Overview of the Energy & Environmental Research Center's Proposed Bakken Production Optimization Program

NDIC - OGRC
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THE UNIVERSITY OF NORTH DAKOTA

Bakken Production Optimization Program

A public–private partnership to optimize oil and gas activities and improve the efficiency of operation.

- Tasks executed within the program will be funded by the commercial partners with matching funds from NDIC-OGRC
- Activities directed by the commercial partners, with technical support from the EERC
  - Laboratory, pilot, and field-based
- Results of the project communicated to NDIC-OGRC and other program sponsors
- Proposing ~$1,000,000/yr for three years from NDIC. Requesting ~$200,000/yr from multiple industry partners

Bakken Production Optimization Program (Cont.)

- Focus areas to be addressed within this proposed program will be developed in collaboration with partners. Preliminarily, the EERC has suggested the following four broad categories:
  - Hydrocarbon utilization
    - Bi-fuel operation of drilling rigs, hydraulic fracture operations
    - Associated gas use for site operations
  - Water management
    - Water treatment, recycle, and reuse technologies
  - Site logistics
    - Evaluation of equipment siting and workflow at multi-operation and/or multi-well locations
    - Site construction materials
    - Environmental challenges
  - Process optimization and systems analysis
    - Investigation of sources of well failure and development of mitigation strategies
    - Standardization of wellsite design to increase efficiency & reduce cost
    - Emission characterization & testing

Program Goal

- Explore wellsite optimization approaches that have potential to
  - Reduce wellsite costs
  - Improve wellsite production
  - Reduce wellsite development and operation impacts to surrounding land owners
  - Decrease demands on surrounding infrastructure and water sources

Possible Examples of Program Tasks

- Specific tasks will be defined/refined by industry partners and OGRC, but might include tasks such as:
  - Combined NGL recovery and natural gas utilization on-site for power
  - On-site wastewater and hydraulic fracturing fluid recycling to minimize transportation and disposal costs
  - Drilling, workover, and completion rig repowering to enable utilization of associated gas available on-site or nearby
  - Wellsite opportunities that integrate power- and water-related aspects during drilling / workover / completion activities, water transport and utilization, and fuel utilization to achieve cost containment (= max economic output)
  - Means of improving handling/disposal efficiency for drilling and production wastes, including naturally occurring radioactive materials (NORM)
  - Any optimizations that result in a net reduction of truck traffic in and out of the wellsite

Anticipated Results

Environmental

- Less truck traffic
  - Decreased diesel emissions
  - Decreased road damage and subsequent maintenance
  - Decreased road dust
  - Decreased incidence of spills
- Less wastewater production and reduced demand for freshwater supplies
- Less flaring/reduced emissions from flares
- Potential for smaller well pads

