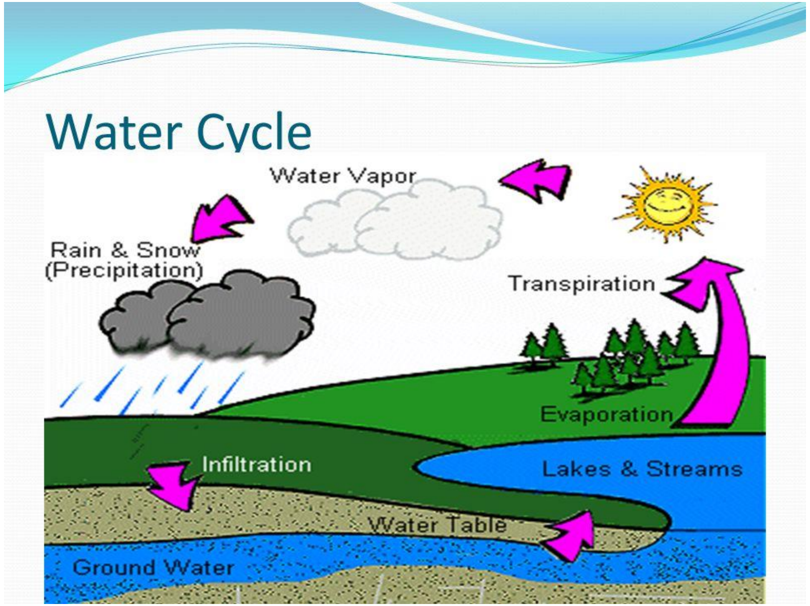
Water Resources

Chapter 9

I. Earth Systems and Resources (10-15%)

A. Earth Science Concepts
B. The Atmosphere
C. Global Water Resources and Use
D. Soil and Soil Dynamics



Module 26: The Availability of Water

After this module you will be able to……

1) Describe major sources of groundwater
2) Identify some of the largest sources of fresh surface water
3) Explain the effects of unusually high and low amounts of precipitation

Groundwater Extraction

Groundwater can be extracted for human use. Approximately 70% of the Earth's surface is covered by water and approximately 97% of Earth's water is found in the oceans as salt water.

The remaining 3% is fresh water that can be consumed by humans, however, much of this is in the form of ice and glaciers.

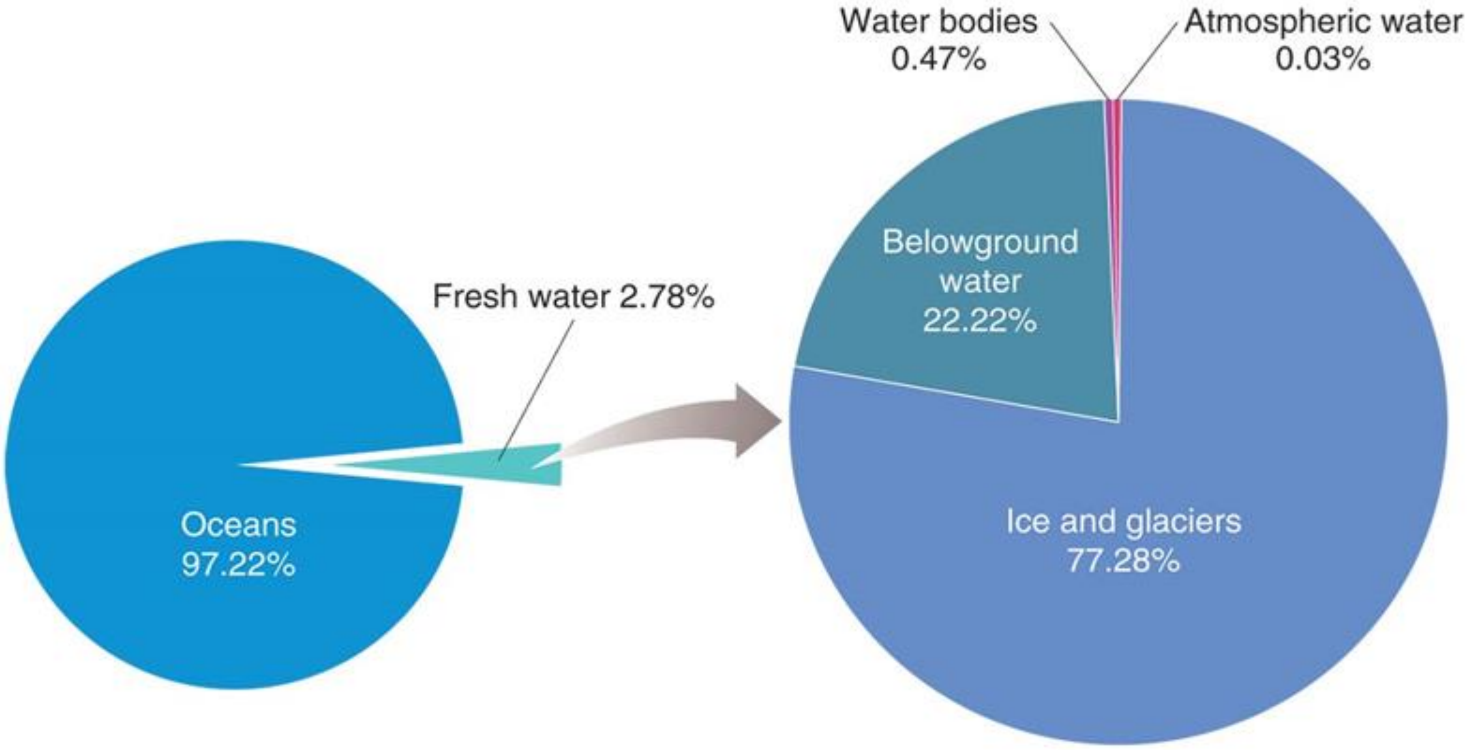


Figure 26.1
Environmental Science for AP®, Second Edition
Data from R. W. Christopherson, Geosystems, 7th ed. Pearson/Prentice Hall, 2009

