Plains CO_2 Reduction (PCOR) Partnership
Energy & Environmental Research Center (EERC)

ANNUAL ASSESSMENT REPORT

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 12 – Deliverable D57

(for the period October 1, 2012, through September 30, 2013)

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EXECUTIVE SUMMARY

The Plains CO_2 Reduction (PCOR) Partnership is one of seven Regional Carbon Sequestration Partnerships (RCSPs) competitively awarded by the U.S. Department of Energy National Energy Technology Laboratory in 2003 as part of a national plan to mitigate greenhouse gas emissions. The PCOR Partnership is led by the Energy & Environmental Research Center (EERC) at the University of North Dakota in Grand Forks, North Dakota, and includes over 90 stakeholders from the public and private sector in Phase III. The PCOR Partnership region includes all or part of nine U.S. states and four Canadian provinces.

Phase III, the 10-year (2007–2017) development phase, is an extension of the characterization (Phase I) and validation (Phase II) phases and is intended to confirm that commercial-scale carbon dioxide (CO_2) capture, transportation, injection, and storage can be achieved safely, permanently, and economically over extended periods in the PCOR Partnership region.

The Phase III efforts of the PCOR Partnership include two large-volume demonstration tests that focus on injecting CO_2 into deep geologic formations for CO_2 storage. The Fort Nelson feasibility project involves monitoring, verification, and accounting (MVA) and risk management support for the injection of CO_2 captured from one of the largest gas-processing plants in North America into a saline formation in British Columbia, Canada. The Bell Creek demonstration involves injection of CO_2 into the sandstone of the Muddy Formation in the Powder River Basin in Southeastern Montana for the dual purpose of CO_2 storage and enhanced oil recovery. Other activities in Phase III include the following: 1) continue to gather regional characterization data to verify the ability of target formations to store CO_2, 2) facilitate the development of infrastructure to transport CO_2 from sources to injection sites, 3) facilitate sensible development of the rapidly evolving North American regulatory and permitting framework, 4) develop opportunities for PCOR Partnership partners to capture and store CO_2, 5) facilitate establishment of a technical framework by which carbon credits can be monetized for CO_2 stored in geologic formations, 6) continue collaboration with other RCSPs, and 7) provide outreach and education for CO_2 capture and storage stakeholders and the general public.

Significant progress occurred in Program Year (PY) 6 (October 1, 2012 – September 30, 2013) on the Bell Creek demonstration project. CO_2 injection began at the Bell Creek test site, and nearly 200,000 metric tons was injected. Efforts were focused on finalizing baseline MVA data, including field sampling events to collect preinjection surface water, groundwater, and soil

gas baseline data and drilling two groundwater-monitoring wells. 3-D seismic baseline data were received, 3-D vertical seismic profile surveys were acquired, and deep monitoring data collection continued at the 05-06 OW monitoring well. In addition, two replacement production wells were drilled, cored, and logged, with technical overview provided by EERC staff. Petrophysical and geochemical analyses were performed on various core samples received from the U.S. Geological Survey, the 05-06 OW monitoring well, and additional well drillings.

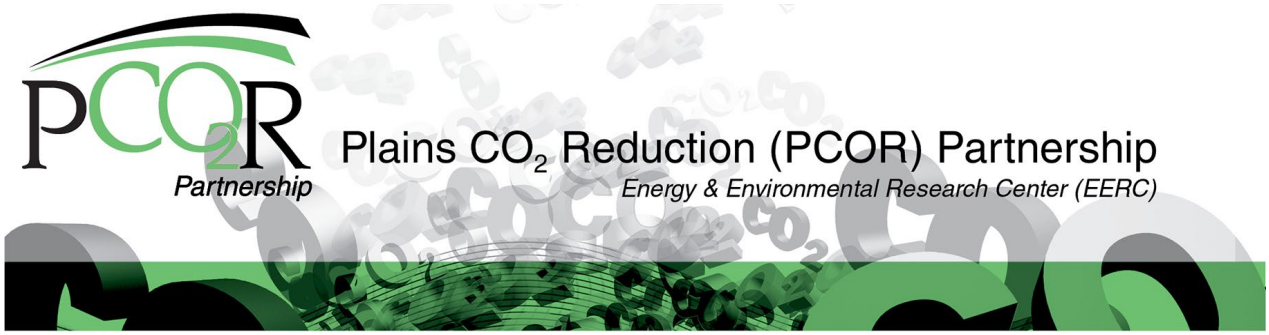
There were no field activities performed at the Fort Nelson demonstration project; however, significant progress was made on a comprehensive summary of all PCOR Partnership activities to date for inclusion in a best practices manual on the carbon capture and storage feasibility study.

The PCOR Partnership submitted 18 abstracts, had nine journal articles published, gave 75 presentations, completed 21 deliverable reports, achieved ten milestones, and prepared a value-added product and 16 progress reports. The annual membership meeting attracted 88 attendees representing 46 organizations. Preparations are well under way for an upcoming expert review of the PCOR Partnership Program in November 2013.

Overall, 14 tasks continued to effectively support program goals in PY6. In addition to the foregoing, regional characterization continued and nearly 900 CO_2 sources, producing an estimated 560 million short tons annually, were verified within the region. Outreach activities included distribution of print materials, oral and poster presentations, Web site updates, and documentary broadcasts. The latest documentary received a 2012 Platinum Best of Show Aurora Award, and throughout the course of the program, over 4800 PCOR Partnership atlases have been distributed, along with over 8500 documentary DVDs. The Fifth Annual Regulatory Roundup was held in summer 2013, and the PCOR Partnership led a task force with the Interstate Oil and Gas Compact Commission to provide recommendations and guidance on operational and postoperational liability issues. A peer-reviewed journal article was published in *Energy & Fuels*. The RCSP Water Working Group was active, holding its fifth annual meeting in August 2013 and producing a new fact sheet. Modeling activities continued on additional pinnacles in the Zama oil field, and geochemical and wellbore evaluations of the basal Cambrian system were prepared. In addition, numerous activities in relation to the Petroleum Technology Research Centre Aquistore project (near Estevan, Saskatchewan) were performed, including filming site activities in fall 2013, updating the geologic model and running predictive simulations, and analyzing core collected to develop an understanding of mineralogical composition and the petrophysical properties of the rocks below the site.

CO_2 injection at Bell Creek will continue in PY7. Operational monitoring and modeling activities will also continue to be performed to verify that injection operations do not adversely impact human health or the environment and that the CO_2 injected has been safely stored, with minimal risk of natural release. All other support tasks (with the exception of Task 7) will continue to be implemented.

This report presents an update of Phase III PCOR Partnership activities from October 1, 2012, through September 30, 2013 (PY6) and planned activities for the following year.



ANNUAL ASSESSMENT REPORT

INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership is one of seven regional partnerships operating under the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) Regional Carbon Sequestration Partnership (RCSP) Program. The PCOR Partnership is led by the Energy & Environmental Research Center (EERC) at the University of North Dakota (UND) in Grand Forks, North Dakota, and includes over 90 stakeholders from the public and private sector in Phase III. The Phase III membership as of September 30, 2013, is listed in Table 1. The PCOR Partnership region includes all or part of nine states (Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming) and four Canadian provinces (Alberta, British Columbia, Manitoba, and Saskatchewan).

The PCOR Partnership falls within the infrastructure element of NETL's Carbon Storage Program and is a government–industry effort tasked with determining the most suitable technologies, regulations, and infrastructure needs for carbon capture, utilization, and storage (CCUS) on the North American continent.

The PCOR Partnership Program is implemented in three phases:

- Phase I – Characterization Phase (2003–2005): characterized opportunities for carbon sequestration.
- Phase II – Validation Phase (2005–2009): conducted small-scale field validation tests.
- Phase III – Development Phase (2007–2017): conducting large-volume carbon storage demonstration tests.

The PCOR Partnership's efforts are in support of NETL's Carbon Storage Program by helping to develop technologies to store carbon dioxide (CO_2) in order to reduce greenhouse gas (GHG) emissions without adversely influencing energy use or hindering economic growth.

The PCOR Partnership's efforts will help enable technologies to overcome a multitude of economic, social, and technical challenges, including cost-effective CO_2 capture through successful integration with fossil fuel conversion systems, effective CO_2 monitoring and verification, permanence of underground CO_2 storage, and public acceptance.

Table 1. PCOR Partnership Membership Phase III (October 1, 2007 – present, inclusive)

DOE NETL	Great Northern Project Development, LP	North Dakota Industrial Commission Oil and Gas Research Council
UND EERC	Great River Energy	North Dakota Natural Resources Trust
Abengoa Bioenergy New Technologies	Halliburton	North Dakota Petroleum Council
Air Products and Chemicals	Hess Corporation	North Dakota Pipeline Authority
Alberta Department of Energy	Huntsman Corporation	Otter Tail Power Company
Alberta Department of Environment	Husky Energy Inc.	Oxand Risk & Project Management Solutions
Alberta Innovates – Technology Futures	Interstate Oil and Gas Compact Commission	Petroleum Technology Research Centre
ALLETE	Indian Land Tenure Foundation	Petroleum Technology Transfer Council
Ameren Corporation	Iowa Department of Natural Resources	Pinnacle, a Halliburton Service
American Coalition for Clean Coal Electricity	Lignite Energy Council	Prairie Public Broadcasting
American Lignite Energy	Manitoba Geological Survey	Pratt & Whitney Rocketdyne, Inc.
Apache Canada Ltd.	Marathon Oil Company	Praxair Inc.
Aquistore	MEG Energy Corporation	Ramgen Power Systems, Inc.
Baker Hughes Incorporated	Melzer Consulting	RPS Energy Canada Ltd.
Basin Electric Power Cooperative	Minnesota Power	Saskatchewan Ministry of Industry and Resources
BillyJack Consulting Inc.	Minnkota Power Cooperative, Inc.	SaskPower
Biorecro AB	Missouri Department of Natural Resources	Schlumberger
Blue Source, LLC	Missouri River Energy Services	Shell Canada Energy
BNI Coal, Ltd.	Montana–Dakota Utilities Co.	Spectra Energy
British Columbia Ministry of Energy, Mines, and Petroleum Resources	Montana Department of Environmental Quality	Suncor Energy Inc.
British Columbia Oil and Gas Commission	National Commission on Energy Policy	TAQA North, Ltd.
C12 Energy, Inc.	Natural Resources Canada	TGS Geological Products and Services
Computer Modelling Group Ltd.	Nebraska Public Power District	University of Alberta
Continental Resources, Inc.	North American Coal Corporation	University of Regina
Dakota Gasification Company	North Dakota Department of Commerce Division of Community Services	Weatherford Advanced Geotechnology
Denbury Onshore LLC	North Dakota Department of Health	Western Governors' Association
Eagle Operating, Inc.	North Dakota Geological Survey	Westmoreland Coal Company
Eastern Iowa Community College District	North Dakota Industrial Commission (NDIC)	Williston Basin Interstate Pipeline Company
Enbridge Inc.	Department of Mineral Resources, Oil and Gas Division	Wisconsin Department of Agriculture, Trade and Consumer Protection
Encore Acquisition Company	North Dakota Industrial Commission Lignite Research, Development and Marketing Program	Wyoming Office of State Lands and Investments
Energy Resources Conservation Board/ Alberta Geological Survey		Xcel Energy
Environment Canada		
Excelsior Energy Inc.		

The PCOR Partnership was established in the fall of 2003. Phase I was focused on characterizing sequestration opportunities in the region. In the fall of 2005, the PCOR Partnership launched its 4-year Phase II program focused on carbon storage field validation projects. These Phase II projects were designed to build core local technical expertise and experience needed to facilitate future large-scale CO_2 storage efforts in the region's subsurface and terrestrial settings. In the fall of 2007, the PCOR Partnership initiated its 10-year Phase III program focused on implementing two commercial-scale geologic carbon storage demonstration projects in the region.

Phase III is divided into three budget periods (BPs), running from October 1, 2007, to September 30, 2017:

BP3: October 1, 2007 – September 30, 2009
BP4: October 1, 2009 – September 30, 2015
BP5: October 1, 2015 – September 30, 2017

BP1 and BP2 were effective in Phase II.

The overall mission of the Phase III program is to 1) gather characterization data to verify the ability of the target formations to store CO_2, 2) facilitate the development of the infrastructure required to transport CO_2 from sources to the injection sites, 3) facilitate development of the rapidly evolving North American regulatory and permitting framework, 4) develop opportunities for PCOR Partnership partners to capture and store CO_2, 5) establish a technical framework by which carbon credits can be monetized for CO_2 stored in geologic formations, 6) continue collaboration with other RCSPs, and 7) provide outreach and education for CO_2 capture and storage stakeholders and the general public.

In Phase III, the PCOR Partnership is building on the information generated in its characterization (Phase I) and validation (Phase II) phases. The PCOR Partnership plans to fully utilize the infrastructure of its region to maximize CO_2 injection volumes. A programmatic development phase (Phase III) goal is implementation of large-scale field testing involving at least 1 million tons (Mt) of CO_2 per project. Each of the RCSP's large-volume injection tests is designed to demonstrate that the CO_2 storage sites have the potential to store regional CO_2 emissions safely, permanently, and economically for hundreds of years.

The PCOR Partnership has established two large-scale demonstration projects. The sites are located 1) in Denbury Resources Inc.'s (Denbury's) Bell Creek oil field in Powder River County, southeastern Montana, and 2) near Spectra Energy's (Spectra's) Fort Nelson gas-processing facility, situated near Fort Nelson, British Columbia, Canada (Figure 1).

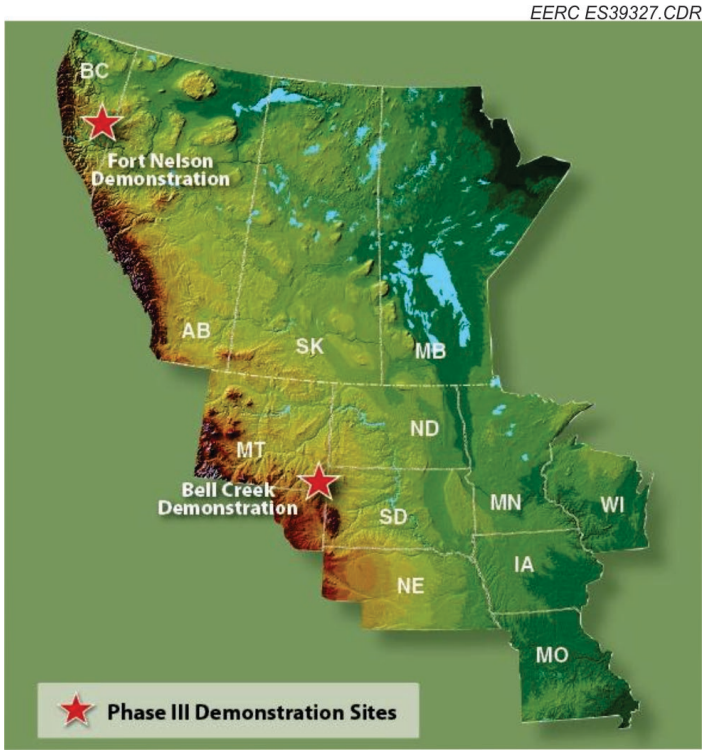


Figure 1. PCOR Partnership Phase III demonstration sites.

In Program Year (PY) 6, CO_2 injection began at the Bell Creek test site, and nearly 200,000 metric tons was injected. Efforts were focused on developing the Bell Creek monitoring, verification, and accounting (MVA) program plan and finalizing baseline MVA data. Two field sampling events were held (for a total of six) to collect preinjection surface water, groundwater, and soil gas baseline data. In addition, two replacement production wells were drilled, cored, and logged, with technical overview provided by EERC staff. Petrophysical evaluations of the core are planned. The processed data from the 2012 40-square-mile 3-D seismic baseline survey were received in April 2013, and 3-D vertical seismic profile (VSP) surveys were acquired in May 2013. Thirty-three baseline pulsed-neutron logs (PNLs) were also completed. Dedicated deep monitoring (05-06 OW) has continued since April 2012 using downhole pressure/temperature gauges and a fiber optic, distributed-temperature system.

In collaboration with Spectra, the PCOR Partnership is supporting the evaluation of the feasibility of a large-scale integrated carbon capture and storage (CCS) project near Spectra's existing Fort Nelson natural gas-processing facility in northeast British Columbia, Canada. The Fort Nelson facility is one of the largest sour gas-processing plants in North America. The PCOR Partnership's MVA efforts will help Spectra determine whether deep underground saline reservoirs and associated infrastructure in the Fort Nelson area are appropriate for CCS. During PY6, activities for the Fort Nelson demonstration project were placed on hold until Spectra can establish a business case for the project. Spectra decided not to pursue drilling a second exploratory well or conducting a 3-D seismic data survey. Spectra plans to continue development of its third-generation reservoir model as well as its MVA strategy in order to advance the project. In the meantime, the PCOR Partnership began preparation of a comprehensive summary of its characterization, modeling and simulation, and risk assessment activities for inclusion in a best practices manual (BPM).

The PCOR Partnership's objectives for the demonstration projects are as follows: 1) conduct a successful Bell Creek demonstration to verify that the region's large number of oil fields have the potential to store significant quantities of CO_2 in a safe, economical, and environmentally responsible manner and 2) support Spectra's feasibility study of a Fort Nelson demonstration to verify the economic feasibility of using the region's carbonate saline formations for safe, long-term CO_2 storage. During Phase III, the PCOR Partnership will continue to refine storage resource estimates and evaluate other factors relevant to regional storage goals.

APPROACH

The PCOR Partnership is identifying practical CO_2 storage options for the PCOR Partnership region, characterizing the technical issues, enhancing the public's understanding of CO_2 storage, identifying the most promising opportunities for storage in the region, and detailing an action plan for the demonstration of regional CO_2 storage opportunities.

The PCOR Partnership is achieving its Phase III mission through a series of 16 tasks, as shown in Figure 2. These tasks include 1) Regional Characterization; 2) Public Outreach and Education; 3) Permitting and National Environmental Policy Act (NEPA) Compliance; 4) Site

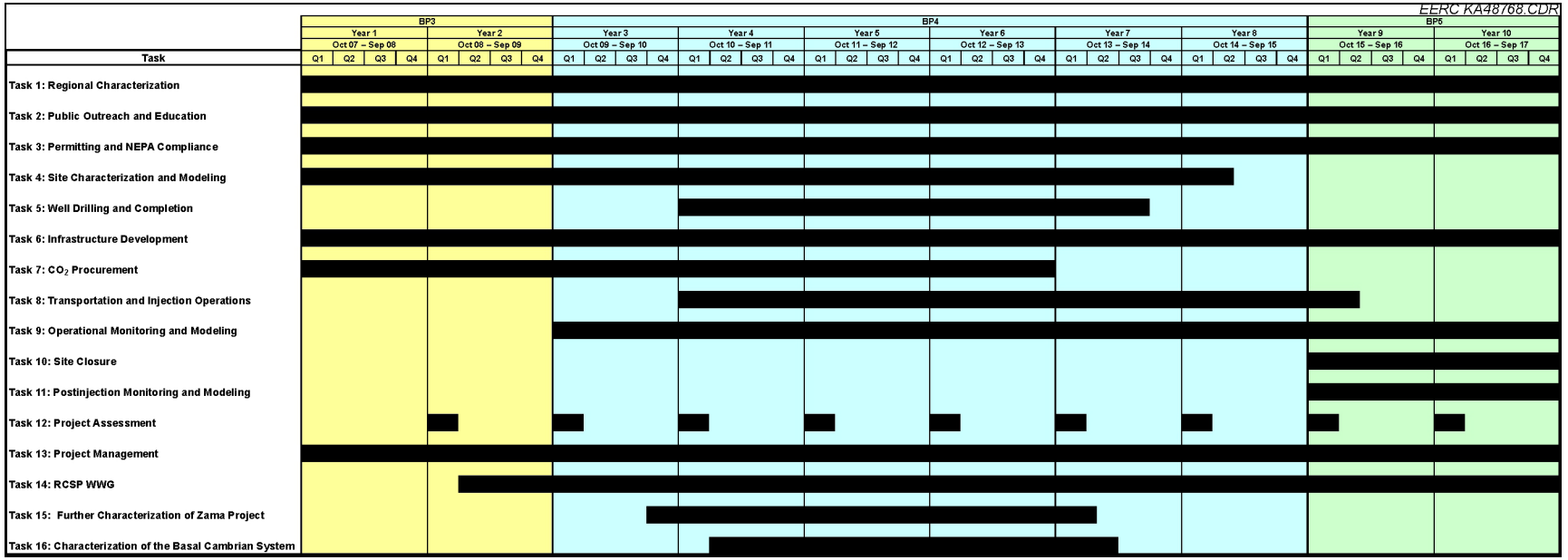


Figure 2. Phase III tasks.

Characterization and Modeling; 5) Well Drilling and Completion; 6) Infrastructure Development; 7) CO_2 Procurement; 8) Transportation and Injection Operations; 9) Operational Monitoring and Modeling; 10) Site Closure; 11) Postinjection Monitoring and Modeling; 12) Project Assessment; 13) Project Management; 14) RCSP Water Working Group (WWG) Coordination; 15) Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project; and 16) Characterization of the Basal Cambrian System. Table 2 contains the responsibility matrix for these 16 tasks.

The EERC entered into a cooperative agreement with DOE NETL for Phase III activities in late September 2007. Phase III is a 10-year project, in three BPs, running from October 1, 2007, to September 30, 2017. This Annual Assessment Report summarizes the activities for PY6 (October 1, 2012 – September 30, 2013) of Phase III.

ASSESSMENT SUMMARY

In BP3, the focus of the program was to select two distinct and regionally significant geologic formations for large-volume (approximately 1 Mt of CO_2 a project) commercial tests designed to demonstrate that CO_2 storage sites have the potential to store regional CO_2 emissions safely, permanently, and economically for hundreds of years. The Fort Nelson test site was selected in December 2007 and involves MVA and risk management support for the injection of up to 2 Mt/year CO_2 captured from one of the largest gas-processing plants in North America into a Devonian-aged carbonate formation in British Columbia, Canada. The Bell Creek test site was selected in September 2009 and involves injection of CO_2 into a Cretaceous-aged sandstone formation in the Powder River Basin (PRB) in southeastern Montana for the dual purpose of CO_2 storage and enhanced oil recovery (EOR).

Table 2. Phase III Responsibility Matrix

Phase III Task Title	Task Leader
Task 1 – Regional Characterization	Wesley D. Peck
Task 2 – Public Outreach and Education	Daniel J. Daly
Task 3 – Permitting and NEPA Compliance	Lisa S. Botnen
Task 4 – Site Characterization and Modeling	James A. Sorensen
Task 5 – Well Drilling and Completion	John A. Hamling
Task 6 – Infrastructure Development	Melanie D. Jensen
Task 7 – CO_2 Procurement	John A. Harju
Task 8 – Transportation and Injection Operations	Melanie D. Jensen
Task 9 – Operational Monitoring and Modeling	Charles D. Gorecki
Task 10 – Site Closure	TBA
Task 11 – Postinjection Monitoring and Modeling	TBA
Task 12 – Project Assessment	Katherine K. Anagnost
Task 13 – Project Management	Charles D. Gorecki
Task 14 – RCSP WWG Coordination	Ryan J. Klapperich
Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project	Charles D. Gorecki
Task 16 – Characterization of the Basal Cambrian System	Wesley D. Peck

Strong project management is crucial to the success of any project. The PCOR Partnership project management team focuses on providing timely completion of milestones, quality deliverables, and accurate and timely project reports as directed in the Federal Assistance Reporting Checklist and effective communication between the PCOR Partnership and DOE NETL management. All required deliverables, milestones, and project reports were completed on schedule during PY6. These included 21 required reports, achievement of mandatory milestones, and four quarterly progress reports.

In August and September 2013, respectively, the PCOR Partnership participated in the RCSP annual project review meetings in Pittsburgh, Pennsylvania, and hosted the 2013 annual meeting in Minneapolis, Minnesota. EERC staff prepared to present an overview and update of Phase III PCOR Partnership activities in November 2013 before the IEA Greenhouse Gas R&D Programme (IEAGHG) expert panel review of the RCSPs to ensure that program goals are being met. Throughout PY6, the PCOR Partnership was represented at 75 conferences and meetings and submitted nearly 20 abstracts. The PCOR Partnership also prepared over 20 (deliverable) technical reports, achieved ten program milestones, and gave nearly 60 presentations (oral and poster combined).

The PCOR Partnership continued to post technical information about its program on its public Web site, which received over 5000 site visits from 90 countries in PY6. The PCOR Partnership distributed over 1600 documentary DVDs and nearly 700 atlases in PY6. In addition, there were nearly 20 telecasts of the documentaries on public television and over 200 teachers heard the PCOR Partnership message and learned about CCUS. Through these efforts, the CO_2 storage community is kept informed of the PCOR Partnership's accomplishments and activities.

Project management cannot be considered complete without identification of technical and nontechnical risks that may threaten successful project implementation. Accordingly, the PCOR Partnership developed a programmatic risk management plan in April 2011 to document individual project risks, consequences, and impacts. This programmatic plan was updated in September 2013 (PY6). During PY4, the EERC worked closely with the Fort Nelson demonstration site owners/operators to prepare a 2011 update to the 2010 first-round risk assessment (RA). In PY5, an internal risk register was developed for the Bell Creek demonstration project. The final processes and procedures have continued to evolve in order to seamlessly integrate with the risk processes and policies of the industry partner, Denbury. Plans are under way to update the Bell Creek technical risk assessment and update the overall programmatic risk management plan by August 2014.

In BP4, the focus of the program is to inject CO_2 at commercial scale at the two demonstration sites. For each site, the critical steps/decision points are 1) securing a CO_2 source, 2) permitting for pipelines and injection, 3) infrastructure development, 4) CO_2 injection, and 5) MVA implementation. Several years of injection and monitoring will be required in BP4 to move into the BP5 site closure and project wrap-up activities.

The CO_2 source has been secured for both the Fort Nelson and Bell Creek sites. In both cases, the CO_2 source is a natural gas-processing facility. Spectra owns the gas-processing facility near the Fort Nelson site. The source of CO_2 for the Bell Creek site is the ConocoPhillips

Lost Cabin Natural Gas-Processing Facility, and Denbury has secured the CO_2 from that facility until 2024.

Permitting of the sites required that the EERC complete DOE environmental questionnaires for both the Fort Nelson and Bell Creek demonstration projects. The Fort Nelson demonstration project received a categorical exclusion in 2010, and a categorical exclusion for the Bell Creek demonstration project was granted in 2011. A permitting action plan was prepared for the Bell Creek project in August 2011 and described the regulatory and permitting steps taken by the EERC and Denbury to conduct the project.

The PCOR Partnership continues to establish and maintain excellent relationships with regional regulatory authorities. EERC staff participates fully in Interstate Oil and Gas Compact Commission (IOGCC) efforts. In fact, John Harju, EERC Associate Director for Research, is a past Chair of the Energy Resources, Research, and Technology Committee. In addition, through the efforts of the IOGCC Carbon Geologic Storage (CGS) Task Force, the PCOR Partnership addressed issues relating to liability (operational and postoperational) that remain as barriers to the establishment of state and federal legal and regulatory frameworks for CCUS. Findings, recommendations, and guidance were developed in August 2013. The PCOR Partnership also hosted its fifth annual regulatory workshop in July 2013, where oil and gas and pipeline regulators met informally to develop strategies to work past state/provincial boundaries and to establish rules and regulations outside of federal mandate. These relationships will prove invaluable as the demonstration projects progress.

For the Fort Nelson CCS Project, the potential pipeline route is under development. For the Bell Creek demonstration project, construction of the 232-mile Greencore CO_2 pipeline to the Bell Creek oil field was completed in late November 2012. Denbury began injecting CO_2 in the Bell Creek oil field in May 2013, and by the end of PY6, nearly 200,000 cumulative metric tons was injected. In August 2013, a site-commissioning ceremony was attended by the Montana governor and staff from DOE, Denbury, and the EERC.

The success of the PCOR Partnership Program will be evidenced by a region that has a supportive population, an accommodating regulatory environment, and, ultimately, a vibrant commercial CCUS industry. Through its outreach and education activities, its rapport with regional regulators and federal decision makers, and its ongoing collaborative MVA activities with supportive partners, the PCOR Partnership is well on its way to achieving its goals.

This Annual Assessment Report provides information about the foregoing activities in more detail and is organized as set forth below:

- Progress update and budget status of the 14 tasks (Tasks 1–9 and 12–16) that were active in BP4, PY6 (October 1, 2012 – September 30, 2013)
- Accomplishments achieved during BP4, PY6 (October 1, 2012 – September 30, 2013)
- Description of planned BP4, PY7 (October 1, 2013 – September 30, 2014) activities

It should be noted that Tasks 10 and 11 will be initiated in BP5.

BP4, PY6 ACTIVITIES (2012–2013)

Progress Report

BP3 included the first 2 years of Phase III, with activities initiated October 1, 2007. Thirteen tasks were originally scheduled for Phase III. A new task, Task 14, was added during PY2 of BP3. Out of the 14 tasks, 12 tasks were active during BP4, PY3. In February 2011, DOE approved moving former Subtask 1.4 to a newly created Task 15 and added a new task, Task 16, as shown in Figure 3. Out of the 16 tasks, 14 tasks were active during BP4, PY6 (Tasks 10 and 11 will not begin until BP5). The progress update for the active tasks is presented within this section. This Annual Assessment Report (Deliverable [D] 57) details activities beginning October 1, 2012, through the end of BP4, PY6, or September 30, 2013.

Charles D. Gorecki is the overall EERC program manager and principal investigator (PI) and provides leadership in fully coordinating and integrating the activities of the PCOR Partnership. To facilitate the management of this project, task leaders were designated, as shown in Table 2.

Task 1 – Regional Characterization

The PCOR Partnership continues to refine the characterization of sources, geologic sinks, and infrastructure within its region. The goal is to further refine the assessment of the region's CO_2 production and storage potential in an effort to optimize source–sink opportunities within the region. This continued regional characterization will be used to refine capacity estimates for DOE NETL's national atlas and to provide context for extrapolating the results of the large-scale demonstrations.

Activities and Results

Phase III regional characterization efforts for BP4, PY6 (October 1, 2012 – September 30, 2013) are addressed as follows.

Review and Update Attribute Data for CO_2 Source Locations Within the Region

The PCOR Partnership maintains a database of significant stationary regional point sources of CO_2. The database is key in the development of CO_2 capture–transportation–storage scenarios that have the potential to reduce GHG emissions in the PCOR Partnership region. To maintain a reasonably current status, the data set undergoes an annual review during which new or missing sources are identified and added, CO_2 emission rates are updated, and facility locations are verified. In PY6, a summary was prepared based on the data review that took place between October 1, 2012, and August 22, 2013. Four primary data sets were used to update the PCOR Partnership CO_2 emission database: 1) Environment Canada Reported Facility Greenhouse Gas Data (1); 2) Emission data at the online Environment Canada National Pollutant Release

Inventory Online Data search engine (2); 3) U.S. Environmental Protection Agency (EPA) Air Markets Program data online emission search engine (3); and 4) EPA Greenhouse Gas Reporting Program data for calendar year 2011 (4).

As of August 22, 2013, the updated PCOR Partnership database contains 895 sources that produce an estimated 563 million short tons of CO_2 annually. This compares to the 2012 values of 1033 sources producing an estimated 620 million short tons of CO_2 each year. Of the 895 sources now contained in the database, updated CO_2 emission information was found for 487 of them. In addition to updating the CO_2 emissions for the large point sources in the PCOR Partnership region, efforts were made to ensure that the name, location, and emission data are consistent for the sources that are shared by both the PCOR Partnership and the Big Sky Partnership.

Refine Storage Analogs for Specific Geologic Horizons Within the Regional Basins

There are eight depositional basins lying fully or partially within the PCOR Partnership region. Efforts are under way to expand the number of assessed target formations in these basins. The largest of these efforts is aimed at characterizing the basal Cambrian saline system lying across the Alberta and Williston Basins. This effort was reassigned its own task (Task 16) in 2011 and is anticipated to run through March 2014.

In PY6, six saline formations within the Williston and Powder River Basins were targeted for additional characterization and geologic modeling. These included the Broom Creek Formation (North Dakota), the Minnelusa Formation (South Dakota and Montana), the Mission Canyon Formation (North Dakota and Montana), the Inyan Kara Formation (North Dakota), the Leduc Formation (Alberta, Canada), and the Winnipegosis Formation (North Dakota, South Dakota, and Montana).

