



Energy & Environmental Research Center (EERC)

Potential Reuse Strategy for High Salinity Produced Water

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U.S. DEPARTMENT OF
ENERGY



NATIONAL
ENERGY
TECHNOLOGY
LABORATORY



ADVISORY PARTNERS ENGAGED THROUGH THE EERC LEAD
BAKKEN PRODUCTION OPTIMIZATION PROGRAM

7 of top 10 Williston Basin Producers

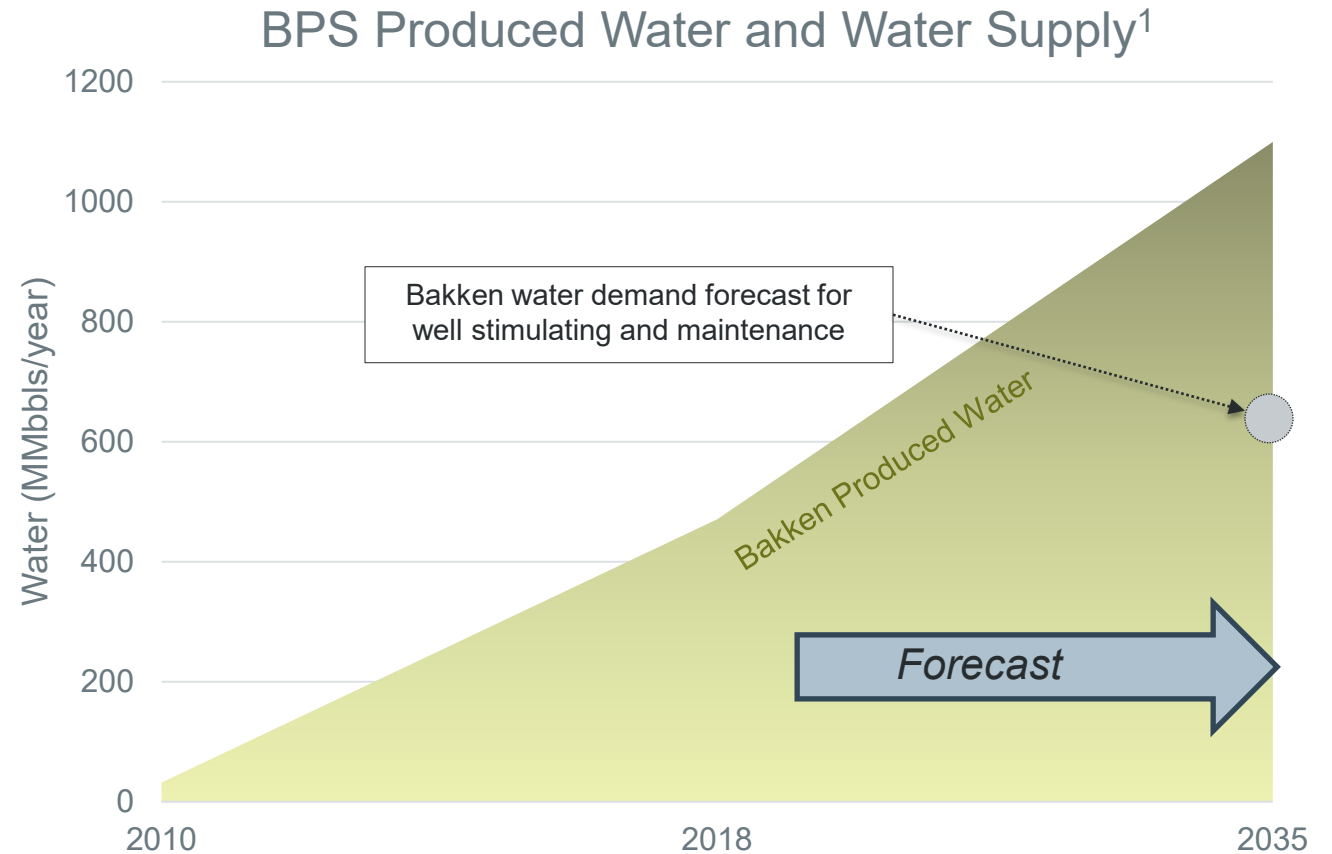


AN EMERGING ISSUE

Produced water management (including flowback water) represents a significant economic and technical challenge for oil and gas production.

Produced water volumes associated with Bakken petroleum system (BPS) production in North Dakota have increased dramatically since 2010.¹

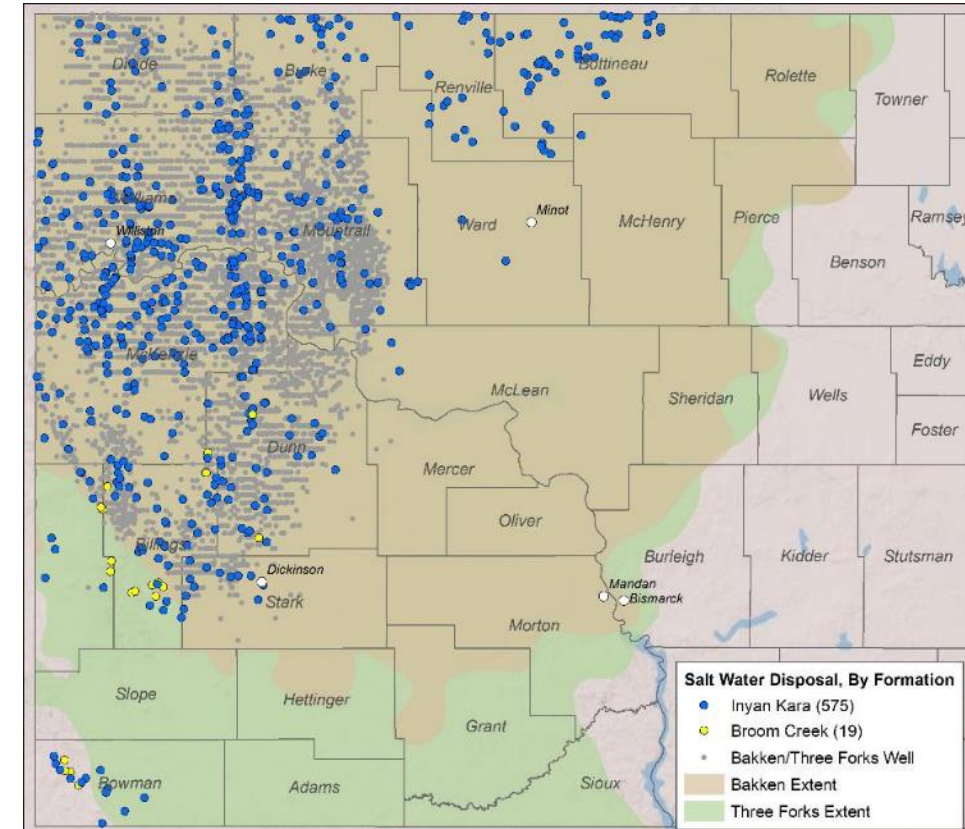
Freshwater demand is projected to surpass 700 million barrels by 2035.



