



# The Bakken Production Optimization Program – Achievements to Date and a Look Forward

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Critical Challenges. **Practical Solutions.**

# Today's Agenda

- Highlights of BPOP 1.0 (2013-2016)
  - Industry Partners
  - Budget
  - Continental Resources' Hawkinson Project
  - EERC-Led Activities
- Look Ahead to BPOP 2.0 (2017-2019)
  - Industry Partners
  - Budget
  - Focus Topics

# BPOP 1.0 – The First Three Years

2013 - 2016

# A High-Caliber Consortium



# BPOP Program Design

## Goals

- Maximize oil production from Bakken and Three Forks wells by employing an “all of the above” approach
  - Perform reservoir characterization to determine whether the oil of the 2<sup>nd</sup> and 3<sup>rd</sup> benches in the Three Forks Formation should be considered separate and unique from those of the 1<sup>st</sup> bench
  - Improve drilling / stimulation / completion / production techniques and sequences
  - Determine optimal well spacing for development
- Optimize wellsite surface operations
  - Reduce operating costs
  - Reduce development and operations impacts to surrounding landowners
  - Reduce demands on surrounding infrastructure and water resources

## Targeted Outcomes

### Economic

- Increased well productivity and economic output of North Dakota’s oil and gas resources.
- Reduced demand for infrastructure construction and maintenance.
- Significant increases to estimates of recoverable hydrocarbons.

### Environmental

- Decreased environmental impacts of wellsite operations.
- Reduced land use impacts.
- Reduced gas flaring.
- Evaluation of technologies to recycle wastewater and decrease freshwater demand.
- Improved TENORM (technologically enhanced naturally occurring radioactive material) waste disposal operations.

### Educational

- Greatly increased understanding of Bakken–Three Forks reservoirs.
- Public education and outreach.

# BPOP 1.0 Financial Picture

Topic	NDIC	Industry	Total
Hawkinson Project	\$ 6,260,000	\$ 99,166,805	\$ 105,426,805
Hydrocarbon Utilization	\$ 568,311	\$ 1,088,480	\$ 1,656,791
Waste Management	\$ 39,954	\$ 370,998	\$ 410,952
Water Management	\$ 45,684	\$ 522,998	\$ 568,682
Site Logistics & Systems Failure Analyses	\$ 160,810	\$ 39,999	\$ 200,809
Spill Remediation & Land Reclamation <i>(Including \$164,586 NDSU Subcontract)</i>	\$ 655,709	--	\$ 655,709
Program Management	\$ 793,711	--	\$ 793,711
<b>TOTAL</b>	<b>\$ 8,524,179</b>	<b>\$ 101,189,280</b>	<b>\$ 109,713,459</b>

*An additional \$32,846 (\$30,321 NDIC + \$2,525 industry) balance remains, and is allocated to final reporting*

# High-Impact Program, High-Value Results



*Hess has been very pleased to participate in the Oil and Gas Research Program. This effort has brought the state's collective intellect and experience together on a significant challenge: improving the overall oil recovery from the Bakken and Three Forks reservoirs.*

–Stephen McNally, General Manager – North Dakota, Hess Corporation

*Serving on Energy and Natural Resources has allowed some insight and perspective useful for judging our oil and gas play. BPOP is helping greatly to bring efficiency, innovation, and coordination as we had hoped it would when creating this public-private entity.*

–Phil Murphy, North Dakota Senate District 20

*The Bakken Production Optimization Program is a remarkable example of how state and industry can and do work together to better define the North Dakota petroleum resource and to maximize productivity of the E&P work in the state.*

–Jessica Unruh, North Dakota Senate District 33

- Few programs have demonstrated a larger measurable impact
- Few programs deliver in so many critical areas of focus tied so closely to state and industry priorities
- Few programs have fostered more trust between state and industry
- NO other programs have demonstrated the ability to bring industry together on common issues in such an open manner
- Arguably, no other OGRP program has resulted in more economic growth potential for North Dakota



