

RETHINKING PRODUCED WATER

Oklahoma Governor's Water Conference

12-4-2019

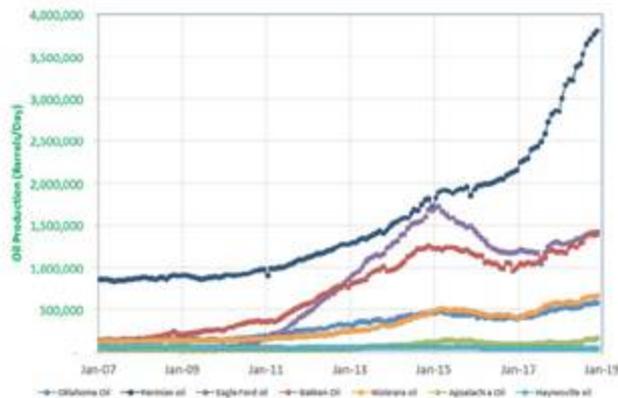

Marathon Oil

Stack/Scoop Production and Water

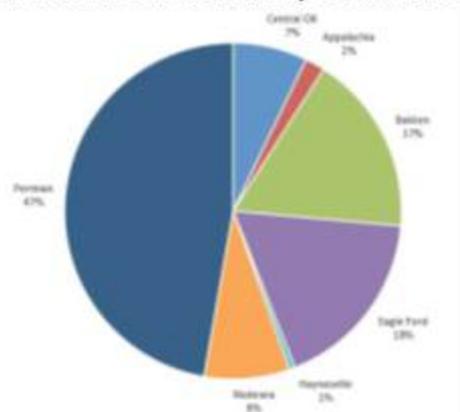
Overall, WOR (water to oil ratio) is expected to be less than 3 with some areas not returning all of the original stimulation water

Water production is highest from new wells with water rates declining fairly quickly

Cost is a key driver of water management and reuse



U.S. Onshore Oil Production by Basin: Dec 2018



Lifecycle of Water Management in the Oilfield

<u>Sourcing</u>	<u>Treatment</u>	<u>Storage</u>	<u>Transport</u>	<u>Disposal</u>
Fresh ↓	Mobile Unit —	Frac Tanks ↓	Trucking ↓	Saltwater Disposal Wells ↑
Brackish ↑	Fixed Plant —	Impoundments ↑	Permanent Pipelines ↑	Reuse in new Frac Wells ↑
Reuse ↑	Wellsite bacteria only —	Above-ground Storage Tanks (ASTs) ↑	Temporary Lines ↑	Reuse outside oil & gas —

Supply

- Intermittent access to large volumes of water necessary (100K-300K per well)
- Ability to cost effectively transport water from source to production site
- Quality is dependent upon frac design



Produced Water Management

- Development Plan
- Quantity and Quality of produced water
- Availability and logistics of disposal options
- Storage and treatment requirements for reuse

