

Prentice Hall

# **EARTH SCIENCE**

**Tarbuck ♦ Lutgens**



Chapter

**6**

# Running Water and Groundwater

# 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

## The Water Cycle

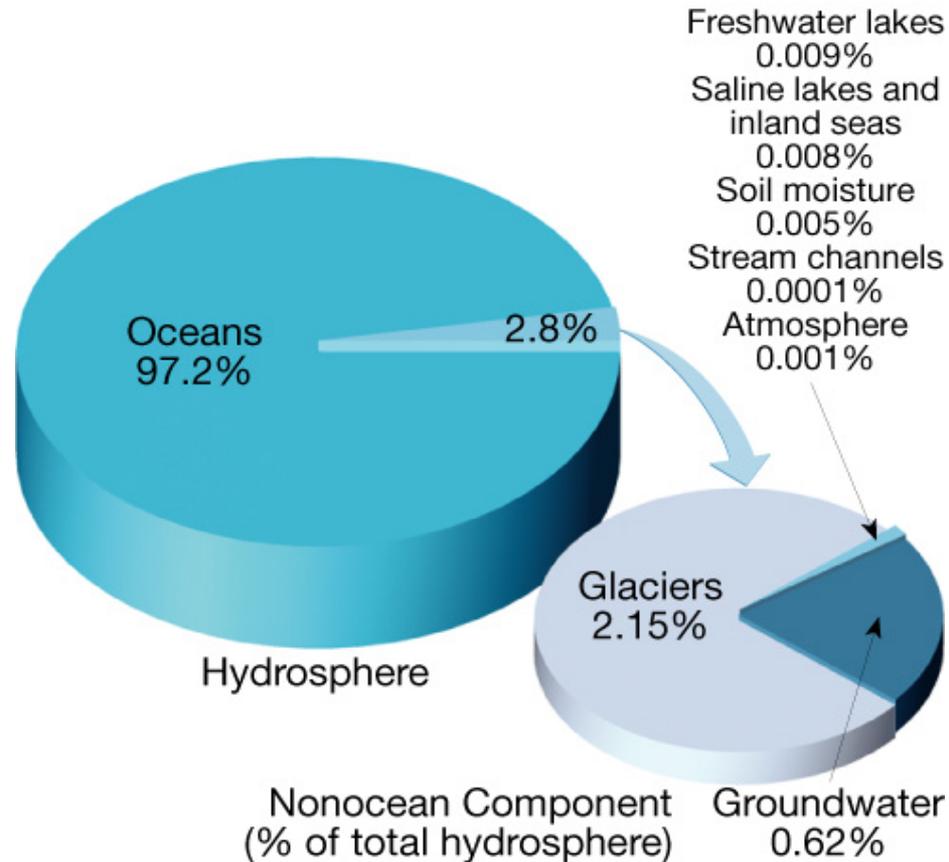
- ◆ Processes involved in the cycle are
  - precipitation
  - evaporation
  - **infiltration**—the movement of surface water into rock or soil through cracks and pore spaces
  - runoff
  - **transpiration**—the release of water into the atmosphere from plants through the ground