A value-added report on the geologic characterization and CO_2 storage potential of the state of Nebraska, including the Cedar Hills sandstone and Amazon dolomite, is well under way and should be ready for submittal in early PY7.

Work with Geological Surveys/Oil and Gas Divisions

In PY6, regional characterization staff continued to work closely with the Montana Board of Oil and Gas (MBOG), the Nebraska Oil and Gas Conservation Commission, and the Wyoming Oil and Gas Conservation Commission to acquire updated cumulative oil production numbers for the fields and pools in the U.S. portion of the PCOR Partnership region.

A preliminary investigation was conducted for CO_2 EOR potential of the area along the Miles City Arch in southeastern Montana, and in late 2012, several visits were made to the MBOG offices in order to collect information on wells in the Pennel and Pine oil fields located on the Cedar Creek Anticline. Historical water injection and oil production data were collected, and data in the PETRA database were updated as appropriate.

PCOR Partnership Atlas

The *PCOR Partnership Atlas* provides an introduction to the concept of global climate change and CCUS as well as a regional profile of CO_2 sources and potential sinks across the nearly 1.4 million square miles of the PCOR Partnership region of central North America. Efforts to reinvent the *PCOR Partnership Atlas, 4th Edition*, were undertaken in PY4, and after the appropriate approvals were received, 1200 atlases were printed in June 2012.

The next iteration of the atlas was due August 2013. However, supply from the 2012 printing was fast depleting and would not survive until the fall. As such, an effort was undertaken to review and revise the 2012 version. Corrections involved fixing typographical errors and making clarifications to figures and text. In addition, updated information was included on pages 14, 15, 54, and 56 with regard to sources shown in the PCOR Partnership region maps and the related text as well as on page 65 with regard to the CO_2 storage resource/ capacity amounts for unminable coal and evaluated saline formations. This revised version, *PCOR Partnership Atlas, 4th Edition, Revised*, was submitted to DOE NETL for approval on May 1, 2013 (nearly 4 months ahead of schedule), and approval was received less than 1 week later. A new printing of 1250 atlases was received in June 2013.

The atlas continues to serve as an excellent resource as well as a valuable outreach tool. It is distributed to partners, visitors, educators, libraries, and conference attendees and is available upon request, including via the public PCOR Partnership Web site. Approximately 684 atlases (576 – 4th edition plus 108 – 4th edition, revised) were distributed in PY6. Overall, since its first printing in 2005, over 4800 atlases have been distributed.

Updating the DSS Web Site (www2.undeerc.org/website/PCORP)

Modifications and refinement to the partners-only Decision Support System (DSS) are continually undertaken to ensure the timely dissemination of data and information as well as to help improve the quality and efficacy to our partners for their carbon management decisions. During PY6, a review of all DSS Web site pages was performed. Most changes involved updating information and eliminating outdated content as detailed below:

- The various databases (oil fields, wells, gas plants) that ultimately feed the DSS were updated as well as the current GIS (geographic information system) well files.

- Images used in the recent edition of the *PCOR Partnership Atlas* were added to the online image gallery along with appropriate descriptions. In addition, images from the Atlas were included in the "CO_2 Sources" information (Figure 3).

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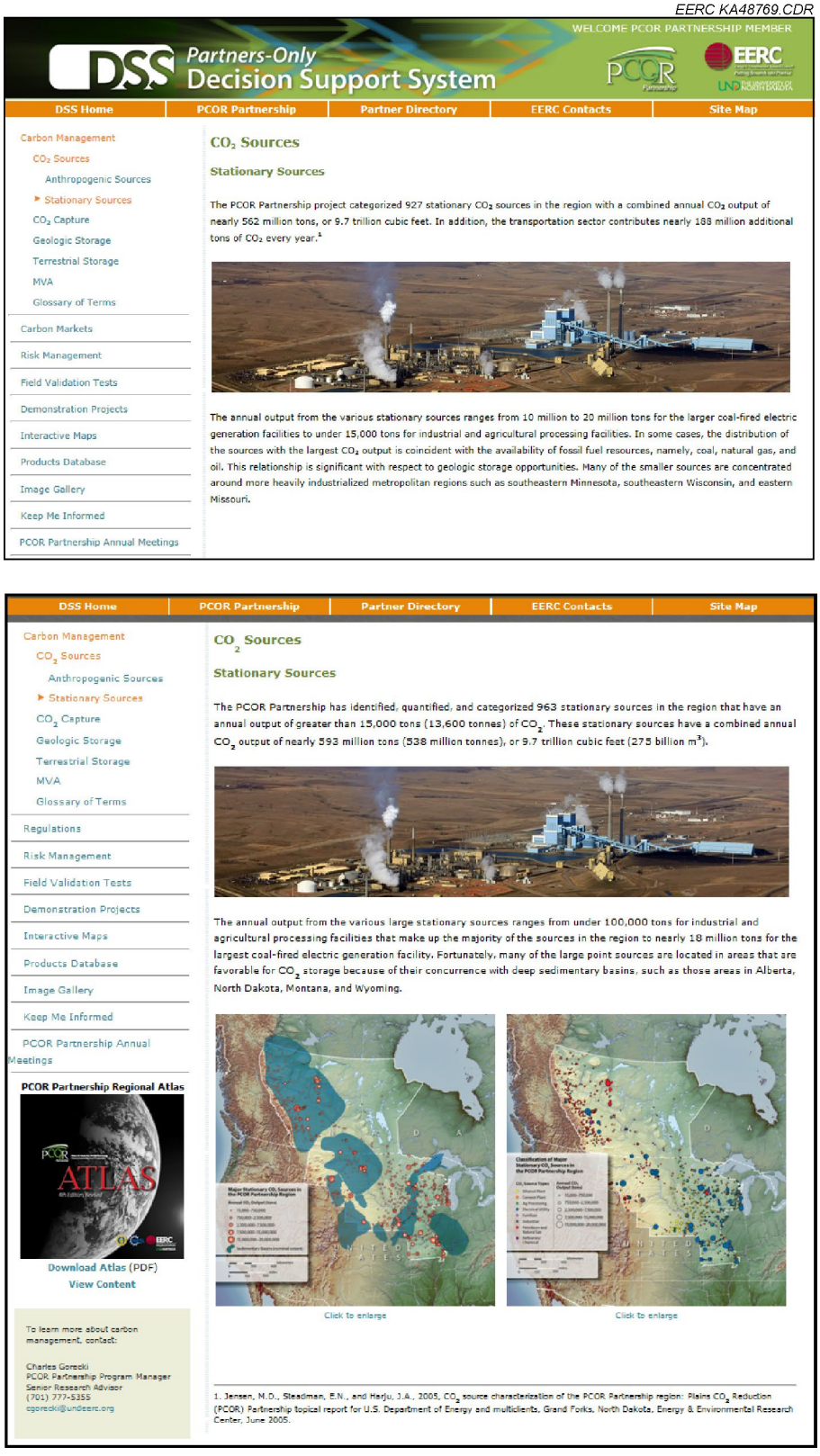


Figure 3. DSS CO_2 Sources Web page before (top) and after (bottom).

- The "Regulations" Web pages were reviewed, and outdated information was deleted. Information remaining relates to the IOGCC Task Force and the Regulatory Roundup meetings.

- The "Keep Me Informed" page was revamped to be more user-friendly and visually appealing.

- New PCOR Partnership products are regularly added to the database once they are approved for release to partners. Currently, the database contains nearly 900 products produced by the PCOR Partnership since its inception in 2003.

- The Partner Directory is a database-driven page that is continuously updated to include the partners' most recent contact information. As new partners join the PCOR Partnership, their company name and URL are updated.

It should be noted that the requirements for updated DSS reports (D9) in September 2013 and 2015 were deleted in September 2012. In PY6, updates to the DSS were reported in the quarterly technical progress reports rather than in stand-alone reports.

Development of a Demonstration Project Reporting System (DPRS)

Collection of information specific to the demonstration sites is ongoing in an effort to populate a Web-based interface to house the data and facilitate communication and interpretation of the data. A DPRS was created to provide structured access to data from the PCOR Partnership Phase III demonstration projects at Bell Creek and Fort Nelson. Each project has its own section, with the following subcategories:

- Background and Scope of Work
- Benefits to the Region
- Characterization Data
- Modeling
- MVA
- Risk Management
- Regulations and Permitting
- Site Operations
- Products

Current and planned activities for the Bell Creek demonstration project involve the development of the MVA protocol, baseline sampling at the site, and other initial site operations such as observation well installation. Therefore, these two sections of the Bell Creek demonstration project Web site (MVA and site operations) were updated in spring 2013.

The DPRS is an important addition to the DSS and will improve the nature and accessibility of the various demonstration project data and, ultimately, augment the well-established outreach and communication efforts of the PCOR Partnership Program.

It should be noted that the requirements for DPRS updates (D10) in September 2014 and 2016 were deleted in September 2012. In PY7, updates to the DPRS will continue to be reported in the quarterly technical progress reports rather than in stand-alone reports.

Collaboration with Petroleum Technology Research Centre's (PTRC's) Aquistore Project

PTRC at the University of Regina is in the process of conducting a CCUS project in southeastern Saskatchewan, Canada, to demonstrate the feasibility of CO_2 storage in a deep saline formation. The formal name for this project is Aquistore.

The PCOR Partnership will collaborate with PTRC, acting as advisor in the site characterization, risk assessment, and MVA activities and directly performing aspects of the modeling and simulation activities. The PCOR Partnership will utilize site characterization data collected by PTRC to update the geologic model and perform predictive simulations. The period of performance for this subtask was July 2012 – June 2013, subsequently extended to March 31, 2014.

EERC staff participated in PTRC SERC (Science and Engineering Research Council) meetings held June 12, 2013, and July 9–12, 2013. The latter meeting included a risk assessment meeting as well as the Aquistore Annual Sponsors' Meeting in Regina, Saskatchewan, Canada.

Because receipt of PTRC's Aquistore model was slightly delayed, the EERC began building its own version of the static model. Upon receipt of the Schlumberger Carbon Services (Schlumberger) model, review and comparison of the models were performed, more specifically the project area, well database, marker tops, structure interpretations, and isopach maps were reviewed and appropriate adjustments noted.

It should be noted that with regard to the Aquistore Project, the capture facility is complete, but turbine installation is delayed. CO_2 injection is now delayed until spring 2014 (in PY7).

DOE NETL Carbon Sequestration Atlas of the United States and Canada (Atlas IV)

The primary purpose of Atlas IV is to update U.S.–Canada CO_2 storage potential and provide updated information on the activities of DOE's seven RCSPs as well as DOE's Carbon Storage Program and international CCS collaborations. In order to support Atlas IV efforts, the PCOR Partnership participated in multiple conference calls to discuss progress of the data compilation and provided data via NATCARB (DOE NETL's distributed NATional CARBon Sequestration Database and Geographic Information System), including aggregated characterized saline aquifer data, recalculated regional coal capacity information, and new GIS layers. Atlas IV was released in December 2012.

RCSP GIS Working Group

The task lead participated in the RCSP GIS Working Group conference calls, as scheduled. There were no working group meetings held in PY6.

Training

Regional characterization staff attended the 2013 North Dakota GIS Users Conference September 10–12, 2013, in Grand Forks, North Dakota.

Task 2 – Public Outreach and Education

This task provides outreach and education mechanisms to raise awareness regarding CO_2 storage opportunities in the region as well as outreach to select target audiences concerned with the demonstration activities.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) are addressed as follows.

Meetings and Conferences

EERC employees attended 75 meetings/conferences at the regional, national, and international level. As a result, numerous external individuals and groups were exposed to the PCOR Partnership name, messaging, and informational materials, and numerous participants within the RCSP Initiative were updated on PCOR Partnership activities. The meetings/ conferences featured audiences ranging from the general public, to educators, to scientists and researchers, to regulators and partners. Specifically, the PCOR Partnership peer and public outreach activities included 31 poster and 45 oral presentations as well as nine exhibit booths. Compared to PY5, the EERC attended an additional 10 meetings/conferences during PY6 and gave an identical number of presentations. However, in PY6, there were significantly more poster presentations given (PY5, 64 oral and 12 poster presentations).

Outreach Material Distribution

The standard PCOR Partnership outreach packet contains some combination of the five documentary DVDs, the regional atlas, fact sheets, and other program materials. The materials are provided as part of presentations in select venues (e.g., teacher workshops), as part of acquainting new contacts with the PCOR Partnership Program, and by request through the PCOR Partnership public Web site or other pathways (e.g., telephone or e-mail). During PY6, the PCOR Partnership distributed over 1600 documentary DVDs and nearly 700 atlases as follows:

- PCOR Partnership documentary entitled "Nature in the Balance: CO_2 Sequestration" – 232

- PCOR Partnership documentary entitled "Reducing Our Carbon Footprint: The Role of Markets" – 230

- PCOR Partnership documentary entitled "Out of the Air: Into the Soil" – 229

- PCOR Partnership documentary entitled "Managing Carbon Dioxide: The Geologic Solution" – 518

- PCOR Partnership documentary entitled "Global Energy and Carbon: Tracking Our Footprint" – 422

- *PCOR Partnership Atlas, 4th Edition* – 576

- *PCOR Partnership Atlas, 4th Edition, Revised* – 108

Throughout the course of the program, the PCOR Partnership has distributed a total of 4858 copies of the various regional atlas editions and 8552 copies of the five different documentary DVDs.

Outreach Planning

An update to the PCOR Partnership outreach action plan (D11) was prepared in March 2010. This plan describes the activities undertaken and products developed to help raise awareness of both the practice of CO_2 storage in general and the PCOR Partnership specifically. The next version of the plan is scheduled for March 2016.

Data Acquisition and Management

The outreach data management system is envisioned as an addition to the DSS to consist of GIS-compatible databases. When completed, these databases will contain information needed to plan, track, and assess outreach actions as well as to produce thematic maps and other products to aid in outreach activities, including the Web site, PowerPoint presentations, fact sheets, and documentary products both at the regional level and for the areas of the demonstration projects. During PY6, efforts continued to populate, test, and refine the outreach tracking database.

Public Web Site (www.undeerc.org/pcor)

Web Site Updates

The PCOR Partnership public Web site has been online since the summer of 2005. This Web site will be updated and expanded as appropriate, with major updates on a biennial basis.

An update (D13) was submitted July 31, 2012, and the proposed changes went "live" on January 9, 2013, after approval from DOE NETL. This update included revisions to the Home Page and Educator Page and an expansion of the CO_2 Sequestration Projects section from one page to nine pages in order to include information on each of the Phase III projects and the

Phase II verification test projects as well as information on other CCUS projects in the PCOR Partnership region.

Additional changes to the Web site made during PY6 included the following:

- The top, horizontal navigation bar was updated to include a site-specific search function.

- The atlas page was updated to include the "4th Edition, Revised" (http://undeerc.org/pcor/NewsAndPubs/Atlas.aspx).

- Additional sections were added to the Educator page (http://undeerc.org/PCOR/Educators/).

- New software was installed to ease navigation through the video clips and documentaries, and the video clip library page was redesigned (Figure 4) to complement the new functionality (www.undeerc.org/PCOR/Video-Clip-Library/).

- Additional Phase III information (prospectus and fact sheet) was added to the site (www.undeerc.org/PCOR/About/).

Web Site Activity Tracking

Google Analytics is utilized to track activity for the PCOR Partnership public Web site. This Web analysis tool has played an integral part in understanding the online behavior of Web site visitors. In the past, site traffic included both internal (EERC and PCOR Partnership staff) and external audiences; however, at the beginning of PY6, the Advanced Segments feature in Google Analytics was utilized to exclude internal (EERC personnel) Web site traffic, thus providing a reasonable starting point to gauge public activity. The results reported below are for public (external) traffic only.

Web Site Traffic

During PY6, there were 5026 visits to the public Web site, representing an increase of 70% over the 2963 external visits made in PY5. In PY6, there were 3822 unique first-time visitors and 217 unique returning visitors, totaling 4039 unique visitors. This represents a 70% increase of the 2375 PY5 visitors.

In PY6, the PCOR Partnership public Web site received traffic from 90 countries (Figure 5). Of the 5026 visits, 62% of the Web traffic was domestic. International traffic, as depicted in Table 3, was primarily from Canada. Aside from the United States (3102), the countries with the highest number of visits included Canada (341), India (175), United Kingdom (168), Australia (128), South Korea (66), France (59), Phillipines (53), Germany (50), and Malaysia (49).

Figure 4. Updated PCOR Partnership Video Clip Library Web page.

Visits originating from within the PCOR Partnership region increased 17% in PY6, with 915 visits as compared to 784 visits previously. Approximately 75% of the regional visits originated from within the United States and 25% came from Canada. Region-specific visits comprised 18% of the overall traffic to the PCOR Partnership public Web site (the totals are skewed to some degree because the visit location data were aggregated at the state and province level even though the PCOR Partnership region includes only portions of British Columbia, Montana, and Wyoming).

Table 3. Visit Activity from the Top 10 Countries and the PCOR Partnership Region

	Country	State/Province	Visits*
1.	United States		3102
		North Dakota	229
		Minnesota	156
		Wyoming	94
		Missouri	54
		Montana	49
		Nebraska	42
		Wisconsin	35
		Iowa	16
		South Dakota	13
2.	Canada		341
		Alberta	138
		Saskatchewan	49
		British Columbia	35
		Manitoba	5
3.	India		175
4.	United Kingdom		168
5.	Australia		128
6.	South Korea		66
7.	France		59
8.	Philippines		53
9.	Germany		50
10.	Malaysia		49
	89 Other Countries		835
		Total Visits	**5026**

*Arranged by the number of visits to the site.

Web Site Traffic Sources

Google Analytics provides a breakdown of how visitors came to the PCOR Partnership Web site, also referred to as traffic sources. The three general sources of traffic include direct, search, and referral sites. These categories and the percentage of the total traffic sources are presented in Figure 6.

Direct traffic consists of those visitors who type in or enter the URL (www.undeerc.org/pcor). This accounted for 17% of the overall traffic.

Search engine traffic refers to the use of keywords and accounted for nearly 70% of the traffic. Google Analytics provides the keywords that visitors used to find their way to the Web site. The top three keywords used include "CO_2 sequestration," "PCOR," and "What is CO_2?"

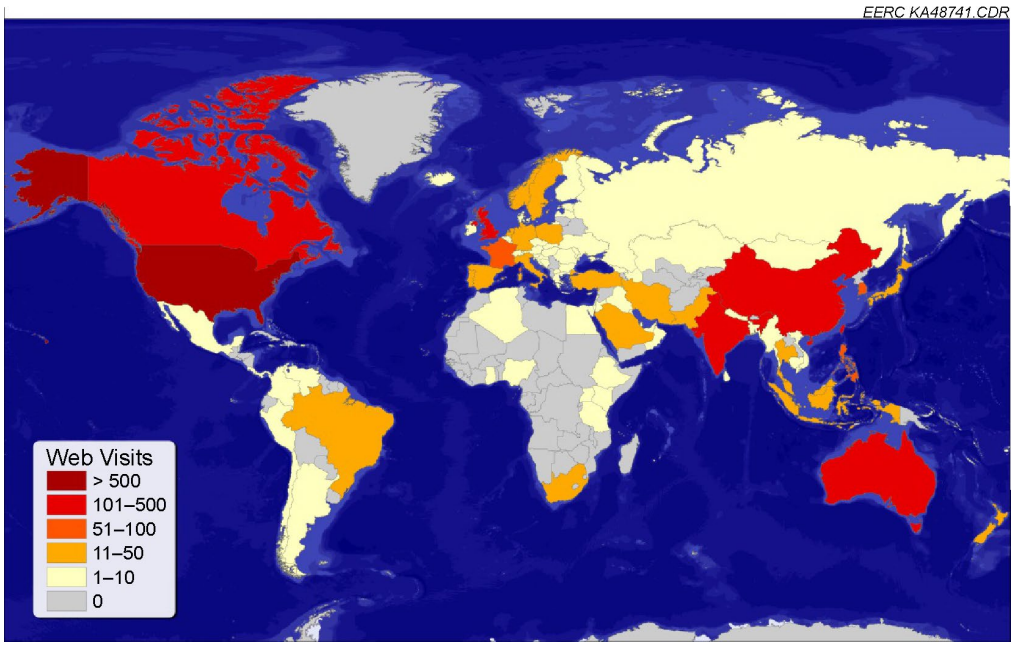


Figure 5. Map of PCOR Partnership global Web traffic for PY6 (source: Google Analytics).

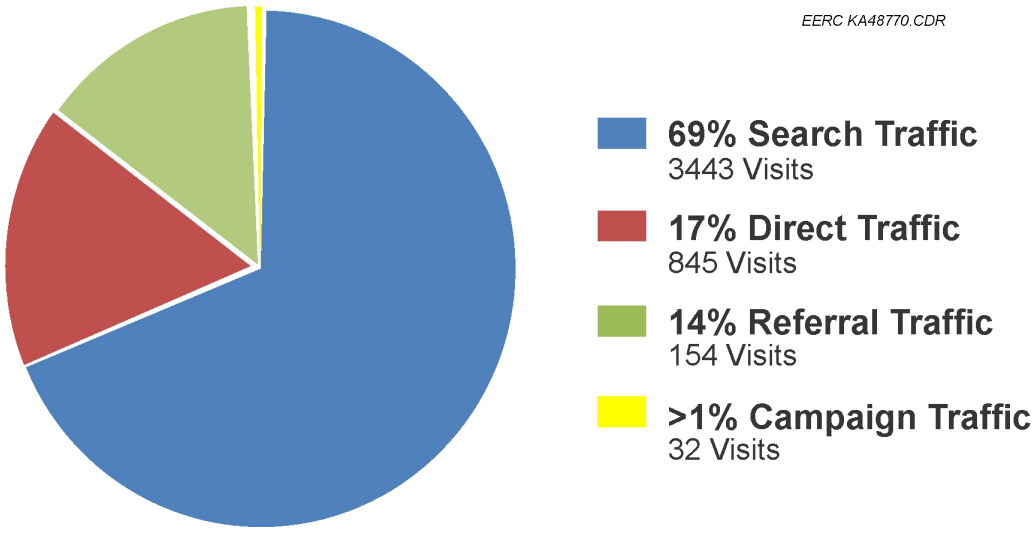


Figure 6. PCOR Partnership public Web site traffic in PY6 (source: Google Analytics).

Referral site traffic is traffic directed to the PCOR Partnership Web page from other sites via links. About 14% of external traffic was from referral sites. The top two referring Web sites were the DOE Office of Fossil Energy (100 referrals) and DOE's main Web site (93 referrals). The two Web sites refer "quality" traffic, meaning the referred traffic included over 76% new visitors. Those visitors stayed on the Web site an average of 4:00 minutes and visit an average of three pages per visit.

Nature of Visits

There were a total of 10,870 page views in PY6, resulting from 5026 visits. The top five viewed PCOR Partnership Web pages comprised about 54% of page views overall. The "Home Page" and "What Is CO_2 Sequestration?" pages dominated, accounting for 37% of the total page views (Table 4).

Fact Sheets

Fact sheets have been created with general background information on the PCOR Partnership Phase III program and a profile on each of the demonstration projects. These fact sheets, along with the ones developed in previous phases, will be updated as needed. Other fact sheets may be developed as needed.

In February 2013, the general Phase III fact sheet (now entitled "PCOR Partnership – Demonstrating CO_2 Storage in the Northern Great Plains") was revised. In March 2013, the fact sheet update (D15) prepared in March 2012 satified the April 2013 requirement, pending revision following initiation of CO_2 injection at the Bell Creek oil field. Because of the "on hold" status for the Fort Nelson project, the requirement for a fact sheet update (D16, originally due in April 2013) was waived.

In July 2012, a requirement for an Aquistore project fact sheet (D94) in collaboration with PTRC was added. The fact sheet was originally due in January 2013, but the due date was extended to September 2013.

PowerPoint Presentations

PowerPoint presentations have been developed for Phase III general activities as well as for each of the demonstration projects and for targeted outreach to specific audiences (e.g., educators). In September 2012, it was approved by DOE NETL that future updates to D18 (Bell Creek) and D19 (Fort Nelson) are no longer required as separate stand-alone presentations. Instead, we will continue to give a variety of presentations related to these projects and will report upon the presentations, including any updates, in the technology transfer section. As indicated above, 45 oral presentations were given in PY6, and the majority included information on the Bell Creek project as well as updates on the Fort Nelson project and other PCOR Partnership activities.

Table 4. Top Pages for Page Views on the PCOR Partnership Public Web Site

Page Title	Page Views	% Page Views	Page
Home Page	2529	23.0	www.undeerc.org/pcor/
What Is CO_2 Sequestration	1546	14.0	www.undeerc.org/pcor/sequestration/whatissequestration.aspx
CO_2 Sequestration Projects	654	6.0	www.undeerc.org/pcor/co2seqprojects/default.aspx
PCOR Video Clips Library	595	5.5	www.undeerc.org/pcor/Video-Clip-Library/
About the Partnership	580	5.3	www.undeerc.org/pcor/about/default.aspx

The general Phase III information PowerPoint presentation (D17) was updated for general use in May 2013.

Outreach Working Group

The RCSP Outreach Working Group (OWG), comprising representatives from each of the seven regional partnerships as well as ad hoc representatives from DOE, recognizes the importance of conducting public outreach in tandem with successful field tests. Its members pool their experiences and resources in an effort to provide a foundation for future commercialization efforts and even more extensive outreach efforts. Based on contributions by the outreach leads of the seven regional partnerships, DOE NETL's outreach BPM entitled "Public Outreach and Education for Carbon Storage Projects" was released in December 2009.

Examples of the PCOR Partnership's participation in the OWG during PY6 include the following:

- Participated in 10 monthly OWG conference calls and in-person meetings held in conjunction with 12th Annual Carbon Capture, Utilization, and Sequestration Conference (CCUS-12) and DOE Carbon Storage R&D Project Review meetings in May and August, respectively. Topics discussed included the development of new message maps as a basis for informing audiences about the differences between CCUS and hydraulic fracturing as well as issues related to CCUS and drinking water.

- Participated in focus group sessions with the OWG lead in October 2012 in Washington, D.C. These focus group sessions were related to the use of message maps in developing, organizing, and testing outreach materials in response to stakeholder concerns. Sessions were held on the topic of CCUS and seismic events.

- Attended the 11th Greenhouse Gas Control Technologies Conference (GHGT-11) and presented the RCSP OWG's "Visual Message Mapping for Carbon Capture and Storage (CCS) Outreach" in Session 9D on November 18–22, 2012, in Kyoto, Japan.

- Prepared presentation materials for CCUS-12 held May 13–16, 2013, in Pittsburgh, Pennsylvania. The RCSP OWG presented a session on message mapping.

- Participated in a side meeting held in conjunction with the DOE project review meeting in August 2013.

Posters

Posters intended for a general audience are under development. These differ from the 31 technical poster presentations given at conferences in PY6. In March 2009, a general outreach poster (D24) was completed, and efforts began in PY6 to prepare an update due in March 2014. Efforts were undertaken in 2011 for individual posters profiling the demonstration projects, more specifically a Bell Creek test site poster (D27) bearing the heading "CO_2 Emissions Go to Work to Produce More Oil" and a Fort Nelson test site poster (D26), similar to the concept of the Bell Creek test site poster, that diagramed the geology under the Fort Nelson demonstration project.

In PY6, Spectra requested the Fort Nelson poster for distribution as part of presentations to select groups in London and Oslo. In addition, 25 copies of the poster were mailed to Spectra for distribution at various conferences.

In July 2012, a requirement for an Aquistore project poster (D95) in collaboration with PTRC was added. The poster was originally due in February 2013, but the due date was extended to September 2013.

Documentaries and Video Products

A spectrum of video products are developed to meet the needs of general and site-level outreach. Thirty-minute broadcast-quality documentaries are produced in partnership with Prairie Public Broadcasting (PPB), are broadcast in the PPB market area, are made available to other public broadcasting markets for possible broadcast, are placed on the public Web site, and are available as DVDs. In March 2013, DOE NETL approved renaming the "Fort Nelson Test Site 30-minute Documentary" to "Domestic Energy and Carbon 30-minute Documentary" and extended the due date to May 2015. At that same time, DOE NETL approved an extension to April 2017 for the "Storage in Carbon Management 30-minute Documentary." Video segments and products are intended for stand-alone use in meetings, in PowerPoint presentations, and on public Web pages.

Bell Creek Project-Related Filming

The Bell Creek (D21) demonstration site documentary is due April 2016 (extended from November 2014). In PY6, in conjunction with PPB, numerous activities were filmed at the Bell Creek test site, including installation of VSP in April 2013 and the Bell Creek commissioning ceremony in August 2013.

In addition, a value-added videographic BPM entitled "Installing a Casing-Conveyed Permanent Downhole Monitoring System" using footage collected at the Bell Creek site was premiered in September 2013 at the PCOR Partnership Annual Membership Meeting (Figure 7).

Aquistore Project-Related Filming

In response to an offer by the EERC as part of the Aquistore Project Communications Advisory Group, PTRC agreed to filming activities by PPB at the Aquistore site near Estevan, Saskatchewan, Canada, as well as interviews of project staff. As a result, several days (October 29 – November 1, 2012) were spent filming on location, capturing the installation of CO_2 soil gas samplers, water sampling, water well drilling, and completion of the second Aquistore well as well as interviews with personnel at PTRC, the International Test Center for CO_2 Capture, and the Saskatchewan Geological Survey.

A similar offer was made to SaskPower with respect to the Boundary Dam project. On March 28, 2013, PPB signed an agreement with SaskPower granting permission for PPB to film at the Boundary Dam site and conduct interviews as part of Aquistore outreach activities. Plans were in place to begin filming on July 23, 2013, but the trip was delayed until October 2013.

Figure 7. Cover art for the videographic BPM of a permanent downhole monitoring (PDM) system using footage captured at the Bell Creek site.

Broadcast of Documentaries

On April 30, 2013, the DOE Office of Fossil Energy released a Techline announcing that the PCOR Partnership–PPB documentary entitled "Global Energy and Carbon: Tracking Our Footprint" received a 2012 Platinum Best of Show Aurora Award in the nature/environment documentary category (http://energy.gov/fe/articles/regional-partnership-documentary-wins-best-show-aurora-award). The 30-minute documentary premiered on Prairie Public Television in October 2010 and has been broadcast more than 100 times in 30 different states. It is the fifth in a series of documentaries produced by the PCOR Partnership and PPB and joins the growing list of award winners, including "Reducing Our Carbon Footprint: The Role of Markets," which won the a 2009 Award of Excellence at the 15th Annual Communicator Awards, "Out of the Air—Into the Soil," which won a 2009 Gold Aurora Award and 2009 Annual Communicator Award, and "Nature in the Balance: CO_2 Sequestration," which won a 2006 Bronze Telly Award.

In PY6, the PCOR Partnership received public television exposure from documentaries that were broadcast in nine states and one Canadian province, as listed in Table 5. A total of 18 broadcasts were aired. The number of telecasts by documentary are as follows: "Reducing Our Carbon Footprint: The Role of Markets" (two), "Out of the Air: Into the Soil" (two), and "Global Energy and Carbon: Tracking our Footprint" (14). All three documentaries were aired within the PCOR Partnership region. No new PCOR Parntership documentaries premiered in PY6, and broadcast rights had expired in several areas. This accounted for the low number of telecasts (18), compared to PY5 (66) and PY4 (221).

Table 5. State/Province Broadcasts

State/Province	Broadcasts
North Dakota	5
Manitoba[1]	5
North Carolina	3
South Carolina	3
Georgia	3
Alaska	1
California	1
Michigan	1
Ohio	1

[1] The Canadian province of Manitoba is part of the PPB service area.

Outreach to Teachers and Librarians

In PY6, the PCOR Partnership participated in three teacher training workshops and seminars. Participation included introducing PCOR Partnership materials (DVDs, atlas, Web site awareness) to educators in K–12 schools as well as the dissemination of the materials to librarians in school, university, government, and public libraries.

The three teacher training workshops and seminars included the following:

1. A 2-day science teacher conference presented by the North Dakota Science Teachers Association (materials disseminated) on February 21–23, 2013, in Bismarck, North Dakota.