Groundwater

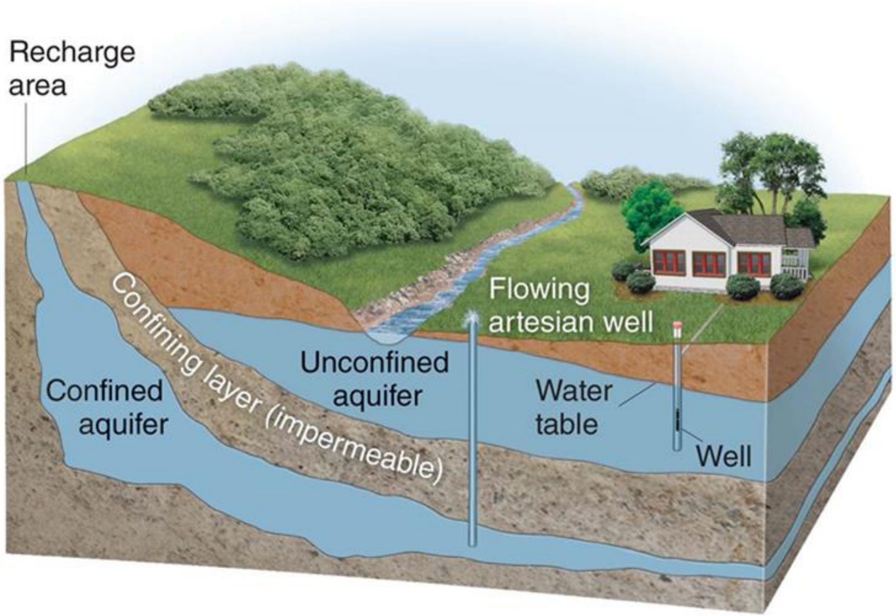


Figure 26.2
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Aquifers are small spaces found within permeable layers of rock and sediments that contain groundwater.

If water can easily flow in and out we consider this an **unconfined aquifer**.

In contrast, **confined aquifers** are surrounded by a layer of impermeable rock or clay.

The **water table** is the uppermost level at which the groundwater in a given area fully saturates the rock or soil.

Groundwater Recharging

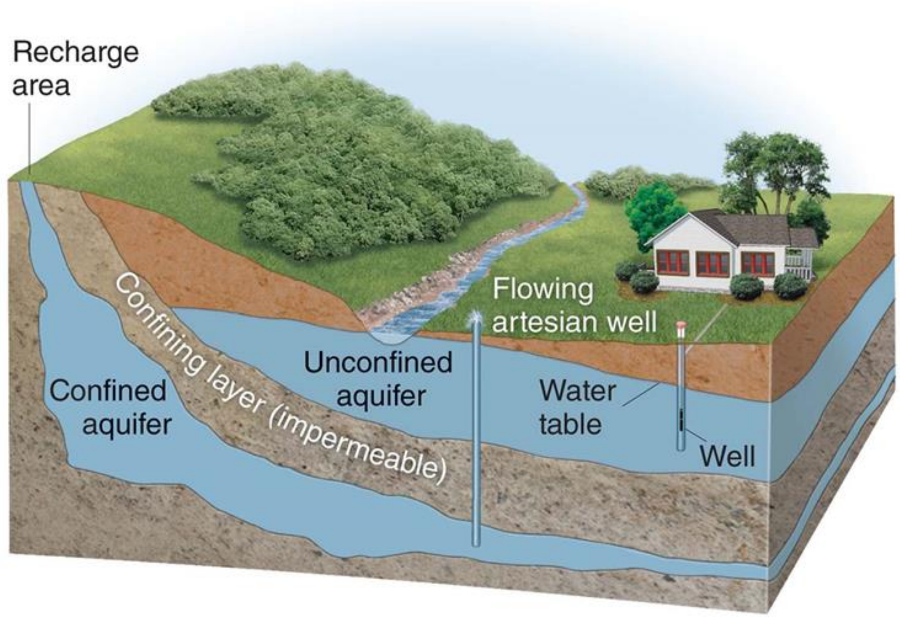

Figure 26.2
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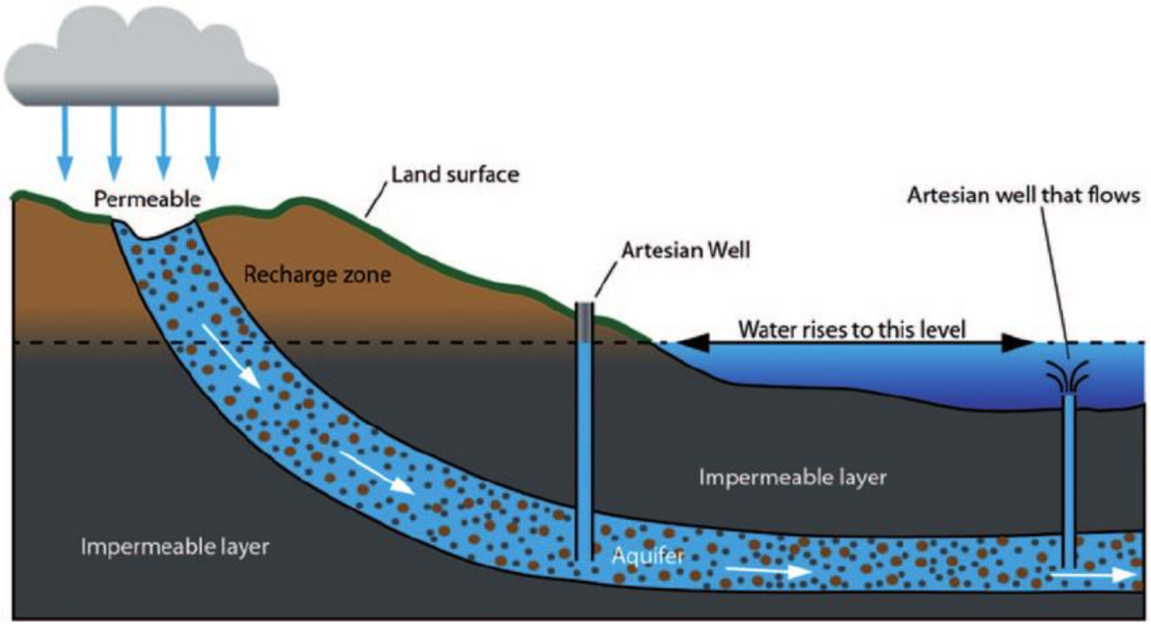
Groundwater recharge is the process by which water from precipitation percolates through the soil and works its way into the groundwater.

Note that the only time a confined aquifer can recharge is if a layer of rock has a surface opening that can serve as a recharge area.

Springs and Wells

Springs are natural sources of water formed when water from an aquifer percolates up to the ground surface.

An **artesian well** is created by drilling a hole into a confined aquifer.



