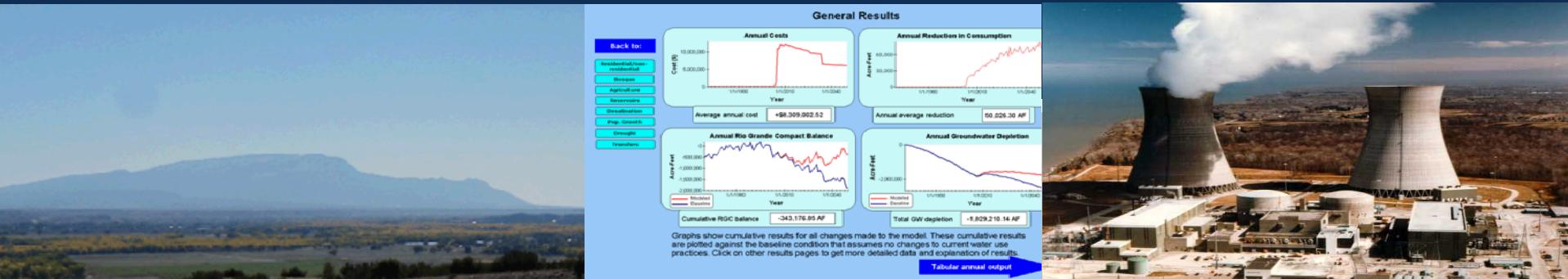


Exceptional service in the national interest



Challenges of Integrating Science into Public Mediated Decision Making

Vincent Tidwell
Earth Systems Department



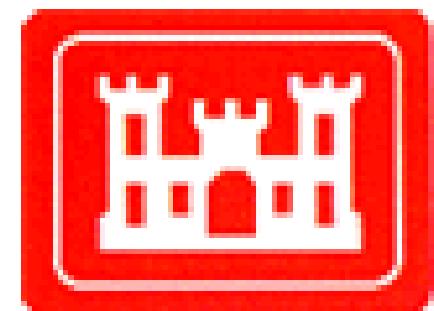
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Collaborators

- Howard Passell
- Len Malczynski
- Tom Lowry
- Jesse Roach
- Beth Richards
- Marissa Reno
- Peter Kobos
- Will Peplinski
- Geoff Klise
- Ron Pate
- Barbie Moreland
- Stephanie Kuzio
- Ray Finley
- Erik Webb



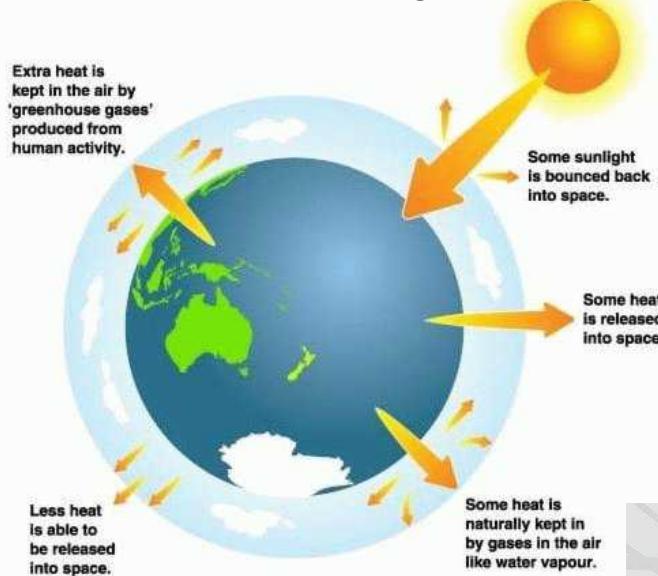
The University of New Mexico



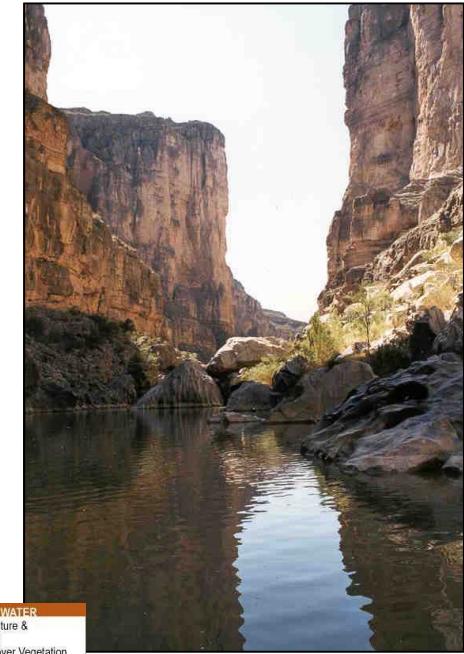
Resource Planning Challenge



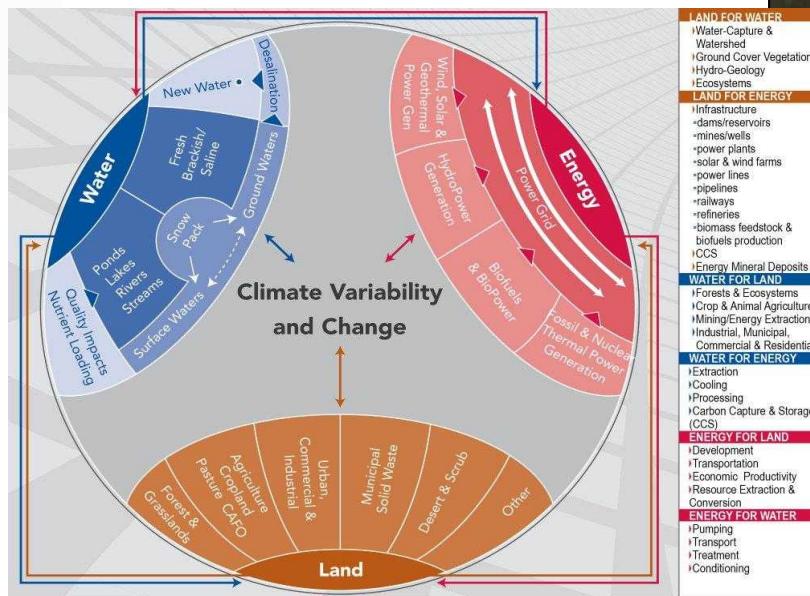
Climate Variability/Change



Growing Demand



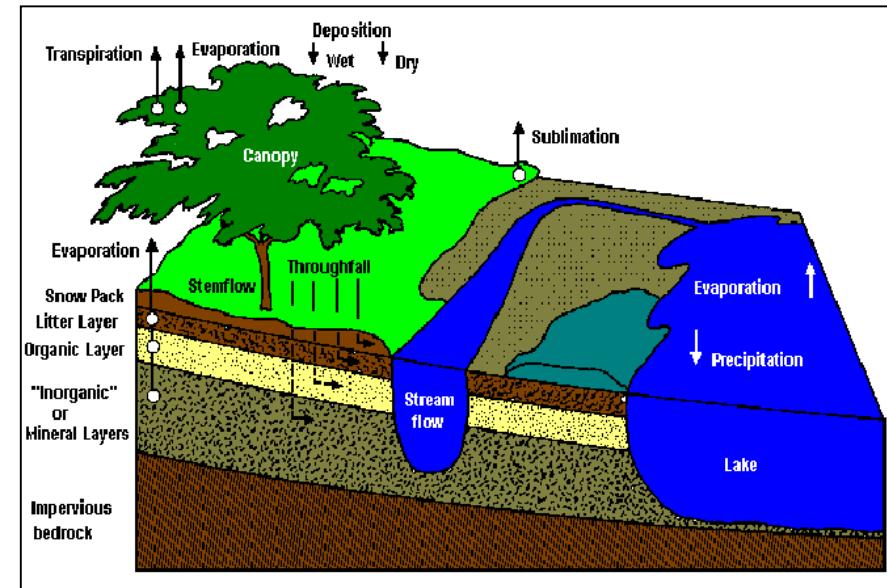
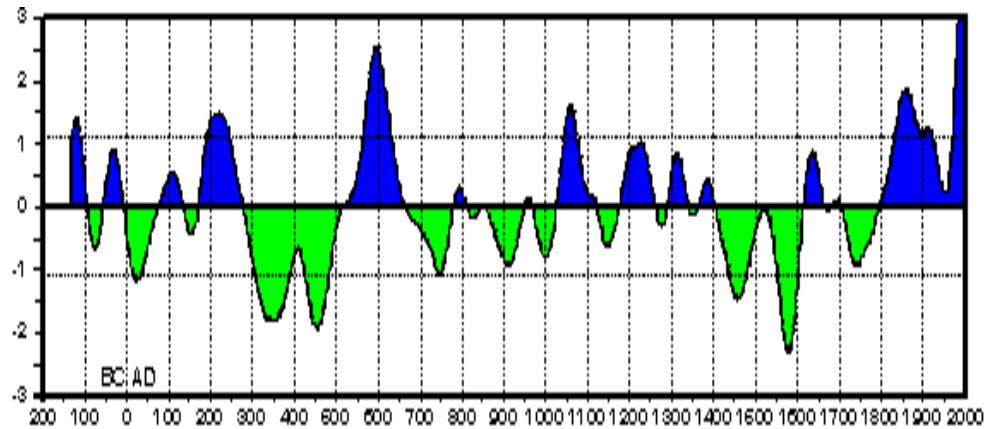
Environmental Health



Competing Human Values

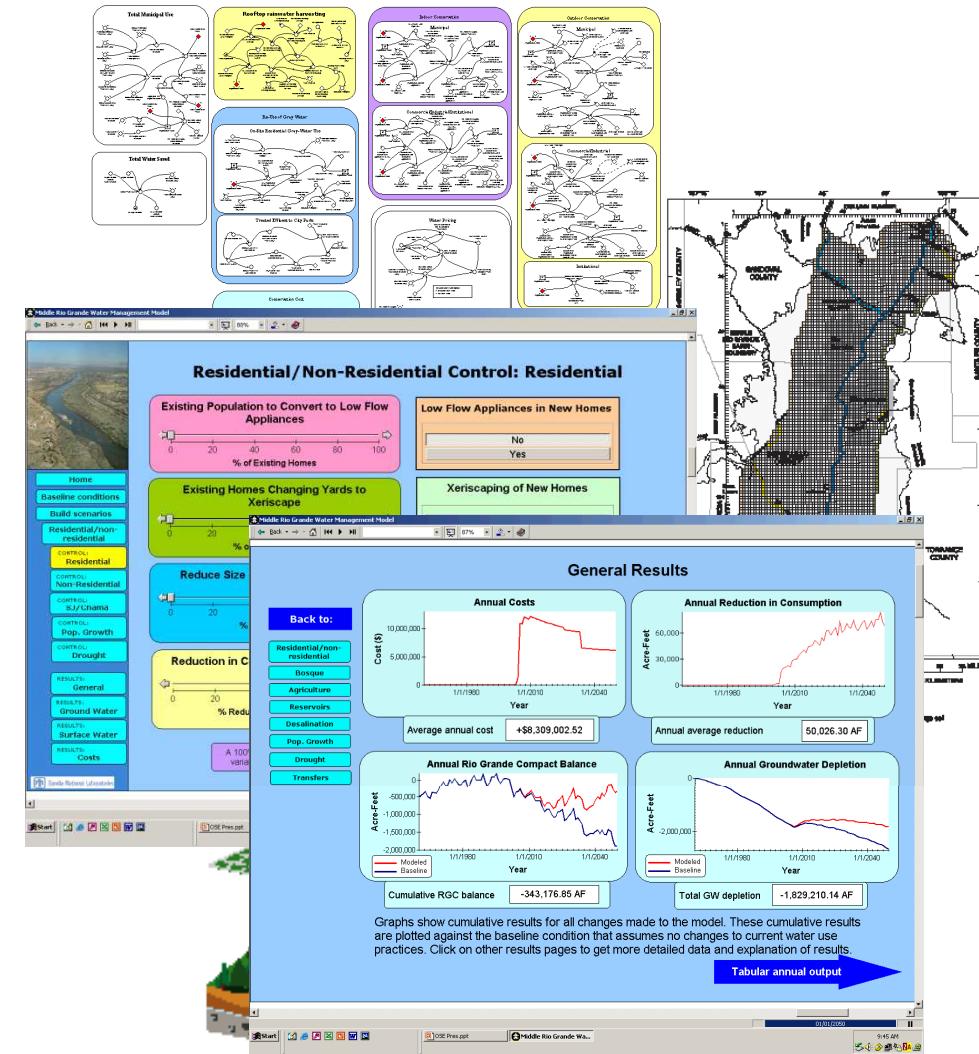
The Need

- *Learn to speak the same language:*
 - Each person brings unique information and experience to the process.
 - No single person has the answer.
 - Need to develop a shared basis for decision making.



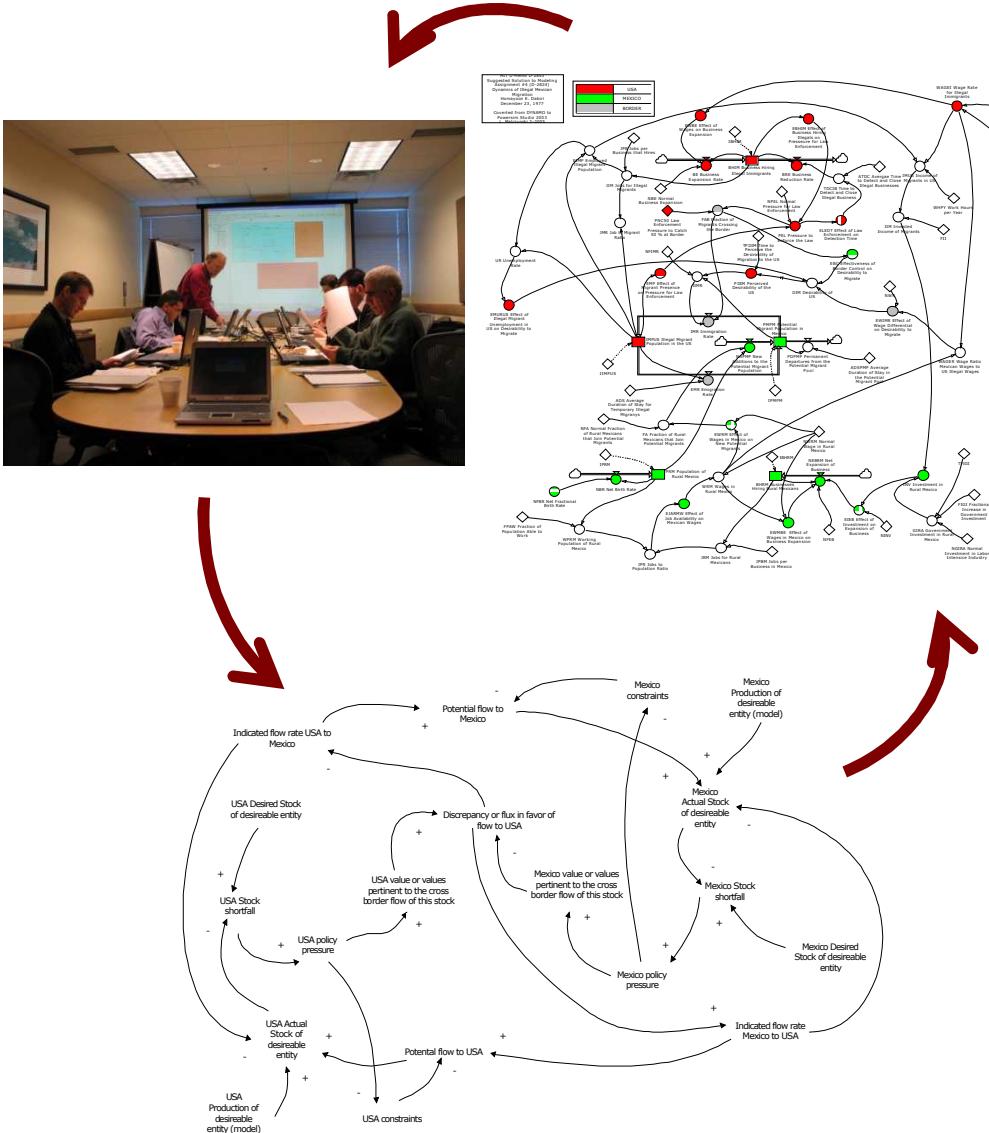
Integrative/Interdisciplinary Modeling

- System management,
 - High resolution,
 - Detailed physics,
 - Focused scope, and
 - Time intensive.
- System planning,
 - Low resolution
 - Scale appropriate physics,
 - Broad scope, and
 - Interactive.



