EERC
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
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May 10, 2013

Ms. Karlene Fine
North Dakota Industrial Commission
ATTN: Oil and Gas Research Council
State Capitol – 14th Floor
600 East Boulevard Avenue, Department 405
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: EERC Proposal No. 2013-0176 Entitled "Program to Determine the Uniqueness of Three Forks Bench Reserves, Determine Optimal Well Density in the Bakken Pool, and Optimize Bakken Production" in Response to the North Dakota Industrial Commission Oil and Gas Research Program Solicitation

The Energy & Environmental Research Center (EERC) is pleased to propose a research program designed to encourage and promote the use of new technologies that have a positive economic and environmental impact on oil and gas exploration and production in North Dakota.

Enclosed please find an original and one copy of the subject proposal along with a check for $100. The EERC, a research organization within the University of North Dakota, an institution of higher education within the state of North Dakota, is not a taxable entity; therefore, it has no tax liability.

This transmittal letter represents a binding commitment by the EERC to complete the program described in this proposal. If you have any questions, please contact me by telephone at (701) 777-5157, by fax at (701) 777-5181, or by e-mail at jharju@undeerc.org.

Sincerely,

John A. Harju
Associate Director for Research

Dr. Gerald H. Groenewold, Director
Energy & Environmental Research Center

JAH/sah

Enclosures

c/enc: Brent Brannan, Oil and Gas Research Council

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: Program to Determine the Uniqueness of Three Forks Bench Reserves, Determine Optimal Well Density in the Bakken Pool, and Optimize Bakken Production

Applicant: Energy & Environmental Research Center (EERC) and Continental Resources, Inc.

Principal Investigators: John A. Harju, EERC, and Stan Wilson, Continental Resources, Inc.

Date of Application: May 10, 2013

Amount of Request: $8,000,000

Total Amount of Proposed Program: $115,230,000

Duration of Program: 3 years

Point of Contact (POC): John A. Harju

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ABSTRACT

Objective: The Energy & Environmental Research Center (EERC), in close coordination with Continental Resources, Inc., and several of the Williston Basin's premier operating companies proposes a research program with the goal of simultaneously improving Bakken system oil recovery while reducing its environmental footprint. This program will investigate new technologies and approaches to simultaneously increase understanding of potential petroleum reserves in the Bakken/Three Forks system and decrease recovery costs in an environmentally sound manner.

Expected Results: The results of the proposed work will increase well productivity and economic output of North Dakota's oil and gas resources, decrease environmental impacts of wellsite operations, and reduce demand for infrastructure construction and maintenance. Specific results will include a) greater understanding of Bakken/Three Forks reservoirs and subsequent significant increases to estimates of recoverable hydrocarbons; b) less truck traffic, resulting in decreased diesel emissions, road dust, and spills; c) reduced road maintenance costs, wastewater production, disposal costs, and freshwater use; d) reduced land use impacts; and e) increased revenue from added product streams, captured earlier in the well life cycle.

Duration: The duration of the North Dakota Industrial Commission (NDIC) portion of the proposed program will be 3 years (July 1, 2013, to June 30, 2016). Three years of Oil and Gas Research Council (OGRC) support is critical to initiate this program. Following the initiation period, the program is expected to continue in subsequent years with commercial participation only, but the program will still benefit North Dakota and support NDIC goals.

Total Program Cost: The total cost of the program is $115,230,000. The amount requested from the Oil and Gas Research Program is $8 million, with $3 million requested in each of the first 2 years of the effort and $2 million in the third year. The remaining funds for the effort will be provided in the form of cash and in-kind contributions by a consortium of Bakken producers.

Participants: Several companies have provided letters regarding their intention to participate, while several others are still contemplating participation. Participants committed to date include the EERC, Continental Resources, Marathon Oil Company, and Whiting Petroleum Corporation. Additional commercial partner participation will be solicited throughout the duration of the program.

PROJECT DESCRIPTION

The Energy & Environmental Research Center (EERC), in close collaboration with Continental Resources, Inc., and several of the Williston Basin's premier operating companies proposes a research program with the goal of simultaneously improving Bakken system oil recovery while reducing the environmental footprint of operations. It is anticipated that this research will result in significantly increased production from the Bakken/Three Forks system, decreased production costs, and decreased environmental impact because of optimized wellsite operations.

This program will investigate new technologies and approaches to decreasing recovery costs in an environmentally sound manner; develop a dataset that will answer the question of whether or not the oil of the second and third benches in the Devonian Three Forks Formations in North Dakota should be considered to be separate and unique reserves from those of the first bench; determine optimal well spacing for development in the Middle Bakken and first, second, and third benches of the Three Forks; further define fracture geometries between newly drilled and completed wells and proximal, partially depleted locations; and predict areas of future reservoir sweet spots.

This program will maximize production using a holistic approach. The subsurface portion of this program will provide insight into what happens during and after hydraulic fracture stimulation in the program's studied productive pay interval of the Bakken Pool's Middle Bakken zone and the first, second, and third bench Three Forks zones and establish a conventional 3-D seismic method to accelerate the development of the Middle Bakken. Recent core results have shown oil saturations in each bench which indicate potential hydrocarbon recovery.

The surface operations portion of this program will explore technologies and logistics that enable multiple, simultaneous operations to occur in a manner that improves production rates and achieves reductions in environmental impacts and impositions on landowners, thus increasing state and producer revenues while improving industry and state standing with landowners and the general public.

Program participants will determine the priorities of the surface operations portion of this program. Based on current discussion with these partners, these priorities are likely to include (but will not be

limited to) combined natural gas liquid (NGL) recovery and natural gas utilization on-site for power, on-site wastewater and hydraulic fracturing fluid management and recycling to minimize transportation and disposal costs, waste management including handling of drill cuttings and naturally occurring radioactive material (NORM), process optimization and system failure analyses, and other optimizations identified by industry participants over the course of the program. The surface operations portion of the program is designed to accommodate scope growth as new partners come on board and the needs of industry evolve.

The subsurface portion of this program will employ 14 wells—three existing wells (one producing from the Middle Bakken and two producing from the first bench of the Three Forks) and 11 new wells drilled and completed in the Middle Bakken as well as the first, second, and third benches of the Three Forks Formation plus the evaluation of a 3-D seismic survey.

Several companies have provided letters regarding their intention to participate, while several others are still contemplating participation. Primary participants include the EERC and Continental Resources. Additional participants interested primarily in the surface operations portion of the program include Marathon Oil Company and Whiting Petroleum Corporation. Letters of commitment received at the time of submission are presented in Appendix B. It is anticipated that additional industry partners will come on board once this effort is approved and as the utility of this program is demonstrated.

Goals and Objectives:

The goal of the proposed program is to maximize oil production from Bakken/Three Forks wells by employing an "all of the above" approach, including advanced reservoir characterization, improved drilling/stimulation/completion/production techniques and sequences, and by optimizing wellsite surface operations that have potential to reduce costs, development and operation impacts to surrounding landowners, and demands on surrounding infrastructure and water sources.

Methodology:

The proposed program will be conducted in four sequential subsurface activity phases and a surface operations phase conducted in parallel to the subsurface work: Phase I – Drilling 11 New Wells; Phase II – Completions; Phase III – Reservoir Engineering; Phase IV – Expansion Applications via 3-D

Seismic; Phase V – Optimization of Wellsite Operations. Detailed work plans for all phases are provided in Appendix D.

In addition to typical pilot hole logs and core data, the subsurface portion of the proposed program will gather data from multiple wells to create a 3-dimensional picture of what happens during and after the hydraulic fracture treatments in a multistage horizontal well. Continental will analyze this dataset to assess the total resource available in the second and third benches of the Three Forks Formation and will attempt to confirm whether these benches are distinct and independent of the existing Middle Bakken.

Phase V of this program will be organized initially along five technical topic areas (more may be added as industry requests dictate) and one program support area. These topic areas are offered here only as examples of expected industry priorities. During any given year, tasks will not necessarily populate each of these topic areas: 1) Site Logistics – focused on improvements of vehicle flow and workflow on well pads, space-saving on well pads, combined functionality of currently independent work units on well pads, and improved well pad materials; 2) Waste Management – focused on improved means of handling drilling and production wastes, including those that may contain NORM; 3) Hydrocarbon Utilization – focused on improving the production of oil, gas, or NGLs from wellsites. Tasks may include investigations of on-site utilization of natural gas prior to gathering, for example; 4) Water Management – focused on technologies to limit demand for freshwater, decrease wastewater production, and reduce water/wastewater trucking to and from the wellsite; and 5) Process Optimization and Systems Failure Analysis – focused on analysis of failures at the wellsite that affect production efficiency. For example, this activity may include corrosion studies of well casing and well pump components or investigating improved wellbore techniques.

A comprehensive program support effort will be required to administer this large program. The program support effort will be primarily accomplished by the EERC. Program management will involve integration of all program efforts, industry-driven public outreach to communities and local stakeholders (such as educational meetings currently being facilitated by OGRC staff), program reporting, collaboration with industry and OGRC, and strategic studies.

The EERC will be responsible for coordination and execution of surface operations optimization tasks with assistance provided by program partners. The EERC will also be responsible for public outreach functions, dissemination of program results, and for briefing NDIC OGRC upon request. Further, the EERC will present yearly progress summaries at OGRC meetings.

Continental Resources will be responsible for the bulk of subsurface work and will report results to the OGRC through the EERC, facilitating a singular reporting function for the program and simplified communication of results to OGRC.

Anticipated Results:

It is anticipated that the results of these activities will provide previously unavailable insight regarding the uniqueness of oil reserves in multiple benches in the Middle Bakken and the Three Forks Formation relative to each other in North Dakota. This would expand the Bakken oil play by adding potentially two new undeveloped zones.

The data collected in this research program will be used to generate a detailed geologic model that will be incorporated into a reservoir simulation of the production and pressure history. This model will then be used to show optimum spacing for development. What is learned from this project can be used to guide NDIC spacing determinations for development efforts across the state.

This program will also provide the oil and gas industry with a valuable tool to address key issues related to wellsite optimization. The results of the proposed work will likely increase well productivity and economic output, decrease environmental impacts of wellsite operations, and reduce demand for infrastructure construction and maintenance.

Facilities, Resources, and Techniques to Be Used:

The EERC possesses a number of laboratory facilities that may be employed at will by individual tasks within this program. The Applied Geology Laboratory conducts geomechanical, petrographic, geochemical, and customized core sample-related experiments designed to solve targeted problems in the oil and gas industry. The Natural Materials Analytical Research Laboratory includes x-ray diffraction, x-ray fluorescence, and scanning electron microscopy systems. The Analytical Research Laboratory

conducts wet-chemistry and advanced trace elemental analyses. Mobile chemistry laboratories owned by the EERC may be employed to conduct quick-turnaround analyses on the wellsite when wellsite logistics permit. The EERC's experienced staff encompasses the geology, chemistry, physics, and engineering disciplines. These laboratories have decades of experience and have been instrumental in conducting a broad range of research to support previous Bakken research activities and reservoir condition experimental work, including work on proppants, drilling and completion fluids, and wastewaters. The EERC also possesses a rich-gas test facility capable of simulating Bakken-like associated gas mixtures to specification.

Continental Resources will employ cutting-edge technical service providers to instrument wells and otherwise seismically measure the zones of interest.

Environmental and Economic Impacts While Program Is under Way:

The subsurface portion of the program will not produce additional environmental impacts, since the wells would be completed in the absence of this program. The additional instrumentation and measurement proposed will impose no additional impact. The pace at which these wells will be completed and instrumented may produce a small positive impact to state production numbers and revenues. Since the proposed surface operations portion of the program will involve an extensive assortment of research activities, the environmental and economic impacts will also be wide-ranging. It is difficult to predict specific environmental impacts evident while the program is under way because the proposed program is designed to accommodate a variety of task specifics. Task evaluation will include an assessment of how the task manages economic impacts or mitigates environmental impacts prior to funding.

Ultimate Technological and Economic Impacts:

Ultimately, this program has the potential to provide broad and far-reaching technical and economic impacts. The subsurface portion of the proposed work is a one-of-a-kind effort to give a 3-dimensional picture of what is happening during and after hydraulic fracture treatments in multistage horizontal wells in the Middle Bakken as well as the first, second, and third benches of the Three Forks Formation. This has never been attempted. This information will provide previously unknown

information regarding potential Bakken development, helping to determine the exact number of wellbores that need to be placed in each zone for proper development. The potential economic impact of understanding the number of wells needed to be drilled in the future for primary development, alone, will lend confidence to the effort to build infrastructure in the region and will develop figures for the potential oil industry employment over the long term. The surface operations portion of this multifaceted program will have the potential to bolster oil and gas industry operations by improving operational logistics, improving resource recovery, decreasing costs, reducing environmental impacts, and increasing revenue to the state and to producers.

Why the Program Is Needed:

The area of interest has already proven productive for the Middle Bakken and first bench of the Three Forks zones. The Three Forks Formation is immediately overlain by the Bakken Formation. This stratigraphic relationship combined with geochemical similarities of the respective formation fluids have led many in the Williston Basin to theorize that the Three Forks zone is in communication with the oil-producing middle member of the Bakken. As a result, petroleum resource estimations have typically summed the two together (U.S. Geological Survey, 2008, Assessment of undiscovered oil resources in the Devonian-Mississippian Bakken Formation, Williston Basin province, Montana and North Dakota, 2008: Fact sheet 2008-3021, USGS, April 2008, 2 p). However, Continental Resources previously proved in its evaluation of the Middle Bakken and first bench of the Three Forks with the Mathistad project (OGRC Project G-018-039) that these formations were indeed separate.

Acquiring new data focused on demonstrating the different benches in the Three Forks are separate from the Bakken will provide the State of North Dakota and the oil industry in the state with new insight which can be used to 1) develop realistic assessments and estimates of the first, second, and third benches of the Three Forks oil reserves and 2) design and implement effective and efficient E&P strategies for defining and exploiting an emerging second and third bench Three Forks play in North Dakota.

