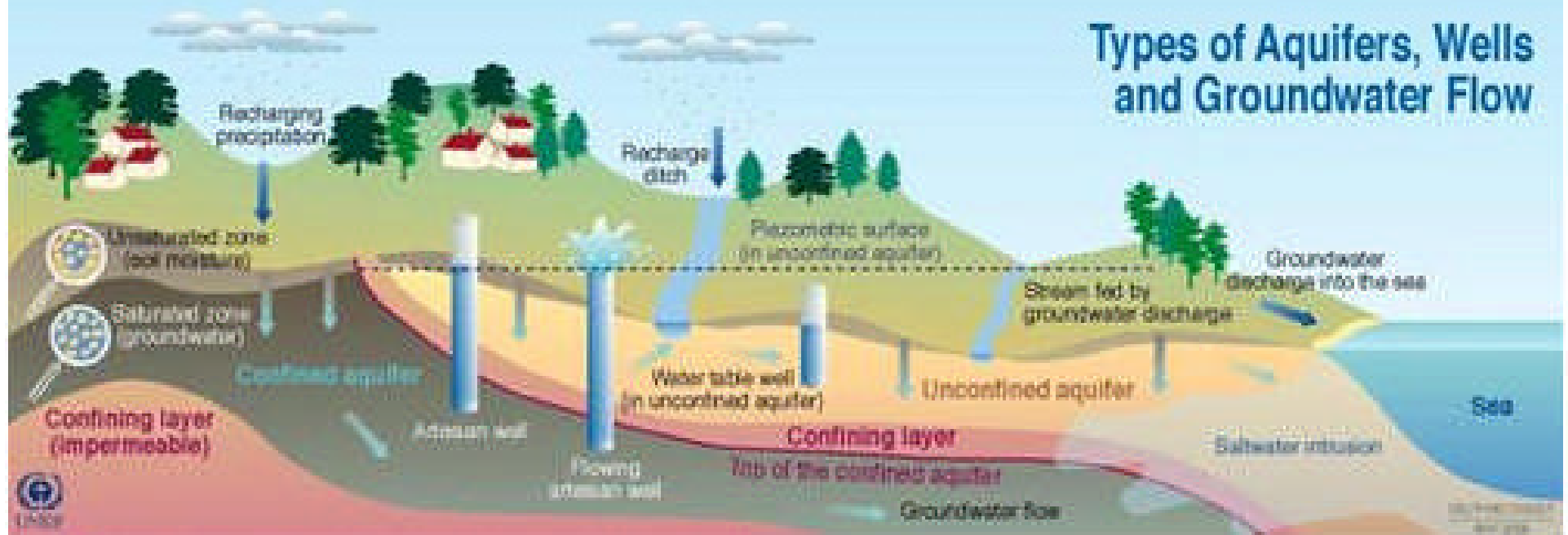


Chapter

# 6

# Running Water and Groundwater

Types of Aquifers, Wells and Groundwater Flow



# 6.1 Running Water

## The Water Cycle

- ◆ **Water constantly moves among the oceans, the atmosphere, the solid Earth, and the biosphere. This unending circulation of Earth's water supply is the water cycle.**

## **6.1 Running Water**

◆ **Processes involved in the cycle are:**

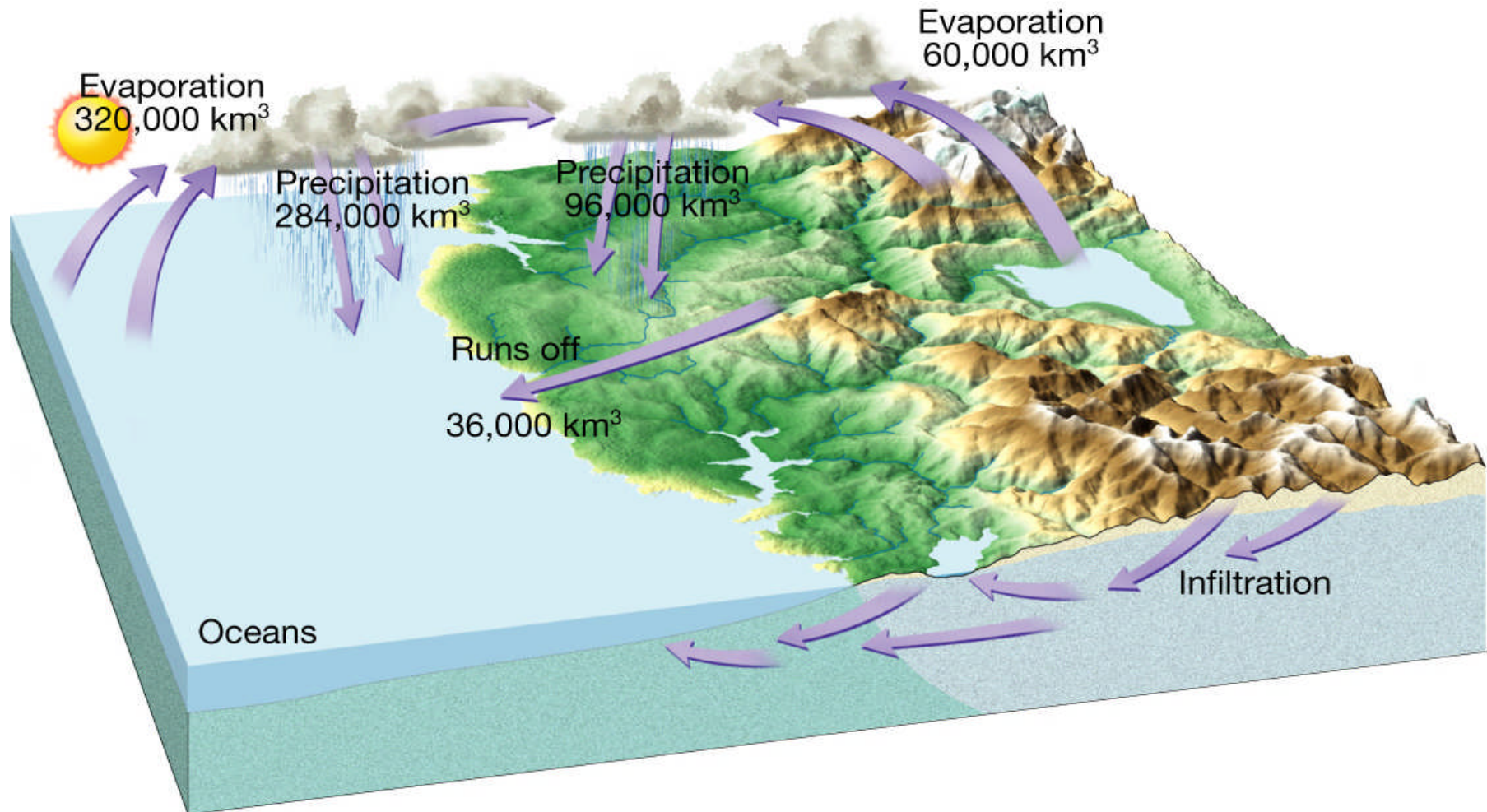
- **precipitation - coming down as rain, snow, hail etc.**
- **evaporation - going up into the air**
- **infiltration—the movement of surface water into rock or soil through cracks and pore spaces**

## **6.1** Running Water

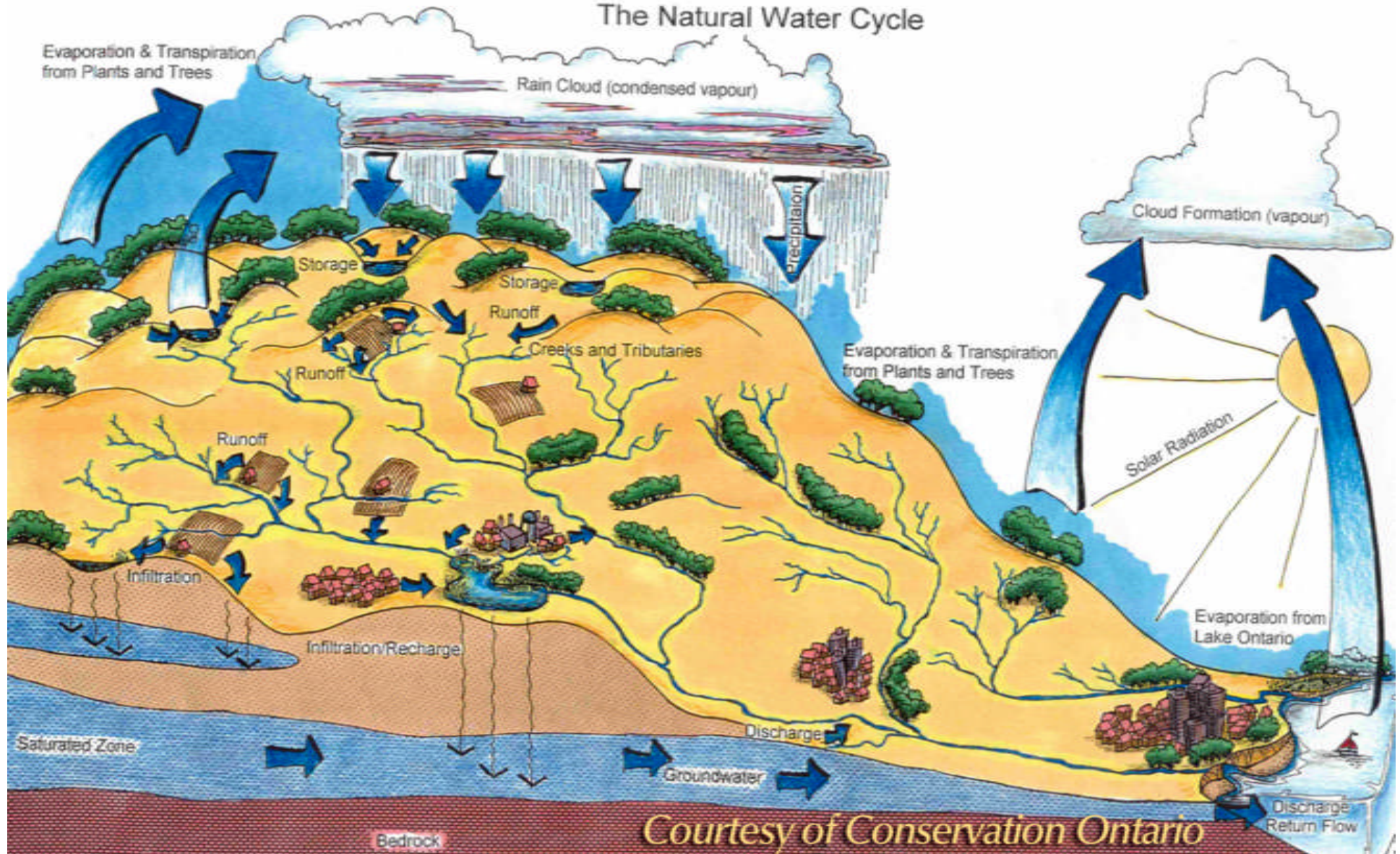
### **◆ Processes involved in the cycle cont.**

- runoff - return to streams, rivers, lakes and oceans**
- transpiration—the release of water into the atmosphere from plants through the ground**

