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Sandia National Laboratories

Exploring Energy-Water Issues in the United States

Vince Tidwell and Barbie Moreland
Sandia National Laboratories

Crosscutting Research and Rare Earth Elements Review
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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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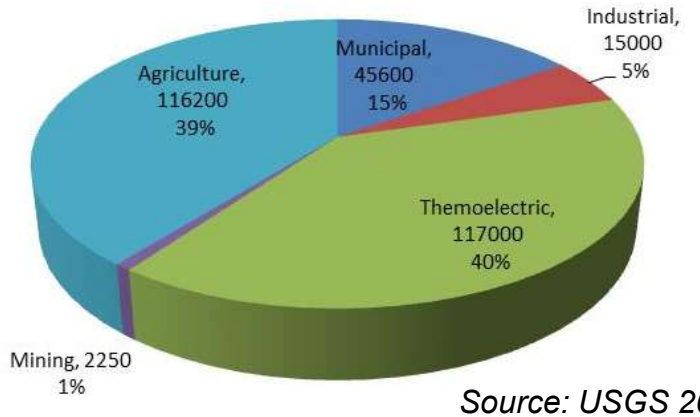
Challenge

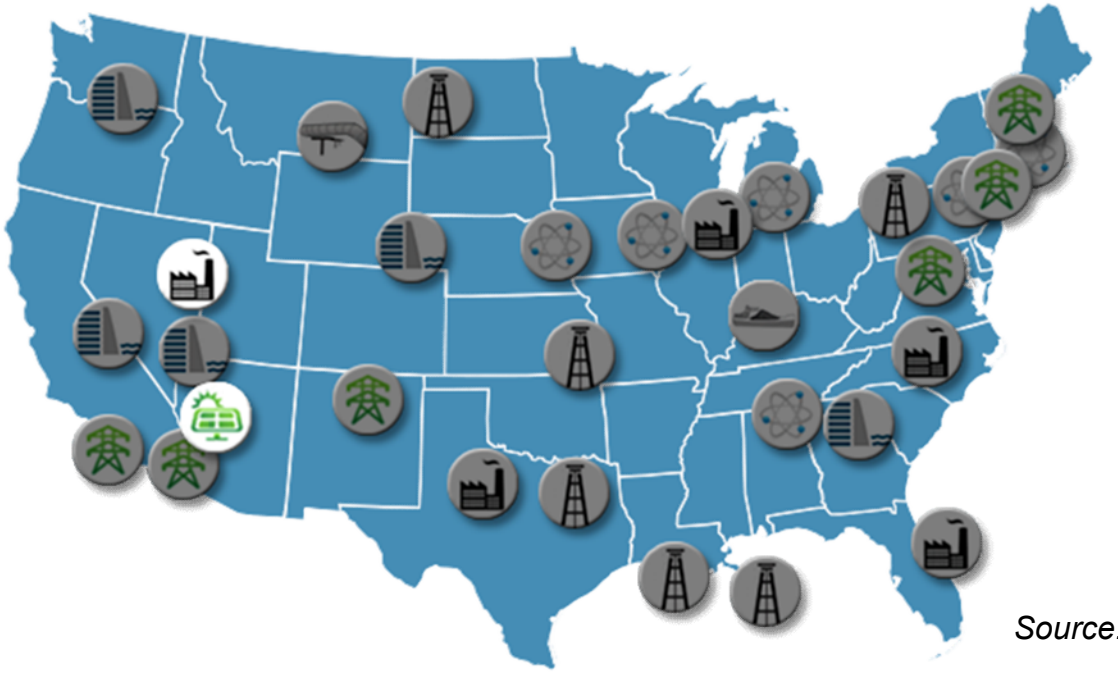
Thermoelectric energy production withdraws more water in the U.S. than any other use sector.



Source: USGS 2014

Energy-Water Nexus Issues are playing out all across the U.S.

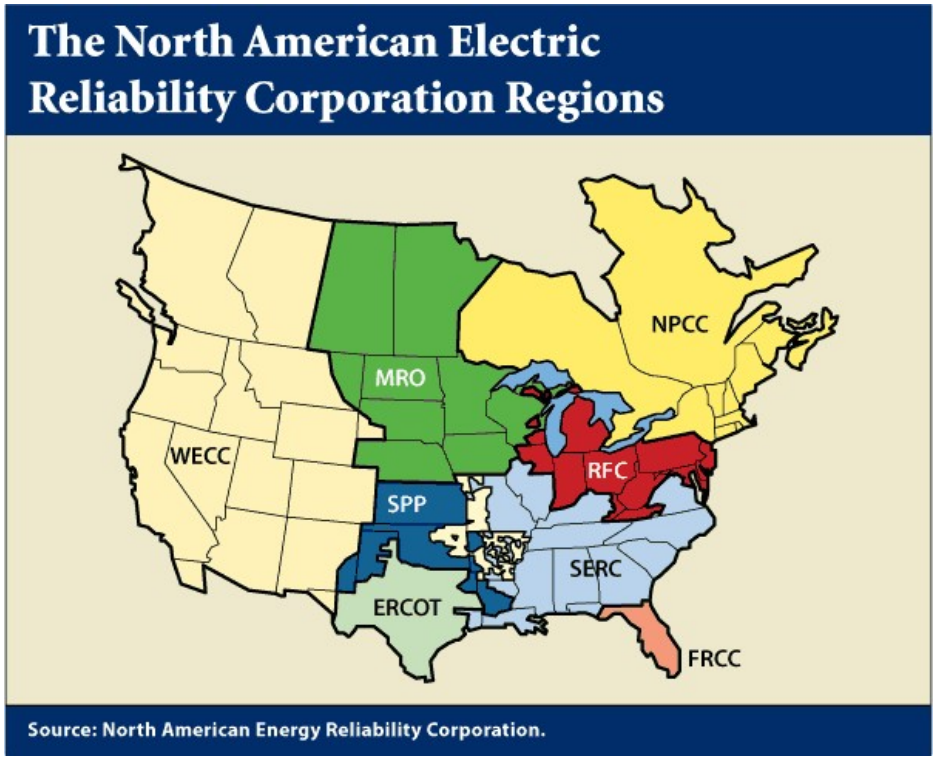
- Power plant outages
- Constrained hydropower
- Infrastructure damage by extreme events
- Curtailed energy resource extraction
- Permitting of New Facilities



Source: DOE 2013

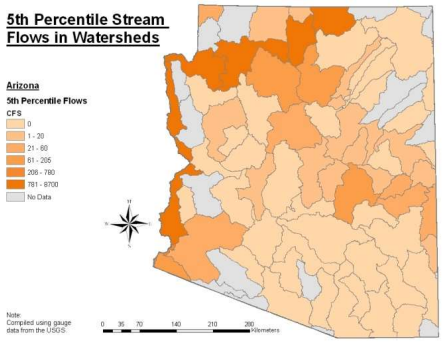
Need

- Interconnections are conducting long-range transmission planning (20 yrs.)
  - Siting of new power plants
  - New transmission capacity
- Where will the next drop of water come from?
- Develop a National Water Atlas at the watershed level (8-digit HUC, or roughly 2250 watersheds) to estimate:
  - Water availability,
  - Water cost, and
  - Competing demands.