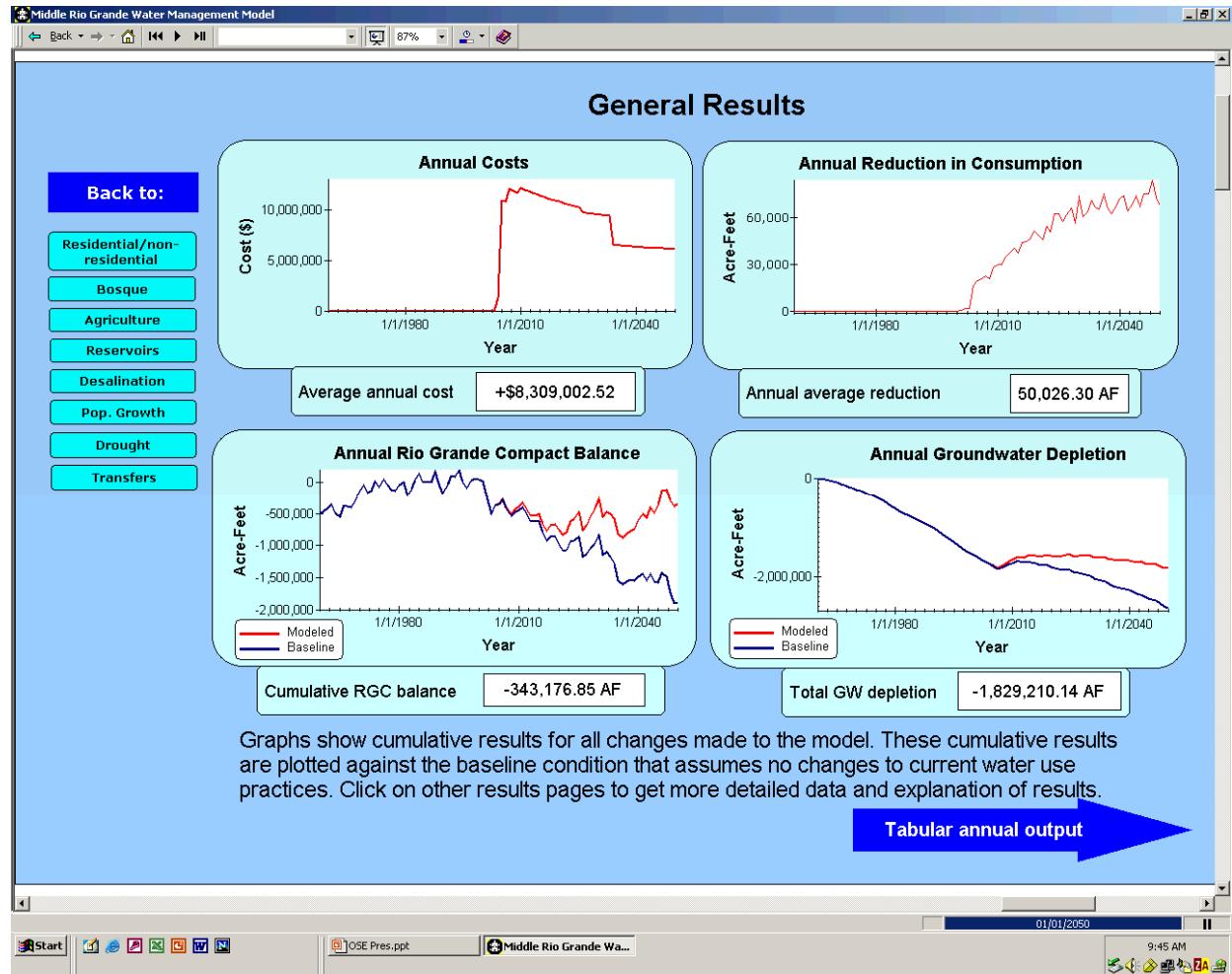
Fostering a Environment of Collaboration

- Process of engaging decision-makers and stakeholders in:
 - Model development, and
 - Decision analysis.
- Purpose of broad input includes:
 - Expand knowledge base,
 - Structure group thinking/discussion,
 - Stimulate group learning, and
 - Ultimately lead to improved advocacy.



Visual/Interactive Environment for Analysis

- Broadly accessible
 - PC based
 - User friendly interfaces
 - Computations in seconds to minutes
- Provides interactive environment for scenario testing



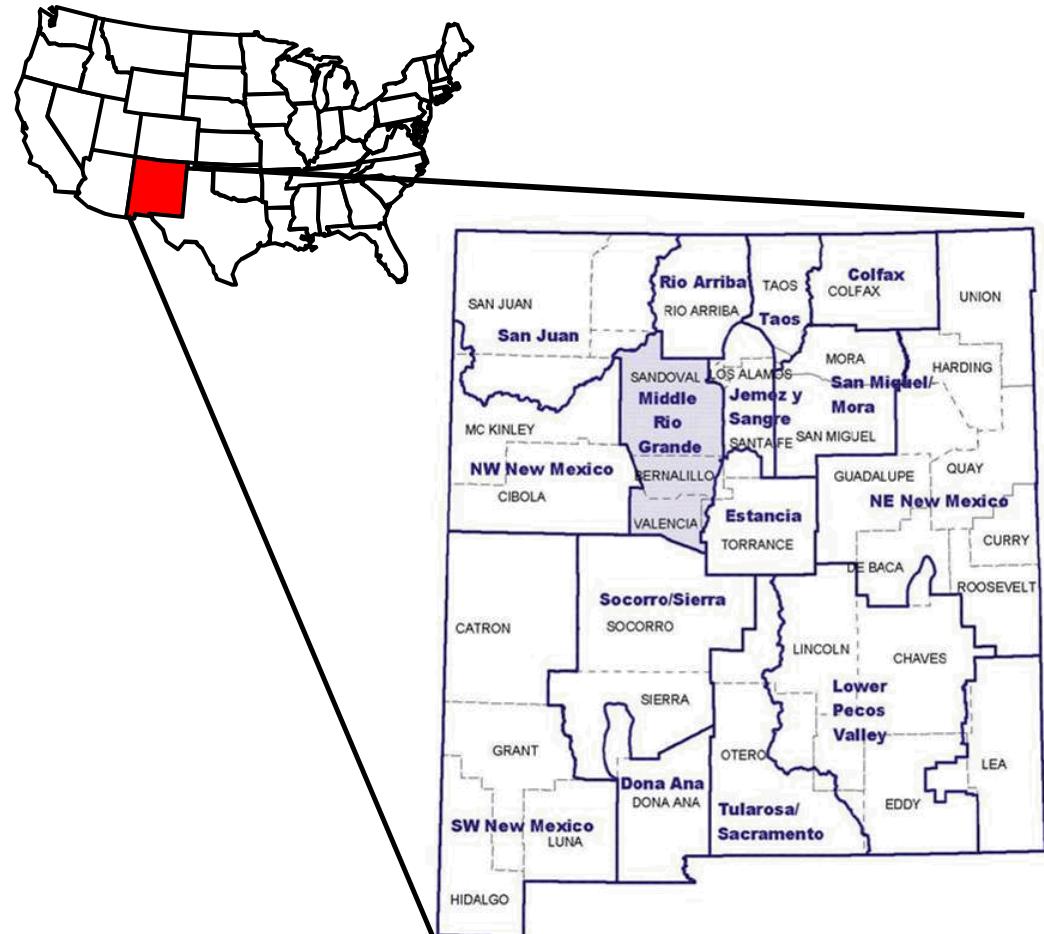
Motivation

Participants must be more afraid of the future than changes to the status quo



Example: MRG State Water Planning

- Three county planning region
 - Bernalillo
 - Sandoval
 - Valencia
- Total population of ~750,000 including Albuquerque, Rio Rancho, Belen, Bernalillo and Los Lunas



Planning Objectives

- 1. What is the region's available water supply?**
- 2. What is the region's future water demand?**
- 3. How will the region balance supply with demand?**
 - What actions can be taken?
 - Which are acceptable to the community?
 - How can they be implemented?



Planning horizon of 50 years!

Model Development Process

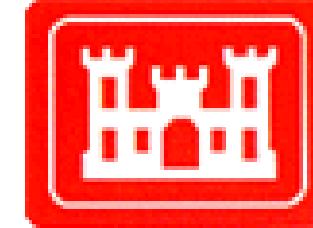
- Assembled a “Cooperative Modeling Team” including members from:
 - Each Water Assembly constituency group,
 - Middle Region Council of Governments (MRCOG), and
 - Utton Transboundary Resources Center, UNM
- Team meets every other week to:
 - Conceptualize model components,
 - Identify external sources of expertise and data, and
 - Review the model
- Community engagement
 - Expose community to model
 - Public forums,
 - Educational venues, and
 - Community events
 - Interactions with the professional community



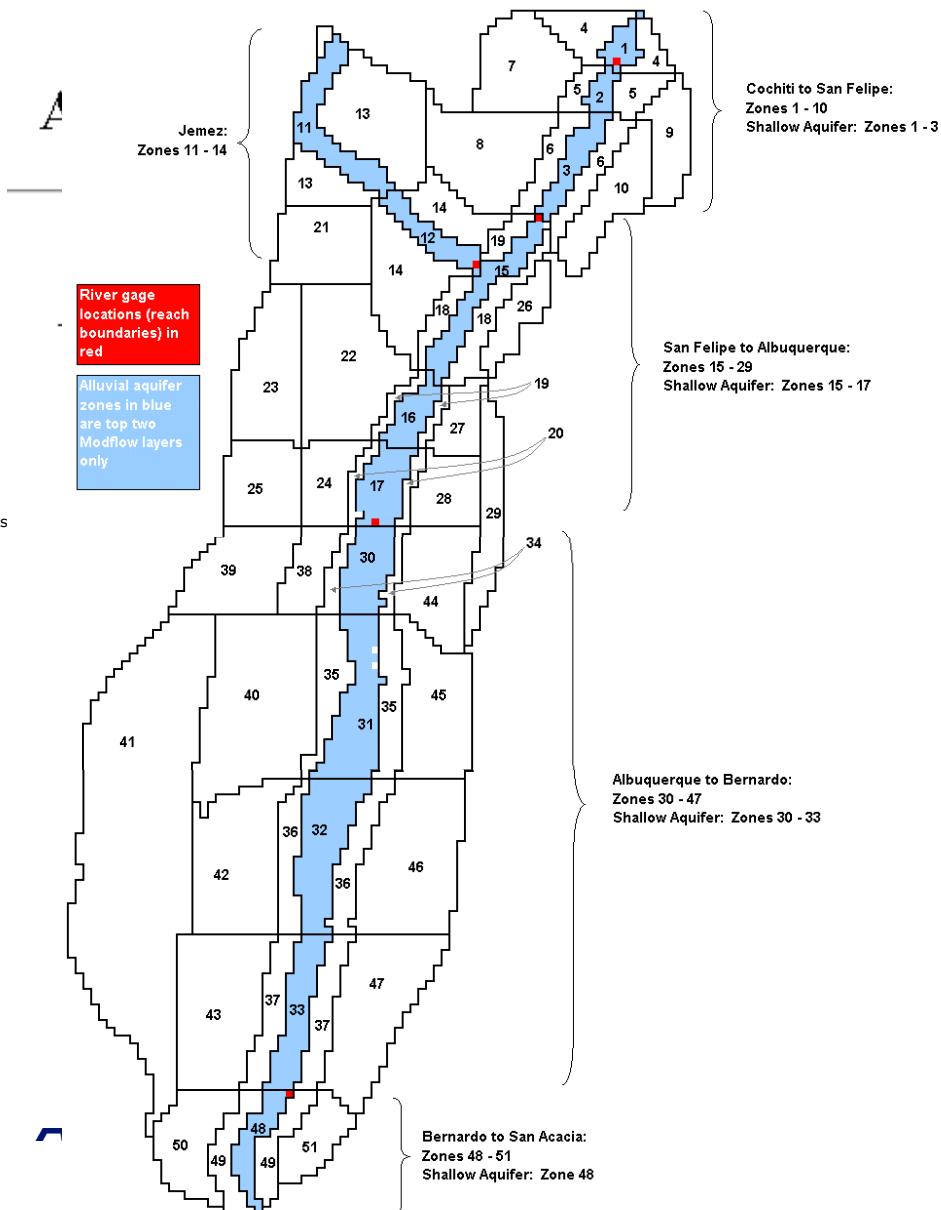
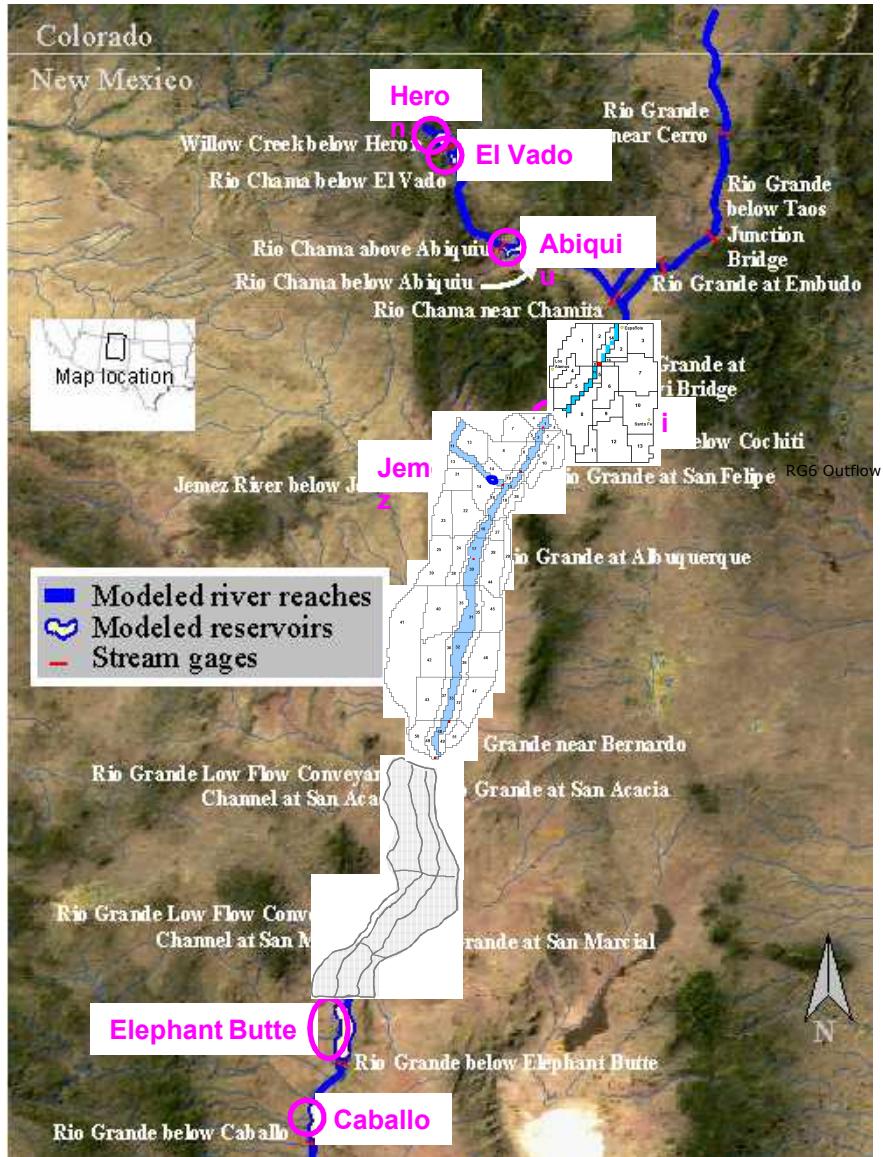
MRG Operations Planning



