EERC
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
15 North 23rd Street — Stop 9018 / Grand Forks, ND 58202-9018 / Phone: (701) 777-5000 Fax: 777-5181
Web Site: www.undeerc.org

October 29, 2010

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue
State Capitol, 10th Floor
Bismarck, ND 58505-0310

Dear Ms. Fine:

Subject: EERC Proposal No. 2011-0085, "Investigation of Improved Conductivity and Proppant Applications in the Bakken"

The EERC is pleased to propose continued research targeted at improving oil and gas production in North Dakota. A qualified team, including representatives from the service industry, experienced petroleum engineering consultancy, and applied geophysical laboratory research, have been assembled to target specific completion practices in the Bakken and Three Forks. The proposed work anticipates contributing research knowledge to enable improved fracture conductivity through a better understanding of specific proppant performance.

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 project 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

Approved by:

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

JAH/hmv

Enclosures

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: Investigation of Improved Conductivity and Proppant Applications in the Bakken

Applicant: Energy & Environmental Research Center

Principal Investigator: Darren D. Schmidt

Date of Application: 10/29/2010

Amount of Request: $150,000

Total Amount of Proposed Project: $332,432

Duration of Project: 12 months

Point of Contact (POC): Darren D. Schmidt

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POC Address: 15 North 23rd Street

Grand Forks, ND 58202-9018

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ABSTRACT

Objective:

The goal of the project is to improve the lateral and vertical drainage of hydrocarbons from the Three Forks and Bakken Formations by identifying the factors that lead to the collapse of propped fractures. Although it has been documented that propped fractures can be created to breach the Lower Bakken shale from Middle Bakken and Three Forks horizontal completions, field evidence to date suggests that operators are typically unable to sustain a hydraulic connection through this barrier (Taylor, 2010). Therefore, laboratory testing is proposed to determine whether more durable fracture conductivity can be achieved in the Bakken by altering the fracturing fluids, proppant types, and proppant concentrations.

The objectives are to determine:

1. Whether conductivity loss is due to collapse of proppant, or collapse of formation face, or some other mechanism.

2. Whether this loss of conductivity can be remedied with a more appropriate selection of fluid types, proppant types, or proppant concentrations/fracture widths.

Expected Results:

The experiments are designed to directly measure performance of hydraulically created fractures under conditions that are as realistic as can be economically justified. The studies are focused to evaluate the effect of treatment changes (fluid type, proppant type, and proppant concentration) such that if specific combinations are identified that can provide a durable connection, these changes can be immediately adopted in the field. If a design change can be identified that allows drainage of both the Three Forks and Middle Bakken from a single lateral, this could reduce the number of necessary wells by nearly 50%, with corresponding reductions in surface footprint, environmental impact, and development costs. These design changes will also impact the required well density and may allow more efficient drainage from a reduced number of wellbores.

Deliverables for this project include timely project reports, publication, and conference presentations.

Duration: 12 months

Total Project Cost:

$150,000	Requested from North Dakota Industrial Commission, Oil and Gas Research Program
$113,201	Provided from U.S. Department of Energy–Energy & Environmental Research Center Joint Program
$ 69,231	Cost share provided from CARBO Ceramics
$332,432	Total Project Cost

Participants: Energy & Environmental Research Center, CARBO Ceramics, Insight Petroleum Consulting, North Dakota Geological Survey

PROJECT DESCRIPTION

Objectives:

The mission of the Oil and Gas Research Council is to promote the growth of the oil and gas industry through research and education. The objectives for this project relative to the Oil and Gas Research Program (OGRP) are to:

1. Present project results in public forums such as the Williston Basin Petroleum Conference, which demonstrates to the general public the importance of the state oil and gas exploration and production industry.
2. Improve hydrocarbon drainage from the Bakken system which promotes the wise and efficient use of energy.
3. Potentially decrease the number of wells required for effective drainage which promotes environmentally sound exploration and production.
4. Improve hydrocarbon recovery to better develop the state's oil and gas resources.
5. Conduct research and provide results to industry and academia through presentations and publications.

The goal of the project is to improve the lateral and vertical drainage of hydrocarbons from the Three Forks and Bakken Formations by identifying the factors that lead to the collapse of propped fractures.

The specific research objectives are to determine:

1. Whether conductivity loss is due to collapse of proppant, or collapse of formation face, or some other mechanism.
2. Whether this loss of conductivity can be remedied with more appropriate selection of fluid types, proppant types, or proppant concentrations/fracture widths.

Methodology:

Although it has been documented that propped fractures can be created to breach the Lower Bakken shale from Middle Bakken and Three Forks horizontal completions, field evidence to date suggests that operators are typically unable to sustain a hydraulic connection through this barrier (Taylor, 2010). Therefore, laboratory testing is proposed to determine whether more durable fracture conductivity can be achieved in the Bakken by altering the fracturing fluids, proppant types, and proppant concentrations. At the current time, this challenge requires operators to drill redundant wells completed in the Middle Bakken and Three Forks reservoirs. Similarly, Bakken operators have fractured into offset wells that are spaced more than 2000 feet apart, demonstrating that very long propped fractures can be created. However, these fractures also lose hydraulic continuity over time. This research is targeted to

identify what parameters are responsible for the collapse of these propped fractures and resulting loss of conductivity, including:

1) Is the loss of conductivity due to failure of the formation material?
   - Evaluate sensitivity of Bakken and Three Forks core to various fracturing fluids including the following:
     - Water
     - Alkali borate cross-linked water-based gels
     - Hydrocarbon-based fracturing fluids
     - Acidic conditions from native CO_2 with combined oil, water, and gas production
2) Is the loss of connection due to inadequate performance of the propping agents?
   - Evaluate performance of sand, resin-coated sand (RCS), and various ceramic proppants
     - Under realistic temperatures (up to 250°F)
     - Range of fracture widths and proppant concentrations
     - In contact with actual core collected from the Bakken and Three Forks
     - Exposed to realistic fluid saturations

The following elements highlight the methodology proposed to achieve the project objectives:

- Collection of core samples from the Middle Bakken, Lower Bakken shale, and Three Forks obtained from the North Dakota Geologic Survey (attached letter of support can be found in Appendix A).
- Initial penetration and embedment testing performed on flat core surfaces to determine the extent of core softening and sloughing after extended exposure to a variety of fracturing fluids.
- Screening and selection of fracturing fluids for further evaluation in static long-term tests and modified conductivity tests conducted at reservoir temperatures and pressures.
- Identification of properties likely to maintain fracture conductivity based on laboratory data.
- Validation of laboratory tests with API and ISO methods performed by CARBO Ceramics' commercial laboratory.

The required quantity of core for the proposed project is approximately six 1-foot intervals of core each from the Middle Bakken, Lower Bakken shale, and Three Forks. A survey of available Bakken cores listed with the North Dakota Department of Mineral Resources (DMR) is shown in Figure 1. The North Dakota Geological Survey has provided a letter indicating support for the proposed project and potential to supply cores for research.

Cores collected for the project will be prepared for embedment and penetration testing. A standard penetrometer (Figure 2) will be used to embed a single proppant grain into a slabbed (1" × 2" × ½") core surface. The capacity of the penetrometer based on 16-mesh proppant is approximately 7700 psi. The core will be saturated with fluid and heated. Force required to embed the particle will be determined. Embedment testing will be completed for core slabs exposed to fracturing fluids including water, alkali borate cross-linked water-based gels, and hydrocarbon-based fracturing fluids and acidic conditions from native CO_2 with combined oil, water, and gas production. Exposure will include saturating samples

for 30 days in a heated chamber at pressure. Embedment is a known issue in the Haynesville shale (Terrancia and others, 2010) and is likely to contribute to conductivity issues in the Bakken.

