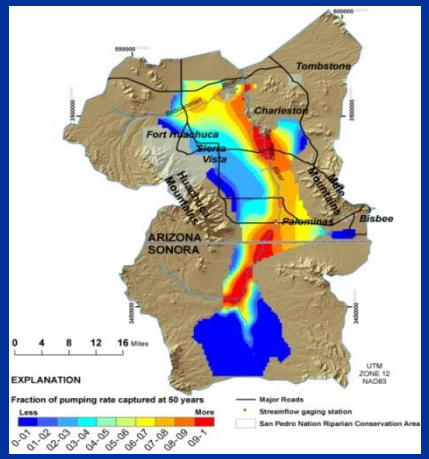
Groundwater Models Used for Management
(Outside California)



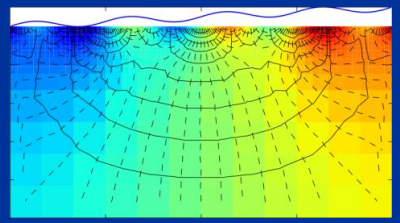
William L. Cunningham

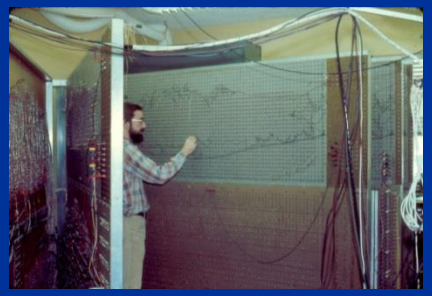
Senior Science Advisor for Groundwater
Chief, Office of Groundwater
U.S. Geological Survey

"Water in the West" Workshop #1

Groundwater Models in the SGMA Context: Tools to Achieve Sustainable Groundwater Management

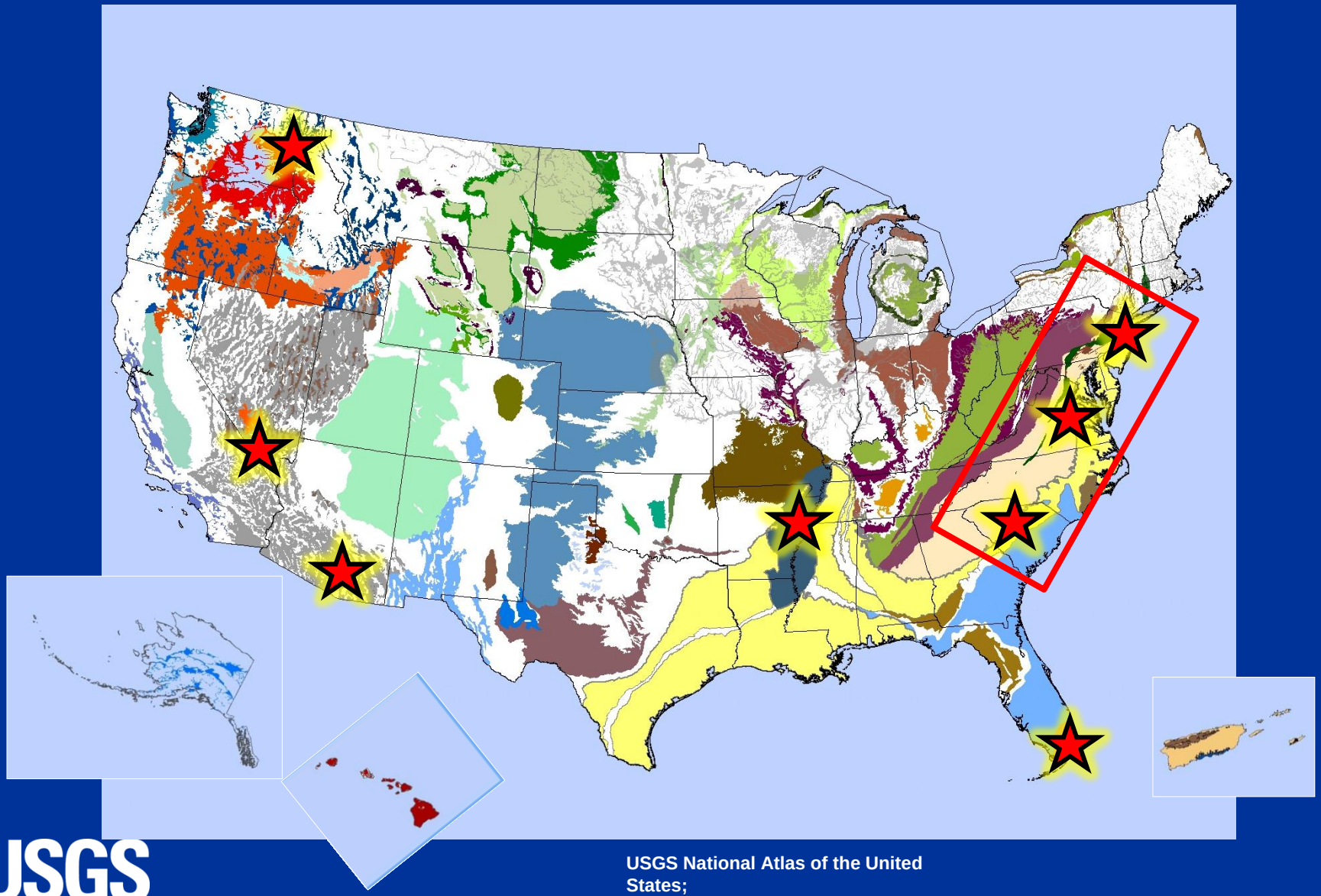
Stanford Woods Institute for the Environment
Stanford University
November 16, 2015