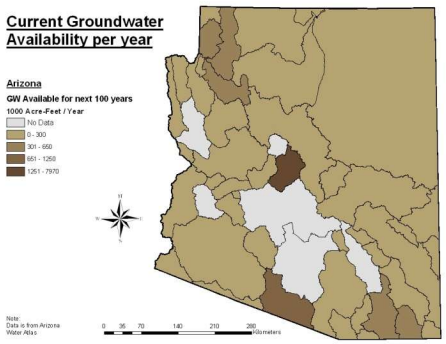


Methods: Collected Data from States

Water Supply

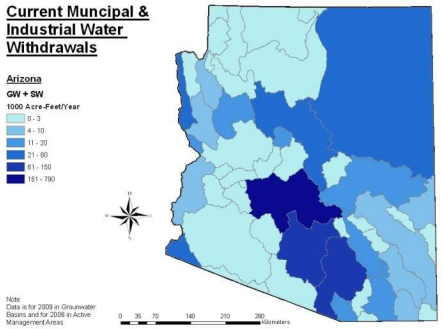


Mean Gauged Streamflow

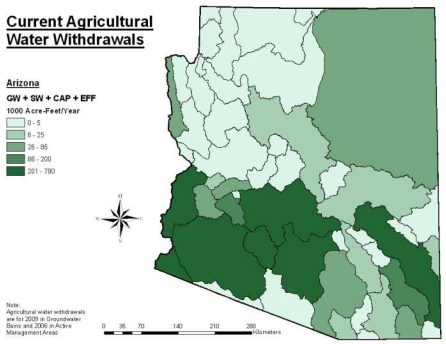


Groundwater Depletion

Water Demand

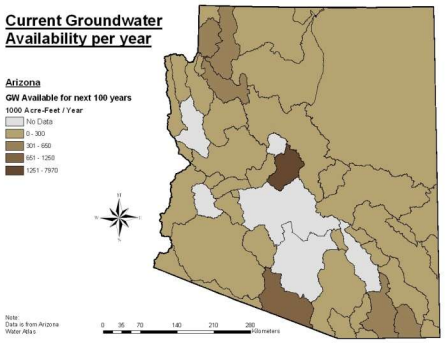


Municipal Demand

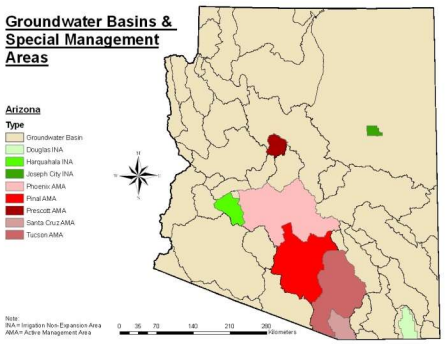


Irrigation Demand

Water Institutions



Unappropriated Water



Administrative Control Areas

Methods: Metric Development

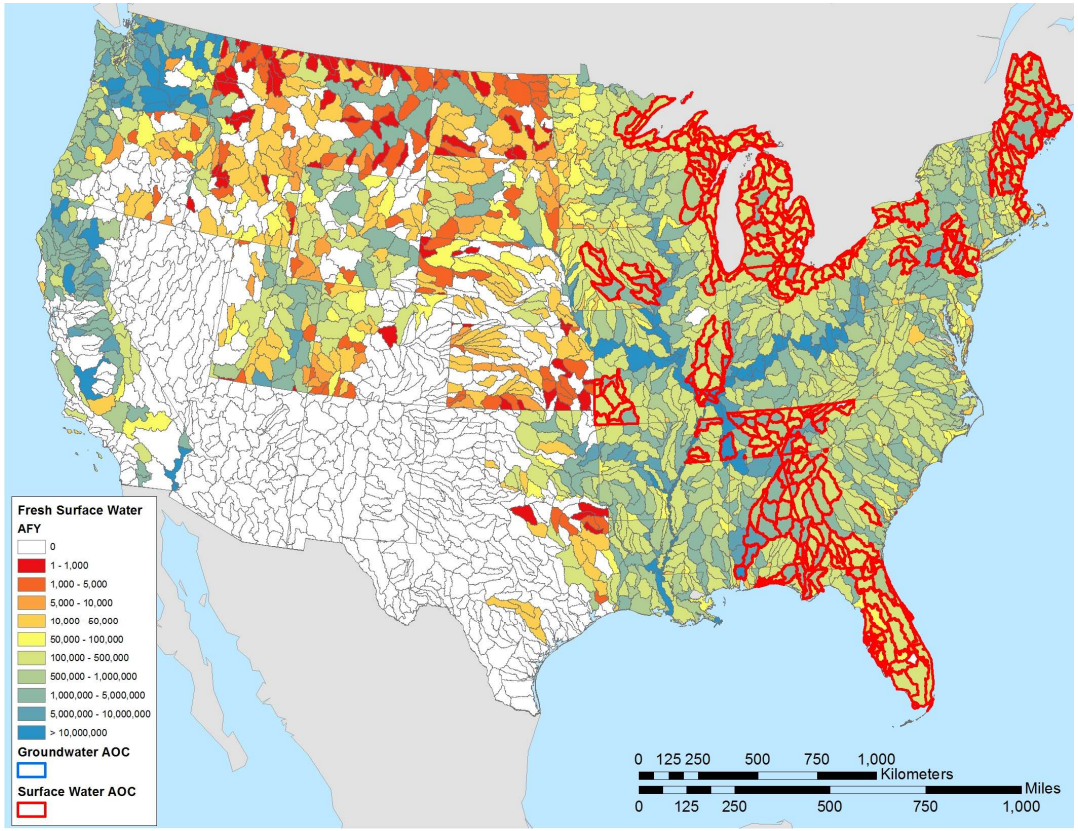
- **Data on "available water" are rare**
- **As such, metrics were estimated from available information**
- **Assisted by volunteer team from WSWC**
  - **Bret Bruce (USGS)**
  - **Dan Hardin (TX)**
  - **Sara Larsen (WSWC)**
  - **Dave Mitamura (TX)**
  - **Andy Moore (CO)**
  - **Ken Stahr (OR)**
  - **Todd Stonely (UT)**
  - **Steve Wolff (WY)**
  - **Dwane Young (WSWC)**

Water Availability: Fresh Surface Water

- **Surface water beyond current use that is available for new development.**
- **Based on environmental constraint:**

