Plains CO_2 Reduction (PCOR) Partnership Monthly Update
April 1–30, 2015

PHASE III ACTIVITIES

Task 1 – Regional Characterization (Wesley D. Peck)

Highlights

- Continued compiling information for the Plains CO_2 Reduction (PCOR) Partnership Atlas (5th edition) due August 2015.
- Worked on modifications to the upcoming U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) Atlas V.
- Continued creating databases to keep the team up-to-date regarding well information.
- Updated information and continued work on the partners-only decision support system (DSS) Web site:
  - Updated carbon dioxide (CO_2) storage in saline formation tables.
  - Updated Bell Creek production/injection GeoPDF maps through February 2015 for upcoming meetings and to the Bell Creek interactive map.
  - Continued work on reformatting the Bell Creek-related information.
  - Continued collecting images from the last version of the PCOR Partnership Atlas to put in the image gallery.
  - Continued to assemble a presentation on the DSS online mapping services to showcase the capabilities for viewing results in a comprehensive and interactive framework.
  - Updated North Dakota and Montana Petra projects with the latest general well information from each state's online resource as follows: 168 new North Dakota wells and six new Montana wells.
  - Updated the North Dakota well injection information and production data and South Dakota, Saskatchewan, and Manitoba project information.
- Continued work on several value-added reports, including the following:
  - Finished the draft Inyan Kara Formation report. It is currently undergoing internal review.
  - Continued work on the report summarizing methods of original oil in place and CO_2 storage calculations.
  - Continued efforts on the Cedar Creek Anticline white paper, including modifying the CO_2 enhanced oil recovery (EOR) section.
- With regard to the **Aquistore** project's static modeling and dynamic predictive simulations effort:
  - Began initiation of Aquistore injection on April 15. As of April 24, over 1555 tons of CO_2 had been injected.

- Worked on updating the Aquistore simulation in an iterative fashion using injection data. This data is being received daily from the Petroleum Technology Research Centre (PTRC).
- Created a script that calculates the average gamma ray value from the logs that were used in the model. This information is being used in the history-matching process.
- Analyzed the previous Aquistore model and prepared it for regular updates with field injection data. Built a new CO_2 injection-monitoring model with nested grids. This model uses the P50 average aquifer properties of the previous model and has a skin factor to simulate injectivity effects.
- Prepared a fact sheet discussing the Energy & Environmental Research Center's (EERC's) role in the Aquistore project and sent to DOE by request.
- Attended and presented at the 14th Annual CCUS (Carbon Capture, Utilization, and Storage) Conference (CCUS-14) in Pittsburgh, Pennsylvania, April 28 – May 1, 2015.
- Continued working with PTRC Science and Engineering Research Committee (SERC) regarding the Aquistore simulation model.

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

Highlights

- Continued efforts on an update to Deliverable 17 (D17), entitled "General Phase III Information PowerPoint," due May 31, 2015.
- Continued to follow up on e-mail invitations to interview and requests for site access as part of the next phase of obtaining interviews and field footage for documentary D22 (*Energy from Coal* 60-minute documentary).
- Presented at the University of North Dakota Harold Hamm School of Geology and Geological Engineering Annual Spring Banquet on April 17, 2015. The presentation featured the debut of clickers for audience feedback during the presentation as part of the continuing effort to gather information on audience feedback systems for use with public presentations and focus groups.
- Continued efforts to expand the type and presentation of statistics for overall past outreach activities and for planning.
- Continued to revise the draft Phase II project fact sheets, including meetings with project personnel to discuss content, with a focus on addressing comments from senior management regarding Northwest McGregor.
- Continued efforts to obtain site footage of the Kemper County facility.
- Completed a review of the 4th edition Atlas (revised) and provided the review to the Atlas team as a first step in contributing to the preparation of the 5th edition Atlas.
- Participated in the monthly Outreach Working Group call on April 23, 2015, that was focused on updating the outreach Best Practices Manual (BPM).
- Participated in the monthly Aquistore Communications Working Group call on April 27, 2015, which focused on the press release and arrangements for the Aquistore ribbon cutting event scheduled for late May.
- Continued efforts with regard to the public Web site (www.undeerc.org/pcor), including the following:
  - Moved forward on the current batch of Web page updates following internal review.