# The Water Cycle



# The Natural Water Cycle



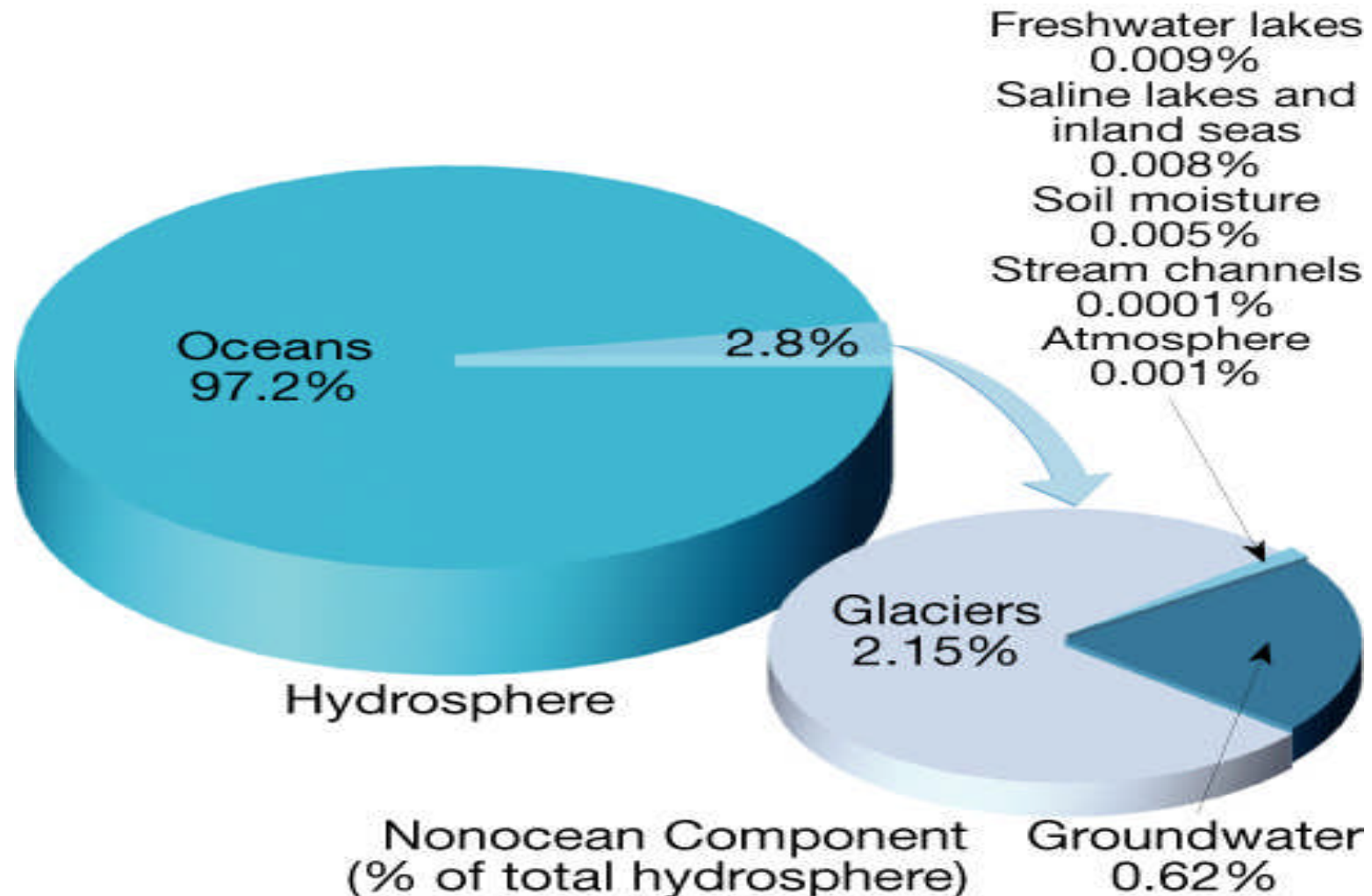
Courtesy of Conservation Ontario

# 6.1 Running Water

## Earth's Water Balance

- ◆ **Balance in the water cycle means the average annual precipitation over Earth equals the amount of water that evaporates.**

# Distribution of Earth's Water





## 6.1 Running Water

### Streamflow

- ◆ **The ability of a stream to erode and transport materials depends largely on its velocity.**
- **Gradient is the slope or steepness of a stream channel.**
  - **Expressed as the vertical drop of a stream over a certain distance.**

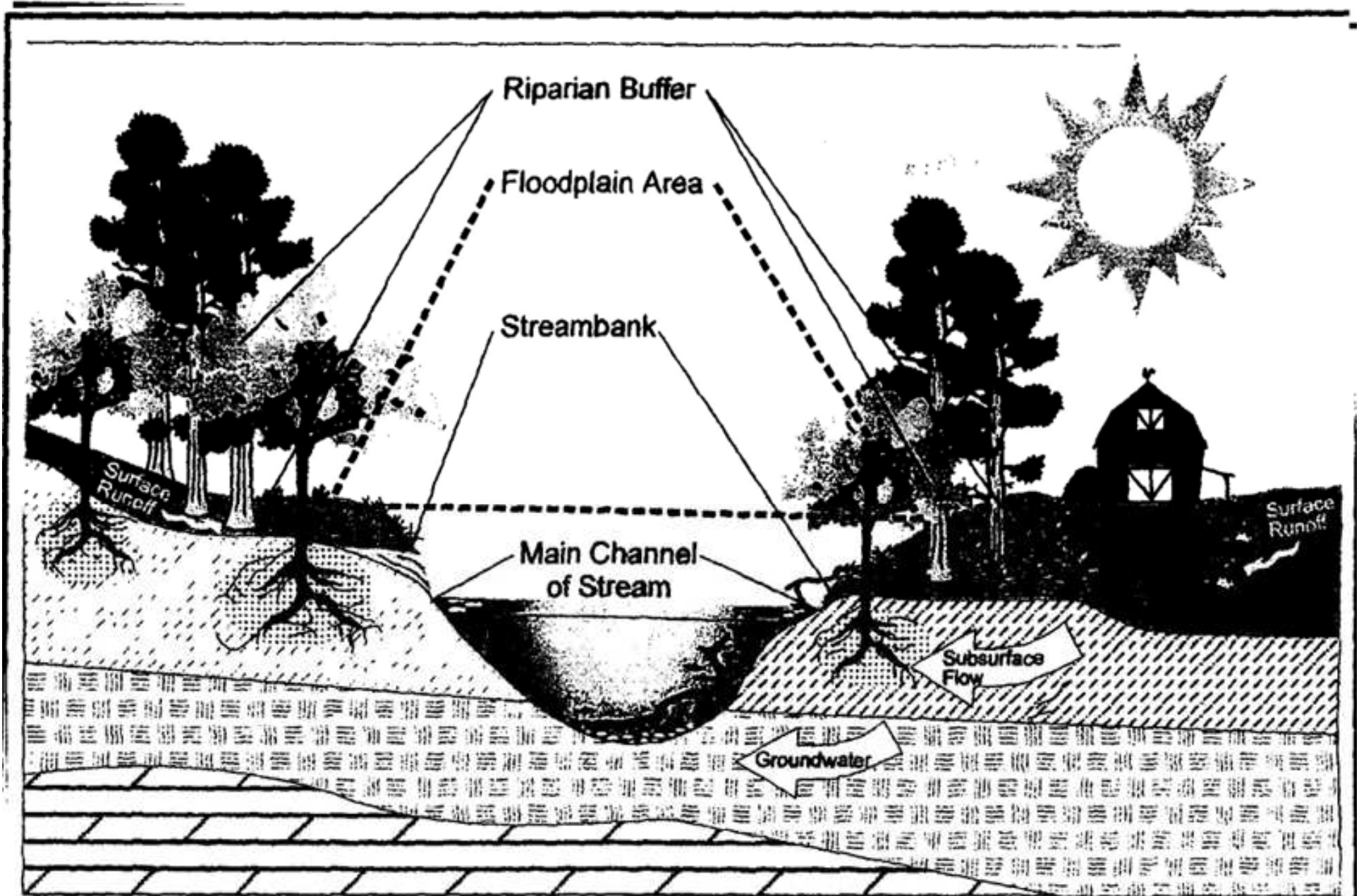
## **6.1 Running Water**

- **Channel Characteristics**
  - **The stream channel is the course the water in a stream follows.**
  - **Shape, size, and roughness of the channel affect the amount of friction.**
- **Discharge of a stream is the volume of water flowing past a certain point in a given unit of time.**
  - **Usually measured in cubic meters per second.**

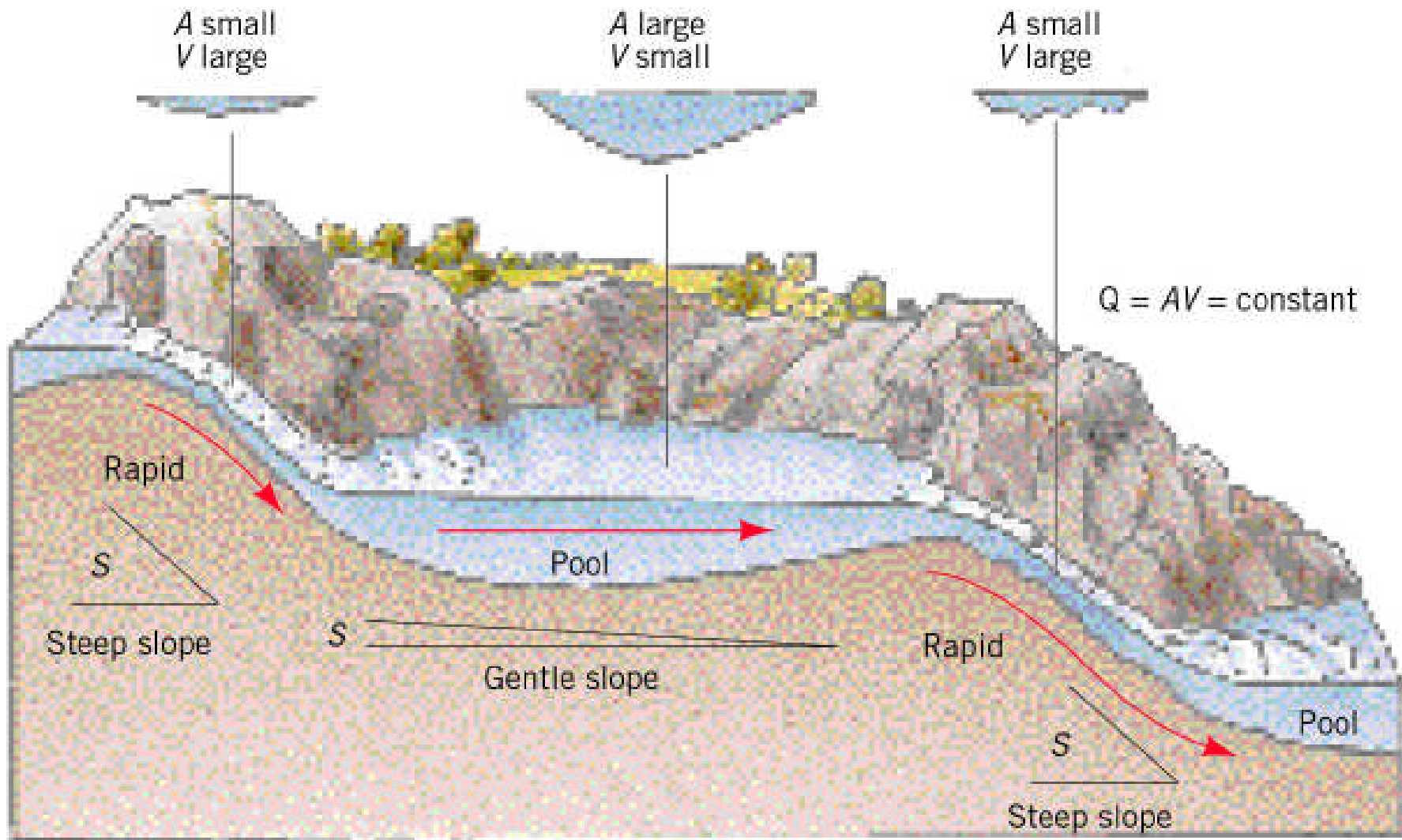
# 6.1 Running Water

## Changes from Upstream to Downstream

- ◆ While gradient decreases between a stream's headwaters and mouth, discharge increases.
- ◆ Profile
  - Cross-sectional view of a stream
  - From head (source) to mouth
  - Profile is a smooth curve
  - Gradient decreases from the head to the mouth

