

Chapter 9

Water Resources

Module 26

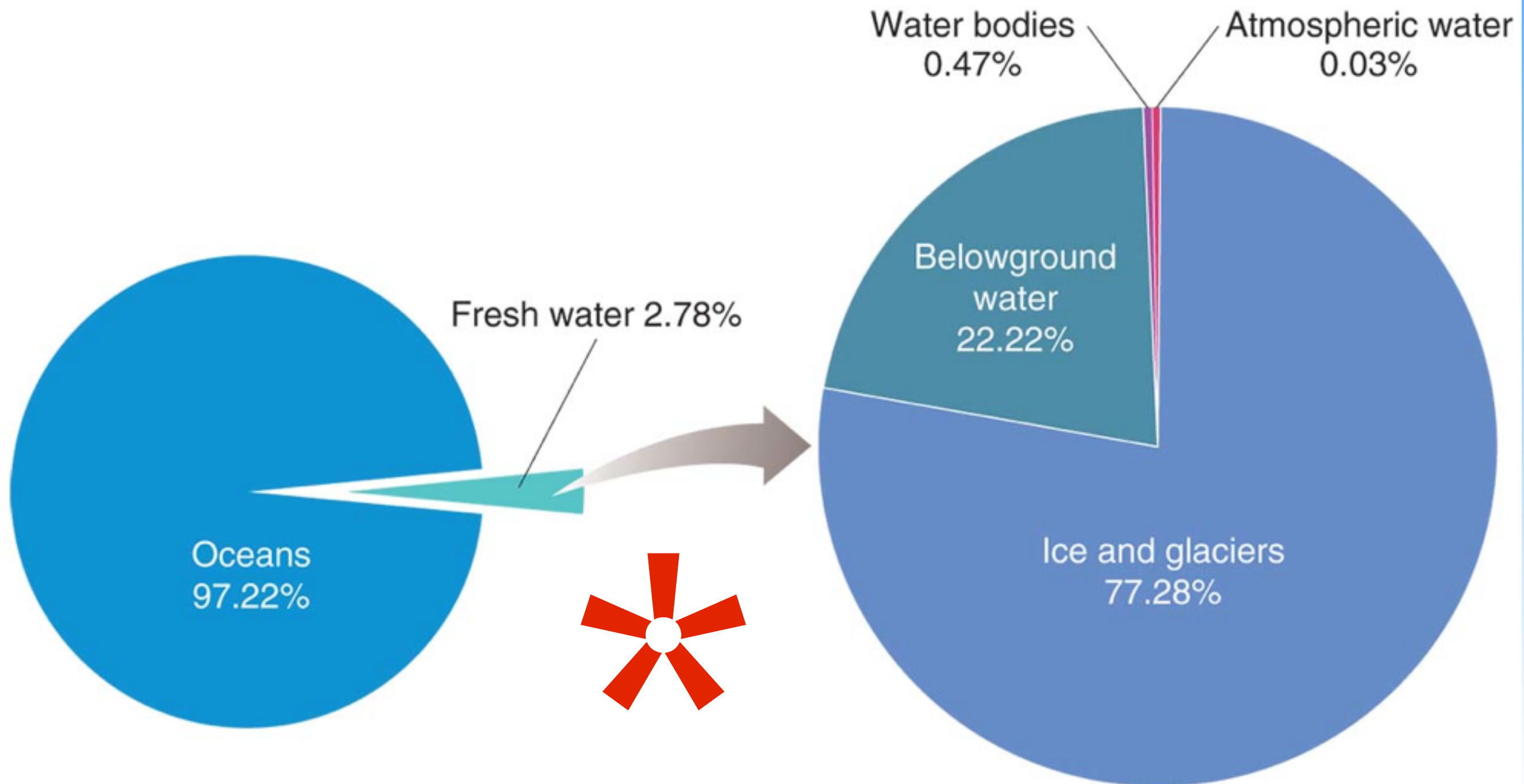
The Availability of Water

After reading this module you should be able to

- describe the major sources of groundwater.
- identify some of the largest sources of fresh surface water.
- explain the effects of unusually high and low amounts of precipitation.

Groundwater can be extracted for human use

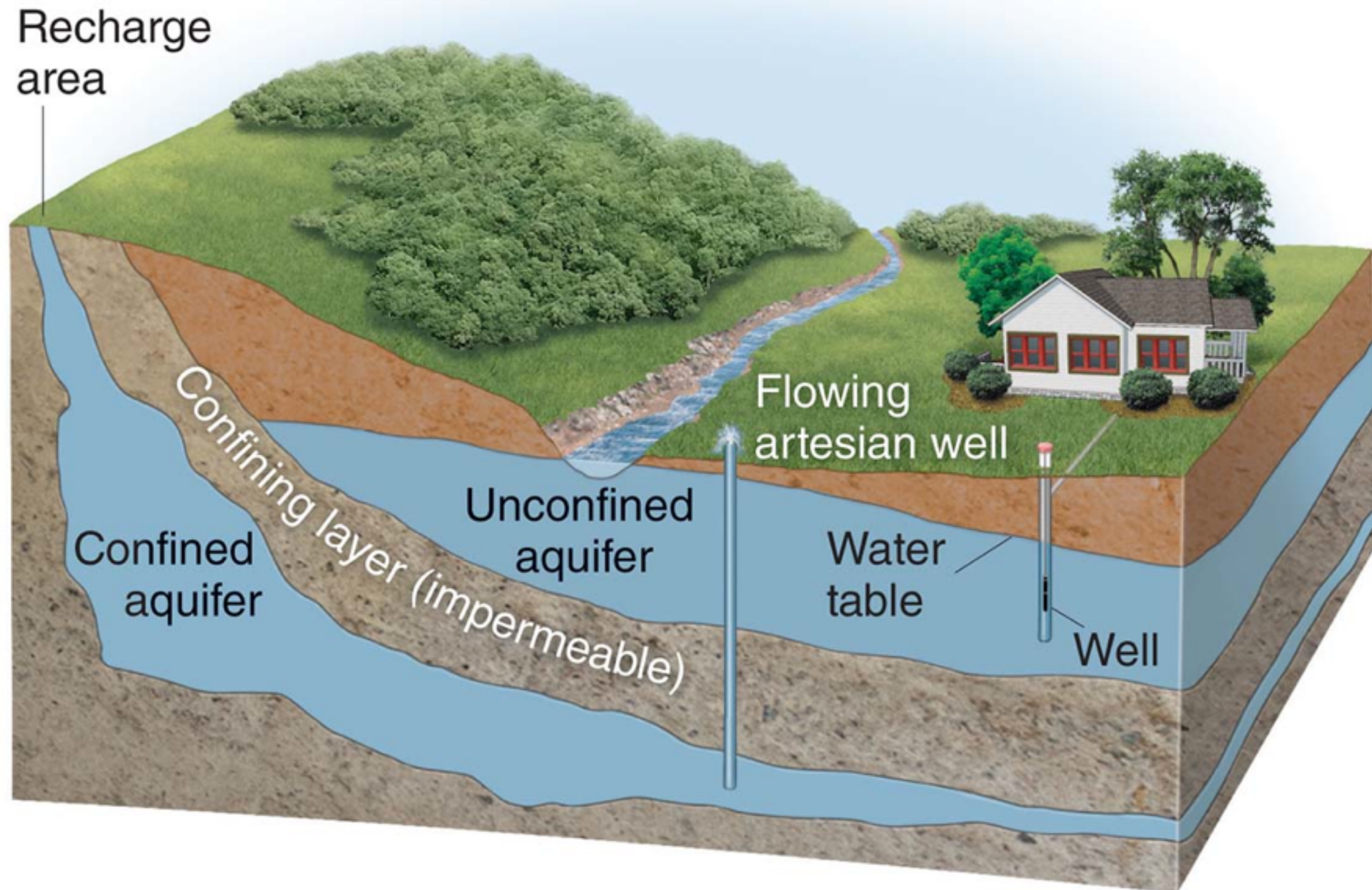
Distribution of water on Earth. Fresh water represents less than 3 percent of all water on Earth, and only about three-fourths of that fresh water is surface water. Most of that surface water is frozen as ice and in glaciers. Therefore, less than 1 percent of all water on the planet is accessible for use by humans.