# 6.1 Running Water

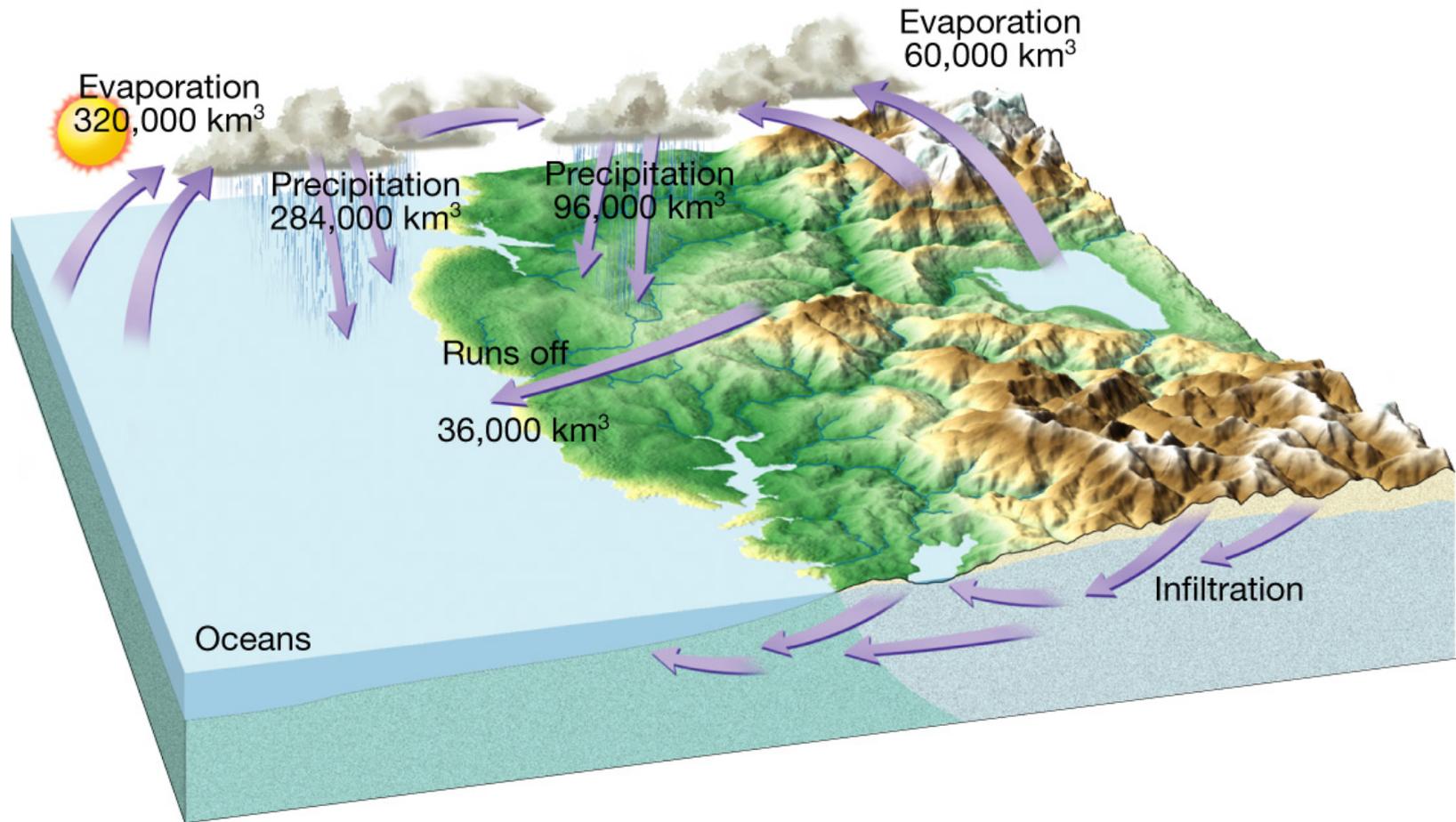
## Earth's Water Balance

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

# Distribution of Earth's Water



# The Water Cycle



# 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.

# 6.1 Running Water

## Streamflow

- Channel Characteristics
  - The **stream channel** is the course the water in a stream follows.
  - Shape, size, and roughness
- **Discharge** of a stream is the volume of water flowing past a certain point in a given unit of time.

