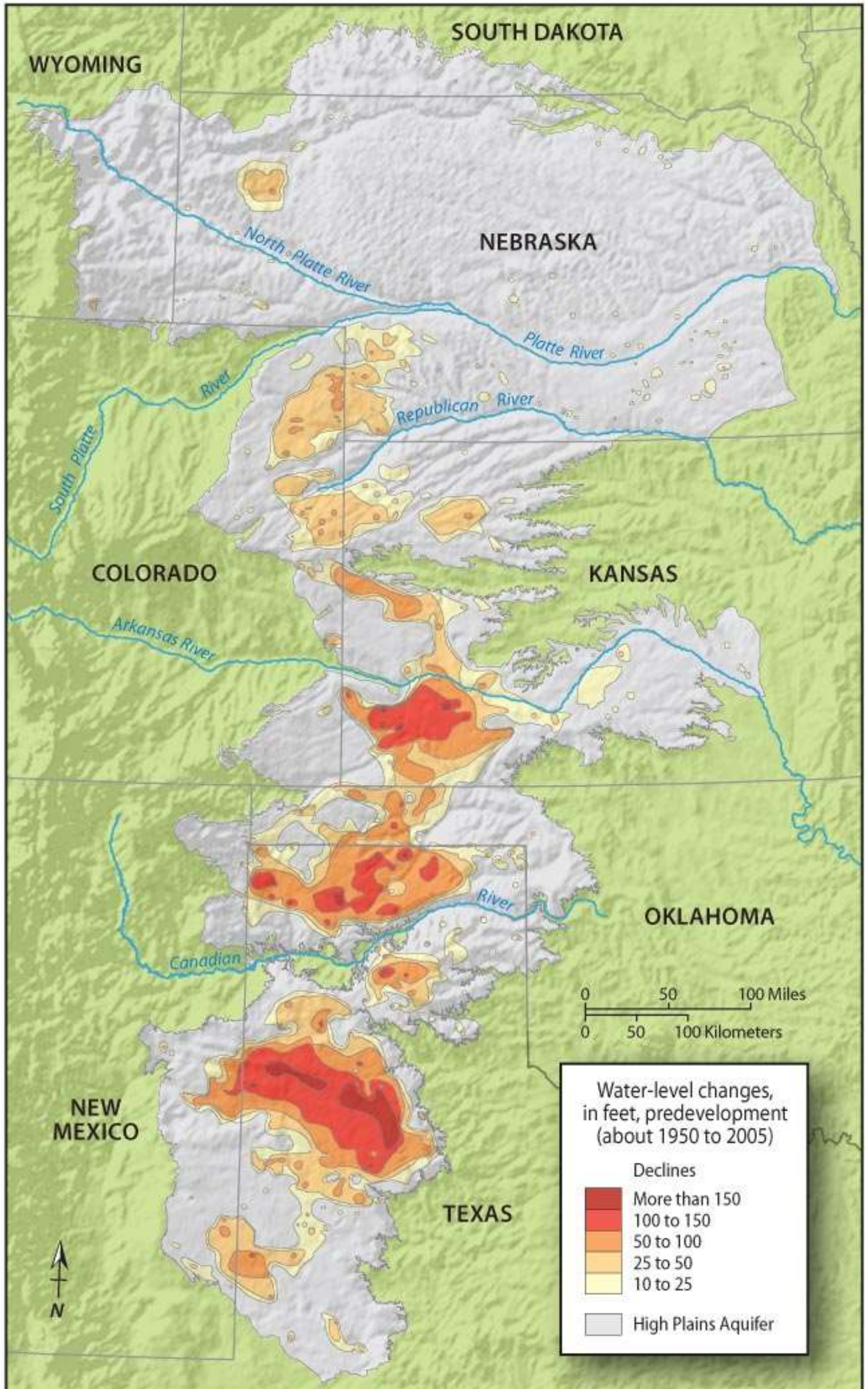


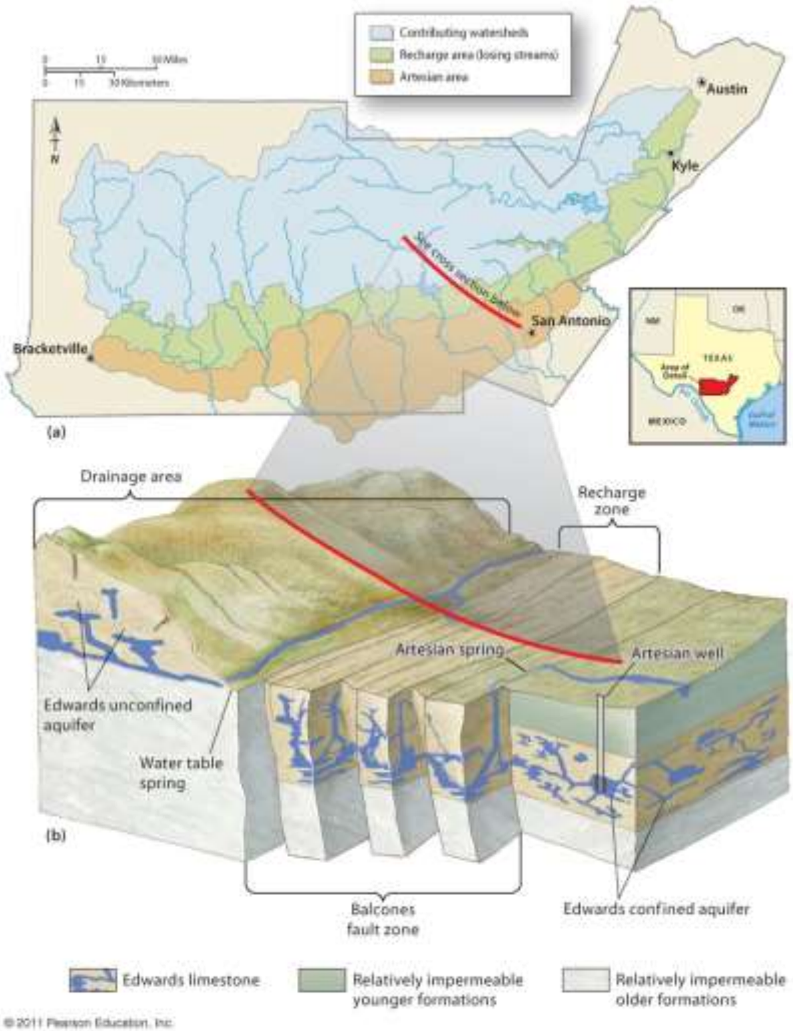
Great Plains Aquifer—the Ogallala

Figure 10-9 The High Plains Aquifer

- Groundwater withdrawal from this unconfined aquifer has lowered the water table over 46 m (150 ft) in places (red areas on map).
- One of the largest aquifers on Earth.
- Unconfined

Why is groundwater being pumped so heavily here in the Southern High Plains? Because they are growing water-intensive crops like cotton there.
Question: If we are going to use water to grow crops in a place like this, shouldn't we at least be making food?

Surface Water and Groundwater Connections—the Edwards Aquifer



Confined aquifers with enough pressure sometimes have water flowing at the surface without pumping—an artesian well.