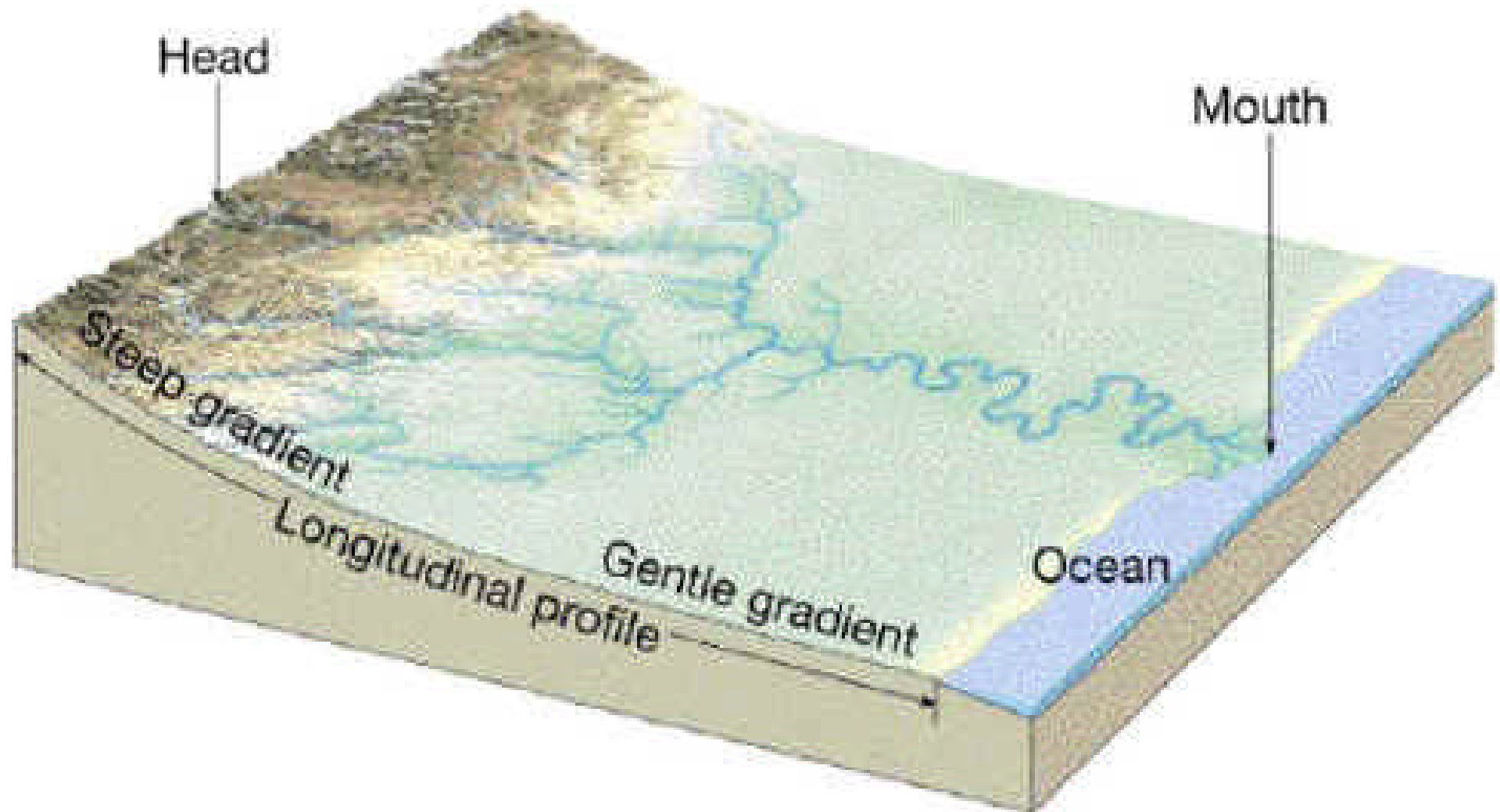


**Figure 6, A Cross Section of A Stream**



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# Sea Level and Streams



# 6.1 Running Water

Changes from Upstream to Downstream

## ◆ Profile

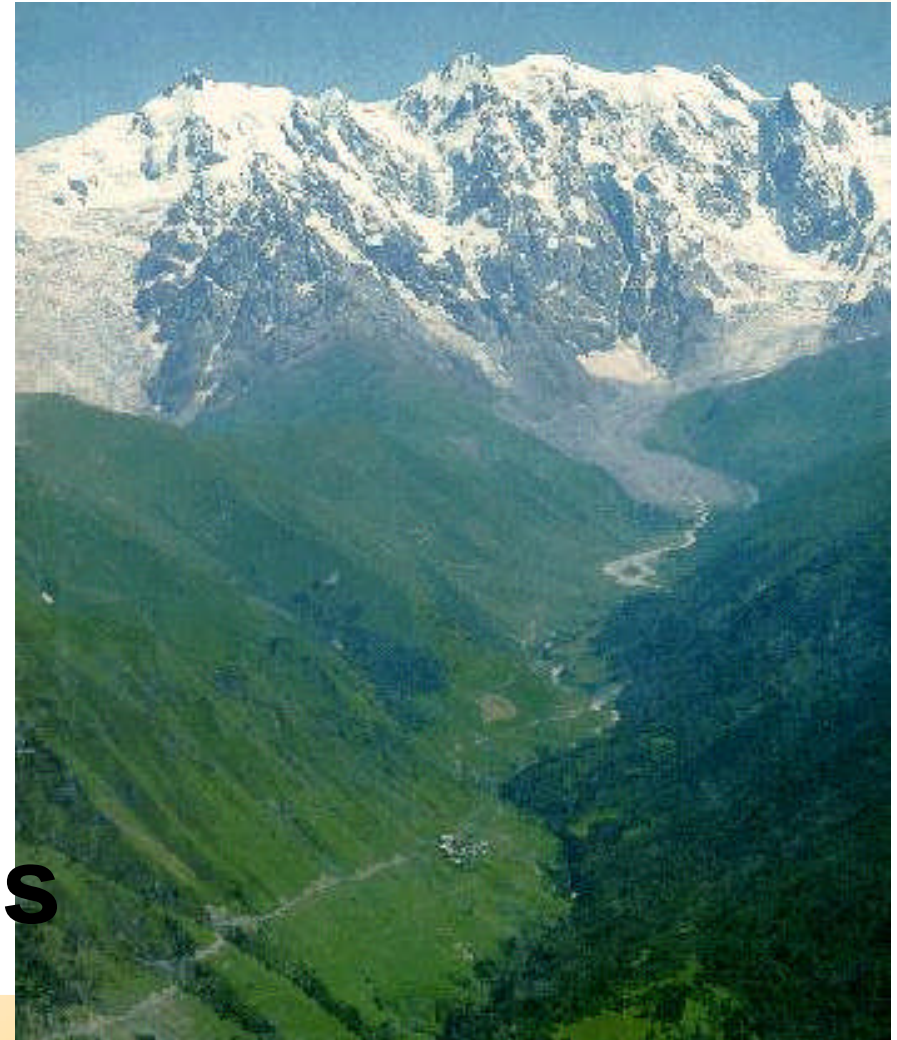
- **A tributary is a stream that empties into another stream.**
- **Factors that increase downstream**
  - **velocity**
  - **discharge**
  - **channel size**

# 6.1 Running Water

## Changes from Upstream to Downstream

### ◆ Profile

- **Factors that decrease downstream include**
  - **gradient, or slope**
  - **channel roughness**





## 6.1 Running Water

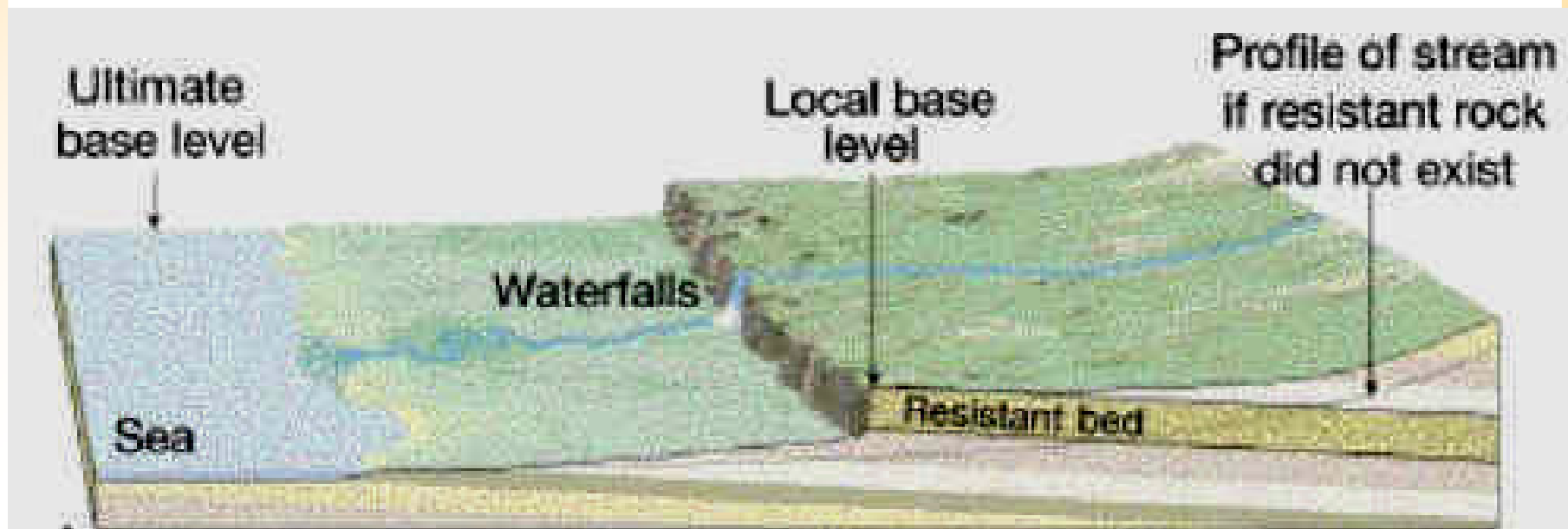
### ◆ Base Level

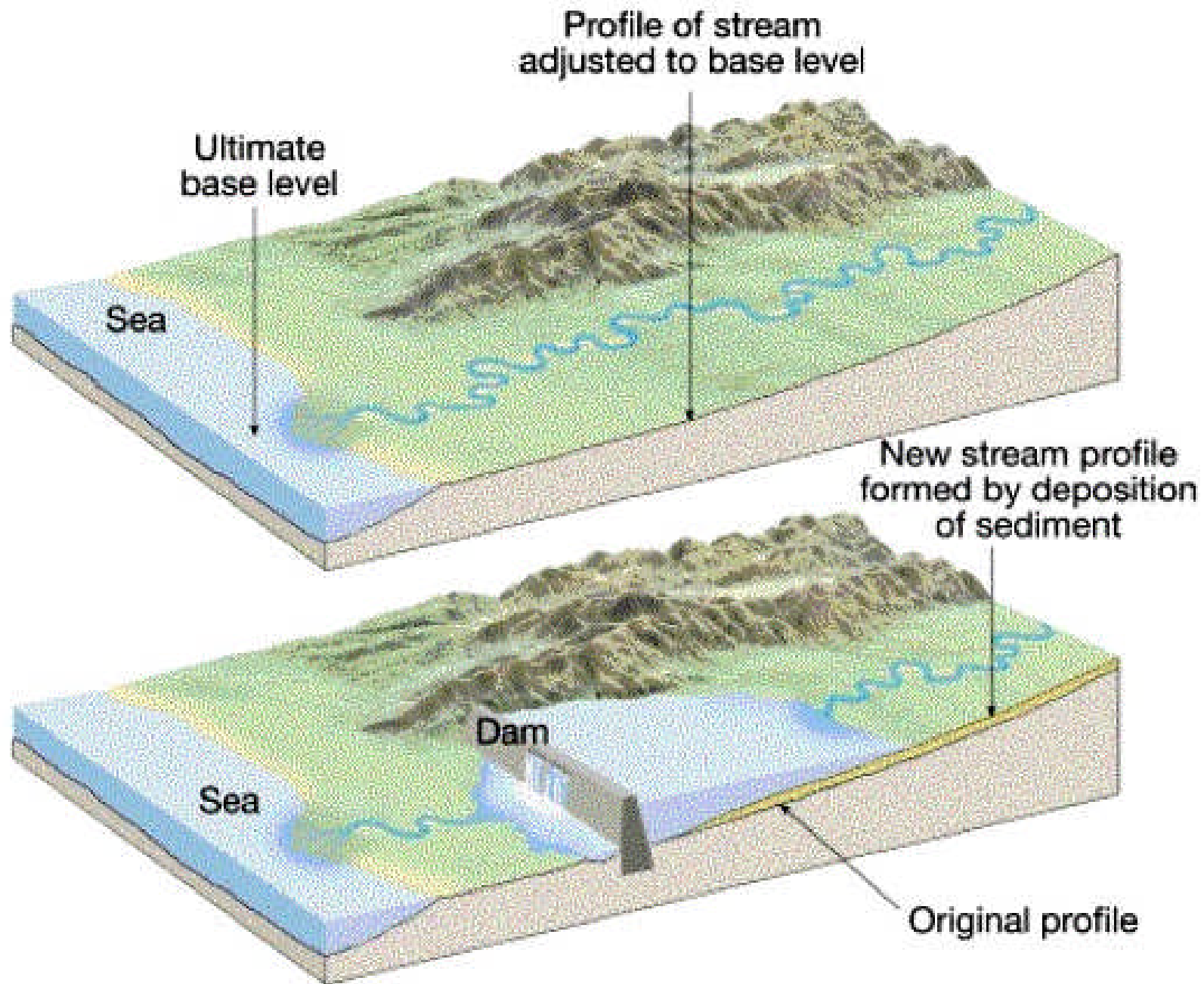
- **Lowest point to which a stream can erode**
  - **Two general types**
    - **ultimate—sea level**
    - **temporary, or local (lakes, resistant layers of rock, and main streams.**

# 6.1 Running Water

## ◆ Base Level

- A stream in a broad, flat-bottomed valley that is near its base level often develops a course with many bends called meanders.