Groundwater

- **Aquifer** A permeable layer of rock and sediment that contains groundwater.
- **Unconfined aquifer** An aquifer made of porous rock covered by soil out of which water can easily flow.
- **Confined aquifer** An aquifer surrounded by a layer of impermeable rock or clay that impedes water flow.

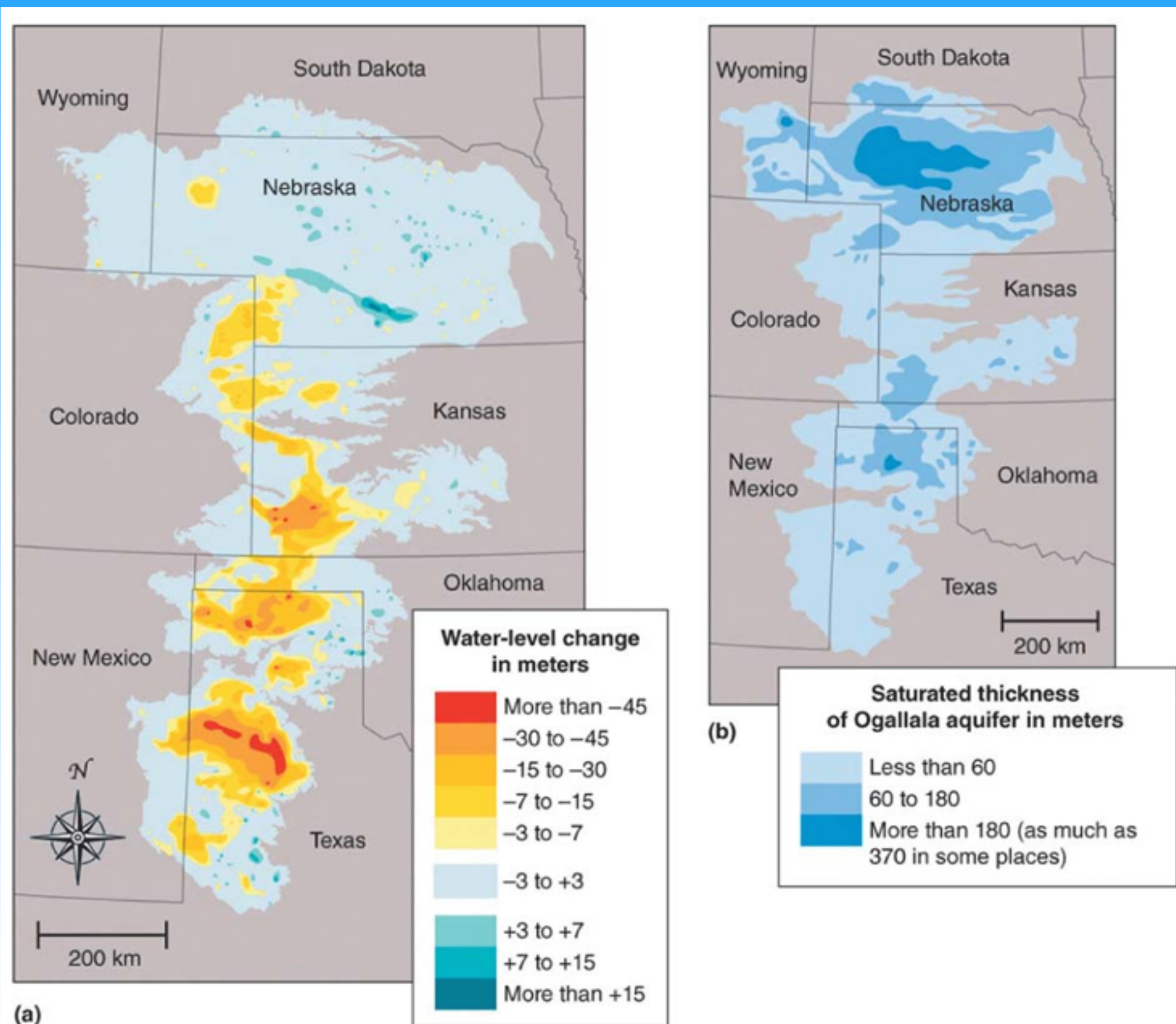
Aquifers. Aquifers are sources of usable groundwater. Unconfined aquifers are rapidly recharged by water that percolates downward from the land surface. Confined aquifers are capped by an impermeable layer of rock or clay, which can cause water pressure to build up underground. Artesian wells are formed when a well is drilled into a confined aquifer and the natural pressure causes water to rise toward the ground surface.



Groundwater

- **Water table** The uppermost level at which the water in a given area fully saturates rock or soil.
- **Groundwater recharge** A process by which water percolates through the soil and works its way into an aquifer.
- **Spring** A natural source of water formed when water from an aquifer percolates up to the ground surface.
- **Artesian well** A well created by drilling a hole into a confined aquifer.

The Ogallala aquifer. The Ogallala aquifer, also called the High Plains aquifer, is the largest in the United States, with a surface area of about 450,000 km² (174,000 miles²).



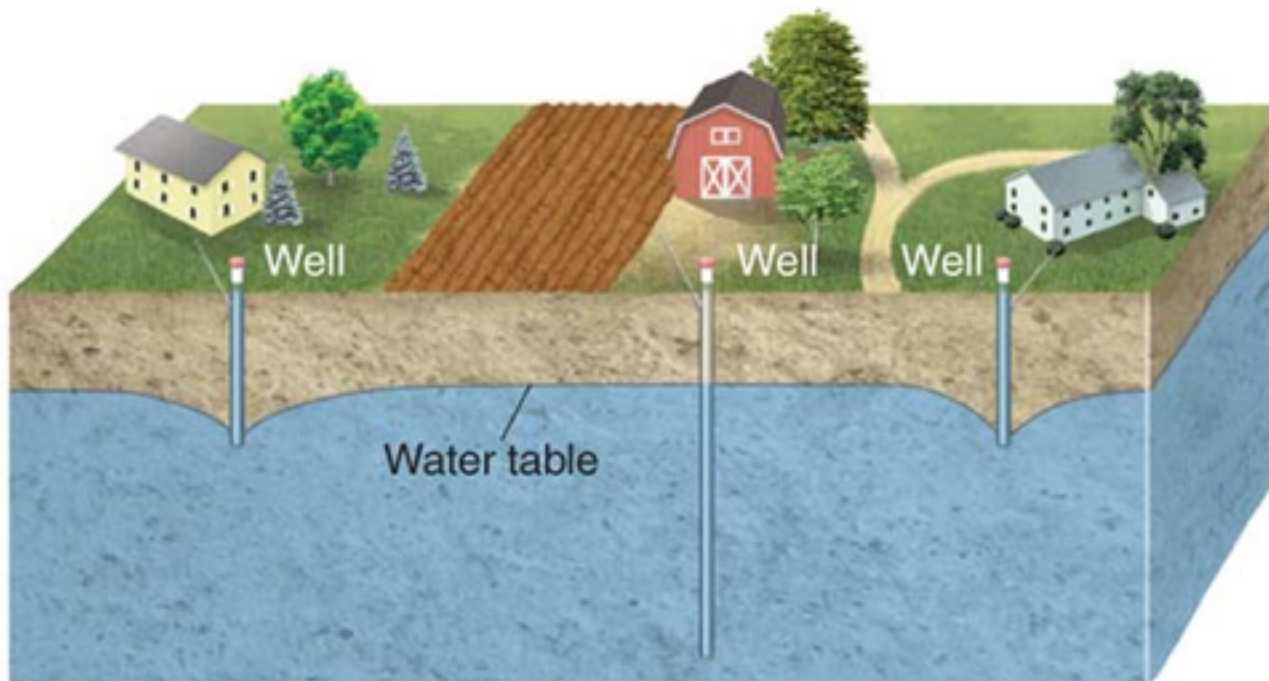
(a) The change in water level from 1950 to 2005, mostly due to withdrawals for irrigation that have exceeded the aquifer's rate of recharge.

