Groundwater Sustainability

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Irrigation Association Drought Forum

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Outline

- What is Groundwater Sustainability?
- Some Myths
- Importance of Water Use
- Human vs Hydrologic Time Scales
- Lessons from Others (Arizona, Australia)
- Integrated Monitoring and Modeling

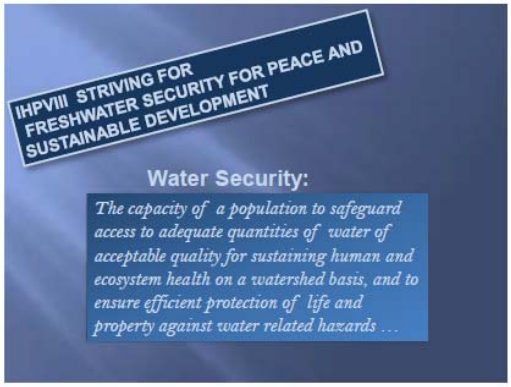
Groundwater Sustainability

- Development and use of groundwater resources to meet current and future beneficial uses without causing unacceptable environmental or socioeconomic consequences (USGS Circular 1186)
- SGMA Definition: the basin is operated in such a way as not to cause "undesirable results," such as chronic depletion of groundwater, seawater intrusion, or land subsidence

Groundwater Sustainability

- A perspective that frames scientific analysis—Not a scientific concept
- Essentially the end result of public acceptance of the tradeoffs of development
- GW hydrologists provide information on the long-term consequences of GW pumping that can be used in helping make societal decisions

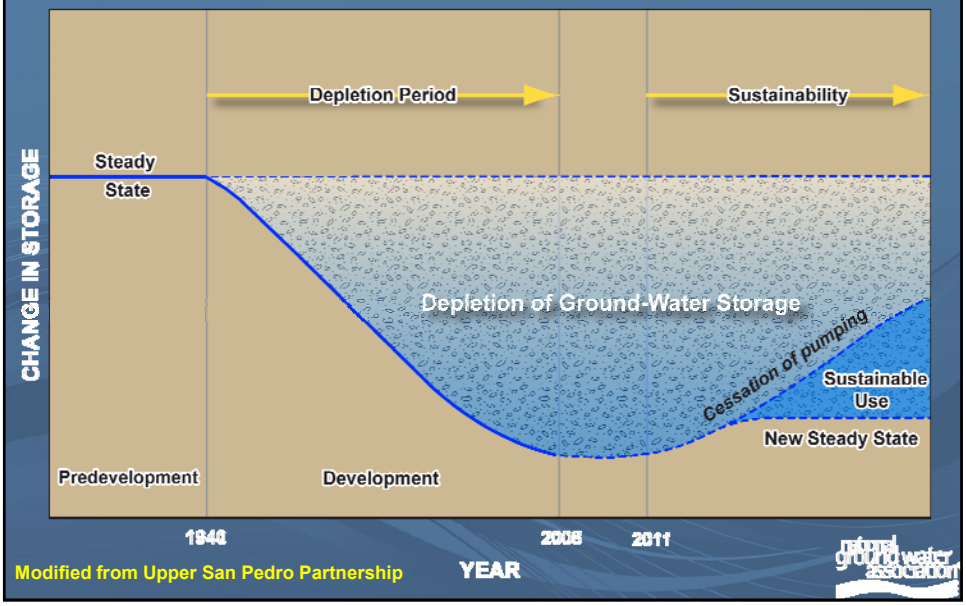
Is Sustainability Passé?



Sustainability is in the eye of the beholder

- Different groups may define sustainability differently:
  - **Ecologists:** Use of resources that allows perpetual survival of existing ecosystems
  - **Economists:** Allocation of resources that leaves future generations no worse off than present generations

Storage Change and Sustainable Yield



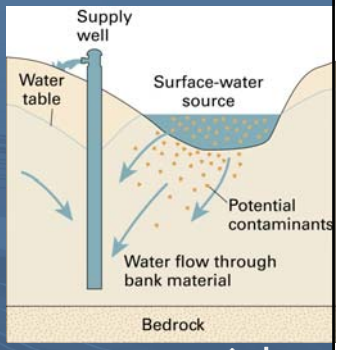
Need to consider management practices in defining sustainability

