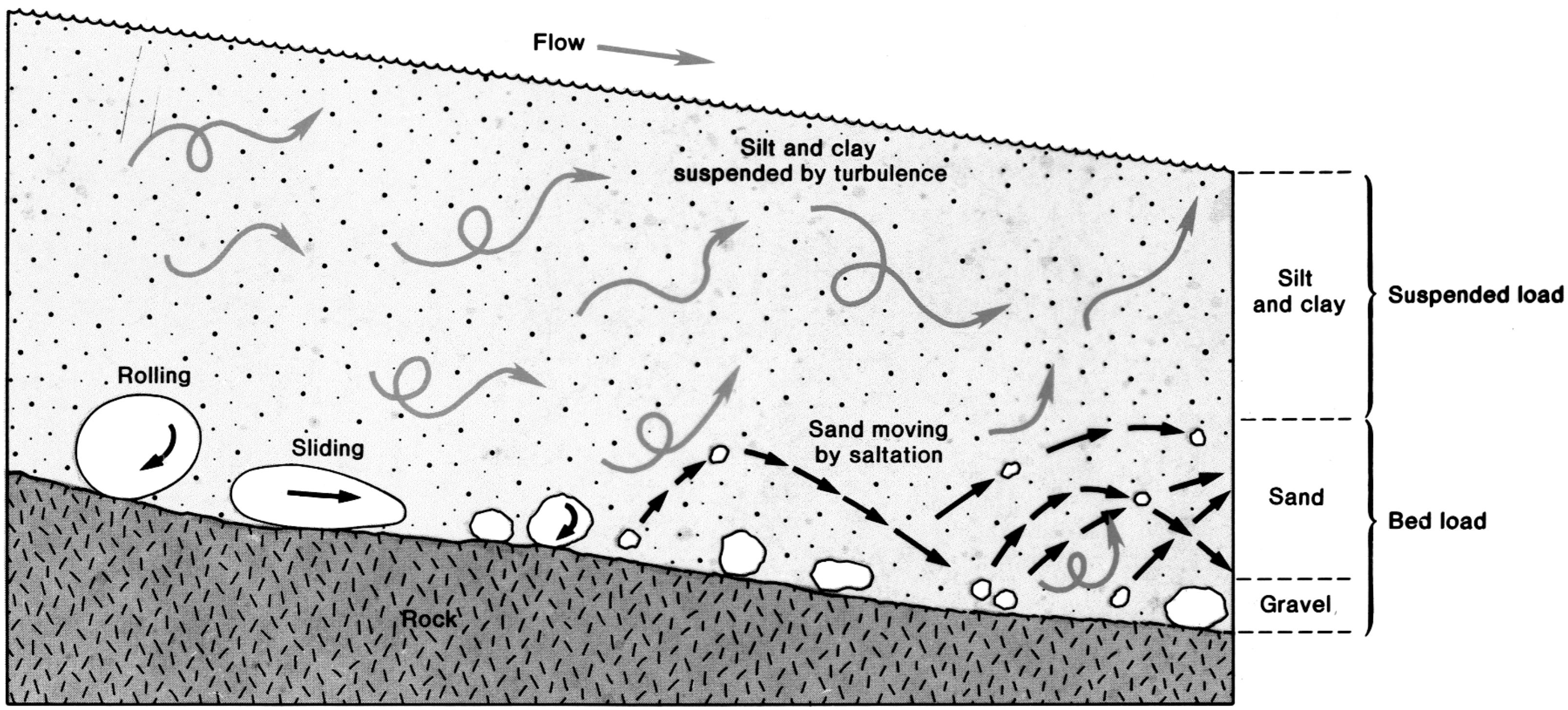
Sediment in Channels

Although most energy in a stream is dissipated by turbulence, a small part is used in the important task of eroding and transporting sediment. Poorly understood and yet significantly important.

River Processes

Sediment in Channels

- Suspended load
- Bedload



River Processes

Sediment in Channels

- ***Entrainment*** - processes that initiates the bursts of motion experienced by any particle
- **Competence** - the size of the largest particle a stream can entrain under any given set of hydraulic conditions.

Is very difficult to determine however for several reasons:

1. particles are entrained by a combination of fluvial forces
2. flow velocity is neither constant nor easily measured, and,
3. sediment of the same size may be packed together differently

River Processes

Sediment in Channels

One method used to represent the flow conditions in competence relationships, is measuring the ***critical shear stress***. It is proportional to the depth-slope product and can be expressed by the DuBoys equation for boundary shear:

$$\tau_c = \gamma * R * S$$

where τ_c = critical shear stress
γ = specific weight of the water
R = hydraulic radius
S = slope

River Processes

Sediment in Channels

Researchers have proposed that entrainment and transportation of bedload may be analyzed in terms of stream power.

Stream power is defined as:

$$\omega = \gamma * Q * S$$

Where: ω = stream power,
γ = specific weight of the water
Q = discharge, and
S = slope

River Processes

Sediment in Channels

Bank erosion - the process of entrainment determine the type and magnitude of erosion that occurs on the channel floor.

fluvial entrainment promotes bank erosion in two ways:

- ***corrasion*** – shear stress generated by water flow – operates on all surfaces, and
- ***Cantilevers*** – differential corrasion produces overhangs which collapse.

