PROGRAM TO DETERMINE THE UNIQUENESS OF THREE FORKS BENCH RESERVES, DETERMINE OPTIMAL WELL DENSITY IN THE BAKKEN POOL, AND OPTIMIZE BAKKEN PRODUCTION (BAKKEN PRODUCTION OPTIMIZATION PROGRAM)

QUARTERLY PROGRESS REPORT
APRIL – JUNE 2014

BACKGROUND

The goal of the Bakken Production Optimization Program (BPOP) being conducted by the Energy & Environmental Research Center (EERC) in close coordination with Continental Resources, Inc. (Continental) and several of the Williston Basin's other premier operating companies is to simultaneously improve Bakken system oil recovery while reducing its environmental footprint. The program is investigating new technologies and approaches to simultaneously increase the understanding of potential petroleum reserves in the Bakken–Three Forks system and decrease recovery costs in an environmentally sound manner.

The anticipated outcomes of BPOP are to 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) 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 for the state, royalty owners, and operators from added product streams captured earlier in the well life cycle.

The following quarterly report summarizes the program activities from April through June 2014.

ACCOMPLISHMENTS DURING REPORTING PERIOD

Phase I – Drilling Wells in the Hawkinson Unit Located in Sec. 22 and 27, 147N-96W

- Weatherford, the vendor completing the core analysis on the Hawkinson 14-22H2, provided a core report (a copy of the report can be accessed on the partners-only Web site at www.undeerc.org/Bakken/Optimization/. If you need assistance with logging in, please contact Rhonda Shirek at (701) 777-5122.

Phase II – Completion Operations of Eleven (11) New Wells

- Vertical seismic profile (VSP) analysis, defining zero-phase waveform, was implemented into the 3-D seismic processing flow. Schlumberger is still working on

final microseismic data interpretation reports. Progress continues beyond the final processing reports. Three treatment wells (#9, 11 and 13) of the Hawkinson microseismic dataset have been sent to ESG. The advanced processing project was initiated, during the 2nd quarter of 2014, implementing raw field records.

Phase III – Reservoir Engineering

- Calibrated fracture modeling grid with core results from Hawkinson 14-22H.
  - Openhole log-derived mechanical properties were calibrated with triaxial test data to model calculated stresses.
  - Incorporated petrophysical derived properties and calculated lithology.
- Hydraulic fracture modeling focused on Well 5-22H.
  - Initial conditions (Initial pore pressure) case modeled.
  - Infill date conditions modeling underway.
- Chemical tracer samples taken in April 2014 did not reveal changes to the original analysis
- A second round of pulse tests was executed in April 2014. Results are being analyzed.
- Work began on setting up the geologic model for simulation. Geologic setup using average layer values from the pilot holes is nearly complete.
- Reservoir modeling is continuing with the finite difference model. Additional simulation work is being performed using a nonorthogonal grid model.
- PTA analysis was performed on Well 1-22H.
- Production analysis was performed on Well 1-22H.
- Numerical multilayer production analysis was initiated on Well 1-27H.

Phase IV – Expansion Applications via 3-D Seismic

- Final PSTM (Preliminary PreStack Migration), having a severe low-frequency static corrected with the best refraction static solution, was accepted and is presently being evaluated.

Phase V – Optimization of Wellsite Operations

Hydrocarbon Utilization (EERC Task 1)

- North Dakota Petroleum Council (NDPC) Flaring Task Force/database development.
  - The EERC continued to work with companies that have technology and services capable of utilizing associated gas upstream of traditional gas-gathering and processing infrastructure and gathered information describing their remote capture offerings. To date, 41 companies have provided company and technical information to the database.
    - Companies with remote capture technology can submit information to the database at www.undeerc.org/Flaring_Solutions/.
    - Companies looking for more information about remote capture technologies can view all of the information contained in the database at www.undeerc.org/Flaring_Solutions/Search.aspx.
  - The EERC has continued to review technical data provided by vendors and is supporting vendors' ongoing efforts to develop offerings that address the challenges leading to gas flaring.
  - The EERC has continued to work with producers and vendors to identify opportunities for demonstration projects that have the potential to improve gas utilization and reduce the risk of implementing new technologies and strategies. Work continues to assess the relative impact individual technologies can have on gas use, thereby decreasing the fraction of flared gas in North Dakota.
  - In addition to the development and maintenance of the Flaring Solutions Database, the following activities were conducted to support the NDPC Flaring Task Force:
    - Flaring statistics were reviewed and analyzed to identify those opportunities with the greatest potential to benefit from deployment of remote capture. Figures and charts were updated to illustrate the nature of gas flaring in North Dakota based on rate of gas flared, quantity of flares, and geographical distribution across the Bakken.
    - On April 22, 2014, EERC personnel traveled to Bismarck, North Dakota, to attend the North Dakota Industrial Commission (NDIC) hearing to discuss possible field rules related to flare reduction.
    - On April 24, 2014, EERC personnel met with Hess Corporation (Hess) staff to discuss start-up of the newly expanded Hess gas-processing plant.