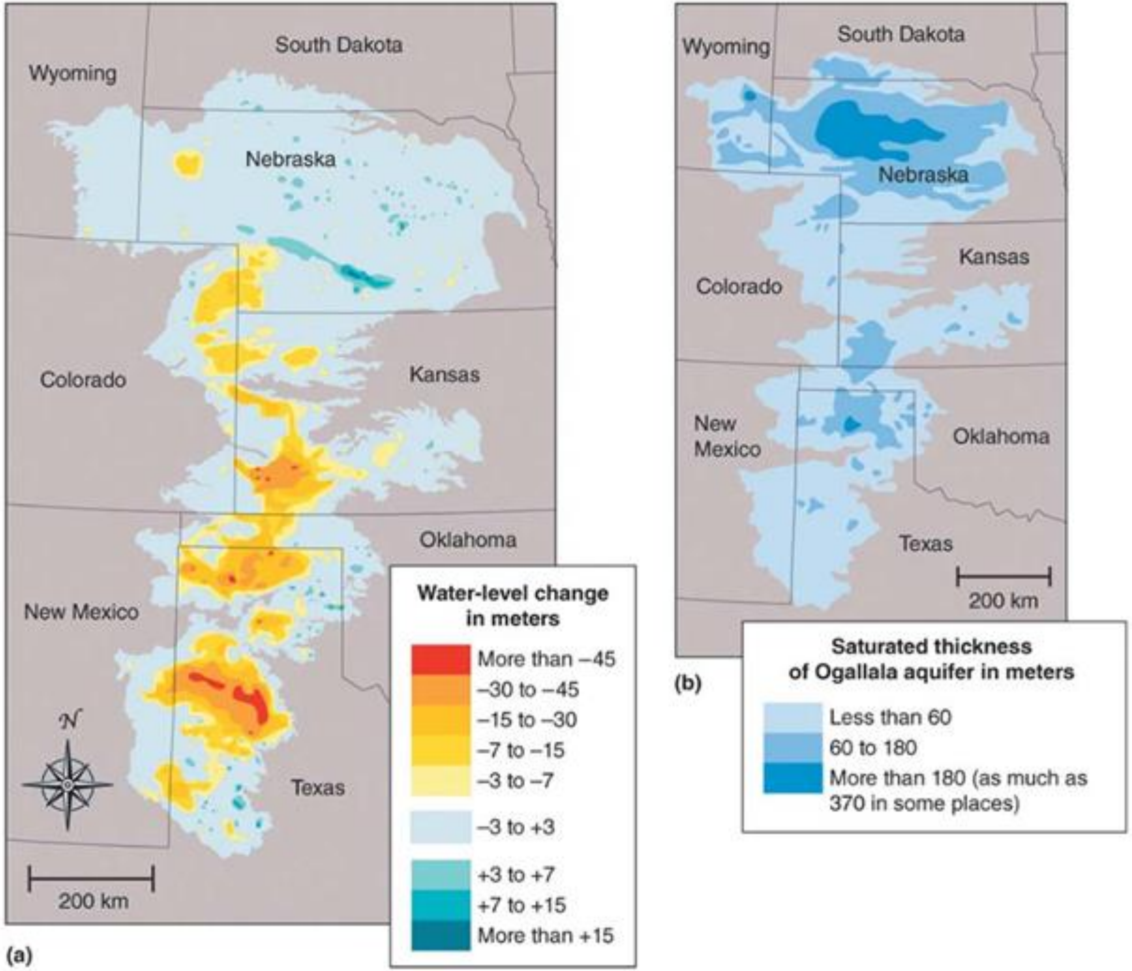


Figure 26.4
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Data from http://pubs.usgs.gov/fs/2004/3097/ and http:// ne.water.usgs.gov/ogw/hpwlms/

Ogallala aquifer

Largest aquifer in the United States. It's current usage surpasses the recharge rate and it's possible it could empty in this century.

What do we do when the Great Plains runs out of water?

Cone of Depression

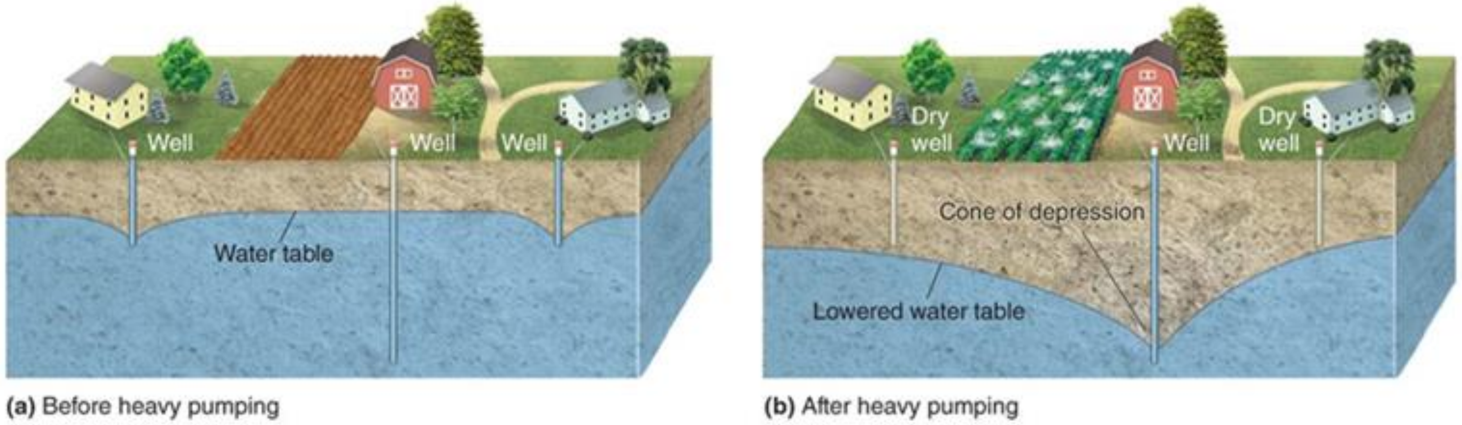

Figure 26.5
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A **cone of depression** is the area lacking groundwater due to rapid withdrawal by a well.

This can cause nearby shallow wells to dry out.