(b) The current thickness of the aquifer.

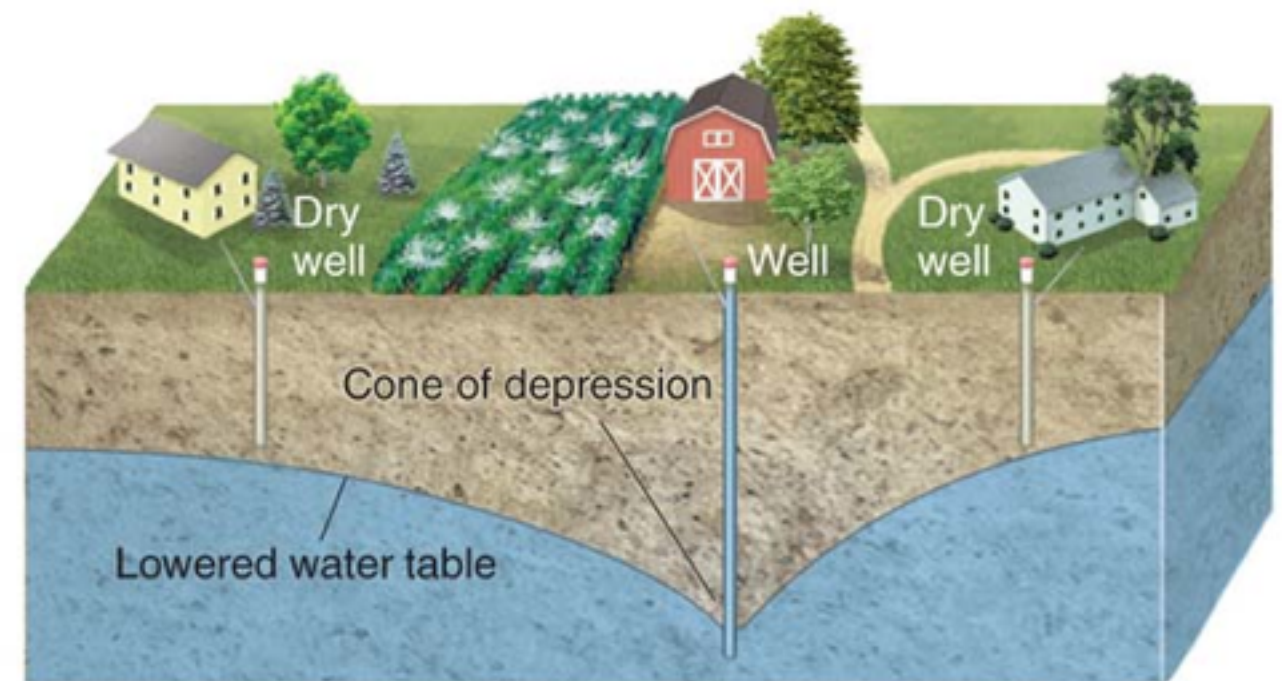
Groundwater

- **Cone of depression** An area lacking groundwater due to rapid withdrawal by a well.
- **Saltwater intrusion** An infiltration of salt water in an area where groundwater pressure has been reduced from extensive drilling of wells.

Groundwater



(a) Before heavy pumping

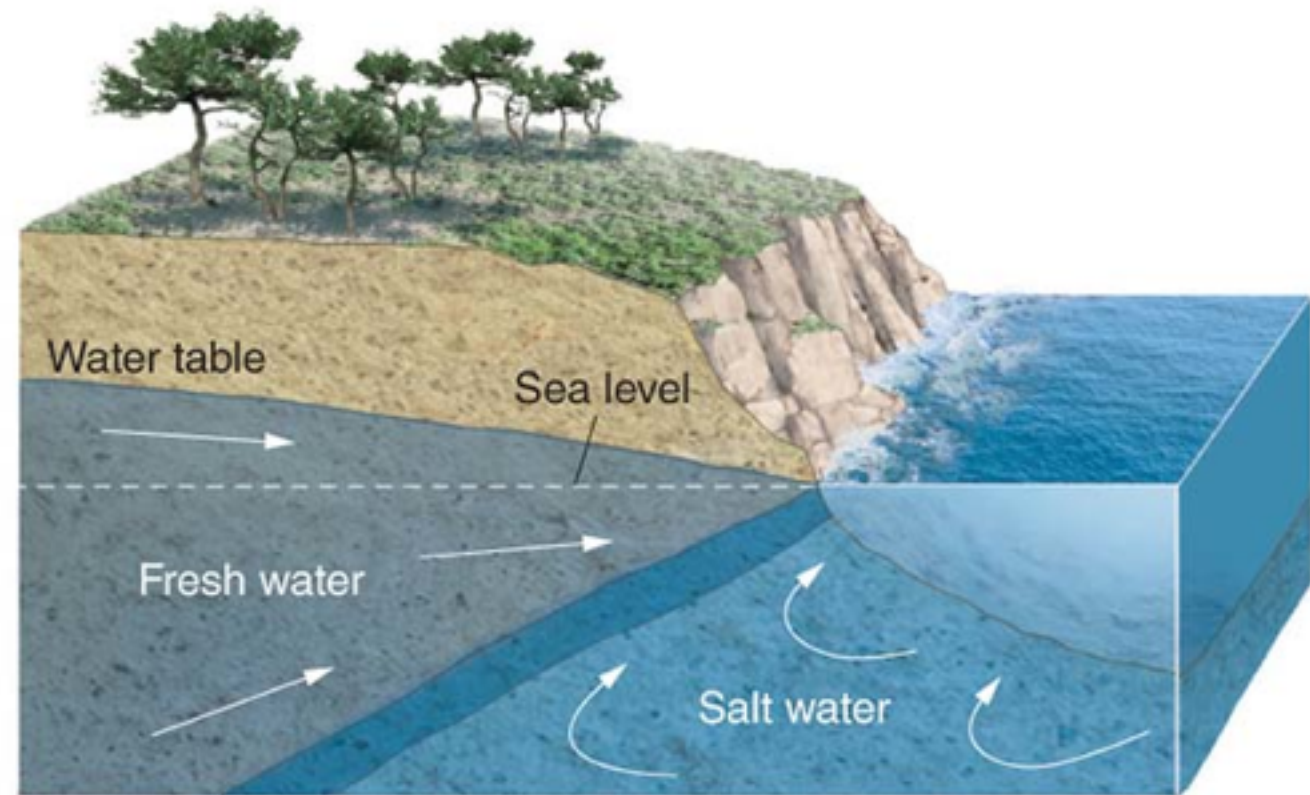


(b) After heavy pumping

Figure 26.5
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Cone of depression. (a) When a deep well is not heavily pumped, the recharge of the water table keeps up with the pumping. (b) In contrast, when a deep well pumps water from an aquifer more rapidly than it can be recharged, it can form a cone of depression in the water table and cause nearby shallow wells to go dry.

Groundwater



(a)



(b)

Saltwater intrusion. (a) When there are few wells along a coastline, the water table remains high and the resulting pressure prevents salt water from intruding. (b) Rapid pumping of wells drilled in aquifers along a coastline can lower the water table. Lowering the water table reduces water pressure in the aquifer, allowing the nearby salt water to move into the aquifer and contaminate the well water with salt.