2. A 4-day coal-centric workshop presented by the North Dakota Lignite Energy Council (materials disseminated) June 17–20, 2013, in Bismarck, North Dakota.

3. A 2-day CCUS-focused teacher training institute (presentation given, materials disseminated) June 25–26 in Moorhead, Minnesota (Figure 8).

A total of 206 teachers representing 75 different school districts in six states in the PCOR Partnership region were in attendance. Fourteen of the teachers participating in the 2-day sequestration-focused training had previously heard a PCOR Partnership outreach presentation at a different workshop. Based on informal discussion during the workshops, many teachers plan to utilize PCOR Partnership materials in their classrooms. Figure 9 shows the geographic distribution of the teachers and school librarians who received materials by their corresponding school districts.

EERC KA48742.CDR

Figure 8. PCOR Partnership Public Outreach and Education lead Dan Daly presenting at a PPB Teacher Training Institute in June 2013 at Concordia College in Moorhead, Minnesota.

EERC KA48740.CDR

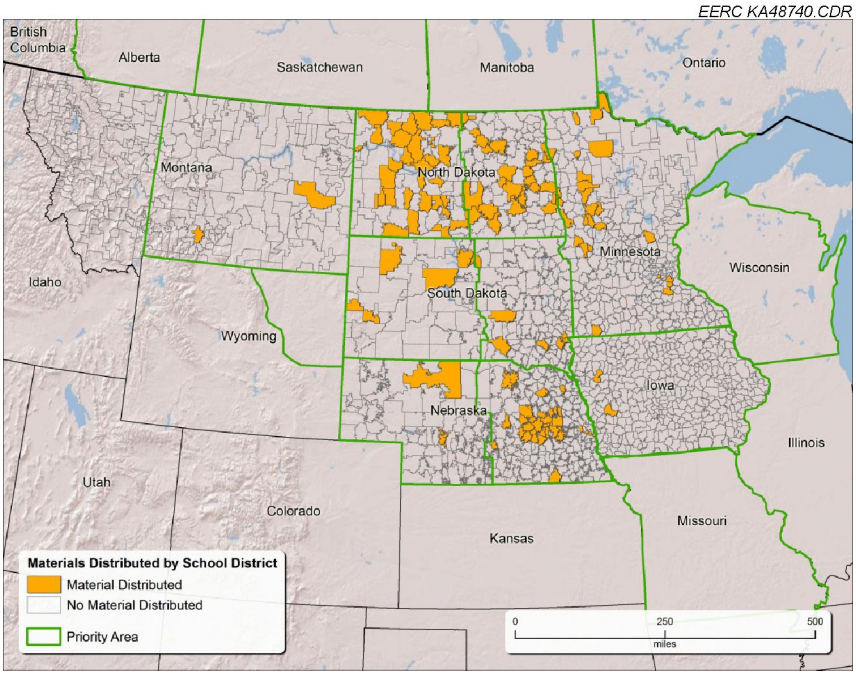


Figure 9. Distribution by school district of teachers and school librarians who received outreach materials in PY6.

Librarian contact took place at the South Dakota Library Association (SDLA) Annual Meeting (October 3–5, 2012) and the Mountain Plains Library Association (MPLA)/Nebraska Library Association (NLA)/Nebraska School Library Association (NSLA) 2012 Tri-Conference (October 17–19, 2012). Materials were provided to 130 librarians from four states in the PCOR Partnership region. Figure 10 illustrates the library type and location of the participants. Potential audiences included primary and secondary teachers and students; university faculty, staff, and students; and public library patrons.

Media Coverage

Media coverage is defined as articles related to the PCOR Partnership covered on television or radio networks or in newspapers and magazines, including both print and online news sources. The EERC tracks media coverage internationally utilizing a variety of clipping and news-gathering services. In addition, Google Alerts is used which e-mails PCOR Partnership-related news retrieved from the Internet.

During PY6, coverage on the PCOR Partnership appeared in 62 different online newspaper articles, 64 additional online articles, ten television networks, and three radio stations.

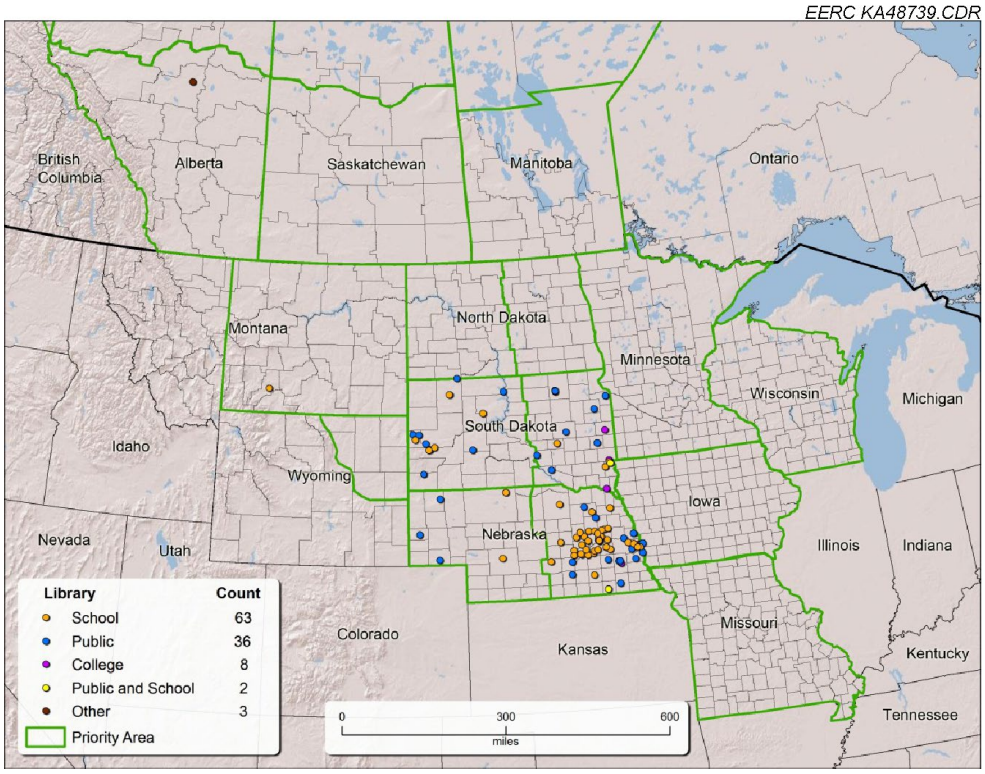


Figure 10. Distribution of public libraries, university libraries, school libraries, and other libraries that received PCOR Partnership materials in PY6.

Task 3 – Permitting and NEPA Compliance

The overall goal of Task 3 is to advance the regulatory and permitting framework for CO_2 storage projects in North America as well as to assist the demonstration site owners as necessary in obtaining the permits and approvals needed for the projects to comply with state, provincial, and federal requirements.

Activities and Results

The PCOR Partnership continues to stay abreast of federal legislative actions occurring in the United States and Canada and follows the developments of various state, provincial, and regional initiatives. Internal documents that outline the activities of these groups are updated on a regular basis. Reviews continue of publications relating to the regulation of CO_2 sequestration, MVA issues, and carbon market developments. Updates are provided to task leaders with regard to federal, state, and provincial actions. In addition, the regulatory section on the DSS is updated regularly.

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) are detailed as follows.

General Permitting Assistance

The EERC interfaces with relevant regulatory agencies within the PCOR Partnership region as well as with federal regulatory agencies (United States and Canada) to understand the regulatory framework for project implementation. The EERC determines anticipated permitting activities for potential projects in all states and provinces of the PCOR Partnership region.

D6, Permitting Review – Update 1

On September 24, 2013, an update to the 2011 permitting review was submitted. This document provided a brief update on the requirements to conduct a geologic CO_2 storage project in the United States or Canada. As of the date submitted, EPA has the authority to permit CO_2 geologic storage wells in all 50 states. Additionally, EPA requires geologic storage projects to comply with the GHG mandatory reporting rule (MRR; 40 Code of Federal Regulations [CFR] 98). In Canada, the provinces have the authority to permit geologic storage projects.

U.S. Environmental Protection Agency

In December 2010, EPA finalized the requirements for a new well class (Class VI) under the authority of the Safe Drinking Water Act's Underground Injection Control (UIC) Program. The rule established federal requirements for the underground injection of CO_2 for the purpose of long-term underground storage, or geologic storage. As of September 7, 2011, EPA directly implemented the Class VI program nationally. As a result, in order to permit a CO_2 geologic storage project, potential owners or operators of a CO_2 geologic storage well will need to submit a permit application to the appropriate EPA regional office.

On June 21, 2013, the official North Dakota Class VI primacy application for the authority to regulate the geologic storage of CO_2 was submitted to EPA, and on August 9, 2013, a public notice for the opportunity to comment and request a public hearing regarding North Dakota's UIC program revision application was published in the Federal Register (78 *Federal Register* 154 [9 August 2013], p. 48639).

Canadian Standards Association

In October 2012, the Canadian Standards Association (CSA) published Z741-12 Geologic Storage of Carbon Dioxide. The standard establishes the requirements and recommendations for the geologic storage of CO_2, primarily in deep saline formations and depleted hydrocarbon reservoirs. This standard may be used by provinces as a reference point when and if development of provincial-specific rules and regulations related to CCS are developed or deemed necessary. In the PCOR Partnership region, Alberta has been the most active province in the development of CCS projects, legislation, and rules. In April 2011, the Carbon Sequestration Tenure Regulation was passed. In addition, Alberta recently completed an 18-month review of its existing regulatory framework. Alberta released the Regulatory Framework Assessment Report on August 19, 2013.

Fifth Annual PCOR Partnership Regulatory Meeting

The 2009 regulatory meeting looked at the regulatory regime associated with subsurface injection of CO_2. At the meeting held in 2010, there was an effort to embrace a larger community by also addressing pipelines and focusing on the efficient movement of CO_2 throughout the region. A continuing goal of the meetings in 2011–2013 was to continue to develop strategies to work past state/provincial boundaries.

Fifteen people attended the 2013 meeting, including regulators from North and South Dakota, Alberta and Saskatchewan, Canada, and five representatives from the EERC. Also present were representatives of IOGCC; Melzer Consulting; The CETER Group; Bliss Consulting; and Premier Oil Recovery, LLC (Figure 11).

Presentations were given on the following topics:

- PCOR Partnership Update
- IOGCC and PCOR Parntership Phase III Project
- IOGCC Update
- Provincial/State CCS Updates
- National EOR Initiative Update
- Class II to Class VI Transition – Status/Potential Concerns

Figure 11. Attendees at the 5th Annual Regulatory Roundup held July 30–31, 2013, in Deadwood, South Dakota.

Interstate Oil and Gas Compact Commission

IOGCC is a multistate government agency that promotes the conservation and efficient recovery of domestic oil and natural gas resources while protecting health, safety, and the environment. The PCOR Partnership participates in IOGCC activities. In fact, John Harju is a past chair of IOGCC's Energy Resources, Research, and Technology Committee and serves on the CGS Task Force.

EERC staff members participated in the following IOGCC meetings in PY6:

- Attended the IOGCC Annual Meeting on October 29–31, 2012, in San Antonio, Texas, and presented "IOGCC Carbon Storage Task Force Operational and Postoperational Liability" before the Council of State Oil and Gas Attorneys on October 30, 2012.

- Attended the IOGCC Midyear Issues Summit held May 19–21, 2013, in Point Clear, Alabama.

IOGCC CGS Task Force Activities

Through the efforts of the IOGCC CGS Task Force, the PCOR Partnership addresses issues relating to liability (operational and postoperational) that remain as barriers to the establishment of state and federal legal and regulatory frameworks for CCUS. Clarification of attendant liability issues will remove significant barriers to CCUS deployment and thus provide

prospective CCUS project developers with greater regulatory certainty, a necessary prerequisite for CCUS project development to move forward. Findings, recommendations, and guidance will be developed. IOGCC will communicate the CGS Task Force output to the public, along with state and local elected and administrative officials, industry representatives, prospective CCUS project operators and financiers, and other stakeholders through an outreach and awareness effort. The period of performance for this subtask is July 1, 2012 – March 30, 2014.

Task Force Kickoff Meeting Held

A task force kickoff meeting was held on October 4, 2012, in Denver, Colorado. The two liability subgroups, i.e., an Operational Liability Subgroup and a Postoperational Liability Subgroup, were formed to conduct CGS Task Force research.

M37, IOGCC Task Force Subgroup Meeting 1 held

The IOGCC Task Force Subgroup Meeting 1 was held via conference call on November 8, 2012. All appointed subgroup members were able to participate. Members include the following:

- Kevin Bliss, Kevin J. Bliss Consulting
- Chris Arnot, Alberta Energy
- Kipp Coddington, Mowrey Meezan Coddington Cloud LLP
- Kevin Connors, North Dakota Industrial Commission
- Scott Anderson, Environmental Defense Fund
- Marvin Rogers, Alabama Oil and Gas Board
- Lisa Botnen, EERC

The meeting summary from the Task Force kickoff meeting was reviewed and discussed. In addition, various financial instruments and their applicability to particular phases of a geologic storage project were analyzed. The subgroup also discussed the development of a bibliography that contains documents relevant to the subject matter.

M37, IOGCC Task Force Subgroup Meeting 2 Held

The IOGCC Task Force Subgroup Meeting 2 was held in Minneapolis, Minnesota, May 8–9, 2013. Subgroup members able to participate included the following:

- Kevin Bliss, Bliss Consulting
- Chris Arnot, Alberta Energy
- Kipp Coddington, Mowrey Meezan Coddington Cloud LLP
- Kevin Connors, North Dakota Industrial Commission
- Fred Eames, Hunton & Williams LLP, representing the Environmental Defense Fund
- Kevin Frederick, Wyoming Department of Environmental Quality
- Lisa Botnen, EERC

The draft report was reviewed and discussed. Various sections were edited by the group and/or rewritten. Some sections required a more thorough rewrite and were assigned to appropriate subgroup members. This was the final subgroup meeting.

M42, Findings and Recommendations of the Operational and Postoperational Subgroups Presented to the CGS Task Force

On May 6, 2013, a request to eliminate D97, Report – Findings and Recommendations of the CGS Task Force's Operational and Postoperational Subgroups, in order to give the full CGS Task Force adequate time to thoroughly review the subgroup findings was approved. The addition of M42, completion of which was evidenced by reporting the subgroup findings and recommendations to the full task force, was also approved.

The IOGCC Task Force Meeting was held in Denver, Colorado, June 19–20, 2013. Task Force members who were able to participate are as follows:

- Chris Arnot (representing Mike Fernandez), Alberta Energy
- Steve Melzer, Melzer Consulting
- John Harju, EERC
- Kevin Connors (representing Lynn Helms), North Dakota Industrial Commission
- Rob Finley, Advanced Energy Technology Initiative, Illinois State Geological Survey
- Scott Anderson, Environmental Defense Fund

Others in attendance included the following:

- Kevin Bliss, Bliss Consulting
- Lisa Botnen, EERC
- Fred Eames, Hunton & Williams LLP

The draft report was reviewed and discussed. Various sections were edited by the group, and the recommendations of the subgroup were accepted by the Task Force. The updated report will be sent to the Task Force by the end of June for a final review.

M38, IOGCC Task Force Wrap-Up Meeting Held

The IOGCC Task Force Wrap-Up Meeting was held via conference call on August 16, 2013. Task Force members who were able to participate included the following:

- Scott Anderson, Environmental Defense Fund
- Rob Finley, Advanced Energy Technology Initiative, Illinois State Geological Survey
- Kevin Connors (representing Lynn Helms), North Dakota Industrial Commission
- Lawrence Bengal, Arkansas Oil and Gas Commission
- Kevin Frederick, Wyoming Department of Environmental Quality

Others participating in the call included the following:

- Kevin Bliss, Bliss Consulting
- Gerry Baker, IOGCC
- Fred Eames, Hunton & Williams LLP
- Laura Ladd, Hewitt Ladd, Inc.
- Lisa Botnen, EERC

The draft report was reviewed and discussed. Comments from the Task Force were noted and incorporated into the text where agreed upon and appropriate. Comments received from Task Force members who were unable to participate in the call were also discussed. The revised text will be circulated to the Task Force once again prior to report finalization and submittal.

M39, IOGCC Task Force Editing Subgroup Meeting Held

The IOGCC Task Force Editing Subgroup Meeting was held in Washington, D.C., June 3–5, 2013. Subgroup members that participated included the following:

- Kevin Bliss, Bliss Consulting
- Kevin Connors, North Dakota Industrial Commission
- Lawrence Bengal, Arkansas Oil and Gas Commission

The draft report was reviewed and discussed. Comments from the subgroup meeting held in Minneapolis in May were incorporated. Various sections were edited and/or rewritten. Subgroup members will review the draft document again, prior to presenting the report to the Task Force in mid-June. The updated documents and meeting notes are available on OneHub, the document-sharing site used by the subgroup and Task Force.

D98, Draft Guidance for States and Provinces on Operational and Postoperational Liability

The draft report was sent on August 30, 2013, for DOE NETL project manager approval. The principal authors of the report included the following:

- IOGCC CGS Task Force
- Lawrence Bengal, Arkansas Oil and Gas Commission
- Kevin Bliss, Bliss Consulting
- Kevin Connors, North Dakota Industrial Commission

Once approved, IOGCC will prepare the report for distribution to its members and other interested parties.

Development of a Permitting Action Plan – Bell Creek Test Site

The EERC is required to develop a permitting action plan in conjunction with the site owner in accordance with relevant local, state, and federal regulatory requirements for the Bell Creek project. D29, permitting action plan, was completed in August 2011. Because permitting for the Bell Creek project has been secured by the site owner and operator, Denbury, there is no

need for the EERC to prepare an update to the permitting action plan. However, during this reporting period a review of the EERC's Bell Creek MVA program was completed in association with EPA GHG MRR, Subpart RR – Geologic Sequestration of Carbon Dioxide.

Fort Nelson Test Site

Legislative and regulatory actions by the province of British Columbia are continually followed for the effect they may have on the Fort Nelson demonstration project.

Plug and Abandon Wells and Land Reclamation of Lignite Project Site

On February 14, 2011, the PCOR Partnership received approval for a cost increase to plug and abandon five wells located at the Lignite Field validation test site in the southeast quarter of Section 36 in Burke County, North Dakota. After permissions to proceed were received from the appropriate North Dakota regulatory agencies and approved subcontracts were in place, the process of plugging and abandoning the wells began in September 2011. Site reclamation activities commenced in October 2011, with weed spraying and fence maintenance responsibilities continuing during this reporting period. Seventeen site visits occurred during PY6 on the following dates:

- October 18; November 1, 15, and 29; and December 13 and 27, 2012.

- January 10 and 24; February 7 and 21; March 7 and 21 (Figure 12); April 4; June 19; July 23; August 8; and September 24, 2013.

Lignite Field Validation Test Site Closure Report

In PY6, the finishing touches were put on the value-added report that details the procedures used to close a carbon storage project (e.g., the carbon storage pilot field test conducted in Burke County, North Dakota from 2009–2011). The report is intended to provide an understanding of industrial procedures that are conducive to securing an environmentally sound project conclusion.

Additional Conference/Meeting Participation

- The task lead attended the MVA Knowledge-Sharing Workshop on October 2, 2012, at Denbury headquarters in Plano, Texas.

- EERC staff attended the 2013 UIC Conference, sponsored by the Ground Water Protection Council (www.gwpc.org/events/2013-uic-conference), held January 22–24, 2013, in Sarasota, Florida, and met with representatives about potential risk-based data management system work.

- The task lead presented in the CO_2 Transportation session at the Introduction to CO_2–EOR Workshop held on June 11 and 12, 2013, in Houston and Port Arthur, Texas. The workshop provided an overview of EOR and CCUS to U.S. state and Canadian provincial regulators.

Figure 12. Results of reclamation efforts at the Lignite Field Validation Test site (top: September 2011, bottom: March 2013).

Task 4 – Site Characterization and Modeling

This task involves selecting the two field-based large-scale demonstration sites and developing baseline characterization data and petrophysical models for such sites.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) are described as follows.

Fort Nelson Demonstration Site

The primary objective of the Fort Nelson project is to verify and validate the concept of utilizing one of North America's numerous saline formations for large-scale CO_2 injection, proposed to be up to 2 Mt a year, of anthropogenic CO_2 for permanent storage. In September 2012 (end of PY5), an e-mail was received from Spectra management indicating that it would not be conducting 2012–2013 winter field activities, i.e., exploratory well-drilling or 3-D seismic activities. This will result in further delaying CO_2 injection at the Fort Nelson test site until Spectra develops a business case for the project.

Carbon Sequestration Leadership Forum (CSLF) Recognition and Progress Reports

At its October 2009 London meeting, CSLF recognized the Fort Nelson CCS Project as a collaborative research project that meets CSLF priorities. Subsequently, the PCOR Partnership submitted to the CSLF Secretariat a required project status report as of September 2013. Progress at the Fort Nelson site was reported to include the development of a comprehensive MVA plan for surface, shallow subsurface, and deep subsurface monitoring. The MVA plan will be based on the results of past characterization, modeling, and risk assessment efforts. The MVA plan is being prepared according to guidelines presented in the CSA Standard Z741-12, Geological Storage of Carbon Dioxide.

Project Update Meetings

A meeting was held with DOE NETL and the EERC on August 19, 2013, prior to the DOE Carbon Storage R&D Project Review Meeting in Pittsburgh, Pennsylvania. The lack of a suitable business case for the Fort Nelson CCS Project for Spectra management was discussed. As a result of the "on hold" status of the project, the requirements for several deliverables were waived. These included D40 – Geomechanical Report and D67 – Simulation Report Updates.

Fort Nelson Test Site – Site Characterization Report

Site characterization must be conducted prior to large-scale injection of CO_2 at the Fort Nelson test site. Effective characterization supports modeling, RA, and MVA programs that will constantly evolve to suit the project's needs. Site characterization activities have been conducted to address three critical issues affecting the viability of the Fort Nelson test site: 1) the capacity of the target formation; 2) the mobility and fate of the CO_2 at near-, intermediate-, and long-term time frames; and 3) the potential for leakage of the injected CO_2 into overlying formations and/or the near-surface environment.

Geochemical, mineralogical/petrophysical, geomechanical, and hydrogeological data have been collected for the purpose of supporting modeling, RA, and MVA activities. The geology, stratigraphy, and lithology have been evaluated, delineated, and described for the entire sedimentary succession from the base of the Devonian-age Presqu'ile reef complex to the ground surface for the Fort Nelson area. The structural elements of the reef complex have been investigated to identify any existing faults and/or fractures that would allow migration of any reservoir and/or injected fluids out of the storage reservoir. On this basis, a geologic model has

been built, with particular attention given to the Devonian injection interval and overlying and underlying sealing formations.

Key findings of the characterization activities to date include the following:

- The Sulphur Point and Keg River Formations appear to have adequate storage- and injectivity-related properties to serve as primary sinks.

- The Fort Simpson and Muskwa Formations appear to have the tightness, competency, thickness, and lateral continuity necessary to be the primary seals.

- The Slave Point Formation has been disqualified as a primary potential sink because of the proximity of commercial gas fields that occur within it.

- Evidence suggests the Slave Point, Sulphur Point, and Keg River Formations are in hydraulic communication (laterally and vertically) with each other.

- Surface, shallow subsurface, and deep subsurface characterization data are limited because of the remote, inaccessible nature of the Fort Nelson area and because of the lack of hydrocarbons in the area being considered for CO_2 storage (Figure 20).

- The storage capacity of the Presqu'ile reef complex in the Fort Nelson area has been estimated to range from 100 to over 240 million tonnes of CO_2.

It was anticipated that future characterization activities would include drilling and testing of a new exploratory well, collecting new seismic survey data, and conducting laboratory-based geochemical and geomechanical investigations. However, because Spectra decided not to pursue these events, no additional characterization activities occurred in PY6. Comments from Spectra were received in February 2013, following its review of D41 – Site Characterization Report. This report is anticipated to be finalized in PY7.

Fort Nelson – Preliminary Geochemical Observations

A screening-level geochemical laboratory test program was conducted (2009 through 2011) at the EERC to investigate the theorized and potential effects of the injection of 100% CO_2 and sour CO_2 (i.e., a mixture of CO_2 and H_2S ranging from 86.5% CO_2 and 13.5% H_2S to 95% CO_2 and 5% H_2S) on the cap rock, transition-zone rock, and reservoir rock from Spectra's Fort Nelson CCS Project in northeastern British Columbia, Canada. The primary goals of this program were as follows:

- Identify the predominant mineral phases of the potential sink and seal formations.

- Determine possible interactions and mineralogical changes within the caprock, transition-zone rock, and reservoir rock when exposed to CO_2 and sour CO_2 at near- and far-from-wellbore reservoir conditions.

- Determine the mineral dissolution and precipitation potential resulting from the exposure of the cap rock, transition-zone rock, and reservoir rock to CO_2 and sour CO_2.

- Determine potential changes in reservoir fluid properties as a result of CO_2 and sour CO_2 injection into the geologic storage reservoir(s).

Samples (drill cuttings) representing approximately 400 meters (m) of stratigraphy were collected from Exploratory Well c-61-E in April 2009 for use in the geochemical laboratory test program (Figure 21). Of the 160 vials of drill cuttings, a total of 26 samples were collected for further evaluation. The depth interval for the sampling program extended from 1840 to 2240 m and consisted of the following six formations, moving from the top to the bottom:

- Fort Simpson shale (cap rock formations), approximate thickness of 200 m, 11 samples.

- Otter Park shale, Upper Slave Point dolomite, and Lower Slave Point dolomite (transition zone formations), approximate thickness of 150 m, ten samples.

- Sulphur Point dolomite and Upper Keg River dolomite (reservoir rock formations), approximate thickness of 50 m, five samples.

The EERC developed a baseline mineralogical and petrophysical characterization profile for this suite of samples using a combination of the following analytical techniques:

- X-ray diffraction (XRD) (bulk mineralogy)

- X-ray fluorescence (XRF) (elemental analysis)

- Scanning electron microscopy (SEM) linked with energy-dispersive spectroscopy (EDS) (mineralogical identification and rock fabric description)

- Inductively coupled plasma–mass spectrometry (ICP–MS) (major ion abundance in brine)

The data and interpretations that resulted from this screening geochemical study were presented in D41, submitted to DOE NETL on December 14, 2012. Spectra provided comments in February 2013, and EERC review is under way. This report is anticipated to be finalized in PY7.

Bell Creek Demonstration Site

The Bell Creek oil field in southeastern Montana has been identified as a PCOR Partnership Phase III demonstration site. Detailed subsurface mapping and characterization are being conducted in advance of a large-scale study of incidental CO_2 storage associated with CO_2 injection for EOR. Site characterization activities will be conducted to develop predictive models that address three critical issues to determine the ultimate effectiveness of the target formation: 1) the capacity of the target formation, in this case, an oil reservoir within an established oil

field; 2) the mobility and fate of the CO_2 at near-, intermediate-, and long-term time frames; and 3) the potential for out-of-zone migration of the injected CO_2 outside of the field or into overlying formations and/or the surface environment. Key site characterization parameters that are being addressed include properties of the reservoir and seal rocks, properties of the fluids in the reservoir and overlying fluid-bearing formations, and the production and operational history of the target oil reservoir.

In-House Project Update Meetings

In an effort to keep the EERC project management team updated and coordinate activities, in-house meetings were scheduled on the following dates: January 15, March 25, April 22, May 28, July 24, and September 13, 2013. At these meetings, action items were reviewed, deliverables and reports were discussed, and project updates were given.

Bell Creek Test Site Baseline Geology Determination

Bell Creek test site baseline geology determination work, as detailed in M14 (achieved April 30, 2013) and D64 (submitted August 31, 2013), included the following:

- Review and interpretation of existing data
  - Three 2-D seismic lines
  - One 3-D VSP
  - Six hundred thirty-two well files
  - Logs from 748 wells
  - Core analysis data from 25 wells
  - Review of the existing body of technical work and geologic studies of the Bell Creek Field, Muddy Formation, and Powder River Basin

- Collection and interpretation of new data sets
  - Over 150 bottomhole pressure surveys
  - Forty-square-mile surface 3-D seismic acquisition
  - Two 3-D VSPs
  - PNLs in 33 wells
  - Continuous downhole pressure and distributed temperature profiles since April 2012
  - Review, description, and analysis of 66 cores at the U.S. Geological Survey (USGS) and Bureau of Economic Geology
  - Collection of a 75-square-mile lidar survey
  - Collection and extensive analysis of approximately 200 feet of new 4-inch-diameter core from three wells (05-06 OW, 33-14R, and 56-14R)
  - Collection of modern high-resolution well logs from four new wells
  - Examination and analysis of Muddy Formation outcrop

Existing reservoir data were interpreted to provide a baseline understanding of the geologic structure, mineralogy, and properties of the reservoir and overlying sealing formations within the Bell Creek oil field. This preliminary geologic interpretation was utilized to target additional data acquisitions where key knowledge gaps existed. The new data were used to reinterpret formation

properties in order to decrease uncertainties in predictive simulations which provide insight into EOR and CO_2 storage performance and guide monitoring efforts. Operations data such as production and injection volumes coupled with monitoring data will be utilized to periodically update characterization efforts to improve the overall understanding of project performance.

A BPM for characterizing oil fields for CO_2 storage (D35) is anticipated to be completed in PY7.

Outcrop Field Trip

In August 2013, EERC staff led a field trip to a Cretaceous Muddy (Newcastle) Formation outcrop in Wyoming which is analogous to the nearby Bell Creek oil field reservoir (Figure 13). Regional uplift in the area of the Black Hills during Tertiary time, and subsequent erosion, has exposed significant outcrops of the Muddy Formation in northeastern Wyoming. The proximity of these outcrops to their deeply buried (~4500 ft) equivalents in the Bell Creek oil field provides an excellent opportunity to understand the potential heterogeneities in the reservoir system.

Petrophysical Evaluations for the Bell Creek Test Site

Full-diameter core was collected from Well 05-06 OW starting on December 21, 2011. Standard core analysis and special core analysis (SCAL) are being performed and utilized to supplement and update modeling efforts.

Figure 13. Denbury and EERC personnel visit to an outcrop of the Muddy Formation near Hulett, Wyoming (August 2013).

In March 2013, the EERC provided on-site technical advice during the collection of horizontal sidewall cores at the 56-14R well (Figure 14). Samples were cut (for thin-section preparation) from the 23 sidewall cores collected, and the EERC photographed, weighed, and measured the core plugs. In April 2013, the EERC provided on-site technical advice during the collection of full-diameter core at the 33-14R well. Additional petrophysical activities are planned for both sets of core in PY7.

Sidewall Core Plugs

An assessment of the reservoir was conducted on sidewall core samples to evaluate the petrographic, petrophysical, and mineralogical variability within five intervals of interest in the oil-producing zones and overlying strata of the Bell Creek reservoir. Twelve of the 47 sidewall core samples collected during drilling of the Bell Creek 0506OW well were selected for this evaluation. One sample was from the Niobrara Formation (4111.0 ft), one was from the Mowry Formation (4400.0 ft), and the remaining samples, ranging in depth from 4508.75 to 4537.5 ft, represent the Coastal Plain, Bell Creek (BC) 10, BC20, and BC30 intervals of the Muddy Formation.

The mineralogical properties of the samples were analyzed using XRD, XRF, and thin-section grain analysis. XRD and XRF were used to quantify the bulk mineralogical and bulk chemical composition of the samples, respectively. Bulk sample mineralogy was also evaluated by thin-section interpretation. Four of the 12 samples were selected for a more detailed mineralogical assessment, including clay typing using XRD and mineralogical and textural evaluation and mapping using SEM. In addition, when high amorphous/unidentified content was

Figure 14. Denbury and EERC personnel examine cut core barrels from 56-14R (March 2013).

identified in a sample, a PerkinElmer® carbon–hydrogen–nitrogen (CHN) analyzer and a LECO® TruSpec® sulfur analyzer were utilized to help determine if the amorphous/unidentified content was attributable to organic matter.

The results of this work suggest that the major differences in permeability of the Bell Creek sand intervals are due primarily to clay content and distribution, with clay-lined and clay-filled pores reducing the permeability in all samples except the BC30 sand interval. In addition, there is no indication that mineralogy is responsible for the reduced resistivity log response found in some locations in the Bell Creek Field; however, Well 05-06OW did not exhibit a pronounced reduction in resistivity response in the BC10.

