What science tells us about regional aquifers in the West

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AGI Critical Issues Forum, October 27, 2016

Outline

- The High Plains aquifer
- Not all aquifers look like the High Plains
- Groundwater storage is just part of the story
- Hydrologic vs human timescales
- Drought-proofing groundwater
- Groundwater visibility

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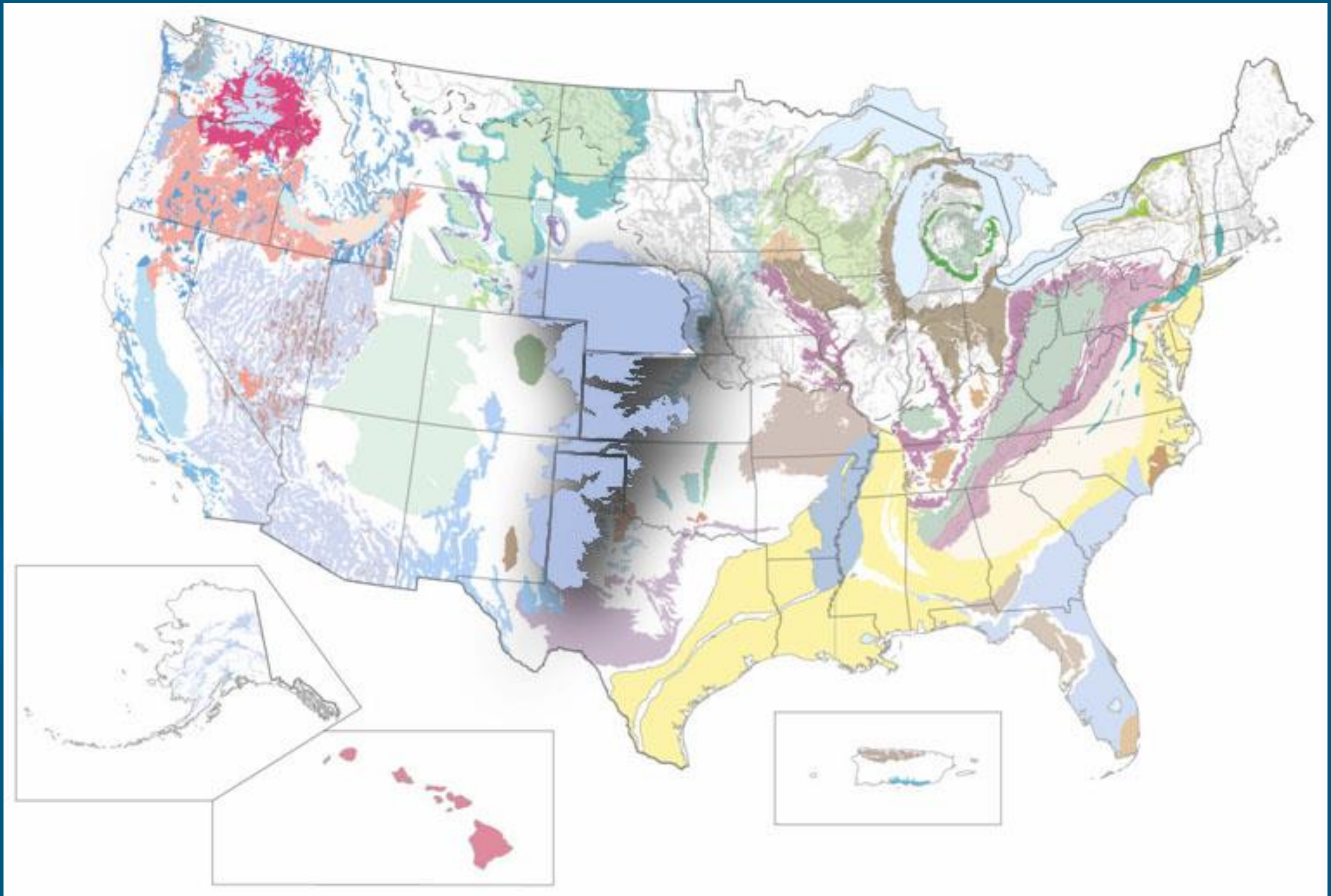
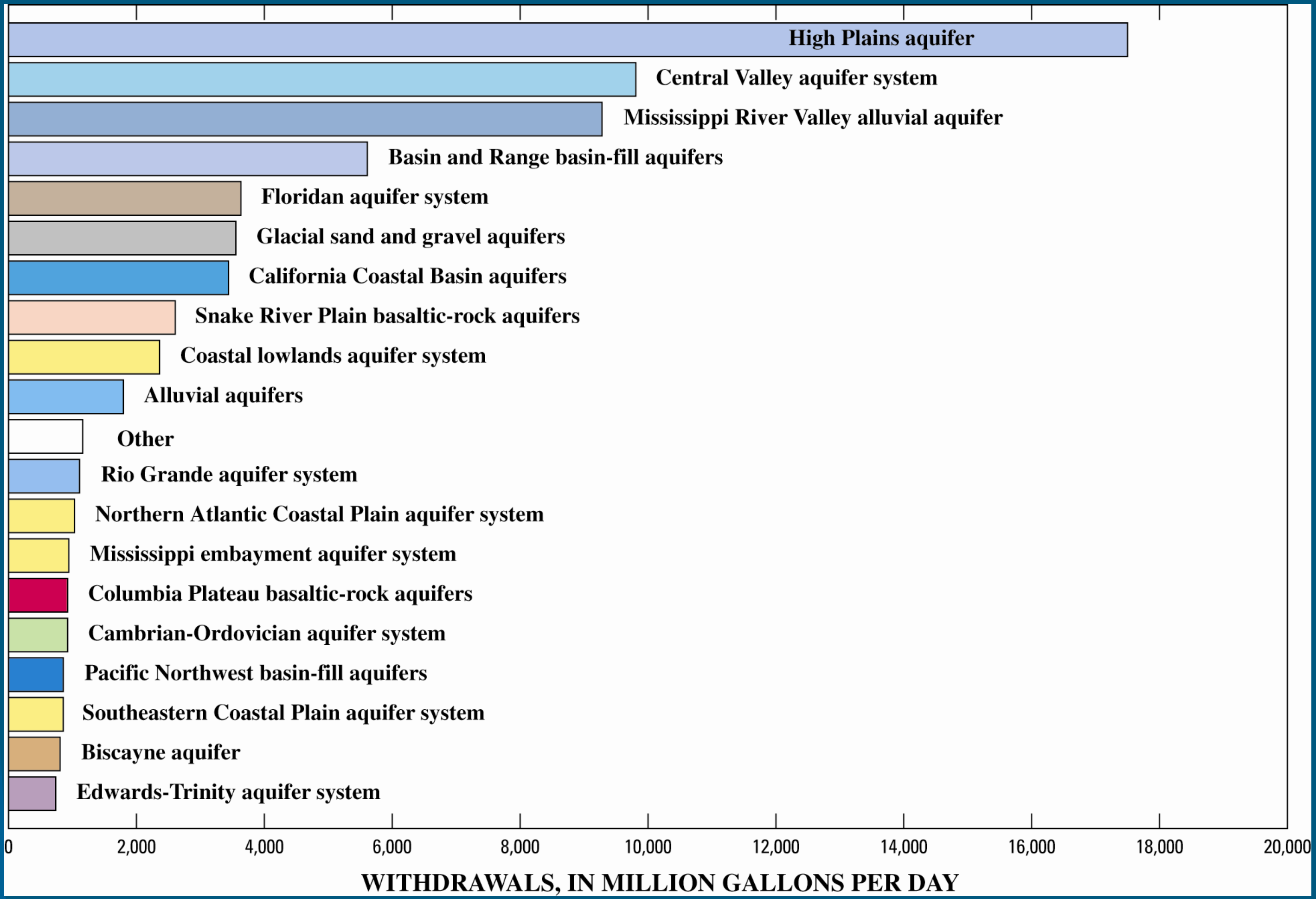
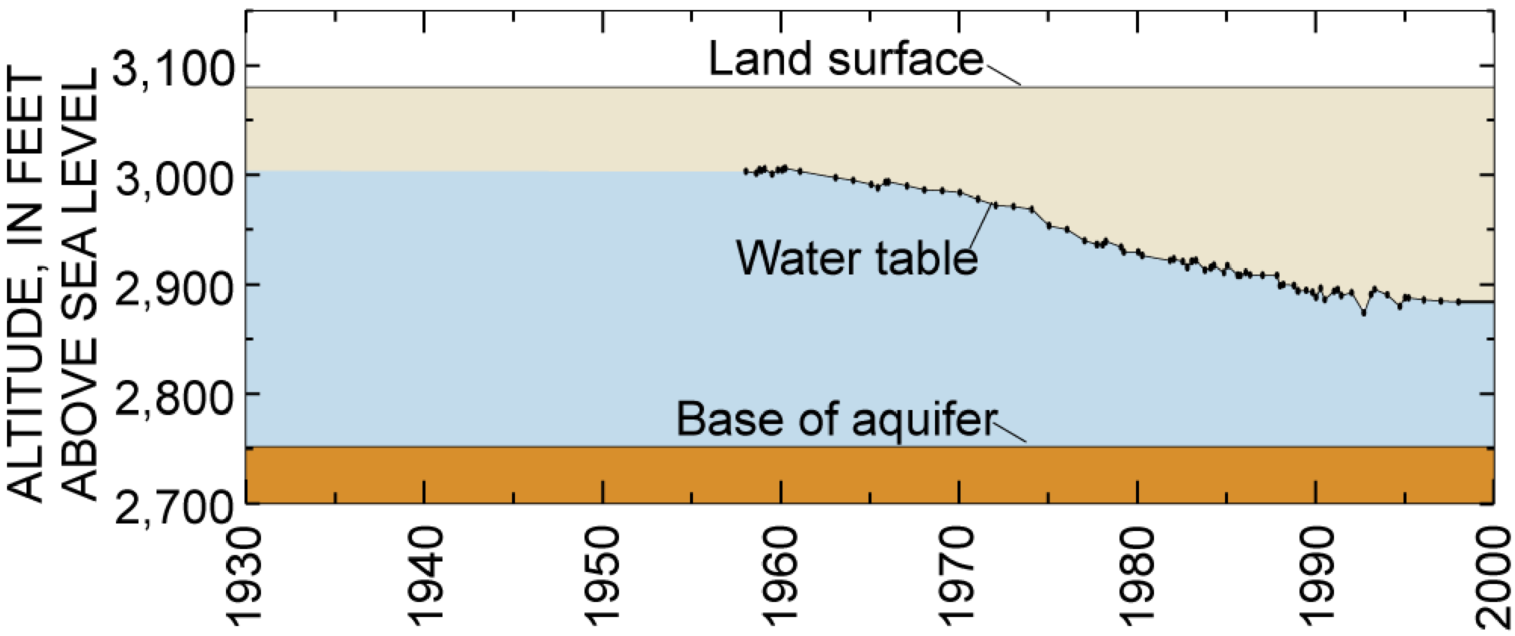
High Plains aquifer



