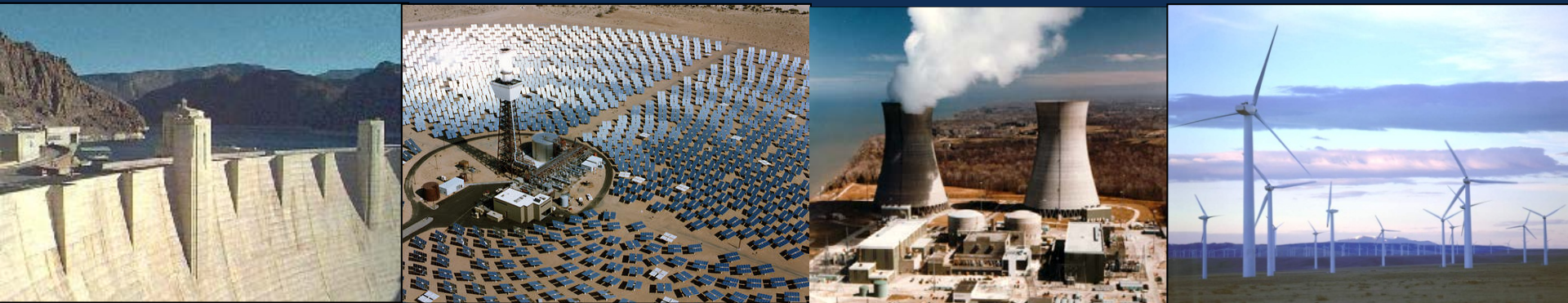


Exceptional service in the national interest



Mapping Water Availability and Cost in the Western U.S.

Vincent C. Tidwell

Sandia National Laboratories

*Technical Workshop on Water Acquisition Modeling
Arlington, VA, June 4, 2013*



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- John Gasper
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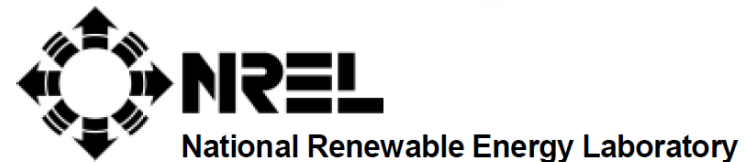