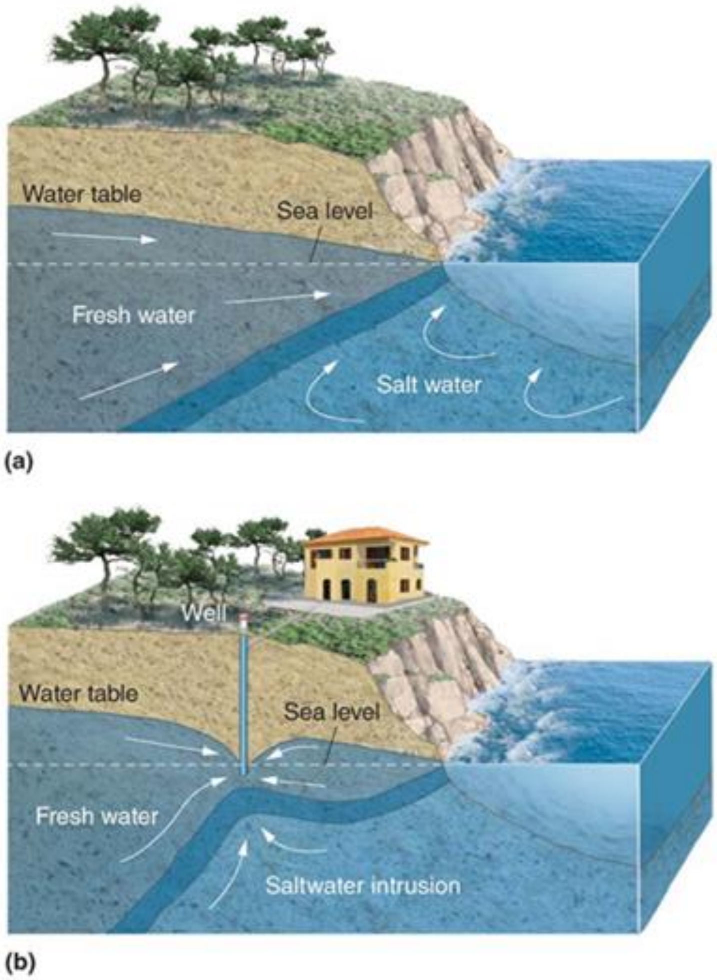

Figure 26.6
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Saltwater Intrusion

Saltwater Intrusion occurs when water infiltrates an area where groundwater pressure has been reduced from extensive drilling of wells.

This occurs because the water table lowers and the water pressure is reduced in the aquifer, allowing nearby salt water to contaminate the well water with salt.

Surface Water

The fresh water that exists above ground is known as the surface water. This includes streams, rivers, ponds, lakes, and wetlands and usually represent freshwater biomes.

The **floodplain** is the land adjacent to a river and are usually very fertile. Popular floodplains are settlements near the largest rivers such as the Nile river in Egypt, Amazon in South America, Congo in Africa, and the Yangtze in China, the latter three being the largest rivers in the world.

Surface Water

Lakes are created by a variety of processes including tectonic activity and glaciation. Their size is measured in deepness and surface area. Depending on how the lakes are formed will lead it to having a higher or lower level of salt. If a lake is formed by tectonic activity it can cause a saltier lake since it was water from the ocean. A good example of this is the Caspian Sea in western Asia.

Surface Water

Sometimes lakes can form due to deep fissures that fill with water (still tectonic). Examples of this are Lake Victoria and Lake Tanganyika in Africa and Lake Baikal in Asia.

Over thousands of years, glacial movement can scrape large depressions in the land that fill with water. It's believed this played a major role in creating the Great Lakes in north America.

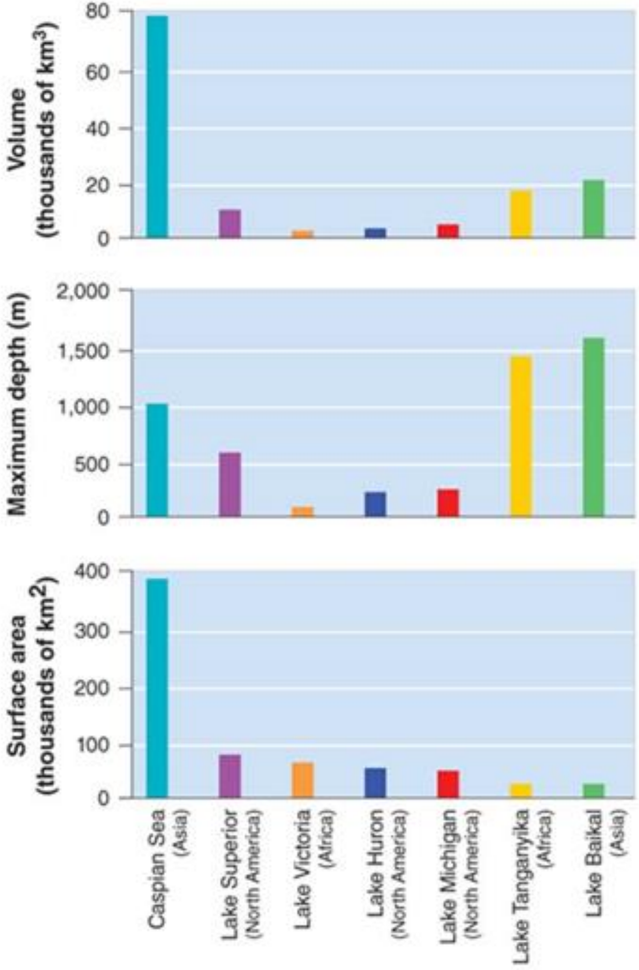

Figure 26.7
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Data from http://wldb.ilec.or.jp/LakeDB2/

Surface Water

Lakes can be measured by volume, maximum depth, and surface area.

Atmospheric Water Produces Precipitation

The Dust Bowl in 1935 - Stratford Texas

Even though the atmosphere contains a small percentage of the water on Earth, that atmospheric water is essential to global water distribution. In arid regions, people rely on precipitation for their water needs.

Droughts lead to direct losses of human lives, livestock, and crops as well as long-term effect on soil. Many nutrients, such as nitrogen and phosphorus, depend on water to cycle through the ecosystem. If topsoil dries out too much, it can blow away in the wind or even become completely impermeable.

Human Activities Connected to Droughts

Austin, TX 2015 Memorial Day Flooding

From the 1920's to 1930's the conversion of wheat fields from native grasslands increased droughts due to wheat fields being more susceptible by soil erosion.

On April 14, 1935 one dust storm completely blocked the sun in the southern Great Plains. - "Black Sunday" - This dust traveled as far as Washington D.C.

Humans have also created **impermeable surfaces**, such as pavements and buildings, that do not allow water to penetrate the soil. This contributes to flooding.

Module 27: Human Alteration of Water Availability

After this module you will be able to……

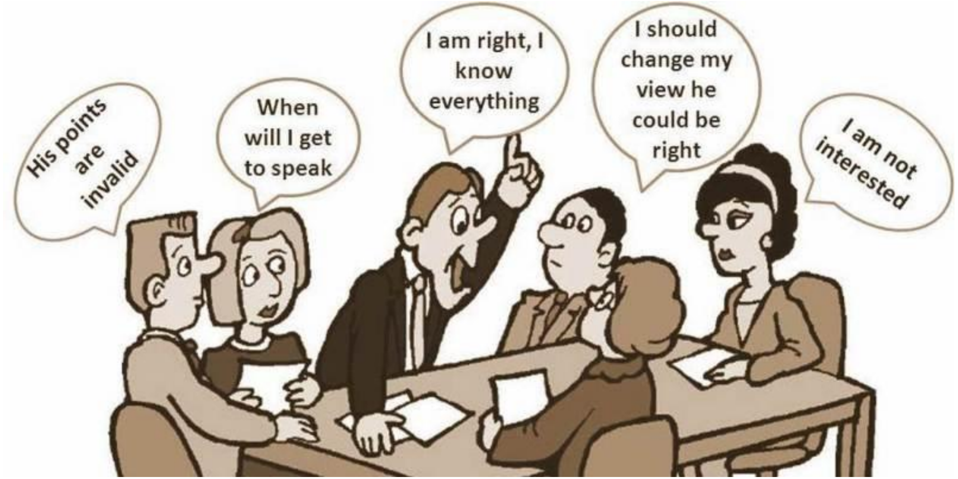
1) Compare and contrast the roles of levees and dikes
2) Explain the benefits and costs of building dams
3) Explain the benefits and costs of building aqueducts
4) Describe the processes used to convert salt water into fresh water

Levees and Dikes to Prevent Flooding

Levees are enlarged banks built up on each side of the river to help reduce flooding. The Mississippi River has the largest system of levees in the world, featuring 2400 km of levees that offer flood protection to more than 15 million acres of floodplains.

