The Why, What, Which and How of Water Reclamation

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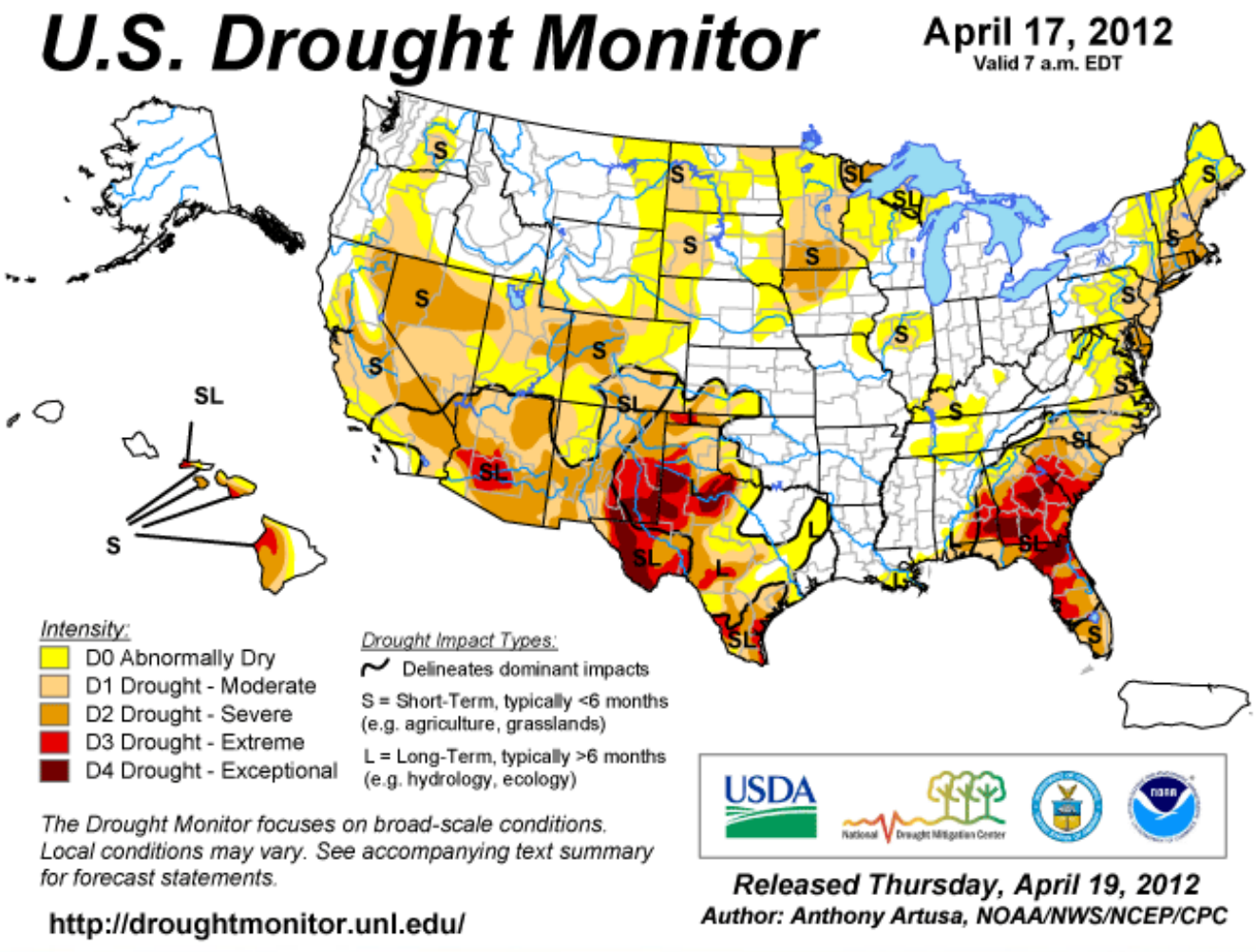
Agenda Topics

- Why Reuse / Reclaim
- Current Practices
- New Technologies
- Improving Vendor Offerings
- Needed Regulation Improvements
- Improving Operator Involvement