Figure 10-10 The Edwards Aquifer
This unconfined aquifer system extends across seven Texas counties **(a)**. It provides water for the famous River Walk in San Antonio. Surface water in recharge area comes from a northern part of the aquifer (called drainage area) separated from southern part by uplift along a series of faults **(b)**.

Water Use in the U.S.A.

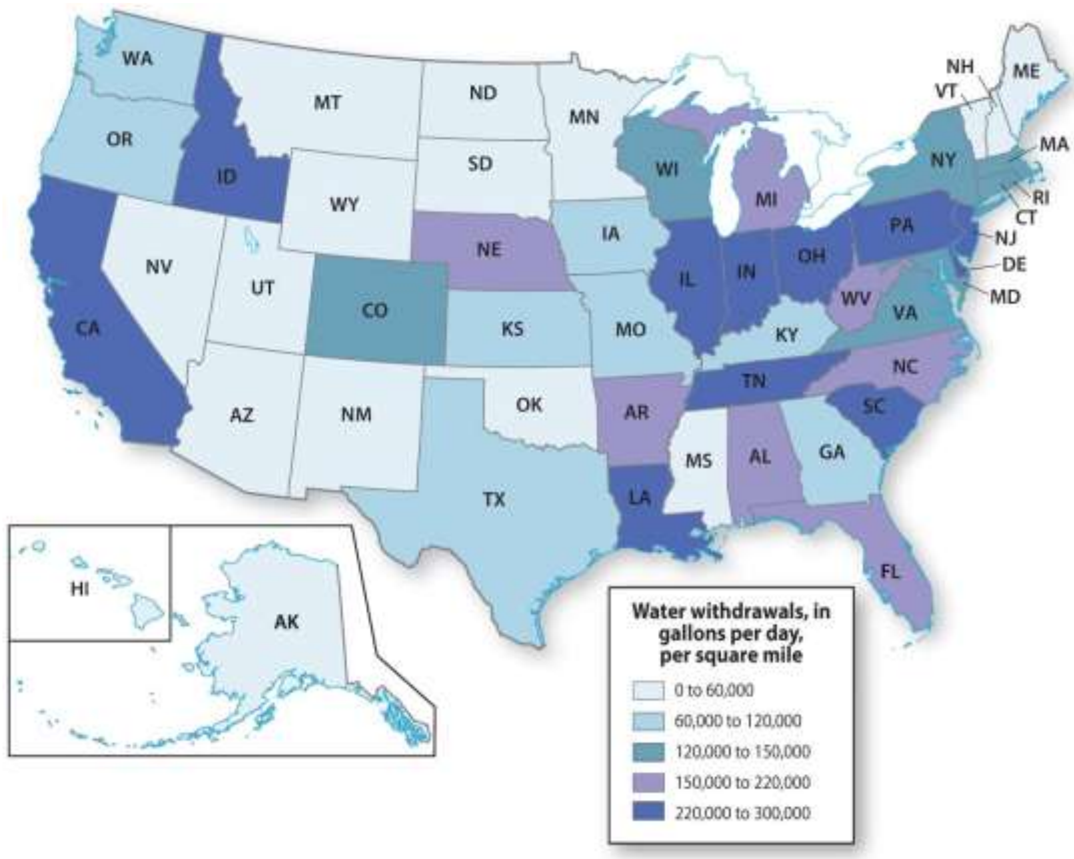


Figure 10-12 A Thirsty Nation
Freshwater withdrawals in the United States, by state. Note that the withdrawals given in the key are per square mile. Altogether, the total daily withdrawal is about 350 billion gallons (1.3 trillion L). Nebraska uses a lot of ground water for agriculture.