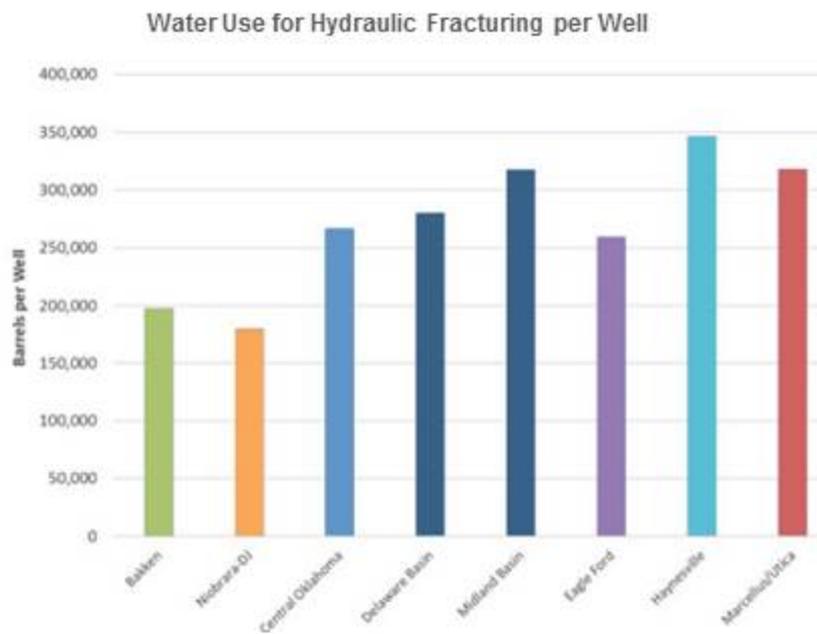
Supply Considerations

In Oklahoma, industry uses a variety of sources for frac water including; surface water, groundwater and recycled produced water

In general, existing sources of water are used when a play is early in development and/or operator acreage is disaggregated

Lease requirements and the ability to use layflat lines to transport water are critical factors when determining a viable supply source

Water constraints and/or water stress in the focus area



Source: After FracFocus, <http://www.fracfocus.org>

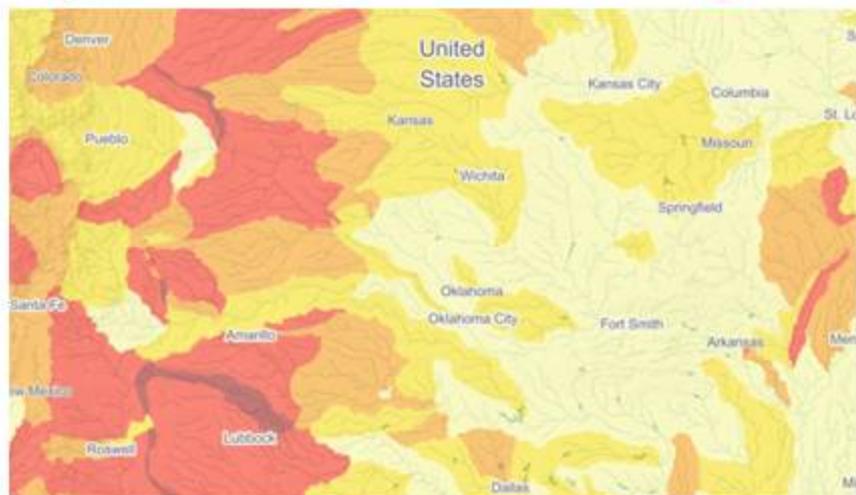
Water Stress

Western Oklahoma has the highest water stress ranking in the state with the Ogallala aquifer experiencing a 9 ft decline over 15 yrs and Rush Springs aquifer declining by 7 ft in the same period



Source: OWRB Website

Physical Water Stress for Oklahoma Region



Source: Aqueduct Water Risk Analysis, Water Research Initiative

Disposal Landscape

Development of midstream water management companies has allowed water haul to pipe conversion for smaller operators and those with disaggregated acreage

Low water cuts in the new plays result in better capital management through multi-operator use of disposal/reuse infrastructure in a volatile commodity environment

Strain on existing infrastructure, both supply and disposal, is driving innovation in the reuse space