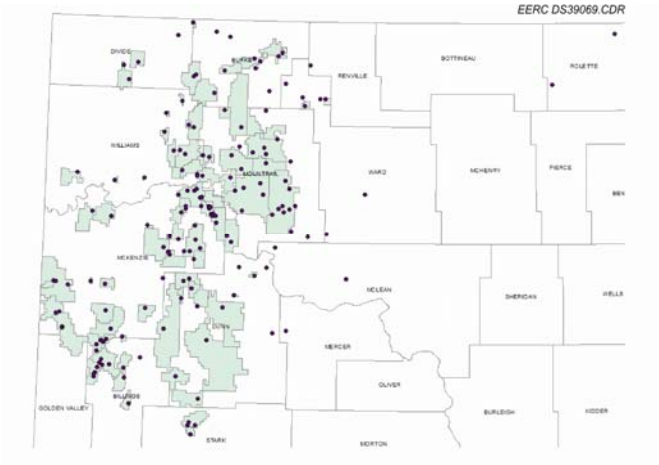

Figure 1. Locations of Bakken core potentially available from the North Dakota Geological Survey's Core Library.

Figure 2. Penetrometer for embedding proppant.

Embedment and penetration testing will enable determination of the relative conductivity loss mechanism with respect to the formation material. The outcome of this testing will prompt investigation of improved proppant packs, selection of fracturing fluids that do not significantly decrease the strength of the formation, or investigation of potential failure modes for proppants.

Potential proppant failures would be identified by first exposing proppant to the previously described fracturing fluids at reservoir conditions for 30 days and then performing a crush test. Details regarding the methodology have been published by Bremer and others (2010) and will be performed at the Energy & Environmental Research Center's (EERC's) Applied Geology Laboratory (AGL). Similar research by LaFollette and Carman (2010) indicate that intermediate strength 40/70 proppant can experience a strength loss by a factor of 2 over 30 days when exposed to borate cross-linked fracturing fluid. Additional testing may be merited to simulate the buffering of pH by formation fluids or eventual acidic conditions expected in the Bakken during long-term production (Smith, 2010; Grimes and McNeal, 2005).

Data collected regarding potential formation strength reduction and proppant degradation relative to the selected fluids will enable an analysis of approaches that may be successful in improving fracture conductivity. The resulting analysis will identify potential strategies for proppant loading, proppant size, and use of less damaging fluids. These strategies will be implemented in a series of conductivity tests using a Hoek cell shown in Figure 3. It is anticipated that a minimum of 18 conductivity tests modified from API RP-61 and ISO 135503-5 will be run using Middle Bakken, Lower Bakken shale, and Three Forks core plugs.

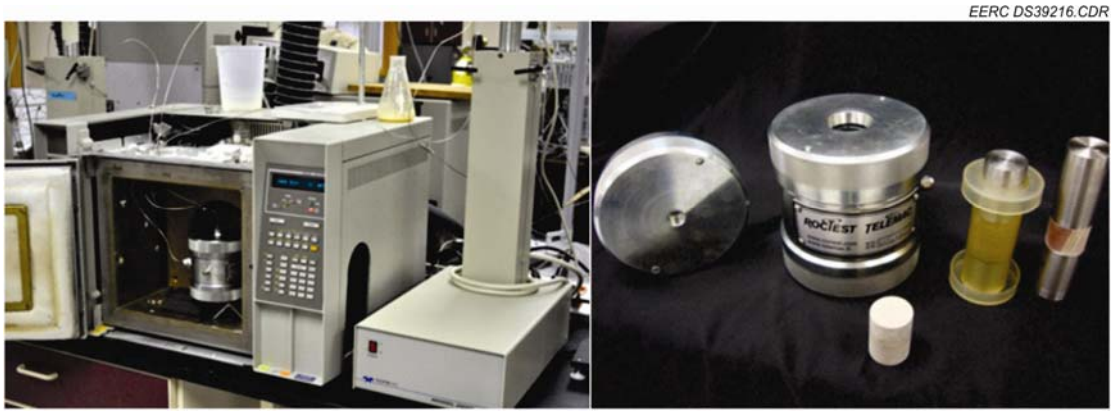

Figure 3. Hoek cell apparatus for conductivity testing at reservoir conditions.

The proposed Hoek cell provides the unique ability to complete a large array of testing and data collection with more efficient use of valuable core relative to standard and more expensive proppant conductivity tests performed in a Cooke conductivity cell designed to evaluate commercial proppant. The Hoek cell enables mounting of full horizontal core plugs and has a capacity of 10,000 psi confining pressure, which is sufficient for replicating Bakken conditions. Core plug diameter is 1.185 inches. Stress can be maintained for up to 30 days at reservoir temperature (230°–250°F) on specific samples to measure the time-dependent collapse of fracture conductivity. The EERC has the capability to flood with a variety of aqueous or hydrocarbon-based fluids or the multiphase flow conditions subject to elevated CO_2 as may be experienced under normal producing conditions. Calibration and comparison to industry standard tests that do not generally accommodate the more realistic fluid systems can be accomplished by accommodating Ohio sandstone shims to compare to baseline Cooke/API/ISO cell results. Any proppant which flows out of the apparatus will be collected and evaluated, as proppant flowback is a documented concern in Bakken completions (Besler and others, 2007; Vincent, 2010). The core plugs will be halved in preparation to receive various proppant concentrations ranging from 0.1 lb/sq ft to 1.5 lb/sq ft when mounted in a Hoek cell (Figure 4).

Anticipated Results:

The experiments are designed to identify the reason for loss of fracture conductivity between adjacent or overlying wellbores. In addition to identifying contributing causes that can be easily remedied by altering fracturing fluids, proppant types, or proppant concentration, these studies will provide other very useful data:

- The first published measurements of proppant conductivity against actual Bakken core.
- The first published measurements showing how these proppants perform under conditions more similar to the Bakken in situ environment, including CO_2 and other acid gases, with actual or synthetic Bakken crude and produced water.
- A comparison of currently utilized proppants to help operators recognize the range of proppant quality, performance, and durability.

Embedment and proppant degradation are anticipated results of the outlined experiments. If for some reason laboratory results do not reinforce mechanisms of formation strength loss and proppant degradation leading toward conductivity loss, additional experiments will be implemented to investigate spalling and scaling issues.

Figure 4. Image depicting a proppant pack placed in core (Bremer and others, 2010).

Facilities:

Laboratory testing will be conducted at the EERC's AGL and at CARBO Ceramics' product testing laboratory. The EERC's AGL conducts geomechanical, geochemical, and customized core sample-related experiments designed to solve targeted problems in the oil and gas industry. The AGL is staffed with experienced personnel, including geological, chemical, and engineering disciplines, and has been instrumental in conducting a range of research to support the U.S. Department of Energy (DOE) under the Plains CO_2 Reduction (PCOR) Partnership Program. The AGL works in conjunction with the EERC's scanning electron microscope laboratories, including the Natural Materials Analytical Research Laboratory and the Analytical Research Laboratory, including wet-chemistry and advanced trace elemental analysis.

CARBO Ceramics operates a product testing laboratory designed to ensure the production of quality products to industry. The laboratory is fully equipped with equipment conforming to API and ISO standards. The CARBO Ceramics' laboratory will be utilized to perform validation testing of EERC results in standard Cooke conductivity test cells.

Equipment listing of the EERC's laboratories relative to the project scope is available in Appendix B.