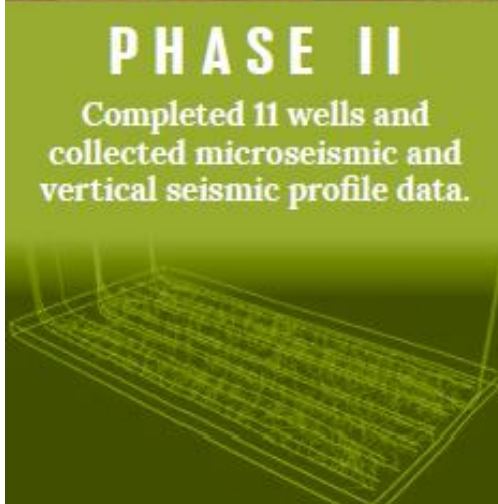
# The Hawkinson Project



**PHASE I**  
Drilled 11 consecutive wells within a single unit and collected log and core data.




**PHASE II**  
Completed 11 wells and collected microseismic and vertical seismic profile data.

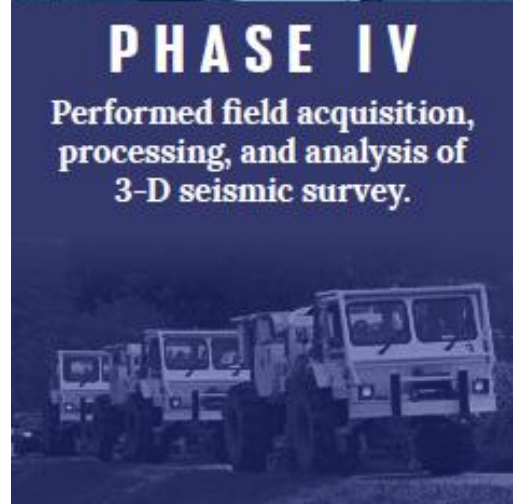


- A research project aimed at significantly increasing total production and production rates from North Dakota oil wells where oil reserves of the 2<sup>nd</sup> and 3<sup>rd</sup> benches of the Three Forks Formation are being explored.
- This research has the potential to result in significantly increased production from the Bakken/Three Forks system and decreased production costs to producers.

**PHASE III**  
Performed reservoir engineering analyses. Analyzed the data from Phases I and II. Integrated these data and analysis results into cohesive stimulation modeling and numerical reservoir simulations.