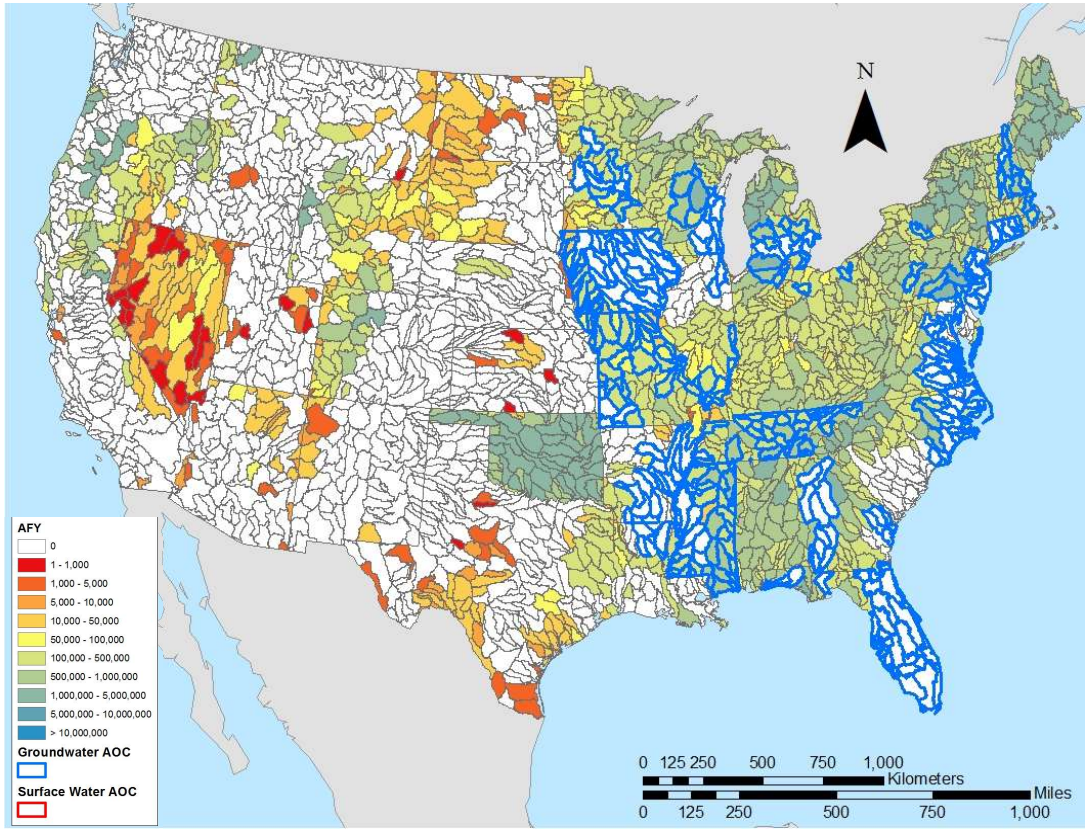
$$Q_{sw}^{j} = 0.5 * \left(Q_{p}^{j} + C^{j}\right) - C^{j}$$

- **Areas of Concern (basins outlined in red) designated regions requiring additional permitting.**



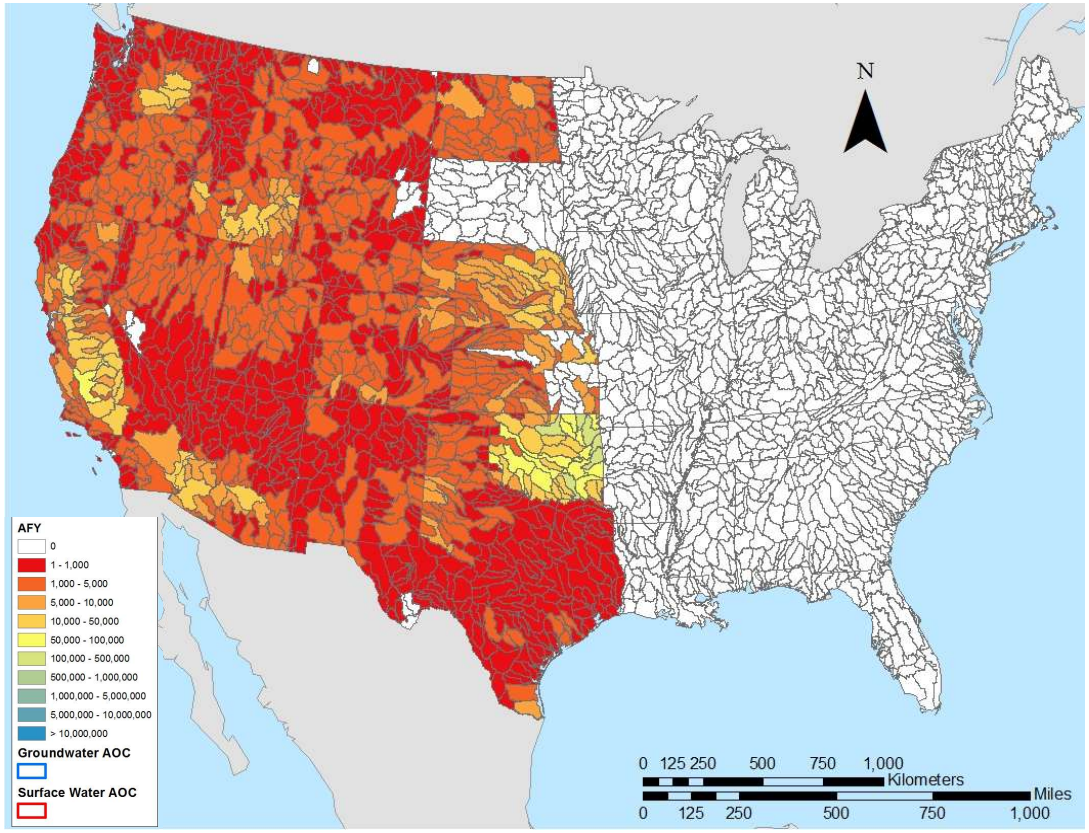
Water Availability: Fresh Groundwater

- **Groundwater beyond current use that is available for new development.**
- **Difference between sustainable recharge and pumping while considering:**
  - **Areas of overdraft, and**
  - **Principle aquifers.**
- **Areas of Concern (basins outlined in blue) designated regions requiring additional permitting.**



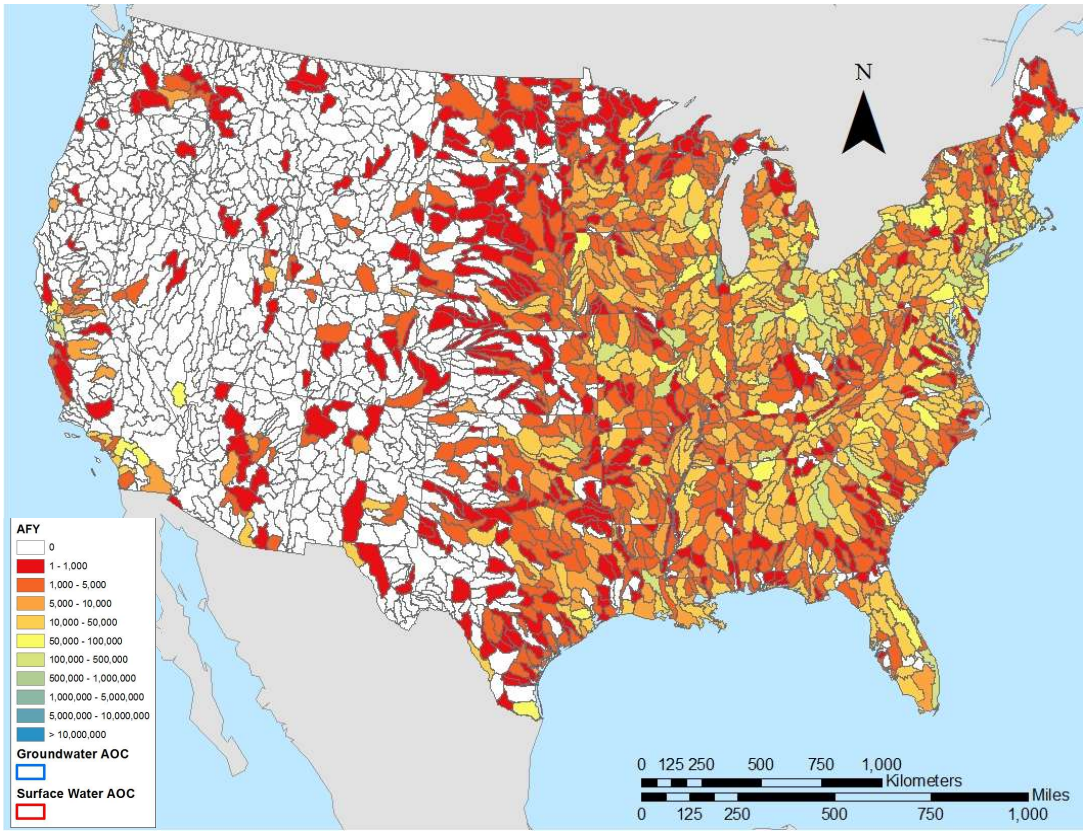
Water Availability: Appropriated Water

- **Water potentially available for transfer from one use to another (generally agriculture to municipal or industrial use)**
- **Limited to 5% of irrigation demand in any watershed based on feedback from state water managers.**



