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January 15, 2019

Ms. Karlene Fine
Executive Director
North Dakota Industrial Commission
600 East Boulevard Avenue, Department 405
State Capitol, 14th Floor
Bismarck, ND 58505-0840

Dear Ms. Fine:

Subject: Quarterly Progress Report for the Period of October 1 – December 31, 2018, "Bakken Production Optimization Program 2.0"; Contract No. G-040-080; EERC Fund 22010

Attached please find the Energy & Environmental Research Center (EERC) Quarterly Progress Report for the subject project. If you have any questions, please contact me by phone at (701) 777-5355 or by e-mail at cgorecki@undeerc.org.

Sincerely,

for

Charles D. Gorecki
Director of Subsurface R&D

CDG/kal

Attachment

BAKKEN PRODUCTION OPTIMIZATION PROGRAM

Quarterly Progress Report

(for the period October 1 – December 31, 2018)

Prepared for:

North Dakota Industrial Commission

Partners of the Bakken Production Optimization Program (BPOP) Consortium
ConocoPhillips
Equinor
Hess Corporation
Liberty Resources LLC
Marathon Oil Company
Oasis Petroleum
Petro-Hunt, LLC
WPX Energy
XTO Energy, Inc.

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January 2019

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BAKKEN PRODUCTION OPTIMIZATION PROGRAM

EXECUTIVE SUMMARY

The Bakken Production Optimization Program (BPOP) was established to facilitate Bakken petroleum system oil recovery while simultaneously reducing the environmental footprint of oil and gas development. This program is administered by the Energy & Environmental Research Center (EERC) with funding from the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP) and the North Dakota petroleum industry. Through BPOP, the EERC is working closely with a consortium of industry partners and the State to address emerging opportunities and challenges related to Bakken development. As of December 31, 2018, nine partner companies support BPOP. This progress report presents an overview of BPOP activities from October 1 through December 31, 2018.

The major research focus areas of the program over the last quarter have included the following:

- Ongoing collaboration with Liberty Resources (Liberty) to evaluate rich gas enhanced oil recovery (EOR) in the Stomping Horse Oil Factory complex in Williams County.

- Various research efforts to address surface-related issues, including environmental support and produced fluids characterization to support ongoing BPOP activities and to gain a better understanding of geographic and temporal variations in produced oil, water and gas.

- Continuation of the development of simplistic spreadsheet-based models that allow the user to estimate the radius of influence of individual saltwater disposal wells based on basic geologic characteristics (cumulative sand thickness, average porosity, and average permeability), injection rate, and period of performance.

- Continuation of analysis of aromatic hydrocarbon to aliphatic hydrocarbon ratios of produced crude oil samples.

BPOP activities in support of the rich gas EOR pilot were largely focused on field-based activities at the Leon–Gohrick drill spacing unit (DSU) in the Stomping Horse complex in Williams County, North Dakota. Initial small-scale injection tests using two gas lift compressors were conducted in the Leon 3TFH and Leon 2MBH over the summer of 2018. Data from the small-scale tests showed that a total of 24.6 MMscf of rich gas was injected into the two wells, at a maximum rate of 1.14 MMscfd and maximum wellhead pressure of 1400 psi. In this past quarter, a compressor capable of achieving wellhead pressures >4000 psi was installed at the Leon–Gohrick pad and large-scale injection testing was initiated into the Gohrick 5MBH well on November 20, 2018, and ceased on December 23, 2018. A gas tracer study was also begun shortly after the start of injection with gas samples being collected and analyzed periodically from several offset wells in the DSU. The Gohrick 5MBH will be brought back onto production

in January 2019 after a relatively short soak period. It is anticipated that injection into the Gohrick 4MBH well will be initiated in mid-January 2019 and continue for up to 30 days. A gas, oil, and water tracer study will also be conducted during the Gohrick 4MBH injection period.

Feedback was incorporated into finalized deliverables from the facility process modeling task that addresses the issue of weather-induced changes to crude oil vapor pressure. A short technical brief and accompanying set of presentation slides were provided to BPOP partners and will be available to the public in April 2020.

Final topical reports for two efforts completed previously, the refracturing optimization and the reservoir performance modeling, were made available to partners for review. Following any changes based on partner review, these reports will be available to all partners for a 15-month period before being made publicly available.

Work began on a BPOP Web site upgrade to update the program information and to serve as a program marketing tool. Several internal meetings were held to discuss the design of the BPOP public Web site and the BPOP partners-only Web site.

Year 3 activities were determined based on partner input. Research will be focused on improved oil recovery, subsurface, and surface activities. Activities will be initiated next quarter.