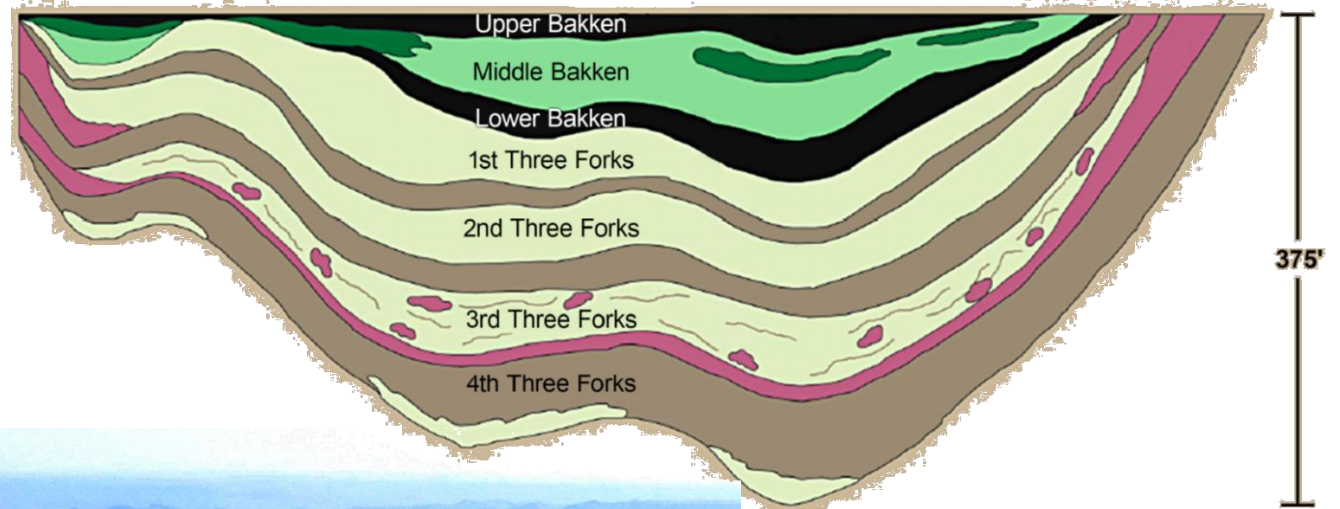


**PHASE IV**  
Performed field acquisition, processing, and analysis of 3-D seismic survey.





# The Hawkinson Project Location



# Industry Firsts Accomplished by the Hawkinson Project

## DRILLING

- Drilled sequentially 11 long laterals in 4 formations within a single unit
- 4 cemented liners, 7 openhole packers

## COMPLETIONS

- Completed 11 wells sequentially
- Tractored longest lateral USIT (ultrasonic imaging tool) runs (>21,000' MD)
- 63 days' continuous, 24/7, microseismic recording field operations

