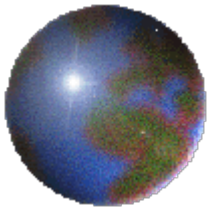
Introduction to Physical Geology



Chapter 14
Streams and Lakes

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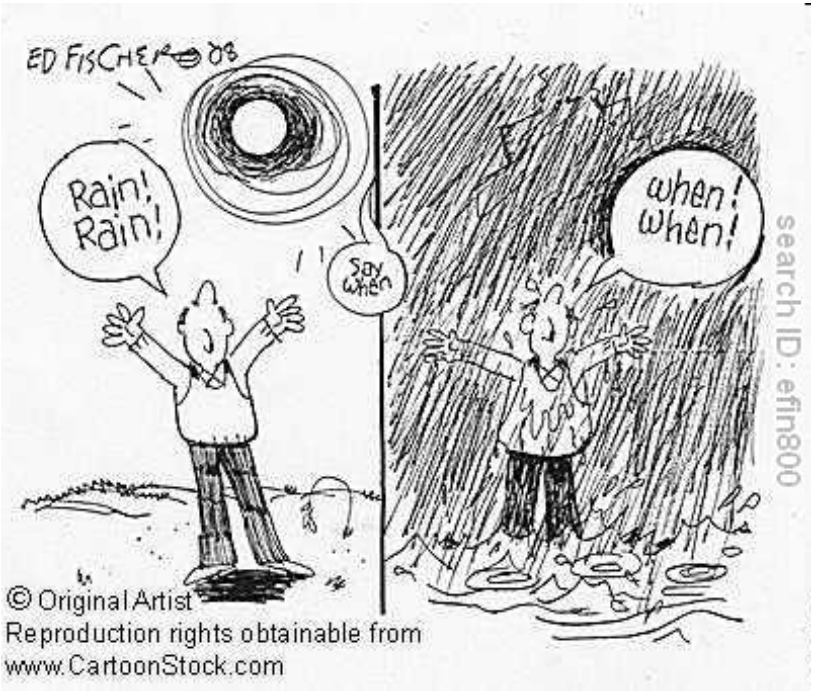
Content

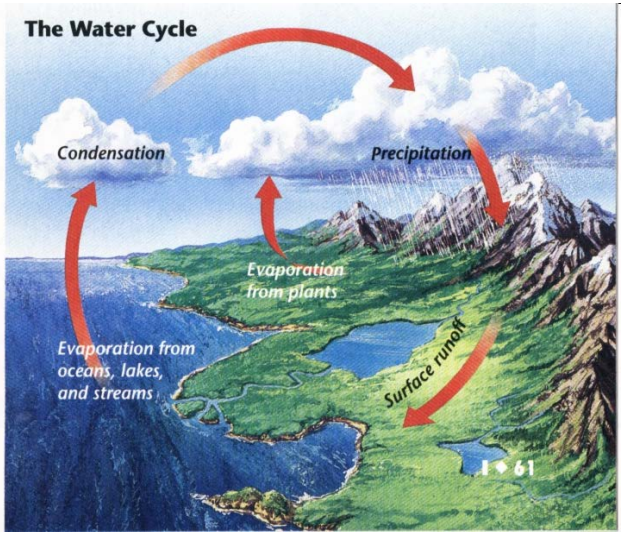
Definition

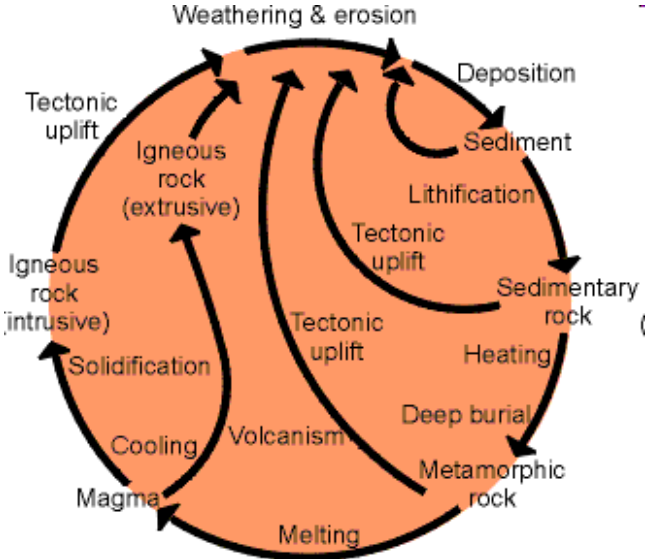
- A ***stream*** is a body of water that carries rock particles and dissolved ions and flows down slope along a clearly defined path, called a ***channel***. Thus, streams may vary in width from a few centimeters to several kilometers.

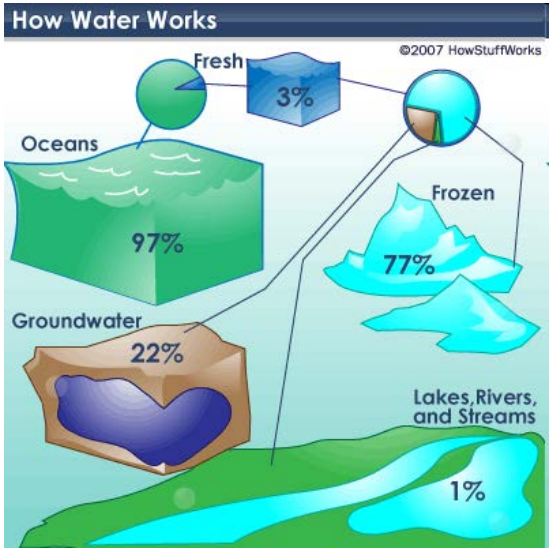


Streams are important for several reasons:

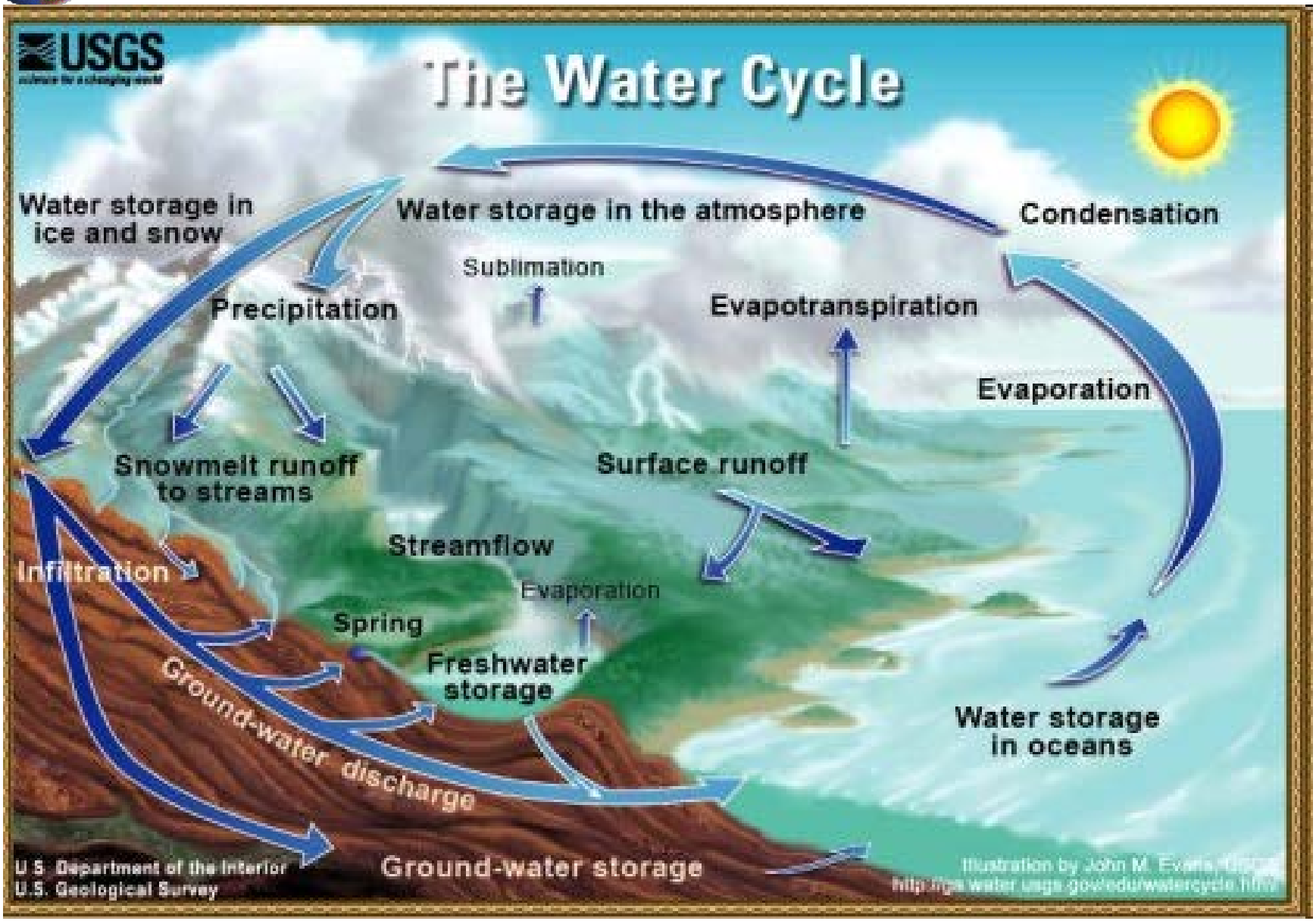
- Streams carry most of the water that goes from the land to the sea, and thus are an important part of the water cycle.
- Streams carry billions of tons of sediment to lower elevations, and thus are one of the main transporting mediums in the production of sedimentary rocks.
- Streams carry dissolved ions, the products of chemical weathering, into the oceans and thus make the sea salty.
- Streams are a major part of the erosional process, working in conjunction with weathering and mass wasting. Much of the surface landscape is controlled by stream erosion, evident to anyone looking out of an airplane window.
- Streams are a major source of water and transportation for the world's human population. Most population centers are located next to streams.