Water Withdrawal and the Environment

(a)

(b)

All this work to move water 100s of km but they didn't put a cover on the aqueduct to stop evaporation in the desert? They're losing 10-20% of the water to the atmosphere!

Figure 10-14 Dams and Diversions
(a) Large dams, like Grand Coulee-Columbia River in Washington, are used for recreation, power generation, flood control, and water supplies.
(b) Canals and aqueducts such as the Los Angeles aqueduct transfers surface water from eastern California to the Los Angeles area, to where it is needed.

Dam Construction over Decades

- Dam construction has essentially stopped in the U.S. Surface-water reservoir capacity has been about the same since 1980 (Fig. 10-16).
- U.S. has built more dams than any other country. Some now being removed because they interfere with fish migration, no longer function, etc. See Marmot Dam, OR removal video.

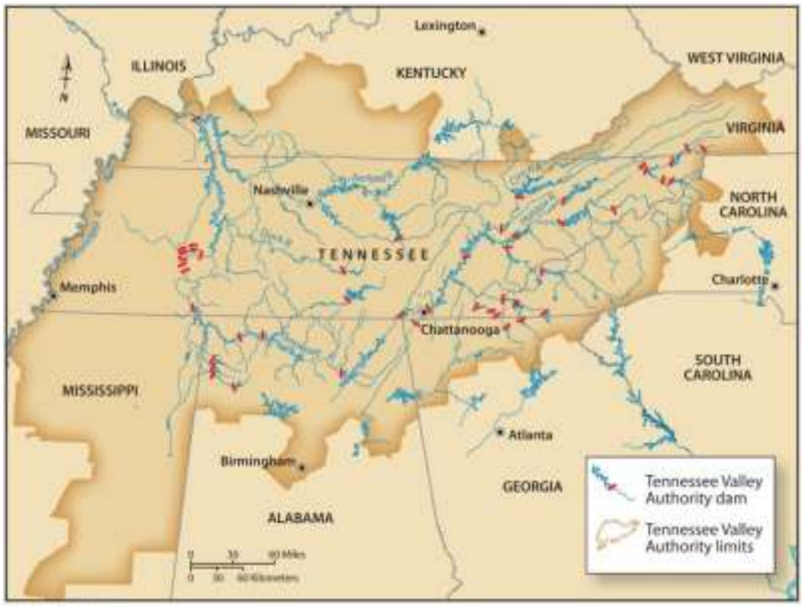


Figure 10-15 Dams—Tennessee Valley Region
The Tennessee Valley Authority manages 49 dams in the Tennessee River watershed.

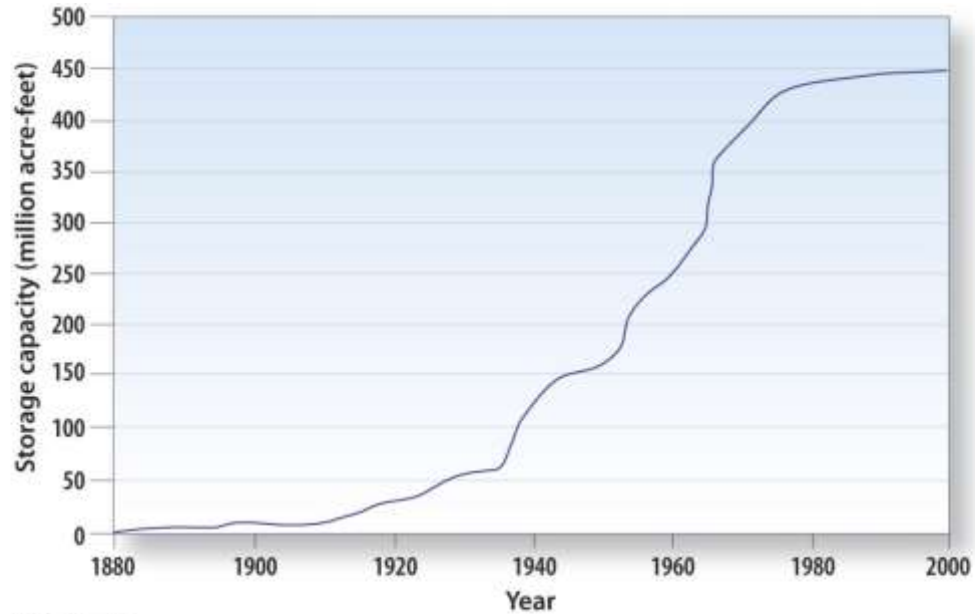


Figure 10-16 U.S. Reservoir Capacity
Reservoir capacity increased dramatically during great period of dam construction from 1935 to 1975.