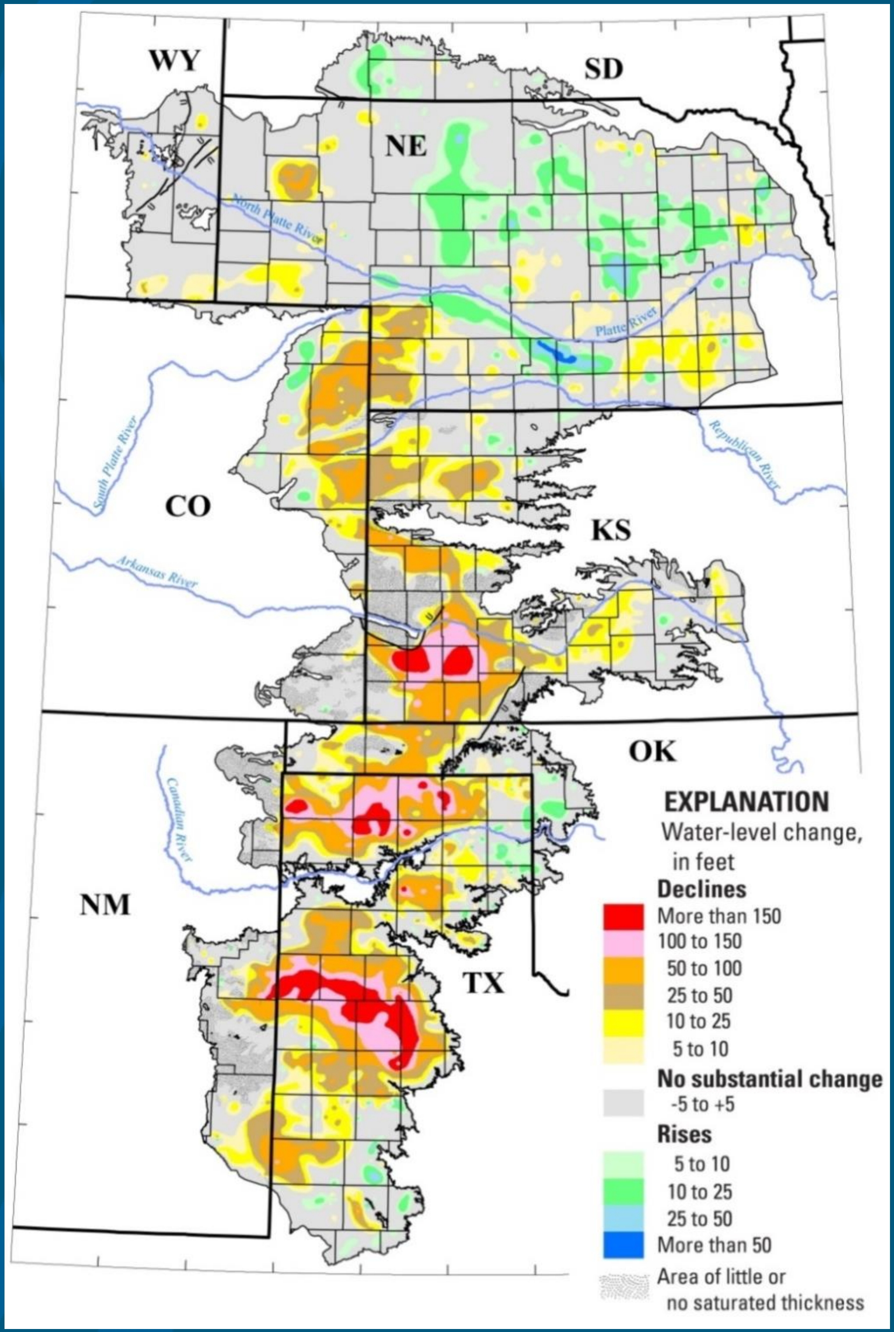
Principal Aquifers by Water Withdrawals



Maupin and Barber (2005)



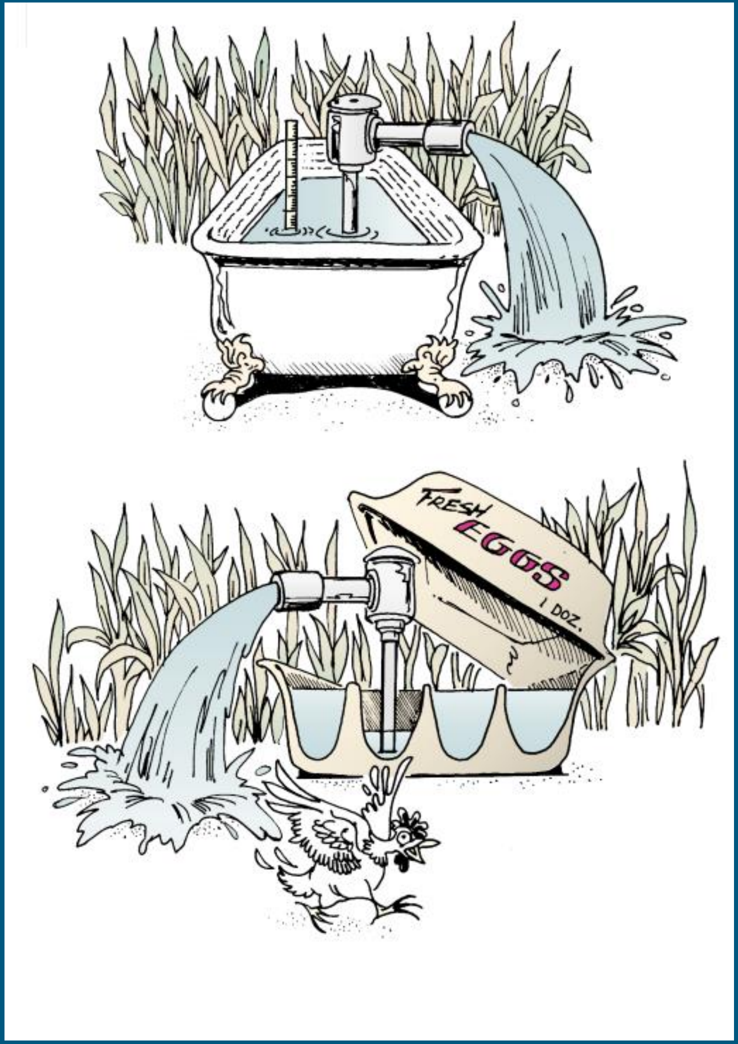
h. Hydrograph for well number 374406101221501
In Grant County, Kansas



Water-Level Change, Predevelopment to 2013

V.L. McGuire (2014)

High Plains Aquifer—Bathtub or Egg Carton?



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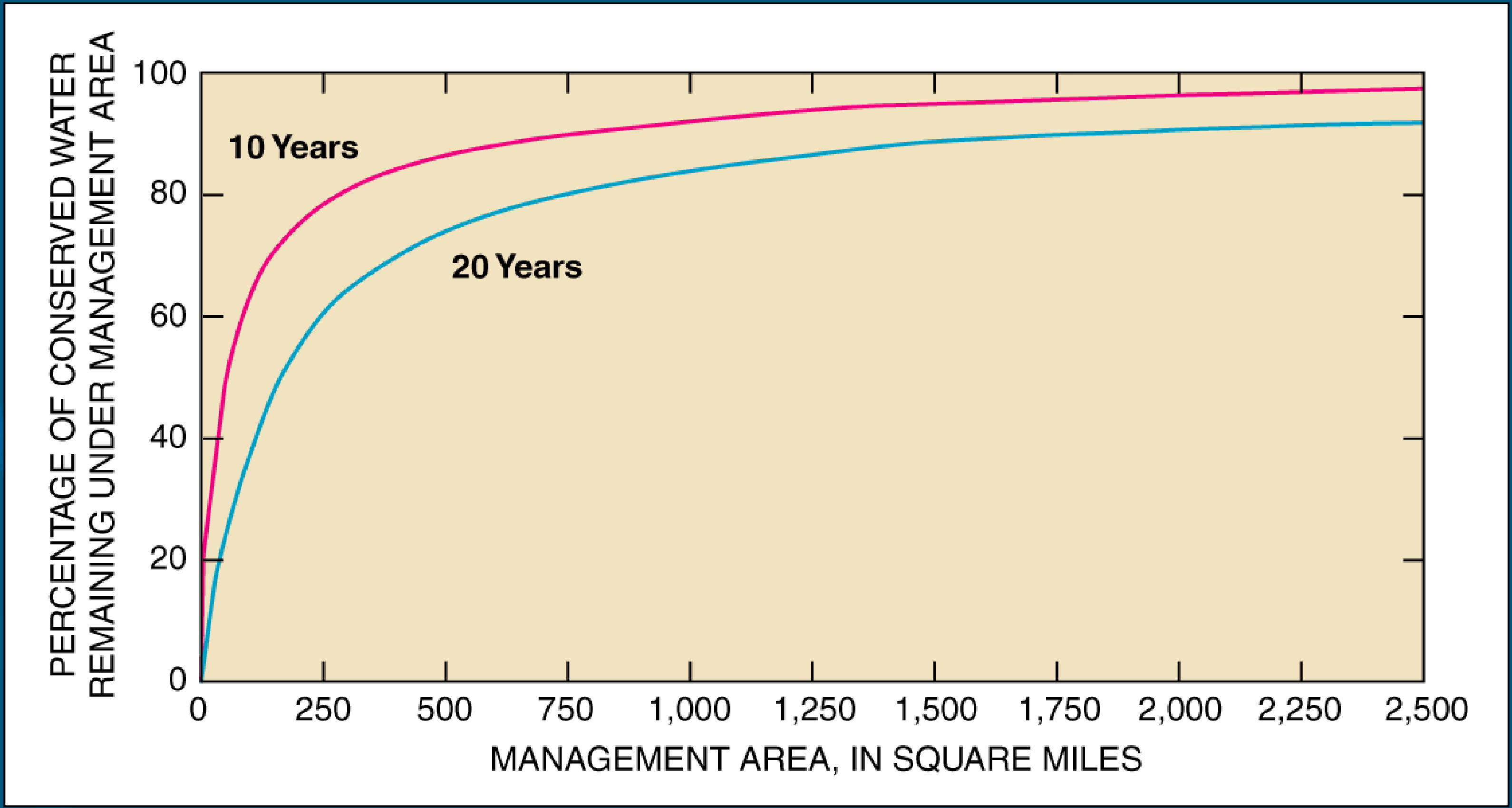
High Plains Aquifer—Bathtub or Egg Carton?



