Plains CO_2 Reduction (PCOR) Partnership Monthly Update
February 1–29, 2016

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Continued efforts to update Deliverable (D) 81, Regional Carbon Sequestration Atlas (update), due August 31, 2016.
  - Added four new pages: two pages will extend Bell Creek information, one page will describe the Basal Cambrian work, and one will be dedicated to the Aquistore project.
  - Areas where text and figures will be updated or completely redone were noted and will be reviewed at a later date.
- Updated information and continued work on the partners-only Decision Support System (DSS) Web site:
  - Continued activities to update the content of the **PCOR Partnership general database**, including the following:
    - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resources: 81 new North Dakota wells and two new Montana wells added.
    - Updated North Dakota injection data.
    - Updated South Dakota and British Columbia projects.
  - Continued database preventive maintenance of Petra projects.
- Continued work on a value-added carbon management plan for the state of North Dakota, which incorporates data from the PCOR Partnership DSS on large point sources and potential sinks.
  - A team of engineers and scientists completed Carnegie Mellon integrated environmental control model (IECM) models used to estimate the change in CO_2 emissions and net power output from the coal-fired power generation facilities in North Dakota. The models were guided by various capture scenarios identified as potential approaches to reduce North Dakota's CO_2 emissions by 45%, as required by the U.S. Environmental Protection Agency (EPA) Clean Power Plan. The data from the model runs will be reduced and analyzed to provide indications of the impact of the various scenarios.
  - Discrepancies between predicted and actual CO_2 emissions for the state's coal-fired power plants were rectified, and work began applying the predicted values (based on various levels of capture) to three different scenarios. The scenarios incorporate various combinations of retrofitted full capture, retrofitted partial capture, conversion to natural-gas firing, retiring small and/or old units, supplementing with wind power to reach current power outputs, and construction of new-build plants with capture.

- With regard to the **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Worked on relative permeability testing conditions for the first Inyan Kara sample being tested: brine permeability, CO_2 permeability, and three CO_2/brine conditions.
  - Modified the length of core samples that will be utilized for relative permeability testing. Performed 3-D scanning for bulk volume and porosity testing on the modified samples.
  - Resumed work on the value-added report.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Modified the model using a different relative permeability setting.
  - Submitted D93 – Geological Modeling and Simulation Report for the Aquistore Project – on February 29, 2016.
  - The SaskPower capture plant was down for routine maintenance during the week of February 8–12, 2016. The plant was returned to service, and injection at the Aquistore well resumed.
  - An Energy & Environmental Research Center (EERC) Senior Geophysicist traveled to Estevan, Saskatchewan, Canada, to observe the collection of 3-D vertical seismic profile (VSP) at the Aquistore site on February 19–20, 2016.
  - Pulsed-neutron logs (PNL) were run in both wells, and a spinner survey was run in the injection well.

Task 2 – Public Outreach and Education (Daniel J. Daly)

Highlights

- Submitted the updated Phase III fact sheet (D14) on February 26, 2016.
- Continued work on the value-added updated Phase II Zama fact sheet. Reviewed draft text and layout and worked on updating figures.
- Continued work on the update to the Outreach Action Plan (D11), including writing sections on tracking, data management, and the Web site; creating figures; and updating appendices.
- An abstract on outreach was submitted to the Greenhouse Gas Control Technologies (GHGT)-13 Conference, in collaboration with PTRC entitled "Communicating about the Geological Storage of Carbon Dioxide – Comparing Public Outreach for CO_2 EOR [enhanced oil recovery] and Saline Storage Projects." Authors include Norman Sacuta, Kyle Worth, and Aleana Young of PTRC and Daniel Daly and Barry Botnen of the EERC.
- Informed the Dakota Science Center of Grand Forks, North Dakota, that the EERC and the PCOR Partnership Task 2 team would be available to host sessions for Grand Forks, North Dakota, teachers in April 2016.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - The new "Technical Posters" section on the public PCOR Partnership Web site was submitted for review on February 19, 2016. The new section was approved and went live on February 23, 2016.
  - Continued ongoing identification and repair of broken links.
- Took part in the monthly Aquistore outreach advisory group phone call on Febraury 29, 2016, and sent out an e-mail summary.

- Continued script development for the D22 coal documentary, including obtaining interview transcripts, reviewing transcripts, and incorporating interview materials into the evolving narrative backbone.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB). Traveled to Denbury Onshore (Denbury) offices in Plano, Texas, on February 18–19, 2016, to interview Phil Rykhoek, President and Chief Executive Officer, and Matt Dahan, Vice President of the North Region, for the Bell Creek documentary (D21).