The Hydrologic Cycle



Major Rivers

Geometry and Dynamics of Streams

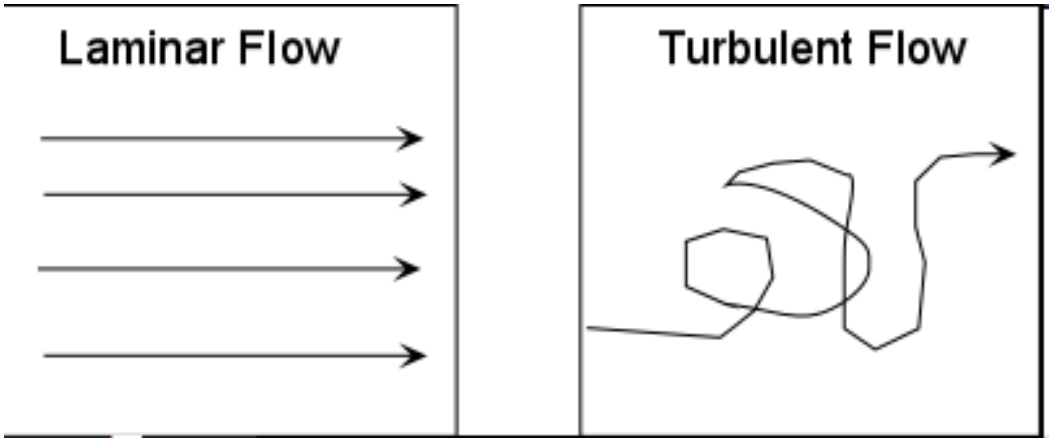
- Normally a stream flows in its **channel**. The floor of the channel is called the **bed**, and the sides of the channel are the **banks**.
- When rainfall is heavy or when snow melts rapidly, a **flood** may occur. During a flood, a stream overflows its banks and spreads over adjacent land called a **flood plain**.

Geometry and Dynamics of Stream Channels

- The stream channel is the conduit for water being carried by the stream.
- The stream can continually adjust its channel shape and path as the amount of water passing through the channel changes.
- The volume of water passing any point on a stream is called the ***discharge***. Discharge is measured in units of volume/time (ft^3/sec).

Velocity

- The average velocity is the time it takes a given particle of water to traverse a given distance.
- Stream flow can be either laminar, in which all water molecules travel along similar parallel paths, or turbulent, in which individual particles take irregular paths.
- Turbulent flow can keep sediment in suspension longer than laminar flow and aids in erosion of the stream bottom. Average linear velocity is generally greater in laminar flow than in turbulent flow.

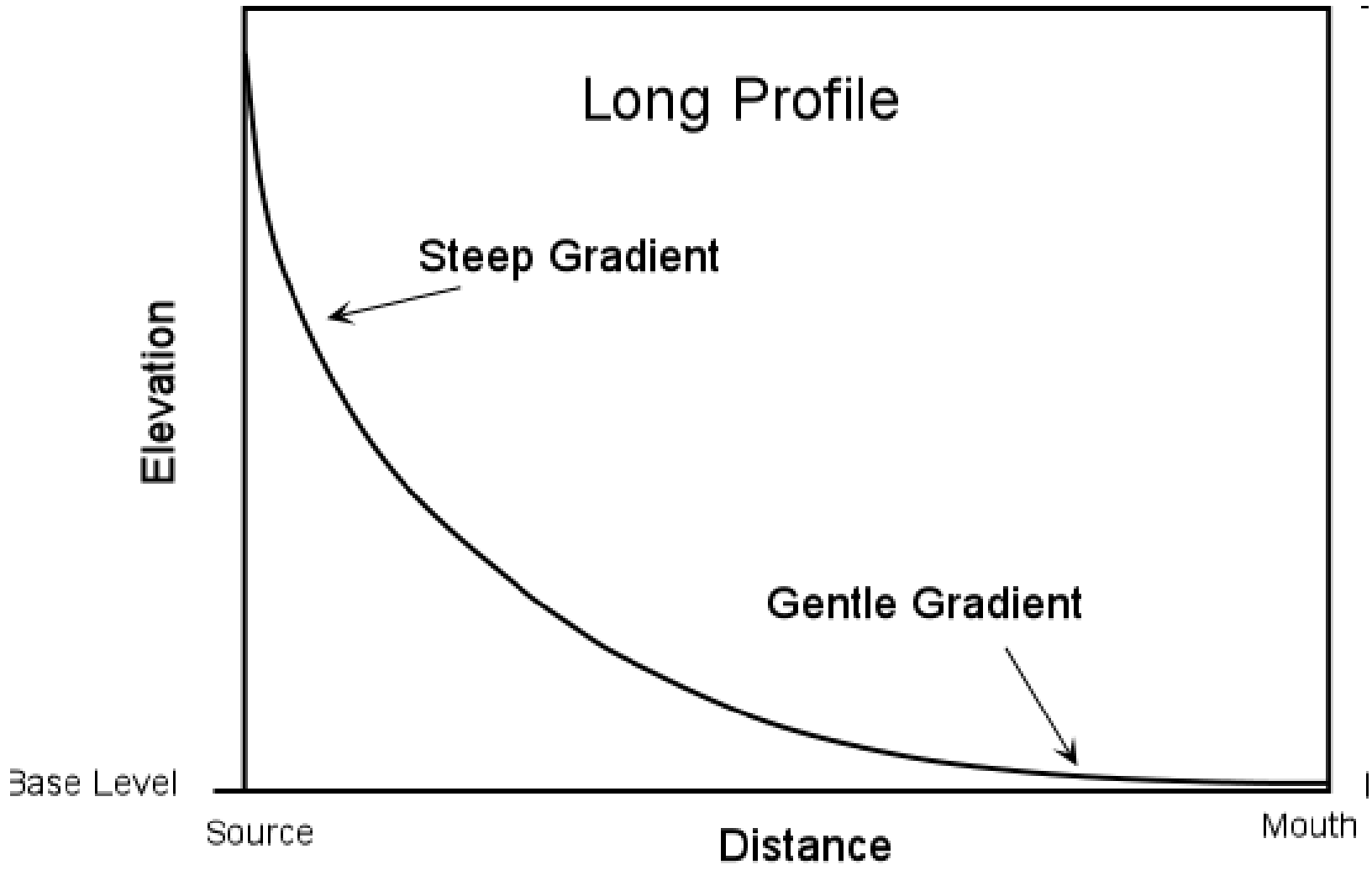


Velocity

- Three factors control current velocity:
- (1) the gradient of the stream;
- (2) the discharge;
- (3) the shape and roughness of the channel.