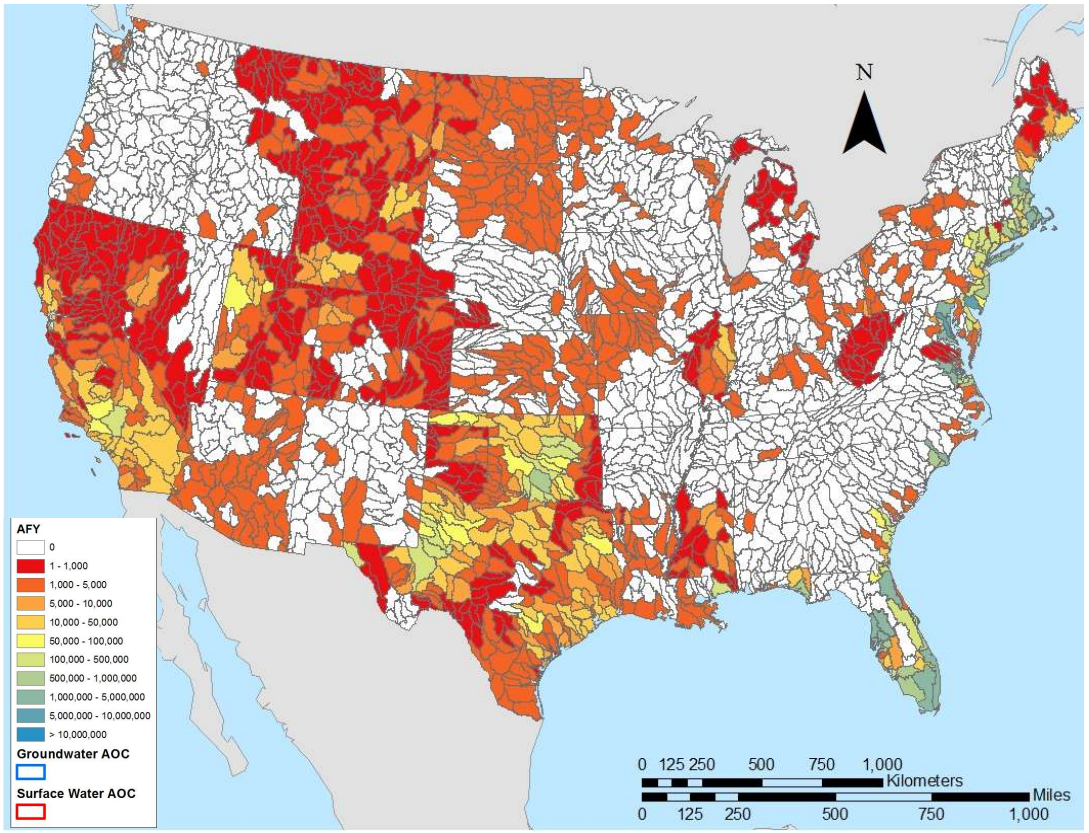
Water Availability: Wastewater

- **Projected future wastewater (2030) available for re-use.**
- **Reflects wastewater currently being reused.**



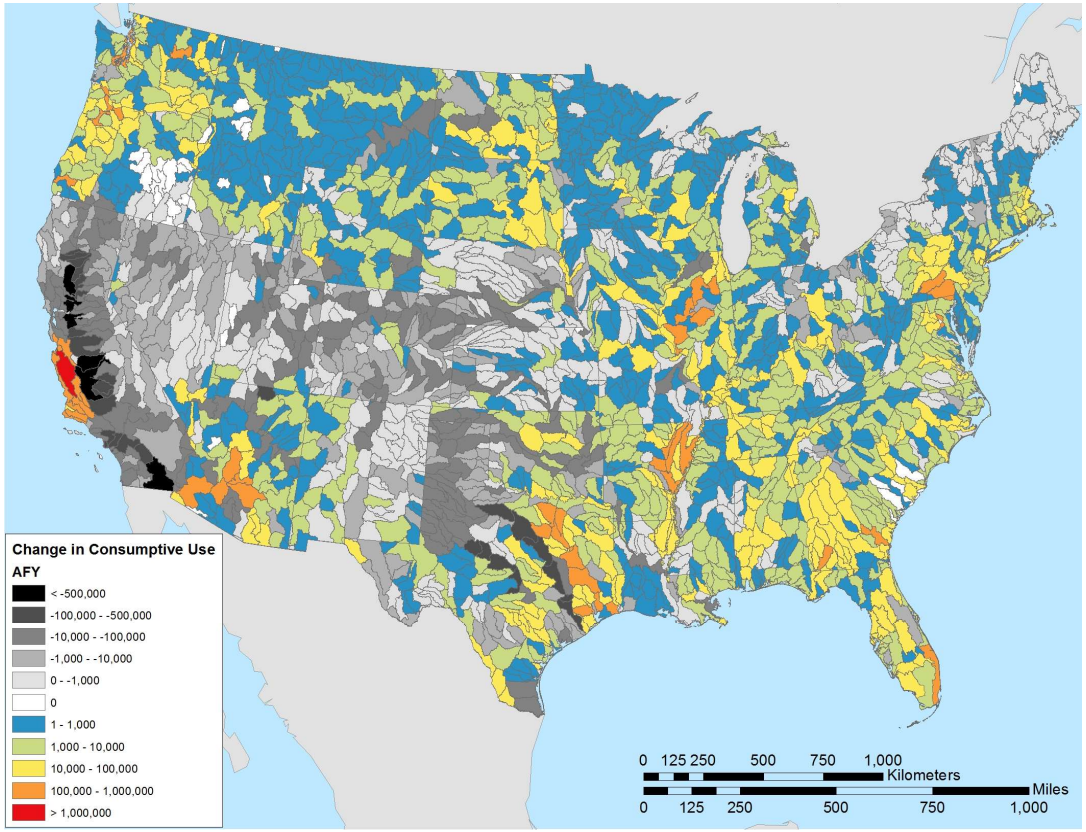
Water Availability: Brackish Groundwater

- Brackish water defined by salinities between 1,000 and 10,000 ppm TDS no deeper than 2500 ft.
- Estimates are data limited based on:
  - Current brackish water use, and
  - USGS well logs that indicated brackish water availability.



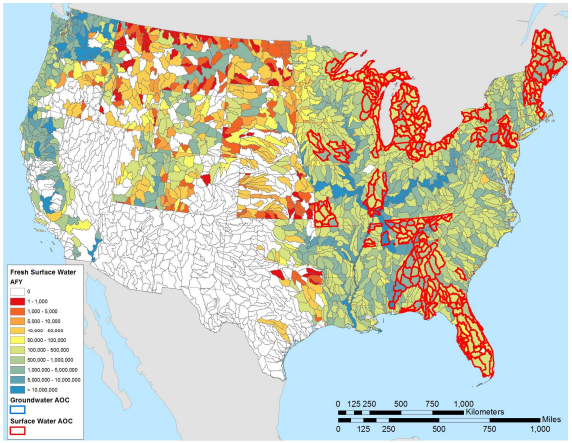
Projected Future Use 2010-2030

- Water needed for development after 2010.
- Based on estimates directly from states.
- Does not include thermoelectric water demand.