Alley and Schefter, 1987, Water Resources Research 23(7):1123-1130

Mississippi Embayment

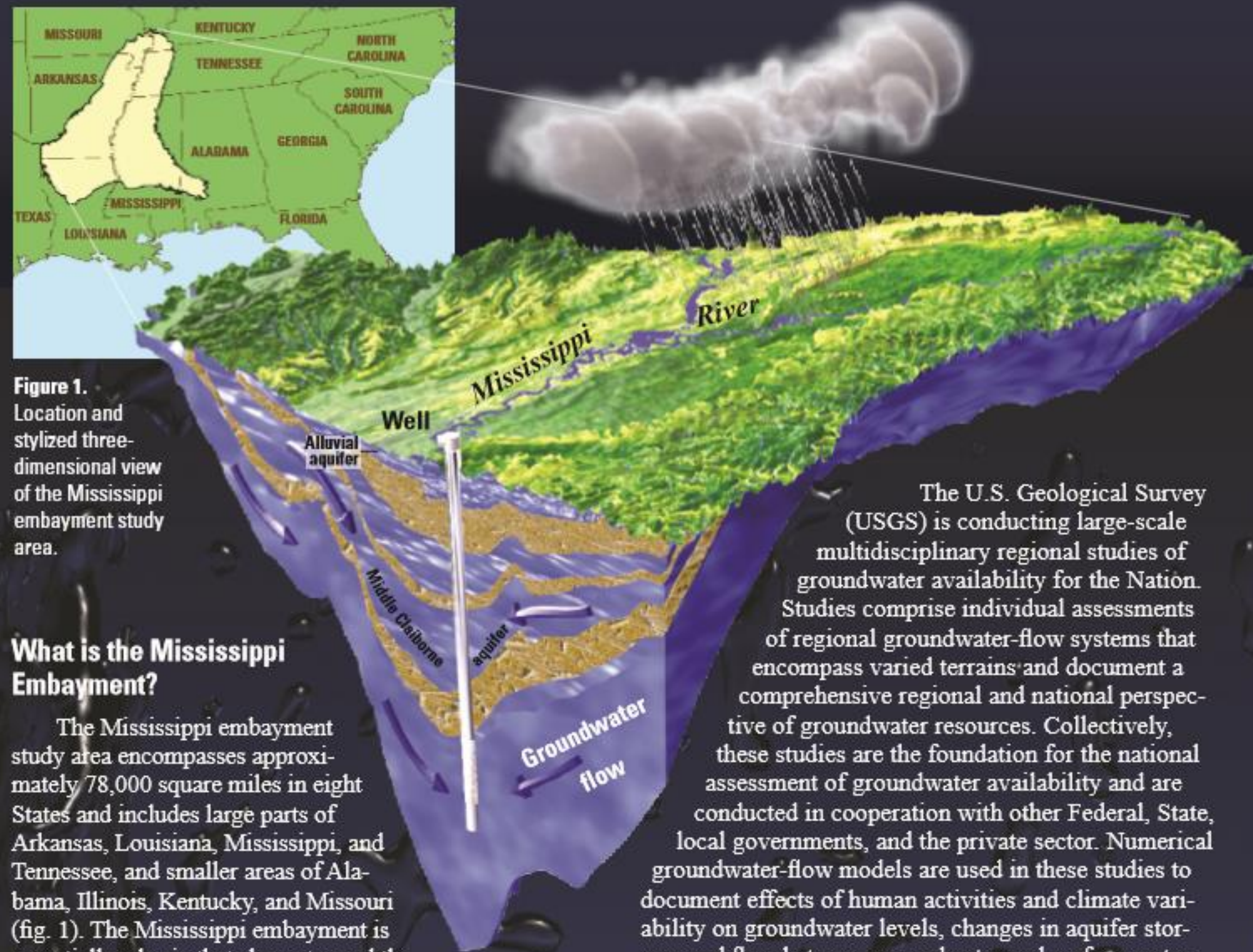


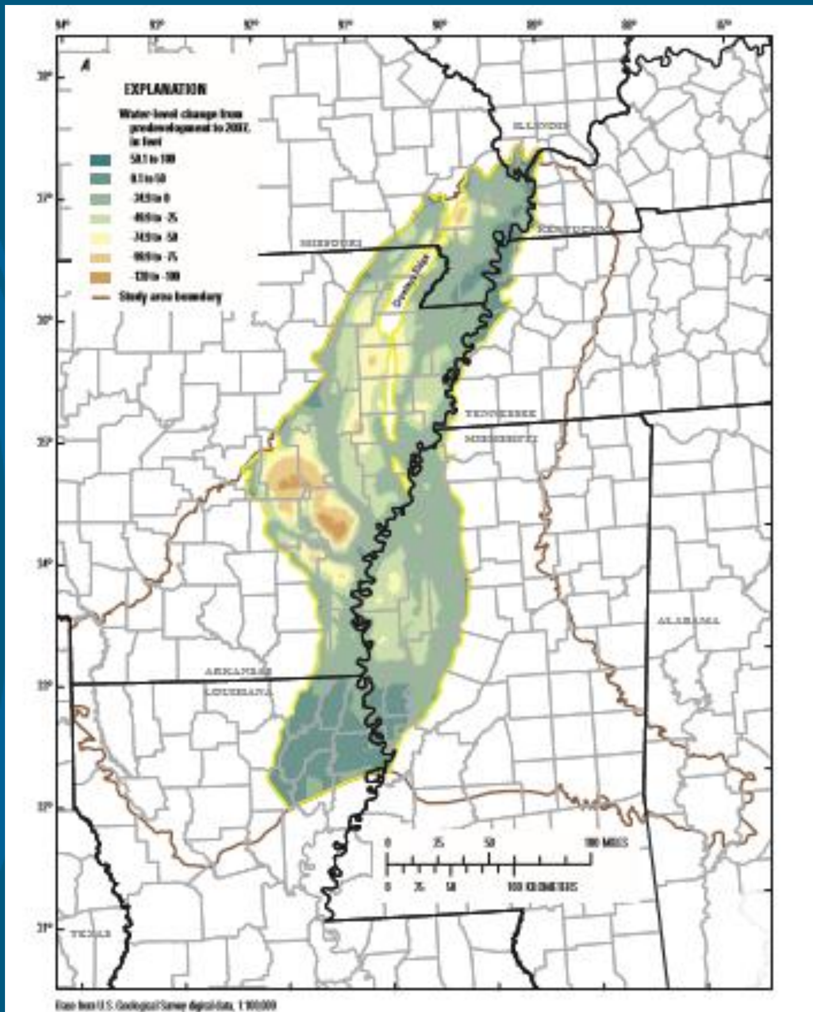
Figure 1. Location and stylized three-dimensional view of the Mississippi embayment study area.

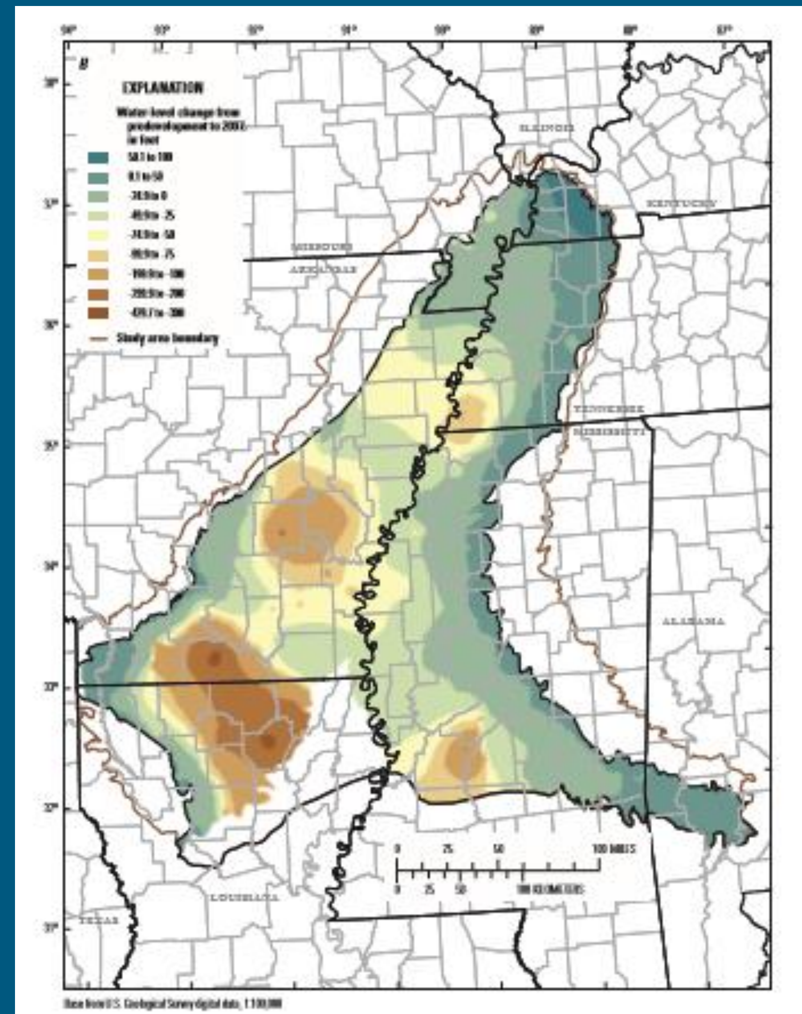
What is the Mississippi Embayment?

The Mississippi embayment study area encompasses approximately 78,000 square miles in eight States and includes large parts of Arkansas, Louisiana, Mississippi, and Tennessee, and smaller areas of Alabama, Illinois, Kentucky, and Missouri (fig. 1). The Mississippi embayment is essentially a basin that slopes toward the

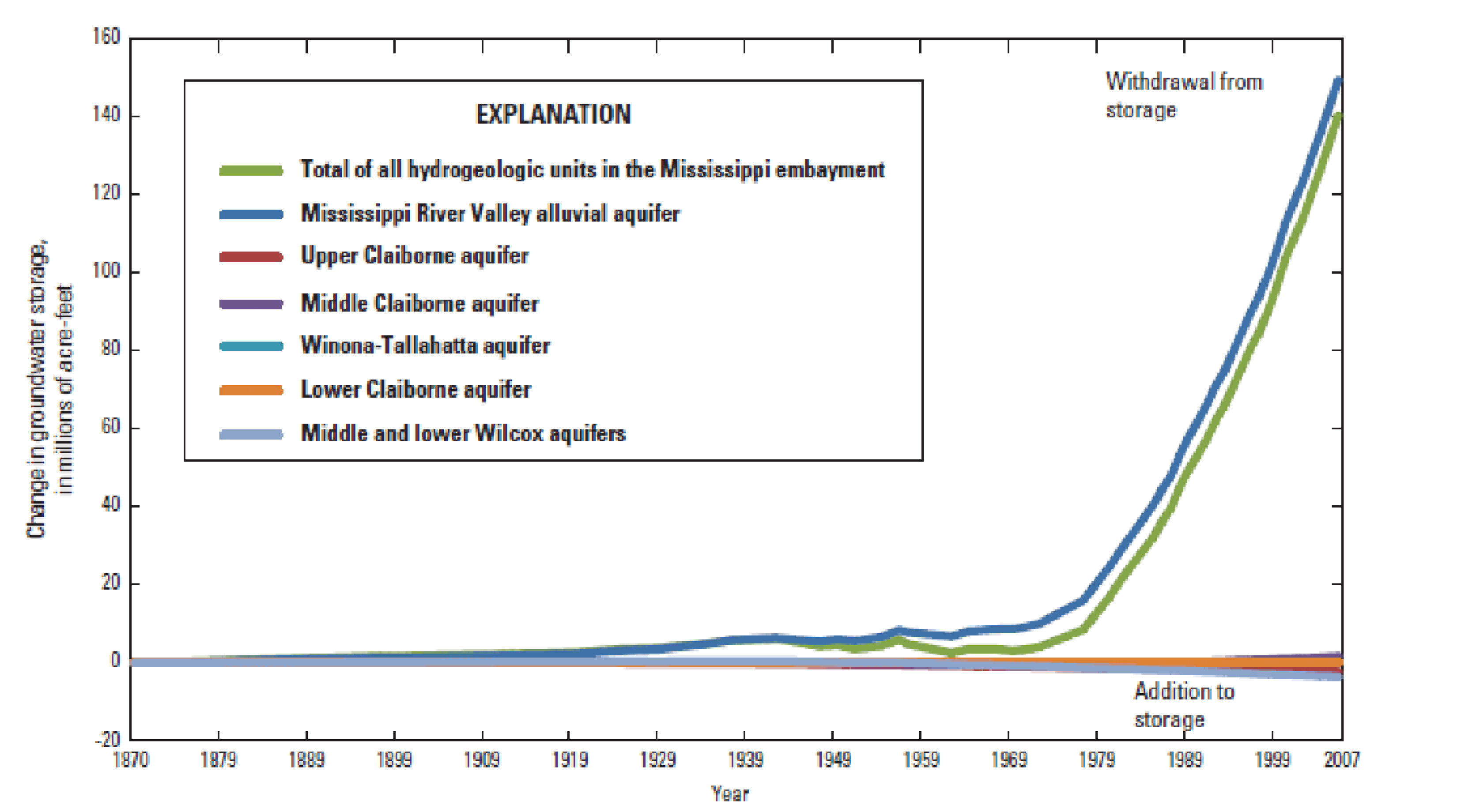
The U.S. Geological Survey (USGS) is conducting large-scale multidisciplinary regional studies of groundwater availability for the Nation. Studies comprise individual assessments of regional groundwater-flow systems that encompass varied terrains and document a comprehensive regional and national perspective of groundwater resources. Collectively, these studies are the foundation for the national assessment of groundwater availability and are conducted in cooperation with other Federal, State, local governments, and the private sector. Numerical groundwater-flow models are used in these studies to document effects of human activities and climate variability on groundwater levels, changes in aquifer storage, and flow between groundwater and surface-water

