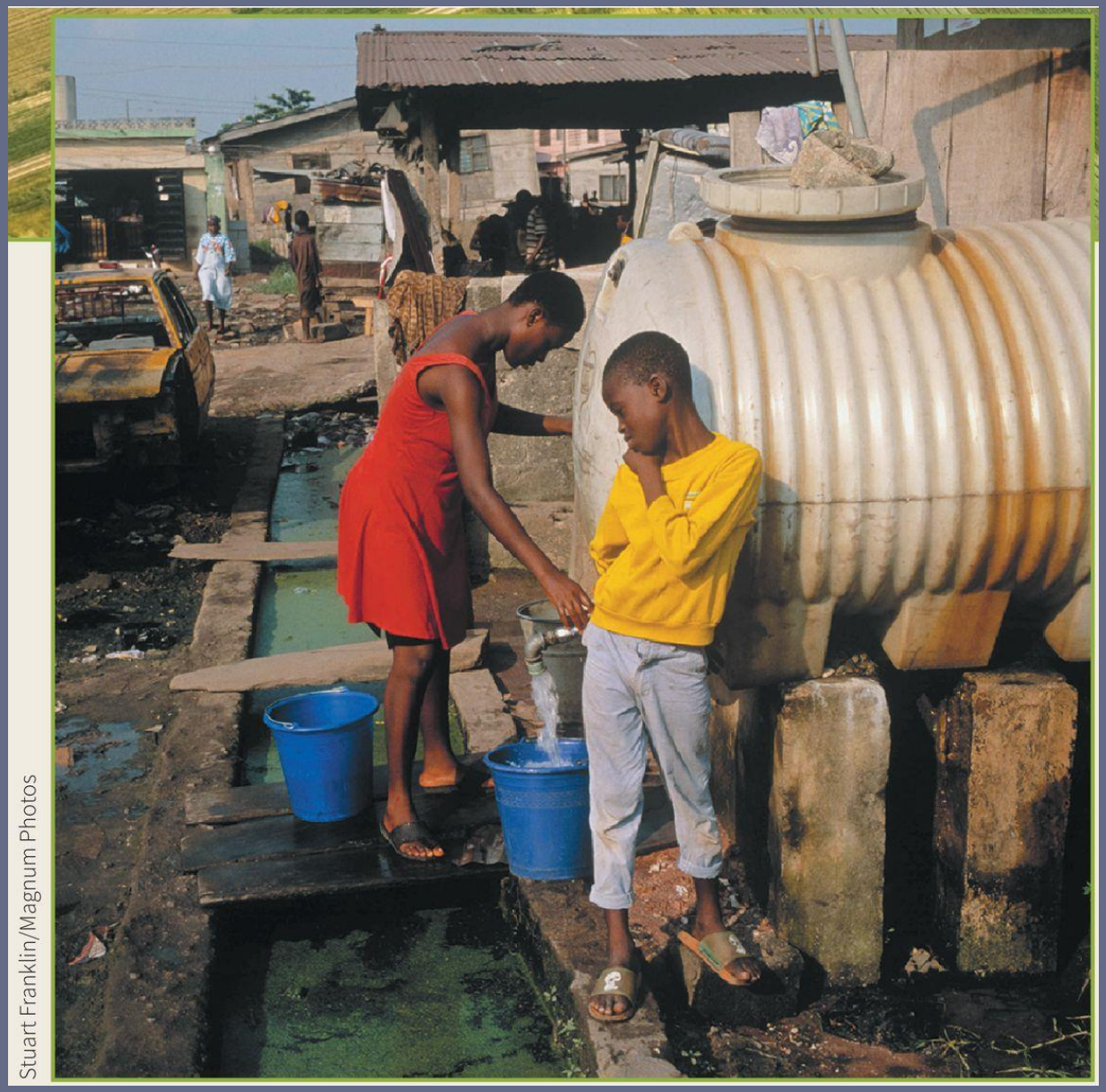


Stuart Franklin/Magnum Photos

13

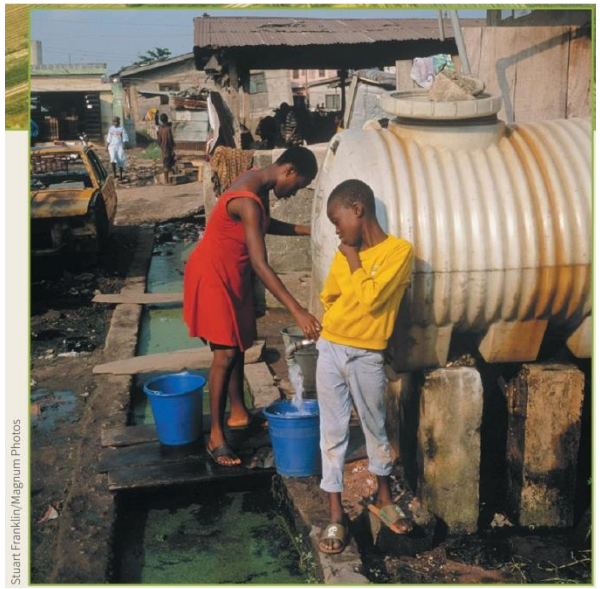
Water: A Limited Resource

Overview of Chapter 13

- Importance of Water
- Water Use and Resource Problems
- Water Problems in U.S. and Canada
- Global Water Problems
- Water Management
- Water Conservation