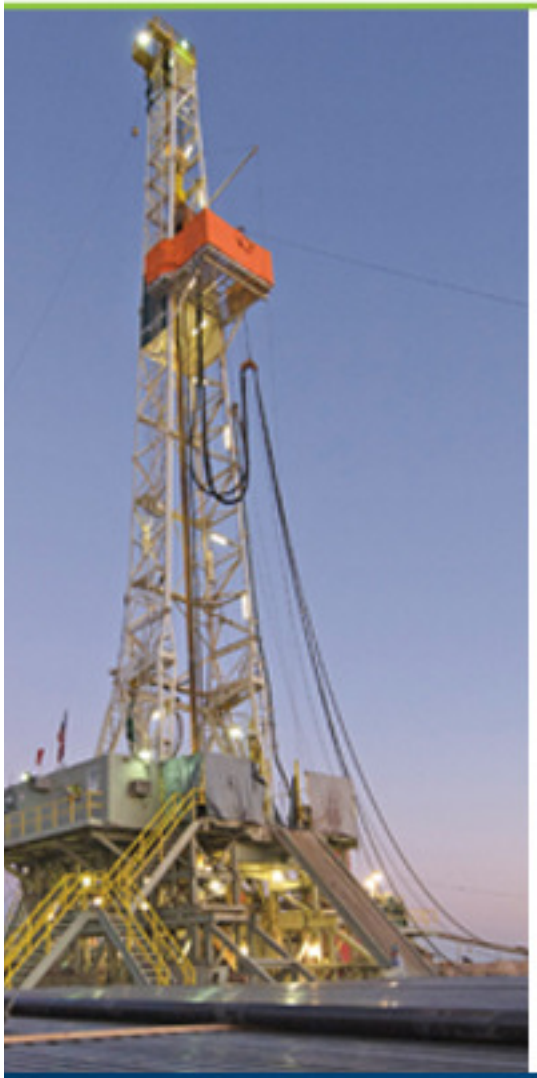
Why Reuse / Reclaim

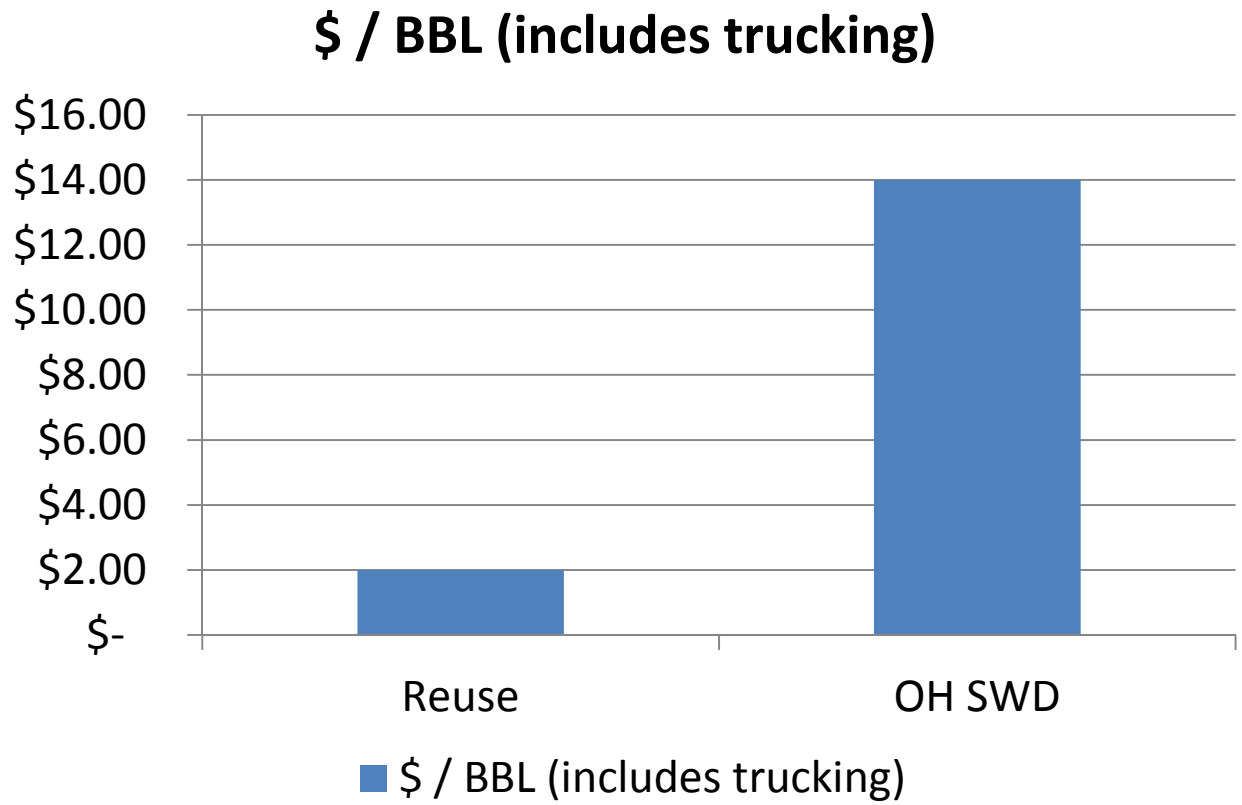


Why Reuse / Reclaim

- Moving brine from NE PA to OH is Costly!

Why Reuse / Reclaim





Why Reuse / Reclaim

- Moving brine from NE PA to OH is Costly!
- A 1 MMCFD well making 143 bwpd is unprofitable with $2.00 / mcf gas and a $14.00 / bbl disposal fee (inc. trucking)
- Road Wear
  - 10,000 bbls with 10 hours travel time
    1.5 MM Ton-miles
- CO_2 Emissions
  - 10,000 bbls to Ohio (12 hours)