  - Worked on quarterly PCOR Partnership outreach maps showing PCOR Partnership Web visits.
  - Reviewed and updated candidate pages for Web updates based on discussions with EERC programmers.
  - Continued ongoing identification and repair of broken links.
  - Continued efforts to revise and update the carbon cycle page on the public Web site, focusing on graphic and interactive elements.
- Continued collaborative efforts with Prairie Public Broadcasting (PPB), including the following:
  - Participated in a conference call to discuss travel plans for D22.
  - Held a conference call on April 9, 2015, to discuss activities for the PPB Teacher Training Institute scheduled for June in the Fargo, North Dakota, area.
  - Continued editing Parts 3 and 4 of the four-part education video, and sent action items to PPB.
  - Continued to review historical sources for the coal documentary, including *Energy and the English Industrial Revolution* by E.A. Wrigley, *Power to the People* by Kandar and others, and *Getting the Coal Out* by Diana Tittle.

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

Highlights

- Continued planning the 2015 Regulatory Roundup scheduled for July 22–23, 2015, in Deadwood, South Dakota, including preparing a draft agenda; inviting potential speakers; and discussing with Interstate Oil and Gas Compact Commission (IOGCC) representatives the regulatory topics for the 2015 PCOR Partnership regulatory meeting, including several IOGCC products.
- Provided an updated agenda to IOGCC for the upcoming Environmental and Safety Committee meeting regarding U.S. Environmental Protection Agency (EPA) UIC Class II Transition to Class VI. Provided contact information for the potential speakers, and volunteered to facilitate the topic discussion.
- Finished presentation on Class II well-to-Class VI transition to be presented later this month at the 7th International Energy Agency (IEA) International Carbon Capture and Sequestration Regulatory Network meeting in Paris, France.
- Discussed updates to the PCOR Partnership Web site.
- Continued planning for D8, Permitting Review – Update 2, due September 30, 2015, including checking the status of North Dakota primacy application and changes to the Canadian and EPA regulations.

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

Highlights

- **Bell Creek** test site activities included the following:
  - Developed a working draft of "seed best practices" and "seed case histories" to be submitted to the working group focused on revising the NETL BPM for site screening,

site selection, and initial characterization. This will be sent to the working group for discussion.

- Analyzed hydrocarbon distributions from 20 Bell Creek crude oil samples collected from three production wells over approximately a 1-year time frame. This includes oil samples collected before, and for several months after, the injection of CO_2. The data are currently being analyzed to determine any changes in crude oil composition that may result from the EOR and whether such changes correspond with the appearance of injected CO_2 in the production wells.
- Worked on renewing Hampson–Russell seismic processing software licenses. This software is donated by CGG to universities for research.
- Conducted literature review for references regarding transferring data between Computer Modelling Group's (CMG's) GEM and FLAC-3D software. Compatibility between the two software packages can be challenging since they are from two different companies. Both are being used for Bell Creek geomechanical work.
- Worked on the numerical tuning process in CMG GEM, specifically using the geomechanics function.
- Continued preparing for the geomechanical simulations, including conducting a review of literature related to the use of CMG and other software packages for designing the geomechanical simulation process, and worked on improving the data accuracy using the well logs and seismic data.
- Continued improving the rock mechanical properties (e.g., Young's modulus, Poisson's ratio) and reservoir stresses using synthetic well logs (e.g., sonic logs) in the 3-D Mechanical Earth Model. Continued setting up practice simulations in CMG GEM to check the efficiency of the software for the simulation of CO_2 plume development during and after injection.
- Continued preparing the site characterization BPM, due August 31, 2015.
- Continued investigating statistical methods for analyzing variability within the pulsed-neutron logging (PNL) results.
- Worked on comparing effective porosity calculated from PNLs to history-matched simulation results. Nineteen wells have been compared to date, and these results were reviewed.
- Worked on characterizing the Mowry lithology using the current PNL data. This has proven difficult because the zone is rich organic shale.
- Worked on a petrophysical workflow to recalculate effective porosity above the reservoir zone using the PNLs. This was presented at a weekly in-house modeling meeting.
- Investigated options of adding newly interpreted petrophysical results into the near-surface model.
- Worked on developing a plan for the next steps with the 3-D seismic inversion to derive properties from the seismic data and, in turn, use these properties in the 3-D MEM.
- Generated plot of official total historical oil production by month for Phases 1, 2, 3, and 4, highlighting improvement to production due to EOR.
- Worked with Schlumberger to get the effective porosity logs from the PNL work in a different format.
- Discussed with team members regarding identifying fault and fracture systems from field data (e.g., logs and seismic data), and potential effects on carbon capture and storage (CCS) projects.