Anticipated activities over the next quarter include ongoing collaboration with Liberty on the rich gas EOR pilot. The data generated from the initial injection tests and the large-scale injection conducted in December 2018 will continue to be evaluated. The lessons learned from the December 2018 injection tests will be used to guide the operation of injection into the second well. A draft white paper on the findings from the surface facility modeling of the Stomping Horse complex is also expected to be developed during the next quarter. Data collection and sample acquisition within the produced fluid characterization task is expected to continue, with results supporting the ongoing compositional evaluations of each fluid and supporting the temporal evaluations and enhancing the size and usefulness of the database to the various BPOP research efforts. Activities will conclude on testing of the spreadsheet-based models in the water injection reservoir assessment task. The EERC will work with the BPOP partners to obtain input on the spreadsheet model and the assumptions therein. EERC researchers will prepare background information regarding recent issues that may affect Bakken facility operations.

BAKKEN PRODUCTION OPTIMIZATION PROGRAM

INTRODUCTION

The Bakken Production Optimization Program (BPOP) was established to facilitate Bakken petroleum system oil recovery while simultaneously reducing the environmental footprint of oil and gas development. This program is administered by the Energy & Environmental Research Center (EERC) with funding from the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP) and the North Dakota petroleum industry. Through BPOP, the EERC is working closely with a consortium of industry partners and the State to address emerging opportunities and challenges related to the Bakken development.

The goals of BPOP are to:

- Develop knowledge that will enhance overall production efficiency, recognizing that improved coordination among various design factors (reservoir management, well design, surface processing, gas management, waste management) can lead to significant improvements in resource recovery efficiency while reducing potential health, safety, and environment impacts.

- Conduct applied research in topic areas that positively impact the efficiency of production and reduce the environmental footprint of operations.

- Advise industry and state entities on scientific aspects of exploration and production activities, especially as they pertain to economic and environmental impacts.

- Facilitate collaboration on issues that may not otherwise receive collaborative attention from industry and/or the state of North Dakota.

The anticipated ongoing outputs of BPOP are 1) increased well productivity and economic output of the Bakken petroleum system, 2) decreased environmental impacts of wellsite operations, and 3) reduced demand for infrastructure construction and maintenance. Specific results will include improved resource recovery efficiency, reduced land use impacts, increased royalties and tax revenue from harnessed associated gas and natural gas liquid streams, and increased revenue from added product streams captured earlier in the well life cycle.

ACCOMPLISHMENTS DURING REPORTING PERIOD

Enhanced Oil Recovery Task

The goal of the BPOP Enhanced Oil Recovery (EOR) Task is to develop knowledge that will support broad commercial implementation of EOR in the Bakken play. To achieve that goal,

the EERC is conducting laboratory-, modeling-, and field-based investigative activities to examine the effectiveness of using rich gas for EOR. The centerpiece of this task is the rich gas EOR pilot being conducted by Liberty Resources (Liberty) at its Stomping Horse complex in Williams County, North Dakota. The NDIC is providing $1,527,234 and the U.S. Department of Energy (DOE) has committed $2,000,000 to support EERC activities related to the Stomping Horse pilot. This past quarter, DOE also committed an additional $1,000,000 toward laboratory-based investigations of the role that the organic-rich shales will play in rich gas-based Bakken EOR, especially with respect to gas utilization rates. The goals of the work to be conducted under this task include the following:

- Determine the effectiveness of cyclic multiwell huff 'n' puff as an injection/production scheme that can maintain conformance of the working fluid within the reservoir.

- Determine the ability of various rich gas mixtures (methane, ethane, and propane) to mobilize oil in Bakken petroleum system reservoir rocks and shales.

- Determine changes in gas and fluid compositions over time in both the reservoir and surface infrastructure environments, and assess how those changes affect reservoir and process facility performance.

- Optimize future commercial-scale tight oil EOR design and operations via iterative modeling of surface infrastructure and reservoir performance using data generated by the field- and laboratory-based activities.

- Establish the effectiveness of selected monitoring techniques as a means of reservoir surveillance and injection conformance monitoring in the Bakken petroleum system.

- Determine the sorptive capacity of Bakken shales for rich gas components and the effects of sorption in the shales on gas utilization rates in samples representing areas of low, medium, and high thermal maturity.

Specific activities conducted under this task during the past quarter include the following:

- A compressor capable of achieving wellhead pressures >4000 psi was installed at the Leon–Gohrick pad. Large-scale injection testing was initiated into the Gohrick 5MBH well on November 20, 2018, and ceased on December 23, 2018. A gas tracer study was also begun shortly after the start of injection. Gas samples were collected and analyzed periodically from several offset wells in the drill spacing unit (DSU) to determine the timing and location of gas breakthrough.

- Modeling and dynamic simulation activities provide technical support and guidance to the design of the pilot injection/production scheme. History-matching exercises, using the previously developed static geomodel, detailed historical operational data, and data from the summer injection testing provided by the project partner were conducted.

