Challenges to Texas Water Quality and Availability

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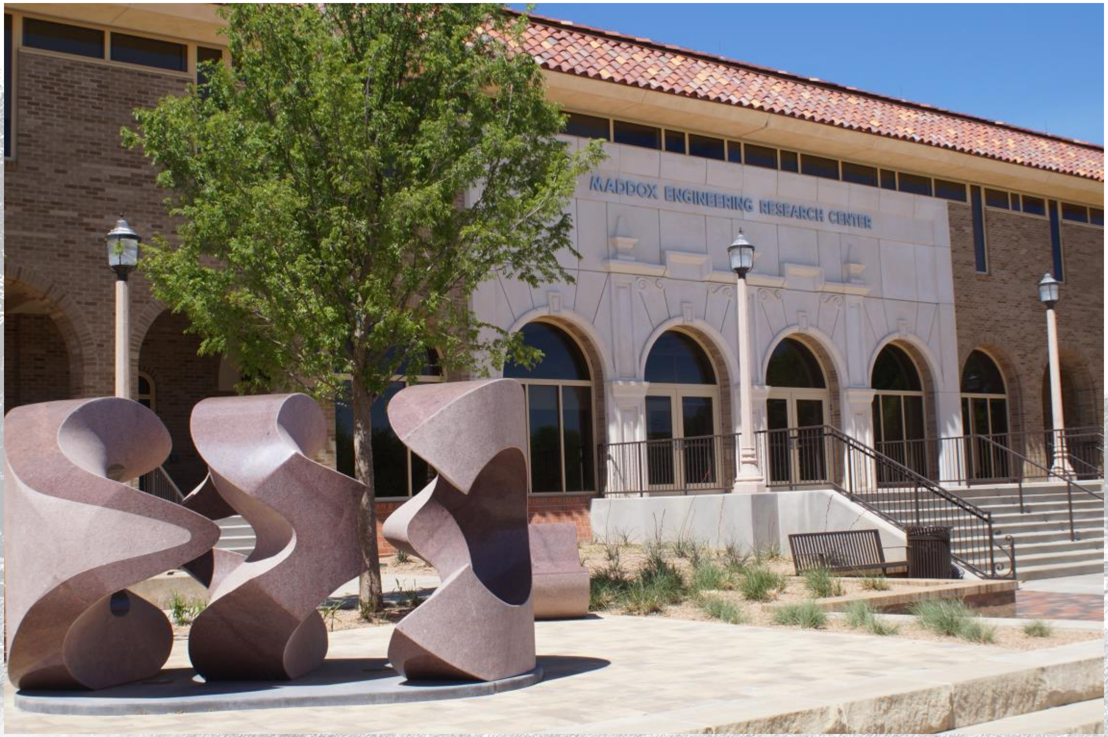


Challenges

- **Water is not valued**
  - ✓ Value added by 1 acre-ft of water in agriculture <\$100 (<\$0.10/m^3)
  - ✓ Municipal value of water \$1000-2000/acre-ft (\$1-2 /m^3)
  - ✓ Hydraulic fracturing for oil and gas >\$100,000/acre-ft (\$100/m^3)
  - ✓ Compare to oil at \$40/bbl = \$314,000 acre-ft (\$330/m^3)
- **Disposal of water is cheaper than treating/recycling**
  - ✓ Social/economic resistance to "toilet to tap"
  - ✓ Produced water disposal wells \$0.10/bbl to \$2-3/bbl (\$0.01-0.24 /m^3)
- **All water problems and solutions are local**
  - ✓ Economics deter any trans-watershed solutions
  - ✓ Legal- social impediments pose challenges to trans-watershed solution
  - ✓ Ideally water should be fit for use but does the local use fit your water?

Our Focus

- **Technologies and practices to produce more resilient water systems**

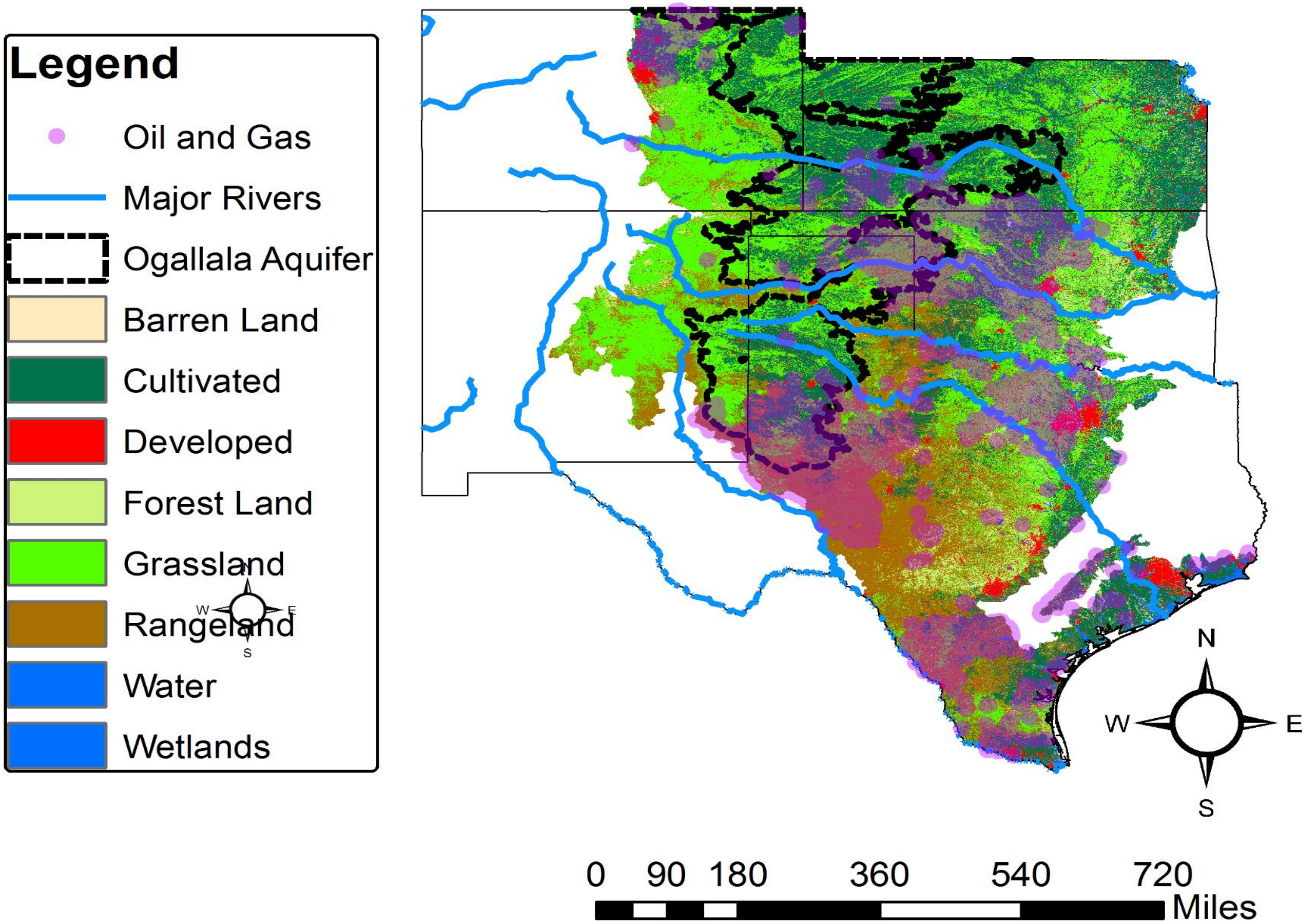
- **Large urban areas have financial, technical and human resources to manage water problems**
  - ✓ Deficiencies from poor planning not lack of capacity?

- **Small western rural and agricultural communities do not have resilient water supplies and do not have the human, technical and financial resources to resolve these problems**
  - ✓ Energy resource development often further stresses water supplies

Water Challenges

- **Too little water**
  - ✓ Population shifts, particularly to the arid southwest, have increased conflicts among urban, agricultural, industrial and environmental needs for water.
  - ✓ Water requires energy, energy requires water and food requires both
  - ✓ Conflicts between human and ecological needs for water increasing
- **Too much water**
  - ✓ Flooding is responsible for 2/3 of all federally declared disasters in the US and their economic and environmental impacts are likely to worsen as climate changes
- **Poor water quality**
  - ✓ Groundwaters of marginal quality throughout much of west
  - ✓ Legacy of contamination from point and distributed sources
  - ✓ Potential new and replacement sources of water generally of poorer quality
- **Inadequate water and wastewater infrastructure**
  - ✓ Aging infrastructure contributing to water loss and quality challenges
  - ✓ Infrastructure inadequately protected from human and natural hazards