Surface water is the collection of aquatic biomes

- Surface water is water that exists aboveground and includes streams, rivers, ponds, and wetlands.
- Early human civilizations typically settled along major rivers. WHY?
- **Floodplain** The land adjacent to a river.

Concept Check

- Compare artesian wells and springs.
- What type of aquifer is most likely to be contaminated by anthropogenic chemicals?
- Why is large-scale use of water from a confined aquifer unsustainable.
- How does salt water intrusion occur?

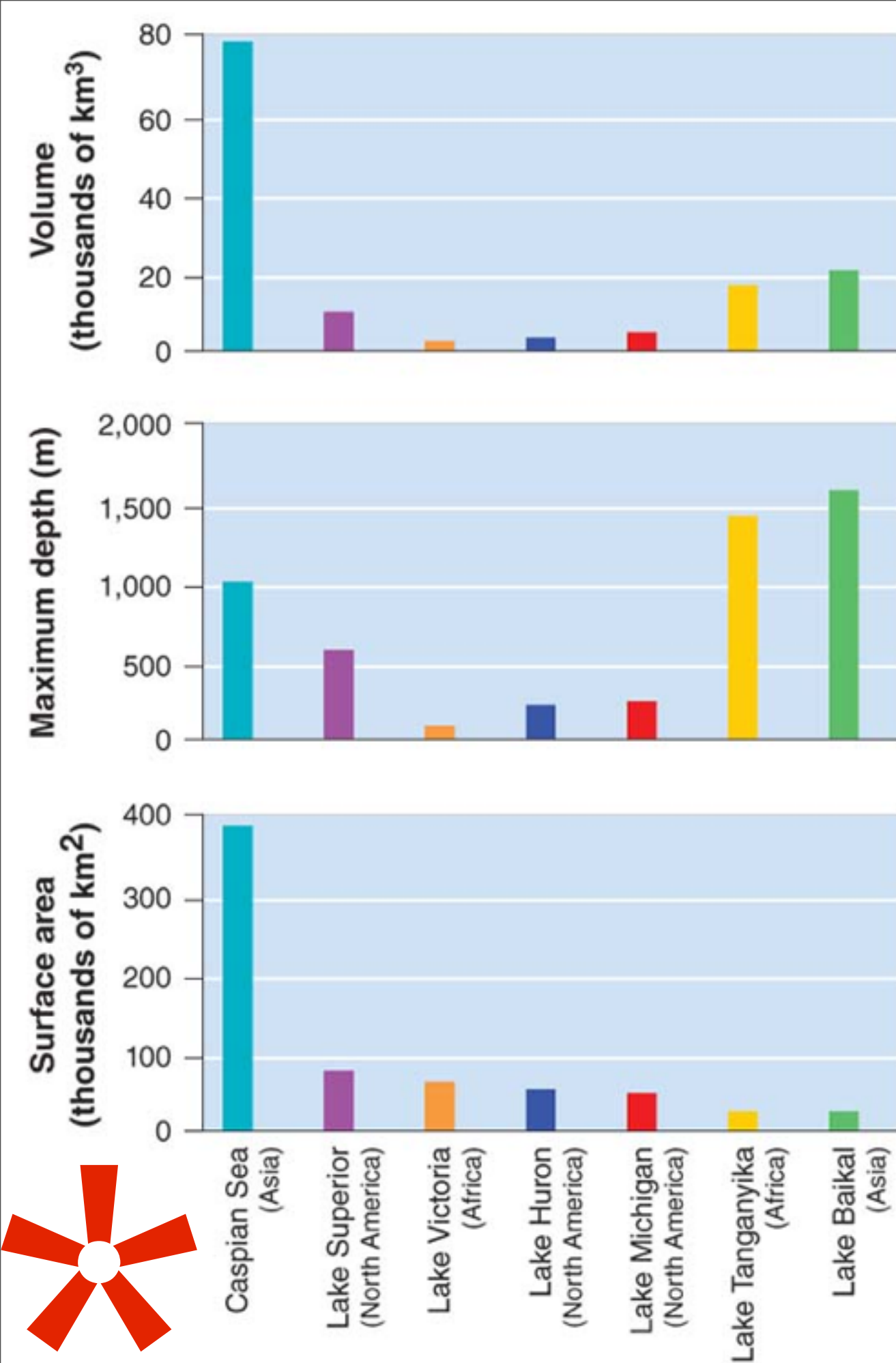
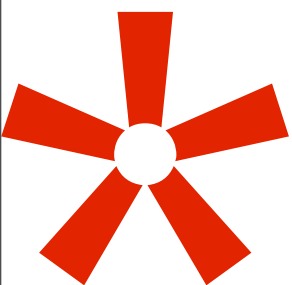
Surface Water

The world's largest lakes.
Measurements of surface area, depth, and volume are shown for each lake.

...greatest depth?

...greatest volume?

...smallest surface area?



Atmospheric water produces precipitation

- Although the atmosphere contains only a very small percentage of the water on Earth, that atmospheric water is essential to global water distribution.
- **Impermeable surface** Pavement or buildings that do not allow water penetration.

Reading Comprehension / Small Group

- List human and ecological impacts associated with droughts.
- Explain how human activities worsen the effects of droughts and floods.

Module 27

Human Alteration of Water Availability

After reading this module you should be able to

- compare and contrast the roles of levees and dikes.
- explain the benefits and costs of building dams.
- explain the benefits and costs of building aqueducts.
- describe the processes used to convert salt water into fresh water.

Levees and dikes are built to prevent flooding

- **Levee** An enlarged bank built up on each side of a river.
- **Dike** A structure built to prevent ocean waters from flooding adjacent land.

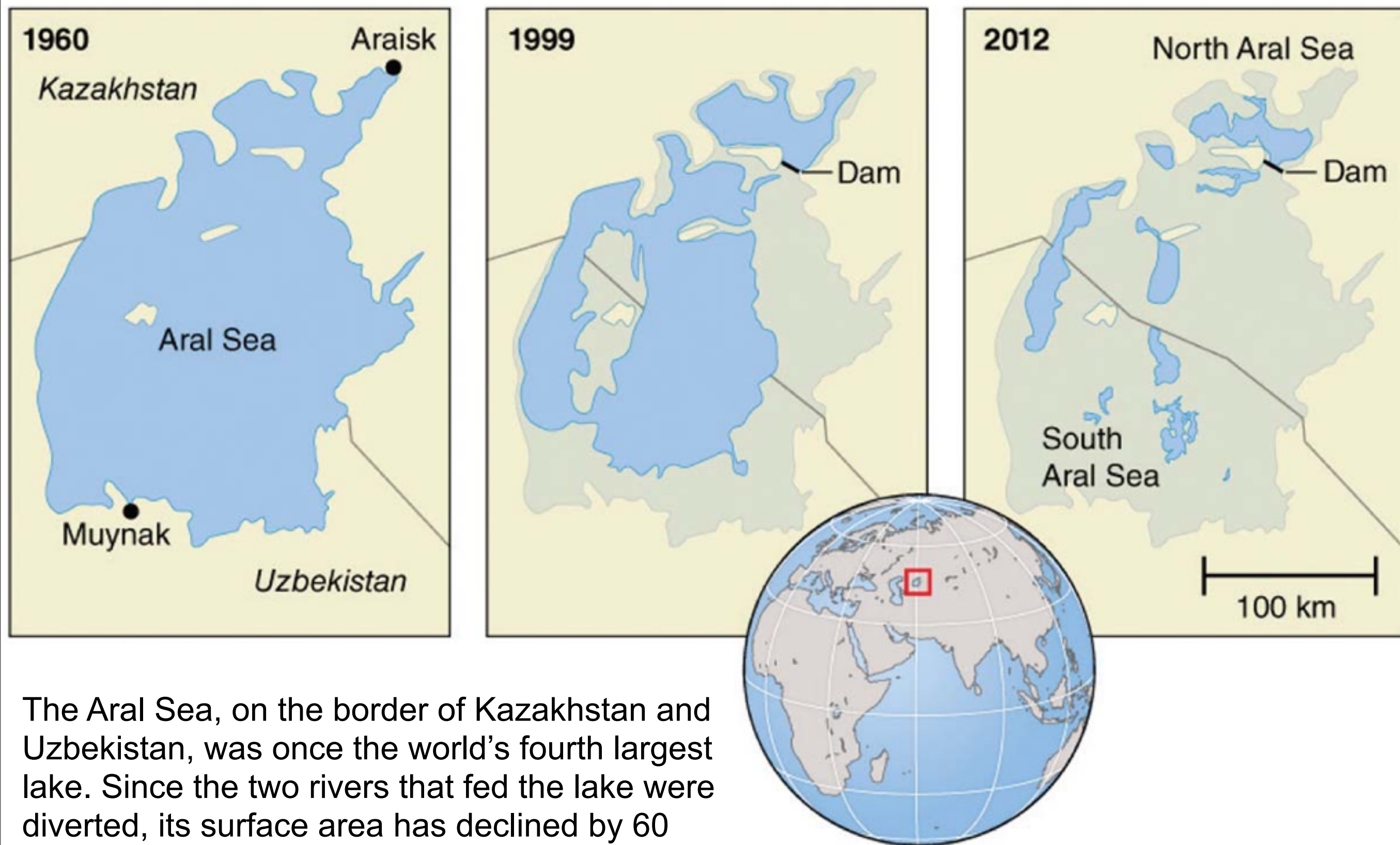
Dams are built to restrict the flow of streams and rivers