Resources:

The project team includes personnel from the EERC, CARBO Ceramics, and Insight Petroleum Consulting. Cost share for the project will be obtained from CARBO and the DOE through the EERC's Jointly Sponsored Research Program. The proposed methodology is of the appropriate magnitude to achieve the project objectives while allowing the flexibility to perform research and analysis-based findings that could influence the scope of laboratory testing. The project team will work closely with the Oil and Gas Research Council (OGRC) through project meetings and quarterly reporting to ensure project quality. The educational contribution of the project will surface in a number of conference presentations and publications, including the Society of Petroleum Engineers (SPE), public reporting to DOE, and the contractual reporting obligations of OGRC. The awareness of the project team's knowledge is demonstrated by the references cited in this proposal and the professional history of Mike Vincent of Insight Petroleum Consulting, who actively publishes SPE articles pertinent to the Bakken and completion practices. The principal investigator is currently managing a DOE research effort considering factors that affect production in the Bakken, has recently published a Phase 1 report, and actively participates with industry in Bakken-related technical conferences and events.

Techniques to Be Used, Their Availability and Capability:

The proposed laboratories are fully functional and actively operated. Laboratories are appropriately staffed and instrumented for simultaneous experimentation to enable completion of data collection within the expected project time frame.

Environmental and Economic Impacts While Project Is Under Way:

No significant environmental impact will occur during the project. Well completion trends in the Bakken are advancing rapidly. It will be paramount to complete laboratory testing and issue draft reports to enable utility of project data prior to significant unforeseen changes in completion strategies. A 1-year project time line is proposed to accomodate project comments, contingency, and scheduling of conference submittals and presentation of results.

Ultimate Technological and Economic Impacts:

The U.S. Geological Survey estimates that 3–4.3 billion bbl of oil is technically recoverable from the Bakken Formation within the Williston Basin. Reserves according to the North Dakota Department of Mineral Resources are approximately 170 billion bbl of original oil in place (OOIP) (Figure 5) for the Three Forks and Bakken Formations, which is equivalent to about 2 billion bbls assuming a modest 1.1% recovery factor. Data from experiences from Bakken wells completed with ceramic proppant versus sand provided for approximately a 20 bbl/day differential (Besler and others, 2007). Assuming a modest similar impact could be realized through the current study, improvements of 150,000 bbl over the life of the well may result. A potential improvement of 30% per well may be possible given current estimated ultimate recoveries (EUR) at nearly 500,000 bbl/well. **This potential improvement in recovery translates to an additional 600 million bbl of oil in North Dakota**.

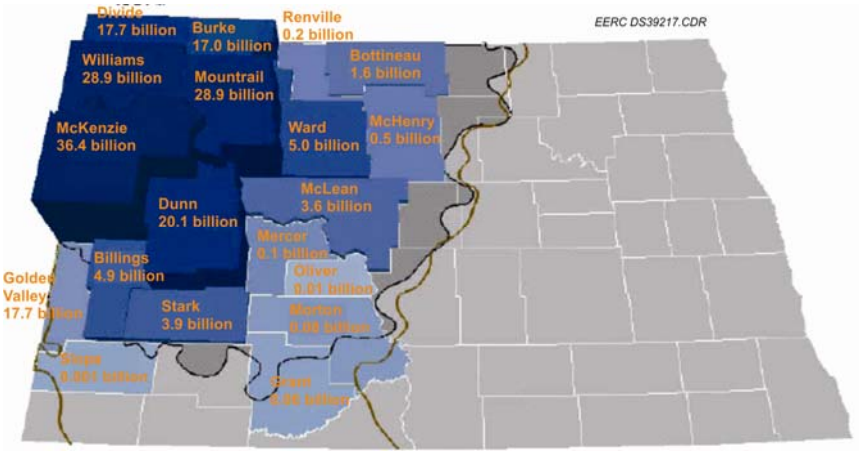

Figure 5. Combined OOIP from the Three Forks and Bakken Formations in North Dakota (Newfield Exploration, 2010).

Why the Project Is Needed:

Background

Proppant selection and application are significant well completion variables for Bakken development in North Dakota. Horizontal drilling and hydraulic fracturing have been described as the technological keys to unlocking hydrocarbons tightly held by the Bakken source system. Proppants, or propping agents, are pumped during hydraulic fracturing treatments to maintain fluid conductivity of the fractures induced in the Bakken Formation.

The three basic types of proppant include ceramic (sintered bauxite, alumina, kaolin), sand (sorted silica sand), and resin-coated (ceramic or sand). Ceramic proppants comprise three groups: lightweight, intermediate density, and high density. The performance of ceramic proppants vary greatly both by composition and manufacturer; however, numerous ceramic proppants have been used in the Bakken which are advertised to withstand closure stresses of 6000 to 14,000 psi. Relative closure stresses of the Bakken Formation in North Dakota cover the performance range of ceramic proppants. Fracturing sand is typically divided into two types: white sand and brown sand. White sand, the stronger of the two, is typically sourced from the St. Peter's sandstone in Ottawa, Illinois, while brown sand is sourced from the Hickory sandstone near Brady, Texas. Frac-sand is typically used in environments below 6000 psi (Halliburton, 2005). Resin coating of sand does not increase strength properties; however, RCS is a popular proppant choice because of better consolidation that reduces flowback and provides for better stress distribution across the proppant pack. Resin-coating ceramic proppant provides similar performance enhancements. All of the above are being used in Bakken completions.

Justification

Although it has been documented that propped fractures can be created to breach the Lower Bakken Shale, field evidence to date suggests that operators are typically unable to sustain a hydraulic connection through this barrier (Taylor, 2010). At the current time, this challenge requires operators to

drill redundant wells completed in each of the Middle Bakken and Three Forks reservoirs. Similarly, Bakken operators have fractured into offset wells that are spaced more than 2000 feet away, demonstrating that very long propped fractures can be created. However, these fractures also lose hydraulic continuity over time. This research is targeted to identify what parameters are responsible for the collapse of these propped fractures and resulting loss of conductivity, including:

1) The evaluation of formation integrity relative to exposure to various facturing fluids and acidic conditions of native fluids.
2) The evaluation of proppant performance under reservoir conditions and exposure to fracturing fluids.

There is a need to examine proppant performance in the laboratory to ascertain the relative effects to conductivity of fluids in the reservoir. The choice between ceramic, sand, and blends of the two influences economic performance. Prices of ceramic proppant and frac-sand in 2009 ranged from $0.40–$0.50/lb, and $0.08-$0.10/lb, respectively (Roberts, 2009). Treatments in the Bakken are using upward of 2 million lb of proppant (Sorensen and others, 2010) in 10,000-ft horizontal completions. Proppant quantity per well is expected to increase as some operators are having success with increasing the number of frac-stages from 10 to near 40 in a 10,000-ft lateral (Rankin and others, 2010). The cost differential between choosing ceramic over sand can be greater than $1 million per well. In addition, competition for proppant can limit the ability to obtain higher performing ceramics. This has led to strategies in the Bakken that include using large amounts of frac-sand followed by ceramic proppant (Continental Resources, 2009; Newfield Exploration, 2010), which enables operators to obtain the strength and longevity benefits of ceramics near the wellbore while supporting the majority of the fracture farthest away from the wellbore with low-cost proppant and hopefully limiting flowback while maintaining conductivity. **The proposed research is intended to reveal alternative strategies for proppant applications which can improve conductivity further into the reservoir than current practices**.

References

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STANDARDS OF SUCCESS

Scope of Work

Task 1 – Obtain Core Samples

The required quantity of core for the proposed project is approximately six 1-foot intervals of core each from the Middle Bakken, Lower Bakken shale, and Three Forks. A survey of available Bakken cores listed with the North Dakota Department of Mineral Resources (DMR) is shown in Figure 1. The North Dakota Geological Survey has provided a letter indicating support for the proposed project and potential to supply cores for research.