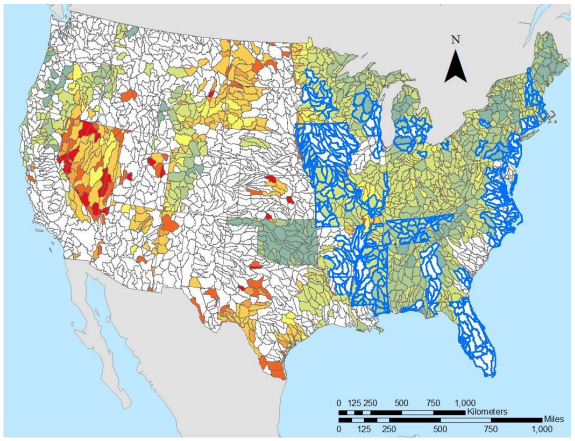


Water Supply Availability

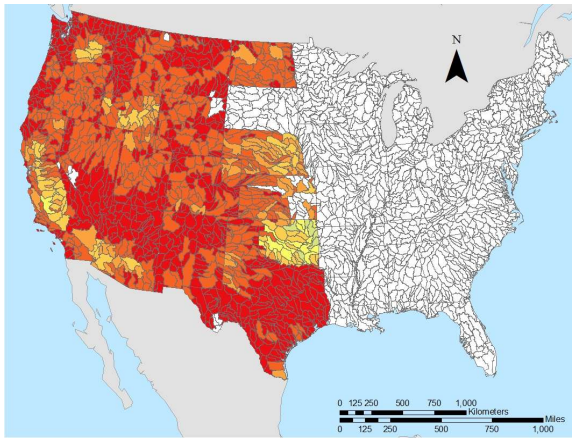
Fresh Surface Water



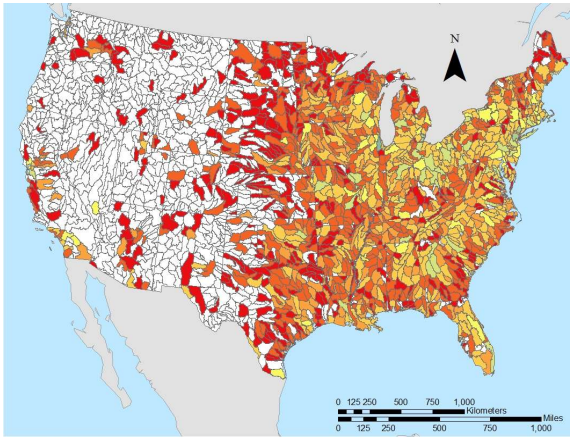
Fresh Groundwater



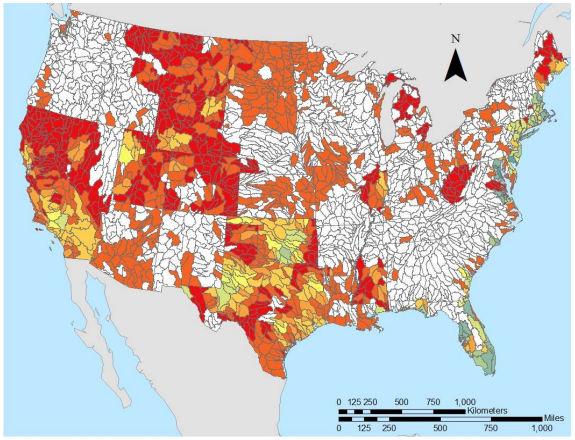
Appropriated Water



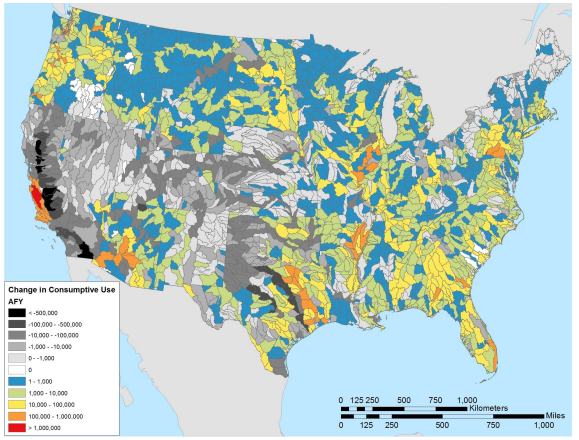
Municipal Wastewater



Brackish Groundwater



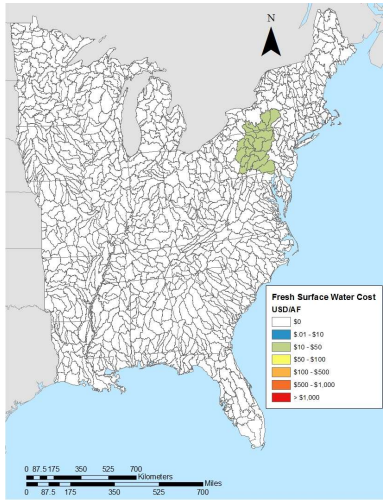
Consumptive Demand 2010-2030



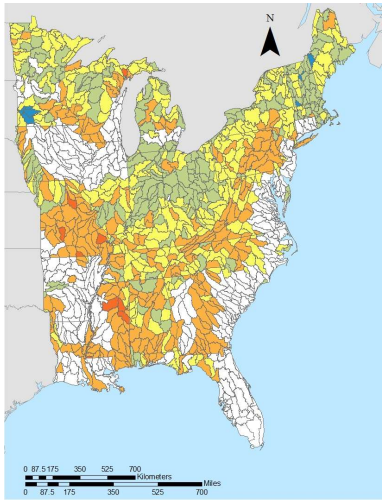
Water Cost

- Goal is to establish a consistent and comparable measure of cost to deliver water of potable quality to the point of use
- Basic costs considered:
  - Capital costs:
    - Purchase water,
    - Wells,
    - Conveyance, and
    - Treatment.
  - Operation and Maintenance:
    - Electricity,
    - Labor,
    - Consumables, and
    - Disposal.