U.S. Department of the Interior
U.S. Geological Survey

Example Modeling Studies



USGS National Atlas of the United States;
http://nationalatlas.gov/atlasftp.html

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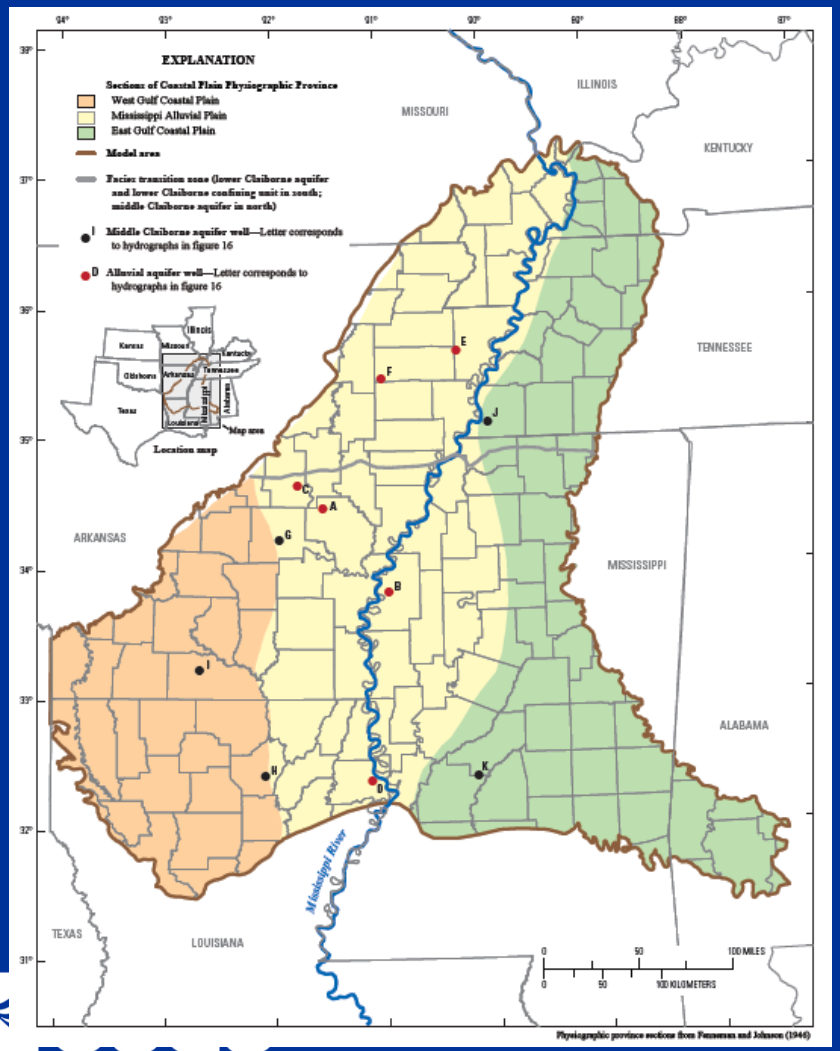
Regional (Multi-State) Model