Task 2 – Embedment and Penetration Testing

Core samples will be required to generate approximately 1-in. slabs for penetration testing. A test matrix will include a series of 21 penetration tests using Middle Bakken, Lower Bakken shale, and Three Forks core and exposure to as many as seven different fracturing fluids.

Task 3 – Proppant Degradation Studies

Proppants will be crush-tested prior to and after exposure to the previously described fracturing fluids at reservoir conditions for 30 days. Details regarding the methodology have been published by Bremer and others (2010) and will be performed at the EERC's AGL.

Task 4 – Conductivity Testing

Core prepared to a 1.185-in. core plug will be used for conductivity tests conducted at the EERC. The core plugs will be halved and fitted to a Hoek cell. The unloaded fracture width will be 1/8-in. A minimum of 18 core plugs will be prepared to conduct conductivity experiments. Conductivity experiments will follow relevant API/ISO procedures using a Hoek cell. A baseline test in the Hoek cell will be performed with an Ohio sandstone core plug and verified at CARBO Ceramcis laboratory in a standard Cooke conductivity cell. Promising results from the Hoek cell that identify improved conductivity from various proppant fluid combinations will be verified in standard tests at CARBO Ceramics.

Task 5 – Analysis and Reporting

It will be critical to provide public results in a timely manner, as completion practices in the Bakken tend to evolve rapidly. Quarterly reports will be made available to the OGRC which will include all pertinent technical data and summary of results. Deliverables for this project include the following:

1. Quarterly report summarizing baseline testing.
2. Quarterly report summarizing testing of ceramic–sand combinations.
3. Final report and publications at technical conferences.

Success Measures

Success will be measured based on the schedule of project deliverables. The value to North Dakota is improved understanding and improved conductivity in the Bakken and Three Forks Formations. Results may directly influence practices and lead toward improved oil recovery with a potential of 600 million bbl. The EERC will produce high-quality publications to be downloadable from the OGRC Web site and technical publications peer-reviewed by organizations such as the SPE targeted to the oil and gas audience that can utilize research findings and translate to practice in the field. Success will be based on the production of technical documents for public dissemination.

BACKGROUND/QUALIFICATIONS

Resumes of key personnel are provided in Appendix C.

Energy & Environmental Research Center

The EERC is a high-tech, nonprofit branch of the University of North Dakota (UND). The EERC operates like a business; conducts research, development, demonstration, and commercialization activities; and is dedicated to moving promising technologies out of the laboratory and into the commercial marketplace.

The EERC's oil and gas experience can be highlighted within the Center for Oil and Gas and the PCOR Partnership. The Center for Oil and Gas is a specialized technical group at the EERC focusing on design and implementation of new approaches to the exploration, development, and production of oil and gas. Practicing under the long-standing EERC philosophy of collaboration and an interdisciplinary approach, the group's success is based on developing effective partnerships with the oil and gas exploration and production industry and government agencies. The projects conducted in the past include studies focused on the Powder River, Denver–Julesburg, Williston, and Western Canadian Sedimentary Basins.

The EERC is currently leading one of the world's largest programs dedicated to developing and demonstrating technologies to reduce CO_2 emission to the atmosphere from large-scale sources. The EERC's PCOR Partnership is one of seven regional partnerships operating under DOE's National Energy Technology Laboratory (NETL) Regional Carbon Sequestration Partnership Program. Since its inception in 2003, the PCOR Partnership's nearly 100 private and public sector members have provided data, guidance, financial resources, and practical experience with carbon capture and storage. The PCOR Partnership region includes all or part of nine states and four Canadian provinces.

Two full commercial-scale CO_2 sequestration projects are being developed that will inject 1 million or more tons of CO_2 a year into the receiving geologic formations. Each large-volume injection test is designed to demonstrate that the site has the potential to store CO_2 emission safely, permanently, and economically for hundreds of years.

CARBO Ceramics

CARBO Ceramics and its predecessor companies have led the industry since ceramic proppant was first introduced in the 1970s for use in the hydraulic fracturing process. Today, CARBO has the most extensive line of ceramic proppants, developed to optimize productivity and economic return in any type of oil or natural gas reservoir conditions.

CARBO operates six manufacturing plants in the United States, China, and Russia designed to serve the needs of any customer anywhere in the world.

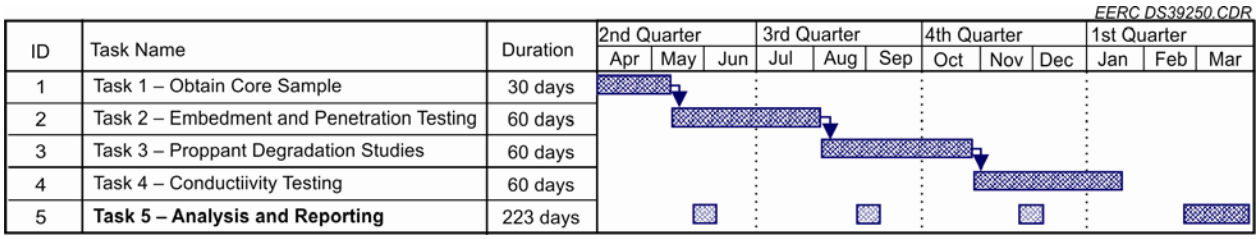
Insight Petroleum Consulting

Mike Vincent is a consulting engineer with 20 years' experience in economic optimization of hydraulic fractures. After completing his degree at the Colorado School of Mines, he worked with Amoco in Denver, and with ARCO in Anchorage, Kuparuk, and Denver. Mike started Insight Petroleum Consulting in 1996, specializing in fracture design and reservoir analyses. Mike has also consulted with CARBO Ceramics since 1998, allowing him to optimize fractures in reservoirs around the world by accurately predicting production under realistic conditions. He has written more than 25 technical papers, has been awarded two patents, and has conducted more than 100 seminars on fluid flow, fracture design, and practical production optimization. He is very active in SPE, serving as a technical editor and on steering committees for several SPE meetings and workshops. Mike frequently lectures at universities and presents fracturing schools to numerous companies and organizations and served as a Distinguished Lecturer for SPE.

MANAGEMENT

The EERC manages on the order of 300 contracts annually totaling 1100 clients in 51 countries and all 50 states. Best practices are provided to EERC project managers and clients in regard to fund accounting, budget reporting, contract milestone tracking, and contract services. The deliverables of this proposal will be incorporated into a contractual agreement ensuring timely delivery of milestones and fund management on a cost-reimbursable basis. The evaluation points are identified in the following project Gantt chart.

TIMETABLE



BUDGET

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)	Other Project Sponsor's Share
Total Direct Salaries	$ 30,324			$ 39,503
Total Fringes	$ 16,375			$ 18,992
Total Labor	$ 46,699			$ 58,495
Travel	$ 23,196			$ 4,635
Supplies	$ 12,311			$ 9,089
Communication	$ 50			$ 50
Printing and Duplicating	$ 250			$ 250
Food	$ 1,000			$ –
Operating Fees and Services	$ 10,244			$ 2,948
Total Direct Costs	$ 93,750			$ 75,467
Total Indirect Costs (F&A)	$ 56,250			$ 37,734
Noncash Cost Share				$ 69,231
Total Project Cost	$ 150,000			$ 182,432

A detailed budget and budget notes can be found in Appendix D.

CONFIDENTIAL INFORMATION

There is no confidential information.

PATENTS/RIGHTS TO TECHNICAL DATA

Patents or rights do not apply to this proposal.

STATUS OF ONGOING PROJECTS (IF ANY)

1. G-005-014 "Plains CO_2 Reduction Partnership Program – Phase II"; OGRP funding $500,000; Total project cost $21,487,892; Presentation completed June 26, 2007; Final report submitted December 30, 2009. Status: Project Completed.