River Processes

Sediment in Channels
Bank erosion

weakening and weathering - tends to reduce the strength of bank materials and thereby promote instability and failure.

The most important control on weakening of bank material is the ***soil moisture condition***.

1. reduce strength within the bank and

2. act on the bank surface to loosen and detach particles and their aggregates.

River Processes

Sediment in Channels
Bank erosion
Other components that weaken and weather bank materials include:

1. ***positive pore pressures,***
2. ***cohesive layers below non-cohesive layers***
3. ***piping (preferential flow)***

So, in many instances, riverbank erosion has nothing to do with rivers. Often it is a mass movement thing controlled by the texture and stratigraphy of floodplain sediments.

River Processes

Sediment in Channels

Deposition

If entrainment of sediment represents a threshold of erosion, a similar threshold must exist when sediment in transport is deposited.

A long episode in which less sediment leaves the bed than is returned results in a distinct period of ***aggradation***

River Processes

Sediment in Channels

Deposition

A long episode in which more sediment leaves the bed than is returned results in a distinct period of ***degradation*****.**

River Processes

Sediment in Channels

Deposition

Fluvial deposition is important to geomorphology in several ways.

1. On a long-term basis, continued deposition results in landforms that reflect distinct periods of geomorphic history – glacial chronologies.

2. On a short-term basis, deposition creates bottom forms such as dunes, bars, and riffle-pool sequences that are closely interrelated with channel pattern and the character and distribution of flow within the channel – ecological reconstructions.

3. Finally, short-term and long-term mechanics of deposition have implications beyond the boundaries of geomorphology – gold mining and contaminant plume migration.

River Processes

Sediment in Channels

Frequency and magnitude of river work

Geomorphic work is usually estimated in one of two ways.

1. The work done by any river can be estimated by the amount of sediment it transports during any given flow

2. Assess the condition under which rivers make adjustments

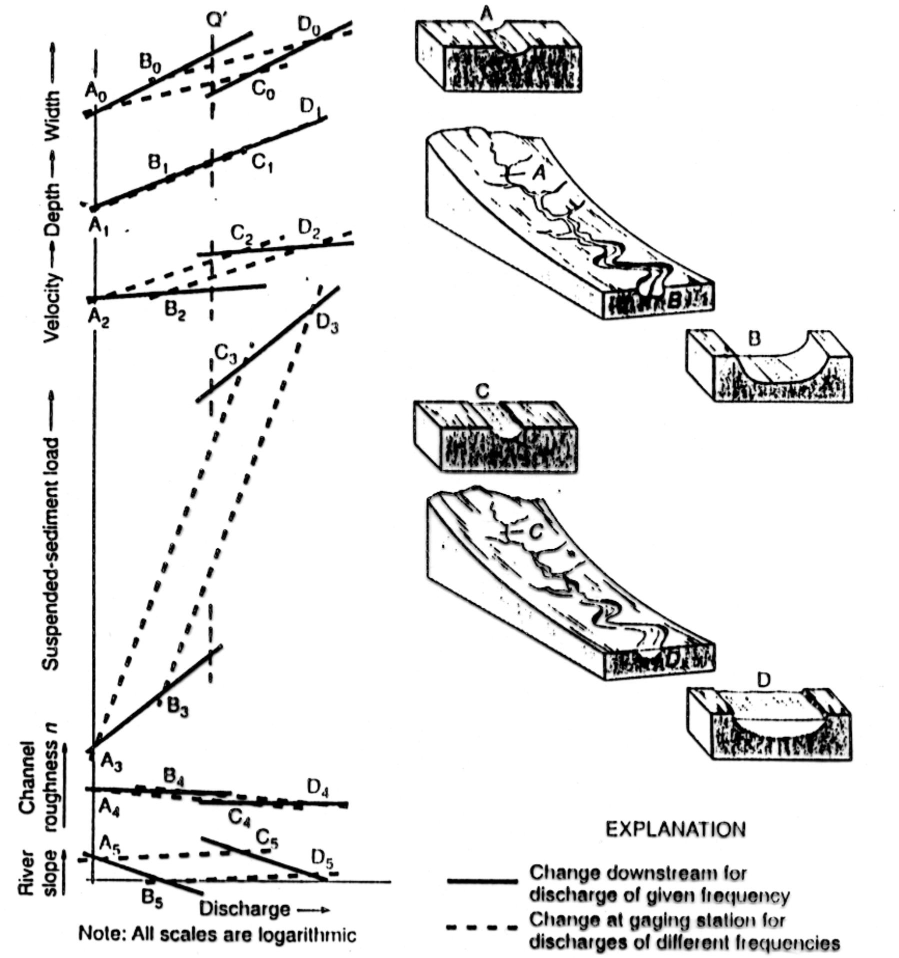
Dominant discharge

(bankful discharge) - channel morphology is adjusted during flows having a recurrence interval of between 1.1 and 2 years.

River Processes

The quasi-equilibrium condition

River variables are mutually interdependent, meaning that a change in any single parameter requires a response in one or more of the others.



Hydraulic geometry relationships of river channels comparing variations of width, depth, velocity, suspended load, roughness, and slope to discharge at a station and downstream.