- Managed aquifer recharge
- Use of recycled or reclaimed water
- Conjunctive use of groundwater and surface water

Spreading Basins in Southern California

Sustainability & Water Quality

- Contamination from land surface
- Contamination by surface water
- Cross contamination in wells
- Naturally-occurring substances
- Saltwater intrusion
- Managed aquifer recharge



GW Myths

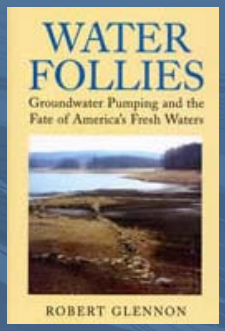
- GW and SW are separate resources

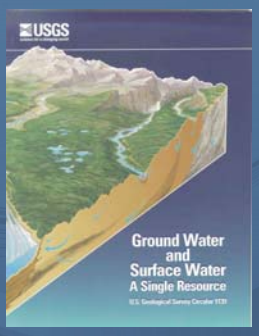
GW and SW: A single resource

"Tonight I'm calling on Democrats and Republicans to pass legislation to protect our groundwater against withdrawals that significantly damage our rivers, lakes, wetlands, and springs."

Governor James Doyle, 2004

Wisconsin State of the State address.

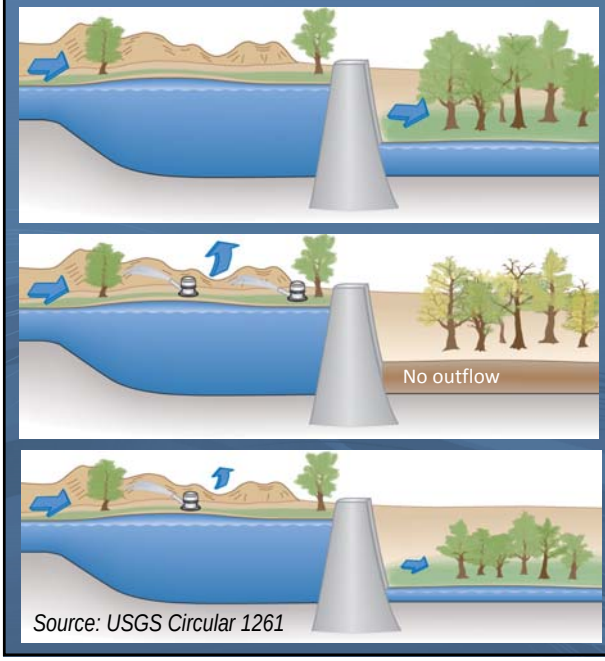




GW Myths

- ~~GW and SW are separate resources~~
- A groundwater system is "safe" as long as pumping doesn't exceed the average rate of recharge