2. G-015-030 "Plains CO_2 Reduction Partnership Program – Phase III"; OGRP funding $500,000; Total project cost $135,731,052; Status: Project ongoing. Phase III is a 10-year project running from October 1, 2007, to September 30, 2017. The activities for Phase III of the PCOR Partnership include two large-volume carbon dioxide (CO_2) storage demonstration tests. Regional characterization and outreach activities to support the demonstrations located in Fort Nelson, British Columbia, and Bell Creek, Montana, are under way.

3. G-018-036 "Bakken Water Opportunities Assessment"; OGRP funding $110,000; Total project cost $230,000; This project is part of the Northern Great Plains Water Consortium Program and is the investigation of the recycling of water flowback after Bakken fracture stimulation. Status: Project ongoing. A final report for Phase 1 was issued April of 2010, and Phase 2 activity is ongoing to test upgrading of water from a saline aquifer for potential fracturing fluid use in the Bakken.

APPENDIX A

LETTERS OF SUPPORT

EERC®
Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
15 North 23rd Street — Stop 9018 / Grand Forks, ND 58202-9018 / Phone: (701) 777-5000 Fax: 777-5181
Web Site: www.undeerc.org

October 29, 2010

Ms. Karlene Fine
Executive Director
Attn: Oil and Gas Research Program
North Dakota Industrial Commission
State Capitol – Fourteenth Floor
600 East Boulevard Avenue
Bismarck, ND 58505

Dear Ms. Fine:

Subject: Cost Share for EERC Proposal No. 2011-0085 Entitled "Investigation of Improved Conductivity and Proppant Applications in the Bakken"

The Energy & Environmental Research Center (EERC) is conducting complementary research and development efforts under a multimillion-dollar 5-year Cooperative Agreement with the U.S. Department of Energy (DOE) entitled "Joint Program on Research and Development for Fossil Energy-Related Resources." Through this joint program, nonfederal entities can team with the EERC and DOE on projects that address the goals and objectives of DOE's Office of Fossil Energy.

The proposed project to the North Dakota Industrial Commission Oil and Gas Research Council (NDIC OGRC) entitled "Investigation of Improved Conductivity and Proppant Applications in the Bakken" is a viable candidate for funding under this program. Therefore, the EERC intends to secure $113,201 in cash cost share from DOE through the cooperative agreement, and CARBO Ceramics Inc. is expected to provide $69,231 as in-kind cost share.

Once the EERC has received formal commitment from all nonfederal participating project sponsors, the EERC will submit a proposal to DOE for its concurrence. Initiation of the proposed work is contingent upon the execution of mutually negotiated agreements or modifications to existing agreements between the EERC and all participating project sponsors. If you have any questions, please contact me by phone at (701) 777-5157 or by e-mail jharju@undeerc.org.

Sincerely,

John A. Harju
Associate Director for Research

JAH/hmv

CARBO CERAMICS

October 26, 2010

Mr. Darren D. Schmidt
Senior Research Advisor
Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street
Grand Forks, ND 58202

Dear Mr. Schmidt,

Carbo Ceramics is pleased to provide in-kind cost share for the project titled “Investigation of Improved Conductivity and Proppant Applications in the Bakken”, and looks forward to contributing a valuable research project for North Dakota’s Oil and Gas Research Council. Carbo’s partnership will include project participation and validation testing relative to the lab work conducted by the Energy and Environmental Research Center. Carbo expects to provide in-kind cost share equivalent to $69,231.

Sincerely,

Bob Duenckel
Director Technical Development

CARBO Ceramics Inc.
Suite 1070
6565 MacArthur Blvd.
Irving, Texas 75039
Telephone 214 296-6900
Fax 972 401-0705

North Dakota Geological Survey

Edward C. Murphy - State Geologist

Department of Mineral Resources

Lynn D. Helms - Director

North Dakota Industrial Commission

https://www.dmr.nd.gov/ndgs/

October 28, 2010

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

Dear John,

The North Dakota Geologic Survey (NDGS) is pleased to support the Energy & Environmental Research Center's (EERC) proposed effort entitled "Investigation of Improved Conductivity and Proppant Applications in the Bakken". I understand that the project team includes the EERC and Carbo Ceramics. The NDGS recognizes the requirement for Bakken and Three Forks core and will facilitate access to and provision of those cores (on an as available basis) to enable the completion of the proposed Oil and Gas Research Council (OGRC) project.

We look forward to working closely with you and your project team in an effort toward achieving the mutually beneficial project goals related to the responsible, efficient and economically viable development of our States' natural resources.

Sincerely,

Edward C. Murphy
State Geologist

APPENDIX B

EQUIPMENT LISTING OF SELECT EERC LABORATORIES

EQUIPMENT LISTING OF SELECT EERC LABORATORIES

- Full prep lab, including slab saw, core drills, micronizing mill, and thin-section mill
- Nanovea PS 50 optical profilometer
- Forney 20+-ton universal compression frame
- Trautwein-Geotac flexible wall permeameter
- Hoek-style triaxial and core-flood cells
- Teledyne Isco high-pressure fluid pumps
- Gas porosimeter/pycnometer
- Terraplus RS125 super gamma spectrometer
- Dead weight consolidation frames
- Thermal dilatometer
- Ion chromatographer
- Distillation, saturation, and chemistry equipment

Natural Materials Analytical Research Laboratory

- 4200-square-foot laboratory facility
- JEOL 5800 scanning electron microscope with NORAN instruments energy-dispersive spectrometer (EDS) detector system, GW Electronics enhanced backscatter detector, and NORAN instruments microanalysis system
- JEOL 5800 LV with Princeton Gamma-Tech Spirit instruments EDS and microanalysis system and a HKL Technology electron backscatter diffraction system.
- QEMSCAN®
- Rigaku ZSK Primus II x-ray fluorescence system
- Bruker AXS D8 advanced x-ray diffraction system

Analytical Research Laboratory

- 4200-square-foot, fully equipped, exceedingly clean laboratory with seven fume hoods
- VG PQ ExCell inductively coupled plasma–mass spectrometer (ICP–MS) with collision cell technology
- CETAC M6000A cold-vapor atomic absorption spectrometer (CVAAS) mercury analyzer
- PS Analytical Millennium Merlin cold-vapor atomic fluorescence spectrometer (CVAFS)
- PS Analytical Millennium Excalibur hydride generation atomic fluorescence spectrometer (HGAFS)
- Varian Spectra AA-880Z graphite furnace atomic absorption spectrometer (GFAAS)
- Mitsubishi TOX-100 chlorine analyzer with oxidative hydrolysis microcoulometry
- Perkin Elmer Optima 2100 ICP–AES
- Dionex ISC3000 ion chromatograph (IC) with conductivity detection
- Dionex 2020i IC with UV–VIS, conductivity, and electrochemical detection
- CEM MDS 2100 microwave with temperature and pressure control
- Pyrohydrolysis/ion-specific electrode for fluorine analysis of fossil fuels

Agilent 1200/Applied Biosystems API 2000 triple quadrupole LC-MS system with a degasser, autosampler, column compartment, binary pump, and DAD detector. The MS has both ESI and APCI sources, with a scan range of 5–1800 m/z.

APPENDIX C

RESUMES OF KEY PERSONNEL

DARREN D. SCHMIDT
Senior Research Advisor
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) 777-5120, Fax: (701) 777-5181, E-Mail: dschmidt@undeerc.org

Principal Areas of Expertise

Mr. Schmidt's principal areas of interest and expertise include geologic CO_2 storage, enhanced gas production from coal, CO_2 enhanced oil production, associated gas utilization, distributed power systems, biomass gasification, combustion, microturbines, gas to liquids, hydrogen, emission control, fuel cells, energy efficiency, and Bakken shale research.