In parallel, only recently have the larger producers in the Bakken called for a rapid shift to a cost containment mode. This shift opens the door to a coordinated, multiparticipant effort to address issues

common to all producers while maximizing economic benefit to North Dakota, oil and gas producers, and mineral rights holders. A coordinated program approach will improve wellsite profits and productivity by employing shared results from focused investigations on methods of optimizing wellsite activities.

STANDARDS OF SUCCESS

Success will be achieved by conducting projects and generating data that lead to improved efficiency in oil and gas production with applicability basinwide. Specific metrics of success will include developing a high-quality dataset and reservoir model that establishes the relationship, or absence thereof, between the Middle Bakken and the first, second, and third benches of the Three Forks oil-producing zones. If the project develops insight to facilitate the effective exploitation of these resources and support decision making related to optimal well spacing, then it will be considered successful. Additionally, activities conducted in collaboration with project stakeholders focused on improving the operational efficiency of oil and gas production processes will encourage broad-scale implementation and overall improvements to production efficiency in North Dakota.

Results will be readily accessible through EERC and Continental Resources reports provided to OGRC for inclusion on its Web site. Success will also be measured by timely achievement of program objectives (deliverables shown below) and the execution of individual tasks that meet the goals of the program.

Deliverables:

1. Fact sheets highlighting the technical and economic challenges and opportunities associated with topics such as associated gas flaring, water treatment and use, and waste management; an example is provided in Appendix E.
2. Quarterly reports to OGRC highlighting results of ongoing research and outlining upcoming activities.
3. Topical reports summarizing the results of each completed task.
4. A final report to OGRC summarizing program achievements, including a 3-D seismic survey, reservoir model, and outcomes of the various well-site optimization demonstration activities.
5. Partner-approved publications at technical conferences.

The value to North Dakota is improved economic output of the entire Williston Basin via identification of, and extraction from, previously unrecognized independent petrological systems and via decreased costs of production.

BACKGROUND/QUALIFICIATIONS

Personnel:

Resumes of key personnel are provided in Appendix A. John Harju, EERC Associate Director of Research, will serve as program manager. Four principal investigators who will coordinate activities are Stan Wilson, Northern Region Resource Development Manager at Continental; Jay Almlie, EERC Senior Research Manager; Tom Doll, EERC Senior Petroleum Engineer; and Chad Wocken, EERC Senior Research Manager.

Continental Resources:

Continental Resources, Inc., is a primary operator of oil and gas wells in the Williston Basin. Continental was established in 1967 and has operated in the Rockies since 1991. Continental is active and a leader in North Dakota's Middle Bakken/Three Forks oil and gas development and exploration.

EERC:

The EERC is a nonprofit contract research center at the University of North Dakota. The EERC's oil and gas experience is highlighted within its Center for Oil and Gas and the Plains CO_2 Reduction (PCOR) Partnership. The Center for Oil and Gas is a specialized technical group focusing on design and implementation of new approaches to the exploration, development, and production of oil and gas. The EERC's PCOR Partnership is one of seven regional partnerships operating under the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory Regional Carbon Sequestration Partnership Program. Since its inception in 2003, the PCOR Partnership has received the support of over 100 private and public sector members who have provided data, guidance, financial resources, and experience with carbon capture, utilization, and storage, including enhanced oil recovery.

MANAGEMENT

The EERC manages approximately 265 contracts a year, with a total of more than 1240 clients in

52 countries and all 50 states. Best practices are provided to EERC project managers and clients with regard to fund accounting, budget reporting, contract milestone tracking, and contract services. The deliverables of this proposal will be incorporated into a contract agreement ensuring timely completion of milestones. Progress reports will be prepared on a quarterly basis and will serve as a means of evaluating the program with respect to budget, schedule, and technical achievement. The evaluation points are identified in the Gantt chart in Figure 1.

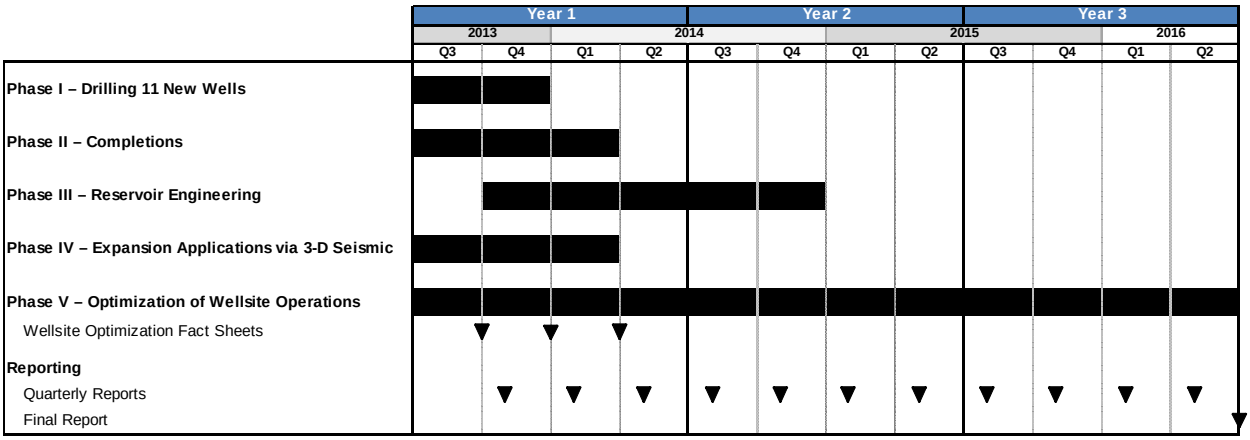


Figure 1. Preliminary program timetable.

John Harju, EERC Associate Director for Research, will oversee the entire program. He will be responsible for coordinating and communicating all program activities and for understanding technical details, budget details, schedule details, and environmental and economic implications of each task investigated. Continental Resources will be responsible for all Hawkinson Project (Phases I–IV) activities and for reporting to OGRC through John Harju and the EERC. Individual tasks within the program (Phase V) will each be led by an assigned task manager who will be responsible for technical execution, task budget management, task schedule maintenance, and task report preparation. Funding for approved tasks will be isolated from the available program funds, and each task will be tracked independently as a facet of the program.

TIMETABLE

This program is proposed as a 3-year program beginning on July 1, 2013, and ending on June 30, 2016. Figure 1 summarizes the program timetable. Phase I–IV activities will be driven by the

drilling and completions schedule and are expected to last 18 months. Phase V activities will occur throughout the 3-year period of performance. A specific activity scope of work for Phase V will be prepared with the support of consortium members and the OGRC at a program kickoff meeting and annually thereafter.

BUDGET

The total cost of the program during the first 3 years is estimated to be $115,230,000 with $3 million requested from OGRC in each of the first 2 years of the effort and $2 million in the third year, for a total request of $8 million. The remaining funds for the effort will be provided in the form of cash and in-kind contributions by a consortium of Bakken producers led by Continental Resources. Other companies committed to participate include Marathon Oil Company and Whiting Petroleum Corporation. Letters of commitment received from initial consortium members, at the time of submission, can be found in Appendix B.

The budget shown in Table 1 comprises a top-level budget assembled from a Continental Resources budget for work associated with Phases I–IV (subsurface work) and an EERC budget for the surface operations optimization effort. Both portions of this top-level budget are based on previous experience with large programs by both organizations. Detailed budgets for surface operations optimization work will be developed as new tasks are identified and reported to OGRC by request. Budget justification can be found in Appendix C. The requested funds are critical to the success of the program as outlined here. Less funding will jeopardize the achievement of the program's objectives.

CONFIDENTIAL INFORMATION

There is no confidential information included in this proposal. It is likely that confidential information will be involved in, or created during, the execution of program tasks. In such cases, confidential information outlined within the task proposal, and after reaching agreement with the consortium, will be withheld from public disclosure. The intent of the program is to make as much information publicly and widely available as possible.

Table 1. Budget Breakdown

Project Associated Expense	NDIC Share	Industry Share	Total Program
Total Labor	$ 1,350,966	$ 1,022,168	$ 2,373,134
Travel	$ 168,032	$ -	$ 168,032
Supplies	$ 174,837	$ 27,960	$ 202,797
Subcontract – Continental Resources	$ 6,260,000	$ -	$ 6,260,000
Facilities and Admin Applied to Subcontract	$ 12,250	$ -	$ 12,250
Communication	$ 3,040	$ 560	$ 3,600
Printing & Duplicating	$ 6,254	$ 475	$ 6,729
Food	$ -	$ 7,200	$ 7,200
Operating Fees & Svcs			
Natural Materials Analytical Res. Lab.	$ -	$ 57,782	$ 57,782
Analytical Research Lab.	$ -	$ 3,914	$ 3,914
Particulate Analysis	$ -	$ 21,565	$ 21,565
Graphics Support	$ 24,621	$ -	$ 24,621
Shop & Operations Support	$ -	$ 33,981	$ 33,981
Remote Sampling Trailer	$ -	$ 24,395	$ 24,395
Continental Resources Cost Share	$ -	$ 106,030,000	$ 106,030,000
Total Project Cost	**$ 8,000,000**	**$ 107,230,000**	**$ 115,230,000**

PATENTS/RIGHTS TO TECHNICAL DATA

No patentable technologies are expected to be created during this work.

STATUS OF ONGOING PROJECTS (IF ANY)

1. G-015-030 "Plains CO_2 Reduction Partnership Program – Phase III"; OGRC funding $500,000; Total project cost $135,731,052. Status: Project ongoing. Phase III is a 10-year program running from October 1, 2007, to September 30, 2017. The activities for Phase III of the PCOR Partnership include two large-volume carbon dioxide storage demonstration tests and the characterization of oil fields in North Dakota for CO_2 enhanced oil recovery (EOR).
2. G-026-060 "Enhanced Bakken Recovery Research Program"; OGRC funding $450,000; Total program cost $1,350,000; Status: Program ongoing. The EERC is in the midst of Task 1 – Detailed Characterization of Selected Bakken Sites and has initiated some of the Task 2 – Examination of the Use of CO_2 for Storage and EOR in the Bakken Formation activities.
3. G-024-057 "Demonstration of Gas-Powered Drilling Operations for Economically Challenged Wellhead Gas and Evaluation of Complementary Platforms"; OGRC funding $750,000; Total project cost $1,900,000; Status: Project complete. This project was completed March 31, 2013.

APPENDIX A

RESUMES OF KEY PERSONNEL

JOHN A. HARJU
Associate Director for Research
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5157, Fax: (701) 777-5181, E-Mail: jharju@undeerc.org

Principal Areas of Expertise

Mr. Harju's principal areas of interest and expertise include carbon sequestration, enhanced oil recovery, waste management, geochemistry, technology development, hydrology, and analytical chemistry, especially as applied to the upstream oil and gas industry.

Qualifications

B.S., Geology, University of North Dakota, 1986.

Postgraduate course work in Management, Economics, Marketing, Education, Climatology, Weathering and Soils, Geochemistry, Geochemical Modeling, Hydrogeochemistry, Hydrogeology, Contaminant Hydrogeology, Advanced Physical Hydrogeology, and Geostatistics.

Professional Experience

2002–Present: EERC, UND, Grand Forks, North Dakota.

2011–Present: Associate Director for Research. Mr. Harju oversees the activities of a team of scientists and engineers focused on research, development, demonstration, and commercialization of energy and environmental technologies. Strategic energy and environmental issues include zero-emission coal utilization; CO_2 capture and sequestration; energy and water sustainability; hydrogen and fuel cells; advanced air emission control technologies, emphasizing SO_x, NO_x, air toxics, fine particulate, and mercury control; renewable energy; wind energy; water management; flood prevention; global climate change; waste utilization; energy efficiency; and contaminant cleanup.

2003–2011: Associate Director for Research. Mr. Harju's responsibilities included developing and administering programs involving petroleum technology, natural resource evaluations, water management and contamination cleanup and building industry–government–academic teams to carry out research, development, demonstration, and commercialization of energy and environmental products and technologies.

2002–2003: Senior Research Advisor. Mr. Harju's responsibilities included development, marketing, management, and dissemination of market-oriented research; development of programs focused on the environmental and health effects of power and natural resource production, contaminant cleanup, water management, and analytical techniques; publication and presentation of results; client interactions; and advisor to internal staff.

1999–2002: Vice President, Crystal Solutions, LLC, Laramie, Wyoming. Mr. Harju's firm was involved in commercial E&P produced water management, regulatory permitting and compliance, and environmental impact monitoring and analysis.

1997–2002: Gas Research Institute (GRI) (now Gas Technology Institute [GTI]), Chicago, Illinois.
2000–2002: Principal Scientist, Produced Water Management. Mr. Harju's responsibilities included development and deployment of produced water management technologies and methodologies for cost-effective and environmentally responsible management of oil and gas produced water.

1998–2000: Program Team Leader, Soil, Water, and Waste. Mr. Harju's responsibilities included project and program management related to the development of environmental technologies and informational products related to the North American oil and gas industry; formulation of RFPs, proposal review, and contract formulation; technology transfer activities; and staff and contractor supervision. Mr. Harju served as Manager of the Environmentally Acceptable Endpoints project, a multiyear, $8MM effort focused on a rigorous determination of appropriate cleanup levels for hydrocarbons and other energy-derived contaminants in soils. He also led GRI/GTI involvement with numerous industry environmental consortia and organizations, including PERF, SPE, AGA, IPEC, and API.

1997–1998: Principal Technology Manager, Soil and Water Quality.
1997: Associate Technology Manager, Soil and Water Quality.