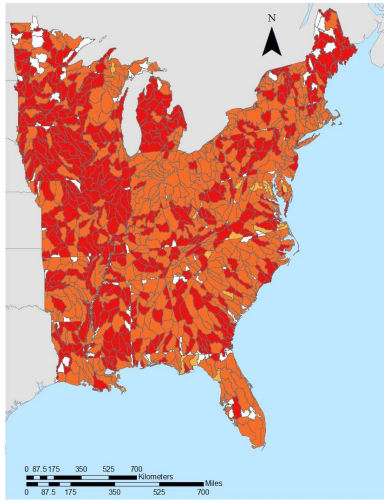
Fresh Surface Water



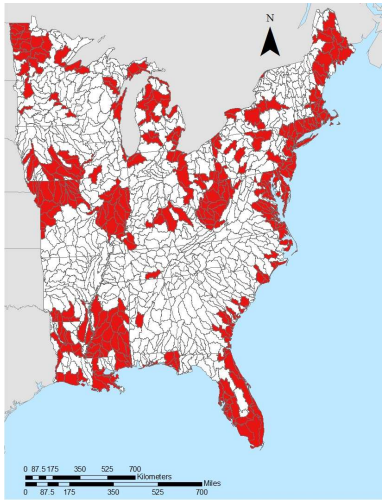
Fresh Groundwater



Municipal Wastewater



Brackish Groundwater



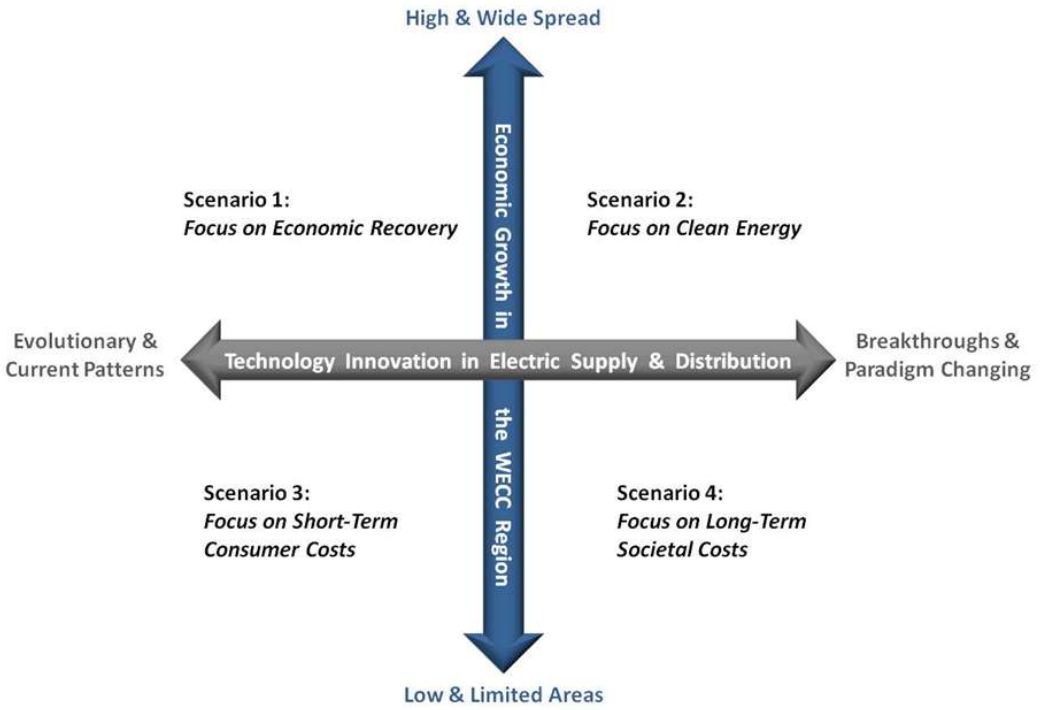
Data Access

Project data available at:

http://water.sandia.gov

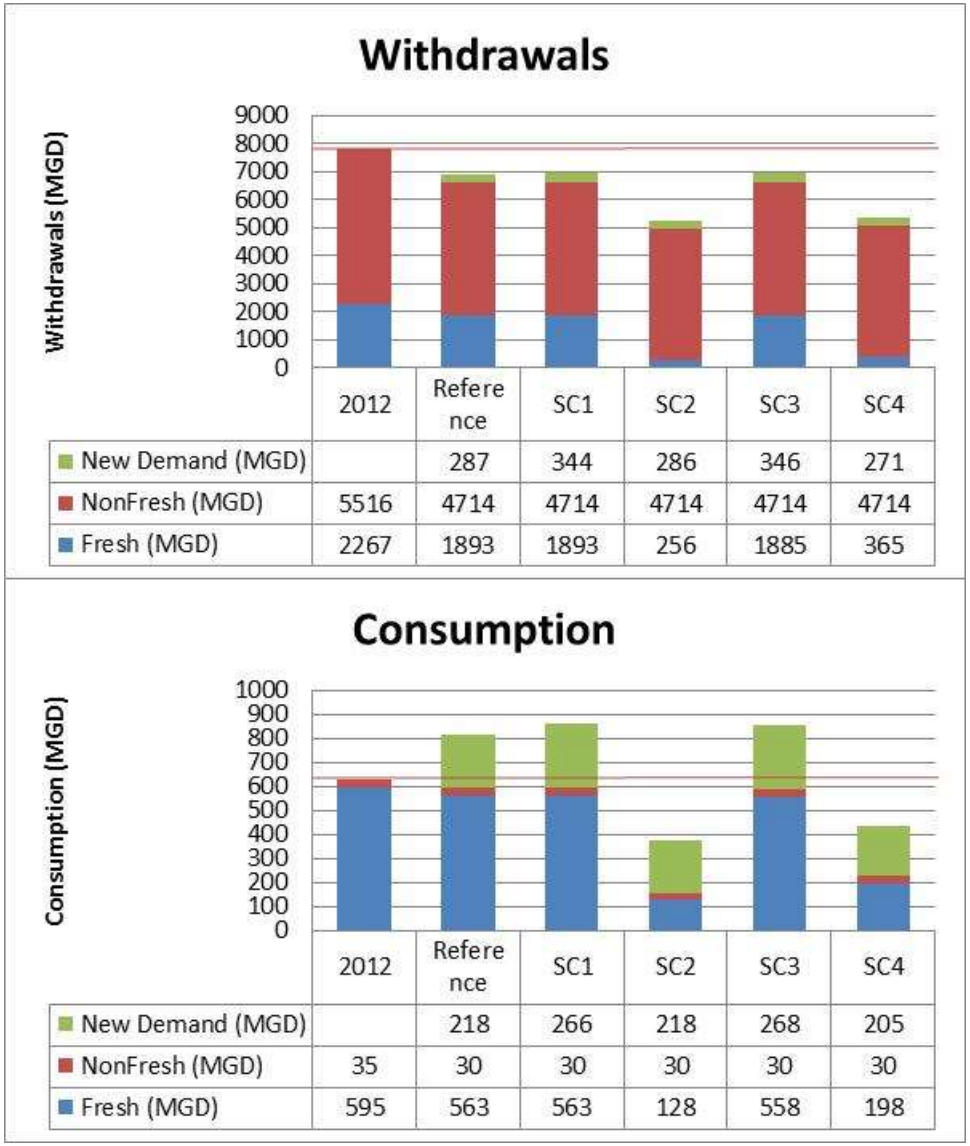
Planning: Scenario Development

- ***Reference Case:*** adopted trajectory of recent WECC planning information.
- ***Scenario One:*** favored continued trends in growing use of natural gas and renewables.
- ***Scenario Two:*** distinct shift toward renewables, energy efficiency and significant carbon tax.
- ***Scenario Three:*** reliance on traditional technologies while simply meeting current state renewable portfolio standards.
- ***Scenario Four:*** similar technology development and policies as in scenario two except limited by sluggish economic growth.