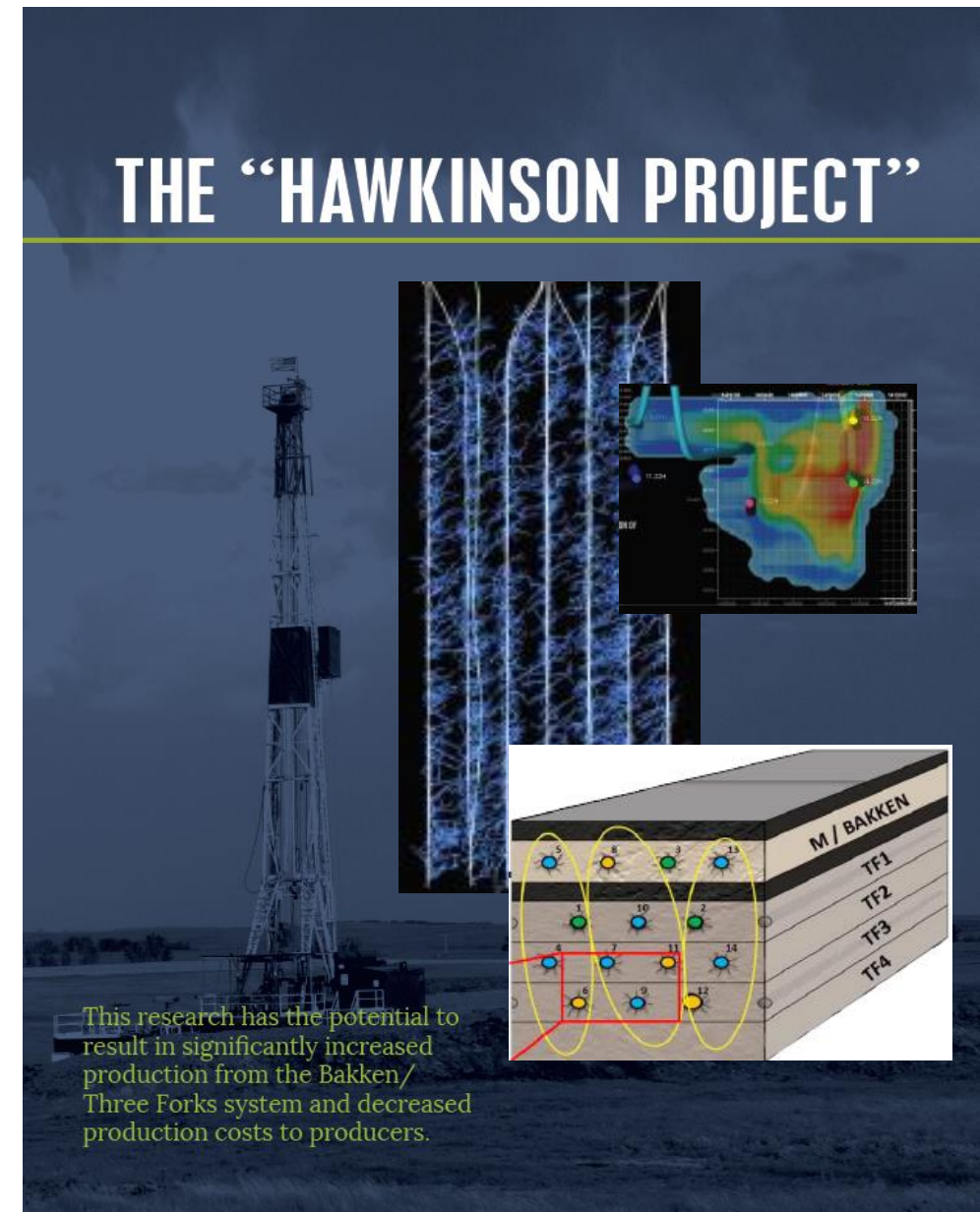
## MICROSEISMIC

- Historically largest to date in the industry
- Ten treatment wells sequentially monitored
- 283 stimulated stages recorded
- 171 tool monitoring days
- Longest laterals with 3 monitoring wells (>21,000' MD)
- Most footage of tractored tools in a single project (microseismic >270,000'; USIT >40,000')
- Longest lateral footage pulling ten geophone shuttles (>21,000' MD)
- Highest bottomhole temperature project designed with 3 monitor wells (266°F)
- ~1,200,000 microseismic event picks generated
- 3-D full elastic modeling to design microseismic data collection