    82.57 metric tonnes CO_2
  - 10,000 bbls reused / reclaimed (3 hours)
    21.15 metric tonnes CO_2

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Current Practices

» POTW

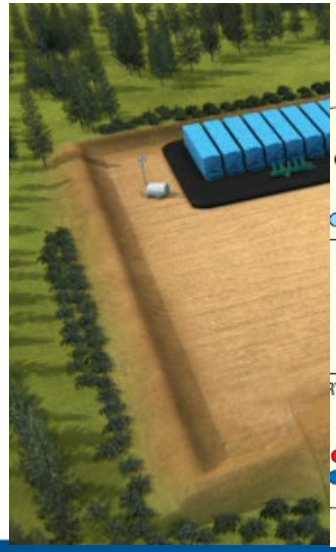
- Once Favored, Now Frowned Upon
- EOP Discharge Limitations

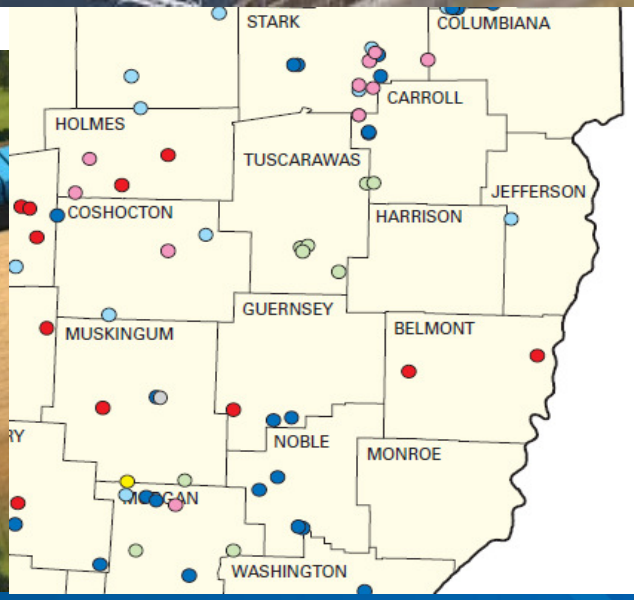
» Deep Well Injection

- Virtually All in Ohio, Some West Virginia
- Commonwealth of Pennsylvania has only 7-8 disposal wells
- 144,000 Class II injection wells in U.S.