Figure 2-13: Water Lifecycle Costs without Reuse
Source: Jacobs Engineering



Figure 2-14: Water Lifecycle Costs with Reuse
Source: Jacobs Engineering

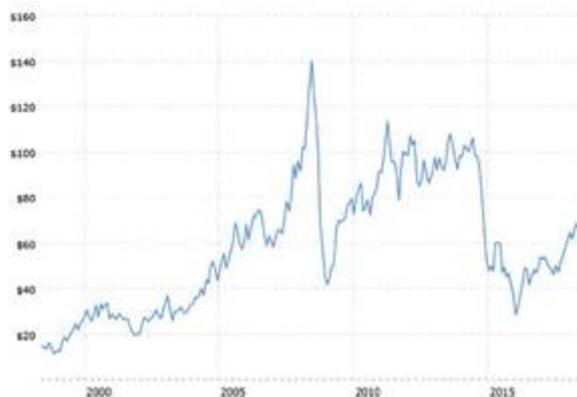
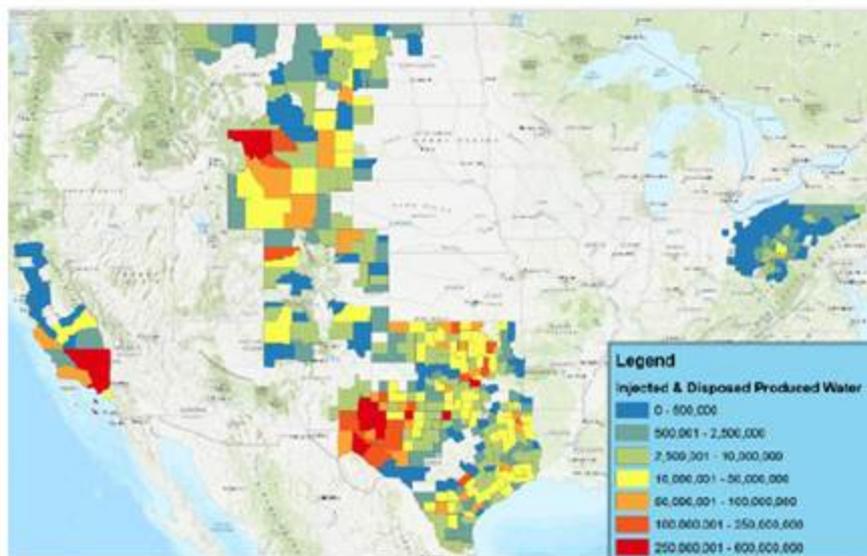
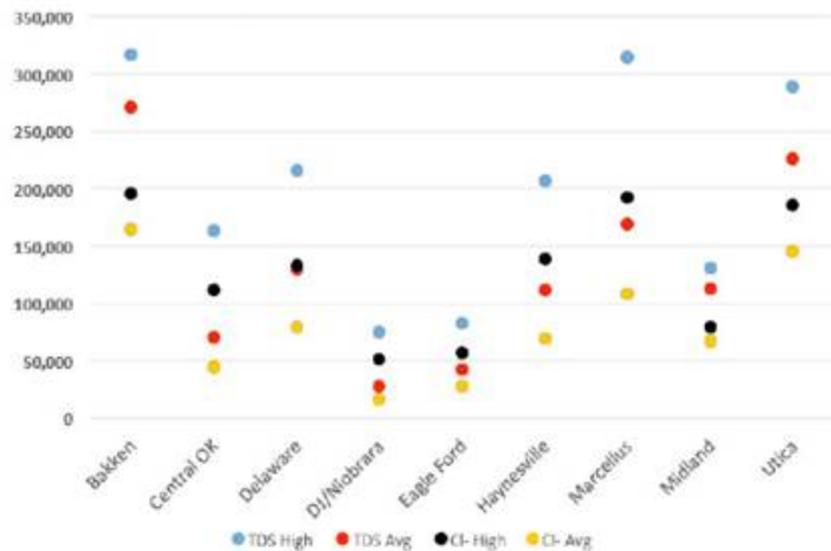


Figure 2-15: Oil Prices Since 2000

Produced Water Quality and Quantity



Legislative Momentum to Advance Reuse

NM-546 The Produced Water Act intends to encourage the reuse and recycling of produced water, particularly for use within the oilfield to relieve stress on available water supplies and disposal infrastructure.

- The Act created necessary clarity to encourage investment in the recycling and reuse of produced water considering ability to transact (possessory interest/ownership) and liability.
- The Produced Water Act also took the first step in clarifying regulatory oversight for produced water use within the state.
- The Act prevents landowner's from forcing the use of fresh water when treated water is available or charging tariffs to transport recycled water on State Surface lands.
- The Produced Water Act was widely supported by state regulators, industry, agriculture, and environmental groups. It passed unanimously the House of Representatives and by a large majority in the Senate.

TX HB 2767/3246 The purpose of both bills was to clarify ownership issues of produced water and provide some limitation for tort liability when transferring produced water for reuse.