Mississippi Embayment

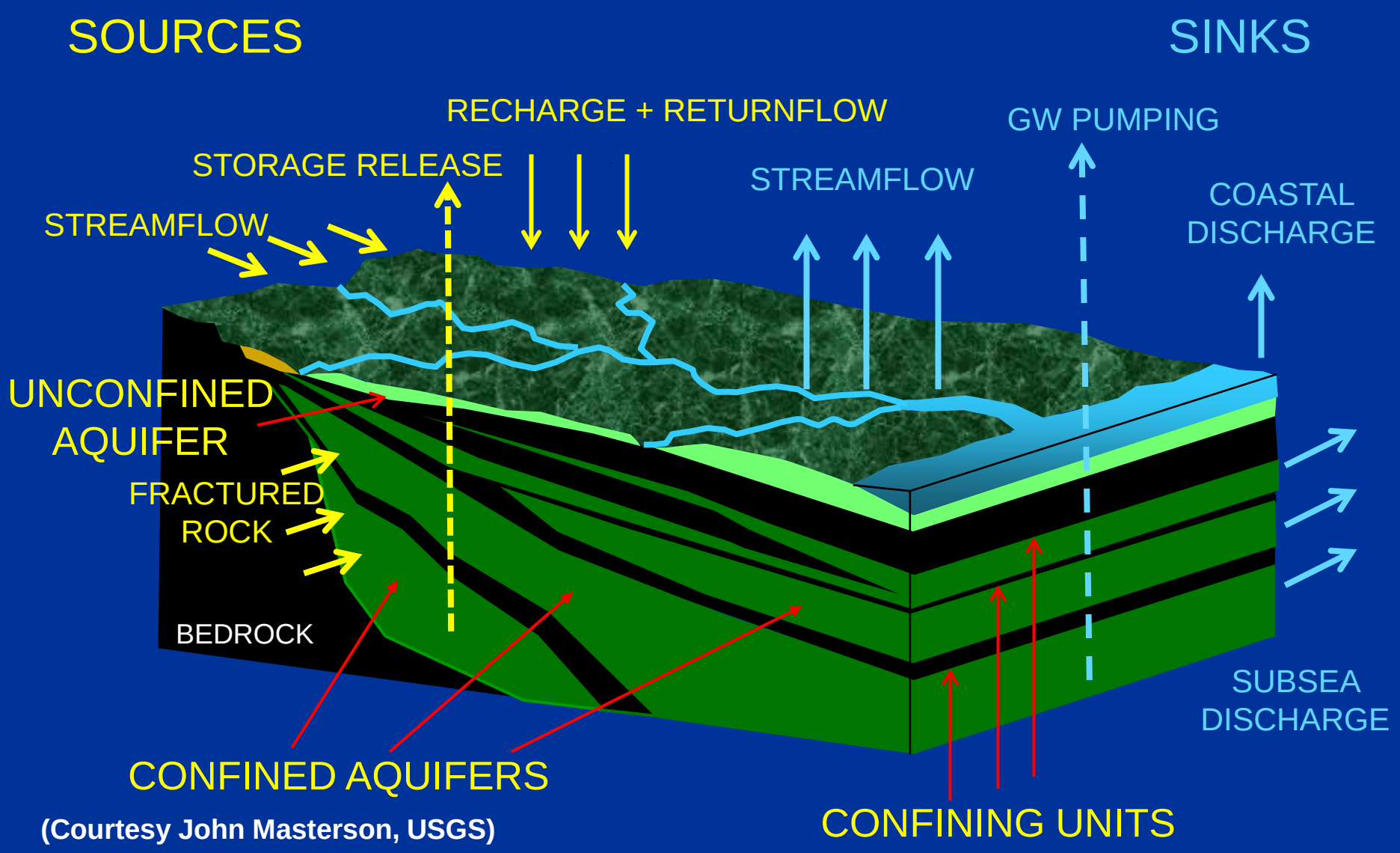


- Multistate model of Embayment
- Required collaboration among states, and local agencies
- Documented effects of human activities and climate variability on GW levels, depletion, storage, and interaction with SW
- Once built, multiple uses:
  - Arkansas State Water Plan developed using this model
  - Mississippi water use conservation scenarios
  - Tennessee evaluated effects of proposed power plant GW use