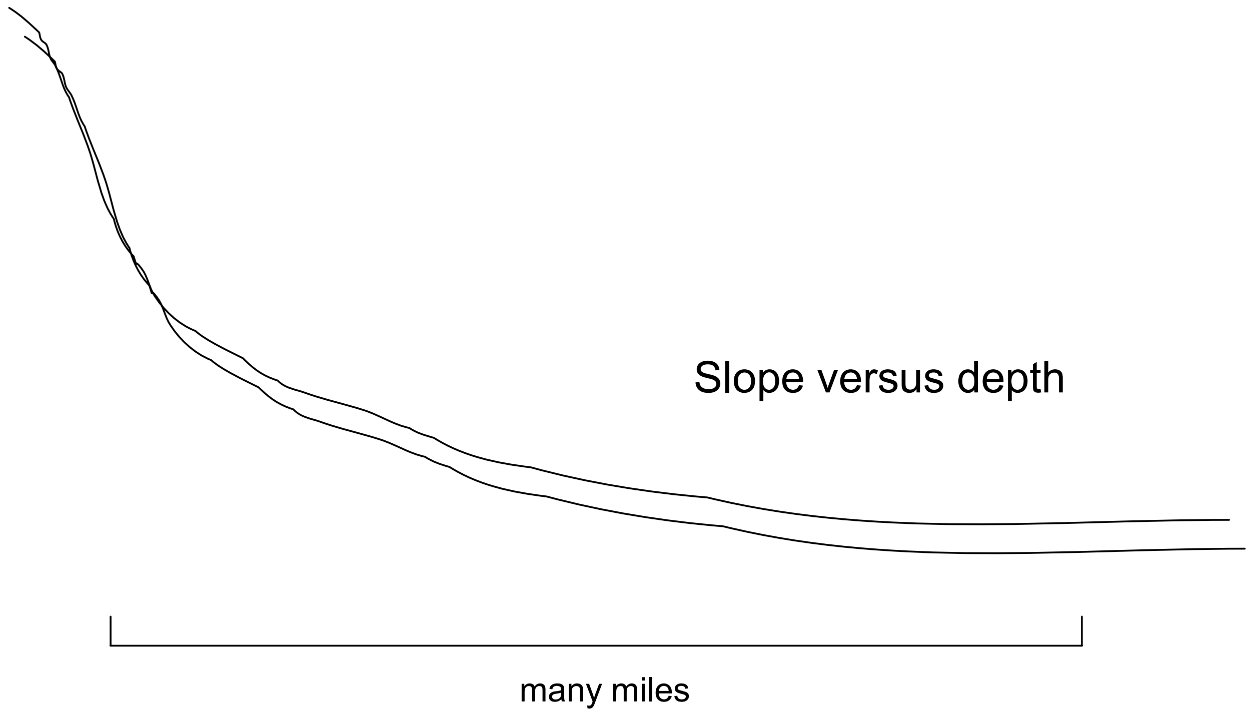
(Leopold and Maddock 1953)

River Processes

The quasi-equilibrium condition

Hydraulic geometry - velocity

Velocity increases downstream. This doesn't fit with what most geologists think. Remember Manning's equation.

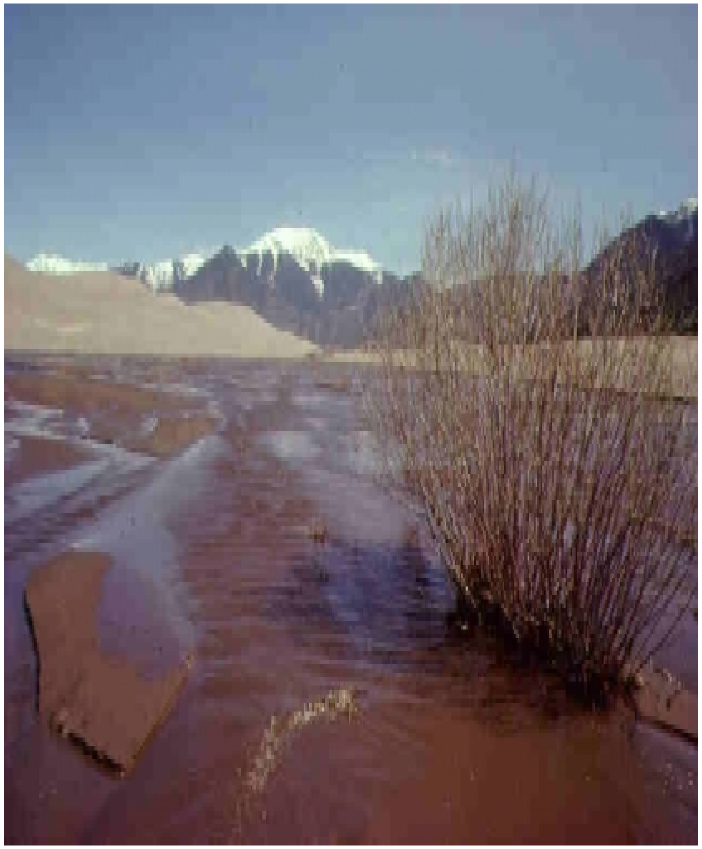


River Processes

The quasi-equilibrium condition

Hydraulic geometry - Channel shape

Logic tells us that unless velocity is completely unrestrained, rivers with a large mean annual discharge have greater cross-sectional areas than streams with smaller average flows.