» TSS Removal & Blending

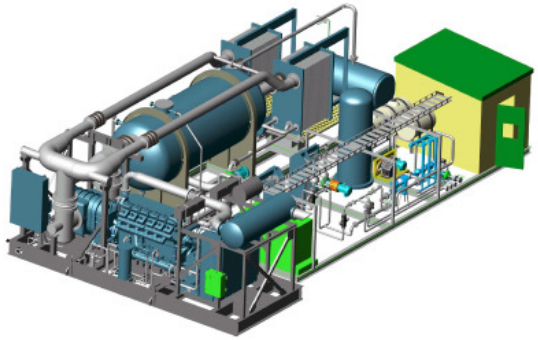
- Condensate / Water Separation (SW)
- Gravitational Separation
- Filtration (100 / 20 micron)
- Successful test on ten wells in Oklahoma using 160K TDS clean brine





Current Practices

- Floc and Drop (w/ filtration)
  - Primary targets
    - TSS, Fe, Ca, Mg
    - Ba and Sr optional
  - Clean brine effluent for reuse
  - 90 day pilot underway in the Utica
- Electro-coagulation
  - Works well for TSS
  - Somewhat effective for Ca/Mg, but poor on Ba/Sr and Cl
  - No additional chemicals
  - Clean brine for reuse
- Evaporation / Distillation
  - Smaller Units <2,500 bwpd
  - Pre-treatment required
  - Distilled effluent for reuse or discharge via POTW



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New Technologies

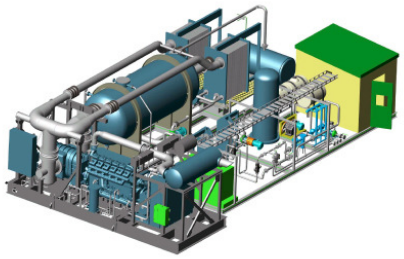
Eons Ago (3 Years)

- Large volume Desalinization Plants
  - $60-80 MM
  - Primarily focused on distillation / brine concentration
  - Sporadic mention of crystallization
- Reverse Osmosis
  - Lower initial capex
  - Lower operating cost
  - Minimal application due to high TDS MS brines

New Technologies

» Last Few Years

- Smaller scale evaporators
  - ~1,000-2500 bwpd
  - Mobile (semi-mobile)
  - Reduced trucking
  - Distilled water (reuse or discharge via POTW)
  - Clean, concentrated brine (reuse or disposal)
  - Solids from PT (landfill)
- Selective ion removal
  - F&D pretreatment systems
  - Electro-coagulation
  - General effluent streams are clean brine (reuse) and solids (landfill)