Levees and Dikes to Prevent Flooding

Levees also cause challenges. Natural floodwaters no longer add fertility to the floodplains by depositing sediments. These sediments now travel farther downstream and settle where rivers enter the ocean.



Levees and Dikes to Prevent Flooding

Dikes are enlarged banks built to prevent ocean waters from flooding adjacent land. Dikes are common in northern Europe, where large areas of farmlands lie below sea level.

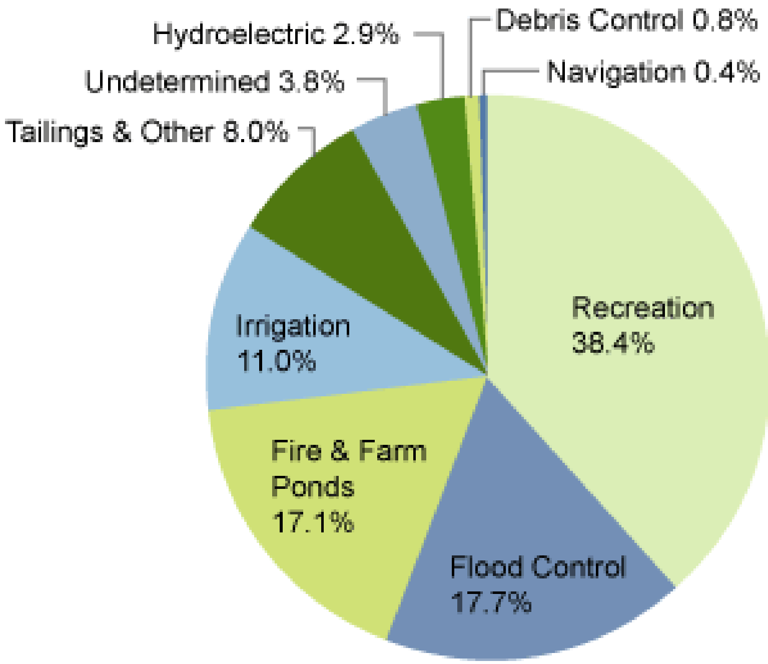
Some dikes in the Netherlands have been used for 2000 years where 27% of the land is below sea level.

Dams to Restrict the Flow of Streams and Rivers

Mansfield Dam

Dams are barriers that run across a river or a stream to control the flow of water. The water created by damming a river or stream is called a **reservoir**. The water can then be used for a variety of purposes such as human consumption, generation of electricity, flood control, and recreation.

Dams to Restrict the Flow of Streams and Rivers



Although hydroelectric dams are some of the largest dams in the world, the represent only 2.9% of all dams in the United States. 17.7% of dams are built with the primary purpose of flood control while 38.4% are built for recreation.

Dams to Restrict the Flow of Streams and Rivers

Dams can be very costly. The Three Gorges Dam in China took 13 years to construct and another 2 years to fill with water. It forced 1.3 million people to relocate due to its construction.

Dams also interrupt the natural flow of water to which many organisms are adapted to. For migrating fish, such as salmon, dams represent an insurmountable obstacle to breeding. This loss creates a cascading effect on other organisms such as bears.

Dams to Restrict the Flow of Streams and Rivers

Fish ladders can help alleviate these problems. They are built like a set of stairs with water flowing over them which allow migrating fish to swim up the ladder to reach their traditional breeding grounds.

Aqueducts Carry Water From One Location to Another

Aqueducts are canals or ditches used to carry water from one location or another. Los Angeles and New York depend on aqueducts to meet their daily needs of water. The Catskill Aqueduct brings clean, fresh water over 120 miles from the streams of the Catskill Mountains to New York City. The Colorado River Aqueduct is a canal that carries water over 250 miles from the Colorado River to Los Angeles.

Aqueducts Carry Water From One Location to Another

Aqueducts can be expensive and disturbs natural habitats. Aboveground aqueducts can fragment an environment and construction of underground an underground pipeline can still disrupt the environment.

Certain rivers , such as the Colorado River and the Rio Grande now loses so much water due to aqueducts that it often goes dry during before reaching the ocean.

Consequences of River Diverging

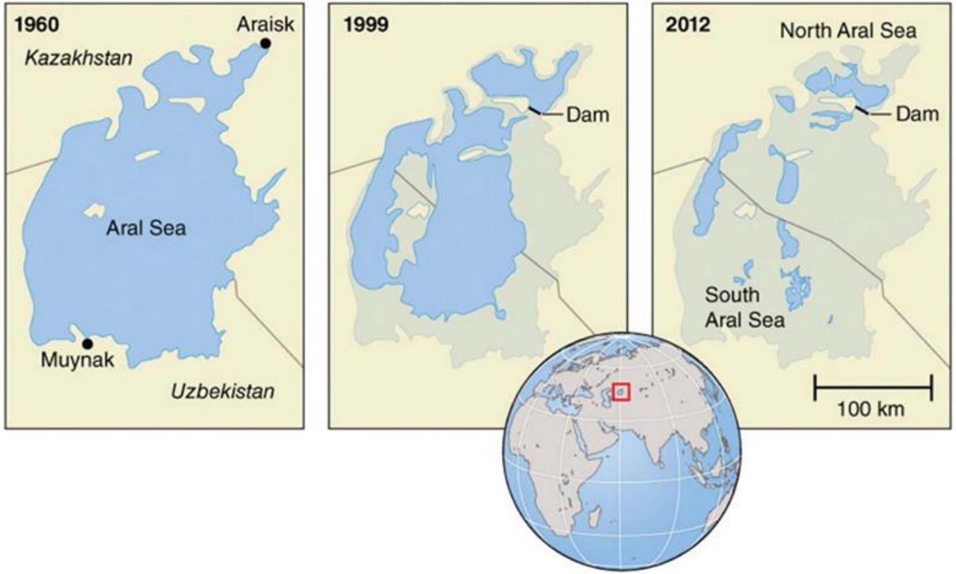


Figure 27.5
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In the 1950's the Soviet Union diverted two rivers that fed the Aral Sea in Central Asia. This dramatically decreased freshwater input into the Aral Sea, increased the salinity of the remaining lake water through the **estuary**, and destroyed fish populations. It's surface area was reduced by 60% So much water was removed the sea was split into two parts, now called the North Aral Sea and South Aral Sea. Efforts to save the South Aral Sea are deemed too expensive and have been abandoned.

