Plains CO_2 Reduction (PCOR) Partnership Monthly Update
August 1–31, 2015

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Attended the Society of Core Analysts Symposium and associated field trip "Stratigraphy of the Neoproterozoic–Cambrian" near St. John's, Newfoundland, Canada, August 16–22, 2015.
- Attended and presented a poster entitled "MVA Deployment Using Near-Real-Time History Matching at the Aquistore Site" at the U.S. Department of Energy (DOE) Carbon Storage R&D Project Review Meeting in Pittsburgh, Pennsylvania, August 18–20, 2015.
- Modified the scope of work for the Williston Basin relative permeability laboratory work and provided to Energy & Environmental Research Center (EERC) Plains CO_2 Reduction (PCOR) Partnership managers for review.
- Selected core intervals at the North Dakota Geological Survey Core Library from several wells for laboratory characterization. Drilled plugs from several intervals.
- Continued working with data for the annual updating of carbon dioxide (CO_2) sources within the PCOR Partnership region.
- Continued compiling regional characterization data for the Mission Canyon Formation.
- Updated information and continued work on the partners-only Decision Support System (DSS) Web site:
  - Updated the PCOR Partnership Annual Membership Meeting information on the DSS Web site.
  - Continued database preventive maintenance of Petra projects.
  - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resource: 236 new North Dakota wells and six new Montana wells were added.
  - Updated North Dakota monthly production information.
  - Updated South Dakota, British Columbia, and Manitoba wells.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Continued to update database with daily injection data from Petroleum Technology Research Centre (PTRC).
  - Continued work on the simulation model.
  - Continued work on comparing properties in the static model with the history-matched simulation model properties. The purpose is to compare the two models to ensure changes made to achieve a history match make sense with the known geologic data.

- A summer graduate student intern helped with Aquistore modeling activities. He continued to review previously developed static and dynamic models, including comparing the current dynamic history-matched simulation model with the static model to compare properties. This information will be used to reinvestigate the model data for accuracy, and the static model will be updated as necessary.

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

Highlights

- Prepared for and held a quarterly update session with senior managers on August 5, 2015. The session featured detailed discussions on next steps for documentary Deliverables (D)21 (Bell Creek story) and D22 ("Coal and the Modern Age").
- Prepared a poster entitled "PCOR Partnership Outreach – A Multifaceted Program," which was presented at the DOE Carbon Storage R&D Project Review Meeting in Pittsburgh, Pennsylvania, August 18–20, 2015.
- Continued work on the draft Phase II project fact sheets. EERC PCOR Partnership managers continued review of the updated Phase II Northwest McGregor and Lignite fact sheets.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Continued work on PCOR Partnership public Web site updates, including addressing comments from internal review.
  - Completed review of the draft final PCOR Partnership Web site upgrade.
  - Continued ongoing identification and repair of broken links.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Continued efforts to schedule interviews and location shoots for documentary D22.
  - Scheduled an interview for D22 for September 15, 2015, in Minneapolis, Minnesota.
  - Completed review of all interview footage and interview transcriptions for documentary D22 as the first step in postproduction.
  - Provided edit notes to PPB on Education Presentations Video Series Parts 3 and 4.

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

Highlights

- Continued gathering information for value-added report on rules, regulations, and statutes for various scenarios of carbon capture and storage (CCS) geologic storage and for CO_2 enhanced oil recovery (EOR) for each of the PCOR Partnership states and provinces.
- Continued planning for D8, Permitting Review – Update 2, due September 30, 2015, including information contained in the U.S. Environmental Protection Agency's (EPA) Final Carbon Pollution Standards for New, Modified and Reconstructed Power Plants released August 3, 2015.
- Continued work on preparing descriptor language and flowcharts of North Dakota injection well permitting requirements.
- Provided comments to NDIC on the Interstate Oil and Gas Compact Commission (IOGCC) resolution and action plan "Clarifying Issues Related to Transitioning a Class II Carbon

Dioxide Enhanced Oil or Gas Recovery Project to a Class VI Geologic Storage Project" for its submittal at the IOGCC Annual Meeting September 28–30, 2015, in Oklahoma City, Oklahoma.

