



Plains CO₂ Reduction (PCOR) Partnership
Energy & Environmental Research Center (EERC)

Plains CO₂ Reduction (PCOR) Partnership Monthly Update May 1–31, 2016

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Continued efforts to update Deliverable (D) 81, Regional Carbon Sequestration Atlas (update), including:
 - Continued adding text and figures where needed in Chapters 1–5, including the Aquistore project and green oil pages.
 - Continued to update and develop new text for the regulatory pages. Text covers the differences in regulations and processes for Class II and Class VI wells and information pertaining to injection construction requirements.
 - Updated list of completed, current, and planned global carbon capture and storage (CCS) projects.
- 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: 83 new North Dakota wells and one new Montana well added.
 - Updated North Dakota production data.
 - Updated South Dakota, Manitoba, and Saskatchewan projects.
 - Updated information on existing wells, such as current operator, status, etc.
 - Continued working with well logs from Wyoming. Finalized the process to fully import the updated Wyoming well list into Petra.
 - Continued database preventive maintenance of Petra projects.
- With regard to the **Williston Basin** CO₂ Storage Sink Relative Permeability Laboratory Characterization:
 - Worked on relative permeability testing on the fifth sample (second Lodgepole limestone).
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
 - Submitted an abstract entitled "A Numerical Simulation Update of the Aquistore CO₂ Storage Project" to be presented at the 2016 AIChE Annual meeting being held November 13–18, 2016.
 - Participated in the Science and Engineering Research Committee (SERC) conference call on May 18, 2016. Presented on the history match modeling efforts, our interpretations of

- changes in injectivity that have been observed, and the results of spinner and pulsed-neutron log (PNL) surveys by WebEx.
- Continued to download and process daily injection and pressure data as available.
- Modified the model to match recent field performance:
 - ◆ Worked on a model with a new grid system and uniformly sized cells. Evaluated a pressure buildup effect in the model.
 - ◆ Analyzed field pressure data.

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

Highlights

- Submitted a value-added report entitled “Household Energy and Carbon Web Pages Report” on May 6, 2016, regarding visitor activity to the North Dakota Department of Commerce Division of Community Services-funded Household Energy and Carbon Web pages linked to the PCOR Partnership Web site. Received approval on May 31, 2016.
- Submitted D17 entitled “General Phase III Information PowerPoint Presentation (Update 7)” on May 31, 2016.
- Continued work on content for D13 (Public Site Update) related to the PCOR Partnership public Web site. Continued updating the standard operating procedures contained in the appendix of D13.
- Continued revisions to the updated Phase II Lignite fact sheet. The fact sheet is under internal review.
- The Regional Carbon Sequestration Partnerships (RCSP) Outreach Working Group (OWG) monthly call was canceled for May 2016.
- Provided a copy of the PCOR Partnership Outreach Action Plan (update) (D11) to the coordinator of the OWG.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
 - Several PCOR Partnership public Web site items went live on May 17, 2016, including:
 - ◆ Replaced the General Phase III PCOR Partnership fact sheet.
 - ◆ Replaced several broken links.
 - ◆ Uploaded several existing fact sheets to improve search engine optimization parameters.
 - ◆ Added a button for the 2016 PCOR Partnership Annual Meeting registration.
 - Worked on the development of a new Web page for the Task 9 life cycle analysis (LCA) model.
 - Continued ongoing identification and repair of broken links.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
 - Updated travel and interview plans for documentaries D21 (the Bell Creek Story) and D22 (Coal and the Modern World).
 - Continued work on documentary D22:
 - ◆ Researched domestic lighting, cooking, and heating in greater detail to bolster sections of the script.
 - ◆ Traveled to Fargo, North Dakota, to meet with PPB personnel on May 10, 2016. Reviewed the rewritten second draft of the script (68 pages) and the material that had been produced from the script.

- ◆ Prepared a third draft of the script (60 pages) based on comments from PPB.
- ◆ Traveled to Fargo, North Dakota, to meet with PPB personnel on May 18, 2016. Produced the 50-minute narrative based on the second draft of the script.
- ◆ Reviewed sources, identified likely interviews, and revised portions of the script in response to an internal review session held May 20, 2016.
- ◆ Contacted a representative from North American Coal Corporation with respect to an interview.