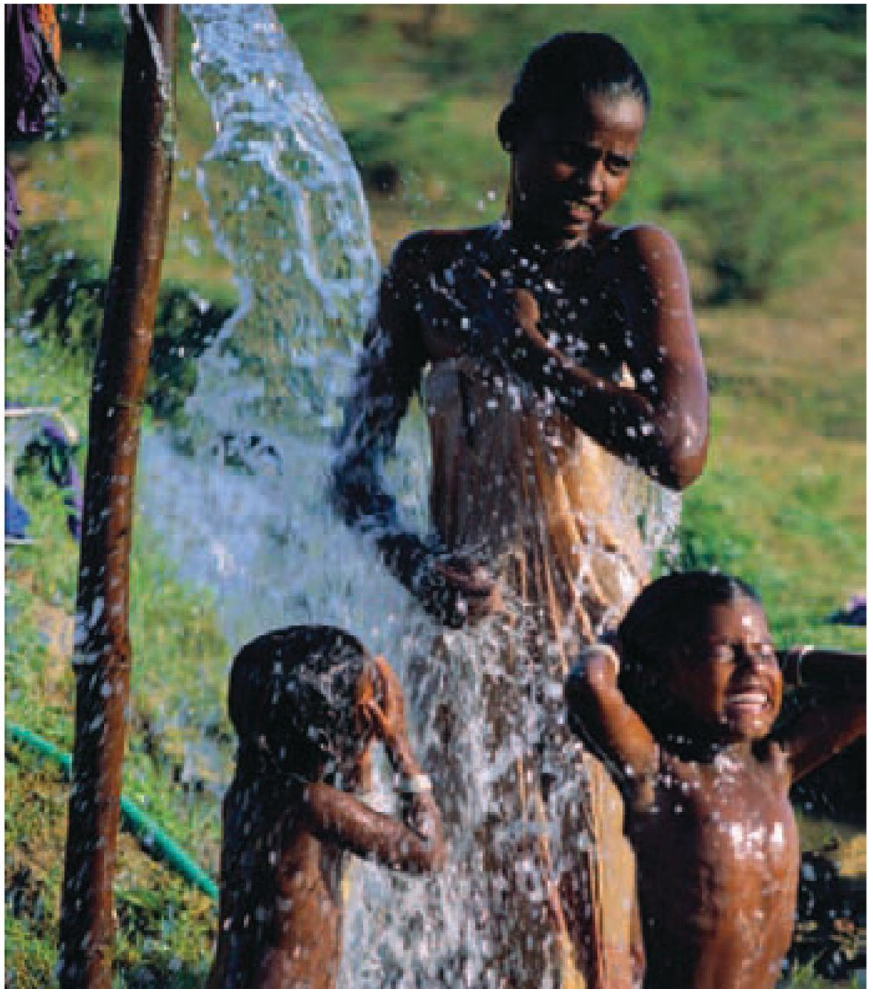
Water Scarcity

- Lack of adequate water
  - 765 people worldwide
  - <10L of clean water daily (Americans use ~340L)
  - Poor can pay ~20% of income on water (0.15% in by book author)
- Water infrastructure lowers cost
  - Infrastructure is lacking in many places


Stuart Franklin/Magnum Photos

Importance of Water

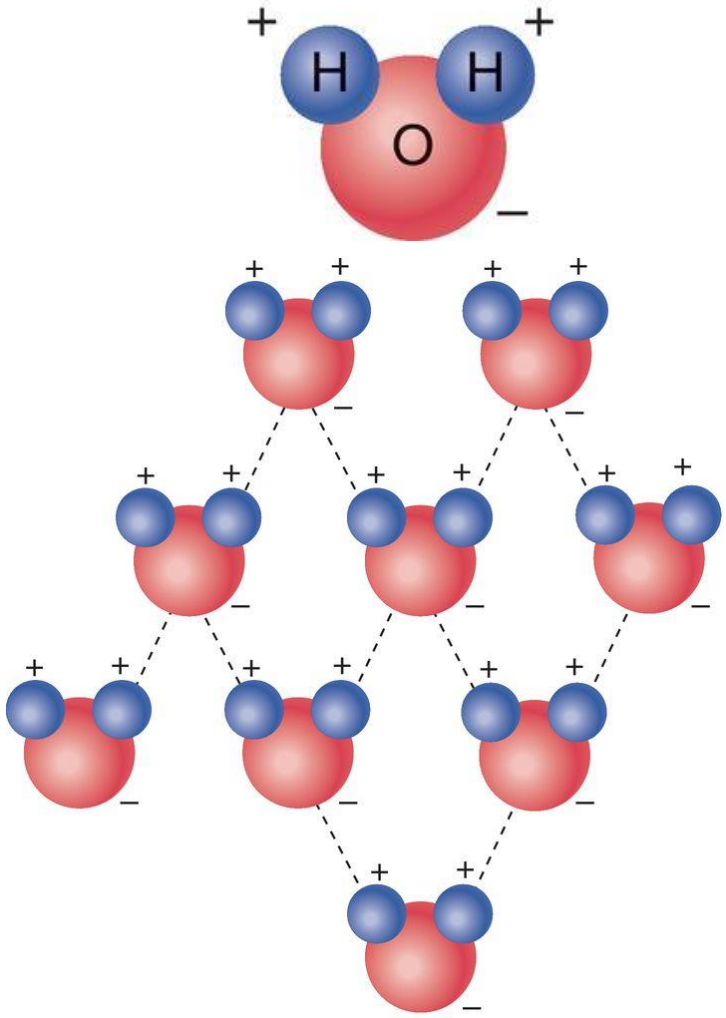
- Cooking & washing
- Agriculture
- Manufacturing
- Mining
- Energy production
- Waste disposal
- Use of freshwater is increasing



Jodi Cobb/ National Geographic Creative

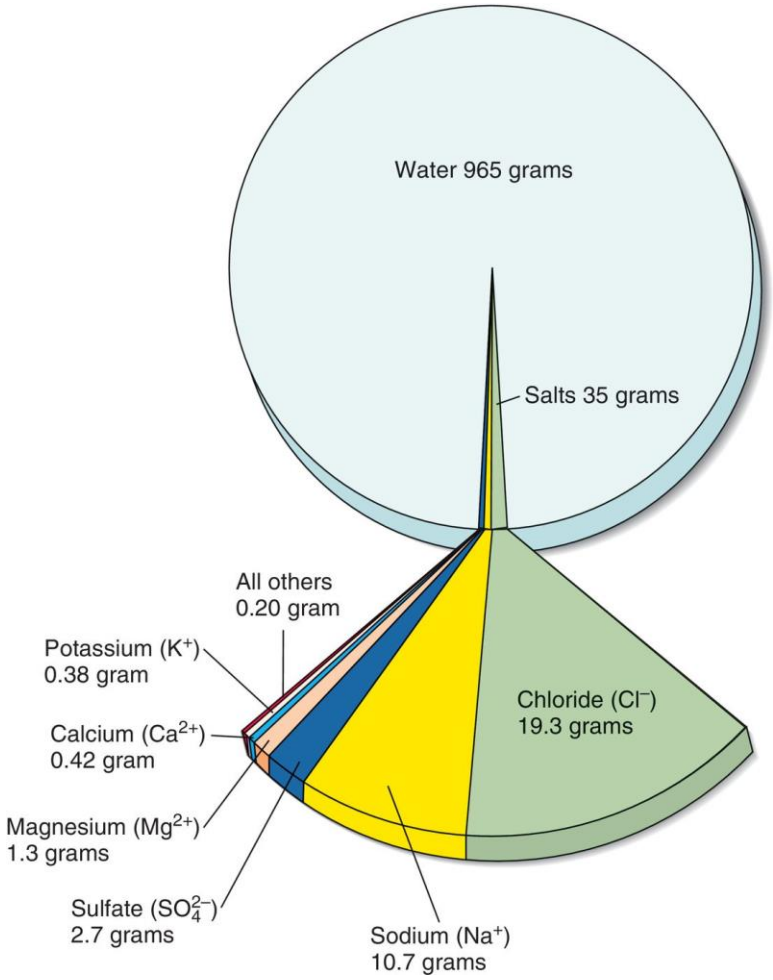
Properties of Water

- Composed of 2 Hydrogen and 1 oxygen
- Exists as solid, liquid or gas
- High heat capacity
- Polar
- Forms hydrogen bond between 2 water molecules
  - H-bonds define water's physical properties