SW Reservoir Analogy to Groundwater Pumping



A—No Pumping

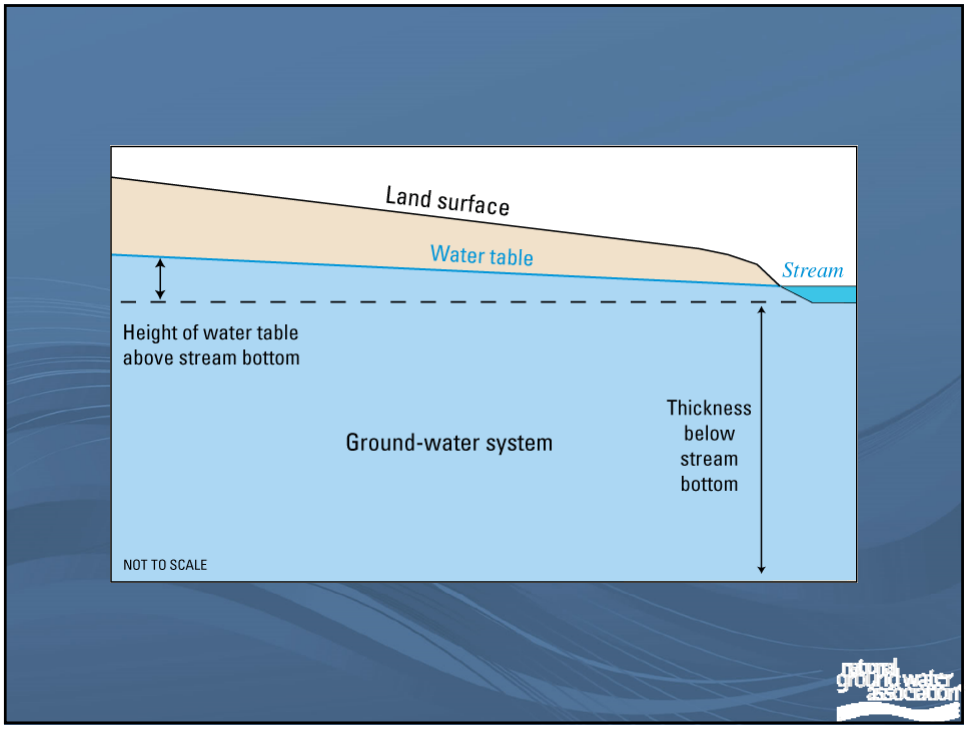
B—Pumping = Inflows

C—Pumping < Inflows

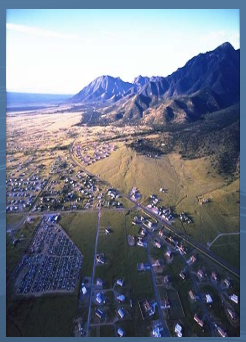
Source: USGS Circular 1261

GW Myths

- ~~GW and SW are separate resources~~
- ~~A groundwater system is "safe" as long as pumping doesn't exceed the average rate of recharge~~
- To manage groundwater we need to know how much we have (i.e., Total Storage)



In some groundwater systems, depletion of a small part of the total volume of groundwater in storage can have large effects on surface water, water quality, or subsidence which become limiting factors to development.



Upper San Pedro Basin, AZ

Houston, TX

Edwards Aquifer, TX

Republican River Basin, CO, KS, NE

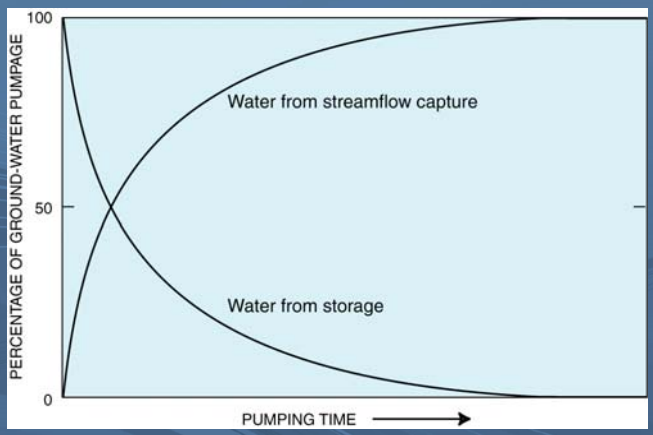
Key Information for Critical Issues

- SW/GW—Gradients, Saturated thickness
- Land Subsidence—Water levels
- Water Quality—Flow systems
- Pumping Costs—Hydraulic heads

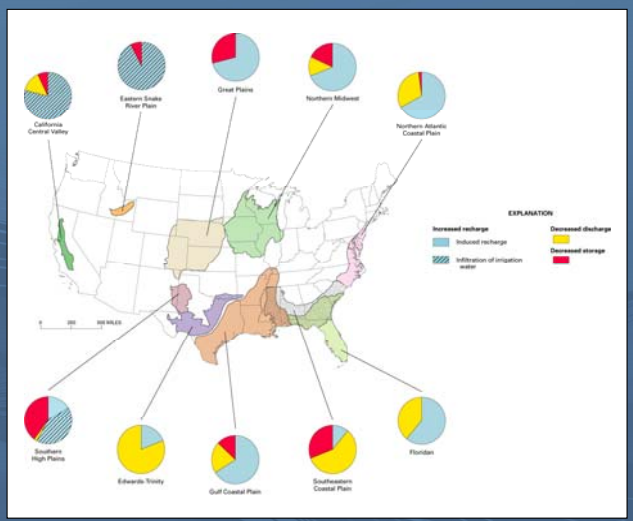
GW Myths

- ~~GW and SW are separate resources~~
- ~~A groundwater system is "safe" as long as pumping doesn't exceed the average rate of recharge~~
- ~~Total groundwater storage is important to know~~
- Groundwater withdrawals primarily come from GW storage

Sources of Water to Pumping Wells



Each groundwater system is unique in its response to pumping



Alley and others, 2002; Data from Johnston, 1997

Water Use: The Most Important Information We Don't Know.