- Continued investigating options regarding microseismic data-processing services.
- Continued developing ideas for a Bell Creek journal article related to facies modeling to be prepared in collaboration with Denbury Resources Inc. (Denbury).
- Continued working on Version 3 of the geologic model, including integration of a 3-D seismic amplitude map, logs, and core to develop detailed geobody, depositional environment, and facies interpretations.
- Continued work on Applied Geology Laboratory activities, which included the following:
  - With regard to the 33-14R core (collected April 2013):
    - Lab analyses are complete.
    - Continued work on the permeability-to-air report.
  - With regard to the 56-14R full-core plugs (collected March 2013):
    - Began preparing the final internal report for the permeability-to-air vs. permeability-to-water evaluation completed.

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 work on the update to D85 "Opportunities and Challenges Associated with CO_2 Compression and Transport During CCS (carbon capture and storage) Activities" (due May 31, 2015), including summarizing the energy requirements and economics of compression and liquefaction and the basis for each method.
- Updated CO_2 source statistics for the document outlining PCOR's accomplishments.
- 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

- Nothing to note at this time.

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

Highlights

Bell Creek injection-phase site activities included the following:

- Compiled all Phase 1 historical production data from the Montana Board of Oil and Gas (MBOG) database to derive final decline curves for estimating CO_2 incremental oil production.
- Participated in a kickoff Webinar meeting for the DOE BPM for monitoring, verification, and accounting (MVA).
- Worked on analyzing CO_2 injection and production in each well of the Bell Creek Field in an attempt to determine why certain wells have higher CO_2 production than others. This information will be useful for predictive simulations and history matching.
- Continued preparing for PCOR Partnership annual meeting workshop.
- Continued planning and preparation for the upcoming semiannual Bell Creek surface and near-surface sampling event including organizing sampling kits; prepared a protocol (standard operating procedure) for prioritizing Bell Creek groundwater sample laboratory analyses based on field analytical results; and generated tables of recorded ranges for pH, alkalinity, and conductance at all groundwater sampling locations to aid the sampling crew in detecting anomalies while in the field.
- Continued contacting landowners ahead of upcoming field event.
- Continued to develop alternate strategies for reduced monitoring, moving toward a commercially viable MVA strategy, specifically regarding frequency and focusing on key indicator analytes.
- Submitted a bid for a geophysics-specific workstation.
- Held a WebEx on April 6, 2015, to prepare for the Bell Creek update meeting with Denbury.
- Held an update meeting with Denbury on April 13, 2015, in Plano, Texas. Distributed comprehensive update binders for the project team and presented on several topics, including monitoring, net carbon negative (green) oil, and seismic activities (i.e., surface, vertical seismic profiling, passive).
- Continued history match for CO_2 flooding in Phase 1 and 2 areas. This work included integrating CO_2 injection and fluid production data; comparing CO_2 flooding with primary depletion and water flooding; examining the geologic structure, permeability, water saturation, and relative permeability distributions in the combined region; and identifying ways to improve matching performance. The overall production and injection profile in a subsection of the Phase 2 area of the combined model was successfully matched. This match included primary and secondary oil, water, and gas production; water injection; etc. Analyzing production data of individual wells to identify possible aquifer and barrier locations in the reservoir. This information will help predict CO_2 plume distribution.
- Attended and presented at the CCUS-14 in Pittsburgh, Pennsylvania, April 28 – May 1, 2015.
- Created a Bell Creek subsurface-monitoring map.
- Began researching depositional environments for object modeling input into the near-surface model.
- Sent comments on an article that Global Carbon Capture and Storage Institute (GCCSI) will feature in its newsletter to promote the EERC videographic BPM entitled "Installing a Casing-Conveyed Permanent Downhole Monitoring (PDM) System." There will be a link on GCCSI's Web site to this BPM.
- Completed additional decline curve analysis examples for a well-by-well approach for estimating incremental oil production from CO_2 EOR.
- Investigated optimal wells for a potential tracer study.
- Continued working on a timely download of field data.

