**Sustaining Water Availability in Rural Communities**

Expanding brackish water use

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**Perspective on the “Global Water Crisis”**

• A global water crisis doesn’t mean the extent of the crisis or its solutions are uniform

• We don’t really value water

• Irrigated agriculture is largest user, lowest value user and largest exporter of water from arid areas

• Municipal and industrial water users are much more resilient than agriculture – they can afford technological solutions

• There are substantial opportunities for conservation and reuse as well “new” water sources including brackish water

• Despite this, there will be disruptions in supply due to climate variability, market instability and lack of long-term planning
Challenges

• Water is not valued
  ✓ Value added by 1 acre-ft of water in agriculture <$100 (<$0.10/m³)
  ✓ Municipal value of water $1000-2000/acre-ft ($1-2 /m³)
  ✓ Hydraulic fracturing for oil and gas >$100,000/acre-ft ($100/m³)
  ✓ Compare to oil at $40/bbl = $314,000 acre-ft ($330/m³)

• 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 /m³)

• 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
Southern Great Plains
Food, Energy, Water, Ecology Nexus

Legend
- Oil and Gas
- Major Rivers
- Ogallala Aquifer
- Barren Land
- Cultivated
- Developed
- Forest Land
- Grassland
- Rangeland
- Water
- Wetlands

Ogallala groundwater level declines

EXPLANATION
WATER-LEVEL CHANGE, IN FEET
- Declines: More than 150, 100 to 150, 50 to 100, 10 to 50
- Rises: More than 10
- LESS THAN 10-FOOT CHANGE

Groundwater level declines beneath the High Plains portion of the Ogallala Aquifer, as of 1997
Water Needs for Energy

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 m³)

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!

Apache's new play
The Houston-based oil exploration company announced a new discovery on Wednesday, with an estimated 75 trillion cubic feet of natural gas and more than 3 billion barrels of oil.

Building Resilience….Strategies

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

Texas Water Development Board, 2012
Saline Groundwater (Brackish Water)?

Mauter et al, 2014

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Research Needs to Expand Use of Brackish Groundwater

• Brackish Aquifers
  ✓ Depth and areal extent largely known
  ✓ Quality partially known but resolution marginal
  ✓ Transmissivity, productivity of brackish aquifers needed

• Optimal Use and Treatment Approaches
  ✓ Variability a significant challenge to conventional technologies
  ✓ Opportunities for non-membrane technologies such as electrosorptive (capactive deionization) technology
    • Robust
    • Scalable
  ✓ Appropriate use schemes
    • Better implementation of “fit for use” – minimize treatment
    • Distribute marginal quality water with point of use treatment?
    • Blending schemes to extend freshwater supplies and minimize treatment
Brackish Water Characteristics
Variability makes use technologically challenging

Legend
TDS
- Slightly Saline
- Moderately Saline
- Highly Saline

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
Other uses for brackish water?

Energy cost of desalinating vs blending for Ag

Uddameri and Reible, 2017

An Alternative Vision for Water Delivery

- **Current practice**
  - Deliver high quality water for all uses
    - ~2% is used for drinking and cook
  - Attempt to move toward segregation of grey water and expand reuse

- **A model more consistent with “fit for use”**
  - Deliver marginal quality water
    - Blend with freshwater for non-potable uses?
    - To allow for inadvertent consumption likely must be treated for pathogens
  - Employ simple scalable technologies to treat water for human consumption
    - Need simple, low maintenance technologies
    - Energy requirements not a significant concern due to low volumes required
  - Implementation
    - New community/development structured as demonstration
    - With infrastructure for delivery of non-potable waters
Brackish Water Desalination Using CDI Electrosorptive Technology

Capacitive Deionization at Texas Tech

Scaled up to meet a single family's need for drinking water
Conclusions

• Energy development and agriculture place significant demands on water and often in water scarce areas

• Rural agricultural areas have limited capacity to respond to challenges of water availability and quality

• Challenges are often logistical rather than technical due to low value of water and cost of transportation and treatment

• Alternatives for increasing high quality water availability
  ✓ Use of brackish waters with innovative treatment and appropriate blending with freshwater

• Rethink our paradigm of high quality water for all uses?
  ✓ Robust low efficiency treatment on small fraction of high quality needs?