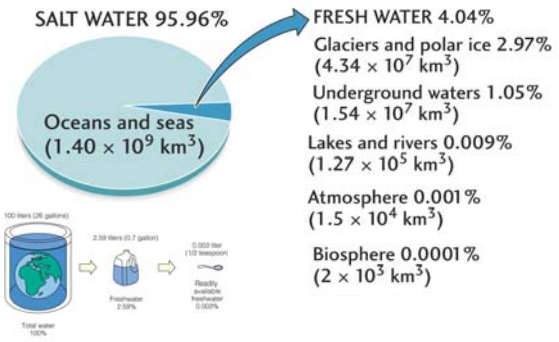
Groundwater: Big Ideas

- Water is essential for life on Earth
- Fresh water is less than 3% of the water at Earth's surface
- Humans affect the quality, availability, and distribution of Earth's water through the modification of streams, lakes, and groundwater
- Water's unique physical and chemical properties are essential to the dynamics of all of Earth's systems
- Humans cannot eliminate natural hazards but can engage in activities that reduce their impacts by identifying high-risk locations

The Distribution of Water on Earth



The Hydrologic Cycle:

The continuous movement of H_2O from one reservoir to another

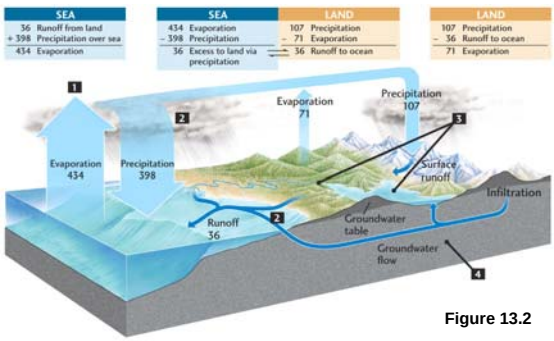
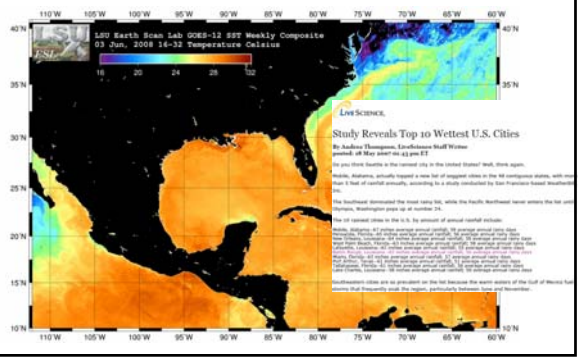


Figure 13.2

GOM – Sea Surface Temperatures



Formation of Rain Shadow Deserts

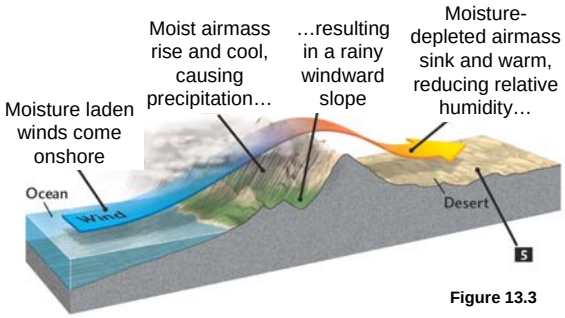


Figure 13.3

Average U.S. Annual Precipitation

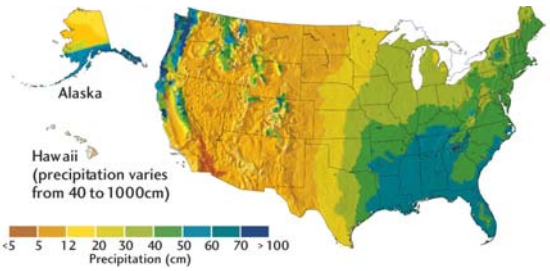


Figure 13.4.a

Average U.S. Annual Runoff

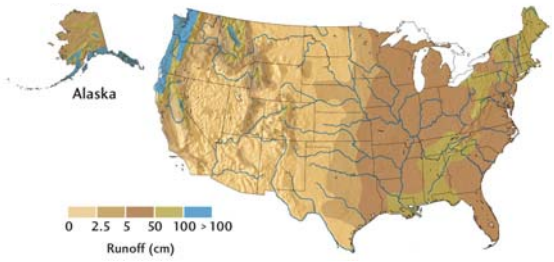
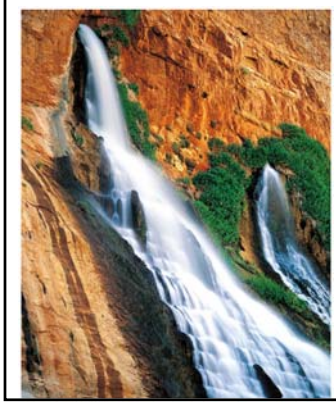