USGS Core Samples

As part of the characterization efforts for the Bell Creek oil field, 81 core samples of the Muddy and Mowry Formations from 21 wells were selected from the USGS Core Research Center in Denver, Colorado, and analyzed by the EERC's Applied Geology Laboratory (AGL). The samples consist of core pieces and plugs. The samples were characterized in detail for several rock properties, such as compositional mineralogy, bulk mineralogy, grain size, porosity, permeability, pore volume, clay type, bulk chemistry, diagenetic features, and biological characteristics. The goal of this characterization activity is to achieve a better understanding of the petrographic and petrophysical properties of the Mowry and Muddy Formations in and around the Bell Creek oil field.

Samples have been classified into five informal sequences of the Muddy and Mowry Formations according to the current field operator's designation: the Shell Creek and Springen Ranch sequences of the Mowry Formation and the Coastal Plain, Bell Creek sand, and Rozet sequences of the Muddy Formation. High-porosity sand predominates the majority of the Bell Creek sand samples; however, varying amounts of clay and/or siderite pore lining/filling were observed in several samples. In addition, a low-porosity, calcite-rich zone was consistently identified in several wells. The samples from the Springen Ranch and Coastal Plain sequences are predominantly siltstone units with high concentrations of clay, siderite, pyrite, and/or microcrystalline quartz. Coastal Plain samples tended to be more varied, with cross-bedded and interfingering layers of low-porosity siltstone and higher-porosity sands. Siderite and pyrite are both important diagenetic features of the Bell Creek samples reported herein.

A value-added report is under preparation and is anticipated to be completed in PY7.

CO_2 Exposure Studies

The EERC conducted a complementary laboratory study to investigate potential CO_2–rock interactions. The goal of that effort was to provide geochemical and mineralogical data sets and develop an understanding of mineral dissolution/precipitation trends as well as groundwater chemistry changes as a result of interaction of CO_2 with the groundwater zone overlying the Bell Creek oil and gas reservoir.

The laboratory experiments were designed to expose Hell Creek groundwater to CO_2 at relevant temperatures and pressures. The results of the batch experiment testing provided

information and semiquantitative data on potential mineralogical dissolution and/or precipitation reactions in the formation rock following exposure to CO_2. Groundwater samples were collected during the June 2012 sampling event. Drill cuttings from the 05-06 OW observation well and groundwater samples collected from wells drilled at depths approximately corresponding to the drill cuttings were utilized for testing. Three distinct groundwater locations along with six different drill cutting samples collected at depths ranging from 120 to 520 feet below ground surface were subjected to continuous CO_2 exposure at 25°C and 200 psig for a 30-day period.

The results will be included in a value-added report anticipated to be completed in PY7.

Geochemical Evaluations and Modeling for the Bell Creek Test Site

Several laboratory, field, and modeling efforts are being conducted that will collectively be used to better understand the existing geochemistry of the reservoir, overlying seals, shallow subsurface, and surface at the Bell Creek site. Ultimately, the laboratory and field monitoring data will be used to refine geologic, geochemical, and CO_2 fate and transport models to gain a better understanding of reservoir response to CO_2 injection, to better predict the long-term incidental CO_2 storage capacity of the reservoir from hydrodynamic and mineralogic trapping mechanisms, and to assess the long-term integrity of the overlying cap rocks. The data will also feed into shallow subsurface geochemical modeling and assessment efforts to better understand the possible effect that CO_2 may have if it were to reach the surface or shallow groundwater in the unlikely event of out-of-zone migration.

In July 2013, the Bell Creek Preinjection Geochemical Report (D33) was submitted, satisfying M12 – preinjection geochemical work completed. Specific efforts summarized in this report include the following:

- Analysis of rock samples within the CO_2 injection zone (Muddy Formation) as well as on the sealing formations (Niobrara and Mowry Formations) to determine their petrographic, petrophysical, and mineralogical characteristics.

- Reservoir fluid sampling and analysis to characterize the formation water chemistry and to better understand the hydrocarbon composition of the reservoir to assess any potential effects on tertiary oil recovery using CO_2.

- Surface water, groundwater, and shallow vadose zone soil gas sampling and analysis to establish baseline characteristics of surface and shallow subsurface environments prior to CO_2 injection.

- Preliminary review of existing literature to identify potential mineralogical effects of CO_2 injection within the Bell Creek reservoir and cap rock and also within the overlying groundwater zones in the unlikely event of out-of-zone migration.

- Laboratory-based CO_2 exposure testing of rock and water samples from the lowest groundwater zone (Hell Creek Formation) overlying the Bell Creek reservoir to better understand the possible effects of out-of-zone CO_2 migration to the shallow subsurface.

Geomechanical Rock Properties and Stress Regime Determination for the Bell Creek Test Site

Site characterization activities for the Bell Creek Field are currently under way, including 1-D and 3-D geomechanical modeling. The comprehensive scope of this work includes building multidimensional, static geomechanical models as well as performing dynamic simulations using site-specific data. Information gained from this work can be used to assess various potential injection schemes, guide strategies for the MVA of the injected CO_2, predict geomechanical changes to the reservoir as a result of injection activities, better understand performance of the reservoir for both production and storage, predict potential risk scenarios, and provide insight into the ultimate fate of injected CO_2.

As reported in D32, Bell Creek Test Site geomechanical report (submitted January 31, 2013, and revised in October 2013), a 1-D mechanical earth model (MEM) was constructed based on existing data as well as field and laboratory data from a monitoring well (05-06 OW) drilled in December 2011. Preliminary analyses using the 1-D MEM include estimation of predrilling wellbore stability and stress polygons for determining the faulting regimes within the reservoir.

A 3-D MEM, which incorporates the entire Bell Creek Field, is currently being constructed and will be completed when additional well logs and seismic data become available. Following the completion of the 3-D MEM, a comprehensive geomechanical analysis will be performed to identify, anticipate, and evaluate predrilling wellbore stability, cap rock integrity, the potential for induced fracturing or faulting, and the potential risk for out-of-zone fluid migration. It will also be used to match, monitor, and predict the geomechanical response from the reservoir, overlying formations, and at the surface. Additionally, predictive geomechanical simulations will be designed and performed that will help guide and update the MVA plan, evaluate potential risk scenarios, and ensure injected CO_2 remains stored within the reservoir.

Assessment of Wellbore Integrity and Leakage Potential at the Bell Creek Test Site

It is not possible to determine the “exact” state of all wellbores within an oil field; consequently, both “real” field data and analytical or numerical simulations will be combined to quantify processes associated with the hydraulic integrity of the wells.

A technical team that includes Denbury, the EERC, and others is currently conducting a variety of activities to determine the baseline geologic characteristics of the subsurface environment and to assess the potential for out-of-zone fluid migrations, both through geologic strata and existing wellbores in the vicinity of the injection site. With respect to wellbore integrity, there are hundreds of existing wellbores in the Bell Creek oil field and many others in close proximity. Identification and examination of data related to drilling, completion, operation and, where applicable, plugging of these existing wellbores are necessary to determine the potential risk of out-of-zone fluid migration via wellbore and to guide monitoring and mitigation plans to identify and eliminate or minimize associated risks. To accomplish this goal, wellbore data were compiled for the Bell Creek oil field and surrounding areas, available from both public databases and from nonpublic data provided by Denbury.

Collection of relevant wellbore data to aid in evaluating the potential for out-of-zone fluid migration via wellbores in the Bell Creek oil field and surrounding area was completed in December 2011. These activities included the collection and scanning of historical wellbore data files for the Bell Creek oil field and surrounding areas via Denbury archives and MBOG in Billings, Montana. A comprehensive wellbore leakage report (D36) is anticipated to be completed in PY7.

Training

EERC modeling staff attended the following training sessions:

- Schlumberger software training entitled "Techlog Formation Evaluation Course" on October 8–12 and October 28 – November 3, 2012, in Houston, Texas.
- Schlumberger software training entitled "Petrel Property Modeling" on October 22–24, 2012, in Houston, Texas.
- Schlumberger Network of Excellence in Training (NExT) software training entitled "Petrel Property Modeling" on February 10–18, 2013, in Houston, Texas.
- Schlumberger NExT software training entitled "Techlog Formation Evaluations" on February 24 – March 1, 2013, in Houston, Texas.
- Schlumberger NExT software training entitled "Petrel Workflow Editor and Uncertainty Analysis" on April 11 and 12, 2013, in Houston, Texas.
- Four half-day in-house Petrel software training sessions and a 1-hour training session led by Schlumberger.
- Full-day training called "Fundamentals of Geostatistics," provided by Dr. Clayton Deutsch on August 5–8, 2013, at the EERC.
- Five half-day in-house Petrel software training sessions and a 1-hour training session led by Schlumberger.

Task 5 – Well Drilling and Completion

The PCOR Partnership is working with Denbury, the operator of the Bell Creek oil field, to develop engineering designs for the installation of a dedicated monitoring and characterization well in the Bell Creek oil field. The feasibility of reentry into existing wells within the field which could provide additional downhole monitoring points is also under evaluation.

The development of operational plans for the injection and recycling of CO_2 over the duration of the project will also be conducted. Because the host site for the Bell Creek large-volume CO_2 injection test is an operational oil field already undergoing large-volume water injection activities, existing wells will be utilized for CO_2 injection, oil production, and

monitoring. These wells are currently being reworked to accommodate long-term injection of supercritical CO_2. The EERC will provide technical support for these activities; however, the actual drilling, completion, and/or reconditioning of injection and production wells will be conducted by Denbury, while the EERC will be responsible for the drilling of a new monitoring well in the field, with support provided by Denbury. Activities under this task commenced October 1, 2010, and are scheduled to end in June 2014 (PY7).

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) included the following.

Injection Scheme Design

The injection scheme will include the minimum number of wells needed to achieve the injection goal and the optimal location of wells. Material needs and costs will be determined for the Bell Creek test. An injection experimental design package (D42) is under development and will be completed in October 2013.

The injection program being developed throughout the Bell Creek oil field, with PY6 injection activities occurring in Phase 1, is dictated by the commercial EOR project. Beginning in May 2013, the current and ongoing activities at Bell Creek are injecting approximately 1 million metric tons of CO_2 a year as part of a commercial EOR operation. CO_2 injection will occur in a staged approach (nine planned CO_2 development phases, designated as Phases 1 to 9) across the field. The injection program was initiated with the continuous injection of CO_2 into the 27 injection wells located within Phase 1. Once suitable reservoir conditions are reached, the remaining 27 producer wells will be brought online. Production will continue until certain recovery minimum targets are reached, at which point a planned CO_2 water alternating gas (WAG) process will be initiated. All of the Phase 1 wells will eventually be part of the CO_2 WAG injection scheme.

Injection/production will occur via a typical five-spot pattern of 40-acre spacing. The average rate of CO_2 WAG injection is expected to be ~2 million cubic feet/day for each Phase 1 CO_2 injection well. As with typical EOR procedures, recovered oil, CO_2, and water will be separated at the process/recycle facilities located on-site, and the CO_2 and water will be recycled into the WAG operation.

Monitoring Scheme Design

A monitoring experimental design package (D43) for the Bell Creek test site was prepared in May 2013. The EERC has designed a monitoring program specific to the needs of the Bell Creek Field which monitors a variety of physical phenomena within the field utilizing a variety of commercially viable technologies and techniques. The suite of technologies is focused on a two-pronged approach that prioritizes monitoring at the reservoir depth and the near-surface environment (Figure 15). Each of these technologies satisfies a specific monitoring need within the field and operates over a unique effective range. However, the specific technologies selected

are also designed to operate in a complementary manner where an anomalous signal from one monitoring technique can be investigated through the use of one or more of the remaining techniques. Additionally, the PCOR Partnership is also evaluating the scientific validity and cost-effectiveness of each of these monitoring technologies in order to provide DOE with recommendations on how these technologies may be deployed at other CO_2 storage sites in the future and to allow future commercial-scale projects to make informed decisions regarding site-specific monitoring strategies.

MVA Work Plan

A work plan was prepared (and approved by Denbury) for the surface and near-surface MVA plan.

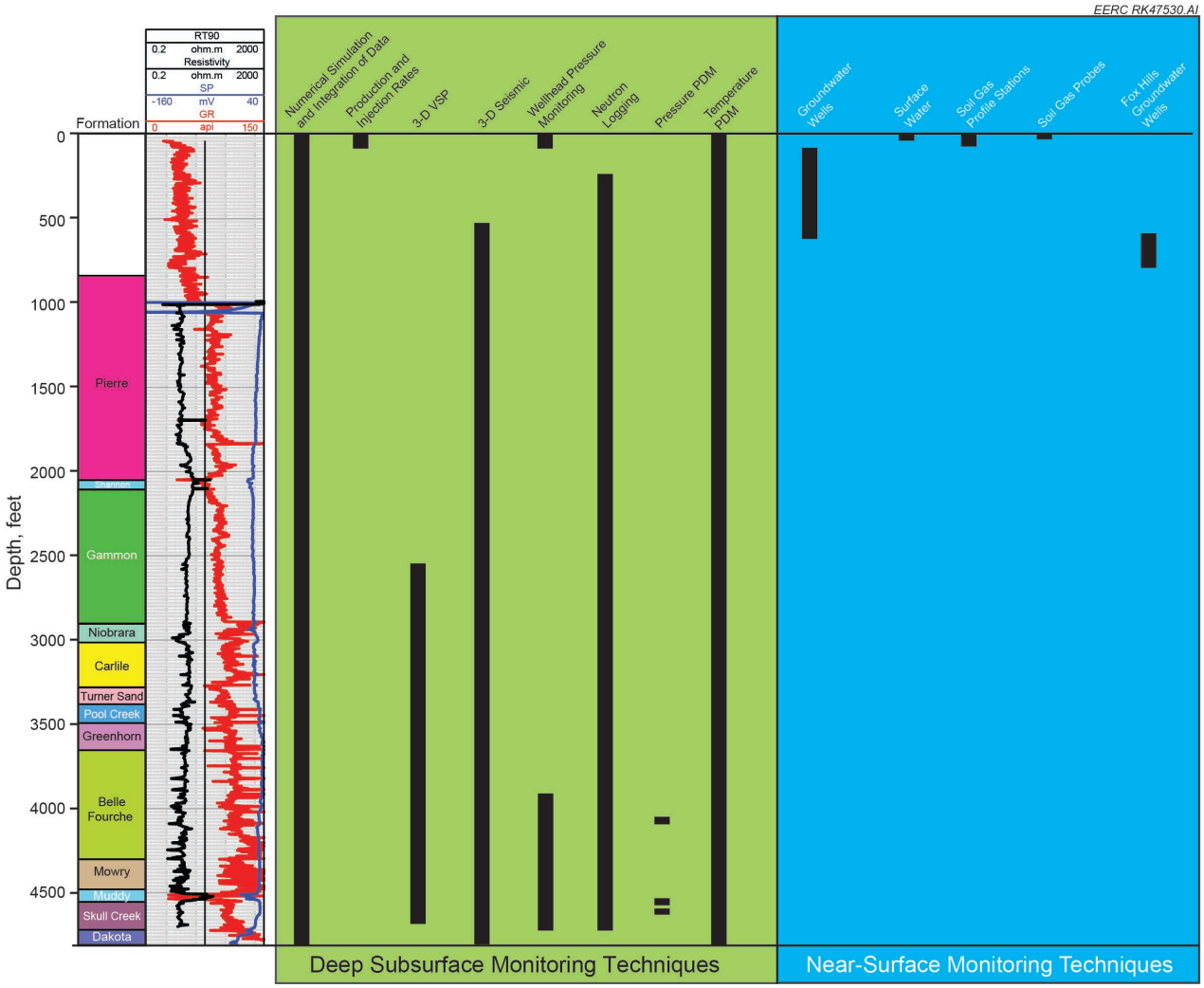


Figure 15. Current and ongoing surface-, near-surface-, and deep subsurface-monitoring techniques employed throughout the Bell Creek oil field and their effective monitoring range as deployed for Bell Creek.

Baseline MVA Activities

In March 2011, the baseline MVA was initiated to aid in evaluating site security, accounting, and location of the lateral and vertical extent of CO_2 in the Bell Creek oil field and surrounding area. These activities can be broken into two main groups (surface and near-surface, and deep MVA). Collection of relevant baseline MVA data was completed in May 2013.

Surface and Near-Surface MVA Program

A baseline soil gas survey was performed over the entire Bell Creek oil field. Sampling began on November 1, 2011, and included several repeat surveys to capture the seasonal variations in the soil gas content. A shallow groundwater-monitoring program was also conducted, including shallow groundwater and surface water monitoring in selected groundwater wells and surface waters throughout the Bell Creek Field, focusing on the Phase 1 area. This baseline activity also began in November 2011 and included several repeat surveys to capture seasonal variation in shallow groundwater and surface water compositions.

These activities included the following:

- Baseline soil gas monitoring
  - Fieldwide soil gas concentrations measured over six baseline sampling events (November 2011, April 2012, June 2012, August 2012, November 2012, and April 2013)
    - One hundred twenty-four (124) active wells
    - Fifty-two (52) plugged and abandoned wells
    - Ten (10) interspaced wells
  - Near-monthly monitoring of ten soil gas profile stations (SGPSs) sampled at depths of 3.5, 9.0, and 14 feet beginning in October 2012

- Groundwater monitoring
  - Fieldwide water chemistry analysis measured over six baseline sampling events (November 2011, April 2012, June 2012, August 2012, November 2012, and April 2013)
    - Seven (7) stock wells
    - Seven (7) residential wells
    - Nine (9) surface waters
  - Near-monthly monitoring of two Fox Hills (FH) groundwater-monitoring wells (deepest regional underground source of drinking water) beginning in April 2013
    - 05-04 FH
    - 33-12 FH

A value-added report covering the baseline surface and shallow subsurface MVA activities is under development and anticipated to be completed in PY7.

Deep MVA Program

The spud date for the deep monitoring well was December 15, 2011. Drilling, coring, logging, and PDM equipment installation at the Bell Creek observation well, 05-06 OW, was completed on January 10, 2012. The specialty wellhead installed permits PDM technologies to be utilized in conjunction with other wireline-deployed downhole-monitoring technologies such as pulsed-neutron well logs and borehole seismic tools. The following activities were used to gather additional baseline data and a point in the field to monitor CO_2 as it moves between injectors and producers.

- Reservoir and subsurface monitoring
  - Pulsed-neutron well logs (33 wells)
    - Liquid–gas saturation from reservoir depth up to 200 ft of surface
    - Water, oil, and CO_2 saturation over the Muddy Formation (storage reservoir)
    - Baseline PNLs may be run on an additional three to six wells if they become available prior to injection.

- Three casing-conveyed downhole pressure and temperature gauges (05-06 OW)
  - Near-continuous since April 2012 (5-minute intervals)
    - Lower facies of the Muddy Sandstone
    - Upper facies of the Muddy Sandstone
    - Niobrara (thin sand lense within the primary seal)

- Fiber optic distributed-temperature system (05-06 OW)
  - Near-continuous since April 2012 (4-hour intervals)
    - 1-meter intervals from ~4700 ft to surface

- 40-square-mile baseline 3-D surface seismic survey centered on the Phase 1 area

- Two 3-D VSP seismic surveys
  - 05-06 OW (60 level)
  - 04-03 OW (50 level)

- Over 150 bottomhole pressure surveys supplied by the commercial EOR project

- Injection and production data for all wells supplied by the commercial EOR project.

Task 6 – Infrastructure Development

This task facilitates the infrastructure planning required for CCS to be implemented on a wide-scale regional basis as well as the development of the specific infrastructure associated with the capture, dehydration, compression, and pipeline transportation of CO_2 from its source to a Bell Creek oil field for EOR. The infrastructure development for the Bell Creek test site will be performed by Denbury, with EERC personnel documenting the activities, interfacing with source facility engineers and vendors, and providing assistance as needed.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) included the following.

It should be noted that on March 25, 2013, DOE NETL waived the requirement for an update to D85, "Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities," due March 31, 2013. A journal article (see below) is under preparation in lieu of the report.

Regional Infrastructure Planning

Efficient and cost-effective implementation of CCS on a wide scale will require a complete understanding of the PCOR Partnership region's infrastructure needs. It will also necessitate the development of a regional pipeline vision connecting various CO_2 sources with the most likely geologic storage opportunities. Activities include the following.

CO_2 Emission Sources

In September 2013, the annual update and quality assurance/quality control of the CO_2 emission source master data spreadsheet were completed (performed in conjunction with Task 1).

Capture Technology "Tree"

A value-added report entitled "Current Status of CO_2 Capture Technology Development and Application" was finalized in January 2011. This report provided a comprehensive overview of the status of carbon capture technology development and application at that time. The overview covered technologies that apply to the three combustion platforms: precombustion, during combustion (oxycombustion and chemical-looping combustion), and postcombustion. The technologies reviewed fall into the categories of physical and chemical absorption; physical and chemical adsorption; mixed absorption and adsorption; oxygen-, hydrogen-, and CO_2-permeable membrane processes; cryogenic processes; mineralization; and photosynthesis and chemical and biochemical reduction processes as well as alternative mass transfer techniques. The document provided an overview of the technical basis for each separation method and information on nearly 100 technologies and/or research efforts. A summary table of the capture technologies was included in the report as an appendix.

The capture technologies table (from the appendix) was adapted into a technology "tree" and made available to partners via the DSS in PY6. The PCOR Partnership capture technology tree will be maintained and updated as a service to the PCOR Partnership partners. The tree provides basic technical information about various capture technologies as well as development status, source type applicability, and economic information (when available).

CO_2 Compression Activities

The majority of research on CCS has been on capture, injection, and subsequent monitoring of the CO_2 plume in a secure geologic setting, with little attention paid to compression or pipeline transport. In March 2011, a report entitled "Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities" was finalized. In lieu of an update to this report in 2013, a journal article entitled "Assessing Temporary Storage Options to Attenuate Variable-Rate CO_2 Emissions for Use During Enhanced Oil Recovery" was proposed and approved. A draft article was written, and a short list of appropriate peer-reviewed journals was reviewed. *Energy & Environmental Science* is the most likely journal to be approached for publication in PY7 and the article was formatted accordingly. In addition, a database of existing and emerging CO_2 compression technologies is under development and will ultimately be incorporated into the partners-only Web site.

Bell Creek Test Site Infrastructure Development

An infrastructure development report (D45) will be prepared in PY8 describing the key elements of infrastructure that are required to cost-effectively distribute and inject CO_2 within an operating oil field as part of a simultaneous CCUS and EOR project. The report will contain the lessons learned from the Bell Creek demonstration project with respect to the capture efficiency and cost, all aspects of CO_2 compression, and all aspects of pipeline transportation of the CO_2 to the injection site.

In PY6, an effort was undertaken by the PCOR Partnership to estimate how a CO_2 pipeline network might be built in the PCOR Partnership region, over what time frame it might be built, and how much it might cost. The information was included in a report entitled "A Phased Approach to Designing a Hypothetical Pipeline Network for CO_2 Transport During CCUS" (D84), finalized in March 2013 and showing hypothetical network development and estimated cost during each phase. It was found that a pipeline network of trunk lines roughly 6700 mi in total length could transport sufficient quantities of CO_2 such that the International Energy Agency (IEA) BLUE Map scenario could be met for the PCOR Partnership region by 2050. The IEA BLUE Map scenario represents a reduction in CO_2 emissions of 50% over 2005 levels by 2050. For the PCOR Partnership, this would be 444.7 Mt/yr. The overall reduction for the PCOR Partnership region using this approach would be about 612.4 Mt/yr by 2050.

Several products were produced and/or published based on the report on the phased approach to building a hypothetical pipeline network for CO_2 transportation during CCUS during PY6. They include the following:

- Presented a poster at GHGT-11 in November 2012 in Kyoto, Japan, and prepared a paper now published in *Energy Procedia* (www.sciencedirect.com/science/article/pii/S1876610213004384, accessed January 2014).

- Presented a paper to the American Institute of Chemical Engineers (AIChE) National Meeting held October 30 – November 2, 2012, in Pittsburgh, Pennsylvania.

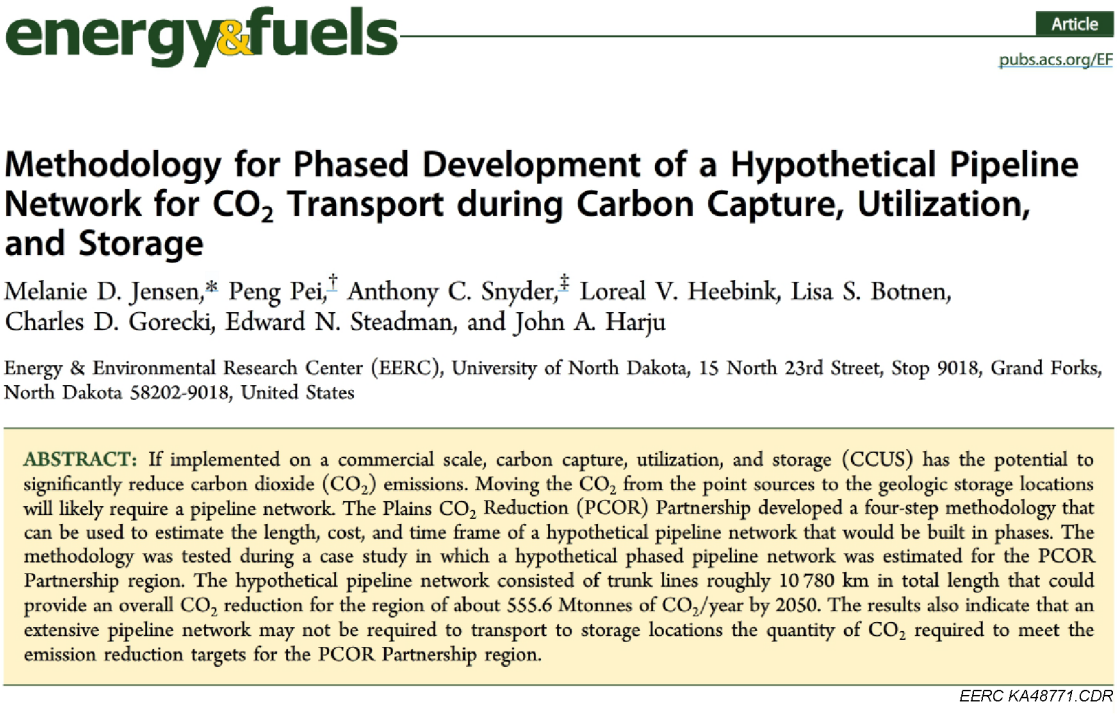
- Published in *Energy & Fuels*, a peer-reviewed journal published by the American Chemical Society (ACS) (http://pubs.acs.org/doi/ipdf/10.1021/ef302042p; accessed January 2014) (Figure 16).

Because turnabout is fair play, the task lead served as a peer reviewer for an *Energy & Fuels* manuscript entitled "Initial Results from a New CO_2 Storage Cost Model: FE/NETL CTS-Saline Cost Model." In addition, a document from Det Norske Veritas entitled "Design and Operation of CO_2 Pipelines" was studied and a brief overview developed.

Ramgen Compression Technology Slipstream Test

The applicability of the Ramgen Power Systems compressor technology to CO_2 streams during CCUS will be evaluated. The EERC will partner with Ramgen Power Systems, LLC, to perform these activities. Initial subcontracted activities with Ramgen ended on September 30, 2009, with the submittal of a topical report on the preliminary design of advanced compression technology (D47). This report summarized Ramgen Power Systems activities relative to integration of the Ramgen compression technology with a power plant.

Since June 2011, and continuing throughout PY6, efforts have concentrated on gathering information about the well depth, diameter, downhole pressure, downhole temperature, etc., that will be needed to develop Bell Creek in-field compression specifications. The Ramgen compressor must be able to meet these specifications to be considered for implementation at the



energy&fuels — Article

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Methodology for Phased Development of a Hypothetical Pipeline Network for CO_2 Transport during Carbon Capture, Utilization, and Storage

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ABSTRACT: If implemented on a commercial scale, carbon capture, utilization, and storage (CCUS) has the potential to significantly reduce carbon dioxide (CO_2) emissions. Moving the CO_2 from the point sources to the geologic storage locations will likely require a pipeline network. The Plains CO_2 Reduction (PCOR) Partnership developed a four-step methodology that can be used to estimate the length, cost, and time frame of a hypothetical pipeline network that would be built in phases. The methodology was tested during a case study in which a hypothetical phased pipeline network was estimated for the PCOR Partnership region. The hypothetical pipeline network consisted of trunk lines roughly 10 780 km in total length that could provide an overall CO_2 reduction for the region of about 555.6 Mtonnes of CO_2/year by 2050. The results also indicate that an extensive pipeline network may not be required to transport to storage locations the quantity of CO_2 required to meet the emission reduction targets for the PCOR Partnership region.

EERC KA48771.CDR

Figure 16. *Energy & Fuels* peer-reviewed journal article published online in 2013.

Bell Creek site. At the annual meeting in September 2013, discussions were held regarding the Rampressor technology and information shared. In addition, Denbury personnel in attendance were introduced to Ramgen personnel. These continuing efforts are culminating to a decision point (M41, due January 2014) regarding incorporation of the Ramgen compression technology into the Bell Creek Project.

Conferences and Meetings

- Attended the 2013 CO_2 Capture Technology Meeting held July 8–11, 2013, in Pittsburgh, Pennsylvania.

- Presented at the AIChE 2012 Annual Meeting held October 28 – November 2, 2012, in Pittsburgh, Pennsylvania.

- Attended the PCOR Partnership Annual Membership Meeting held September 25 and 26, 2013, in Minneapolis, Minnesota.

Task 7 – CO_2 Procurement

This task documents CO_2 procurement procedures for CCS and EOR activities in the PCOR Partnership region. This task provides for EERC personnel to interface with commercial partners with respect to CO_2 procurement in the region as a means of documenting critical pathways for future projects.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) included the following activities.

Ongoing Monitoring and Assessment of the Commercial Issues of CO_2 Procurement

Through numerous discussions with industrial partners as well as Internet and other literature searches, efforts are ongoing to keep abreast of the various commercial issues associated with CO_2 procurement, such as contractual pricing mechanisms for CO_2, other potential customers, etc.

Procurement Plan and Agreement Facilitation

In 2009, Encore (now merged into Denbury) entered into a purchase and sale agreement to procure a CO_2 supply in the Bell Creek Field. Under the terms of the agreement, Denbury will purchase all of the volumes available from the Lost Cabin Gas Plant located in Fremont County, Wyoming. Initially, the volumes are estimated to be approximately 50 million cubic feet per day. The initial term of the contract is 15 years. Many of the details surrounding the CO_2 procurement for the Bell Creek site are considered proprietary by the buyer and site operator, Denbury. In fact, many of the details are most likely wrapped up in Denbury's $4.5 billion acquisition of Encore, which included adding oil fields in the Rocky Mountains and Gulf of Mexico and

doubling the oil reserves for Denbury (5). The PCOR Partnership was not privy to the CO_2 procurement negotiations or final agreement terms. It was also not a party to the construction of the CO_2 carrier, the Greencore Pipeline. The PCOR Partnership is developing a set of cost-effective MVA protocols for the project along with Denbury and hopes to successfully demonstrate in Phase III what it proved in Phase II—that MVA programs can be designed that are technically effective, cost-effective, and unobtrusive to commercial operations (6).

Little more is known about the specific details of the CO_2 agreement for Bell Creek except the preceding term and purchase quantity. While it is not publicly known how the price of CO_2 is calculated, Denbury's existing Lost Cabin contract includes price adjustments that fluctuate based on the price of oil (7). Quality, quantity, pressure, and transfer point are other terms to take into consideration and are specific in nature to each project.

Efforts continued in PY6 to document the nonproprietary business activities that are conducted to develop a CO_2 procurement plan and agreement for the Bell Creek project. A number of project meetings, discussions, and site visits were held, specifically at CO_2 Conference Week (December 2012), Denbury headquarters (May 2013), a Bell Creek site visit (July 2013), and the outcrop field trip and site commissioning event (both in August 2013). In addition, the task lead met with Denbury personnel in attendance at the PCOR Partnership Annual Membership Meeting held in September 2013.

Task 8 – Transportation and Injection Operations

This task consists of monitoring and documenting commercial partner activities related to compression and transport of CO_2 via pipeline to the Bell Creek site, particularly as they relate to on-site injection. This task does not cover activities for the Fort Nelson site.