1988–1996: EERC, UND, Grand Forks, North Dakota.
1994–1996: Senior Research Manager, Oil and Gas Group. Mr. Harju's responsibilities included the following:

- Program Manager for program to assess the environmental transport and fate of oil- and gas-derived contaminants, focused on mercury and sweetening and dehydration processes.
- Project Manager for field demonstration of innovative produced water treatment technology using freeze crystallization and evaporation at oil and gas industry site.
- Program Manager for environmental transport and fate assessment of MEA and its degradation compounds at Canadian sour gas-processing site.
- Program Manager for demonstration of unique design for oil and gas surface impoundments.
- Director, National Mine Land Reclamation Center for Western Region.
- Co-Principal Investigator on project exploring feasibility of underground coal gasification in southern Thailand.
- Consultant to International Atomic Energy Agency for program entitled "Solid Wastes and Disposal Methods Associated with Electricity Generation Fuel Chains."

1994: Research Manager.
1990–1994: Hydrogeologist.
1989–1990: Research Specialist.
1988–1989: Laboratory Technician.

Professional Memberships
National Petroleum Council
Interstate Oil & Gas Compact Commission, Chairman, Energy Resources, Research and Technology Committee
U.S. Department of Energy Unconventional Resources Technology Advisory Committee
Rocky Mountain Association of Geologists

Publications and Presentations
Has authored and coauthored numerous publications.

Stan Wilson
Manager, Resource Development Northern Region
Continental Resources, Inc.
20 N. Broadway
OKC, OK 73102

Summary

Results driven leader in the exploration & production, midstream and electric generation sectors of the energy industry. Leadership skills include resource optimization, short & long-range planning as well as internal corporate process improvements to not only meet but exceed company goals and objectives. Successfully led teams (geology, land, reservoir engineering, drilling, production and geophysics) to improve overall asset performance including: initial production rates, ultimate reserve recoveries, reserve bookings and ultimate field development.

Professional Experience

Continental Resources, Inc.

Manager, Resource Development Northern Region (4/2010 – Present)

Oversee the Northern Region (North Dakota and Montana) resource and asset development including an annual budget exceeding $2 Billion, 20+ rig program, executing short and long-range planning, commercial evaluations, optimizing drilling/development schedules, reservoir engineering, regulatory testimony, developing budgets of unconventional resource assets and internal/external presentations.

Leadership skills include:

- Led development of drilling schedule optimization software ("Optimizer"). The Optimizer maximizes or minimizes a selected output (production, NPV, lease bonus renewal expense, etc.) for a resource play.
- Maximize asset performance by facilitating development plans with members from geology, drilling, land, operations and reservoir to maximize asset performance. Consistently setting improving record of initial rates (IP's) and improving ultimate reserve recoveries.
- Led industry process to modernize regulatory field rules in North Dakota and Montana.
- Develop younger reservoir engineers to where they present projects to senior management and give regulatory testimony. Develop landmen skills to understand technical aspects to acquisitions and divestitures.
- Changed internal process in which land trades are evaluated and approved.

Resource Development duties include:

- Oversee reservoir engineers, analysts and staff to develop mid-year and annual SEC reserve reports.

- Supervise economic evaluations including acquisitions, acreage trades, exploration projects, state lease sales, budget forecasts and SEC reserve evaluations.
- Execute appropriate documents on outside well proposals and AFE's.
- Mentor younger engineers on reservoir engineering and economic evaluations including present value, decline curve and early time linear flow analysis.

Senior Reservoir Engineer (5/2009 – 4/2010)

Responsible for reservoir engineering and economic evaluations of unconventional resources. Economic evaluations included acquisitions, exploration development projects, acreage trades, state and federal lease sales, budget forecasts and SEC reserve evaluations.

Reservoir engineering duties included calculation of recoverable reserves and cash flow projections including risk analysis. Developed type curves representing reserve improvements as recommended fracture technology changes were implemented improving initial production rates as well as estimated ultimate recoveries.

Give presentations with recommendations weekly to senior corporate executives.

Reservoir Engineering / Business Development accomplishments:

- Given lead role for evaluation, making recommendations to management for approval on all inside and outside operated well proposals in North Dakota and Montana.
- Led corporate process change in manner in which well capital (AFE's) were approved.
- Led team efforts in well pattern selection and order for optimal reserve booking and field development.

Alpine, Inc.

Vice President, Business Development (5/2005 – 4/2009)

Recruited by senior executive departing OGE Energy Corp. to join start-up exploration company targeting unconventional resource plays for the purpose of acquiring acreage, drilling a small number of wells and selling position.

Responsible for the reservoir engineering, economic evaluation of corporate assets including conventional resources as well as unconventional shale gas resources, midstream facilities engineering and gas marketing.

Reservoir engineering duties included economic evaluation of proposed development, calculated estimates of recoverable reserves and cash flow projections including risk analysis. Gas marketing duties included negotiation of new contracts including interconnects, throughput & transporation agreements and wellhead purchases. Selected and negotiated with potential marketing firms to purchase wellhead gas; and oversaw monthly nomination process and monitored imbalances. Facilities engineering included evaluating pipeline connects, designing pipelines and bid packages for vendors and construction companies; coordinated all activities to ensure timely pipeline connection and flow upon well completion.

Accomplishments:

- Developed type curves for stacked pay horizontal and vertical shale gas wells in new shale gas resource play.
- Managed all due diligence activities on two successful joint ventures and asset divestitures.
- Negotiated the lowest gas transportation fee contract in new shale gas development area.

Enogex, Inc. / OGE Energy Corporation

Manager, Optimization and Control (3/2002 – 5/2005)
Manager, Pipeline System Optimization (12/2000 – 3/2002)

Responsible for the daily pipeline operations, budgets and personnel matters for three departments: Pipeline System Optimization, Volume Control, and Gas Control:

Accomplishments:

- Led newly formed group, Pipeline System Optimization, and communicated vision to improve asset performance by utilizing software and process improvements.
- Improved corporate financial performance in excess of $10 million per year due to higher revenues and reduced expenses on a sustainable basis.
- Implemented process redesign for fuel expense which reduced fuel from a negative $10 million per year impact to a neutral contributor through process redesign, new reports and regulatory filings.
- Led development of metrics for each department to identify key business drivers and measure same.
- Mentored fuel coordinator and company members to understand fuel and its financial impact.
- Led and coordinated special projects at direction of senior management that include corporate profitability analysis, regulatory filings and asset management.
- Responsible for Operations and Maintenance budgets for all groups with monthly review of actual versus targets, explanations and appropriate adjustments.
- Elected as member to Optimization Implementation Team tasked with formulating, developing and improving corporate profitability.
- Member of Strategy & Growth team tasked to determine strategic direction of unregulated business.
- Presented projects to entire company, select groups and executives as needed.

Manager, Mergers and Acquisitions (8/1998 – 12/2000)
Senior Business Development Representative (1/1998 – 8/1998)
Acquisitions Engineer (4/1996 – 1/1998)

Led and assisted with deal flow generation, negotiation, evaluation, and deal closings on a wide variety of new business opportunities for all business areas of OGE Energy Corp. and Enogex, Inc. including oil & gas, electric, midstream, alternative energy and other opportunities.

Accomplishments:

- Closed several asset and stock acquisitions ranging from $1 million to $710 million covering oil & gas properties, electric generation and midstream projects.

- Closed several strategic divestitures from $250,000 to $5 million.
- Managed business development activity by searching for projects with strategic fit.
- Developed all economic models and competitor analysis on all acquisitions.
- Lead, organized and managed due diligence on all acquisitions and divestitures.
- Evaluated complex legal, regulatory, and tax issues.
- Negotiated transaction terms, as well as being involved in the drafting of transaction documents.
- Led post-close Hart Scott Rodino filings and other regulatory filings (FTC & SEC)
- Co-led meetings with COO to target and improve financially underperforming areas of the company.

Delhi Gas Pipeline Corporation

Lead Engineer (6/1994 – 4/1996)
Gas Supply Engineer (9/1990 – 6/1994)

Reviewed all departmental engineering reports and analysis for potential supply sources. As Business Center Leader, integrated the efforts of gas supply, engineering, gas purchasing, field operations and contracts in project development for numerous geographic areas of the company.

Accomplishments:
- Elected Business Center Leader and led two separate business units simultaneously.
- Responsible for the coordination of evaluations, contract offers, negotiations and operational aspects for new and existing gas supply sources including acquisitions.
- Mentored engineers on economic evaluation skills and reservoir engineering techniques.
- During tenure as Business Center Leader coordinated the installations of numerous lateral compressor stations and acquired third party pipeline systems.
- Led premier project to extend an existing lateral, compress and treat sour gas well with proven developed producing reserves exceeding 100 BCF.
- Present projects to executive and senior level management weekly.

Education

B.S. Petroleum Engineering	*University of Oklahoma*
Master of Business Administration	*Oklahoma City University*
Juris Doctorate *(1st three years of night program)*	*Oklahoma City University*

Professional Activities and Other

Memberships
- SPE

Miscellaneous
- Advisory Committee member: Bismarck State College (Bismarck, ND)
- Speaker:
    - Reserves Estimation for Unconventional Resources
    - SPE Liquids-Rich Basins Conference
    - Enhancing Shale Oil and Gas Development Strategies

JAY C. ALMLIE
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5260, Fax: (701) 777-5181, E-Mail: jalmlie@undeerc.org

Principal Areas of Expertise

Mr. Almlie's principal areas of interest and expertise include hydrogen production technologies, particle capture in electrostatic precipitators, mercury control technologies, thermal control systems, water-processing systems, and environmental control and life support systems.

Qualifications

B.S., Mechanical Engineering, and B.S., Engineering Management, University of North Dakota, 1995.

Proficient in the use of LabView, AutoCad, Autodesk Inventor, MS Excel, MS Project, MathCAD, Rockwell Software RSLogix, and RSView Studio.

Professional Experience

2009–Present: Senior Research Manager, Environmental Technologies, EERC, UND. Mr. Almlie's responsibilities include supervision and direction of a diverse group of approximately 30 researchers focused on emission control technology development and hydrogen generation technology development. Mr. Almlie is responsible for technical, managerial, and business development aspects of this work. Mr. Almlie has managed several successful multimillion-dollar projects during his tenure in this position.

2006–2009: Research Manager, Environmental Technologies, EERC, UND. Mr. Almlie's responsibilities included supervising a team of researchers focused on mercury emission control, particulate matter emission control, and hydrogen production. Mr. Almlie was also involved technically in projects in each of these areas.

2001–2006: Research Engineer, Environmental Technologies, EERC, UND. Mr. Almlie's responsibilities included projects involving mercury control, particulate matter emission control, and emission control for diesel systems.

2000–2001: Lead Mechanical Engineer, Water Systems, International Space Station Habitability Outfitting, and Deputy Project Manager, International Space Station Galley, Lockheed Martin Space Operations Company, Houston, Texas. Mr. Almlie's responsibilities included supervision of the Galley Potable Water System and Waste and Hygiene Compartment Crew Hygiene System design teams, development of system architecture and component specs, design of water system engineering development units, and thermal and fluid mechanics analysis and testing on water systems. He was also responsible for customer interfacing, team integration, project direction and cost/schedule estimates for both projects, including planning and analyzing project

performance, monitoring progress, and developing "to-completion" cost estimates within an earned value system.

1995–2000: Mechanical Engineer, Hernandez Engineering, Inc. Mr. Almlie's responsibilities included involvement in several projects:

- Lead mechanical engineer for a potential Space Shuttle thermal control system upgrade, including performing thermal design, analysis, and test functions and serving as project manager for the $1 million research project. This was one of 10 projects identified by the National Research Council as leading contenders to extend the life of the Space Shuttle fleet.
- Lead mechanical engineer for water recovery systems, including performing mechanical system design and analysis functions; designing, testing, and analyzing a potable water tank/radiation protection system for a crew habitat vehicle; and performing project management functions.
- Test engineer for the International Space Station Active Thermal Control System (ATCS), including conducting fluid line, fluid flow balance, and thermal/vacuum testing on ISS Active Thermal Control components and participating in Analysis and Integration Team activities to ensure ISS Thermal Control System function on-orbit.

1994–1995: Research Assistant, School of Engineering and Mines, UND. Mr. Almlie's responsibilities included computational fluid mechanics model generation for combustion applications using Fluent software.

Summer 1994: Engineering Intern, Orbital Sciences Corporation, Inc., Dulles, Virginia. Mr. Almlie's responsibilities included performing launch vehicle dynamic separation analyses, designing payload separation system components, performing multiple stress/strain analyses on payload carrier structures using COSMOS/M finite element analysis software.

1993–1994: Teaching Assistant, School of Engineering and Mines, UND. Mr. Almlie's responsibilities included assisting with thermodynamics, heat and mass transfer, and fluid mechanics courses.

1991–1993: Mechanical Engineering Cooperative Education Program Participant, Eagle Engineering, Inc., Houston, Texas. Mr. Almlie's responsibilities included authoring a satellite ground tracking code, coauthoring a separation simulation code, serving as a company representative on launch vehicle mission status reviews, and performing payload fairing separation analysis for the Pegasus rocket.

Publications and Presentations

Has coauthored several professional publications.

Patents and Technology Disclosures

Advanced Particulate Matter Control Apparatus and Methods, US8,092,768, January 2012.
Water Membrane Evaporator
Radiation Shield Water Tank: Microgravity Water Tank with Capillary Air/Liquid Separation Used for Radiation Shielding

THOMAS E. DOLL
Senior Petroleum Engineer
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5190, Fax: (701) 777-5181, E-Mail: tdoll@undeerc.org

Principal Areas of Expertise
Mr. Doll's principal areas of interest and expertise include petroleum engineering and project, engineering, and general management.

Qualifications
B.S., Petroleum Engineering, University of Wyoming, 1971.
Registered Professional Engineer:
- Wyoming, PE 3543, February 1981
- North Dakota, PE 1829, February 1976

Professional Experience
2012–Present: Senior Petroleum Engineer, EERC, UND, Grand Forks, North Dakota. Mr. Doll's responsibilities include working under contract with the Plains CO_2 Reduction (PCOR) Partnership for carbon capture, utilization, and sequestration (CCUS) for the Cedar Creek Anticline in southeastern Montana, including project, drilling, completion, and production optimization of the Bakken Formation in North Dakota and Montana, as well as providing EERC petroleum engineering input for various projects such as the Bell Creek CO_2 Enhanced Oil Recovery (EOR) project.