- 2767-Allowed for the ownership of produced water for the purpose of treatment and reuse to be transferred from the generator to the treatment company, etc. with limited protection for tort liability
- 3246-Clarified that ownership of produced water resides with the operator (originally) to cover the situation of internal reuse of produced water by a single operator

TX HB 2771 Required TCEQ to seek delegation of authority for NPDES discharges from the EPA by 2021

Existing Produced Water Use Within the Oilfield

Companies have innovated to be able to use higher salinity source water in their fracturing operations opening the door to limited treatment recycle and alternative water sourcing from brackish resources

Key Factors for Successful Reuse:

- Consolidation of enough produced water (either stored or pipelined) to provide an adequate supply source, typically 50,000 BPD of water dependent upon frac design. Duration is dependent upon the number of wells to be fraced
- Frac design and produced water quality
- Treatment requirements: dependent upon the need to store, cost of treatment, disposal ability for waste generated
- LOGISTICS: Proximity to the well site and the ability to run temporary lines are critical considerations that impact the cost of the job

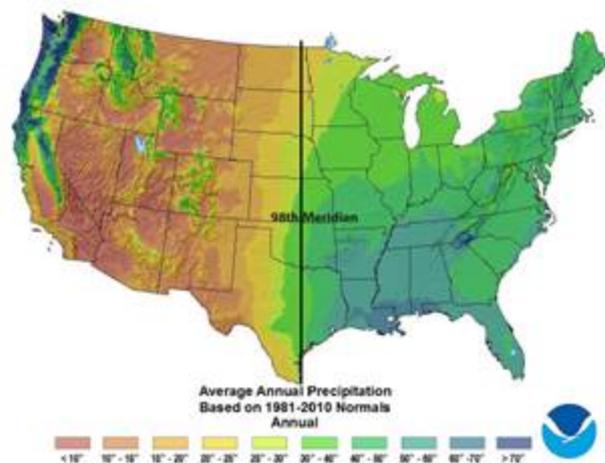
Supplementation of State Water Resources

Oklahoma's forward thinking regarding alternative use for produced water provides the state with options for the most water stressed region of the state

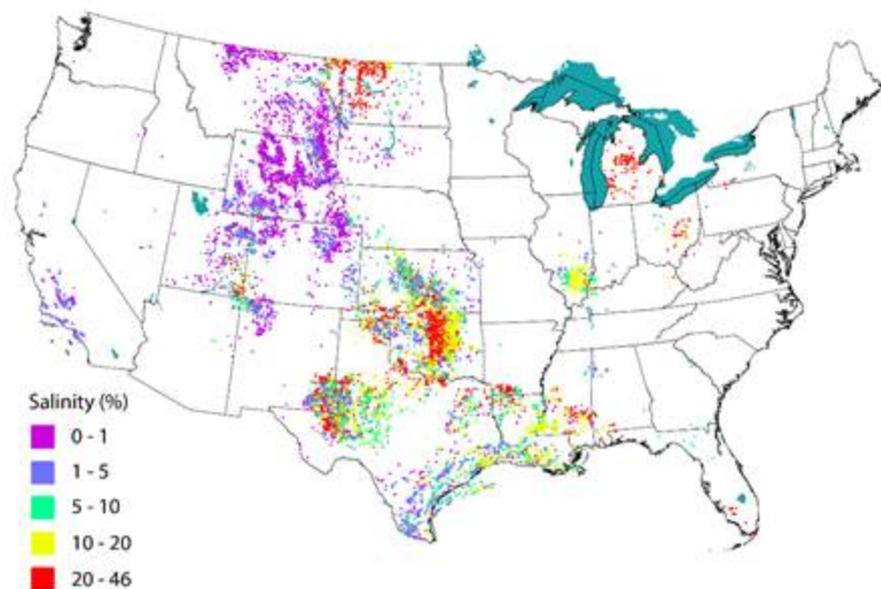
The western half of Oklahoma is west of the 98th meridian which qualifies the state to utilize both 40 CFR Part 435 and 437 of the Clean Water Act.