## Aggradation to raise profile

# Rivers with Many Meanders



## Earth's Longest Rivers

NAME	LENGTH(miles)	SOURCE	MOUTH
Nile	4,160	Burundi and Ethiopia	Mediterranean Sea
Amazon	4,000	Peru	Atlantic Ocean
Yangtze	3,964	China	East China Sea
Mississippi-Missouri	3,710	Red Rock, Montana (USA)	Gulf of Mexico
Yenisey-Angara	2,543	Russia	Arctic Ocean

## 6.2 The Work of Streams

### Erosion

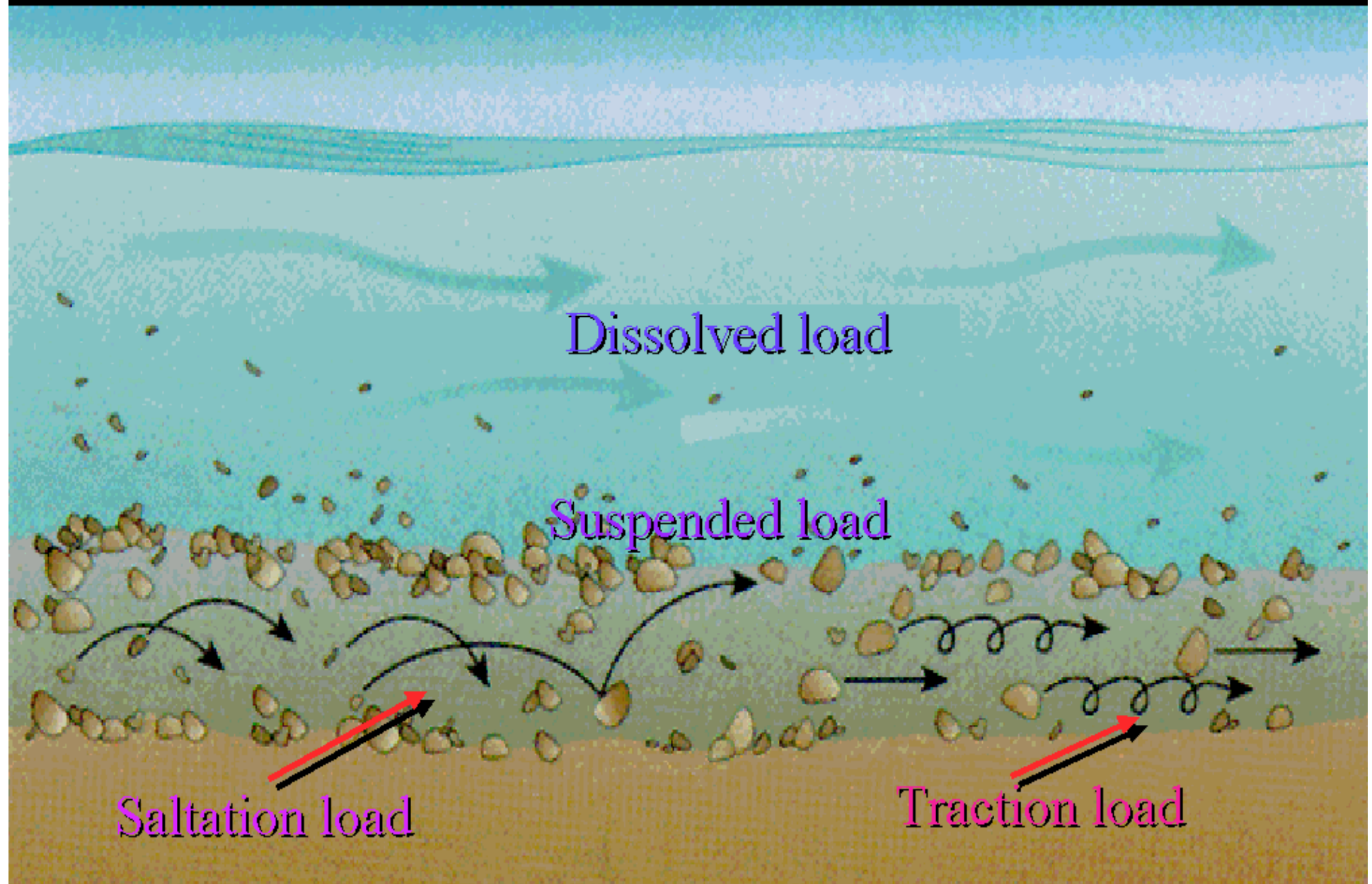
- ◆ **Streams generally erode their channels, lifting loose particles by abrasion, grinding, and by dissolving soluble material.**

## 6.2 The Work of Streams

### Sediment Transport

- ◆ **Stream transport sediment in three ways:**
  - **in solution (dissolved load)**
  - **in suspension (suspended load)**
  - **scooting or rolling along the bottom (bed load)**

# Transport of stream load





## 6.2 The Work of Streams

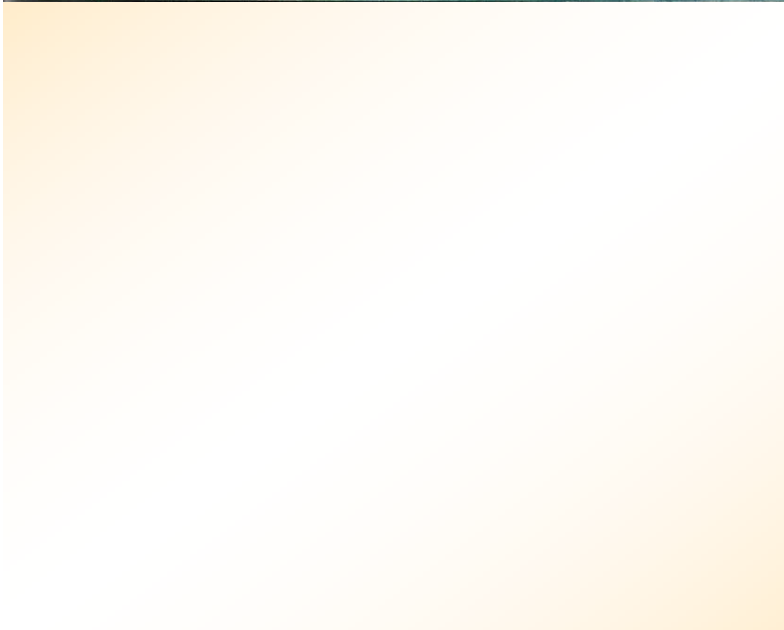
### Deposition

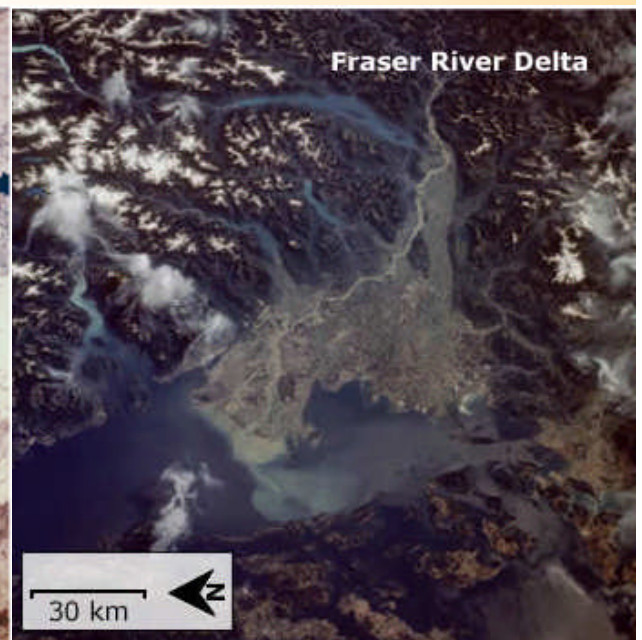
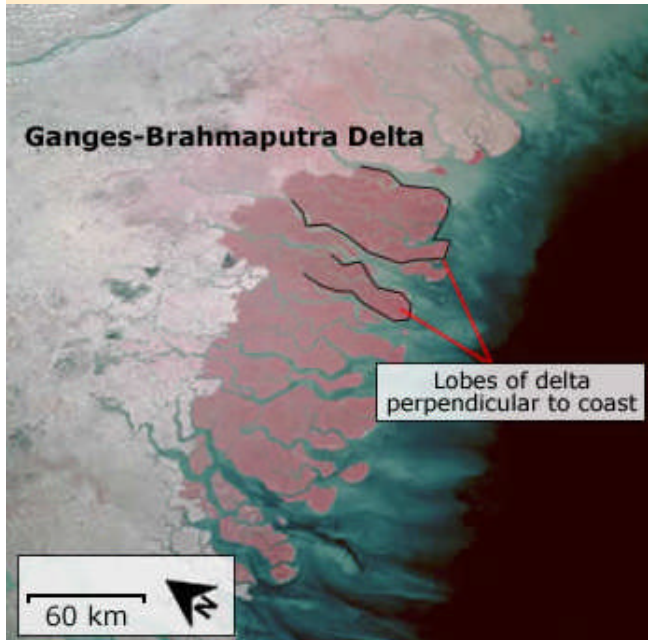
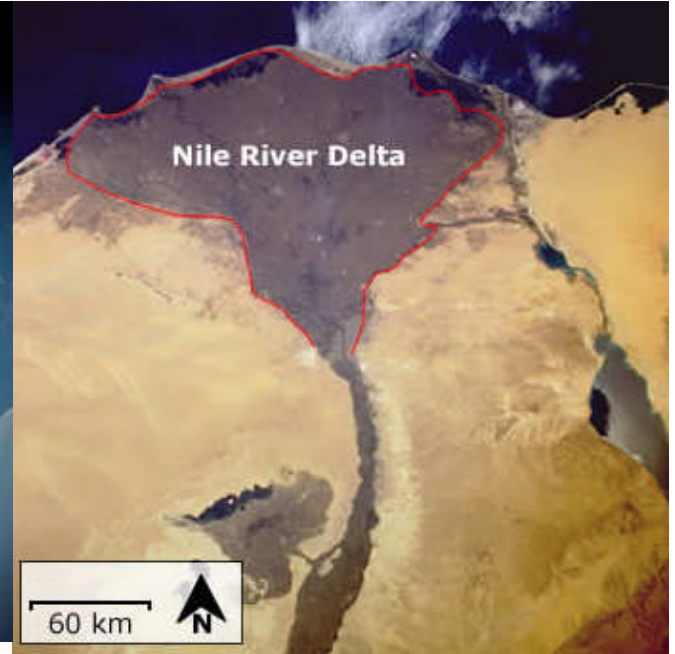
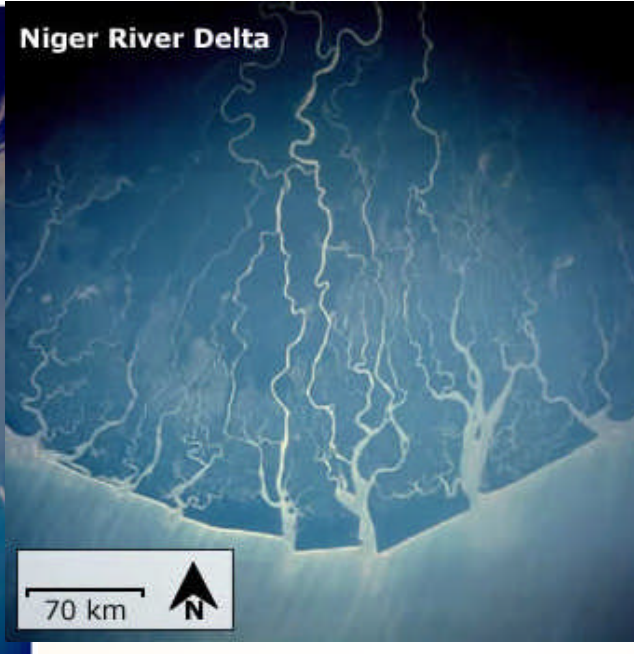
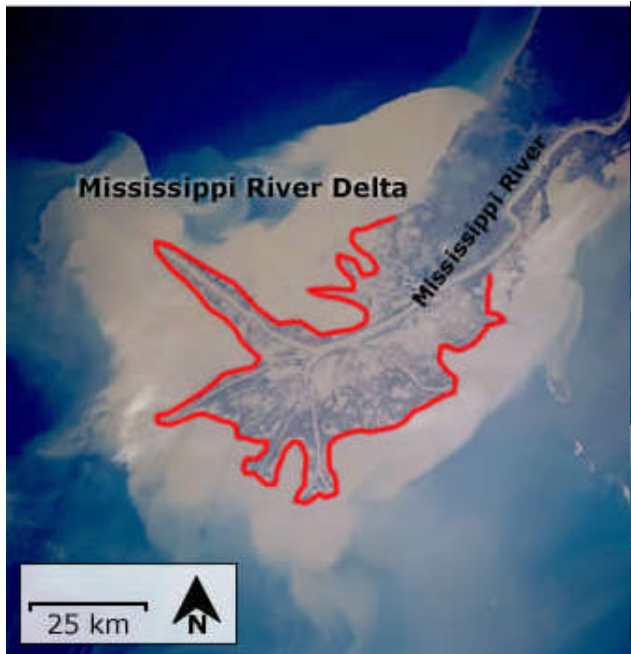
- ◆ **A stream's bed load is solid material too large to carry in suspension.**
- ◆ **The capacity of a stream is the maximum load it can carry.**
- ◆ **Deposition occurs as streamflow drops below the critical settling velocity of a certain particle size. The deposits are called alluvium.**