2009–2012: Supervisor, Wyoming Oil and Gas Conservation Commission, Casper, Wyoming. Mr. Doll's responsibilities included managing a state agency with 40 employees and a biennial budget of $9.5 million. Mr. Doll authored and implemented Commission rules on well stimulation including hydraulic fracturing chemical compound disclosure; participated in a carbon sequestration financial assurance task force and authored the Commission's carbon sequestration unitization rule to meet a legislative mandate; prepared and presented oil and natural gas information at over 60 educational forums such as professional meetings and federal and state government agency meetings, including formal testimony to the House Energy and the Environment Subcommittee and the Department of the Interior, at various public, academic, and industry forums; and enforced Commission rules and regulations through field inspections, hearings, and show cause actions to ensure compliance.

2008–2009: Independent Petroleum Engineering Consultant. Mr. Doll was recognized as an expert witness as a registered Professional Petroleum Engineer for the Wyoming Oil and Gas Conservation Commission hearings and prepared an Underground Injection Control (UIC) Permit for Wyoming Department of Environmental Quality (WDEQ) Water Quality Division (WQD) approval for a client to complete a nonhazardous waste disposal well in Crook County, Wyoming.

1997–2008: District Manager, Williams Production RMT (now WPX Energy), Gillette, Wyoming. Mr. Doll provided management, engineering, and supervision of the Powder River Basin asset, including management of the development and exploitation of coalbed natural gas resources on leasehold in the Powder River Basin, serving as Senior Petroleum Engineer; Project Manager; and Drilling, Regulatory, and Land Manager during the period and providing coordination/communication with joint venture partner counterparts for over 6600 coalbed natural gas wells producing over 505 MMcfd.

1989–1997: General Manager, Fluor Daniel (NPOSR), Inc. Mr. Doll provided general management, engineering management, and field operations management of Fluor Daniel (NPOSR) personnel and contractors of the Naval Petroleum Reserve Number 3, under contract to the U.S. Department of Energy (DOE) in Casper, Wyoming; managed all aspects of activities including conventional oil and gas production, gas reinjection for pressure maintenance, enhanced oil recovery via steamflood, polymer enhanced waterflood and fireflood operations, and directional and slant-hole drilling including a gas liquids extraction plant; and initiation of new technologies testing under typical oil field conditions through the Rocky Mountain Oil Field Testing Center (RMOTC).

1987–1989: Project Manager; TIORCO, Inc. (The Improved Oil Recovery Company), Wyoming, Montana, South Dakota, and Colorado, based in Gillette, Wyoming **(s**ee 1984–1986).

1986–1987: Independent Petroleum Engineering Consultant, Petroleum Engineering/Chemical Consultant, Gillette, Wyoming. Mr. Doll provided chemical and monitoring for wells producing up to 25% hydrogen sulfide with potential for severe tubular and surface facilities corrosion, and provided a postmortem report and to DOE via operating contractor John Brown Engineering at the Naval Petroleum Reserve No. 3 polymer augmented waterflood.

1984–1986: Project Manager; TIORCO, Inc. (The Improved Oil Recovery Company), Wyoming, Montana, South Dakota and Colorado, based in Gillette, Wyoming. Mr. Doll provided engineering supervision and technical monitoring, oversight, and reporting of chemically augmented injection projects for various independent oil companies to maximize oil recovery through cost-effective improved injectivity, sweep improvement, reduced produced water quantity, and injected water quality control.

1983–1984: Director of Engineering (Acting), DOE, Casper, Wyoming. Mr. Doll was the Acting Director of Engineering for the DOE Naval Petroleum and Oil Shale Reserves in Colorado, Utah, and Wyoming. He provided supervision/direction to three engineers and support staff at Teapot Dome Naval Petroleum Reserve No. 3 and Anvil Points Oil Shale Reserve and provided technical and engineering oversight of the operating contractor to DOE, Lawrence-Allison and Associates West (LAAW).

1983–1983: Drilling Engineer, LAAW, Casper, Wyoming. LAAW contracted to DOE to operate the Naval Petroleum Reserve No. 3 in Casper, Wyoming; provided well design and daily field engineering oversight of drilling well operation on a DOE-owned rig; and identified severe steel tool joint wear to failure caused by aluminum drill pipe in a compression–rig picked up steel drill pipe, and a shallow drilling program was initiated.

1981–1983: Petroleum Engineering Consultant, Clausen Operating Company, Douglas, Wyoming. Mr. Doll provided supervision and direction of eight on-site operations consultants for conventional oil and gas drilling, workovers, and production operations in the Powder River Basin; 18-month petroleum engineering contract to John Brown Engineering and LAAW at DOE's Naval Petroleum Reserve No. 3 for engineering design and fieldwork for injectivity testing followed up with a pilot project; and wellbore, well site, and facilities design, specification, and construction supervision and drilling supervision with resultant implementation of a polymer-augmented waterflood pilot at Naval Petroleum Reserve No. 3.

1980–1981: Petroleum Engineer, WYOCO Petroleum, Walcott, Wyoming. Mr. Doll provided engineering management and field supervision of a field supervisor and roustabout for a small independent oil and gas producer in the Southwestern Hanna Basin; evaluation of Niobrara oil shale production problems and low-Btu natural gas production problems; and provided analysis and recommendations to management.

1977–1980: Petroleum Engineer, Louisiana Land and Exploration Company, Denver, Colorado. Mr. Doll provided drilling and production engineering and field operations design, specification, implementation, and oversight in the northern Rocky Mountains and California. Tasks included preparation of AFE cost estimates and reserves estimates; well economic evaluation for proposed wells in the leasehold area, working directly with geoscientists in prospect evaluation and providing Monte Carlo economic simulations for management decision making; managed and directed consultants during wildcat drilling, providing an on-site drillstem test and logging evaluation and for long string cementing; and on-site management and direction of consultants on well completions and stimulations.

1974–1977: Petroleum Engineer, Amerada Hess Corporation, Williston, North Dakota, and Tulsa, Oklahoma, including production engineering based in Williston, North Dakota. Mr. Doll was responsible for 350 producing oil wells on the Nesson Anticline in northwestern North Dakota and drilling engineering based in Tulsa, Oklahoma. Responsible for design, implementation, oversight, and management of wildcat and infield drilling programs in the central Alberta overthrust, onshore California directional drilling, and Williston Basin field expansion in North Dakota; and reserves/reservoir engineering in Tulsa, Oklahoma, responsible for reserves reporting companywide, operated and nonoperated properties.

1971–1974: Petroleum Engineer, Halliburton Services, Rock Springs, Wyoming. Mr. Doll was responsible for engineering support to cementing, hydraulic fracture stimulation, acidization, and drillstem testing for the major service contractor in western Wyoming, northern Colorado, and eastern Utah.

Publications and Presentations
Has authored and coauthored numerous publications and presentations.

CHAD A. WOCKEN
Senior Research Manager
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, North Dakota 58202-9018 USA
Phone: (701) 777-5273, Fax: (701) 777-5181, E-Mail: cwocken@undeerc.org

Principal Areas of Expertise

Mr. Wocken's principal areas of research include developing alternative energy technologies and renewable fuels. Currently, he is leading projects focused on developing and advancing alternative energy systems at the bench, lab, and pilot scale for technologies associated with renewable liquid fuels, hydrogen production and purification, and gasification. Mr. Wocken currently manages a group of researchers and a lab facility containing batch and continuous reactor systems capable of testing a variety of thermochemical processes.

Qualifications

B.S., Chemical Engineering, University of North Dakota, 1994

Certifications: E.I.T. Chemical Engineering, U.S. Army Corps of Engineers Construction Quality Management, 40-hour OSHA Health and Safety, 8-hour HAZWOPER Supervisor, 10-hour Construction Safety and Health.

Professional Experience

2009–Present: Senior Research Manager (2001–2009, Research Engineer), EERC, UND.

Project/Program Management

- Comanaged a Defense Advanced Research Projects Agency (DARPA)-funded project that successfully developed technology to produce drop-in compatible jet fuel for the military from renewable feedstock. Activities included planning work activities, developing and executing a risk-based project management plan, coordinating activities of five project partners to meet project goals, and communicating with the DARPA project manager.
- Managed the scale-up and design of a renewable fuel technology capable of producing specification-compliant jet and diesel fuels from renewable oil feedstock. The pilot-scale facility to be collocated with a petroleum refinery will have the capability of processing up to 300 barrels/day of renewable oil feedstock.

Technology Development and Research

- Conducted a technical and economic assessment of alternative uses for associated gas in an effort to reduce the amount of gas being flared in the Williston Basin. Technologies evaluated included gas-processing operations to recover natural gas liquids, the use of rich gas in internal combustion engines for transportation and power, and traditional petrochemical unit operations.
- Performed a system-level engineering evaluation of integrated algae production at a coal-fired power plant to assess carbon uptake, emission control requirements, relative scale, and the viability of water and waste heat utilization.
- Designed, fabricated, and operated several fixed-catalyst bed reactor systems to evaluate a variety of thermocatalytic processes to produce renewable fuels and chemicals.

- Conducted testing at coal-fired power plants, and developed control technologies to reduce atmospheric emission of particulate matter, mercury, and other contaminants.

1995–2001: Project Engineer, URS/Radian International, Salt Lake City, Utah (1997–2001), and Milwaukee, Wisconsin (1995–1997).

Process Design, Operation, and Optimization

- Designed groundwater remediation systems to remove BTEX compounds and chlorinated solvents from groundwater. The projects consisted of site evaluation, technology selection and design of several groundwater circulation wells, air sparge/soil vapor extraction treatment systems, and groundwater extraction with air stripper treatment technology. Design aspects included mass balance calculations, equipment design (pumps, pipe sizing, blowers, filters, etc.), equipment selection and specification, bid/construction specifications, and design drawing development.
- Performed start-up and long-term operations for a variety of groundwater remediation systems. Responsibilities included troubleshooting equipment/system malfunctions, process optimization, writing operations and maintenance manuals, establishing performance verification criteria, defining operational cost, and directing technicians' work.
- Conducted detailed reviews of industrial wastewater treatment systems to identify alternative treatment technologies, process optimizations, cost-saving measures, water reuse and zero discharge alternatives, and regulatory considerations.

Construction Oversight

- Provided on-site quality control oversight for several construction projects consisting of mechanical equipment installation, instrumentation and process control, building and road construction, excavation, and underground utility installation. Daily responsibilities included evaluating work for conformance with construction drawings and specifications; conducting progress meetings; coordinating subcontractor work activities; and facilitating communication between the design firm, client, and subcontractors.

Project Management

- Served as project manager for several large projects that were completed successfully. Activities included developing cost proposals, managing budget and schedule, equipment and subcontractor acquisition, and maintaining effective communication with the client.

1994–1995: Process Engineer, Archer Daniels Midland, Clinton, Iowa.

Plant Operation

- Supervised operations and personnel at a wet corn mill and corn oil extraction and refining plant. Tasks consisted of prioritizing work activities, scheduling maintenance and repairing process equipment, reviewing quality control, and extensive system troubleshooting and failure analysis.

Publications and Presentations

Has authored or coauthored numerous publications.

APPENDIX B

LETTERS OF COMMITMENT

America's Oil Champion

Continental
RESOURCES

May 9, 2013

Mr. John Harju
Associate Director for Research
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Subject: Program Entitled "Program to Determine the Uniqueness of Three Forks Benches Reserves, Determine Optimal Well Density in the Bakken Pool, and Optimize Bakken Production"

Dear John:

This letter is in support of an Energy & Environmental Research Center ("EERC")-led proposal entitled "Program to Determine the Uniqueness of Three Forks Benches Reserves, Determine Optimal Well Density in the Bakken Pool, and Optimize Bakken Production" (referred to herein as the "Program"). We feel this is an excellent program that will be of significant benefit to North Dakota's oil and gas industry. The study will provide important information to producers, technology providers, and gas processors by:

1) Investigating new technologies and approaches to decreasing recovery costs in an environmentally sound manner;
2) Developing a dataset that will answer the question of whether or not the oil of the 2nd and 3rd Benches in the Devonian Three Forks Formations in North Dakota should be considered to be separate and unique reserves from those of the 1st Bench;
3) Determining optimal well spacing for development in the Middle Bakken and 1st, 2nd and 3rd Benches of the Three Forks Formations;
4) Further defining fracture geometries between the new drilled and completed wells and proximity to the partially depleted locations; and
5) Predicting areas of future reservoir sweet spots.

Continental Resources, Inc. ("CLR") wishes to partner with the EERC to pursue R&D funding for this project through the North Dakota Industrial Commission (NDIC) Oil & Gas Research Council and several other producers. CLR requests cash support of $6,260,000 in connection with the Program, and intends to meet its obligations as outlined in the draft of the Application (the "Application") relating to the Program attached to the email from Jay C. Almlie of EERC to Stan E. Wilson of CLR (received by CLR at 12:36 p.m). Continental Resources' commitment to the obligations described in the Application is contingent on the receipt by CLR of matching funds in the amount indicated above and the negotiation of a mutually acceptable scope of work and attendant contractual terms with all applicable partners.

We are looking forward to participating in this program. Any questions regarding CLR's involvement in the project may be directed to me by phone at (405) 234-9163 or by e-mail at stan.wilson@clr.com.