- Electric Power Research Institute

- Robert Goldstein

- National Renewable Energy Laboratory

- Jordan Macknick
- Kathleen Hallett



- Idaho National Laboratory

- Gerald Sehlke
- Dan Jensen
- Chris Forsgren



- Pacific Northwest National Laboratory

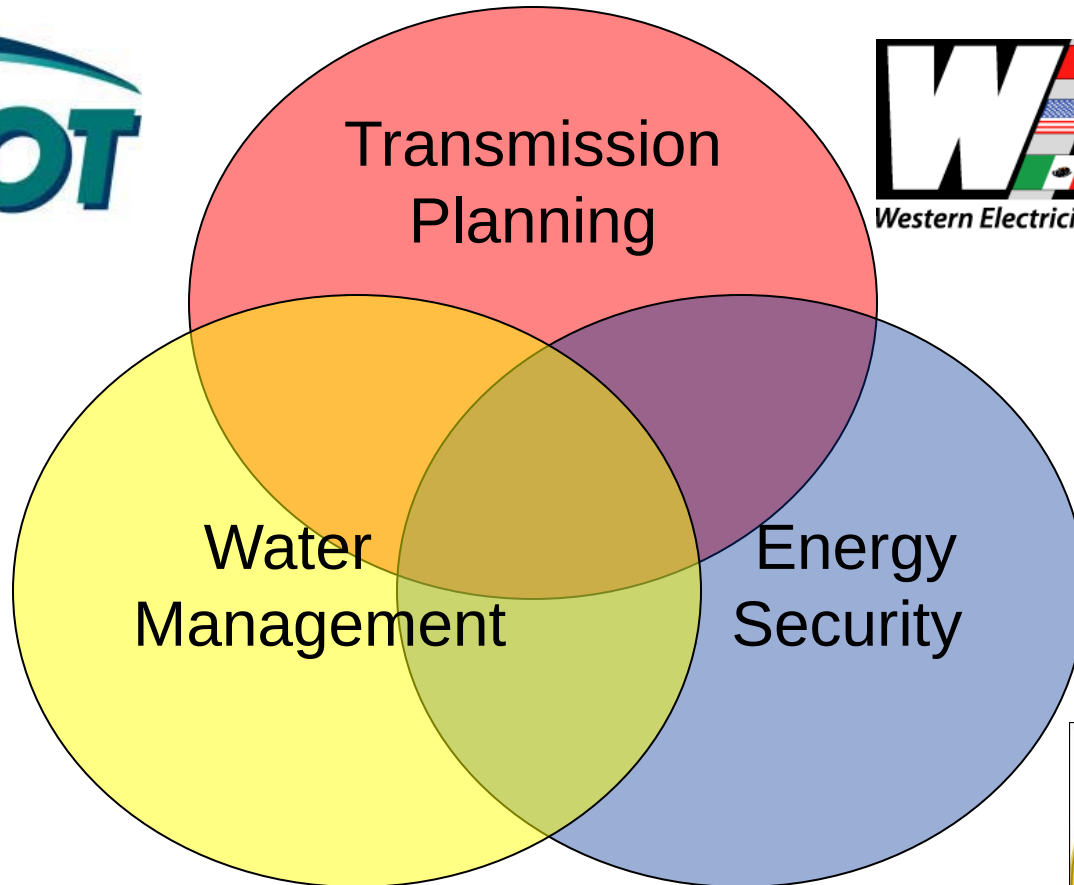
- Mark Wigmosta
- Ruby Leung

- University of Texas

- Michael Webber
- Carey King

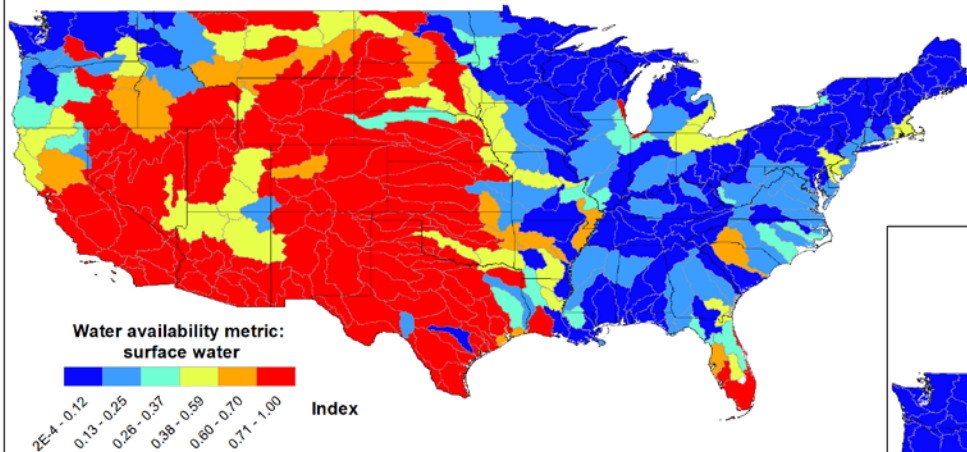


Integrated Planning

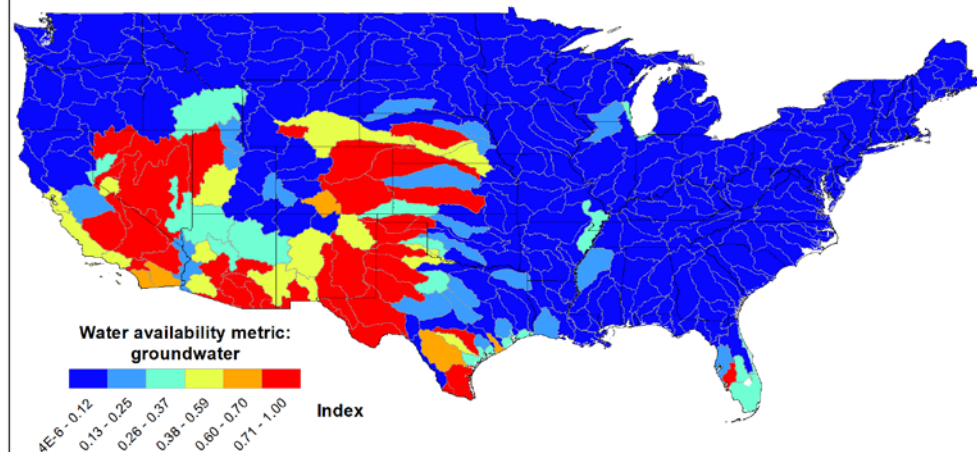


Potential Limits to Development

Gauged Streamflow vs. Consumption



Sustainable Recharge vs. Pumping



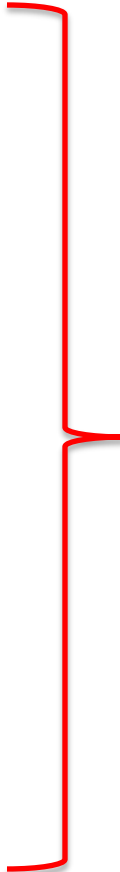
Key Water Sources

- **Potable Water**

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

- **Non-Potable Water**

- Municipal/Industrial wastewater
- Shallow brackish water



Relative
Availability
and Cost

Water Availability Indicators: Demand

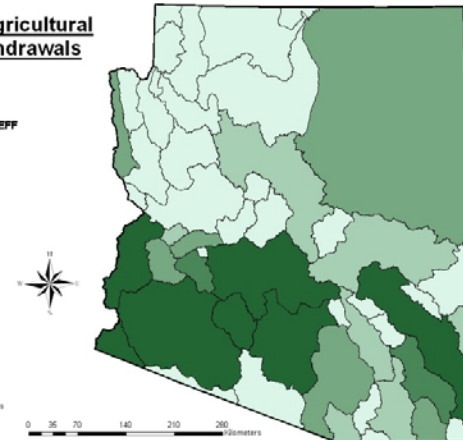
- ***Focus on withdrawals***
- ***Estimate consumption from withdrawals***
- ***Disaggregate by:***
 - ***8-digit watershed***
 - ***Sector***
 - ❖ ***M&I***
 - ❖ ***Agriculture***
 - ❖ ***Evaporative***
 - ❖ ***Instream***
 - ***Water source***

Current Agricultural Water Withdrawals

Arizona

GW + SW + CAP + EFF
1000 Acre-Feet/Year

0 - 5
6 - 25
26 - 65
66 - 200
201 - 700



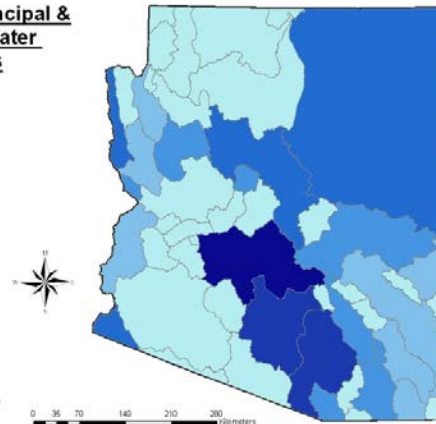
Note:
Agricultural water withdrawals
are for 2009 in Groundwater
Basins and 2006 in Active
Management Areas

Current Municipal & Industrial Water Withdrawals

Arizona

GW + SW
1000 Acre-Feet/Year

0 - 3
4 - 10
11 - 20
21 - 60
61 - 150
151 - 700



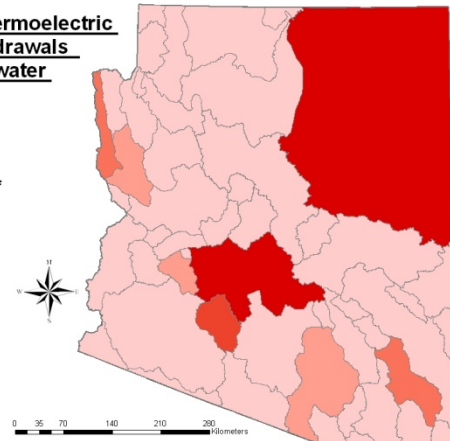
Note:
Data is for 2009 in Groundwater
Basins and for 2006 in Active
Management Areas

Current Thermoelectric Water Withdrawals By Groundwater Basin

Arizona

GW + SW + CAP + EFF
1000 Acre-Feet/Year

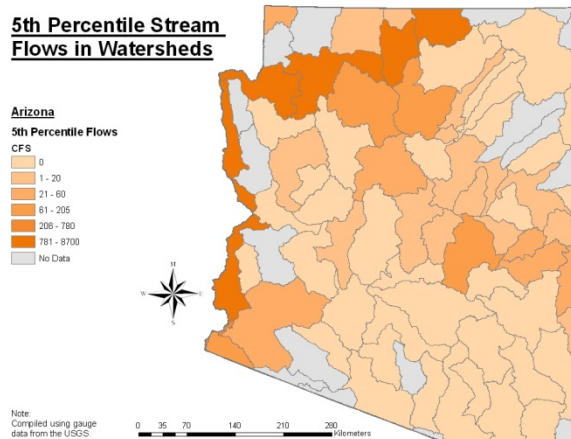
0 - 1
2 - 3
4 - 5
6 - 10
11 - 71



Note:
Values are for 2009 in
Groundwater Basins and
for 2006 in Active
Management Areas