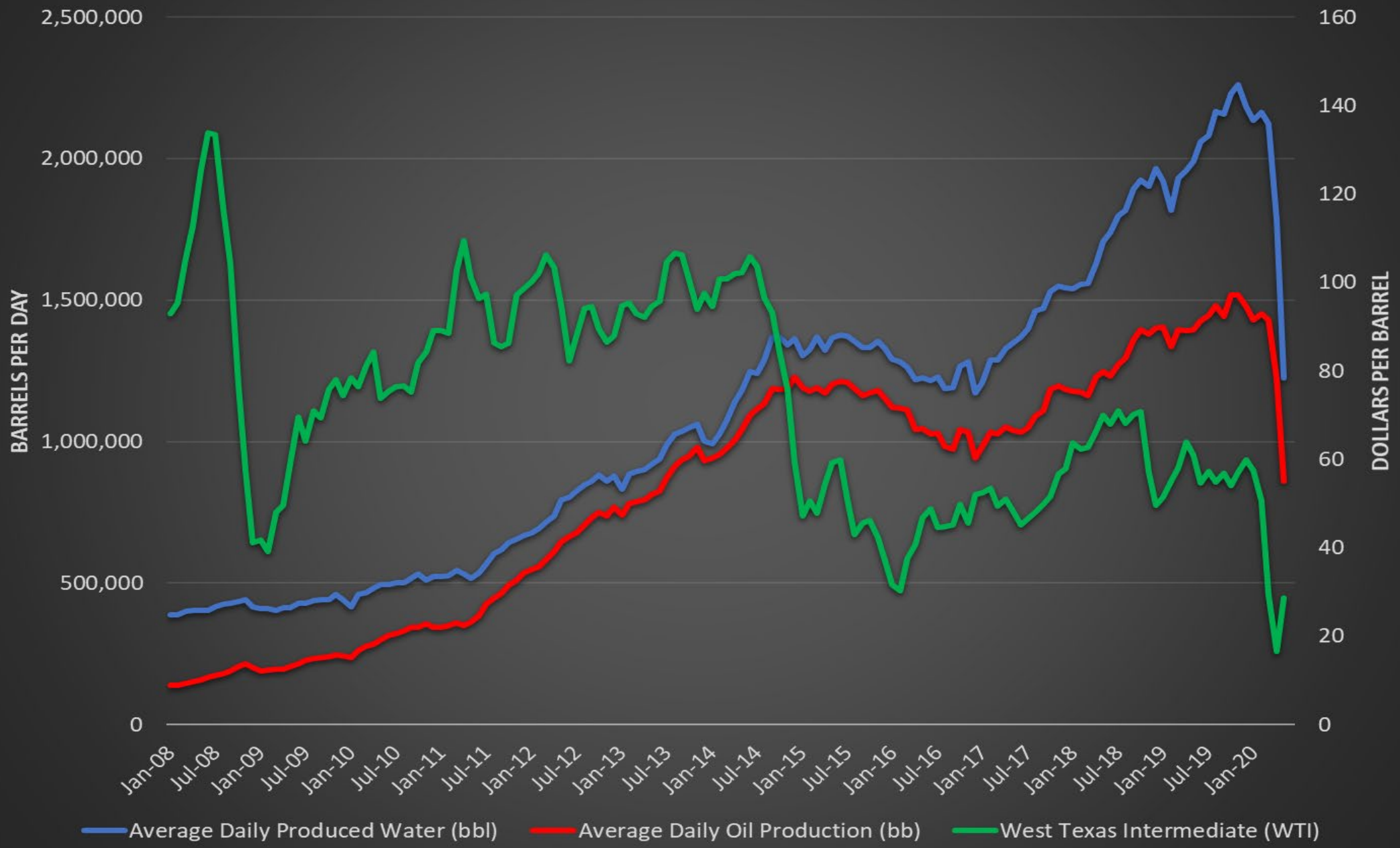
¹Kurz, B.A., Stepan, D.J., Glazewski, K.A., Stevens, B.G., Doll, T.E., Kovacevich, J.T., and Wocken, C.A., 2016, A review of Bakken water management practices and potential outlook: Final report for members of the Bakken Production Optimization Program, EERC Publication 2016-EERC-03-11, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

THE CHALLENGE

- ND saltwater disposal (SWD) is already resulting in localized areas of high pressure in the Inyan Kara.
 - >95% of SWD occurs in Inyan Kara Formation.
 - Impacts economics and risk associated with oil and gas development.
 - ◆ Intermediate casing string increases drilling cost by \$300–\$700k per well due to Inyan Kara pressurization.
 - ◆ Sufficient capacity to continue to meet SWD demand?
 - 25,000 –70,000 additional wells forecasted to develop BPS.
 - Essentially no recycling/reuse to date
- Produced water treatment and reuse is constrained by:
 - Variability and extremely high salinity
 - ◆ ~ 250,000–350,000 mg/L TDS fluids.
 - Large volume surface storage is challenged/constrained.
 - ◆ Regulatory and environmental considerations w/ attendant costs.



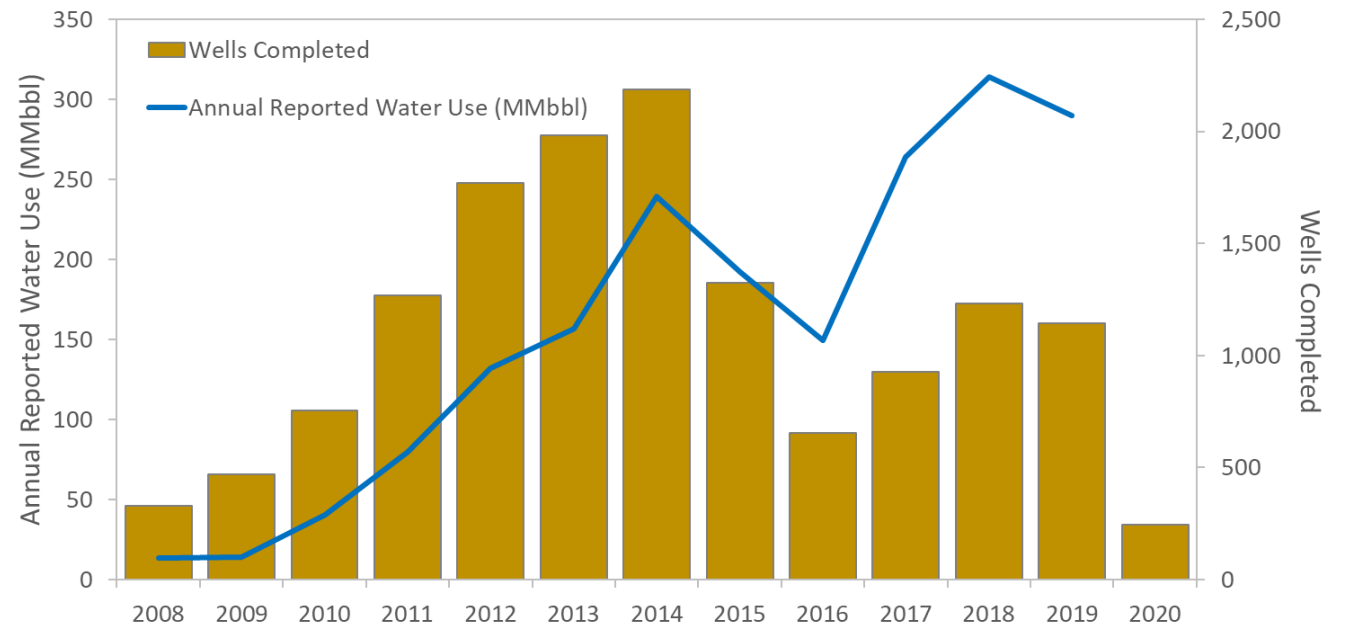
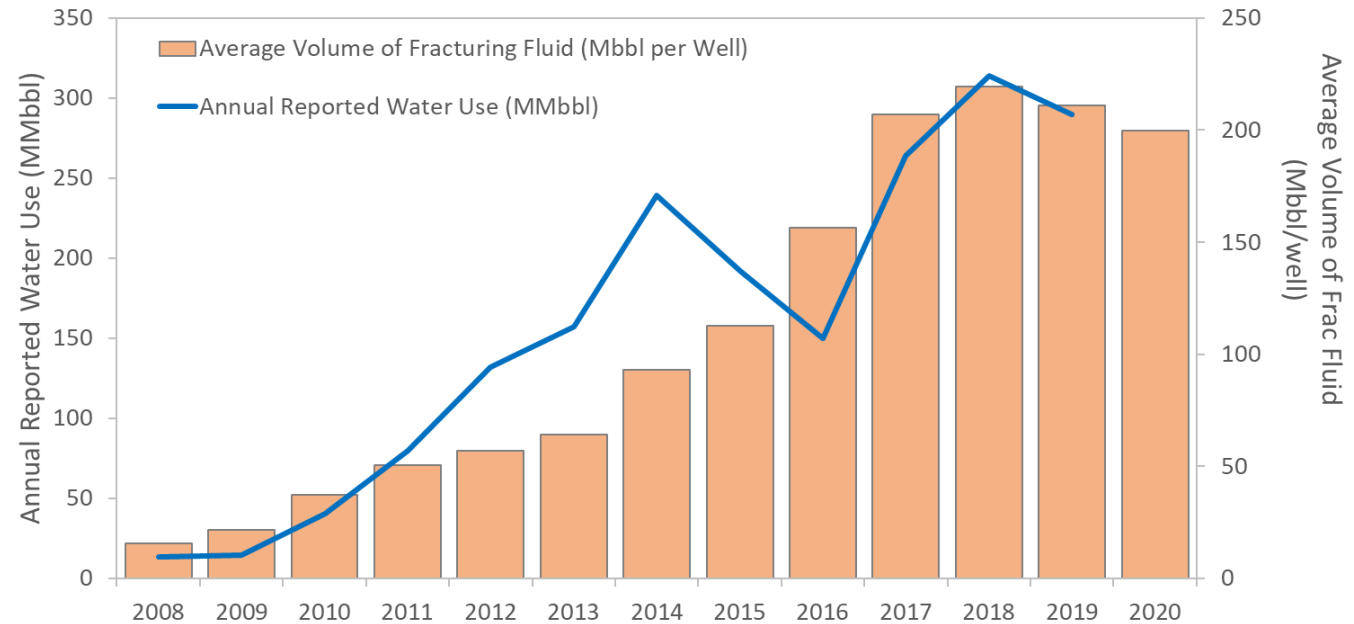
Average Daily Oil & Water Production and Market Price