# 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

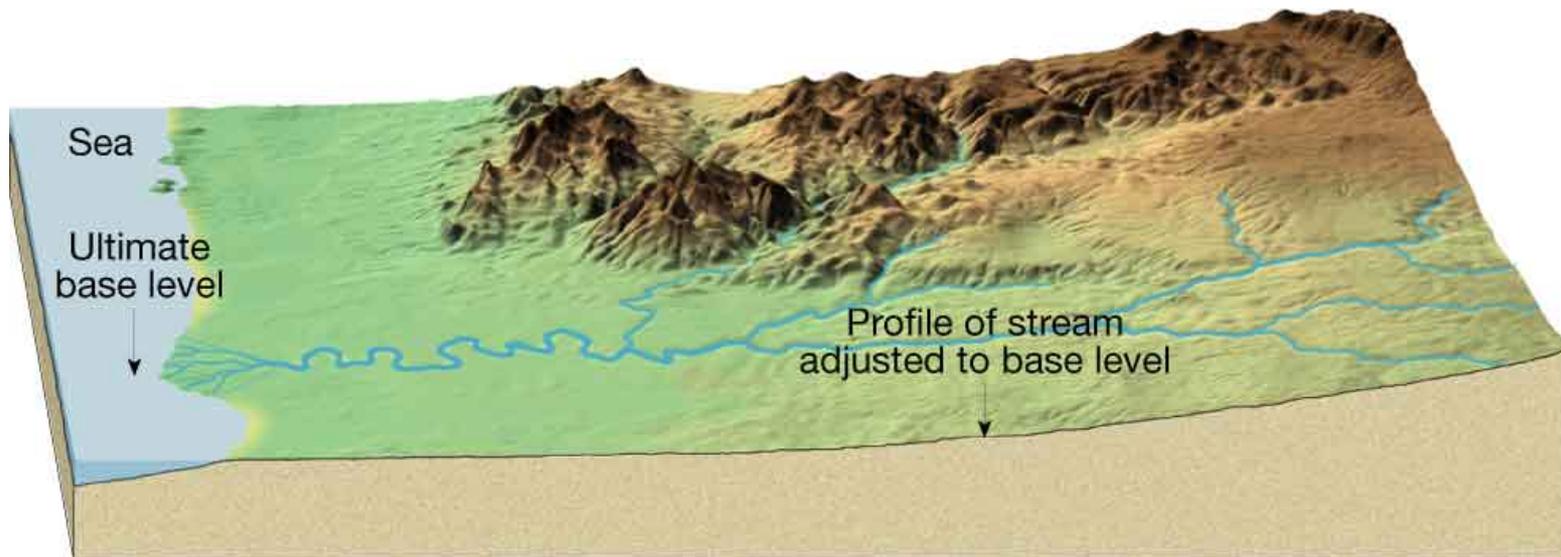
# 6.1 Running Water

## Changes from Upstream to Downstream

### ◆ Profile

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

# Sea Level and Streams



# 6.1 Running Water

## Changes from Upstream to Downstream

### ◆ Profile

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

# Rivers with Many Meanders



# 6.1 Running Water

## Changes from Upstream to Downstream

### ◆ Base Level

- Lowest point to which a stream can erode
- Two general types
  - ultimate—sea level
  - temporary, or local
- A stream in a broad, flat-bottomed valley that is near its base level often develops a course with many bends called **meanders**.

# 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

## Deposition

- ◆ A stream's **bedload** 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**.
- ◆ **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.