Figure 13.4.b

Table 13.1 Water Flows of Some Great Rivers

River	Water Flow (m^3/s)
Amazon, South America	175,000
La Plata, South America	79,300
Congo, Africa	39,600
Yangtze, Asia	21,800
Brahmaputra, Asia	19,800
Ganges, Asia	18,700
Mississippi, North America	17,500



Vasey's Paradise

Groundwater discharges from the wall of Marble Canyon to form a series of natural springs.

Figure 13.6

Key Terms

- **Porosity**: percent void space (potential storage)
- **Permeability**: ability of a material to transmit a fluid (how fast)
- **Aquifer**: geologic unit capable of storing and transmitting water in sufficient quantities to supply wells

Porosity Varies with % **Cement**

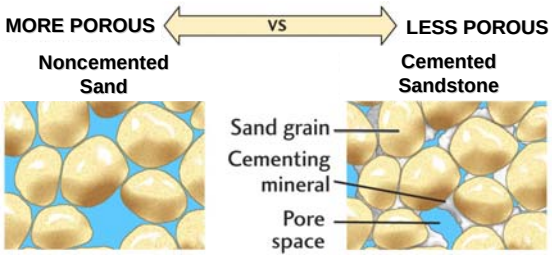


Figure 13.7

Porosity Varies with **Sorting**

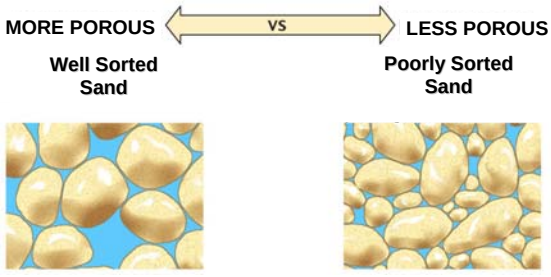


Figure 13.7

Porosity Varies with **Fracturing**

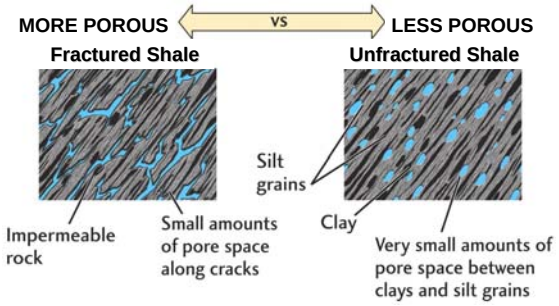


Figure 13.7

Porosity and Permeability of Different Aquifer Types

Type of Aquifer	Porosity	Permeability
Gravel	Very High	Very High
Coarse- to fine sand	High	High
Fine-grained sand & silt	Moderate	Mod - Low
Sandstone, mod. cemented	Mod - Low	Low
Fractured Shale	Low	Low
Metamorphic Rocks	Low	Very Low
Unfractured Shale	Very Low	Very Low

Table 13.2

Types of Aquifers

- **Unconfined** Aquifer: the permeable layer extends to the surface. It consists of an **unsaturated** zone separated from the **saturated** zone by the **groundwater table**.
- **Confined** Aquifer: the permeable layer is overlain and underlain by a less permeable layer (confining layer)