- Measured (via vertical seismic profiling) and applied “Q” to the microseismic data



# Hawkinson Project Conclusions

- The Bakken and Three Forks Formations represent unique and distinct reserves.
- Producers must drill on a denser spacing to maximize production from the DSU.
- 200' heel/toe setbacks result in uncaptured resources.
- Significant undrained resources remain along section lines.
- Stimulations are contained within the Bakken petroleum system.
- Identified parameters best suited to predict well performance.

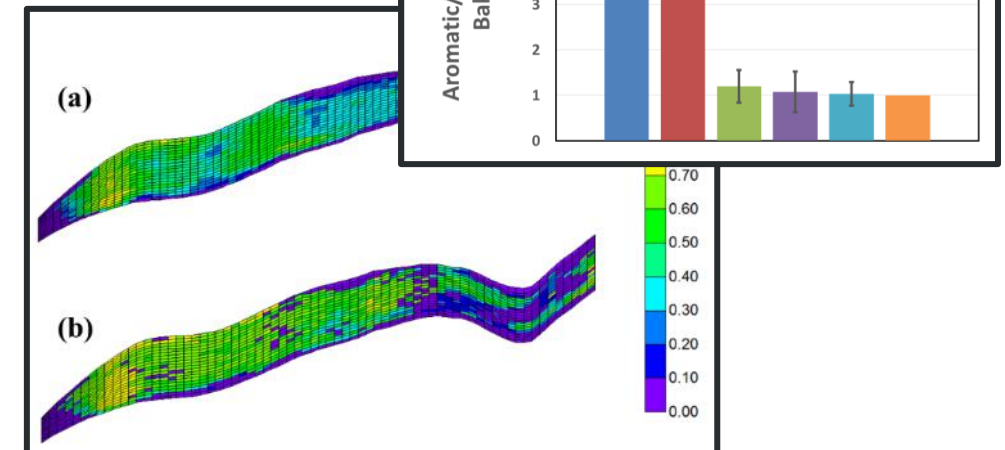
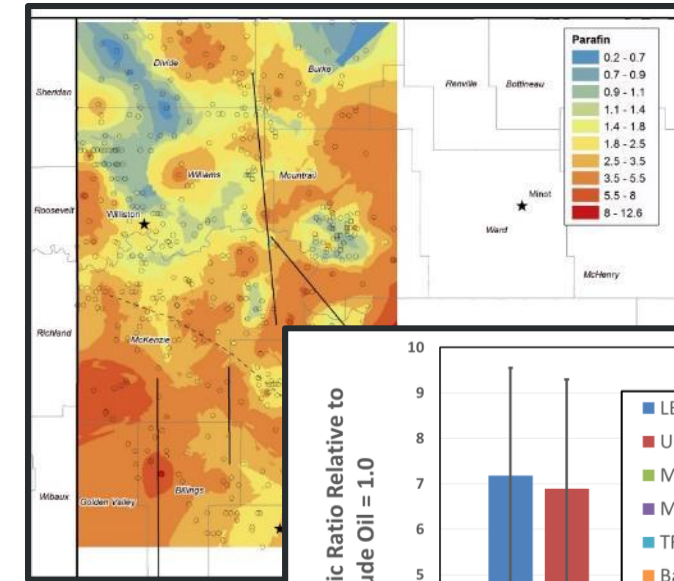