- **Dam** A barrier that runs across a river or stream to control the flow of water.
- **Reservoir** The water body created by a damming a river or stream.
- **Fish ladder** A stair-like structure that allows migrating fish to get around a dam.

Aqueducts carry water from one location to another

- **Aqueduct** A canal or ditch used to carry water from one location to another.
 - In the United States, both Los Angeles and New York City depend on aqueducts to meet their daily water needs.
 - *The consequences of water diversion can be severe.
- * See your table from the chapter opener Klamath River

Consequences of river diversion. Diverting river water can have devastating impacts downstream.



The Aral Sea, on the border of Kazakhstan and Uzbekistan, was once the world's fourth largest lake. Since the two rivers that fed the lake were diverted, its surface area has declined by 60 percent and the lake has split into two parts: the North and South Aral seas.

Individual work ---> Group Work

- Name three primary purposes of dams
- Create a table of the Pros and Cons to dams
- Create a table of the Pros and Cons to aqueducts
- List a series of events that occurred as a result of water diversions from the Aral Sea during the Soviet Period.

Desalination converts salt water into fresh water

- **Desalination** The process of removing the salt from salt water. *Also known as **Desalinization**.*
- **Distillation** A process of desalination in which water is boiled and the resulting steam is captured and condensed to yield pure water.
- **Reverse osmosis** A process of desalination in which water is forced through a thin semipermeable membrane at high pressure.

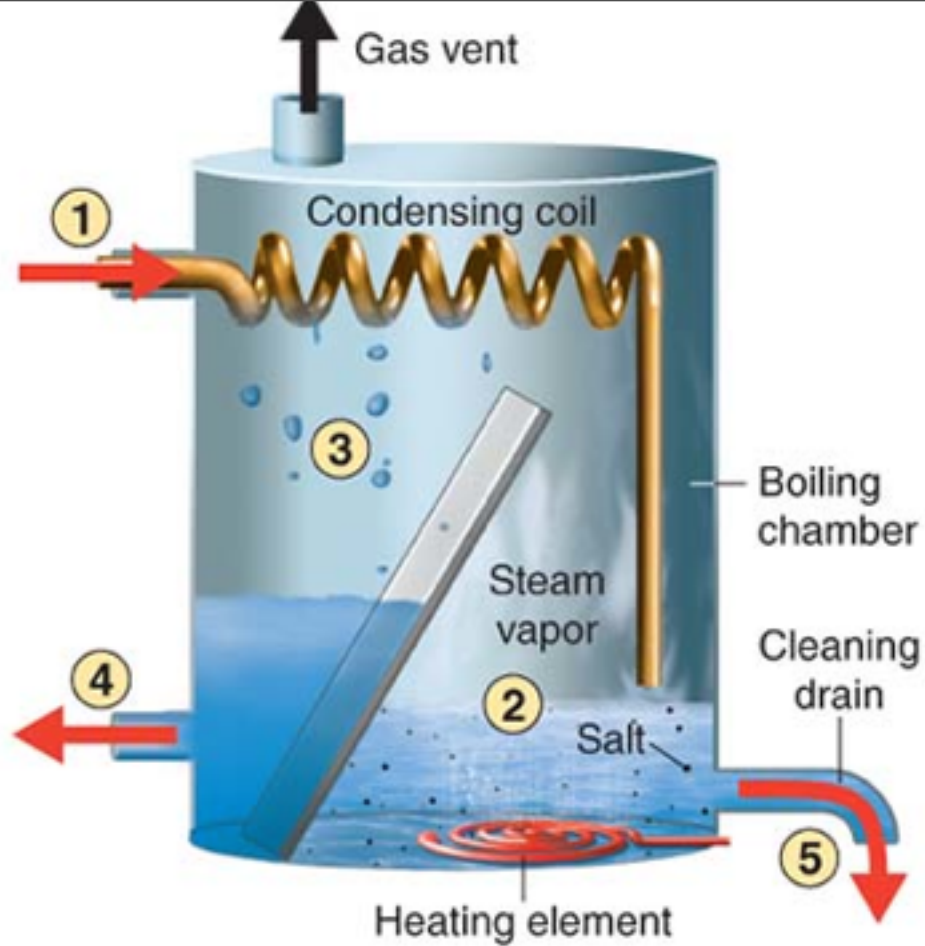
Desalination

Desalination technologies. Salt water can be converted into fresh water in one of two ways.

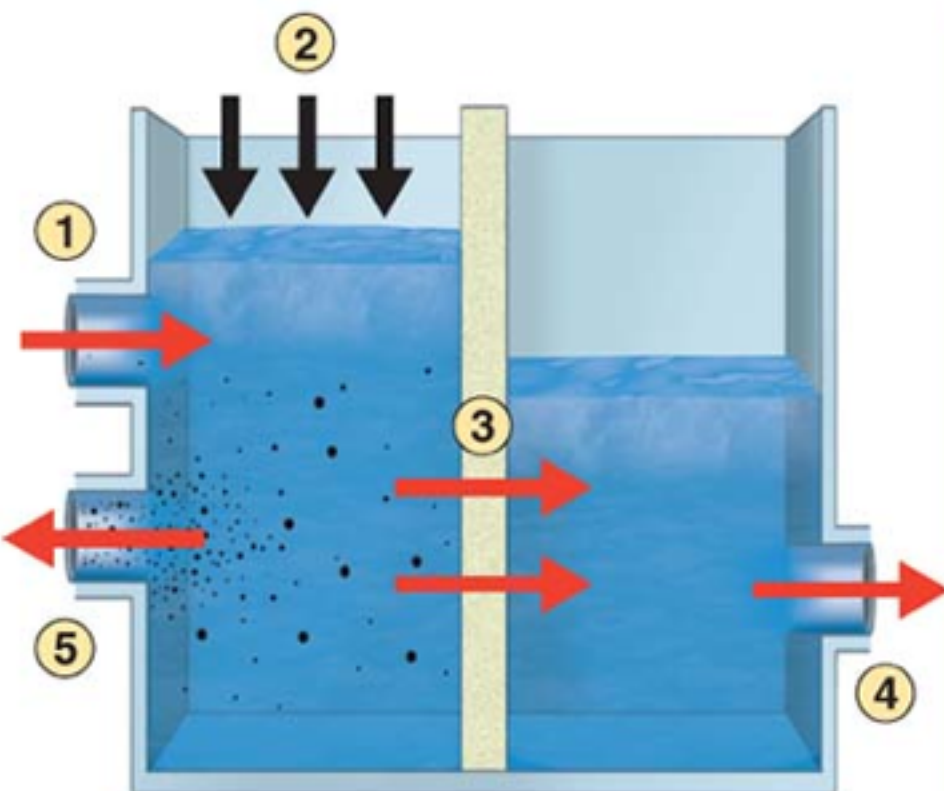
(a) Distillation uses heat to convert pure water into steam that is later condensed, leaving the salt behind.