*96% of current production is from Bakken and Three Forks.

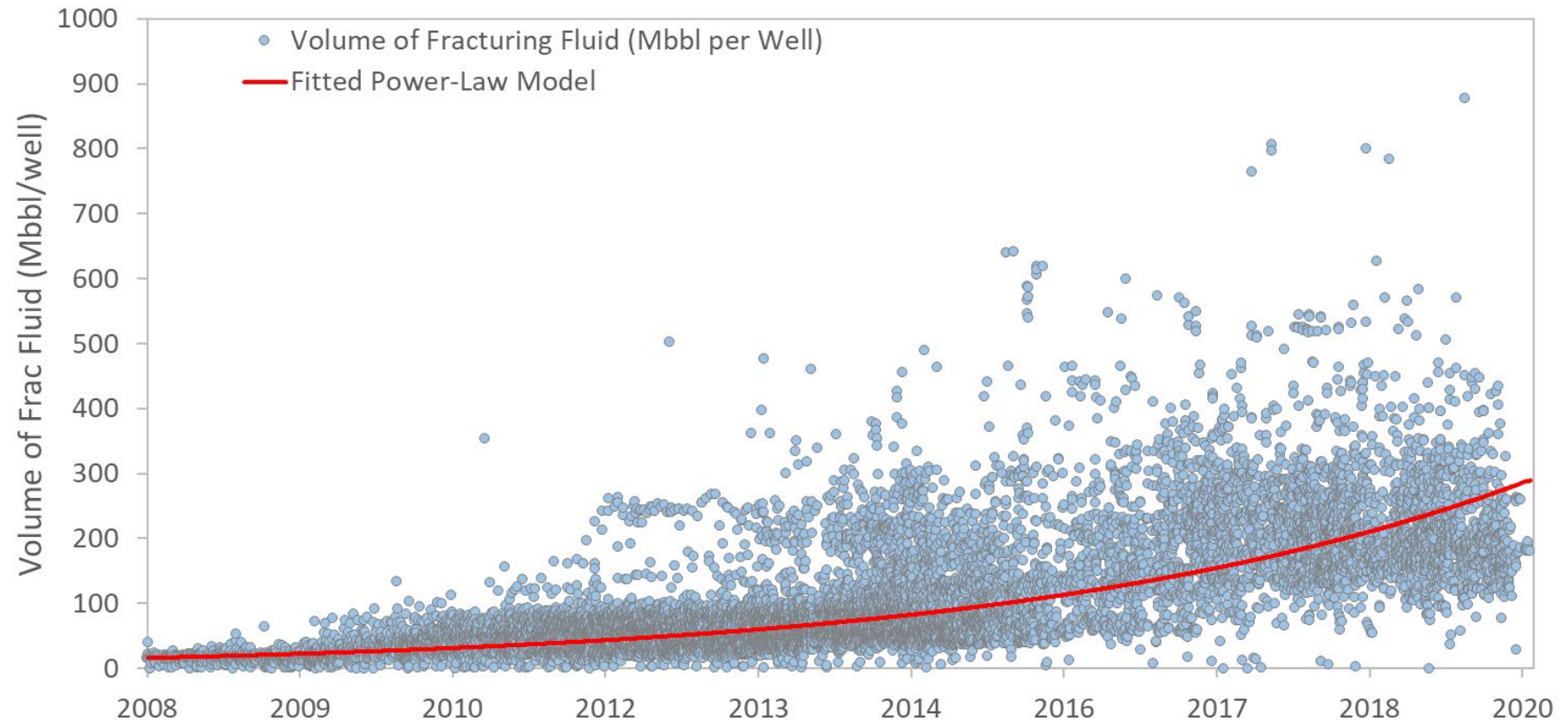
Fresh Water Use

- Industry freshwater use has increased:
 - 2008: 13.5 million bbl
 - 2019: 290 million bbl
- Fresh water used in drilling, fracturing fluid makeup, and well maintenance.
 - Makeup water: 87% of freshwater use for the last 5 years (based on Frac Focus reported clean water and ND SWC industrial water use)
 - Maintenance water: 15 bbl/day/well to 50 bbl/day/well.