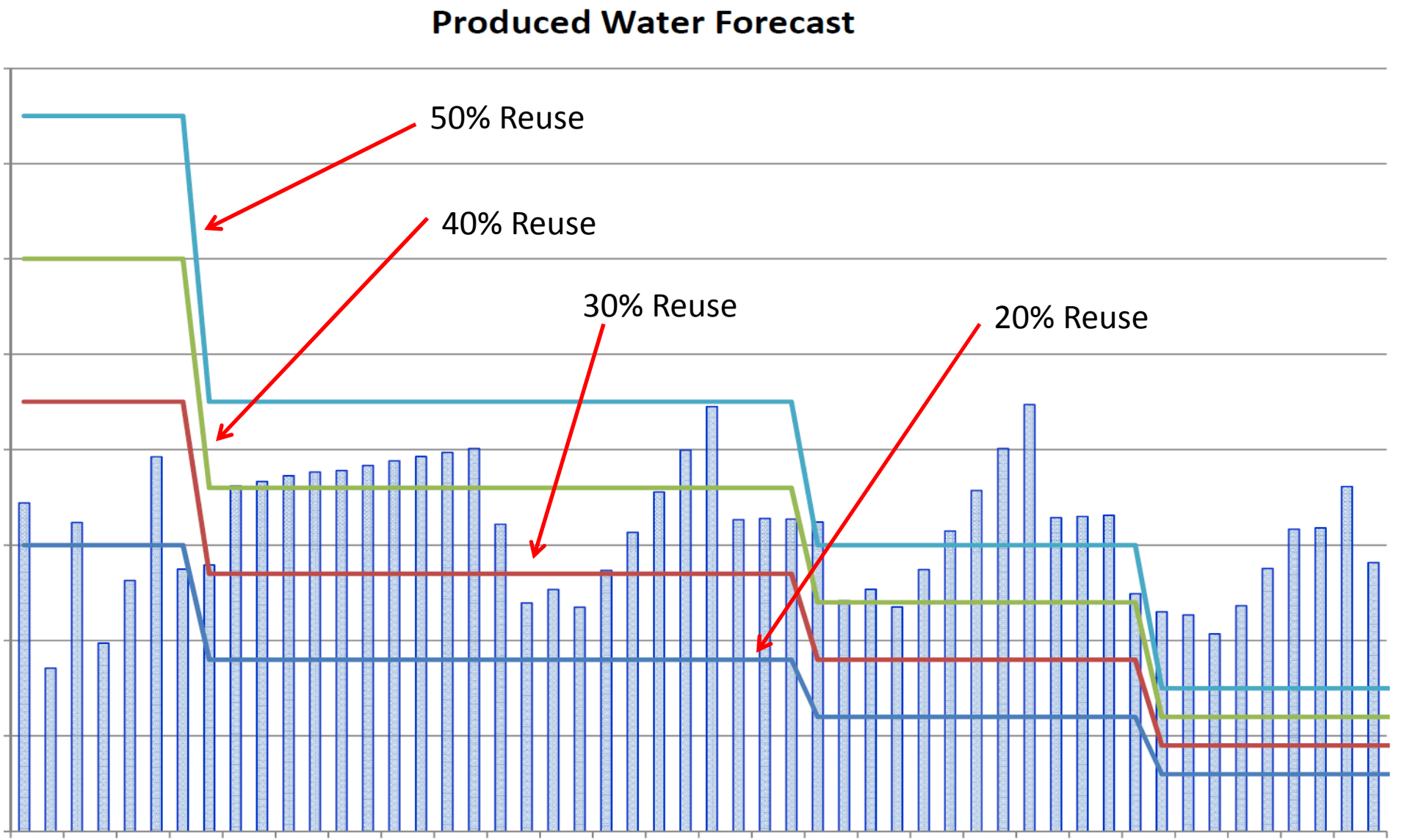


New Technologies

» Which Brings Us to Today

- Crystallization
  - <10,000 bwpd capacity
  - Markets for effluent streams (?)
  - Distilled Water (?)
  - Most will require multiple operator commitment

On The Horizon



New Technologies

» Crystallization

- <10,000 bwpd capacity
- Markets for effluent streams (?)
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» Forward Osmosis

- Less fouling issues than RO
- Higher TDS limits (?)

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- Why Reuse / Reclaim
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- New Technologies
- **Improving Vendor Offerings**
- Needed Regulation Improvements
- Improving Operator Involvement