Clark and Hart, 2009

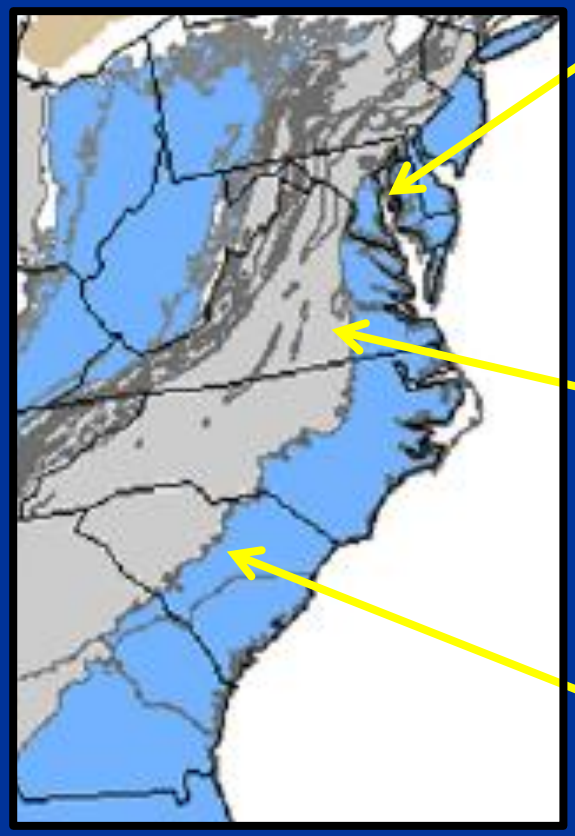
Management in the Atlantic Coastal Plain

Coastal Plain Conceptual Model



(Courtesy John Masterson, USGS)

Management in the Atlantic Coastal Plain
State Examples



- **New Jersey**
  - NJDEP Permit required for >= 100K gpd for a month (0.307 af/d)
  - Multiple models regularly updated
  - Permits evaluated via modeling, hydrographs, and/or potentiometric-surface mapping
- **Virginia**
  - "GW Management Area" -- VADEQ Permit required for >= 300K gallons (0.92 af) per month
  - Statewide model with LGR
- **South Carolina**
  - "Capacity Use Area"-- SCDHEC Permit required for >= 3 million gallons (9.2 af) per month
  - Statewide model used to screen applications

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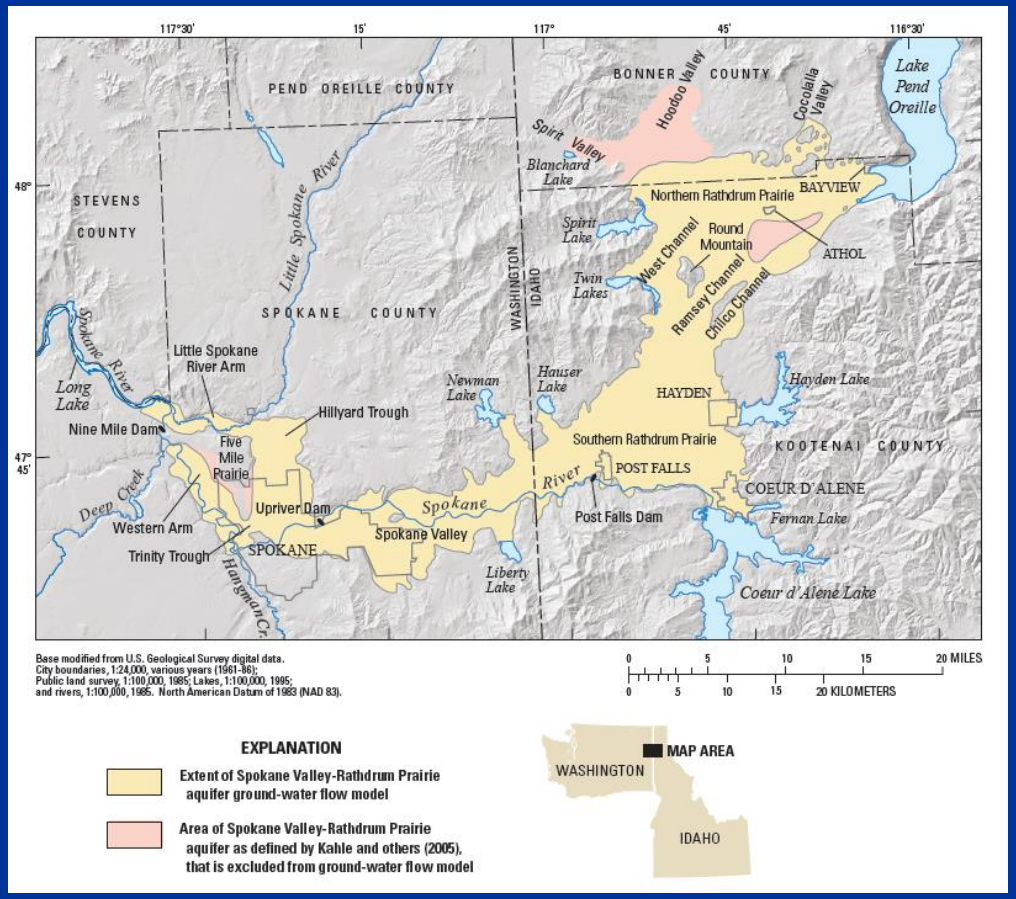
Transboundary Collaboration