## 6.2 The Work of Streams

### Deposition

- ◆ **Deltas are an accumulation of sediment formed where a stream enters a lake or ocean.**
- ◆ **A natural levee parallels a stream and helps to contain its waters, except during floodstage.**



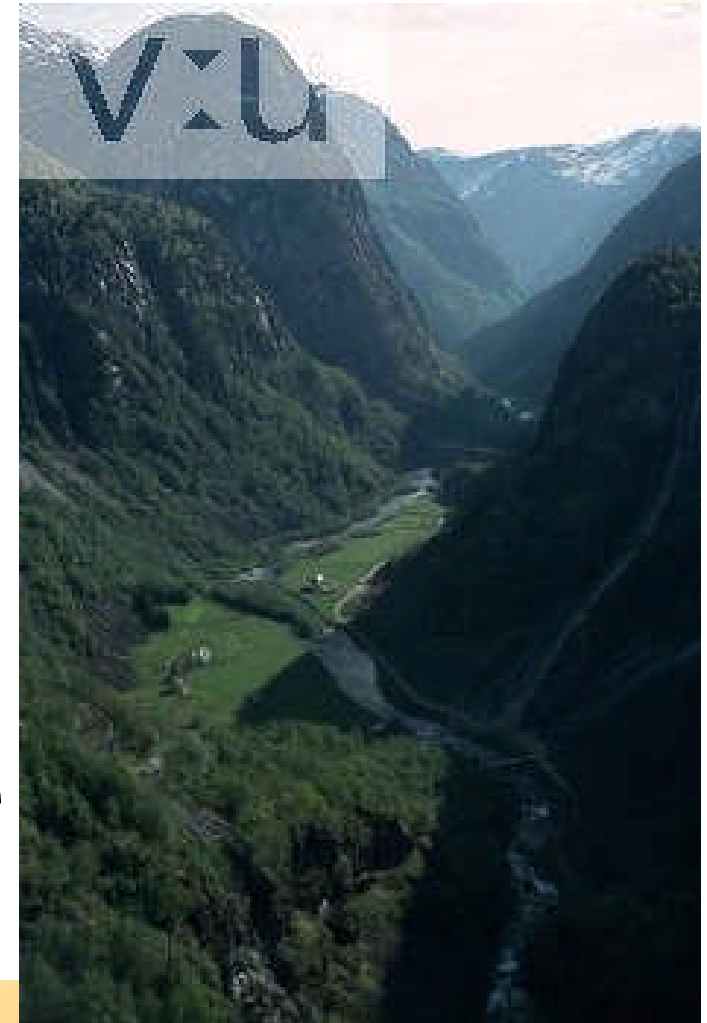


## 6.2 The Work of Streams

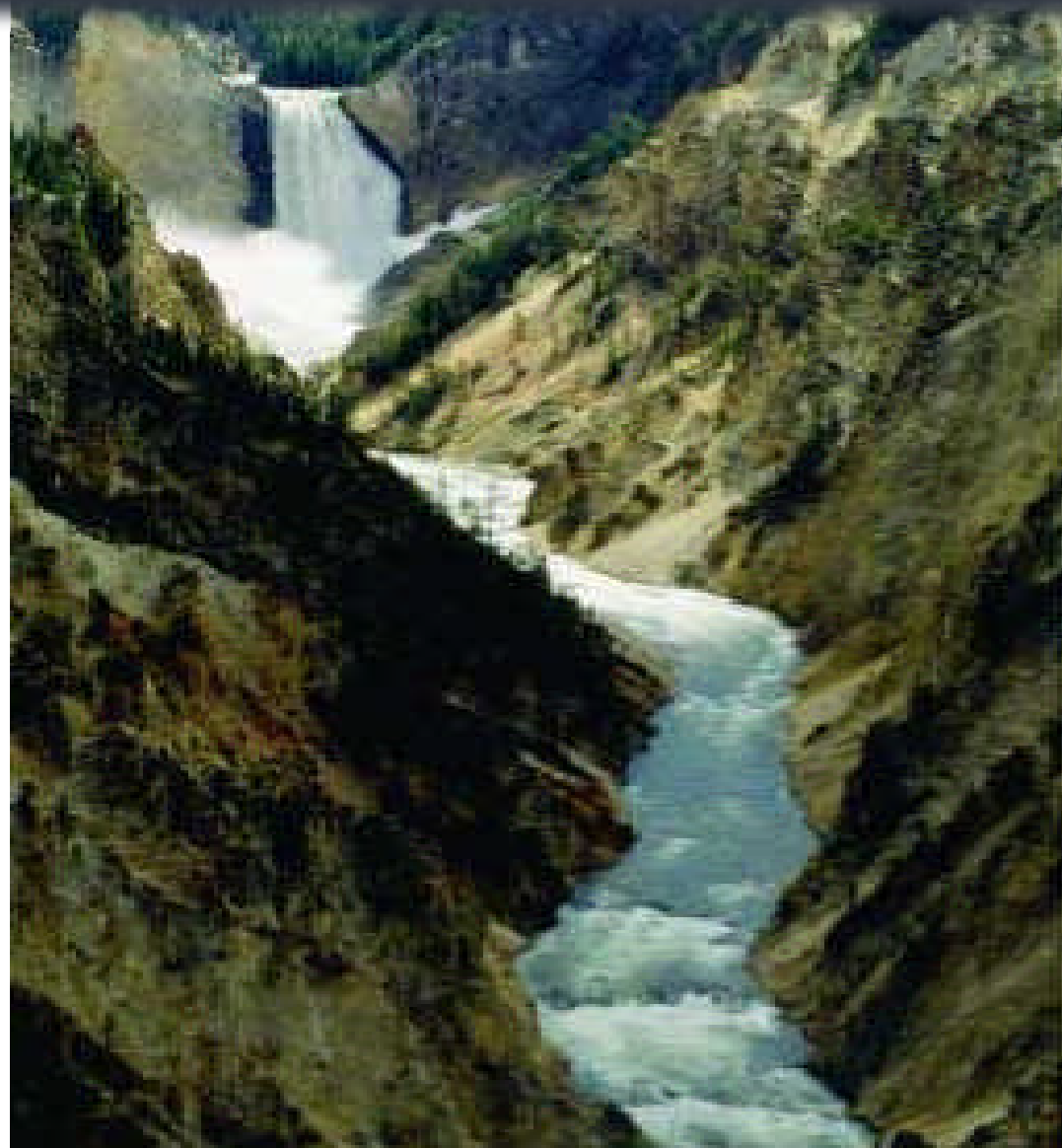
### Stream Valleys

#### ◆ Narrow Valleys

- A narrow V-shaped valley shows that the stream's primary work has been downcutting toward base level.
- Features often include
  - waterfalls - rapids



# The Yellowstone River Is an Example of a V-Shaped Valley



## 6.2 The Work of Streams

### Stream Valleys

#### ◆ Wide Valleys

- **Stream is near base level.**
  - **Downward erosion is less dominant.**
  - **Stream energy is directed from side to side.**
- **The floodplain is the flat, low-lying portion of a stream valley subject to periodic flooding.**

## 6.2 The Work of Streams

### Stream Valleys

- ◆ **Wide Valleys**
  - **Features often include**
    - **meanders**
    - **cutoffs**
    - **oxbow lakes**





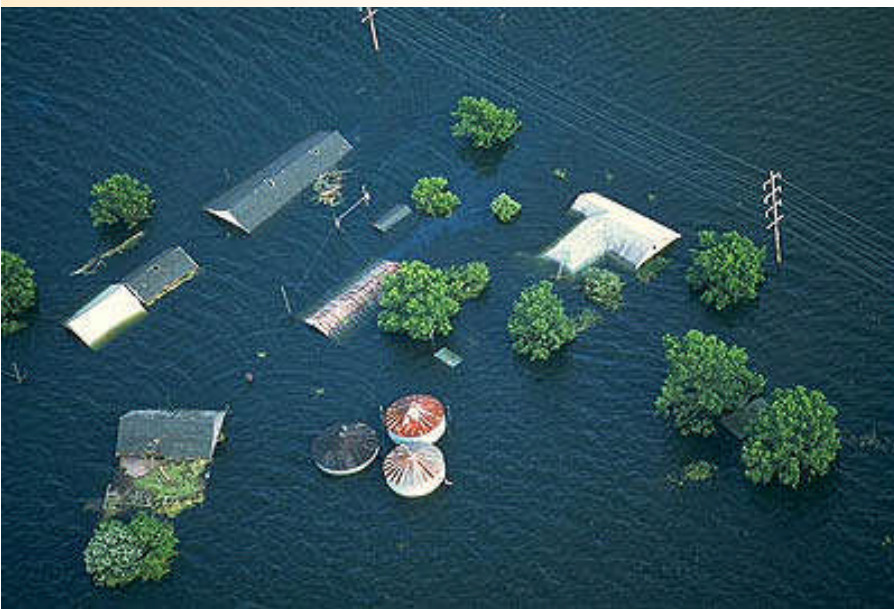
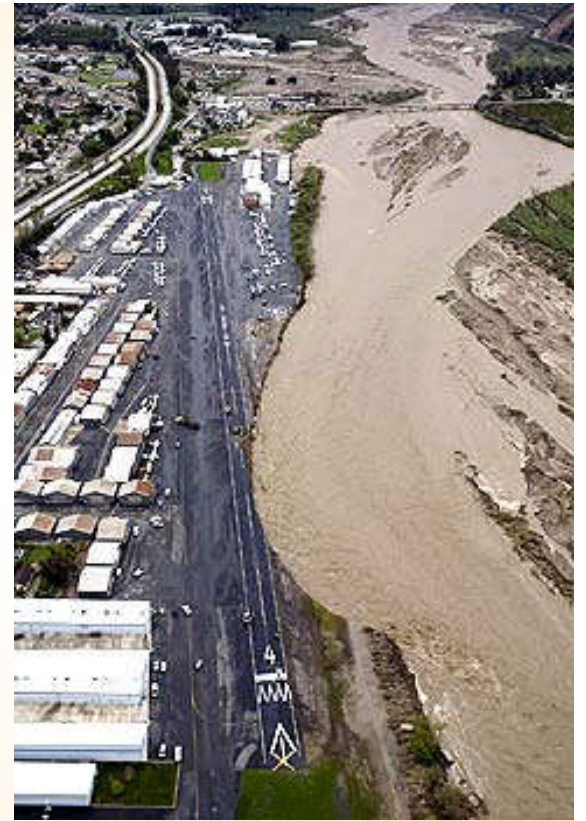
# Formation of a Cutoff and Oxbow Lake