Desalination Converts Salt Water Into Fresh Water

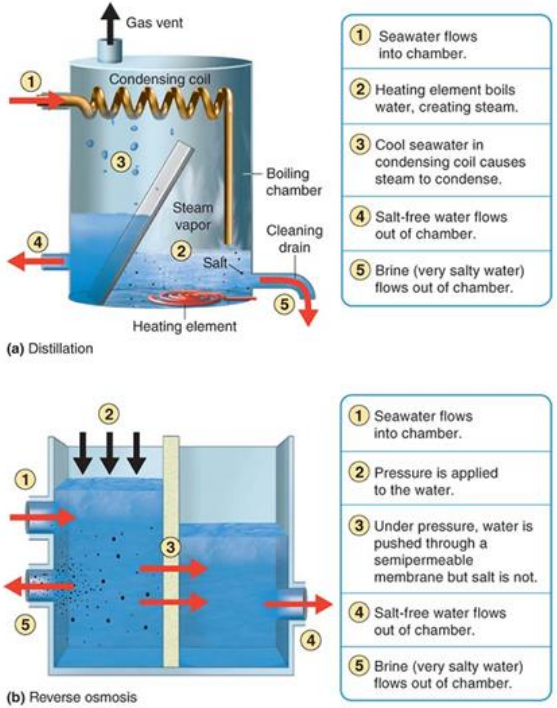

Figure 27.6
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Desalination is the process of removing the salt from salt water.

Distillation is the process of desalination in which water is boiled and the resulting steam is captured and condensed to yield pure water.

Reverse Osmosis is the process of desalination in which water is forced through a thin semipermeable membrane at high pressure.

Distribution of Freshwater

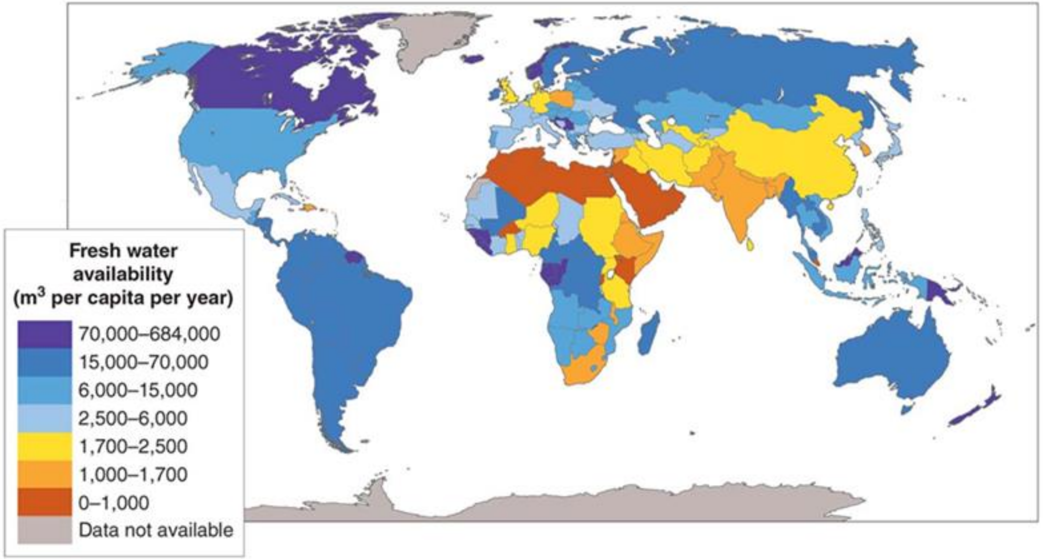

Figure 27.7
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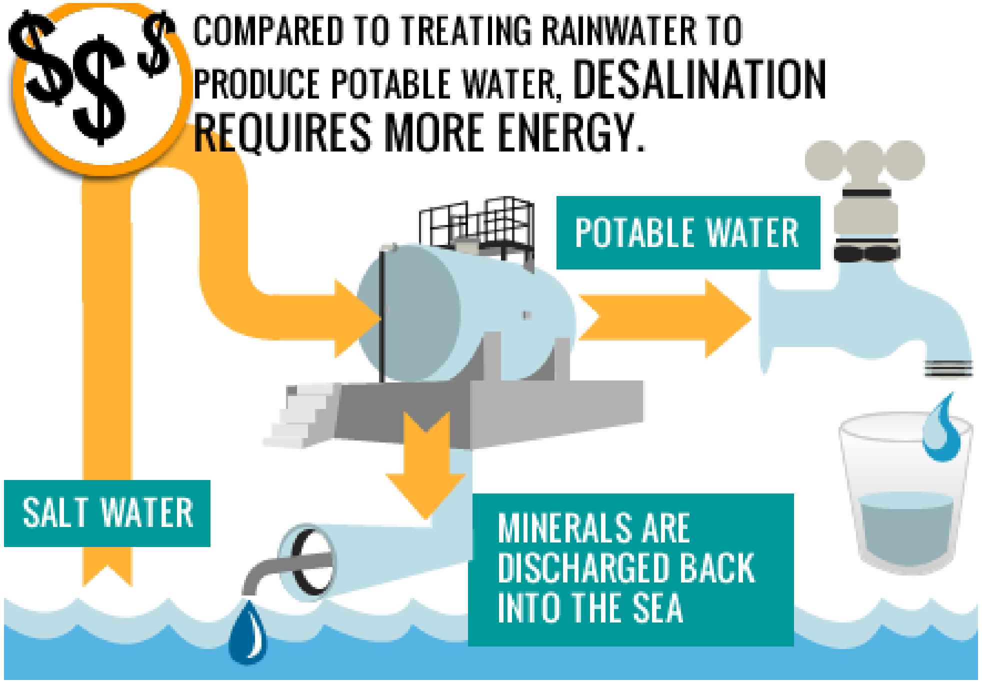
Freshwater is not evenly distributed in the world, which complicates certain areas with obtaining water. For example, Middle Eastern and North African countries represent about 5 percent of the world's population, yet they have less than 1 percent of the freshwater available for drinking.