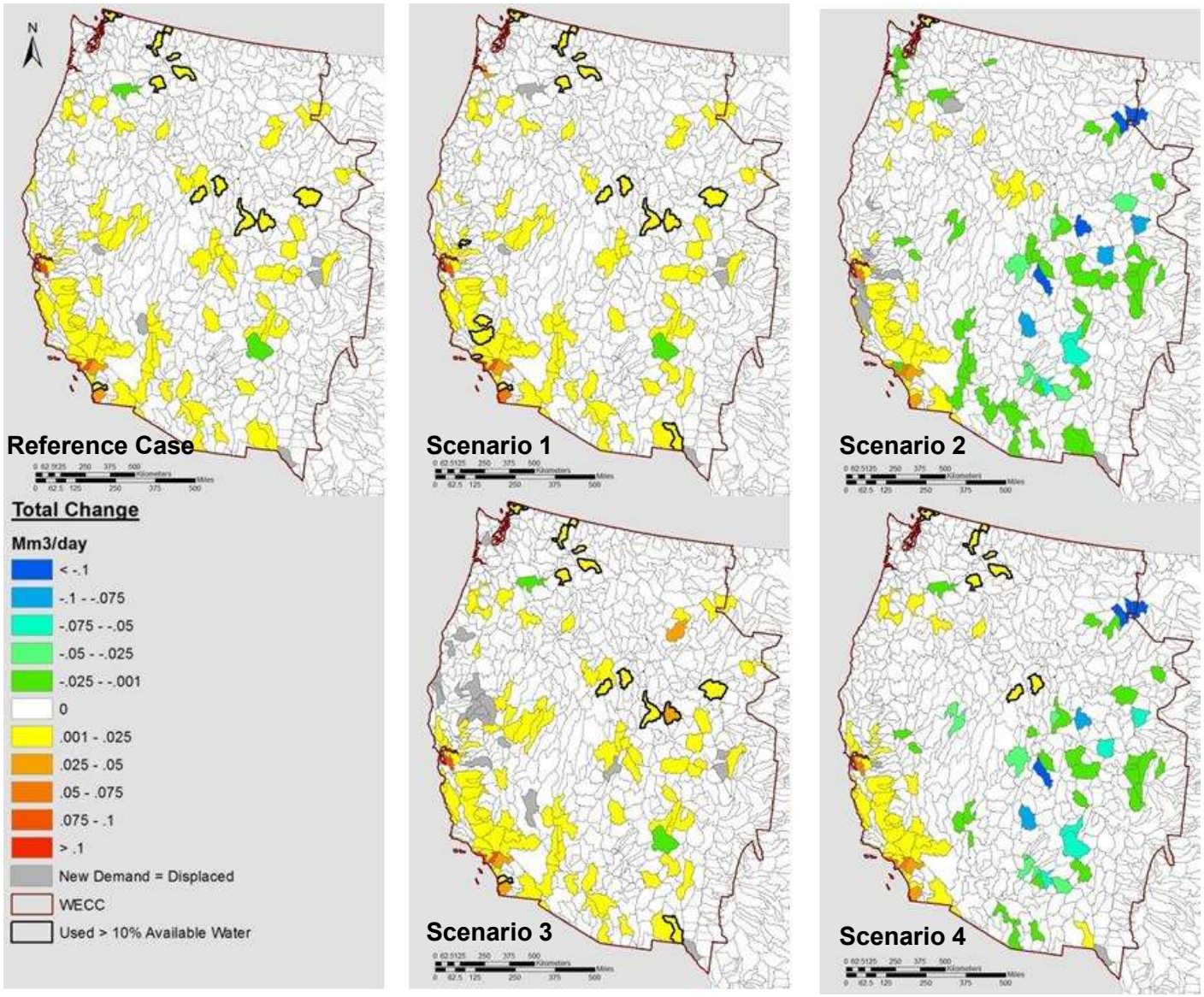
Source: WECC 2013

Planning: Water Use

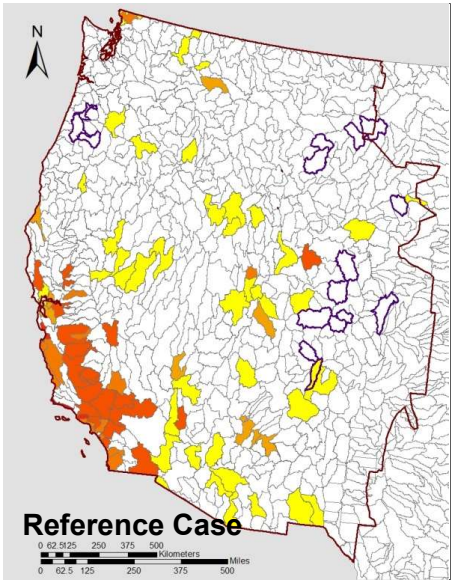


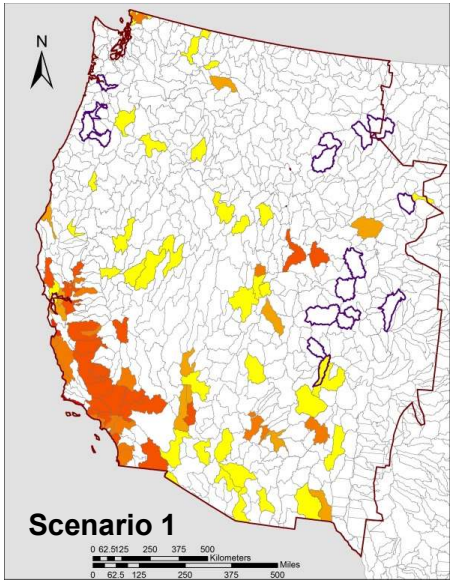
- Uniform reductions in withdrawals:
  - Similar additions across scenarios,
  - Retirements of 14% of seawater and 4 % freshwater withdrawals,
  - >70% displacement of freshwater withdrawal in scenarios 2 and 4
- Consumption varies by scenario:
  - Uniform additions,
  - >30% decrease for scenarios 2 and 4 (displaced coal)
  - >30% increase for other scenarios