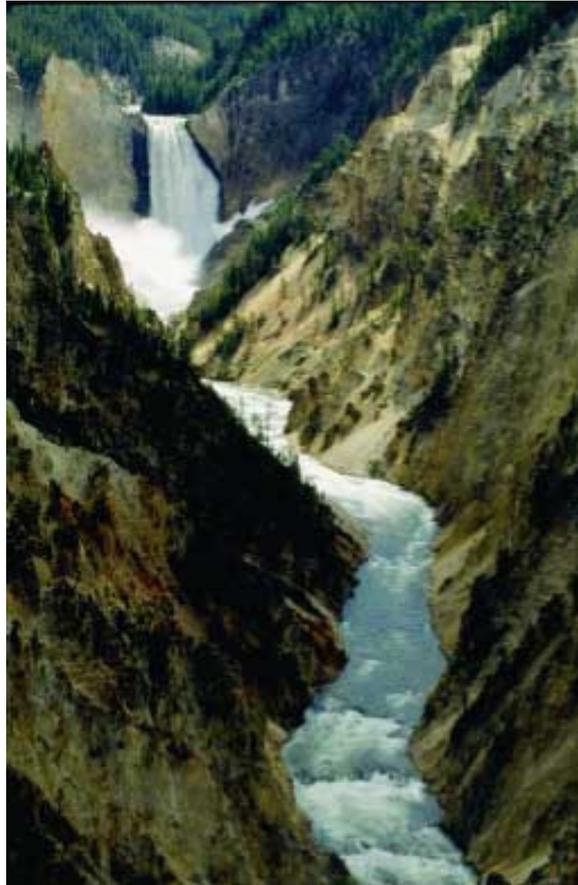
# 6.2 The Work of Streams

## 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
  - rapids
  - waterfalls

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



# 6.2 The Work of Streams

## Stream Valleys

### ◆ Wide Valleys

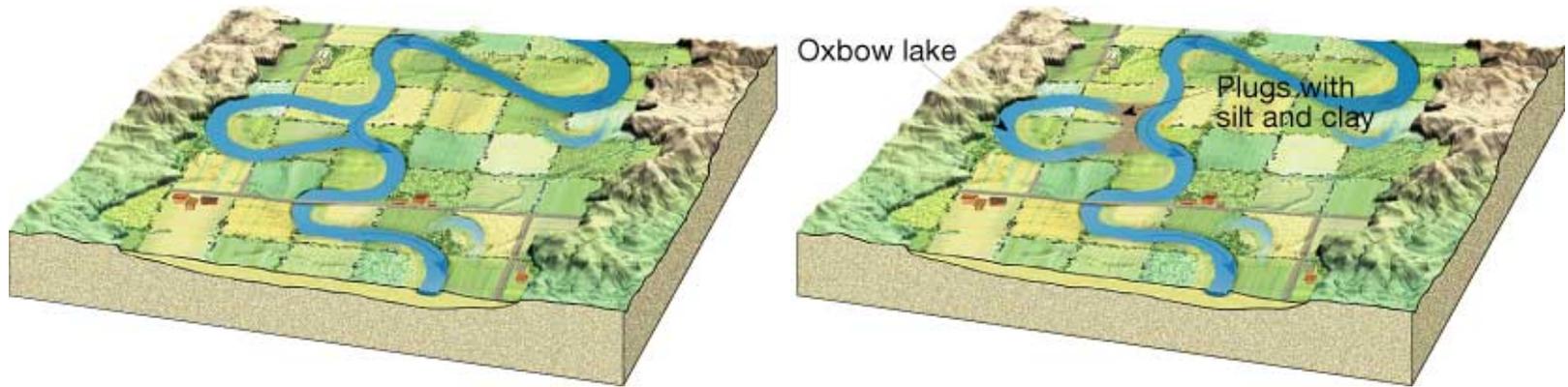
- Stream is near base level.
  - Downward erosion is less dominant.
  - Stream energy is directed from side to side.
- The **floodplain** is the flat, low-lying portion of a stream valley subject to periodic flooding.