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

Highlights

- Attended the Interstate Oil and Gas Compact Commission (IOGCC) Annual Business Meeting in Denver, Colorado, on May 16–17, 2016. Topics of interest included new and proposed rules and regulations, marginal wells and their challenges, and enhanced oil recovery (EOR) and CO₂ storage in mature marginal oil wells.
- Attended the Williston Basin Petroleum Conference (WBPC) Annual Meeting in Bismarck, North Dakota, on May 24–26, 2016.
- 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 review of the preliminary outline and draft introduction text prepared by a consultant from The CETER Group (CETER).
 - Discussed D76 development with a consultant from CETER.
- Reviewed comments on the regulatory portion of the PCOR Partnership Regional Carbon Sequestration Atlas and researched California carbon markets and offsets.

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

Highlights

- **Bell Creek** test site activities included the following:
 - Submitted D33/Milestone (M) 12 entitled “Bell Creek Test Site – Preinjection Geochemical Report” on May 2, 2016. D33/M12 was originally approved by DOE on January 30, 2014, with one change requested. Denbury Onshore (Denbury) reviewed the document, changes were made, and Denbury approved the changes.
 - Continued work on the PCOR Partnership Site Characterization BPM (best practices manual, D35), including revising the outline based on PCOR Partnership management recommendations and working on the executive summary.
 - Continued work on **modeling**, including the following:
 - ◆ Continued work on the Version 3 facies model, including performing depositional environment research.
 - ◆ Continued work on the Bell Creek near-surface model. This model will be used to help understand the effect of CO₂ storage on the near-surface environment. Work included:
 - Researched the petrophysics of the Hell Creek and Fox Hills Formations.
 - Modified surfaces, defined facies, and analyzed petrophysical data acquired for the Hell Creek and Fox Hills Formations.

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

- Reformatted the manuscript that was included in the value-added report entitled “Assessing Temporary Storage Options to Manage Variable-Rate CO₂ Emissions for Use During Enhanced Oil Recovery” as required for submission to *Energy & Environmental Science*.

Task 7 – CO₂ 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 and Larry J. Pekot)

Highlights

- Participated in the California Area Resource Board CCS Technical Discussion Series: Well Mechanical Integrity Technical Discussion Webinar held May 12, 2016. Presented on the topic of risk and criteria for legacy wells and tools for well integrity.
- Submitted two memos regarding official updated numbers for metric tons of CO₂ purchased for injection and metric tons of CO₂ stored at Bell Creek.
 - As of February 29, 2016, 2.974 million tonnes of total gas (composition of approximately 98% CO₂) has been purchased for injection into the Bell Creek Field, equating to an estimated 2.920 million tonnes of CO₂ stored.
 - As of April 30, 2016, the most recent month of record, 3.100 million tonnes of total gas (composition of approximately 98% CO₂) has been purchased for injection into the Bell Creek Field, equating to an estimated **3.044 million tonnes of CO₂ stored**.
- Submitted M57 entitled “Life Cycle Analysis for Primary and Secondary Enhanced Oil Recovery at the Bell Creek Field Completed” on May 26, 2016. Received approval on May 31, 2016.
- Submitted an abstract entitled “Lessons Learned in Near-Surface Monitoring for Large-Scale CO₂ Storage” to be presented at the 2016 AIChE Annual Meeting being held November 13–18, 2016.
- Attended the WBPC Annual Meeting in Bismarck, North Dakota, on May 24–26, 2016.
- Worked on a presentation regarding Bell Creek simulation and history matching that will be presented at Computer Modelling Group’s (CMG’s) 37th Technical Symposium to be held June 13–14, 2016, in Calgary, Alberta, Canada.
- Upon request from the National Energy Technology Laboratory (NETL) review, revised a figure caption related to a sidebar provided for the DOE monitoring, verification, and accounting (MVA) BPM.