- Part 435 allows for discharge of treated oilfield waste water to waters of the US for beneficial reuse. 435 is only allowed west of the 98th meridian
- Part 437 allows for discharge of treated oilfield waste by centralized waste treatment facilities

Use of treated water applied to the surface for dust control, agriculture purposes, grassland restoration, stock use, etc. would be subject to ODEQ rules and requirements, which must meet or exceed EPA standards

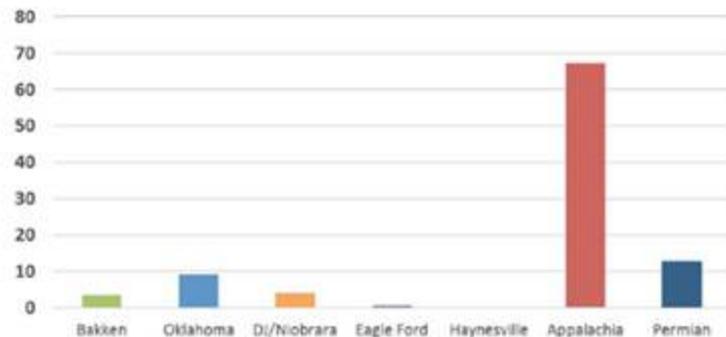


Lower 48 Produced Water Quality



Salinity (total dissolved solids) of produced water in the United States. The comparison of produced water depends strongly on where it comes from and influences options for treatment and reuse. For comparison, seawater has a salinity of 3.5%. Image credit: Terry Atkinson (U.S. Geological Survey)

Percentage of Produced Water Reused by Basin



Reuse Percentage for Key Basins (18 reported companies)

<http://www.qwpc.org/sites/default/files/files/Produced%20Water%20Full%20Report%20-%20Digital%20Use.pdf>

Existing Produced Water Use Outside the Oilfield

Produced water has been used in several states for agriculture or wildlife benefit. These historic uses have predominantly focused on lower TDS (<20,000 ppm) produced water due to the ability to manage TDS through blending and/or cost effective desalination.

A reuse program (outside the oilfield) should consider waste streams generated by the treatment process and identify disposal options. A total cost per usable barrel versus alternative methods of management should be compared along with operational and risk considerations

Examples:

- Thousands of acres in the Powder River Basin (Wyoming and Montana) are irrigated using treated produced water to restore range land/livestock forage and provide livestock/wildlife water
- Aquifer storage and recovery in Wellington, Colorado
- 16 billion gallons of low TDS, treated produced water is used in California for irrigation of crops for human consumption (conventional wells)

Range of Produced Water Quality

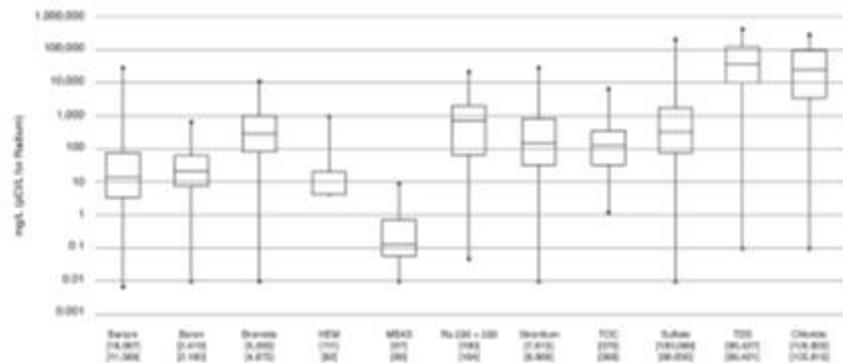


Figure 1-1. Oil and Gas Produced Water Condition Concentration Data (EPA's National Produced Water Geochemical Database, V1.2)