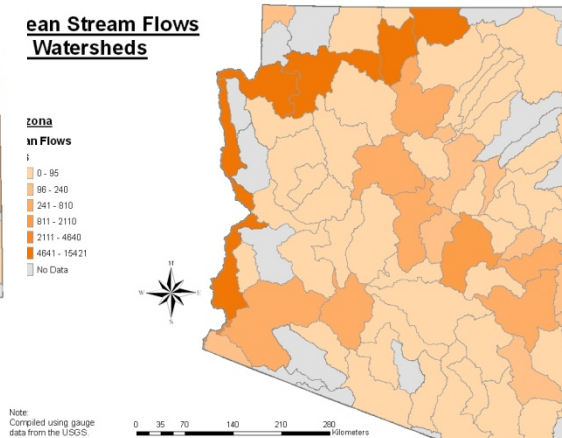
Water Availability Indicators: Supply

5th Percentile Stream Flows in Watersheds



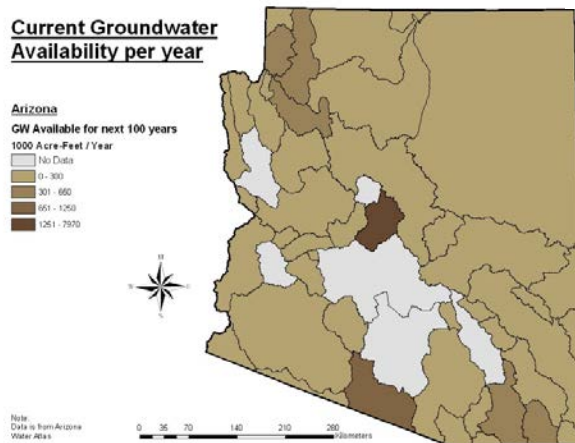
Mean Gauged Streamflow

Mean Stream Flows in Watersheds



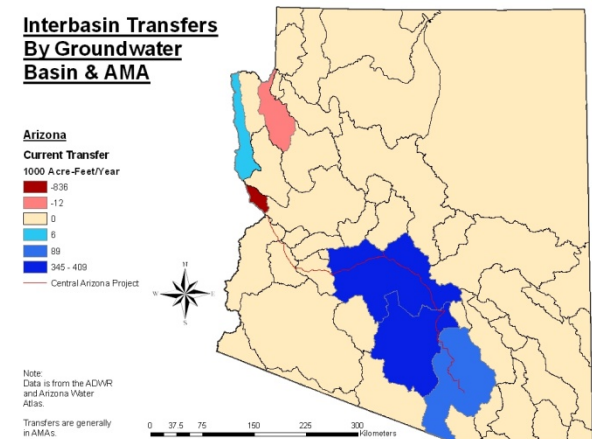
Annual Low Flow

Current Groundwater Availability per year



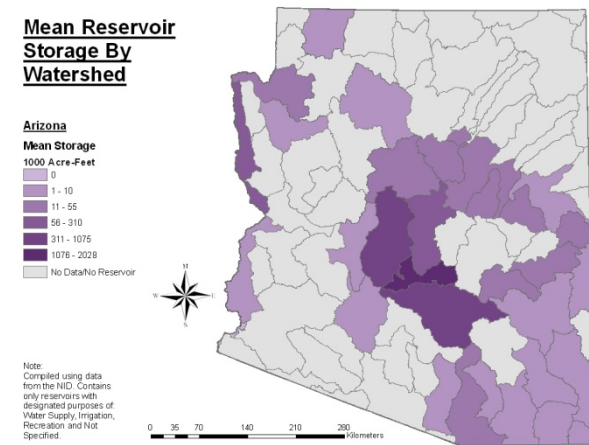
Groundwater Depletion

Interbasin Transfers By Groundwater Basin & AMA



Interbasin Transfers

Mean Reservoir Storage By Watershed



Reservoir Storage

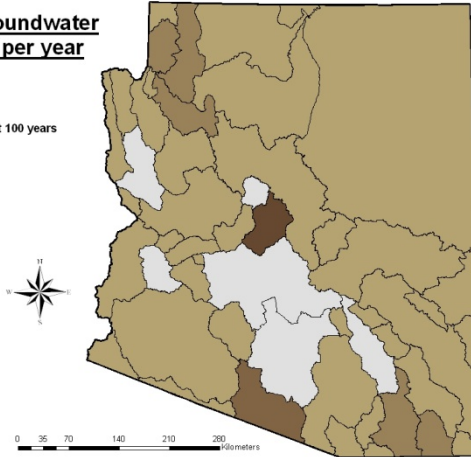
Water Availability Indicators: Institutional Factors

Current Groundwater Availability per year

Arizona
GW Available for next 100 years
1000 Acre-Feet / Year

- No Data
- 0 - 300
- 301 - 650
- 651 - 1250
- 1251 - 7970

Note:
Data is from Arizona
Water Atlas



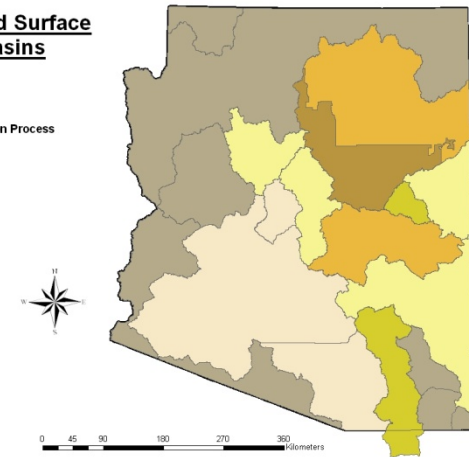
Unappropriated Water

Adjudicated Surface of Water Basins

Arizona
Status of Adjudication Process

- ACTIVE
- FINAL
- NONE
- ONGOING
- PENDING
- PRELIMINARY

Note:
Includes agreements with
other states and Mexico



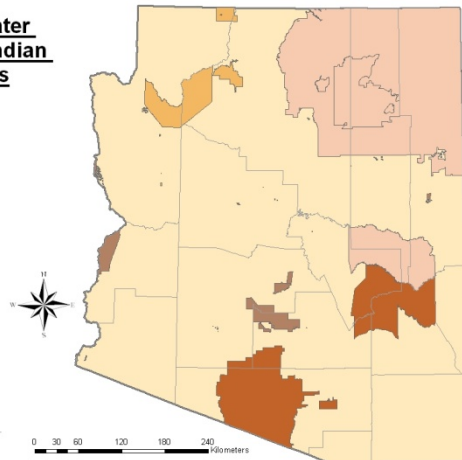
Adjudication Status

Status of Water Claims for Indian Communities

Arizona
Status

- In Negotiations
- Settled
- Settled/Unresolved
- Unresolved

Note:
Settled/Unresolved = Portions
of claims have been settled,
while others remain unresolved.
Status as of Sept. 2010



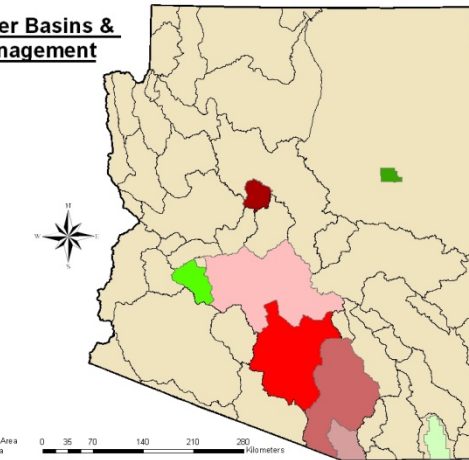
Indian Water

Groundwater Basins & Special Management Areas

Arizona
Type

- Groundwater Basin
- Douglas INA
- Harquahala INA
- Joseph City INA
- Phoenix AMA
- Pinal AMA
- Prescott AMA
- Santa Cruz AMA
- Tucson AMA

Note:
INA = Irrigation Non-Expansion Area
AMA = Active Management Area



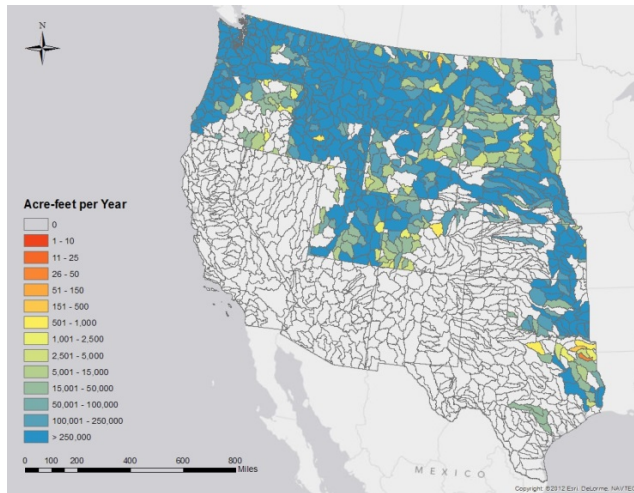
Administrative Control Areas

Metric Development

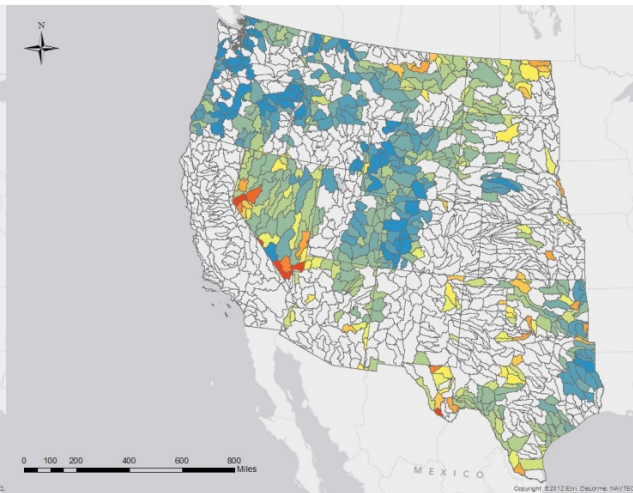
- **Data on “available water” are rare**
- **As such, metrics were estimated from available information**
- **Assisted by volunteer team from WSWC**
 - **Bret Bruce (USGS)**
 - **Dan Hardin (TX)**
 - **Sara Larsen (WSWC)**
 - **Dave Mitamura (TX)**
 - **Andy Moore (CO)**
 - **Ken Stahr (OR)**
 - **Todd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