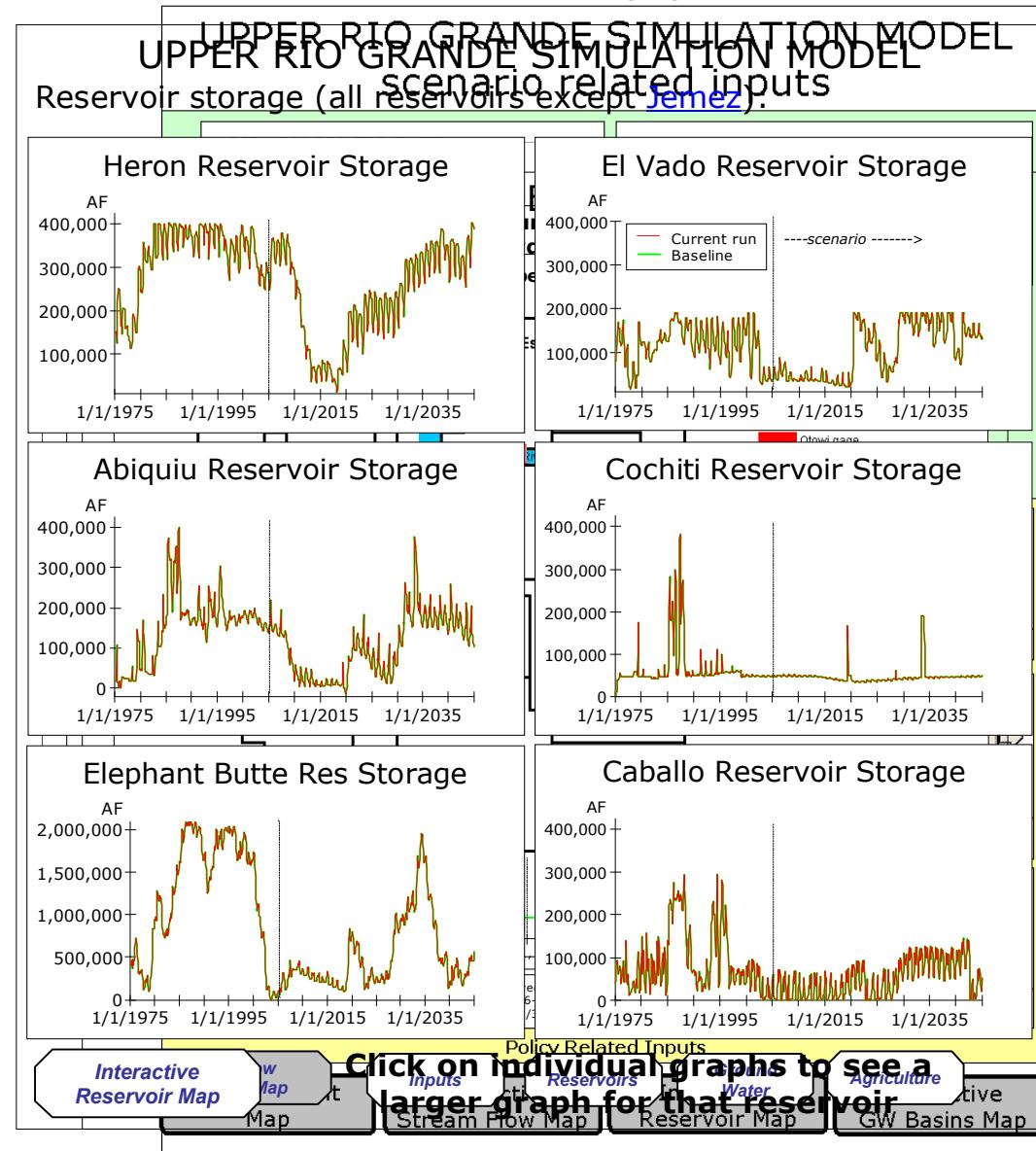
- Develop a decision support tool that is consistent with and complimentary to the Upper Rio Grande Water Operations Model (URWOM).
 - The primary purpose of the tool is to provide a platform for rapid scenario screening, and
 - Educate and engage the public and decision makers in water operations decision-making and planning.



Operations Model for the Upper Rio Grande



Operations Model for the Upper Rio Grande

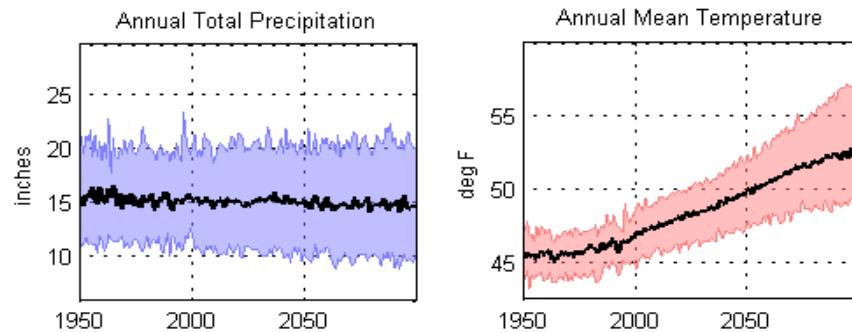


Modeling: Downscaling IPCC Model

112 runs
1950-2099

General Circulation Model
(GCM)

112 Statistically
Downscaled Regional
Projections of ΔP and ΔT



Post processing bias
correction of flows (224
hydrographs)

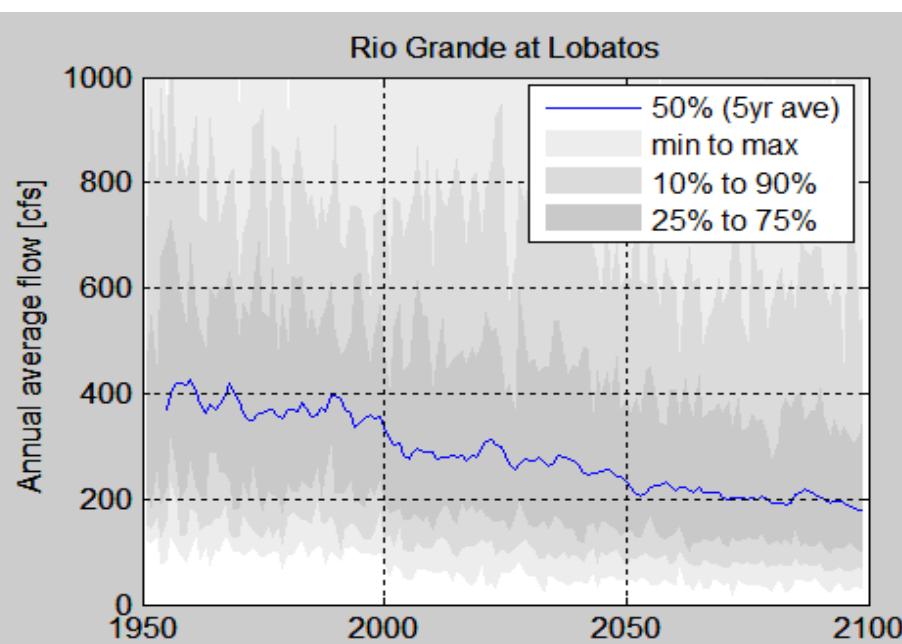
Operations model
(URGSiM)

Variable
Infiltration
Capacity
(VIC) Model

112 Runoff Projections
Using Rainfall Runoff
Model

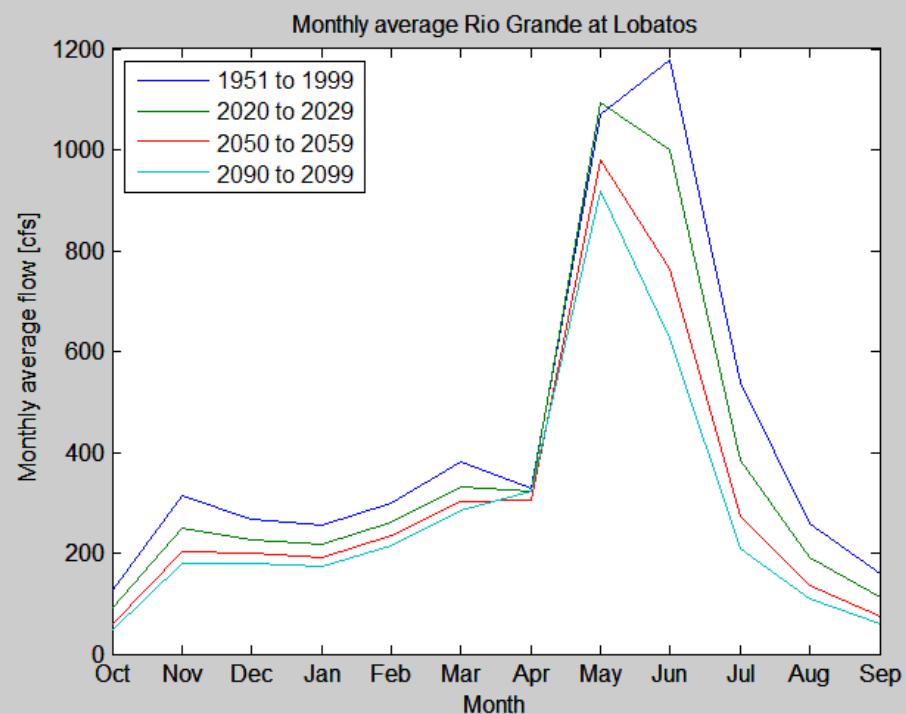
Impacts to water
deliveries, flows, and
reservoir levels.

Impact on Rio Grande Flows

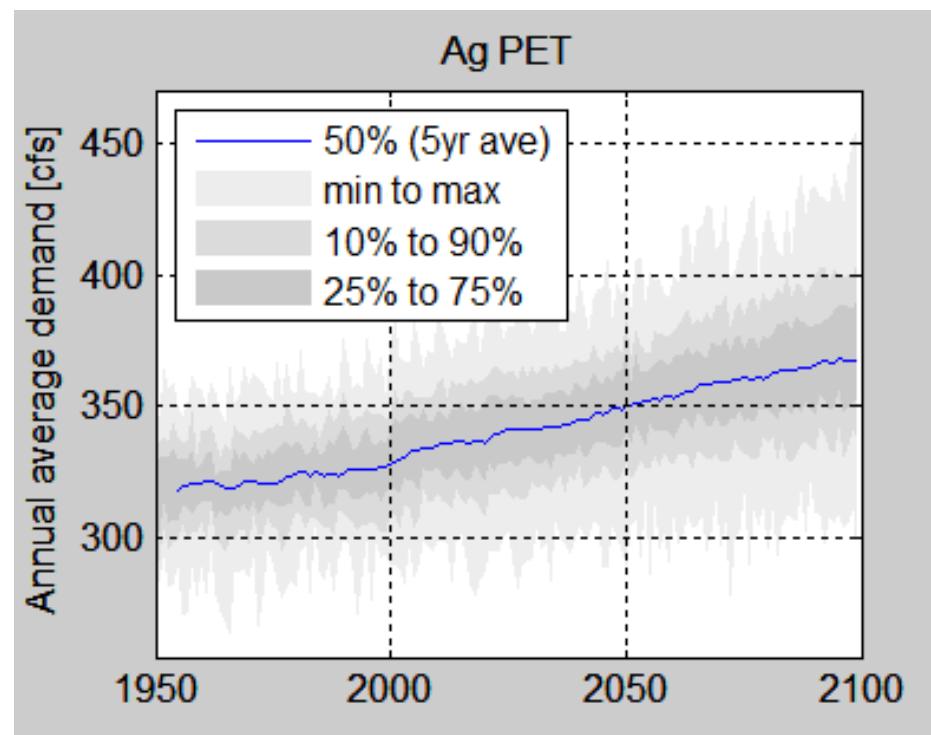


“Results are not predictions, but rather a starting point for dialogue and increased awareness of potential impacts of climate change.”