Task 4 – Site Characterization and Modeling (James A. Sorensen)

Highlights

- **Bell Creek** test site activities included the following:
  - Traveled to Denver, Colorado, to view cores at the U.S. Geological Survey Core Research Center August 9–12, 2015.
  - Continued work on the PCOR Partnership site characterization best practices manual (BPM) (D35).
  - Continued working on the construction of regional- and basin-scale Bell Creek Muddy Formation models.
  - Continued work on geomechanical modeling, including the following:
    - Reviewed the process for creating a 1-D mechanical earth model (MEM) using JewelSuite Geomechanics software. This recently acquired software may serve as an alternate means of developing these types of models.
    - Used JewelSuite Geomechanics software to investigate potential improvements to the rock mechanics in the 1-D MEM, and perform 1-D geomechanical analyses (including wellbore stability).
    - Reviewed the values for Young's modulus and Poisson's ratio derived from the 3-D seismic amplitude versus offset (AVO) inversion and comparing them with previous values.
    - Worked on the stress regime calculations with the 3-D seismic data.
    - Continued using Hampson–Russell seismic interpretation software to review the workflow for seismic inversion of the Bell Creek seismic data.
  - Installed the newest version of Computer Modelling Group (CMG) software and reviewed the new features related to geomechanical simulations for their applicability to the Bell Creek work.
  - Worked on creating facies logs for wells in the Bell Creek Field. These logs will be important as control points for a multiple-point statistics facies distribution that will be performed in the model.
  - Continued working on improving the 3-D rock mechanical properties using additional information from well logs, pulsed-neutron logs (PNLs), lab data, and 3-D seismic data.
  - Worked on creating detailed cross sections in Phases 3–6 to determine both lateral and vertical facies associations. This will serve as a knowledge base for modeling efforts in Phases 3–6.
  - Continued analyzing the formation tops in the Version 2 geologic model. Tops are being adjusted as needed to create a more realistic structure which, in turn, will lead to better simulation and history-matching results.
  - Summer graduate student interns continued preparing Bell Creek data for modeling.
  - Continued exploring the geomechanics module of COMSOL multiphysics and investigating the application of this software to the Bell Creek geomechanical simulation work.
  - Continued work on Applied Geology Laboratory activities, which included the following:

- ♦ With regard to the 33-14R core (collected April 2013):
  - Continued work on the permeability-to-air report.
- ♦ With regard to the 56-14R full-core plugs (collected March 2013):
  - Continued work on final reporting of core work on 56-14R, including a brine permeability study.

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 internal PCOR Partnership management review of a value-added report entitled "Assessing Temporary Storage Options to Manage Variable-Rate CO_2 Emissions for Use During Enhanced Oil Recovery." Following DOE review, the authors plan to submit the manuscript for possible publication in *Energy & Environmental Science*.

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)

Highlights

- Continued preparation of D49 (due September 30, 2015), the Bell Creek Test Site Transportation and Injection Operations Report.

Task 9 – Operational Monitoring and Modeling (Charles D. Gorecki)

Highlights

- Attended CMG EOR Modeling Using GEM training course in Calgary, Alberta, Canada, August 1–9, 2015.
- Traveled to Gillette, Wyoming, to collect samples and to meet with landowners for the Bell Creek project August 4–6, 2015.
- EERC personnel attended the CMG Webinar: Mechanistic Modelling of Low Salinity Water Flooding in Clastics and Carbonates.
- Prepared posters entitled "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" and "The Adaptive Management Approach to CCS Project Planning: The Fort Nelson CCS Project As a Case Study" presented at the DOE Carbon Storage R&D Project Review Meeting in Pittsburgh, Pennsylvania, August 18–20, 2015.
- Began preparing a poster to be presented at the 2015 European Association of Geoscientists and Engineers (EAGE) Petroleum Geostatistics conference in Biarritz, France, in September entitled "Multiscale Reservoir Modeling for CO_2 Storage and Enhanced Oil Recovery Using Multiple-Point Statistics."

- Prepared a presentation on the use of adaptive management approach to develop a risk-based monitoring, verification, and accounting (MVA) plan for Fort Nelson for the International Energy Agency Greenhouse Gas (IEAGHG) Risk Management & Environmental Research Combined Networks Meeting in Southampton, United Kingdom, September 29 – October 2, 2015.
- **Bell Creek** injection-phase site activities included the following:
  - Continued experimentation of mobilized hydrocarbons using methane, CO_2, and ethane at Bell Creek reservoir conditions and data evaluation.
  - Began preparation for a Denbury update meeting to be held in September.
  - Began efforts to develop a Bell Creek Phase 3–7 simulation model to begin the history-matching process, including processing the production and injection data for the Phase 3 area.
  - Compared continuous CO_2 injection and water-alternating-gas (WAG) cases in the Phase 1 and 2 areas. Investigated the effect of variable water injection rates on reservoir performance.
  - Samples have arrived from Core Labs for the special core analysis (SCAL) work performed on the 33-14R cores. CO_2–oil relative permeability will be performed on the same samples to determine the hysteresis effect with multiple injections.
  - Submitted D66, "Bell Creek Test Site – Simulation Report (Update 4)."
  - Submitted Milestone (M)51 "Bell Creek Test Site – Initial Analysis for First Large-Scale Repeat Pulsed-Neutron Logging Campaign Post-Significant CO_2 Injection Completed."
  - The recording issues of the borehole seismic array in 04-03 OW were fixed. It was likely a power surge that caused the recording to stop.
  - Worked on microseismic processing using GeoTomo software. Worked on constructing the 3-D velocity model.
  - Held weekly Bell Creek modeling and simulation meeting. Work completed to date on the history matching of single wells in the Bell Creek Field was presented.
  - Continued to monitor the seismic acquisition system via remote check-in and e-mail updates.
  - Continued development of Bell Creek near-surface MVA sampling strategies for FY2016.
  - Continued working on preliminary planning for a potential PNL campaign centering on Phases 1–4. This process includes identifying wells important for monitoring CO_2 saturation changes during injection, wells needing additional characterization data, and wells important for understanding sweep efficiency in specific geologic conditions and the impacts of WAG compared to continuous CO_2 injection.
  - Continued work on numerical tuning for the simulation model to reduce run time and improve computational efficiency.
  - Continued determination of Bell Creek crude oil density to get API (American Petroleum Institute) gravity.
  - Continued developing an outline and executive summary of the PCOR Partnership MVA BPM.
  - A graduate student intern continued working on processing the microseismic data collected at Bell Creek.