(b) Reverse osmosis uses pressure to force pure water through a semipermeable membrane, leaving the salt behind.

What are some drawbacks?

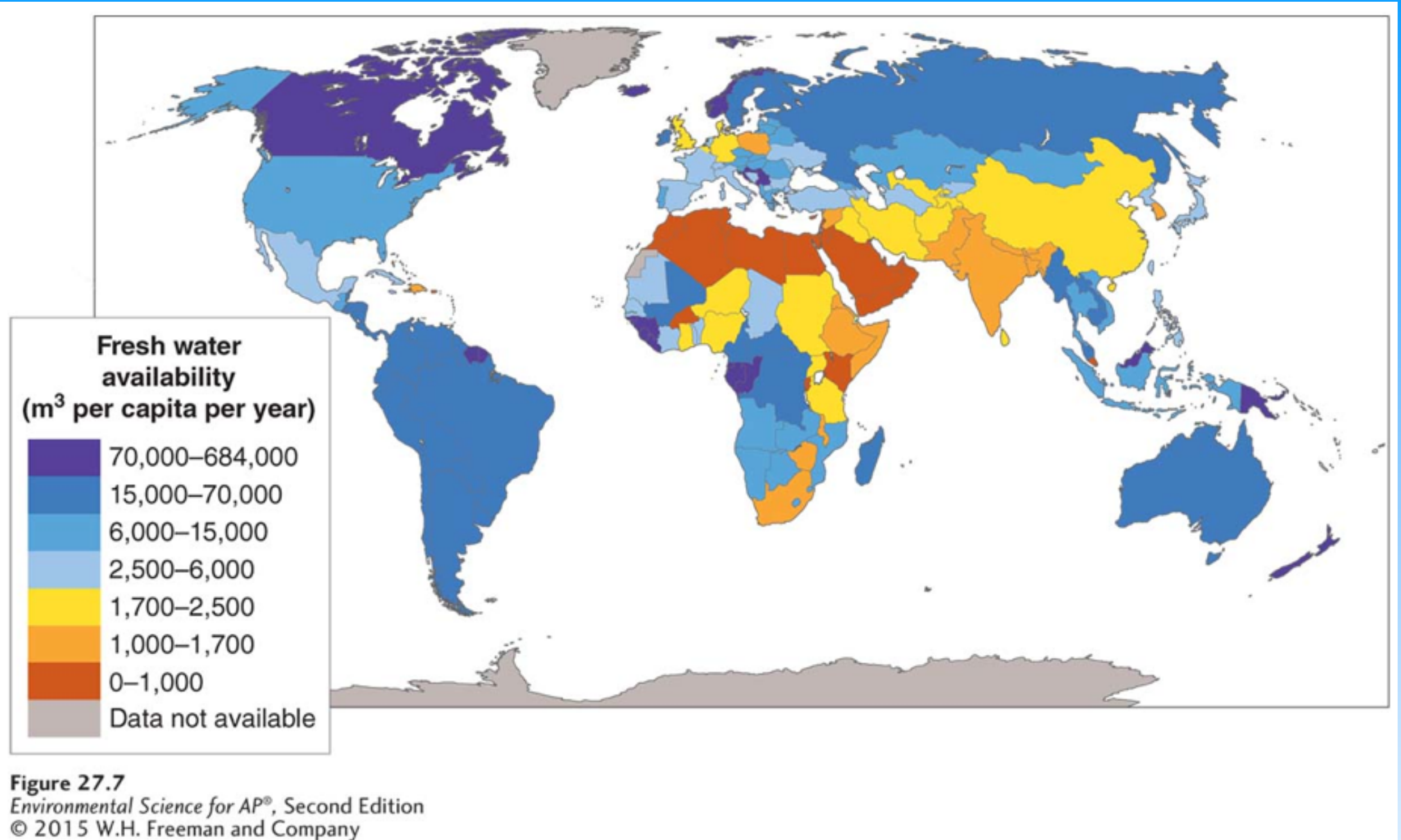


- 1 Seawater flows into chamber.
- 2 Heating element boils water, creating steam.
- 3 Cool seawater in condensing coil causes steam to condense.
- 4 Salt-free water flows out of chamber.
- 5 Brine (very salty water) flows out of chamber.



- 1 Seawater flows into chamber.
- 2 Pressure is applied to the water.
- 3 Under pressure, water is pushed through a semipermeable membrane but salt is not.
- 4 Salt-free water flows out of chamber.
- 5 Brine (very salty water) flows out of chamber.

Water Availability



Water availability per capita. The amount of water available per person varies tremendously around the world. North Africa and the Middle East are the regions with the lowest amounts of available fresh water.

Module 28

Human use of Water Now and in the Future

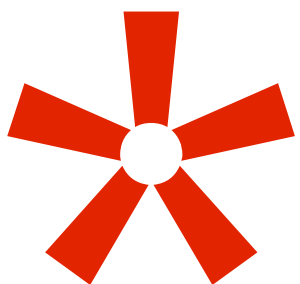
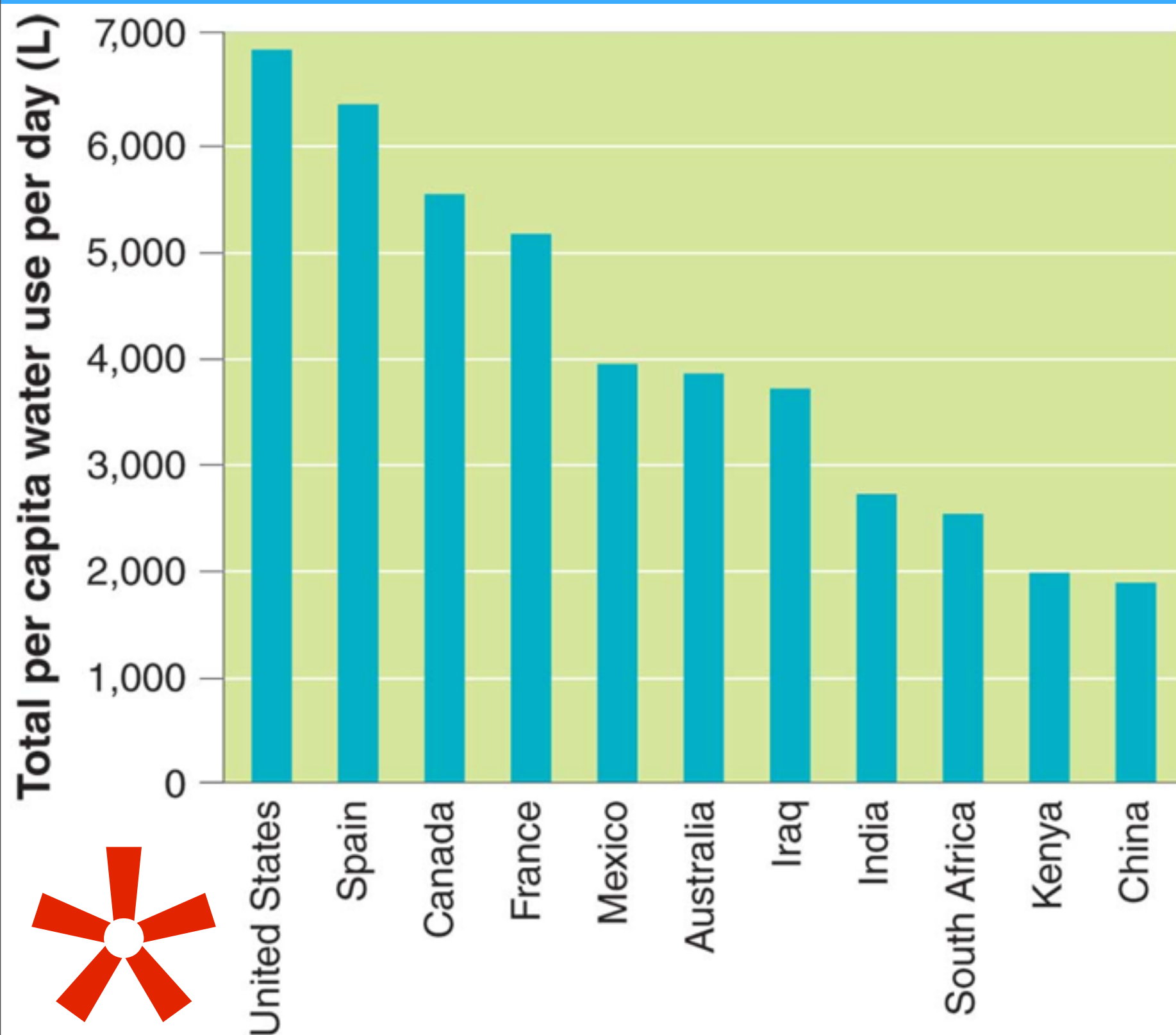
After reading this module you should be able to