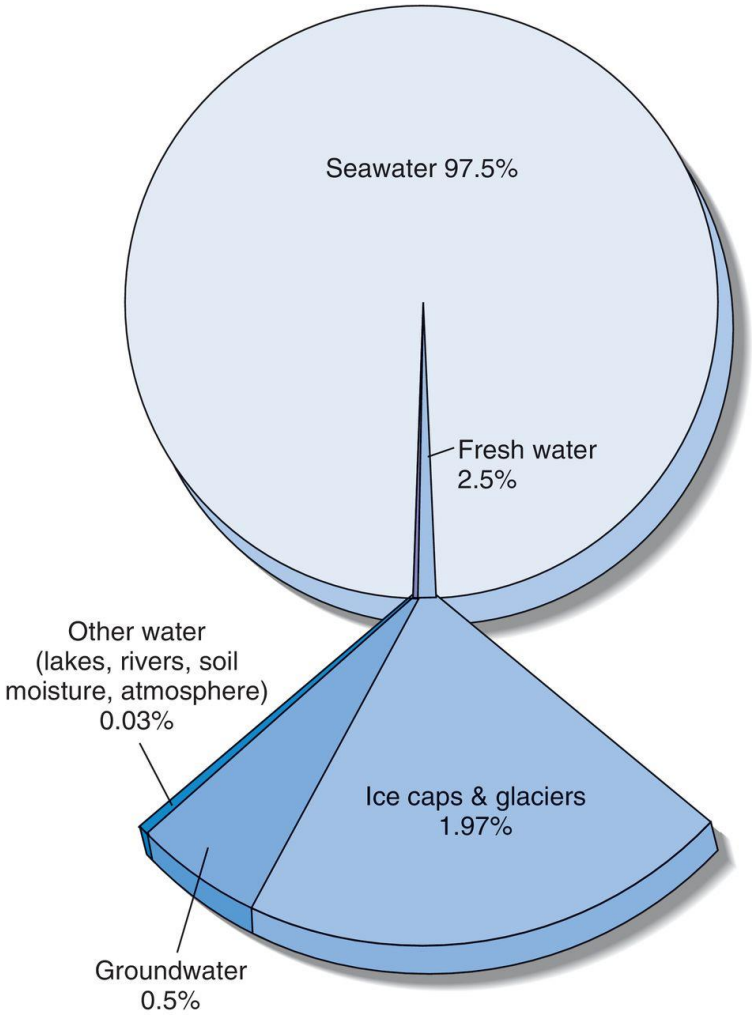
Properties of Water

- Water is never completely pure in nature
- Content of seawater (left)
- Water dissolves many chemicals that can act as pollutants



Distribution of Water

- <2.5% of water on earth is freshwater
  - 2% of this in the form of ice
- Only ~0.5% of water on earth is available freshwater
- Forms of freshwater are used preferentially



Freshwater Terminology

- Surface water
  - Precipitation that remains on the surface and does not seep into soil
- Runoff
  - Movement of surface water to lakes, rivers, etc.
- Watershed (drainage basin)
  - Land area that delivers water into a stream or river system
- Groundwater
  - Freshwater under the earth's surface stored in aquifers
- Aquifer
  - Underground caverns and porous layers of sand, gravel and rock in which groundwater is stored

Watersheds

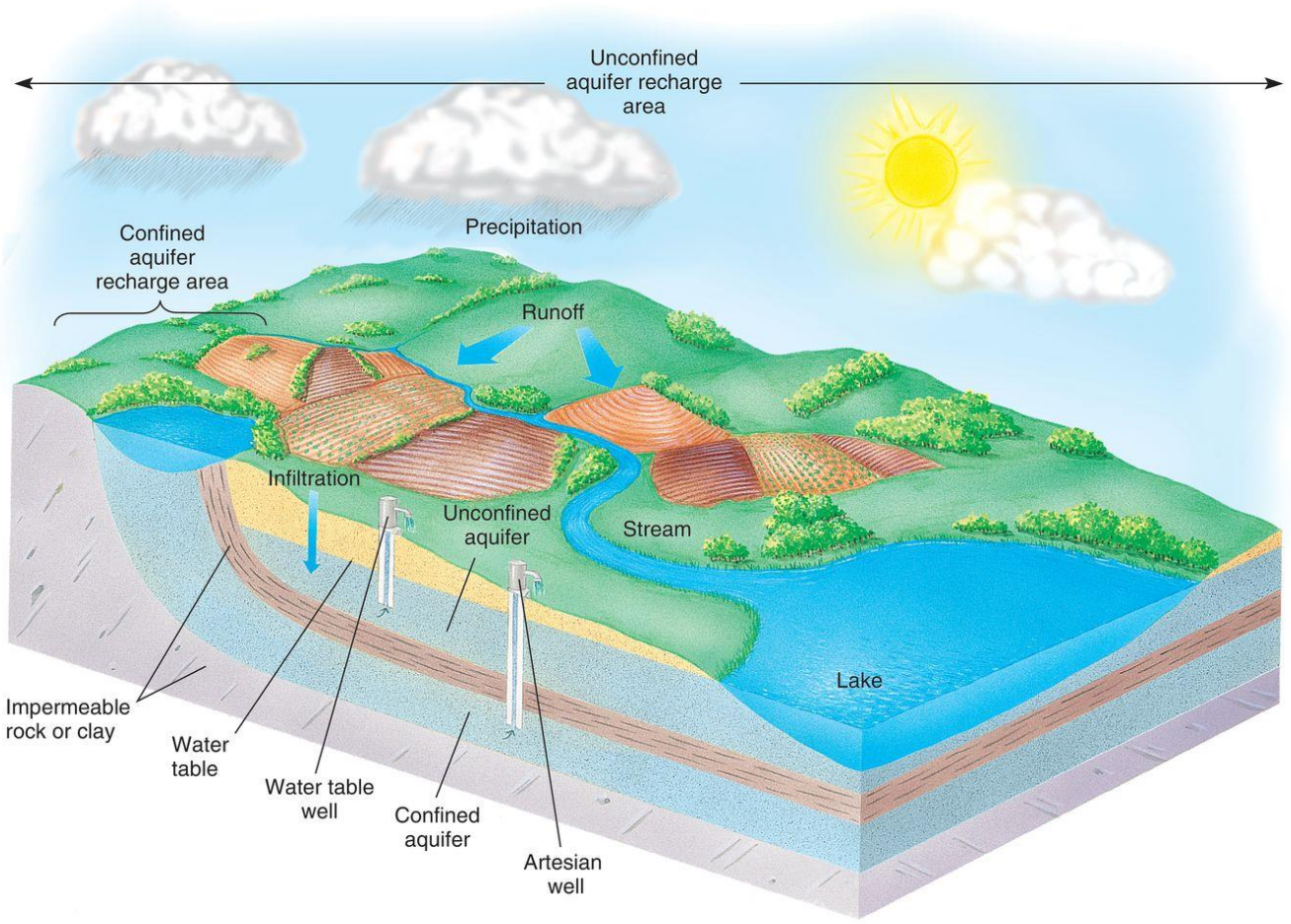
- Also known as catchment basin
  - Watersheds are essential for water access

Table 13.1 The World's 10 Largest Watersheds

Watershed	*Region*	*Area of Watershed (thousand km²)*
Amazon	South America	6145
Congo	Africa	3731
Nile	Africa	3255
Mississippi	North America	3202
Ob	Asia	2972
Paraná	South America	2583
Yenisey	Asia	2554
Lena	Asia	2307
Niger	Africa	2262
Yangtze	Asia	1722

Source: Water Resources of the World, World Resources Institute (2010).