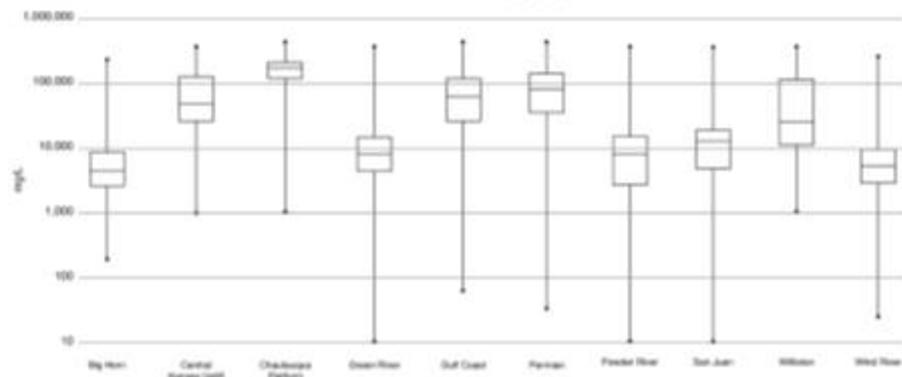
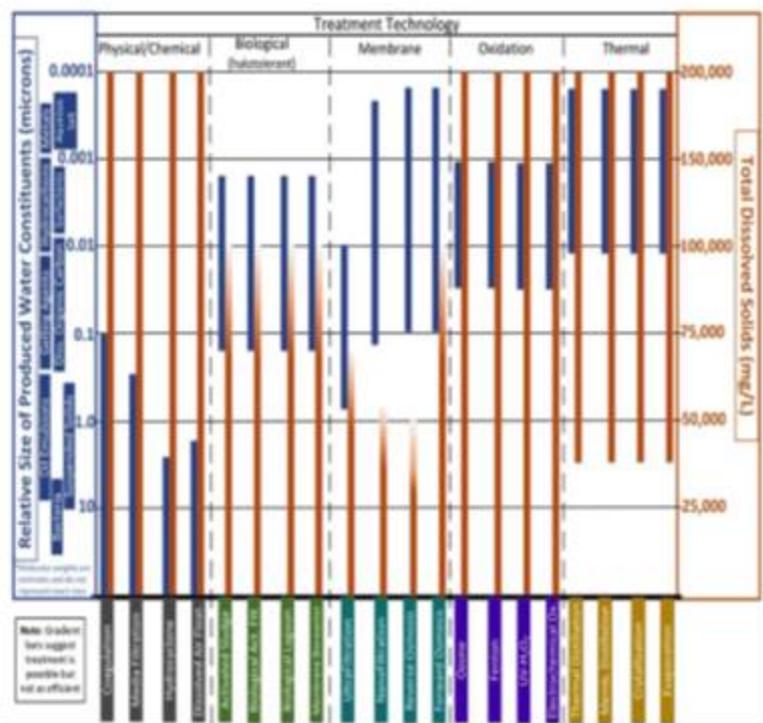


Figure 1-2. Oil and Gas Produced Water TDM Concentration by Basin (EPA's National Produced Water Geochemical Database, V1.2)

Available Treatment Technologies (Fit for Purpose Reuse)

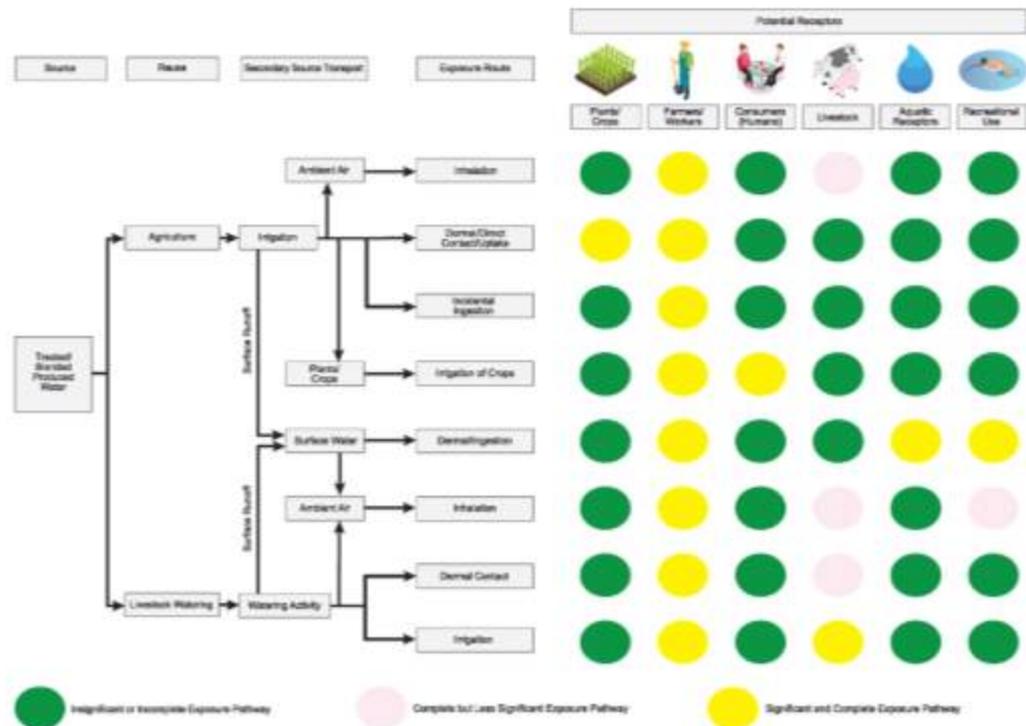
Visual Representation of Treatment Technologies and their Average Capabilities for Constituent Removal