USGS Fact Sheet 2011-3115



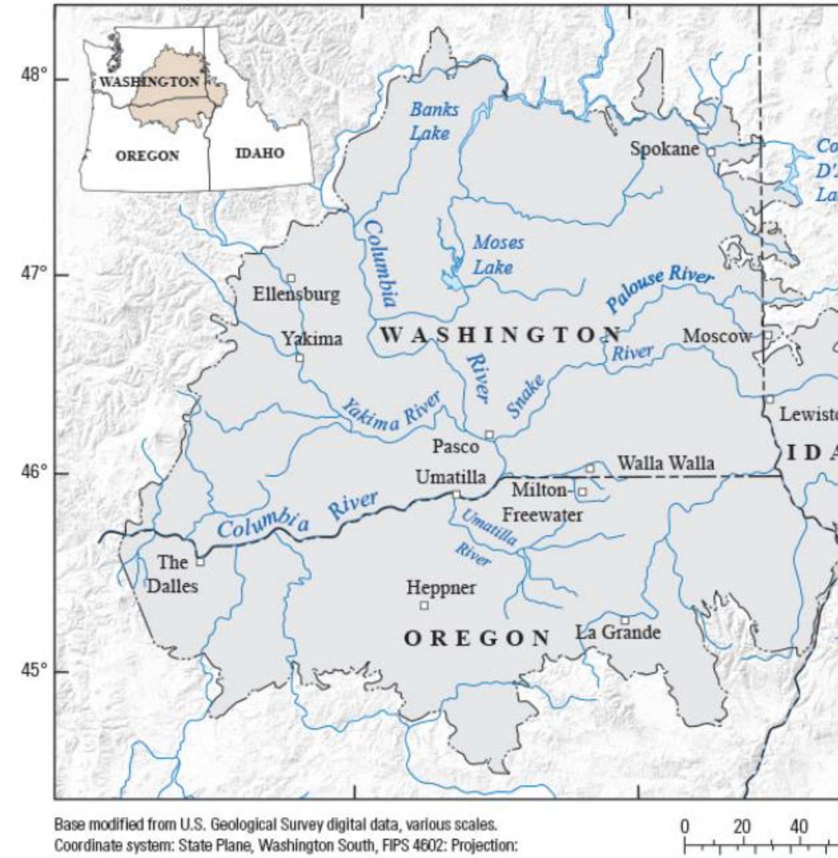


USGS Professional Paper 1785

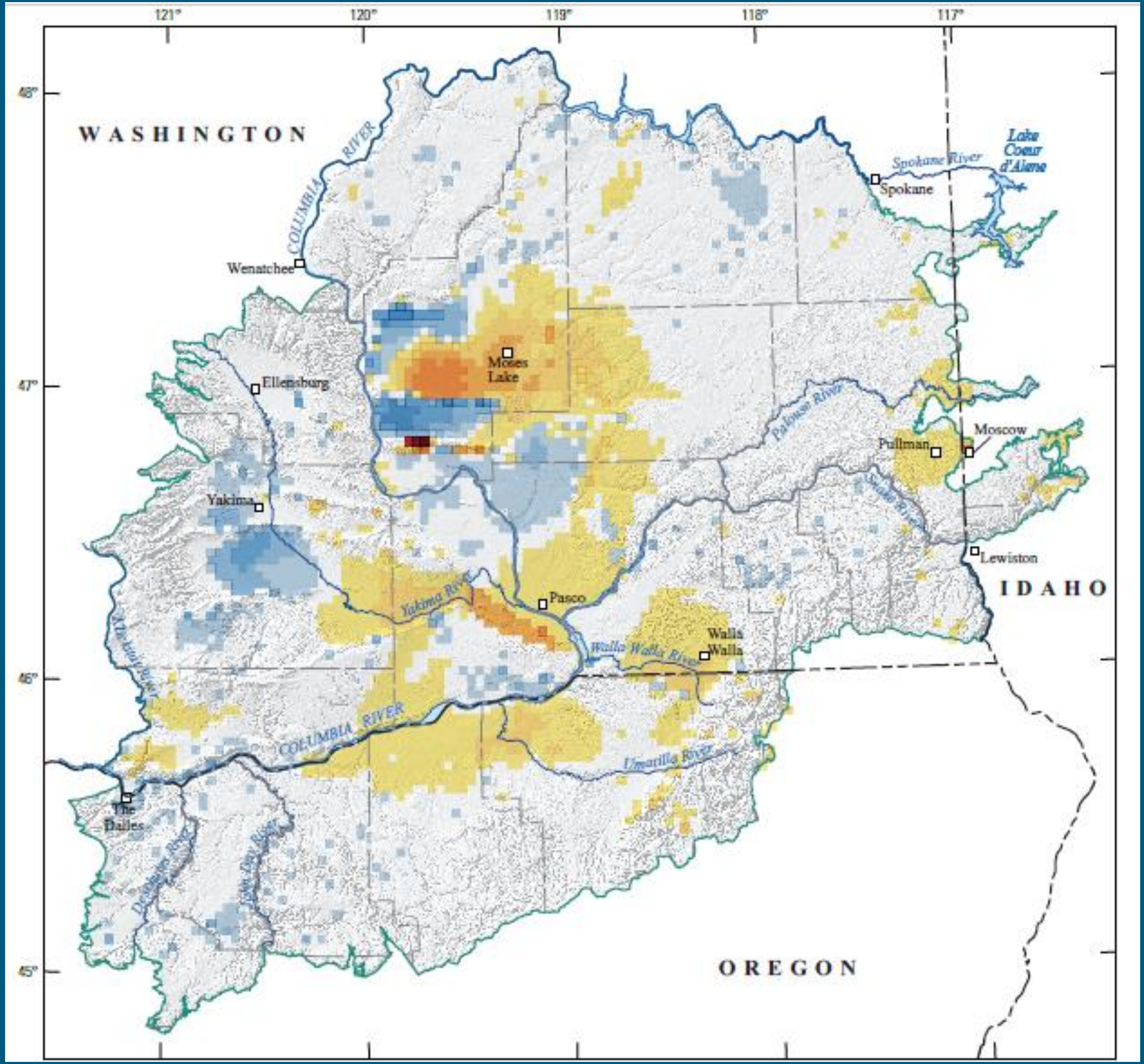


USGS Professional Paper 1785

Columbia Plateau



USGS Fact Sheet 2015-3063



Vaccaro et al. (2015)

Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes

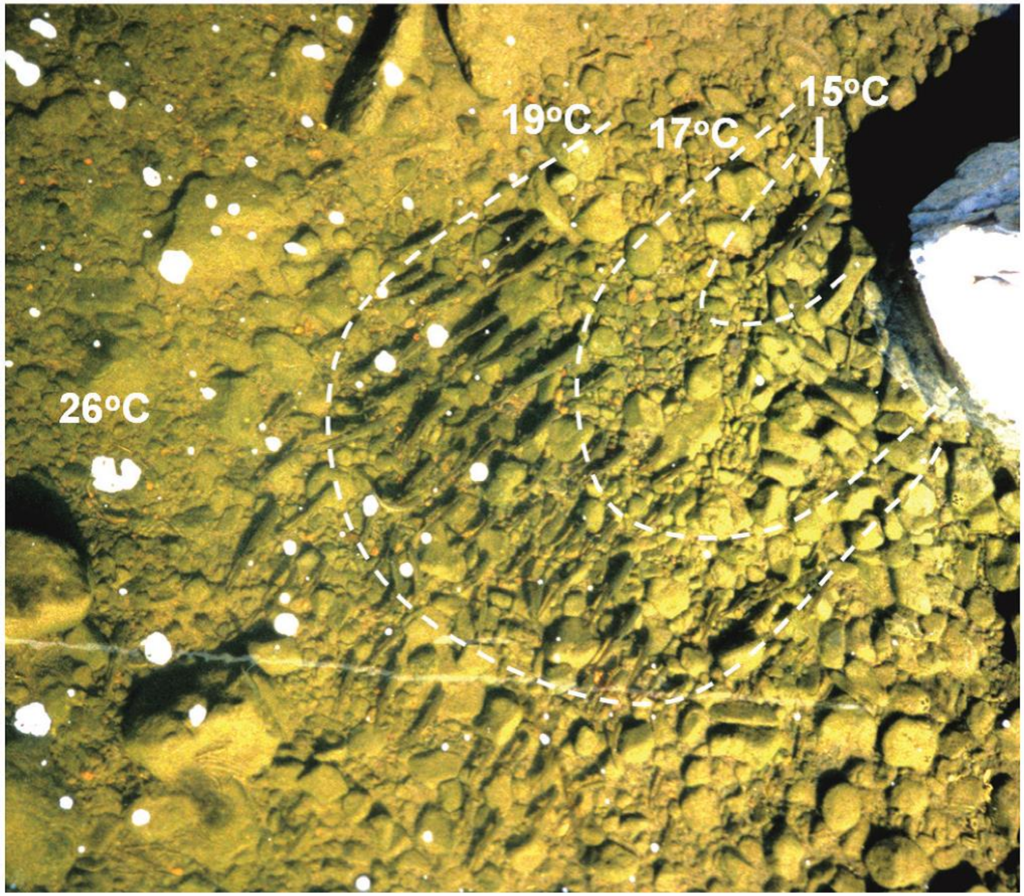


Figure 2.4.1.2. Rainbow trout in Joseph Creek in northeastern Oregon exhibit size hierarchy in occupying a cold-water refuge, with the largest individual in the coldest thermal zone (see Ebersole and others, 2001). When the availability and size of cold-water areas is limited, fish may elect habitats that are less desirable for growth and disease resistance (i.e., through crowding) in order to minimize deleterious physiological effects of high water temperature. Photograph taken by J. Ebersole in 1994. [77]

Torgersen, C.E., Ebersole, J.L., Keenan, D.M., 2012, *Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes*: EPA 910-C-12-001

Basic Considerations in Assessing Groundwater Depletion

- Groundwater as a three dimensional system
- Analyses at multiple spatial scales
- Multiple cones of depression often are juxtaposed with areas of little or no storage depletion
- Different response of unconfined vs confined aquifers
- Complexities of irrigated agricultural systems
- Legal and regulatory constraints
- Effects on environmental flows
- Availability of infrastructure and alternate water sources