- On April 24, 2014, EERC personnel presented at the Society of Petroleum Engineers meeting in Minot, North Dakota, to provide an update on activities related to flare gas reduction and opportunities for remote capture.

- A PowerPoint presentation describing the EERC's work supporting the Flaring Task Force was prepared and presented at the Williston Basin Petroleum Conference in Bismarck, North Dakota, May 20, 2014. The presentation described opportunities for remote capture, highlighted possible impact to gas utilization, and reported on the program's overall progress. A copy of this presentation can be found at www.ndoil.org/?id=279&page=2014+WBPC+Presentations.

- Chad Wocken attended the Governor's Pipeline Summit in Bismarck, North Dakota, June, 24, 2014. The purpose of the summit was to discuss the impact of pipelines on transportation of both crude oil and associated gas within the state and interstate. The delay in installing gas-gathering pipeline has been identified by the Flaring Task Force as the biggest factor leading to flaring of associated gas in North Dakota, and efforts are ongoing to improve the pace of pipeline installation, including improved outreach to landowners and an investigation into winter installation of pipeline.

- The EERC's laboratory study evaluating the potential for utilizing rich Bakken gas for enhanced oil recovery (EOR) in the Bakken made the following progress:

  – Previous work with CO_2 in high-pressure view cells showed preferential mobilization of light hydrocarbons into an upper CO_2 phase. To investigate this effect with methane, oil hydrocarbons mobilized into the methane (upper phase) during crude oil exposure (lower phase) were sampled at pressure and analyzed using gas chromatography with flame ionization detection (GC/FID). As was the case for CO_2-mobilized oil, the oil components mobilized into the methane (upper) phase were concentrated with respect to lower-molecular-weight hydrocarbons when compared to the bulk crude oil. However, the selectivity for lower-molecular-weight hydrocarbons in methane-mobilized oil was stronger than that observed with CO_2.

  – A hypothesized thermal desorption mechanism for the unexpectedly high oil recoveries obtained from Bakken rocks using methane and methane/ethane was investigated by extracting Middle Bakken rock sample at the same conditions, except using pure nitrogen. While nitrogen did extract some of the lower-molecular-weight hydrocarbons, the recovery was much lower than that achieved with methane and methane/ethane, and only the most volatile hydrocarbons showed significant recoveries. These results show that thermal desorption is a minor mechanism for recovering oil from the Bakken reservoir using associated gas.

  – Laboratory activities were completed as of July 1, 2014.

– A portion of Steve Hawthorne's presentation entitled "Laboratory Comparisons of CO_2 and Rich Gas Injection on Oil Recovery from Bakken Reservoir Rock and Shales" at the 2014 Williston Basin Petroleum Conference, May 2014, focused on the use of rich gas for EOR. A copy of the presentation can be found at www.ndoil.org/?id=279&page=2014+WBPC+Presentations.

Waste Management (EERC Task 2)

- Distribution of the EERC-produced naturally occurring radioactive material (NORM) fact sheets continued. Numerous copies were distributed at the Williston Basin Petroleum Conference in Bismarck, North Dakota, in May. Many more have been individually sent to specific parties who have requested information on NORM waste associated with oil production.

- A public education campaign was kicked off with multiple media interviews involving EERC staff with expertise in NORM waste science. Media included daily newspapers throughout North Dakota, regional print media running stories on oilfield issues, topical Internet blogs, and local and regional radio interviews. EERC experts also authored a feature article on NORM waste science in every major daily newspaper in North Dakota.

- EERC experts testified before the North Dakota Legislature's Energy Development and Transmission Interim Committee on the topic of program activities with a focus on NORM waste issues and flaring mitigation issues.

- The EERC coordinated a NORM-sampling effort among several oil producers of the NDPC NORM Task Force. The EERC also supported the Task Force in interpretation of the results. The results of the NORM analysis of 50 discrete samples of drill cuttings, produced water, and fracture flowback water will be shared with the North Dakota Department of Health (NDDH).