Spokane Valley-Rathdrum Prairie Aquifer Washington-Idaho



(Hsieh and others, 2007)

- Sole Source Aquifer for 500K in WA and ID
- Negotiated "Modeling Team" from WA Dept Ecology, ID DWR, and USGS.
- Decisions on approach, methodology, assumptions, and interpretations were reached by consensus
- Analyzed aquifer budget, simulated effects of future changes in groundwater withdrawals, and evaluated aquifer management strategies
- Model available to all

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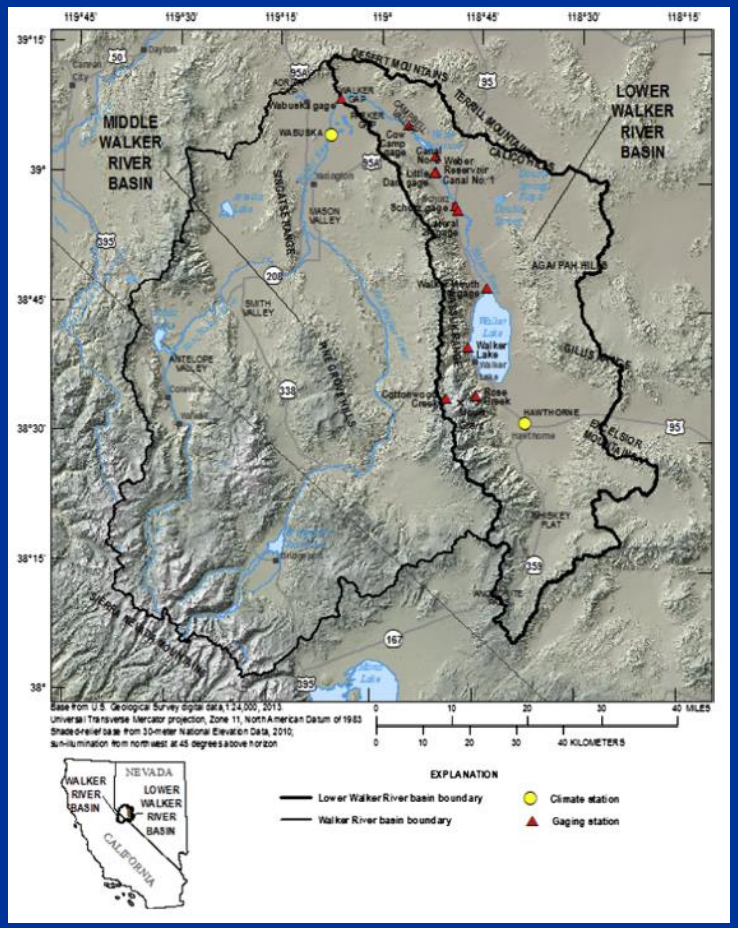
Collaborative Modeling / Decision Support

Walker Lake, Nevada



- Decreased inflow resulted in 100 km^2 loss of lake surface area.
- Total loss of fisheries due to salinization
- Stakeholders, water institutions, and scientists engaged in collaborative modeling and the development of a decision support system (DSS)
- DSS used to develop and analyze management change options to restore the lake.

(Niswonger and others, 2014)