Qualifications

B.S., Mechanical Engineering, West Virginia University, 1994
Registered P.E.
Certified Energy Manager
Certified Green Building Engineer

Professional Experience

2008–Present: Senior Research Advisor, EERC, UND. Mr. Schmidt provides engineering, project management, and field services for oil- and gas-related projects at the EERC, which include CO_2 pilot injection and geologic storage research, enhanced gas production from coal, and Bakken shale research. Additionally, Mr. Schmidt is an advisor to distributed biomass gasification development and contributes to the organization's revenue through research proposals, publications, and intellectual property.

2006–Present: Consultant, Advanced Biomass Gasification Technologies, Grand Forks, North Dakota. Applied research in the area of biomass gasification has resulted in intellectual property for microgasification energy systems. Microgasification includes the generation of heat and electricity from biomass via gasification and firing of generators with low-Btu gas. Mr. Schmidt is the primary innovator and has sold technology rights to the EERC Foundation and Xethanol Corporation. Mr. Schmidt is working to develop the product for commercialization through a subsidiary, Advanced Biomass Gasification Technologies.

1998–2008: Research Manager, EERC, UND. Mr. Schmidt's responsibilities include securing research contracts, managing projects, and performing engineering tasks in the areas of cofiring and biomass power systems, including combustion, fluidized-bed, gasification, microturbine, and internal combustion engine generators; energy efficiency; ground-source heat pumps; hydrogen production from biomass; and researching the behavior of biomass in combustion systems relative to ash fouling and trace elements.

1994–1998: Mechanical Engineer III, Research Triangle Institute (RTI), Research Triangle Park, North Carolina. Mr. Schmidt's responsibilities included serving as project leader for a $3M

Cooperative Agreement with the U.S. Environmental Protection Agency (EPA) to demonstrate electricity production using a 1-MW wood gasification technology. The project involved engineering design, specification, purchase, fabrication, installation, and testing for a wood chip feed system; obtaining a North Carolina air quality permit; development of a computer program to interactively solve thermodynamics for drying; interaction with the EPA client, project subcontractors, and RTI project team; budget tracking and projecting; operation and testing of the power plant facility; preparing an 1-MW Waukesha engine generator set to burn low-Btu wood gas; and completion of technical reports for the EPA project monitor and for RTI management. Other activities at RTI included support of marketing activities and coauthoring publications.

Summer 1993: Internship, EERC, UND. Mr. Schmidt's responsibilities included operation of a pressurized drop-tube furnace to analyze coal ash deposition in large-scale utility boilers. Ash samples were scanned by an electron microscope, and data analysis techniques were used to characterize the coal ash. Other activities involved design and testing of an experimental coal slurry feed system for the drop-tube furnace and compiling reports on testing procedures and test results.

Summer 1992: Internship, Foster Wheeler Development Corporation, Livingston, New Jersey. Mr. Schmidt's responsibilities included a research project involving testing the first stage of a fluidized-bed coal gasification combined-cycle process. Duties included collecting and logging all process samples during a 2-week test run; analyzing data collected for all previous test runs to establish relationships between the data and the plant-operating conditions; and submitting internal reports to the supervising research professor to state conclusions.

Publications and Presentations

Has authored or coauthored numerous publications.

JORDAN M. BREMER
Research Scientist
Energy & Environmental Research Center (EERC), University of North Dakota (UND)
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018 USA
Phone (701) 777-0877, Fax (701) 777-5181, E-Mail: jbremer@undeerc.org

Principal Areas of Expertise
Mr. Bremer's principal areas of interest and expertise include mineralogy, geochemistry, engineering, drilling, CO_2 storage and utilization, lab testing, and field testing.

Qualifications
B.S. Geology, University of North Dakota, 2005.
Field Camp, South Dakota School of Mines and Technology, 2004.
Certified Geologist-in-Training (G.I.T.), ASBOG

Professional Experience
2008–Present: Research Scientist, EERC, UND. Mr. Bremer's responsibilities include research, reporting, data analysis, laboratory functions in the Applied Geology Laboratory, and modeling.

2007–2008: Staff Geologist, Interstate Drilling Services, Grand Forks, North Dakota. Mr. Bremer's responsibilities included supervising drilling operations and logging subsurface conditions, sample collection, data processing, report writing and preparation, surveying, project management, field testing, safety and compliance management, drill rig hand, Web site design, creating and updating forms, assistant mechanics and fabrication, equipment operation, and welding.

2005–2007: Staff Geologist, Geotechnical Engineering Department, CE&MT, Gillette, Wyoming. Mr. Bremer's responsibilities included supervising drilling operations and logging subsurface conditions, geotechnical and mineral resource coring and sampling, running various ASTM and AASHTO laboratory and field tests, overseeing laboratory functions, data processing, report writing, surveying, assisting with Phase 1 ESAs, construction testing, and drill rig hand.

2004–2005: Department of Geology and Geological Engineering, UND, Grand Forks, North Dakota. Mr. Bremer ran borehole climate change models, including downloading, processing, and presenting data using Microsoft Excel.

2003–2004: Teaching Assistant and Lab Instructor, Geology 101 and 203 Labs, Department of Geology and Geological Engineering, UND, Grand Forks, North Dakota. Mr. Bremer's responsibilities included administering labs and tests, answering questions, grading, and record keeping.

2003–2005: Teaching Assistant, Environmental Issues, National Parks, and Minerals, Gems, and Gold, Department of Geology and Geological Engineering, UND, Grand Forks, North Dakota. Mr. Bremer's responsibilities included grading and proofreading papers and writing lab assignments.

2004: Wetland Surveying and Research, Department of Geology and Geological Engineering, UND, Grand Forks, North Dakota. Mr. Bremer's responsibilities included surveying, data processing and analysis, mapping, and research.

Professional Memberships
American Association of Petroleum Geologists
Society of Petroleum Engineers

Publications and Presentations
Has coauthored several publications.

BLAISE A.F. MIBECK
Research Scientist
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) 777-5077, Fax: (701) 777-5181, E-Mail: bmibeck@undeerc.org

Principal Areas of Expertise

Mr. Mibeck's principal areas of interest and expertise include materials science, crystallography, spectroscopy, instrument development, and industrial physics.

Qualifications

M.S., Physics, University of North Dakota, 1999.
B.A., Physics, Lake Forest College, Lake Forest, Illinois, 1996.

Professional Experience

2003–Present: Research Scientist, EERC, UND. Mr. Mibeck's responsibilities include managing the Applied Geology Laboratory, designing experiments and novel measurement techniques, writing proposals, and reporting results. Mr. Mibeck develops test plans and procedures that use x-ray diffraction (XRD), scanning electron microscopy (SEM), and other advanced analytical techniques. He is involved with geomechanical and geochemical testing to support research in the field of geological CO_2 sequestration. He has 5 years of experience using and modifying continuous emission mercury monitors (Hg CEMs) for use in coal-fired pollution-monitoring applications. Mr. Mibeck has developed a novel source of $HgCl_2$ for evaluating Hg CEMs and has participated in numerous field-, pilot-, and bench-scale experiments. His skills include Rietveld analysis, image analysis, experimental design, electronics, and the design of scientific apparatuses.

2002–2003: Research Instrumentation Technician, EERC, UND. Mr. Mibeck's responsibilities included installing, maintaining, repairing, and operating instruments and equipment used in field-, pilot-, and bench-scale testing. He also participated in research, including assisting with test programs, adapting equipment for nonstandard applications, and developing new sampling technologies.

2001–2002: NASA Space Grant Graduate Fellowship recipient. Mr. Mibeck cooperated with the EERC on behalf of the High Altitude Balloon Group in the initial design and operation of a balloonborne mercury detection mission.