Southern Great Plains
Food, Energy, Water, Ecology Nexus



Texas Water Demand and Value

Sources:
Texas Water Development Board
Office of State Comptroller

Irrigated agriculture 56% of consumptive water demand but 0.6-0.8% of economy

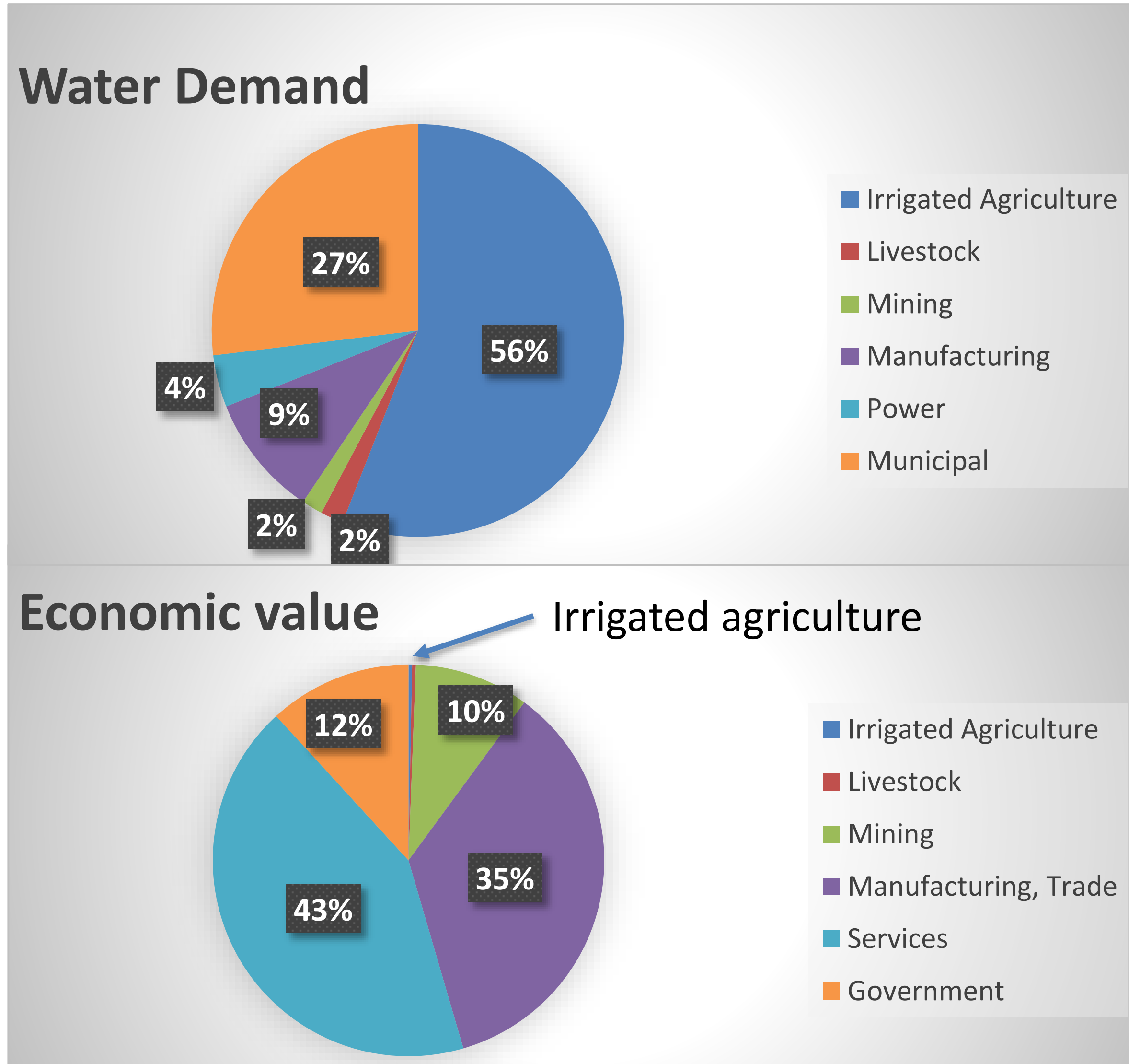
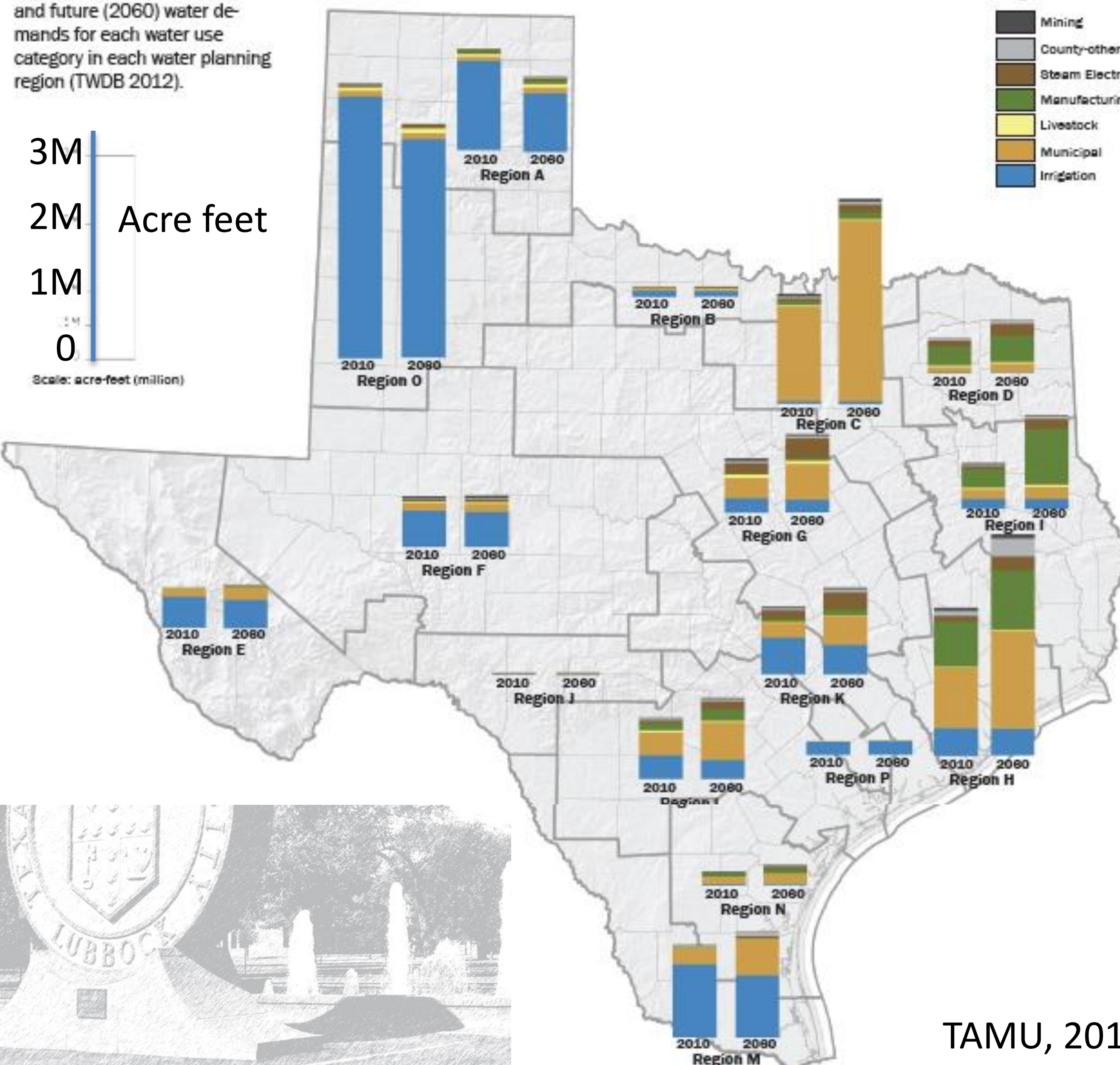


Figure 4. Existing (as of 2010) and future (2060) water demands for each water use category in each water planning region (TWDB 2012).



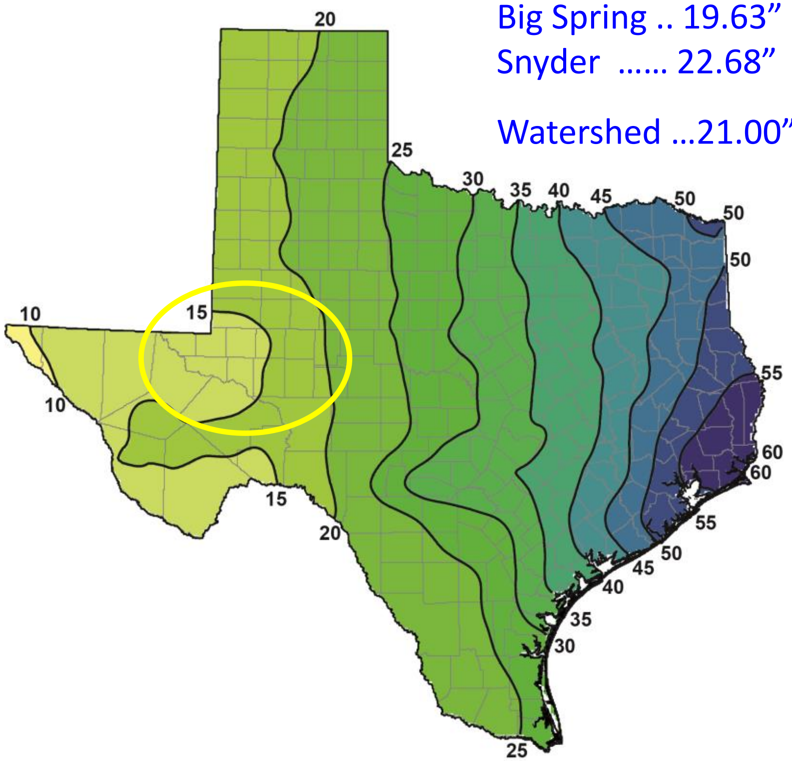
TAMU, 2012

Water Allocation and Demand

Texas Rainfall/Evaporation Map

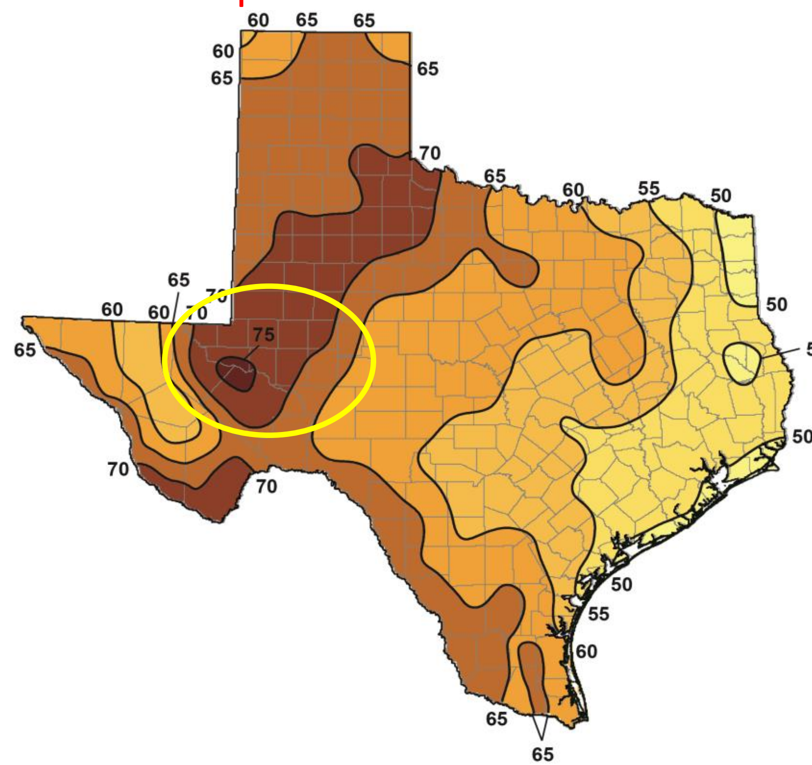
Odessa ….. 14.48”
Big Spring .. 19.63”
Snyder …… 22.68”

Watershed …21.00”