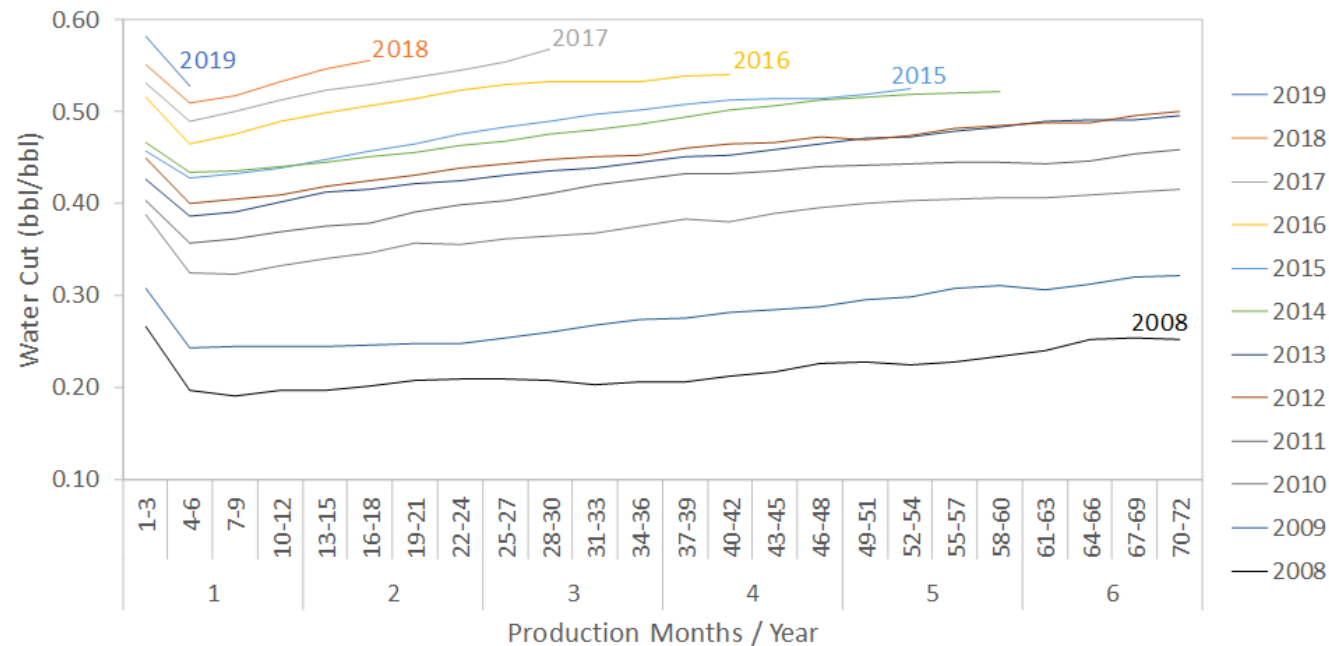
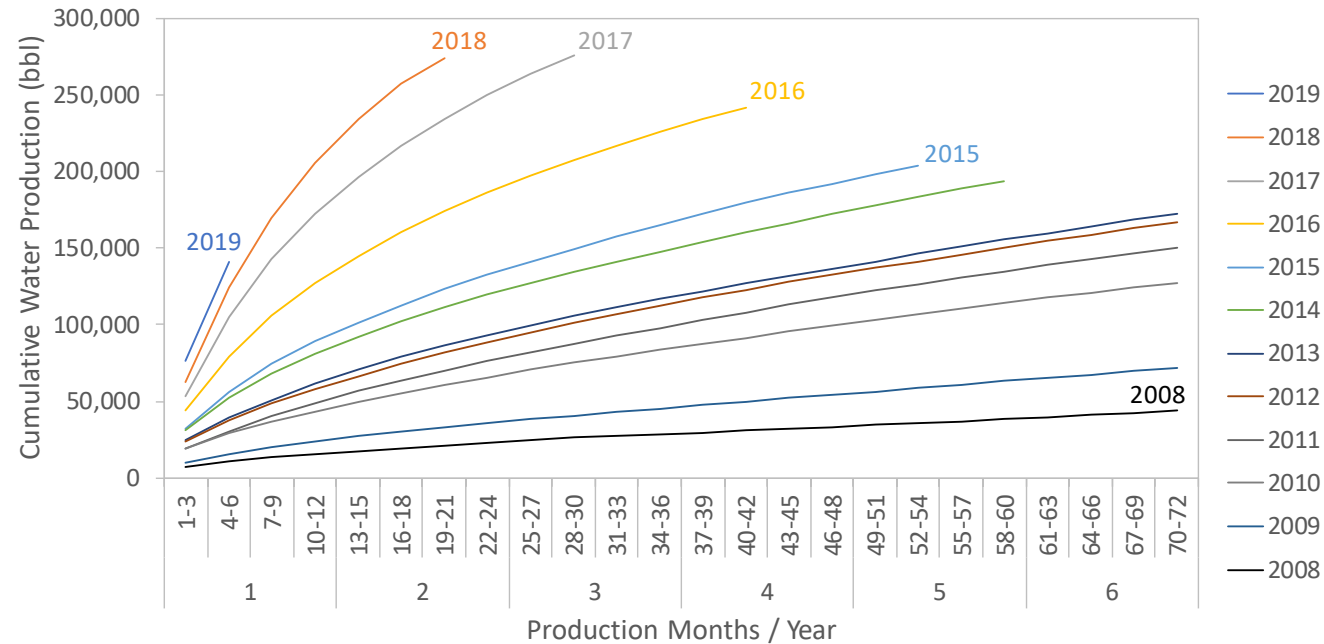
Fresh Water Use

- Hydraulic fracturing volumes:
 - 2008: 15,000 bbl/well
 - 2020: 200,000 bbl/well