Considerations:

- What quality does the water need to be for the desired use
- Environmental and health assessment
- Cost of treatment increases substantially as treatment moves from the left to the right
- Waste management
- Quality assurance and control

Environmental and Health Risk Assessments



Research Efforts and Studies

Department of Energy

\$100MM Energy-Water Desalination Hub-Focus on early-stage R&D for energy efficient and cost-competitive desalination technologies and for treating non-traditional water sources. Led by NAWI (20 University consortium that includes NMSU, CSM, Rice, UT, Texas A&M and 4 national labs)

Texas A&M Agrilife Research

Agricultural Reuse of Treated Produced Water-Evaluated cotton growth and yield response to irrigating with treated produced water blended with groundwater and determine the effect on soil chemical properties (West Texas focus). Need to conduct additional study with differing blend ratios and alternate crops

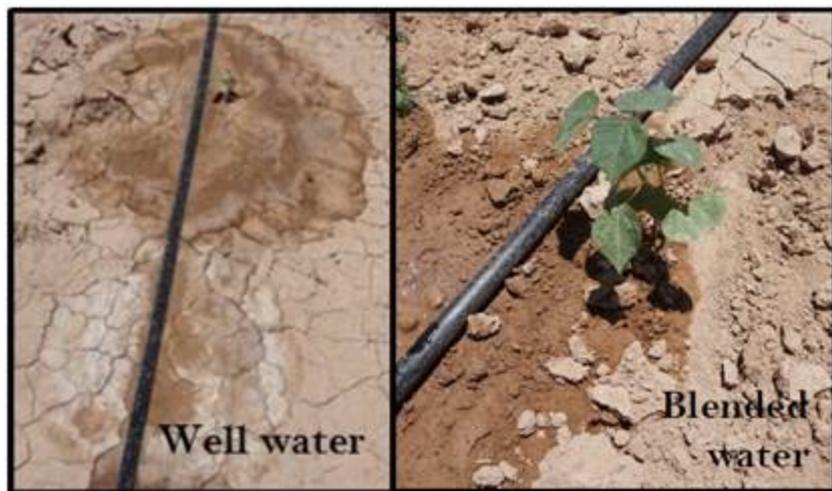
- Study chose cotton (salt tolerant crop)
- Blended water 4:1 ratio, GW:treated produced water
- Treated water TDS was 98 ppm, GW was 3218ppm, blended water 2470ppm
- Summary-Irrigating with treated produced water blended with groundwater did not reduce cotton yield or lint quality and reduced soil salinity parameters

Final Thoughts

Creative use of a waste product can lead to lower costs and more sustainable operations for the unconventional oil and gas industry.

Water midstream infrastructure attracted by unconventional operations can be leveraged by conventional operators to reduce their operating costs.

Thoughtful application of technology coupled with robust regulation and monitoring may provide a drought resistant supplemental state water resource.



Q&A

A photograph of an oil drilling rig in a field at sunset. The rig is on the left side of the frame, and the sun is setting on the right, creating a warm, golden glow. The sky is filled with wispy clouds. The text "THANK YOU" is overlaid in the center of the image.

THANK YOU