1 **Introduction to Environmental Geology, 5e**
Chapter 13
Water Resources

2 **Water resources: summary in haiku form**
The grass is greener
over the septic system
said Erma Bombeck.

3 **Case History: Long Island**
- Groundwater pollution: A serious problem on the western end of the island since the beginning of twentieth century
- Groundwater is the sole water supply for the Nassau and Suffolk counties, 3 million people
- Groundwater below Nassau County is tremendous, yet intensive pumping causing as much as 15 m decline in water level
- Salt-water intrusion due to declination in water level
- Urbanization triggered more serious water pollution: Urban runoff, sewage and fertilizers, road salt, industrial and other wastes, and landfills (most of them have been closed)

4 **Case History: Long Island**
Figure 13.2

5 **Water: A Global Perspective**
- Cyclic nature
  - Global movement of water between different water storage compartments
  -
- Global distribution
  - Abundance not a problem
  - Distribution in space and over time a problem
  - Supply versus use a problem
  -
  - More than 99 percent of Earth's water is unavailable or unsuitable for beneficial human use (salt and ice), all people compete for less than 1 percent of Earth's water supply

6 **Global Water Cycle**
- Water's vertical movement
  - Upflow: Evaporation, transpiration
  - Downflow: Precipitation and infiltration
  -
- Water's horizontal movement
  - Surface runoff
  - Shallow subsurface through flow
  - Groundwater flow

7 **Global Water Supply**
Table 13.1

8 **Surface Water (1)**
Surface runoff: Important effects on both the transportation and erosion
- Drainage network
-
- Drainage basin or watershed: An area of land that contributes water to a particular stream or river, a basic unit of landscape
-
- Drainage divide: The boundary between drainage basins
-

- Stream order and size of drainage basin

9 **Surface Water (2)**

Factors affecting runoff and sediment yield

- Geological factors: Type and structure of soils and rocks
- Topographic factors: Relief and slope gradient
- Climatic factors: Type, intensity, duration, and distribution of precipitation
- Vegetation factors: Type, size, and distribution
- Land-use practice factors

10 **Groundwater (1)**

Groundwater (GW) profile

- Vadose zone (unsaturated zone, zone of aeration)
- Zone of saturation
- Water table: The boundary of the above two zones
- Perched water table: Local water table above a regional water table

11 **Groundwater (2)**

- Aquifer: A unit capable of supplying water at an economically useful rate
- Aquitard or aquiclude: A confining layer or unit restricting and retarding groundwater flow
- Unconfined aquifer: No overlying confining layer
- Confining aquifer: With an overlying aquitard layer
- Perched aquifer: Local zone of saturation above a regional water table

12 **Groundwater (3)**

Figure 13.9

13 **Groundwater (4)**

Groundwater recharge and discharge

- Recharge zone: Area where water infiltrates downward from surface to groundwater
- Discharge zone: Area where groundwater is removed from an aquifer, such as spring, well, river, etc.
- Influent stream: Above the water table, recharge water to groundwater, may be intermittent
- Effluent stream: Perennial stream with the addition of groundwater when precipitation is low

14 **Groundwater (5)**

- Groundwater pressure surface: Generally declining from source along the flow from recharge area to discharge area
- Artesian well: Water self-rising above the land surface in a confined aquifer
- Cone of depression: Drawdown cone of groundwater in a well

15 **Groundwater Movement (1)**

- Hydraulic gradient: The gradient of water table, generally following the topographic gradient
- Hydraulic conductivity: Ability of rock materials to allow water to move through ($m^3/day/m^2$)

- Porosity: Percentage of void (empty) space in sediment or rock to store water
-
- Permeability: Measuring the interconnection of pores in a rock material

16 **Groundwater Movement (2)**

Table 13.2

17 **Groundwater Use and Supply (1)**

- Available groundwater estimated above the total flow of the Mississippi during the last 200 years
-
- Groundwater as primary drinking water source for ~50 percent of the U.S. population
-
- Groundwater overdraft problems (extraction rate exceeding recharging rate) in many parts of the country, particularly some states in the Great Plains region
-
- Estimated 5 percent of groundwater depleted, but water level declined more than 15 m (50 ft) in some areas

18 **Groundwater Use and Supply (2)**

Figure 13.13

19 **Interactions Between Surface Water and Groundwater**

- Overdraft of groundwater : Leads to lower water levels of streams, lakes, reservoirs, etc.
- Overuse of surface water: Yields lower discharge rates of groundwater
- Effluent stream (in groundwater discharge zone): Tends to be perennial
- Influent stream (in groundwater recharge zone above the water table): Often intermittent or ephemeral
- Special linkage area: Sinkholes and cavern systems in the karst terrains

20 **Interactions Between Surface Water and Groundwater**

Figure 13.15

21 **Karst Topography Problems**

- Water pollution occurs where sinkholes have been used for waste disposal.
-
- Cavern systems are prone to collapse, producing sinkholes that may form in areas that damage buildings on the ground surface, roads, and other facilities
-
- In many areas underlain by limestone, such as the Edwards Plateau in Texas, groundwater is being mined. As a result of the mining, important karst springs where water emerges from caverns are being changed, causing a reduction in biodiversity

