Energy & Environmental Research Center (EERC)

The Bakken Production Optimization Program 2.0 Update

Presented to: Oil & Gas Research Council
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Critical Challenges. Practical Solutions.

Agenda

- Budget
- Rich Gas EOR with Liberty Resource
- Refrac Study
- Statistical Analysis of Production Data
- Industry Support
  - Vapor Pressure
  - Remediation
- Produced Water Studies

BPOP 2.0 Budget

Sponsors	Expected Budget	Actual Expenses as of 3/31/17	Balance
NDIC Share – Cash	$6,000,000	$2,147,769	$3,852,231
Industry Share – Cash	$600,000	$318,387	$281,613
Marathon – In-Kind	$7,280,000	$4,749,086	$2,530,914
Liberty – In-Kind*	$141,103	$141,103	–
DOE – Cash	$2,000,000	$274,317	$1,725,683
Total	**$16,021,103**	**$7,630,662**	**$8,390,441**

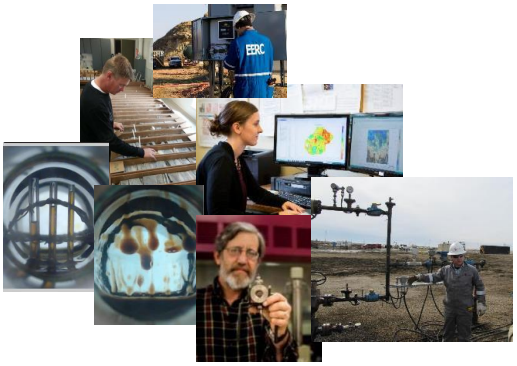
* An estimate for the total expected in-kind cost share from Liberty is not available. Liberty will periodically report actual costs to the EERC, which will be subsequently presented in the quarterly report.

Rich Gas EOR – Goals

- **Determine the ability of rich gas to mobilize Bakken oil**
  - Increased oil production
  - Alternative use of gas to flaring
- **Assess how changing gas and fluid compositions affect reservoir and process facility performance**
  - Increase in overall process efficiency
- **Optimize future EOR design and operations through modeling and reservoir performance**
  - Improved field-wide production

Rich Gas EOR – Activities and Highlights

- **Lab studies of rich gas interactions with fluids and rocks**
  - Ethane and propane showing promising results relative to CO_2
- **Detailed characterization of produced gas and fluids over time**
  - Baseline samples nearly completely acquired
- **Iterative modeling of surface and subsurface components.**
  - Models built and numerous schemes simulated
- **Pilot performance assessment**



Rich Gas EOR – Next Steps

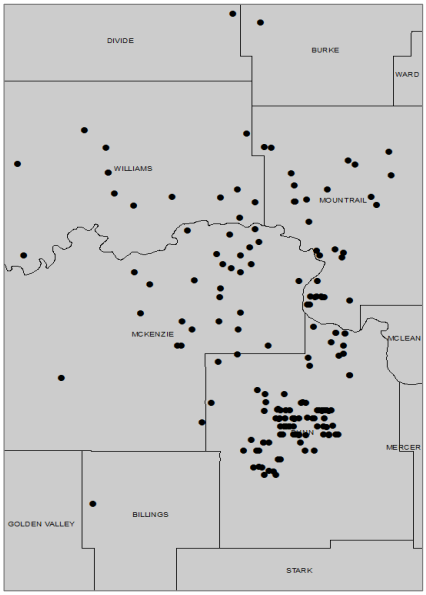
- **Rich gas injection imminent**
  - Compressor arriving mid-May (capable of 4200 psi and 3 MMscf/day)
  - Injection start target for end of May with 1 well at 1.5 MMscf/day for 30 days

- **Continued sampling and characterization of produced fluids**

Refrac Performance Evaluation

- **Existing refracs in ND performing well (from production standpoint)**
  - Average uplift in daily oil production of 300 stb/day during 30 days following refrac
  - Incremental EUR ranging from 85–260 Mstb
  - Average decrease in GOR of 20% during 30 days following refrac