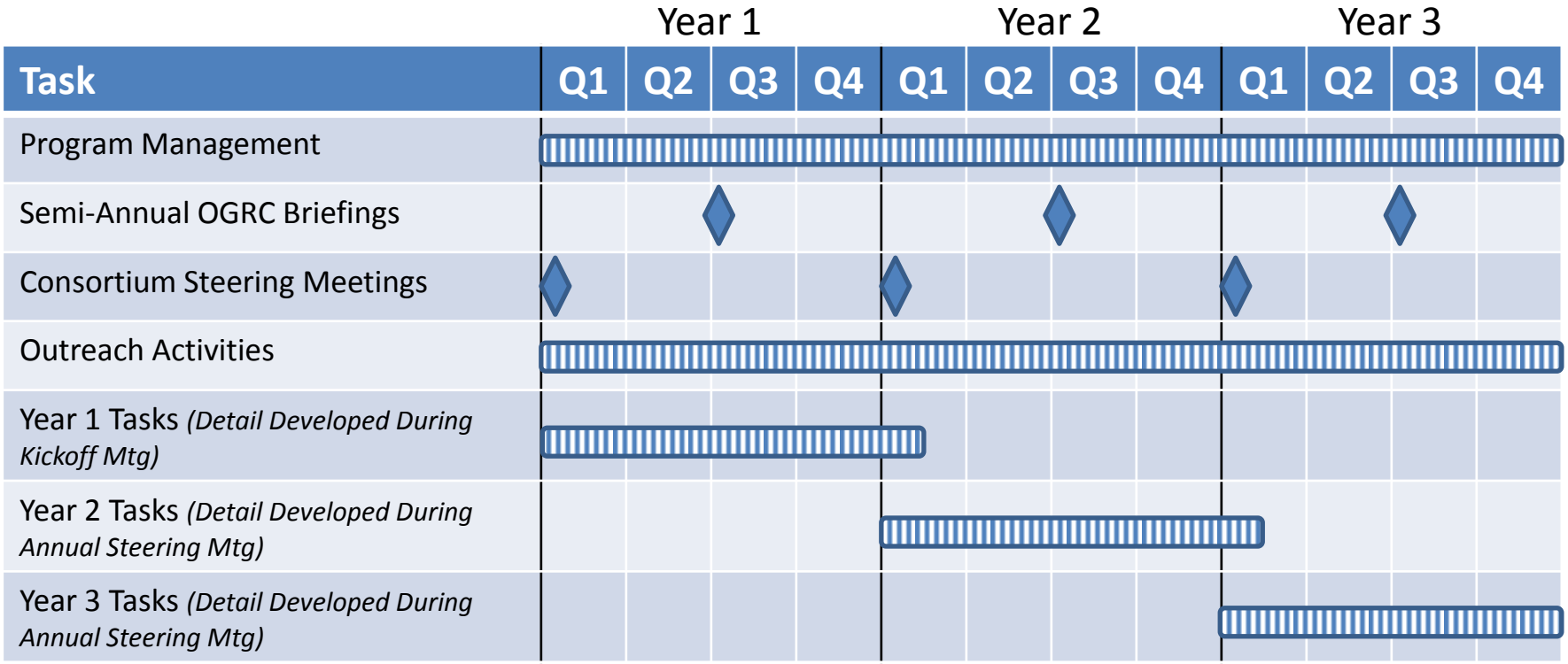
Economic

- Increased royalties and tax base from oil, harnessed associated gas and NGL streams
- Increased profits from added product streams, engaged earlier in the well life cycle
- Decreased road maintenance costs
- Decreased costs for water and wastewater hauling and disposal

Industrial Partners to Date

- Committed at Time of Proposal Submittal
  - Marathon Oil
  - Whiting
  - Continental
- Near-Term Commitment Possible from Other Partners
  - Halcón
  - Hess
  - Oxy
  - XTO
  - Oasis
  - Statoil

Program Schedule



Program 3-Year Budget

Project Associated Expense	NDIC Share	Industry Share	Total Program
Total Labor	$ 2,433,292	$ 2,498,342	$ 4,931,634
Travel	$ 104,522	$ 237,590	$ 342,112
Supplies	$ 179,545	$ 191,200	$ 370,745
Communication	$ 4,349	$ 2,957	$ 7,306
Printing & Duplicating	$ 8,940	$ 8,640	$ 17,580
Food	$ 7,599	$ 8,640	$ 16,239
Operating Fees & Svcs			
Natural Materials Analytical Res. Lab.	$ 109,145	$ -	$ 109,145
Analytical Research Laboratory	$ 7,155	$ -	$ 7,155
Particulate Analysis	$ 39,421	$ -	$ 39,421
Graphics Support	$ 24,165	$ 25,949	$ 50,114
Shop and Operations Support	$ 37,271	$ 26,682	$ 63,953
Remote Sampling Trailer	$ 44,596	$ -	$ 44,596
Total Project Cost	$ 3,000,000	$ 3,000,000	$ 6,000,000

Backup Slides

EERC's Oil- and Gas-Related Experience and Capabilities

State-of-the-Art Facilities

More than 245,000 square feet of state-of-the art laboratory, demonstration, and office space.

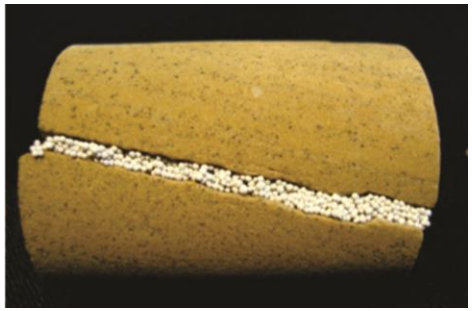
EERC Engineering Capabilities

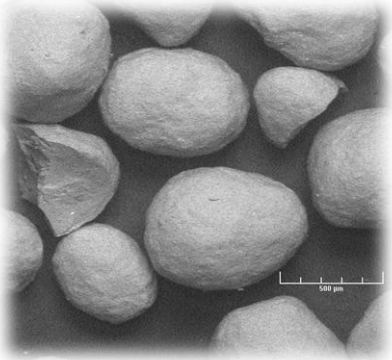
- The EERC has dedicated staff to carry mechanical and chemical process designs from conception through fabrication and installation.
  - Multiskilled, matrixed engineering and science staff
  - Instrumentation and automation specialists
  - Process design group
  - Mechanical design group
  - Fabrication shop
  - Quality assurance/quality control personnel
  - Skilled technician/operator staff

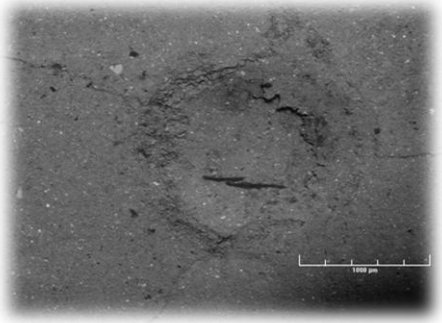
AGL Equipment

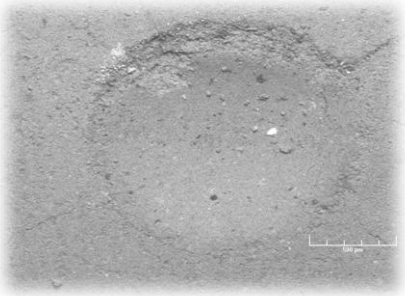
- Optical profilometer
- +20-ton universal compression frame
- Flexible-wall permeameter
- Hoek-style triaxial and core-flood cells
- Scanning electron microscopy (SEM)
- Supergamma spectrometer
- GC-MS
- Thermal dilatometer
- Ion chromatographer
- X-ray diffraction (XRD) and x-ray fluorescence (XRF)
- Helium porosimeter
- Petrographic microscope