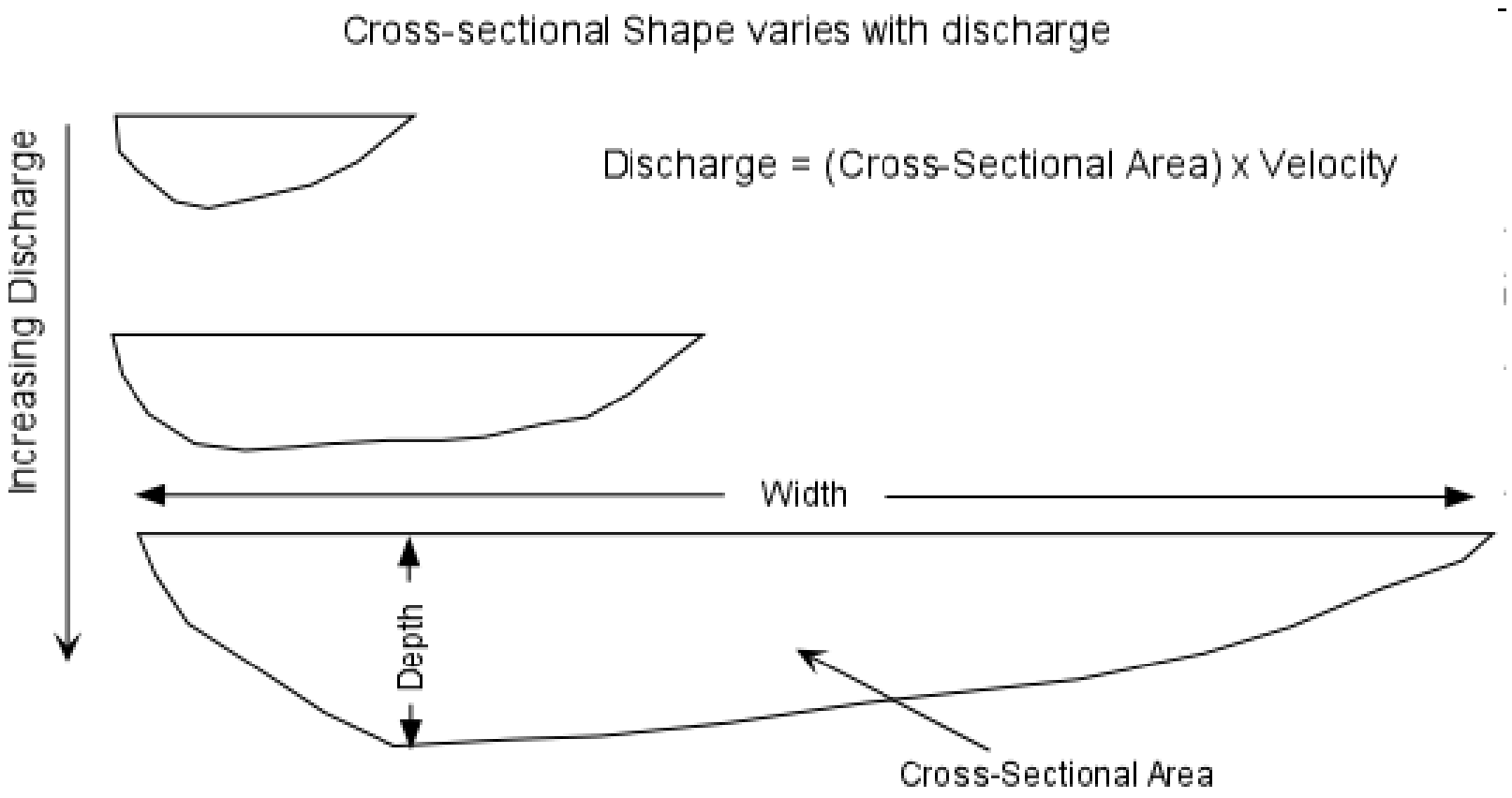
Long Profile

Gradient is the steepness of a stream.



Cross Sectional Shape

Discharge is the amount of water flowing down a stream. It is expressed as the volume of water flowing past a point per unit time, usually in cubic meters per second.

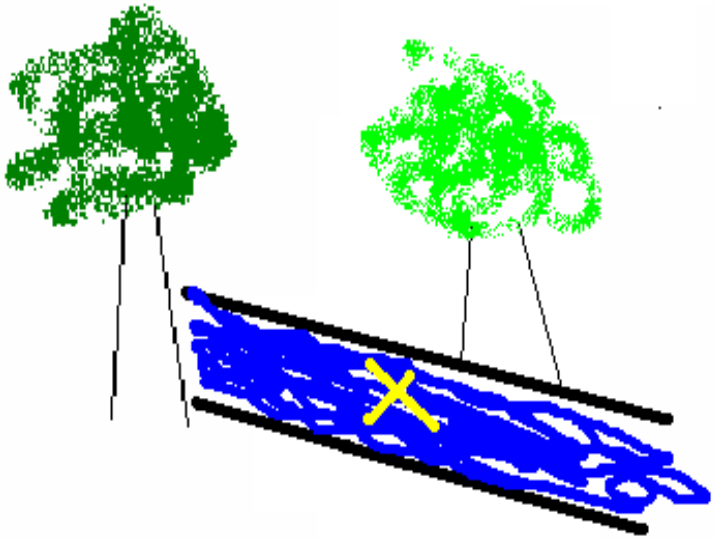


Channel Shape and Roughness

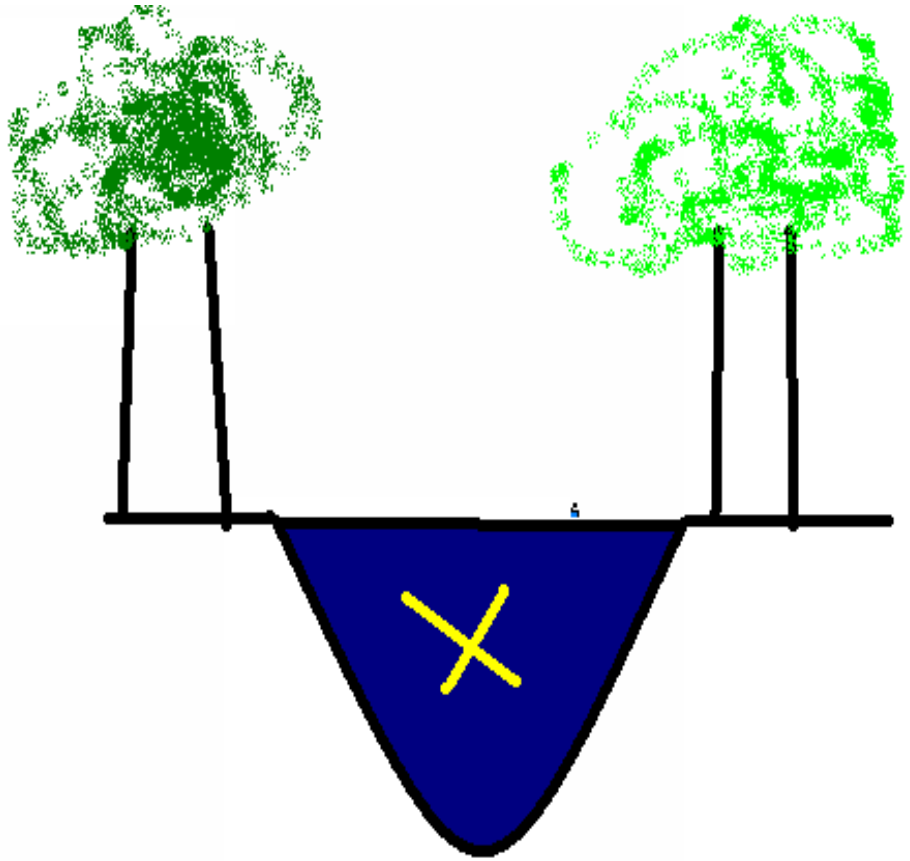
- Friction between flowing water and the stream channel slows current velocity.
- The total friction depends on both the shape of a stream channel and its roughness.
- If streams of equal cross-sectional area are compared, a stream with semicircular channel will flow more rapidly than one that is either wide and shallow or narrow and deep.
- A rough channel creates more friction than a smooth one.

WATER VELOCITY

- Streams flow fastest in the middle, just below the surface
- The surface is slower because air provides a little friction
- The bottom is slower because the ground provides friction
- The sides are slower because the edge/shore provides friction