Desalination Converts Salt Water Into Fresh Water

Desalination can be challenging. Distillation requires a great deal of energy in order to boil the water and can be very expensive. Reverse osmosis is is more efficient and cheaper than distillation, but leaves behind brine, a very high concentration of salt water which cannot be deposited on land due the effects on plant and animal life. Typically, brine is returned to the ocean, although it's high salt concentration can still harm ocean life in the areas where it's dumped.



Module 28: Human Use of Water Now and in the Future

After this module you will be able to……

1) Compare and contrast the four methods of agricultural irrigation
2) Describe the major industrial and household uses of water
3) Discuss how water ownership and water conservation are important in determining future water availability

Water is Used for Agriculture

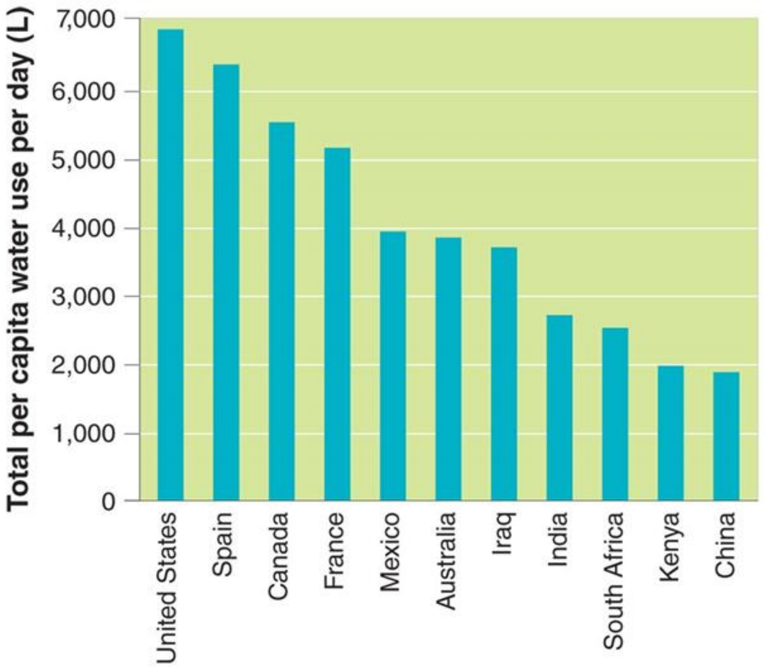


Figure 28.1
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Water footprint is the total daily per capita use of freshwater. This water use reflects the total water use by a country for agriculture, industry, and residences divided by the population of that country. It allows us to compare water use among nations.

For example, a person living in the US, Spain, or Canada uses about three times more water than a person living in Kenya or China.

Water is Used for Agriculture

Since the largest use of water is for agriculture the output has grown along with human population. The amount of water used for irrigation throughout the world has more than doubled in the last 50 years. Together, India, China, the United States, and Pakistan account for more than half of the irrigated land in the entire world.

Water is Used for Agriculture

The largest use of water worldwide is for agriculture. During the last 50 years, as agriculture output has grown along with human population, the amount of water used for irrigation throughout the world has more than doubled. Together, India, China, the US, and Pakistan account for more than half the irrigated land in the world.

In the US, approximately one-third of all freshwater use is for irrigation. Raising livestock for meat also requires vast quantities of water. Producing 1 kg of beef in the US requires about 11 times more water than producing 1 kg of wheat.

Irrigation

Irrigation practices can conserve water in agriculture. There are four major techniques for irrigating crops:

- Furrow irrigation
- Flood irrigation
- Spray irrigation
- Drip irrigation

Furrow Irrigation

Furrow Irrigation is the oldest technique, very easy, and inexpensive. The farmer digs trenches, or furrows, along the crop rows and fills them with water, which seeps into the ground and provides moisture to plant roots. It's about 65% efficient, while the other 35% either runs off the field or evaporates.

Flood Irrigation

Flood Irrigation involves flooding an entire field with water and letting the water soak in evenly. This technique is generally more disruptive to plant growth than furrow irrigation, but is also slightly more efficient, ranging from 70-80% efficiency.

Spray Irrigation

Spray Irrigation involves pumping water from a well into an apparatus that contains a series of spray nozzles that spray water across the field. This is 75-95% efficient, but is more expensive than a furrow or flood irrigation system and uses more energy in order to pump the water.

Drip Irrigation

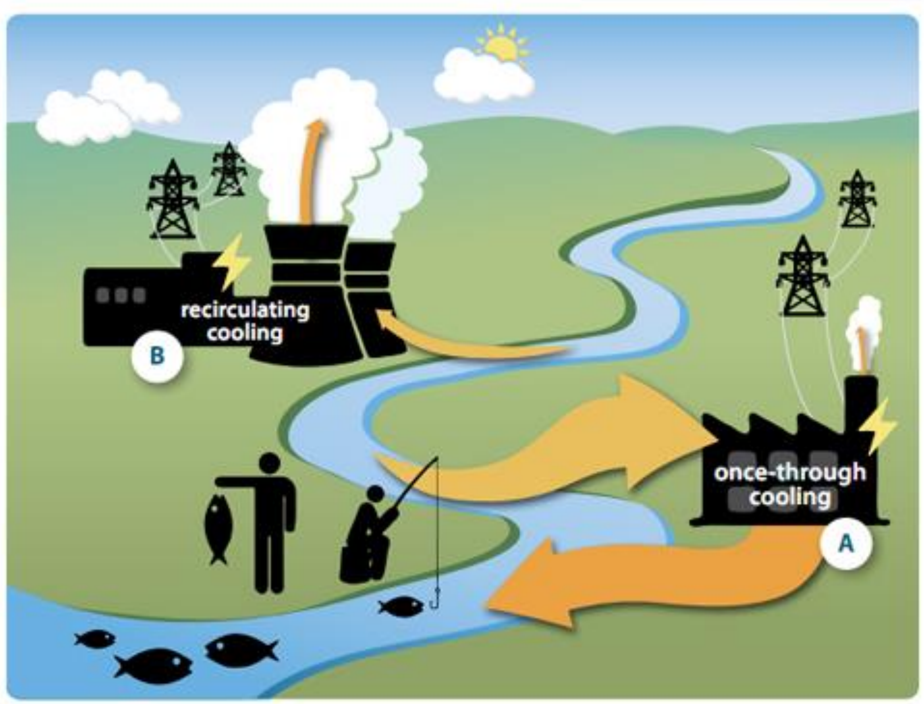
Drip Irrigation uses a slowly dripping hose that is either laid on the ground or buried beneath the soil. This is over 95% efficient. It also has the added benefit of reducing weed growth because the surface soil remains dry.

Hydroponic Agriculture

Hydroponic Agriculture is the cultivation of plants in greenhouse conditions by immersing roots in a nutrient-rich solution. Water that is not taken up by the plant can be reused, so it uses up to 95% less water than traditional irrigation techniques. Crops can be grown under ideal conditions, grown any every season of the year, and grown without the use of pesticides.