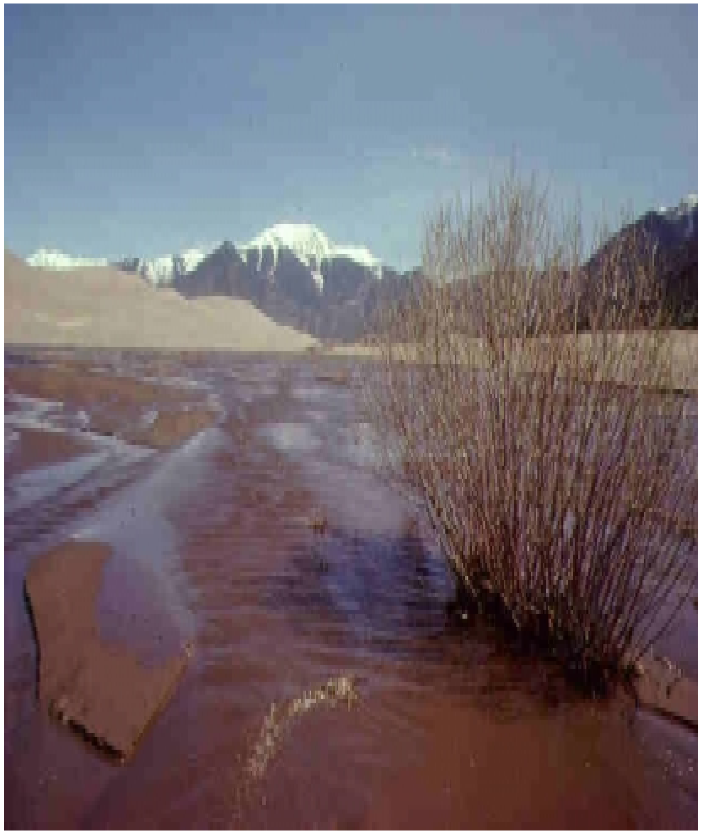


River Processes

The quasi-equilibrium condition

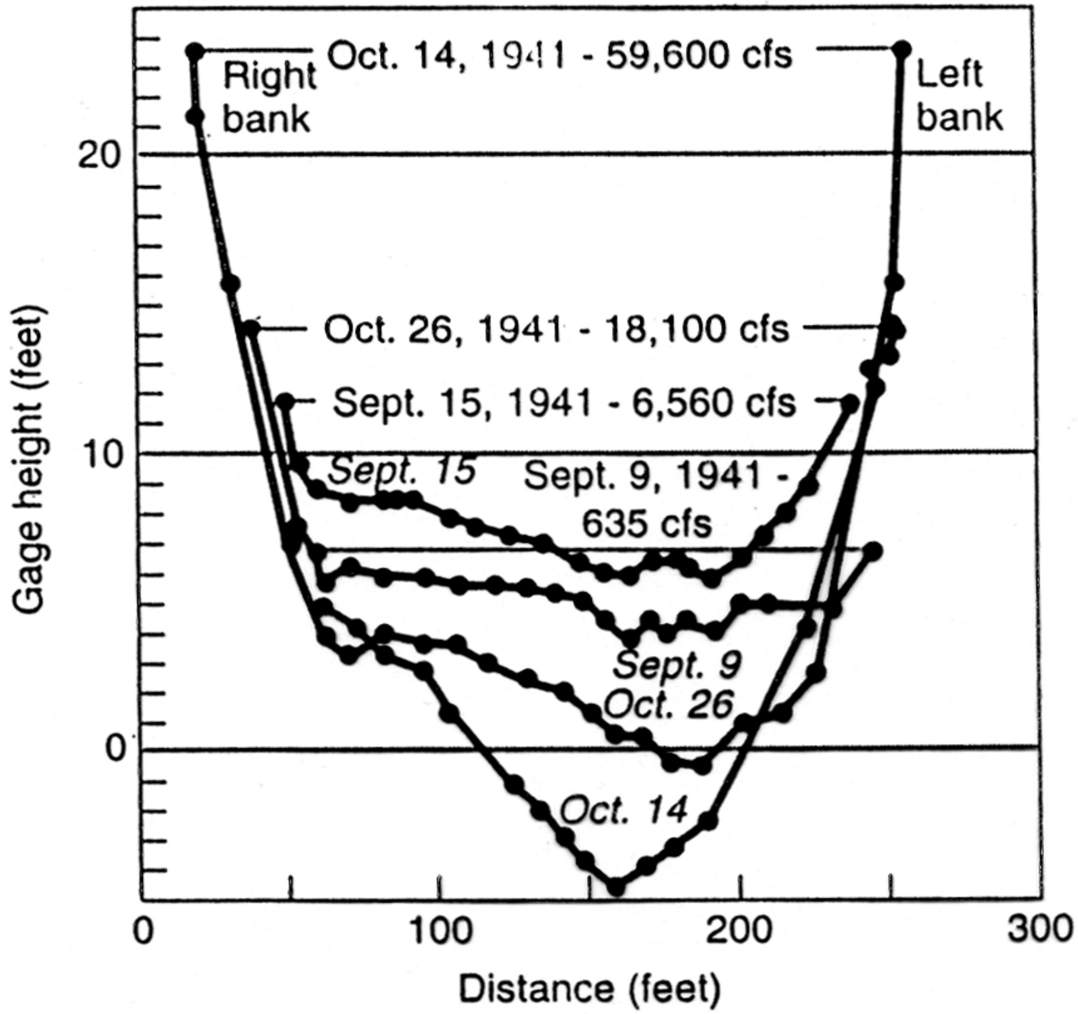
Hydraulic geometry - Channel shape

Schumm (1960) present arguments that suggested that channel shape as defined by W/D, is determined primarily by the nature of the sediment in the channel perimeter.