## 6.2 The Work of Streams

### Floods and Flood Control

- ◆ **A flood occurs when the discharge of a stream becomes so great that it exceeds the capacity of its channel and overflows its banks.**
- ◆ **Measures to control flooding include artificial levees, flood control dams, and placing limits on floodplain development.**



# Ohio River Flooding

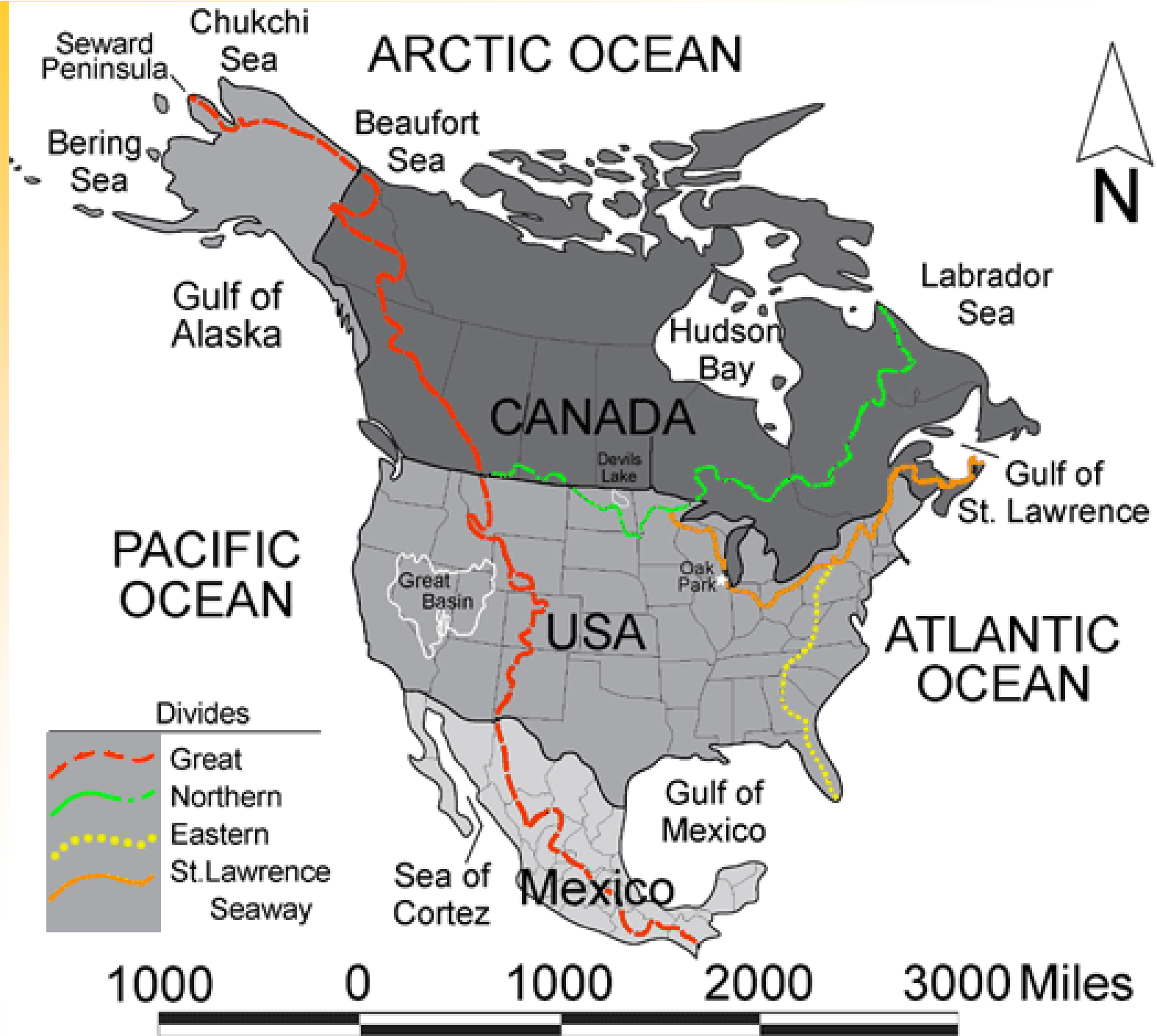


## 6.2 The Work of Streams

### Drainage Basins

- ◆ A drainage basin is the land area that contributes water to a stream.
- ◆ A divide is an imaginary line that separates the drainage basins of one stream from another.





## 6.3 Water Beneath the Surface

### Distribution and Movement of Water Underground

- ◆ Much of the water in soil seeps downward until it reaches the zone of saturation.
- ◆ The zone of saturation is the area where water fills all of the open spaces in sediment and rock.
  - Groundwater is the water within this zone.
  - The water table is the upper level of the saturation zone of groundwater.

## 6.3 Water Beneath the Surface

### Distribution and Movement of Water Underground

#### ◆ Movement

- **Groundwater moves by twisting and turning through interconnected small openings.**
- **The groundwater moves more slowly when the pore spaces are smaller.**



## 6.3 Water Beneath the Surface

### Distribution and Movement of Water Underground

#### ◆ Movement

- Porosity

- The percentage of pore spaces
- Determines how much groundwater can be stored

## **6.3 Water Beneath the Surface**

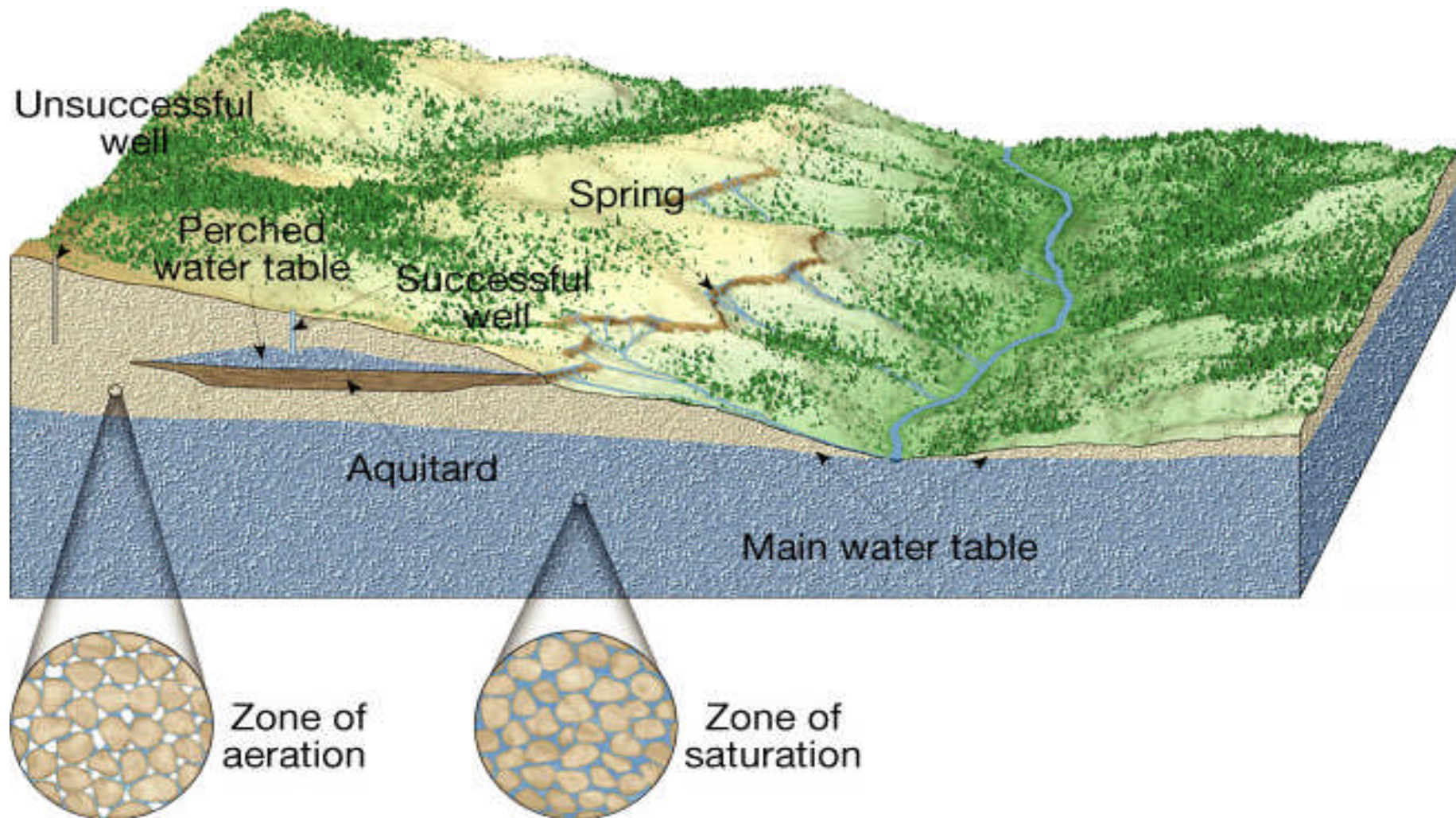
### **Distribution and Movement of Water Underground**

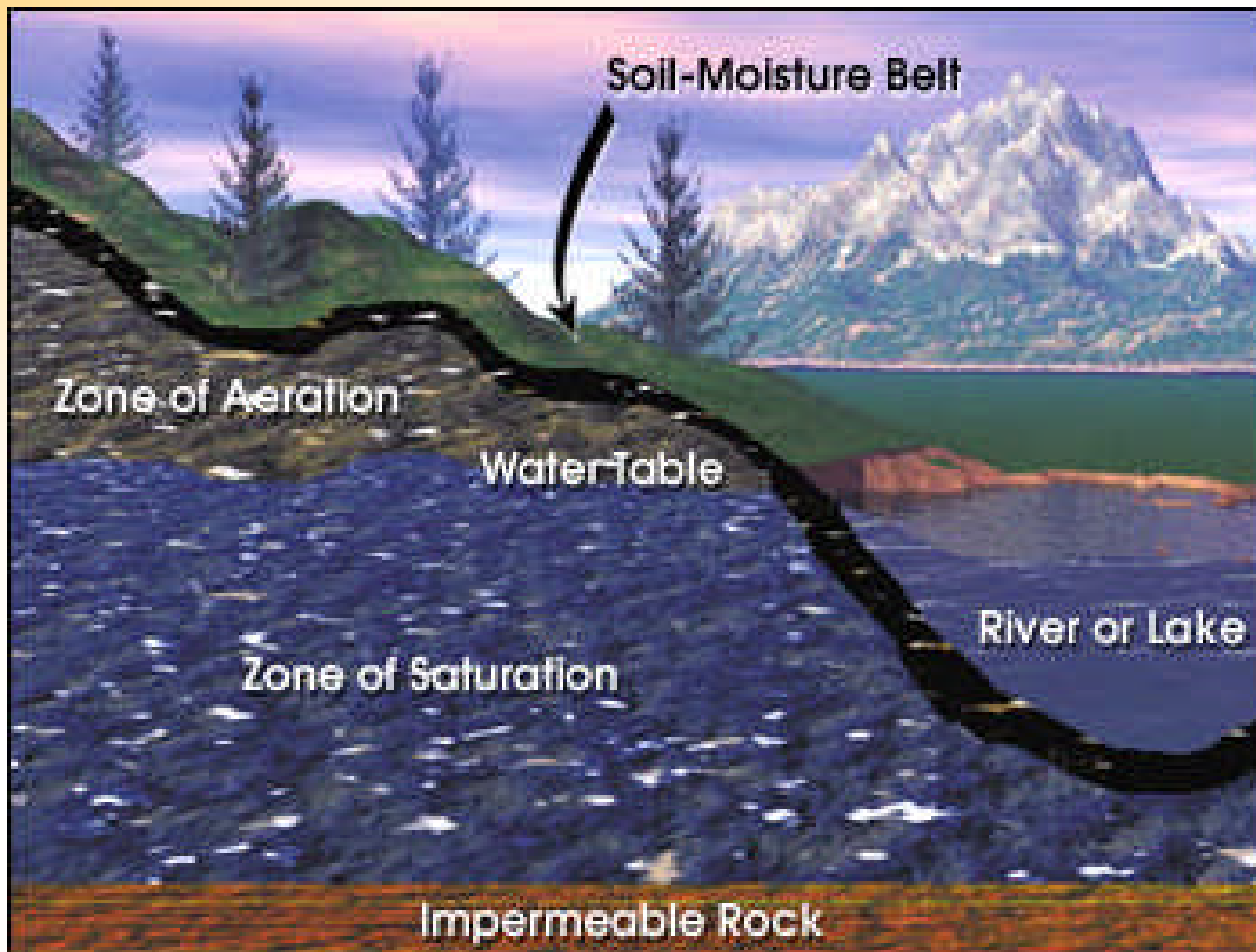
#### **◆ Movement**

- **Permeability**

- **Ability to transmit water through connected pore spaces**
- **Aquifers are permeable rock layers or sediments that transmit groundwater freely**