Water Management (EERC Task 3)

- A scope of work was compiled to conduct an updated assessment of Bakken water management practices. This effort will focus on updating the information in a 2009 report that summarized the water needs and quality requirements for hydraulic fracturing; volumes and quality of water recovered following fracturing; recycling and reuse options; special handling considerations; and costs for water acquisition, disposal, and transport.

Site Logistics (EERC Task 4)

No activities were conducted under the site logistics area during this quarter.

Process Optimization and System Failure Analysis (EERC Task 5)

- Literature was reviewed and information compiled on current hydrocarbon remediation practices of surface spills for use in developing a fact sheet for public distribution.

Waste Minimization and Utilization (EERC Task 6)

- EERC staff accompanied North Dakota's chief state regulator responsible for mineral resources, representatives of several of the state's largest oil producers, and NDPC leadership to Texas for a tour of advanced drill cuttings-processing facilities and Halliburton's research and development laboratories and field operations sites. The goal of this trip was to acquire information regarding best practices from other operators in similar shale plays.

Spill Remediation (EERC Task 7) and Land Reclamation (EERC Task 8)

- The EERC met several times with project partners from North Dakota State University (NDSU) Range Science and Soil Science to set priorities for project activities and to formulate the first set of deliverables – two fact sheets for public education on the topics of spill remediation and land reclamation. The drafts of these fact sheets were begun during this reporting period and will be released to the public during the early portion of the following reporting period.

- NDSU Range Science experts produced a draft of a more detailed circular entitled "Successful Reclamation of Lands Disturbed by Oil and Gas Development and Infrastructure Construction." This document will provide a basis for a best management practices guideline to be produced within this program later this summer and fall.

- The EERC is in discussions with program industrial partners on projects to demonstrate reuse and improved disposal of drill cuttings.

- In June, EERC staff attended a one-day workshop in Williston, North Dakota, entitled "Remediation and Restoration of Hydrocarbon and Brine Contaminated Soils." The stated goals for the workshop were to a) be able to manage a soil remediation project; b) if a contractor is used, be able to tell when the contractor knows what he or she is doing, and c) be able to evaluate vendor claims for soil remediation products. Attendees were provided a thorough education behind the science and engineering of bioremediation of hydrocarbon and brine spills from first response to corrective actions to postremediation monitoring. Attendees also received a large resource document in both hard copy and electronic versions. The workshop was attended by an estimated 70 people, most of whom were from exploration and production (E&P) companies.

Program Management and Development

- In the previous quarter, a proposal was submitted in response to a U.S. Department of Energy (DOE) Funding Opportunity Announcement (FOA) (DE-FOA-0001037 –

Research for Safe and Permanent Geologic Storage of CO_2) in which BPOP agreed to participate through the provision of up to $145,000 of cash cofunding. The proposal goal of improved characterization and modeling of fracture networks and fluid flow in the Bakken and its relevance to better understanding mechanisms that may enhance resource recovery are consistent with the greater programmatic goals of the optimization program. Unfortunately, this quarter, the EERC received notification that this proposal was not selected for award.

- A proposal was prepared for submission in early July 2014 in response to a DOA FOA (DE-FOA-0001110 – Opportunities, Knowledge Advancements, and Technology Improvements for Increased Carbon Dioxide [CO_2] Storage in Enhanced Oil Recovery [EOR] Operations) in which BPOP would potentially participate through the provision of up to $500,000 of cash cofunding. The proposal goal to better assess and validate CO_2 transport and fluid flow in fractured tight oil reservoirs of the Bakken, is consistent with the greater programmatic goals of BPOP.

- A team of Hitachi Data Systems (Hitachi) personnel visited the EERC in April 2014 to discuss "big data" management technologies and approaches and to evaluate potential complementary Hitachi–EERC efforts with respect to BPOP. One such complementary effort was completed in this quarter, the submission of a proposal entitled "Associated Gas Capture and Injection for Improved Oil Recovery and Reduced Flaring for the Bakken Petroleum System" in response to a DOE FOA entitled "Environmentally Prudent Unconventional Resource Development" (DE-FOA-0001076). No financial resources were committed from BPOP, although another program member pledged in-kind resources to the project, if awarded, while Hitachi would provide cutting-edge hardware and software for the proposed effort.

- General BPOP presentations were provided to the North Dakota Legislature's Interim Committee on Energy Development and Transmission (Minot) and the EmPower Commission (Bismarck) in early April.