Unconfined Aquifer

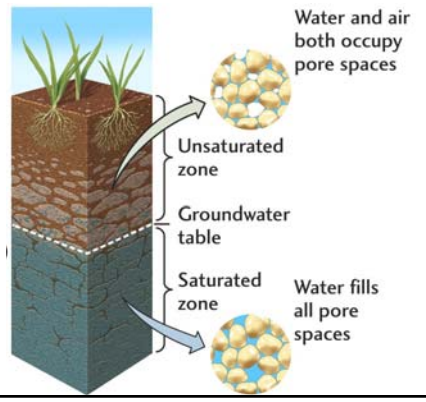


Figure 13.8

Dynamics of an Unconfined Aquifer in a Temperate Climate

During the Wet Season… **During the Dry Season…**

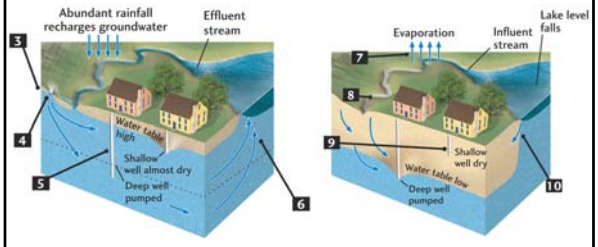


Figure 13.9

Confined Aquifer

Recharge Area:
where the confined aquifer is recharged by infiltration

Pressure Surface:
Height to which water will rise in the confined aquifer

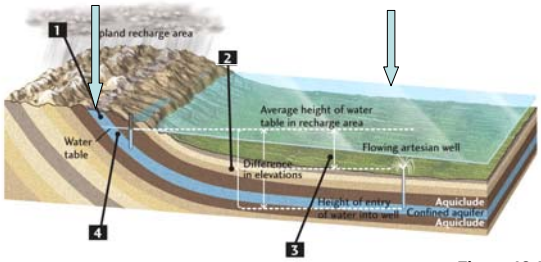
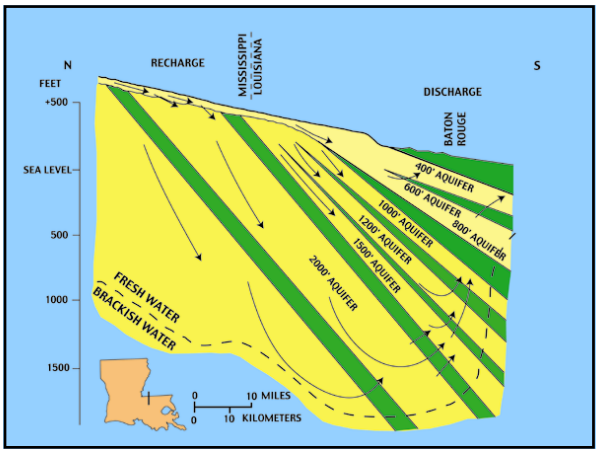
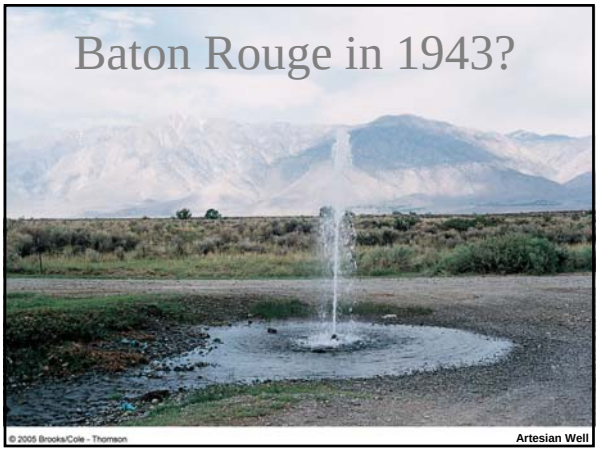


Figure 13.10


N
S
RECHARGE
MISSISSIPPI
LOUISIANA
DISCHARGE
BATON ROUGE
FEET
+500
SEA LEVEL
500
1000
1500
400' AQUIFER
600' AQUIFER
800' AQUIFER
1000' AQUIFER
1200' AQUIFER
1500' AQUIFER
2000' AQUIFER
FRESH WATER
BRACKISH WATER
0 10 MILES
0 10 KILOMETERS


Baton Rouge in 1943?
© 2005 Brooks/Cole - Thomson
Artesian Well

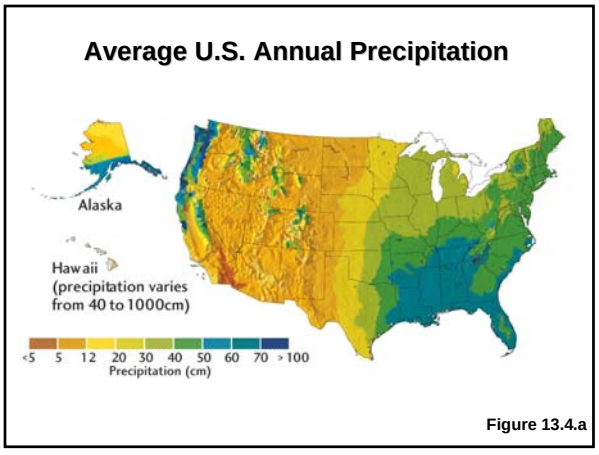

Average U.S. Annual Precipitation
Alaska
Hawaii
(precipitation varies
from 40 to 1000cm)
<5 5 12 20 30 40 50 60 70 >100
Precipitation (cm)