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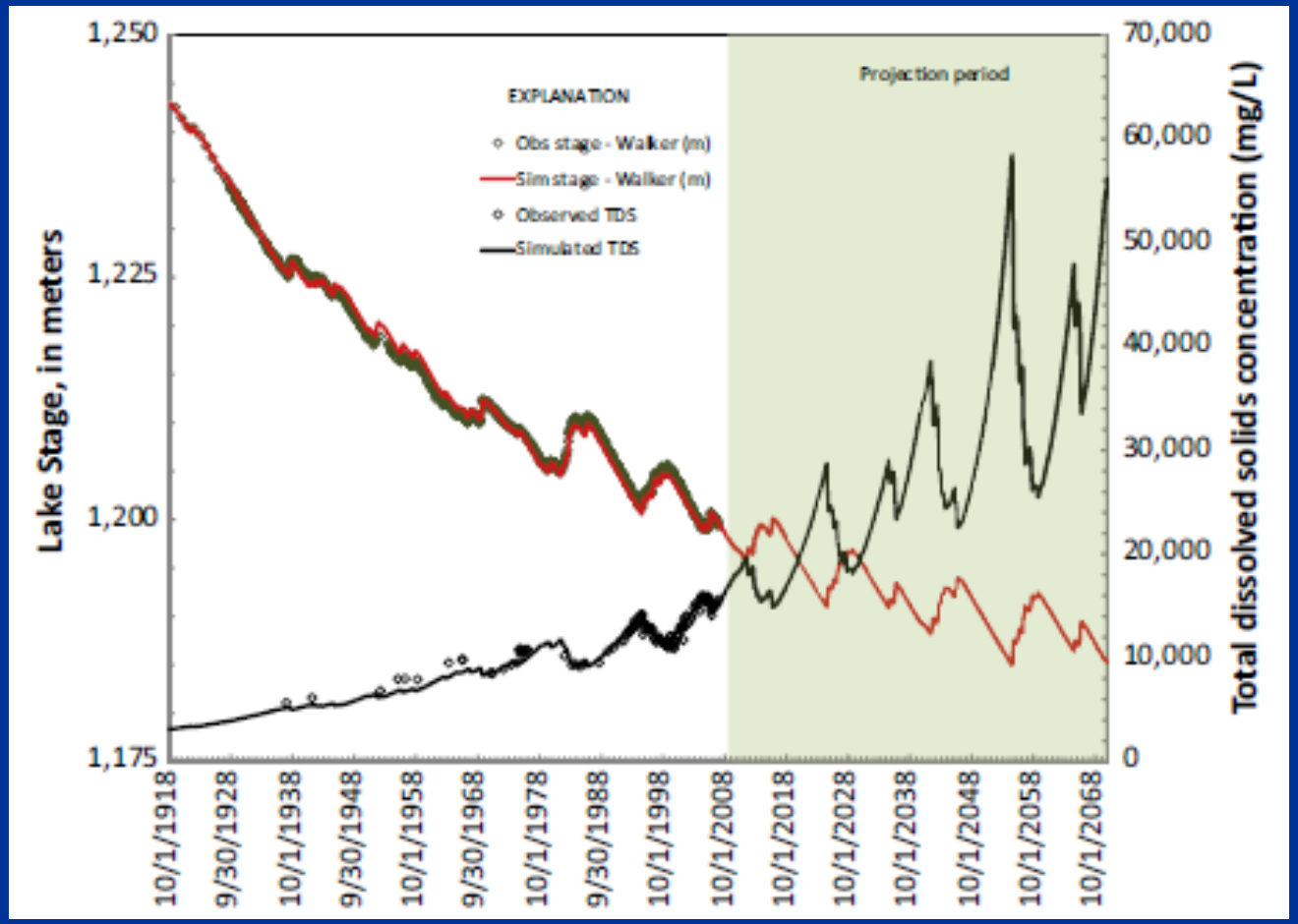
Walker Lake Integrated Management and Hydrologic Model

Can salinity of the lake be reduced by changes in water-management practices?



(Niswonger and others, 2014)

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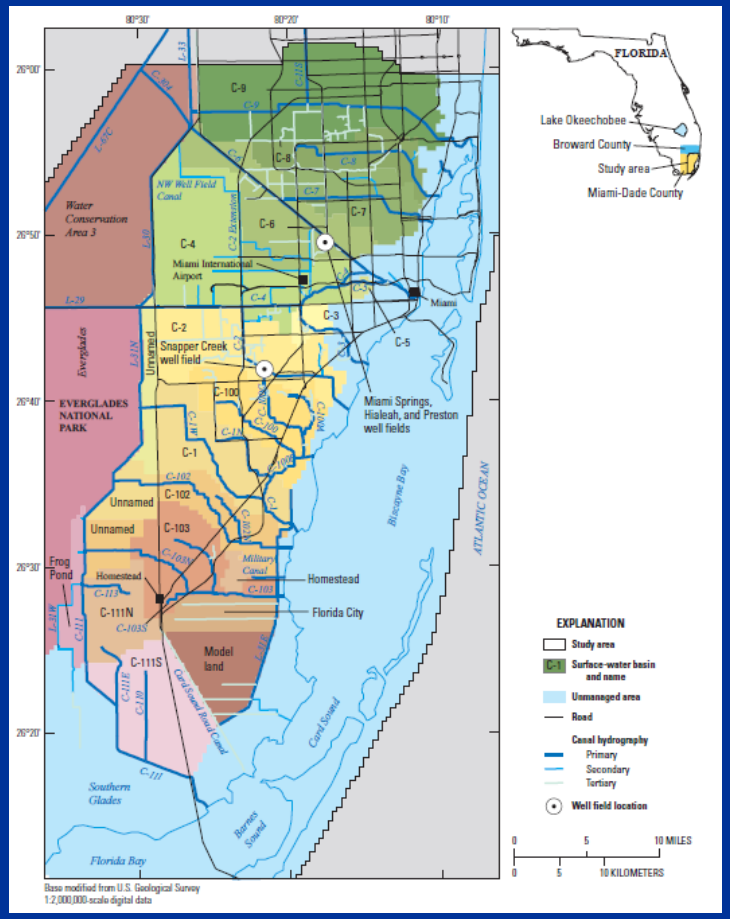
Integrated Hydrologic Model: Pumping Effects on Canals; SL Rise