River Processes

The quasi-equilibrium condition
Hydraulic geometry - Channel shape



River Processes

Channel Patterns

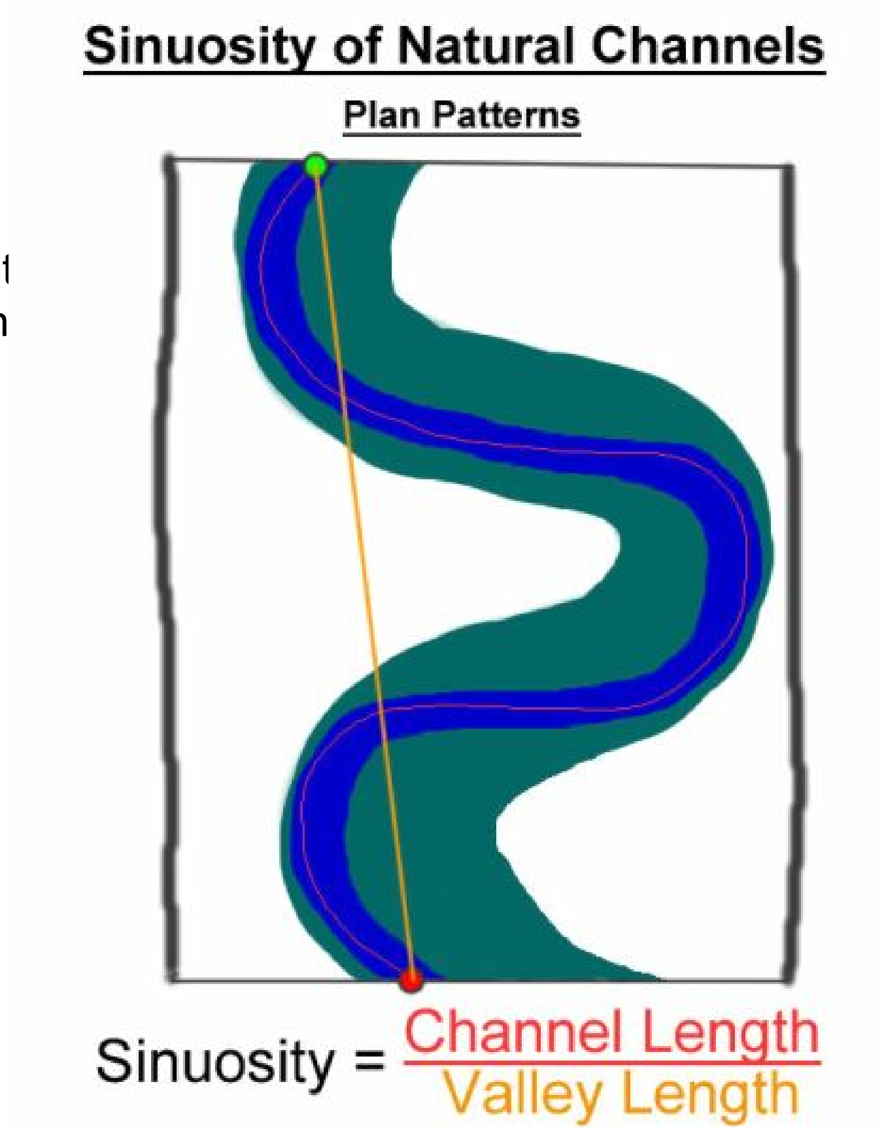
Rivers also have characteristic forms extending over long stretches of their total length which, when observed in plain view, display a distinct geometric pattern.

River Processes

Channel Patterns

Patterns are usually classified as ***straight, meandering***, or ***braided***,

sinuosity - the ratio of stream lengt (measured along the center of th channel) to valley length (measured along the axis of the valley).