- Continued updating maps for coal and power plants and oil recovery and CO_2 needed for fields in North Dakota and Montana.
- Continued to work with Denbury personnel to collect periodic oil and gas samples from select wells in the Phase 1 area. A plan was devised to collect one gas and one oil sample from each of the three production wells (32-02, 56-14, and 05-06) on an estimated quarterly basis.
- Continued analysis of processed PDM data.
- Continued database entry for tracking data drives for the borehole array and recording system.
- Continued injection-phase sampling work, including the following:
  - Completed processing of over 210 soil gas samples collected from Phases 1 and 2 for the December 2014 quarterly sampling event.
    - Laboratory gas chromatography (GC) confirmation analyses were also completed for the 12 selected soil gas samples as part of the quality assurance/quality control procedure.
  - Completed the field (Micro Quad) and laboratory GC produced gas analyses for three production wells:
    - 32-02 (sampled in November 2014)
    - 56-14 and 05-06 (sampled in December 2014)
  - Sampling trip (April 24–29, 2015):
    - Finalized the Bell Creek groundwater sampling prioritization protocol.
  - Completed the semiannual near-surface MVA sampling event as follows:
    - Groundwater samples were collected from six stock wells and nine residential wells.
    - Surface water samples were collected from nine locations.
    - Fox Hills Formation groundwater-monitoring wells were sampled from two locations:
      - Analysis is under way.
    - Collected approximately 350 total soil gas samples from individual well pads, interspaced locations, soil gas profile stations, plugged and abandoned well locations, redrilled well locations, and regional background samples.
      - Analysis is under way.
  - Collected gas samples from the purchase and recycle stream and Production Wells 32-02, 56-14, and 05-06.
  - Collected oil samples from Production Wells 05-06 and 32-02.
    - Conducted training with EERC personnel on downloading procedures for the MOREVision and Qorex units.
    - Downloaded PDM data (January 15 – April 28, 2015) from the MOREVision and Qorex units.
- Used the most recent publicly available data to determine that cumulative CO_2 injection is 1,660,570 metric tons through November 30, 2014 (Table 1).
- Continued the literature review for CO_2 EOR simulation strategies.

Table 1. Bell Creek CO_2 Injection Totals for November 2014 (cumulative totals May 2013 to November 2014)

	November 2014 Injection
Total, Mscf	3,046,040
Total, U.S. tons*	174,229
Total, metric tons*	158,211
Cumulative Total, Mscf [+]	31,970,963
Cumulative Total, U.S. tons*[+]	1,828,689
Cumulative Total, metric tons*[+]	1,660,570

Source: MBOG database.

* There is an approximately 2–3-month 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.

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

- This task is anticipated to be initiated in Quarter 1 – BP5, Year 9 (October 2015).

Task 11 – Postinjection Monitoring and Modeling (TBA)

- This task is anticipated to be initiated in Quarter 1 – BP5, Year 9 (October 2015).

Task 12 – Project Assessment (Loreal V. Heebink)

Highlights

- Submitted the annual assessment (D57) on December 30, 2014.