- Continued work on the Bell Creek Test Site – BPM – Monitoring for CO₂ Storage and CO₂ EOR (D51), including writing the lessons learned section and revising the outline based on PCOR Partnership management recommendations.
- Continued revision of D66 (Bell Creek Test Site – Simulation Report [Update 4]) based on comments from Denbury.
- Continued work on the LCA of oil produced during EOR compared with oil produced conventionally:
 - Collected information for the Bell Creek Field-specific LCA models and requested additional data from Denbury.
 - Worked with the internal outreach group to create a plan for making a spreadsheet-based model for conducting LCA of CO₂ EOR available on the PCOR Partnership public Web site.
- Continued working with CETER to finalize the LCA journal article that will be resubmitted to the *International Journal of Greenhouse Gas Control* (IJGGC). This revised draft incorporates the comments from the reviewers and should be ready for publication.
- Worked on fluid characterization and equation of state (EOS) data requested from the editor of the minimum miscibility pressure (MMP) paper submitted to *Energy & Fuels*.
- **Bell Creek** injection-phase site activities included the following:
 - Continued reservoir pressure and distributed temperature monitoring of the 05-06 OW (observation well) from the permanent downhole monitoring (PDM) system using the casing-conveyed pressure–temperature gauges (PTGs) and fiber-optic distributed temperature system (DTS):
 - ♦ Near-continuous operation since April 2012.
 - Continued dynamic reservoir pressure and multiphase fluid flow simulation efforts:
 - ♦ Continued reviewing and comparing several simulation results from the simulation cluster.
 - ♦ Continued work on a long-term CO₂ migration model at reservoir scale for the Bell Creek oil field. The purpose of the model is to see how CO₂ migrates in the reservoir on a basin scale over 10,000 years. Started running two simulation cases with different CO₂ injection levels. Initial results show the overall migration is slow, with plume distribution controlled by the reservoir properties and structure.
 - ♦ Discussed grid upscaling and sensitivity in CMG Builder with a representative from CMG.
 - Continued passive seismic monitoring of 04-03 OW using the borehole seismic array:
 - ♦ Near-continuous operation since May 22, 2013.
 - Continued 4-D vertical seismic profile (VSP) analysis and interpretation, including 4-D VSP differencing.
 - Used the most recent publicly available data to determine that cumulative total CO₂ gas injection is 4,863,587 metric tons through March 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% CO₂ (Table 1).
 - As of March 31, 2016, corresponding to the end of BP4, 3.034 million tonnes of total gas (composition of approximately 98% CO₂) had been purchased for injection into the Bell Creek Field, equating to an estimated **2.979 million tonnes of CO₂ stored**.

Table 1. Bell Creek CO₂ Gas Injection Totals for March 2016 (cumulative totals May 2013 to March 2016)¹

	March 2016 Injection
Total, Mscf	3,371,617
Total, U.S. tons ²	192,851
Total, metric tons ²	175,122
Cumulative Total, Mscf ²	93,638,644
Cumulative Total, U.S. tons ^{2,3}	5,355,983
Cumulative Total, metric tons ^{2,3}	4,863,587

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.

- As of April 31, 2016, the most recent month of record, 3.100 million tonnes of total gas (composition of approximately 98% CO₂) has been purchased for injection into the Bell Creek Field, equating to an estimated 3.004 million tonnes of CO₂ 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 CO₂ storage volume estimate by correcting the gas purchase volume (approximately 98% CO₂) obtained from Denbury's custody transfer meter with gas compositional data.
- Staff traveled to Gillette, Wyoming, to perform Bell Creek oil compositional monitoring during a sampling trip the week of May 16, 2016. Sampled Wells 56-14R, 05-06, 04-04, 28-02, 21-10, and 21-14. Four other wells were not sampled because of no production. Samples will continue to be collected every 5–6 weeks unless otherwise noted.
- A summary of all oil and CO₂ gas stream samples collected for analyses to date is provided in Table 3.
- Staff traveled to Gillette, Wyoming, the week of May 23, 2016, for sample collection and site maintenance.
 - ♦ Collected 21 soil gas sample bags and associated field readings at ten soil gas profile stations in the Bell Creek Field on May 24, 2016. Field gas chromatography analyses are under way.
- Continued internal review of landowner package water quality final overview compilation.

Table 2. Cumulative Total Gas Purchased and Estimated Associated CO₂ Storage Volumes for the Bell Creek Field¹

	April 2016 Gas Volume
Monthly Total Gas Purchased, MMscf ²	1271
Monthly Total Gas Purchased, million tons ²	0.073
Monthly Total Gas Purchased, million tonnes ²	0.066
Cumulative Total Gas Purchased, MMscf ^{2,3}	59,689
Cumulative Total Gas Purchased, million tons ^{2,3}	3.414
Cumulative Total Gas Purchased, million tonnes ^{2,3}	3.100
Cumulative Total CO ₂ Stored, MMscf ^{3,4}	58,604
Cumulative Total CO ₂ Stored, million tons ^{3,4}	3.352
Cumulative Total CO ₂ Stored, million tonnes ^{3,4}	3.044

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 CO₂ stored volumes are **CORRECTED** for gas composition.