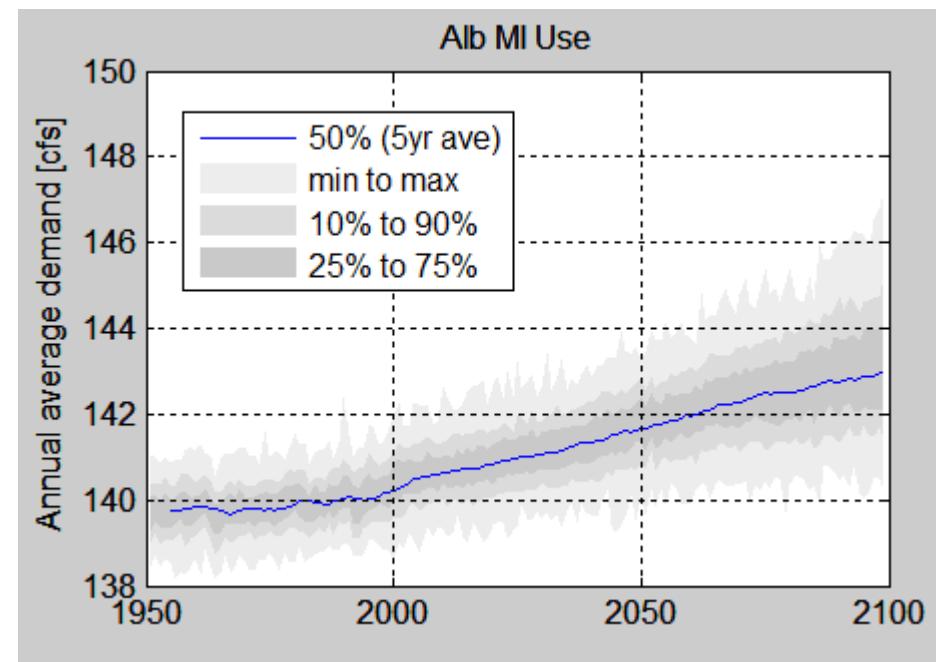
Roach et. al., 2013



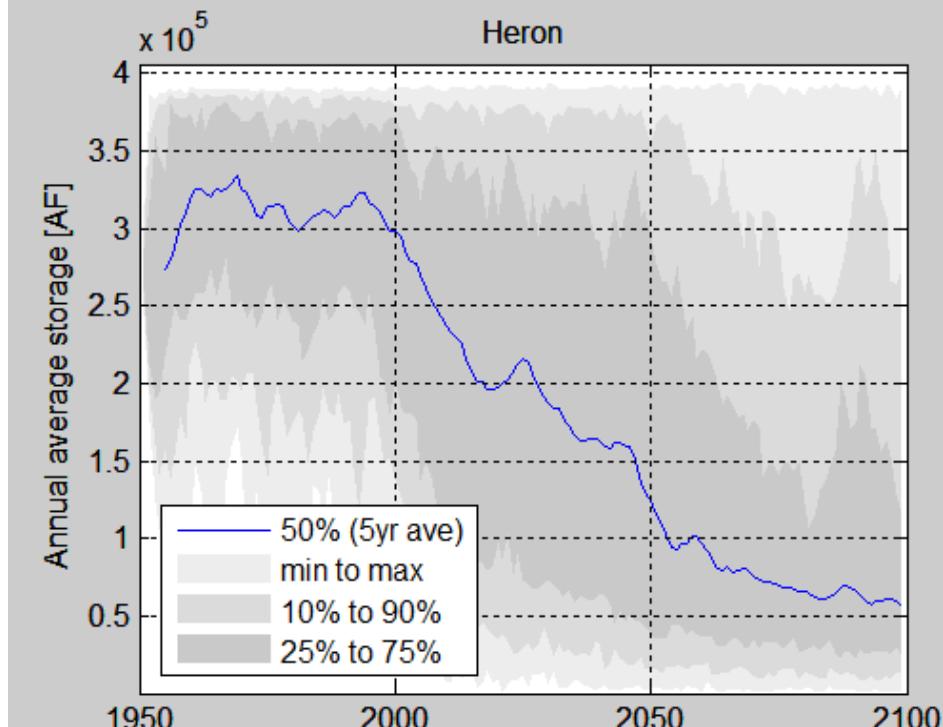
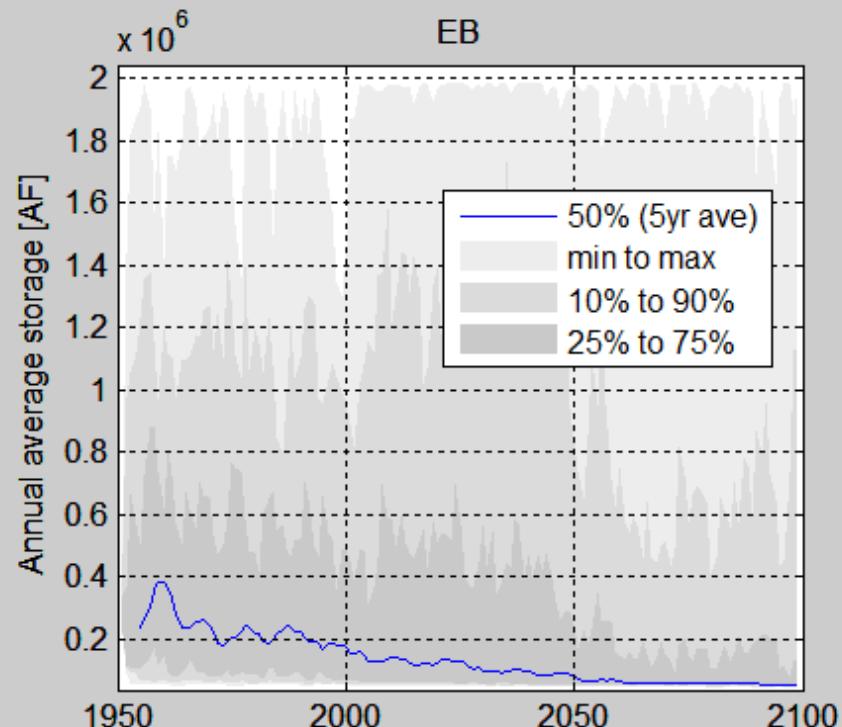
Impacts on Water Demand



Roach et. al., 2013

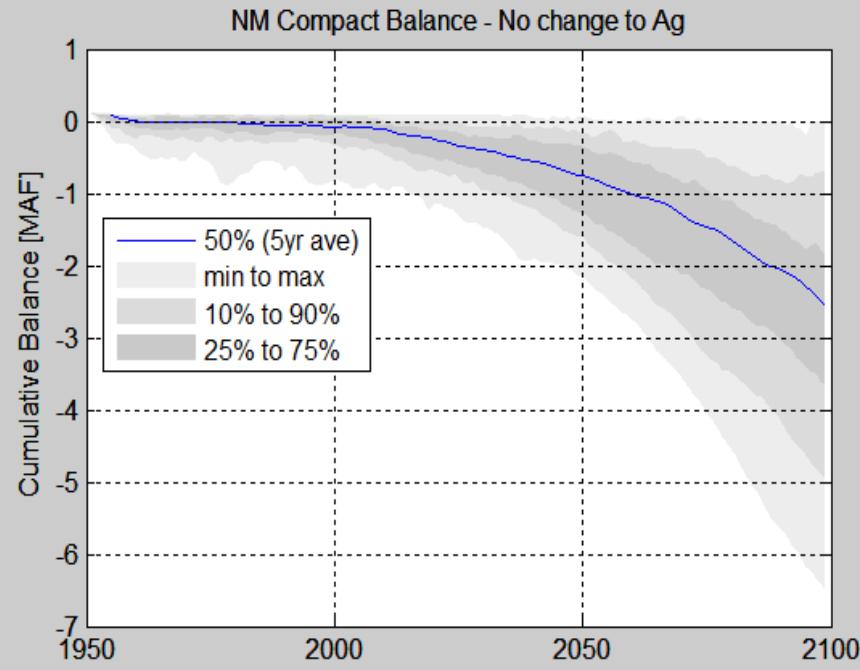


Impacts to Reservoirs

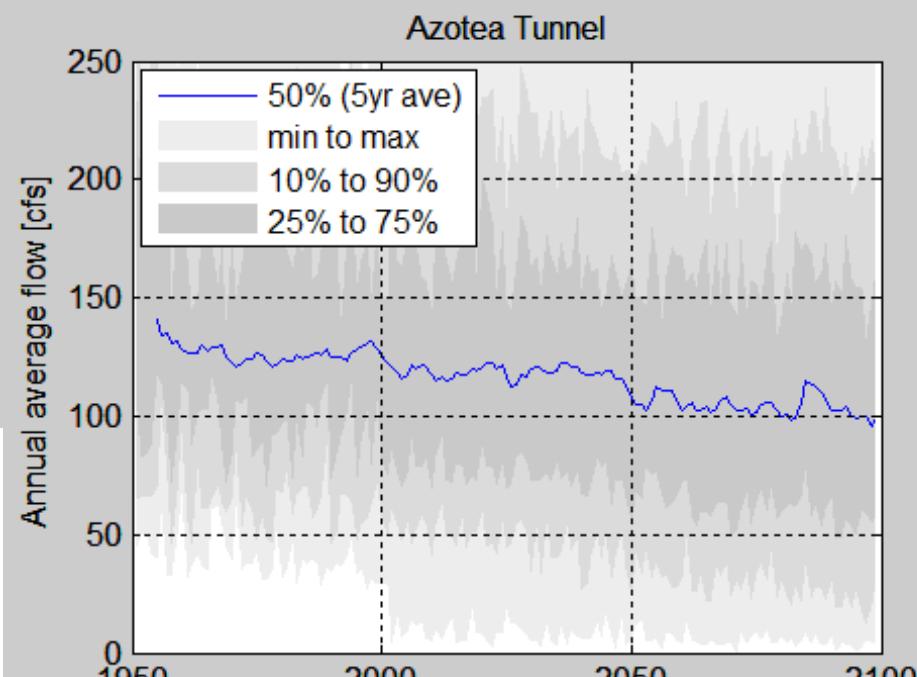


Roach et. al., 2013

Impacts on Water Deliveries



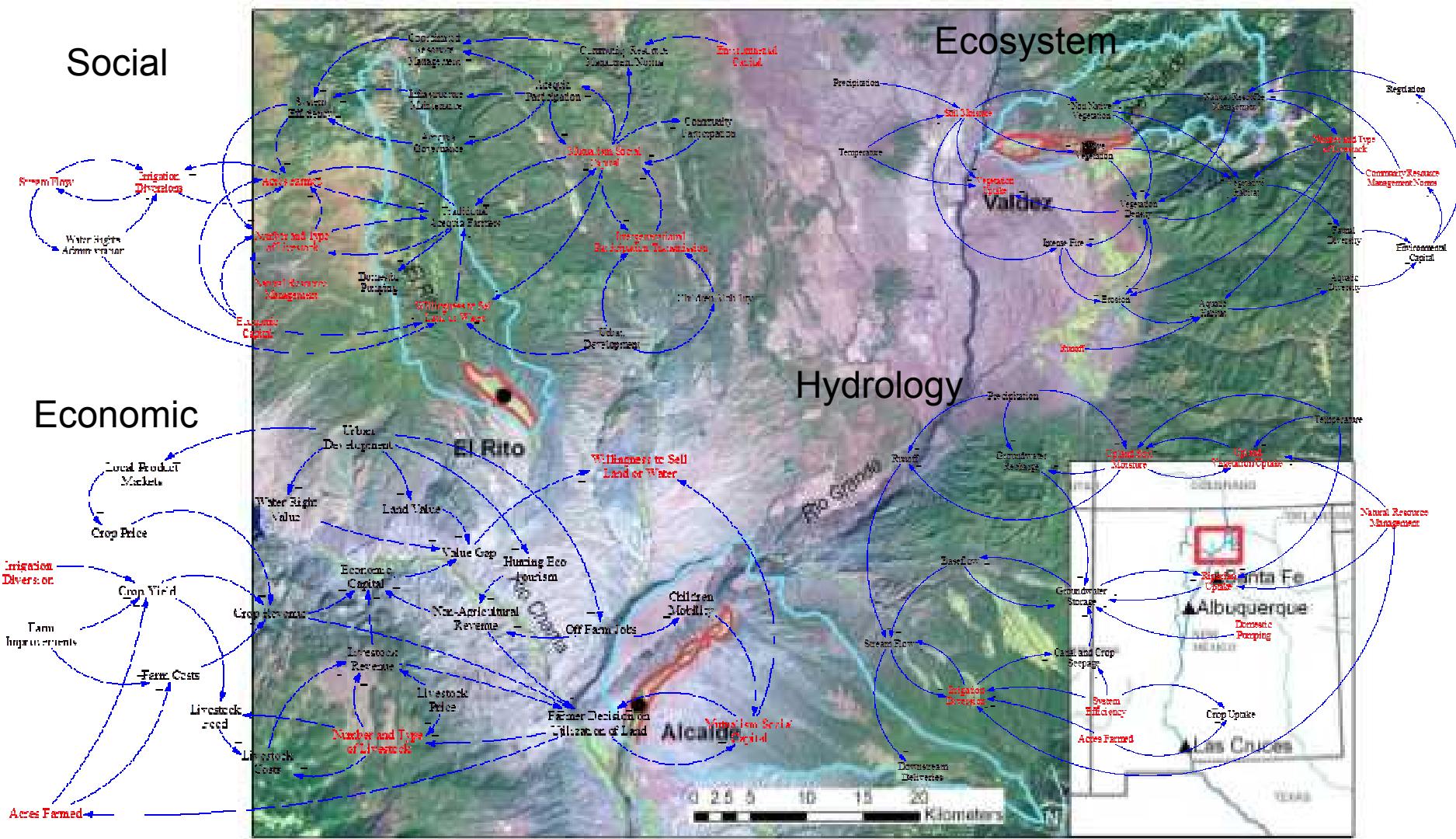
Roach et. al., 2013



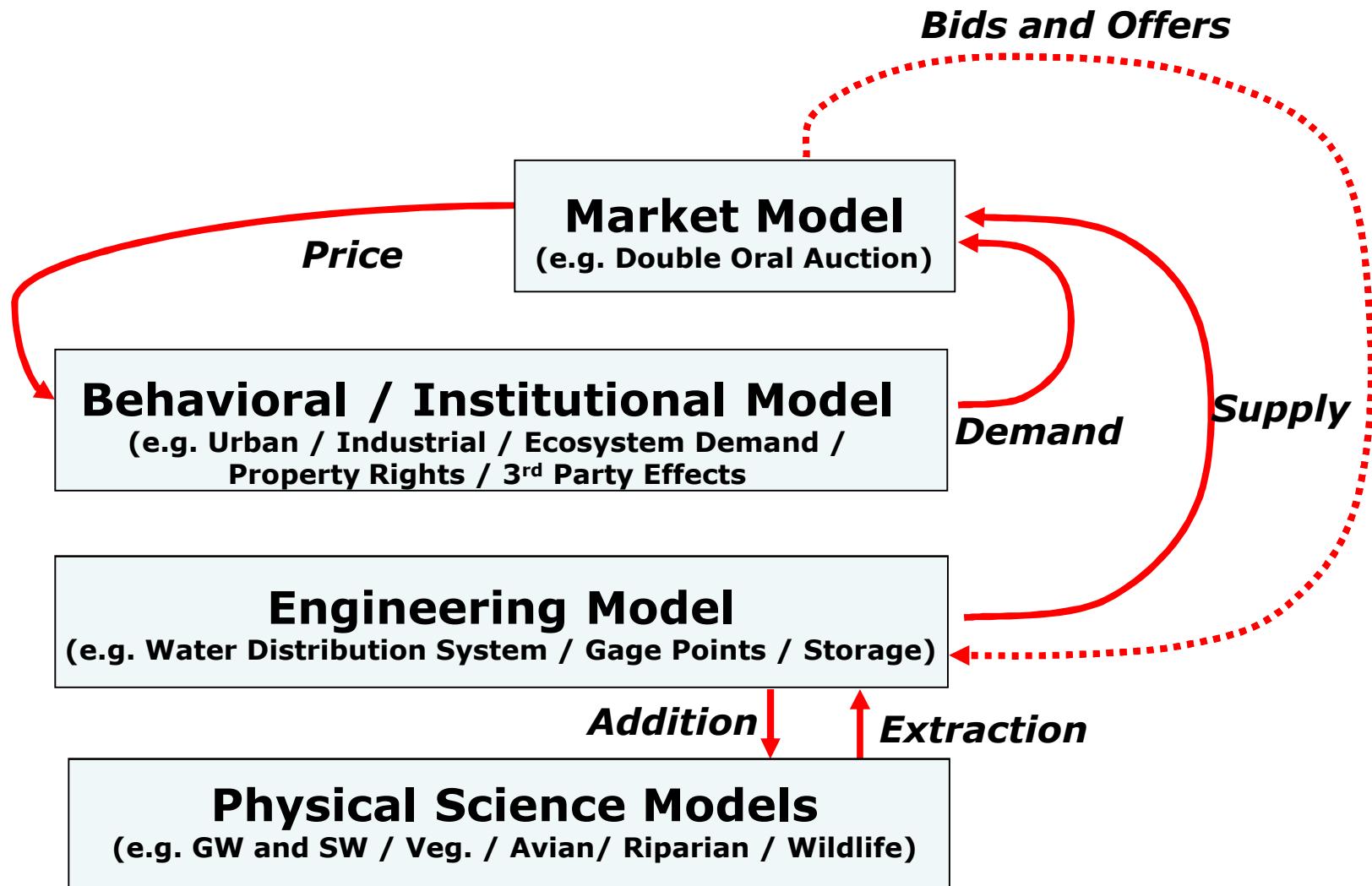
Acequias vs. Climate Change and Urban Growth



Acequias vs. Climate Change and Urban Growth

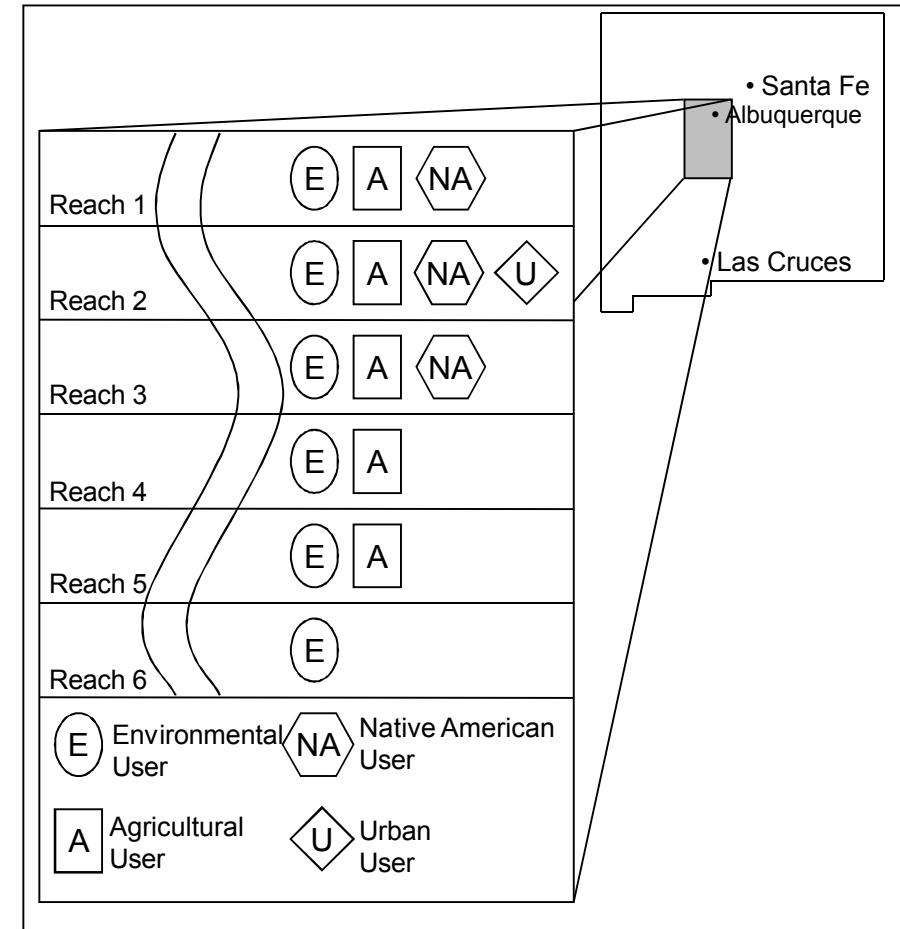


Water Leasing Market Experiments



Experimental Layout

- 4 types of users with distinct payoff and demand functions
 - Agricultural users
 - Environmental users
 - Urban User trustees
 - Native American users



Water Leasing Market Experiments

You are Cash Farmer 1 on Reach 1

What do you want to do?