# Features Associated with Subsurface Water





## 6.3 Water Beneath the Surface

### **Springs**

- ◆ **A spring forms whenever the water table intersects the ground surface.**
- ◆ **Hot Springs**
  - **Water is 6–9°C warmer than the mean air temperature of the locality.**
  - **Water is heated by cooling of igneous rock.**

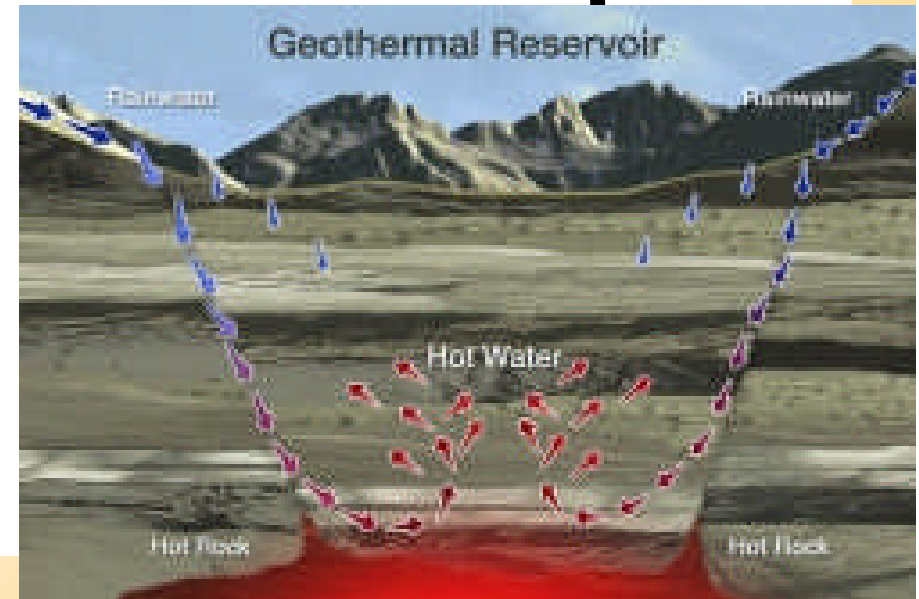


## 6.3 Water Beneath the Surface

### Springs

#### ◆ Geysers

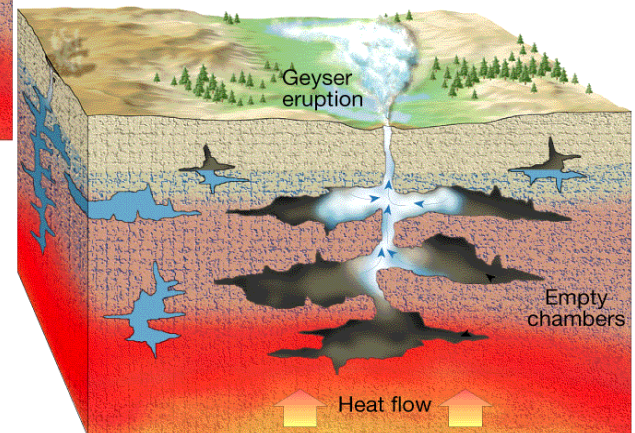
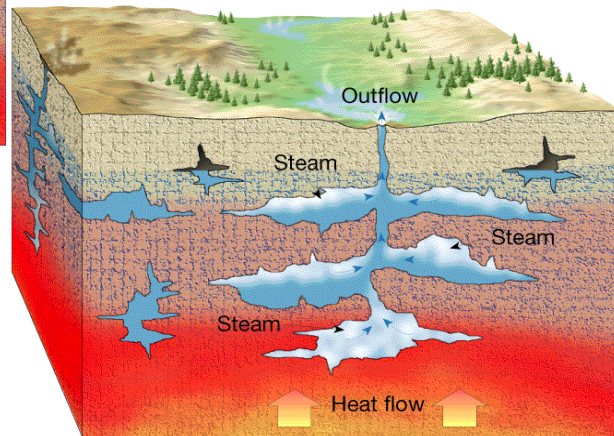
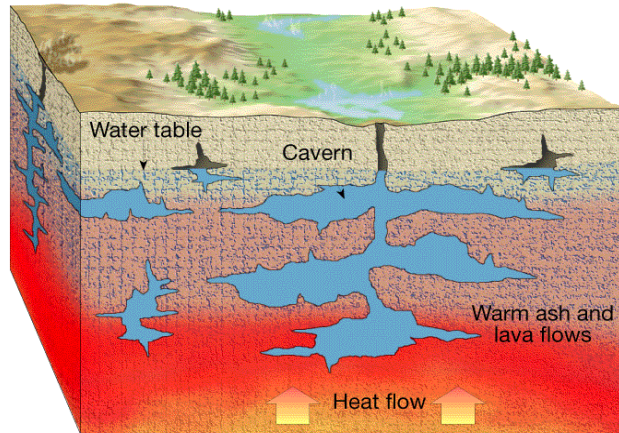
- Intermittent hot springs
- Water turns to steam and erupts.







# Geyser Eruption Cycle

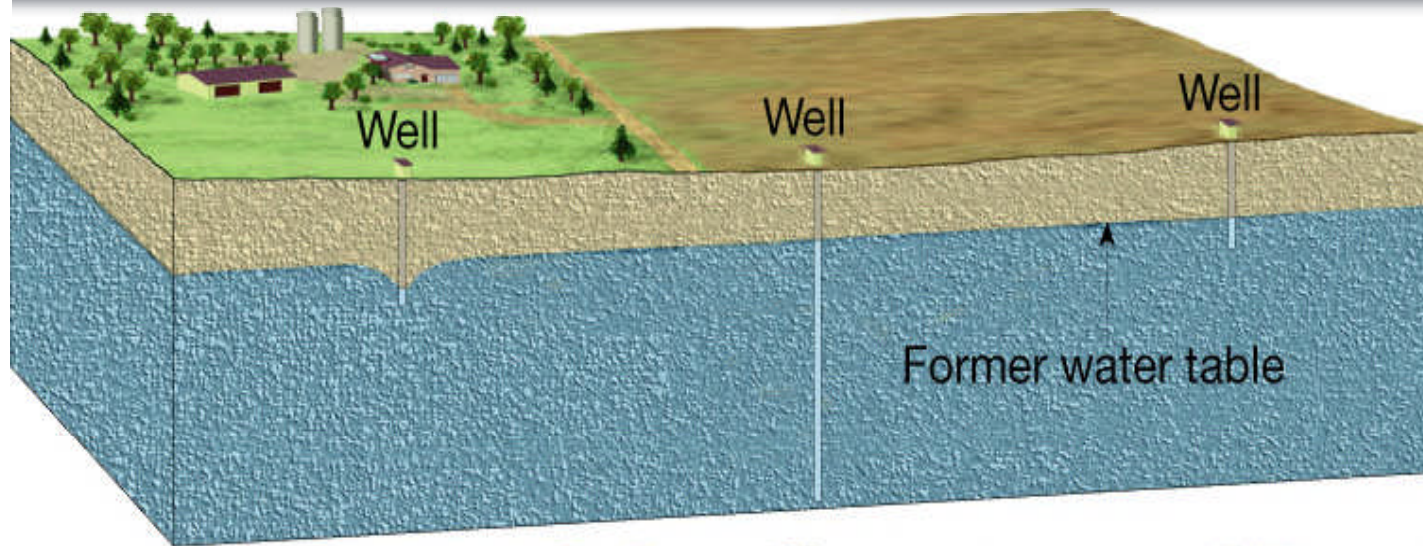


## 6.3 Water Beneath the Surface

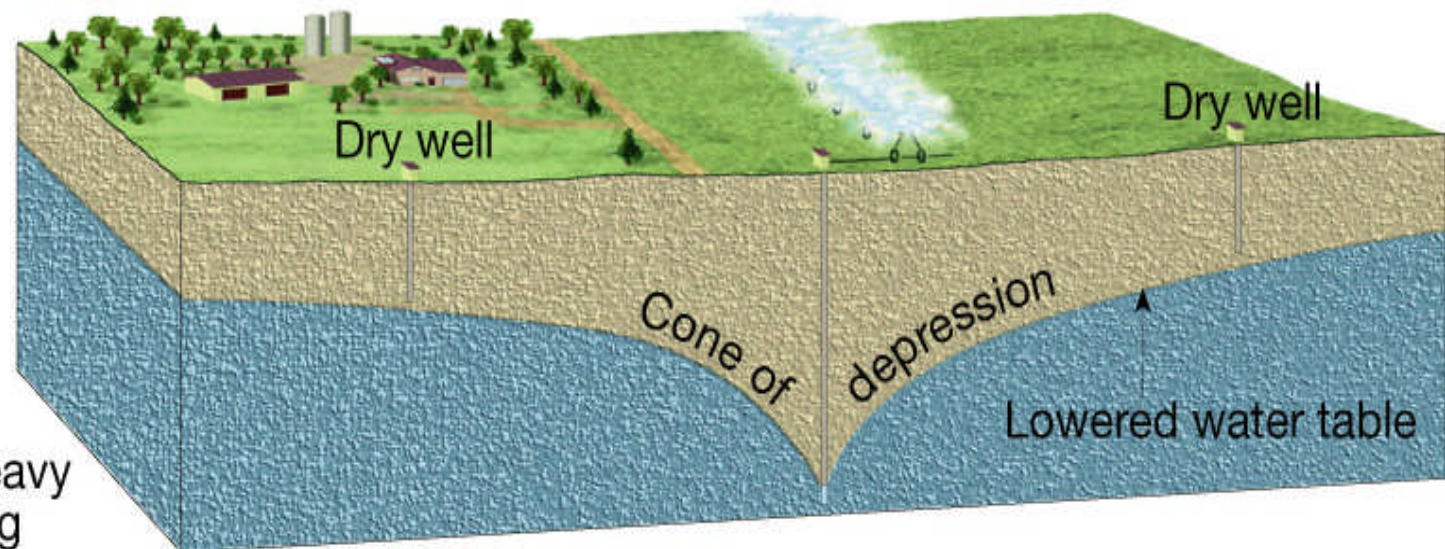
### Wells

- ◆ **A well is a hole bored into the zone of saturation.**
- **An artesian well is any formation in which groundwater rises on its own under pressure.**
- **Pumping can cause a drawdown (lowering) of the water table.**
- **Pumping can form a cone of depression in the water table.**