River Processes

Channel Patterns

Straight channels

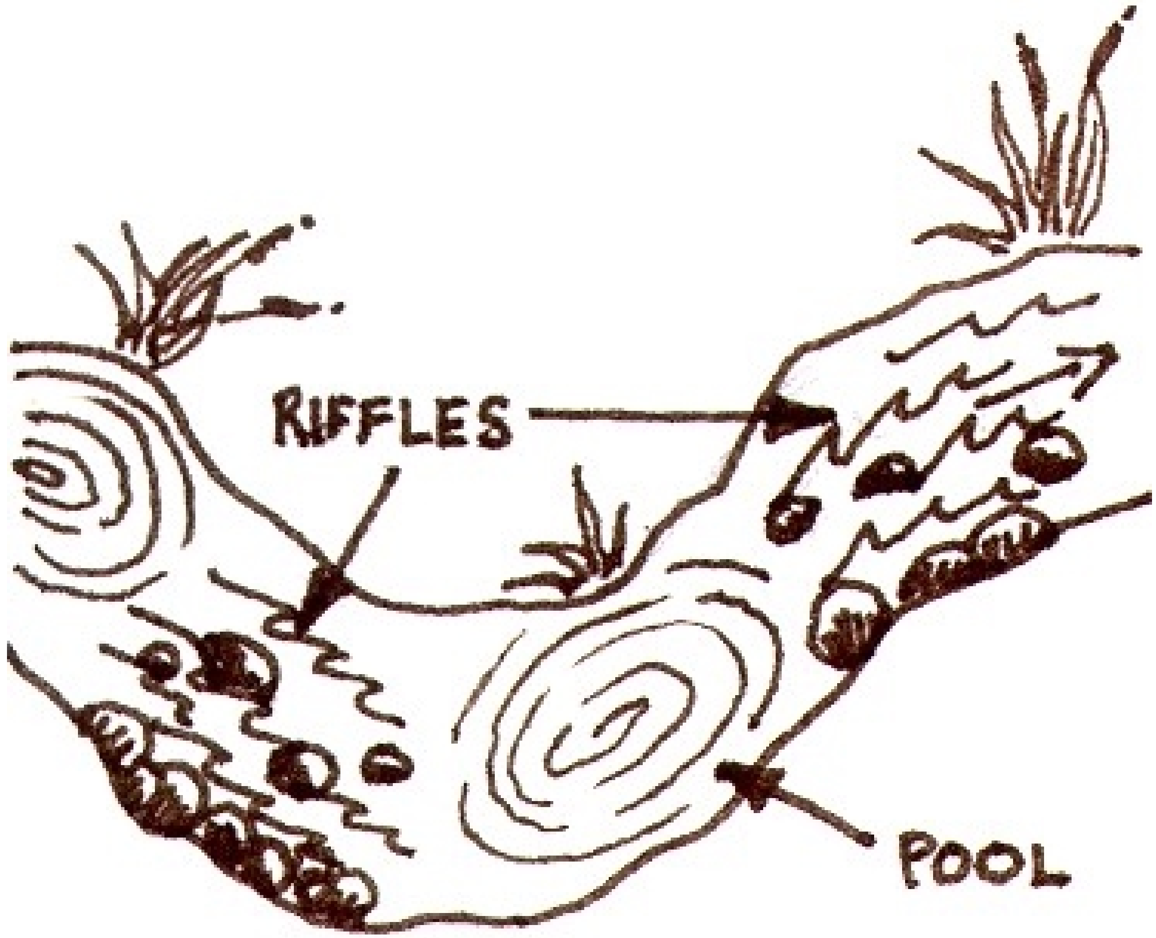
- ***alternate bars***
- ***thalweg***

River Processes

Channel Patterns

Straight channels

- ***riffles***
- ***Pools***



River Processes

Channel Patterns

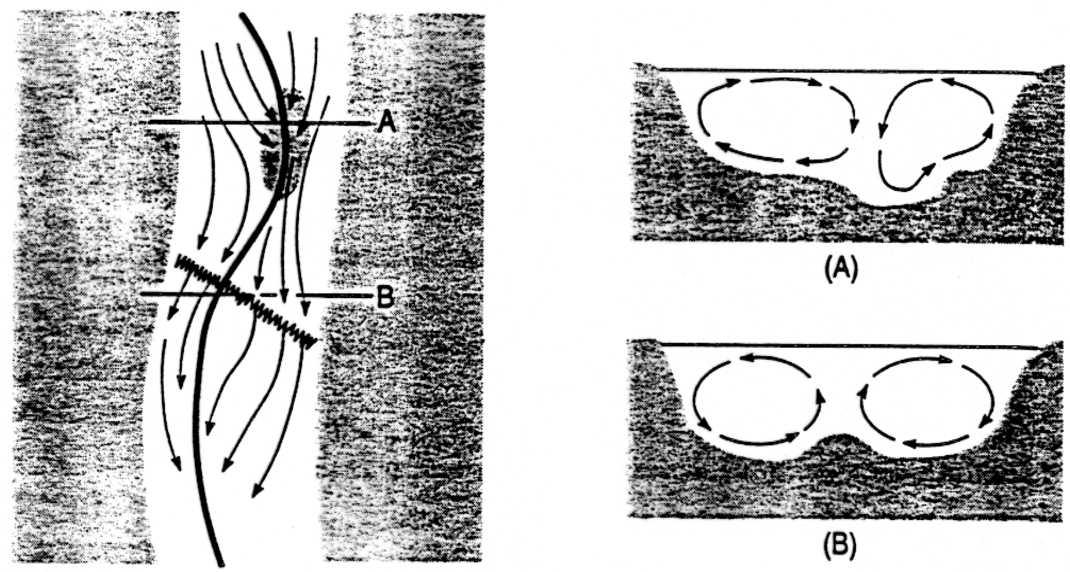
Straight channels

But shouldn't the pools eventually fill up?