Buy

Sell

1.00 AF units

For this Price: \$

Cost per AF: \$ / AF

YEAR	ROUND	TIME LEFT
1976	May of Year 1	03:05

CURRENT PAYOFF	
Water Balance (B)	4.35AF
Water Balance Value (V)	\$0.0
Trading Cash (C)	\$10.0
Year-end Earnings (C+V)	\$10.0

Min. AF to get yield 0.67

[Refresh me](#)

[Previous Round Earnings](#)

BIDS AND OFFERS (click on link to sell or buy)

Reach	Player	Click to Sell	Click to Buy
1	Cash Farmer 1		
1	Cash Farmer 3		0.7 AF @ \$4.00 (\$5.71/AF)
1	Cash Farmer 2		
2	Pecan Farmer 1		
2	Urban		
2	Cash Farmer 5		
2	Cash Farmer 4		
3	Pecan Farmer 2		
3	Cash Farmer 7		
3	Cash Farmer 6		
4	Pecan Farmer 3		
4	Cash Farmer 8		
5	Cash Farmer 9		0.79 AF @ \$8.00 (\$10.11/AF)
5	Cash Farmer 10		
0	Environmental		1.20 AF @ \$7.00 (\$6.50/AF)

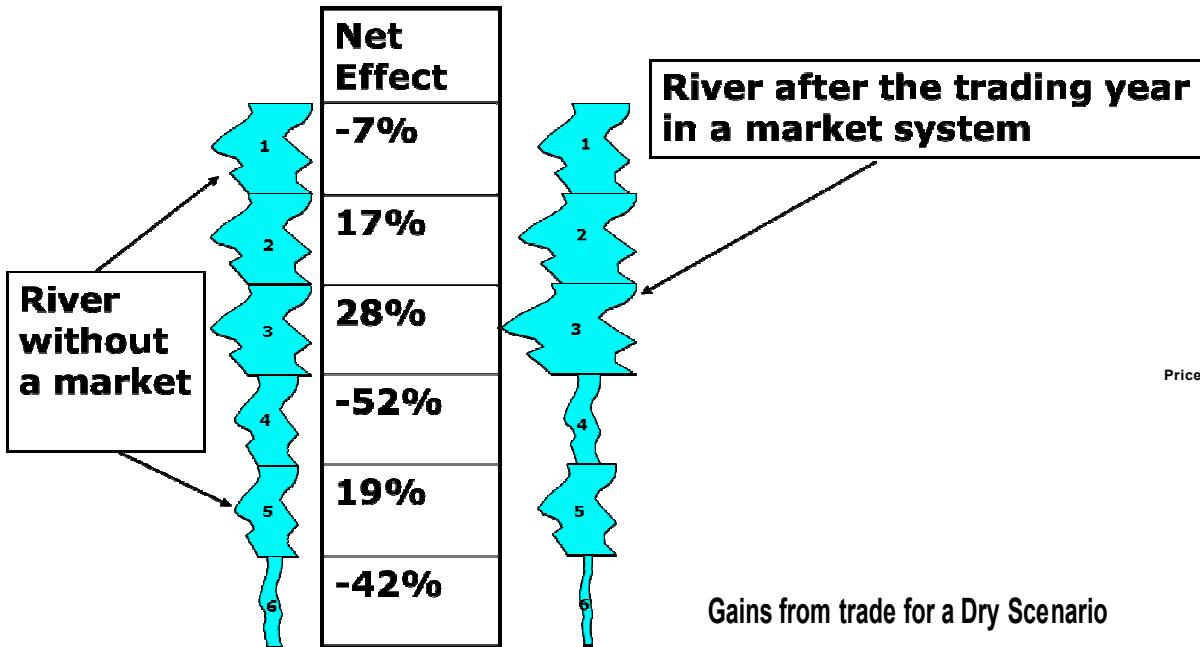
ALL TRANSACTIONS FOR EXPERIMENT

Player	Action	Player	Actual Units	Price	Price per AF
Cash Farmer 5	>>	Cash Farmer 1	1	\$8	\$8
Cash Farmer 6	<<	Env.	1	\$5	\$5
Cash Farmer 6	>>	Env.	1	\$4	\$4
Cash Farmer 6	<<	Cash Farmer 8	1	\$2	\$2
Cash Farmer 9	>>	Urban	1	\$8	\$8

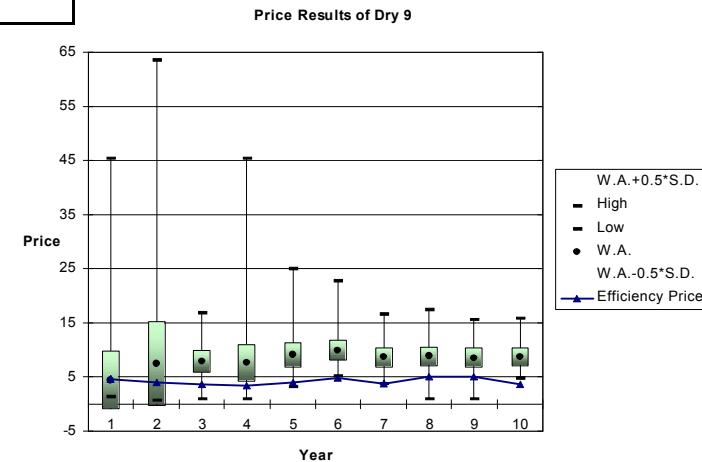
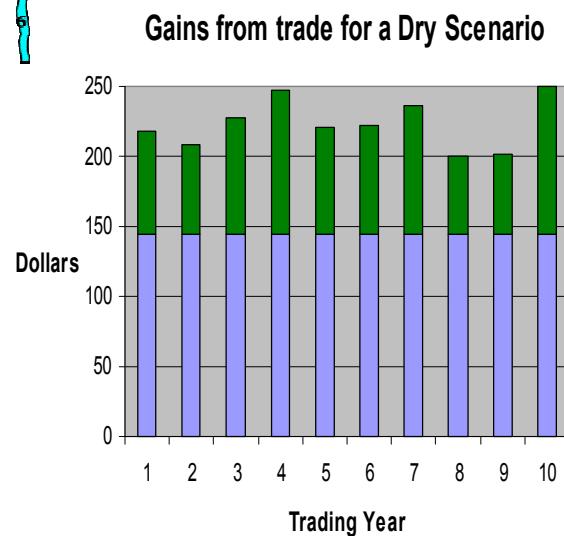
Water Leasing Stage Development

Stage	Focus of Research	General Experimental Results
1	Stylized Proof of Concept (2003-2005)	<ul style="list-style-type: none"> • Convergence to expected price
2	Enhanced Farming Decisions (2005-2006)	<ul style="list-style-type: none"> • Economic welfare gains from reallocating water
3	Futures and Climatic Uncertainty (2006-2008)	<ul style="list-style-type: none"> • Achieve endogenous market equilibrium from participant choices
4	Third Party Effects (2005-Current)	<ul style="list-style-type: none"> • Enhanced inter-temporal trading and risk management
5	Café Style – Real Time Market in the Upper Mimbres Basin (2006-Current)	<ul style="list-style-type: none"> • Demonstrate minimal 3rd party effects? • Understanding “Stacking” pre and post call incentives (change in current institutional rules)

Water Leasing Market Experiments



Impacts on
Distribution of
River Flows



Prices Trend to
Theory

Gains from market
Without a market

Financial Gains
Demonstrated

Application in the Mimbres Basin

- 9 Ditches
 - Fully adjudicated and appropriated
 - Rights structure is bottom up
- Predominately Agriculture
- One reservoir at the top of the basin
 - Bear Canyon Reservoir



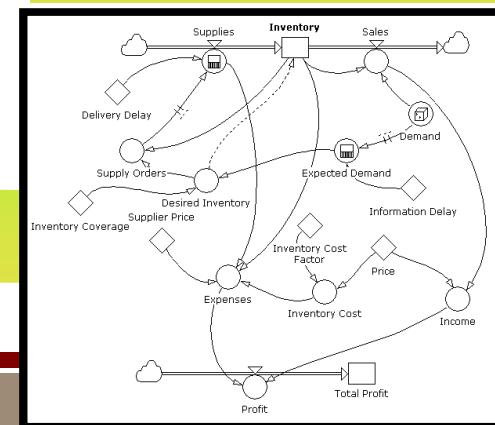
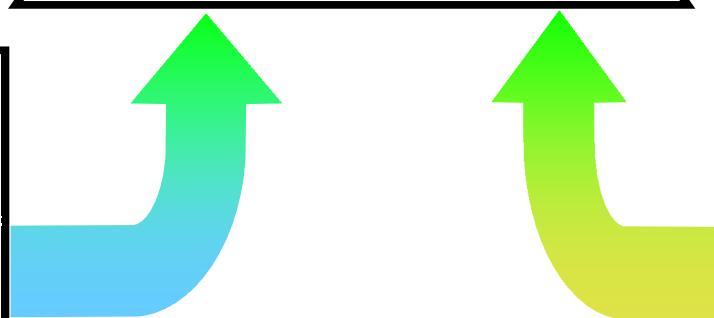
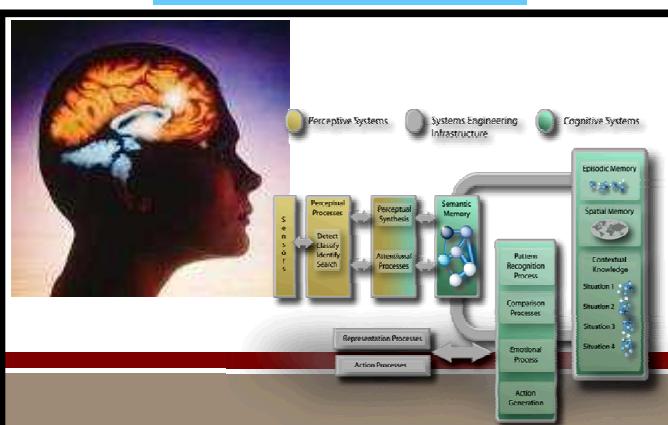
Decision Insight into Stakeholder Conflict



Approach: Develop an decision support system that integrates agent-based models of stakeholder decision-making with traditional system dynamics models of resource constraints and economics, with advanced processes and tools (e.g., automated learning, serious gaming) for expedited data capture.

Agent Based
Modeling

System Dynamics

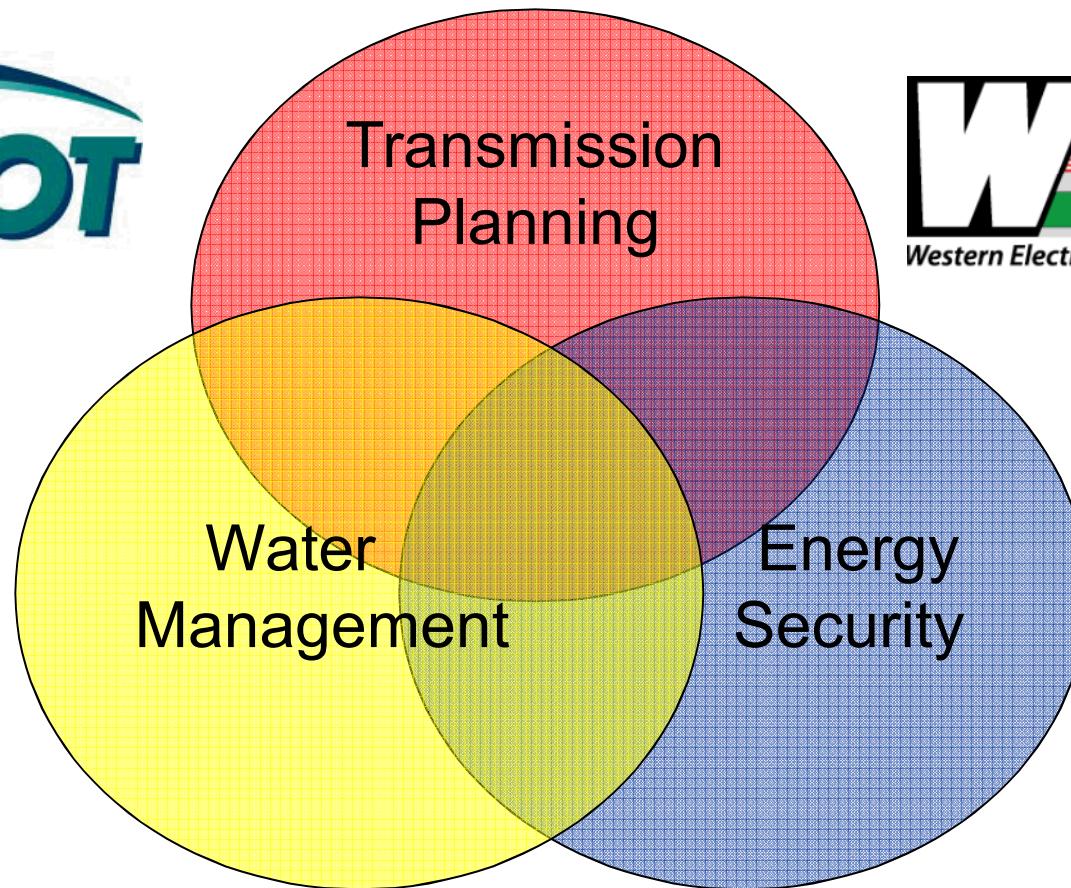


Serious Game Interface

- Water Wars Serious Game
 - SimCity style game
 - Built on Intel's Opensim gaming environment
 - SNL's integrated model serves as the "physics" to the game interface
 - Game is served over the web
- Game provides automated data capture on stakeholder behavior
- Game play controlled to expose desired action
- Game modes:
 - Multi player
 - Man against machine
 - Hybrid



Energy and Water in the Western and Texas Interconnections

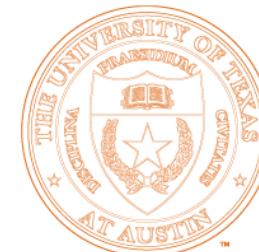


Project Objectives

- Reduce the water footprint of electric power production in western North America:
 - Develop tools for quantitative assessment of the energy-water nexus,
 - Engage stakeholders across the energy-water spectrum, and
 - Evaluate water implications of alternative interconnection-wide transmission expansion scenarios.