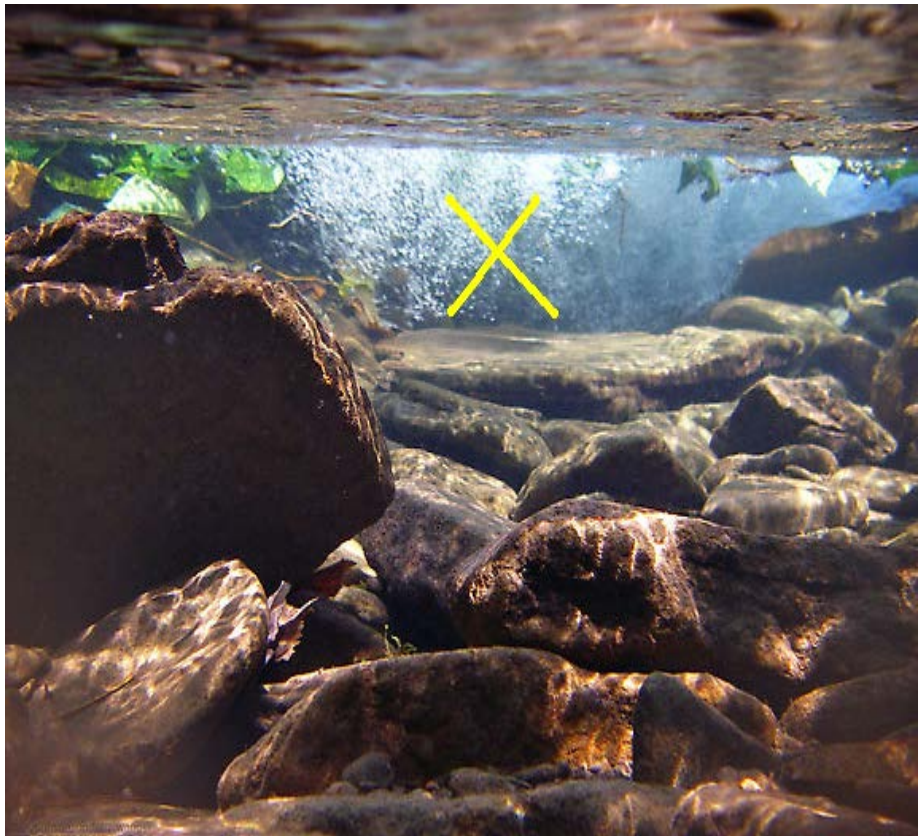


From Above



From Within

X is the area of fastest movement/highest velocity



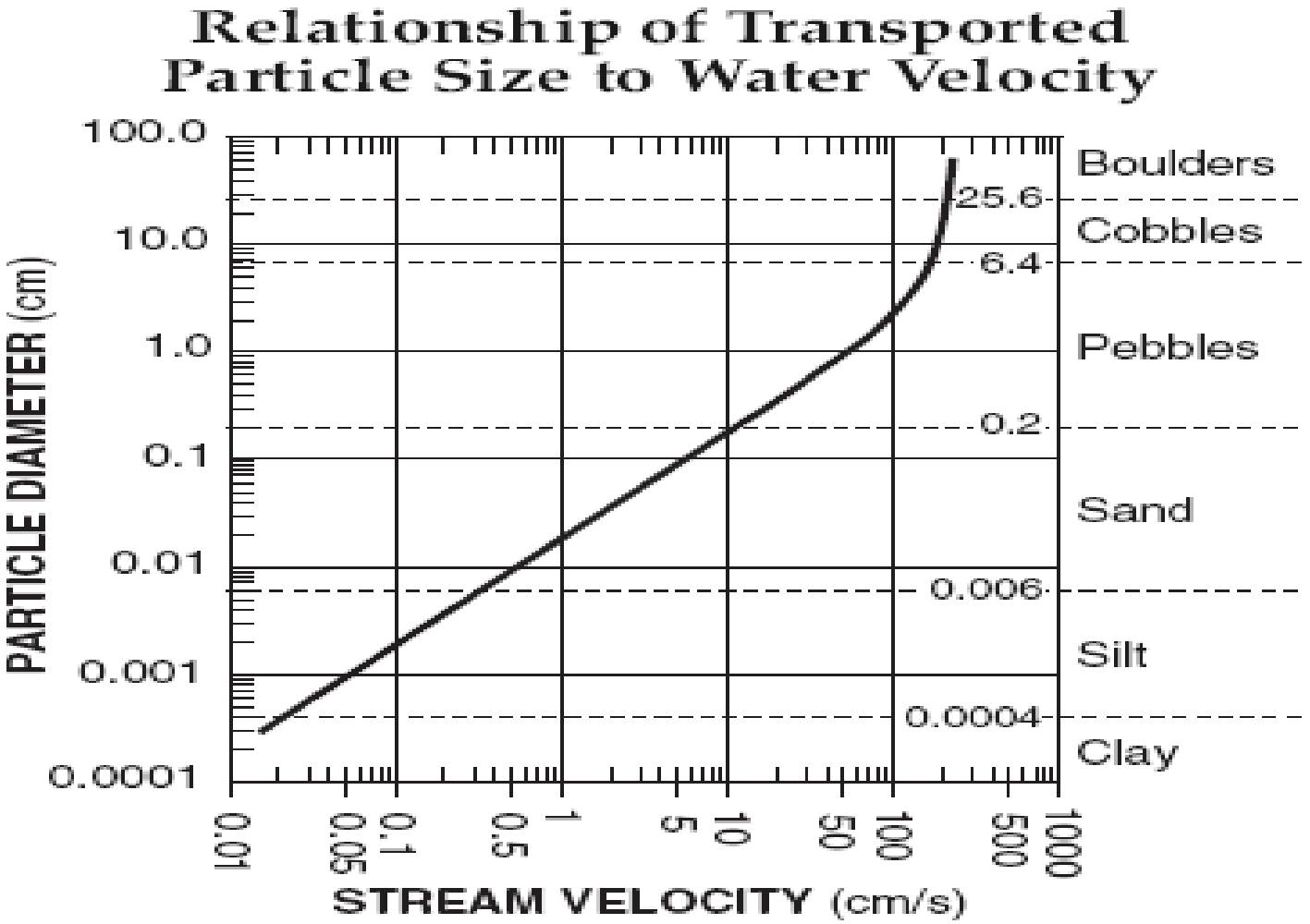
From Above *From Within*

X marks the area of highest velocity

Erosion by Streams

- Streams erode because they have the ability to pick up rock fragments and transport them to a new location.
- The ability of a stream to erode and carry sediment depends on its energy. The energy of a stream is proportional to both velocity and discharge.
- The size of the fragments that can be transported depends on the velocity of the stream and whether the flow is laminar or turbulent.
- Turbulent flow can keep fragments in suspension longer than laminar flow.

Erosion by Streams



This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

Erosion by Streams

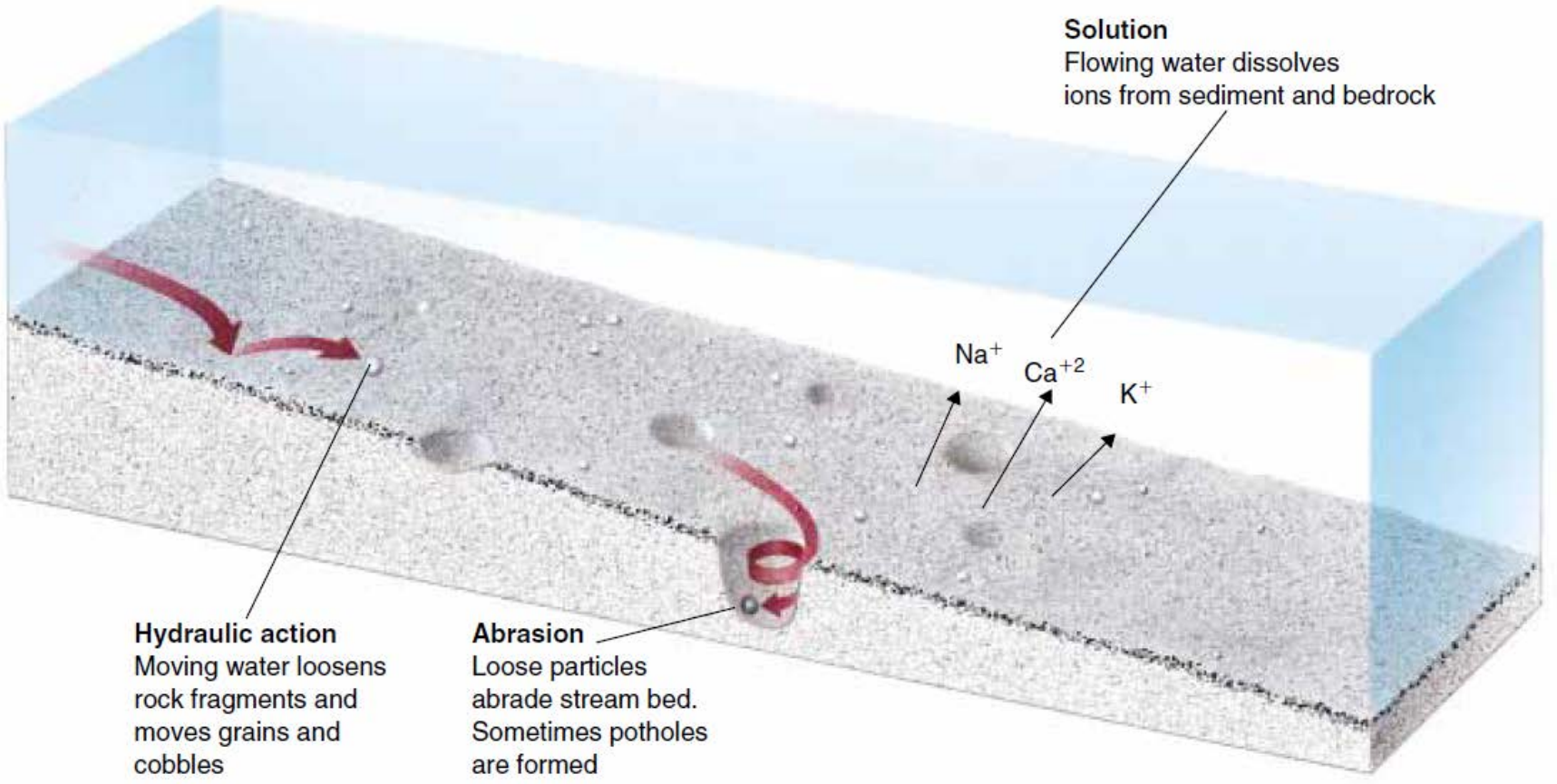
- Streams can also erode by undercutting their banks resulting in mass-wasting processes like slumps or slides. When the undercut material falls into the stream, the fragments can be transported away by the stream.
- Streams can cut deeper into their channels if the region is uplifted or if there is a local change in base level. As they cut deeper into their channels the stream removes the material that once made up the channel bottom and sides.

Erosion by Streams

A stream may erode sediment and bedrock from its channel.