Activities and Results

CO_2 transport and injection will be conducted by Denbury as part of the commercial EOR project. The EERC will monitor and assess these operations. The results of the CO_2 transport and injection operations will be summarized in a report (D49) due in February 2016.

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) included the following activities.

Participation in the in-house Bell Creek project update meetings ensures keeping abreast of transportation and injection operations. The Greencore Pipeline was completed at the end of November 2012, and injection began at Bell Creek in May 2013.

Monitoring and Assessment of Commercial Operations

A cursory literature review was conducted regarding injection-related documents. In particular, potential methods of measurement or estimation of fugitive CO_2 emissions during activities at injection sites are under investigation. The accuracy and application of the techniques as they apply to surface facilities as well as wellbores and the subsurface are being

studied. The results of the study will be discussed in a value-added report that is anticipated to be completed in PY7.

Task 9 – Operational Monitoring and Modeling

This task develops data sets for the large-volume CO_2 injection tests that 1) verify that injection operations do not adversely impact human health or the environment and 2) validate the storage of CO_2 for the purpose of developing an understanding of the process for monetizing carbon credits.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) include the following.

Bell Creek Test Site

CO_2 Injection Began

Injection began at the Bell Creek oil field in May 2013. Cumulative CO_2 injection is 180,752 metric tons through September 30, 2013 (Table 6).

In August 2013, EERC and DOE staff joined Denbury staff in welcoming Montana Governor Steve Bullock to the Bell Creek oil field for a ribbon-cutting ceremony to laud the state's first production CO_2 injection oil field (Figure 17). Denbury staff said it has invested more than $300 million in an effort to revive a 1960s era oil field. Carbon dioxide is piped 232 miles to the plant from natural gas processing in Wyoming and pumped underground to

Table 6. Bell Creek CO_2 Injection Totals May 2013 – September 2013

	May 2013 Injection	June 2013 Injection	July 2013 Injection	August 2013 Injection	September 2013 Injection
Monthly Total, mscf*	187,073	932,103	590,030	648,220	1,122,584
Monthly Total, m[3][1]	5,297,318	26,394,221	16,707,791	18,355,549	31,788,043
Monthly Total, U.S. short tons[2]	10,700	53,315	33,749	37,077	64,210
Monthly Total, metric tons[3]	9717	48,413	30,646	33,669	58,307
Cumulative Total, mscf	187,073	1,119,176	1,709,206	2,357,426	3,480,010
Cumulative Total, m[3][1]	5,297,318	31,691,539	48,399,330	66,754,878	98,542,921
Cumulative Total, U.S. short tons[2]	10,700	64,015	97,764	134,841	199,051
Cumulative Total, metric tons[3]	9717	58,130	88,776	122,445	180,752

* Source: MBOG Online Database.

[1] Calculated utilizing conversion of 28.31685 m^3/Mscf (NIST.gov Special Publication 1038).

[2] Calculated utilizing conversion of 17.483 Mscf/U.S. short ton.

[3] Calculated utilizing conversion of 19.253 Mscf/metric ton.

Note: There is an approximately 2–3-month delay in posting injection/production volumes to the MBOG database.

Figure 17. Steve Bullock, Montana Governor, and Phil Rykhoek, Denbury CEO, with the ceremonial scissors at the Bell Creek commissioning ceremony on August 16, 2013 (photo courtesy of Denbury Resources, Inc.).

force out more oil. An incidental benefit is the underground storage of CO_2. The Governor said that this technology is good for the environment by capturing the GHG and good for the economy by bringing more jobs and tax base to the state. He said the EOR can help keep energy affordable (8).

Implementation of Monitoring Plan

The quarterly summary of monitoring operations is reported in the quarterly technical progress reports (D58/D59). The following is a bulleted summary of injection-phase activities in PY6:

- Continuous downhole injection monitoring since May 2013, including:
  - Pressure in two lobes of the Bell Creek sands.
  - Pressure in the overlying zone.
  - Continuous distributed temperature.
  - Continued analysis of data.

- PNL
  - Acquisition of the first repeat PNL log in 05-06 OW on August 27, 2013.
  - Tentatively planning acquisition of three PNL logs in the 05-05, 05-07, and 05-01 injection wells and a spinner production log in 05-01 by October 20, 2013.

  - Held PNL review and operational planning meeting with Schlumberger, Denbury, and EERC personnel on September 24, 2013.

- Conducted monthly soil gas sampling at select well locations, SGPSs, and water samples at Fox Hills monitoring wells, including:
  - Ninety-six (96) soil gas samples (July 31, 2013) and two Fox Hills groundwater-monitoring well samples.
  - One hundred twenty-five (125) soil gas samples (August 27–28, 2013) and two Fox Hills groundwater-monitoring well samples (August 27, 2013).

- Collected annual first full-repeat near-surface operational monitoring survey for soil gas and water samples. This effort was coordinated concurrently with the monthly September event for sampling soil gas at selected well locations, SGPSs, and water at the Fox Hills groundwater-monitoring wells (September 29 – October 6, 2013), including:
  - Approximately 300 soil gas samples.
  - Twenty-two (22) water samples.

- Continued passive seismic monitoring since May 2013 from 04-03 OW permanent geophone array.

Bell Creek Risk Management Activities for the Bell Creek Test Site

An internal, preliminary risk register has been developed for the Bell Creek Demonstration project. Risk management activities for the Bell Creek project will use the same risk management framework that is being applied to the Fort Nelson site. The final processes and procedures that are ultimately used are evolving in order to seamlessly integrate with the risk processes and policies of the industry partner, Denbury. An updated risk assessment (including updated risk register) is planned in PY7.

Reservoir Modeling

Attributes such as injectivity, fluid production, and reservoir dynamics will be modeled using relevant software packages. The ultimate fate of the CO_2 over short-, intermediate-, long-, and extremely long term time frames will be predicted. A report on the specific results of the Bell Creek oil field simulations was prepared in August 2011, updated in August 2012, and updated again in August 2013 (D66).

With the goal of providing a comprehensive assessment of incidental CO_2 storage behavior, the EERC has initiated a modeling and numerical simulation program to 1) characterize and model the study area using advanced geologic modeling workflows; 2) develop a robust pressure, volume, and temperature (PVT) model to predict miscibility behavior of the CO_2–Bell Creek crude system and to aid in compositional simulation; 3) history-match the constructed dynamic reservoir model, and 4) utilize predictive simulations to aid in monitoring long-term behavior of injected CO_2.

As summarized in August 2013, a detailed 3-D static geocellular model of the Bell Creek oil field area (Version 2 model) was constructed utilizing pertinent reservoir characterization data gathered in an extensive literature review and current core analysis work for the entire Bell Creek oil field and surrounding area. Seven hundred forty-eight wells with wireline logs and many with core data were analyzed, interpreted, and incorporated into the 3-D static geocellular and dynamic reservoir models to represent geologic stratigraphy, petrophysical facies, and reservoir properties in order to provide a solid groundwork for simulation activities. In addition, the following activities were undertaken:

- A seven-component Peng–Robinson equation-of-state (EOS) model was developed and tuned to laboratory PVT tests from Bell Creek crude oil samples in Computer Modelling Group's (CMG's) Winprop software package.

- A simulation model was clipped from the full-field 3-D model and included the Phase 1 and immediately adjacent area.

- Both the Phase 1 area and wells within it were matched to oil rate, water cut, and gas/oil ratio (GOR) by using individual well liquid rate production and injection rates and bottomhole pressure constraints.

- Six predictive simulation cases were run to evaluate WAG, continuous CO_2 injection, two injection bottomhole pressure constraints, and varying WAG cycle length.

Future modeling and simulation work on the Bell Creek oil field will include building a Version 3 geocellular model utilizing newly acquired 3-D seismic data, PNLs, and log and core data and history matching and running predictions on both the Phase 1 and Phase 2 areas.

Fort Nelson Test Site

A BPM summarizing activities performed in conjunction with the CCS feasibility study for the Fort Nelson test site is under preparation (D100, due June 2014). This comprehensive manual will also include a) a comparison of site activities with the CSA Guidelines for Geological Storage of CO_2 and b) a rudimentary MVA plan that combines the shallow-surface and deep-subsurace MVA plans into a CSA-compliant MVA plan.

Modeling Training Courses

- Modeling staff attended the Society of Petroleum Engineers (SPE) 2013 Reservoir Simulation Symposium and premeeting training courses entitled "Fundamentals of Reservoir Simulation" and "Reservoir Simulation for Practical Decision Making" in The Woodlands, Texas.

- Modeling staff attended Schlumberger Oil Field Management (OFM) software training entitled "OFM Using Oil and Waterflood Examples" and "OFM Forecast Analysis & Mapping Applications Fundamentals Combined Course" held April 15–18, 2013, in Denver, Colorado.

- Modeling staff participated in a 2-day workshop understanding the TOUGH2-EGS (Enhanced Geothermal Systems) simulator on June 3 and 4, 2013, at the Colorado School of Mines in Golden, Colorado.

- Modeling staff participated in a 2-day workshop on understanding and using the TOUGH2-CSM (Carbon Sequestration Modeling) simulator on June 5 and 6, 2013, at the Colorado School of Mines in Golden, Colorado.

- Modeling staff attended an SPE training course entitled "Modern Production Data Analysis for Unconventional Reservoirs" on September 28 and 29, 2013, in New Orleans, Louisiana.

Task 10 – Site Closure

This task was not active in BP4, PY6.

Task 11 – Postinjection Monitoring and Modeling

This task was not active in BP4, PY6.

Task 12 – Project Assessment

This task communicates and disseminates all Phase III activities detailed in annual progress reports. Reports summarize program progress, accomplishments, program recognition, travel, planned activities, and goals.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) include the following.

Assessment was conducted for the tasks during the period October 1, 2011 – September 30, 2012. A project assessment annual report (D57) was submitted on December 28, 2012.

Task 13 – Project Management

This task focuses on ensuring the overall success of the entire program by providing experienced management and leadership to each of the individual tasks and to the program as a whole. The PI and task leaders meet regularly to report the progress of their tasks and discuss any issues and corrective actions necessary. Task leaders are also responsible to provide the PI with written weekly updates. These updates include highlights (including trip reports), issues (i.e., budget, staffing, technical issues, etc.), opportunities, and travel plans. The monthly, quarterly, and yearly updates can be found on the PCOR Partnership DSS.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) include the following.

Progress Reports

Quarterly progress reports (D58), each including a milestone report (D59), were submitted to DOE and the PCOR Partnership partners 1 month after the end of each calendar quarter. In addition, monthly progress reports are submitted to the DOE NETL project manager shortly after month end and are also posted on the partners-only Web site. Informal weekly updates are e-mailed to the DOE NETL project manager.

DOE Contract (DE-FC26-05NT42592) Modifications

During PY6, three modifications to the contract were issued.

The EERC received DOE Cooperative Agreement Amendment 24 effective December 21, 2012. The amendment authorized an additional amount of incremental funding in the amount of $6,290,884.

The EERC received DOE Cooperative Agreement Modification 25 effective June 3, 2013. This modification authorized the following:

- Additional scope of work and budget for the Denbury Onshore, LLC, Vendor Agreement and accompanying laboratory services by the EERC for $2,226,394.
- Corrected administrative errors found in Modification 24 with respect to the "Estimated DOE Share" and "Cost Share" sections.
- Changed the DOE award administrator from Juliana Heynes to Kellyn Cassell.
- Incorporated a revised BP4 project budget.

The EERC received DOE Cooperative Agreement Amendment 26 effective September 16, 2013. The purpose of this amendment was to obligate federal funds in the amount of $8,649,446 in support of the project efforts.

IEAGHG Expert Review of the RCSPs

DOE requires that an independent technical review of the Phase III program be periodically conducted. In October 2010, the PCOR Partnership provided an update as to the current status of recommendations detailed by the 2008 expert review panel. DOE selected IEAGHG to undertake the expert review held in March 2011. On August 12, 2011, responses to the expert review panel's comments and recommendations were submitted. An outcome of note stemming from the expert panel's review was the recommendation to create a technical advisory

board (TAB) to provide scientific and/or operational guidance to the PCOR Partnership Program, including both demonstration sites (Modification 21 to the PCOR Partnership award provided funding and authorization for such an advisory board).

DOE again selected IEAGHG to undertake the expert review scheduled for November 15, 2013. IEAGHG has extensive experience with CO_2 injection projects worldwide and has organized a number of independent technical reviews. In order to review the Phase III activities, IEAGHG appointed an independent international panel of experts drawn from on-shore CO_2 injection projects under way in Canada, Europe, and Australia. The PCOR Partnership submitted a project information form (PIF) for the "Bell Creek CO_2 CCS and EOR Demonstration" on September 13, 2013, with revisions sent October 1 and 11, 2013. The required PowerPoint presentation was submitted September 27, 2013, with revisions on October 11 and 31, 2013. The 45-minute presentation is scheduled to be given before the expert panel on November 15, 2013.

Project Management Plan

In January 2013, an update to the 2011 project management plan incorporating changes to the PCOR Partnership Program was submitted. Revisions to the plan are under way and will be submitted as necessary.

Annual Meetings

Regular project meetings (annual or as otherwise directed) will be held to ensure that project management and PCOR Partnership partner goals are being met. During PY6, the 11th partners meeting (the tenth meeting that included project results) was held.

The 2013 PCOR Partnership Annual Membership Meeting was held September 25 and 26, 2013, in Minneapolis, Minnesota, and attracted 88 attendees representing 46 organizations from 15 states, the District of Columbia, and three Canadian provinces (Figure 18). The annual meeting provided an overview of carbon management topics, including new developments in CCUS strategies, updates on projects within the region and beyond, regulatory updates, and

Figure 18. Attendees at the PCOR Partnership 2013 Annual Membership Meeting held September 25 and 26, 2013, in Minneapolis, Minnesota.

relevant products and services. The meeting also provided summaries of the PCOR Partnership's completed and ongoing activities. The presentations from the meeting and workshop are now available in the Products Database of the Partners-Only Web site.

RCSP Support

- The PCOR Partnership was asked to coordinate the RCSP WWG. This task began in January 2009 and is ongoing through 2017.

- Members of the GIS, Outreach, Water, and Sim/RA Working Groups took part in scheduled conference calls.

- An EERC staff member has served as Chairman of North American Energy Working Group's (NAEWG's) Subcommittee on CO_2 Storage Capacity Estimation, also known as the Methodology Subcommittee. This subcommittee discusses geologic storage capacity coefficients and the methodology for estimations. The data sharing of this group will lead to a solid foundation in the area of CO_2 capture and sequestration mapping and estimations in North America. This subcommittee coordinates its activities closely with NAEWG–NACAP (North American Carbon Atlas Partnership). Natural Resources Canada (NRCan), the Mexican Ministry of Energy (SENER), and DOE released the North American Carbon Storage Atlas (NACSA) in 2012, which was produced under the leadership of NACAP. In PY6, no meetings were held, but EERC staff presented on NACSA at the CanGEA 2013 Geothermal Conference "DIGGING DEEP" in March 2013 in Calgary, Alberta, Canada.

  CCS is one of the topics that both the United States and Canada have expressed interest in to continue discussions. The U.S.–Canada Clean Energy Dialogue is led on the U.S. side by the DOE Office of Policy and International Affairs. Previous dialogues addressed MVA/ measurement, mitigation, and verification (MMV) in CCS demonstration projects and large-scale CO_2 injection tests (Mobile, Alabama, May 2012), building a business case for CCS (Regina, Saskatchewan, September 2012), and opportunities for collaboration in research in next-generation CCS technologies (Pittsburgh, April 2012 and Ottawa, October 2012). At the request of DOE, EERC staff participated in the U.S.–Canada Bilateral National Conference on April 23 and 24, 2013, in Champaign, Illinois. At this meeting, the dialogue focused on the planned activities after CO_2 injection is complete, i.e., the postinjection period.

DOE Fossil Energy Techlines

On April 30, 2013, DOE released a Techline about the award won by the documentary "Global Energy and Carbon: Tracking Our Footprint." This documentary coproduced by PPB and the PCOR Partnership with support from DOE received a 2012 Platinum Best of Show Aurora Award—the highest honor awarded—in the nature/environment documentary category. The Aurora Awards are an international competition designed to recognize film and video excellence. Entrants are judged by panels of working film and video professionals, mostly previous award winners.

Several proposed Techlines addressing the injection of CO_2 at the Bell Creek site were prepared, but were not released by DOE.

Annual Carbon Capture and Sequestration Conference

Four staff members attended CCUS-12, sponsored by ExchangeMonitor Publications & Forums, held May 13–16, 2013, in Pittsburgh, Pennsylvania.

Annual Review Meeting

Eight staff members attended and presented five posters at the DOE Carbon Storage Project Review Meeting held August 20–22, 2013, in Pittsburgh, Pennsylvania. There were several side meetings held on August 19, prior to the project review meeting, including the following:

- U.S.–Norway Workshop on CO_2 Storage Demonstration Projects: The Value of Monitoring Technology
- DOE NETL–EERC PCOR Partnership project review meeting
- RCSP WWG Open House
- WWG Annual Meeting

PCOR Partnership Partners

The PCOR Partnership has significant support and participation from its partners. As of September 30, 2013, over 90 partners are supporting Phase III activities. Continental Resources, Inc., was added as a new partner in April 2013.

Task Leader Meetings

Approximately once a month, internal EERC meetings are held with all the task leaders, the PI/program manager, budget personnel, and support staff. These meetings are convened in order to share information, create time lines for the completion of products, and disseminate data.

Carbon Sequestration Leadership Forum

CSLF promotes collaborative research, development, and demonstration projects that reflect member priorities. CSLF may recognize collaborative projects that 1) facilitate the development of improved cost-effective technologies for the separation and capture of CO_2 for transport and long-term safe storage, 2) make these technologies broadly available internationally, and 3) identify and address wider issues relating to CCS. The RCSP project, comprising the seven regional partnerships including the PCOR Partnership, was recognized by CSLF at its Berlin meeting in September 2005.

The PCOR Partnership's Fort Nelson CCS Project was granted CSLF recognition in October 2009 and is one of 43 such projects formally recognized. The PCOR Partnership has received project recognition for not only one project, but two projects. the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project received recognition in 2007. In PY6, the PCOR Partnership submitted progress updates for September 2013 to CSLF on both of its recognized projects.

In April 2013, PCOR Partnership management staff attended the CSLF Technical Group Meeting and CO_2 Monitoring Interactive Workshop in Rome, Italy. Ed Steadman presented an overview of the Bell Creek MVA program (Figure 19).

In PY7, efforts will continue to encourage Denbury to seek recognition of the Bell Creek project.

Advisory Board Meetings

In September 2011, DOE issued a contract modification, No. 21, authorizing the creation of an advisory board under statement of project objectives (SOPO) Task 13 – Project Management. DOE also agreed to fund meetings and associated expenses through September 30, 2015.

The inaugural TAB meeting was held in February 2012 in San Diego, California. The first TAB includes the following CCUS and EOR experts:

- Bill Jackson, BillyJack Consulting, Inc. (Chair)
- Stefan Bachu, Alberta Innovates – Technology Futures (AITF)
- Ray Hattenbach, Blue Strategies
- Lynn Helms, NDIC
- Mike Jones, Lignite Energy Council
- Steve Melzer, Melzer Consulting
- Tom Olle, Texas International Energy Partners
- Steve Whittaker, Global CCS Institute
- Neil Wildgust, PTRC

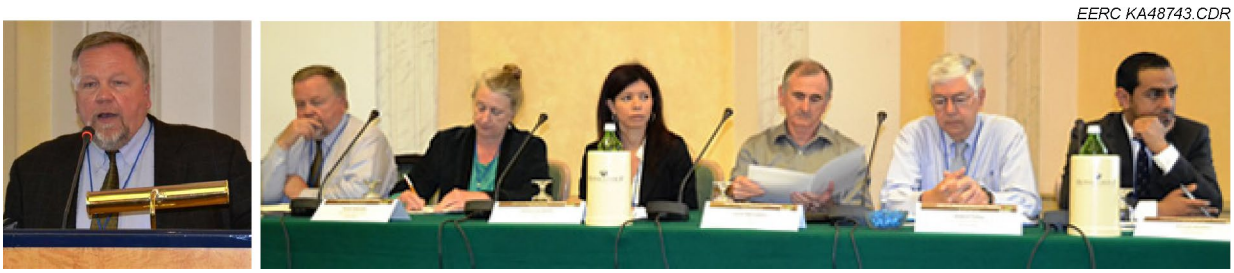

Figure 19. Ed Steadman (left) presenting at the CSLF CO_2 Monitoring Interactive Workshop in Rome, Italy, and seated (far left in second photo) with other session participants (photos courtesy of CSLF; www.cslforum.org/meetings/workshops/technical_rome2013.html, accessed January 2014).

Although only five board members are required for a quorum, all nine appointed members were present and participated in the first meeting.

A second TAB meeting was scheduled and held March 5–6, 2013, in Orlando, Florida, with eight of the nine appointed TAB members able to attend (only Steve Whittaker was unable to participate) (Figure 20). Several presentations were given to update the TAB on the most recent status of the PCOR Partnership's projects, including near-future plans. The TAB commended the PCOR Partnership on its work to date, encouraging it to continue working with its industry partners and writing peer-reviewed journal articles. In addition, they encouraged the PCOR Partnership to remember the site-specific nature of each CCS project and cautioned against practices that could become prescriptive.

In addition, several technical WebEx meetings were held in PY6. This format was preferable to the TAB members to accommodate their busy travel schedules, and this meeting was held in lieu of a face-to-face meeting at the EERC. In January 2013, the PCOR Partnership presented to the TAB members the surface and near-surface MVA activities being conducted at one of its demonstration sites. The TAB members commented on these activities and provided advice on how to incorporate them into an overall MVA program for this project. In August 2013, an update on the basal Cambrian system characterization efforts was presented via WebEx meeting.

Figure 20. PCOR Partnership TAB members in attendance at second winter meeting; back row (from left): Tom Olle, Ray Hattenbach, Stefan Bachu, Mike Jones; front row (from left): Steve Melzer, Neil Wildgust, Lynn Helms, and Bill Jackson.

Brief TAB updates are also held in conjunction with the PCOR Partnership Annual Membership Meetings.

Programmatic Risk Management Plan (RMP)

A preliminary risk analysis was completed for the overall PCOR Partnership Program. A brainstorming meeting was held for all program task leaders, and the primary program risks were identified in four categories: technical, external, organizational, and project management.

Each of the program risks was then assigned a probability of occurrence and a severity of impact associated with each occurrence. These values were used to rank the risks in a programmatic risk register, which will be reviewed to develop a set of risk management strategies for the program. In accordance with the overall risk management framework, this evaluation and ranking process was repeated on September 5, 2013, to ensure that the identified risks are being properly managed.

Task 14 – RCSP WWG Coordination

In order to investigate the relationship between water and CCS, members of the RCSPs have formed the WWG. Each RCSP has its own unique set of challenges related to water utilization and the implementation of CCS activity, and the WWG will help to address those concerns. The PCOR Partnership leads the RCSP WWG comprising appropriate stakeholders. The RCSP WWG was initiated in January 2009. The purpose of the WWG is to address the wide variety of concerns and opportunities at the nexus of carbon storage and water resources. Development of documents under this task is led by the EERC, with input from all WWG participants.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) include the following.

Monthly Conference Calls

A total of 44 monthly conference calls (Milestone [M] 23) have taken place since the inception of this task, ten of which were completed in PY6, as follows: October 25, 2012; November 28, 2012; January 16, 2013; February 28, 2013; March 28, 2013; April 25, 2013; May 30, 2013; June 20, 2013; July 25, 2013; and September 30, 2013. DOE NETL waived the requirement for conference calls during the months of December 2012 and August 2013. Minutes of the calls are submitted to the WWG the subsequent month following a call.

Status of the WWG

The WWG has completed the following items:

- Produced a white paper that identified a wide variety of nexus of water and CCS, provided a comprehensive review of related processes and concepts, and began identifying the various challenges and opportunities.

- Created a mission statement:

  "The mission of the RSCP WWG is to provide a resource of knowledge, insight, and guidance to stakeholders involved with water and water resources and their relationship to the developing technology of CCS."

- Developed a water and CCS fact sheet (Fact Sheet No. 1; 2011) and general PowerPoint presentation that summarized work in the white paper. In March 2013, Fact Sheet No. 2 entitled "Carbon Capture and Storage: Protecting Freshwater Resources" was finalized. Efforts are currently under way for Fact Sheet No. 3 (due October 31, 2013). These products provide public outreach for the WWG and are distributed/presented at several conferences throughout the year.

- Developed a technologies gap assessment document (2011).

Annual Meetings

On March 25, 2013, DOE NETL approved a change to the requirement for the annual meeting to be held by June each year now to be held by December each year (for 2013–2016). This will allow flexibility in scheduling the meeting in coordination with other DOE meetings.

Prior to the WWG annual meeting on August 19, 2013, the WWG hosted an open house and poster session (Figure 21) at the Sheraton Station Square Hotel, in Pittsburgh, Pennsylvania. Several nonmembers attended and provided feedback using the WWG survey.

The fifth annual WWG meeting (M24) was held on August 19, 2013, in Pittsburgh, Pennsylvania, prior to the DOE Carbon Storage R&D Project Review Meeting. There were nine attendees from four partnerships. The meeting agenda items included the following:

- Review open house response
- Revisit mission statement
- Value – are the products useful?
- Future products
- MVA fact sheet review and discussion

The meeting concluded following updates given by each of the participating regional partnerships.

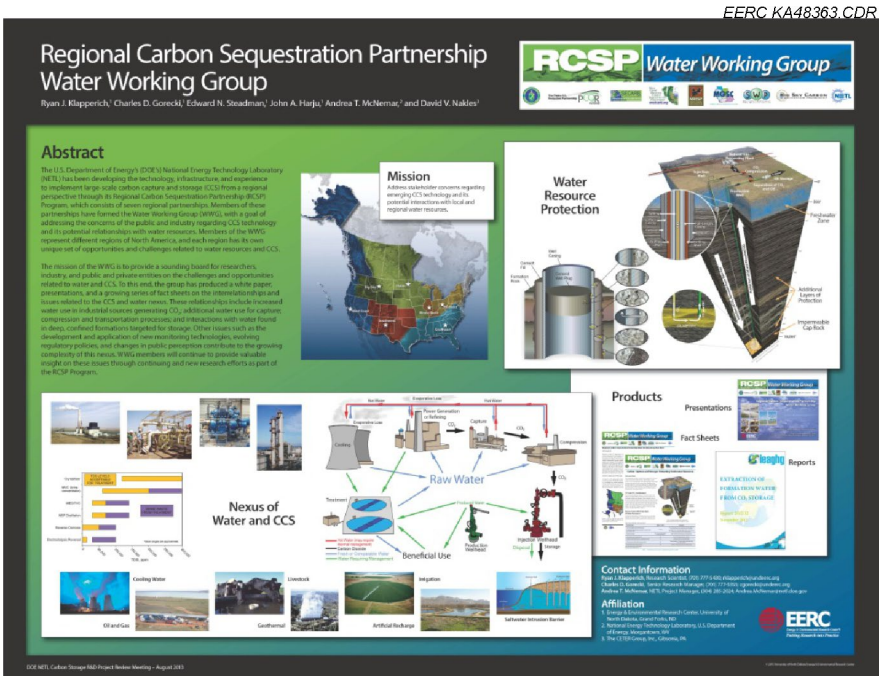

Figure 21. RCSP WWG poster presented at the WWG Open House and DOE Review Meeting (August 2013).

Methodology Document

A methodology document (D79) to estimate the resource that might be available in different reservoirs will be generated as storage projects are developed. Because of the lack of water produced in current RCSP storage projects, on December 15, 2009, DOE waived the requirement for water resource estimation methodology documents originally due February 2010 and May 2011. The fact sheet submitted April 30, 2010, replaced the former. The technology gaps assessment document replaced the latter. In September 2012, DOE waived the requirement for the methodology documents originally due November 30, 2012, and November 30, 2015. New fact sheets will be created to replace these requirements (see section below). There are still two methodology documents required, and they are due May 31, 2014, and May 31, 2017.

Fact Sheet Development

In December 2011, the WWG distributed a Stakeholder Group Outreach Survey. The results of the survey were compiled into a WWG interest inventory. The primary vehicle to address the WWG survey results is through the development of fact sheets. In September 2012, a new deliverable, D99 – water/CCS nexus-related fact sheet, was created. The WWG will determine the topics of three fact sheets due March 31, 2013; October 31, 2013; and October 31, 2014, respectively.

In March 2013, a fact sheet entitled "Carbon Capture and Storage: Protecting Freshwater Resources" was finalized. This fact sheet identifies the keys to successfully protect water resources during CCS and introduces the evolving regulatory framework set up for that purpose.

Best Practices Manual

A BPM on the nexus of water and carbon storage activities will be assembled (D80) in BP5. This report will highlight the findings of the WWG and identify opportunities for water resource conservation and optimization in CCUS. The requirement for an interim report, originally due June 30, 2013, was eliminated in September 2012 and replaced with the requirement for another fact sheet (due October 2014).

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project

The Zama oil field in Alberta, Canada, was one of the geologic storage validation test sites during Phase II of the program. This project focused on the injection of acid gas into a partially depleted oil field for the simultaneous purpose of acid gas disposal, CO_2 storage, and EOR. Because of the useful results and positive outcomes developed throughout the Phase II project, the site owner, Apache Canada Ltd. (Apache), was amenable to participation in follow-on characterization efforts at the Zama site. Accordingly, in June 2010, DOE NETL approved furtherance of the work that was performed in the Zama oil field during Phase II. A new deliverable was added for this new work, i.e., D86, which will provide an updated regional technology implementation plan for the Zama project. In September 2012, because of data acquisition delays, D86, entitled Updated Regional Technology Implementation Plan, was extended from April 30, 2013, to September 30, 2013. Effective April 29, 2013, Charles Gorecki assumed the task leader responsibilities. An extension from September 30, 2013, to February 28, 2014, for D86 was requested. DOE NETL approved the request on September 16, 2013.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) include the following.

Apache was planning to divest certain conventional properties in Canada, including its EOR project in the Zama Field located in Alberta. However, during a meeting held in Calgary on June 22, 2011, Apache revealed that it will be retaining ownership and operation of the Zama Field. Because of Apache's corporate planning strategies and personnel redistribution, efforts to initiate the seismic profiles, logging suites, and MVA activities were delayed. They were originally slated to begin in January 2011.

In January 2012, EERC staff met with Apache staff in Calgary, Alberta, Canada. At that time, they shared new information regarding Apache's planned operations for the Zama project. In response to Apache's shutdown of the Zama gas plant and stay on any future EOR operations, the EERC will not be able to complete the seismic profiles, logging suites, and MVA activities

detailed in the 2011 SOPO. Modification 23 (June 2012) to the PCOR Partnership award included a revised SOPO that included revisions to Subtasks 15.3–15.5.

In January 2013, Apache staff traveled to Grand Forks to meet at the EERC offices. The EERC participated in discussions with Apache's team and presented a progress update.

CSLF Recognition and Progress Reports

CSLF recognized the Zama Acid Gas EOR, CO_2 Sequestration, and Monitoring Project at its Paris meeting in March 2007. In PY6, the PCOR Partnership submitted to the CSLF Secretariat a required project status report for September 2013. Progress at the Zama site was reported as follows:

- Improved static geologic models of additional pinnacles have been developed, and detailed dynamic simulations of injection and production have been conducted.

- Modeling activities have resulted in improved estimates of OOIP, recoverable reserves, and CO_2 storage capacity for six pinnacles in the Zama oil field.

- Over 100,000 tons of acid gas has been injected through January 2013. Approximately 65,000 incremental barrels of oil have been produced using this technique.

- At Zama, the CO_2 retained in the subsurface by the six selected pinnacles (through May 2012) is 172,947 metric tons. The amounts (in metric tons) for the individual pools are as follows: F = 36,611; G2G = 27,415; NNN = 20,977; RRR = 65,843; Z3Z = 6390; and Muskeg L = 15,711.

- A report presenting the results of the laboratory and modeling activities conducted since 2011 is under preparation. The report is anticipated to be finalized in early 2014.

