

Chapter 19: GROUNDWATER

- MAJOR GLOBAL RESERVOIR
 - ... most of what exists is not accessible: Either too deep, or brackish
- EXTRACTING GROUNDWATER
 - Is this a renewable resource?
- DESCRIBING WATER IN SOIL
 - There is always some level of water in soils
 - Usually some fraction of voids or spaces in soil
 - Saturated zone: pore spaces are filled with water
- GROUNDWATER ZONES POROSITY & PERMEABILITY
 - Porosity: how much void space there is
 - Ranges of different porosities in different soils and rocks
- POROSITY & PERMEABILITY
 - Permeability: how connected voids are
 - Top: impermeable soil; Bottom: permeable soil
- AQUIFERS
 - NOT underground rivers!
 - Aquifers are formations (soils, rocks) that transmit water
 - Aquitards do not transmit water easily
 - Confined aquifers: separated from the surface by an aquitard
- ARTESIAN WELLS
 - These are wells that flow at the surface without pumping
 - How can this happen?
- THE HIGH PLAINS AQUIFER
 - a.k.a. Ogallala Aquifer
- HIGH PLAINS AQUIFER
 - Dakota sandstone makes up most of this aquifer Ogallala has been significantly depleted...
- WATER TABLE VARIABILITY
 - Fluctuations due in part to surface water changes During rainy season, water table is higher
- WATER TABLE VARIABILITY
 - In some regions, groundwater height is driven by rainfall and infiltration
 - Thus groundwater can be a renewable resource
- NOT ALWAYS A RENEWABLE RESOURCE
 - Travel times depends on the material (porosity, permeability) and pressure
- GROUNDWATER AND TOPOGRAPHY
 - The groundwater table somewhat follows topography
 - The water table can be above sea level
- GROUNDWATER FLOW PATHS
 - Flow is from areas of high pressure to low pressure “Pressure” is characterized by hydraulic head
- POTENTIOMETRIC SURFACE
 - The height to which water rises in a standpipe
 - Water tower gives water height and potential energy
 - Friction in pipe causes potentiometric surface to diminish

- ARTESIAN WELLS
 - Wells are artesian when potentiometric surface is above ground Surface
- GROUNDWATER FLOW
 - Flow is controlled by:
 - Hydraulic gradient
 - Hydraulic conductivity, related to permeability
 - Hydraulic gradient is change in the potentiometric surface divided by distance.
- SUBSURFACE CAN BE COMPLEX
 - “Perched water table”: zone of saturation perched on an aquitard below which is an unsaturated zone
- SOUTHERN CALIFORNIA GROUNDWATER MODELING WHAT HAPPENS DURING PUMPING?
 - Confined aquifer : hydraulic head lowers
 - Unconfined aquifer : Water table lowers
- PUMPING FASTER THAN RECHARGE
 - In places, we have pumped until the water table is out of reach in a few decades
 - Often water has been stored for millions of years
- OGALLALA DEPLETION
 - Began pumping for irrigation in the 1930s
 - Around 13 million acres of irrigated land
 - Has declined over 150 feet in some places
 - Estimate: we have used up 0% of the water here
- SUBSIDENCE
 - Major problem in Central Valley
- GROUNDWATER FROM SPACE GRACE INDIA AND GROUNDWATER
 - Massive amounts of pumping have lowered reservoir levels
 - In some places it is no longer economical to pump
- INDIA, GROUND WATER, AND THE GREEN REVOLUTION
 - High-yield rice helped avoid a food crisis in the 1960s
 - High-yield rice requires more water
- SALTWATER INTRUSION
 - Originally, water recharged aquifers beneath Florida from Lake Okeechobee to feed the Everglades
 - Pumping has disrupted groundwater flow
 - One result is that salty sea water intrudes into aquifers
 - Also a problem in Southern California
- SALTWATER INTRUSION
 - Purification systems are not capable of dealing with the saltwater
 - We end up using additional pumps to push the saltwater back in order to solve this
- GROUNDWATER CONTAMINATION
 - Once contaminants get into groundwater, how do they move?
 - Pumping can significantly change hydraulic head and piezometric surface