# Cone of Depression



Before heavy pumping



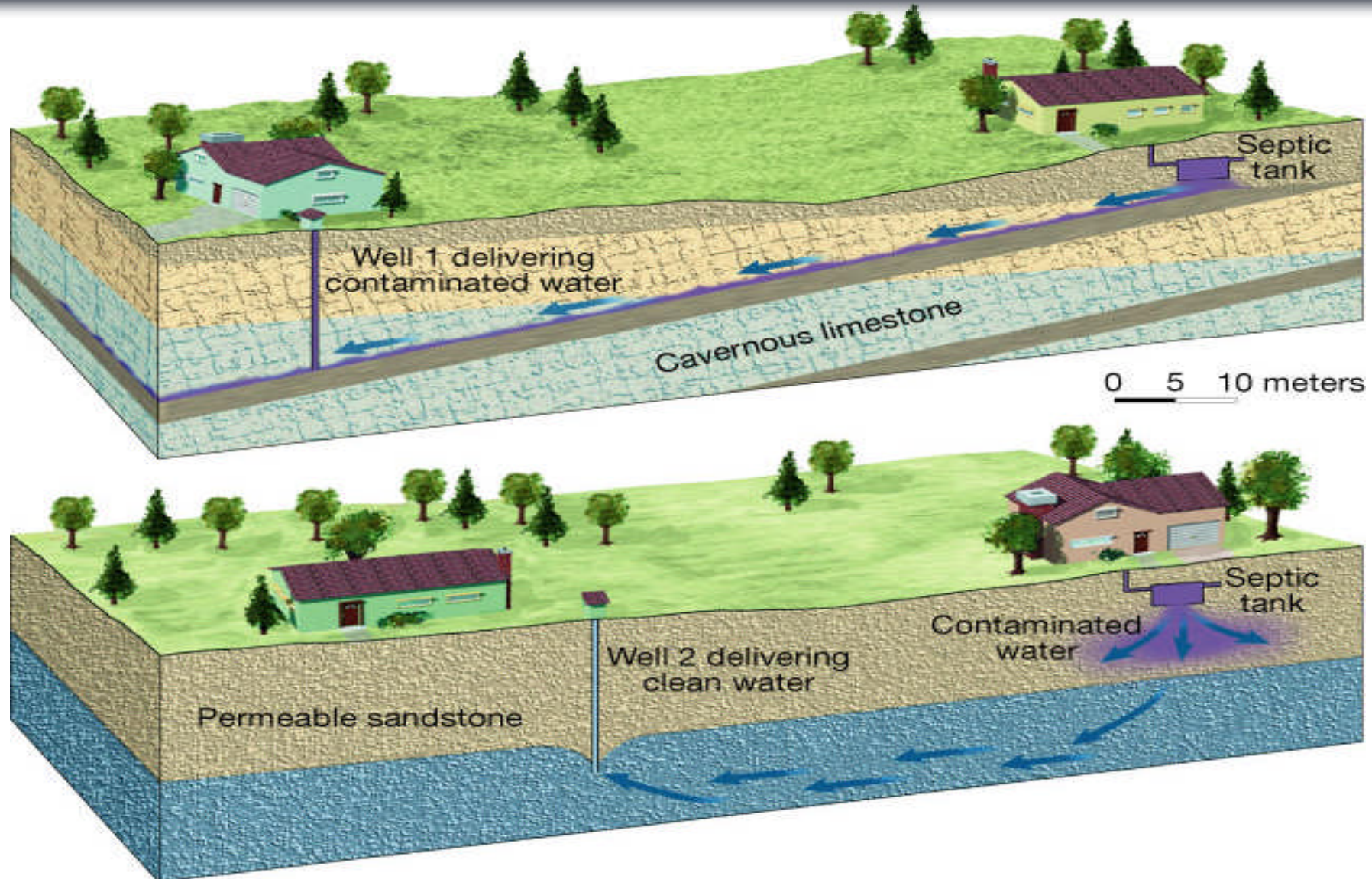
After heavy pumping

## 6.3 Water Beneath the Surface

### Environmental Problems Associated with Groundwater

- ◆ **Overuse and contamination threatens groundwater supplies in some areas.**
- **Treating it as a nonrenewable resource**
- **Contamination**
- **Land subsidence caused by its withdrawal**

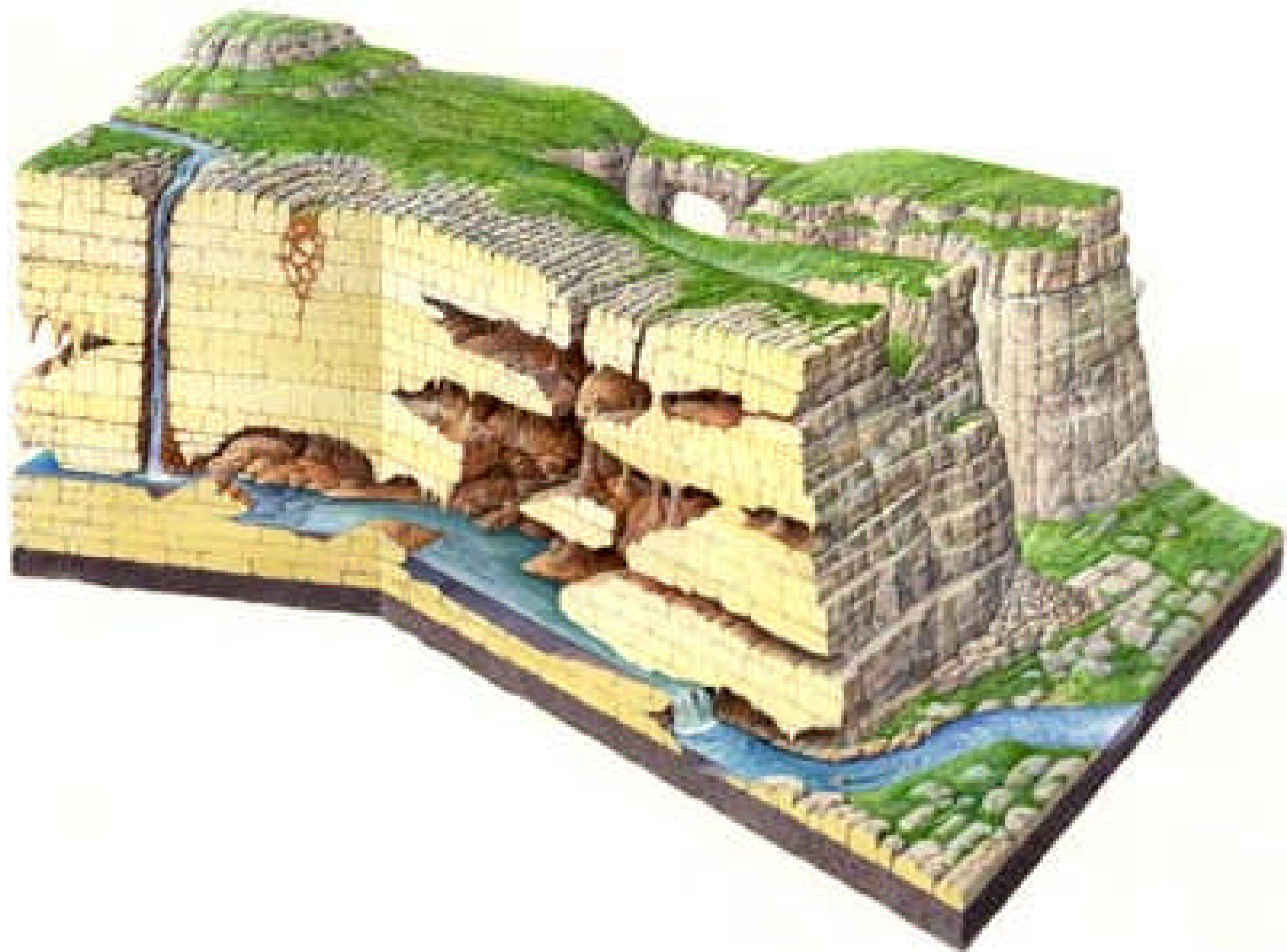
# Groundwater Contamination



## 6.3 Water Beneath the Surface

### Caverns

- ◆ A cavern is a naturally formed underground chamber.
- ◆ Erosion forms most caverns at or below the water table in the zone of saturation.
- ◆ Travertine is a form of limestone that is deposited by hot springs or as a cave deposit.



# Dissolving of Groundwater Creates Caverns





## 6.3 Water Beneath the Surface

### Caverns

- ◆ **Characteristics of features found within caverns**
  - **Formed in the zone of aeration**
  - **Composed of dripstone**
  - **Formed from calcite deposited as dripping water evaporates**
  - **Common features include stalactites (hanging from the ceiling) and stalagmites (growing upward from the floor).**

## 6.3 Water Beneath the Surface

### Karst Topography

- ◆ Formed by dissolving rock at, or near, Earth's surface
- ◆ Common features
  - Sinkholes—surface depressions
    - Sinkholes form when bedrock dissolves and caverns collapse.
  - Caves and caverns
- ◆ Area lacks good surface drainage.

# Sinkhole Formation

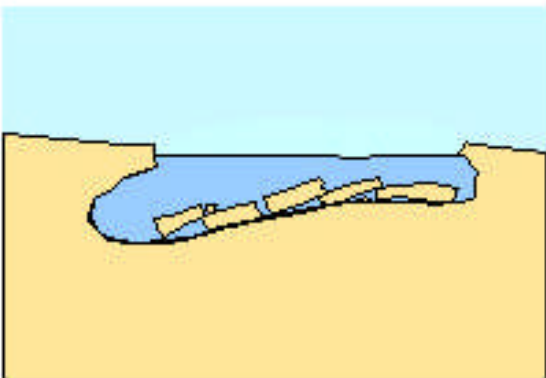
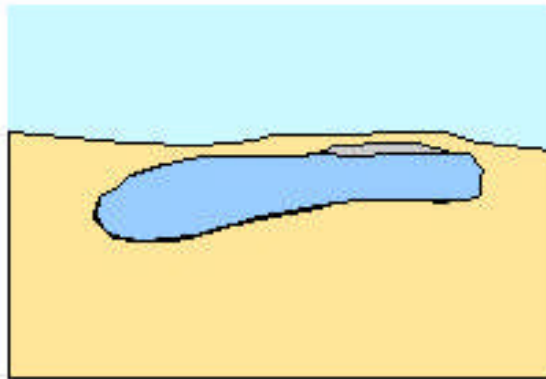
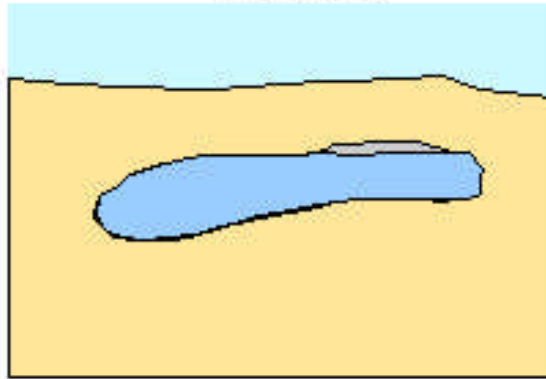




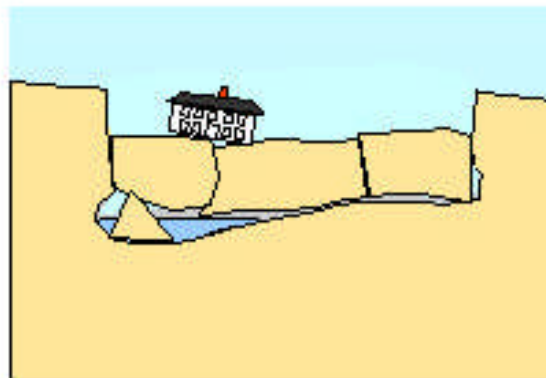
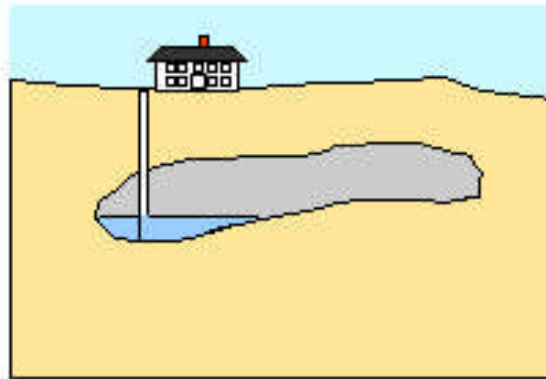
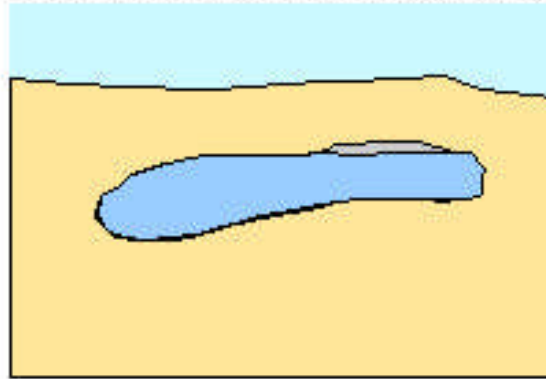


# Causes of sinkhole collapse

Erosion



Groundwater Withdrawal



Surface Loading