- compare and contrast the four methods of agricultural irrigation.
- describe the major industrial and household uses of water.
- discuss how water ownership and water conservation are important in determining future water availability.

Water is used for agriculture

- **Water footprint** The total daily per capita use of fresh water.
- Around the world, more water is used for agriculture than anything else.
- The daily use of water per capita varies dramatically among the nations of the world.

Water Footprint



Total per capita water use per day. The total water use per person for agriculture, industry, and households varies tremendously by country.

Of all the water used in the U.S. how much goes toward generation of electricity?

Irrigation

- Technological advances have made water use for crops more efficient.

There are four types of irrigation:

- Furrow: a trench that is flooded with water
- Flood: the entire field is flooded with water
- Spray: an apparatus sprays water across a field
- Drip: a slow dripping hose is laid on or buried beneath the soil

Rank them in order worst to best in terms of efficiency

Hydroponic Agriculture

- **Hydroponic agriculture** The cultivation of plants in greenhouse conditions by immersing roots in a nutrient-rich solution.

An alternative to irrigation, hydroponic agriculture is more expensive but has several advantages:

- Requires little or no pesticide use.
- Uses up to 95 percent less water than traditional irrigation.
- Crops can be grown year-round.

Water is also used for industrial processes and households

After agriculture (~70%), the most common use of water is for industry (~20%) and households (~10%).

What are the major industrial uses for water?

Industrial Water Use

Water is required for many industrial purposes:

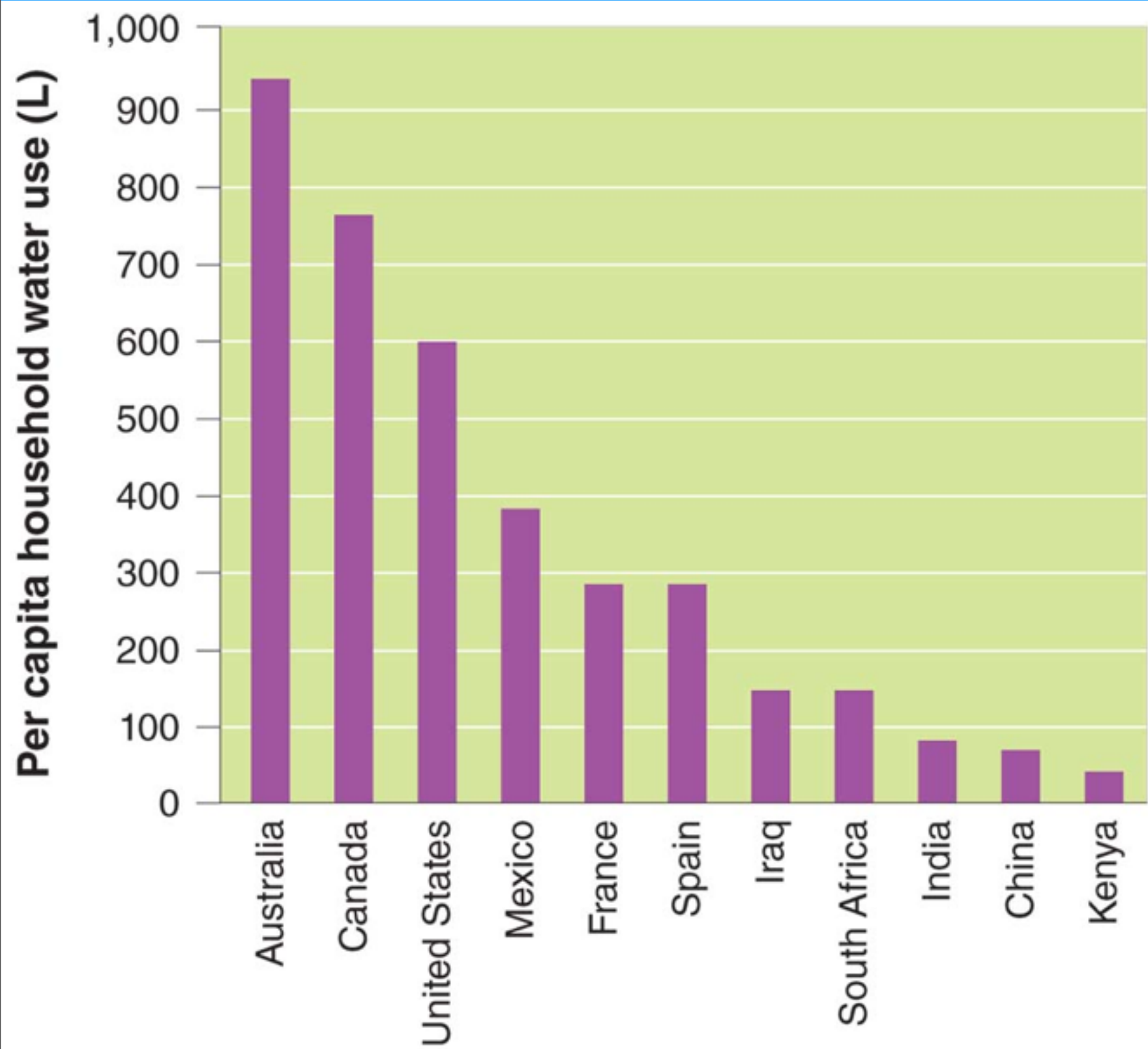
- Generating electricity
- Cooling machinery
- Refining metals
- Making paper

Household Water Use

- Household water use accounts for 10 percent of all water used in the United States.
- Per capita household water use varies dramatically among nations.