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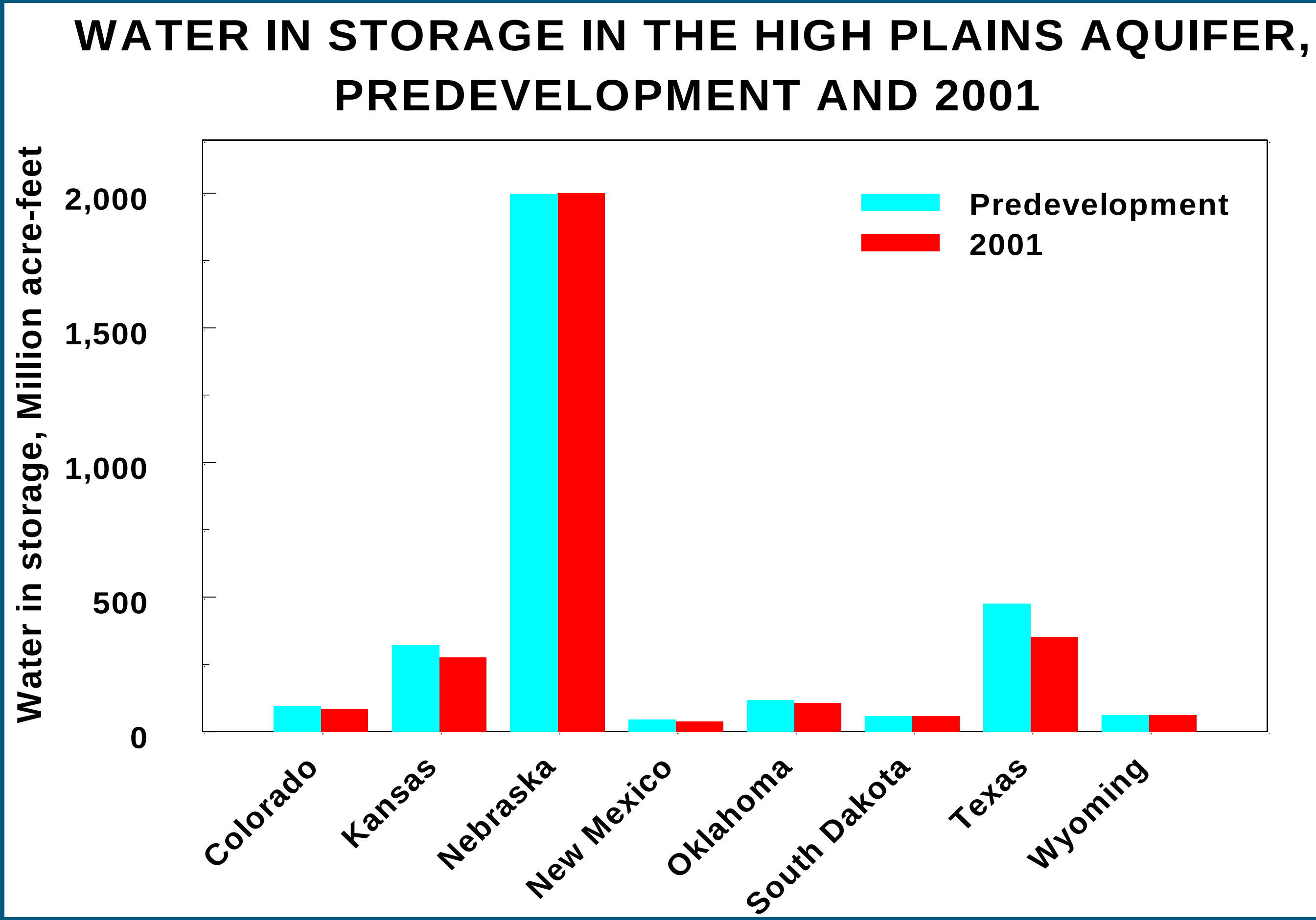
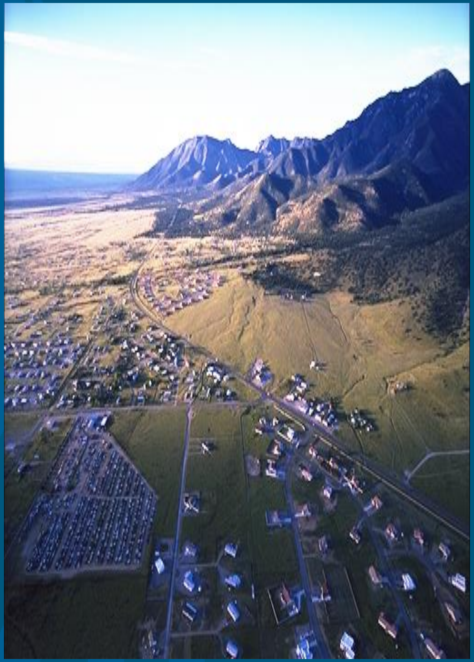
How Important is Knowing Total Groundwater Storage Volume?



Data from McGuire and others, 2003

Depletion of a small part of the total volume of groundwater 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

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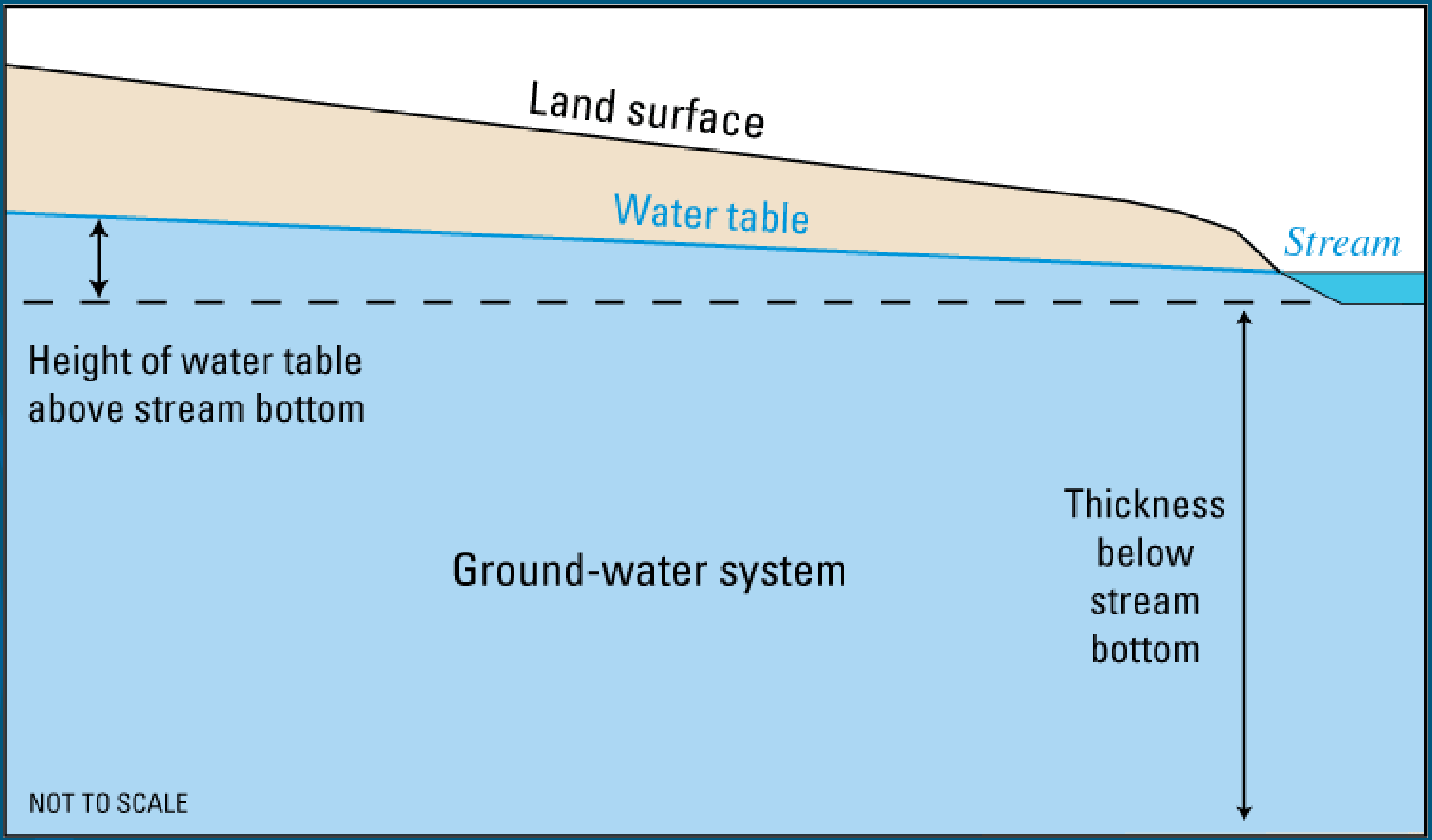

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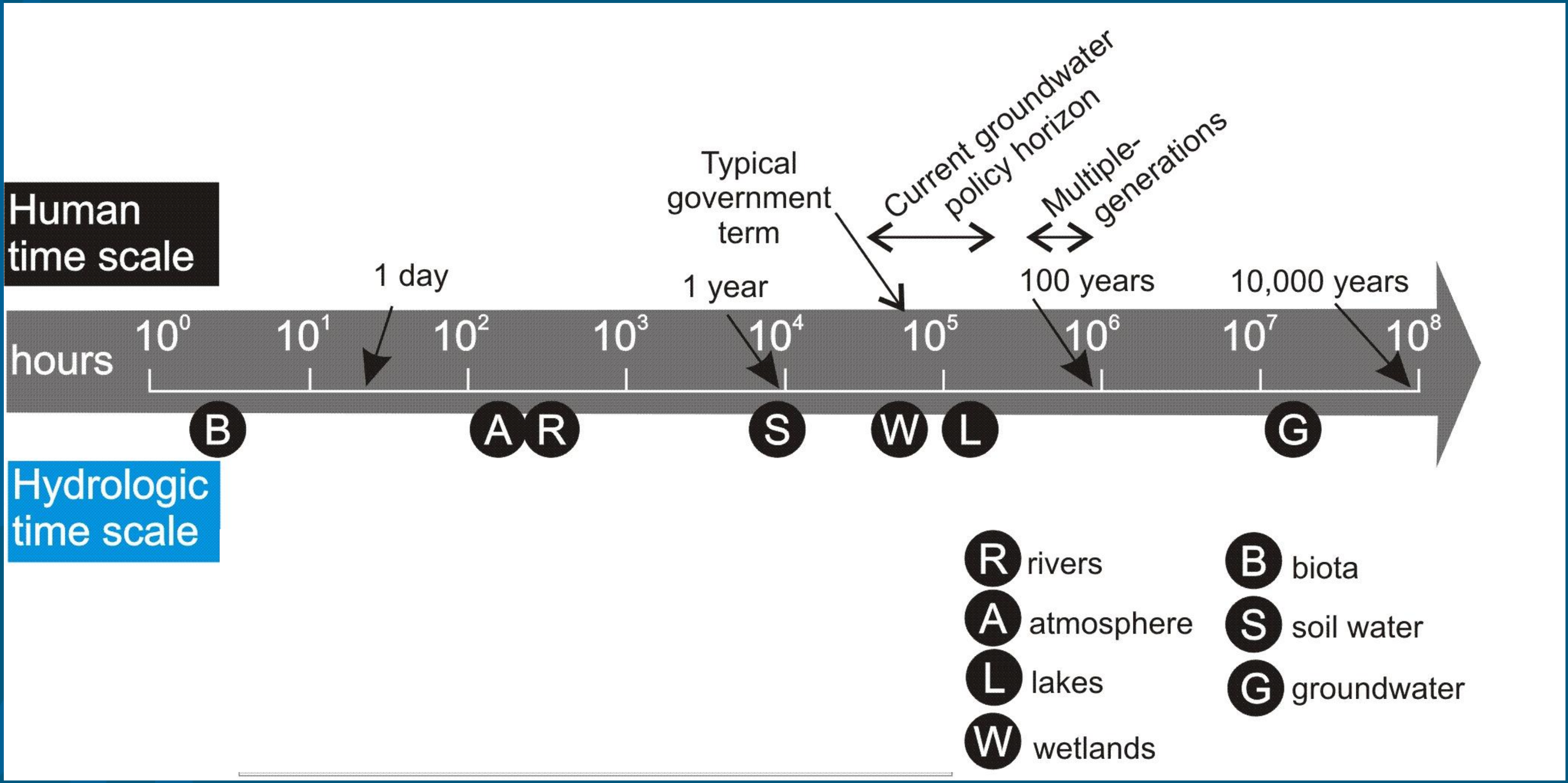
Key Information for Critical Issues

- SW/GW—Gradients, Saturated thickness
- Land Subsidence—Water levels
- Water Quality—Flow systems
- Pumping Costs—Depth to water, Saturated thickness

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

Photo: Claudia Faunt, USGS

Human vs Hydrologic Time Scales



Gleeson et al. (2012)