Cement Integrity Studies, Wellbores

There are a number of potential areas where casing/cement failure may be of concern with respect to the long-term (up to 500-year) containment of the stored injectate. To better understand the rate at which leakage could be expected to occur, the EERC conducted the following testing:

- Basic casing corrosion and failure testing: Testing was conducted to evaluate the rate of degradation of the casing in an acid gas/brine exposure environment.

- Dissolution rate of cement and increase in cement permeability testing: Testing was conducted to determine the rate of degradation of cement (measured by an increase in the effective permeability) when exposed to brine or brine plus acid gas mixtures.

Static and Dynamic Modeling

A new site-specific model of the F Pool target injection zone was developed. This model has provided Apache with the necessary information required to determine sweep efficiency, wellbore placement, and further understanding of the heterogeneity of the reef structure.

The preliminary static geologic model was developed utilizing as much as 50 years worth of reservoir-specific data (core analyses, wireline logs, facies distributions of the pinnacles, etc.) provided by Apache. The EERC modified the F-Pool static geologic model based on a combination of history-matching results and a revised geological interpretation of the pinnacle reef morphology. The newly built site-specific Zama F Pool static geologic model was used to perform detailed history matching and future CO_2 EOR and CO_2 storage predictions.

Data Acquisition at Additional Zama Pinnacles

The EERC, in collaboration with Apache and BillyJack Consulting, gathered additional data needed to conduct petrophysical, geostatistical, and geochemical/fracture modeling on pinnacles at the Zama oil field that are undergoing or have undergone CO_2 flood. The EERC imported Apache's updated production and injection data (through May 2012) to the dynamic model. It then compiled data for updated injection and production volumes. Apache also provided reservoir operational data and geologic characterization data for four additional pinnacles.

Static Model, History Matching, and Dynamic Simulation at Additional Zama Pinnacles

The EERC used newly acquired data to develop additional site-specific models at various pinnacles within the Zama oil field that are undergoing or have undergone CO_2 flood. These models assisted in the development of improved estimates of original oil in place (OOIP), recoverable reserves, and CO_2 storage capacity for each of those pinnacles which, in turn, provided more insight regarding the overall potential for EOR in the Zama Field as a whole. This work began on September 1, 2012, and included data compilation for building the static and dynamic models for additional pinnacles.

On September 30, 2013, M40, entitled Further Characterization Completed, was satisfied. Six pinnacle reefs currently undergoing acid gas EOR were evaluated. The additional characterization focused on 1) estimating the feasibility of using existing wells to inject and store acid gas, 2) evaluating gas–rock reactions to further understand potential geochemical reactions, 3) developing a robust PVT model to predict miscibility behavior, 4) constructing high-resolution geocellular models, and 5) conducting dynamic reservoir simulations to develop effective strategies for EOR and long-term CO_2 storage.

The following work was conducted as part of the additional characterization activities for the Zama project:

- The feasibility of using existing wells as storage sites was evaluated. Wellbore integrity for CO_2 injection wells was demonstrated from both the standpoint of maintaining cost-

effective CCS operations and protecting the environment, especially drinking water sources. The effects of a typical Zama acid gas stream on the three materials that comprise the wellbore—reservoir rock, cement, and steel casing—were examined by a series of laboratory-based activities.

- The potential risks and factors related to cap rock degradation during long-term storage have been fully investigated and analyzed. Since there were no laboratory geochemical experimental data to support or refute the results of the Phase II study, laboratory activities were conducted to directly examine the geochemical interactions between Zama reservoir rocks, brine, and injectant (CO_2 and H_2S) under Zama reservoir pressure and temperature conditions.

- Efforts were made to minimize data gaps and reduce uncertainty during modeling. A wide variety of data (both geological and operational) were obtained to support modeling efforts, including petrophysical, completion, core analysis, fluid properties, and production.

- Rigorous PVT models were created for the F, G2G, and Muskeg L Pools. In the phase behavior study, the minimum miscibility pressure (MMP) was estimated. The effect of H_2S on MMP was investigated, as were MMP changes due to reservoir depletion.

- High-resolution geocellular models for the F, G2G, and Muskeg L Pools were constructed. Each of these models was history-matched, and the flooding efficiencies of current production and injection systems were analyzed using production data.

- EOR prediction scenarios for the F, G2G, and Muskeg L Pools were simulated based on the analysis of current production conditions and continuing EOR operations into the future to gain insight into the potential for incremental oil recovery and long-term CO_2 storage capacity.

A methodology was generated to quickly and efficiently evaluate the storage potential for other similar pinnacles. The results of this evaluation could be used to determine EOR and storage potential for other pinnacles in the Zama Field (Z3Z, NNN, and RRR) and other pinnacles throughout the world.

Acid Gas-Phase Behavior and Rock Interactions Studies

The EERC conducted batch reactor experiments on Zama reservoir core samples. Samples were exposed to pure CO_2 and acid gas and then analyzed for reaction products and chemical kinetic rates as well as morphology and SEM surface chemistry.

Task 16 – Basal Cambrian System Characterization

As part of the ongoing effort to characterize the northern Great Plains region of North America, a multiyear project is under way, with a goal of determining the potential for geologic storage of CO_2 in rock formations of the basal Cambrian system. This sequence of saline formations is continuous throughout much of the PCOR Partnership region and underlies many

of the area's large point sources of CO_2. The basal Cambrian system represents a regionally significant target for CCS but is an area that has not previously been systematically evaluated with respect to CO_2 storage resource.

Because the basal Cambrian system occurs in large parts of both the United States and Canada, this project is under way by the EERC in cooperation with AITF as a binational effort. The EERC will work closely with key partners in the United States to evaluate the American portion of the basal Cambrian system. AITF is leading a multiprovince team to conduct a similar evaluation for the Canadian portion of this system.

Activities and Results

Accomplishments during BP4, PY6 (October 1, 2012 – September 30, 2013) include the following.

CO_2 Source Characterization

In September 2011, a value-added report was prepared entitled "Overview of U.S. Sources that Overlay the Basal Cambrian Deadwood Formation." The stationary sources emitting more than 100,000 tonnes CO_2/year that overlay the U.S. portion of the basal Cambrian Deadwood Formation were identified. Sources that met the minimum emission limit included electricity generation, ethanol production, cement/clinker production, lime production, fuel/chemical production, petroleum refining, and institutional heat/power facilities.

Geological Characterization

Significant effort has been devoted to fully understanding the geological and hydrogeological character of the basal Cambrian system.

"Geological Characterization of the Basal Cambrian System in the Williston Basin" (D91) was prepared in February 2012. The initial phase of this project focused on delineating and characterizing separately the Canadian and U.S. portions of the Cambro–Ordovician Saline System (COSS). D91 describes the effort to characterize the U.S. portion of the region and how the data from the two countries were brought together into a single geologic model. The completed 2-D model incorporates the geologic data collected in the baseline characterization effort and distributes the various rock properties throughout the study region through geostatistical methods. The CO_2 storage resource derived from the resulting 2-D model for the U.S. portion of the COSS was determined to be 28 Gt at the P50 probability level. When added to the 85 Gt of storage resource determined from the Canadian effort, this results in a combined CO_2 storage resource of 113 Gt. This work also provides the groundwork for the development of a massive 3-D geologic model encompassing the entire study area.

In late August 2012, core was collected from the basal (Winnipeg/Deadwood) aquifer at the Aquistore site from the PTRC_INJ_5-6-2-8 W2M well. The EERC was invited to view the 19.2 m (63 feet) of core collected from the lowermost section of the Deadwood Formation in order to develop an understanding of mineralogical composition and the petrophysical properties

of the rocks within the basal Cambrian saline system below the Aquistore CO_2 storage site. Several tests were conducted on the samples from the well, analyzing for petrophysical attributes, including mineralogy, porosity, and permeability. The project objectives were accomplished through the completion of three distinct activities consisting of several specific tasks. Each of the first two activities had a decision point regarding the specific work to be performed and samples to be tested in the subsequent activities. The tests included petrographic analysis via thin sections and gas pycnometer/porosimetry on all samples in Activity 1; SEM, XRD, and permeability to gas and liquid on a varied number of samples in Activity 2; and CO_2–brine relative permeability testing on one sample in Activity 3.

It was determined that the sandstones evaluated from the lower Deadwood Formation are dominated by well-compacted quartz sand, with glauconite clay in varying stages of dissolution. Samples range in porosity from 2.7% to as high as 15.9%, with permeability to air values ranging from 0.002 to 136.53 mD. Of the 20 samples tested, six were determined to have a porosity of less than 9%. In each of these cases, the corresponding permeability value was less than 2 mD, implying that where porosity exists, it is likely not well-connected.

Storage Capacity Evaluation

A regional estimate will be developed of the available storage capacity within the basal Cambrian system and the effects of potential large-scale multiple-point injection scenarios. The following activities continued in PY6:

- Evaluation of the volumetric storage capacity of the system based on system geometry, pore space, CO_2 density, and storage efficiency coefficients.
- Evaluation of the dynamic storage capacity of the system in terms of injection of CO_2 from possible injection scenarios.
- A determination of the effects of brine displacement on the overall storage capacity and pressure regime will be conducted.

The base case results of one injector for each of the 16 aggregated large-scale CO_2 sources (Figure 22) show that the injectivity of the system is not sufficient to accommodate the cumulative mass of emitted CO_2. Exploring various optimization strategies, such as increasing the number of injectors, adding water extractors around the injectors, and modifying the relative permeability, showed a moderate to significant role in increasing the injectivity and, ultimately, the total amount of injected CO_2. The best case of the various scenarios is 3.17 times higher than the base case. However, even with this increased injectivity, the system was not able to accommodate the cumulative mass of CO_2 over the given time frame. It should be noted that all of the simulation efforts in this report are based on one geological realization. This single realization likely does not reflect the true natural characteristics of the injection zones at a particular CO_2 source location. As the next step in optimizing the potential storage resource, the aggregated CO_2 sources will be separated into 25 source points. Each of these new source points will be shifted geographically to coincide with the more promising geologic properties as depicted by the geologic model. In addition, more injection wells will be modeled at each of these new locations.

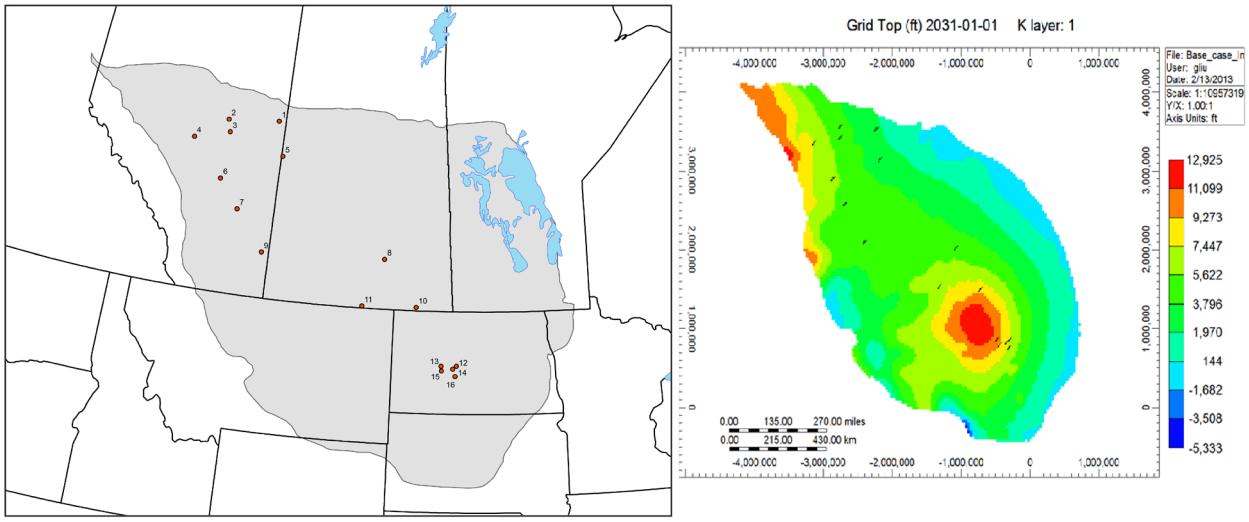

Figure 22. Location of the 16 CO_2 sources in the study area (left) and 16 injectors in the simulation model based on the location shown on the left (right).

The successful exploration of the study for CO_2 storage in the basal saline system of central North America provides a basic guideline to address evaluations of large-scale CO_2 storage demonstration projects. Specifically, the efforts help to answer questions regarding reservoir pressure buildup over the injection and postinjection periods and track the CO_2 movement. These play a crucial role in the whole process of CO_2 MVA for such a large-scale case of CO_2 storage estimation.

A comprehensive report presenting the estimates of the storage capacity of the basal Cambrian system and regional implications for large-scale storage in the basal Cambrian system (D92, due March 2014) will be prepared.

Storage Integrity

An assessment of the general overall integrity of the basal Cambrian system was conducted. It was necessary that the characterization and storage capacity evaluation be under way in order to begin the assessment. In PY6, dynamic simulations and laboratory activities were performed as follows:

- Evaluation of the geochemical effects of CO_2 storage in the system, including that of impurities contained in the injection stream where known.
- Evaluation of potential geochemical effects of the injected CO_2 and associated impurities on cap rock and well integrity.

Geochemical Evaluation of the Basal Cambrian System

A report detailing the findings of the geochemical evaluation of the basal Cambrian system (D89) was prepared in March 2013. The geochemical modeling study was performed using publicly available PHREEQC software and databases. Rock samples, mineralogy, and water analysis data for both the sandstone injection target and the shale cap rock were also obtained from publicly available sources (Figure 23). The laboratory-based exposure tests entailed exposure of various COSS rock samples to CO_2 for 28 days at formation pressure and temperature.

The results of the geochemical modeling were consistent with existing literature, and suggested that because most of the COSS comprises quartz-rich sandstone, much of the rock matrix will be nonreactive. Reactions can, however, occur with secondary components (clays, carbonates, micas, K-feldspar) that can be contained within the sandstone and the heterogeneous mixed lithology zones between the primary sand layers. The geochemical modeling study predicted that a geochemical effect from the interaction of CO_2 with the COSS minerals and formation water was the dissolution of calcite and concurrent formation of dolomite. The source of Mg^{2+} for this reaction was either from Mg^{2+} contained within secondary formation minerals, such as illite, phlogopite, celadonite, and clinochlore, or from Mg^{2+} in the formation water.

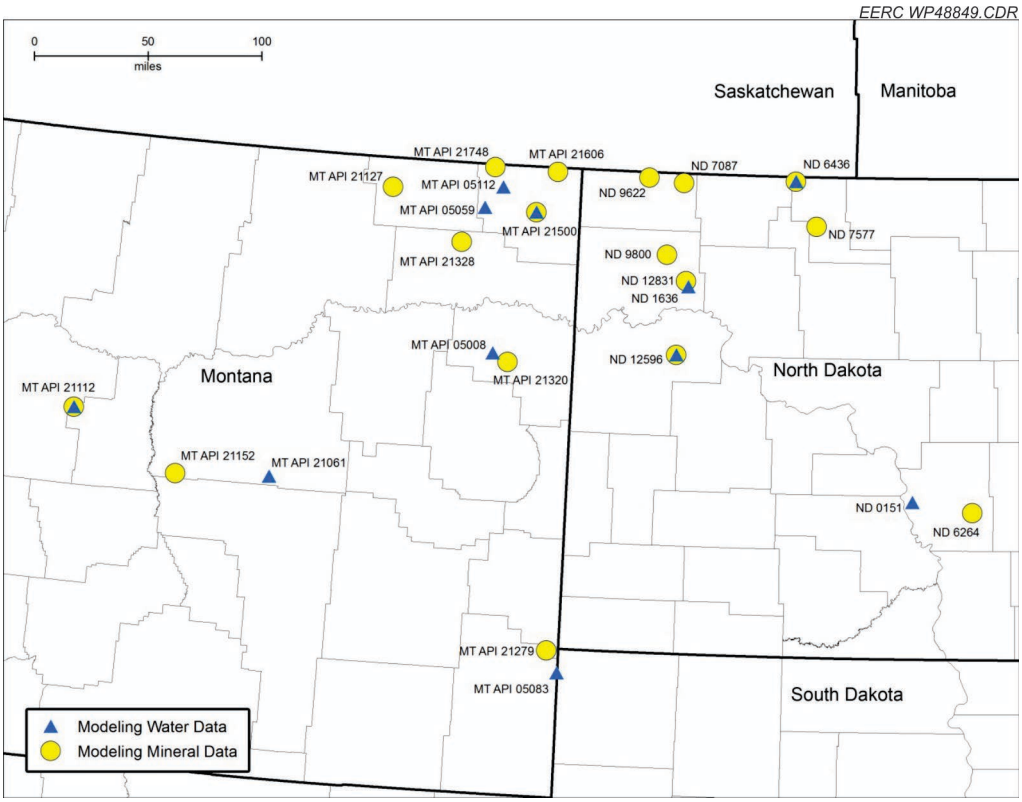

Figure 23. Map of sample locations for modeling and CO_2 exposure experiments.

The modeling calculations also indicated a potential reaction of the CO_2 with illite and K-feldspar in the formation. The K-feldspar was predicted to decompose into quartz, clay, and carbonates, thus trapping the CO_2 in a mineral form.

The results of the laboratory experiments generally compared favorably with the modeling portion of the study. The analytical data generated from the exposed samples show a variable mix of concentrations of K-feldspar and a general trend of decreases in illite. Illite and K-feldspar behaviors were generally in agreement with the geochemical modeling results. The most significant reactions occurred between CO_2 and dolomite/calcite and glauconite in the sandstone. Glauconite contained within samples completely dissolved and decomposed during the exposure experiments. The decomposition of glauconite will form siderite and quartz as well as some ions that will remain in solution. This phenomenon in glauconite-rich areas may increase local permeability as well as provide a mineral-trapping mechanism for CO_2. Samples of shale that were exposed to CO_2 showed no change in morphology or chemistry, with the exception of halite precipitation. The formation of halite that was seen is most likely an artifact of the samples being dried (not rinsed) after exposure to CO_2 and brine solutions.

The modeling calculations and laboratory experiments both suggest that CO_2 interactions with the COSS mineral phases (reservoir and cap rock) are not detrimental to CO_2 storage. Large areal changes in porosity and permeability are not anticipated from the interactions of CO_2 with the COSS. Minerals within the COSS that reacted with CO_2 are typically found in lower concentrations in the quartz-dominated sandstone or within the low-porosity cap rock. Any reactions with the cap rock are not likely to penetrate past the CO_2–cap rock interface because of low porosity/permeability. Variations in formation water chemistry, mineral content, and porosity in the COSS can result in large variations in the amount of CO_2 that can be trapped. These variations occur both geographically between different areas of the COSS and vertically at each location.

Additional focused efforts are needed on both the modeling and rock–CO_2 exposure fronts to better understand the potential effects of CO_2 storage in the COSS. With respect to future modeling efforts, additional data are necessary for more robust calculations to address the effects of pressure, kinetics, and concentrated brines in the COSS. Laboratory-based CO_2 exposure experiments could be improved by implementing more advanced sampling methodologies for highly heterogeneous rocks to ensure that observed differences in chemistry are accurate. Heterogeneity in the rock samples provides for challenging interpretation of results when minute changes in chemistry are observed. Improvements to the CO_2 exposure methodology to allow for better detection of minute mineralogical changes within the rock fabric will greatly aid in the refinement of this experimental process.

Wellbore Evaluation of the Basal Cambrian System

A report detailing the findings of the wellbore evaluation of the basal Cambrian system (D90) was prepared in September 2013. The PCOR Partnership performed a wellbore integrity assessment to evaluate the relative leakage potential of 826 wells penetrating the basal Cambrian system in the United States, drilled between 1921 and 2010 (Figure 24). The basal Cambrian system is a deep saline reservoir that has been identified by DOE as a potential CO_2 storage site. The ability of the basal Cambrian system to retain injected CO_2 over an extended period of time

is, in part, dependent on the integrity of wellbores that penetrate the target reservoir. Wellbore integrity is the ability of a well to maintain hydraulic isolation of geologic formations and prevent the vertical migration of fluids (9, 10). This study's evaluation of wellbore integrity involves analyzing wellbore characteristics (i.e., cement types, cement additives, completion techniques, well depths, and well casing) to derive a relative leakage potential score using methods similar to Bachu and others (11). Wells were assigned a classification of minimal, lower, moderate, or higher based on their relative leakage potential. This study provides a screening-level evaluation to compare and rank wells for further detailed evaluation.

The results of this regional screening-level evaluation determined that 15% of the wells assessed were classified as moderate or higher potential for deep well leakage, and 6.0% of the wells were classified moderate or higher for shallow well leakage. Of the wells assessed, 3.4% exhibited moderate or higher potential for both shallow and deep leakage. The majority of the moderate- or higher-potential wells are located in western North Dakota and eastern Montana in areas of intensive oil and gas exploration and production. The practice of producing oil and gas from these wells has increased the relative well leakage potential (based on the available data and methods utilized). The ranking of the relative leakage potential provides a mechanism to screen wells for detailed evaluation in areas targeted for CO_2 injection.

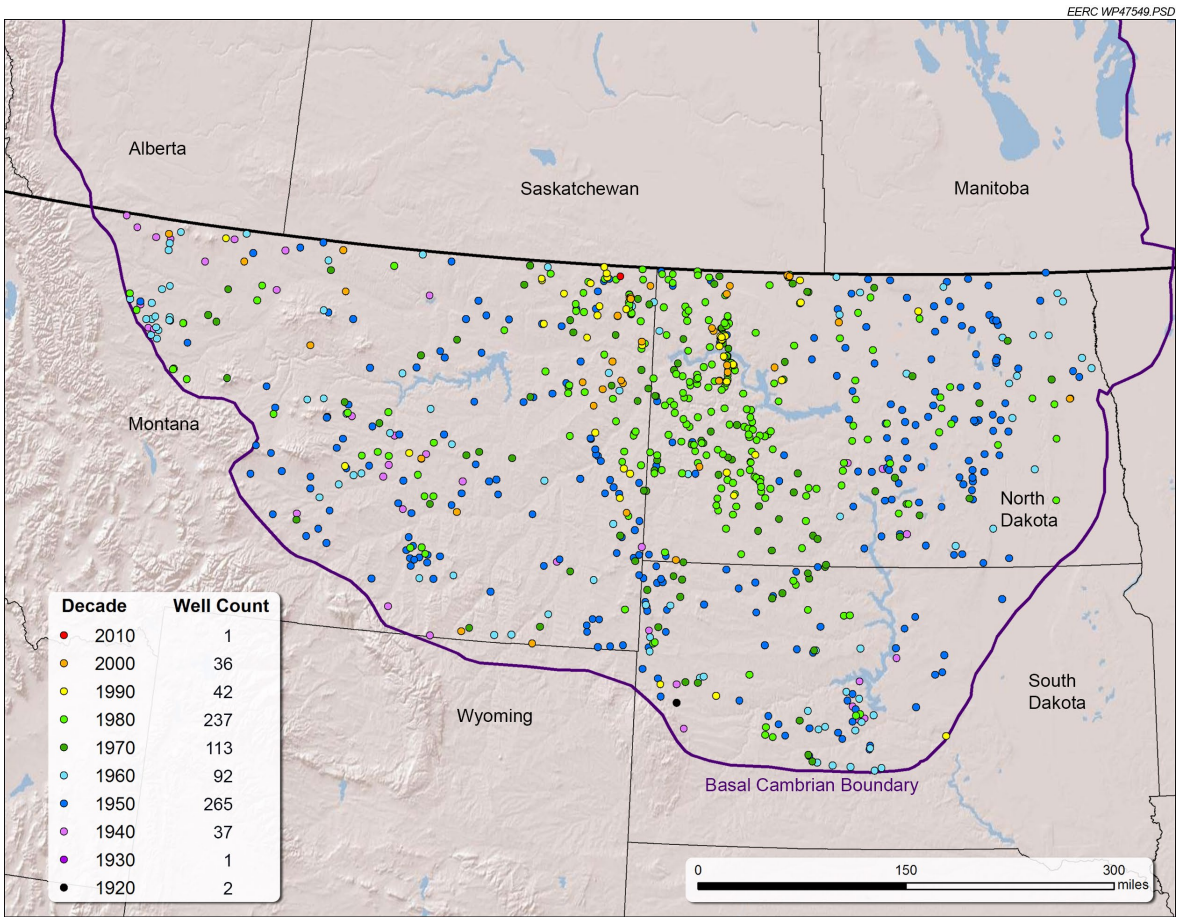

Figure 24. Spud dates by decade across the study area for 826 wells (sources: MBOG, NDIC, and South Dakota Department of Environment and Natural Resources).

Joint U.S.–Canada Basal Aquifer Project, A Binational Effort

Members of the steering and technical committees include the following:

United States
- DOE NETL
- EERC
- Lawrence Berkeley National Laboratory (LBNL)
- Princeton University

Canada
- AITF
- Alberta Innovates – Energy & Environmental Solutions
- CANMETenergy
- Manitoba Innovation, Energy, and Mines
- Manitoba Water Stewardship
- NRCan
- PTRC
- Saskatchewan Energy & Resources
- TOTAL E&P Ltd.

The following project meeting was held in PY6:

The Joint Technical and Steering Committee Meeting for the Basal Aquifer Project was held on February 21, 2013, in Berkeley, California. Representatives from AITF, NRCan, LBNL, and Princeton University (by phone) participated. A review of modifications to the EERC-prepared 3-D geomodel was conducted and discussions were held on preliminary dynamic simulation modeling. It was recognized that insufficient injectivity existed at the local extent to accommodate the CO_2 (at the current annual rate) for some of the large stationary sources even though there is a large storage resource available in the system.

COST STATUS

The currently approved budget for Phase III is shown in Table 7.

On September 30, 2013, the PCOR Partnership completed its sixth year of BP4 activities (PY6, October 1, 2012 – September 30, 2013). Actual cash expenditures of DOE and nonfederal sources, as well as noncash cost share reported through September 30, 2013, are listed in Table 8.

SCHEDULE STATUS

Table 9 contains all of the Phase III deliverables, milestones, and submission dates for the reporting period. Tables 10 and 11 provide Gantt charts for BP4, including the reporting period (BP4, PY6).

Table 7. PCOR Partnership Phase III Budget as of Mod. 26

	BP3 Year 1 – Year 2 10/1/07 – 9/30/09		BP4 Year 3 – Year 8 10/1/09 – 9/30/15		BP5 Year 9 – Year 10 10/1/015 – 9/30/17		**Total**	
DOE Share	$4,209,149	54.59%	$59,400,262	64.50%	$9,668,307	80.00%	$73,277,718	65.49%
Nonfederal Cost Share								
Cash*	$887,428		$2,411,971		$0		$3,299,399	
Noncash	$2,613,890		$30,279,844		$2,417,076		$35,310,810	
Total Nonfederal Cost Share	$3,501,318	45.41%	$32,691,815	35.50%	$2,417,076	20.00%	$38,610,209	34.51%
Total	$7,710,467	100.00%	$92,092,077	100.00%	$12,085,383	100.00%	$111,887,927	100.00%

* Cash as recognized by DOE.

Table 8. BP4 Funding and Actual Costs as of September 30, 2013

Organization	Approved Budget, $	Actual Costs Incurred, $
DOE Share – Cash	59,400,262	37,908,995
Nonfederal Share – Cash	2,411,971	2,685,376
Nonfederal Share – In-Kind	30,279,844	24,989,073
Total	92,092,077	65,580,444

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones

Title/Description	Due Date	Actual Completion Date
Year 1 – Quarter 1 (October–December 2007)		
D37: Task 4 – Fort Nelson Test Site – Geological Characterization Experimental Design Package	12/31/07	12/28/07
D63: Task 13 – Project Management Plan	12/31/07	12/28/07
M17: Task 4 – Fort Nelson Test Site Selected	12/31/07	12/28/07
Year 1 – Quarter 2 (January–March 2008)		
D38: Task 4 – Fort Nelson Test Site – Geomechanical Experimental Design Package	1/31/08	1/31/08
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/08	1/31/08
D11: Task 2 – Outreach Plan	3/31/08	3/31/08
D27: Task 3 – Environmental Questionnaire – Fort Nelson Test Site	3/31/08	4/02/08
D30: Task 4 – Williston Basin Test Site – Geomechanical Experimental Design Package	3/31/08	3/31/08
M1: Task 1 – Three Target Areas Selected for Detailed Characterization	3/31/08	3/20/08
M18: Task 4 – Fort Nelson Test Site Geochemical Work Initiated	3/31/08	3/19/08
Year 1 – Quarter 3 (April–June 2008)		
D14: Task 2 – General Phase III Fact Sheet	4/30/08	4/30/08
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/08	4/30/08
D17: Task 2 – General Phase III Information PowerPoint Presentation	5/30/08	5/30/08
M3: Task 3 – Start Environmental Questionnaire for Williston Basin Test Site	6/30/08	6/27/08
M6: Task 4 – Williston Basin Test Site Geochemical Work Initiated	6/30/08	6/30/08
M7: Task 4 – Williston Basin Test Site Geological Characterization Data Collection Initiated	6/30/08	6/30/08
Year 1 – Quarter 4 (July–September 2008)		
D12: Task 2 – Demonstration Web Pages on the Public Site	7/31/08	7/31/08
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/08	7/31/08
D1: Task 1 – Review of Source Attributes	9/30/08	9/26/08
M2: Task 1 – Demonstration Project Reporting System (DPRS) Prototype Completed	9/30/08	9/26/08
Year 2 – Quarter 1 (October–December 2008)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/08	10/31/08
D20: Task 2 – Documentary Support to PowerPoint and Web Site	12/31/08	12/31/08
D57: Task 12 – Project Assessment Annual Report	12/31/08	12/31/08

Continued…

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 2 – Quarter 2 (January–March 2009)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/09	1/30/09
M21: Task 14 – Outline of White Paper on Nexus of CO_2 Capture and Sequestration (CCS) and Water, Part Subtask 14.2 – White Paper on Nexus of CCS and Water	2/28/09	2/27/09
D24: Task 2 – PCOR Partnership Region CO_2 Storage General Poster	3/31/09	3/31/09
Year 2 – Quarter 3 (April–June 2009)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/09	4/30/09
M23: Task 14 – Monthly WWG Conference Call Held	4/30/09	4/15/09
D2: Task 1 – First Target Area Completed	5/29/09	5/29/09
M23: Task 14 – Monthly WWG Conference Call Held	5/29/09	5/29/09
D16: Task 2 – Fort Nelson Test Site Fact Sheet	5/29/09	5/29/09
M24: Task 14 – WWG Annual Meeting Held	5/31/09	5/07/09
M23: Task 14 – Monthly WWG Conference Call Held	6/30/09	6/25/09
Year 2 – Quarter 4 (July–September 2009)		
M23: Task 14 – Monthly WWG Conference Call Held	N/A	Waived by DOE
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation	7/31/09	7/31/09
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/09	7/31/09
M22: Task 14 – Draft White Paper - Nexus of CCS and Water Available for Comments	8/17/09	8/18/09
M23: Task 14 – Monthly WWG Conference Call Held	8/31/09	8/25/09
D1: Task 1 – Review of Source Attributes (Update)	9/30/09	9/25/09
D3: Task 1 – Permitting Review – One State and One Province	9/30/09	9/30/09
D9: Task 1 – Updated DSS	9/30/09	9/29/09
D47: Task 6 – Report on the Preliminary Design of Advanced Compression Technology	9/30/09	9/30/09
D77: Task 13 – Risk Management Plan Outline	9/30/09	9/18/09
M4: Task 4 – Bell Creek Test Site Selected	9/30/09	9/30/09
M5: Task 4 – Bell Creek Test Site – Data Collection Initiated	9/30/09	9/30/09
M23: Task 14 – Monthly WWG Conference Call Held	9/30/09	9/22/09