Sincerely,

Stan Wilson
Manager
Resource Development
Northern Region

Marathon Oil Company
3172 Highway 22 North
Dickinson, ND 58601
Telephone 701.456.7500
Fax 701.456.7525

October 31, 2012

Mr. John Harju
Associate Director for Research
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

Project Entitled "Bakken Production Optimization Program"

This letter is in response to your request for participation in the proposed Energy & Environmental Research Center (EERC)-led effort entitled "Bakken Production Optimization Program." We feel this is an excellent program that will be of significant benefit to North Dakota's oil and gas industry. The study will provide important information to producers, technology providers, and gas processors by 1) exploring the spectrum of technologies and strategies that may optimize Bakken production, 2) facilitating the adaptation of those technologies and strategies under the unique challenges posed by Bakken operations, and 3) establishing the operating and market conditions necessary for their viability. In addition, the program will provide high visibility, high-impact education and outreach to key stakeholders across the region, relating the positive efforts and outcomes of North Dakota's oil and gas producers.

We understand that the EERC is pursuing core funding for this project through the North Dakota Industrial Commission (NDIC) Oil & Gas Research Council, the U.S. Department of Energy, and several other producers. Marathon can commit to supporting the project by providing data, expertise, facilities, and the participation of our experienced staff. In addition, Marathon will commit to providing cash cost share of up to $200,000 per year for up to 3 years, as this program has many synergies with our interests in the Williston Basin's Bakken play. Marathon's commitment is contingent on the award of adequate matching funds from NDIC's Oil & Gas Research Program and other producers and the negotiation of a mutually acceptable scope of work and attendant contractual terms with all applicable partners.

We are looking forward to participating in this program. Any questions regarding Marathon's involvement in the project may be directed to me by phone at (701) 456-7501 or by e-mail at tjkovacevich@marathonoil.com.

Sincerely,

Terry Kovacevich
Bakken Asset Manager

October 30, 2012

Mr. John Harju
Associate Director for Research
Energy & Environmental Research Center
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

Dear John:

Subject: Project Entitled "Bakken Production Optimization Program"

This letter is in response to your request for participation in the proposed Energy & Environmental Research Center (EERC)-led effort entitled "Bakken Production Optimization Program." We feel this is an excellent program that will be of significant benefit to North Dakota's oil and gas industry. The study will provide important information to producers, technology providers, and gas processors by 1) exploring the spectrum of technologies and strategies that may optimize Bakken production, 2) facilitating the adaptation of those technologies and strategies under the unique challenges posed by Bakken operations, and 3) establishing the operating and market conditions necessary for their viability. In addition, the program will provide high visibility, high-impact education and outreach to key stakeholders across the region, relating the positive efforts and outcomes of North Dakota's oil and gas producers.

We understand that the EERC is pursuing core funding for this project through the North Dakota Industrial Commission (NDIC) Oil & Gas Research Council, the U.S. Department of Energy, and several other producers. Whiting can commit to supporting the project by providing data, expertise, facilities, and the participation of our experienced staff. In addition, Whiting will commit to providing cash cost share of $200,000 per year for up to 3 years, as this program has many synergies with our interests in the Williston Basin's Bakken play. Whiting's commitment is contingent on the award of adequate matching funds from NDIC's Oil & Gas Research Program and other producers and the negotiation of a mutually acceptable scope of work and attendant contractual terms with all applicable partners.

We are looking forward to participating in this program. Any questions regarding Whiting's involvement in the project may be directed to me by phone at (303) 803-5465 or by e-mail at jack.ekstrom@whiting.com.

Sincerely,

Jack Ekstrom

Whiting Petroleum Corporation
and its wholly owned subsidiary
Whiting Oil and Gas Corporation
1700 Broadway, Suite 2300, Denver, Colorado 80290-2300 Office: 303.837.1661 Fax: 303.861.4023

APPENDIX C

BUDGET JUSTIFICATION

BUDGET JUSTIFICATION

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC is funded through federal and nonfederal grants, contracts, and other agreements. Although the EERC is not affiliated with any one academic department, university faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

INTELLECTUAL PROPERTY

The applicable federal intellectual property (IP) regulations will govern any resulting research agreement(s). In the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this project, such IP, including rights, title, interest, and obligations, may be transferred to the EERC Foundation, a separate legal entity.

BUDGET INFORMATION

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, etc.) and among funding sources of the same scope of work is for planning purposes only. The project manager may incur and allocate allowable project costs among the funding sources for this scope of work in accordance with Office of Management and Budget (OMB) Circular A-21.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the university's current fiscal year (July 1 – June 30). Escalation is calculated by prorating an average annual increase over the anticipated life of the project.

The cost of this project is based on a specific start date indicated at the top of the EERC budget. Any delay in the start of this project may result in a budget increase. Budget category descriptions presented below are for informational purposes; some categories may not appear in the budget.

Labor: Estimated labor includes direct salaries and fringe benefits. Salary estimates are based on the scope of work and prior experience on projects of similar scope. Salary costs incurred are based on direct hourly effort on the project. Fringe benefits consist of two components which are budgeted as 57% of direct labor. The first component is a fixed percentage approved annually by the UND cognizant audit agency, the Department of Health and Human Services. This portion of the rate covers vacation, holiday, and sick leave (VSL) and is applied to direct labor for permanent staff eligible for VSL benefits. Only the actual approved rate will be charged to the project. The second component is estimated on the basis of historical data and is charged as actual expenses for items such as health, life, and unemployment insurance; social security; worker's compensation; and UND retirement contributions. The following table represents a breakdown by labor category and hours for technical staff for the proposed effort.

Labor Categories	Labor Hrs
Research Scientists/Engineers	10,168
Research Technicians	1,140
Senior Management	243
Technical Support Services	984
	12,535

Travel: Travel may include site visits, fieldwork, meetings, and conferences. Travel costs are estimated and paid in accordance with OMB Circular A-21, Section 53, and UND travel policies, which can be found at http://und.edu/finance-operations (Policies & Procedures, A–Z Policy Index, Travel). Daily meal rates are based on U.S. General Services Administration (GSA) rates unless further limited by UND travel policies; other estimates such as airfare, lodging, etc., are based on historical costs. Miscellaneous travel costs may include taxis, parking fees, Internet charges, long-distance phone, copies, faxes, shipping, and postage.

Equipment: If equipment (value of $5000 or more) is budgeted, it is discussed in the text of the proposal and/or identified more specifically in the accompanying budget detail.

Supplies: Supplies include items and materials that are necessary for the research project and can be directly identified to the project. Supply and material estimates are based on prior experience with similar projects. Examples of supply items are chemicals, gases, glassware, nuts, bolts, piping, data storage, paper, memory, software, toner cartridges, maps, sample containers, minor equipment (value less than $5000), signage, safety items, subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the F&A cost.

Subcontracts: Continental Resources will be responsible for all Hawkinson project (Phase I–IV) activities. Continental Resources will employ cutting-edge technical service providers to instrument wells and otherwise seismically measure the zones of interest.

Professional Fees: Not applicable.

Communications: Telephone, cell phone, and fax line charges are included in the F&A cost; however, direct project costs may include line charges at remote locations, long-distance telephone charges, postage, and other data or document transportation costs that can be directly identified to a project. Estimated costs are based on prior experience with similar projects.

Printing and Duplicating: Page rates are established annually by the university's duplicating center. Printing and duplicating costs are allocated to the appropriate funding source. Estimated costs are based on prior experience with similar projects.

Food: Expenditures for project partner meetings where the primary purpose is dissemination of technical information may include the cost of food. The project will not be charged for any costs exceeding the applicable GSA meal rate. EERC employees in attendance will not receive per diem reimbursement for meals that are paid by project funds. The estimated cost is based on the number and location of project partner meetings.

Professional Development: Fees are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout the development and execution of the project by the research team.

Operating Fees: Operating fees generally include EERC recharge centers, outside laboratories, and freight.

EERC recharge center rates are established annually.

Laboratory and analytical recharge fees are charged on a per-sample, hourly, or daily rate. Additionally, laboratory analyses may be performed outside the university when necessary. The estimated cost is based on the test protocol required for the scope of work.

Graphics recharge fees are based on an hourly rate for production of such items as report figures, posters, and/or images for presentations, maps, schematics, Web site design, brochures, and photographs. The estimated cost is based on prior experience with similar projects.

Shop and operation recharge fees are for expenses directly associated with the operation of the pilot plant, including safety training, personal safety items (protective eyeglasses, boots, gloves), and annual physicals for pilot plant personnel. The estimated cost is based on the estimated hours for pilot plant personnel.

Freight expenditures generally occur for outgoing items and field sample shipments.

Facilities and Administrative Cost: The facilities and administrative rate of 49% (indirect cost rate) included in this proposal is approved by the Department of Health and Human Services. Facilities and administrative cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual capital expenditures, such as equipment or software costing $5000 or more with a useful life of greater than 1 year, as well as subawards in excess of the first $25,000 for each award. The facilities and administrative rate has been applied to each line item presented in the budget table.

Noncash Cost Share: Continental Resources will commit to supporting the majority of the project by providing data, expertise, facilities, drilling and instrumenting operations, and the participation of its experienced staff.

APPENDIX D

DETAILED WORK SCOPES FOR EACH PHASE

PHASE I – DRILLING 11 NEW WELLS

The Hawkinson 1-22H and 2-27H will continue producing from the first bench of the Three Forks, and the Hawkinson 3-27H will continue producing from the Middle Bakken Formation until completion operations are ready to start. In the interim, 11 new Hawkinson wells will be drilled into the following formations: three in the Middle Bakken, one in the first bench of the Three Forks, four in the second bench of the Three Forks, and three in the third bench of the Three Forks.

Extra Rig Operation Time:

During the 11-well drilling program, one location will be chosen to be a pilot hole drilling 150 feet into the top of the Birdbear. A conventional core, discussed further below, will be taken. This additional footage not only yields the ability to core the targeted footage but also allows the running of the appropriate logs to capture technical information not available by drilling the Bakken and Three Forks horizontally. Extraordinary rig time and, therefore, expense is necessary to drill the footage required, set a cement plug, and kickoff efficiently.

Conventional Core:

A conventional core will be taken in the interval from 50 feet above the top of the Bakken continuously through 50 feet into the top of the Birdbear. This core will be analyzed to define physical properties including, but not limited to, oil saturation, porosity, permeability, and evaluation of the lithology and optimum drilling target of the second and third bench of the Three Forks. Technical testing to maximize the quality of the results will be routine core analysis, mercury injection, dynamic measurement/predictive Poisson's Ratio and Young's Modulus, and capillary pressure. The actual Middle Bakken and first, second and third bench of the Three Forks rocks-in-hand will allow a direct correlation to the logs and microseismic and seismic physics.

Petrophysical Logs in the Pilot Hole:

Petrophysical logs will be acquired from the bottom of the vertical pilot hole through the upper 150 feet of the Birdbear. These logs will include the normal quad-combo along with the addition of dipole sonic (Sonic Scanner), elemental capture spectroscopy (ECS), magnetic resonance (MR), and triaxial

induction (RT Scanner). The quad-combo, for typical analysis, will be run up to the base of the surface casing. The Sonic Scanner will record a shear wave directly generated by a shear wave source. This shear wave information will be implemented for updated fracture modeling and is a critical and required measurement to attain the best results as we evaluate the data integrated with the microseismic studies, to be discussed later. The ECS, MR, and RT scanner logs will allow the generation of an ELAN. This imaged composite log analysis will be correlated to the conventional core and integrated into defining the Three Forks second and third benches specific drilling target. Additionally, the log defines the pore throat size relating to oil storage capacity and productivity.

Cementing Production Liners:

The tools used to record the very weak microseismic events require the monitoring well production liner is, at minimum, indirectly in contact with the earth. Therefore, for four monitoring wells, out of the 11 drilled, we plan to cement in the production liner rather than our historical design using inflatable packers. This will allow for continuous contact between the production liner and the earth.

PHASE II – COMPLETIONS

This phase of work includes hydraulically fracturing 11 wells sequentially to optimize the reservoir management. We plan on using 30 stage fracture treatments in each of the 11 wells employing plug and perf technology.

Microseismic Studies:

The industry's de facto technical tool available today to image hydraulic fracture geometry is the study of microseismic events. These low-strength seismic events are caused by the earth's movement induced near wellbore by hydraulic fracturing. The extensiveness of this effort to drill and complete 11 wells, back to back, in a single 1280-acre unit is "the" unique opportunity to record, study, and integrate with a significant amount of completion data. The geometry of the available well locations across the Middle Bakken, Three Forks 1, 2, and 3 allows for the recording of 27 microseismic wellbore studies. Comparatively, past microseismic projects usually included only one to two wellbore studies.

Three of the 11 wellbores will have a series of 12 sets of geophones tractored into the lateral portion of the wells. This string of geophones will be 1100 feet in length pulled by a tractor out and along the lateral. The first microseismic measurements of an offsetting well being fractured will be near the toe of the monitoring location. As a well is fractured from toe to heel, the geophones will be moved, within the three monitor wells, in parallel to this procedure. At each stopping point, the series of geophones will record, measure, and locate the seismic events. These microseismic events imaged depict the extensiveness and spatial geometry of each individual fracture stage. This interpretative evaluation of the microseismic events includes, but is not limited to, imaging the fracture length, width, and height along with the strength and orientation of the induced energy.

We have an expectation of a unique induced fracture system as we sequentially fracture multiple locations, both vertically and laterally offsetting each other and near the three historically producing wells. Our technical challenge is to complete an evaluation of the entire 1280-acre unit, maximizing the recording of as many microseismic events as possible, around all of the fractured wellbores. The concerns related to the microseismic event energy has been modeled by Schlumberger's Research and

Development Group located in Cambridge, England. Multiple researchers throughout Schlumberger are involved in the discussion of this program's microseismic studies' optimum design and field acquisition to take advantage of the very unique wellbore geometry.

Real-time monitoring and interpretation of the microseismic events will take place to achieve our reservoir efficiency goals due to the potential of any fractures requiring a significantly different pumping rate. This would occur if one of the fractured wells pressured up or connected into a nearby wellbore. This extremely large program's magnitude of data is the first of its kind for Schlumberger, as we believe it would be for any service provider. The complex nature of the geometry and the number of the wells include, but is not limited to, the length of the job in the field being 40–50 days, having a very large number of sensitive geophone tools in multiple monitoring wells, the recently implemented Schlumberger proprietary Tuff-Trac tractor, the processing required to have the interpretation finalized in a timely manner, and the integration of this magnitude of data into reservoir scenarios, etc.