2000–2001: Graduate Research Assistant, Department of Space Studies, UND. Mr. Mibeck pursued improved methods for low-cost scientific ballooning for basic research and education; designed electronics for global positioning systems (GPSs), Geiger counter, microcontrollers, terminal node controllers (TNC), TIQIT Matchbox 486, and various digital and analog devices; and performed georectification on balloon imagery via collection and use of field GPS data and Erdas Imagine (GIS software).

1999–2000: Graduate Teaching Assistant, Department of Space Studies, UND. Mr. Mibeck maintained observatory-supporting operations of the asteroid and comet Internet telescope (ACIT).

1996–1999: Graduate Research Assistant, Department of Physics, UND. Mr. Mibeck designed, built, and tested a cryostat for performing in situ low-temperature x-ray diffraction (LTXRD); his work also determined the low-temperature structure of a thallium-based superconductor, $T1_2Ba_2CuO_{6+d}$. He regularly volunteered for education and public outreach activities as a member of the UND Society of Physics Students.

1991–1996: Laboratory Assistant, Department of Physics, Lake Forest College, Lake Forest, Illinois. During the school year, Mr. Mibeck assisted research, maintained teaching equipment, and interacted with various equipment manufacture technical support services. In the summer, he conducted independent research projects.

Licenses/Certificates
National Weather Service Skywarn Trained Observer, May 2001.
FCC Technician Class HAM Radio Operator, 1999.

Publications and Presentations
Has authored or coauthored numerous publications.

BENJAMIN W. HUFFMAN
Research Scientist
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) 777-5188, Fax: (701) 777-5181, E-Mail: bhuffman@undeerc.org

Principal Areas of Expertise

Mr. Huffman's principal areas of interest and expertise include geochemical and geomechanical test equipment, rock core sample preservation and preparation, instrumentation electronics, and well-logging techniques.

Qualifications

B.S., Geology, University of North Dakota, 2009.
A.A.S., Electronics Technology, North Dakota State College of Science, 2005

Professional Experience

March 2010–Present: Research Scientist, EERC, UND. Mr. Huffman's responsibilities include support of the work of the EERC's Applied Geology Laboratory. Tasks include conducting geomechanical and geochemical tests on geological media, cataloging samples, sample preparation, experimental design, operating and maintaining experimental apparatus for geomechanical and geochemical testing, and modifying equipment for nonstandard testing.

2009–2010: Researcher, EERC, UND. Mr. Huffman performed a full range of geomechanical and geochemical laboratory analysis and field work including devising procedures to solve complex sample preparation problems while considering the requirements of a given research project; provide skilled technical assistance in the construction of new scientific apparatus; configure, procure, install, or arrange for installation of new hardware including the construction of high pressure an electrical apparatus; identify, record, and document data for rock core, plug, and cutting samples; prepare samples for x-ray diffraction and x-ray fluorescence analysis using standard and nonstandard techniques; and participate in field trips, log core from drill sites, and identified samples based on knowledge of mineralogy and petrology of sedimentary rocks..

2008–2009: Laboratory Research Assistant, Department of Geology, UND. Mr. Huffman's responsibilities included operating and maintaining an experimental reservoir simulator, calibrating and performing troubleshooting on transducers such as thermocouples and ultrasonic acoustic sensors, and data acquisition and computer control of experimental apparatuses including knowledge of small transient signal analysis and signal processing.

September–December 2008: Teaching Assistant, Department of Geology, UND. Mr. Huffman was responsible for setup and tear down of geology laboratory training equipment, evaluating students by grading papers and providing tutoring, and maintaining the appearance of training laboratories.

JAMES A. SORENSEN
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) 777-5287, Fax: (701) 777-5181, E-Mail: jsorensen@undeerc.org

Principal Areas of Expertise

Mr. Sorensen's principal areas of interest and expertise include geologic storage of carbon dioxide, petroleum geology, subsurface transport and fate of organic and inorganic contaminants associated with the natural gas industry, research program management, technical report writing, and presentations.

Education

B.S., Geology, University of North Dakota, 1991.
Postgraduate course work in Hydrogeology, Advanced Geomorphology, Groundwater Monitoring and Remediation, Geochemistry, and Contaminant Hydrogeology, 1993–1995.

Professional Experience

1999–Present: Senior Research Manager, EERC, UND. Mr. Sorensen currently serves as manager and coprincipal investigator for several research programs, including the Plains CO_2 Reduction (PCOR) Partnership, a multiyear, multimillion-dollar program focused on developing strategies for reducing carbon dioxide emissions in nine states and four Canadian provinces. Responsibilities include supervision of research personnel, preparing and executing work plans, budget preparation and management, writing technical reports and papers, presentation of work plans and results at conferences and client meetings, interacting with clients and industrial contacts, and proposal writing and presentation.

1997–1999: Program Manager, EERC, UND. Mr. Sorensen managed projects on topics that included treatment of produced water, environmental fate of mercury and natural gas-processing chemicals, coalbed methane, and gas methane hydrates.

1993–1997: Geologist, EERC, UND. Mr. Sorensen conducted a variety of field-based hydrogeologic investigations throughout the United States and Canada. Activities were primarily focused on evaluating the subsurface transport and fate of mercury and natural gas-processing chemicals associated with natural gas production sites.

1991–1993: Research Specialist, EERC, UND. Mr. Sorensen assembled and maintained comprehensive databases related to oil and gas drilling, production, and waste management.

Professional Memberships

Society of Petroleum Engineers

Publications and Presentations
Has coauthored numerous publications.

APPENDIX D

DETAILED BUDGET AND BUDGET NOTES

INVESTIGATION OF IMPROVED CONDUCTIVITY AND PROPPANT APPLICATIONS IN THE BAKKEN
NORTH DAKOTA INDUSTRIAL COMMISSION - OIL AND GAS RESEARCH PROGRAM
PROPOSED PROJECT START DATE: 4/1/2011
EERC PROPOSAL #2011-0085

BUDGET

CATEGORY			TOTAL		NDIC - OGRC SHARE		CARBO CERAMICS SHARE		DOE JSRP SHARE	
LABOR		Rate	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost
Sorensen, J.	Project Manager	$ 62.40	80	$ 4,992	40	$ 2,496	-	$ -	40	$ 2,496
Schmidt, D.	Principal Investigator	$ 55.11	500	$ 27,555	300	$ 16,533	-	$ -	200	$ 11,022
Huffman, B.	Research Scientist/Engineer	$ 21.63	260	$ 5,624	120	$ 2,596	-	$ -	140	$ 3,028
Bremer, J.	Research Scientist/Engineer	$ 25.01	260	$ 6,503	120	$ 3,001	-	$ -	140	$ 3,502
Mibeck, B.	Research Scientist/Engineer	$ 31.49	260	$ 8,187	120	$ 3,779	-	$ -	140	$ 4,408
----------	Senior Management	$ 74.19	65	$ 4,822	-	$ -	-	$ -	65	$ 4,822
----------	Research Technicians	$ 25.94	143	$ 3,709	-	$ -	-	$ -	143	$ 3,709
----------	Undergrad-Res.	$ 10.61	400	$ 4,244	-	$ -	-	$ -	400	$ 4,244
----------	Technical Support Services	$ 21.50	70	$ 1,505	35	$ 753	-	$ -	35	$ 752
				$ 67,141		$ 29,158		$ -		$ 37,983
Escalation Above Base		4%		$ 2,686		$ 1,166		$ -		$ 1,520
TOTAL DIRECT HRS/SALARIES			2,038	$ 69,827	735	$ 30,324	-	$ -	1,303	$ 39,503
Fringe Benefits - % of Direct Labor - Staff		54%		$ 35,323		$ 16,375		$ -		$ 18,948
Fringe Benefits - % of Direct Labor - Undergrad. Research		1%		$ 44		$ -		$ -		$ 44
TOTAL FRINGE BENEFITS				$ 35,367		$ 16,375		$ -		$ 18,992
TOTAL LABOR				$ 105,194		$ 46,699		$ -		$ 58,495
OTHER DIRECT COSTS										
TRAVEL				$ 27,831		$ 23,196		$ -		$ 4,635
SUPPLIES				$ 21,400		$ 12,311		$ -		$ 9,089
COMMUNICATION - LONG DISTANCE & POSTAGE				$ 100		$ 50		$ -		$ 50
PRINTING & DUPLICATING				$ 500		$ 250		$ -		$ 250
FOOD				$ 1,000		$ 1,000		$ -		$ -
OPERATING FEES & SVCS										
Natural Materials Analytical Res. Lab.				$ 10,244		$ 10,244		$ -		$ -
Graphics Support				$ 2,948		$ -		$ -		$ 2,948
TOTAL DIRECT COST				$ 169,217		$ 93,750		$ -		$ 75,467
FACILITIES & ADMIN. RATE - % OF MTDC			VAR	$ 93,984	60%	$ 56,250	60%	$ -	50%	$ 37,734
TOTAL IN-KIND COST SHARE				$ 69,231		$ -		$ 69,231		$ -
TOTAL PROJECT COST - US DOLLARS				$ 332,432		$ 150,000		$ 69,231		$ 113,201