Mining/Pumping Underground Water

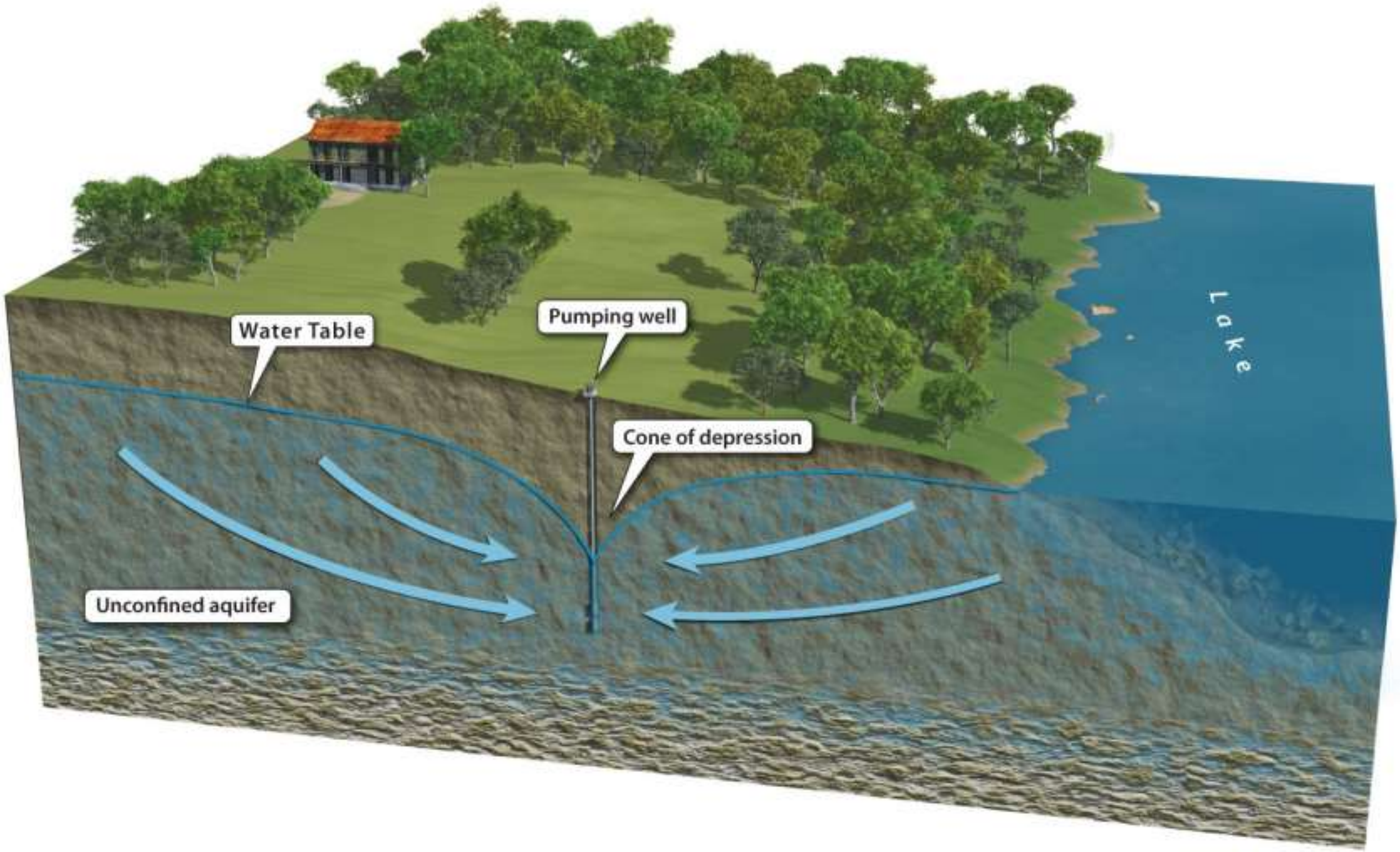
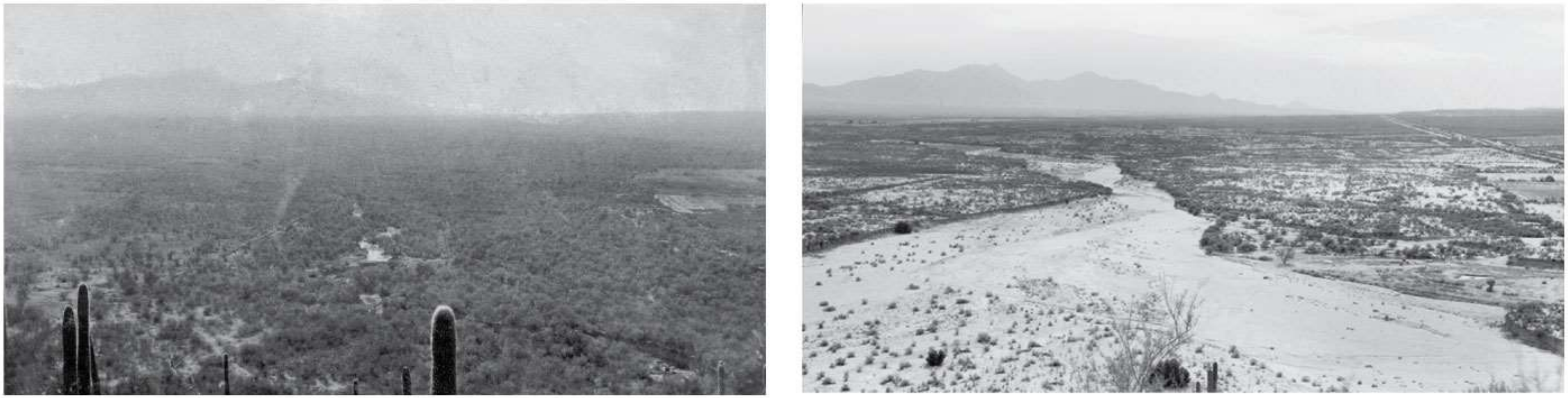


Figure 10-17 Aquifer Depletion
Pumping more water than natural recharge can replace lowers the water table. The drop is greatest where the water is being withdrawn, creating a cone of depression in the water table around the well site.