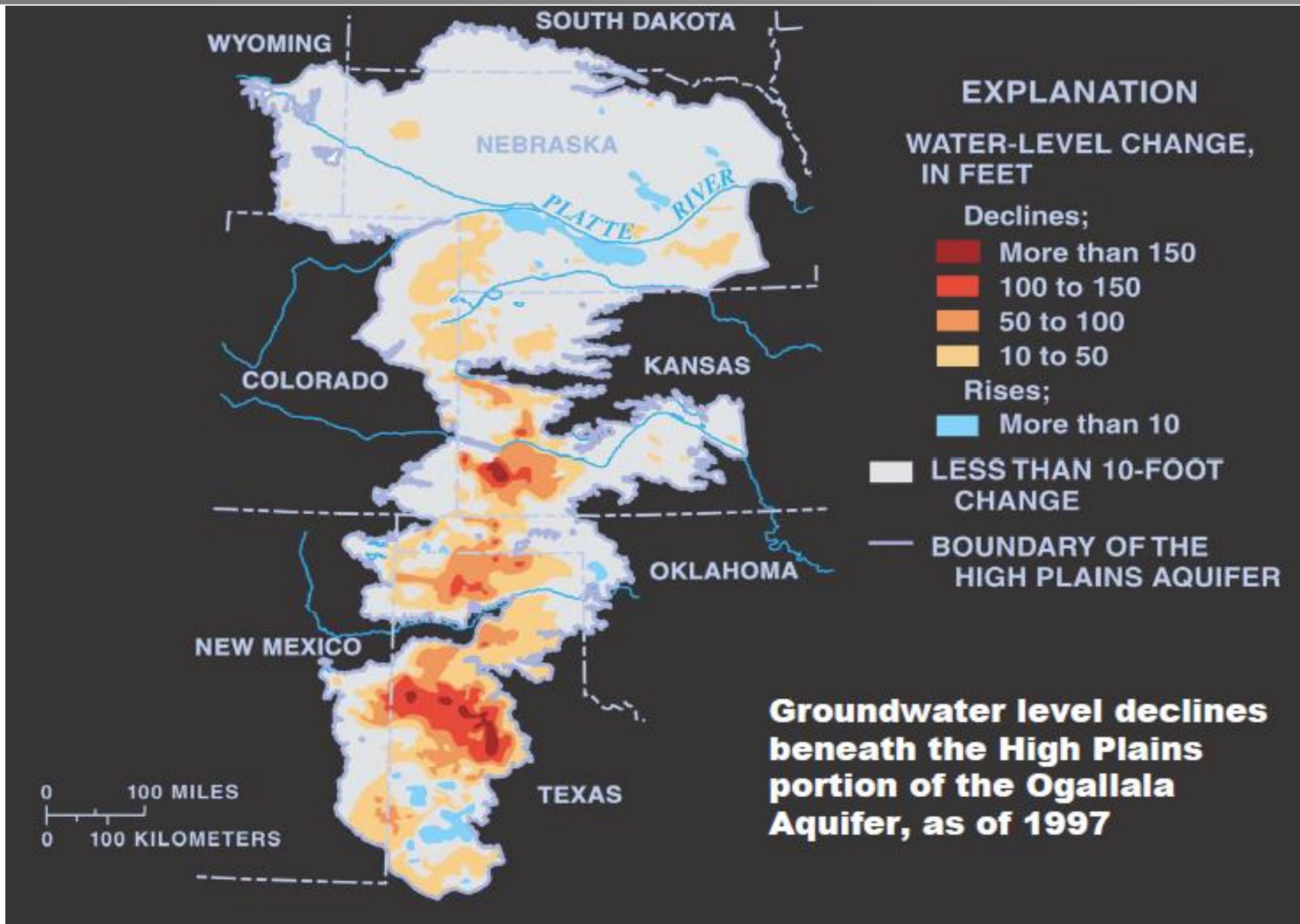
Precipitation

Evaporation- Watershed ….. 61.00”



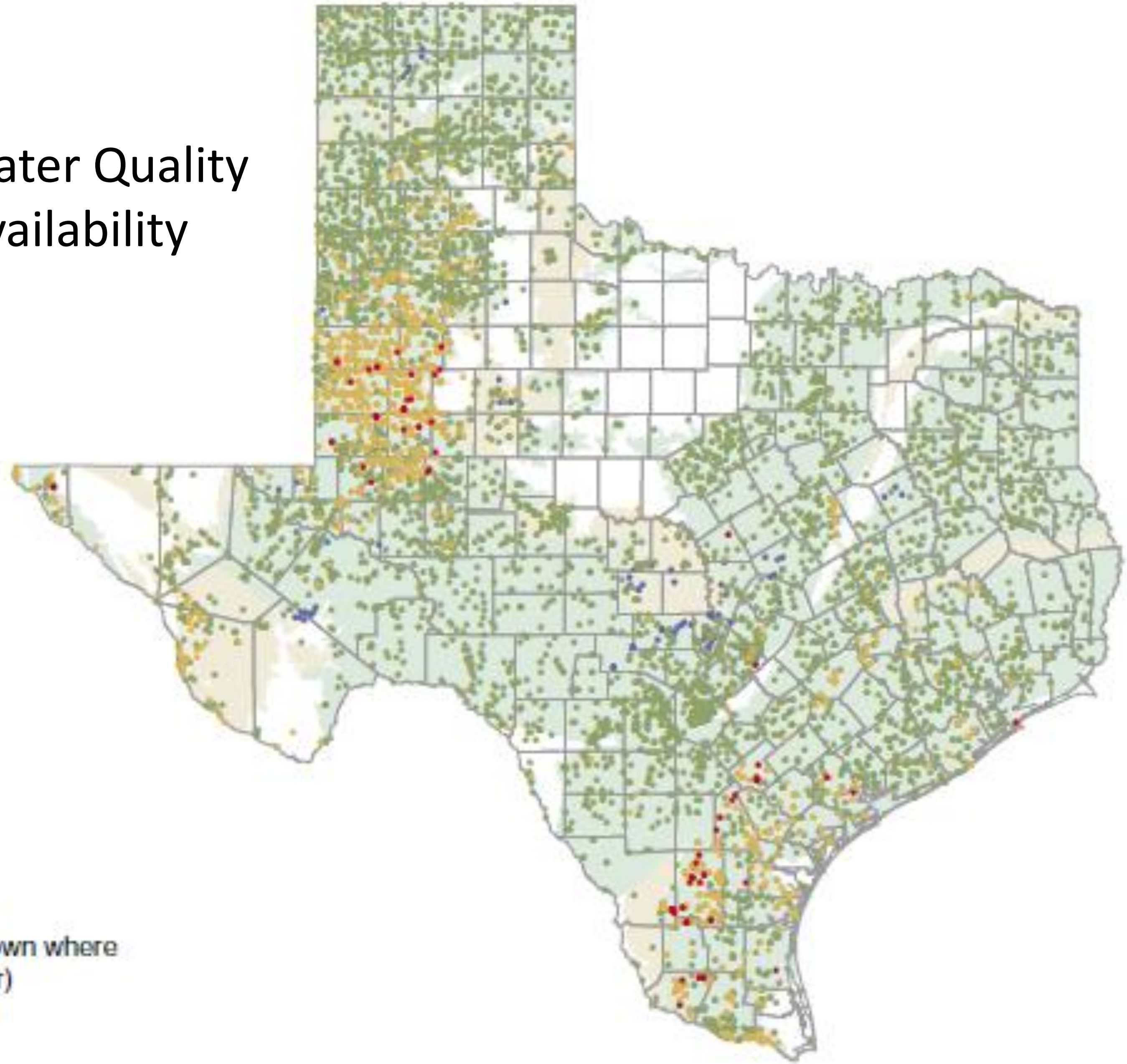
Evaporation

Ogallala groundwater level declines



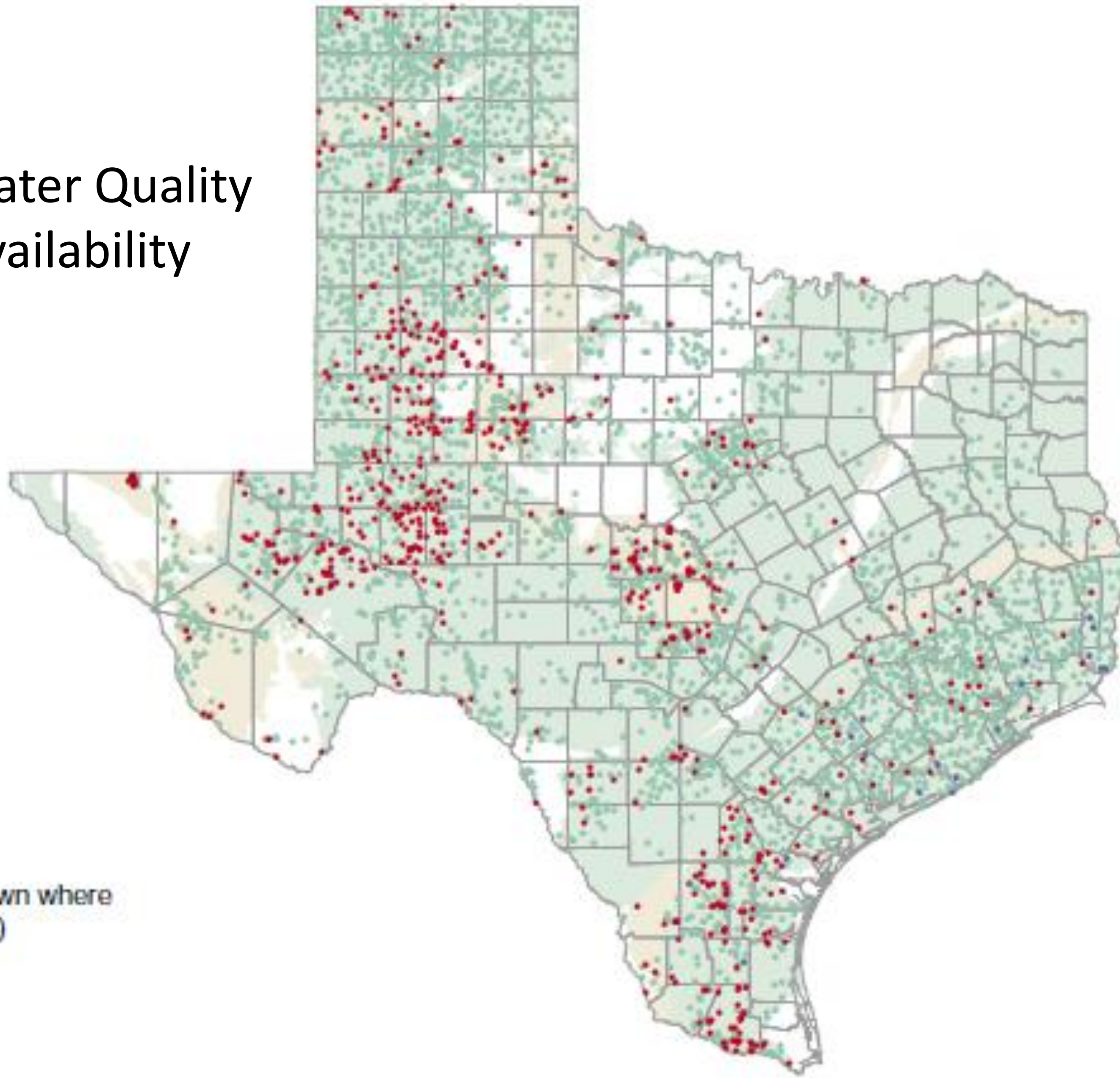
IMPAIRED GROUNDWATER WELLS/AQUIFERS FOR ARSENIC.