Freshwater Aquifer



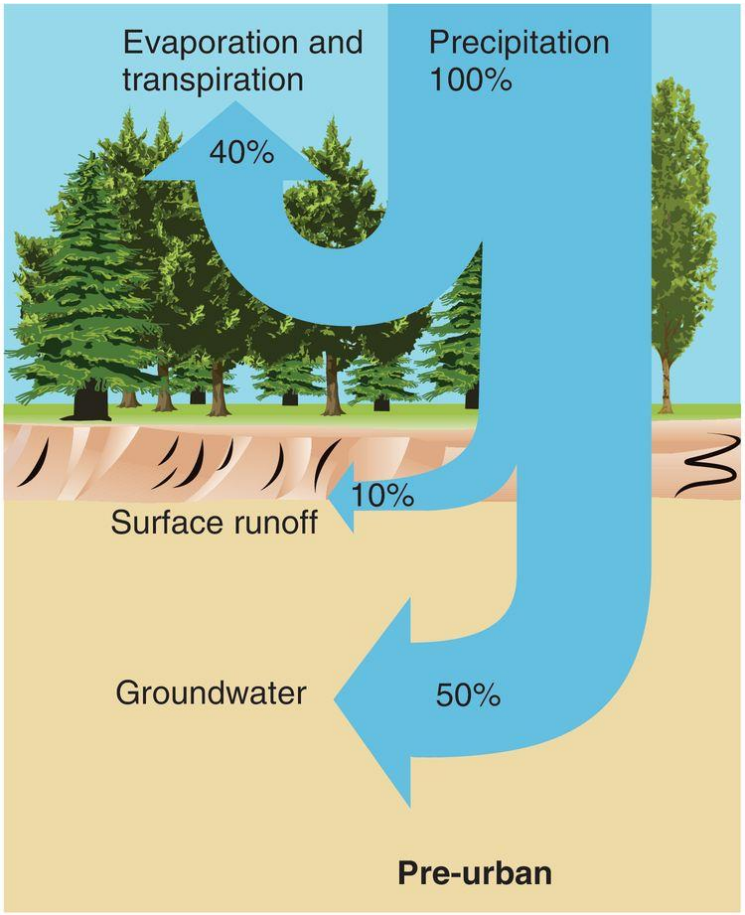
Water Use and Resource Problems

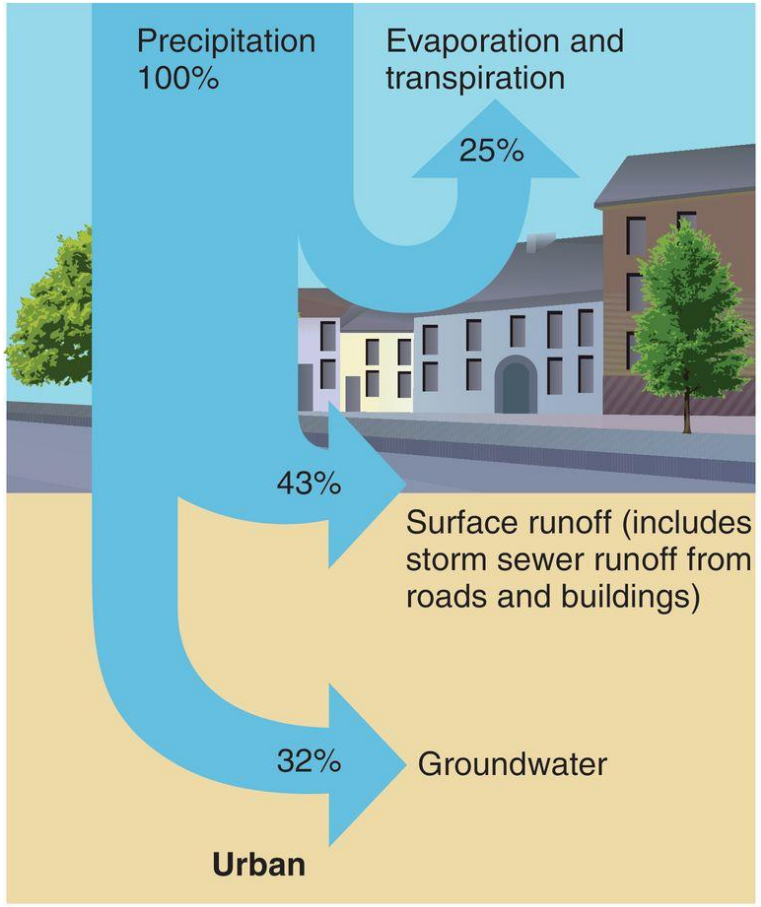
- Fall into Three Categories
  - Too much water
  - Too little water
  - Poor quality/contamination (addressed in Chapter 21)

Too Much Water

- Flooding
  - Both natural and human-induced
- Modern floods are highly destructive
  - Humans have removed water-absorbing plant cover from soil
  - Humans construct buildings on floodplains
- Floodplain
  - Area bordering a river channel that has the potential to flood