Photo: Claudia Faunt, USGS

Example 1: Blue River Basin, NE

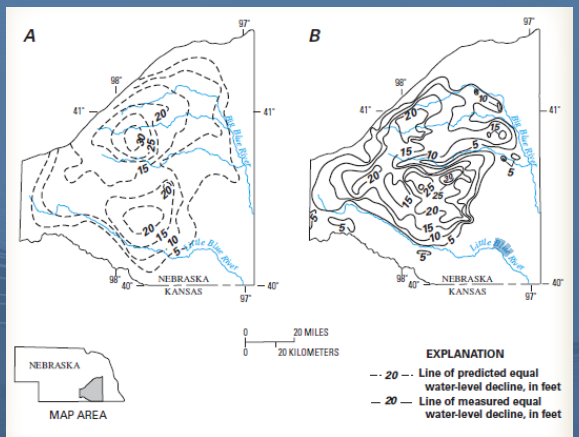
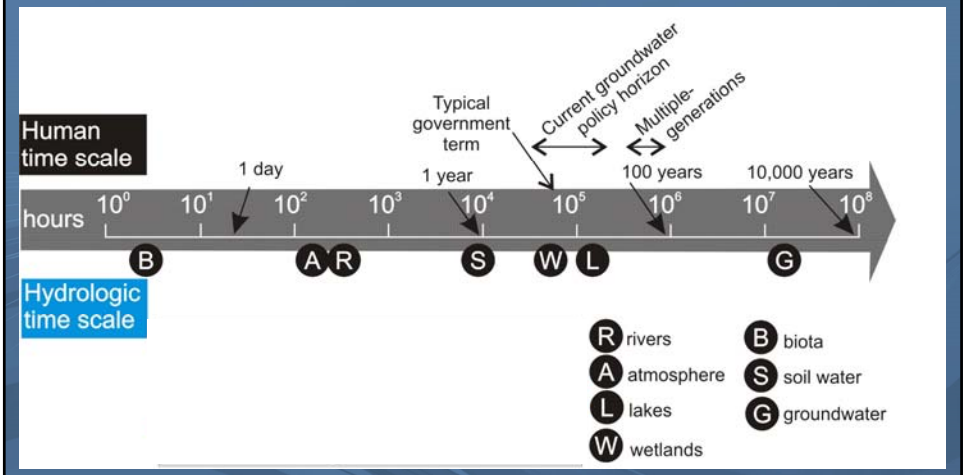


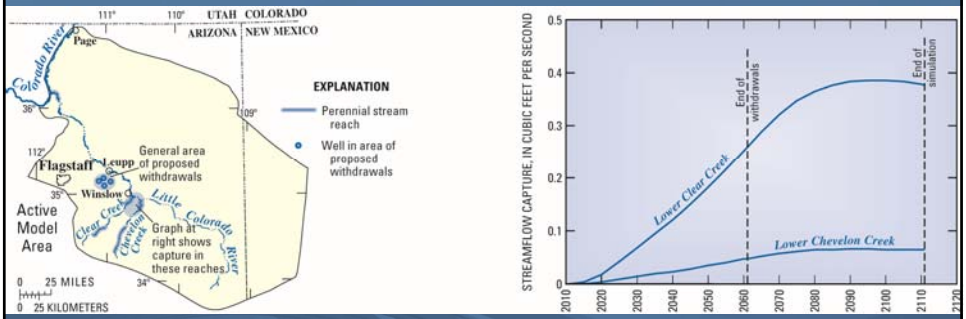
Figure D–3. Contours of model predicted (A) and measured (B) ground-water levels for the Blue River Basin, Nebraska (Alley and Emery, 1986).