ESG Solutions, located in Kingston, Ontario, Canada, will apply its unique software technology and advanced vision of maximizing the microseismic data's value initially in a few wells. ESG's technical vision of the industry's future requirements from the microseismic science is related to the predictability of the opening and/or closing of the hydraulic-induced fractures. ESG's processing and interpretation software in the advanced postanalysis includes, but is not limited to, providing an insight into understanding the movement of the rock as high-pressure fluid is injected into the formation. We believe ESG's advanced processing technical logic and capabilities are leading edge and experimental in nature. But being in the realm of measuring the actual opening and/or closing of hydraulic fractures could be the ultimate microseismic application. Understanding, during and after hydraulic fracturing, how the rock's movement occurs and breaks, the induced fracture network and its connectivity will allow for the ability to calculate and visualize the reservoir drainage system.

The Bakken of North Dakota is known throughout the industry as being microseismically "unfriendly." The low hydraulic fracture pump rates induce a lower impact on the rock surrounding the targeted formation, thus generating a low-strength seismic event. Another natural physics problem is the

decreasing strength of the event naturally because of the overall carbonate section above and below the Bakken/Three Forks interval plus the distance to the geophone. The implementation of correctly designed microseismic studies within the industry, both E&P companies and contractors, are many times called "experimental." The industry's de facto technology of the possible measuring of the overall post-hydraulic fracture permeability leads to a potentially significant reservoir management tool. There is a true logistical and technical opportunity to take advantage of the uniqueness of this 11-well effort. The ability to measure, integrate, and act upon the microseismic studies will delineate potentially valuable results for the industry's future productivity and capital efficiency.

VSP (vertical seismic profile):

A VSP, using a vibroseis truck on-site, will be recorded and processed to image a zero-phase well-tie to the future 3-D seismic survey, discussed below. These are critical technical data to build a foundation to process and maximize the applications of the 3-D seismic. The VSP also allows for the measurement of the natural attenuation of the earth to apply to the microseismic events. Integration of this information with the microseismic studies will image a more accurate placement of the hydraulic fracture-induced events.

PHASE III – RESERVOIR ENGINEERING

The reservoir engineering phase will be conducted as follows. The produced fluid and pressure history for the existing Middle Bakken and Three Forks wells will be used to create a computer model for test design. Reservoir modeling has already been conducted to develop an initial match of the Hawkinson 1-22H, Hawkinson 2-27H, and Hawkinson 3-27H production. Data obtained by the proposed research in this phase of work will be used to update the models. The bottomhole pressure (BHP) and wellhead pressure (WHP) data obtained for the Middle Bakken and first bench of the Three Forks wells will be incorporated into the model to create a WHP-to-BHP correlation, which will then be used to refine and retune the current history match of the existing producers. Phase III will also include the performance of pulse tests, whereby a pressure pulse is created to evaluate the nature, if any, of the communication between the Middle Bakken and the first, second, and third benches of the Three Forks. The pulse tests will be conducted as follows. Pressure will be monitored during the fracture job (including flowback) on an offset well during the fracture which will create an initial pressure pulse. The offset well will then be shut in for an appropriate time period, after which it will be produced, thereby creating an additional pressure pulse. Additional pressure pulses created by shutting in wells and returning them to production will be used to check the changes, if any, that occur over time. This process will be repeated at 3-, 6-, and 9-month intervals. Production and pressure data from the pulse testing will be incorporated into the reservoir simulation model.

The results from Phase I, II, and II activities will be used to determine the uniqueness of the producing zones, thereby shedding previously unavailable insight into the separation, or lack thereof, that has been hypothesized to exist between the Middle Bakken and first, second, and third benches of the Three Forks. The results of this phase of work will be published and disseminated according to the standards of the OGRC.

Pressure Gauges:

A recent pressure survey has shown major fracture growth vertically to the Middle Bakken from the portion of the wellbore in the lower Three Forks 2. However, the portion of the wellbore in the target

zone of the Three Forks 3 did not show growth to the Middle Bakken zone. Microseismic studies can provide information on fracture growth in the instances when pressure communication does not occur and thus increase our understanding of fracture behavior. Tying the microseismic studies to pressure data gathered should further enhance our understanding of the fracture behavior and drainage in the Bakken and Three Forks 1, 2, and 3.

This phase of work will gather BHP data before, during, and after the hydraulic fracture treatment of the new completions. The pressure data would provide solid evidence of fracture growth that would be tied to the microseismic events and enhance our understanding of the meaning and usefulness of events identified by microseismic. Pressure data gathered during a nearby fracture treatment of a Three Forks 3 well showed partial pressure communication up to the existing Middle Bakken well.

Considerable data are available during fracture treatments showing communication during fracturing operations, but this proposal would also include gathering data on pressure communication after the wells are produced. By pressure-pulsing wells and monitoring pressure pulses generated by shutting in wells over time, the long-term communication can be included into the reservoir simulation model. The long-term behavior of the hydraulic fractures is a major factor in determining infill density for optimum development. The design and amount of pressure data gathered will depend on postcompletion behavior, especially the length of time the wells flow before being put on pump.

PHASE IV – EXPANSION APPLICATIONS VIA 3-D SEISMIC

3-D Seismic Survey:

During the 11-well portion of the program we have discussed the collection and study of the research and development data, including the coring of the critical formations to attain hands-on measurements, running of advanced technical logs in an intentionally drilled pilot hole, and the recording of the microseismic events to learn about the hydraulic fracturing geometry and pressure measurements potentially relating to reservoir postfracture production. We plan to integrate the data collected from the wellbores with a 3-D seismic survey. The goal set out to be the definition of a seismic attribute that is regionally relative to the productivity of the Middle Bakken and Three Forks. If successful in implementing these results geographically away from the Hawkinson, we believe future drilling and completion capital will be more efficiently spent, allowing for the drilling of the best locations earlier, thereby increasing the daily production rates and present value of the envisioned program. Maximizing conventional 3-D seismic data's potential technical capabilities over the Hawkinson unit requires approximately 42 square miles of shooting data in the field.

Dawson Geophysical will acquire a 3-D seismic survey with its GSR (geospace seismic recorder) cableless seismic field acquisition system. This recently developed field acquisition system allows for data collection in surface environments which were not previously feasible. Geotrace will process the data implementing its proprietary software capabilities developed recently to maximize the seismic imaging of the Middle Bakken and Three Forks. All of this hardware and software seismic technology has developed over the last 2 years.

The rock characteristics of the Middle Bakken and Three Forks relate directly to their recoverable reserves. Understanding the collected data by its integration of the core, petrophysical logs, microseismic studies, and 3-D seismic could allow for a substantial improvement on the future efficiency of developing the subject reserves and capital expenditures required. In the above series of data collection, research and integration all have a common component: the imaging and prediction of the brittleness of the reservoir rock. This research and development program will enhance not only our local knowledge at the Hawkinson but be applicable geographically on a much larger regional scale.

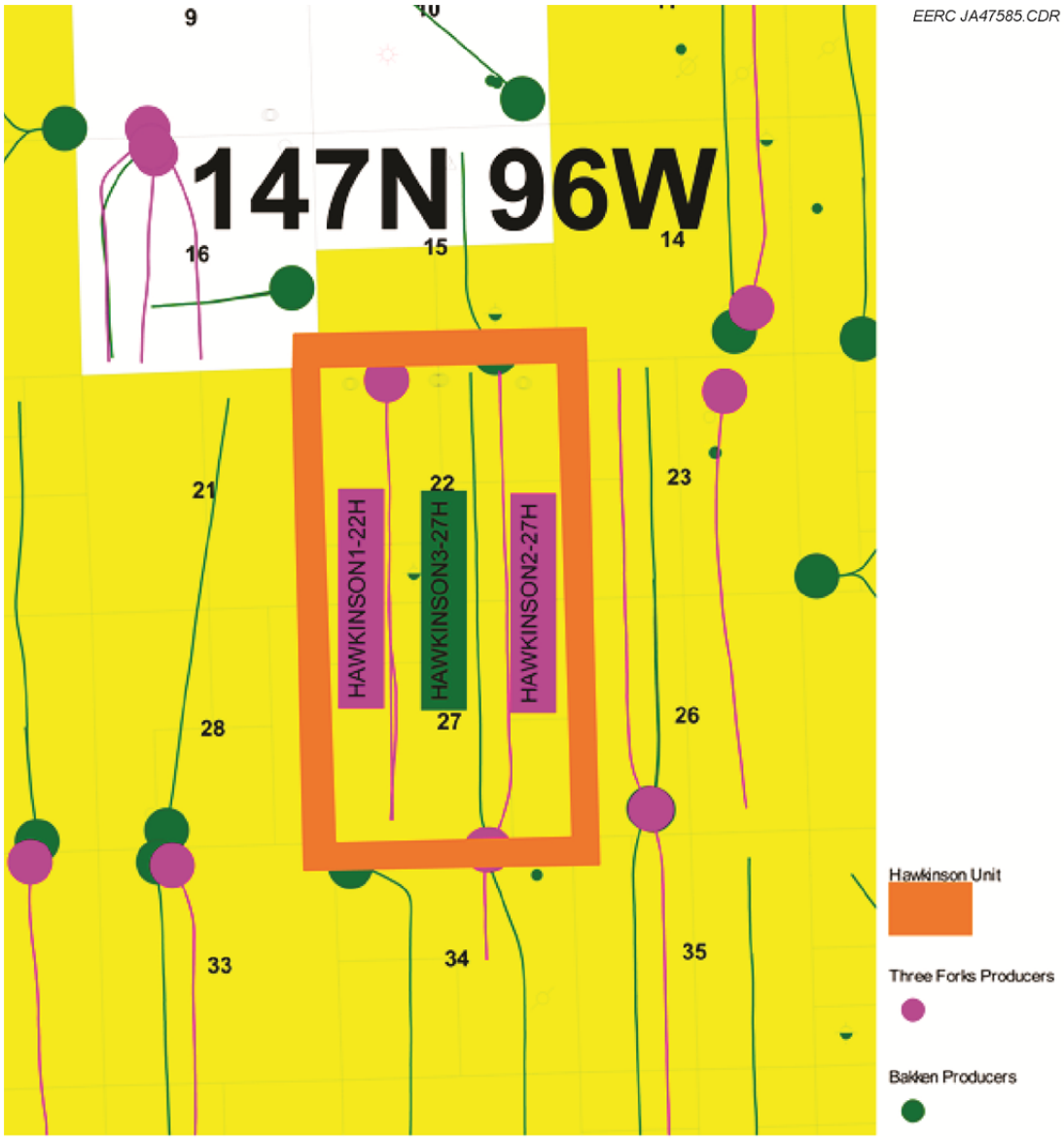


Figure 1. Hawkinson Project 1280-acre spacing unit (Sections 22&27–T147N-R96W, Dunn County, North Dakota) (taken from Continental Resources).

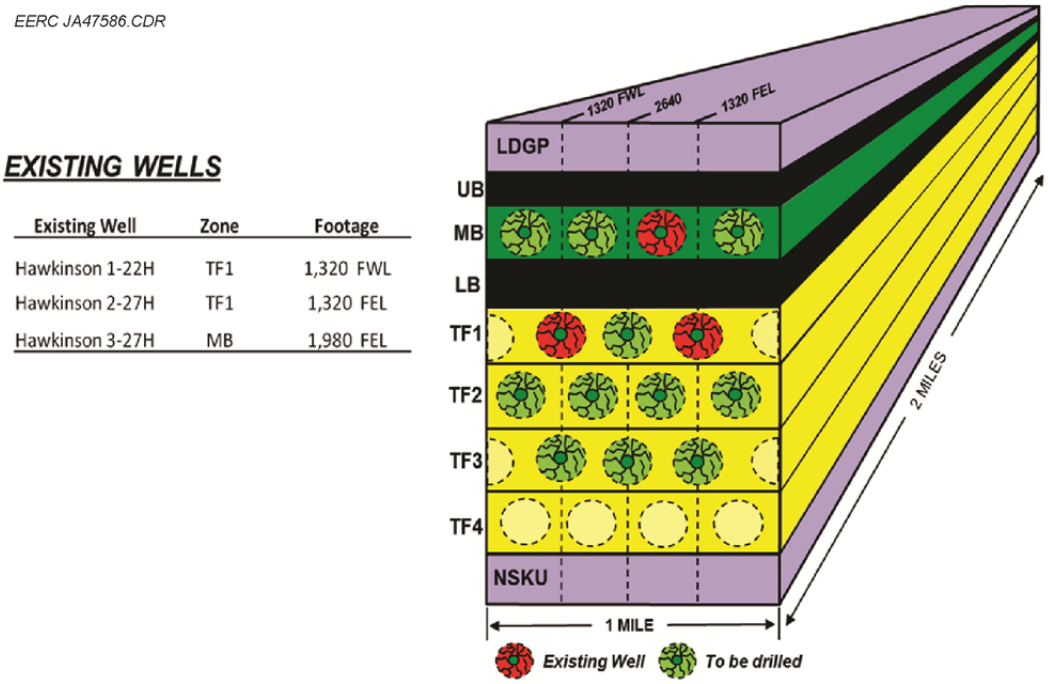


Figure 2. Existing producing wells and future wells to be drilled in the Hawkinson Project (taken from Continental Resources).