Urban vs. Pre-Urban Floodplains

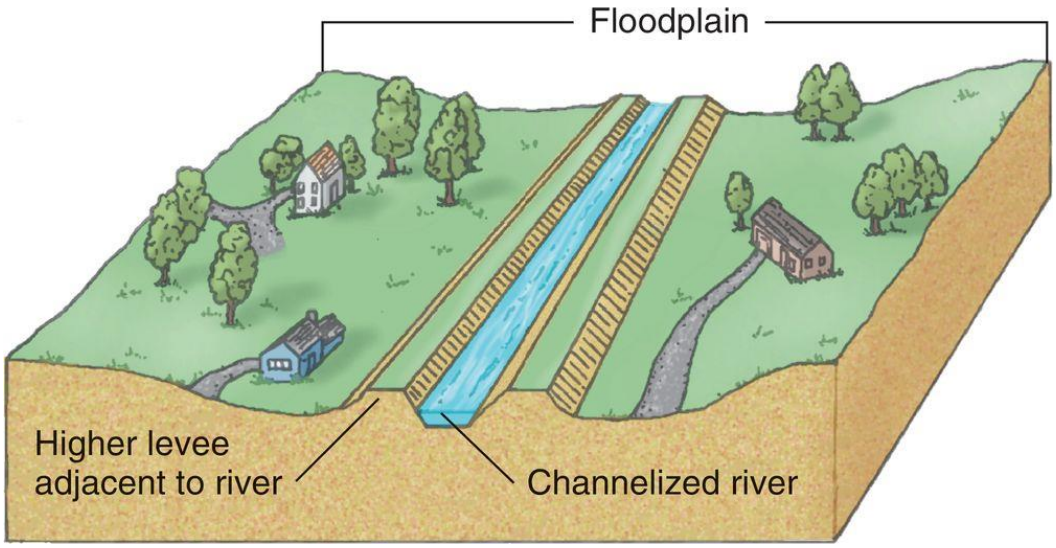




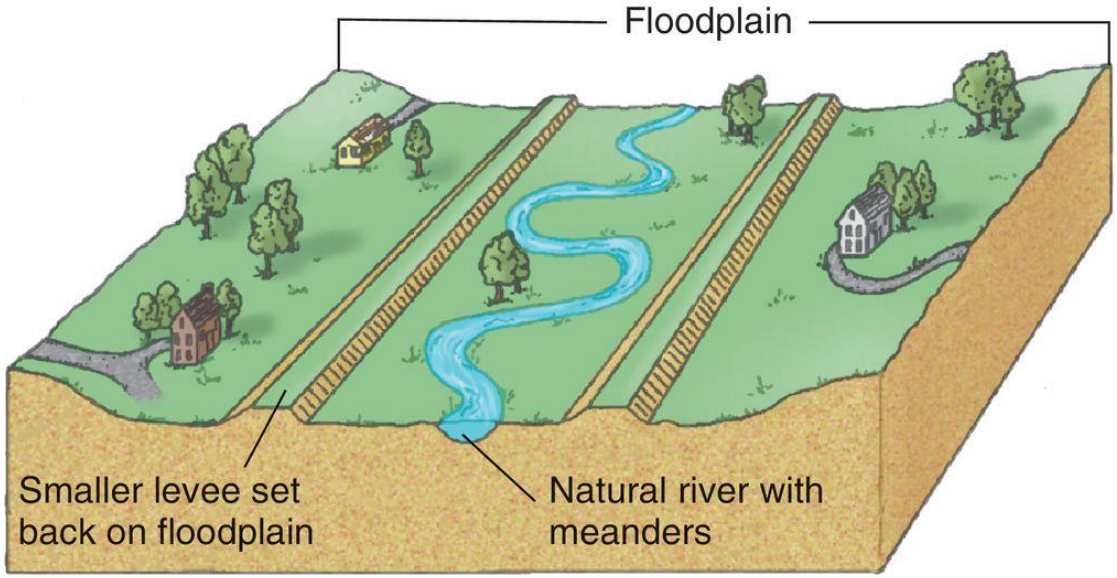
Floodplain

- Area bordering a river channel that can flood
  - We increasingly build on floodplains
- Government restrictions on building
  - Levees can fail
- Rather than rebuild levees adjacent to rivers, experts suggest allowing some floodplains to flood
  - (Next slide)

AP Photo/The Merced Sun-Star, Jack Bland



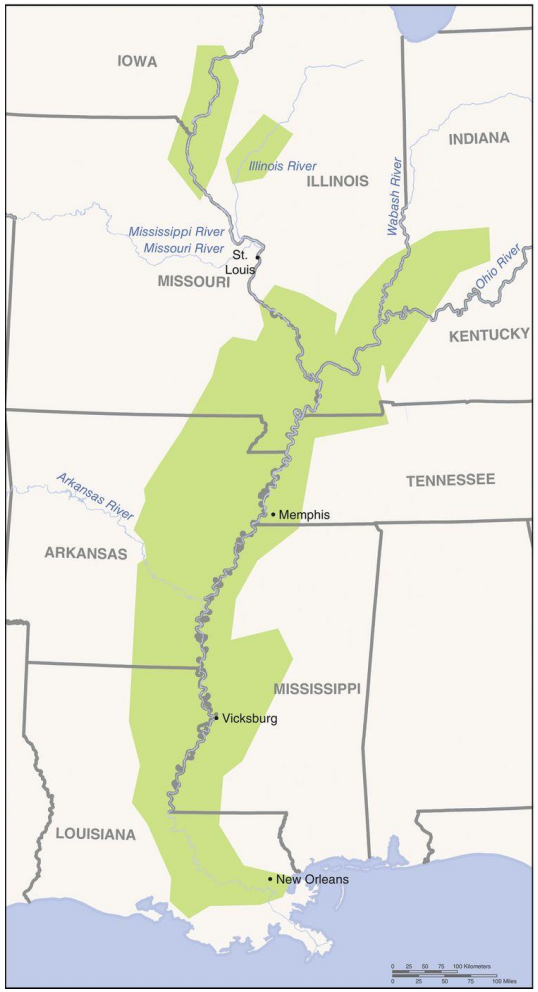
Left: Traditional levees adjacent to river



Right: Suggested levee style, set back from river

Floods of Summer 2011

- Heavy rains and abundant snowmelt high in Mississippi River watershed
- Has extensive flood control mechanisms
  - Many failures, but many floods prevented



Floods of Summer 2011

- Debate over the degree of river alteration and building in floodplain
- Alteration in precipitation with climate change?

© STR/Reuters/Corbis

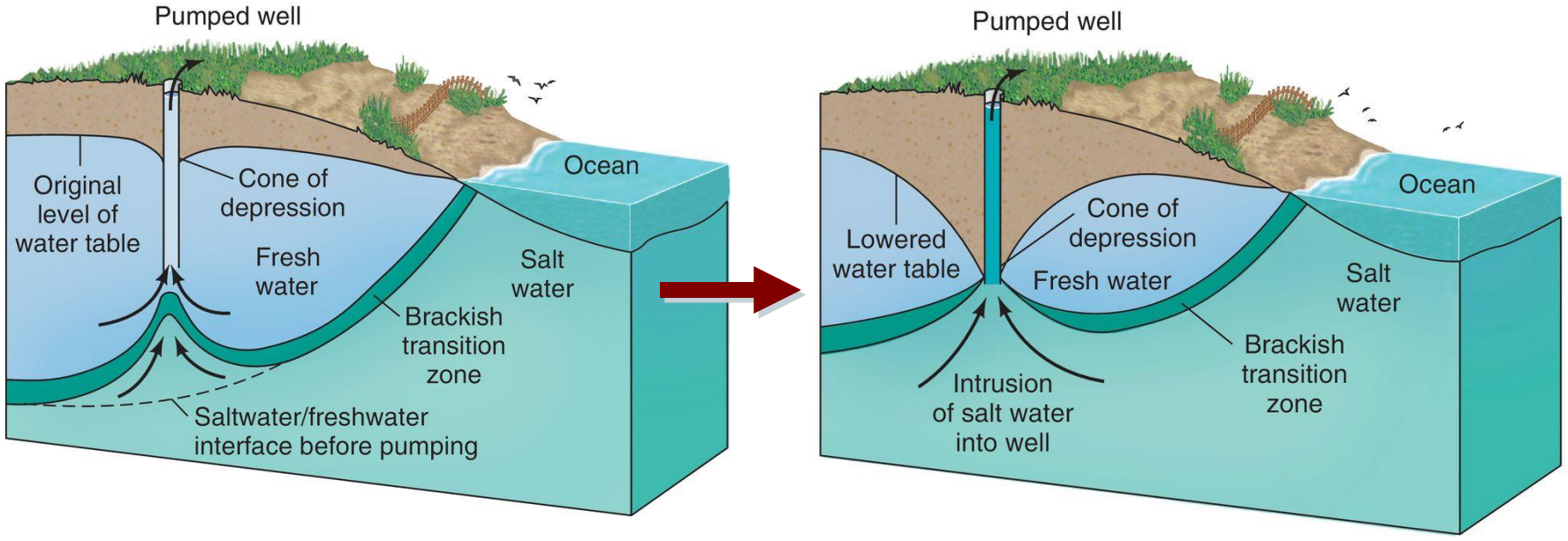
Too Little Water

- Typically found in arid land
- Problems
  - Drought
  - Overdrawing water for irrigation purposes
  - Aquifer depletion
    - Subsidence
    - Sinkholes

Bryan and Cherry Alexander/Science Source

Too Little Water

- Problems (continued)
  - Saltwater Intrusion



Water Problems In U.S. and Canada

- Overall, U.S. has a plentiful supply of freshwater
- Many areas have a severe shortages
  - Geographical variations
  - Seasonal variations

Water Problems In U.S. and Canada

- Water shortages in West and Southwest
  - Water is diverted and transported via aqueducts