- Efforts to conduct laboratory-based experiments to determine the permeability and sorption behavior of rich gas components in Bakken shale continued. A high-pressure magnetic balance and specialized centrifuge purchased for use in these investigations were delivered to the EERC in December 2018.

- Experiments focused on determining the effect of pressure on the ability of the mixed C1/C2/C3 produced gas to mobilize crude oil hydrocarbons into the "miscible" phase were conducted. The effects of pressure were examined both in terms of the mass of oil mobilized and the molecular weight selectivity shown by the different pressures.

- A WebEx was held November 13, 2018, to update BPOP partners on the rich gas–oil fluid behavior and rock extraction studies. The presentation was uploaded to the BPOP partners-only Web site.

- Biweekly conference calls with DOE were held to provide updates on the status and progress of the various aspects of the project.

- Biweekly conference calls were held with staff from Liberty to discuss progress on the various aspects of the project.

Refracturing Optimization Task

The refracturing optimization study was conducted to 1) analyze production performance of wells that have been refractured (or restimulated) in the Bakken Formation, 2) investigate the economics of well refracturing, and 3) evaluate the overall potential for Bakken-wide refracturing operations. Several metrics were used to evaluate refracturing performance, including changes in peak oil rate, uplift in oil production rate following refracturing, decrease in gas–oil ratio (GOR), and low, middle and high incremental estimated ultimate recoveries (EURs). The economic analysis focused on discounted net oil revenue, defined as the oil revenue after deducting royalties, state tax, and refracturing costs, assuming an annual discount rate. The discounted net oil revenue was investigated using Monte Carlo simulation with different combinations of oil price, refracturing cost, and the low, middle, and high incremental annual oil production from the refracturing production analysis.

The final report entitled "Bakken Refracturing Data Analysis" was added to the partners-only Web site for review by BPOP partners. Any review comments received by January 31, 2019, will be considered for modification to the report, after which the report will be available to the entire BPOP partnership for a 15-month period before the report is fully public.

Produced Fluid Characterization Task

The produced fluids characterization task was established for the purpose of compiling physical and chemical property data pertaining to Bakken Formation fluids, including crude, produced water, and associated gas. The goal of this task was to develop and maintain a robust database of Bakken-related fluids data, and facilitate data and sample acquisition and analyses to support the many ongoing BPOP activities conducting basin-specific research of interest to

industry and the state of North Dakota. The objectives of this task include thorough review and compilation of relevant publicly available data, establishing industry partnerships to enable acquisition of nonpublic information and potential access for sample acquisition, conducting sampling and analysis efforts to support project needs, and performing a review of relevant information to identify specific data needs.

Key accomplishments for this quarter include continued collaboration with key industry partners to obtain access to fluids sample collection and acquisition of existing compositional data to support the ongoing research efforts of individual BPOP program tasks. Sampling and analysis activities have also continued, supporting an increased geographical distribution of data and providing a temporal evaluation of compositional changes throughout a well's production life. Specific activities conducted this quarter include the following:

- Continued crude, water, and gas sampling and analysis activities at two locations in the northern and southern portions of the Bakken play in North Dakota.

- Continued sampling and analysis activities on fluid samples from two adjacent producing Bakken wells (one stimulated and one nonstimulated) for the purpose of evaluating compositional differences that may indicate possible fluid migration pathways.

- Continued conducting additional sample collection and analysis on four separate wells for the purpose of a temporal evaluation of compositional changes throughout the production life of newly established wells.

- Supported an industry partner through the collection and analysis of fluid samples to evaluate the performance and effects of an ongoing EOR project.

- Reviewed and refined collected data/information for inclusion in the previously developed database and to identify specific data gaps/needs.

Reservoir Performance Modeling Task

There has been a trend of increasing initial oil production rates over time, which is related, at least in part, to advances in technology and improvements in engineering practice over time. However, some older wells outperform younger wells despite the technology improvements, which suggests that geology or other factors have a greater impact on long-term oil production than the engineering practices of drilling and hydraulic fracturing. This study employed multivariate statistical analysis to evaluate the factors that influence well production performance in the Bakken. The database compiled for this work includes 400 wells completed in the Bakken and Three Forks Formations with a broad geographic distribution. Approximately 30 different factors (completion-related and geology-related) were analyzed to assess their effects on short-term (6-month) and long-term (60-month) production using a multivariate statistical approach.

The final report entitled "Bakken Production Evaluation Using Multivariate Statistical Analysis" was added to the partners-only Web site for review by BPOP partners. Any review

comments received by January 31, 2019, will be considered for modification to the report, after which the report will be available to the entire BPOP partnership for a 15-month period before the report is fully public.