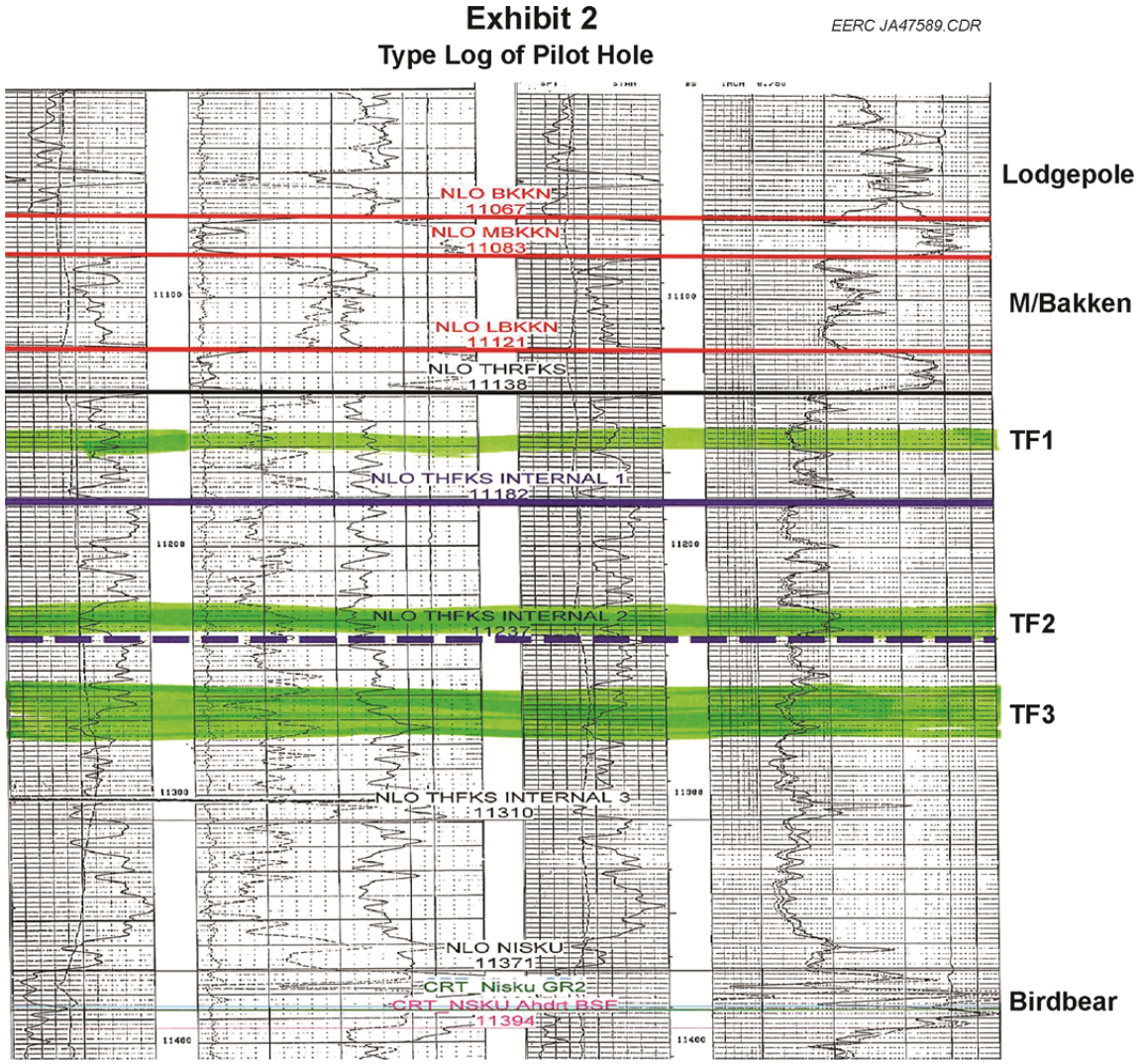


Figure 3. Type log of typical well near the Hawkinson Project (taken from Continental Resources).

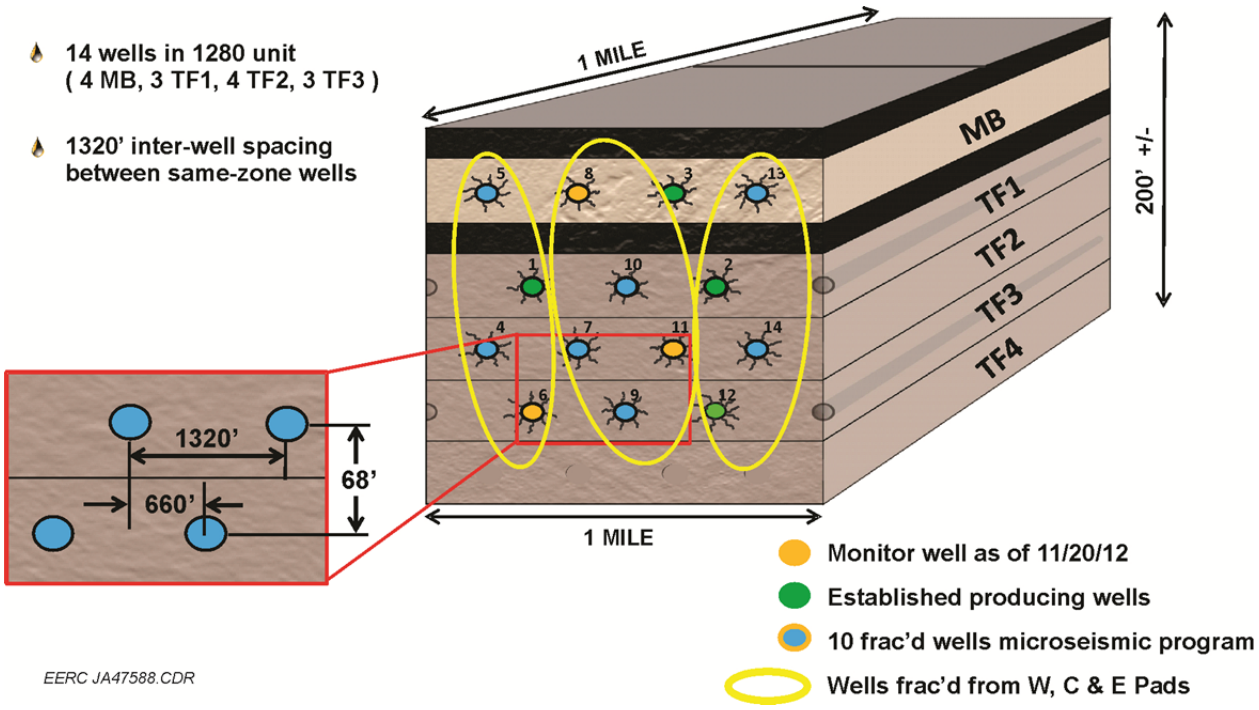


Figure 4. Locations of producing and monitoring wells to be fracture-stimulated in the Hawkinson Project (taken from Continental Resources).

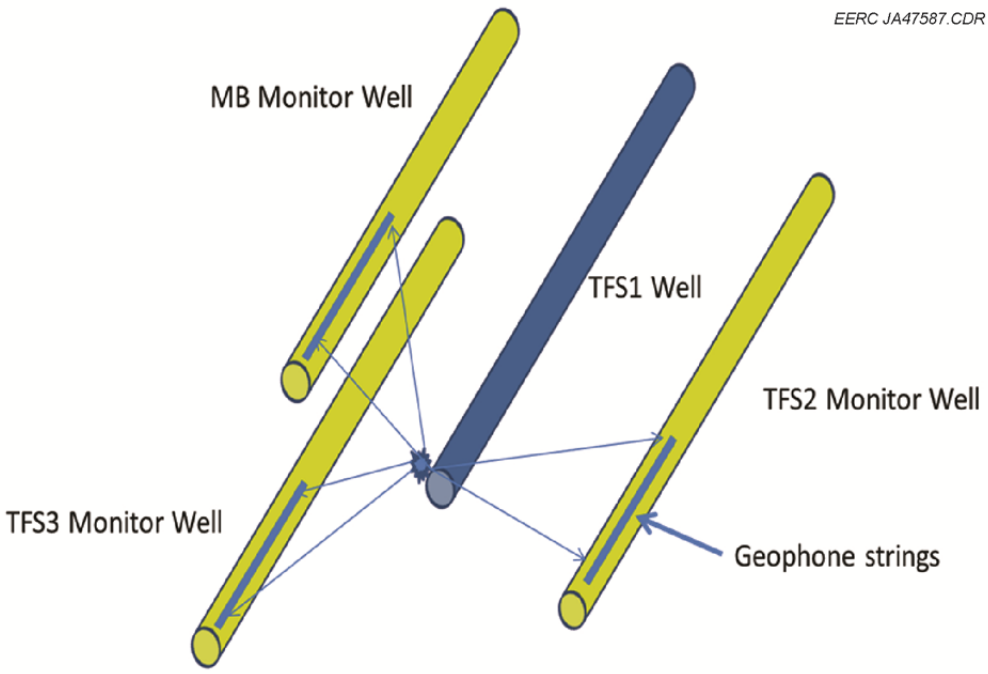


Figure 5. Schematic showing the three strings of geophones in the microseismic monitoring wells (taken from Continental Resources).

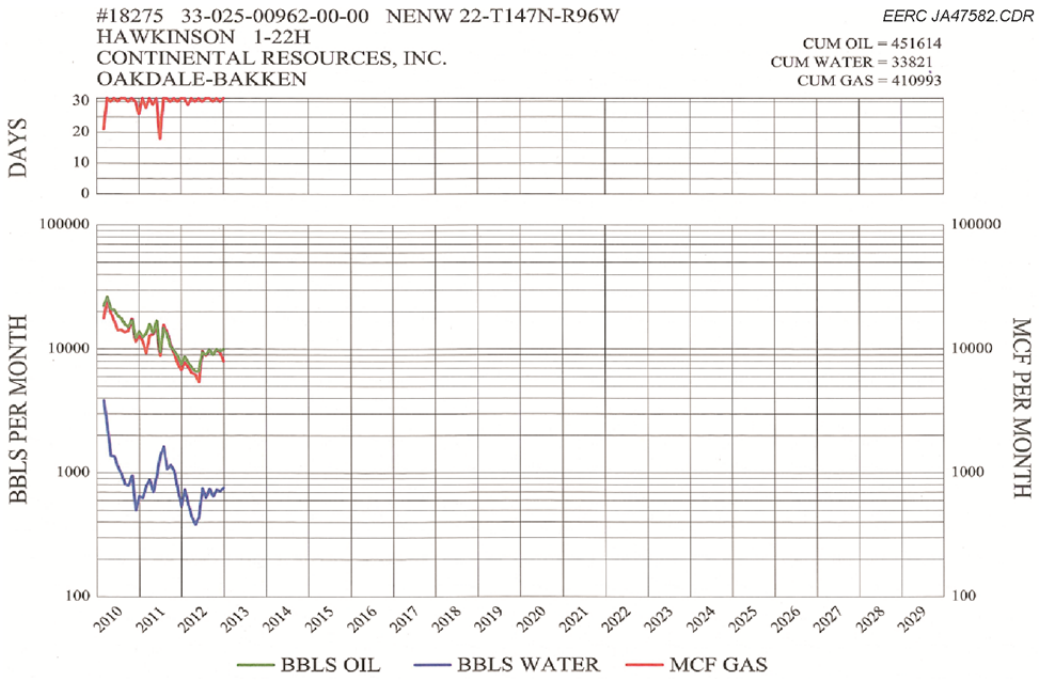


Figure 6. Hawkinson 1-22H production curve (taken from Continental Resources).

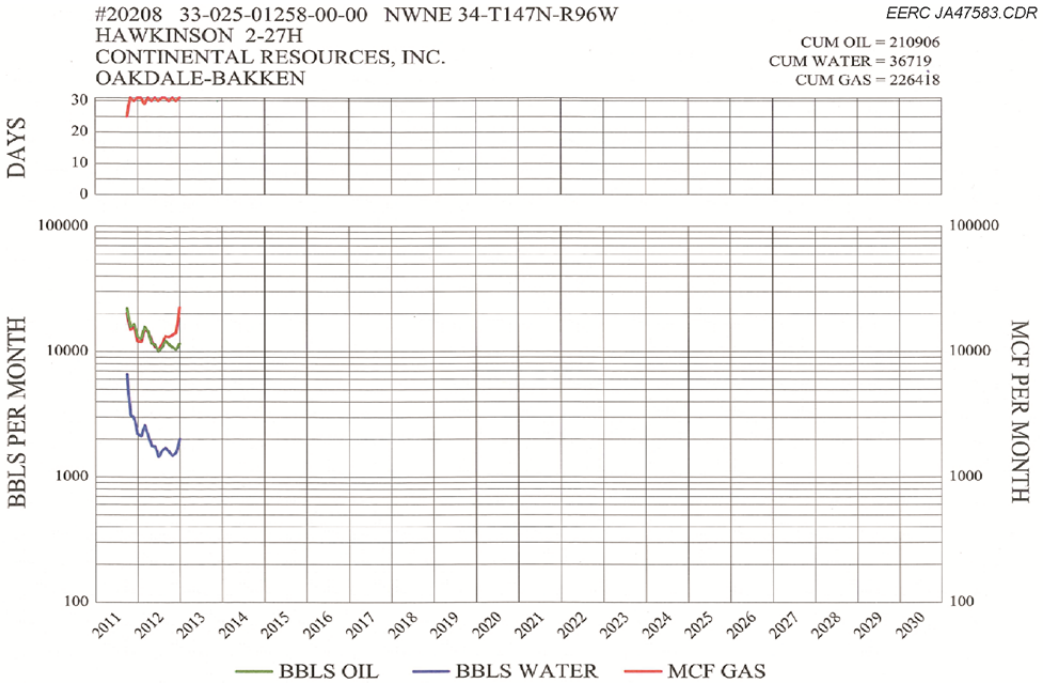


Figure 7. Hawkinson 2-27H production curve (taken from Continental Resources).