Due to limitations within the University's accounting system, bolded budget line items represent how the University proposes, reports and accounts for expenses. Supplementary budget information, if provided, is for proposal evaluation.

INVESTIGATION OF IMPROVED CONDUCTIVITY AND PROPPANT APPLICATIONS IN THE BAKKEN
EERC PROPOSAL #2011-0085

BUDGET - TRAVEL

RATES USED TO CALCULATE ESTIMATED TRAVEL EXPENSES

DESTINATION	AIRFARE	LODGING	MEALS	CAR RENTAL	REGIST.
Unspecified Destination (USA)	$ 900	$ 200	$ 71	$ 85	$ 575
Denver, CO	$ 775	$ 225	$ 66	$ 85	$ -

PURPOSE/DESTINATION	NUMBER OF TRIPS	NUMBER OF PEOPLE	NUMBER OF DAYS	AIRFARE	LODGING	MEALS	CAR RENTAL	MISC.	REGIST.	TOTAL
Conference Presentations/Unspecified Dest. (USA)	3	2	4	$ 5,400	$ 3,600	$ 1,704	$ 1,020	$ 480	$ 3,450	$ 15,654
Project Meetings/Denver, CO	3	2	2	$ 4,650	$ 1,350	$ 792	$ 510	$ 240	$ -	$ 7,542
Project Meeting/Denver, CO	1	2	5	$ 1,550	$ 1,800	$ 660	$ 425	$ 200	$ -	$ 4,635
TOTAL ESTIMATED TRAVEL										$ 27,831

INVESTIGATION OF IMPROVED CONDUCTIVITY AND PROPPANT APPLICATIONS IN THE BAKKEN
EERC PROPOSAL #2011-0085

DETAILED BUDGET - EERC RECHARGE CENTERS

			TOTAL
Natural Materials Analytical Res. Lab.	Rate	#	$Cost
QEMSCAN	$497	10	$ 4,970
QEMSCAN - S.I.P.	$116	10	$ 1,160
XRD	$211	10	$ 2,110
XRFA	$161	10	$ 1,610
Subtotal			$ 9,850
Escalation		4%	$ 394
Total Natural Materials Analytical Res. Lab.			$ 10,244

Graphics Support	Rate	#	$Cost
Graphics (hourly)	$63	45	$ 2,835
Subtotal			$ 2,835
Escalation		4%	$ 113
Total Graphics Support			$ 2,948

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

BACKGROUND

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC receives no appropriated funding from the state of North Dakota and 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

If federal funding is proposed as part of this project, the applicable federal intellectual property (IP) regulations may govern any resulting research agreement. In addition, in the event that IP with the potential to generate revenue to which the EERC is entitled is developed under this agreement, 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.) is for planning purposes only. The project manager may, as dictated by the needs of the work, incur costs in accordance with Office of Management and Budget (OMB) Circular A-21 found at www.whitehouse.gov/omb/circulars. If the Scope of Work (by task, if applicable) encompasses research activities which may be funded by one or more sponsors, then allowable project costs may be allocated at the Scope of Work or task level, as appropriate, to any or all of the funding sources. Financial reporting will be at the total-agreement level.

Escalation of labor and EERC recharge center rates is incorporated into the budget when a project's duration extends beyond the current fiscal year. 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.

Salaries: The EERC employs administrative staff to provide required services for various direct and indirect support functions. Salary estimates are based on the scope of work and prior experience on projects of similar scope. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the current average rate of a personnel group with a similar job description. Salary costs incurred are based on direct hourly effort on the project. Faculty who work on this project will be paid an amount over their normal base salary, creating an overload which is subject to limitation in accordance with university policy. Costs for general support services such as contracts and intellectual property, accounting, human resources, purchasing, shipping/receiving, and clerical support of these functions are included in the EERC facilities and administrative cost rate.

Fringe Benefits: Fringe benefits consist of two components which are budgeted as a percentage 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.

Travel: Travel is estimated on the basis of UND travel policies which can be found at www.und.edu/dept/accounts/policiesandprocedures.html. Estimates include General Services Administration (GSA) daily meal rates. Travel may include site visits, field work, meetings, and conference participation as indicated by the scope of work and/or budget.

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 – Professional, Information Technology, and Miscellaneous: Supply and material estimates are based on prior experience and may include chemicals, gases, glassware, nuts, bolts, and piping. Computer supplies may include data storage, paper, memory, software, and toner cartridges. Maps, sample containers, minor equipment (value less than $5000), signage, and safety supplies may be necessary as well as other organizational materials such as subscriptions, books, and reference materials. General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are included in the facilities and administrative cost.

Subcontracts/Subrecipients: Not applicable.

Professional Fees/Services (consultants): Not applicable.

Other Direct Costs

Communications and Postage: Telephone, cell phone, and fax line charges are generally included in the facilities and administrative cost. Direct project costs may include line charges at remote locations, long-distance telephone, postage, and other data or document transportation costs.

Printing and Duplicating: Photocopy estimates are based on prior experience with similar projects. Page rates for various photocopiers are established annually by the university's duplicating center.

Food: Food expenditures for project meetings, workshops, and conferences where the primary purpose is dissemination of technical information may include costs of food, some of which may exceed the institutional limit.

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 development and execution of the project by the research team.

Fees and Services – EERC Recharge Centers, Outside Labs, Freight: EERC recharge center rates for laboratory, analytical, graphics, and shop/operation fees are established and approved at the beginning of the university's fiscal year.

Laboratory and analytical fees are charged on a per sample, hourly, or daily rate, depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the university when necessary.

Graphics fees are based on an established per hour rate for production of such items as report figures, posters, and/or PowerPoint images for presentations, maps, schematics, Web site design, professional brochures, and photographs.

Shop and operation fees are for expenses directly associated with the operation of the pilot plant facility. These fees cover such items as training, personal safety (protective eyeglasses, boots, gloves), and physicals for pilot plant and shop personnel.

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

Facilities and Administrative Cost: Facilities and administrative (F&A) 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 one year, as well as subawards in excess of the first $25,000 for each award. The F&A rate for commercial sponsors is 60%. This rate is based on costs that are not included in the federally approved rate, such as administrative costs that exceed the 26% federal cap and depreciation/use allowance on buildings and equipment purchased with federal dollars.