Water Injection Reservoir Assessment Task

Because of industry's current reliance on the Inyan Kara Formation as a saltwater disposal (SWD) target, an effort was conducted through BPOP to estimate local and regional pressure effects that have occurred as a result of historic SWD and to evaluate areas that may be suitable or problematic for disposal through reservoir simulation of hypothetical future injection scenarios. An additional goal was to evaluate the overall disposal potential of the Inyan Kara in the areas that are currently targeted for injection.

The report on the modeling and simulation portion of this task entitled "Modeling and Simulation of the Inyan Kara Formation to Estimate Saltwater Disposal Potential: Final Report" is available on the BPOP partners-only Web site. The report will be available to the public in April 2020.

As a complementary activity for this task, the EERC has been working on the development of simplistic spreadsheet-based models that allow the user to estimate the radius of influence of individual SWD wells based on basic geologic characteristics (cumulative sand thickness, average porosity, and average permeability), injection rate, and period of performance. This past quarter, two additional spreadsheet models were developed and included in the overall spreadsheet package. Additional activities focused on comparing the spreadsheet-based predictions with those estimated using the Inyan Kara reservoir model based on a simplistic SWD scenario.

Bakken Trend Analysis

This task is focused on the evaluation of various trends related to Bakken fluids production and completion practices to better understand the potential future impacts of those trends on fluids production surface-related infrastructure, freshwater demand, and SWD capacity. The scope of work for this task for BPOP Year 3 funding was determined. A key focus will be to evaluate trends in oil, gas, and water generation between parent and child wells on a well pad.

Facility Process Optimization Task

The overall goal of this task is to apply process simulation to the operation of Bakken surface facilities to improve performance, reduce emissions, and ultimately streamline operating costs. These facilities are a key link in the overall Bakken production chain, and under this task, models have been created with partner input to examine in detail parameters that affect fugitive emissions and crude oil properties. Modeling results are then reduced to actionable suggestions for partner producers to consider when evaluating their operations.

Within the past quarter, partner feedback was incorporated into finalized deliverables that address the issue of weather-induced changes to crude oil vapor pressure. Typically, vapor

pressure specifications are most difficult to meet during winter months when there is excessive heat loss from exposed process equipment. To evaluate solutions for this problem, the EERC created validated, cold-weather models that were used to screen and rank design changes that could be used to ensure vapor pressure compliance during cold weather.

A short technical brief entitled “Vapor Pressure Modeling of Cold Weather Modifications for Bakken Surface Facilities” and an accompanying set of presentation slides entitled “Surface Facility Vapor Pressure Modeling” were uploaded to the BPOP partners-only Web site. The technical brief and slides will be available to the public in April 2020.

Aromatic/Aliphatic Study Task

The goal of the Aromatic/Aliphatic (A/A) task is to investigate and develop the use of the determination of the relative ratios of aromatic hydrocarbons to aliphatic hydrocarbons in rock cores and produced crude oil for two general applications: 1) to provide a well management tool that can determine the changes in produced crude oil contributed from the adjacent source shales to wells completed in the Middle Bakken (or Three Forks) and 2) to yield a better understanding of oil migration from the source shales to the target reservoir formations. Studies on rock core samples are continuing to increase the understanding of thermal maturity and oil migration across the Basin, and crude oil samples collected temporally during oil production from several wells are being analyzed to determine the efficacy of using A/A ratios to facilitate well management.

Activities during this quarter included the following:

- Data reduction was completed on the 40 Lower and Upper Bakken shale samples that were extracted and analyzed as reported in previous quarters, as well as the additional 33 rock core samples including several Middle Bakken, Three Forks, Pronghorn, and additional Upper and Lower Bakken shales that were extracted and analyzed for their A/A ratios reported in previous quarters. These samples were selected to give complete profiles (including multiple depths of single lithofacies for some wells) of multiple wells including all relevant source and reservoir rocks.

- Analysis for A/A ratios of all produced crude oil samples collected from the beginning of the project through the end of 2018 continued.

Environmental Support Task

The environmental support task was largely focused on providing assistance to our partners on issues related to brine and hydrocarbon spills and the associated cleanup. In addition to spill remediation-related efforts, EERC staff participated in activities associated with wellsite emissions and etc.

Activities during this quarter included the following:

- EERC staff continued the process of finalizing the North Dakota Remediation Resource Manual. This included facilitating the external review by BPOP partners.

- EERC staff participated in meetings and conference calls with BPOP partners to review, discuss, and comment on the draft Department of Health Hydrocarbon Remediation Guidance document.