Convergent flow

Divergent flow

Schematic diagram of convergent flow and secondary circulation over a pool (A) and divergent flow and secondary circulation over a riffle (B) in a straight channel.



River Processes

Channel Patterns

Meandering channels

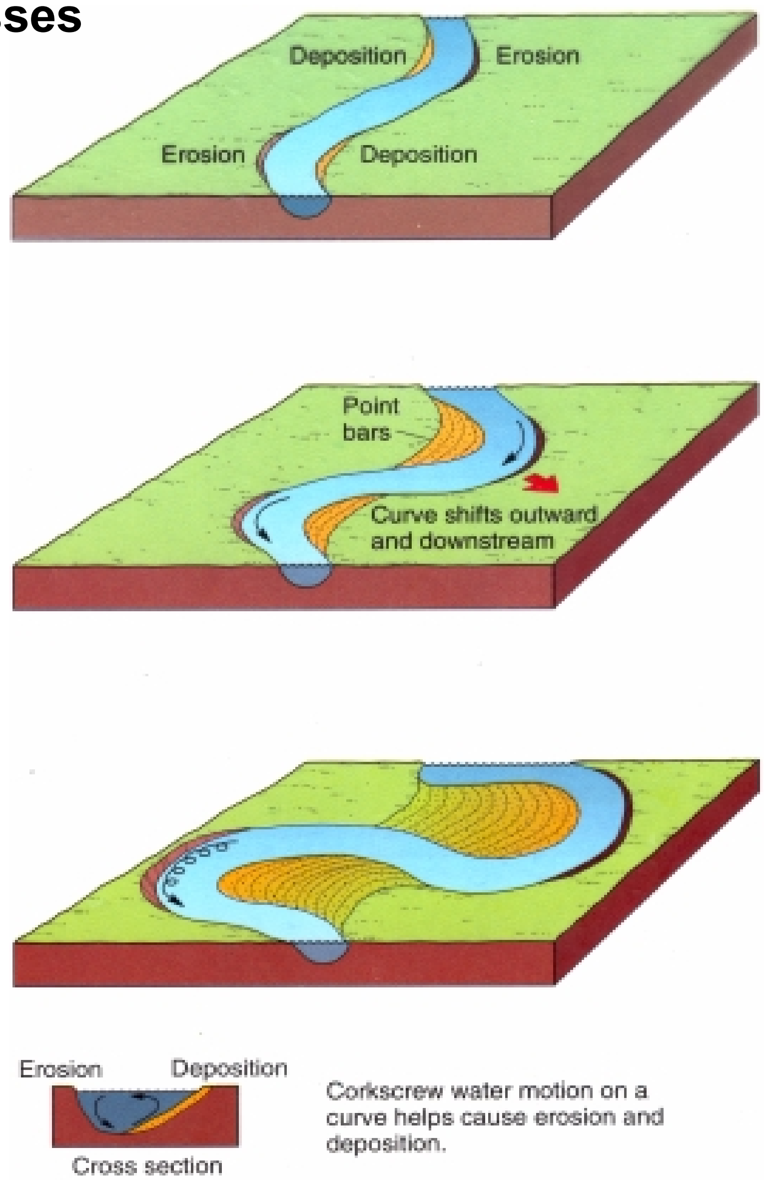
www.hi.is/~oi/siberia_photos.htm

River Processes

Channel Patterns

Meandering channels

- ***Point bar***
- ***Cut bank***



River Processes

Channel Patterns

Meandering channels

River Processes

Channel Patterns

Meandering channels

Most analyses of river energy indicate that meandering streams are probably closer to equilibrium condition than straight streams because:

1. meandering tends to dissipate energy in equal amounts along the length of the channel and

2. under the constraints of (1), meandering tends to minimize the total energy expenditure (to do the least work) or the rate of energy expenditure.

River Processes

Channel Patterns

Braided channels - division of a single trunk channel into a network of branches and the growth and stabilization of intervening islands.

- Braided zones are usually steeper and shallower;
- Total width is greater
- Changes in channel positions are likely to be extremely rapid