# EERC's Optimization of Wellsite Operations Activities

- Hydrocarbon Utilization
- Waste Management
- Water Management
- Site Logistics
- Process Optimization & Systems Failure Analysis
- Spill Remediation
- Land Reclamation
- Industry Forums
- Public Outreach
- NDPC Task Force Science Support

# Hydrocarbon Utilization

- Flaring Reduction
- Crude Oil Volatility
- Produced Fluids Characterization
- Investigation of Oil Compositional Analysis for Source Determination
- Investigation of Rich Gas for Enhanced Oil Recovery
- Simulation of Ethane Flooding in Conventional Resources
- Surface Facilities Process Model Development
- Decline Curve Analysis



# Waste Management & Water Management

## Waste Management

- TENORM Waste Disposal



## Water Management

- Bakken Water Management Practices and Potential Outlook
- Dakota Sandstone Capacity Modeling
- Decline Curve Analysis





# Failure Analyses

- Investigation of Sucker Rod Guide Premature Deterioration



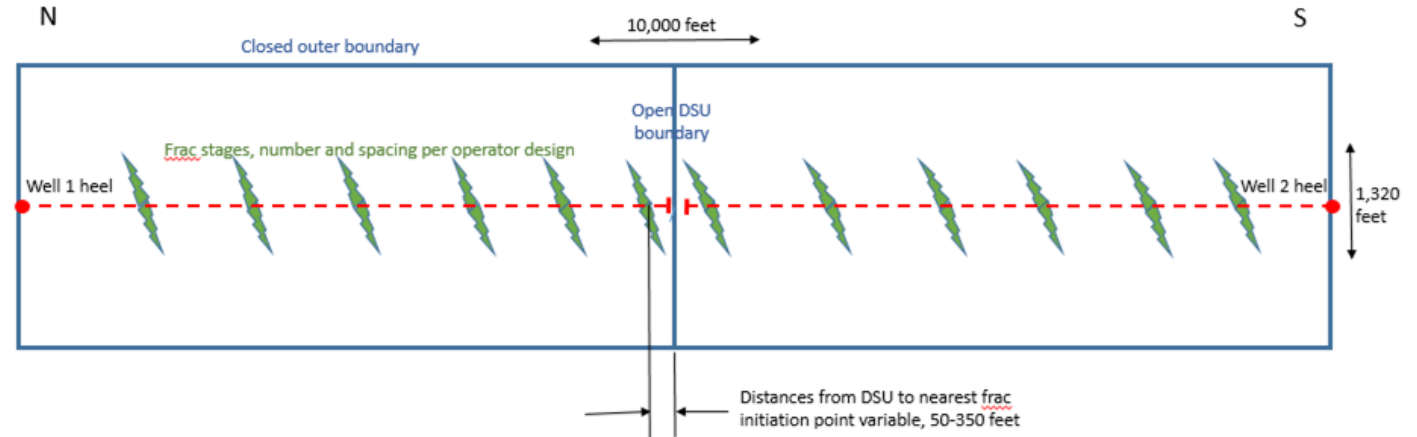
# Spill Remediation & Land Reclamation

- Saltwater Spills Task Force Support
- Spills Primer
- North Dakota Remediation Resource Manual



# DSU Setbacks

## Bakken-Three Forks DSU Offset Simulation Problem (Schematic Plan View- Not to Scale)



### The Issue

- Current rules include 200' setback for the well toe
- Opinion varies among interested parties concerning the ability of a 200' well toe setback to balance efficient development and correlative rights.

### BPOP's Role

- BPOP held a workshop to discuss the issue.
- BPOP members agreed to perform a numerical simulation comparison study and compare results toward the goal of a change recommendation to the state.
- BPOP refereed the modeling

# DSU Setbacks Results

- Horizontal well setbacks changed to:
  - well bore not isolated by cement at the heel >150'
  - wells completed open hole, well bore toe >150'
  - wells completed with the production liner or casing cemented in the lateral, well bore toe >50' (unless well is stimulated through the shoe at the toe ... then >150')
  - wells completed with the production liner or casing externally isolated in the lateral by the use of packers, well bore toe >100' (unless well is stimulated through the shoe at the toe ... then >150')



# BPOP Public Outreach

More in work ... hydraulic fracturing, induced seismicity, fugitive emissions



# BPOP 2.0 – The NEXT Three Years

2017 – 2019



# Anticipated BPOP 2.0 Focus Areas (cont'd)

- **Rich Gas EOR** - *Develop broader understanding of reservoir interactions with reinjected rich gas as a means of reducing flaring, reducing emissions, and improving ultimate recovery.*
- **Refrac Optimization** - *Facilitate broad industry engagement regarding candidate selection criteria, refrac execution, and post-execution evaluation.*
- **Produced Fluid Characterization** - *Collect and analyze data on crude oil, associated gas, and produced water to gain a better understanding of the resource and support facilities process modeling and reservoir modeling.*
- **Fugitive Emissions** - *Inform industry and state on the evolving emission regulatory picture, available emission measurement technologies, and available emission control technology.*
- **Hydrocarbon Sampling** - *Systematically investigate evolution of HC composition over time for surface equipment design, efficient reservoir recovery operations, and EOR planning.*
- **Reservoir Performance Modeling** - *Identify key reservoir and well performance metrics to enable better planning of surface facility development.*

# Anticipated BPOP 2.0 Focus Areas (cont'd)

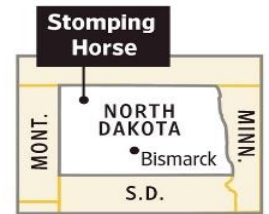
- **Water Injection Reservoir Assessments** - *Identify key reservoir and well performance metrics to enable better planning of surface facility development.*
- **Facility Process Modeling** - *Develop a foundational tool for holistic examination of the coupled effects of several operations variables (produced fluid composition, climate, processing equipment, operating conditions, equipment suite designs, etc.) on fugitive emissions, crude oil properties, and equipment performance.*
- **Aromatic/Aliphatic Study**- *Evaluate oil composition as a tool to identify the source of produced oil and improve the understanding of oil recovery.*
- **Site Equipment Survey** - *Develop an empirical inventory of typical operational well site processing equipment and their performance parameters.*
- **Regulatory Review** - *Create tools to facilitate better understanding of regulations driving actions in the oil field, then use these tools to inform other BPOP 2.0 activities.*