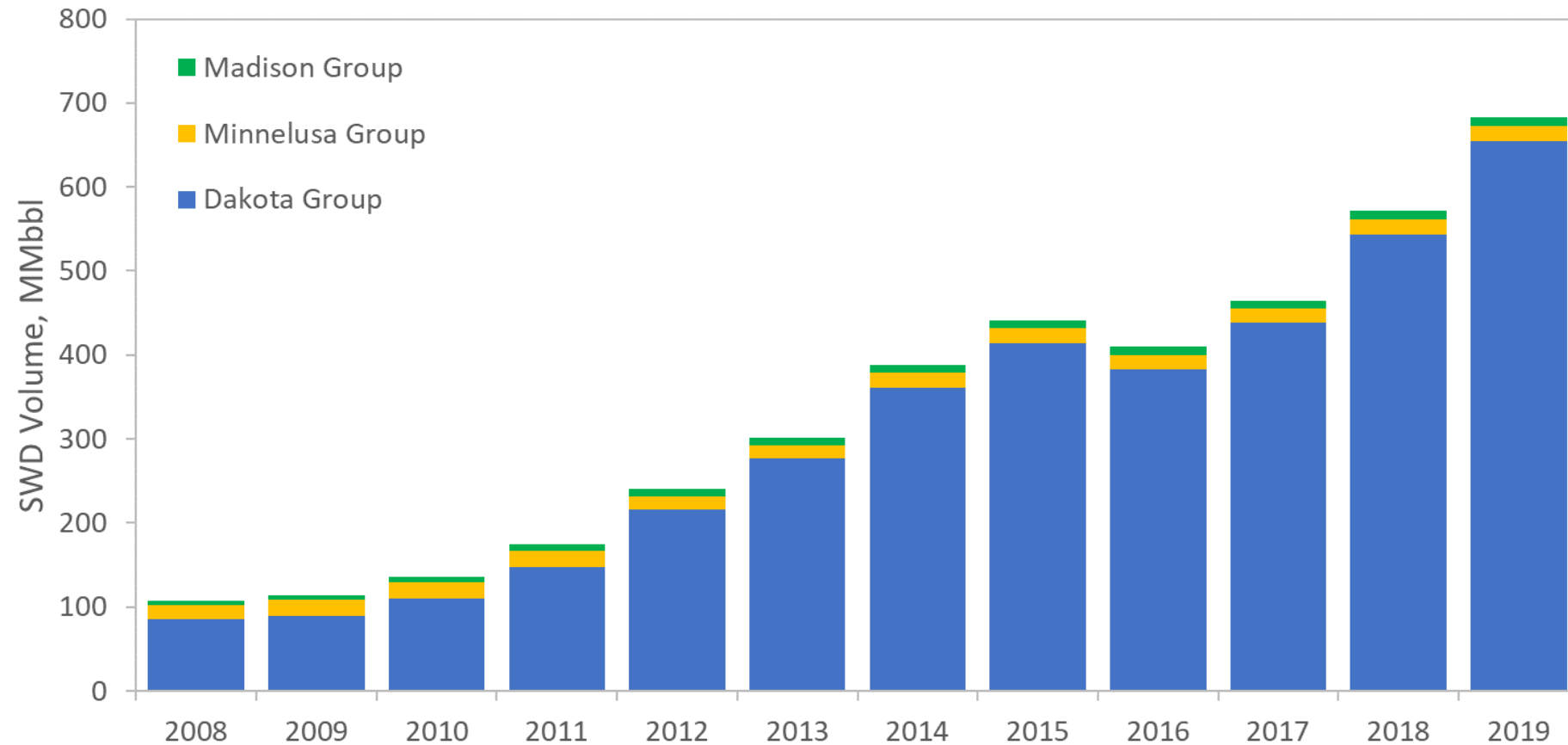
Produced Water

- State produced water volumes increased four-fold since 2008 to ~700 million bbl/yr.
- Increasing volumes per well and increasing water cut.
- Total dissolved solids (TDS) up to 350,000 mg/L.

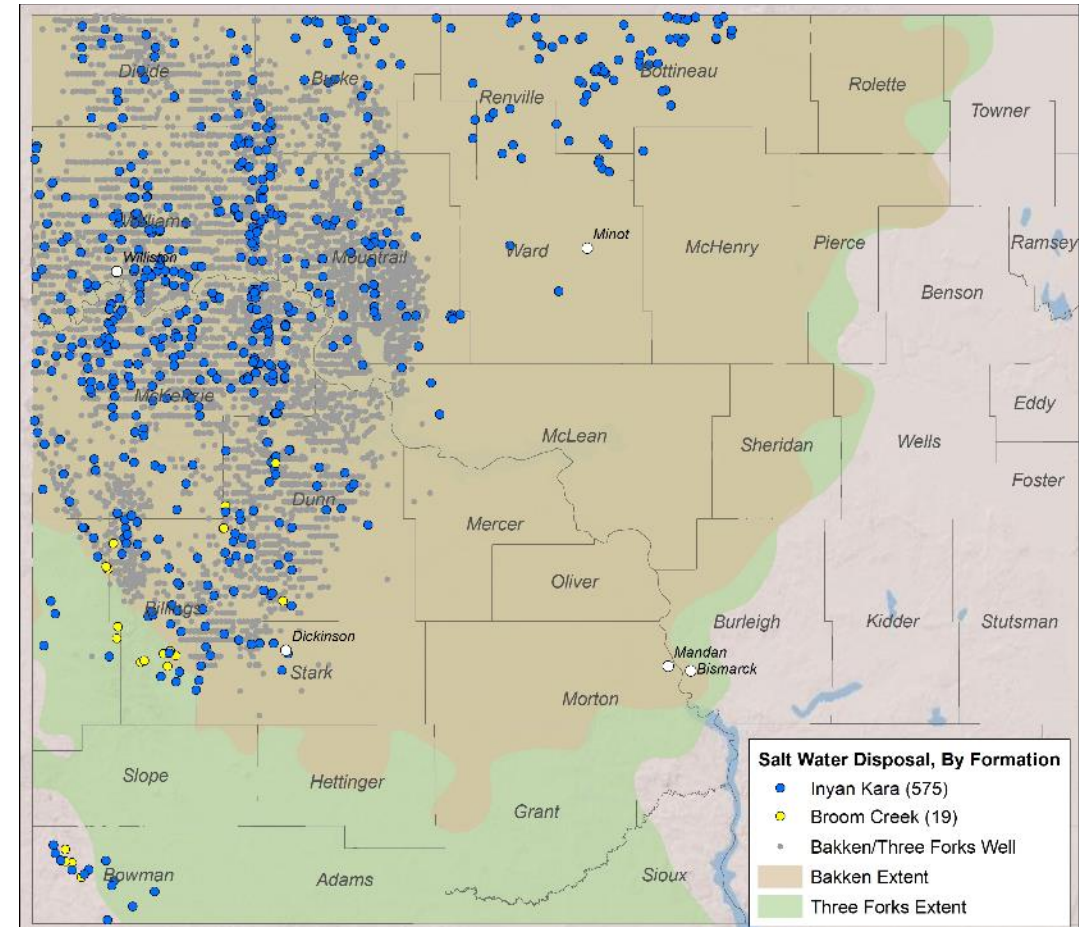
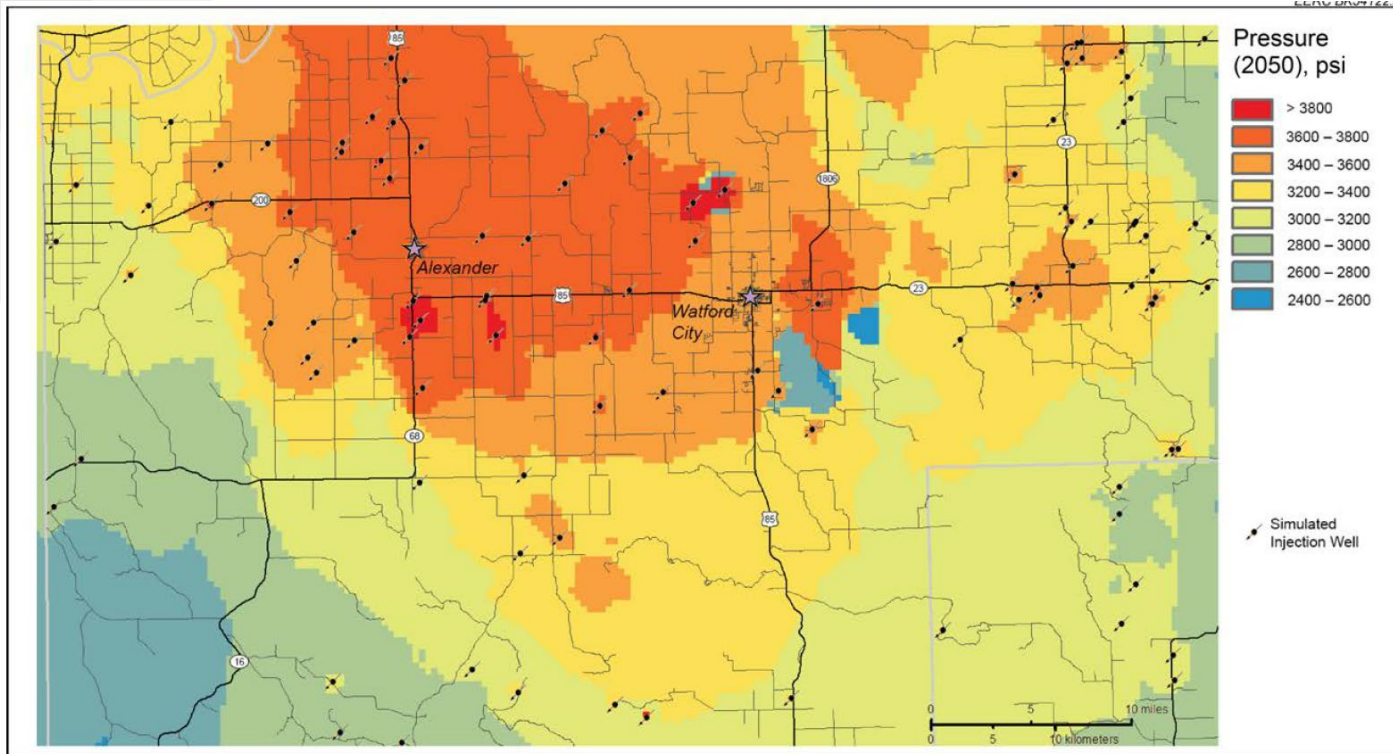


Produced Water Disposal

- Disposal volumes five-fold increase since 2008 to ~680 million bbl/yr.
- Over 95% of saltwater disposal (SWD) targets the Dakota Group.
- Primarily transported by pipeline.