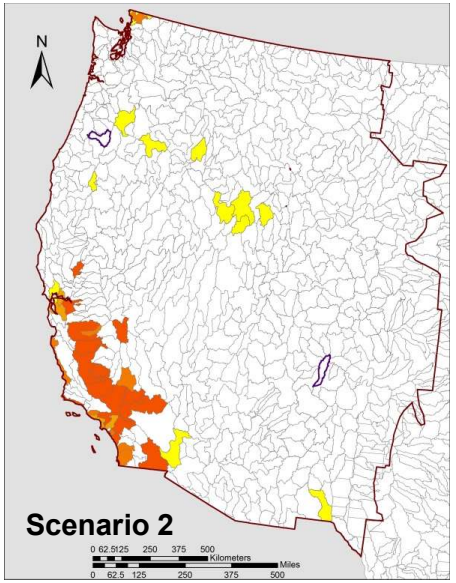
Planning: Watershed Impact

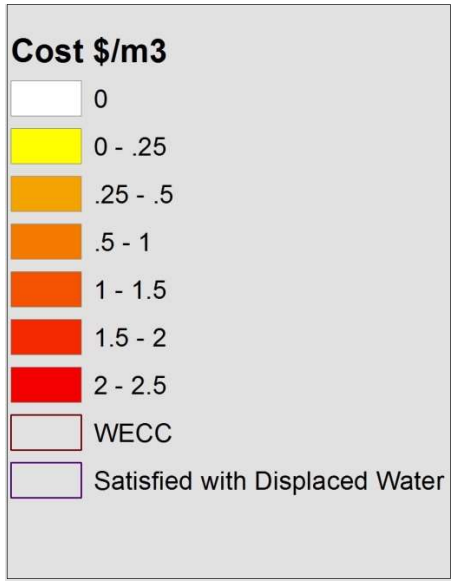


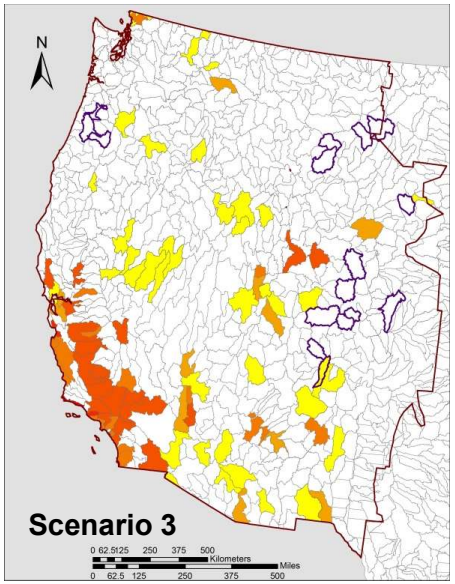
Planning: Watershed Cost Analysis

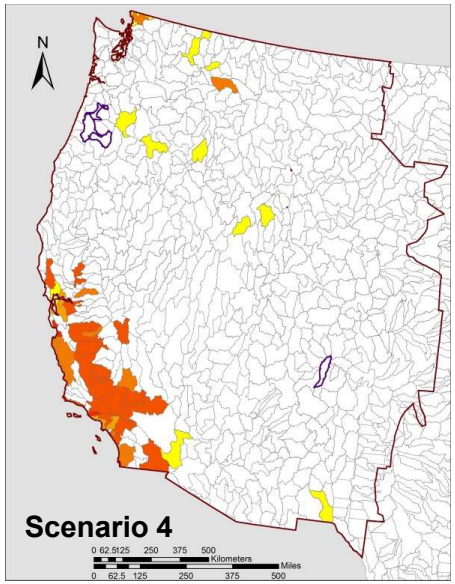






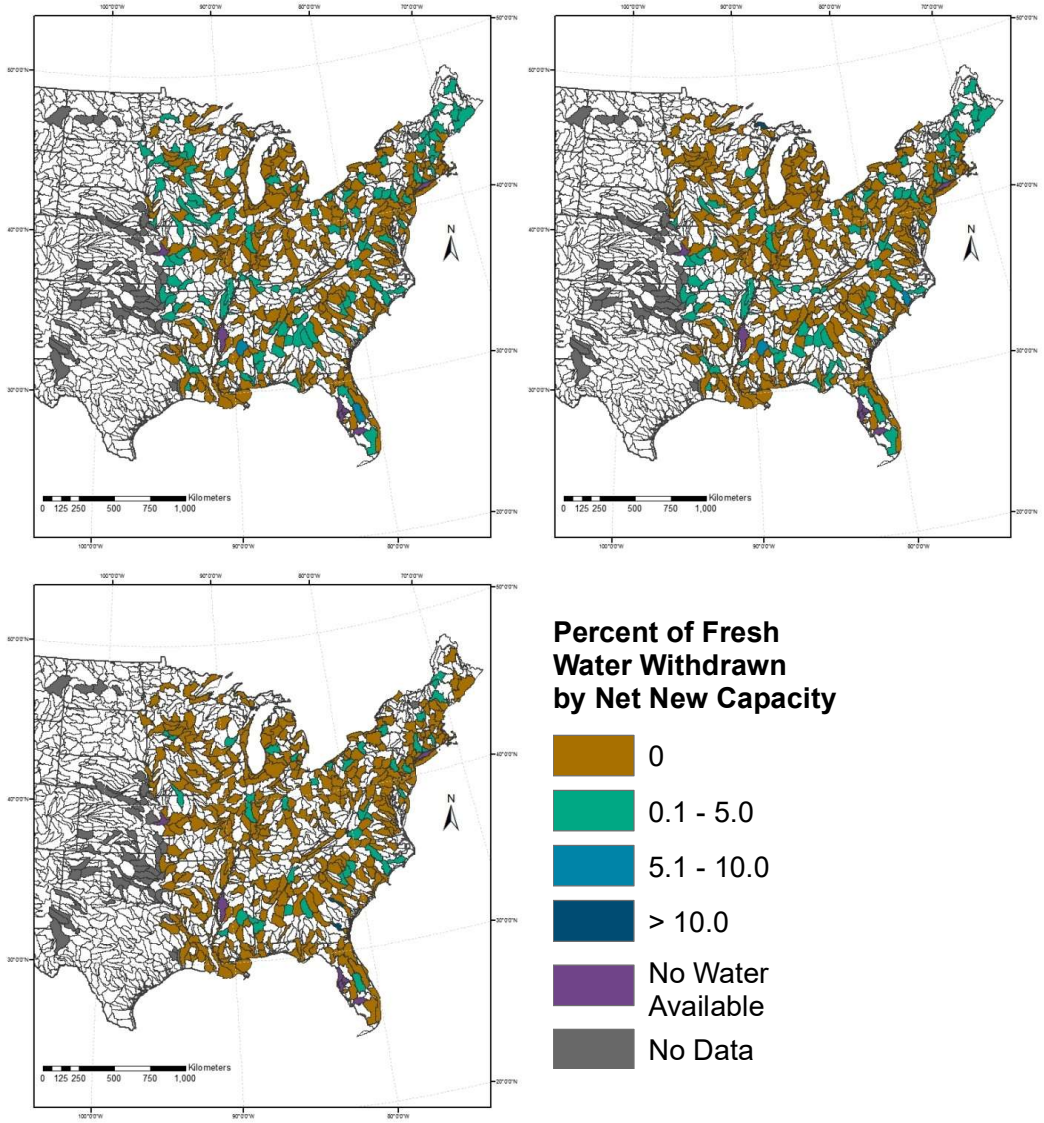




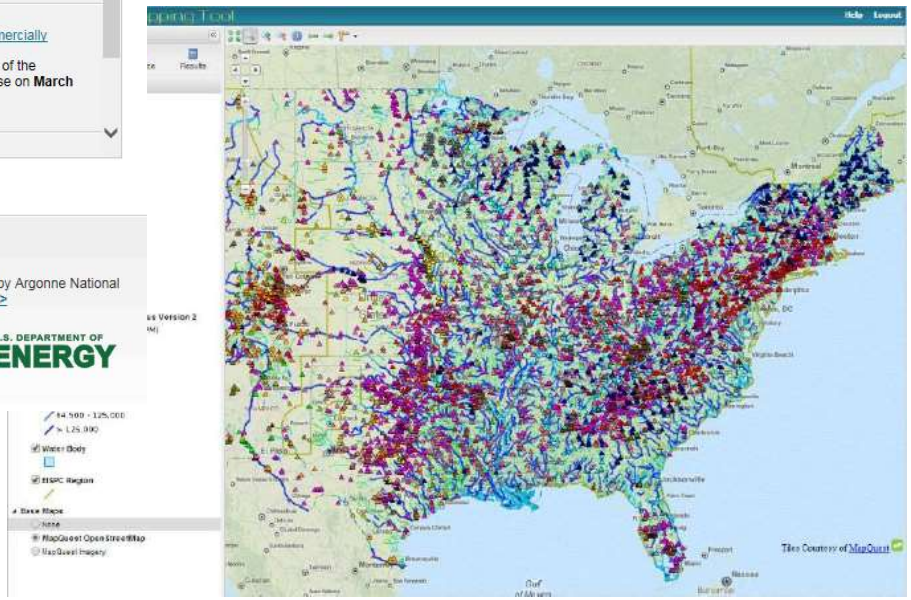


Planning: Watershed Impact

- Three scenarios
  - Business as Usual
  - High renewables
  - Emission controls
- Significant retirement of high-water use capacity to retire
- Freshwater able to meet future demands except in rare instances



Planning: EISPC EZ Mapping Tool



Water Atlas: Next Generation

- Scoping study to envision decision support system to inform technology and supply choices related to water for energy:
  - Planning for new development, and
  - Planning system up-grades at existing facilities.
- Propose basic system framework.
- Propose basic content while identifying potential sources of information.