- Used the most recent publicly available data to determine that cumulative CO_2 gas injection is 2,539,042 metric tons through April 30, 2015 (Table 1).
- New methodology has been implemented to provide DOE with cumulative total gas purchase volumes for injection (not corrected for gas composition) and estimated associated CO_2 storage volumes (corrected for gas composition) in addition to total gas injection volumes. Custody transfer meter data supplied by Denbury provides monthly total gas purchase volumes, which are then corrected using gas compositional data. As of July 31, 2015, the most recent month of record, 2.383 million tonnes of total gas (composition of approximately 96% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated 2.301 million tonnes of CO_2 stored (Table 2).
- Continued injection-phase sampling work, including the following:
  - Traveled to Gillette, Wyoming, for sampling at the Bell Creek site August 23 – September 1, 2015.
  - Traveled to Miles City, Montana, for Bell Creek site sampling work August 24–28, 2015.

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

	April 2015 Injection
Total, Mscf	3,280,561
Total, U.S. tons*	187,643
Total, metric tons*	170,392
Cumulative Total, Mscf[+]	48,884,167
Cumulative Total, U.S. tons*[+]	2,796,097
Cumulative Total, metric tons*[+]	2,539,042

Source: MBOG database.

* There has been a lag in posting of injection/production volumes to the MBOG database. This was calculated utilizing a conversion of 17.483 Mscf/U.S. ton and 19.253 Mscf/metric ton.

[+] 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]

	July 2015 Gas Volume
Month Total Gas Purchased, MMscf[2]	1928
Month Total Gas Purchased, million tons[2]	0.110
Month Total Gas Purchased, million tonnes[2]	0.100
Cumulative Total Gas Purchased, MMscf[2,4]	45,876
Cumulative Total Gas Purchased, million tons[2,4]	2.624
Cumulative Total Gas Purchased, million tonnes[2,4]	2.383
Cumulative Total CO_2 Stored, MMscf[3,4]	44,299
Cumulative Total CO_2 Stored, million tons[3,4]	2.534
Cumulative Total CO_2 Stored, million tonnes[3,4]	2.301

[1] Conversion factors of 17.483 Mscf/ton and 19.253 Mscf/tonne were used to calculate volumes.

[2] Total gas injection volumes ***NOT CORRECTED*** for gas composition.

[3] Total gas injection volumes ***CORRECTED*** for gas composition.

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

- ♦ Activities completed from the annual full-field event (August 24–28, 2015):
  - Collected approximately 350 total soil gas samples, including original samples, field blanks, and duplicates.
    - Analysis is under way.
  - Sampled 19 out of 20 groundwater planned groundwater locations, including the two Fox Hills Formation groundwater monitoring wells.
    - One groundwater site could not be sampled as no power was available to pump the sample.
    - Analysis is under way.
  - Distributed remaining finalized landowner packages (April 2015 groundwater results) previously approved by Denbury to landowners.
    - The initial April 2015 packages were delivered to the landowners during the August 4–6 site visit.
- ♦ Activities completed from the Bell Creek MVA sampling event (June 22–27, 2015):
  - Completed data compilation, archiving, quality assurance/quality control (QA/QC), and processing for over 200 total soil gas samples from the micro gas chromatography (GC) and handheld meter analysis data sheets. Processing is under way.
  - Selected 15 Bell Creek soil gas samples from the June 2015 monitoring event for QA/QC verification analyses.
  - Completed laboratory GC QA/QC verification analysis for nine confirmation samples.
- ♦ Activities completed from the sampling trip (April 24–30, 2015):
  - Completed laboratory GC confirmation analyses (26 samples).
  - Completed QA/QC review of database; minor corrections and updates were made.