Continued…

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 3 – Quarter 1 (October–December 2009)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/30/09	11/02/09
D78: Task 14 – Final White Paper on the Nexus of CCS and Water	10/30/09	10/28/09
M23: Task 14 – Monthly WWG Conference Call Held	10/31/09	10/26/09
M23: Task 14 – Monthly WWG Conference Call Held	11/30/09	11/16/09
D57: Task 12 – Project Assessment Annual Report	12/31/09	12/31/09
M23: Task 14 – Monthly WWG Conference Call Held	12/31/09	Waived by DOE
Year 3 – Quarter 2 (January–March 2010)		
D13: Task 2 – Public Site Updates	1/15/10	1/15/10
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/10	1/29/10
M23: Task 14 – Monthly WWG Conference Call Held	1/31/10	1/6/10
D79: Task 14 – Water Resource Estimation Methodology Document	2/28/10	Waived by DOE
M23: Task 14 – Monthly WWG Conference Call Held	2/28/10	2/25/10
D11: Task 2 – Outreach Plan	3/31/10	3/31/10
M23: Task 14 – Monthly WWG Conference Call Held	3/31/10	3/23/10
Year 3 – Quarter 3 (April–June 2010)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/10	4/30/10
M23: Task 14 – Monthly WWG Conference Call Held	4/30/10	4/28/10
M23: Task 14 – Monthly WWG Conference Call Held	5/31/10	5/13/10
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	6/30/10	6/30/10
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation (Update)	6/30/10	6/29/10
M23: Task 14 – Monthly WWG Conference Call Held	6/30/10	6/23/10
M24: Task 14 – WWG Annual Meeting Held	6/30/10	5/13/10
Year 3 – Quarter 4 (July–September 2010)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/10	7/29/10
M23: Task 14 – Monthly WWG Conference Call Held	7/31/10	7/28/10
M23: Task 14 – Monthly WWG Conference Call Held	8/31/10	8/31/10
D1: Task 1 – Review of Source Attributes – (Update)	9/30/10	9/20/10
D52: Task 9 – Fort Nelson Test Site – Site Characterization, Modeling, and Monitoring Plan	9/30/10	9/30/10*
M9: Task 4 – Bell Creek Test Site Geological Model Development Initiated	9/30/10	9/30/10
M23: Task 14 – Monthly WWG Conference Call Held	9/30/10	Waived by DOE

Continued…

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 4 – Quarter 1 (October–December 2010)		
D87: Task 4 – Bell Creek Test Site – Geomechanical Experimental Design Package	10/30/10	10/29/10
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/10	10/29/10
M23: Task 14 – Monthly WWG Conference Call Held	10/31/10	10/26/10
M23: Task 14 – Monthly WWG Conference Call Held	11/30/10	Waived by DOE
D57: Task 12 – Project Assessment Annual Report	12/31/10	12/23/10
M23: Task 14 – Monthly WWG Conference Call Held	12/31/10	12/23/10
Year 4 – Quarter 2 (January–March 2011)		
M8: Task 4 – Bell Creek Test Site Wellbore Leakage Data Collection Initiated	1/15/11	1/14/11
D31: Task 4 – Bell Creek Test Site – Geological Characterization Experimental Design Package	1/31/11	1/27/11
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/11	1/31/11
M23: Task 14 – Monthly WWG Conference Call Held	1/31/11	1/19/11
M28: Task 4 – Bell Creek Geological Experimental Design Package Completed	1/31/11	1/27/11
D15: Task 2 – Bell Creek Test Site Fact Sheet	2/28/11	2/28/11
M23: Task 14 – Monthly WWG Conference Call Held	2/28/11	Waived by DOE
D10: Task 1 – Demonstration Project Reporting System Update	3/31/11	3/25/11
D18: Task 2 – Bell Creek Test Site PowerPoint Presentation	3/31/11	3/31/11
D26: Task 2 – Fort Nelson Test Site Poster	3/31/11	3/31/11
D28 : Task 3 – Environmental Questionnaire – Bell Creek Test Site	3/31/11	3/30/11
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities	3/31/11	3/31/11
M23: Task 14 – Monthly WWG Conference Call Held	3/31/11	3/22/11
Year 4 – Quarter 3 (April–June 2011)		
M30: Task 5 – Bell Creek Test Site Baseline MVA will be initiated	4/01/11	3/24/11
M23: Task 14 – Monthly WWG Conference Call Held	4/30/11	4/21/11
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/11	4/29/11
D88: Task 13 – Programmatic Risk Management Plan	4/30/11	4/29/11
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	5/31/11	5/31/11
D34: Task 4 – Bell Creek Test Site – Baseline Hydrogeological Experimental Design Package	5/31/11	5/31/11
M23: Task 14 – Monthly WWG Conference Call Held	5/31/11	5/5/11

Continued…

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 4 – Quarter 3 (April–June 2011) (continued)		
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation (Update)	6/30/11	6/30/11
M23: Task 14 – Monthly WWG Conference Call Held	6/30/11	6/23/11
M24: Task 14 – WWG Annual Meeting Held	6/30/11	5/5/11
Year 4 – Quarter 4 (July–September 2011)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/11	7/28/11
M23: Task 14 – Monthly WWG Conference Call Held	7/31/11	7/26/11
D29: Task 3 – Permitting Action Plan	8/31/11	8/31/11
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/11	8/31/11
D67: Task 9 – Fort Nelson Test Site – Simulation Report	8/31/11	8/31/11
M23: Task 14 – Monthly WWG Conference Call Held	8/31/11	8/24/11
D1: Task 1 – Review of Source Attributes (Update)	9/30/11	9/21/11
D4: Task 3 – Permitting Review – Basic EPA Requirements	9/30/11	9/30/11
D9: Task 1 – Updated DSS	9/30/11	9/23/11
D25: Task 2 – Bell Creek Test Site Poster	9/30/11	9/30/11
D50: Task 9 – Bell Creek Test Site – Site Characterization, Modeling, and Monitoring Plan	9/30/11	9/30/11
M23: Task 14 – Monthly WWG Conference Call Held	9/30/11	Waived by DOE
M31: Task 9 – Bell Creek Test Site – Site Characterization, Modeling, and Monitoring Plan Completed	9/30/11	9/30/11
M33: Task 16 – Basal Cambrian Baseline Geological Characterization Completed	9/30/11	9/29/11
Year 5 – Quarter 1 (October–December 2011)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/11	10/31/11
M23: Task 14 – Monthly WWG Conference Call Held	10/31/11	10/26/11
M23: Task 14 – Monthly WWG Conference Call Held	11/30/11	11/30/11
D57: Task 12 – Project Assessment Annual Report	12/31/11	12/30/11
M23: Task 14 – Monthly WWG Conference Call Held	12/31/11	Waived by DOE
M34: Task 16 – Basal Cambrian Static Geological Model Completed	12/31/11	12/21/11

Continued . . .

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 5 – Quarter 2 (January–March 2012)		
M16: Task 4 – Bell Creek Test Site – Initiation of Production and Injection Simulation	1/13/12	12/29/11
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/12	1/31/12
D65: Task 4 – Fort Nelson Test Site – Site Characterization Report	1/31/12	1/31/12
D81: Task 1 – Regional Carbon Sequestration Atlas (Update)	1/31/12	1/31/12
M29: Task 4 – Fort Nelson Site Characterization Report Completed	1/31/12	1/31/12
M23: Task 14 – Monthly WWG Conference Call Held	1/31/12	1/19/12
D91: Task 16 – Report – Geological Characterization of the Basal Cambrian System in the Williston Basin	2/29/12	2/29/12
M23: Task 14 – Monthly WWG Conference Call Held	2/29/12	2/28/12
D5: Task 1 – Second Target Area Completed	3/31/12	3/30/12
D18: Task 2 – Bell Creek Test Site PowerPoint Presentation (Update)	3/31/12	3/30/12
M10: Task 4 – Bell Creek Test Site Wellbore Leakage Data Collection Completed	3/31/12	3/12/12
M23: Task 14 – Monthly WWG Conference Call Held	3/31/12	3/27/12
M36: Annual Advisory Board Meeting Scheduled	3/31/12	3/28/12
Year 5 – Quarter 3 (April–June 2012)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/12	4/30/12
M23: Task 14 – Monthly WWG Conference Call Held	4/30/12	Waived by DOE
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	5/31/12	5/31/12
M23: Task 14 – Monthly WWG Conference Call Held	5/31/12	5/31/12
D19: Task 2 – Fort Nelson Test Site PowerPoint Presentation (Update)	6/30/12	6/29/12
D41: Task 4 – Fort Nelson Test Site – Geochemical Report	6/30/12	6/29/12
D84: Task 6 – Report – A Phased Approach to Building Pipeline Network for CO_2 Transportation During CCUS	6/30/12	6/29/12
M23: Task 14 – Monthly WWG Conference Call Held	6/30/12	6/28/12
M24: Task 14 – WWG Annual Meeting Held	6/30/12	5/3/12
M32: Task 4 – Fort Nelson Geochemical Report Completed	6/30/12	6/29/12

Continued . . .

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 5 – Quarter 4 (July–September 2012)		
D13: Task 2 – Public Site Updates	7/31/12	7/31/12
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/12	7/31/12
D67: Task 9 – Fort Nelson Test Site – Simulation Report	7/31/12	7/31/12
M23: Task 14 – Monthly WWG Conference Call Held	7/31/12	7/24/12
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/12	8/31/12
M23: Task 14 – Monthly WWG Conference Call Held	8/31/12	8/30/12
D1: Task 1 – Review of Source Attributes (Update)	9/30/12	9/28/12
D10: Task 1 – DPRS Update	9/30/12	9/28/12
M23: Task 14 – Monthly WWG Conference Call Held	9/30/12	9/27/12
Year 6 – Quarter 1 (October–December 2012)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/12	10/31/12
M23: Task 14 – Monthly WWG Conference Call Held	10/31/12	10/25/12
M23: Task 14 – Monthly WWG Conference Call Held	11/30/12	11/28/12
D41: Fort Nelson Test Site – Geochemical Report (Update 1)	12/15/12	12/15/12
D57: Task 12 – Project Assessment Annual Report	12/31/12	12/28/12
M23: Task 14 – Monthly WWG Conference Call Held	12/31/12	Waived by DOE
M37: Task 3 – IOGCC Task Force Subgroup Meeting 1 Held	12/31/12	12/21/12
Year 6 – Quarter 2 (January–March 2013)		
D32: Task 4 – Bell Creek Test Site – Geomechanical Report	1/31/13	1/31/13
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/13	1/31/13
M23: Task 14 – Monthly WWG Conference Call Held	1/31/13	1/16/13
D14: Task 2 – General Phase III Fact Sheet (Update)	2/28/13	2/28/13
M23: Task 14 – Monthly WWG Conference Call Held	2/28/13	2/26/13
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities	3/31/13	Waived by DOE
D89: Task 16 – Report – Geochemical Evaluation of the Basal Cambrian System	3/31/13	3/28/13
D99: Task 14 – Water/CCS Nexus-Related Fact Sheet	3/31/13	3/22/13
M23: Task 14 – Monthly WWG Conference Call Held	3/31/13	3/26/13
M36: Task 13 – Annual Advisory Board Meeting Scheduled	3/31/13	3/27/13

Continued . . .

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 6 – Quarter 3 (April–June 2013)		
D15: Task 2 – Bell Creek Test Site Fact Sheet (Update)	4/15/13	3/25/13
D16: Task 2 – Fort Nelson Test Site Fact Sheet (Update)	4/30/13	Waived by DOE
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/13	4/30/13
M14: Task 4 – Bell Creek Test Site Geological Characterization Data Collection Completed	4/30/13	4/30/13
M23: Task 14 – Monthly WWG Conference Call Held	4/30/13	4/25/13
M35: Task 16 – Basal Cambrian Dynamic Capacity Estimation Completed	4/30/13	4/30/13
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	5/31/13	5/31/13
D43: Task 5 – Bell Creek Test Site – Monitoring Experimental Design Package	5/31/13	5/31/13
M23: Task 14 – Monthly WWG Conference Call Held	5/31/13	5/30/13
M27: Task 5 – Bell Creek Test Site – MVA Equipment Installation and Baseline MVA Activities Completed	5/31/13	5/31/13
M42: Task 3 –Findings and Recommendations of the Operational and Postoperational Subgroups Presented to the CGS Task Force	6/30/13	6/28/13
M23: Task 14 – Monthly WWG Conference Call Held	6/30/13	6/27/13
M26: Task 8 – Bell Creek Test Site – CO_2 Injection Initiated	6/30/13	May 2013
M37: Task 3 – IOGCC Task Force Subgroup Meeting 2 Held	6/30/13	5/9/13
Year 6 – Quarter 4 (July–September 2013)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/13	7/31/13
D33: Task 4 – Bell Creek Test Site – Preinjection Geochemical Report	7/31/13	7/31/13
M12: Task 4 – Bell Creek Test Site – Preinjection Geochemical Work Completed	7/31/13	7/31/13
M23: Task 14 – Monthly WWG Conference Call Held	7/31/13	7/25/13
D64: Task 4 – Bell Creek Test Site – Site Characterization Report	8/31/13	8/29/13
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/13	8/30/13
D81: Task 1 – Regional Carbon Sequestration Atlas (Update)	8/31/13	5/1/13
M23: Task 14 – Monthly WWG Conference Call Held	8/31/13	Waived by DOE

Continued . . .

Table 9. PCOR Partnership Phase III, BP3 and BP4 (through 9/30/2013) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 6 – Quarter 4 (July–September 2013) (continued)		
D1: Task 1 – Review of Source Attributes (Update)	9/30/13	9/5/13
D6: Task 3 – Permitting Review – Update 1	9/30/13	9/24/13
D48: Task 7 – Bell Creek Test Site – Procurement Plan and Agreement Report	9/30/13	9/24/13
D90: Task 16 – Report – Wellbore Evaluation of the Basal Cambrian System	9/30/13	9/5/13
D94:Task 2 – Aquistore Project Fact Sheet	9/30/13	9/30/13
D95: Task 2 – Aquistore Project Poster	9/30/13	9/30/13
D98: Task 3 – Report – Findings, Recommendations, and Guidance of the CGS Task Force on Operational and Postoperational Liability	9/30/13	8/30/13
M23: Task 14 – Monthly WWG Conference Call Held	9/30/13	9/30/13
M38: Task 3 – IOGCC Task Force Wrap-Up Meeting Held	9/30/13	8/16/13 and 9/5/13
M39: Task 3 – IOGCC Task Force Editing Subgroup Meeting Held	9/30/13	6/3/13 and 9/5/13
M40: Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project Completed	9/30/13	9/24/13

Table 10. PCOR Partnership Phase III Gantt Chart (BP4, PY3–PY4)

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Table 10. PCOR Partnership Phase III Gantt Chart (BP4, PY3–PY4) (continued)

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Table 10. PCOR Partnership Phase III Gantt Chart (BP4, PY3–PY4) (continued)

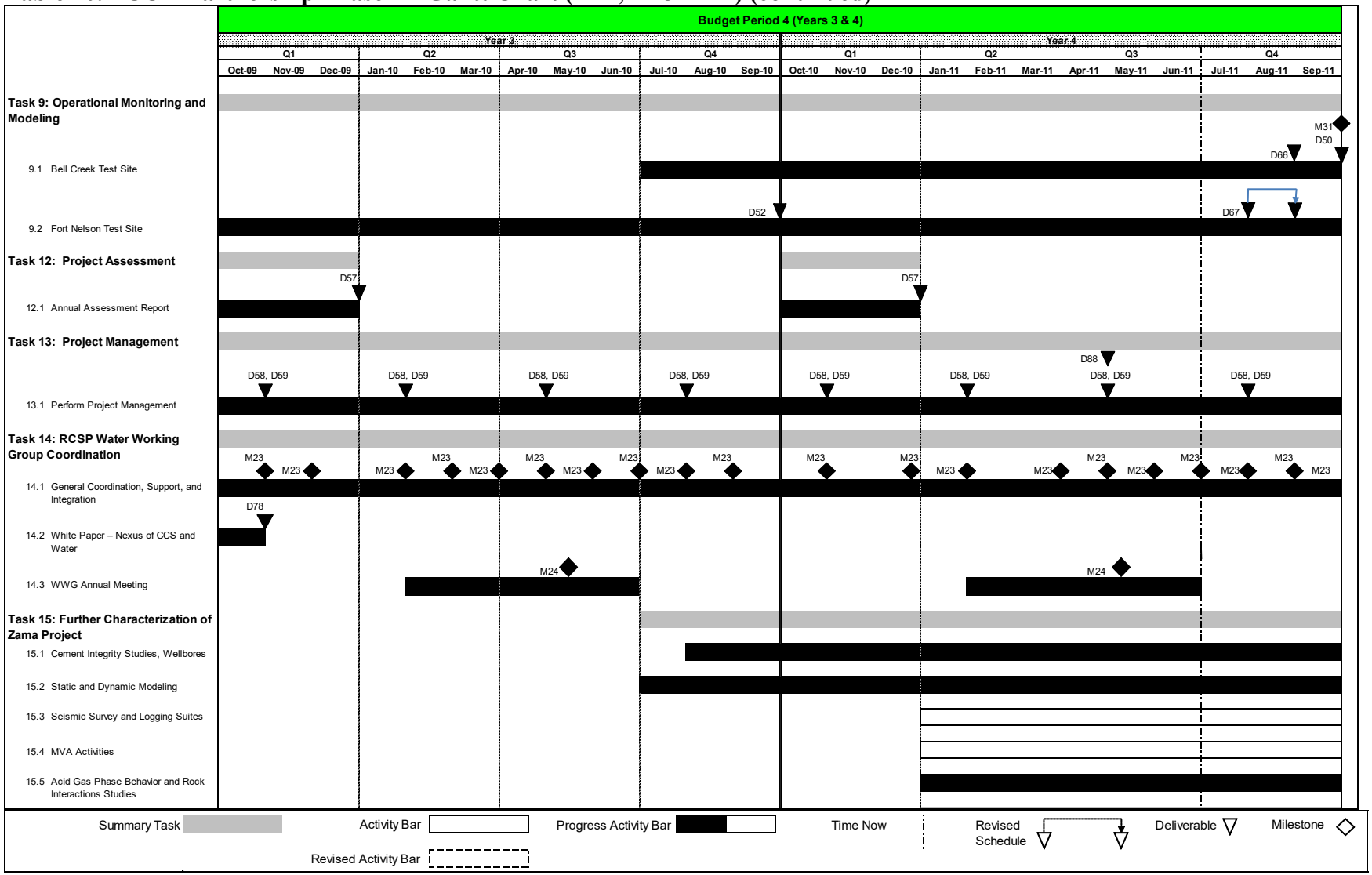

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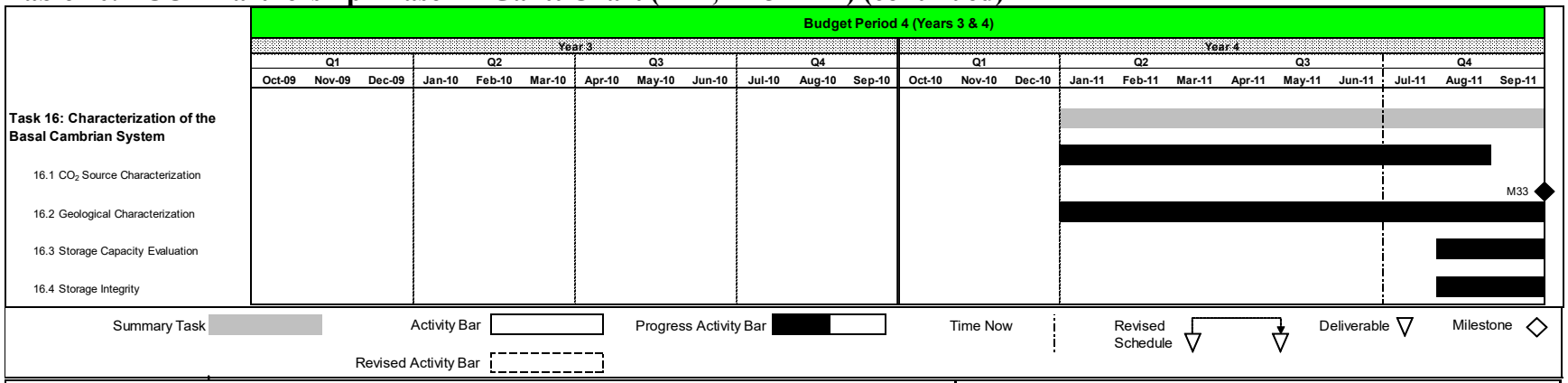
Table 10. PCOR Partnership Phase III Gantt Chart (BP4, PY3–PY4) (continued)



Key for Deliverables (D)			
D1	Review of Source Attributes	D29	Permitting Action Plan
D4	Permitting Review – Basic EPA Requirements	D31	BC Test Site – Geological Characterization Experimental Design Package
D9	Updated DSS	D34	BC Test Site – Baseline Hydrogeological Experimental Design Package
D10	DPRS Update	D50	BC Test Site – Site Characterization, Modeling, and Monitoring Plan
D11	Outreach Plan	D52	FN Test Site – Site Characterization, Modeling, and Monitoring Plan
D13	Public Site Updates	D57	Project Assessment Annual Report
D15	Bell Creek (BC) Test Site Fact Sheet	D58	Quarterly Progress Report
D16	Fort Nelson (FN) Test Site Fact Sheet	D59	Milestone Quarterly Report
D17	General Phase III Information PowerPoint Presentation	D66	BC Test Site – Simulation Report
D18	BC Test Site PowerPoint Presentation	D67	FN Test Site – Simulation Report
D19	FN Test Site PowerPoint Presentation	D78	White Paper – Nexus of CCS and Water
D20	Video Support to PowerPoint and Web Site	D81	Regional Carbon Sequestration Atlas (update)
D24	PCOR Partnership Region CO_2 Storage General Poster	D85	Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities
D25	BC Test Site Poster		
D26	FN Test Site Poster	D87	BC Test Site – Geomechanical Experimental Design Package
D28	BC Test Site – Environmental Questionnaire	D88	Programmatic Risk Management Plan

Key for Milestones (M)	
M8	BC Test Site – Wellbore Leakage Data Collection Initiated
M9	BC Test Site – Geological Model Development Initiated
M23	Monthly WWG Conference Call Held
M24	WWG Annual Meeting Held
M28	BC Test Site – Geological Characterization Experimental Design Package Completed
M30	BC Test Site – Baseline MVA Activities Initiated
M31	BC Test Site – Site Characterization, Modeling, and Monitoring Plan Completed
M33	Basal Cambrian Baseline Geological Characterization Completed

Table 11. PCOR Partnership Phase III Gantt Chart (BP4, PY5–PY6)

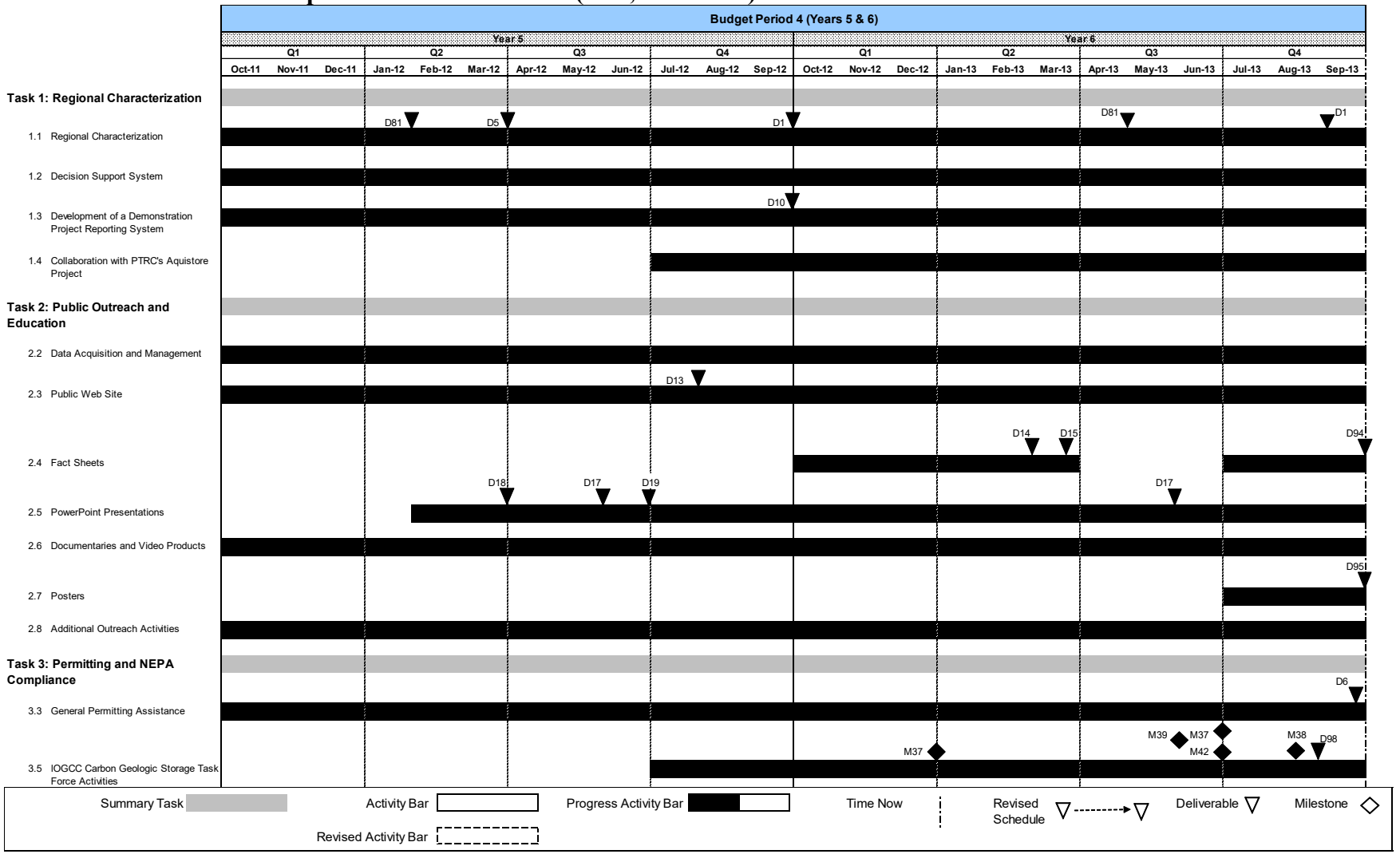


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Table 11. PCOR Partnership Phase III Gantt Chart (BP4, PY5–PY6) (continued)

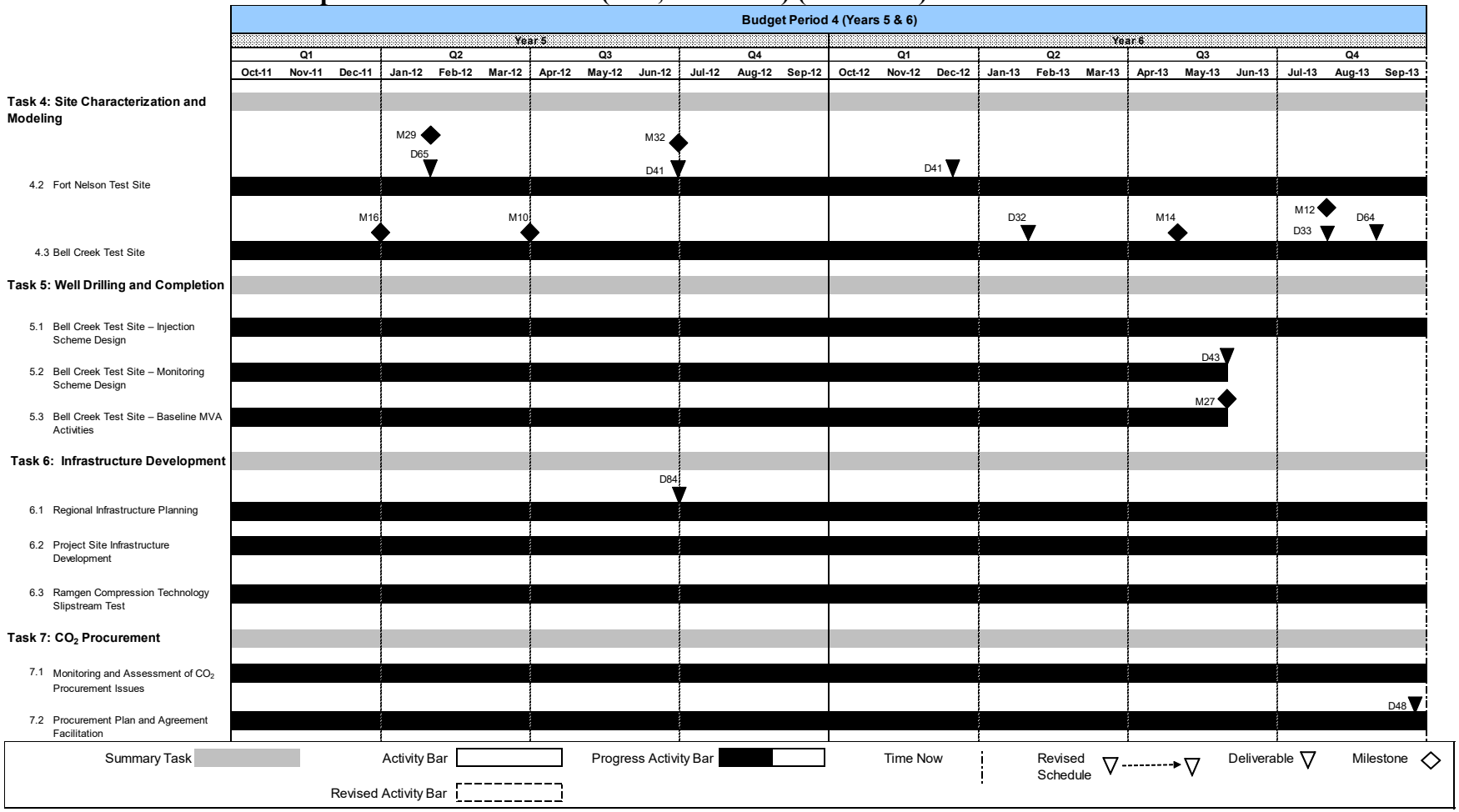

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Table 11. PCOR Partnership Phase III Gantt Chart (BP4, PY5–PY6) (continued)

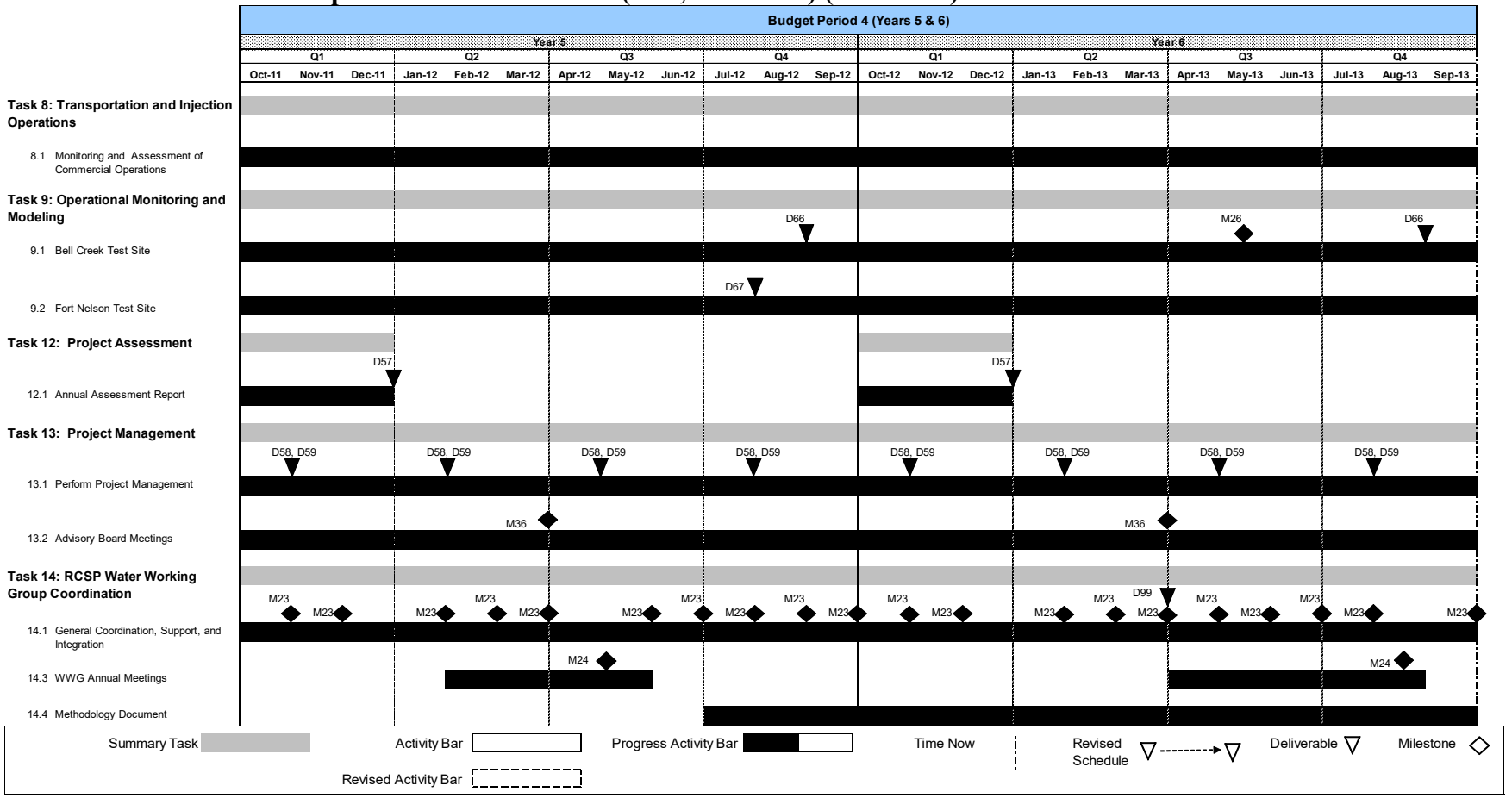

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Table 11. PCOR Partnership Phase III Gantt Chart (BP4, PY5–PY6) (continued)