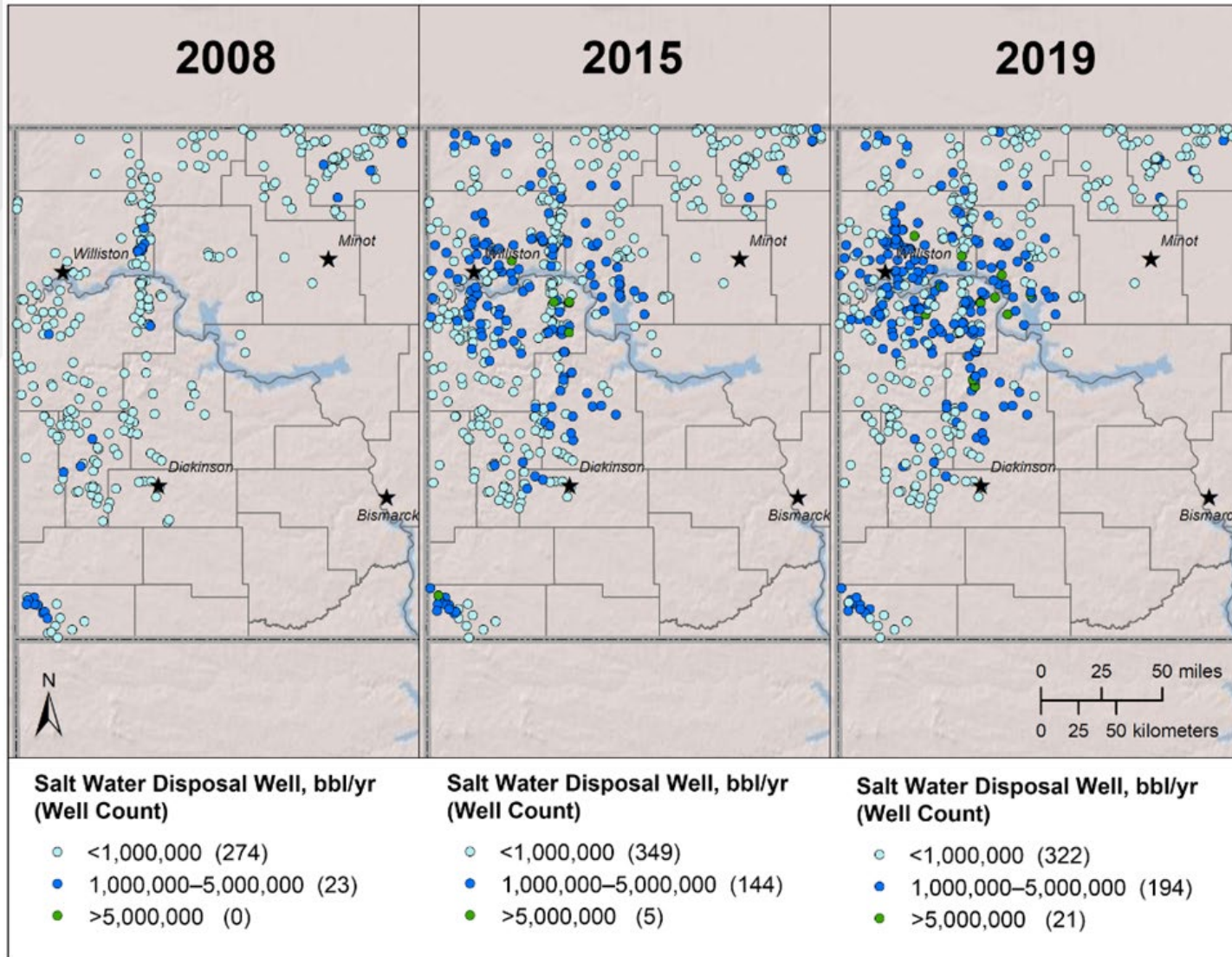


THE CHALLENGE

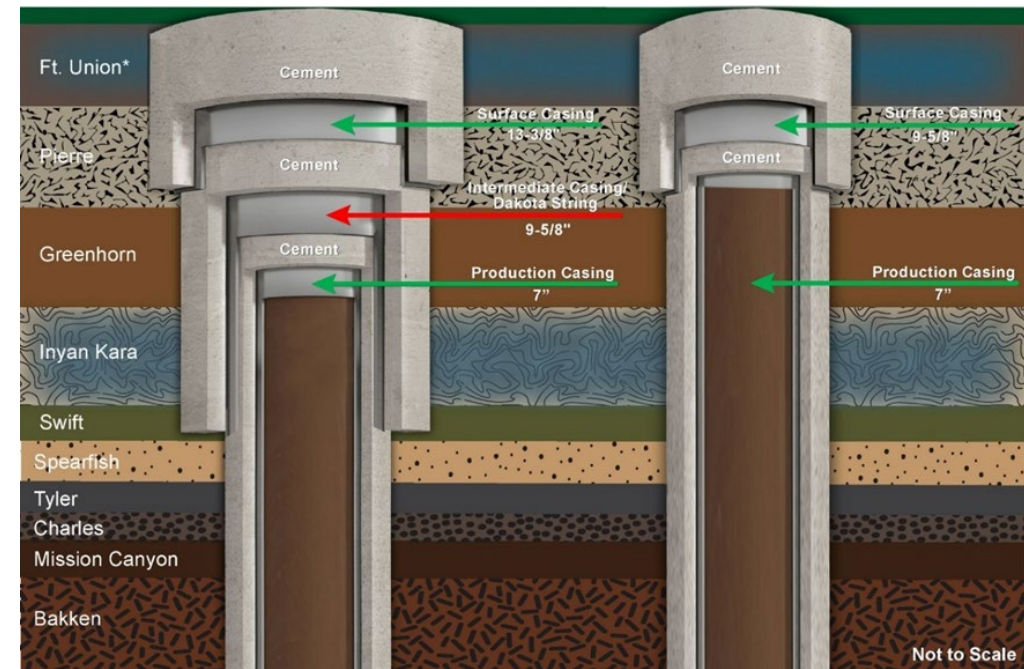


Modeled distribution of reservoir pressure assuming the 93 SWD wells currently injecting within the model extent, continue operations until 2050 (assuming closed boundaries to North, West and South). Hydrostatic is ~ 2500 psi.