©Jim West / Alamy

Water Problems in U.S. and Canada-Surface Water

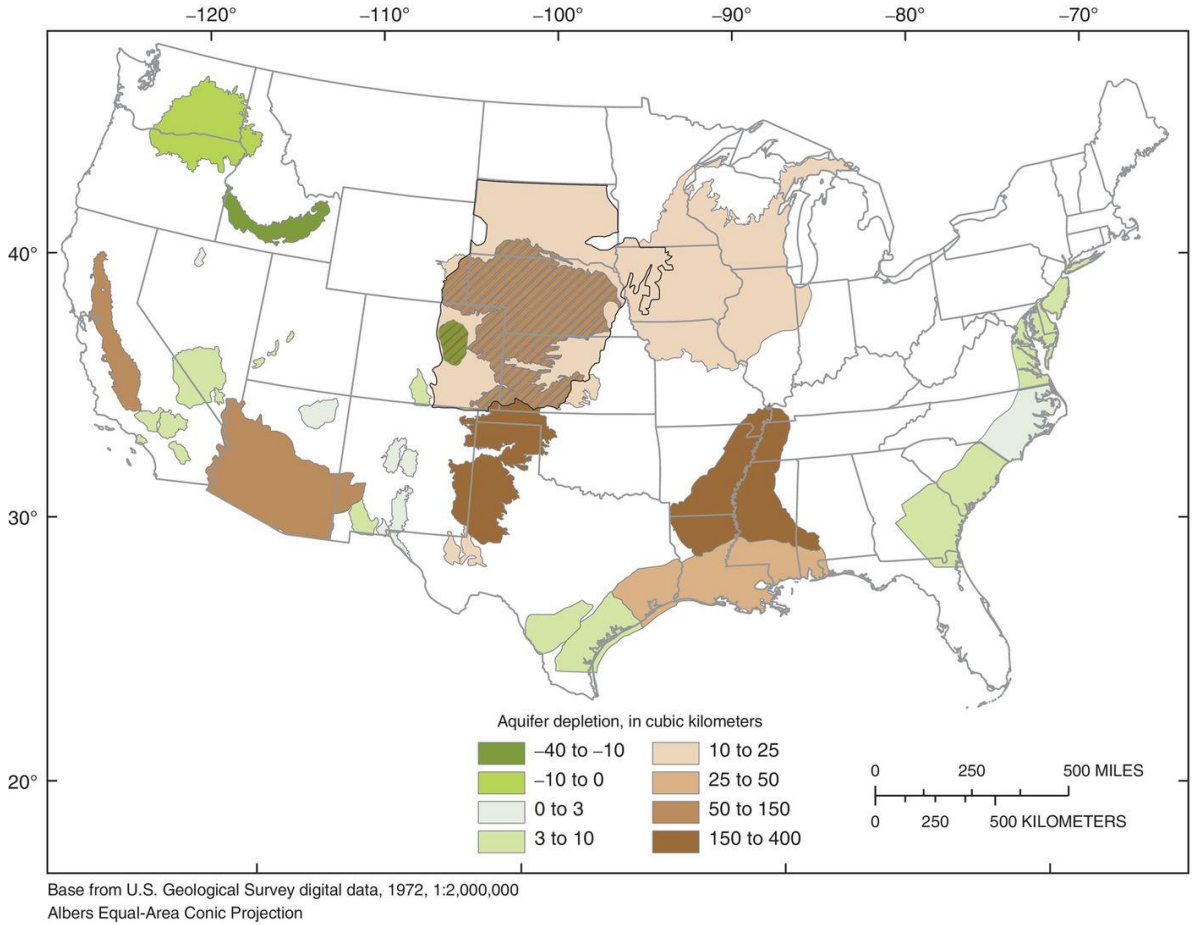
- Mono Lake (Eastern CA)
  - Rivers and streams that once fed this lake are diverted to Los Angeles (275mi away)
  - Becoming highly saline
  - Court ordered water diversion reduction
- Colorado River Basin
  - Provides water for 27 million people
  - Numerous dams for Hydropower
  - Colorado River rarely reaches ocean – dries up

Colorado River bed in Mexico

PETE MCBRIDE/National Geographic Creative

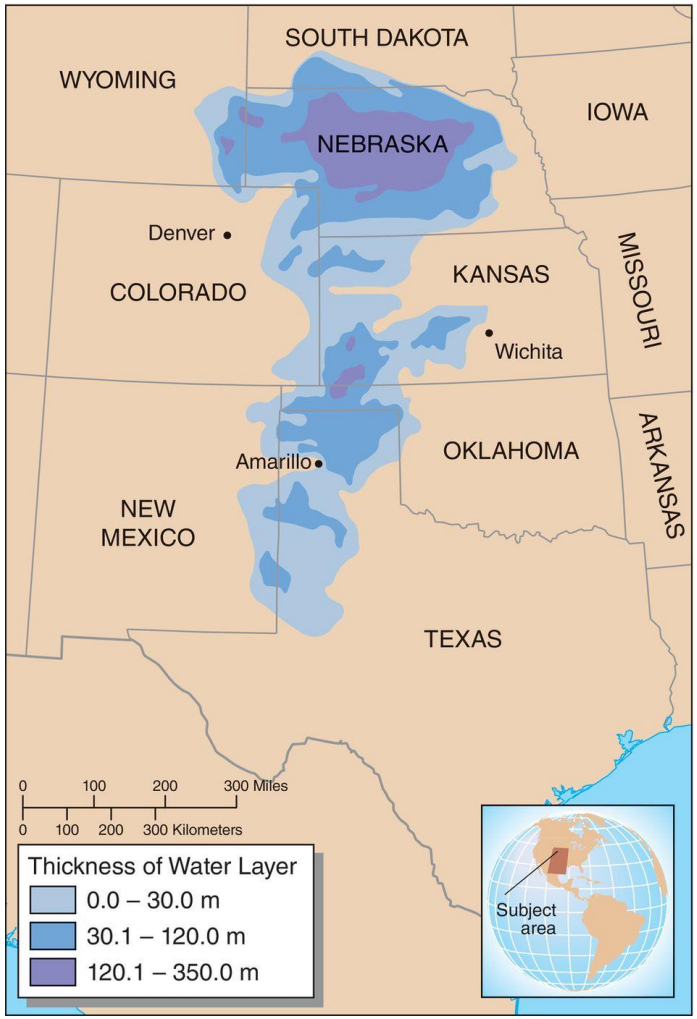
Water Problems in U.S. and Canada- Groundwater

- Aquifer Depletion



Water Problems in US and Canada- Groundwater

- Ogallala Aquifer
  - High Plains
  - Largest groundwater deposit in world
  - Water withdrawn for agriculture faster than nature replaces it
  - Water table lowered 100ft in places
  - Uneconomical to pump within decades



Global Water Problems

- Amount of freshwater on planet CAN meet human needs
  - BUT, it is unevenly distributed and some places lack stable runoff
    - Dependent amount of runoff every month
- Problems:
  - Weather and Climate
  - Drinking Water
  - Population Growth
  - Sharing Water Resources Among Countries

Global Water Problems

- Water and Climate
  - Climate change affects the type and distribution of precipitation
  - Potential issues:
    - Reduced snowfall (or variable runoff) will impact water resources downstream
      - Ex: Californian drought 2014-2015
    - Sea level rise will cause saltwater intrusion into drinking water supplies