Table 3. Oil and CO₂ 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} May 2016 ⁶
Production: CO ₂ Gas ¹	Sept 2014, ² Nov/Dec 2014, Jan 2015, ⁷ March 2015, July 2015
Purchase/Recycle: CO ₂ Gas ⁸	May 2014, ⁹ 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 Wells 56-14R, 05-06, 04-04, 28-02, 21-10, and 21-14.

⁷ Well 05-06 only.

⁸ Both purchase and recycle streams unless otherwise noted.

⁹ Purchase stream only.

Task 10 – Site Closure (John A. Hamling)

Highlights

- This task was initiated at the start of BP5 on April 1, 2016.

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

Highlights

- This task was initiated at the start of BP5 on April 1, 2016.

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights

- Nothing to note at this time.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- **Red Trail Energy, LLC, and Tundra Oil and Gas joined the PCOR Partnership as paying members.**
- Attended the 2016 Midwest Carbon Sequestration Science Conference in Champaign, Illinois, May 16–17, 2016. The Midwest Geological Sequestration Consortium (MGSC), the Sequestration Training and Education Program (STEP), and Schlumberger Carbon Services hosted the knowledge-sharing event focused on accomplishments at the Illinois Basin – Decatur Project in Decatur, Illinois. The PCOR Partnership program manager presented a “Lessons Learned” PowerPoint presentation in a panel discussion.
- Attended the WBPC held May 24–26, 2016, in Bismarck, North Dakota. Presented work performed under multiple tasks.
- Worked on a presentation for the 5th U.S.–China Symposium on CO₂ Emission Control to be held in Hangzhou, China, June 5–7, 2016. The PCOR Partnership program manager and a researcher will attend this conference and present. The presentation gives an overview of the PCOR Partnership’s CO₂ storage activities.
- Began compiling possible images for use on the cover pages of the various DOE BPMs, as requested by DOE.
- Worked on D102 – Adaptive Management Approach BPM, including:
 - Revised the document outline.
 - Held several phone calls with a consultant from CETER to discuss the outline and vision for the document.
 - Prepared and reviewed the draft document summary.
- Continued planning the 2016 PCOR Partnership Annual Membership Meeting and workshop. The meeting Web site went live May 16, 2016 (<http://www.undeerc.org/PCOR16/>). On May 18, 2016, sent an e-mail blast announcing that registration is open.
- Held a task leader meeting May 3, 2016. Topics discussed included hiring and interviewing additional personnel, Bell Creek and Aquistore project updates, upcoming conferences and meetings, and individual task leader updates. Also discussed was the continued commercial interest in PCOR Partnership membership; three companies were currently discussing membership at the time of the task leader meeting.
- Responded to a partner’s request regarding information on the PCOR Partnership Terrestrial Field Validation Test.
- Completed deliverables and milestones in May:
 - April monthly update
 - Task 2: D17 – General Phase III Information PowerPoint Presentation (Update 7)
 - Task 9: M57 – Life Cycle Analysis for Primary and Secondary Enhanced Oil Recovery at the Bell Creek Field Completed
 - Task 14: D101 – Water Working Group Web Site Content Update

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

Highlights

- Created a draft outline for D107 (Journal Article or Topical Report – Major Research Focuses for Water and CCS).
- Submitted D101 entitled “Water Working Group Web Site Content Update” on May 31, 2016.
- With regard to the IJGGC Special Issue:
 - Reviewed a revised paper submission.
 - Discussed progress of other reviews with a consultant from CETER.
 - Received a draft of the revised introductory paper from a consultant from CETER.
 - Sent one paper back to the author for revision.
 - Discussed progress of the overview paper with a consultant from CETER. Provided comments.
- Continued annual meeting agenda development. Discussed potential ideas with Andrea McNemar.

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO₂ 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

- May 10, 2016: Traveled to Fargo, North Dakota, for planning and documentary script development meetings.
- May 14–18, 2016: Traveled to Denver, Colorado, to attend the IOGCC Annual Meeting.
- May 16–17, 2016: Traveled to Champaign, Illinois, to present at the 2016 Midwest Carbon Sequestration Science Conference.
- May 16–20, 2016: Traveled to Gillette, Wyoming, for Bell Creek sample collections.
- May 18, 2016: Traveled to Fargo, North Dakota, to work on the coal documentary with PPB.
- May 23–26, 2016: Traveled to Bismarck, North Dakota, to attend the WBPC.
- May 23–27, 2016: Traveled to Gillette, Wyoming, for sample collection and site maintenance.

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