- **Complete loss of three wells during refrac attempt**
  - Highlights operational risks



Surface location of evaluated wells

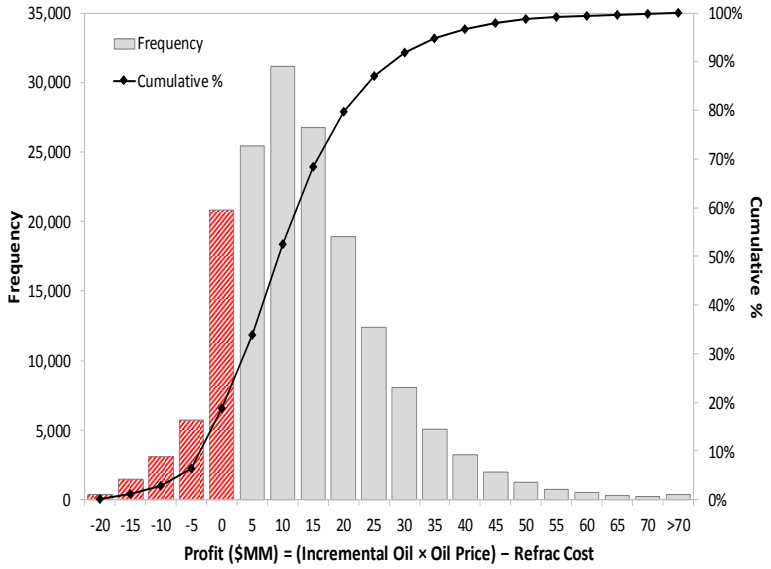
Refrac Economic Evaluation

- **Statistical analysis shows potential for per well losses of $15 million, to profit of over $70 million**
  - Based on simulations of all combinations of b values = 0, expected, and 1, oil price = 40, 60, and 120 usd/bbl, and cost of refrac = 2, 3, and 4 million dollars
- **Dataset of 168 wells shows some positive potential in Bakken refracs, but…**
- **Current refrac dataset substantially influenced by wells of specific initial completion type**
  - Limited inventory of openhole wells originally completed as a single stage remaining
  - Risk increases with increasingly complex completion methods

Refrac Economic Evaluation

- **About 20% of predicted refracs in EERC analysis resulted in losses or no profit**

Estimates outcomes using all combinations of:
b value = 0, expected, 1
Oil price = 40, 60, 120 $/bbl
Refrac cost = $2, 3, 4 million

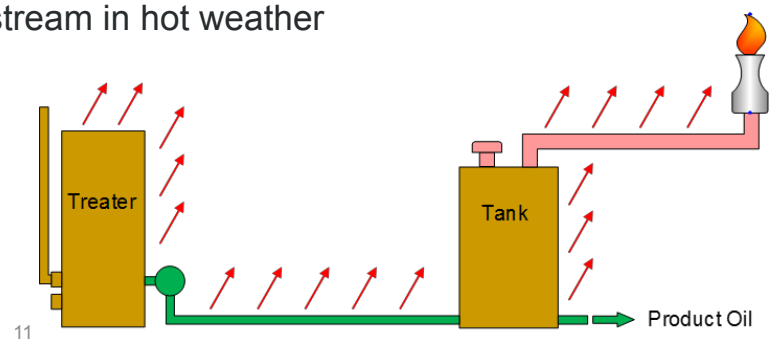


Statistical Analysis of Bakken Production Data

- **Analyzed 400 wells completed in the Bakken and Three Forks Formations located across the Bakken Production System**
  - 30 key completion and geologic variables observed at 6 and 60 months
  - Quantified the magnitude and effect of these variables (predictors)
- **Multiple completion and geologic variables affect 6 month production**
- **Only 1 completion variable and multiple geologic variables affect 60 month production**
  - Suggests geologic factors play greater roles over larger timescales
- **Results allow for improved well and field decision making**