Water Availability

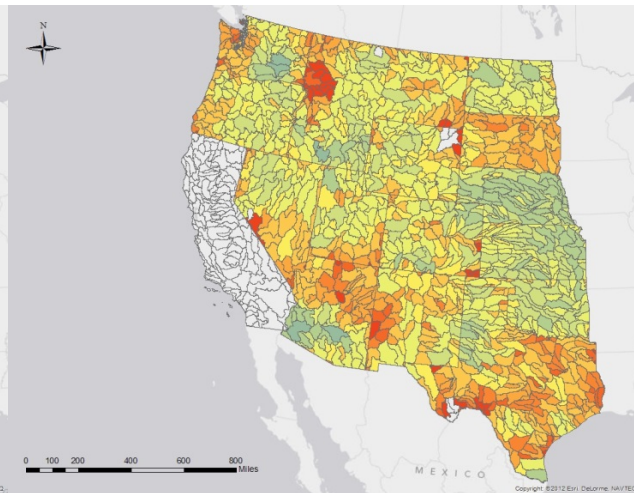
Unappropriated Surface Water



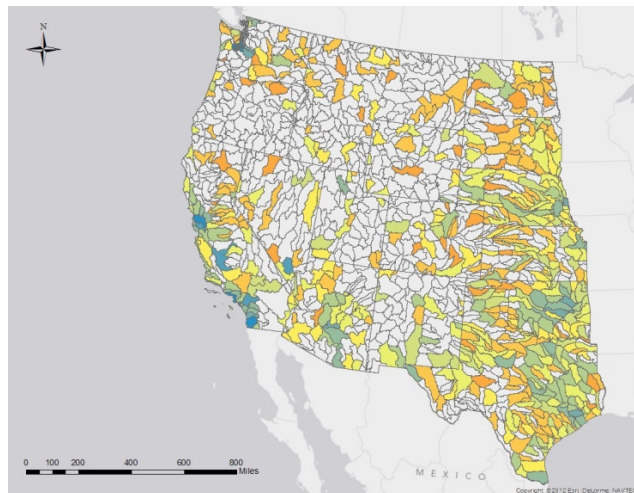
Unappropriated Groundwater



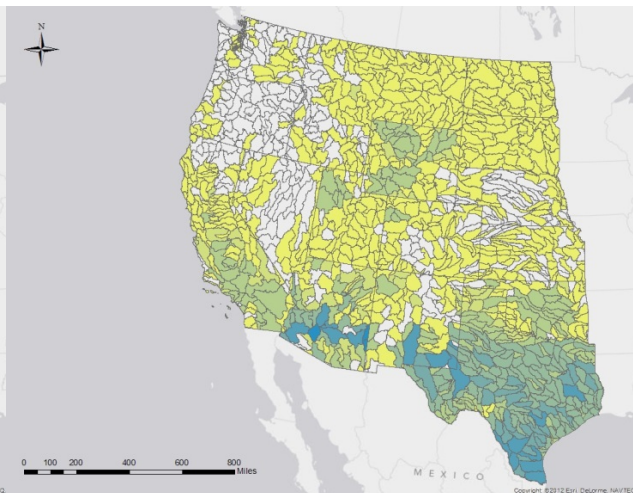
Appropriated Water



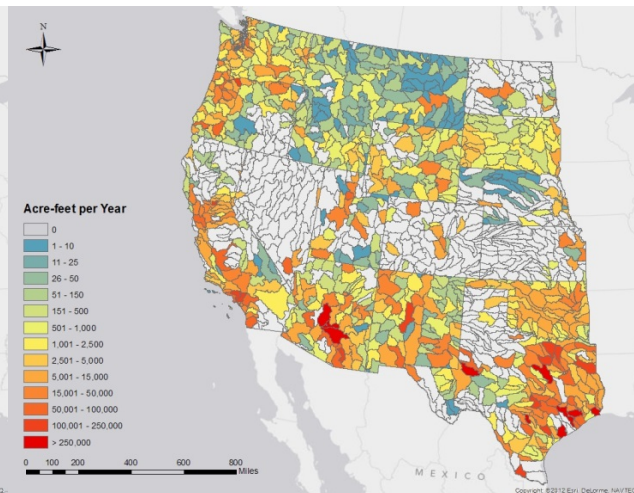
Municipal Wastewater



Brackish Groundwater

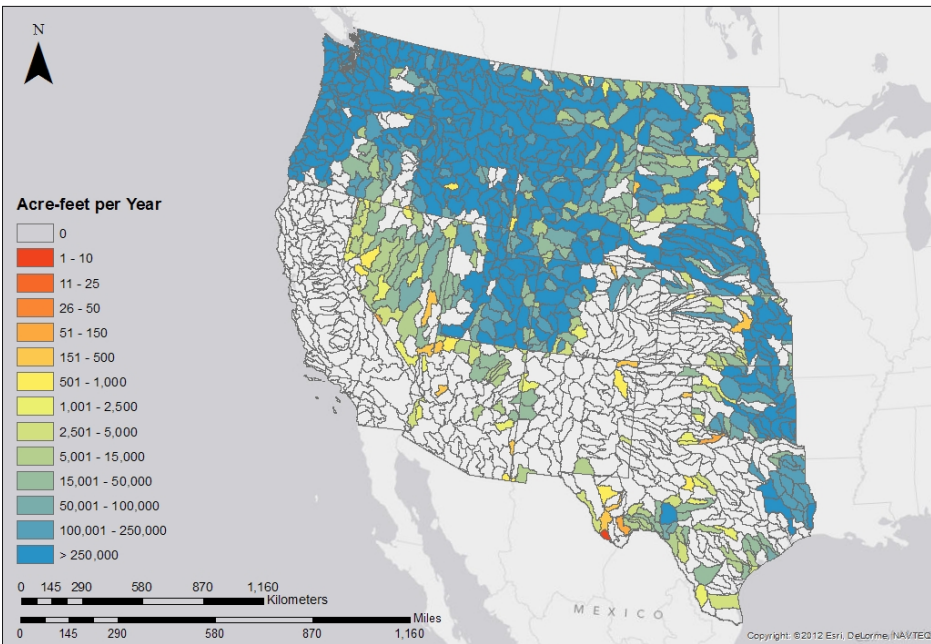


Consumptive Demand 2010-2030

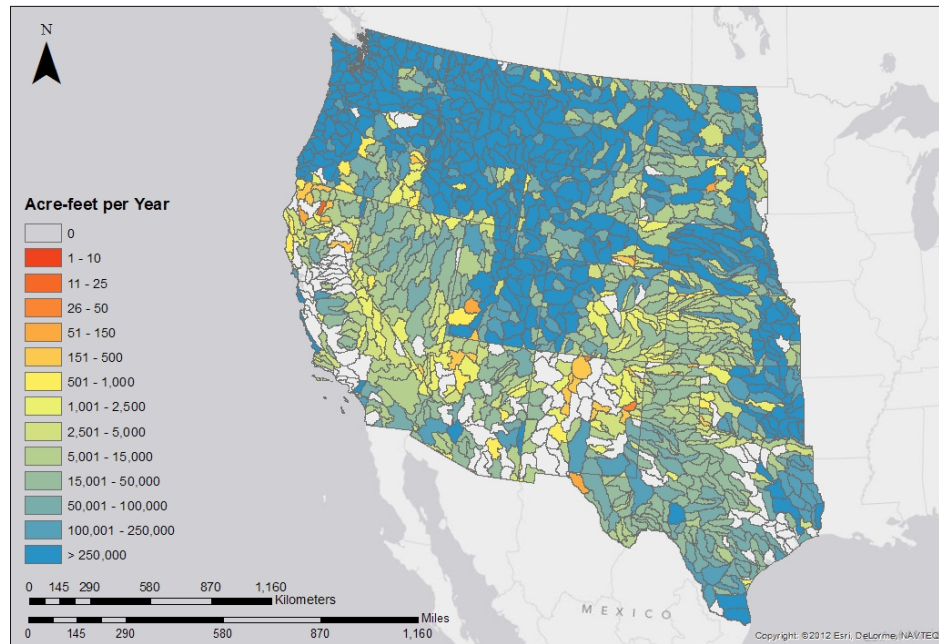


Water for Development

Unappropriated Water Sources - Change in Demand, 2030

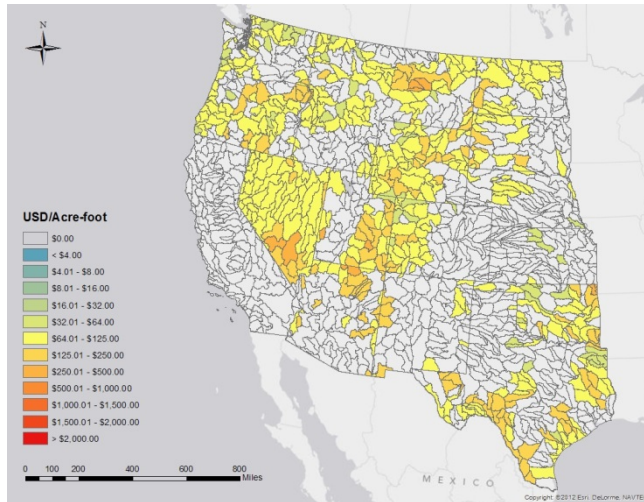


All Water Sources - Change in Demand, 2030

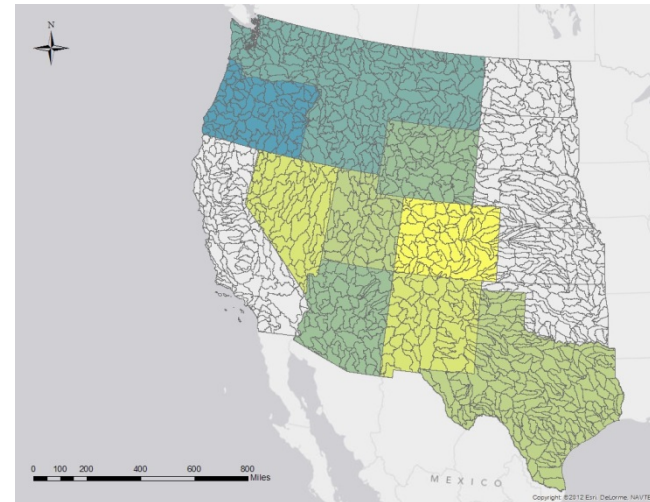


Relative Cost of Water