Program Management and Development

The Year 3 activities were determined based on partner input. Activities will be initiated next quarter and additional details on the goal of each area will be provided in the next quarterly report. Some funding was reserved for potential match to DOE funding opportunities to be released in 2019. A summary of the Year 3 activities is as follows:

- Improved oil recovery (IOR) activities
  - Reinjection of rich gas into parent wells – effects on offset wells
  - Refracs/IOR workshop
- Subsurface activities
  - Data analytics and trend analysis
  - Reservoir characteristics and fluids database
  - Produced water management tools and general topics
- Surface activities
  - Facilities optimization
  - Fluids characterization
- Management
  - Program oversight, document control, Web site upgrade, etc.

John Harju presented "Bakken Production Optimization Program 2.0 (BPOP 2.0) Update" at the NDIC Oil and Gas Research Council (OGRC) meeting on December 18, 2018. Presentation items included updates on activities including rich gas EOR with Liberty, facilities modeling, fluids characterization, a summary of upcoming Year 3 activities, an overview of the final report review process, and a report status. A copy of the presentation is provided in Appendix A.

Work began on a BPOP Web site upgrade to update the program information and to serve as a program marketing tool. Several internal meetings were held to discuss the design of the BPOP public Web site and the BPOP partners-only Web site. Programming was initiated on the Web site upgrade. The BPOP partners-only Web site will allow partners access to products for 15 months prior to public distribution. All BPOP product titles will be visible on the public BPOP Web site and will be accompanied by a public abstract and key words for searchability. Publicly available products will be downloadable instantly, while BPOP partners-only products will contain a link to the BPOP partners-only Web site and information on how to join BPOP.

TRAVEL ACTIVITIES

Representatives from BPOP incurred travel costs for their participation in the following meetings and sampling trips:

- October 2–3, 2018: traveled to Dickinson, North Dakota, to attend North Dakota Petroleum Council (NDPC) meetings.
- October 12 and November 20–21, and 29, 2018: traveled to the Liberty wellsites near Tioga, North Dakota, to conduct sample collection.
- October 15–17, 2018: traveled to Denver, Colorado, to attend a project meeting with Liberty.
- October 25–26, 2018: traveled to the Liberty wellsites near Tioga, North Dakota, to perform a subsurface tracer injection.
- October 28 – November 2, 2018: traveled to Pittsburgh, Pennsylvania, to attend the American Chemical Institute of Chemical Engineers 2018 Annual Meeting.
- November 12–14, 2018: traveled to Denver, Colorado, to participate in the Mudrocks and Tight Oil Characterization (MUDTOC) Fall 2018 Consortium Meeting at the Colorado School of Mines in Golden, Colorado.
- December 18–19, 2018: traveled to Bismarck, North Dakota, to present at the NDIC OGRC meeting.

PARTNERSHIP AND FINANCIAL INFORMATION

The original budget as proposed to NDIC OGRP is $13,280,000, as shown in Table 1.

The EERC continues to seek support for this program, and to date, additional cost share has been secured from the Bakken producers listed in Table 2.

Table 1. BPOP – Original Budget

	Y1	Y2	Y3	
Sponsors	**Nov 2016 to Oct 2017**	**Nov 2017 to Oct 2018**	**Nov 2018 to Oct 2019**	**Total**
NDIC Share – Cash	$2,000,000	$2,000,000	$2,000,000	**$6,000,000**
Industry Share (Marathon) – In-Kind	$2,500,000	$3,500,000	$1,280,000	**$7,280,000**
Total	**$4,500,000**	**$5,500,000**	**$3,280,000**	**$13,280,000**

Table 2. BPOP Partners

ConocoPhillips	Liberty Resources	Petro-Hunt
Equinor	Marathon Oil	WPX Energy
Hess Corporation	Oasis Petroleum	XTO Energy

In addition, the EERC has secured $2,000,000 from DOE to complement the ongoing work to determine the feasibility of reinjecting captured rich gas into a Bakken reservoir to enhance oil recovery. Liberty is providing in-kind contributions that support this programmatic scope.

Table 3 presents a revised expected budget based on the additional cost share secured by the EERC. This revised budget is an increase of over 80% over the original budget. Expenses to date are also listed in Table 3.

Table 3. BPOP – Expected Budget and Expenses to Date

Sponsors	Expected Budget	Actual Expenses as of 12/31/18	Balance
NDIC Share – Cash	$6,000,000	$3,338,136	$2,661,864
Industry Share – Cash	$1,350,000	$533,944	$816,056
Marathon – In-Kind	$12,615,401	$12,615,401	$0
Liberty – In-Kind*	$2,328,987	$2,328,987	$0
DOE – Cash	$2,000,000	$875,096	$1,124,904
Total	**$24,294,388**	**$19,691,564**	**$4,602,824**

* An estimate for the total expected in-kind cost share from Liberty is not available. Liberty will periodically report actual costs to the EERC, which will be subsequently presented in the quarterly report.