Figure 13.4.a

Formation of a Cone of Depression

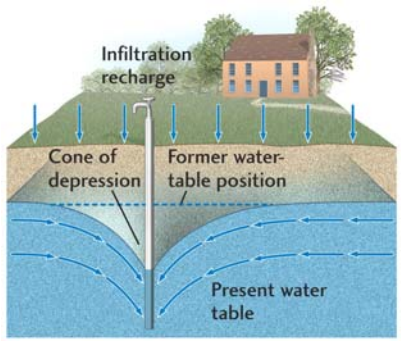
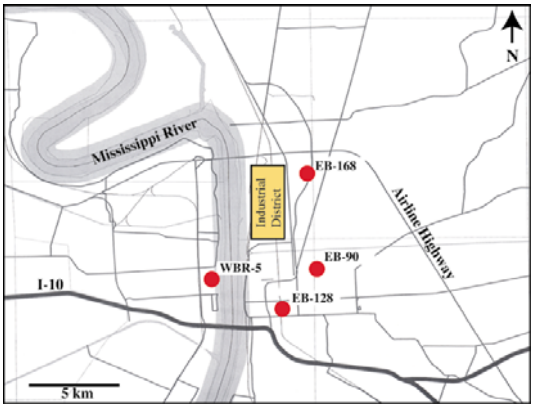
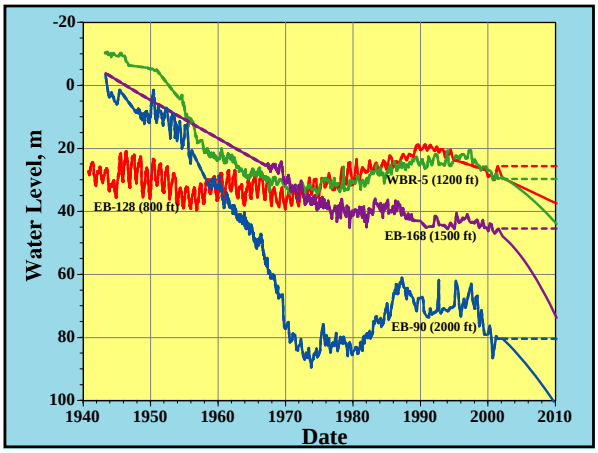
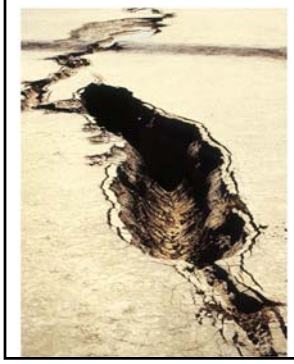


Figure 13.12





Fissures & depressions caused by ground subsidence due to over pumping of groundwater