Human vs Hydrologic Time Scales



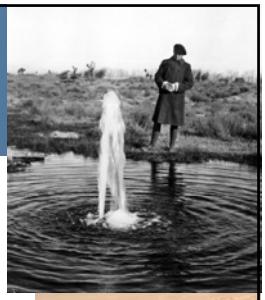
Gleeson et al. (2012)

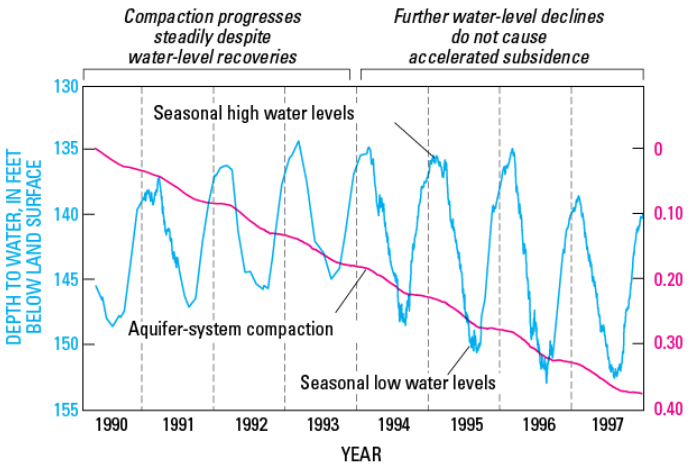
Streamflow Capture



Leake, Hoffmann, and Dickinson, 2005

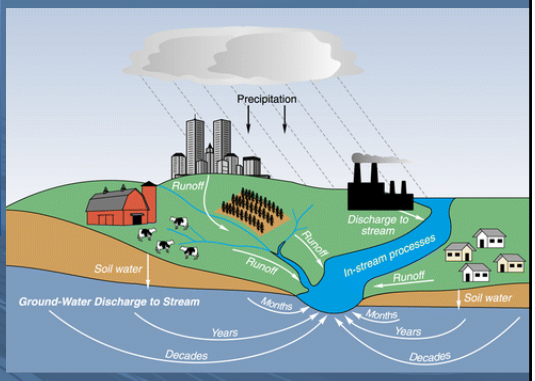
Land Subsidence





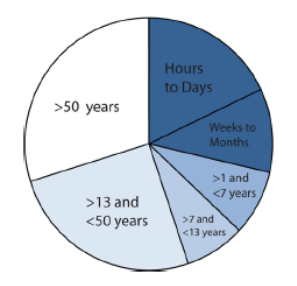
Sneed and Galloway (2000)

Nitrate to Chesapeake Bay

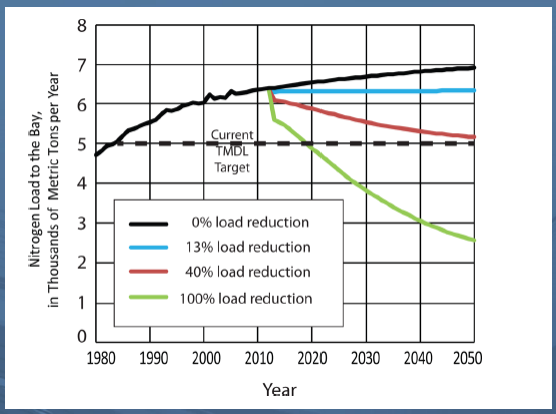


Phillips and others (1999)

Nitrate to Chesapeake Bay



Baseflow age distribution
Sanford and Pope (2013)



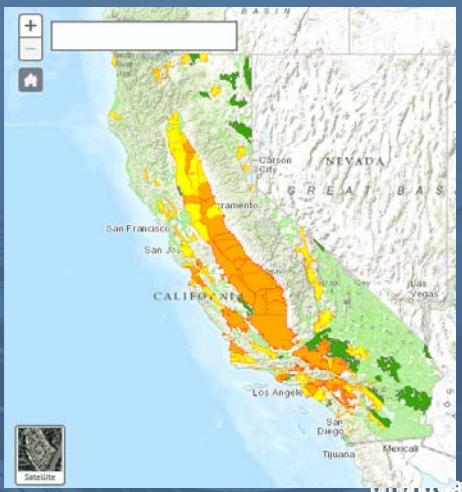
Arizona Groundwater Management Act

AMA Management Goals

- Phoenix, Tucson, Prescott (urban)
  - "Safe yield" by 2025
  - "long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge"
- Santa Cruz (riparian)
  - maintain safe-yield and prevent local water tables from experiencing long-term declines
- Pinal (ag)
  - extend the life of the agricultural economy for as long as feasible, and preserve water supplies for future non-agricultural uses