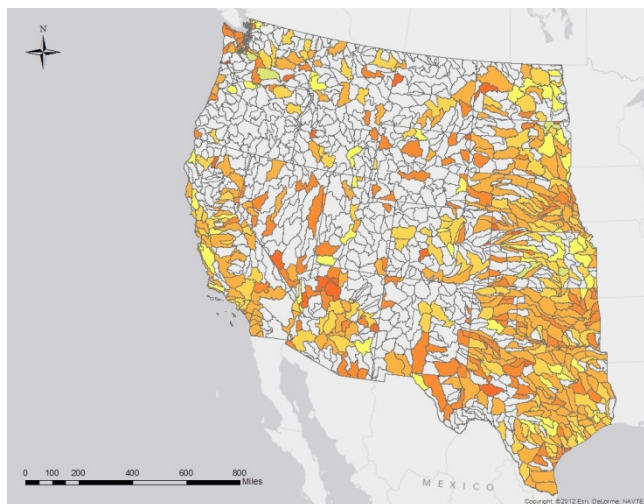
Unappropriated Groundwater



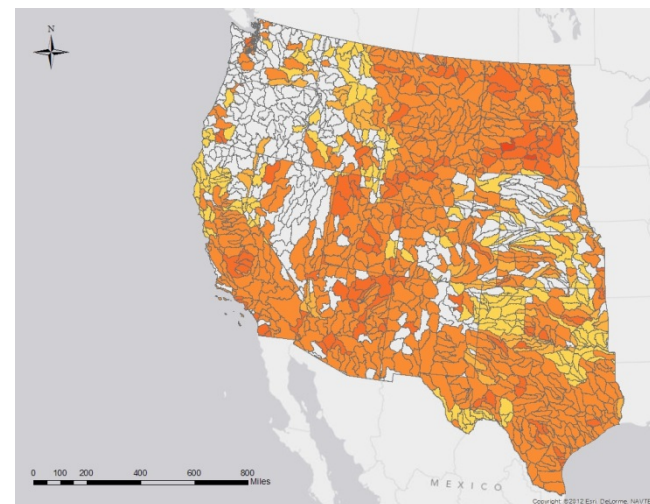
Appropriated Water



Municipal Wastewater



Brackish Groundwater

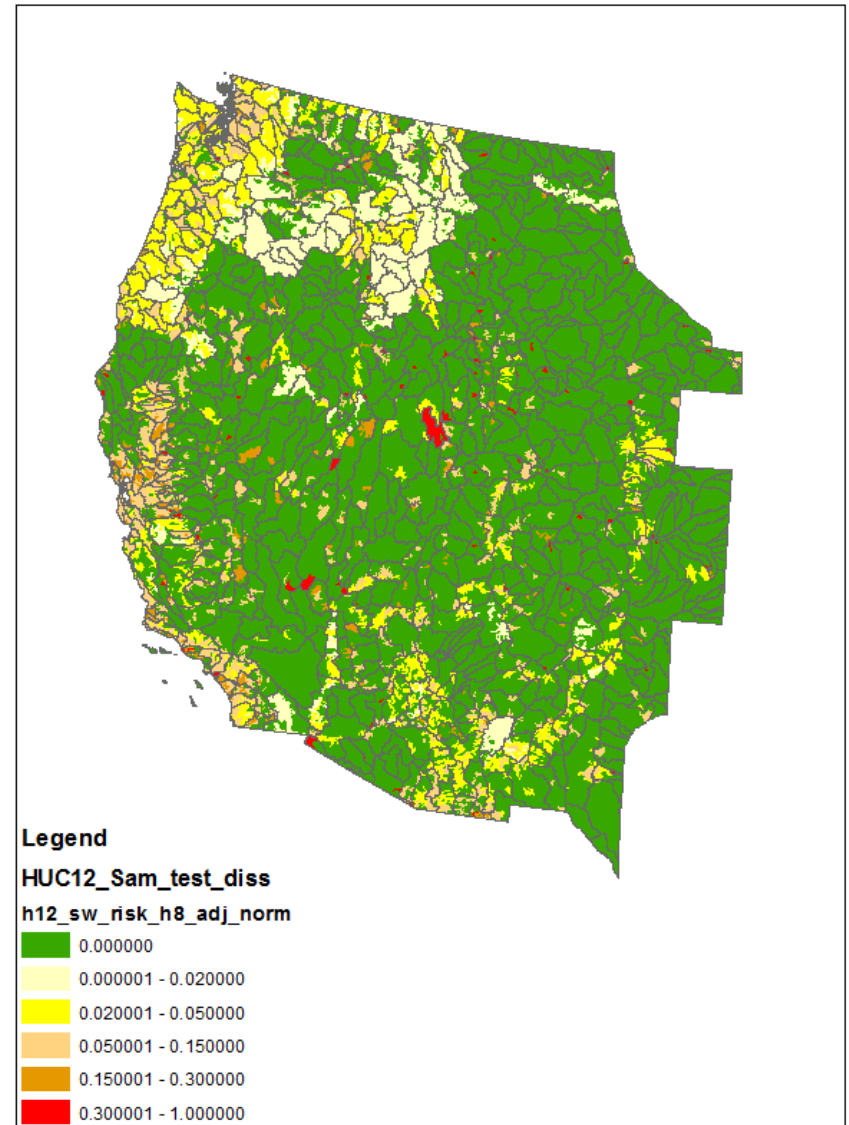


Environmental Risk Metric

Risk Calculation Methodology

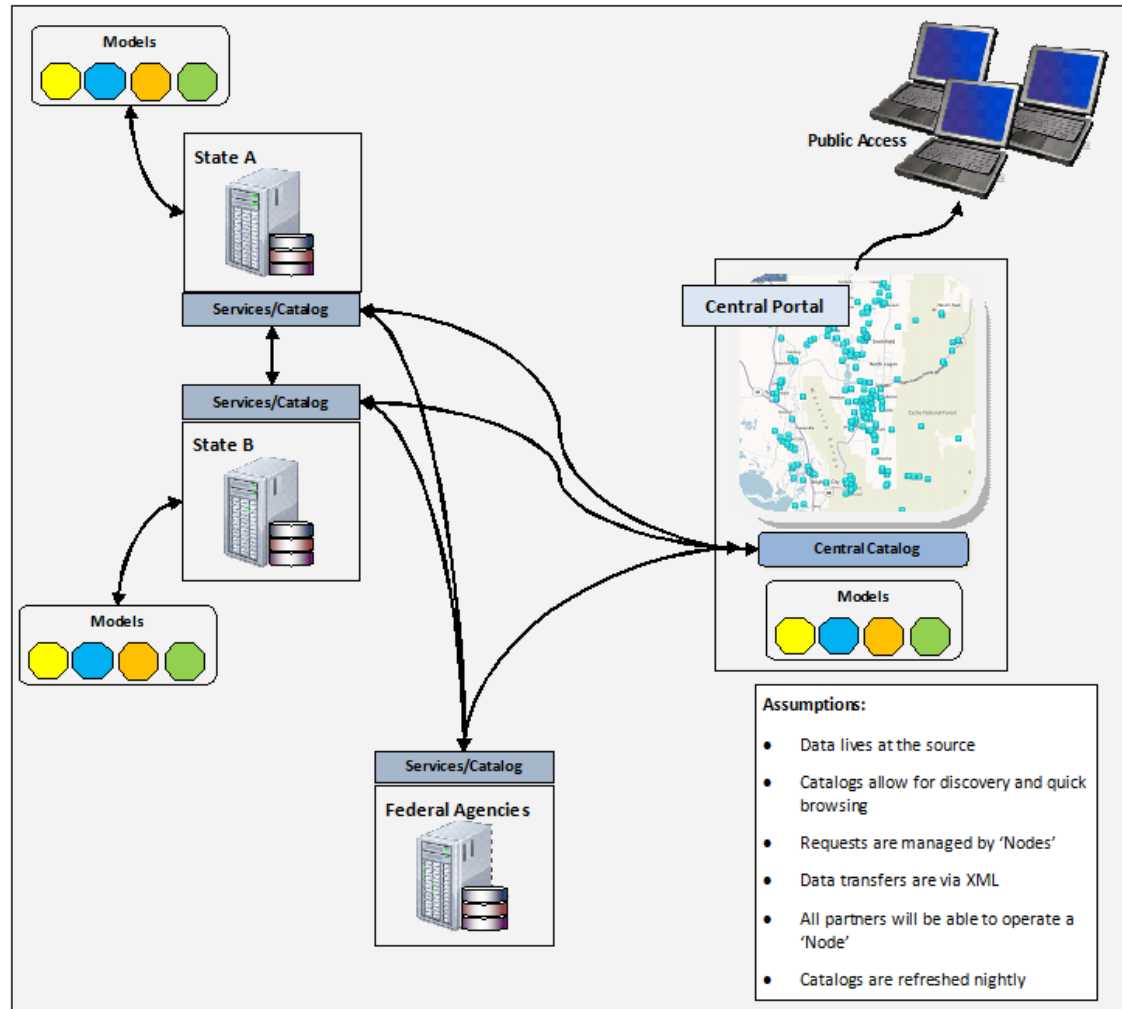
- Only species utilizing aquatic and riparian habitats are considered
- Overall Risk** to a region from Water Extraction (**OR**) = **IR** + **AR**Eq1
- Individual Risk (IR)** to a region is product of 4 Species Vulnerability Categories (**sij**'s) and 3 Habitat Vulnerability Categories (**hik**'s)