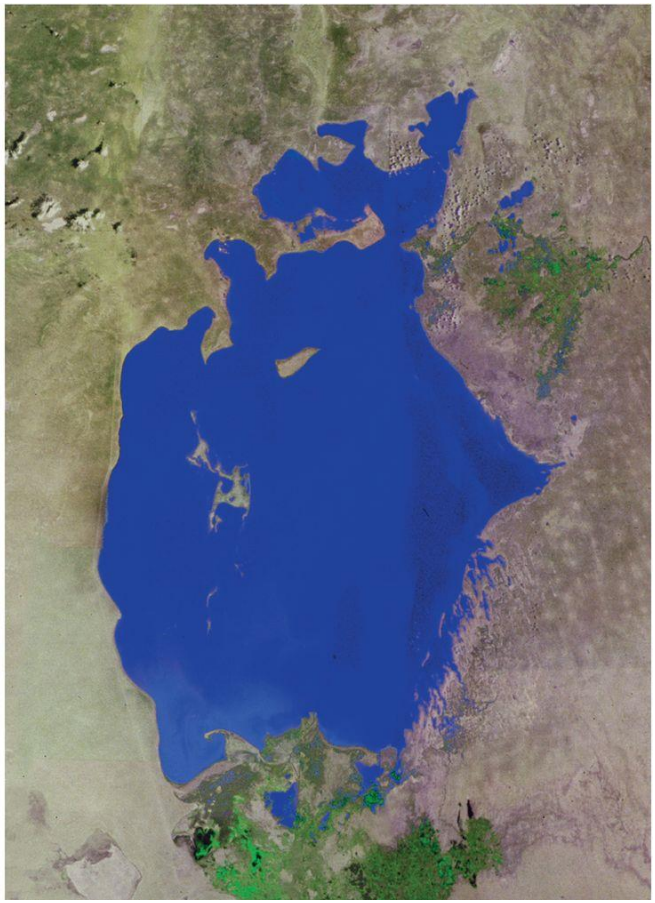
Global Water Problems

- Drinking Water Problems
  - Many developing countries have insufficient water to meet drinking and household needs
  - ~748 million people lack access to safe drinking water
    - ~80% of human illnesses due to poor water quality
- Population Growth
  - Increase in population means an increase in freshwater requirements
  - Limits drinking water available
  - Limits water available for agriculture (food)

Global Water Problems

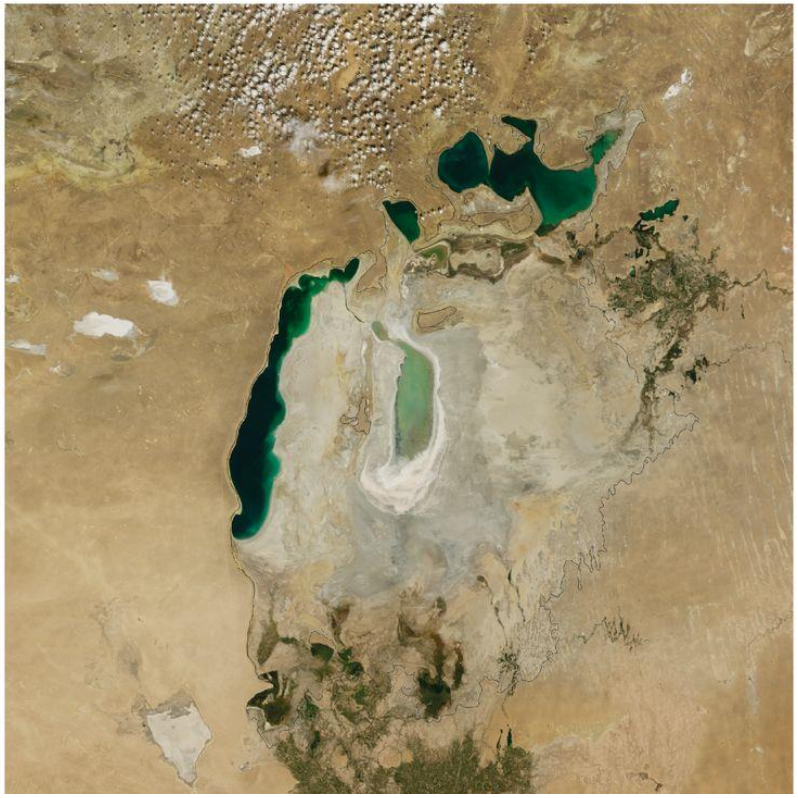
- Sharing Water Resources among Countries
  - Rhine River Basin (right)
    - Countries upstream discharged pollutants into river
    - Countries downstream had to pay to clean the water before they could drink it
  - Aral Sea (next slide)
    - Water diversion for irrigation has caused sea to become too saline

Aral Sea



Worldsat International, Inc.

1976



Courtesy NASA Earth Observtory

2013

Global Water Problems

Table 13.2 Some Historical and Recent Water Conflicts

Date	*Conflict*	*Description*
2500 B.C.E.	Military tool	King Urlama of Lagash diverts flow of water from rival kingdom Umma (Lagash and Umma were both kingdoms in what is now Iraq).
1187 C.E.	Military tool	Saladin defeats European Crusaders, in part by depriving them of access to water. This includes filling wells with debris and eliminating villages that could have supported the Crusaders.
1672	Military tool	The Dutch breach their protective dikes to prevent Spanish armies from invading by land. Dikes around Amsterdam and other Dutch cities are designed both to keep out seawater in peace-time and deter potential invaders in times of war.
1850s	Development dispute/terrorism	When a dam is built to provide water for factories in New Hampshire, locals who object to the effect on their water supplies attack the dam.
1907–1913	Terrorism/development dispute	The aqueduct from Owens Valley to Los Angeles is bombed multiple times by people objecting to the large-scale shift in allocation of this water resource.
1969	Military target	Israel attacks the East Ghor Canal in Jordan to prevent diversion of water from the Yarmouk River.
1991	Military target	During the First Gulf War, Iraq destroys desalinization facilities in Kuwait.
2003–2007	Military tool, target/terrorism	Wells in Sudan and Darfur are destroyed and poisoned as part of civil war–related violence.
2009	Development dispute	Ethiopian village attacked in disagreement over a water pipe.
2010	Development dispute	Water dispute between Pakistani tribes leads to more than 100 deaths.
2012	Military target	Water pipeline to city of Aleppo severely damaged during Syrian Civil War; 3 million residents suffer serious water shortages.

Source: Peter H. Gleick (2011). *Water Conflict Chronology*. Pacific Institute for Studies in Development, Environment, and Security; additional updates from the Pacific Institute online chronology.