# Liberty Resources – “Oil Factory”

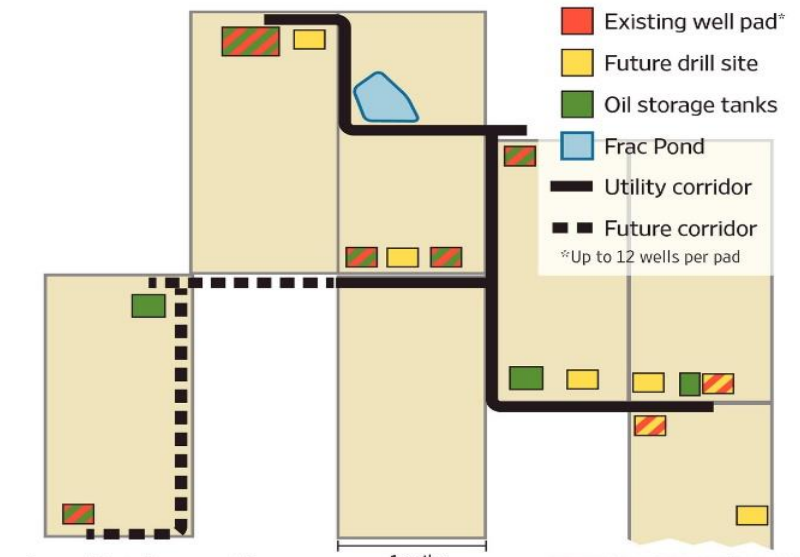
- Liberty approached the EERC in late 2016 to explore leveraging BPOP 2.0 with their “Oil Factory” project
  - A methodical, structured approach to oil field development
  - Designing a system of well sites, rather than site-by-site
  - Maximizing field and DSU productivity
  - Minimizing environmental impact
- Expect to finalize an MSA/NDA/JDA this week.

## Building an Oil Factory

Instead of drilling wells on an ad hoc basis, Liberty Resources is developing a 96-well North Dakota development called Stomping Horse in a methodical manner to reduce costs. The company has built a “utility corridor” that connects and services the well pads, reducing the need for heavy truck traffic and long runs of pipeline to isolated units.



- ◆ **A network** of 16-inch pipe will collect the natural gas for sale; a 6.5-inch oil pipeline will gather the oil.
- ◆ **Natural gas** will also be captured and piped around the project to power drilling rigs and other equipment.
- ◆ **Water for hydraulic-fracturing** operations in the 96 wells will come from a single “frac pond” connected by pipeline to the well pads.
- ◆ **A saltwater disposal** well will take wastewater via pipeline from oil-extraction operations.