Produced Water Disposal



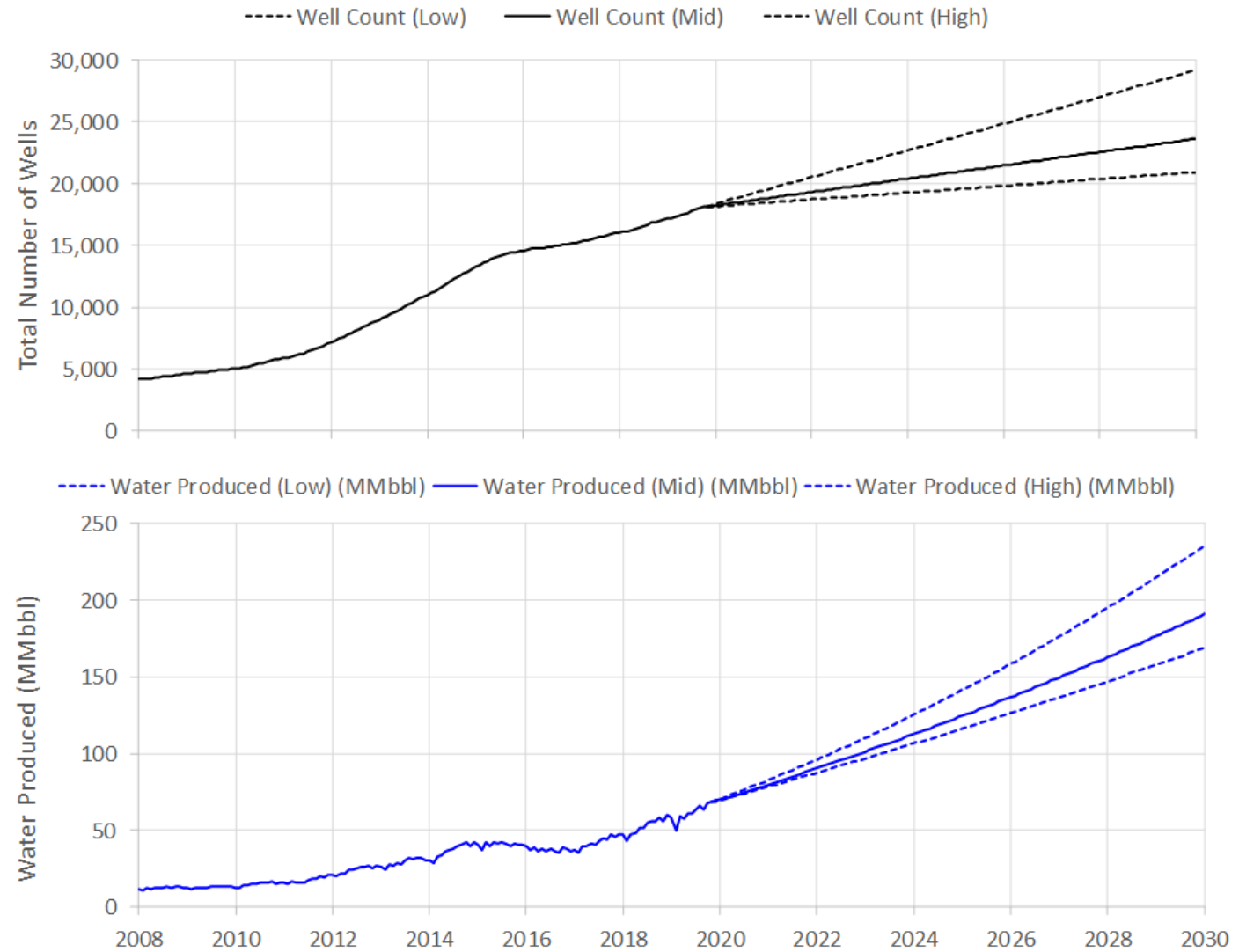
- Pressure increases in the Dakota causing changes to drilling operations, costing ~\$0.5 million/well.
 - Affects operator decisions.
 - Identified ~200 wells thus far with additional casing string.



Note: Horizontal/lateral section is not included in this illustration
 *Lowest Underground Source of Drinking Water (USDW)

Looking Ahead

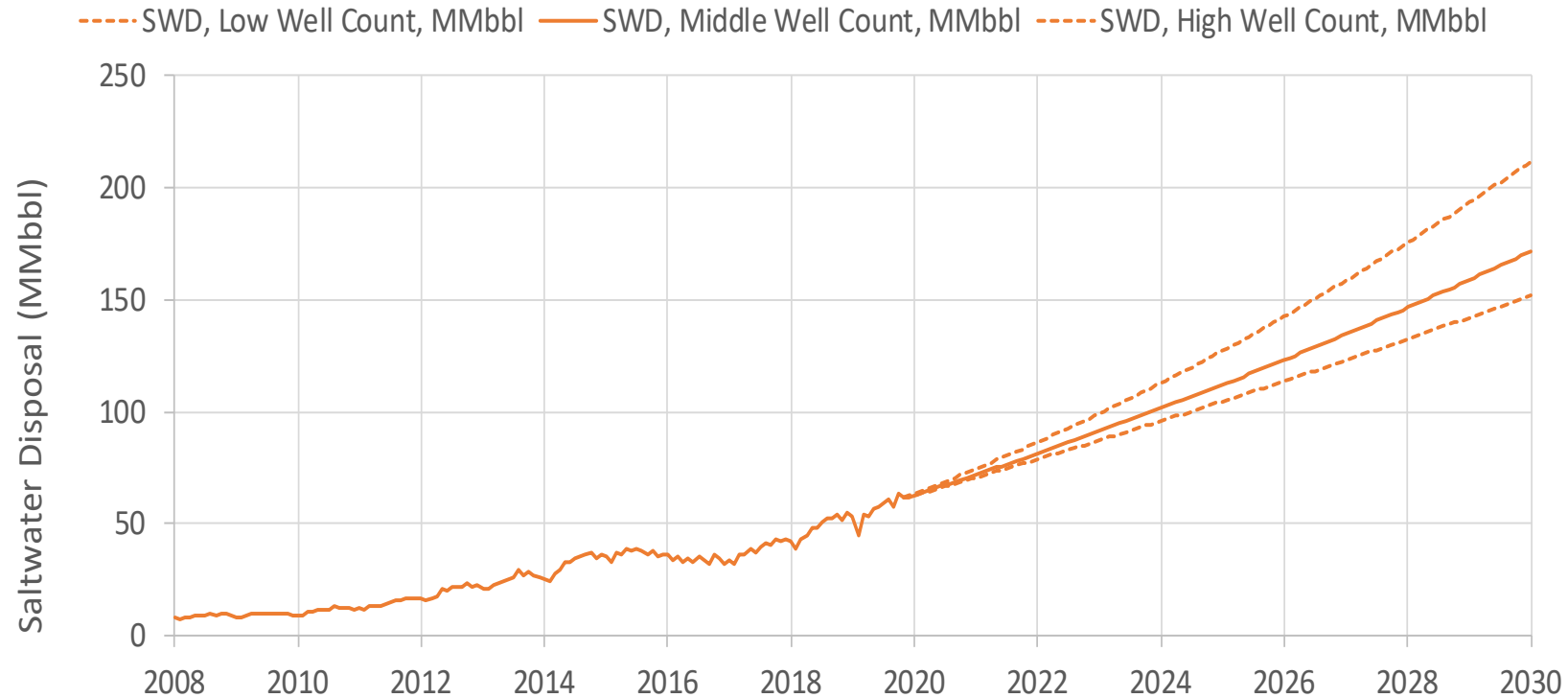
- Forecast more than double volumes of produced water by 2030.
- Based on data trends from 2017-2019.
- With 96% of current oil production, Bakken primary driver of these projections.