Water Management

- Main Goal: Provide sustainable supply of high-quality water
  - Dams and Reservoirs
  - Water Diversion Projects
  - Desalinization

Dams and Reservoirs

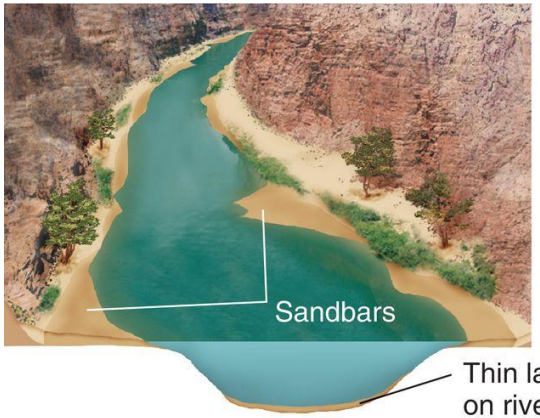
- Benefits:
  - Ensure year-round supply of water with regulated flow
  - Generate electricity
  - Provide recreational activities
- Disadvantages
  - Alter the ecosystem
  - Reduce sediment load

Courtesy U.S. Department of Energy

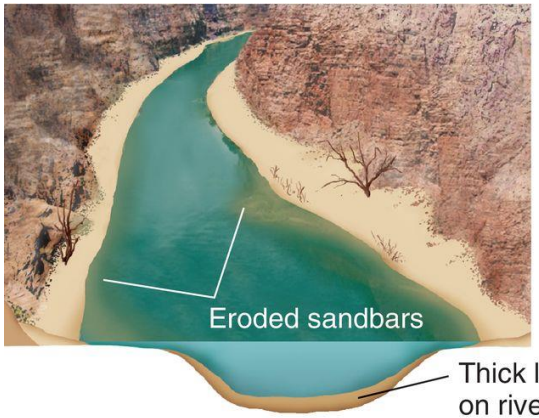
Dams and Reservoirs

- Glen Canyon Dam
  - Powerful spring floods brought sediment, which created sandbar habitat
  - Regulated flow is detrimental to wildlife
  - To rectify this, government started flooding the Grand Canyon periodically starting in 1996

Dams and Reservoirs

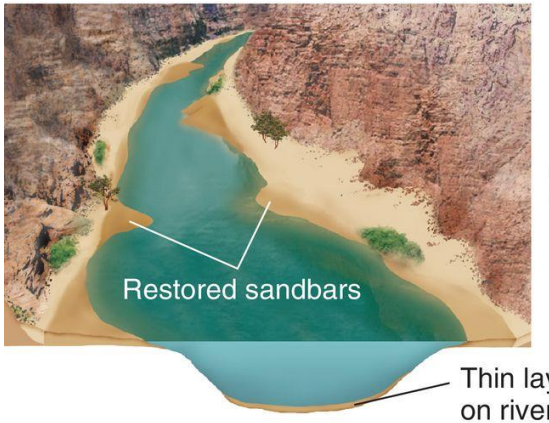


Before dam construction, natural floods carried sediment that built and maintained sandbars.



After dam construction, sandbars eroded and sand accumulated on river bottom.

During regulated flood, river water is turbid with sediment.



After regulated flood, sandbars are partially restored.

Dams and Reservoirs

- Salmon population in Columbia River very low due to dams that impede migration
- Fish ladders help, but are not highly effective

Tim Matsui/Getty Images

Water Diversion Projects

- Water diverted to areas that are deficient
- Much of Southern CA receives its water supply from diverted water from Northern CA
- Controversial and expensive

Desalinization

- Removal of salt from ocean or brackish water
- Two methods:
  - Distillation - salt water is evaporated, and water vapor is condensed into freshwater
  - Reverse Osmosis- involves forcing salt water through a membrane permeable to water, but not salt
- Very expensive, but becoming more economical due to technology and demand
  - Huge industry in Africa and Middle East (where water is scarce)

Water Conservation

- Reducing Agricultural Water Waste
  - Agriculture is very inefficient with water
  - Microirrigation - irrigation that conserves water by piping to crops through sealed systems
  - Also called drip or trickle irrigation

Courtesy U.S. Department of Agriculture

Water Conservation

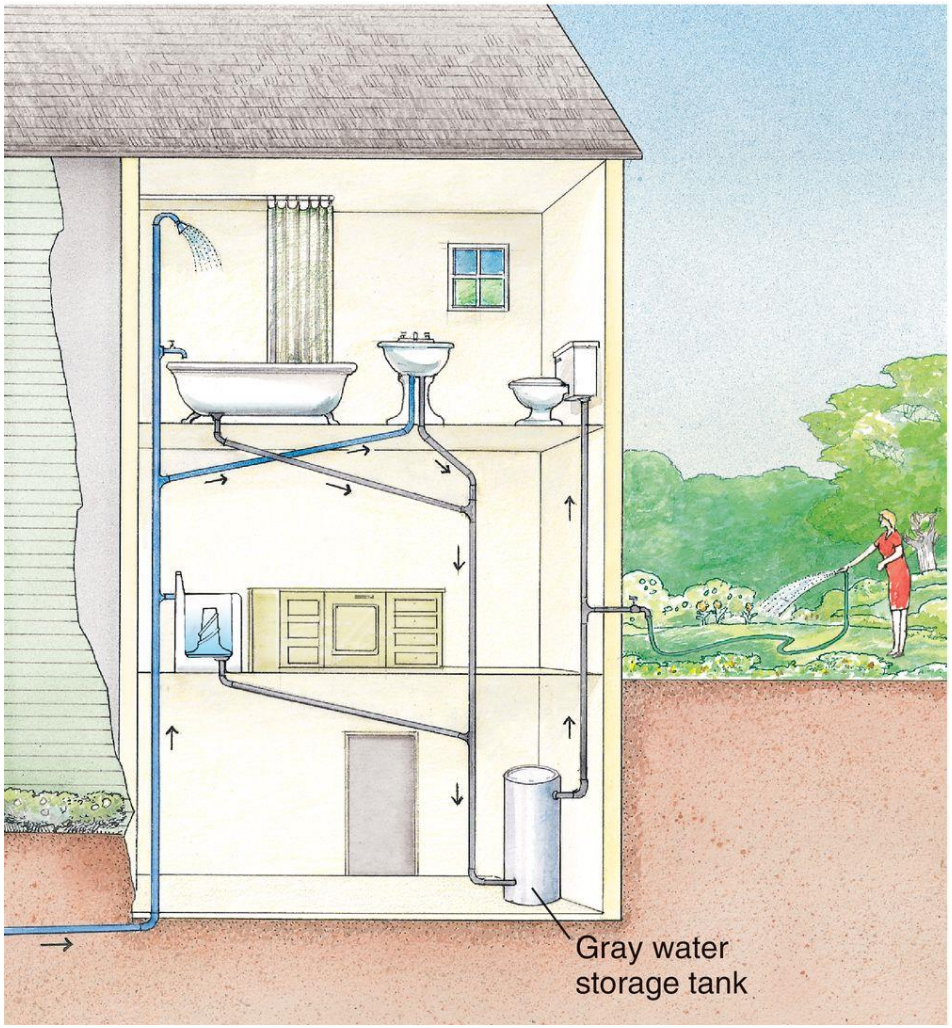
- New technologies to aid conservation strategies
  - Low-energy precision application (LEPA) irrigation tied to geographic information systems (GIS)
    - Water used when needed (estimated by GIS)
    - Water conserved when not needed

Water Conservation

- Reducing Industrial Water Waste
  - Stricter laws provide incentive to conserve water
  - Water scarcity encourages further industrial recycling
  - Potential to conserve water is huge

Water Conservation

- Reducing Municipal Water Waste
- Gray Water
  - Can be used to flush toilets, wash car or water lawn
- Water saving household fixtures
- Government incentives



Conserving at Home

- Install water-saving shower heads and faucets
- Install low-flush toilets
- Fix leaky fixtures
- Purchase high efficiency appliances
- Modify personal habits
- Use the dishwasher when full instead of washing by hand