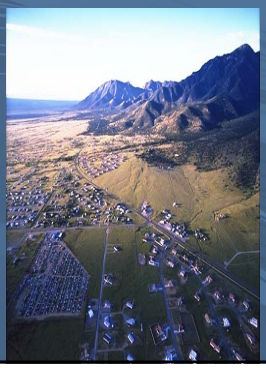
No. of Management Basins: AZ vs. CA

Active Management Areas



Upper San Pedro River Basin, AZ

- First National Riparian Area
- Concerns about streamflow depletion
- Depletion of only a small part of the total volume of groundwater in storage



Upper San Pedro River Basin, AZ

- Managing the cone of depression vs managing the riparian system

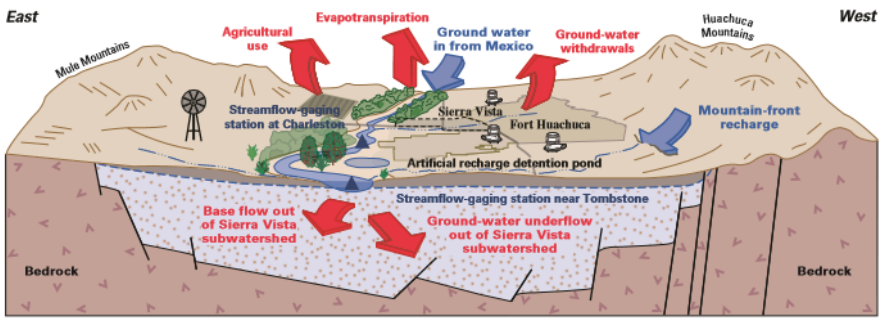


Figure 48. Simulated annual ground-water budget for the upper San Pedro River basin (U.S. Department of the Interior, 2005).

Australia Water Reforms

"The Big Dry"

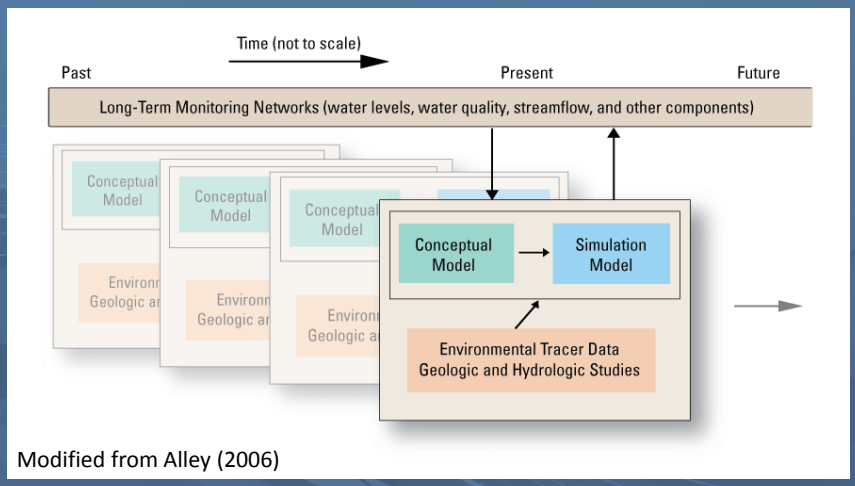
Figure 3.1: Tensions over Australian interstate water sharing

Source: *Quiz*, 4 November 1904, p. 1, reproduced in SA State Library (2011).

Australian Water Reforms

- Licensing and metering of groundwater pumping
- Recognition of GW and SW as a 'whole water cycle'
- Water markets and trading
- Relatively adaptable water policies
- Ability to share shortages
- Joint water management by States and Commonwealth

Final Thought: Importance of Integrated Monitoring and Modeling



Modified from Alley (2006)