A stream weathers and erodes its bed and banks by three processes: hydraulic action, abrasion, and solution

Erosion by Streams



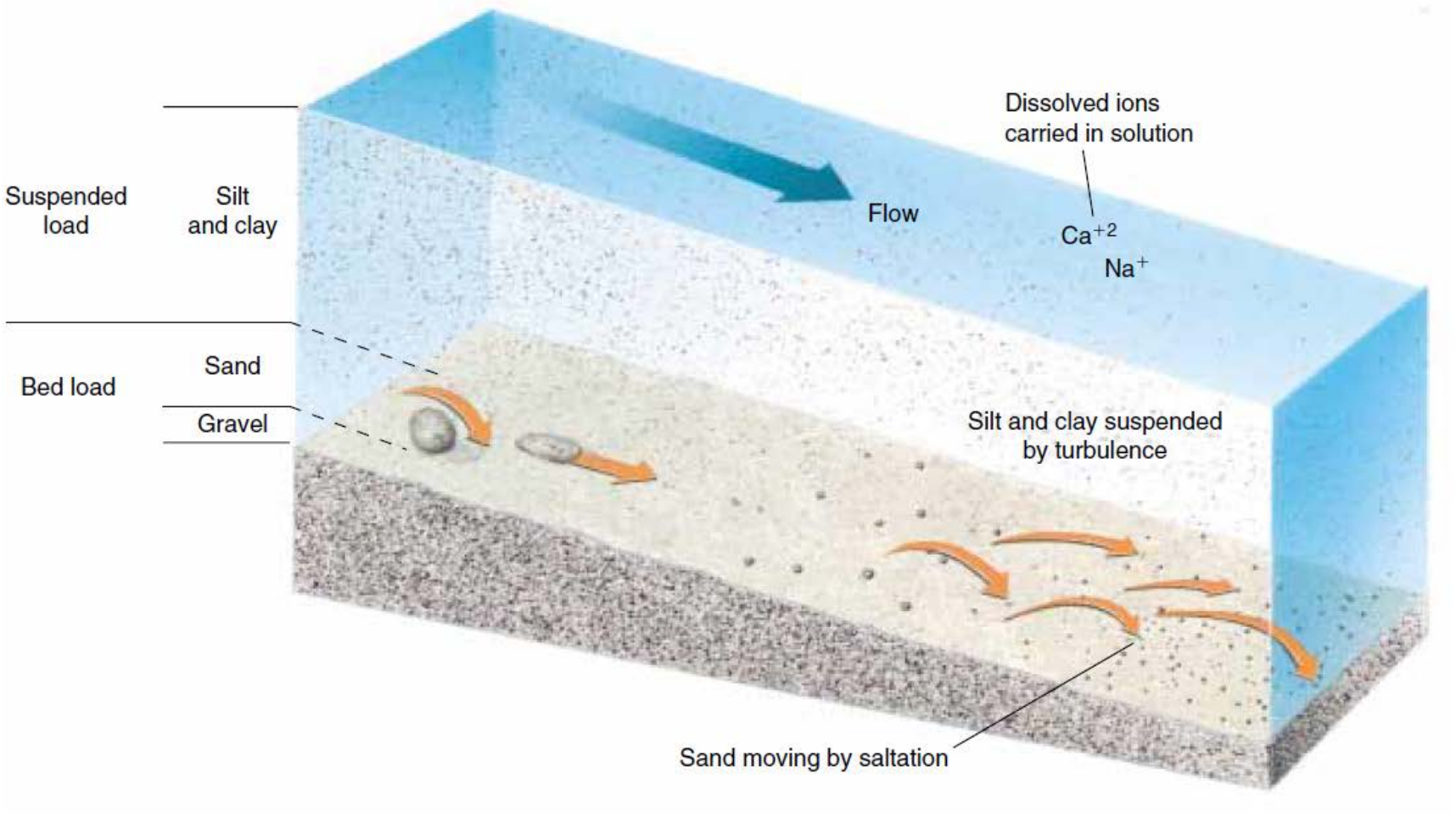
Sediment Transport

After a stream erodes soil or bedrock, it carries the sediment downstream in three forms:

- Dissolved load
- Suspended load
- Bed load

Load

- ***Suspended Load*** - particles that are carried along with the water in the main part of the streams. The size of these particles depends on their density and the velocity of the stream. Higher velocity currents in the stream can carry larger and denser particles.
- ***Bed Load*** - coarser and denser particles that remain on the bed of the stream most of the time but move by a process of saltation (jumping) as a result of collisions between particles, and turbulent eddies. Note that sediment can move between bed load and suspended load as the velocity of the stream changes.
- ***Dissolved Load*** - ions that have been introduced into the water by chemical weathering of rocks. This load is invisible because the ions are dissolved in the water. The dissolved load consists mainly of HCO3- (bicarbonate ions), Ca+2, SO4-2, Cl-, Na+2, Mg+2, and K+. These ions are eventually carried to the oceans and give the oceans their salty character. Streams that have a deep underground source generally have higher dissolved load than those whose source is on the Earth's surface.

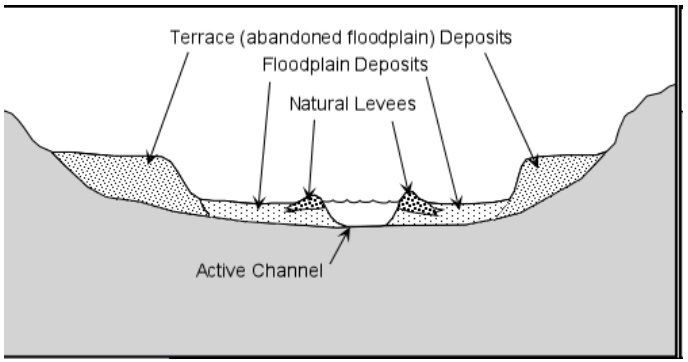

Suspended load
Silt and clay
Bed load
Sand
Gravel
Flow
Dissolved ions carried in solution
Ca^{+2}
Na^{+}
Silt and clay suspended by turbulence
Sand moving by saltation

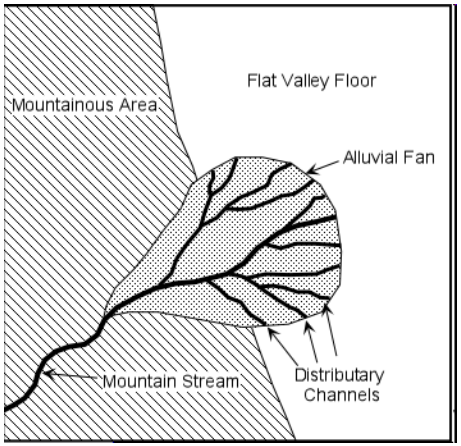
Stream Deposits

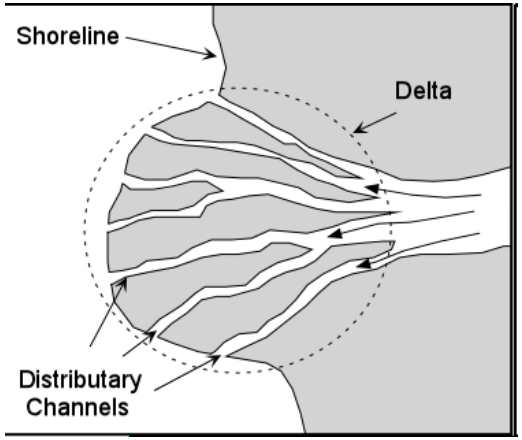
- A stream deposits its sediment in three environments:
- (1) **Channel deposits** form in the stream channel itself;
- (2) **Alluvial fans** and **deltas** form where stream gradient suddenly decreases as a stream enters a flat plain, a lake, or the sea;
- (3) **Flood plain** deposits accumulate on a flood plain adjacent to the stream channel.