Actual (2008-2019) and projected (2020-2030) well counts under three different growth assumptions (top) and the associated monthly produced water volumes (bottom).

Produced Water Disposal

- SWD volumes projected to more than double by 2030.
- Based on data trends from 2017-2019.



Actual (2008-2019) and projected (2020-2030) saltwater disposal under three different growth assumptions.

Produced Water Recycling Challenges and Opportunities

Challenges

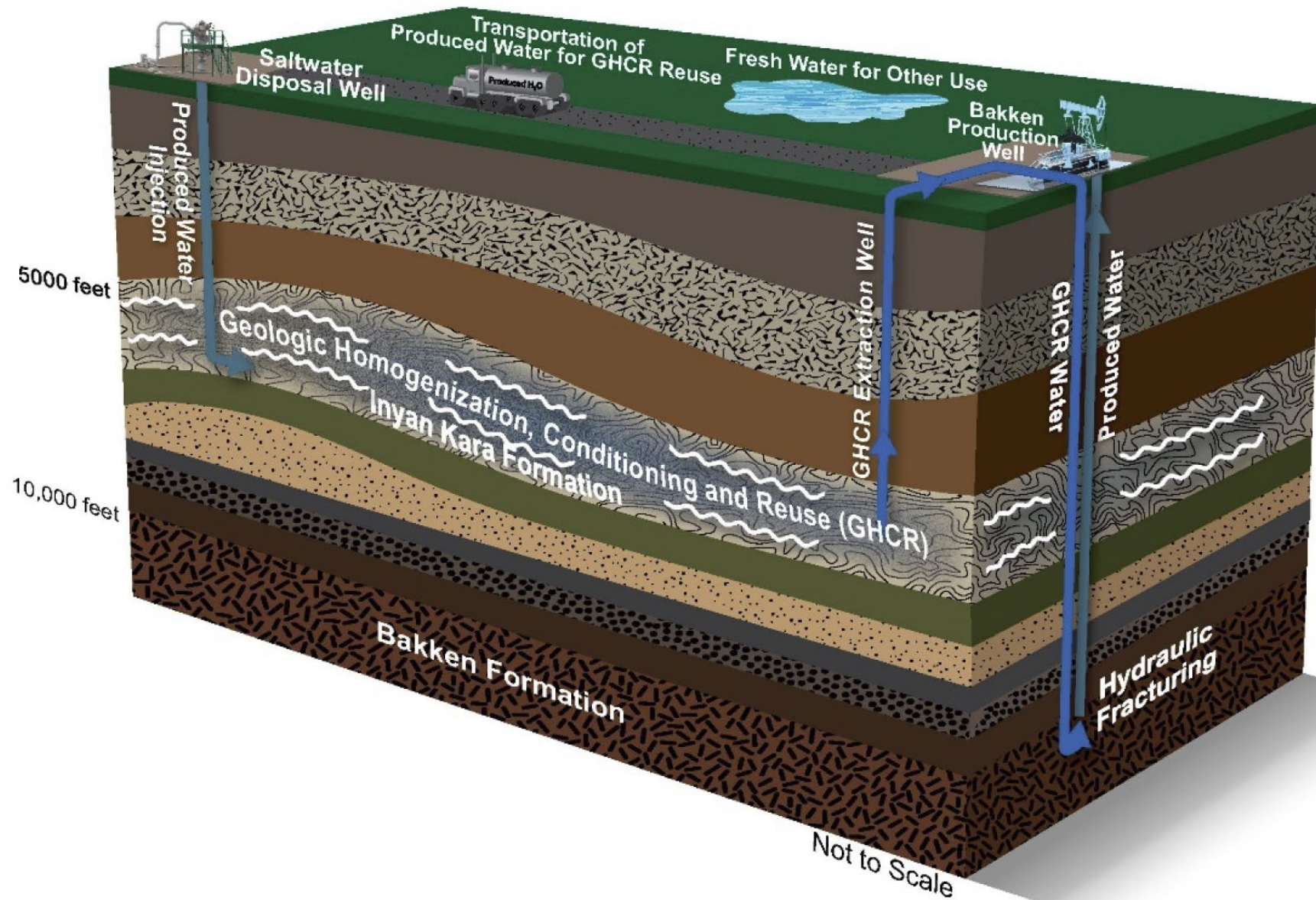
- High TDS
- Economics need to work
- Prevention of spills
- Waste handling
- Centralized infrastructure
- Surface storage

Opportunities

- Relieve capacity constraints in Dakota.
- Reduce localized pressure that has increased drilling costs.
- Reduce freshwater consumption.
- Value-add products: turning produced water from waste to a valued product.



GHCR CONCEPT



POTENTIAL BENEFITS OF GHCR

- Reduce net SWD.
- Reduce magnitude and rate of pressurization in disposal zone:
 - Extended life of SWD wells.
 - Reduced oil and gas development costs associated with pressurization.
- Provide means of displacing freshwater demand, assuring water supply in event of future curtailments on water appropriations.
- Employs existing infrastructure.
- Enables large-volume storage and limitless supply of consistent-quality water for reuse.



GHCR deployed at scale could provide an **innovative solution** to the emerging challenge of Inyan Kara pressurization that will likely contribute to of **\$1.5 to \$10 billion*** in increased costs for Bakken development and SWD in the Williston Basin.

**If 20% of the projected remaining Bakken development is impacted by Inyan Kara pressurization.*

While the GPCR concept appears promising, commercial demonstration and adoption require diligent evaluation, technical validation, and the techno-economic feasibility information that the proposed Stage I effort will provide.

Lacking an imminent threat to produced water management practices in North Dakota, the proposed efforts are unlikely to be undertaken in the private sector until such threats (e.g., constraint on SWD injection, freshwater limitations, pervasive pressure impacts, and inflated drilling costs) are present.

The State and federal research programs supporting this effort are providing foundational knowledge to understand and address emerging produced water management challenges and supporting the development of sustainable produced water management practices applicable to North Dakota and beyond.

Fall 2020 Quarterly Report Excerpt

- The composition of an extracted water sample collected from the BEST-E1 well on July 2, 2020 and compared with the composition of a sample of Bakken Produced water prior to SWD injection collected from the Nuverra Operated SWD facility. Preliminary analysis of these fluids suggest that the project has successfully extracted and analyzed Bakken Produced water that was injected into, and has migrated more than 1500 ft through, the Inyan Kara formation. Initial analysis of the extracted fluids support the hypothesis that geologic homogenizing and conditioning of oil and gas produced water could provide an effective means of conditioning in advance of treatment and/or beneficial reuse applications. In addition there are several indications that biogenic reactions are occurring within the formation which could be beneficial for addressing dissolved organics that have a tendency to complicate treatment of produced waters. Work is ongoing to understand the efficacy of GHRC approach and processes taking place in the geologic formation that can enable or inhibit subsequent treatment and recycling of produced water for beneficial reuse applications.

Key Takeaways

- Oil and gas industry continues to handle increasing volumes of water.
- Emerging need for alternative produced water handling options to supplement the Dakota.
- High TDS Bakken produced water is a primary challenge in treatment and reuse.
- New subsurface technique is being evaluated as an approach to recycling/reuse.



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A wide-angle photograph of a university campus during sunset. The sun is low on the horizon, casting a warm glow over the scene. In the foreground, there are large trees with some yellowing leaves. In the background, several multi-story brick buildings and a parking lot with many cars are visible under a clear sky.

THANK YOU

Critical Challenges. Practical Solutions.