- IR** = $\sum [(sij1 + sij2 + sij3 + sij4 + CF) * (hik1 + hik2 + hik3_{sw/gw}) * EE]$ Eq2
 - sij1 = Diversity hik1 = Area
 - sij2 = Imperilment hik2 = Critical habitat
 - sij3 = Endemicity hik3 = Habitat type
 - sij4 = Sensitivity hik3 risks are separate for surface- (**sw**) and groundwater (**gw**)
- Edge-effect filter **EE**₈ factors (0.5, 1) and **EE**₁₂ factors (1, 2)
- Association Risk (AR)** = 0.5 * IR of Immediate Downstream PolygonEq3
- Correction Factor (**CF** - Binary), Edge-effect (**EE**) filter, and Association Risk (**AR**) – Not used for this analysis

HUC-12 Risk Map (From Surface Withdrawals)



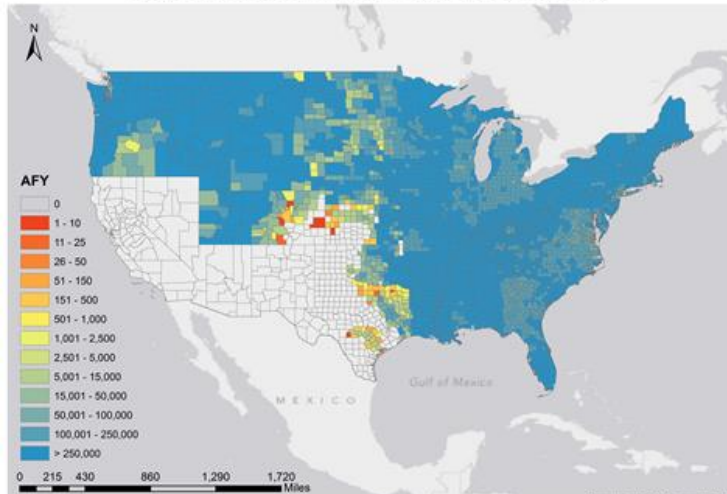
Water Use Data Exchange (WaDE)