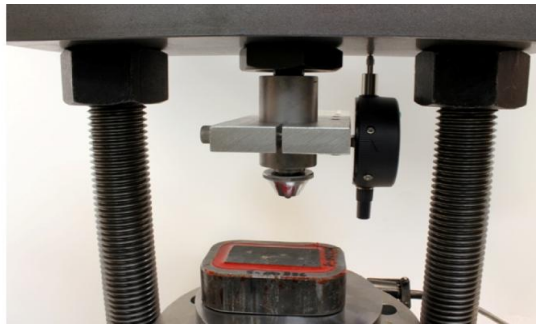
Proppant Embedment and Penetration Testing







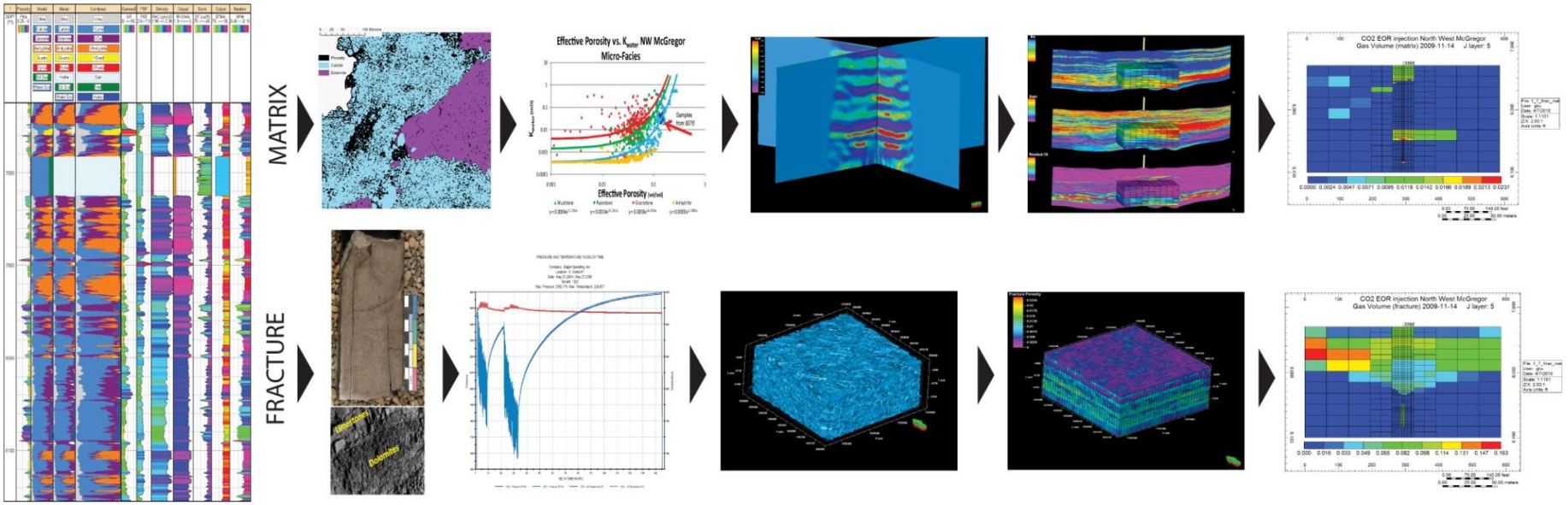




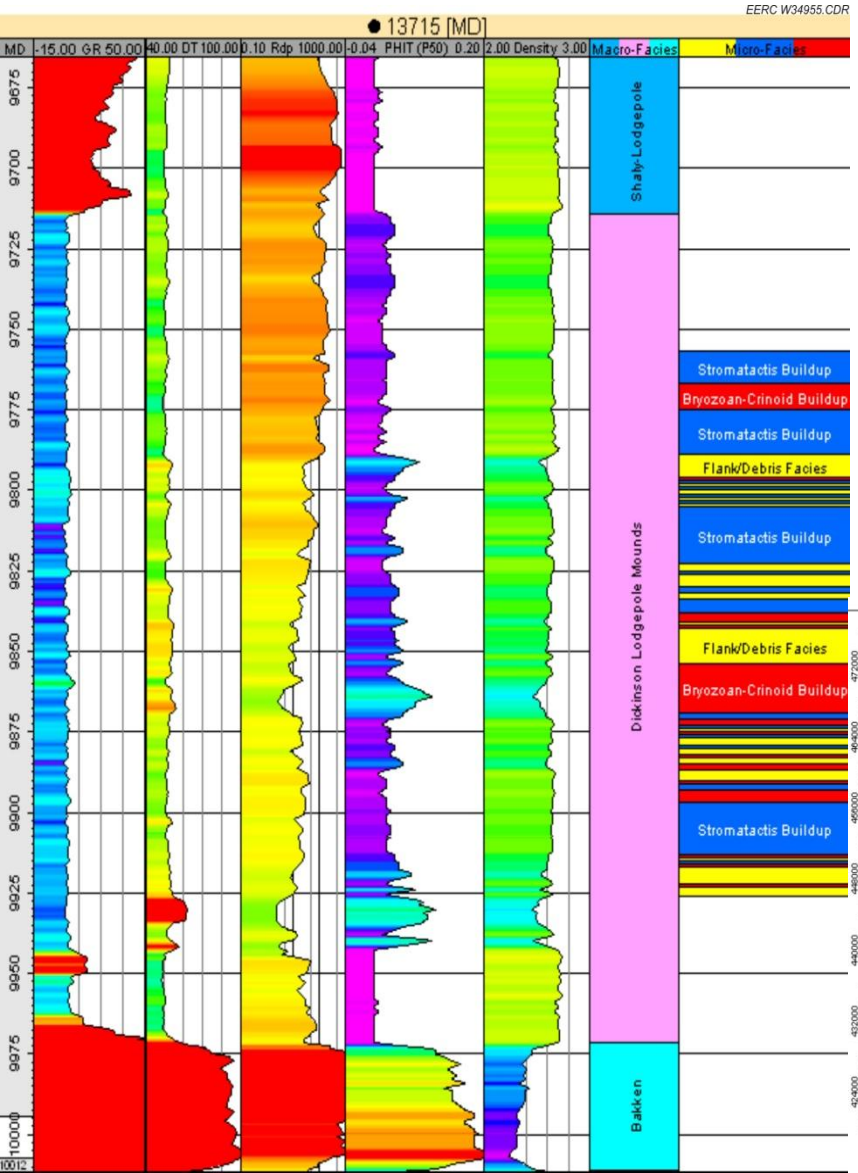
Modeling and Simulation

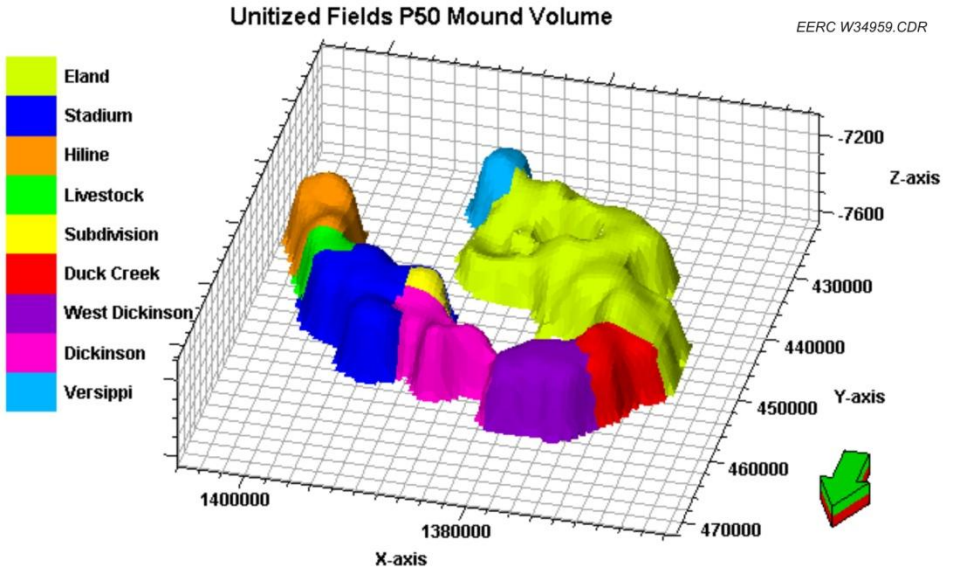
Modeling Capabilities

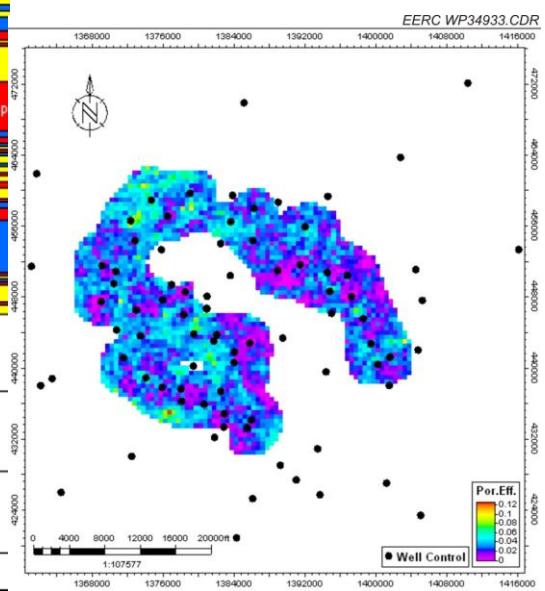
- Log and well test normalization and interpretation
- Petrophysical analysis
- Property modeling, including facies modeling using multiple-point statistics
- Fluid modeling and equation-of-state calibration
- Numerical simulation, including history matching and prediction