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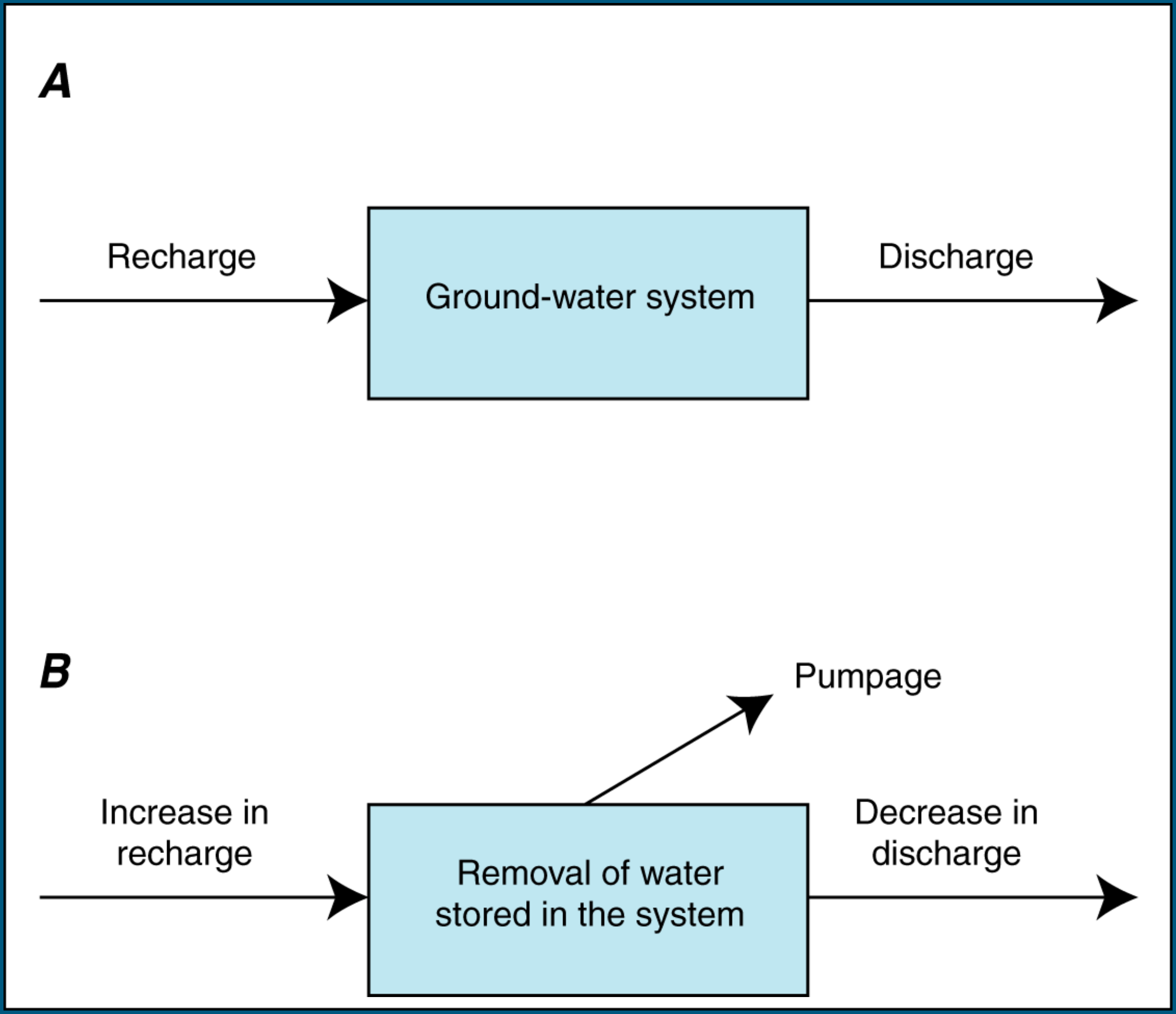
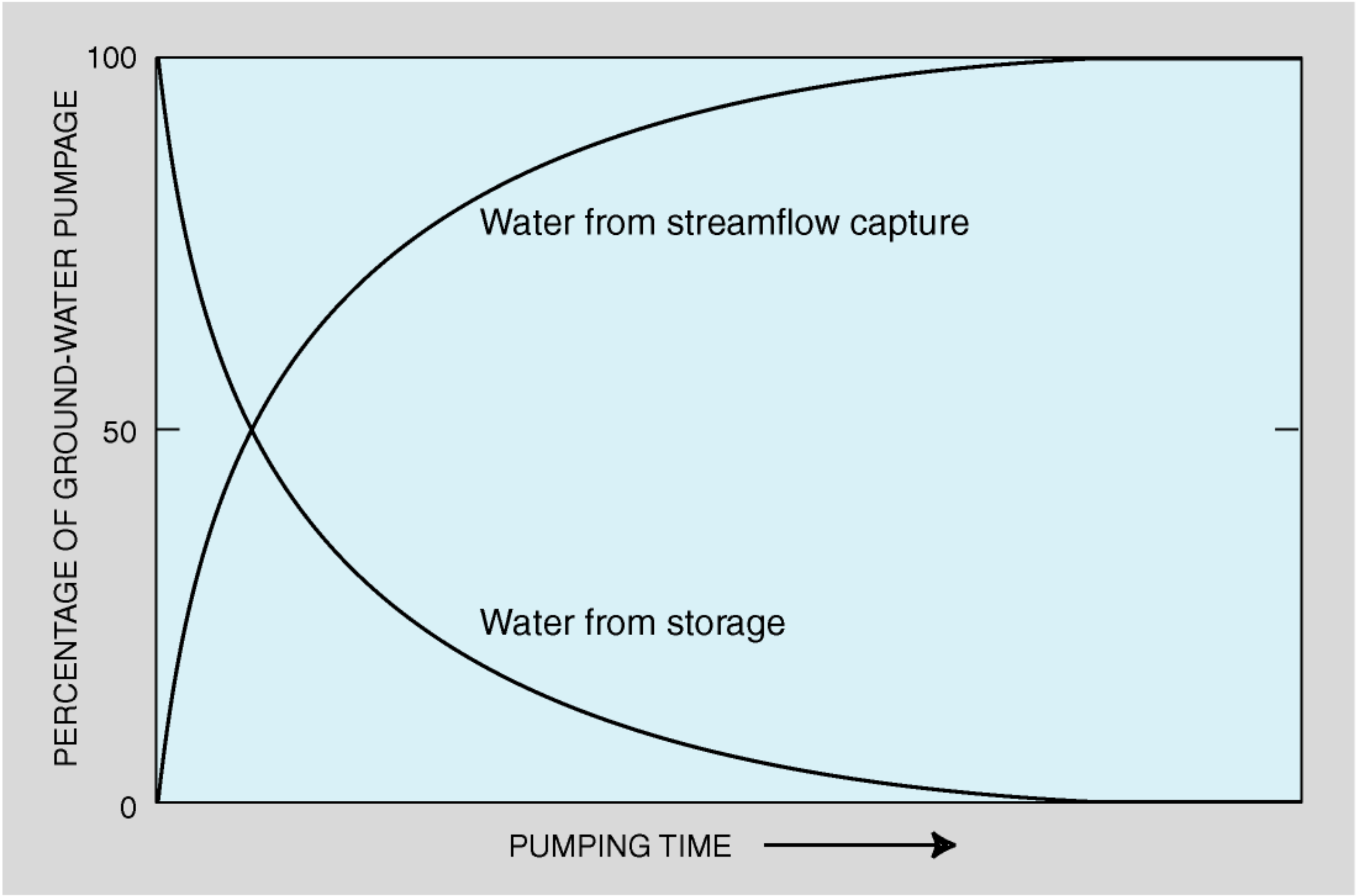
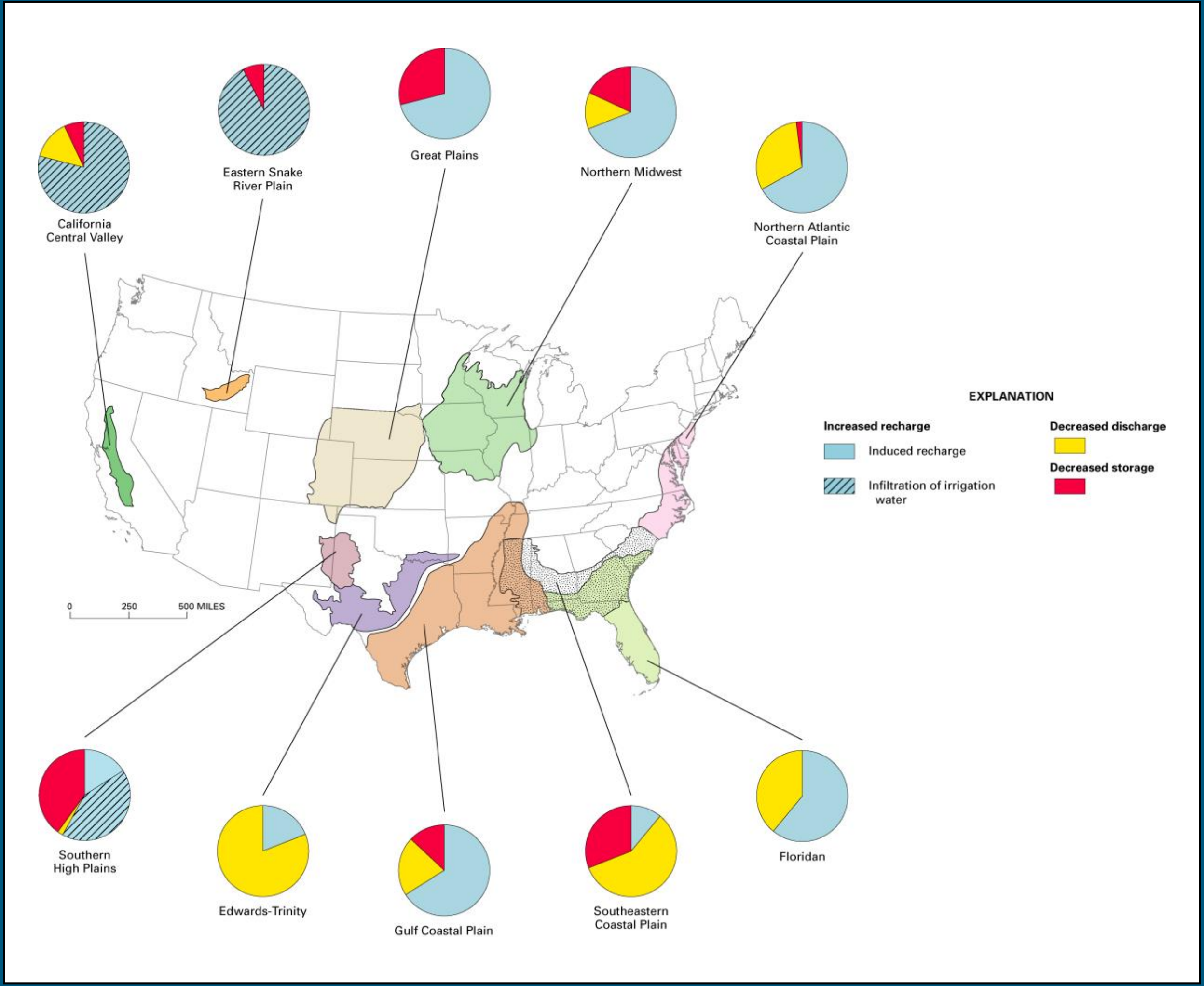
Sources of Water to Pumping Well