- John Harju delivered a presentation on behalf of Stan Wilson (Continental) at the Williston Basin Petroleum Conference that was held in Bismarck, North Dakota, May 20–22, 2014. The presentation, entitled "Continental's Multiple Bench Development," focused on Continental's basinwide multibench efforts, but also introduced BPOP in a more general sense. A copy of the presentation can be found at www.ndoil.org/?id=279&page=2014+WBPC+Presentations.

MEMBERSHIP AND FINANCIAL INFORMATION

This program is being sponsored by the NDIC Oil and Gas Research Council, Continental, and a consortium of Bakken producers and service companies. Table 1 presents the current budget for this program. Continental's expected in-kind contribution over the project duration is $106,000,000. The anticipated contribution from other industry sponsors is $850,000 a year for a total of $2,550,000. To date, Whiting Petroleum Corporation, Marathon Oil Company, Nuverra

Environmental Solutions, SM Energy Company, ConocoPhillips, Oasis Petroleum, XTO Energy, and Hess have provided payments for Year 1 totaling $725,000. Invoices have been requested by and provided to Petro-Hunt and Hitachi, totaling $125,000 of potential additional funding for Year 1. It is expected that equal payments will be provided by the industry partners in subsequent years. During this quarter the EERC received Year 2 payment from Whiting Petroleum Corporation and Hess. Invoices for Year 2 payment will be sent to the rest of the members shortly. The EERC will also continue to seek broader industry participation.

Expenses to date by funding source are listed in Table 2.

Table 1. BPOP – Expected Budget

Sponsors	Y1	Y2	Y3	Total
NDIC Share – Cash*	$3,137,350	$3,137,350	$2,208,625	$8,554,500
Industry Share – Cash (confirmed participation)	$725,000	$725,000	$725,000	$2,175,000
Industry Share – Cash (Year 1 payment pending)	$125,000	$125,000	$125,000	$375,000
Continental Share – In-Kind	$40,989,233	$40,989,233	$24,051,534	$106,030,000
Total	**$44,976,583**	**$45,047,758**	**$27,110,159**	**$117,134,500**

*Includes $6.26M subcontract to Continental.

Table 2. BPOP – Expenses to Date

	Funding Source		
	NDIC	Industry	Total
EERC	$595,827	$336,858	$932,685
Continental – Subcontract*	$2,420,000		$2,420,000
Continental – In-Kind**		$96,177,392	$96,177,392
Total	**$3,015,827**	**$96,514,250**	**$99,530,077**

* Invoiced to the EERC.
** Reported to the EERC.

FUTURE ACTIVITIES

The planned activities for the next quarter include the following:

- The North Dakota Legislature's Interim Committee on Energy Development and Transmission has scheduled a meeting at the EERC for October 2014. A BPOP presentation will be provided.

- A BPOP membership meeting will be held at the EERC, August 19, 2014. More details will be announced soon.

- Continue working with vendors to identify opportunities to deploy technology and/or services that match the needs of producers in their efforts to improve gas capture and utilization.

- Continue working with industry partners and vendors to identify opportunities to conduct demonstration projects that allow stakeholders the ability to evaluate technologies capable of improving gas use.

- Monitor progress on new rules and regulations intended to reduce gas flaring in North Dakota, and continue to assess how changes in rules impact the technical and economic viability of remote capture use.

- Additional curve-fitting modeling will be performed during the next quarter on the methane and methane/ethane oil extraction profiles from the Upper, Lower, and Middle Bakken rocks.

- Continue working with program partners to identify opportunities to deploy technology and/or services to improve waste disposal practices and drill cuttings recycling.

- Continue to consult with partners on NORM waste management strategies via the NDPC NORM Task Force. Provide input as the Task Force formulates a complementary approach to NDDH's ongoing NORM study.

- Continue to consult with partners on near-term industry needs regarding current deficiencies in spill remediation and land reclamation methodologies.

- Release fact sheets on spill remediation and land reclamation for public education efforts.

- Continue to consult with partners on demonstration of advanced spill remediation and land reclamation methodologies.

- Work will commence on the updated assessment of Bakken water management practices.

- The EERC's proposal entitled "Opportunities, Knowledge Advancements, and Technology Improvements for Increased Carbon Dioxide (CO_2) Storage in Enhanced Oil Recovery (EOR) Operations" in which BPOP would potentially participate through the provision of up to $500,000 of cash cofounding will be submitted to DOE.

- Continental will continue to perform fracture modeling of completion operations for existing producers as well as recent completions.