Stream Deposits

- *Floodplains and Levees*
- *Terraces*
- *Alluvial Fans*
- *Deltas*



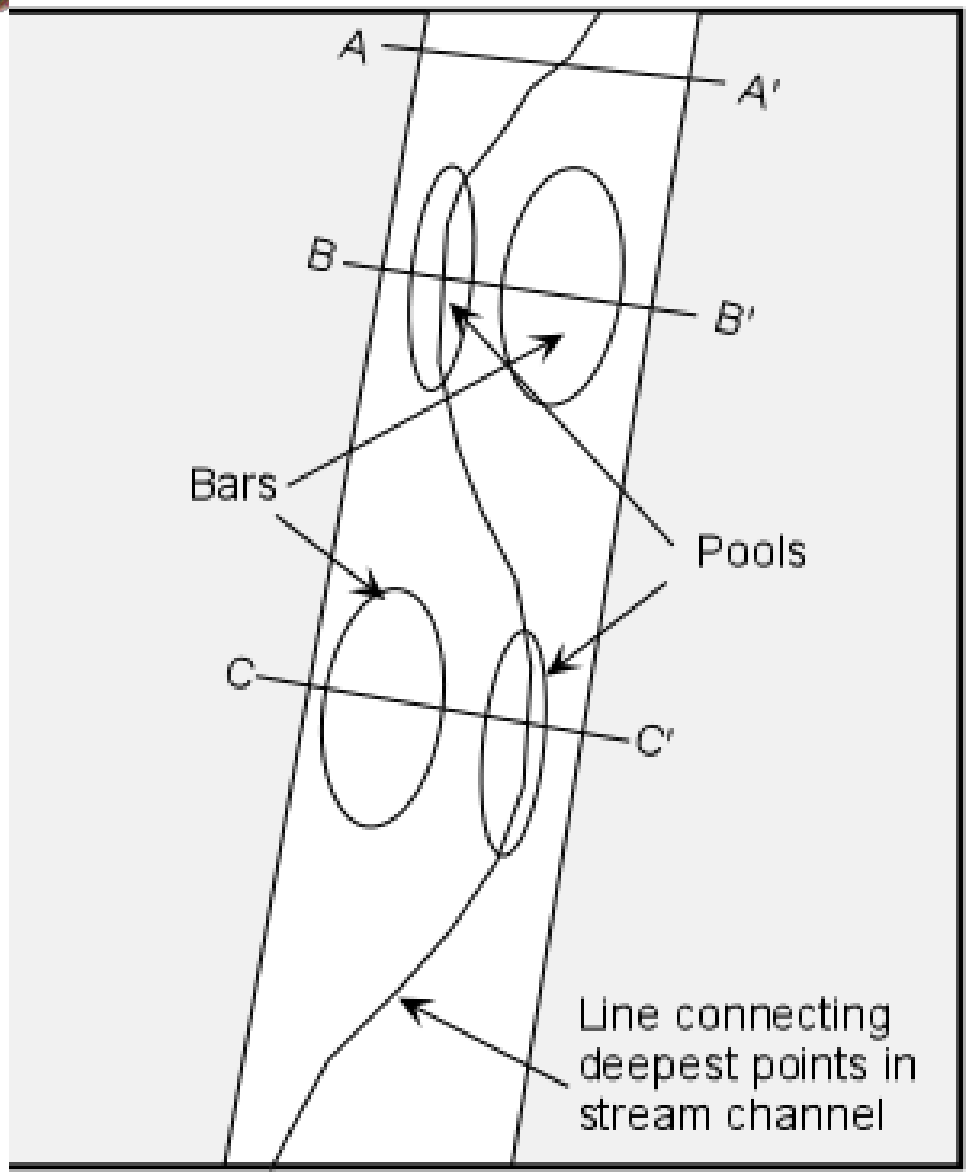


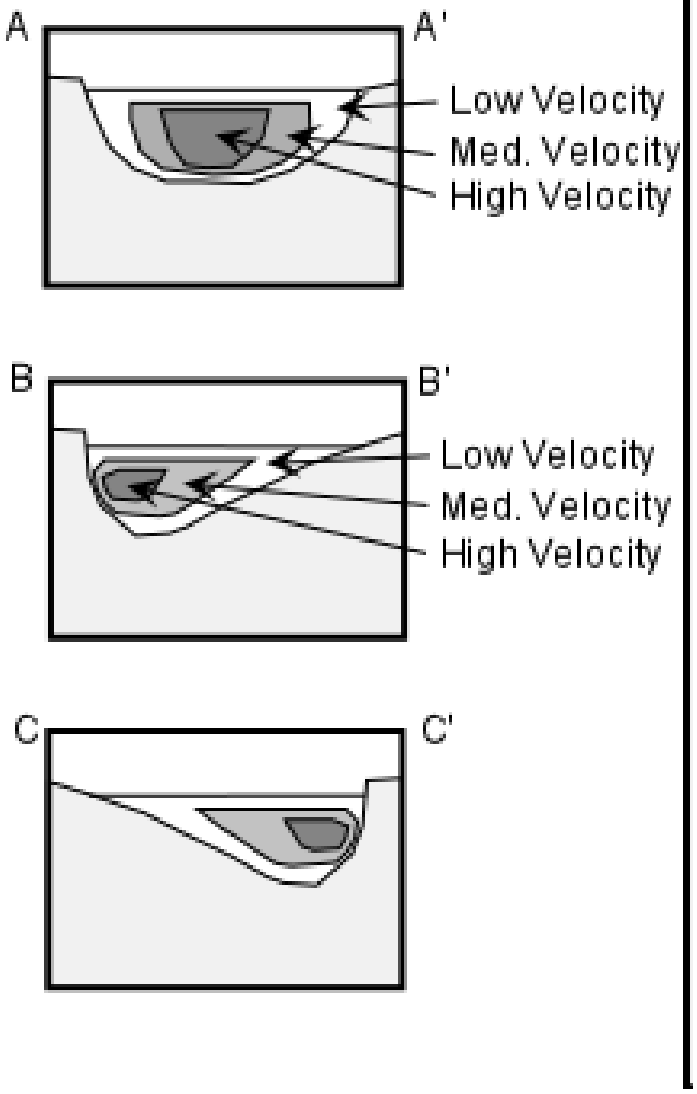


Channel Patterns

- **Straight Channels –**
- Straight stream channels are rare. Where they do occur, the channel is usually controlled by a linear zone of weakness in the underlying rock, like a fault or joint system.
- Even in straight channel segments water flows in a sinuous fashion, with the deepest part of the channel changing from near one bank to near the other.
- Velocity is highest in the zone overlying the deepest part of the stream. In these areas, sediment is transported readily resulting in ***pools***.
- Where the velocity of the stream is low, sediment is deposited to form ***bars***. The bank closest to the zone of highest velocity is usually eroded and results in a ***cutbank***.

Straight Channels





Stanislaus River

at 6,000 feet elevation near Dardanelle

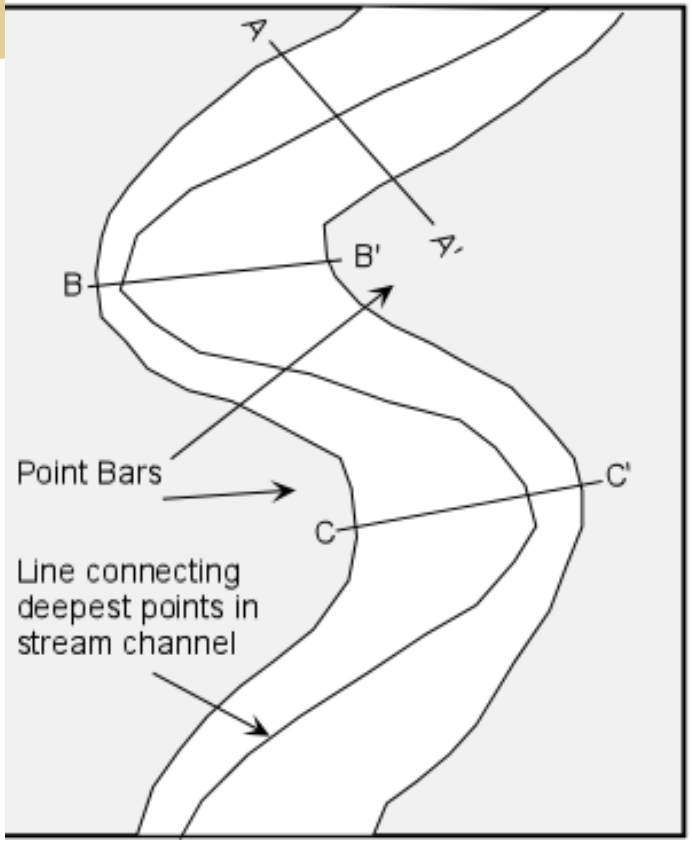
Meandering Channels

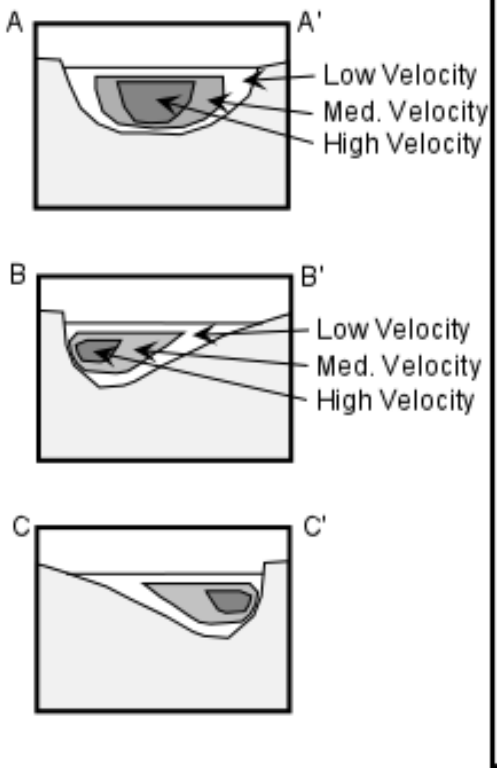
- **Meandering Channels -** Because of the velocity structure of a stream, and especially in streams flowing over low gradients with easily eroded banks, straight channels will eventually erode into ***meandering channels***.
- Erosion will take place on the outer parts of the meander bends where the velocity of the stream is highest.
- Sediment deposition will occur along the inner meander bends where the velocity is low. Such deposition of sediment results in exposed bars, called ***point bars***.