22 **The Edwards Aquifer**

- Mark Twain “Whisky is for drinking and water is for fighting over.” Intense conflict over water in central TX
- One of the most prolific in N. America, providing water for more than 2 million people, with a natural yield of 25,000 gallons per minute
- Recharged primarily through influent streams flowing over the recharge zone where water sinks into the limestone
- Increased water demand for growing urban areas and for irrigation
- Ecosystems dependent upon the spring water: the San Marcos spring salamander, the fountain darter fish, and Texas wild rice are endangered species

23 **The Edwards Aquifer**

Figure 13.A

24 **Water Use (1)**

- Offstream use: Removal or diversion from its surface water or groundwater sources temporarily (e.g., irrigation, thermoelectric, industrial use)

- Consumptive use: Type of offstream use of water without intermediate return to the surface water or groundwater, such as transpiration and human use
- Instream use: Navigation, fish and wildlife, recreational uses

25 **Water Use (2)**

In major urban areas

- Over withdrawal of groundwater
- Overuse of local surface water
- Threats of local urban landfills to the water supply (e.g., Long Island, NY)
- Water import issues and problems: What is distance to transport? How much water available? From where? Conflicts with other areas, litigations, and long-range planning

26 **Trends in Water Use (1)**

Based on the data from 1950–1995

- Surface water use far greater than groundwater use
- The rate of water use decreased and leveled off since 1980
- Irrigation and thermoelectric are major fresh consumptive water use
- Less fresh water use since 1980 due to new tech and water recycling

27 **Trends in Water Use (2)**

Figure 13.21a

28 **Trends in Water Use (3)**

Figure 13.21b

29 **Water Conservation**

- Improved agricultural irrigation could reduce water withdrawals by between 20 percent and 30 percent
- Engineering technology and structure (canals): Regulating irrigation and reducing evaporation
- Better technologies in power plants and other industries: Less use of water due to improved efficiency
- Domestic use of water (urban and rural) accounts for only 10 percent of the total national withdrawals, can be reduced at a relatively small cost with more efficient bathroom and sink fixtures
- Global water conservation: Virtual water budgets

30 **Conservation of Water at the Global Scale**

Figure 13.22

31 **Water Management (1)**

Needs for water management

- Increasing demand for water use (population and economic development)
- Water supply problems in semiarid and arid regions
- Water supply problems in mega cities of humid regions
- Water traded as a commodity: Capital, market, and regulations?

32 **Water Management (2)**

Aspects to be considered: Leopold philosophy
- Natural environmental factors: Geologic, geographic, and climatic
- Human environmental factors: Economic, social, and political
- Strategies
  - More surface water use in wet years, more groundwater use in dry years
  - Reuse and recycle water regular basis as well as emergencies

33 **Management of the Colorado River (1)**

Managing the water
- Water appropriation to seven states in the United States and to Mexico
- Local needs versus regional needs (Colorado River compact of 1922)
- The United States versus Mexico (Treaty with Mexico in 1944)
- Human use versus needs of lands (1974 Salinity Control Act)

34 **Management of the Colorado River (2)**

Managing the river
- Dam construction
- Impact on flood frequency
- Impact on sediment distribution, particularly downstream
- Impact on wildlife habitats
- Controlled and planned floods

35 **Water and Ecosystems**
- Ecosystems: Changes in response to climate, nutrient input, soils, and hydrology
- General tendency: Increased human use of water, increased degradation of natural ecosystems
- Overall reconciliation between multiple water uses
  - Water resources development (dam, reservoirs, canals) and associated impact on surface water environment
  - Reconciling the uses of water: Agriculture, industry, urbanization, and recreation
  - Protection of wetland and water resources

36 **Wetlands and Ecosystems**

Wetlands: swamps, marshes, bogs, prairie potholes, vernal pools
- Wetlands are one of nature's natural filters. Plants in wetlands may effectively trap sediment, nutrients, and pollutants
- Freshwater wetlands are a natural sponge. During floods, they store water, helping to reduce downstream flooding and release water after the flood, nourishing low flows of river systems
- Wetlands are highly productive lands where many nutrients and chemicals are naturally cycled while providing habitat for a wide variety of plants and animals
- Freshwater wetlands are often areas of groundwater recharge to aquifers. Some of them, a spring-fed marsh, for example, are points of groundwater discharge

37 **Emerging Global Water Shortage**

- Isolated shortage of water: Indication of a global pattern of water shortage
- Depleted water resources: Over-drafted aquifers, dried lakes (Aral Sea), troubled streams (Colorado and Yellow River not reaching seas some years)
- Polluted limited water resources due to development and increased wastes
- Demands for water resources tripled as populated more doubled last 50 yrs and growing fast next
  50 yrs
- Global warming: Causing more problems

Critical Thinking Topics

- In your area, which type of water source
  (surface water or groundwater) is more important? Why? Why not?
-
- If we change the ways we use water, what would be the impact on the global water cycle?
-
- What sort of wetlands are found in your region? Any changes over the years?
-
- Which continent will the global warming have a greater impact on its water resources?

Figures from Chapter 13 follow…

End of Chapter