Plains CO_2 Reduction (PCOR) Partnership Monthly Update
March 1–31, 2016

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Prepared one of the two presentations to be given at the North America Energy Ministers Trilateral (NAEMT) Meeting in Mexico City and Villahermosa, Mexico, which will be held April 11–15, 2016.
- Prepared a presentation on North Dakota storage targets for the North Dakota Carbon Management Industrial Working Group Meeting held March 9–10, 2016, in Bismarck, North Dakota.
- Continued efforts to update Deliverable (D) 81, Regional Carbon Sequestration Atlas (update), due August 31, 2016, including:
  - Worked on graphics, including maps, and figures in the preface through Chapter 2.
  - Updated text in the preface through Chapter 2.
  - Worked on new pages for Chapter 2, which are related to "Green Oil" or CO_2 enhanced oil recovery (EOR) and carbon capture and storage (CCS).
- Provided comments on the latest version of the U.S. Department of Energy (DOE) Site Characterization best practices manual (BPM).
- 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: 100 new North Dakota wells and two new Montana wells added.
  - Updated North Dakota production data.
  - Scanned the over 100,000 well logs, and began downloading well logs from the Wyoming Oil and Gas Conservation Commission Web site. These will be formatted, downloaded, and imported into the Petra database.
  - Continued database preventive maintenance of Petra projects.
- Continued efforts on assessing data from the PCOR Partnership DSS on large point sources and potential sinks.
  - Used the Carnegie Mellon Integrated Environmental Control Model to estimate the energy production and CO_2 emission from each baseload coal-fired unit in North Dakota for various CO_2 emission reduction scenarios. Energy load growth for the year 2030 was taken

into account in the CO_2 emission and energy production estimates. The information regarding CO_2 emission and energy production for each of the scenarios (as well as assumptions that were made) was summarized in a very brief internal report, which will be expanded in a draft report.

- With regard to the **Williston Basin** CO_2 Storage Sink Relative Permeability Laboratory Characterization:
  - Completed relative permeability testing on the first sample (Inyan Kara Formation).
  - Completed relative permeability testing on the second sample (Deadwood Formation).
  - Cleaned and prepared system for testing the third sample (Broom Creek Formation). Testing will begin April 1, 2016.
  - Prepared brine to be used in Lodgepole core relative permeability testing at a later date.
  - Completed permeability-to-air testing on Broom Creek samples.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Continued to download and process daily injection and pressure data.
  - Compared older versions of the geologic model with the current version to search for possible simulation improvements.
  - Held a conference call with the Petroleum Technology Research Centre (PTRC) Aquistore project manager. The February site work program at the Aquistore site has been completed, which included surface seismic, vertical seismic profile (VSP), pulsed-neutron logs (PNLs), and spinner survey testing.
  - Received processed PNL of observation well from a PTRC representative. Other results to be transmitted when available.
  - Participated in a Science and Engineering Research Committee (SERC) conference call on March 16, 2016.
  - As of March 22, 2016, 49,000 metric tons of CO_2 has been injected.

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

Highlights

- Submitted D11 entitled "Outreach Action Plan (Update 2)" on March 28, 2016, for review.
- Reviewed and provided written comments to DOE on behalf of the PCOR Partnership for the draft outreach BPM authored by the Regional Carbon Sequestration Partnerships (RCSP) Program Outreach Working Group (OWG).
- Worked to develop a new set of maps showing outreach coverage, outreach sectors, and areas with storage potential in the region.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued work on the D13 Web update for the public PCOR Partnership Web site, including reviewing materials to include in update, discussing report development schedule and duties list, and updating content.
  - Added a link to the upcoming Lignite Energy Council Education Seminar to the Educators page. Task 2 personnel will be at the seminar to be held June 14, 2016, in Bismarck, North Dakota.
  - Completed a routine broken link inventory on the public Web site.

- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Met with PPB on March 23, 2016, to review progress on documentaries D21 (the Bell Creek Story) and D22 (Coal and the Modern Age). Reviewed the D22 script, and initiated editing on the first third of the script.
  - Scheduled a meeting for April 8, 2016, to review D22 script updates.
  - Reviewed sources and initiated script updates for the remaining two-thirds of the D22 script.
- Participated in the monthly Aquistore outreach advisory group conference call on March 30, 2016.
- Participated in the OWG monthly conference call on March 17, 2016. Discussion focused on the status of the outreach BPM and its upcoming review.

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

Highlights

- 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 and provinces through the permitting process. Continued compiling rules, regulations, and statutes crosswalk worksheets and flowcharts for various scenarios of CCS geologic storage including CO_2 EOR for each of the PCOR Partnership states and provinces.
  - Discussed the 2016 North Dakota Industrial Commission (NDIC) proposed rule language and possible changes to the North Dakota crosswalk spreadsheet.
- Worked on slides pertaining to CO_2 CCS/EOR regulatory processes for the upcoming PCOR Partnership Technical Advisory Board meeting.