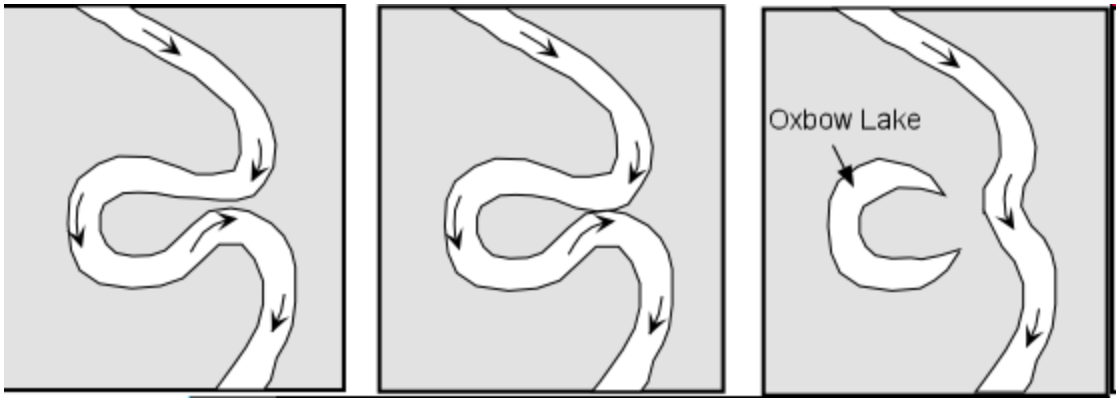
Meandering Channels

- Given enough time, the meandering stream erodes the narrow neck of land separating the two meanders and creates a new channel, abandoning the old meander loop.
- Because the current no longer flows through the entrance and exit of the abandoned meander, sediment accumulates at those points, isolating the old meander from the stream to form an **oxbow lake**.

Meandering Channels







Stanislaus River

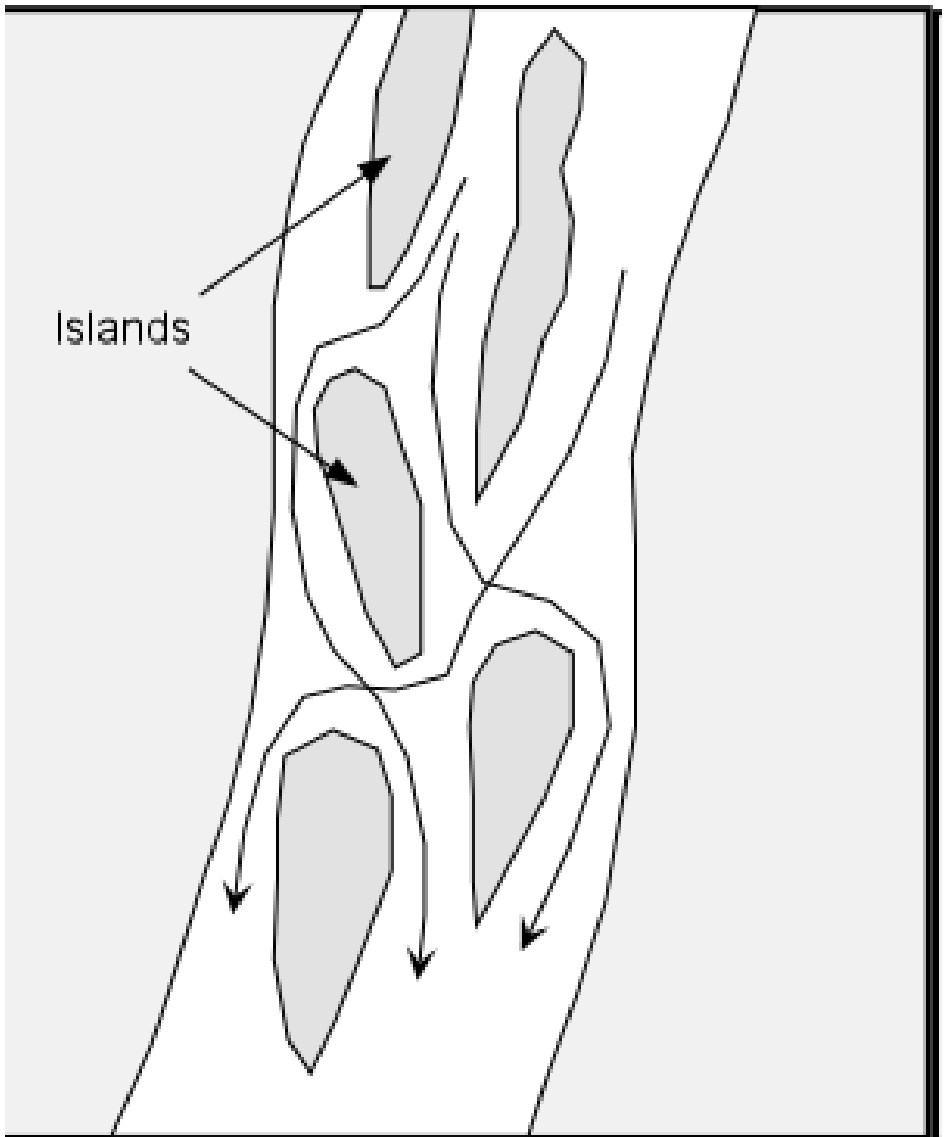
at 6,000 feet elevation near Kennedy Meadow

Braided Channels

- **Braided Channels** - In streams having highly variable discharge and easily eroded banks, sediment gets deposited to form bars and islands that are exposed during periods of low discharge.
- In such a stream the water flows in a braided pattern around the islands and bars, dividing and reuniting as it flows downstream. ---***braided channel***.
- During periods of high discharge, the entire stream channel may contain water and the islands are covered to become submerged bars. During such high discharge, some of the islands could erode, but the sediment would be re-deposited as the discharge decreases, forming new islands or submerged bars. Islands may become resistant to erosion if they become inhabited by vegetation.

Braided Channels

Braided Channel



Little Walker River

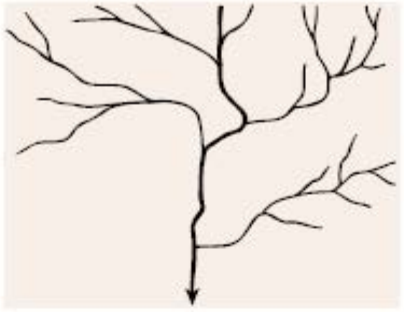
near Sonora Pass at 6,600 feet elevation

Drainage Systems

- **Drainage Basins and Divides -** Drainage systems develop in such a way as to efficiently move water off the land. Each stream in a drainage system drains a certain area, called a **drainage basin**.
- In a single drainage basin, all water falling in the basin drains into the same stream.
- Drainage basins can range in size from a few km^2, for small streams, to extremely large areas, such as the Mississippi River drainage basin which covers about 40% of the contiguous United States (see figure 14.29 in your text).
- A divide separates each drainage basin from other drainage basins.

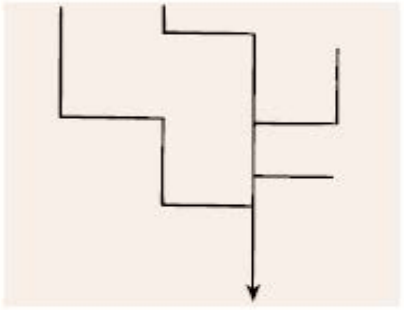
Map view

Perspective view



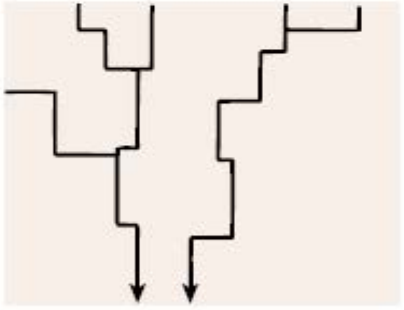
(a)

Dendritic drainage pattern. Bedrock is relatively uniform.



(b)

Trellis drainage pattern. Streams develop along faults, joints, or other parallel structures in the rock.



(c)

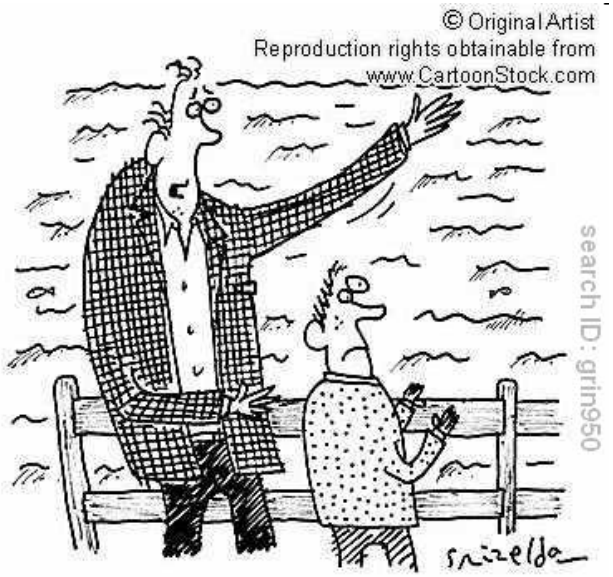
Rectangular drainage pattern. Streams follow joints that intersect at right angles.

(d)

Radial drainage pattern. Stream channels flow from mountain peak.

Floods

- Floods occur when the discharge of the stream becomes too high to be accommodated in the normal stream channel.
- When the discharge becomes too high, the stream widens its channel by overtopping its banks and flooding the low-lying areas surrounding the stream.
- The areas that become flooded are called ***floodplains***.



"One day son, all this will be houses."