FUTURE ACTIVITIES

The planned activities for the next quarter are detailed below. Work within the Year 3 activities will be initiated.

Enhanced Oil Recovery Task

Anticipated activities over the next quarter will focus on continued collaboration with Liberty on the rich gas EOR pilot. The data generated from the injection tests in the summer of 2018 and December 2018 will be evaluated. The lessons learned from those injection tests will be used to guide operation of the second injection test that is anticipated to be initiated early in the next quarter. The Gohrick 5MBH will be brought back onto production in January 2019 after a relatively short soak period. It is anticipated that injection into the Gohrick 4MBH well will be initiated in mid-January 2019 and continue for up to 30 days. A gas, oil, and water tracer study will also be conducted during the Gohrick 4MBH injection period. A draft white paper on the findings from the surface facility modeling of the Stomping Horse complex is also expected to be developed during the next quarter.

Laboratory experiments to examine the sorptive capacity of Bakken shale samples for rich gas components will continue to be conducted. The magnetic balance and centrifuge will be set up during the coming quarter.

With respect to modeling, ongoing efforts will continue to calibrate gas and water production at longer times. Once calibrated, the DSU model will allow obtaining predictions that are more reliable. Later, dynamic simulations will allow forecasting, assessing, and optimizing short-term and long-term recovery efficiencies.

Refracturing Optimization Task

The activities under the current scope of work are complete. External partner review comments will be received and incorporated into the task final report. The report will be posted on the partners-only Web site.

Produced Fluid Characterization Task

Key upcoming activities for this task include developing additional partnerships with industry to further understand their specific needs related to Bakken production issues and practices and to expand the geographical extent of the sampling and analysis effort. Data collection and sample acquisition is expected to continue, with results supporting the ongoing compositional evaluations of each fluid and supporting the temporal evaluations and enhancing the size and usefulness of the database to the various BPOP research efforts. Specific activities to be conducted include the following:

- Continue monthly and quarterly sample collection and analysis events on established wells.
- Review and evaluate collected data as they pertain to overall production characteristics throughout the Bakken play.
- Coordinate access and sample acquisition/analysis on additional wells throughout the basin.
- Continue to provide sample acquisition and analytical interpretation support to an ongoing EOR project within the Bakken play.

Reservoir Performance Modeling Task

The activities under the current scope of work are complete. External partner review comments will be received and incorporated into the task final report. The report will be posted on the partners-only Web site.

Water Injection Reservoir Assessment Task

Activities will conclude on testing of the spreadsheet-based models. The EERC will work the BPOP partners to obtain input on the spreadsheet model and the assumptions therein.

Bakken Trend Analysis

Work on this task is scheduled to resume this coming quarter. A key focus will be to evaluate trends in oil, gas, and water generation between parent and child wells on a well pad.

Facility Process Optimization Task

EERC researchers will prepare background information regarding recent issues that may affect Bakken facility operations. Specific topics include changes to tank headspace purging with lower volatility oil, and permitting impacts arising from facility consolidation. The EERC plans to send a representative to the next NDPC Technical Solutions Group meeting in January 2019 for an opportunity to gather producer perspectives on these evolving issues.

Aromatic/Aliphatic Study Task

Analysis for A/A ratios of all produced crude oil samples collected from the beginning of the project through the end of 2018 will continue. Upcoming activities over the next quarter include compilation of the A/A results for the rock samples that have been analyzed to date.

Environmental Support Task

EERC staff will complete the revision of the North Dakota Remediation Resource Manual and publish the updated version.

Program Management and Development

DOE funding opportunities released in 2019 will be evaluated for potential match with BPOP funding. Discussions and activities related to the upgrade of the BPOP public and partners-only Web sites will continue.

APPENDIX A

BPOP 2.0 UPDATE TO OGRC DECEMBER 2018

Energy & Environmental Research Center (EERC)

BAKKEN PRODUCTION OPTIMIZATION PROGRAM 2.0 (BPOP 2.0) UPDATE

Presented to Oil & Gas Research Council

Bismarck, North Dakota

December 18, 2018

Charles Gorecki

Director of Subsurface R&D

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AGENDA

- Rich Gas Enhanced Oil Recovery (EOR) with Liberty Resources
- Facilities Modeling
- Fluids Characterization
- Year 3 Activities
- Final Report Review Process
- Report Status

RICH GAS EOR – HIGHLIGHTS

- **Lab studies of rich gas interactions with fluids and rocks**
  - The richer the gas, the lower the MMP.
- **Iterative modeling of surface and subsurface components**
  - Rich gas EOR predicted to not adversely affect surface facility operations.
  - Predicted incremental oil recovery >25%.
- **Pilot performance assessment**
  - Summer pilot tests (July–September) injected 24.6 MMscf into two wells over three injection periods.
  - Fall–winter pilot tests started November 20 and are ongoing. Injection into four wells planned at max. rate of ~2 MMscfd at wellhead pressure ~4000 psi.
  - Results are being analyzed and interpreted, models updated.