Mining /Pumping Underground Water (cont.)



(a) (b)

Figure 10-18 Effects of Groundwater Pumping (a) A 1942 photograph of a reach of the Santa Cruz River south of Tucson, Arizona. **(b)** A 1989 photograph of the same site shows that the riverside trees have largely disappeared and the habitat has significantly changed. Groundwater pumping lowered the water table and created a losing stream in this area.

Karez

FIG. 3.31 (A) Photograph of karez cleanout shafts along valley floor. Karez along irrigation canal or ephemeral or perennial rivers can take advantage of leaky canals and infiltration from nearby losing or infiltrating streams to gain shallow ground-water recharge (*Photograph by L. Sinfield, 2012*). (B) Photograph of multiple generations of karez cleanout shafts showing filled and abandoned portions, together with more recent open shafts (*Photograph by U.S. military*).

Shroder and Ahmadzai, 2016

Karez

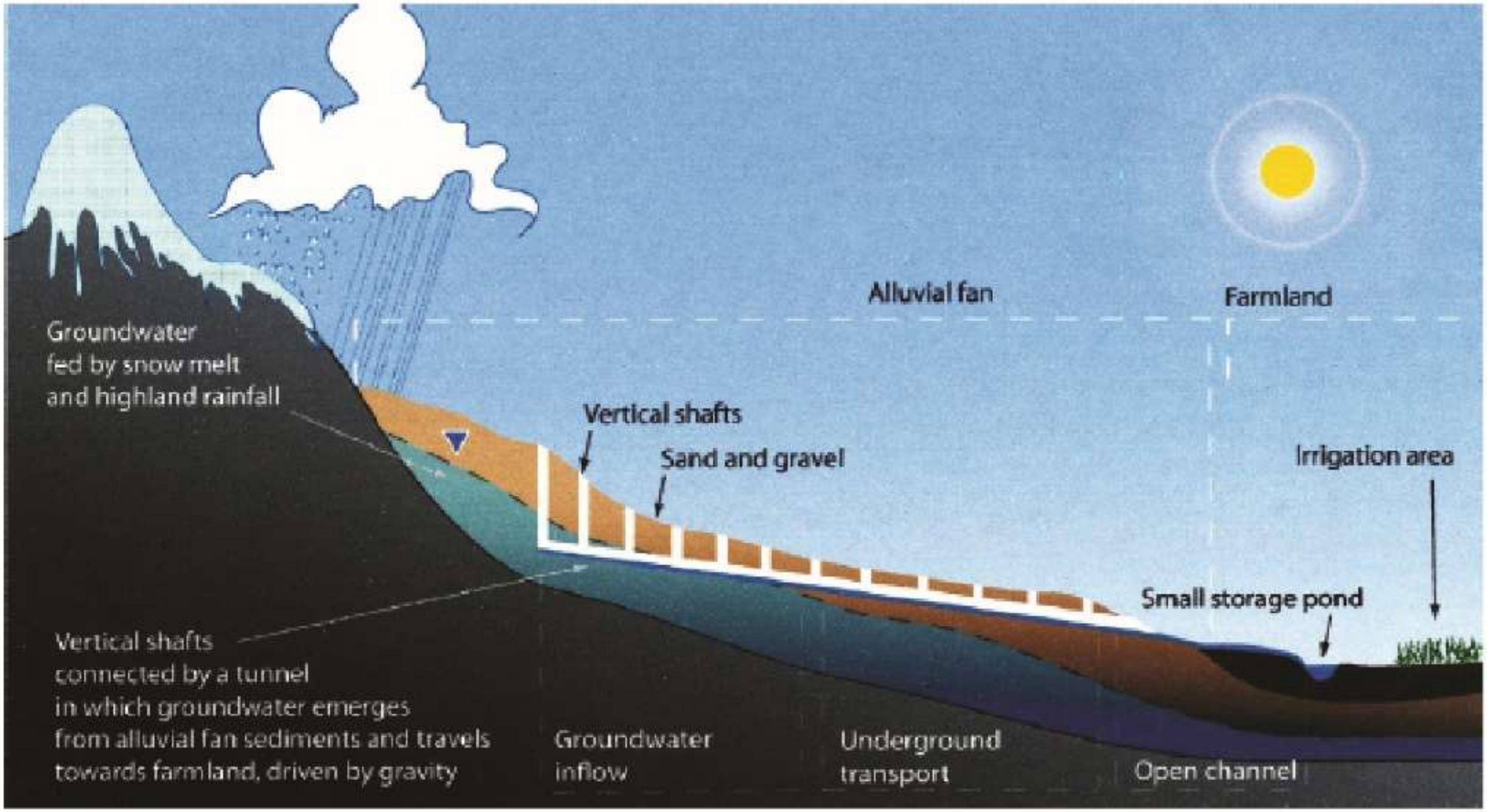


FIG. 3.30 Diagram of typical and traditional karez. *From Fig. 5.33 in Shroder, J.F., 2014. Natural Resources in Afghanistan: Geographic and Geologic Perspectives on Centuries of Conflict. Elsevier, Amsterdam; by permission from Earth magazine.*