# 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

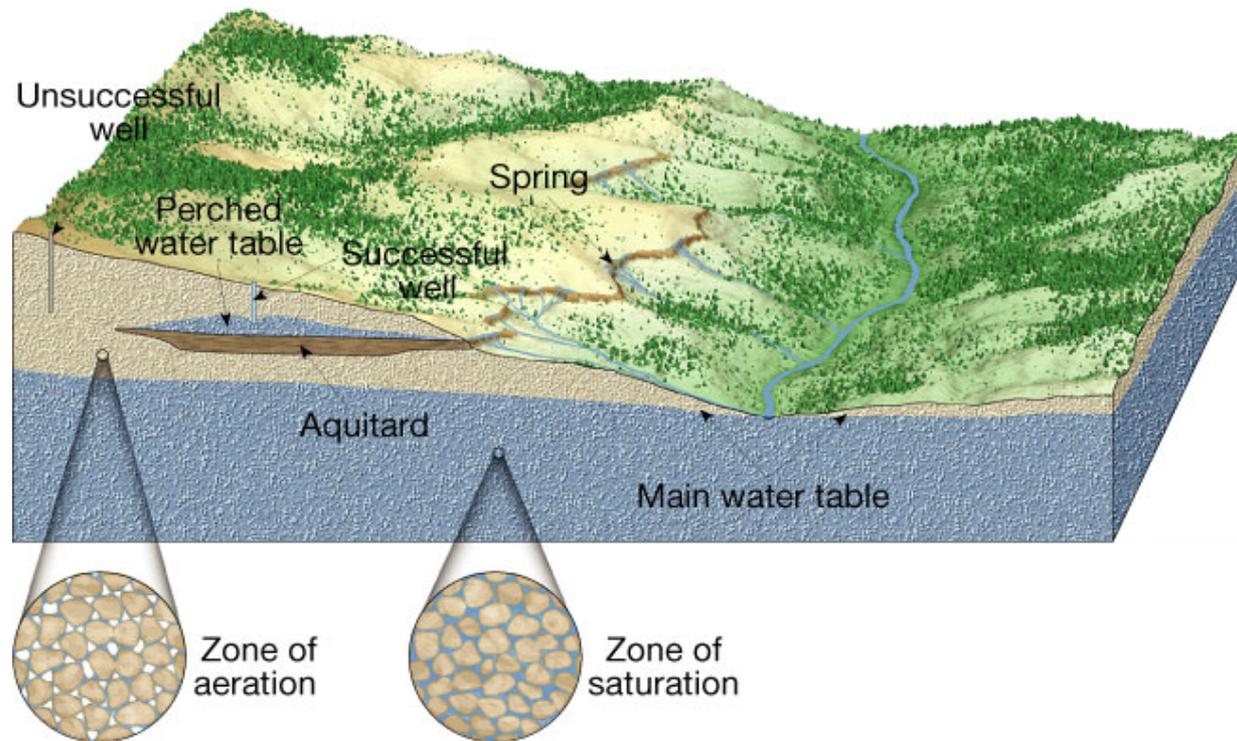
- **Porosity**

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

- **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