Biscayne Aquifer, Miami-Dade, FL



- Can no longer take water from the Everglades—what is the effect of increased GW pumping?
- Complex and coupled GW/SW environment
- Going beyond requirements: evaluate effect of increased GW pumping under sea level rise scenarios on regional GW flow and on seawater intrusion
- Finding: Canal system limits the adverse effect of pumping increases; FW/SW interface does not move significantly; water table rise increases flood prone area by 10 mi^2

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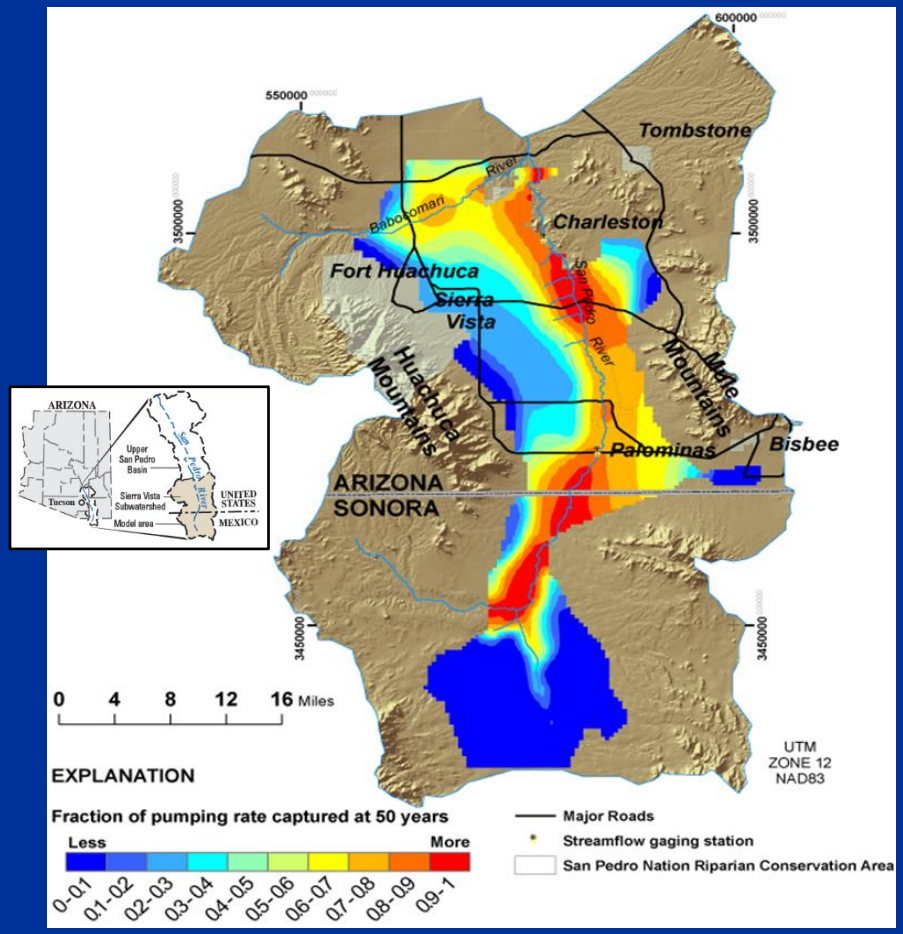
(Hughes and White, 2014)

The Power of Partnership

Upper San Pedro Basin, Arizona



(Leake and others, 2014)

- Transboundary desert basin
- Increased GW use threatened riparian ecosystem
- Consortium of 23 agencies, business, and NGO's [*the San Pedro Partnership*] pooled resources to develop a regional GW model
- Groundwater capture maps illustrated the most sensitive areas; used to guide land purchases and ID recharge zones
- Subsequent modeling efforts used local area models