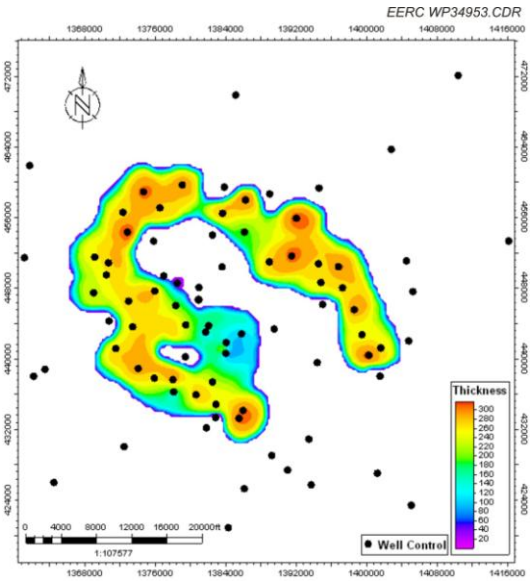


Dickinson Lodgepole Mounds









Monitoring and Characterization Well Real-Time Data for Bell Creek Oil Field

Casing-Conveyed Pressure/Temperature Gauges

Distributed-Temperature Fiber Optic Cable

Environmental Experience

Soil Gas Field Analyses

- Near active wells, and between active wells (interspaced)
- Near plugged and abandoned (P&A) wells (three-spot)

RAE Systems PGM-54 Handheld Multigas Analyzer

CO_2, total VOCs, O_2, H_2S

Agilent 490 Micro Quad GC (field laboratory)

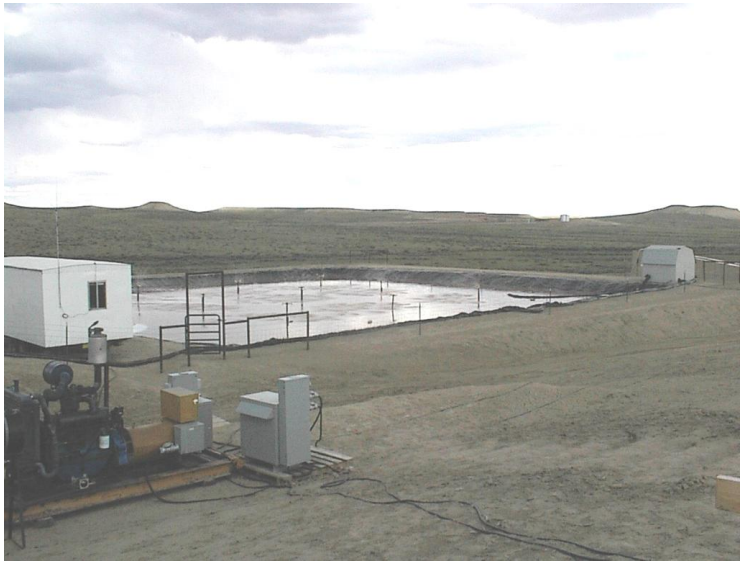
CO_2, individual VOCs, N_2, O_2, H_2, H_2S

Soil Remediation

- Joint industry–government-funded programs.
- Remediation of soils impacted by hydrocarbons and gas-processing constituents.

- Complete removal of amines after 200 days of operation.
- Other parameters were below regulatory limits after 300 days of operation.

Innovative Management of Produced Water and Frac Fluids



Produced brine is suitable (ideal) for use in deep (>2200 ft) drilling applications.

Treated water is suitable for use in surface and near-surface (<2200 ft) drilling applications.

In some states, treated water can be used for stock-watering and/or irrigation.

Freeze–Thaw Evaporation (FTE®) facility at Jonah Gas Field, Wyoming.

Joint industry–government-funded project.