Task 3 – Permitting and NEPA (National Environmental Policy Act) Compliance (Charles D. Gorecki)

Highlights

- Attended the Groundwater Protection Council 2016 Underground Injection Control Conference held February 23–25, 2016, in Denver, Colorado.
- Continued working on the regulatory permitting document for the PCOR Partnership region (D76 – Regional Regulatory Perspective). The goal of this document is to help PCOR Partnership states through the permitting process. Continued compiling rules, regulations, and statutes crosswalks and flowcharts for various scenarios of carbon capture and storage (CCS), geologic storage, and CO_2 EOR for each of the PCOR Partnership states and provinces.
  - Completed first draft of North Dakota Industrial Commission (NDIC) crosswalk spreadsheet.
  - Researched CCS rules for British Columbia.
  - Worked on the Missouri crosswalk spreadsheet.

Task 4 – Site Characterization and Modeling (Charles D. Gorecki)

Highlights

- **Bell Creek** test site activities included the following:
  - Completed the draft outline for the PCOR Partnership Site Characterization Best Practices Manual (BPM) (D35).
  - Continued work on **modeling**, including the following:
    - Constructed a series of well cross sections within Phase 4 of the Bell Creek Field. These can be used for assessments of the field and assisting in planning field work.
    - Worked on importing PNL logs from the fall 2015 campaign into Petrel.

Task 5 – Well Drilling and Completion (John A. Hamling)

This task ended in Quarter 3 – Budget Period (BP) 4, Year 7 (June 2014).

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Continued preparation of D45 (Bell Creek Test Site – Infrastructure Development Report).
- Researched a few other capture technologies for addition to the update of the 2011 value-added CO_2 capture technologies overview document.

Task 7 – CO_2 Procurement (John A. Harju)

This task ended in Quarter 4 – BP4, Year 6 (September 2013).

Task 8 – Transportation and Injection Operations (Melanie D. Jensen)

This task ended in Quarter 4 – BP4, Year 8 (September 2015).

Task 9 – Operational Monitoring and Modeling (John A. Hamling/Larry J. Pekot)

Highlights

- Held a Webinar with representatives from Denbury and Schlumberger on February 26, 2016, to review PNL processing results for 18 wells, which were acquired as part of the fall 2015 PNL campaign. Based on the results discussed during the call, the PNL logs will be reprocessed using a lower value for formation water sigma to improve oil versus water saturation interpretations.
- Received the revised draft DOE monitoring, verification, and accounting (MVA) BPM back from the group lead for review. Updated a figure. Continued preparation of a Bell Creek MVA overview call-out box at DOE's request.
- Received feedback from Operating Carbon Storage Project BPM team lead on collaborated DOE BPM draft document on CCS wells for review. Submitted review comments to the BPM lead on February 26, 2016.
- Received input on the incremental value of additional sample collection and other topics related to sampling frequencies from a consultant from The CETER Group (CETER) for inclusion in the PCOR Partnership MVA BPM D51 (Monitoring for CO_2 Storage and CO_2 EOR).
- Began writing milestone M56 (Life Cycle Analysis for Primary and Secondary Recovery Oil Completed).
- Evaluated the National Risk Assessment Partnership (NRAP) DREAM (Designs for Risk Evaluation and Monitoring) tool to determine its use with PCOR Partnership MVA data. The DREAM tool will not fit the objectives the PCOR Partnership is trying to accomplish.
- Working on injection gas optimization for field operation prediction, including the impact of impurities such as methane on the CO_2 minimum miscibility pressure (MMP).
- Building simple gas injection models for heterogeneous reservoirs to investigate the gas sweep efficiency by visualizing the gas flow behavior; the current regional scale model is too large to analyze the fluid displacement behavior between wells.
- Continued importing PNL logs from the fall 2015 campaign into Petrel.
- Completed production/injection GeoPDF map update for the most recent Denbury data available.
- **Bell Creek** injection-phase site activities included the following:
  - Continued reservoir pressure monitoring of the 05-06 OW (observation well) from the permanent downhole monitoring (PDM) system using the casing-conveyed pressure–temperature gauges (PTGs).
    - Near-continuous operation since April 2012.
    - Followed up on the fiber-optic distributed temperature system (DTS) unit repair. This system provides a profile of temperature from the bottom of the well to the surface

using the fiber-optic cable that runs the entire length of the casing. A short occurred on the motherboard of the DTS unit on November 4, 2015, resulting in it being removed and sent in for repair. The repairs should be completed and the unit shipped by the end of February.

- Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts:
  - ♦ Consistent progress since April 2011.
  - ♦ Built two new pressure, volume, and temperature (PVT) models based on fluid test data of Bell Creek oil. The models can be used to study pure gas flooding performance such as CO_2 flooding, ethane flooding, etc.
  - ♦ Two smaller sectors located in Bell Creek Development Phases 1 and 2 have been taken from the full-field model as base models to study the ethane flooding performance. The new PVT models have been integrated into the base models. Designing simulation cases for different ethane flooding scenarios.
- Continued passive seismic monitoring of 04-03 OW using the borehole seismic array:
  - ♦ Near-continuous operation since May 22, 2013.
  - ♦ Continued 4-D VSP analysis.
  - ♦ Continued looking into time-lapse interpretation of the 4-D seismic difference attribute maps.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 4,274,631 metric tons through December 31, 2015. This value represents the total gas volume injected, which includes purchase and recycle streams and is NOT corrected for a gas composition of approximately 98% CO_2 (Table 1).
- As of December 31, 2015, the most recent month of record, 2.807 million tonnes of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated 2.753 million tonnes of CO_2 stored (Table 2), with the difference comprising other trace gases in the purchase gas stream. A separate methodology from that used to calculate total gas injected was used to calculate a cumulative associated CO_2 storage volume estimate by correcting the gas purchase volume (approximately 98% CO_2) obtained from Denbury's custody transfer meter with gas compositional data.

Table 1. Bell Creek CO_2 Gas Injection Totals for December 2015 (cumulative totals May 2013 to December 2015)[1]

	December 2015 Injection
Total, Mscf	4,063,711
Total, U.S. tons[2]	232,438
Total, metric tons[2]	211,069
Cumulative Total, Mscf [2]	82,299,470
Cumulative Total, U.S. tons[2,3]	4,707,400
Cumulative Total, metric tons[2,3]	4,274,631

Source: Montana Board of Oil and Gas (MBOG) database.

[1] There has been a lag in posting of injection/production volumes to the MBOG database. Total gas injection volumes are ***NOT CORRECTED*** for gas composition and include the combined purchased and recycled gas streams.

[2] This was calculated utilizing a conversion of 17.483 Mscf/U.S. ton and 19.253 Mscf/metric ton.

[3] Cumulative totals are for the period from May 2013 to the month listed.

Table 2. Cumulative Total Gas Purchased and Estimated Associated CO_2 Storage Volumes for the Bell Creek Field[1]

	December 2015 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	1717
Monthly Total Gas Purchased, million tons[2]	0.098
Monthly Total Gas Purchased, million tonnes[2]	0.089
Cumulative Total Gas Purchased, MMscf[2,3]	54,034
Cumulative Total Gas Purchased, million tons[2,3]	3.091
Cumulative Total Gas Purchased, million tonnes[2,3]	2.807
Cumulative Total CO_2 Stored, MMscf[3,4]	53,003
Cumulative Total CO_2 Stored, million tons[3,4]	3.032
Cumulative Total CO_2 Stored, million tonnes[3,4]	2.753

[1] Conversion factors of 17.483 Mscf/ton and 19.253 Mscf/tonne were used to calculate volumes.
[2] Total gas-purchased volumes are ***NOT CORRECTED*** for gas composition.
[3] Cumulative totals are for the period from May 2013 to the month listed.
[4] Total gas CO_2 stored volumes are ***CORRECTED*** for gas composition.

- Completed landowner packages for all groundwater monitoring activities that occurred after August 2015. Denbury approved the packages on February 24, 2016. The packages have a different format, consisting of field measurements and select laboratory analyses for 18 groundwater locations. Packages will be printed and distributed by the end of March 2016.
- Completed laboratory analyses of the purchase and recycle gas stream samples collected on January 25, 2016. A summary of all oil and CO_2 gas stream samples collected for analyses to date is provided in Table 3.

Table 3. Oil and CO_2 Gas Stream Sampling and Analyses

Stream(s)	Dates Sampled
Production: Oil[1]	Jan 2014, March 2014,[2] May 2014, June 2014, July 2014, Sept 2014, Oct 2014
Production: CO_2 Gas[1]	Sept 2014,[2] Nov/Dec 2014, Jan 2015,[3] March 2015, July 2015
Purchase/Recycle: CO_2 Gas[4]	May 2014,[5] June 2014, July 2014, Sept 2014, Oct 2014, April 2015, July 2015, Sept 2015, Jan 2016

[1] Wells 56-14R, 32-02, and 05-06 unless otherwise noted.
[2] Wells 56-14R and 32-02 only.
[3] Well 05-06 only.
[4] Both purchase and recycle streams unless otherwise noted.
[5] Purchase stream only.

Task 10 – Site Closure (John A. Hamling/Larry J. Pekot)

This task is anticipated to be initiated in Quarter 3 – BP 5, Year 9 (April 2016).