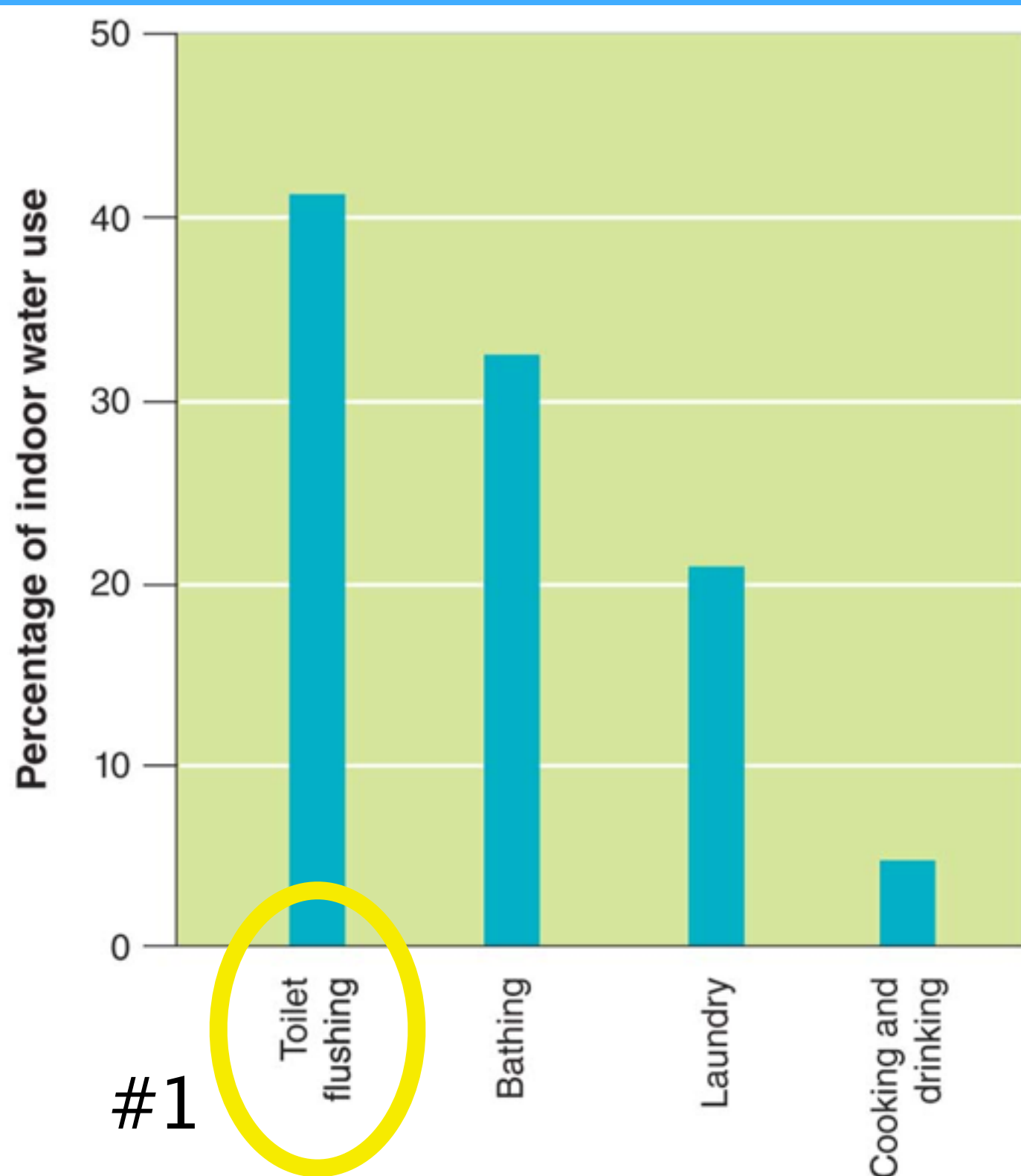
Household Water Use

Household per capita water use per day. The amount of household water use per capita is different from that of total water use.

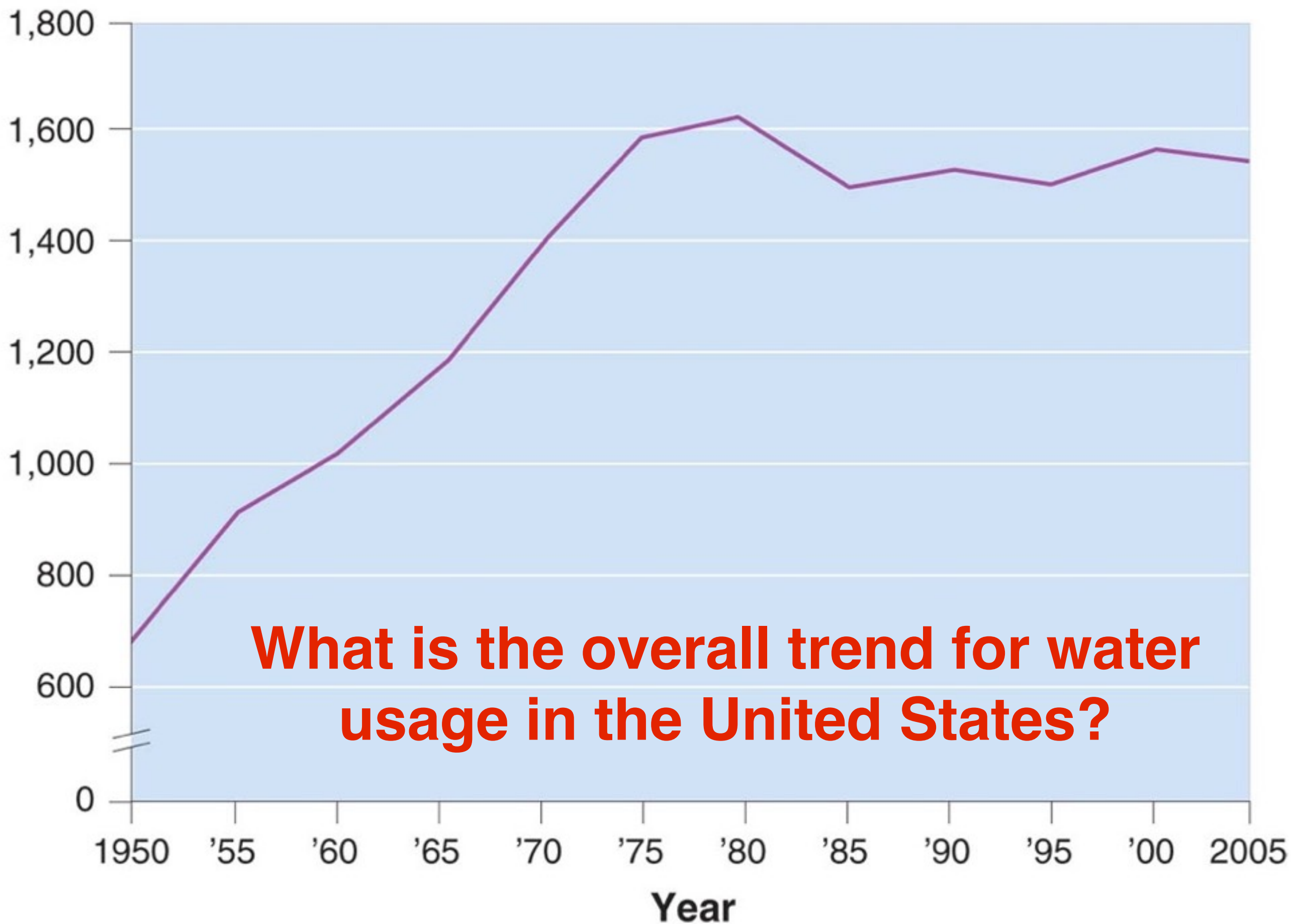


Which household activity has the greatest impact on water consumption in the U.S.?

Indoor household water use. Most water used indoors is used in the bathroom



Water withdrawals (billions of liters)



What is the overall trend for water usage in the United States?

The future availability of water depends on water ownership and water conservation

- Throughout the world, issues of water ownership and water rights have created conflicts.
- Many countries have found ways to conserve water through improved technology.
- **Gray water** Wastewater from baths, showers, bathrooms, and washing machines.
- **Contaminated water** Wastewater from toilets, kitchen sinks, and dishwashers.

Reading Comprehension / Small Group

- What are the factors that limit access to clean water in many developing nations?
- How does the lack access to clean water affect people living in developing nations?
- Why is it more difficult to determine ownership of water than for many other resources?
- What is a possible method to resolve water-ownership conflicts?
- List some ways in which people conserve water.