Task 10 – Site Closure (to be announced [TBA])

- This task is anticipated to be initiated in Quarter 1 – BP 5, Year 9 (April 2016).

Task 11 – Postinjection Monitoring and Modeling (TBA)

- This task is anticipated to be initiated in Quarter 1 – 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
- Held a task leader meeting August 4, 2015. Topics discussed included the BP4 extension; brief updates on Bell Creek and Aquistore; upcoming conferences/meetings, including the DOE Carbon Storage R&D Program Review meeting; and task leader updates.

- Attended the U.S.–Norway data-sharing workshop/meeting on August 17, 2015, in Pittsburgh, Pennsylvania.
- Attended the U.S. DOE Carbon Storage R&D Project Review Meeting in Pittsburgh, Pennsylvania, August 18–20, 2015. Five PCOR Partnership posters and a booth that included PCOR Partnership materials were presented at the meeting. The posters covered the following topics: Aquistore history matching, outreach, Fort Nelson Best Practices Manual, Water Working Group (WWG), and laboratory minimum miscibility testing. A poster regarding the PCOR Partnership's regulatory activities was planned but never developed. The abstract covering this topic was withdrawn from the conference. A Bell Creek talk was given during a plenary session. A booth backdrop was created for the conference.
- Attended the National Risk Assessment Partnership (NRAP) Stakeholders Meeting in Pittsburgh, Pennsylvania, August 20–21, 2015.
- Travel to Billings, Montana, to attend the China Inaugural Clean Coal Initiative meeting August 24–28, 2015.
- Continued preparing for the PCOR Partnership Annual Membership Meeting, including finalizing speakers and agendas for the CO_2 EOR Workshop, Aquistore Project side meeting, and Technical Advisory Board (TAB) side meeting.
- Completed deliverables and milestones in August:
  - July monthly update
  - Task 13: D66 – Bell Creek Test Site – Simulation Report (Update 4)
  - Task 9: M51 – Bell Creek Test Site – Initial Analysis for First Large-Scale Repeat Pulsed-Neutron Logging Campaign Post-Significant CO_2 Injection Completed

Task 14 – Regional Carbon Sequestration Partnership (RCSP) Water Working Group (WWG) Coordination (Ryan J. Klapperich)

Highlights

- Hosted the RCSP WWG Annual Meeting in Pittsburgh, Pennsylvania, August 18, 2015.
- Reviewed notes and action items from the WWG Annual Meeting.
- Attended the DOE Carbon Storage R&D Project Review meeting in Pittsburgh, Pennsylvania, August 18–20, 2015.
- Prepared a poster entitled "Long-Term Protection of Freshwater Resources" presented at the DOE Carbon Storage R&D Project Review Meeting in Pittsburgh, Pennsylvania, August 18–20, 2015.
- Sent confirmation e-mails along with instructions to authors responding to the abstract call for the special issue of *International Journal of Greenhouse Gas Control* (IJGGC) on the "Nexus of Water and Carbon Capture and Storage." Abstracts were due July 17, 2015.
- Received two additional special journal entries resulting from conversations at the U.S. DOE Carbon Storage R&D Project Review Meeting.
- Continued development of draft journal article for the special journal issue of IJGGC on behalf of the WWG.
- Received outlines of the DOE BPMs from Andrea McNemar and began review.
- Provided Key Logic with a copy of the updated WWG presentation for the WWG Web site and began a review of content.
- Distributed notes from the June 2015 call.

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

- August 1–9, 2015: Traveled to Calgary, Alberta, Canada, to attend CMG's EOR Modeling Using GEM training course.
- August 4–6, 2015: Traveled to Gillette, Wyoming, to collect samples and to meet with landowners for the Bell Creek project.
- August 9–12, 2015: Traveled to Denver, Colorado, to view cores at the U.S. Geological Survey Core Research Center.
- August 16–22, 2015: Traveled to St. John's, Newfoundland, Canada, to attend the Society of Core Analysts Symposium and field trip "Stratigraphy of the Neoproterozoic–Cambrian" near St. John's.
- August 17–20, 2015: Traveled to Pittsburgh, Pennsylvania, to attend the U.S.–Norway data-sharing workshop/meeting, present at the 2015 DOE Carbon Storage R&D Project Review Meeting, and attend the NRAP Stakeholders Meeting.
- August 23 – September 1, 2015: Traveled to Gillette, Wyoming, for sampling at the Bell Creek site.
- August 24–27, 2015: Traveled to Billings, Montana, to attend the China Inaugural Clean Coal Initiative meeting.
- August 24–28, 2015: Traveled to Miles City, Montana, for Bell Creek site sampling work.

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