Storage Depletion vs Capture Over Time

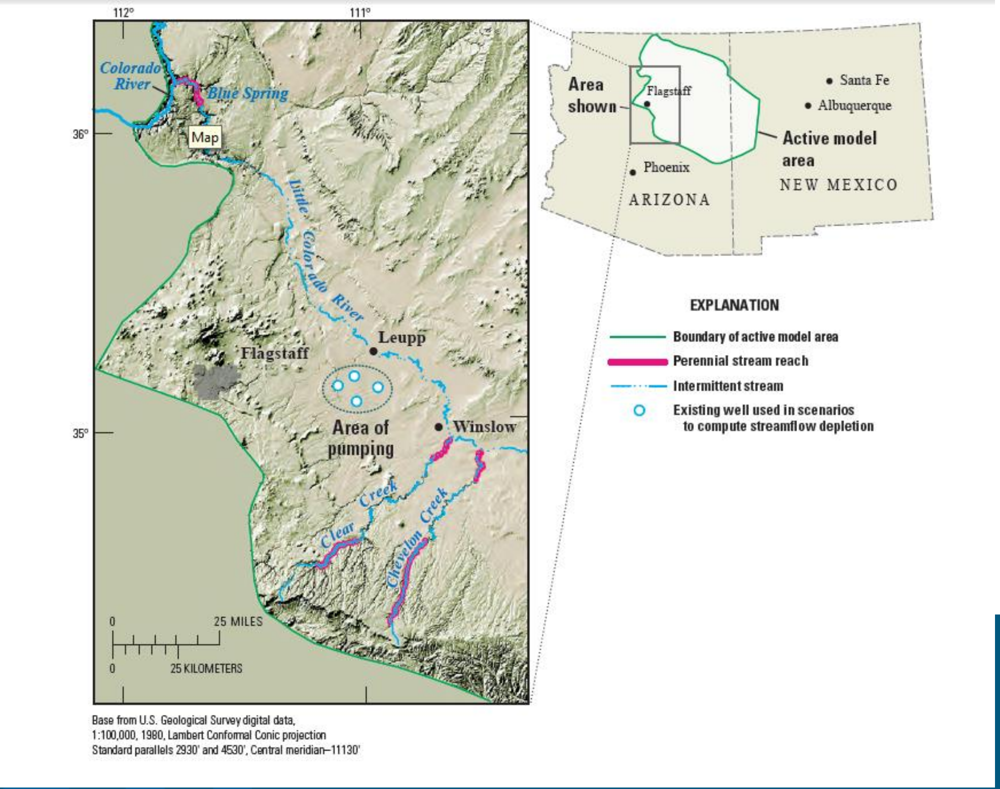


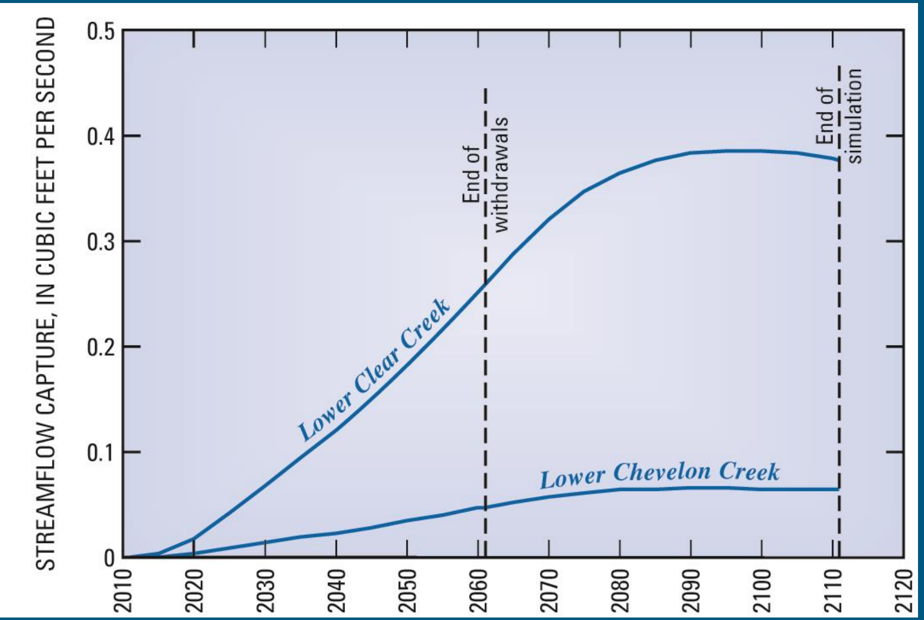
Storage Depletion vs Capture by Aquifer



Alley and others, 2002; Data from Johnston, 1997

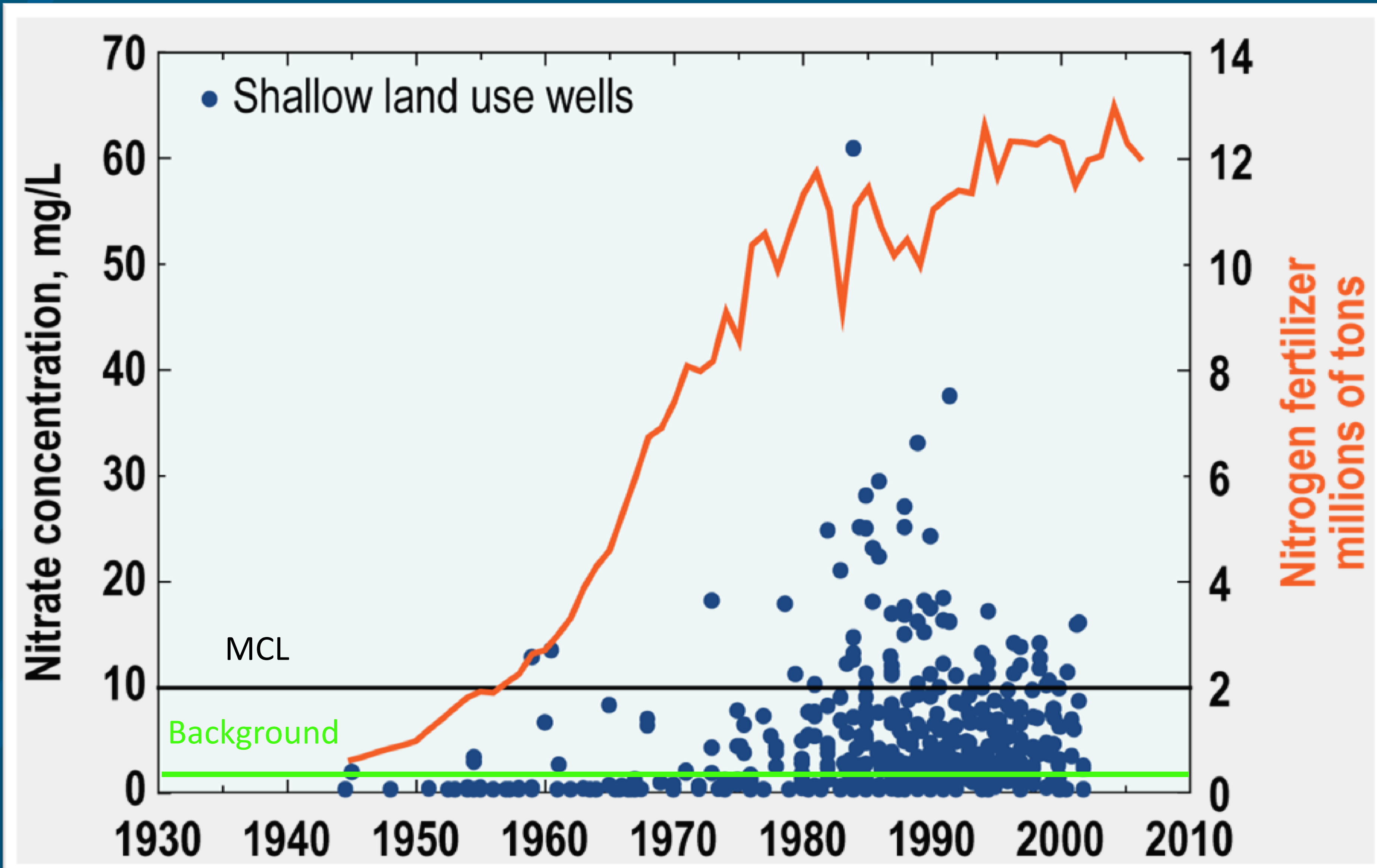
Streamflow Capture: Arizona





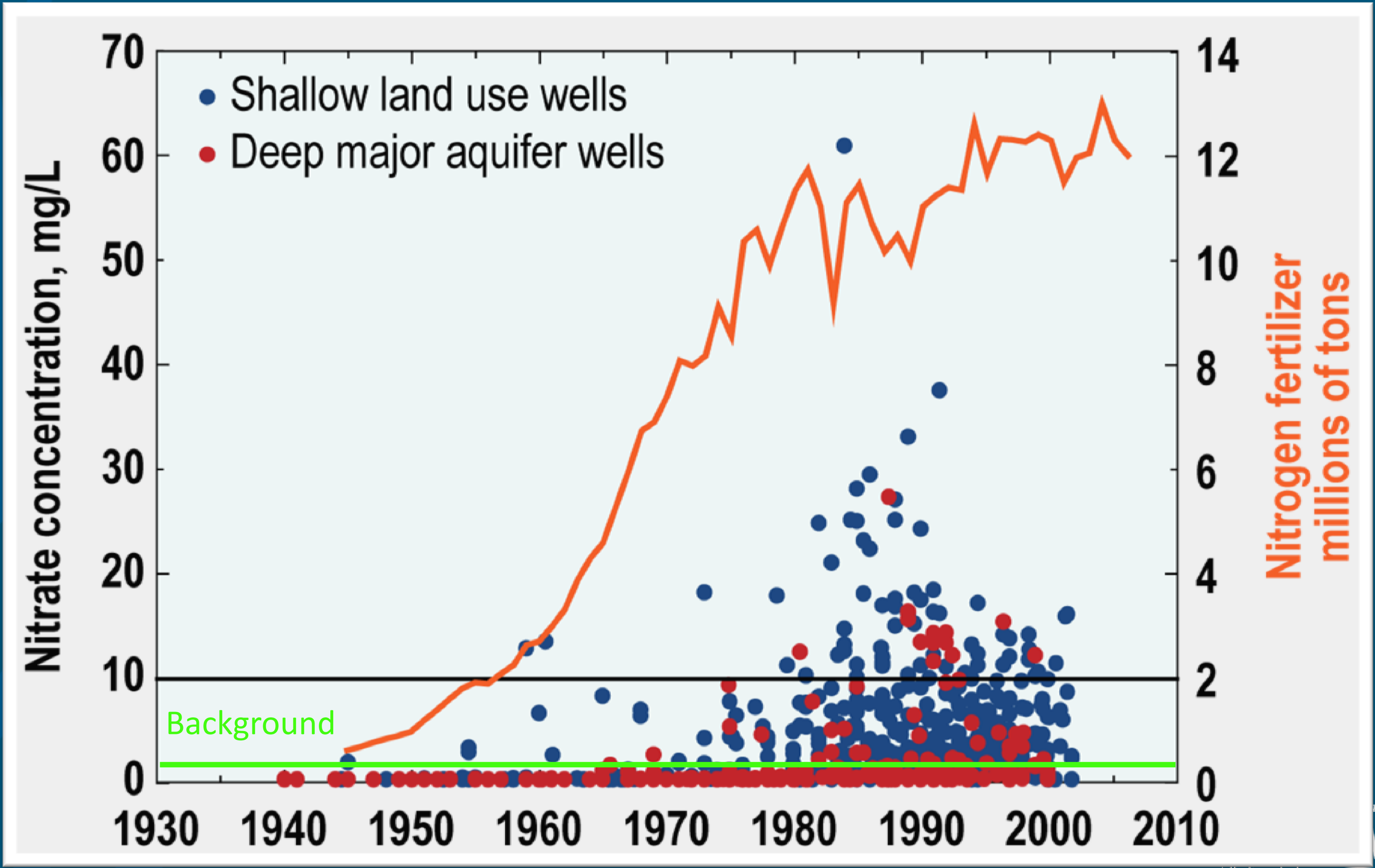
Leake, Hoffmann, and Dickinson, 2005

Nitrate Concentration in Groundwater



Dubrovsky et al. (2010)

Nitrate Concentration in Groundwater



Dubrovsky et al. (2010)

Resilience

- Capacity of a groundwater (or water-resources) system to withstand either short-term ‘shocks’ (e.g., drought) or longer term change (e.g., climate change).