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

Highlights

- **Bell Creek** test site activities included the following:
  - Submitted D36 entitled "Bell Creek Wellbore Integrity Study" on March 30, 2016, upon completion of Denbury Onshore (Denbury)'s review. No changes were requested by Denbury. D36 was initially submitted to DOE on May 19, 2014.
  - Completed a revised outline for the PCOR Partnership Site Characterization BPM (D35).
  - Completed a PowerPoint presentation regarding the quality control of the PNL data collected from the fall 2015 campaign.
  - Continued work on **modeling**, including the following:
    - Imported PNL logs from the fall 2015 campaign into the current model.
    - Worked on updating the PNL data in the static model. Some of the PNL logs are being reprocessed using updated water salinity values to ensure accuracy.
    - Updated temperature data in the 3-D model using the most current data collected by the distributed temperature system (DTS) in 05-06 OW (observation well).
    - Worked on reservoir model, including quality check of the Bell Creek well tops.

- ♦ Continued work on improving the 3-D mechanical earth model (MEM) geomechanical properties. Reviewed available data to calibrate properties in the MEM, including checking processed PNLs.

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

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

- Submitted D44 entitled "Bell Creek Test Site – Drilling and Completion Activities Report" on March 30, 2016, upon completion of Denbury's review. No changes were requested by Denbury. D44 was initially submitted to DOE on May 30, 2014.

Task 6 – Infrastructure Development (Melanie D. Jensen)

Highlights

- Submitted D45 entitled "Bell Creek Test Site – Infrastructure Development Report" on March 31, 2016, for review.
- E-mailed the director of business development for Dresser-Rand asking permission to pass on his contact information to a group that may be interested in demonstrating the DATUM S supercompressor (previously known as the Ramgen Rampressor). This is part of a continuing effort to assist in finding a demonstration site for the compressor because once it is demonstrated in a field setting, it could be a boon to future CCS projects in the PCOR Partnership region.
- Assisted a partner with questions about the CO2ncrete capture technology. The partner's primary question was if it was a real technology, and secondly, if it would be of use at a coal-fired power plant. The task lead sent information regarding similar mineralization technologies: Calera, C-Quest, SkyMine, New Sky Energy, and Cemtrex. A link was provided for Solidia's home page. The primary difference between CO2ncrete and the other known mineralization technologies is that CO2ncrete plans to make use of 3-D printers to fabricate the building material.

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

- Milestone (M) 58 entitled "Bell Creek Test Site – Completion of 2.75M Metric Tons of CO_2 Stored" was submitted and approved by DOE on March 22, 2016.
- Submitted M56 entitled "Life Cycle Analysis for Primary and Secondary Recovery Oil Completed" on March 31, 2016, for review. A life cycle analysis (LCA) of oil production is

being conducted using two tools: spreadsheet models that use emission factors from U.S. DOE NETL publications and customized programming of the Argonne National Laboratory GREET model. This milestone concentrated on developing models for generic LCAs featuring conventional oil production and natural gas processing. Future efforts will focus specifically on the Bell Creek project in which CO_2 from natural gas processing is used for EOR.

- Submitted a draft article entitled "Rapid and Simple Capillary-Rise/Vanishing Interfacial Tension Method to Determine Crude Oil Minimum Miscibility Pressure: Pure and Mixed CO_2 Methane and Ethane" for DOE review on March 23, 2016. Received approval from DOE on March 31, 2016. The target journal for publication is *Energy & Fuels*.
- Continued review of current version of DOE monitoring, verification, and accounting (MVA) BPM. Sent comments on March 4, 2016. Upon request, provided a near-surface monitoring stratigraphic column and related text for the DOE MVA BPM.
- Participated in a DOE Operating Carbon Storage Projects BPM conference call on March 4, 2016. Provided an updated image for a landowner relations call-out box for use in the DOE Operating Carbon Storage Projects BPM. Reviewed the final draft.
- Completed the revised outline for Bell Creek Test Site – BPM – Monitoring for CO_2 Storage and CO_2 EOR (D51).
- Drafted an abstract on a simulation study of CO_2 flooding in the Bell Creek oil field for the Computer Modelling Group (CMG) 2016 Technical Conference to be held June 13–14, 2016, in Calgary, Alberta, Canada.
- In response to comments from Denbury on D66 reports (Bell Creek Test Site – Simulation Report [update]), revised technical content and figures in Update 4.
- **Bell Creek** injection-phase site activities included the following:
  - Continued reservoir pressure and distributed temperature monitoring of 05-06 OW from the permanent downhole monitoring (PDM) system using the casing-conveyed pressure–temperature gauges (PTGs) and fiber-optic DTS:
    - Near-continuous operation since April 2012.
    - The repaired fiber-optic DTS unit arrived at the Energy & Environmental Research Center (EERC) the week of March 7, 2016. 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. Installed the repaired DTS unit on March 23, 2016.
  - Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts:
    - Consistent progress since April 2011.
    - Updated the simulation database for Phase 3 with production/injection data.
    - Analyzed Bell Creek Phase 3 water-flooding stage and boundary conditions for use in simulation activities.
  - Continued passive seismic monitoring of 04-03 OW using the borehole seismic array:
    - Near-continuous operation since May 22, 2013.
    - Completed 3-D VSP horizon picks, allowing the first look at the differencing and cross-equalization measures.
    - Continued 4-D VSP analysis, including well logs data loading and analysis and calibration with 3-D VSP.
  - Completed a PowerPoint presentation regarding the quality control of the PNL data collected from the fall 2015 campaign.