Project Experience

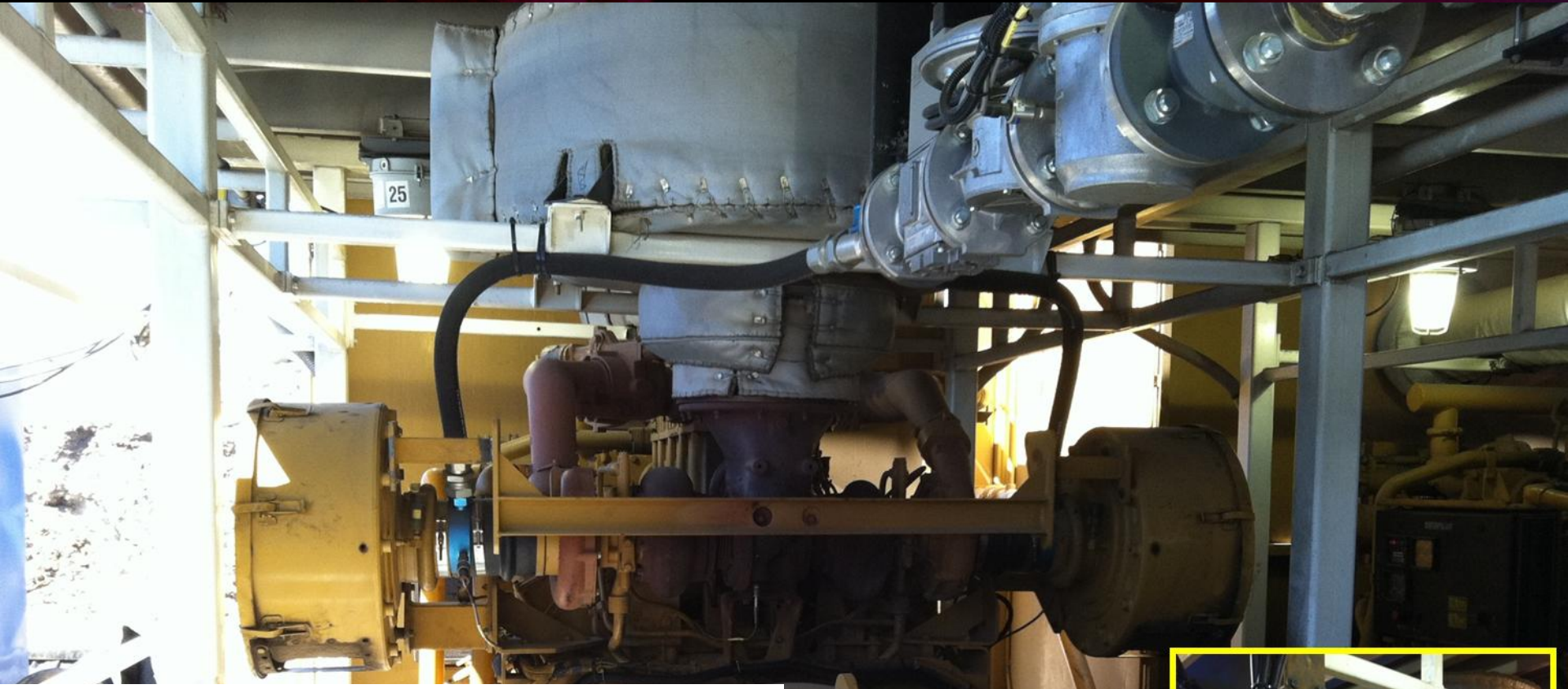
Gas/Diesel-Powered Drilling Rig Project Overview

- Tested dual-fuel operation of a Caterpillar 3512 engine at the EERC using simulated rich gas.
  - Butler Machine supplied Caterpillar 3512 engine.
  - Simulated rich-gas mixture produced using bottled/tank-delivered industrial gases and EERC-fabricated gas-metering system.
  - GTI Bi-Fuel® system used to supply gas to engine.
  - Monitored engine performance and emissions over a range of operating conditions and fuel mixtures.

- Field demonstration of gas-powered drilling operations using rich Bakken gas.
  - Two wells drilled using GTI Bi-Fuel system and rich wellhead gas from nearby well.
  - Monitored engine performance, gaseous and diesel fuel use, and emissions.

Rich-Gas Test Results

- Simulated rich-gas tests at the EERC
  - Tests completed June 2012; report summarizing results submitted to North Dakota Industrial Commission (NDIC).
  - Diesel replacement rates of greater than 40% can be achieved, and the GTI Bi-Fuel system can control fuel use to ensure safe engine operation.
  - Matching engine load with diesel replacement rate is important to prevent poor fuel utilization and to minimize unburned hydrocarbon emissions.
- Field testing of gas-powered drilling operations
  - GTI Bi-Fuel system was operated August–September.
  - The EERC installed a data acquisition system to enable real-time continuous monitoring and logging of engine performance; provided on-site technical support throughout field test.
  - Data analysis and reporting are ongoing; final report will be submitted to NDIC in late 2012.
  - Demonstrated efficient, economical use of wellhead gas; vendor claimed savings of >$3000/day.



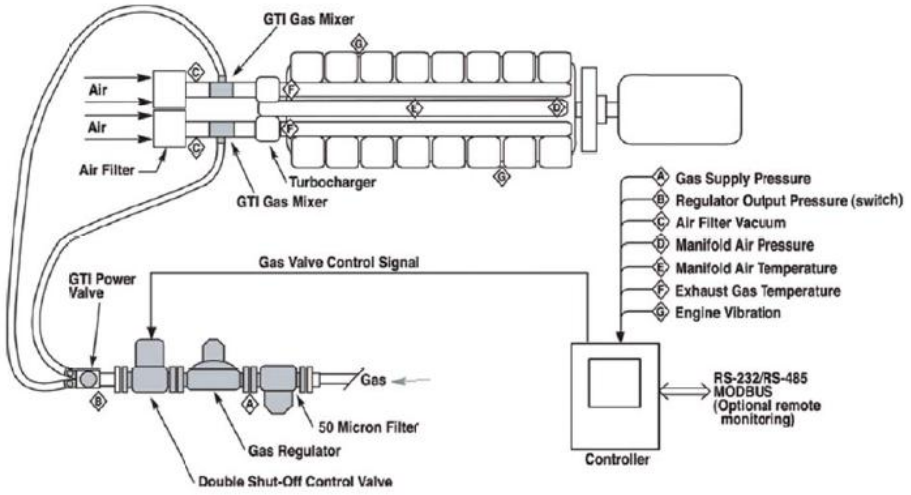


Figure A-1. GTI Bi-Fuel System schematic (www.gti-altronic.com)