Improving Vendor Offerings

» Learn Our Language

- GPM? = BPD? = AFY?
- 50 GPM = 1,714 BPD = 80.6 AFY

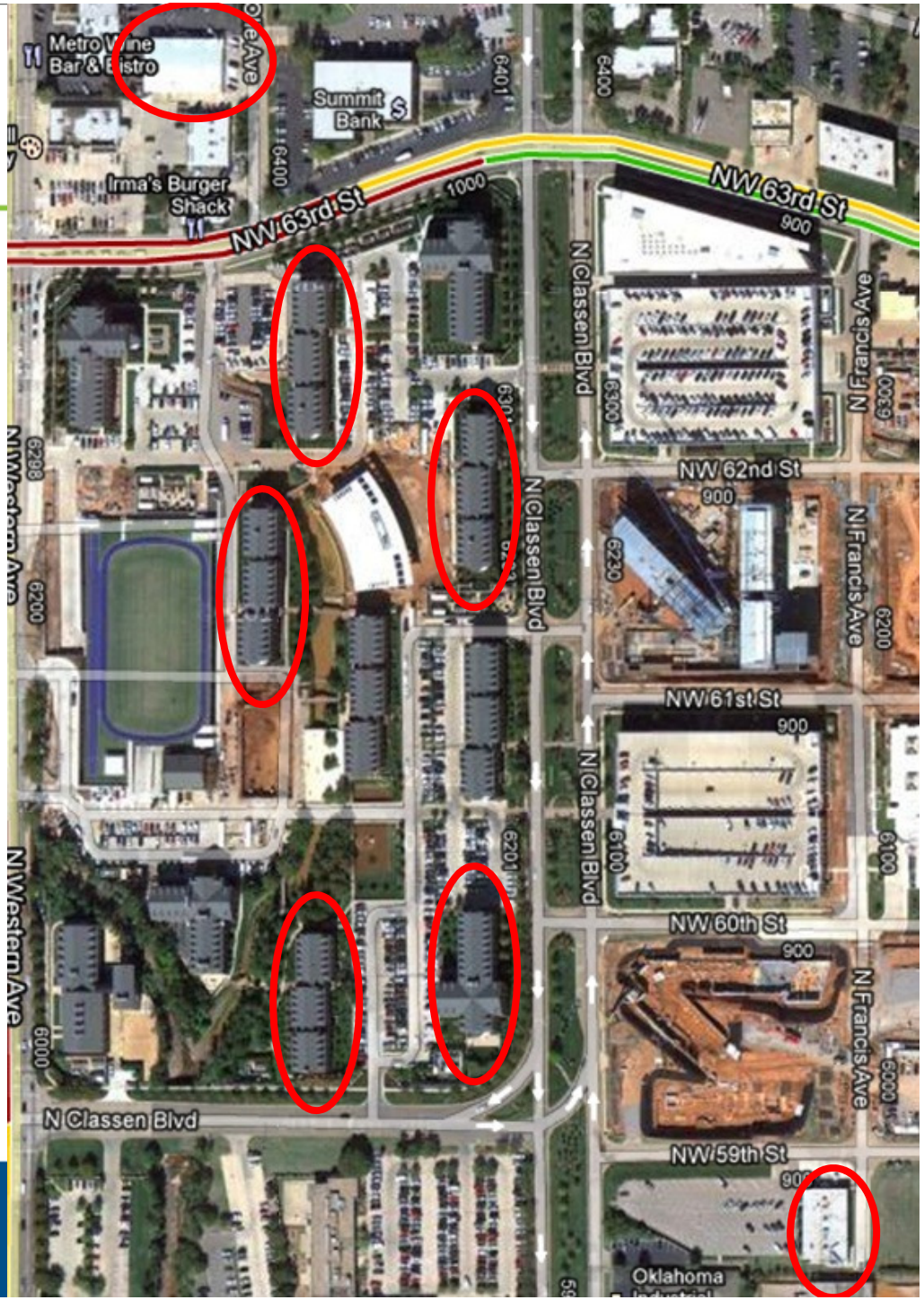
» Provide Specifics – We Don't Trust You!

- NORM will not be an issue?
  - Explain what you have done to back that up.
- "We have a market for the salt" – Provide Details!
  - We have no intention of cutting into your market
  - Do you have State or County-level commitments?
  - What will the incumbent suppliers do?
  - What about pressure from Enviro's / Public?

» Understand That We Know Our Business Very Well

Welcome to OKC!

- Eastern Division Operations
- Western Division Operations
- Research Technology Centers
- Petrophysics
- Geology Technology Group
- Northern Division Operations & Engineering Technology Group



Improving Vendor Offerings

» Speak Our Language

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- 50 GPM = 1,714 BPD = 80.6 AFY

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» Understand That We Know Our Business Very Well

- Pro forma curves
- Estimated Ultimate Recovery (EUR)

Improving Vendors Offerings

» Avoid "Black Box" Pitches

- We understand your need to protect IP, but when you make claims that challenge the laws of physics and chemistry – you need to provide facts!
- Murky brine in one side – distilled water out the other
  NO OTHER EFFLUENT STREAM!