Monday, July 14, 2008

Why More Men Die in Floods

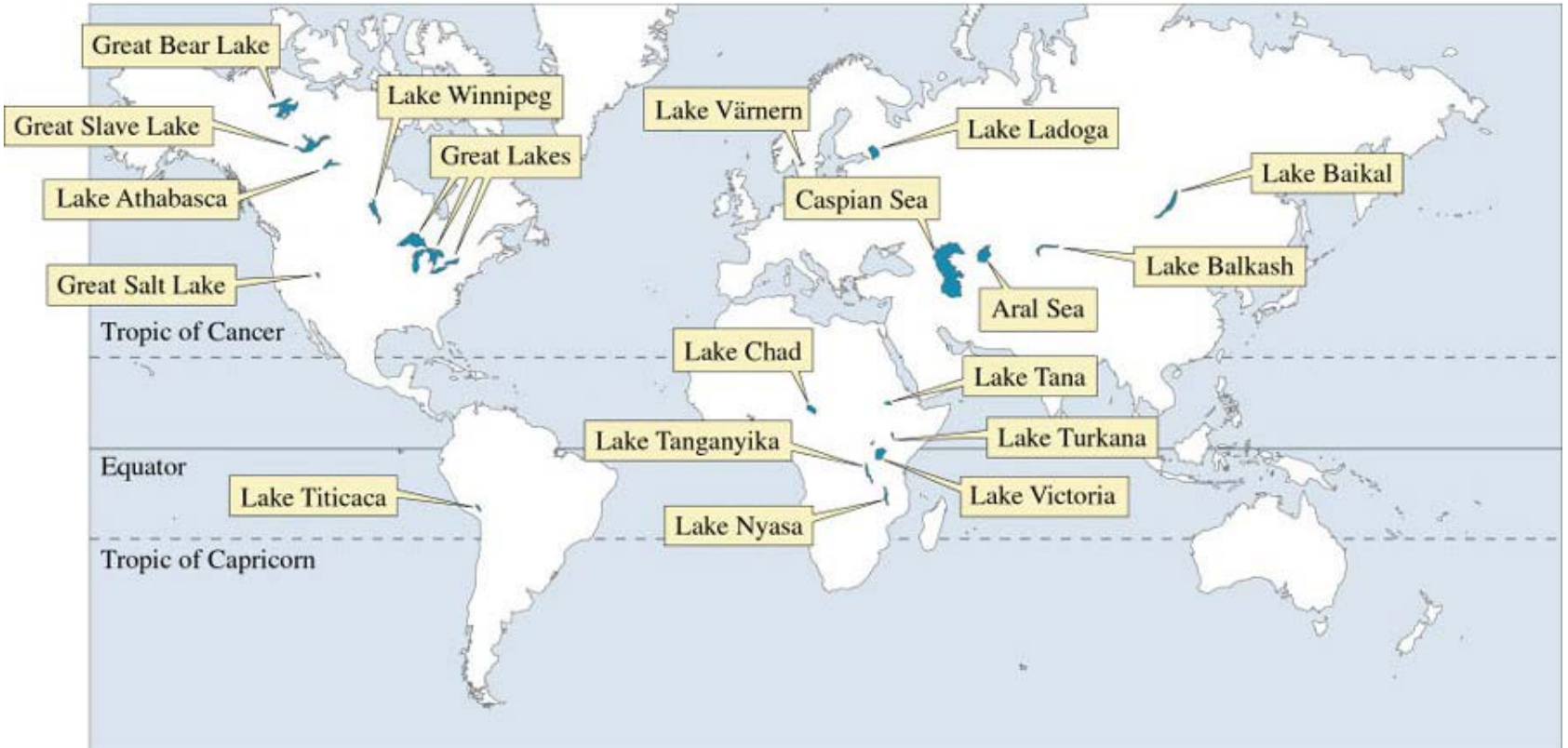
Why More Men Die in Floods

In the floods that have swamped the U.S. this month, at least 12 people have been killed. Nine of them were men: in Iowa, three men, ages 33, 35 and 50, died in the floods; three middle-aged men perished in Indiana; Wisconsin, West Virginia and Minnesota lost one man each.

The ratio, it turns out, is typical for storms. Men are more likely than women to die in floods, year after year, all over the country. A study of U.S. thunderstorm-related deaths from 1994 to 2000 found that men were more than twice as likely to die than women. Of the 1,442 fatalities, 70% were men, according to research by Thomas Songer at the University of Pittsburgh's Graduate School of Public Health. Most of the deaths happened outside the home during flash floods or lightning strikes. That is partly because men are more likely to be outside for their jobs. But men are also more likely to take risks of all kinds — which can be a fatally bad idea in ugly weather.

Lakes

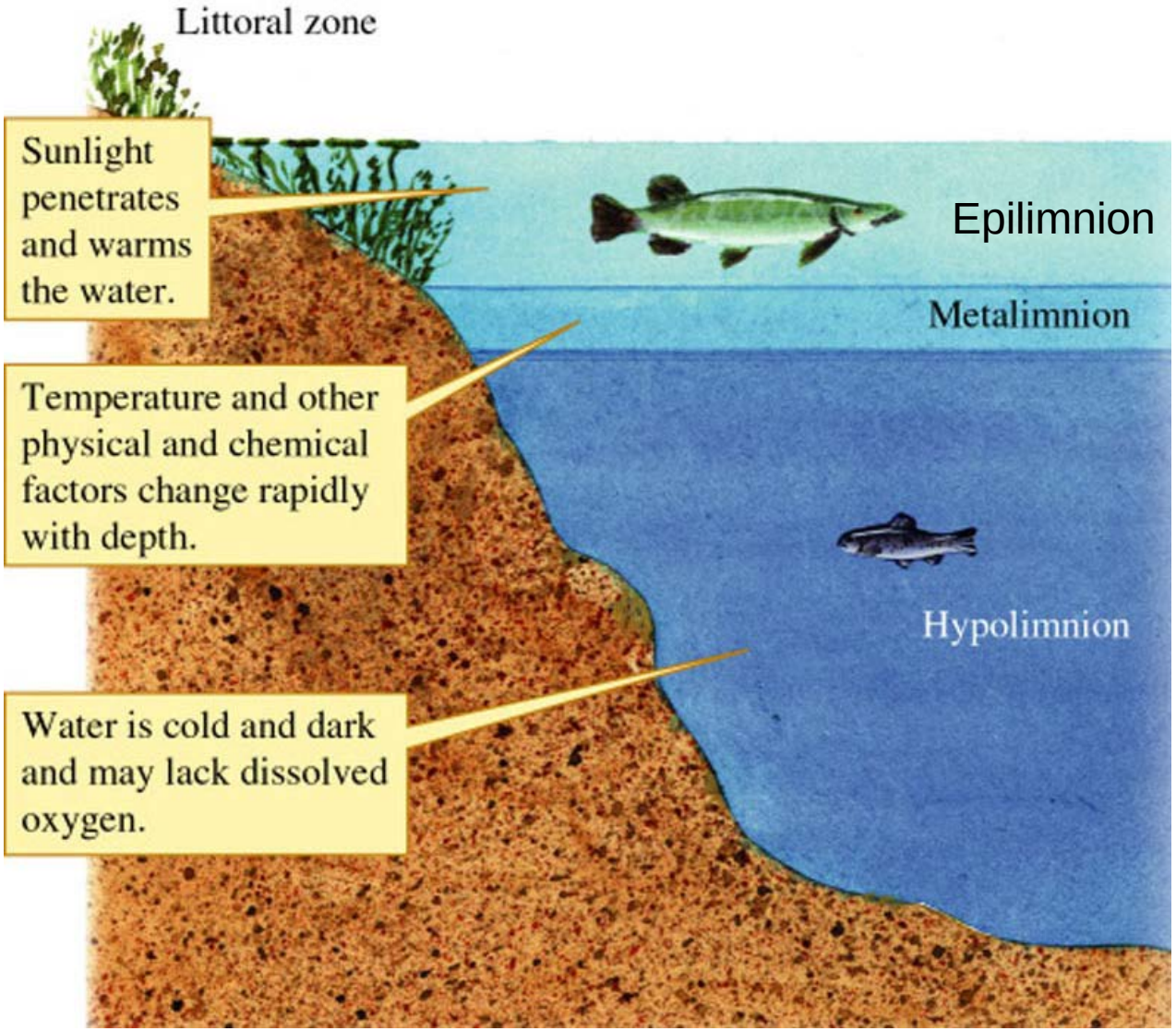
- Most of the world's freshwater resides in a few large lakes.
  - Great Lakes of North America contain 20% of freshwater in the world.

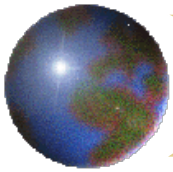


Lakes - Structure

- Structure
  - Littoral zone: Shallows
  - Limnetic zone: Open lake
    - Epilimnion: Warm surface layers.
    - Metalimnion: Temperature changes with depth.
    - Hypolimnion: Cold dark waters.

Lake Structure





Summary

- Streams carry water and sediment downslope
- Streams are important since they erode and deposit materials shaping the earth's surface and they are a source of water and transportation to humans
- Streams are part of the hydrologic cycle
- In general streams have a geometry based on the rock types they flow through and the amount of water they discharge
- Streams also flood, producing hazards and human activities and land uses should take into account hazards associated with flooding
- Many modern **lakes** were created by recent glaciers; as a result, we live in an unusual time of abundant lakes.