RICH GAS EOR – NEXT STEPS

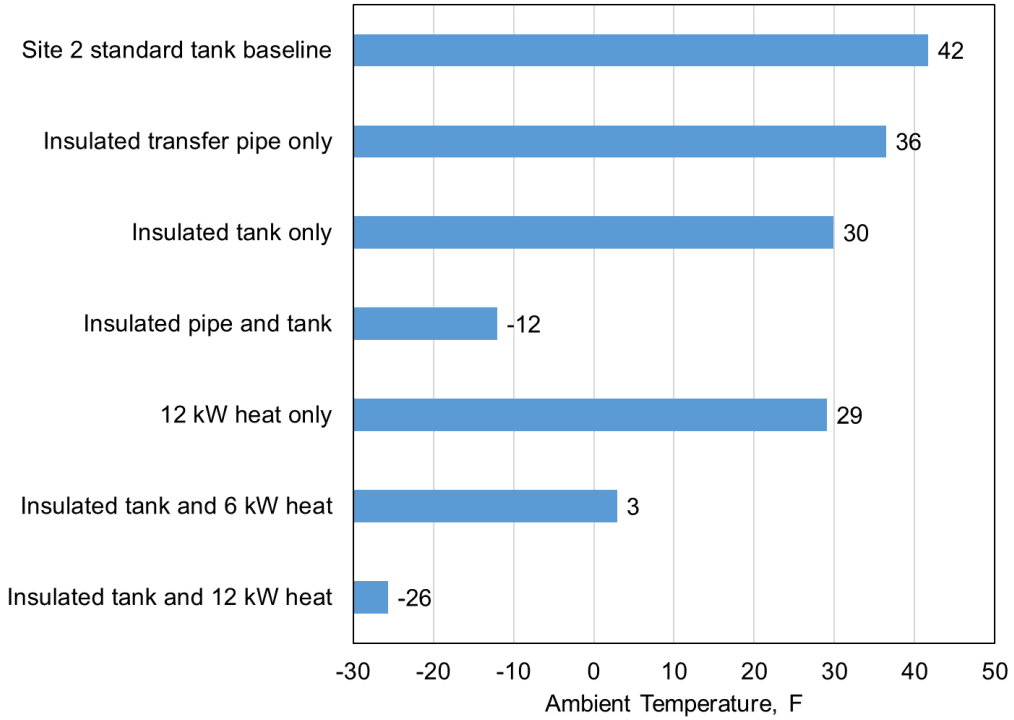
- Rich gas injection anticipated to continue through the winter and spring.
- Fluid samples representing the reservoir and the surface processing facilities will continue to be collected to determine effects of rich gas injection on both.
- Laboratory experiments to determine the sorptive capacity of Bakken shale for rich gas components will be conducted.

FACILITIES MODELING

- **Impact**: Apply process-modeling tools to address Bakken-specific issues arising at production facilities.
  - Crude quality and shrinkage
  - Emissions
  - Safety
- **Products:** Whitepapers and presentations that address specific needs, including:
  - Tank battery emissions.
  - Wintertime crude vapor pressure limits.
- **Next Steps**
  - Continued participation in information exchange forums (TSG and others).
  - Develop new calculators as site configurations evolve.

Cold Weather Modification Ranking *

Minimum ambient temperature threshold for 13.7 psia oil.