Crude Oil Vapor Pressure Management

- **Goal**: Assist industry in understanding and optimizing vapor pressure management in surface production equipment
- **Activities**: worked with industry operators to gather data, develop computer models, and validate them with field data
  - Flash to atmospheric pressure in storage tanks greatly impacts oil vapor pressure
- **Impact**: determining optimal conditions for efficient operation will…
  - Help compliance with the State and midstream operators in cold weather
  - Minimize hydrocarbon losses to gas stream in hot weather



Crude Oil Vapor Pressure Management

Next Steps

- Conduct simulations and evaluate the impact of different variables on crude oil vapor pressure such as ambient conditions, insulation, and equipment configurations
- Summarize findings prioritizing strategies to meet vapor pressure targets

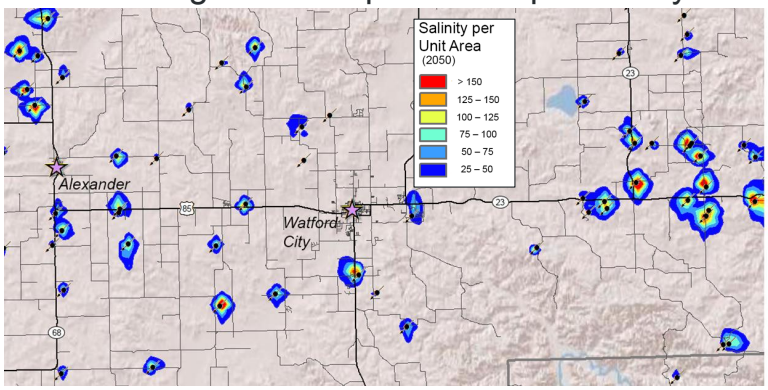
Ancillary Activities

Remediation Support

- Providing information to the Hydrocarbon Remediation Task Force as subject-matter experts
- Work compiling and updating the North Dakota Remediation Resource Manual to additionally include hydrocarbon along with produced water remediation content