Challenges to Water Quality
In Addition to Availability



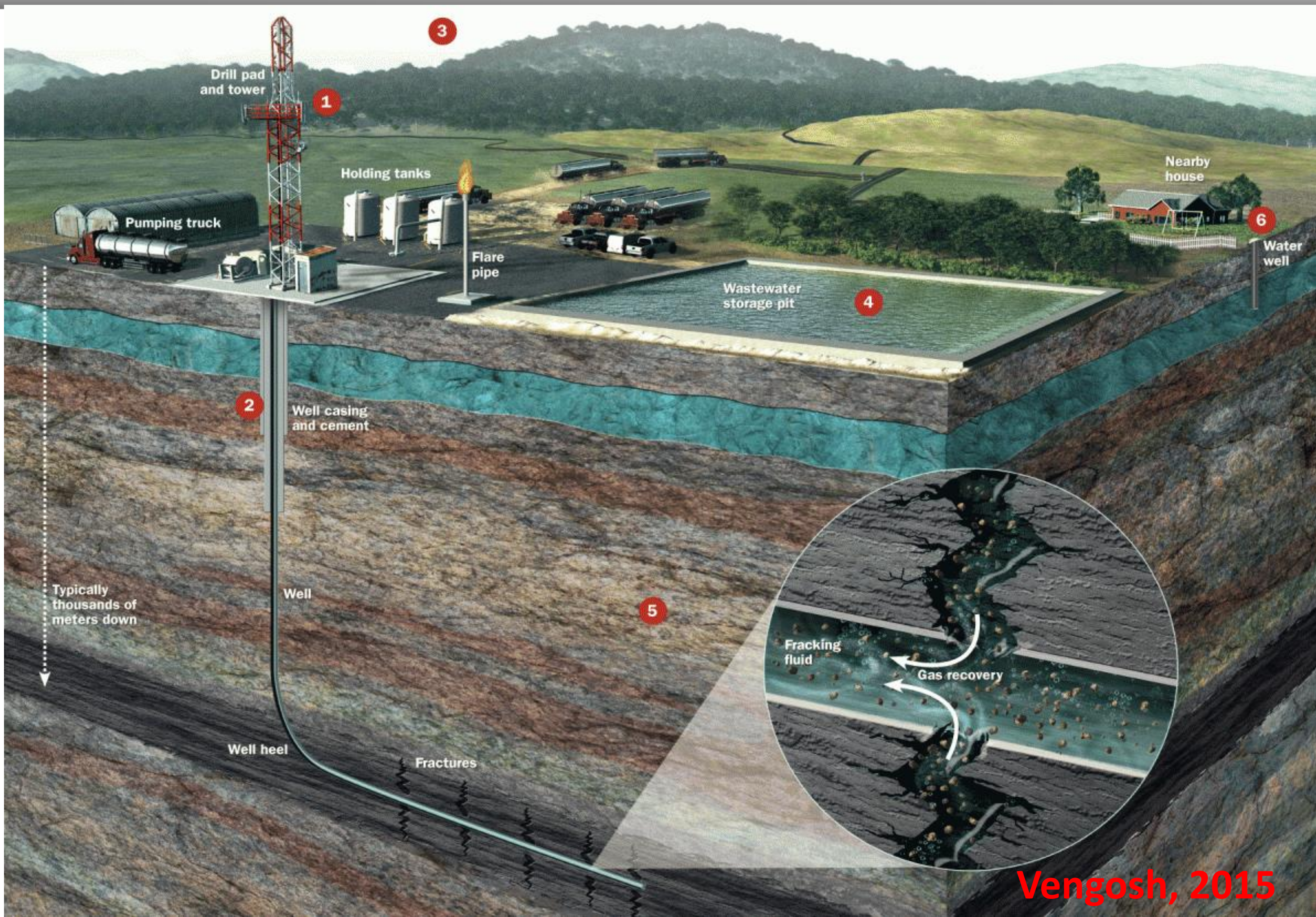
IMPAIRED GROUNDWATER WELLS/AQUIFERS FOR RADIONUCLIDES.

Challenges to Water Quality
In Addition to Availability



Water Needs for Energy

Hydraulic Fracturing?



Vengosh, 2015

Water Needs and Availability Hydraulic Fracturing

- **Typical hydraulic fracturing water needs**
  - ✓ 1000 gal/ft (1128 L/m) of horizontal extent
  - ✓ Total Water needs 4-10 M gallons (15-40,000 m^3)

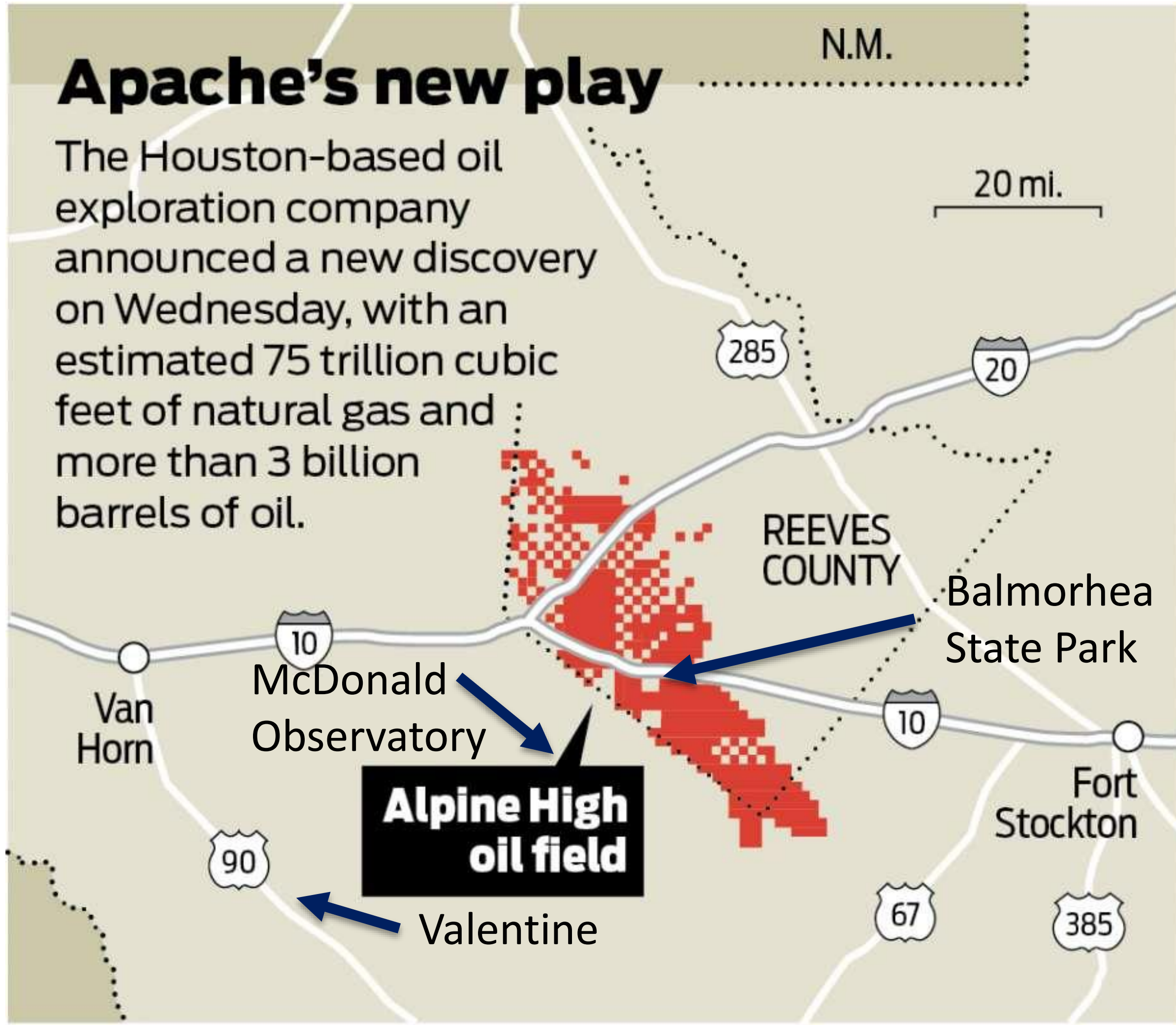
- **Overall small part of water needs**
  - ✓ Texas ~125,000 acre-ft/yr (~ 0.5% of state total use)
  - ✓ Hydraulic fracturing for gas one of most water-efficient technologies for energy

- **But local challenges- Eagle Ford Play in South Texas**
  - ✓ Water demand- 5-6.7% of total (Jester, 2011)
  - ✓ But local use can be much higher
  - ✓ Projected water needs as % of total water use by county in Eagle Ford
    - **Webb – 5.2%**
    - **De Witt – 35%**
    - **Karnes – 39%**
    - **Live Oak – 12%**
    - **Dimmit – 55%**
    - **La Salle – 89%**

Increasingly rural and lower overall water use
(Nicot & Scanlon, 2012)

Alpine High Oil and Gas Play

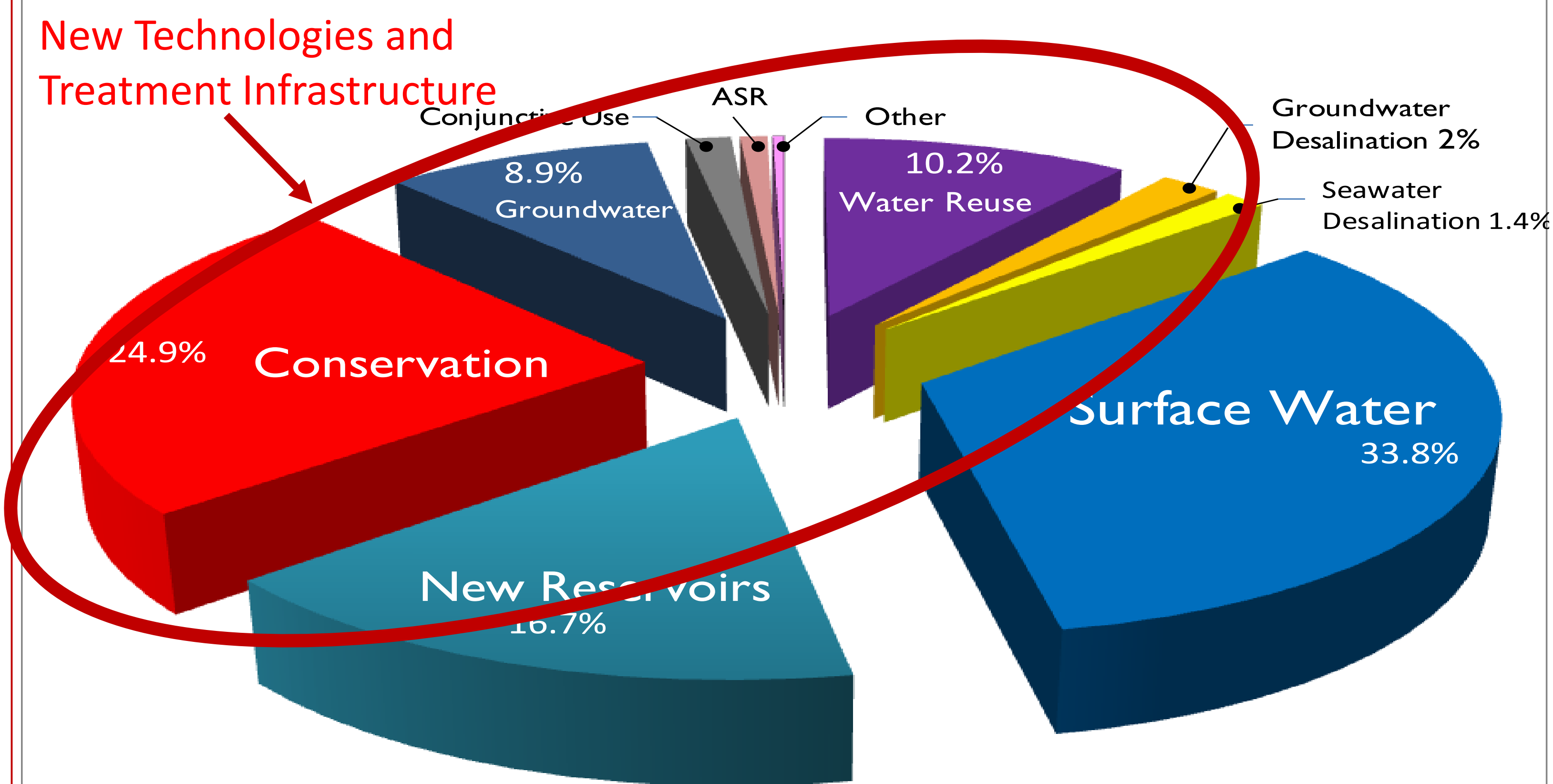
- **Limited water resources**
  - ✓ 10 in rain/yr
  - ✓ Ephemeral rivers
- **Sensitive areas**
- ***Development Controlled by Water Availability!***