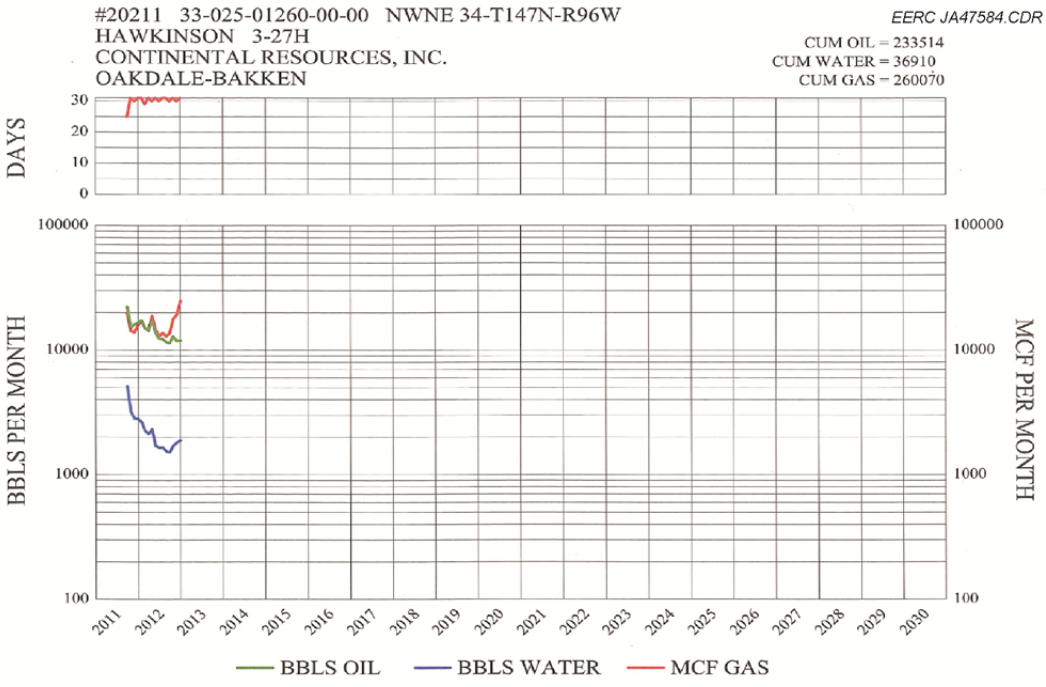


Figure 8. Hawkinson 3-27H production curve (taken from Continental Resources).

Detailed Timetable for Phases I–IV:

	Continental Budgeted $(000)	Requested From OGRC $(000)
March – August 2013		
Drill and complete 11 wells in the Hawkinson unit Cyclone 28 (2–3 well pads) Cyclone 34 (5 well pad)	$101,500	N/C
March – April 2013		
Pilot hole (extraordinary rig operation time)	N/C	$500
Conventional core and analysis	N/C	$600
Advanced petrophysical logs in vertical hole	N/C	$100
June – August 2013		
VSP	N/C	$40
Microseismic SLB studies	N/C	$4,600
August – December 2013		
ESG SMTI conductivity studies	N/C	$600
June 2013 – June 2014		
Running pressure gauges	N/C	$150
February – December 2013		
3-D seismic acquisition and processing	N/C	**$4,200**
GRAND TOTALS	**$101,500**	**$10,790**

REPORTS AND DATA SUBMISSION:

March 1, 2013 – September 2014	Quarterly activity update reports and data submission
December 2014	Final report

The above budget and schedule were prepared by Continental Resources for a prior submission to OGRC. Since that submission, Continental Resources has agreed to complete the same scope of work with a financial distribution of $106,030,000 as Continental Resource's cost share and $6,260,000 as OGRC's cost share. Schedules will be adjusted accordingly.

PHASE V – OPTIMIZATION OF WELLSITE OPERATIONS

This phase of work will target improving the overall efficiency of wellsite activities, thus achieving significant cost containment strategies for participating producers and improved economic output of each well. This goal will be achieved by investigating new and novel methods of integrating various wellsite functions, capitalizing on available on-site resources in lieu of "importing" fuels to accomplish the same functions and recycling various drilling, well treatment, and completion fluids. Bakken oil has been demonstrated to be expensive to recover. This phase of the overall program will investigate new technologies and approaches to decrease recovery costs in an environmentally sound manner.

Tasks within this phase of work will be dictated by project participants but will likely include (but not be limited to) combined natural gas liquid (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; and many other possible optimizations that will be identified by industry participants. 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 (and thus maximization of economic output of wellsites) will be explored. Means of improving the efficiency of handling and disposing of drilling and production wastes, including naturally occurring radioactive materials (NORM) will also be explored. Wellsite logistics (such as efficiency opportunities arising from simultaneous drilling, completion, flow testing, and production operations on a single wellsite) will also be included, as will any optimizations that result in a net reduction of truck traffic in and out of the wellsite.

The phase of work is designed to accommodate scope growth as new partners come on board and as the needs of industry continue to evolve. Ongoing discussions with several potential partners have led the EERC to focus on four major areas in the first year of this phase of work:

- Site logistics
- Hydrocarbon utilization
- Water management
- Process optimization and systems failure analysis

Goals and Objectives:

The goal of this phase of work is to explore wellsite optimization approaches that have potential to reduce wellsite costs, improve wellsite production, reduce wellsite development and operation impacts to surrounding landowners, and decrease demands on surrounding infrastructure and water sources. This goal will be achieved by executing a responsive, dynamic, industry-driven scope of work targeted to address critical issues faced by the oil and gas industry. Specific objectives of this phase of work will include the following:

1. Initiate the phase with high-priority tasks driven by industry input.
2. Share results of completed tasks among consortium members for rapid adoption of new methods and maximum economic and environmental impact within North Dakota.
3. Investigate additional optimization opportunities with existing and potential consortium members.
4. Provide public outreach to public and private organizations.

Methodology:

This phase of work will be organized initially along four technical topic areas (more may be added as industry requests dictate). Topic areas listed here are only examples of expected priorities held by industry. During any given year, tasks will not necessarily populate each of these topic areas.

Site Logistics – These are individual tasks focused on improvements of vehicle flow and workflow on well pads, space-saving on well pads, combined functionality of currently independent work units on well pads, improved well pad materials, and/or improved means of handling drilling and production wastes, including those that may contain NORM.

Hydrocarbon Utilization – These are individual tasks focused on improving the production of oil, gas, or NGLs from wellsites. Tasks may include investigations of on-site utilization of natural gas prior to gathering, for example.

Water Management – These are individual tasks focused on technologies to limit demand for freshwater, decrease wastewater production, and reduce water/wastewater trucking to and from the wellsite.

Process Optimization and Systems Failure Analysis – These are individual tasks focused on analysis of failures at the wellsite that affect production efficiency. For example, this activity may include corrosion studies of well casing and well pump components or investigating improved wellbore techniques.

This phase of work will begin with a kickoff meeting for industry partners and OGRC. At this meeting, initial research task proposals will be offered, and the group will prioritize those tasks to pursue during the first year. Detailed scopes of work, time lines, and budgets will be developed for each selected task. A similar exercise will be conducted at least annually during each year of this phase of work. Nonproprietary results of tasks selected by the consortium will be shared among all members of the consortium and reported to OGRC.

The EERC will be responsible for coordination and execution of tasks with assistance provided by members of the consortium. The EERC will also be responsible for dissemination of results and for briefing NDIC OGRC upon request. Further, the EERC will present yearly progress summaries at OGRC meetings.

A significant effort within this phase of work will focus on looking for integration opportunities between individual tasks. It is envisioned that many tasks will occupy adjacent spaces physically, operationally, and financially. Every opportunity to combine tasks will be sought for the sake of overall efficiency.

This phase of work will provide the oil and gas industry with a valuable tool to address key issues related to wellsite optimization. The results of the proposed work will likely increase well productivity

and economic output, decrease environmental impacts of wellsite operations, and reduce demand for infrastructure construction and maintenance. The overall outcomes of this phase may include the following.

Environmental:

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

Economic:

- Increased royalties from harnessed associated gas and NGL streams.
- Increased tax base from 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.

APPENDIX E

SAMPLE FACT SHEET FORMAT

Northern Great Plains Water Consortium *Water Use Fact Sheet*

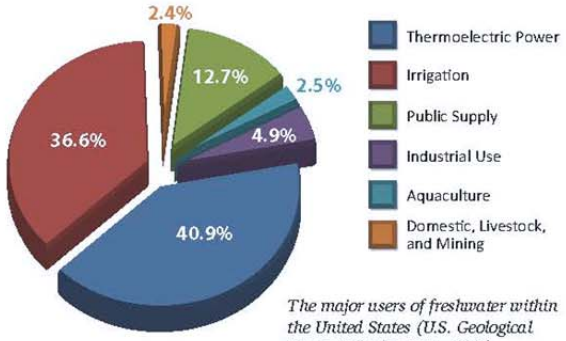
EERC Energy & Environmental Research Center® Putting Research into Practice

The Demand for Water

Water is the most critical limiting resource throughout the world. Sustainable economic growth requires a reliable supply of water for energy, agriculture, and a growing population. Water is necessary for urban development, power production, growing and processing high-value crops, oil and gas development and processing, and industrial manufacturing. Satisfying all of these competing needs requires a better understanding of water resources and new approaches to water management. Energy, agriculture, industry, and municipalities all urgently need a scientifically valid basis upon which to make management and regulatory decisions related to water use and quality.

The Northern Great Plains Water Consortium® (NGPWC) is a partnership between the Energy & Environmental Research Center (EERC), the U.S. Department of Energy (DOE) and key energy-producing entities in the northern Great Plains to address issues related to water availability, reducing freshwater use, and minimizing the impacts of facility and industry operations on water quality. The key goals of the NGPWC are:

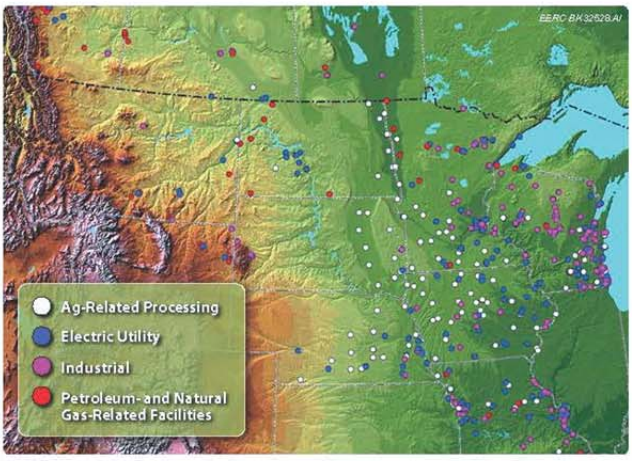
- To evaluate water demand and consumption from competing users in the northern Great Plains region, including energy production, agriculture, industry, and domestic/municipal users.
- To assess, develop, and demonstrate technologies and methodologies that minimize water use and reduce wastewater discharge from energy production and agricultural processing facilities.
- To identify nontraditional water supply sources and innovative options for water reuse.



The major users of freshwater within the United States (U.S. Geological Survey Circular 1344, 2009).

Thinking Outside the Box to Address Water Issues

As the United States continues to pursue economic development and the population increases, demand for ever-increasing amounts of energy to support that growth will require water. In areas where water resources are limited or become scarce because of overallocation and/or drought, competing interests for water could limit energy development and production. With the vibrant oil, gas, and utility interests in the region, potential water reuse synergies among energy-related industries should be explored. For example, in 2005, thermoelectric power generation was the largest domestic user of water, accounting for nearly 41% of all freshwater withdrawals in the United States, as illustrated in the figure above. A portion of that cooling water effluent could be used in other industries. Significant volumes of water are also used in the drilling and completion of oil and gas wells. Wastewater from other industries could be used to supply water needed for drilling operations, and options may exist to treat and reuse the produced water from oil and gas operations. Finding innovative solutions that expand water resource options for the energy industries in the region is one of the key goals of the NGPWC.



NGPWC region showing the locations of key energy, agricultural, and industrial facilities.

Putting Regional Water Use in Perspective

The various industries and water users within the region often use different units of reference when referring to water consumption and discharge. To gain a perspective on the relationship between municipal, industrial, and agricultural water use, below are comparisons of some common units and examples of water use among the sectors.

Approximate Volumetric Equivalents

barrels	gallons	acre-feet	cubic feet	cubic meters
1	42	0.000129	5.6146	0.15897
7758	325,851	1	43,560	1233
23,810	1,000,000	3.1	133,681	3785

Approximate Flow Equivalents

barrels per day (bbl/day)	million gallons per day (Mgd)	gallons per minute (gpm)	cubic feet per second (cfs)	cubic meters per second (m^3/s)
23,810	1.0	694.4	1.55	0.04381
34.3	0.00144	1.0	0.0022	0.00006
100	0.0042	2.9167	0.0065	0.000184

Conversion Factors

1 cubic foot = 7.4805 gallons
1 gallon = 3.785 liters
1 cubic meter = 1000 liters
1 acre = 43,560 square feet

Water Use Comparisons

Use	gallons (millions)	barrels (thousands)	acre-feet	cubic meters
Typical **Daily** Use for a 50,000-Person Midwestern City (including industrial users)	10	238	30.7	37,850
Daily Pumping Volume for a Center-Pivot Irrigator for 130 acres (irrigated portion of ¼ section)	1.008	24	3.1	3815
Average **Daily** Water Withdrawal for Once-Through Cooling at a 400-MW Coal-Fired Power Plant	365	8691	1120	1,381,525
Water Used to Fracture the Formation for an Oil Well in the Bakken Formation (**one-time use**)	1.0–5.0	24–119	3.1–15.3	3785–18,920
Proposed Maximum **Daily** Volume of Water Imported for the Red River Valley Water Supply Project	77.56	1847	238	293,556

Interested in Participating?

The EERC is actively seeking commercial partners to complement DOE funding and to help direct the program's efforts. The NGPWC recently completed Phase I of the program, wherein current program efforts and demonstration projects were prioritized and selected. Phase II of the effort, begun in late 2009, focuses on demonstrating the selected water minimization and beneficial reuse strategies and technologies.

The NGPWC is a partnership of key public and private water users in the northern Great Plains region. New members are welcome. To learn more, contact:

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