  --Need to define timeframe

  --Applies to both water quantity and quality

  -- May be an important part of GW sustainability

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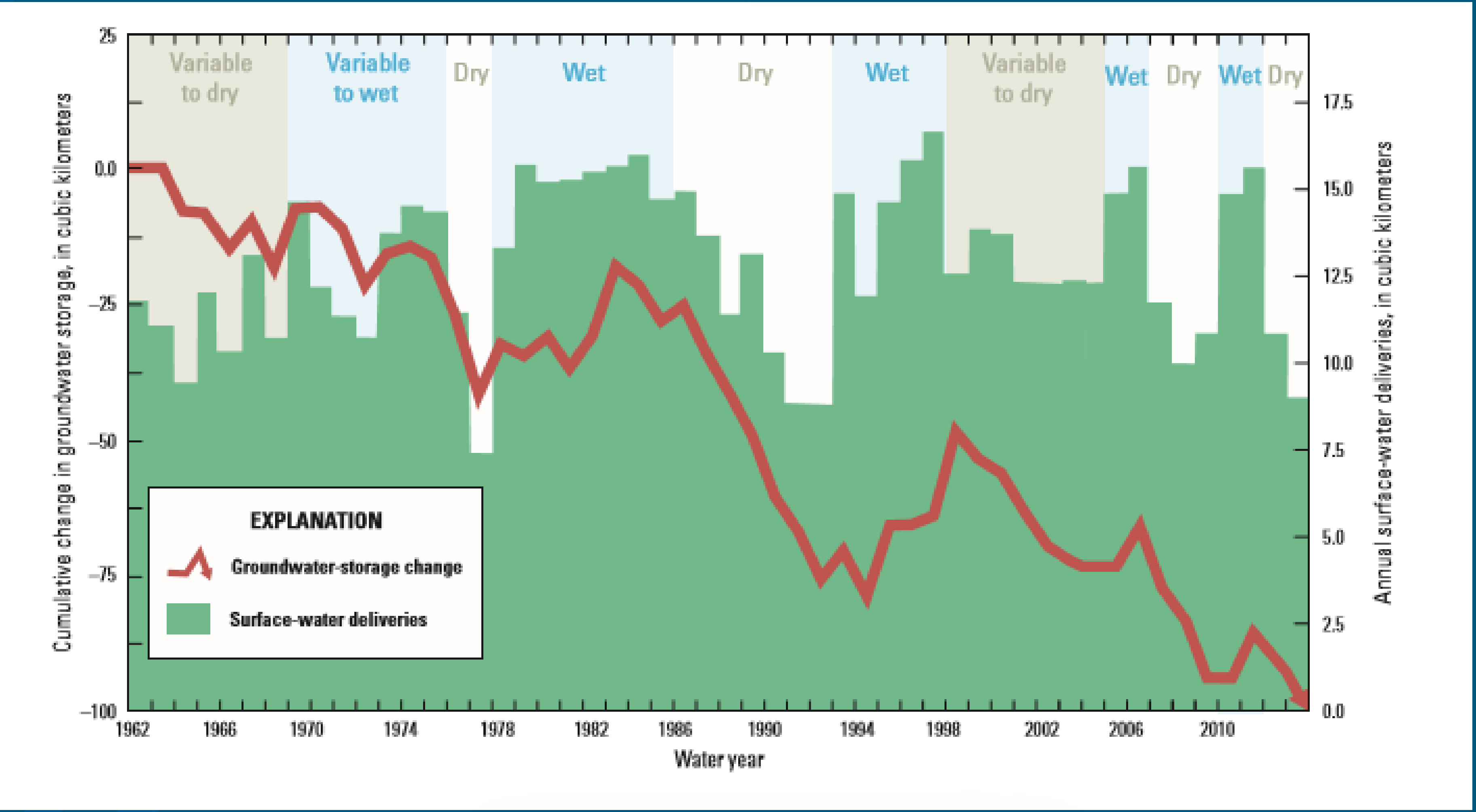
How resilient is groundwater?



USGS Fact Sheet 2015-3084

Drought-proofing Groundwater

- Analyze GW systems for their resilience and vulnerability to climate perturbations rather than just assuming groundwater is a convenient backup supply

- Raise awareness about maintaining groundwater as a reserve
  --Monitoring water use and water levels
  --Potential for managed aquifer recharge

- Work toward laws, regulations, and incentives that encourage use of surface water during wet periods and **prepare** for increased groundwater use during droughts

(Alley, "Drought-Proofing Groundwater," *Groundwater*, May-June 2016)

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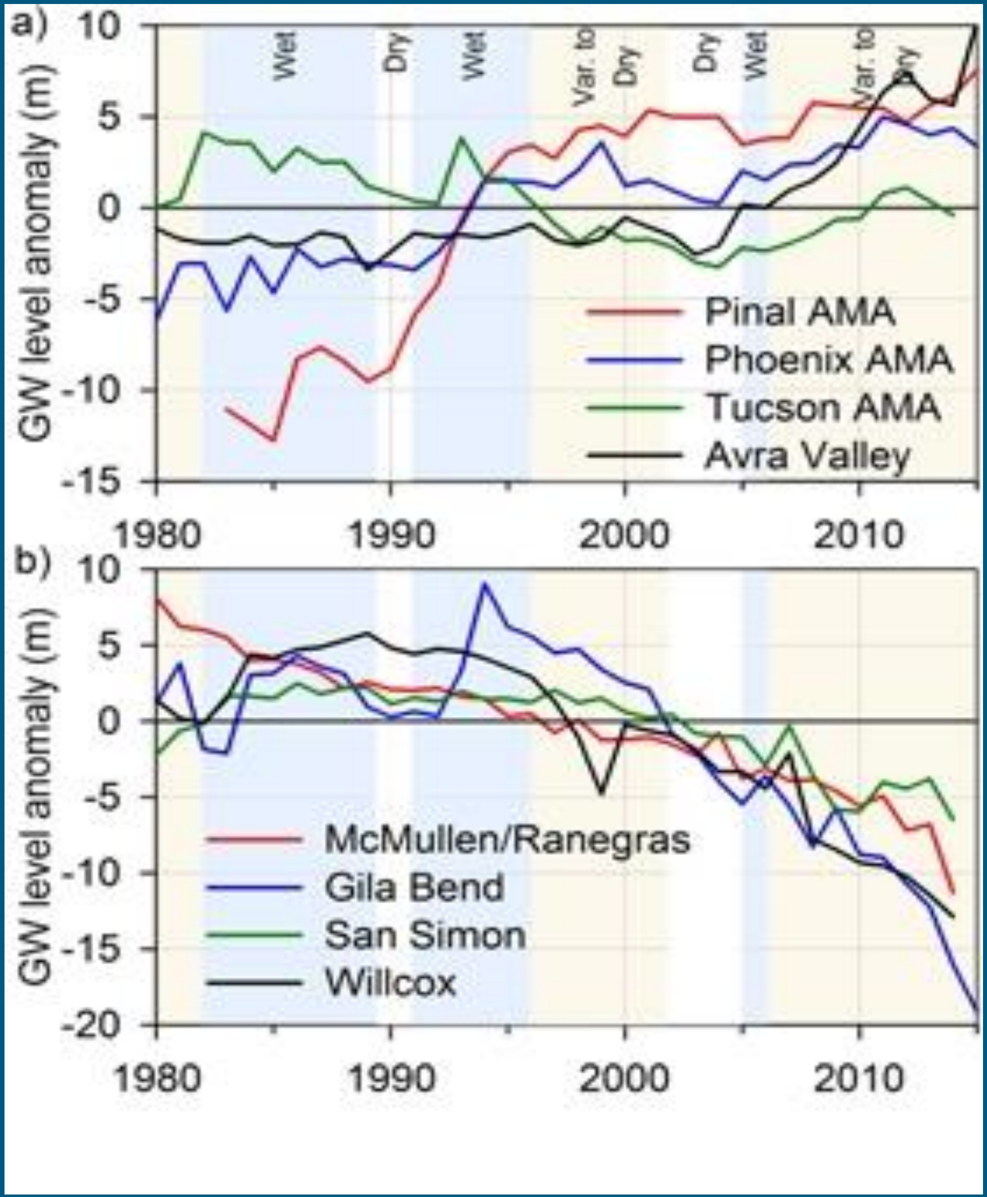

Scanlon et al. (2016) *Environ. Res. Lett*.

NGWA/AWRA Groundwater Visibility Initiative

- Improving groundwater "visibility":
  - Connections to surface water
  - Climate variability and change
  - Policies for agriculture, land use, energy, etc.
  - Importance of monitoring groundwater status and trends
  - Transparency of groundwater information and management
- Workshop April 2016; continuing outreach

http://www.ngwa.org/Media-Center/news/Pages/The-Groundwater-Visibility-Initiative-Report.aspx

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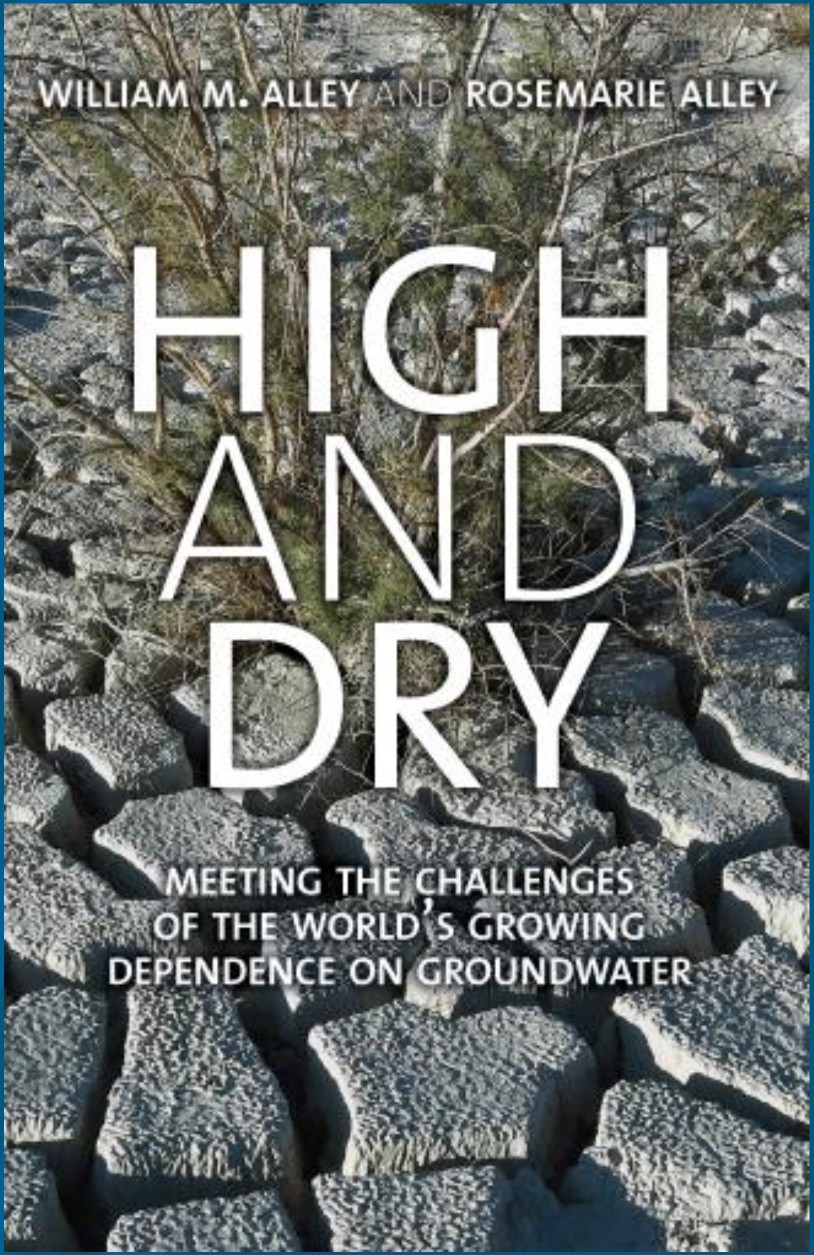

Contents

Yale University Press; Feb 2017

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