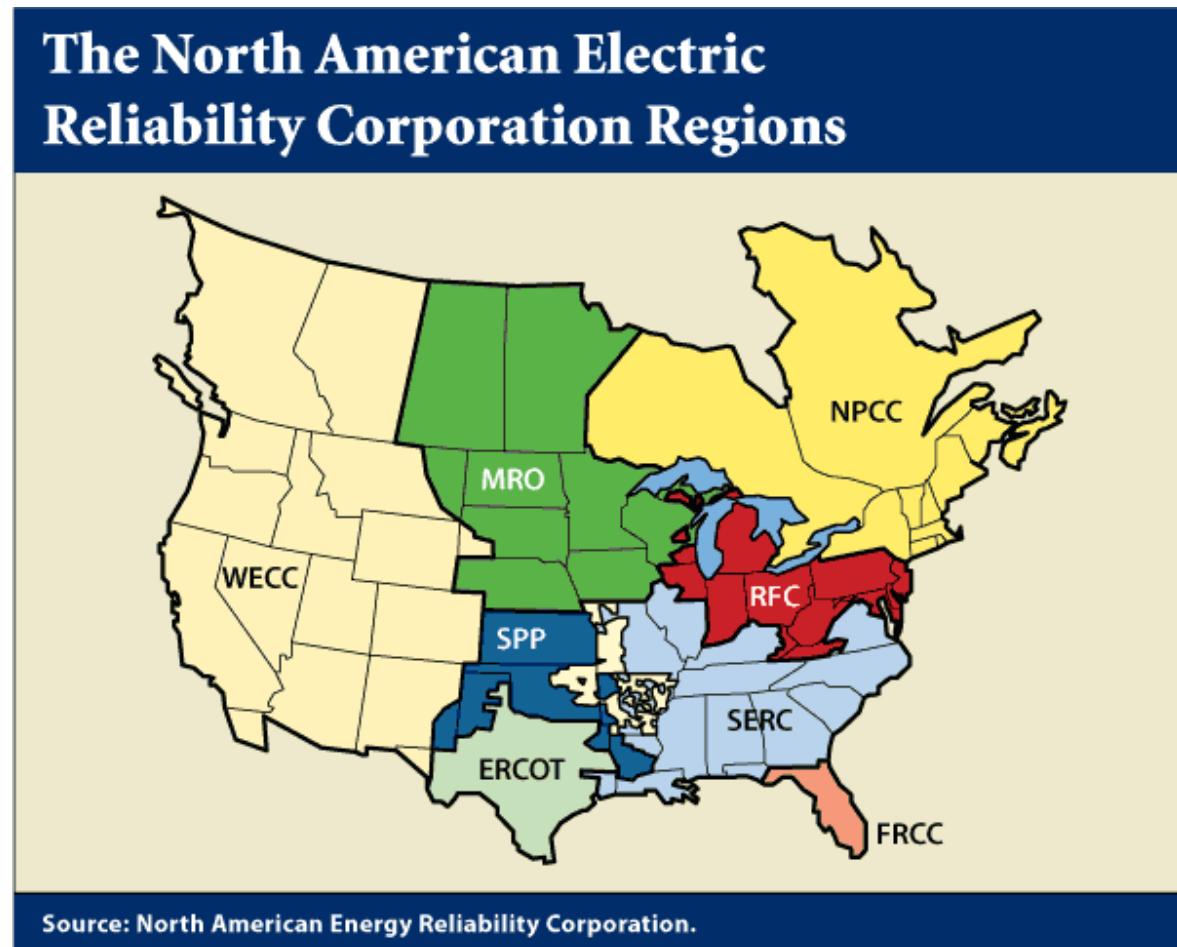
Project Partners

- Sandia National Laboratories
 - Vincent Tidwell
 - Barbie Moreland
 - Howard Passell
- Argonne National Laboratory
 - John Gasper
 - John Veil
 - Chris Harto
- Electric Power Research Institute
 - Robert Goldstein
- National Renewable Energy Laboratory
 - Jordan Macknick
 - Robin Newmark
 - Daniel Inman
 - Kathleen Hallett
- Idaho National Laboratory
 - Gerald Sehlke
 - Randy Lee
- Pacific Northwest National Laboratory
 - Mark Wigmosta
 - Richard Skaggs
 - Ruby Leung
- University of Texas
 - Michael Webber
 - Carey King



Transmission Planning

- WECC and ERCOT are conduction long-range transmission planning (20 yrs.)
 - Siting of new power plants
 - New transmission capacity

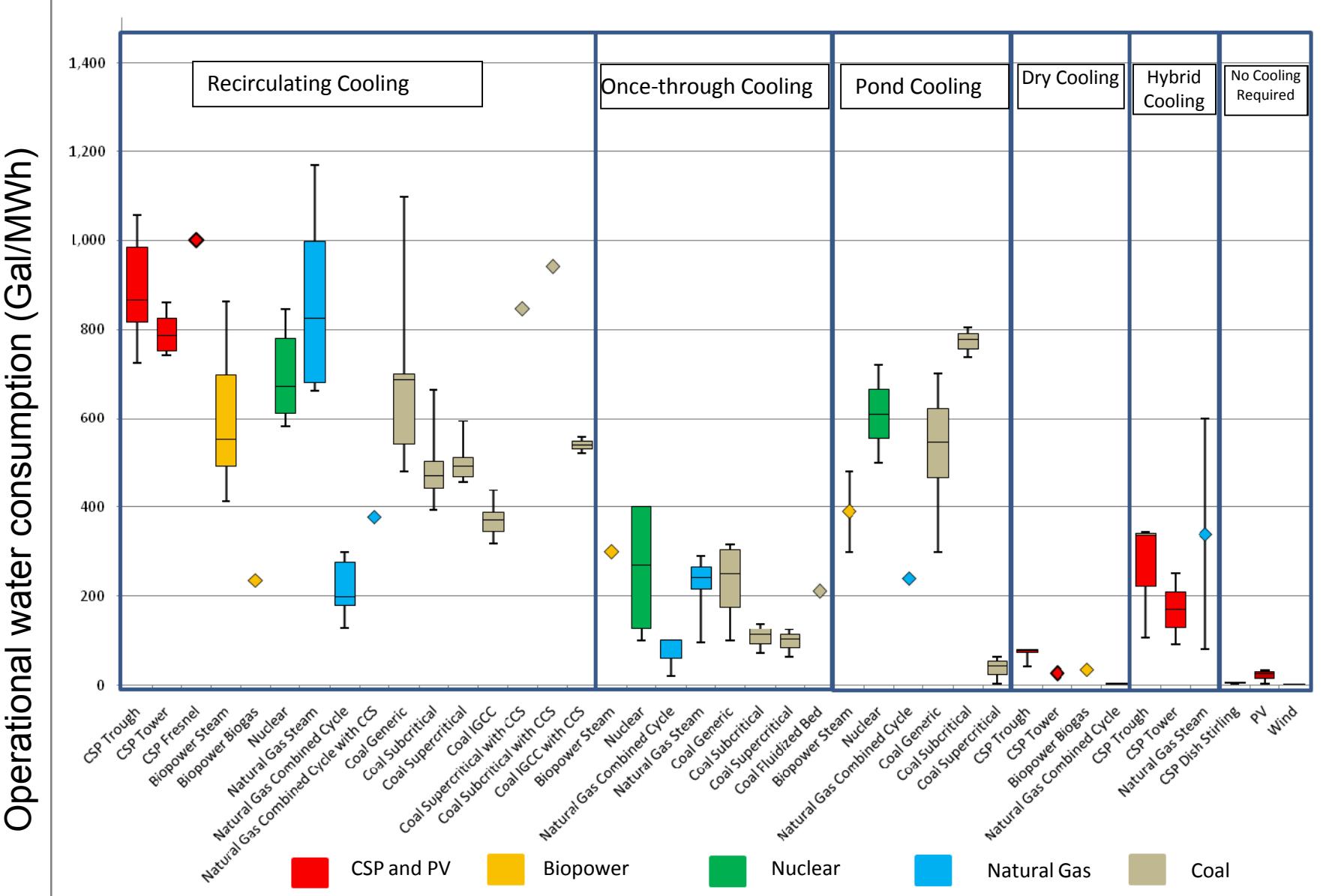


Power Plant Siting Decisions

- West-wide objectives
 - Minimize cost
 - Maximize reliability
 - Maximize transmission capacity utilization
 - Limit exposure to policy change
 - ***Minimize stress over water***
- Power plant siting criteria
 - Fuel type
 - Cooling type
 - Capacity
 - Location
 - Water source

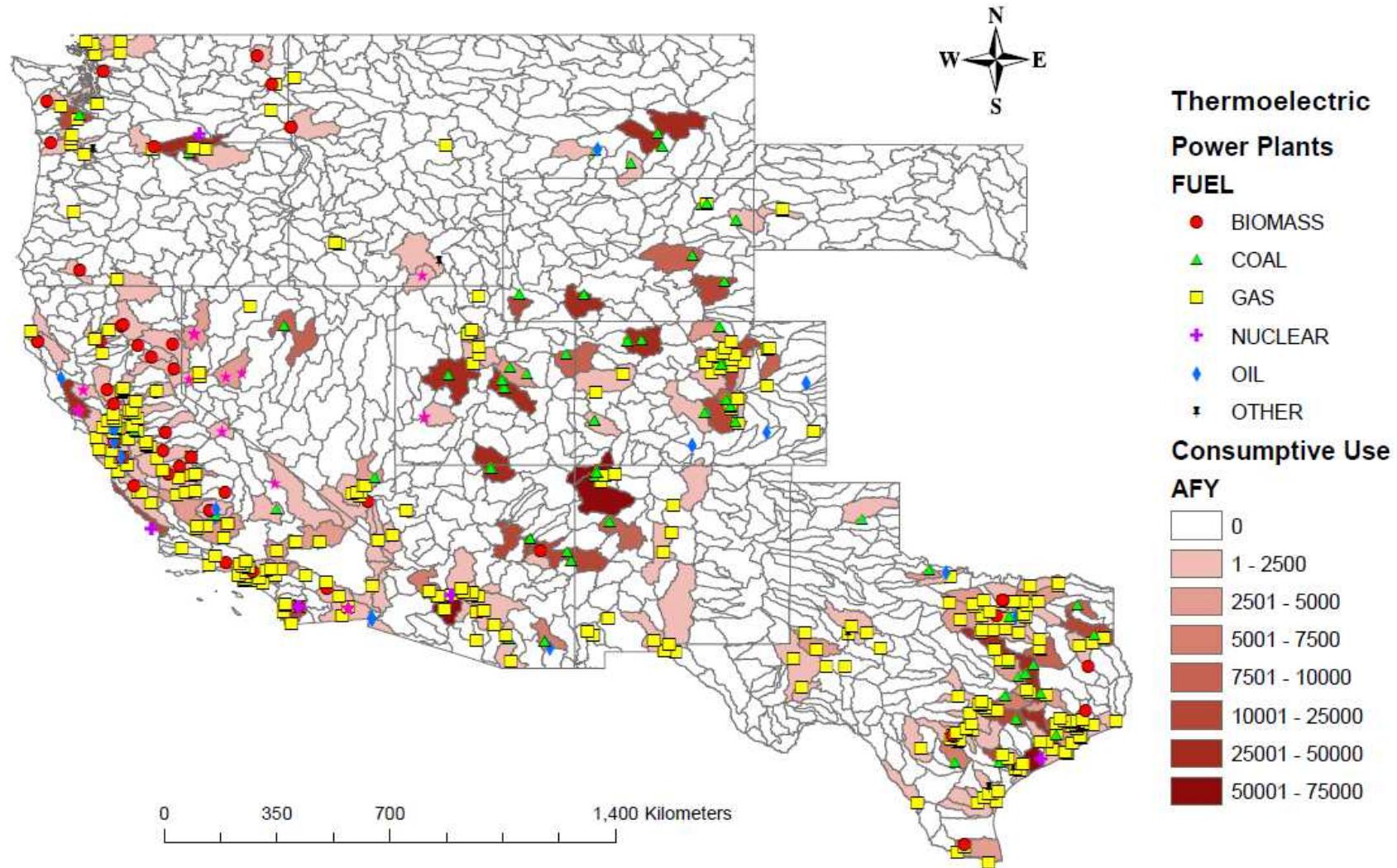


Operational water consumption factors for electricity generating technologies



Source: Macknick *et al.* 2011

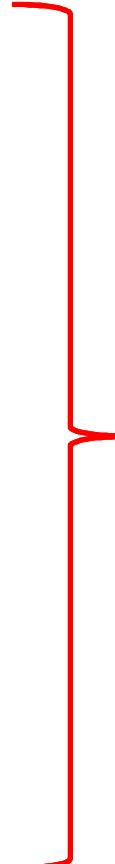
Thermoelectric Consumptive Use and Power Plants (Current)



Key Water Sources

- **Potable Water**

- Unappropriated surface water
- Unappropriated groundwater
- Appropriated water (rights transfers)