Task 11 – Postinjection Monitoring and Modeling (John A. Hamling)

This task is anticipated to be initiated in Quarter 3 – BP5, Year 9 (April 2016).

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights

- Nothing to note at this time.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Dr. Chantsalmaa Dalkhaa joined the EERC team as a Reservoir Engineer on February 1, 2016.
- Submitted nine PCOR Partnership abstracts on February 10, 2016, for the GHGT-13 Conference to be held November 14–18, 2016. Abstracts were sent to DOE for review in an e-mail on February 11, 2016. Author notification is scheduled for June 1, 2016. The abstract titles are as follows:
  - 4-D Seismic Monitoring of Injected CO_2 Enhances Geological Interpretation, Reservoir Simulation, and Production Operations
  - Effects of Reservoir Temperature and Percent Levels of Methane and Ethane on CO_2/Oil MMP Values as Determined Using Vanishing Interfacial Tension/Capillary Rise
  - Engaging Teachers to Facilitate Learning – PCOR Partnership Outreach in Action
  - How Green Is My Oil? A Detailed Look at Carbon Accounting For CO_2 Enhanced Oil Recovery Sites (CO_2 EOR)
  - Impact of CO_2 Impurity on MMP and Oil Recovery Performance of Bell Creek Oil Field
  - Monitoring 2.5 Million Tonnes of CO_2 at the Bell Creek Oil Field
  - Numerical Modeling of the Aquistore CO_2 Storage Project
  - Regionwide and Project-Level Outreach – The PCOR Partnership Approach
  - Relative Permeability of Williston Basin CO_2 Storage Targets
- Reviewed and commented on the DOE Simulation and Risk Assessment BPM. Submitted comments to the BPM lead on February 25, 2016.
- Participated in a BPM Synergy WebEx led by DOE on February 26, 2016. The overall estimated time line for the completion of the BPMs was discussed.
- Continued planning for the spring 2016 Technical Advisory Board (TAB) meeting to be held in New Orleans, Louisiana, on April 4–6, 2016. Contacted the TAB member from the Lignite Energy Council (LEC) regarding hotel arrangements. Contacted several TAB members regarding the meeting.
- Continued planning the 2016 PCOR Partnership Annual Membership Meeting. The workshop will be held September 13, 2016, and the annual meeting will be held September 14–15, 2016, in Grand Forks, North Dakota.
  - Sent postcards announcing the PCOR Partnership annual meeting.
  - Made room block arrangements.
  - Sent a "Save the Date" e-mail blast announcing the PCOR Partnership annual meeting and workshop.

- Held a task leader meeting February 2, 2016. Topics included the BP5 continuation application, abstracts for the upcoming CCUS (carbon capture, utilization, and storage) and GHGT-13 conferences, Bell Creek and Aquistore project updates, upcoming conferences and meetings, and task leader updates.
- Computer Modelling Group (CMG) software licenses were renewed. CMG software is being used to conduct the dynamic modeling activities for the PCOR Partnership.
- Completed deliverables and milestones in February:
  - January monthly update
  - Task 1: D93 – Geologic Modeling and Simulation Report for the Aquistore Project
  - Task 2: D14 – General Phase III Fact Sheet (update)

Task 14 – RCSP Water Working Group (WWG) Coordination (Ryan J. Klapperich)

Highlights

- With regard to the *International Journal of Greenhouse Gas Control* (IJGGC) Special Issue:
  - Completed author review of submissions.
  - Initiated editorial review to combine reviewer comments.
  - Discussed the issue with PCOR Partnership management and a consultant from CETER.
  - Readjusted editorial assignments.
  - Returned two articles to the authors for minor revisions.
- The publication schedule for the IJGGC Special Issue has been revised because of delays with submissions and completing reviews. We will have the previously submitted articles published in the regular edition of IJGGC and collect those articles and other related articles on the subject to produce the Special Issue later this spring. A few submitted articles will be rejected as part of this process for either poor quality or poor fit.
- Provided review of the WWG portion of the Task 2 PCOR Partnership Phase III fact sheet (D14).

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project (Charles D. Gorecki)

This task ended in Quarter 2 – BP4, Year 7 (February 2014).

Task 16 – Characterization of the Basal Cambrian System (Wesley D. Peck)

This task ended in Quarter 2 – BP4, Year 7 (March 2014).

Travel/Meetings

- February 17–19, 2016: Traveled to Fargo, North Dakota, for meetings with Prairie Publie Broadcasting and to Plano, Texas, to conduct interviews at Denbury.
- February 22–26, 2016: Traveled to Denver, Colorado, to attend the Ground Water Protection Council Underground Injection Control Meeting.

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