* Illustration of single hypothetical scenario

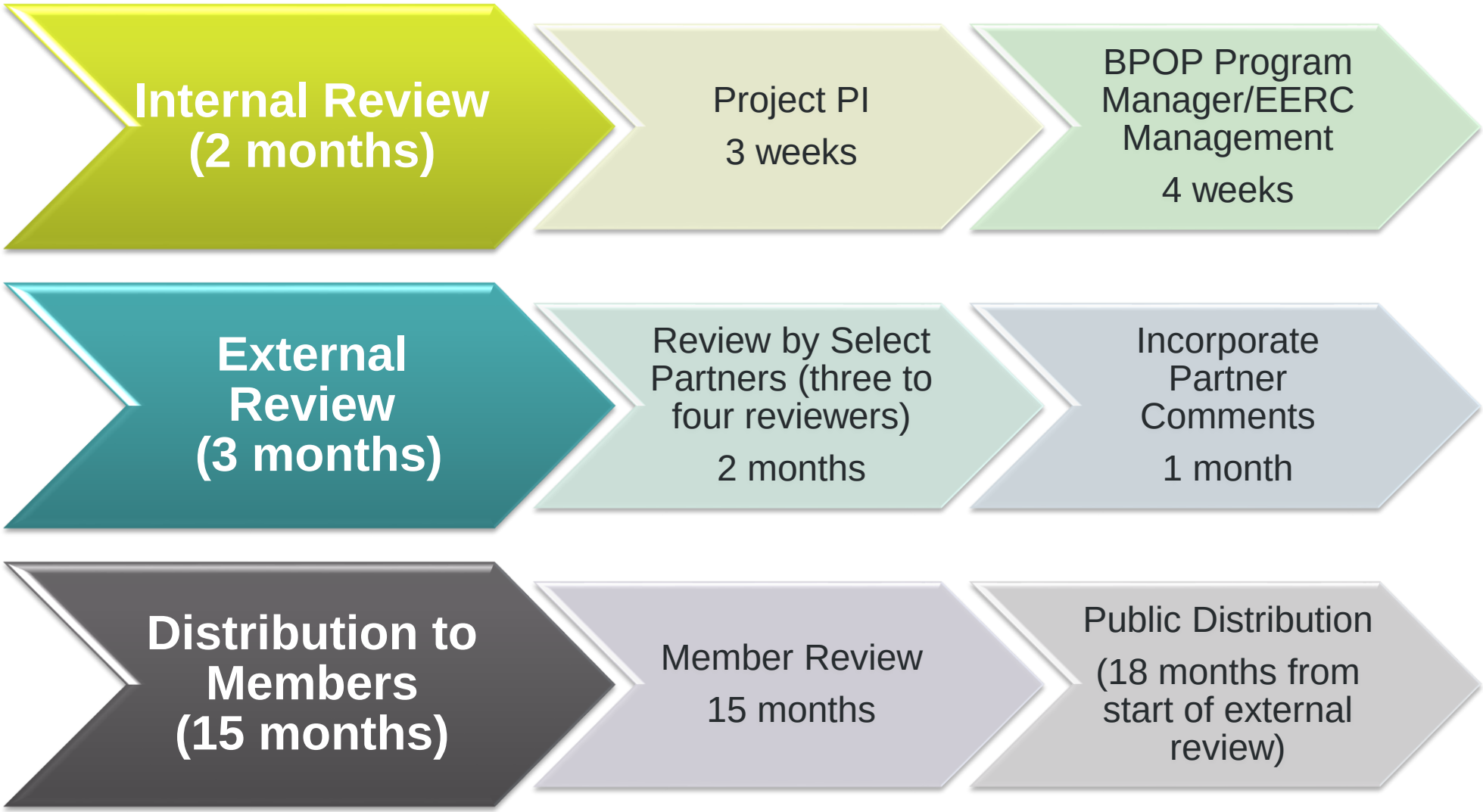
FLUIDS CHARACTERIZATION

- Coordinated with program leads to identify key information and data needed for ongoing and planned research efforts.
- Developed partnerships with key industry entities to obtain access to fluids data and information and site access for additional sample collection efforts.
- Supported a BPOP industry member conducting a rich gas injection EOR demonstration through periodic sampling and analysis of fluids potentially impacted through the EOR activity.
- Coordinated with a BPOP industry member, and initiated sampling and analysis activities on a stimulated and nonstimulated well for evaluating compositional differences that may indicate possible fluid migration pathways and possible sources of produced water in typical stimulated Bakken wells.

BPOP YEAR 3 ACTIVITIES – SUMMARY

- Improved oil recovery (IOR) encompasses any subsurface action that supplements the initial recovery profile of an oil well, including fluids injection for pressure maintenance, EOR, new stimulations, etc.
  - Reinjection of rich gas into parent wells – effects on offset wells
  - Refracs/IOR Workshop
- Subsurface activities
  - Data analytics and trend analysis
  - Reservoir characteristics and fluids database
  - Produced water management tools and general topics
- Surface activities
  - Facilities optimization
  - Fluids characterization
- Management
  - Program oversight, document control, Web site, etc.
- Reserve for possible U.S. Department of Energy match

BPOP 2.0 PRODUCT REVIEW PROCESS



BPOP 2.0 PRODUCTS

Title	Status
Process Modeling of Wellsite Production Operations	Public
Modeling and Simulation of the Inyan Kara Formation to Estimate Saltwater Disposal Potential	Partners only through April 2020
Bakken Refracturing Data Analysis	Under partner review; partners only through July 2020
Bakken Production Evaluation Using Multivariate Statistical Analysis	Under partner review; partners only through July 2020
Vapor Pressure Modeling of Cold Weather Modifications for Bakken Surface Facilities	Partners only through April 2020
BakkenSMART Fugitive Emissions Fact Sheet	Public
BakkenSMART Hydraulic Fracturing Fact Sheet	Public

QUESTIONS?

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THANK YOU

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