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Partnership Lessons Learned

Upper San Pedro Basin, Arizona

- **Engage decision makers and key stakeholders early in the process to define the science and technical tools needed for an integrated water management approach.**
- **Collaboratively define desired outcomes as specifically as possible both temporally and spatially.**
- **Stakeholders with varied interests are more likely to work successfully toward a common goal if they feel that their individual interests are represented, and can actually benefit from the process.**
- **The importance of effective communication and two-way learning between scientists and decision makers cannot be overstated**

"Development of a Shared Vision for Groundwater Management to Protect and Sustain Baseflows of the Upper San Pedro River, Arizona, USA"

(Richter and others, 2014)

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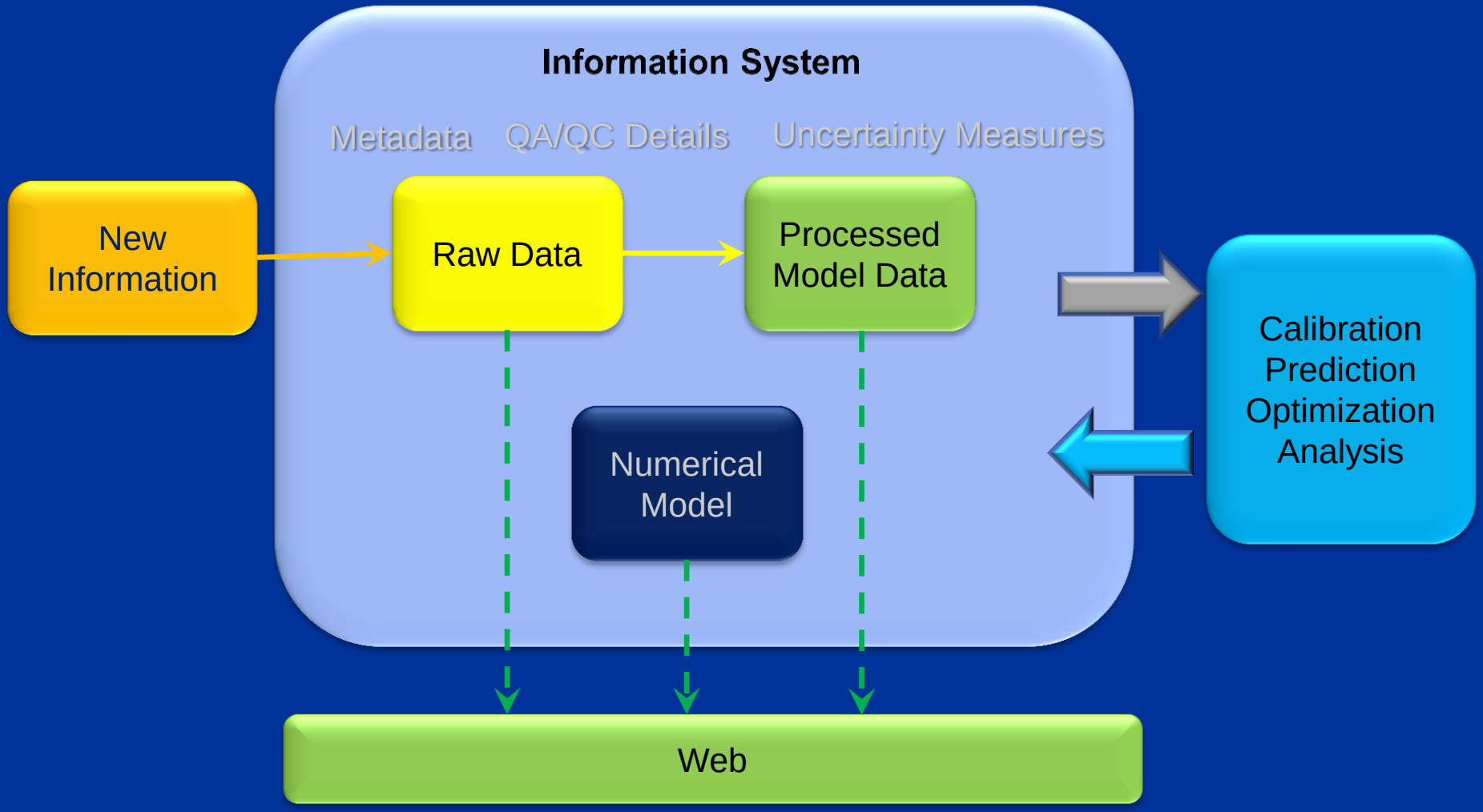
Modeling Trends in 2015 and Beyond

Data-Driven Modeling



Modified from Refsgaard et al. (2010)