Karez

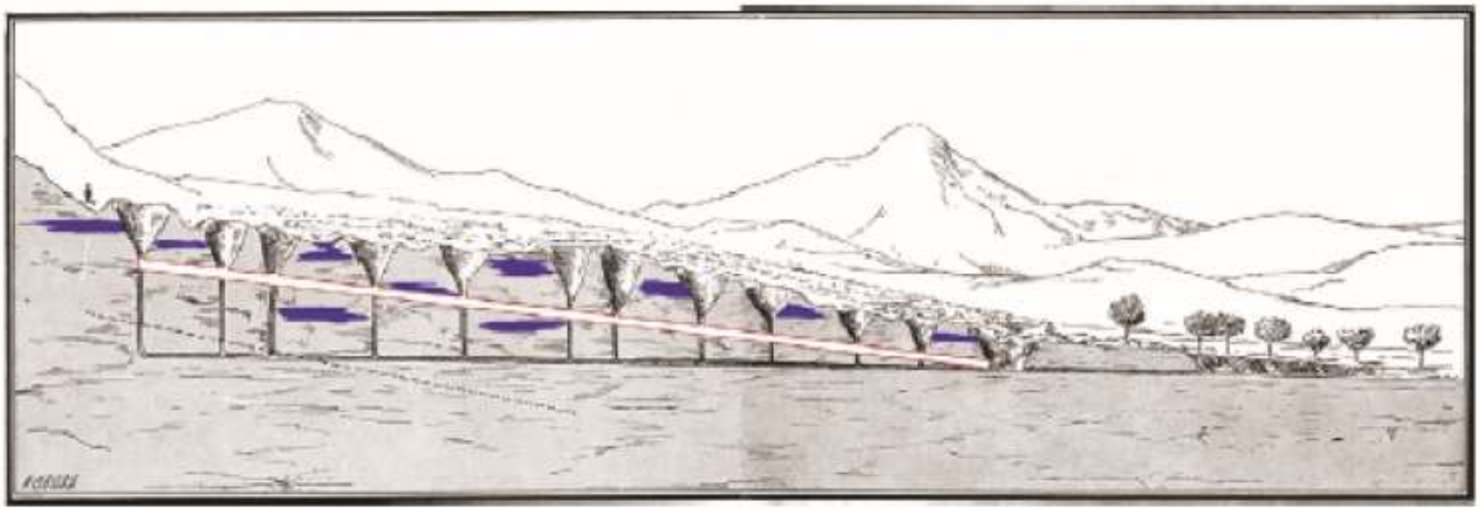


FIG. 3.34 Comparison between the old and new karez construction models, with the old concept of a near horizontal tunnel is shown in black, and the new concept above it with an exaggerated steeper gradient in white and red. The new concept, however, must intersect various perched aquifers or infiltration zones from surficial ephemeral streams to be effective.