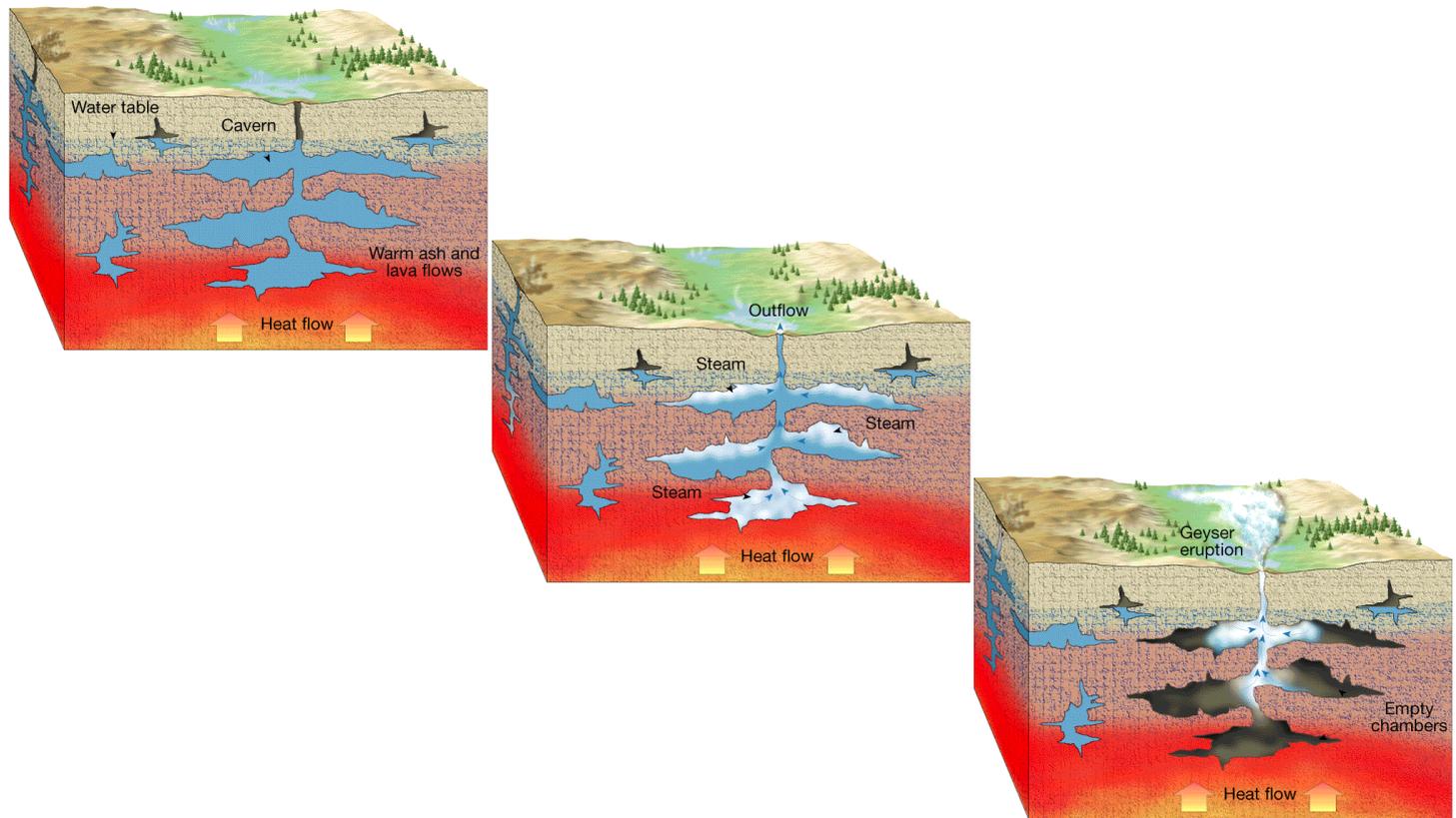


# 6.3 Water Beneath the Surface

## 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.
- ◆ **Geysers**
  - Intermittent hot springs
  - Water turns to steam and erupts.