» 21st Century Gold Rush

- The Solution
- >100 different technology providers

Actual Sales Pitches

- Uses perpetual motion magnets
- Developed in Cold War era Russia
- Developed to provide water for the indigenous people of the Amazon
- Nanocavitation creates an instantaneous temperature of 700°C without increasing the overall temperature of the base fluid

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Needed Regulation Improvements

- **Distilled Water**
  - Make it easier / less expensive for storage and transportation
  - Reuse not always the best option
  - Dewasting to allow other industries to use
- **Reuse**
  - Improved permitting timeline for reuse applications
  - "All in one permit"?
    - Air quality
    - Water quality
    - Waste
- **Don't Be Afraid of Underground Injection**
  - Seismicity needs to be evaluated, but keep in mind:
  - 80+ years of underground injection of produced brine
  - Federal / State oversight of underground injection - >40 years
  - ~144,000 Class II injection wells in U.S.
  - Over 2 billion gallons of brine injected daily

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Improving Operator Involvement

- Be More Forthright With Data
  - Back to the trust issue again

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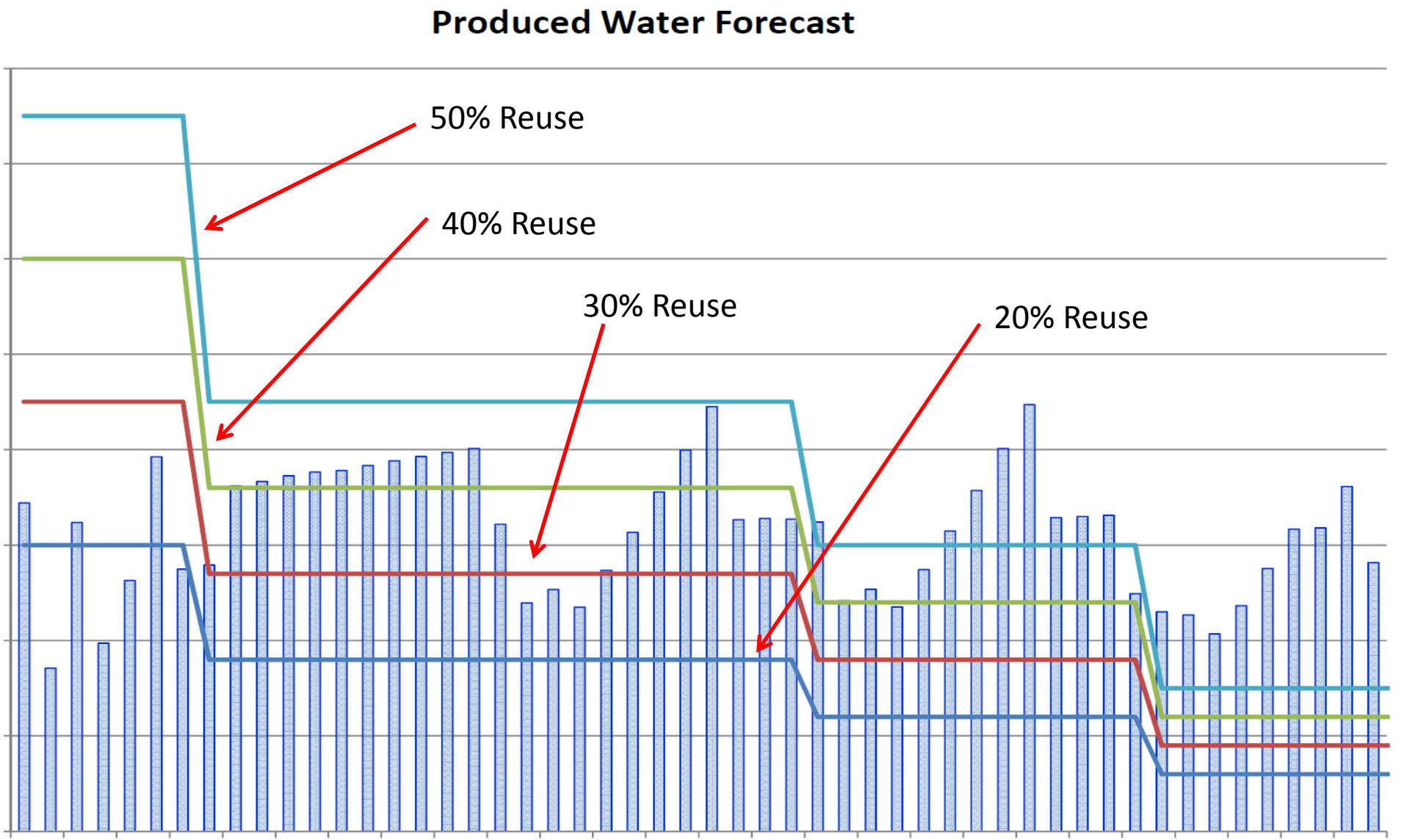
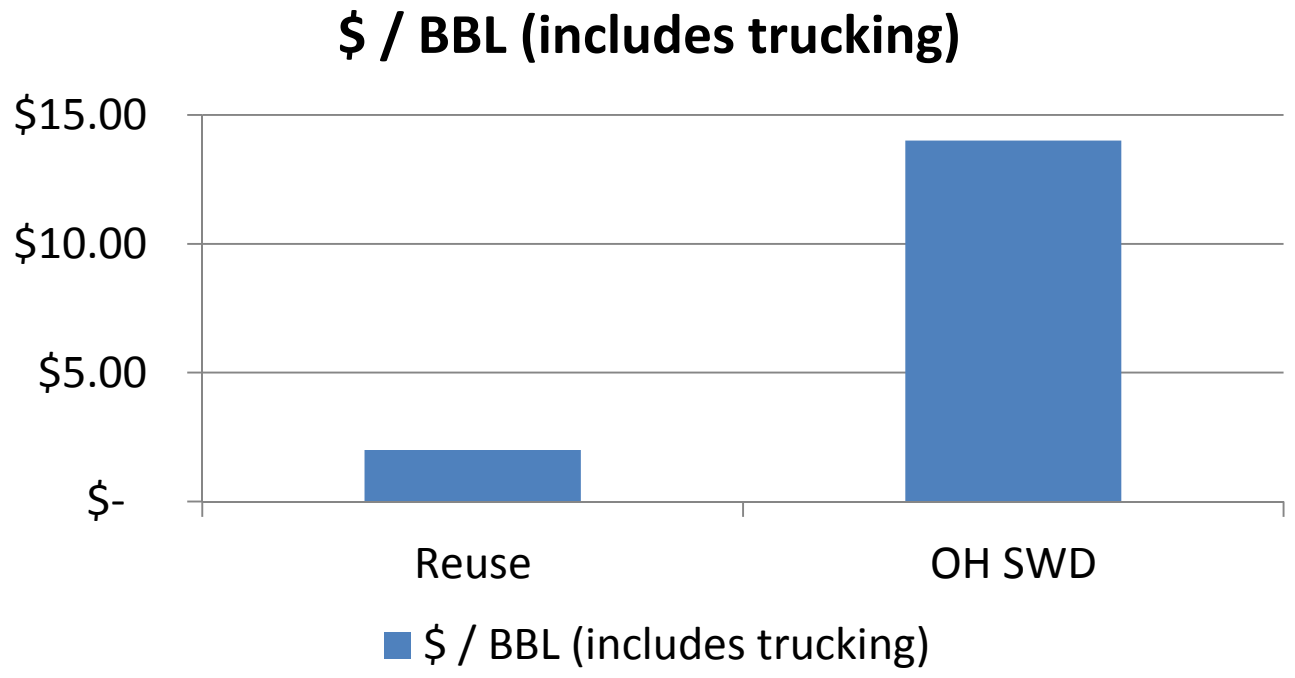


Improving Operator Involvement

» Be More Forthright With Data

- Back to the trust issue again
- It would help if every treatment process didn't cost $0.25 / bbl less than what we are currently doing



Improving Operator Involvement

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» Provide More Fluids

- Transportation an issue

» Provide More Field Level Access / Pilots

- Permitting issues in some areas
- Manpower
- Third party testing

Thank You!

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