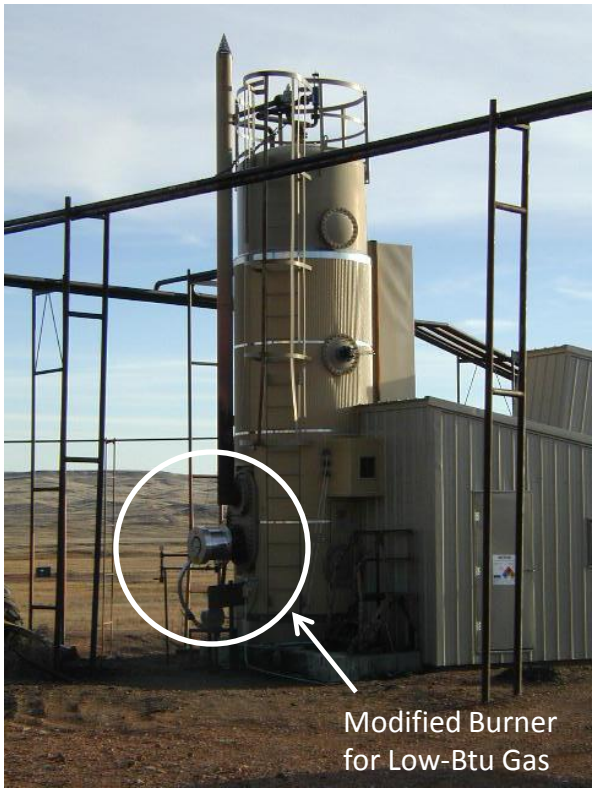
Associated Gas Use Study

- Study goal: to evaluate technologies capable of utilizing associated gas upstream of natural gas-processing plants
  - Natural gas liquids recovery
  - Compressed natural gas for vehicle fuels
  - Electrical power generation
  - Chemical production
- Broad contribution from a wide variety of stakeholders
- Study submitted to NDIC July 2012
- Webinar tentatively scheduled November 5, 2012
  - https://www.dmr.nd.gov/pipeline/

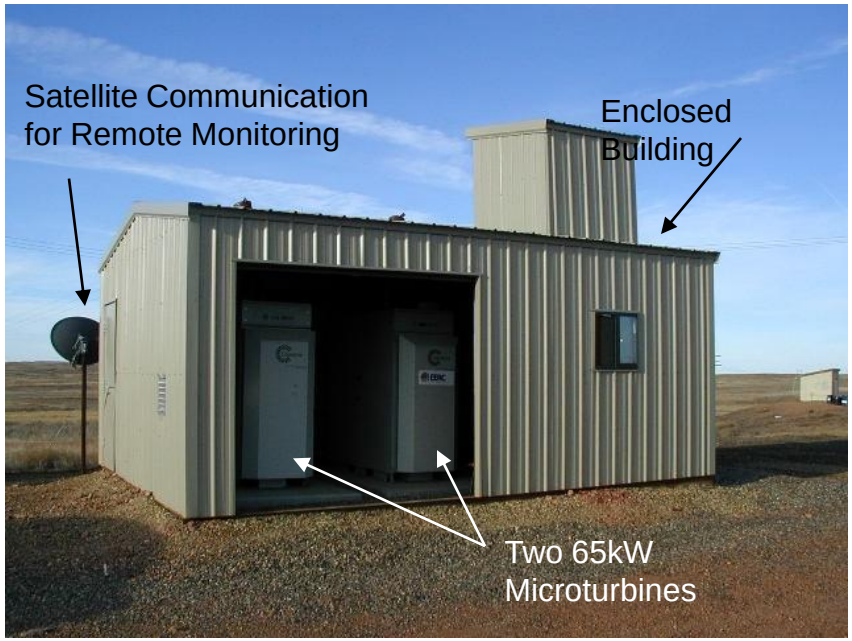
Low-Btu Gas Utilization

Low-Btu Gas Utilization:

Thermal Application

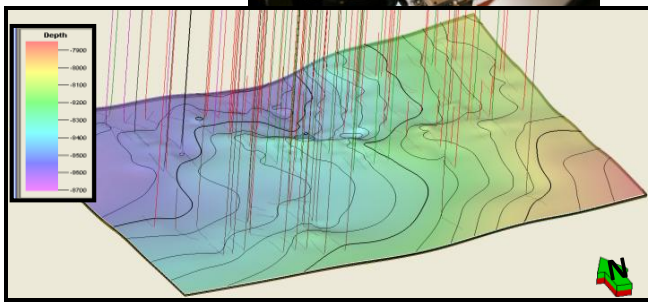


Power Generation



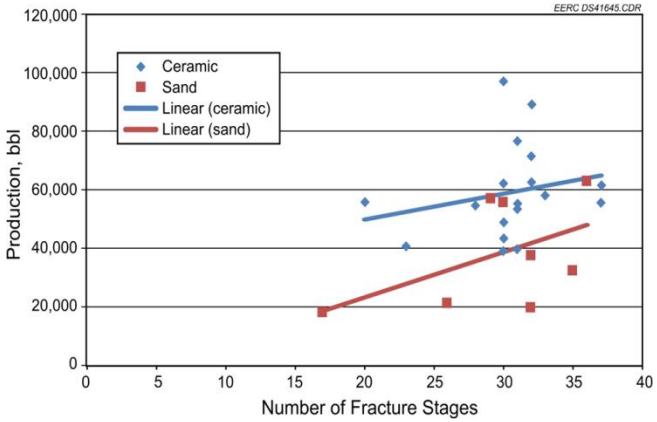
Bakken CO_2 EOR Project Goals

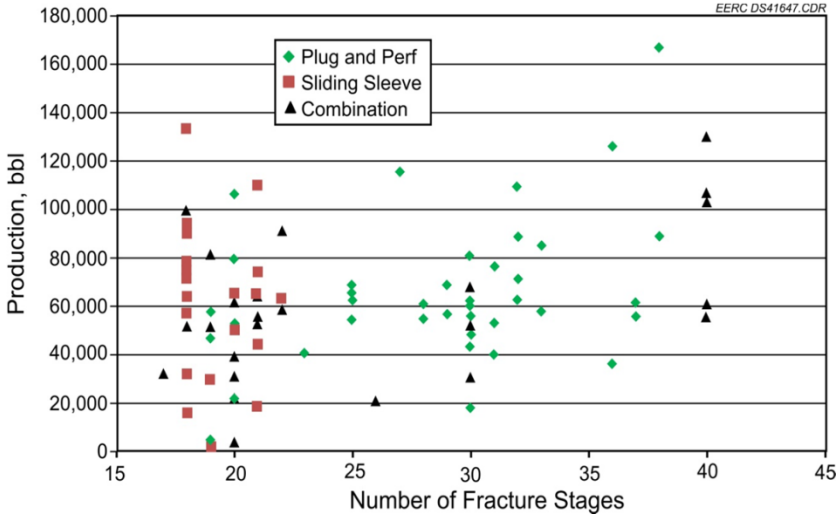
- To predict the performance of CO_2 EOR in the Bakken using lab experiments coupled with modeling.
  - Quantify phase behavior and fluid properties under reservoir conditions.
  - Compare different Bakken reservoir types.
  - Lab analyses include:
    - Detailed analyses of Bakken reservoir rocks.
    - Effects of CO_2 on key oil properties.
  - Modeling activities will:
    - Generate geologic reservoir models.
    - Conduct dynamic simulation modeling.



Recent Bakken Work – Benchmarking Proppants, Stimulation Methods, and Frac Fluids

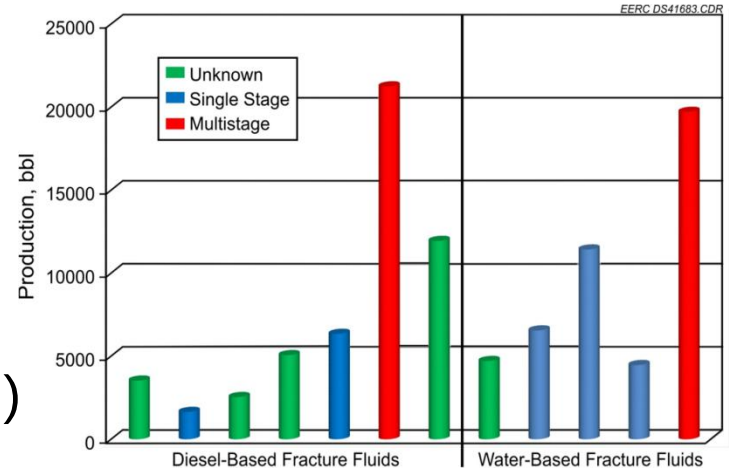
Proppants
(ceramic vs. sand)





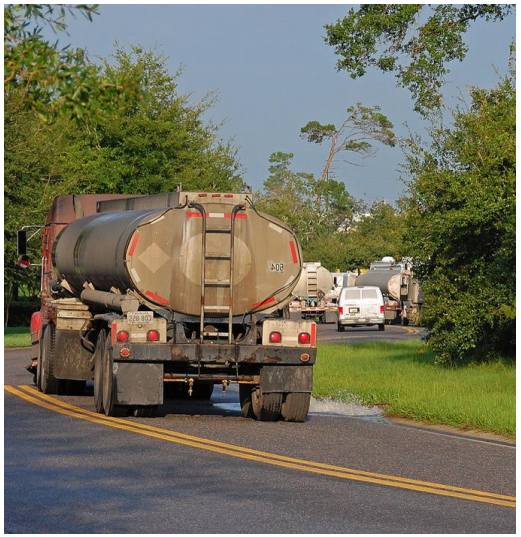
Stimulation Methods
(sliding sleeves vs. plug and perf vs. combo)

Frac fluid types
(diesel-based vs. water-based)



Bakken Water Opportunities Assessment

- Goals
  - Evaluate feasibility of recycling frac flowback waters.
  - Assess technical and economic feasibility of upgrading nonpotable groundwater for use in fracs.
- Outcomes:
  - Frac flowback quantity and quality data collected from 89 wells, representing five producers.
  - Because of low initial flowback water recovery rates and extremely high dissolved salt content, **recycling of Bakken frac flowback water is challenging**.
  - A pilot project using reverse osmosis (RO) to treat brackish groundwater was conducted.
  - If access to freshwater sources is limited, **RO treatment may be economically feasible**.



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