# Geyser Eruption Cycle

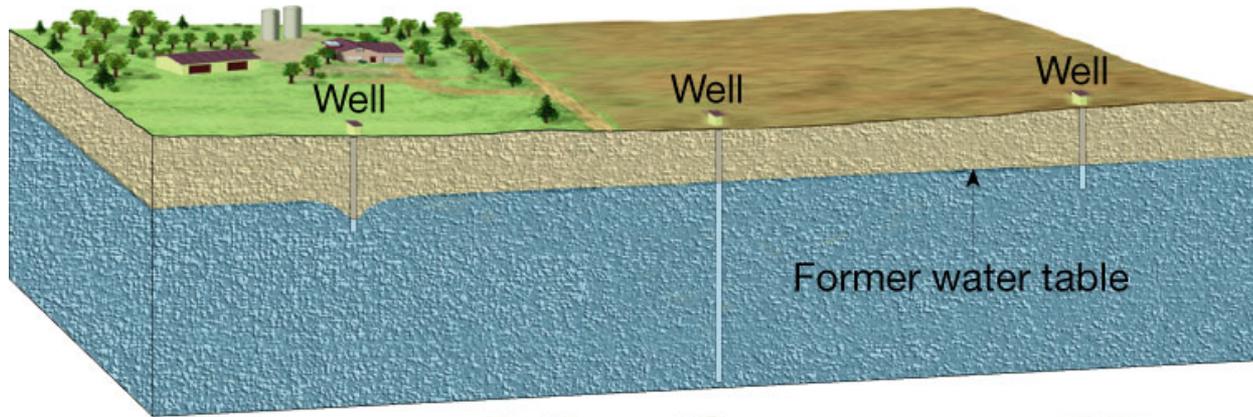


# 6.3 Water Beneath the Surface

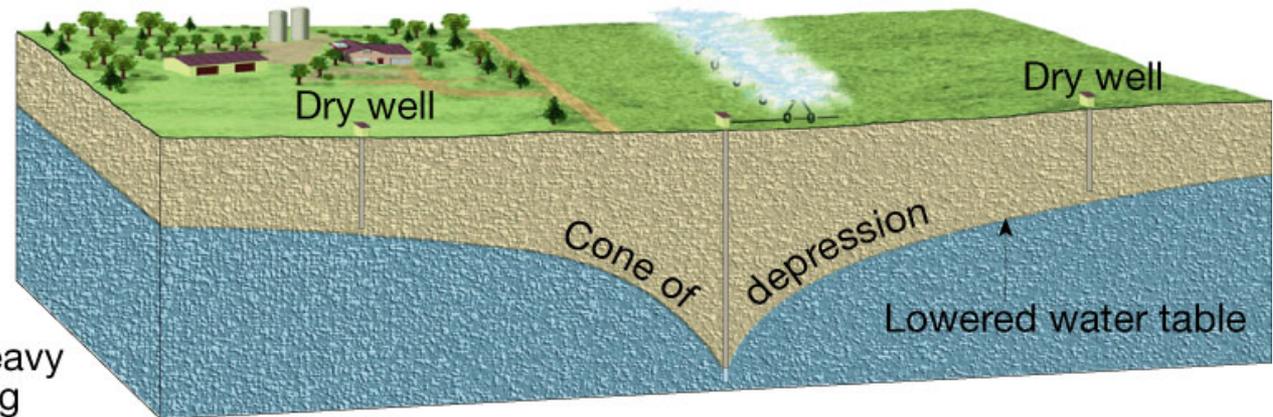
## Wells

- ◆ 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



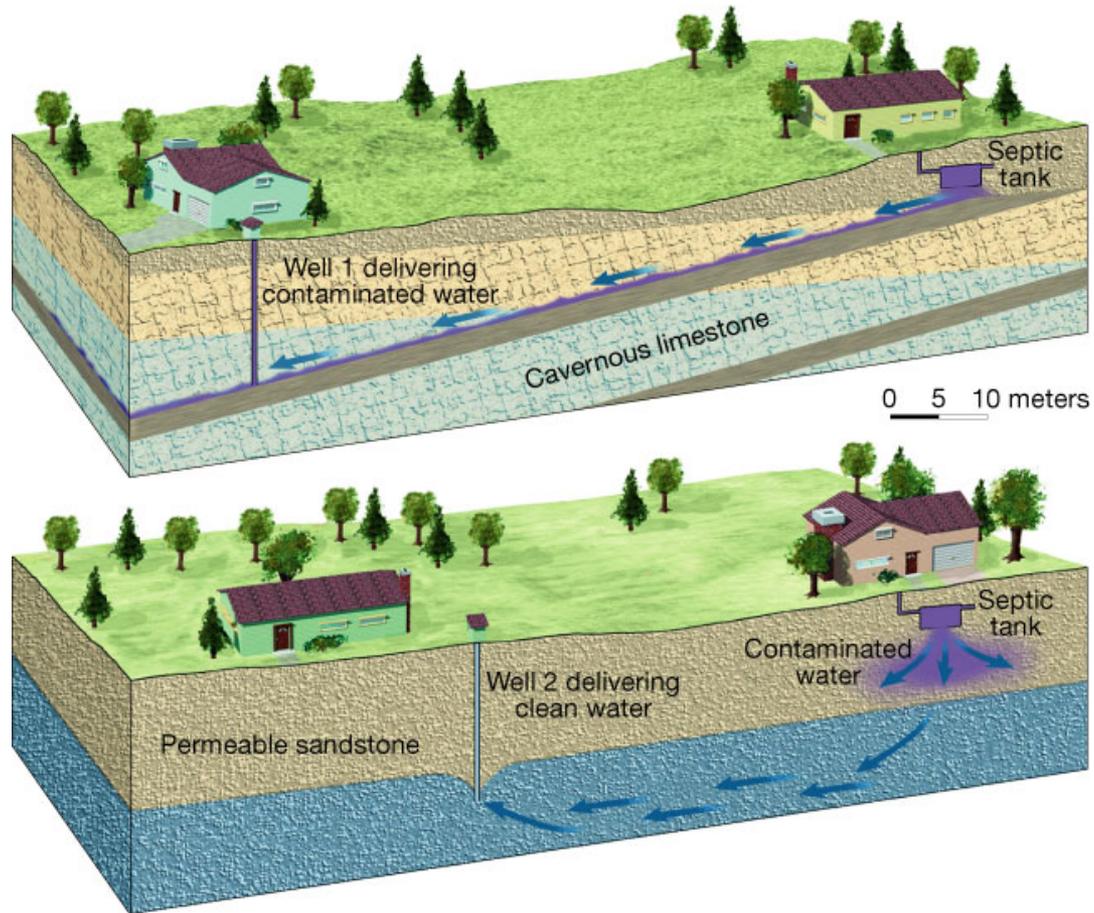
After heavy pumping

# 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
  - Land subsidence caused by its withdrawal
  - Contamination

# 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