Task 13 – Project Management (Charles D. Gorecki)

Highlights

- Staff participated in the EDX 101 and 102 training Webinars in preparation for the development of the DOE BPMs.
- Spoke with consultant Dave Nakles of The CETER Group (CETER), Inc. regarding CETER's participation in the development of DOE BPMs, and PCOR Partnership value-added reports.
- Continued planning for the 2015 annual meeting to be held in Chicago, Illinois, in September. This included working on the draft meeting and workshop agendas. The Web page is now available. Additional information will be added as planning continues.
- Attended and presented on Class II well-to-Class VI transition at the IEA International CCS Regulatory Network Meeting in Paris, France, on April 23, 2015.
- Attended and presented at the Workshop on CCS–EOR Utilization and Storage hosted by the Global Carbon Capture and Storage Institute in Beijing, China, April 16, 2015.
- Hosted visitors from DOE NETL personnel on April 8–9, 2015, and presented an update on the PCOR Partnership.

- Prepared and submitted three abstracts to the CO_2 GeoNet Open Forum that will be held in Venice, Italy, May 11–12, 2015. The abstract topics include a PCOR Partnership overview, the PCOR Partnership adaptive management approach for CCS projects, and PCOR Partnership outreach.
- Attended and presented at the CCUS-14 in Pittsburgh, Pennsylvania, April 28 – May 1, 2015.
- Attended and exhibited at the Williston Basin Petroleum Conference held April 28–30 in Regina, Saskatchewan, Canada.
- Spoke with Denbury regarding potential future surface seismic activities and InSAR monitoring at Bell Creek. Investigating the possibility of setting up a monthly WebEx with Denbury to discuss ongoing seismic activities.
- Prepared a document outlining the PCOR Partnership's technical and nontechnical accomplishments throughout all phases (Phases I–III). This was prepared by request from DOE for inclusion in a document it is creating on the accomplishments of the entire Regional Carbon Sequestration Partnerships (RCSP) program.
- Prepared a list (descriptions and photographs) for DOE regarding suggestions of what the EERC could submit to support DOE's National Lab Day. The list was submitted on April 17.
- Prepared a list of all of the stakeholders that have been involved in the PCOR Partnership over all phases and years. The list was submitted on April 14.
- Participated in a kickoff Webinar meeting regarding the DOE BPMs. A list of contact information for EERC staff who will be participating in the development of the BPMs was sent to DOE.
- Held a task leader meeting April 10, 2015. Topics discussed included brief updates on Bell Creek and Aquistore, upcoming conferences/meetings, and Task Leader updates.
- Completed deliverables and milestones in April:
  - March monthly update
  - Task 13: D58/D59 – Quarterly Progress Report
  - Task 14: M23 – monthly Water Working Group (WWG) call held

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

Highlights

- Held the monthly conference call on April 28, 2015. Discussed updates for the current WWG BPM, the annual meeting agenda items and potential guests, and continued planning the annual WWG meeting during DOE's annual partnership review meeting in August.
- Continued collaborative efforts with CETER, including the following:
  - Discussed last month's WWG conference call.
  - Distributed the March WWG conference call notes.
  - Reviewed revisions for the BPM and suggestions for the annual meeting.
  - Discussed upcoming conference call and how to move forward with the BPM outline.
  - Discussed development of a solicitation for the special edition of the International Journal of Greenhouse Gas Control.
  - Continued to make revisions to the draft WWG BPM (D80, due November 30, 2016).

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

- April 10–13, 2015: traveled to Plano, Texas, for update meetings with Denbury.
- April 20–25, 2015: traveled to Paris, France, to present at the 7th IEA International Carbon Capture and Sequestration Regulatory Network meeting.
- April 22–24, 2015: traveled to Miles City, Montana, for Bell Creek site work.
- April 22 – May 1, 2015: traveled to Gillette, Wyoming, for Bell Creek project work.
- April 27–30, 2015: traveled to Regina, Saskatchewan, Canada, to attend the Williston Basin Petroleum Conference.
- April 27 – May 2, 2015: traveled to Pittsburgh, Pennsylvania, to present at the CCUS-14.
- April 28 – May 1, 2015: traveled to Miles City, Montana, for Bell Creek site work.

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