Industrial Water Use

Water is used for electricity, cooling machinery, and refining metals and paper. In the United States, approximately ½ of all water used goes towards generating electricity. Some of this water is returned to its source, while some enters the atmosphere as water vapor.



Household Water Use

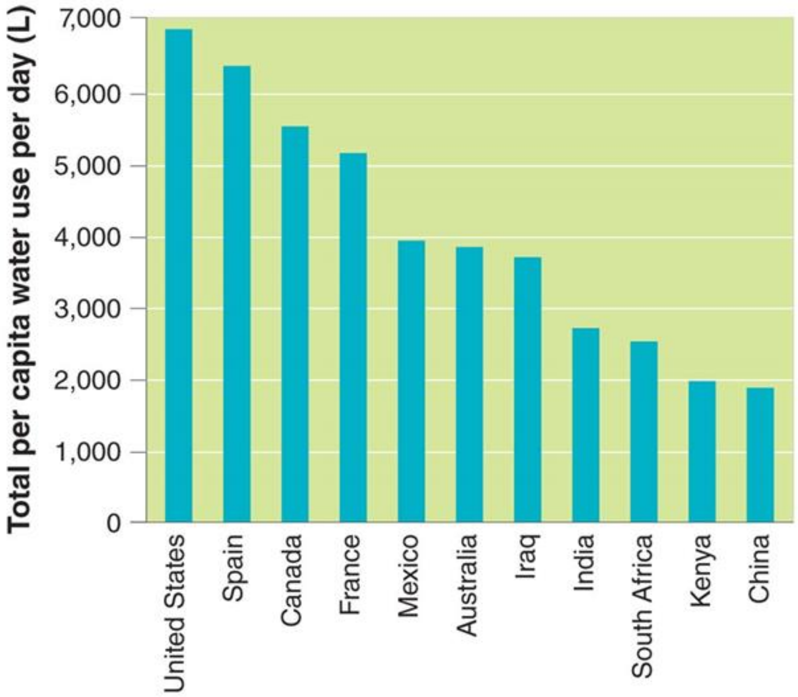


Figure 28.1
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According to the U.S. Geological Survey, household use accounts for approximately 10 percent of all water used in the United States. On average, an individual in the United States uses 157 gallons per day, whereas an average individual in Kenya uses only 11 gallons per day.

Household Water Use

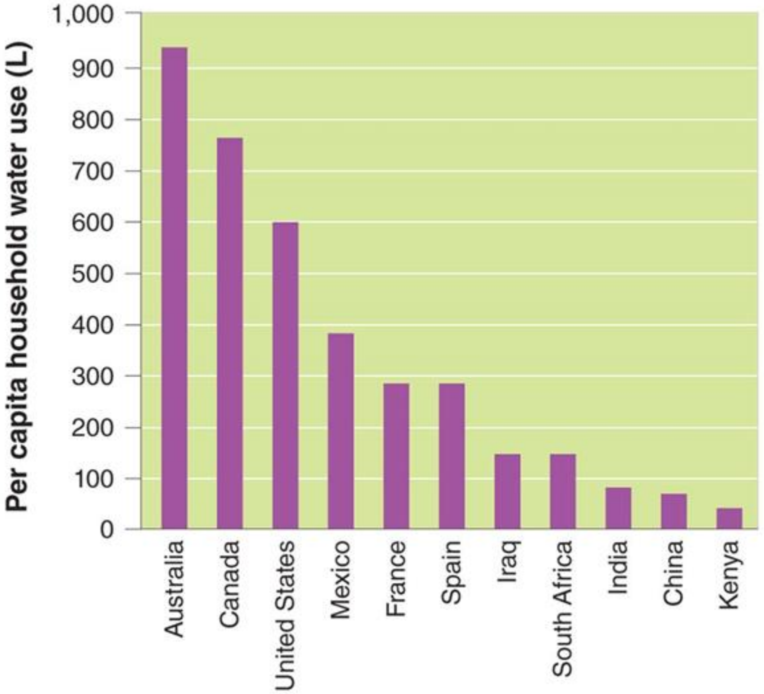

Figure 28.5
Environmental Science for AP®, Second Edition
A. K. Chapagain and A. Y. Hoekstra, Water Footprints of Nations, Vol. 1, Main Report, UNESCO-IHE. Research R

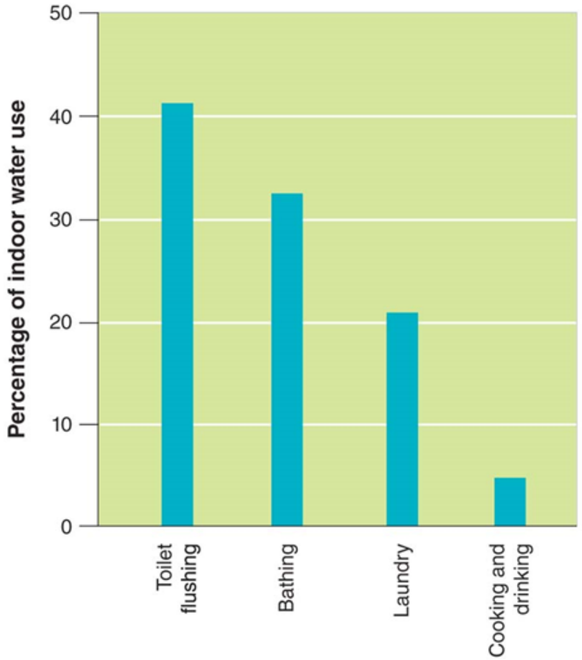

Figure 28.6
Environmental Science for AP®, Second Edition
Data from U.S. Environmental Protection Agency, 2003, http://esa21.kennesaw.edu/activ

Future Water

The future of water availability will depend on many things, including how we resolve issues of water ownership, how we improve water conservation, and-as world population grows-how we develop new water saving technologies.

Water Ownership

Water ownership is complicated. Regional and national governments often set priorities for water distribution, but they have no control over whether or not a particular year will bring an abundance of rain and snow.

Conflicts are created throughout the world over the rights of water ownership.

Water Conservation

Ultimately, there is a finite amount of water that we all must share. In recent years, many countries have begun to find ways to use water more efficiently through technological improvements, such as water fixtures, faucets, and washing machines.

In 1994, new federal standards were issued for toilets and showerheads. Dual-flush systems are becoming increasingly popular.

In some regions of the United States, plant vegetation must be appropriate for the local habitat. For example, in Las Vegas homeowners were paid to remove water-intensive turf grass from their lawns and replace it with more water-efficient native landscaping.

Some inexpensive ways to conserve water are gutter systems to collect rainwater into barrels or tanks.