- 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

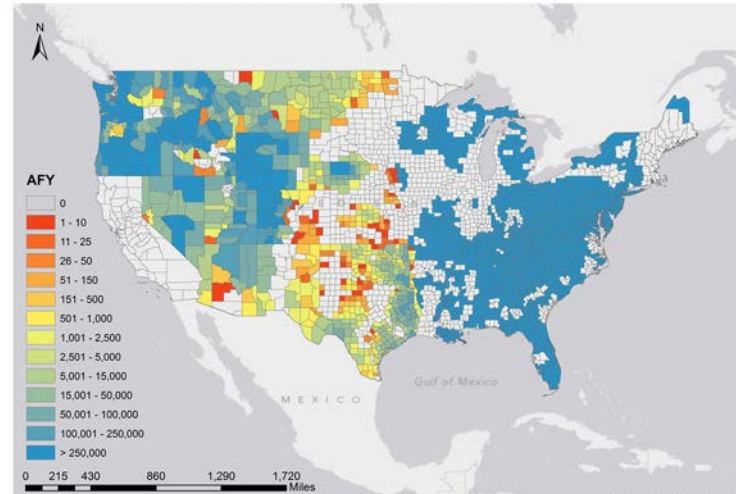


Water Availability

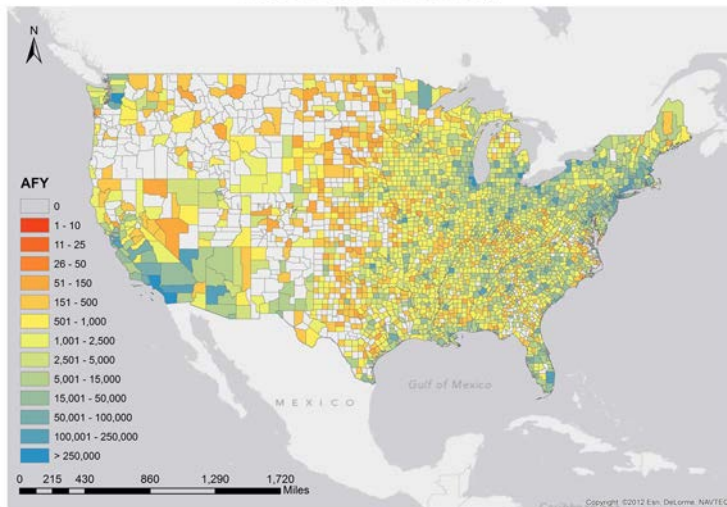
Unappropriated Surface Water Availability