Shroder and Ahmadzai, 2016

Kabul Basin Groundwater Material Flows

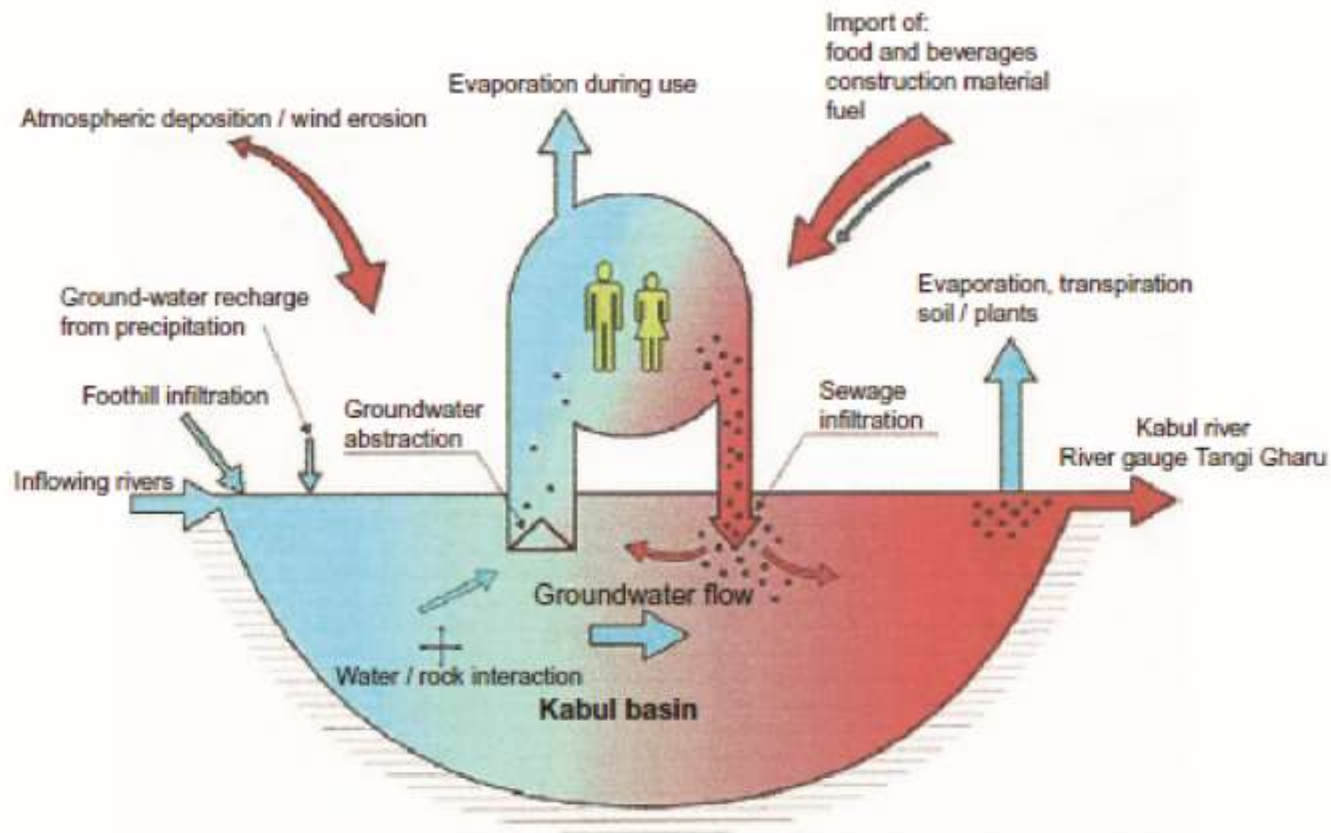


FIG. 4.20 Schematic diagram of material flows in ground water of the Kabul Basin. *From* Houben and Himmelsbach (2005).

Shroder and Ahmadzai, 2016

Dumping Raw Sewage into a Stream

Photo by L. Sinfield

Washing clothes in the gutter (*juie*). No other sewage system occurs in the city. Most of the gutters drain to the main canals

(A) Photo by L. Sinfield

Photos of concrete sewage gutters in the city of Kandahar where the first photo shows children washing clothes

Photo by L. Sinfield

Photo of hand-operated well in Kandahar near sewer gutter. Hand-operated wells (India Mark III type) typically tap the shallowest aquifers beneath the city of Kandahar.

Children selling vegetables over open sewer ditch from where they can get contaminated water to sprinkle of the vegetables to prevent desiccation.

Photo of raw sewage seeping upwards from a septic system. Maintenance and repair of sewer systems are not a high priority for many Afghan institutions

Photo by L. Sinfield, 2012

Salty Groundwater

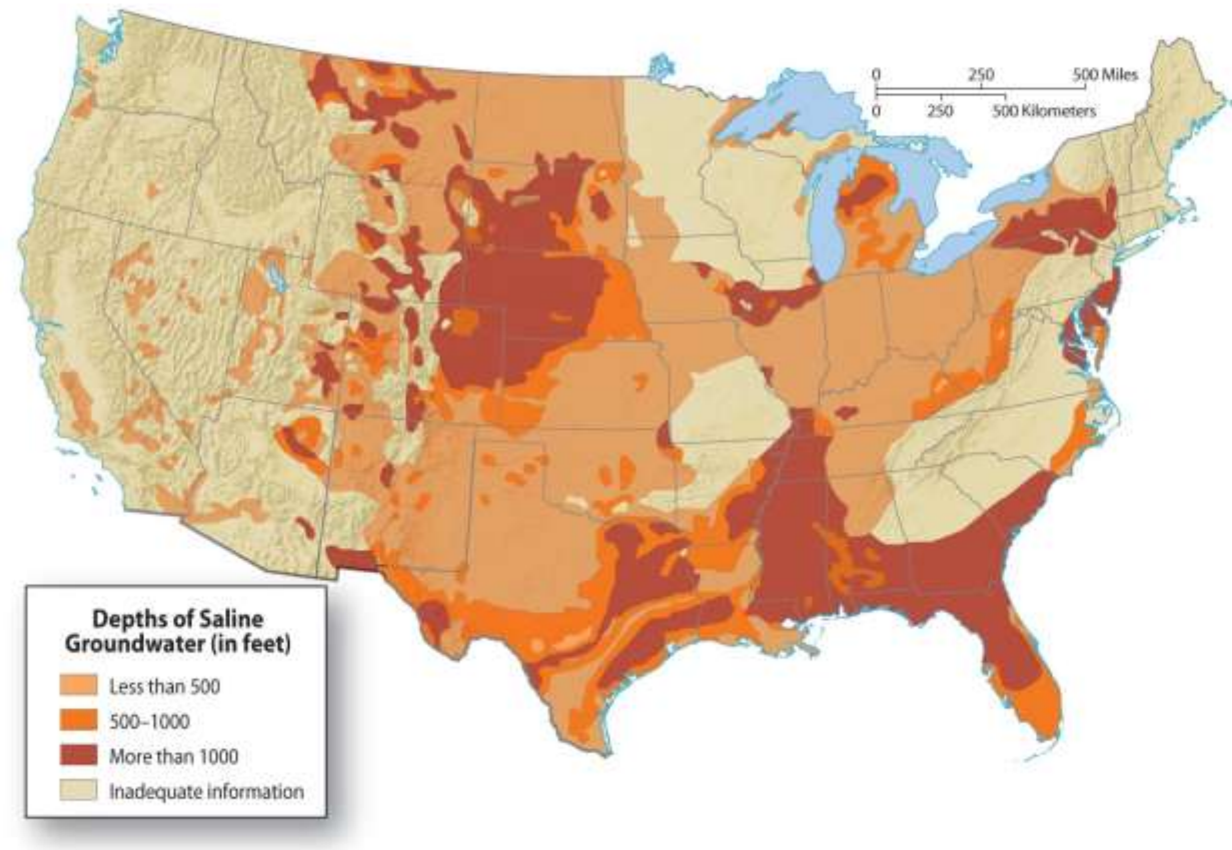


Figure 10-11 Saline Groundwater in the United States Saline groundwater, a potential water resource, can be found at moderate depths through large parts of America.