Source: Apache

Houston Chronicle

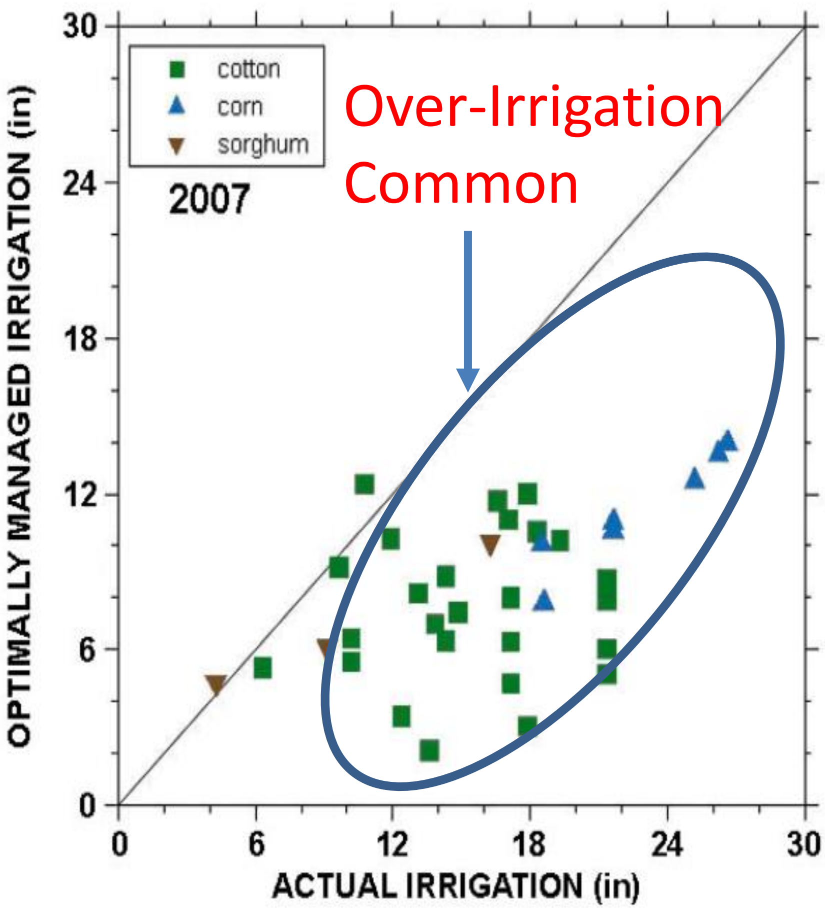
Building Resilience….Strategies



Developed by Regional Water Management Districts: Cost- $53 Billion

Texas Water Development Board, 2012

Agricultural Irrigation



Approaches

– Appropriate crop selection
  – Efficient hybrids
– Efficient Irrigation Systems
  • Drip irrigation
– Efficient scheduling
  • Canopy Temperature Control
  • Satellite Soil Moisture Sensing
– Target ~80% of crop ET needs

evapotranspiration needs

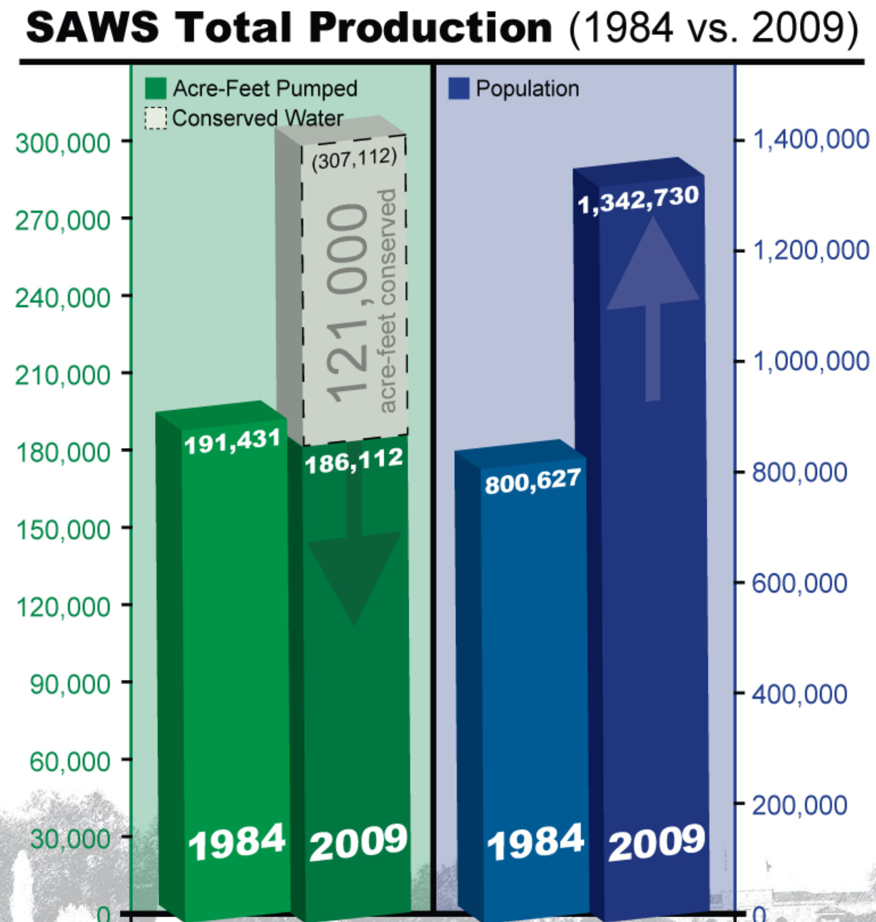
West, 2014

Municipal Conservation

San Antonio 1984-2009

Customers ↑ 67%

Water ↑ 0%



Puente, 2012

Alternative Water Sources

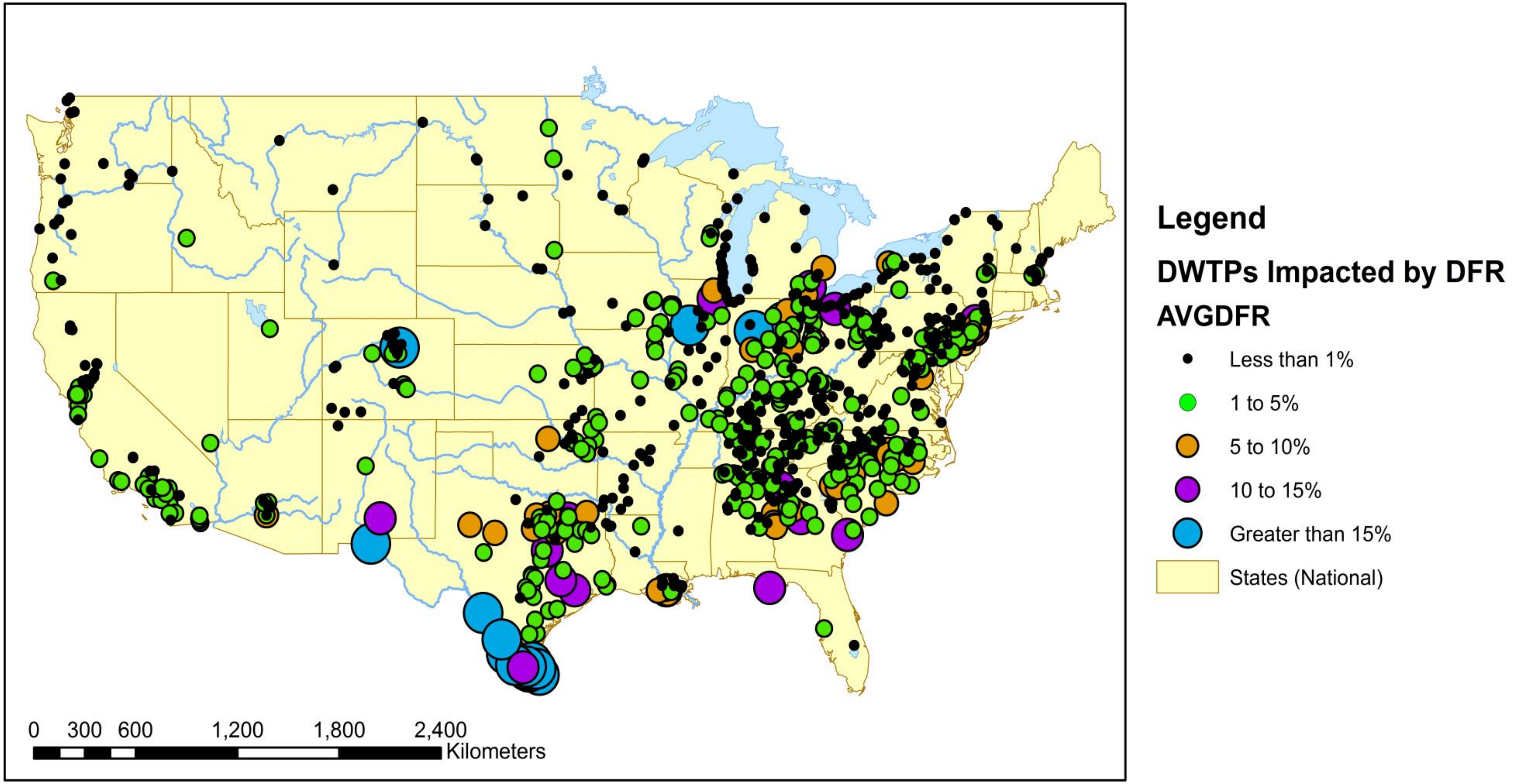
Location, Location, Location……

- **Employ Municipal Wastewaters**
  - ✓ Available in sufficient volume near point of use?
  - ✓ Limited by any requirements for effluent return to surface waters
  - ✓ Can quality be guaranteed for direct reuse?