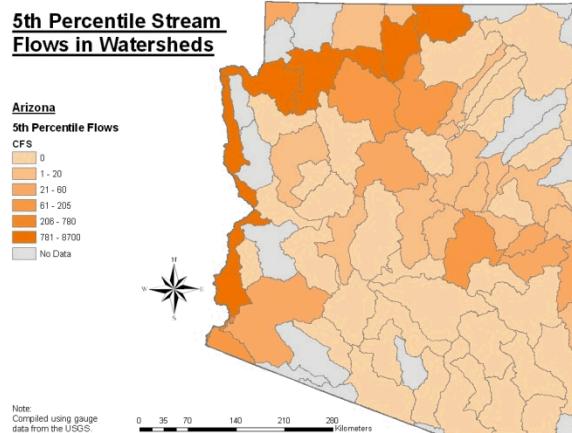


Relative
Availability
and Cost

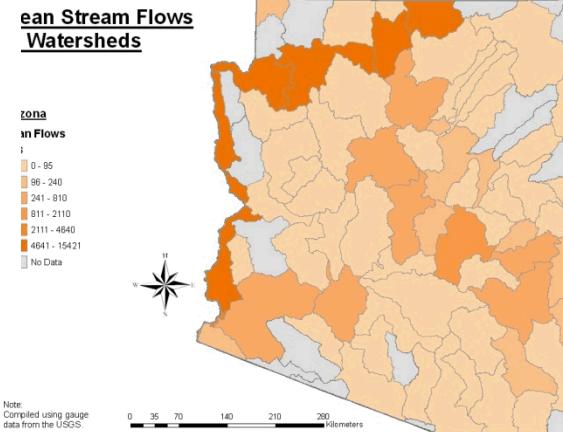
- **Non-Potable Water**

- Municipal/Industrial wastewater
- Shallow brackish water

Water Availability Indicators: Supply



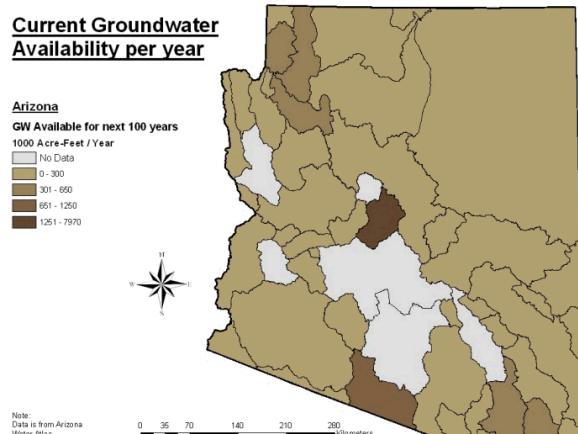
Mean Gauged Streamflow



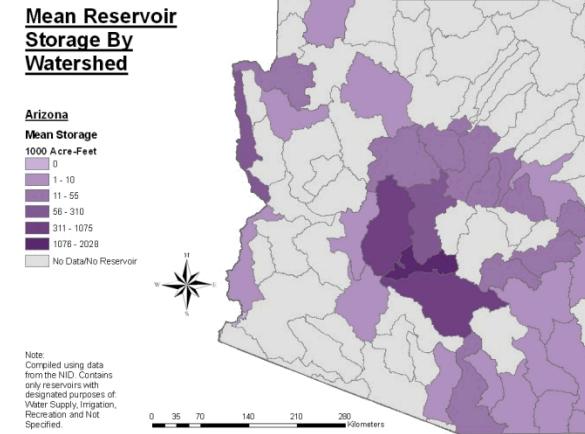
Annual Low Flow



Interbasin Transfers



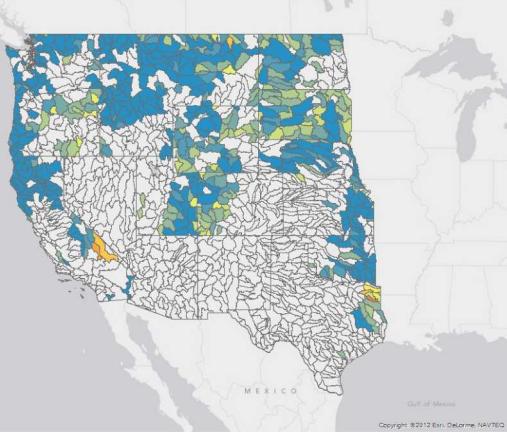
Groundwater Depletion



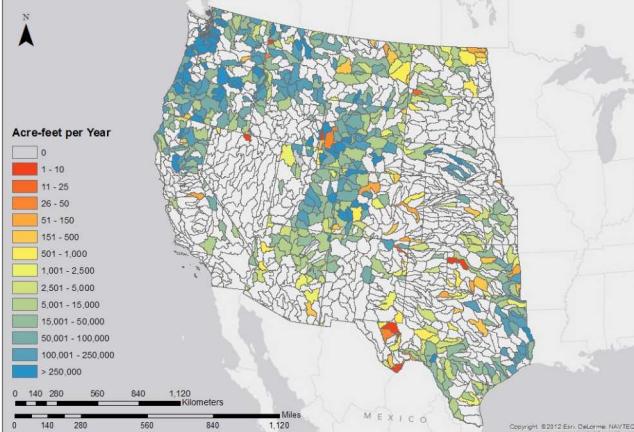
Reservoir Storage

Water Availability

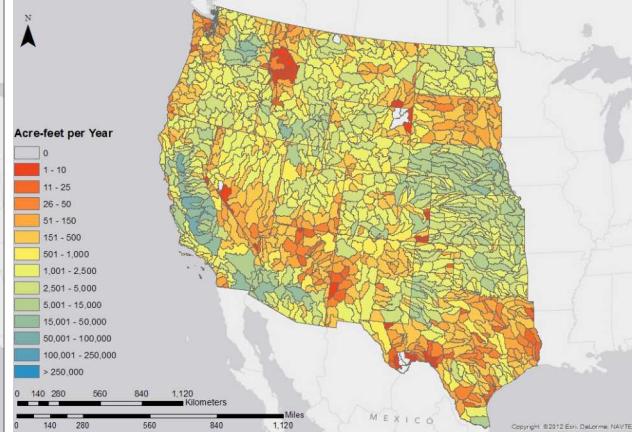
UNAPPROPRIATED SURFACE WATER



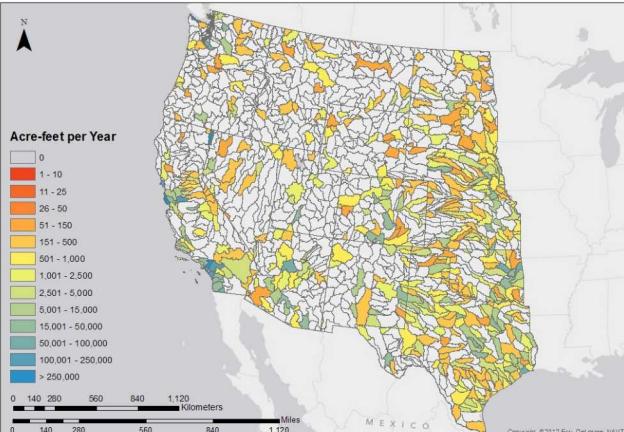
Potable Groundwater Availability



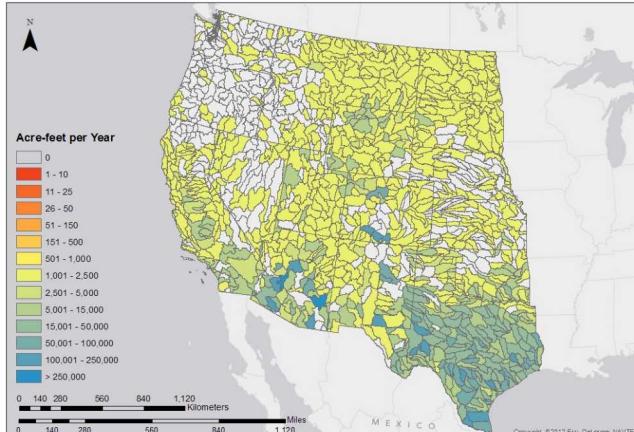
Appropriated Water Availability



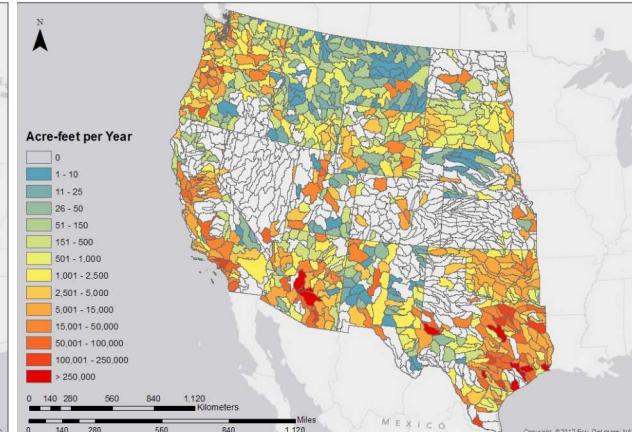
Wastewater Availability



Brackish Groundwater Availability

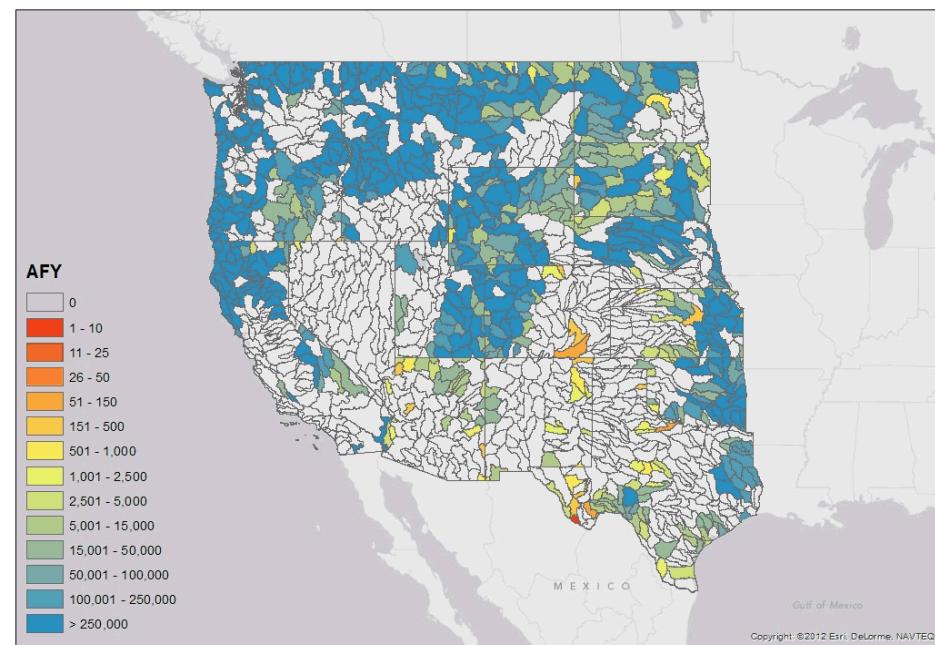


Change in Demand through 2030

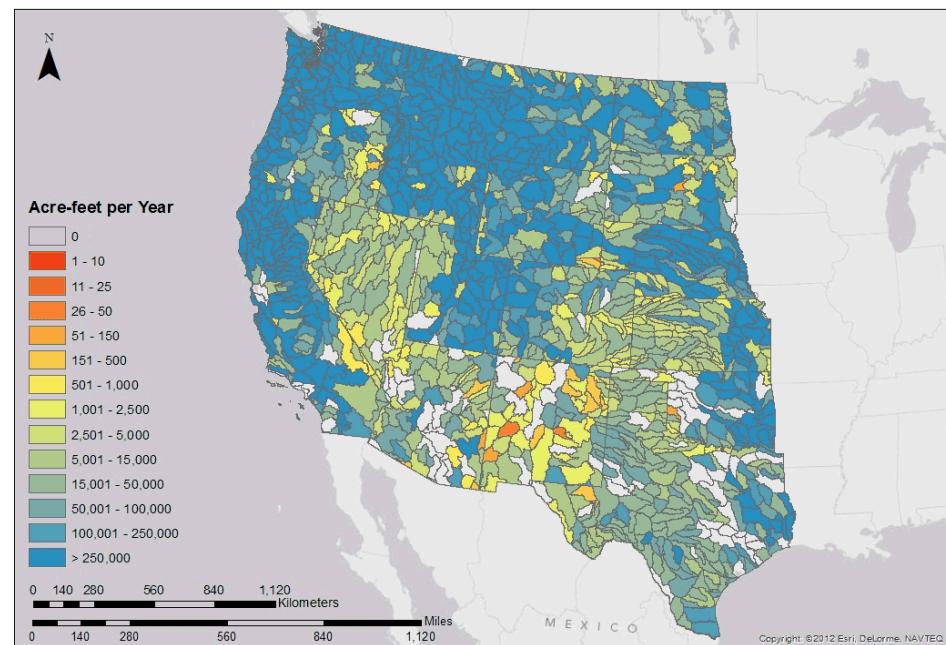


Water for Development

UNAPPROPRIATED WATER SOURCES - DEMAND, 2030

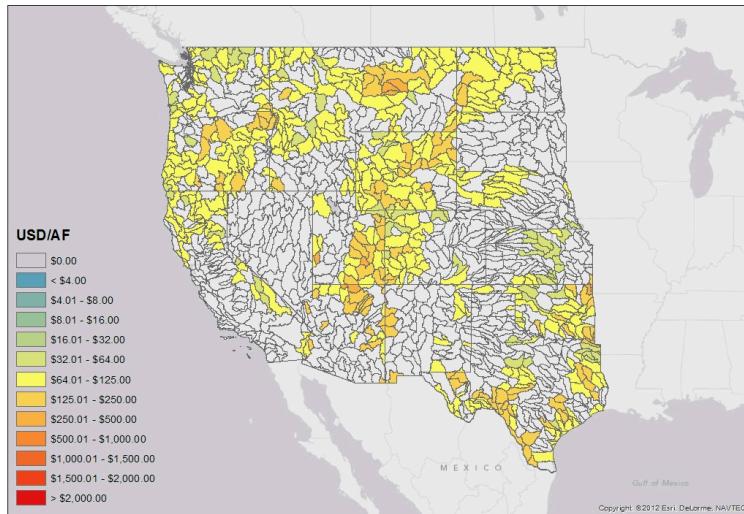


All Water Sources - Demand, 2030

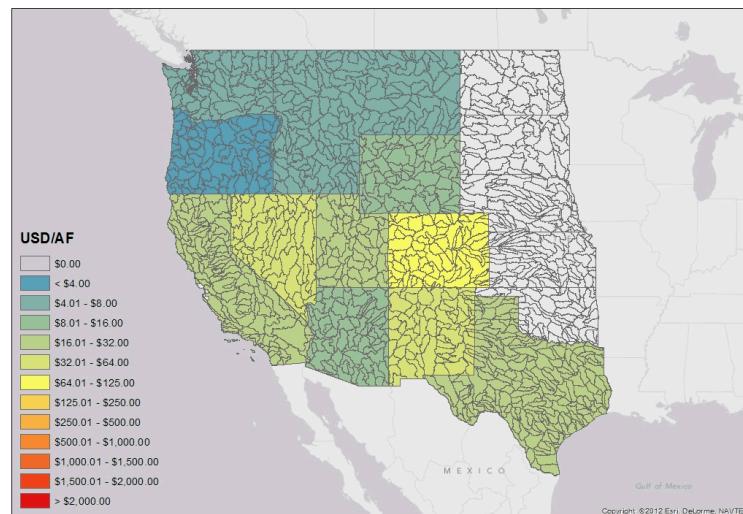


Relative Cost of Water

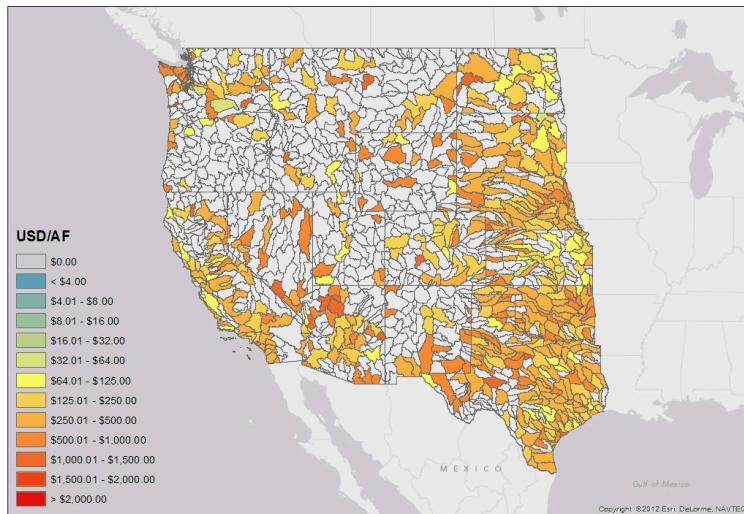
Portable Groundwater Cost



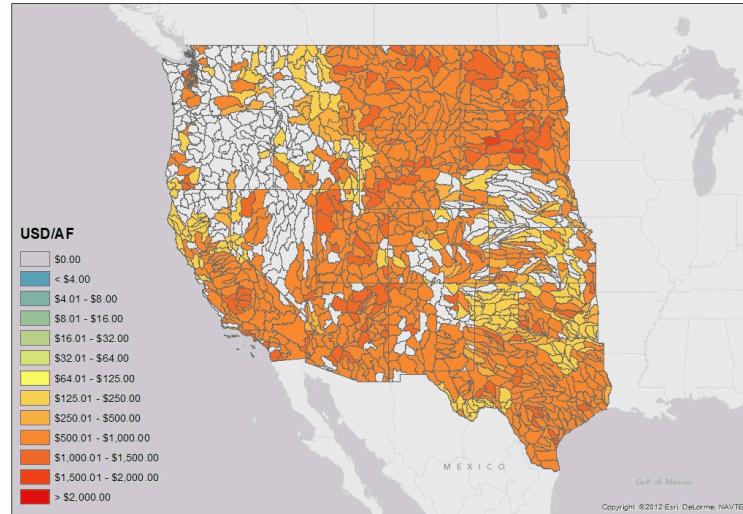