Drilling Process and Waste Products

- Salt water pollution from drilling can cause salt scarring at the surface, pollute breached freshwater aquifers, and sterilize surface soils…
- Drilling requires fluids to lubricate the well bore and control pressure in it; fluid is a mixture of water, clay, barite, and chemicals; commonly called drilling mud.
- As the well is advanced, drilling mud circulates down and up the well bore, carrying displaced rock chips (cuttings)—they are separated at the surface and the mud is circulated back down to collect more.
- Cuttings and mud, perhaps containing some oil, are waste that must be disposed of. Waste is placed in pits, removed and injected into the subsurface, and area reclaimed.

Figure 13-14 Mud Pit Remediation
(a) Pond is an abandoned mud pit whose bottom is covered with drilling-mud waste.
(b) Remediation involves draining pond and removing old drilling mud and other waste.
(c) Remediation is complete when the pond is filled with clean soil and graded.

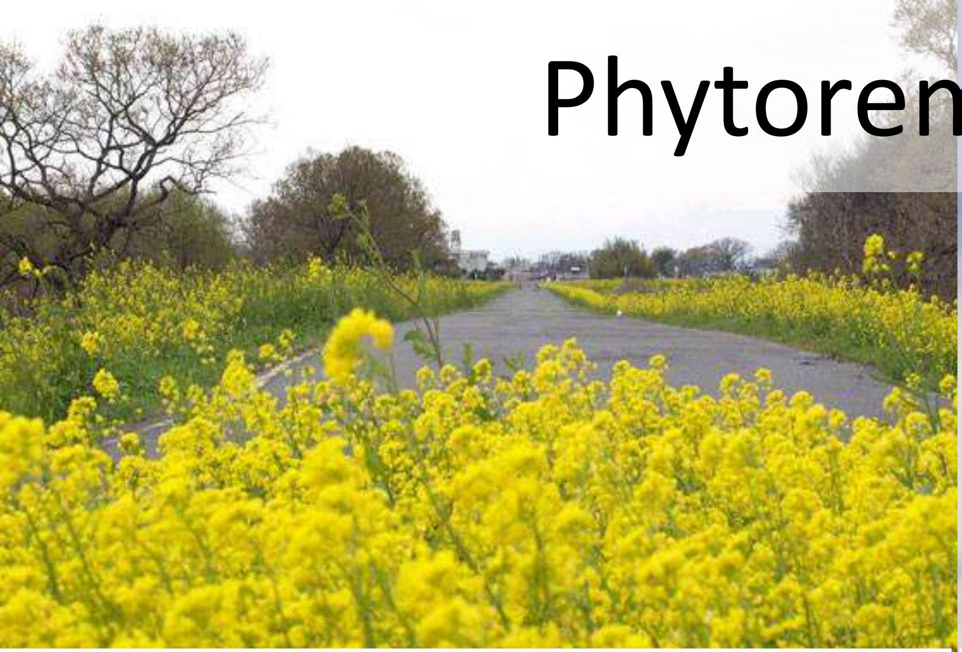
Salty Production Water—Oil, Gas, and Coal Fields

- In the U.S., many oil wells are decades old and as time passes the amount of produced water increases (e.g., many wells produce 6 or more barrels of water per barrel of produced oil). This production water is salty and must be disposed of properly or reinjected into the reservoir as a drive mechanism for additional oil production.

- Salt scars are problem areas from preregulatory times (e.g., pre-1970s) where production waters from oil wells were simply drained onto the surface, killing plants and sterilizing the soil. Brine waters are also associated with coal-bed methane production.

- To remediate salt scar areas gypsum (for calcium source) and fertilizers are being worked into the soil. Planting salt-tolerant vegetation and irrigating the area to help flush and clean soil are other remedial actions taken. Some plants can be used to remediate polluted soils (phytoremediation)…

Phytoremediation



Indian mustard (Brassica juncea L.) Info: Brassica juncea (L.) Czern. – Indian Mustard

Sunflower (Helianthus Annuus L.) (Helianthus annuus L. common sunflower)

Indian grass (Sorghastrum nutans) (Sorghastrum nutans (L.) Nash)

Willow (Salix species). (White Willow)

Sustaining Water Resources

There are a number of ways to help sustain water resources, such as through:

- Water treatment
- Recycling wastewater
- Conservation or using less water

Figure 10-29 Municipal Water Treatment Plant Communities collect sewage and wastewater and treat it in plants before releasing it to surface water.Treatment includes removing contaminants: primary (solids, fats, floating masses), secondary (biological degradation of primary pass water), and tertiary (disinfection if needed—such as with addition of chlorine).