- **Use of Produced Water**
  - ✓ Typically very poor quality limits its use to industrial (hydraulic fracturing)
  - ✓ Sufficient production wells near point of use?
  - ✓ Discouraged by water owners, regulatory issues
  - ✓ Cost of any necessary treatment competitive with disposal

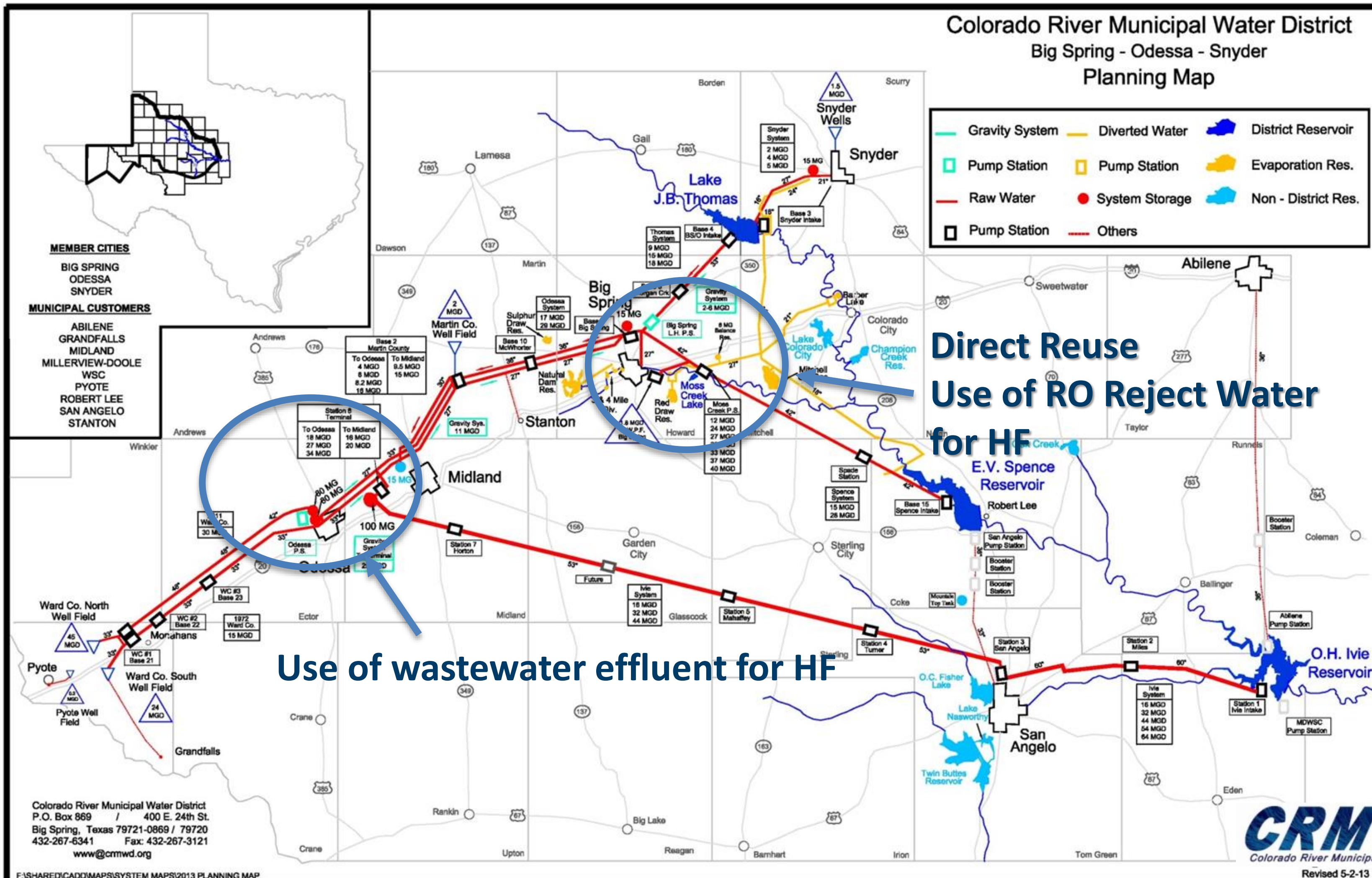
- **Employ Brackish Waters**
  - ✓ Infrastructure, cost and energy requirements for treatment?
  - ✓ Available in sufficient volume near point of use?
  - ✓ Who owns access rights?
  - ✓ Limited by variable chemistry and aquifer characteristics
  - ✓ Connections to surface water and other aquifers?

Magnitude of de facto reuse



Rice, J. and Westerhoff, P. "Spatial and Temporal Variation in De Facto Wastewater Reuse in Drinking Water Systems across the USA", *ES&T*, 49:982-989 (2015)

Reuse Municipal Effluents

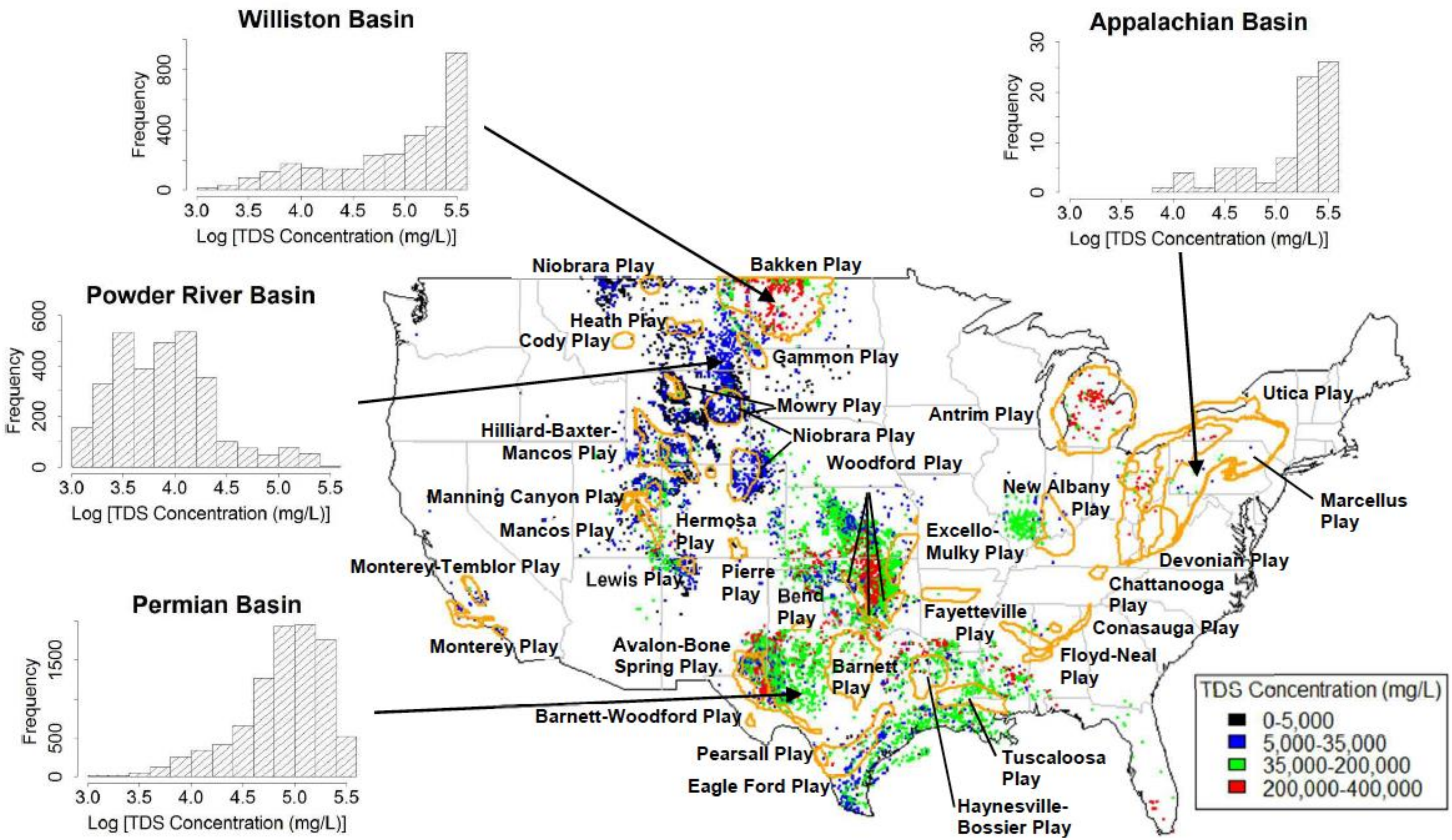


Direct Reuse

Use of RO Reject Water for HF

Use of wastewater effluent for HF

Reuse Produced Water?