River Processes

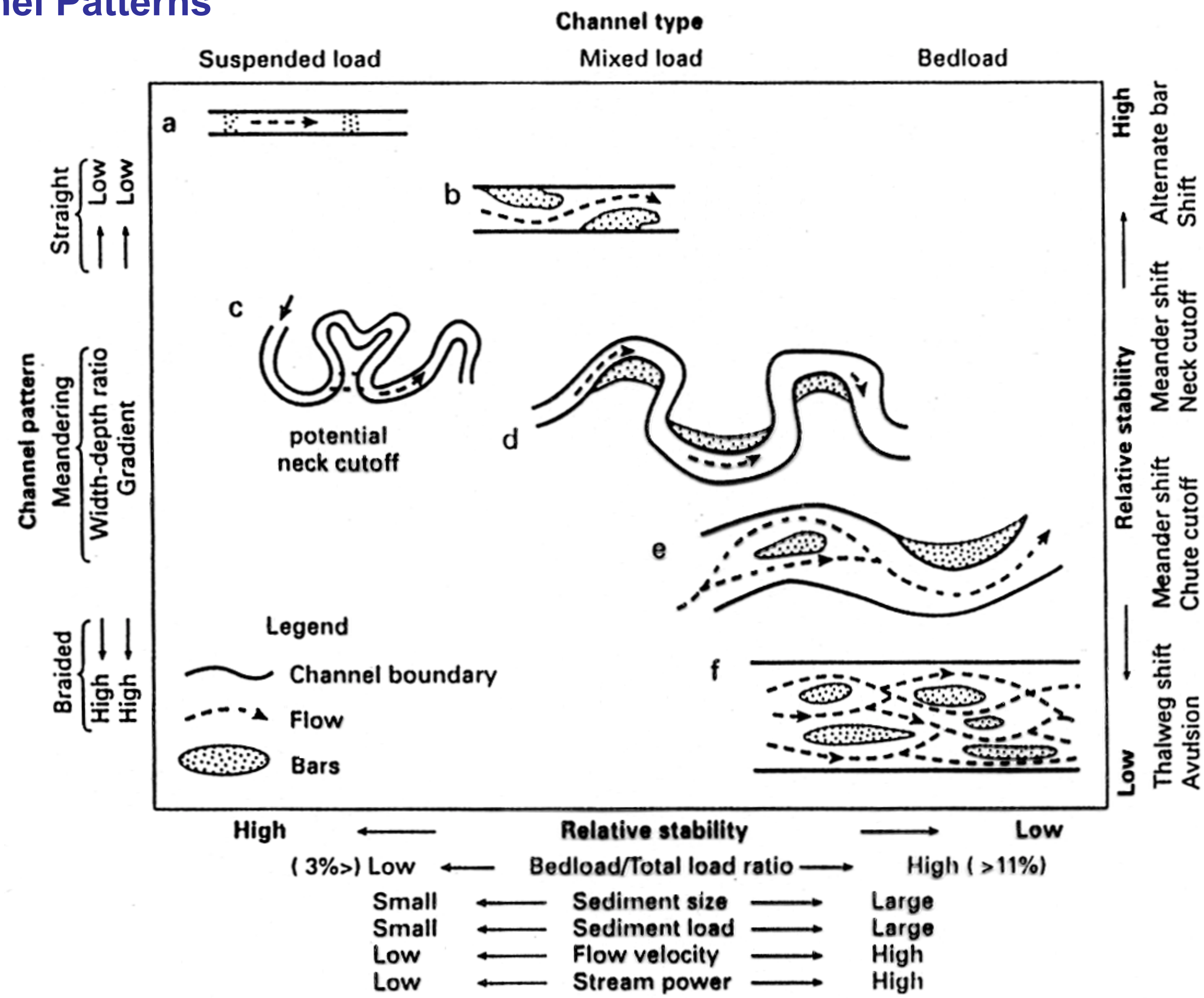
Channel Patterns

Braided channels
The origin of braids

- ***Erodible banks***
- ***Sediment transport and abundant load***
- ***Rapid and frequent variations in Q***

River Processes

Channel Patterns



River Processes

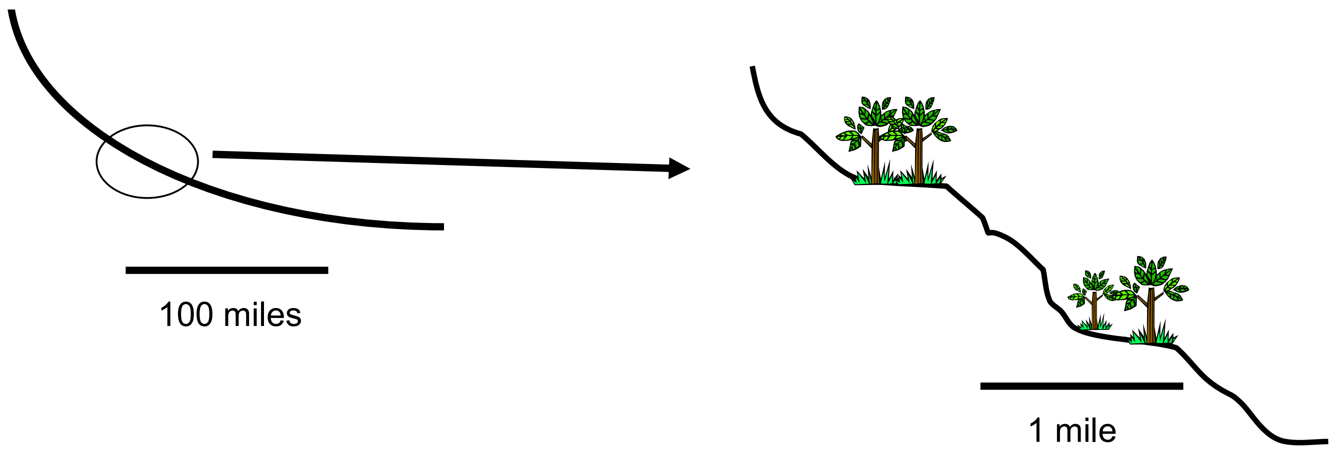
Rivers, Equilibrium and Time

Time span of consideration

River Processes

Rivers, Equilibrium and Time

Adjustment of Gradient



River Processes

Rivers, Equilibrium and Time

Adjustment of Gradient

- ***knickpoint***

River Processes

Rivers, Equilibrium and Time

Adjustment of Shape and Pattern

links

River Processes