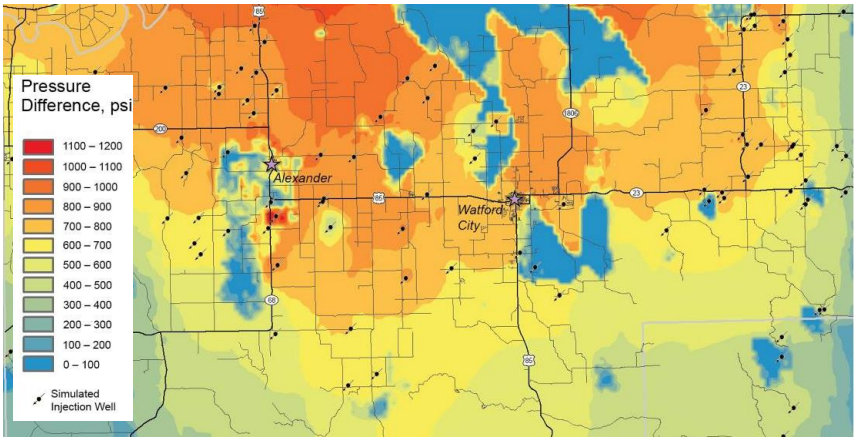
Salt Water Disposal (SWD) Modeling

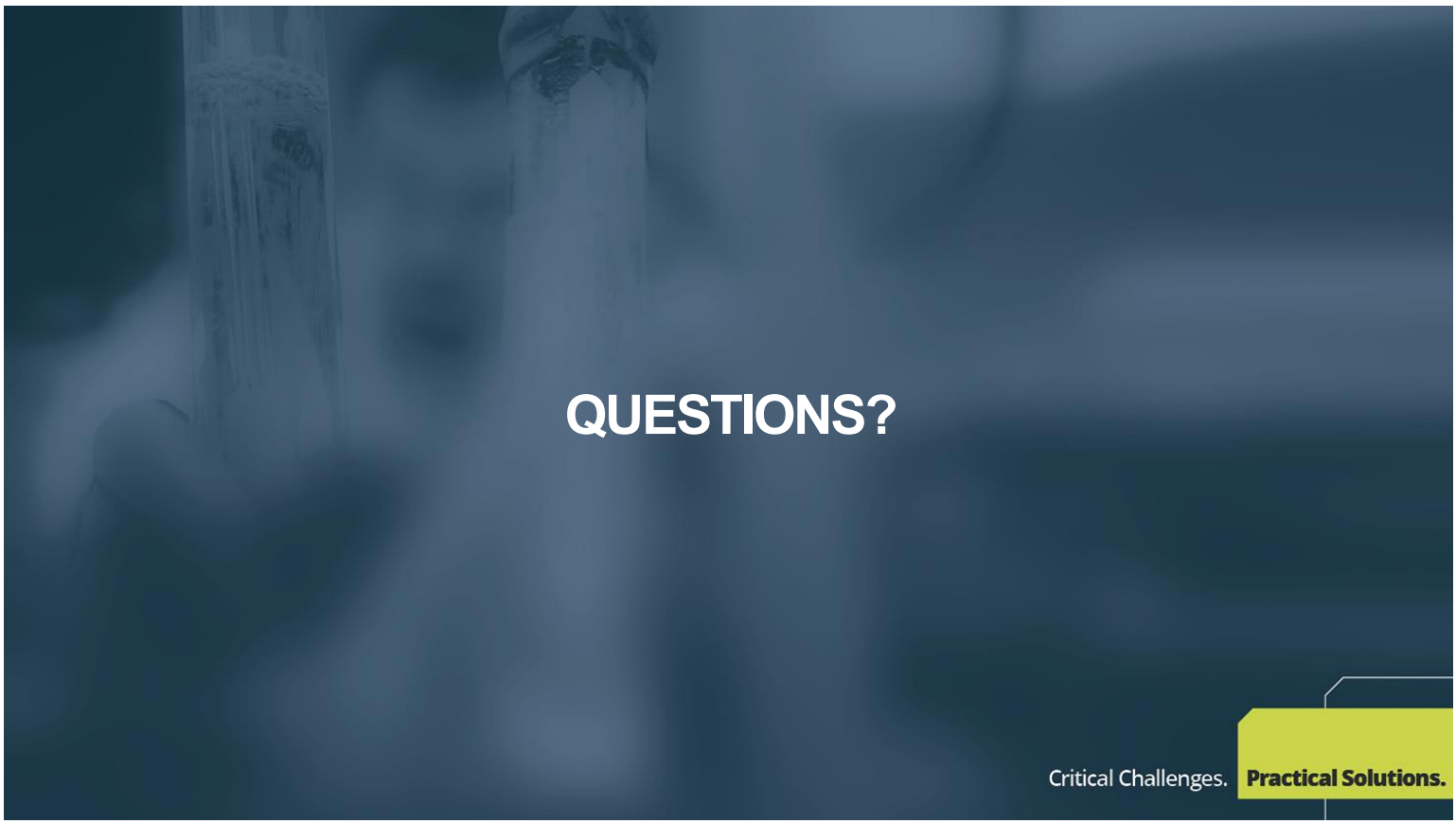
- **Goal**: evaluate the disposal potential of the Inyan Kara formation and to identify areas that may be conducive or problematic for future SWD operations
- Produced water requiring disposal:
  - 106 MM BBL in 2008
  - 456 MM BBL in 2017
- **Activities:** 3D simulations illustrate large overall storage potential with operational considerations, and increasing reservoir pressures potentially limiting some areas



SWD Modeling – Next Steps

- **Simplistic model being developed to assist with estimating the zone of influence of SWD wells**
  - Could be used to assist in locating/siting SWD wells
- **Continue to work with the State and BPOP membership to provide tools to assist with SWD and produced water management**




QUESTIONS?
Critical Challenges.
Practical Solutions.

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