Too Saline for anything except industrial uses such as for hydraulic fracturing

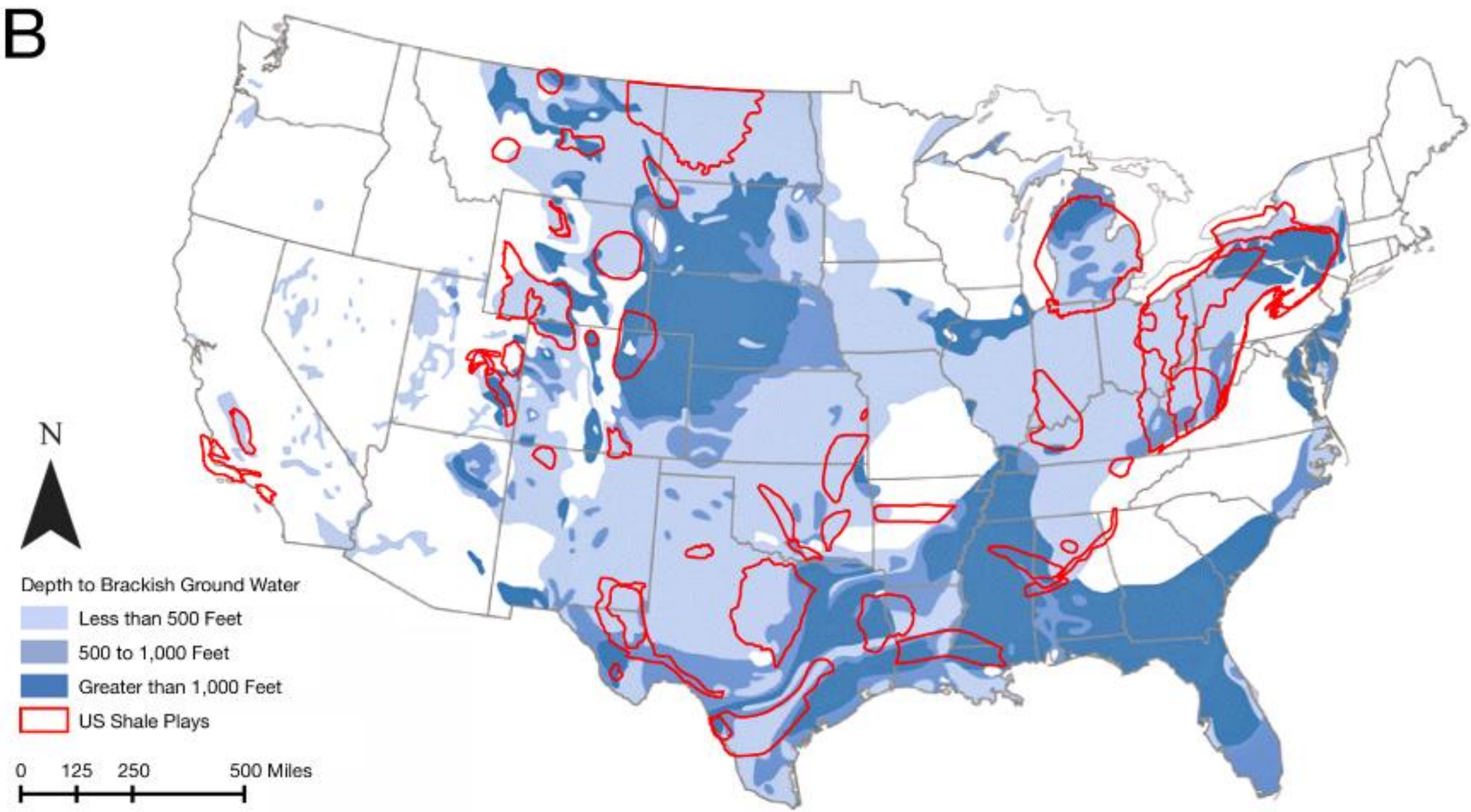
Barriers to Use of Produced Water

- **Poor water quality limits options for beneficial use**
  - ✓ Brackish waters far easier to divert to other beneficial uses than produced water
  - ✓ Cheaper to desalinate seawater and pump to west Texas than desalinate produced water?

- **Primary option for produced water is use as hydraulic fracturing fluid but barriers remain**
  - ✓ Low disposal costs
  - ✓ Imbalance between produced water and fracturing needs
    - **Volume**
    - **proximity**
  - ✓ Availability of fresh or brackish waters
    - **Landowner benefits from fresh or brackish water sales**
  - ✓ Regulatory impediments
    - **Inability to redirect produced water to non-O&G uses**

Saline Groundwater (Brackish Water)?

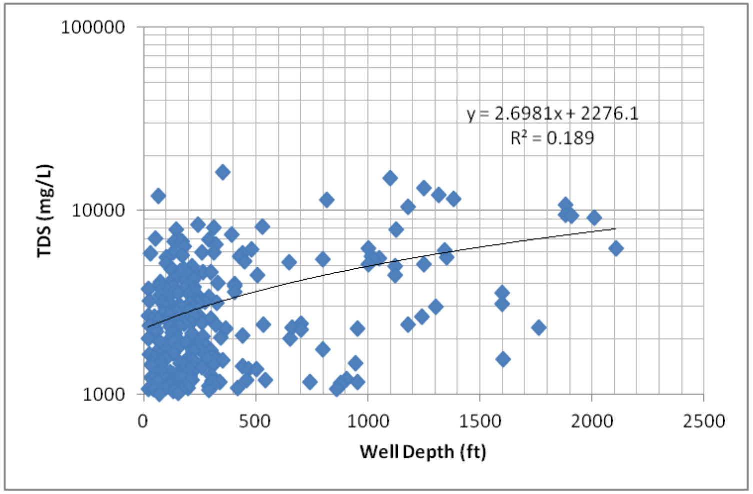
Mauter et al, 2014



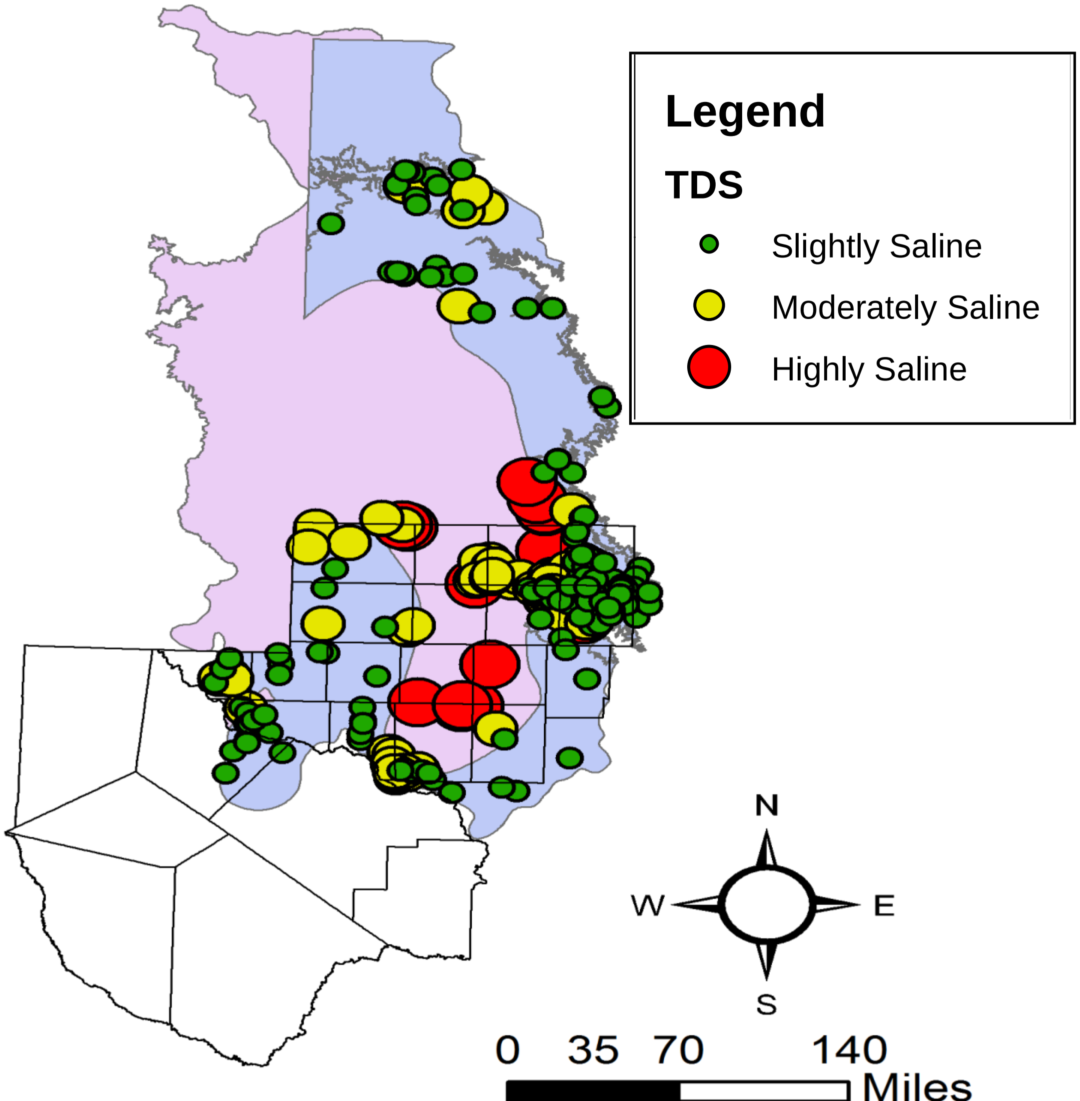
Low Salinity Brackish Water Uses

- **Substantial water reserves**
  - ✓ 10 times Great Lakes in Southwestern US
- **Requires better assessment**
  - ✓ Chemistry and implications
  - ✓ Productivity of aquifers, aquifer characteristics
- **Requires efficient use of technologies for utilization**
  - ✓ FIT FOR USE! Change the use not the water
  - ✓ Variability a significant challenge to conventional technologies
  - ✓ Opportunities such as electrosorptive (capactive deionization) technology for flexible scalable minimal treatment options
- **There is not "one" solution nor "one" water source**

Brackish Aquifer -Dockum



Extreme Spatial Variability
General increase with depth

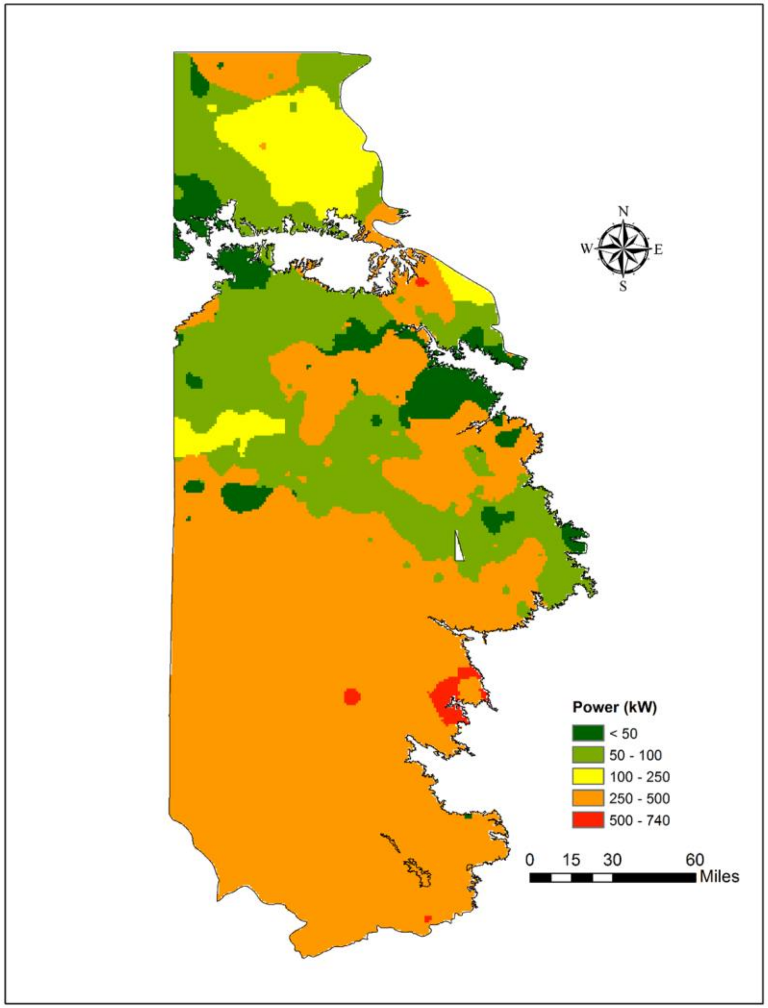


Uddameri, 2016

Energy Requirements for Desalination

- **Direct use of Dockum aquifer under Ogallala limited by Water quality**
  - ✓ TDS > EC > SAR > B