Source: WSJ, May 5, 2015

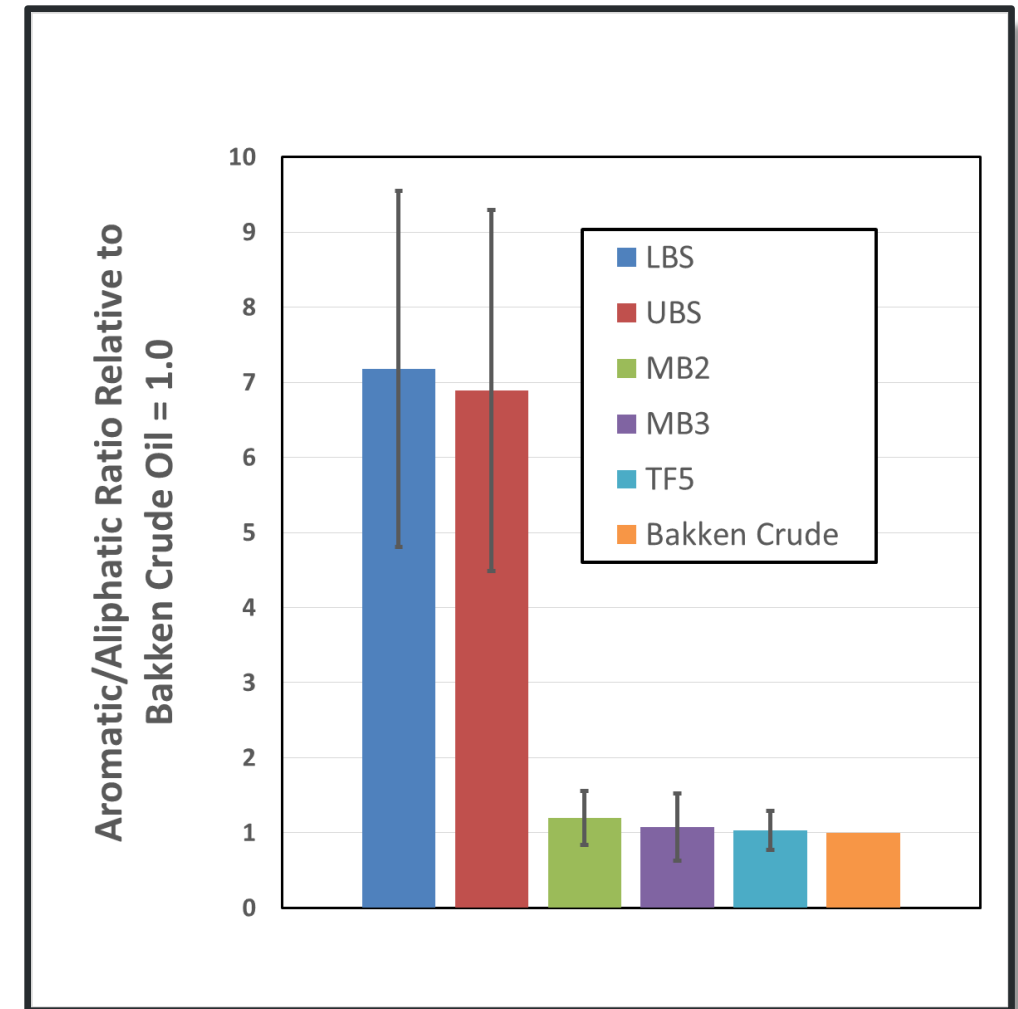
# Liberty Resources



- EERC/BPOP will contribute
  - Lab research
  - Reservoir simulation
  - Data interpretation
- Liberty will contribute the following, then share data with the state via BPOP
  - Project implementation and operation
  - Reservoir interpretation and characterization
- First product:
  - A “Reader’s Digest” version of how to permit a DSU pilot, and to develop and permit a unit for full field Bakken EOR

# Marathon Oil

- Marathon has committed to partnering with BPOP 2.0 to explore application of unique integrated field and lab approaches to reservoir characterization and resource assessment (aromatic/aliphatic study).
- EERC/BPOP will contribute
  - Methods development
  - Laboratory research and analysis
  - Reservoir modeling
- Marathon will contribute
  - Well drilling and completion
  - Collection of core samples



# BPOP 2.0 Anticipated Budget – Year 1 (subject to change)

Task	Budget
Emerging Issues	\$ 225,000
Aromatic/Aliphatic	\$ 285,000
Environmental Support	\$ 48,000
Ethane/Rich Gas EOR	\$ 295,000
Produced Fluid Characterization	\$ 100,000
Water Management	\$ 120,000
Reservoir Modeling	\$ 228,000
Process Modeling	\$ 215,000
Strategic Research	\$ 240,000
Management	\$ 244,000
<b>TOTAL</b>	<b>\$ 2,000,000</b>

- NDIC
  - \$2M / year for 3 years
- Industry
  - Marathon: \$7.28M in-kind
  - Liberty: “*in negotiation*”
  - Additional cash dues being solicited from BPOP 1.0 members and others



# CONTACT INFORMATION

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