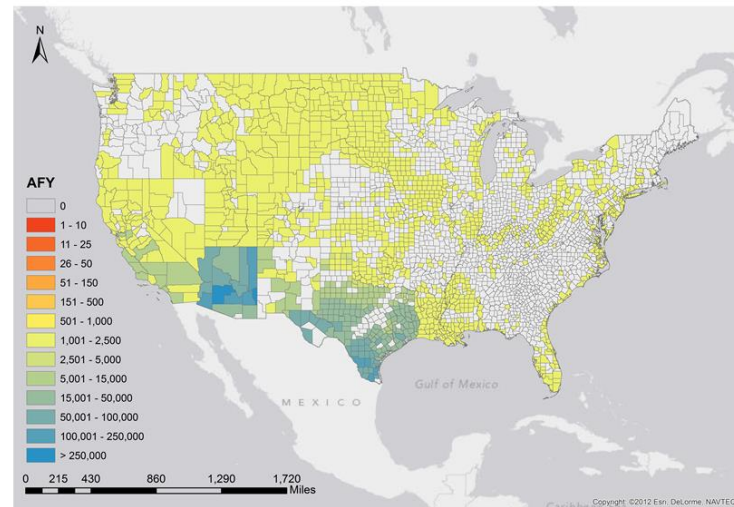
Potable Groundwater Availability



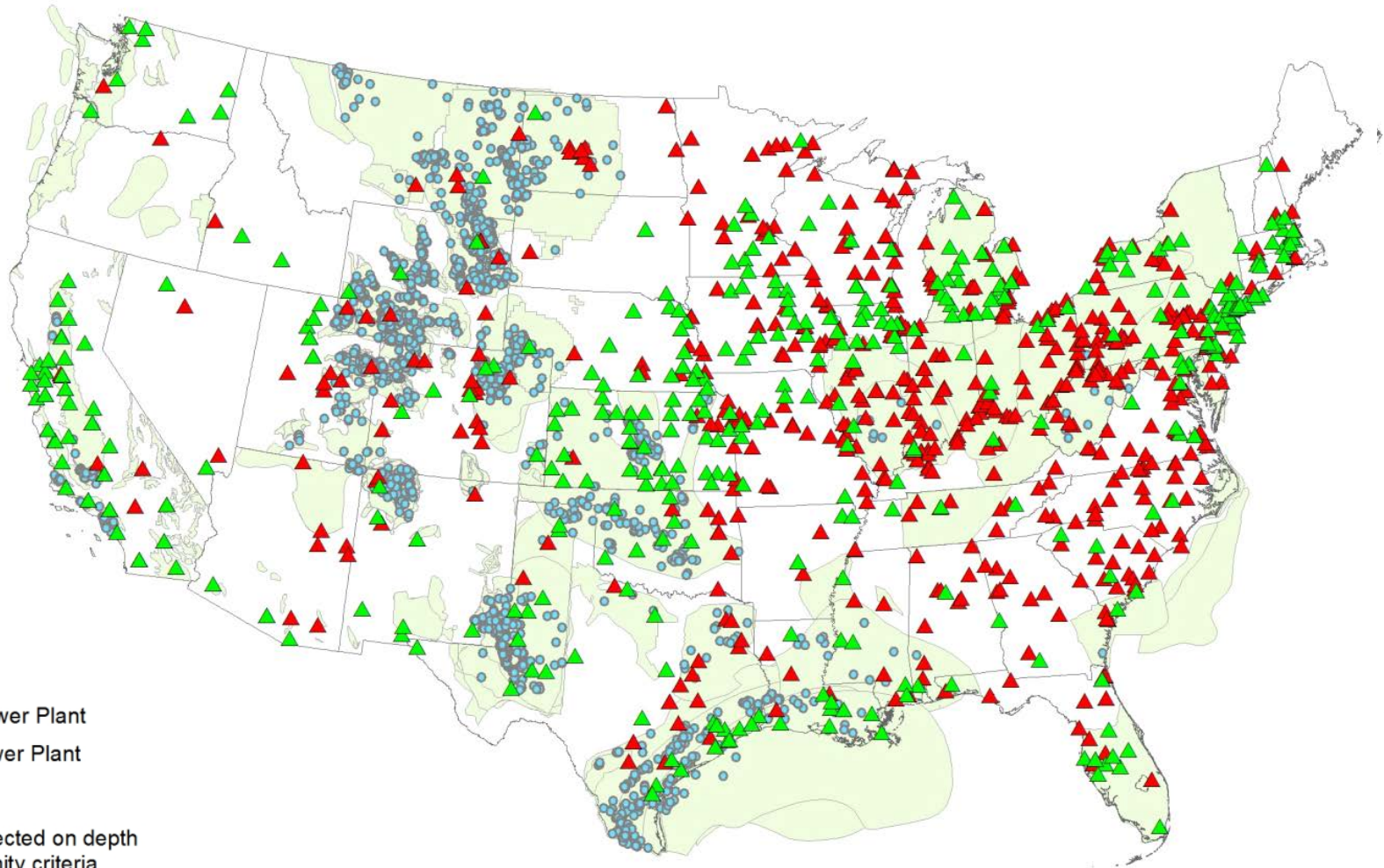
Wastewater Availability



Brackish Groundwater Availability



U.S. CO₂ Saline Formation Sinks



Legend

▲ Coal Power Plant

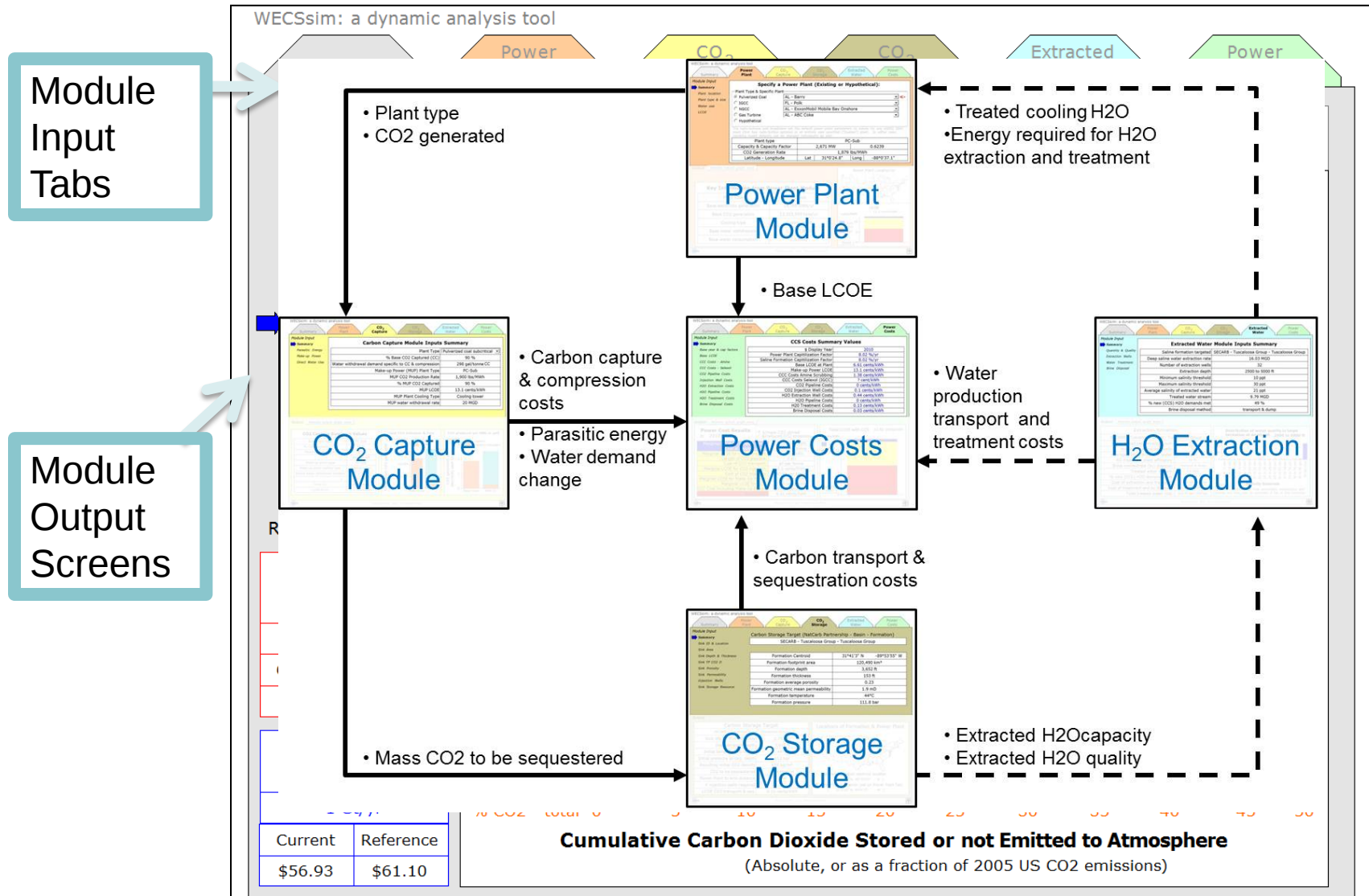
▲ Gas Power Plant

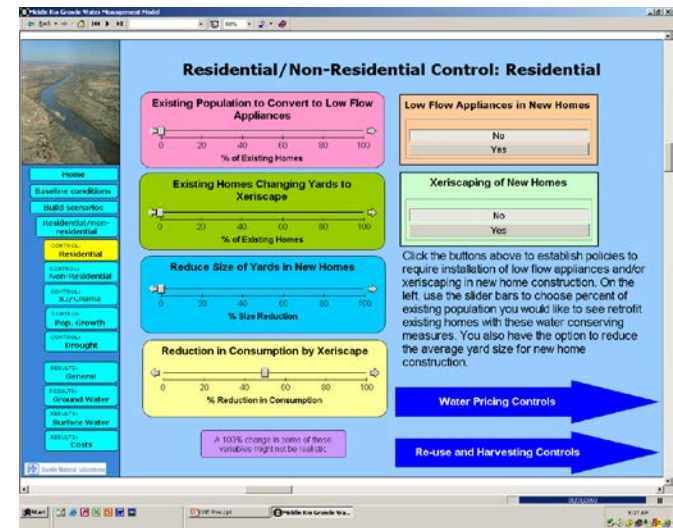
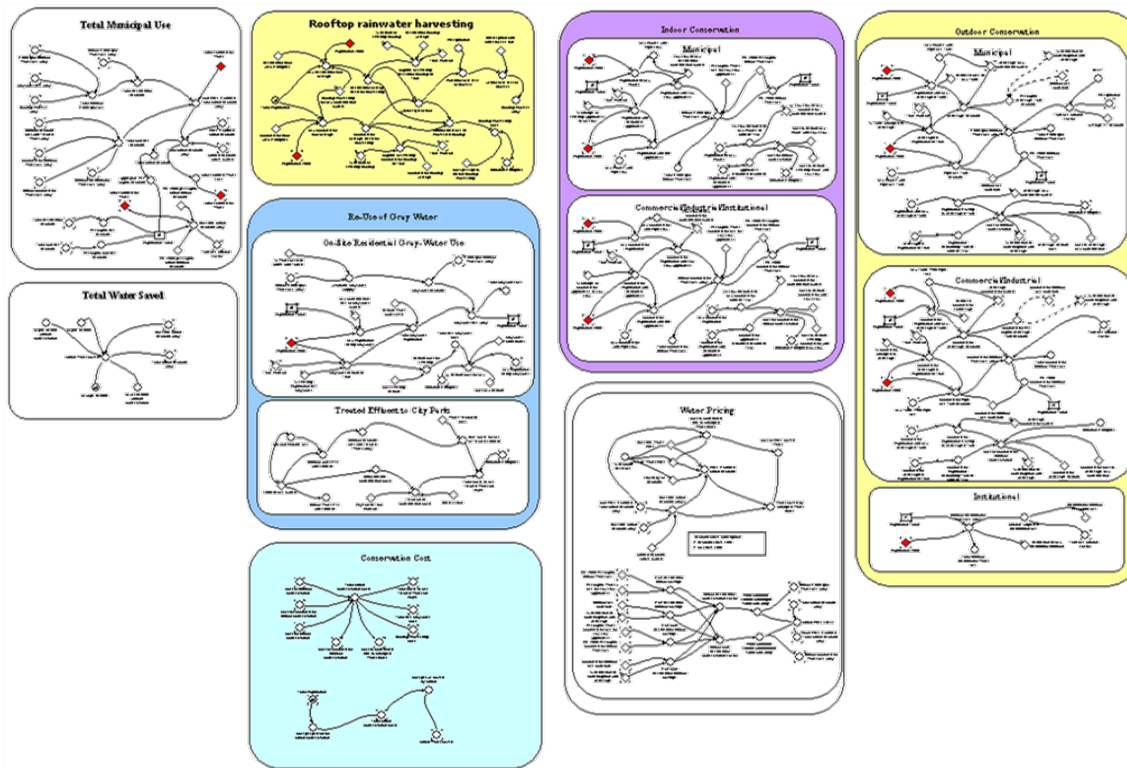
● Well

● Well selected on depth
and salinity criteria

325 downselected formations from
original NatCarb Atlas data

Modeling Deep Saline CO₂ Storage





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