Salt Water Intrusion: weight of fresh water holds salt water down

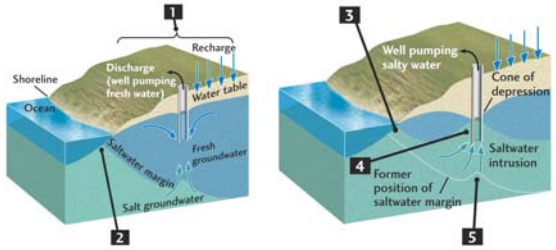


Figure 13.14

U.S. Groundwater Withdrawals: 1950-1995

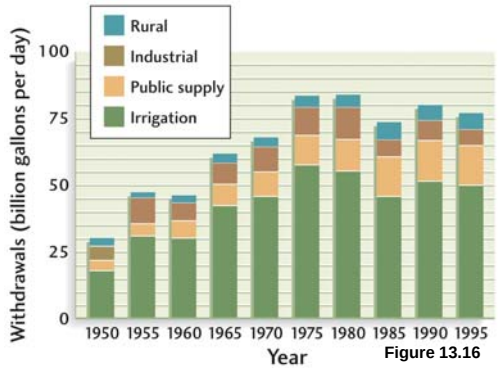
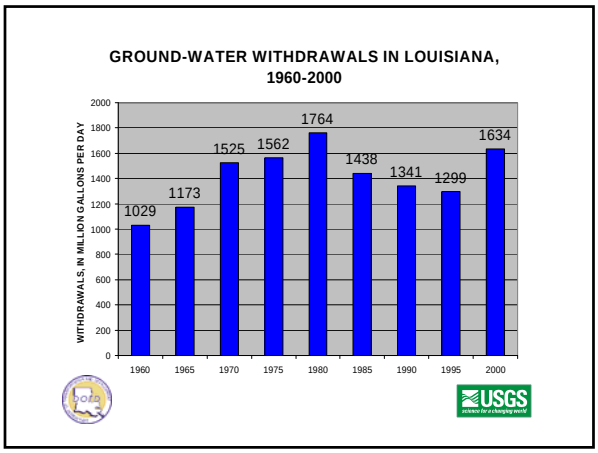
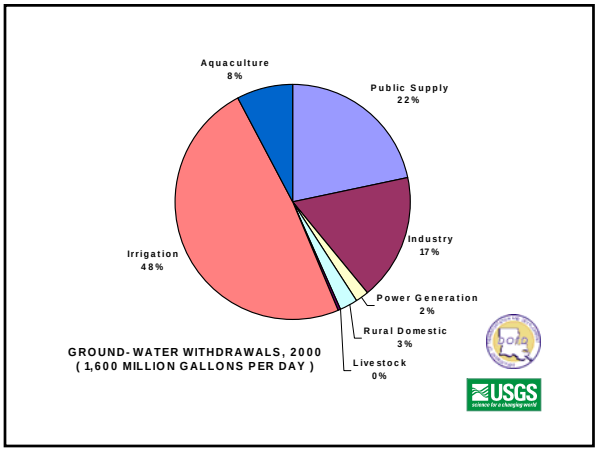


Figure 13.16





Irrigation Farming

Rice Farming

Salt accumulation at soil surface from evaporation of irrigation water, CA

The Ogallala Aquifer:

"Mining Groundwater"

Box 13.2

Karst Landscape

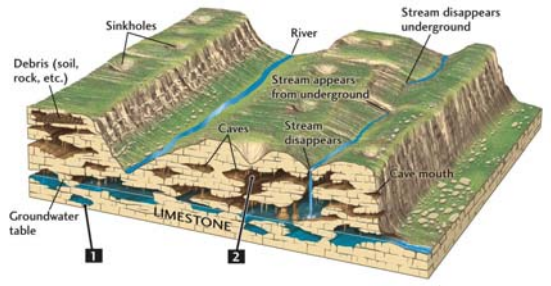


Figure 13.19

The Winter Park Sinkhole, Florida

Figure 13.18

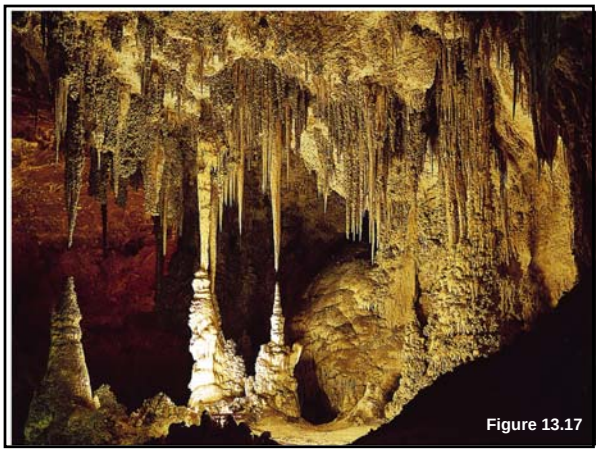


Figure 13.17

Some Human Activities that Can Contaminate Groundwater

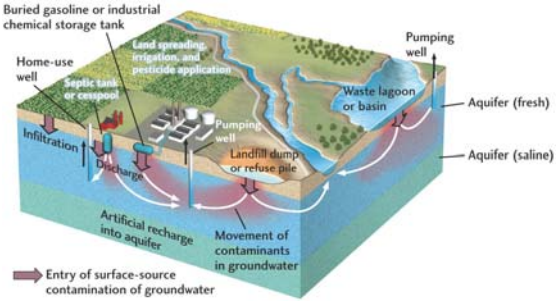


Figure 13.20

Water in the Continental Crust

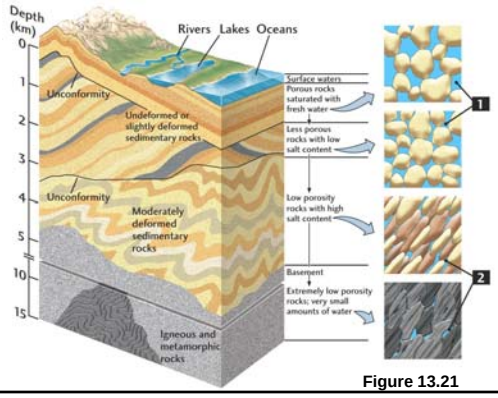


Figure 13.21