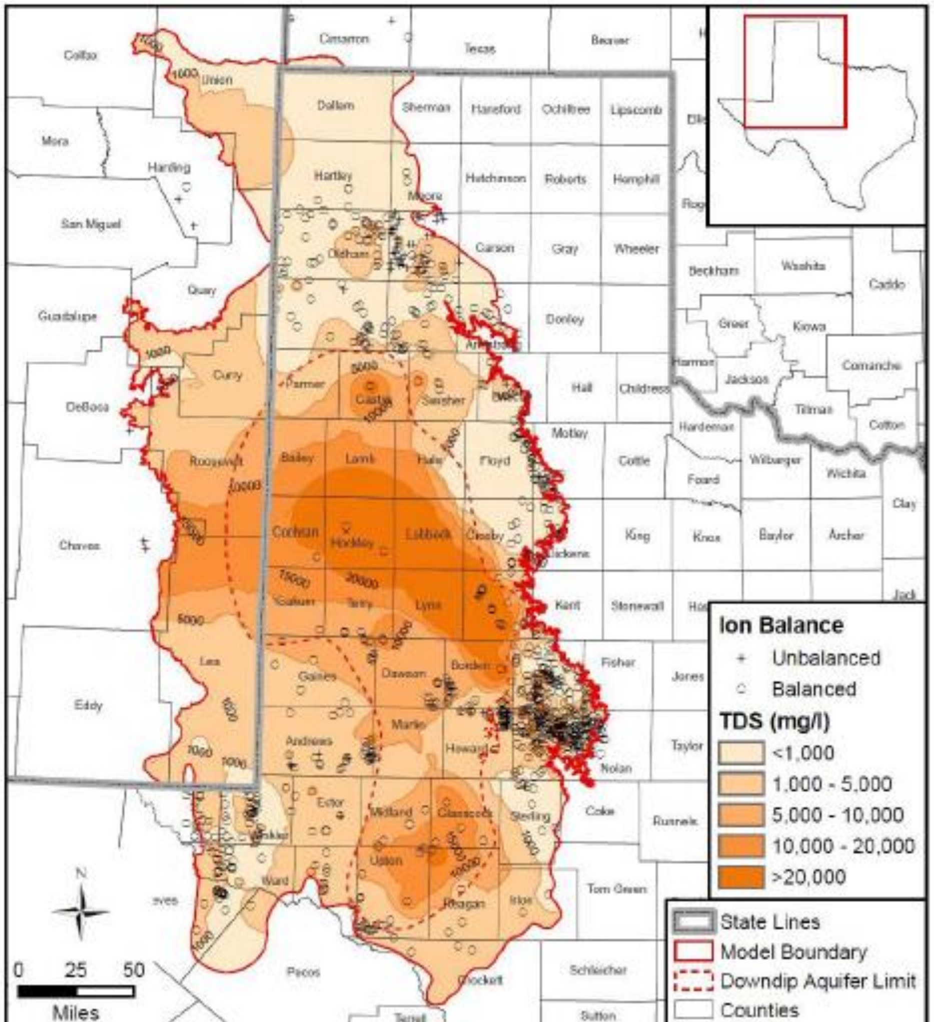
- **Energy needs are highest were water is more scarce**



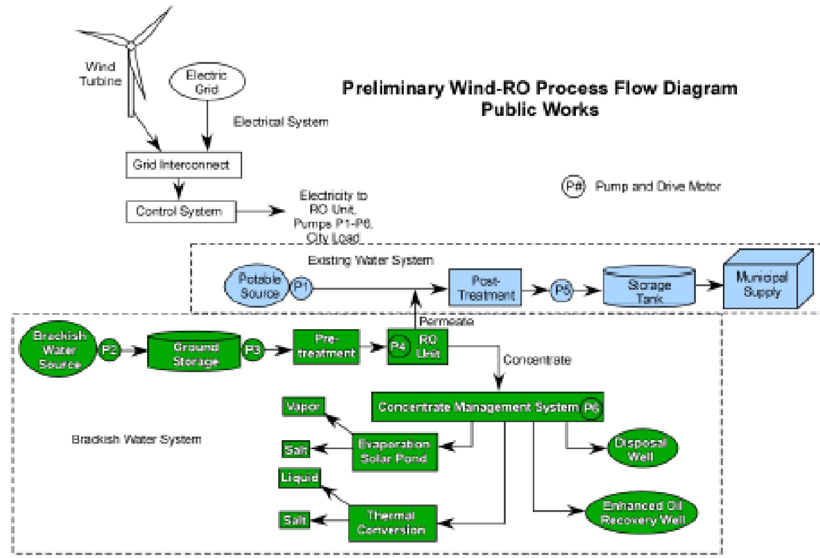
Uddameri and Reible, 2017

Wind Driven Reverse Osmosis Desalination

K. Rainwater, A. Swift



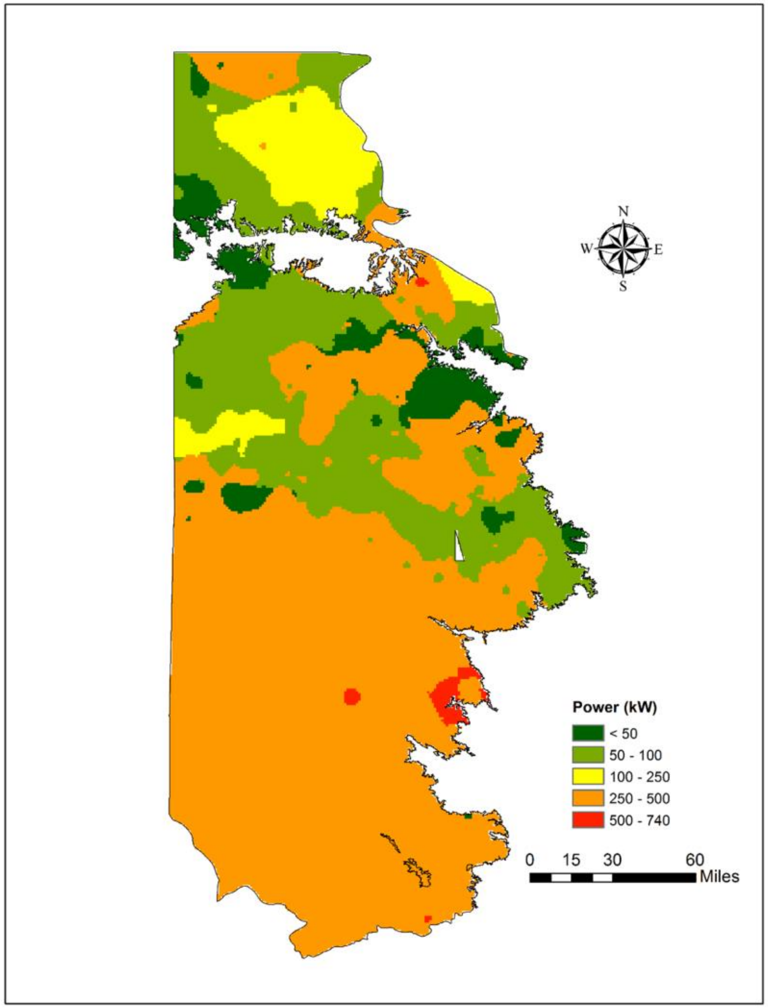
Source: TWDB, Panhandle GCD; USGS/New Mexico; Hart and others (1976)

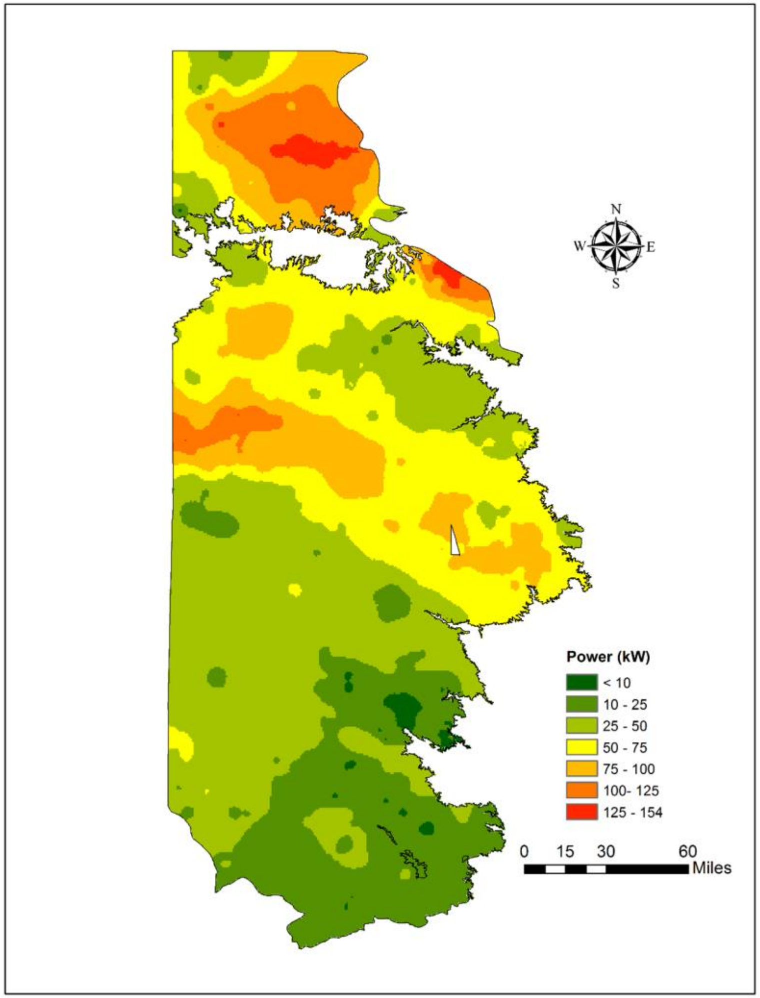


Other uses for brackish water ?

Energy cost of desalinating vs blending for Ag

Uddameri and Reible, 2017





Conclusions

- **Energy development and agriculture place significant demands on water and often in water scarce areas**
  - ✓ Freshwater use can be minimized and sources extended by alternatives
  - ✓ Alternatives for avoiding freshwater use for oil and gas development and hydraulic fracturing
    - **Flowback and Produced Water**
    - **Brackish Water**
  - ✓ Alternatives for increasing high quality water availability
    - **Use of brackish waters with innovative treatment and appropriate blending with freshwater**
  - ✓ Challenges are often logistical rather than technical due to low value of water and cost of transportation and treatment
  - ✓ Should we rethink our paradigm of high quality water for all uses?

Acknowledgements

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Department of Homeland Security
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