Appropriated Water Cost



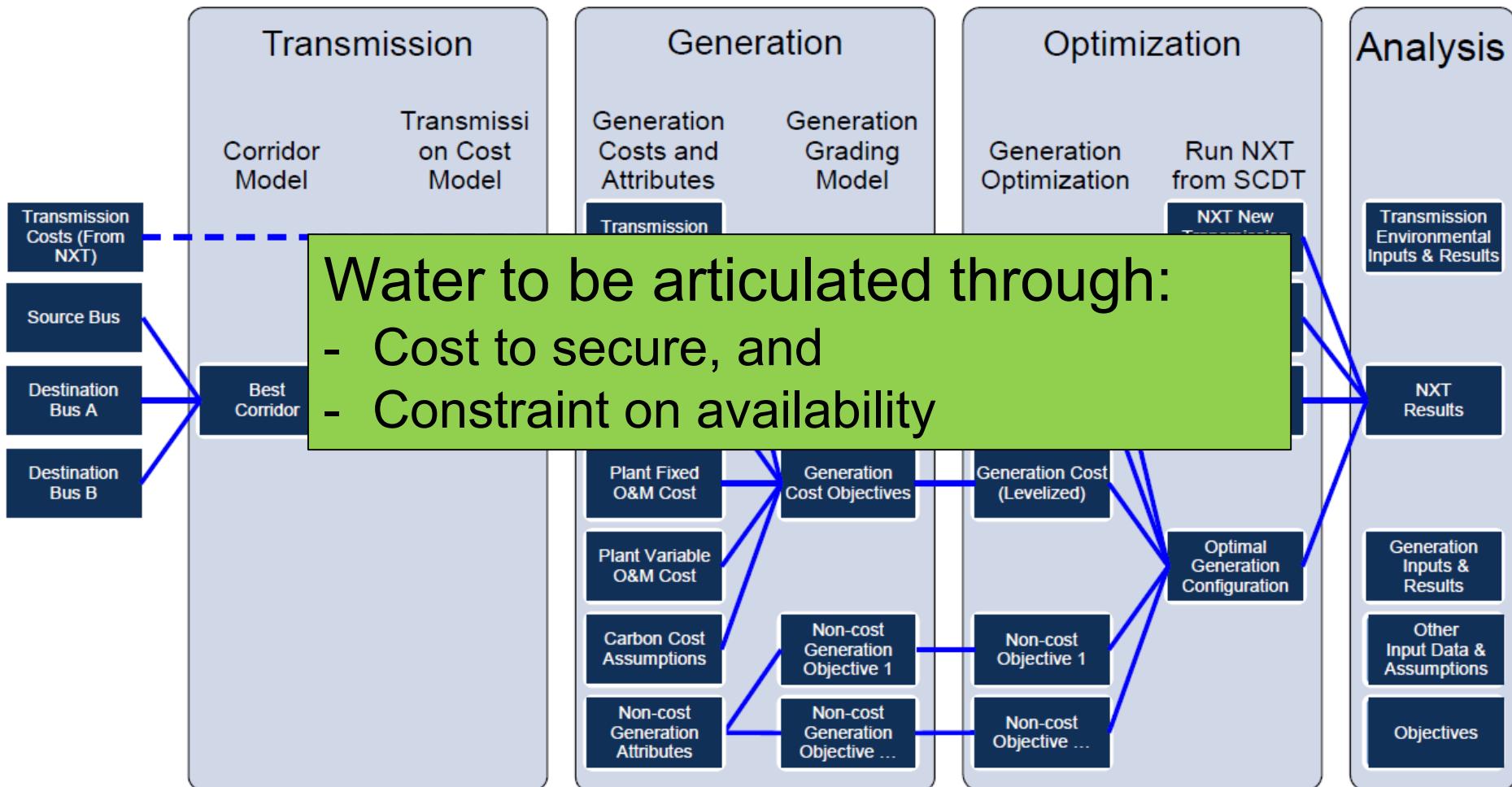
Wastewater Cost



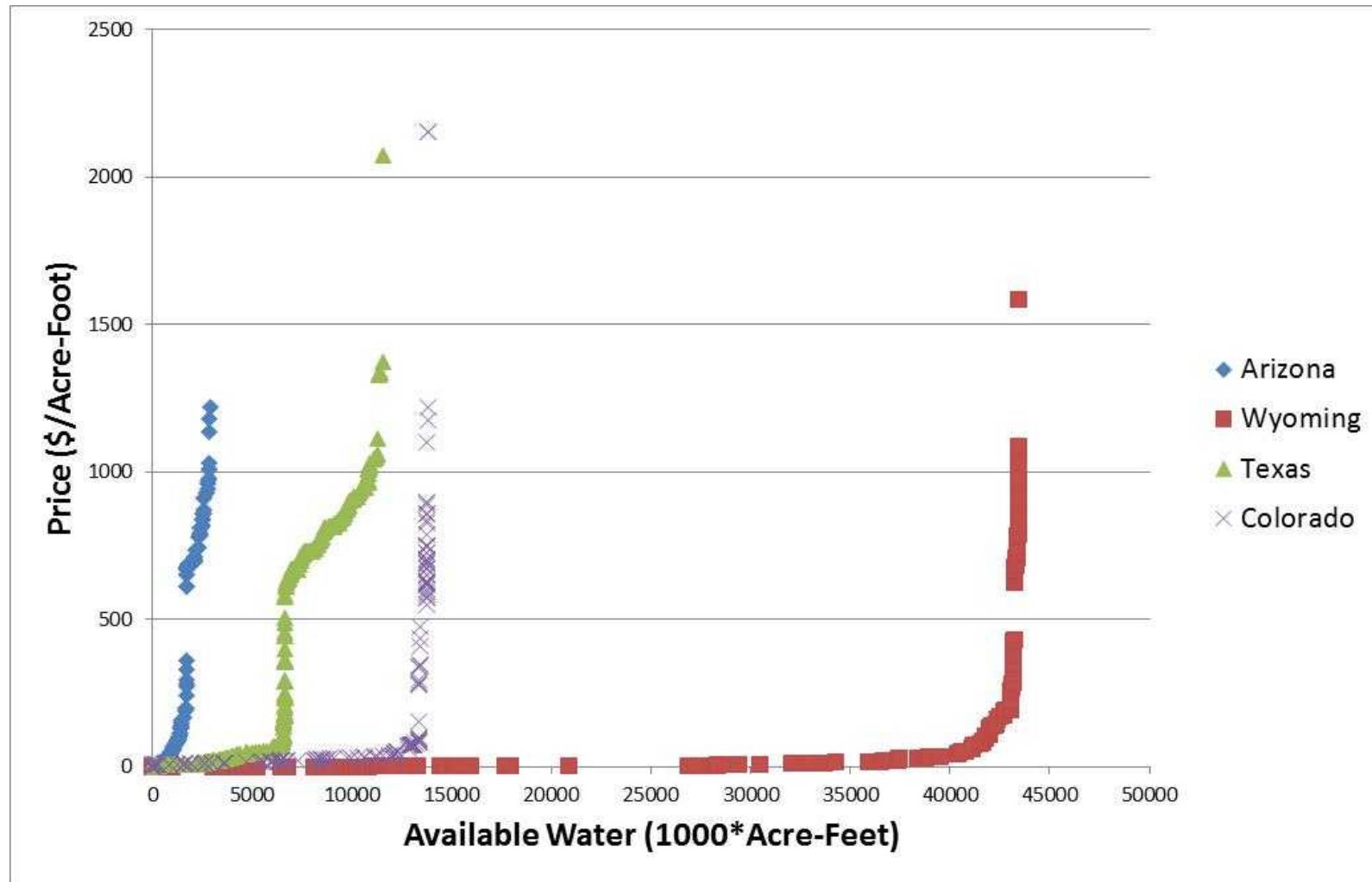
Brackish Groundwater Cost



Long Term Planning Tool (LTPT)

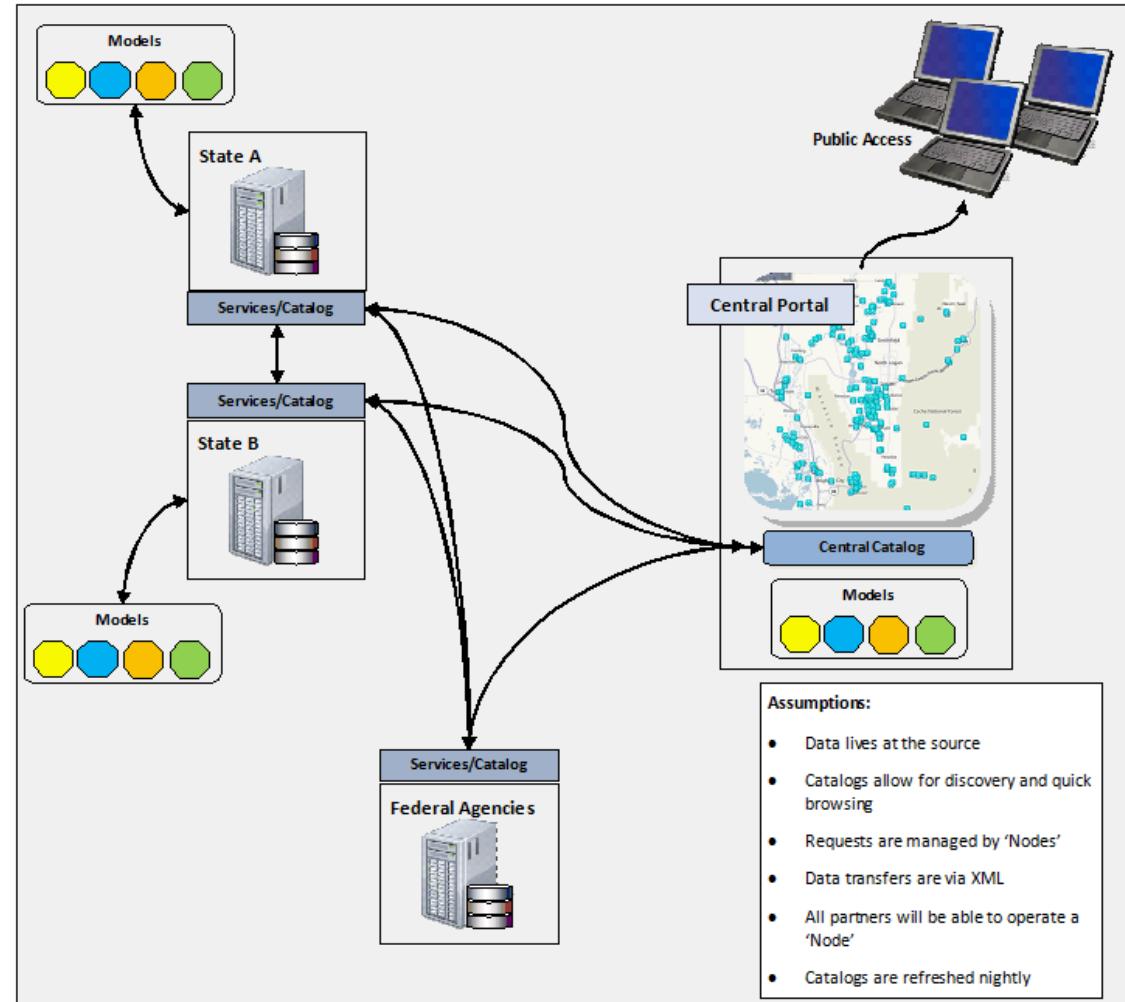


Water Supply Curves



Water Database Exchange (WaDE)

- Use Web Services to transfer data
- Data Stay at the Source (i.e. the states)
- Provide transparent link between state data and integrated water metrics
 - Link to metadata
 - Changes in state data are automatically reflected in metrics



Collaborative Modeling

- Learning to speak the same language:
 - Integrated/interdisciplinary modeling,
 - Environment of collaboration,
 - Visual/interactive platform for analysis, and
 - Motivation.

Collaborative Modeling Community

- Conducted three conferences
- Produced published proceedings and book
- Tools of the trade:
 - Best practices,
 - Metrics of success,
 - Practitioners list/project survey.



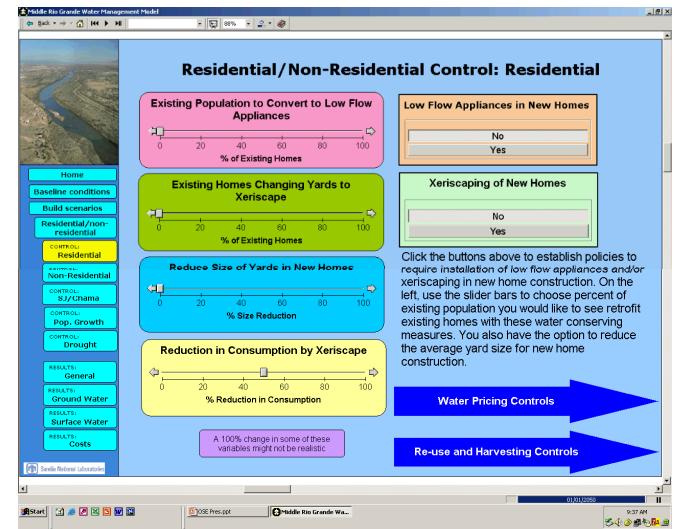
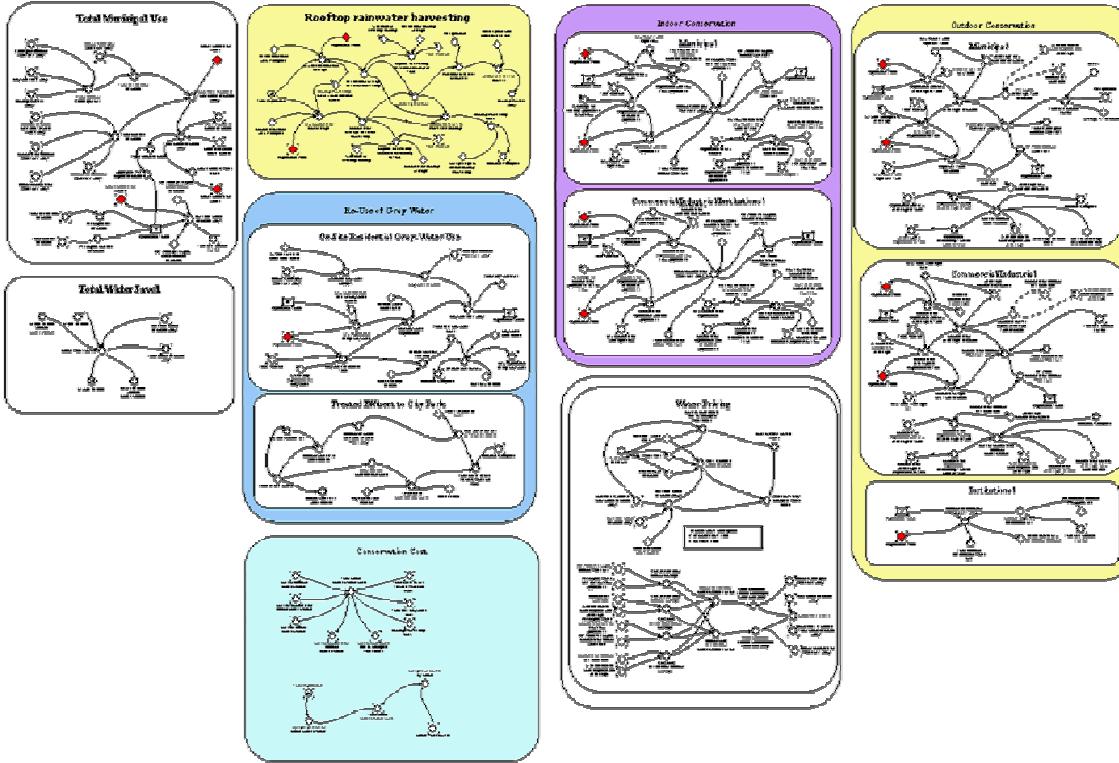
**COMPUTER AIDED
DISPUTE RESOLUTION
(CADRe) WORKSHOP**

 Sandia National Laboratories  IWR INSTITUTE FOR WATER RESOURCES

U.S. Institute for Environmental Conflict Resolution
Morris K. Udall Foundation

Albuquerque, New Mexico
September 13-14, 2007





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