- Worked with historical InSAR data for the Bell Creek Field prior to CO_2 injection (2007–2012), and compared results with historical production/injection data over the same time period. Began statistical analyses of "noise" in the available InSAR data to determine the baseline for comparison with potential future InSAR surveys.
- Used the most recent publicly available data to determine that cumulative total CO_2 gas injection is 4,489,133 metric tons through January 31, 2016. 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.
- Continued working with a Denbury representative to start collecting ten additional oil samples from the Bell Creek Field. This is slated to begin in BP5 (April 2016). Samples will be collected every 2 months for 1.5 years and analyzed at the EERC.
- A summary of all oil and CO_2 gas stream samples collected for analysis to date is provided in Table 3.
- Participated in several conference call meetings with a consultant from The CETER Group (CETER) discussing Bell Creek MVA measurements, risk assessment categories, etc. Initiated an effort with a consultant from CETER to draft a white paper that will be the product of a Bell Creek MVA efforts review.

Table 1. Bell Creek CO_2 Gas Injection Totals for January 2016 (cumulative totals May 2013 to January 2016)[1]

	January 2016 Injection
Total, Mscf	4,129,816
Total, U.S. tons[2]	236,219
Total, metric tons[2]	214,502
Cumulative Total, Mscf [2]	86,429,286
Cumulative Total, U.S. tons[2,3]	4,943,619
Cumulative Total, metric tons[2,3]	4,489,133

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.

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,[2] Jan 2015,[2,3] May 2015,[3,4] June 2015,[3] Nov 2015[3,5]
Production: CO_2 Gas[1]	Sept 2014,[2] Nov/Dec 2014, Jan 2015,[6] March 2015, July 2015
Purchase/Recycle: CO_2 Gas[7]	May 2014,[8] 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] Samples collected but not analyzed.
[4] Wells 32-02 and 05-06 only.
[5] Wells 56-14R and 05-06 only.
[6] Well 05-06 only.
[7] Both purchase and recycle streams unless otherwise noted.
[8] 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

- Attended and presented at the North Dakota Carbon Management Industrial Working Group Meeting held March 9–10, 2016, in Bismarck, North Dakota.
- Submitted M36 entitled "Technical Advisory Board Meeting Scheduled" on March 31, 2016, for review. Received approval March 31, 2016.
- Participated in a DOE BPM Synergy conference call and WebEx on March 17, 2016. The status of all of the DOE BPMs and a schedule for completing the documents for NETL management review were discussed.
- Reviewed and commented on the current draft of the DOE Simulation and Risk Assessment BPM. The comments were submitted to DOE, along with text for specific sections of the document as requested.
- Continued planning for the spring 2016 Technical Advisory Board meeting to be held in New Orleans, Louisiana, on April 5–6, 2016. Finalized the agenda, presentation, and meeting/hotel logistics.
- Continued planning the 2016 PCOR Partnership Annual Membership Meeting, including choosing the evening event venue and discussing topics for the workshop.
- Held a task leader meeting March 1, 2016. Topics included upcoming conferences, including CCUS (carbon capture, utilization, and storage) and Greenhouse Gas Control Technologies (GHGT)-13, for which abstracts were submitted; Bell Creek and Aquistore project updates; upcoming meetings; and task leader updates.
- Completed deliverables and milestones in March:
  - February monthly update
  - Task 2: D11 – Outreach Action Plan (Update 2)
  - Task 6: D45 – Bell Creek Test Site – Infrastructure Development Report
  - Task 9: M56 – Life Cycle Analysis for Primary and Secondary Recovery Oil Completed
  - Task 9: M58 – Bell Creek Test Site – Completion of 2.75M Metric Tons of CO_2 Stored
  - Task 13: M36 – Technical Advisory Board Meeting Scheduled

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

Highlights

- Formally waived the March conference call based on limited work required by the WWG at this time.
- Discussed progress of the *International Journal of Greenhouse Gas Control* (IJGGC) Special Issue and path forward with a consultant from CETER. Elsevier has suggested that existing submissions be processed for regular publication and then be included with other prior submissions to create a "virtual jounal" focused on water issues.
- Discussed status of remaining papers for the IJGGC Special Issue with PCOR Partnership management and a consultant from CETER. Three papers still require a decision to proceed.

Began reviewing the papers in light of the alternate publication plan proposed by Elsevier and will make a decision in April. A review team is being assigned to the remaining papers.

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

- March 9–10, 2016: Traveled to Bismarck, North Dakota, to attend the North Dakota Carbon Management Industrial Working Group meeting.
- March 22–24, 2016: Traveled to Glendive, Montana, for site work at the Bell Creek site.

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