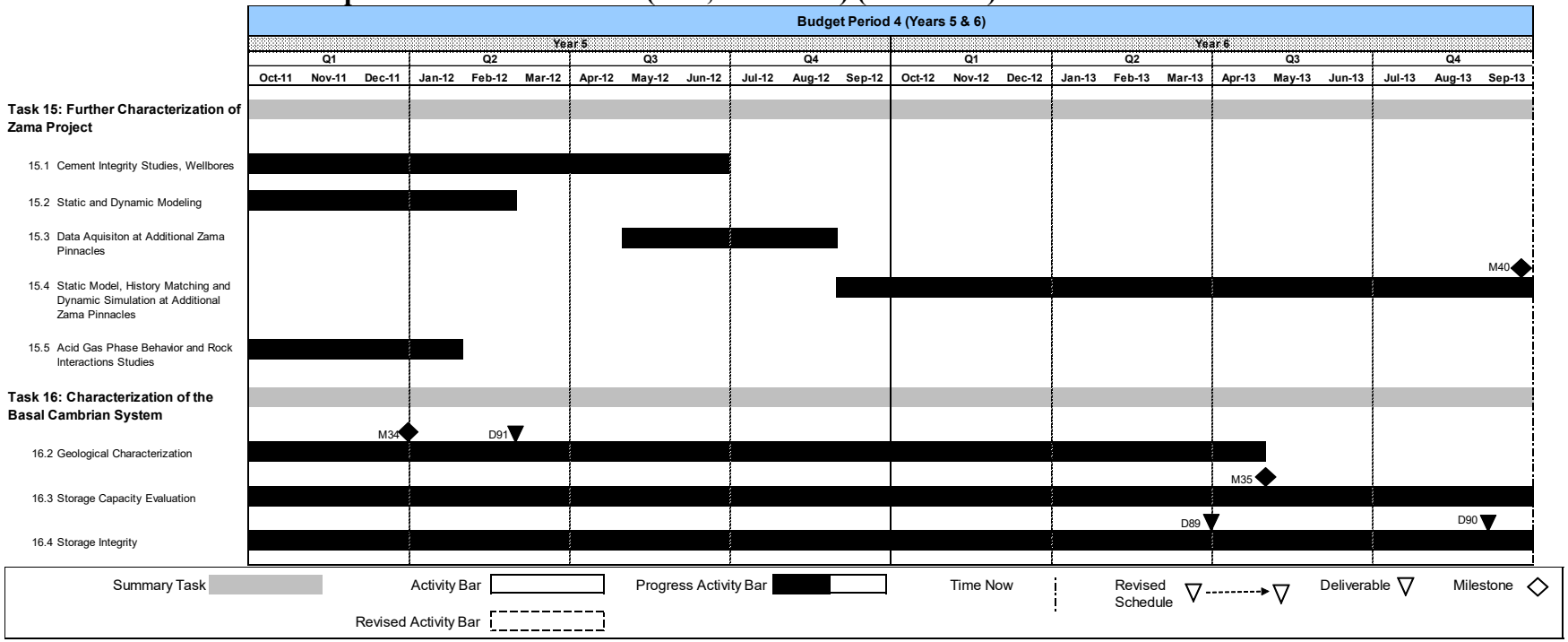

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Table 11. PCOR Partnership Phase III Gantt Chart (BP4, PY5–PY6) (continued)

Key for Deliverables (D) ▼				Key for Milestones (M) ◆	
D1	Review of Source Attributes	D52	FN Test Site – Site Characterization, Modeling, and Monitoring Plan	M8	BC Test Site – Wellbore Leakage Data Collection Initiated
D4	Permitting Review – Basic EPA Requirements	D57	Project Assessment Annual Report	M9	BC Test Site – Geological Model Development Initiated
D5	Second Target Area Completed	D58	Quarterly Progress Report	M10	BC Test Site – Wellbore Leakage Data Collection Completed
D6	Permitting Review – Update 1	D59	Milestone Quarterly Report	M12	BC Test Site – Preinjection Geochemical Work Completed
D9	Updated DSS	D64	BC Test Site – Site Characterization Report	M14	BC Test Site – Geological Characterization Data Collection Completed
D10	DPRS Update	D65	FN Test Site – Site Characterization Report	M16	BC Test Site – Initiation of Production and Injection Simulations
D11	Outreach Plan	D66	BC Test Site – Simulation Report	M23	Monthly WWG Conference Call Held
D13	Public Site Updates	D67	FN Test Site – Simulation Report	M24	WWG Annual Meeting Held
D14	General Phase III Fact Sheet	D78	White Paper – Nexus of CCS and Water	M26	BC Test Site – CO_2 Injection Initiated
D15	BC Test Site Fact Sheet	D81	Regional Carbon Sequestration Atlas	M27	BC Test Site – MVA Equipment Installation and Baseline MVA Activities Completed
D17	General Phase III Information PowerPoint Presentation	D84	Report – A Phased Approach to Building Pipeline Network for CO_2 Transportation During CCUS	M28	BC Test Site – Geological Characterization Experimental Design Package Completed
D18	BC Test Site PowerPoint Presentation			M29	FN Test Site – Site Characterization Report Completed
D19	FN Test Site PowerPoint Presentation	D85	Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities	M30	BC Test Site – Baseline MVA Activities Initiated
D20	Video Support to PowerPoint and Web Site			M31	BC Test Site – Site Characterization, Modeling, and Monitoring Plan Completed
D24	PCOR Partnership Region CO_2 Storage General Poster	D87	BC Test Site – Geomechanical Experimental Design Package	M32	FN Test Site – Geochemical Report Completed
D25	BC Test Site Poster	D88	Programmatic Risk Assessment	M33	Basal Cambrian Baseline Geological Characterization Completed
D26	FN Test Site Poster	D89	Report – Geochemical Evaluation of the Basal Cambrian System	M34	Basal Cambrian Static Geological Model Completed
D28	BC Test Site – Environmental Questionnaire	D90	Report – Wellbore Evaluation of the Basal Cambrian System	M35	Basal Cambrian Dynamic Capacity Estimation Completed
D29	Permitting Action Plan	D91	Report – Geological Characterization of the Basal Cambrian System in the Williston Basin	M36	Annual Advisory Board Meeting Scheduled
D31	BC Test Site – Geological Characterization Experimental Design Package			M37	Subgroup Meetings Held
D32	BC Test Site – Geomechanical Report	D93	Report – Geological Modeling and Simulation for the Aquistore Project	M38	Task Force Wrap-Up Meeting Held
D33	BC Test Site – Preinjection Geochemical Report	D94	Aquistore Project Fact Sheet	M39	Editing Subgroup Meeting Held
D34	BC Test Site – Baseline Hydrogeological Experimental Design Package	D95	Aquistore Project Poster	M40	Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project Completed
D41	FN Test Site – Geochemical Report	D98	Report – Findings, Recommendations and Guidance of the GCS Task Force on Operational and Postoperational Liability		
D43	BC Test Site – Monitoring Experimental Design Package			M42	Findings and Recommendations of the Operational and Postoperational Liability Subgroups Presented to the GCS Task Force
D48	BC Test Site – Procurement Plan and Agreement Report	D99	Water/CCS Nexus Related Fact Sheet		
D50	BC Test Site – Site Characterization, Modeling, and Monitoring Plan				

PLANNED ACTIVITIES

Task 1 – Regional Characterization

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Review and update attribute data for existing sources. Add additional attributes as necessary for characterization. Incorporate new sources as they come online (D1).

- Continue to work with the geological surveys/oil and gas divisions of the states and provinces to develop greater detail of the field and reservoir data.

- Continue to update the DSS and DPRS, and report changes in the quarterly progress reports.

- Prepare a white paper on the characterization of relevant oil fields located in the Cedar Creek Anticline.

- Prepare a detailed characterization of a third target area (D7) located within the PCOR Partnership region.

- Prepare reports detailing geologic modeling and simulation activities for the Aquistore project (D93).

Task 2 – Public Outreach and Education

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Continue to review and improve the public PCOR Partnership Web site (D13).

- Update the PowerPoint presentation for Phase III general activities (D17). Other PowerPoint presentations may be developed as needed.

- Prepare a general outreach poster (D24) for use explaining CO_2 storage and PCOR Partnership efforts to educators and general public.

- Continue to develop video products to meet the needs of general and site-level outreach.

- Continue to collaborate with PTRC on outreach activities related to the Aquistore project. These activities may include assisting in assembling material for public presentations, assisting in collection of information about public perception, participating in meetings with PTRC about public outreach activities, and collecting video of the activities at the project site.

- Continue to update project-related fact sheets, and develop new fact sheets as needed.

- Continue to act on opportunities to provide outreach both at the regional level and in the vicinity of the demonstrations, and address needs with respect to general information on CO_2 storage as well as information on the specific demonstration projects. Activities may include public presentations; assembly of materials for the press and for specific audiences, including middle and high school students; conducting focus groups and undertaking other means of gaining audience feedback to gauge the knowledge of target audiences as well as the effectiveness of outreach materials; and working with outreach and education professionals in an effort to improve the effectiveness of outreach and education activities.

- Continue participation in the RCSP OWG, the Weyburn–Midale Outreach Advisory Panel, and the Aquistore Project Communications Advisory Group.

Task 3 – Permitting and NEPA Compliance

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Continue to gather information on current and planned CO_2 storage-related regulations at the state, province, and federal levels.

- Continue to facilitate the Regulatory Roundup meeting with regulators in the PCOR Partnership region.

- Interface with relevant regulatory agencies within the PCOR Partnership region as well as with federal regulatory agencies (United States and Canada) to understand the regulatory framework for project implementation.

- Continue participation in IOGCC activities as well as in the North Dakota CO_2 Storage Workgroup.

Task 4 – Site Characterization and Modeling

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Bell Creek Test Site

  – Prepare a wellbore leakage report (D36) by March 31, 2014.
  – Complete the 3-D seismic acquisition and characterization report (D96) by March 31, 2014.
  – Complete the BPM on site characterization (D35) by September 30, 2014.

Task 5 – Well Drilling and Completion

During a portion of the next program year (October 1, 2013 – June 30, 2014), the following activities will be undertaken:

- Prepare an injection experimental design package (D42) by October 30, 2013.
- Prepare a drilling and completion activities report (D44) by June 30, 2014.
- This task is scheduled to end June 30, 2014.

Task 6 – Infrastructure Development

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Determine whether to incorporate Ramgen compression technology into Bell Creek Project (M41) by January 31, 2014.

- Prepare a report on the integration of advanced compression technology with CO_2 storage (D83) by September 30, 2014.

- Publish a journal article on the topic of assessing temporary storage options to attenuate variable-rate CO_2 emissions for use during EOR.

- Update the interactive capture technologies table on the DSS.

- Complete an interactive table of compression technologies for the DSS.

- Continue to investigate regional infrastructure needs. Information will be made available for possible inclusion in the DSS.

- Continue to assist commercial partners with the activities required to develop the infrastructure to deliver CO_2 to the EOR site for the Bell Creek demonstration.

Task 7 – CO_2 Procurement

This task ended September 30, 2013. No further activity is anticipated.

Task 8 – Transportation and Injection Operations

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Monitor and assess the CO_2 transport and injection operations conducted by the site owner/operator of the Bell Creek test site.

Task 9 – Operational Monitoring and Modeling

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Fort Nelson test site
  - Complete the BPM on the Fort Nelson feasibility study (D100) by June 30, 2014.
- Bell Creek test site
  - Complete the first full-repeat sampling of the groundwater- and soil gas-monitoring program (M43) by December 31, 2013.
  - Complete the first 3-D VSP repeat surveys (M44) by March 31, 2014.
  - Continue to provide a quarterly summary of injection operations in the quarterly technical progress reports.
  - Complete the first full-repeat of pulsed neutron logging campaign (M45) by June 30, 2014.
  - Complete one full year of CO_2 injection (M46) by May 31, 2014.
  - Update the simulation report (D66) by August 31, 2014.

Task 10 – Site Closure

No activity is anticipated during the next program year.

Task 11 – Postinjection Monitoring and Modeling

No activity is anticipated during the next program year.

Task 12 – Project Assessment

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Prepare the Annual Project Assessment Report (D57).

Task 13 – Project Management

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Continue to ensure timely production of deliverables and overall project management.
- Continue to expand the PCOR Partnership's membership base.
- Continue to update the TAB, and execute at least one meeting prior to the next annual meeting.
- Plan the next annual meeting.
- Continue to participate in and support RCSP efforts.
- Update the project management plan as necessary.
- Update the risk management plan as necessary.

Task 14 – RCSP WWG Coordination

During the next program year (October 1, 2013 – September 30, 2014), the following activities will be undertaken:

- Continue to conduct monthly WWG conference calls.
- Plan and conduct the sixth annual meeting of the WWG.
- Prepare a fact sheet on MVA plans for protection of water resources during the geologic storage of CO_2 (D99-2) by October 31, 2014.
- Prepare a water resource estimation methodology document (D79) or alternative product by May 31, 2014.

Task 15 – Further Characterization of the Zama Acid Gas EOR, CO_2 Storage, and Monitoring Project

During a portion of the next program year (October 1, 2013 – February 28, 2014), the following activities will be undertaken:

- Update and augment the regional technology implementation plan document developed in Phase II for the Zama project (D86) to incorporate the results of the added-on Phase III work.
- This task is scheduled to end February 28, 2014.

Task 16 – Basal Cambrian System Characterization

During a portion of the next program year (October 1, 2013 – March 31, 2014), the following activities will be undertaken:

- Prepare a report on the storage capacity and regional implications for large-scale storage in the basal Cambrian system (D92) by March 31, 2014.

- This task is scheduled to end March 31, 2014.

PLANNED SCHEDULE

Table 12 contains all of the Phase III deliverables, milestones, and submission dates for PY7 (October 1, 2013 – September 30, 2014). Table 13 provides a Gantt chart for PY7.

Table 12. PCOR Partnership Phase III Milestones and Deliverables (BP4, PY7)

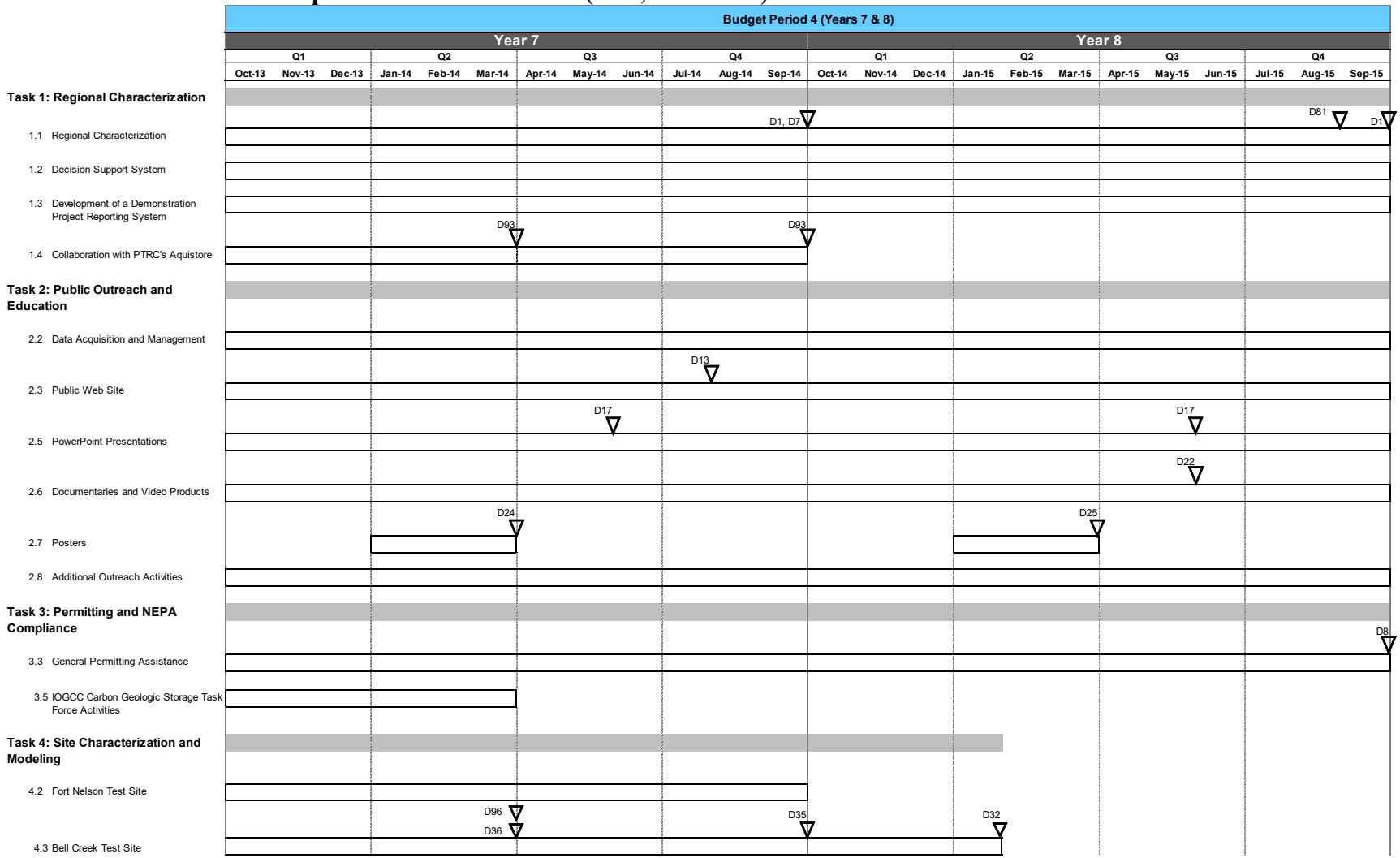
Title/Description	Due Date	Actual Completion Date
Year 7 – Quarter 1 (October–December 2013)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/13	10/31/13
D42: Task 5 – Bell Creek Test Site – Injection Experimental Design Package	10/31/13	10/30/13
D99: Task 14 – Water/CCS Nexus-Related Fact Sheet	10/31/13	10/31/13
M23: Task 14 – Monthly WWG Conference Call Held	10/31/13	10/31/13
M23: Task 14 – Monthly WWG Conference Call Held	11/30/13	11/21/13
D57: Task 12 – Project Assessment Annual Report	12/31/13	
M23: Task 14 – Monthly WWG Conference Call Held	12/31/13	Waived by DOE
M24: Task 14 – WWG Annual Meeting Held	12/31/13	8/19/13
M43: Task 9 – Bell Creek Test Site – First Full-Repeat Sampling of the Groundwater- and Soil Gas-Monitoring Program Completed	12/31/13	
Year 7 – Quarter 2 (January–March 2014)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/14	
M23: Task 14 – Monthly WWG Conference Call Held	1/31/14	
M41: Task 6 – Decision to Incorporate Ramgen Compression Technology into Bell Creek Project	1/31/14	
D86: Task 15 – Updated Regional Technology Implementation Plan for Zama	2/28/14	
M23: Task 14 – Monthly WWG Conference Call Held	2/28/14	
D24: Task 2 – PCOR Partnership Region CO_2 Storage General Poster (Update)	3/31/14	
D36: Task 4 – Bell Creek Test Site – Wellbore Leakage Final Report	3/31/14	
D92: Task 16 – Report – Storage Capacity and Regional Implications for Large-Scale Storage in the Basal Cambrian System	3/31/14	
D93: Task 1 – Geological Modeling and Simulation Report for the Aquistore Project	3/31/14	
D96: Task 4 – Bell Creek Test Site – 3-D Seismic Acquisition and Characterization Report	3/31/14	
M23: Task 14 – Monthly WWG Conference Call Held	3/31/14	
M36: Task 13 – Annual Advisory Board Meeting Scheduled	3/31/14	
M44: Task 4 – Bell Creek Test Site – First 3-D VSP Repeat Surveys Completed	3/31/14	
Year 7 – Quarter 3 (April–June 2014)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/14	
M23: Task 14 – Monthly WWG Conference Call Held	4/30/14	
D17: Task 2 – General Phase III Information PowerPoint Presentation (Update)	5/31/14	

Continued . . .

Table 12. PCOR Partnership Phase III Milestones and Deliverables (BP4, PY7) (continued)

Title/Description	Due Date	Actual Completion Date
Year 7 – Quarter 3 (April–June 2014) (continued)		
D79: Task 14 – Water Resource Estimation Methodology Document (Update)	5/31/14	
D44: Task 5 – Bell Creek Test Site – Drilling and Completion Activities Report	6/30/14	
D100: Task 9 – Fort Nelson Test Site – BPM – Feasibility Study	6/30/14	
M23: Task 14 – Monthly WWG Conference Call Held	6/30/14	
M45: Task 4 – Bell Creek Test Site – First full-repeat of pulsed-neutron logging campaign completed	6/30/14	
M46: Task 9 – Bell Creek Test Site – 1 Year of Injection Completed	6/30/14	
Year 7 – Quarter 4 (July–September 2014)		
D13: Task 2 – Public Site Updates	7/31/14	
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/14	
M23: Task 14 – Monthly WWG Conference Call Held	7/31/14	
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/14	
M23: Task 14 – Monthly WWG Conference Call Held	8/31/14	
D1: Task 1 – Review of Source Attributes (Update)	9/30/14	
D7: Task 1 – Third Target Area Completed	9/30/14	
D35: Task 4 – Bell Creek Test Site – BPM – Site Characterization	9/30/14	
D83: Task 6 – Report – Integration of Advanced Compression Technology with CO_2 Storage	9/30/14	
D93: Task 1 – Geological Modeling and Simulation Report for the Aquistore Project (Update)	9/30/14	
M23: Task 14 – Monthly WWG Conference Call Held	9/30/14	

Table 13. PCOR Partnership Phase III Gantt Chart (BP4, PY7–PY8)



Continued…

Table 13. PCOR Partnership Phase III Gantt Chart (BP4, PY7–PY8) (continued)

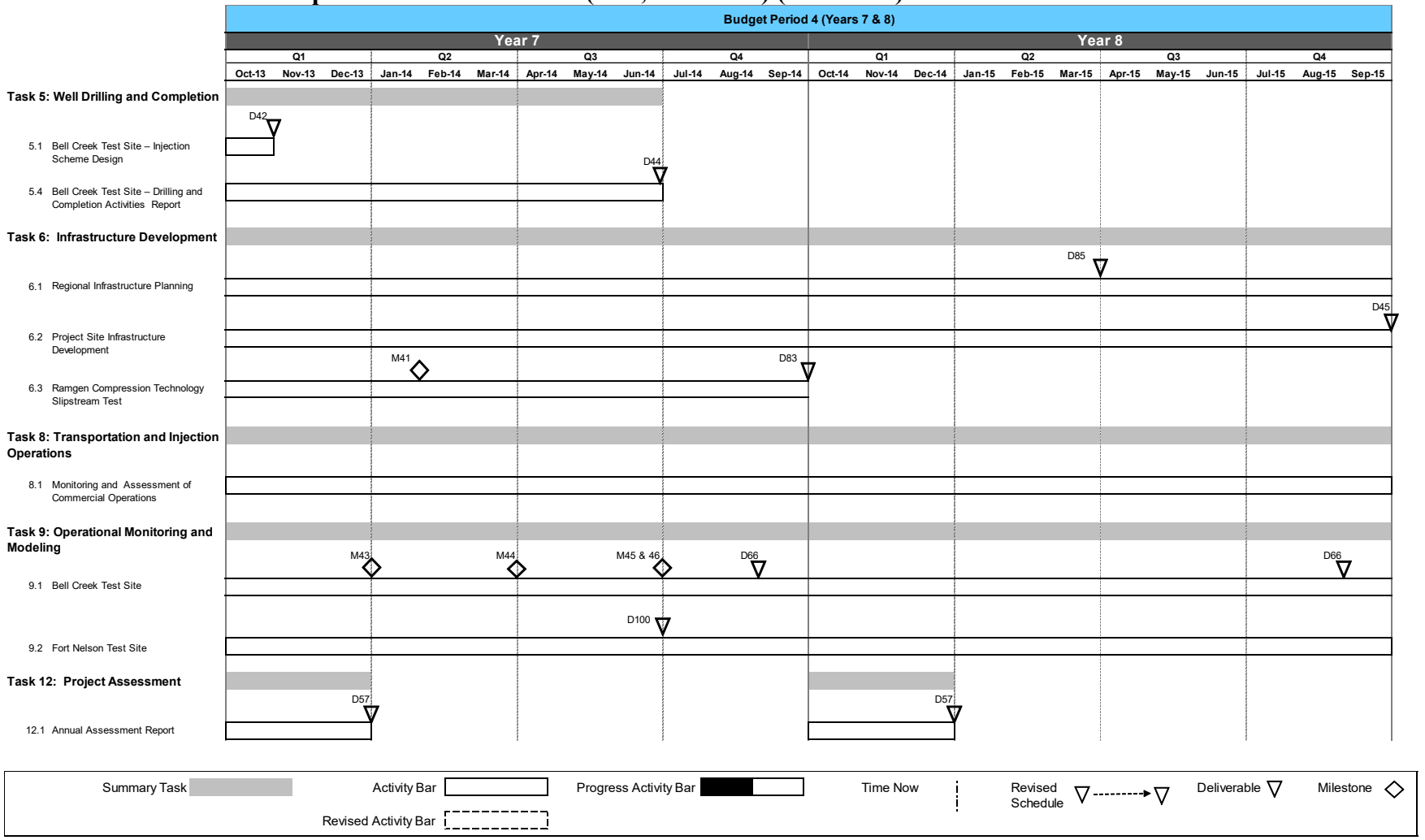


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Table13. PCOR Partnership Phase III Gantt Chart (BP4, PY7–PY8) (continued)

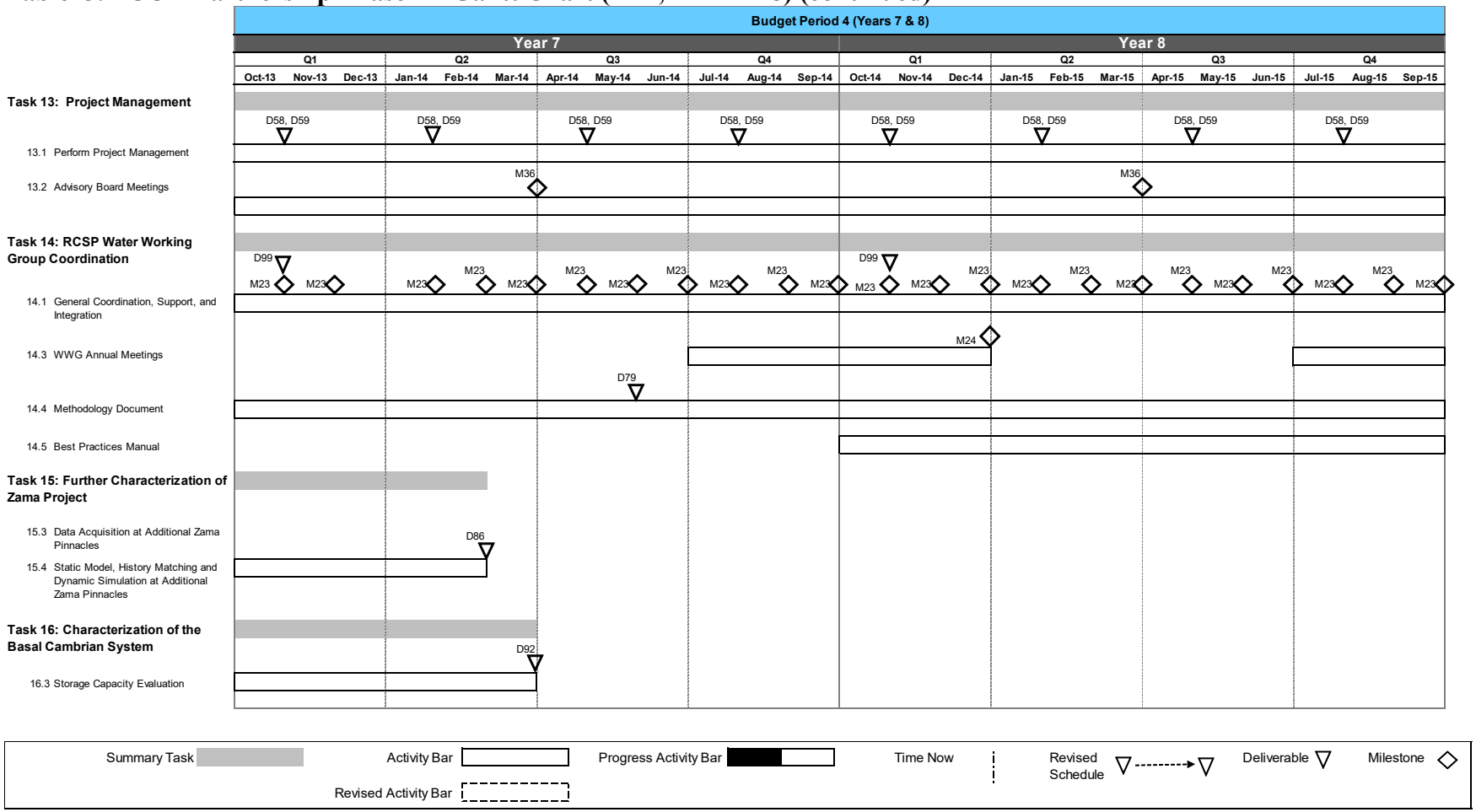

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Table 13. PCOR Partnership Phase III Gantt Chart (BP4, PY7–PY8) (continued)

Key for Deliverables ▼				Key for Milestones ◆	
D1	Review of Source Attributes	D57	Project Assessment Annual Report	M23	Monthly WWG Conference Call Held
D7	Third Target Area Completed	D59	Milestone Quarterly Report	M24	WWG Annual Meeting Held
D8	Permitting Review – Update 2	D66	BC Test Site – Simulation Report	M36	Annual Advisory Board Meeting Scheduled
D13	Public Site Updates	D79	Report – Water Resource Estimation Methodology	M41	Decision to Incorporate Ramgen Compression Technology into BC Project
D17	General Phase III Information PowerPoint Presentation	D81	Regional Carbon Sequestration Atlas		
D22	Domestic Energy and Carbon 30-Minute Documentary	D83	Report – Integration of Advanced Compression Technology With CO_2 Storage	M43	BC Test Site – First Full-Repeat Sampling of the Groundwater- and Soil Gas- Monitoring Program Completed
D24	PCOR Partnership Region CO_2 Storage General Poster	D85	Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities	M44	BC Test Site – First 3-D VSP Repeat Surveys Completed
D25	BC Test Site Poster (Update)			M45	BC Test Site – First Full-Repeat of Pulsed-Neutron Logging Campaign Completed
D32	BC Test Site – Geomechanical Report	D86	Updated Regional Technology Implementation Plan for Zama	M46	BC Test Site – 1 Year of Injection Completed
D35	BC Test Site – Best Practices Manual – Site Characterization	D92	Report – Storage Capacity and Regional Implications for Large-Scale Storage in the Basal Cambrian System		
D36	BC Test Site – Wellbore Leakage Final Report				
D42	BC Test Site – Injection Experimental Design Package	D93	Report – Geological Modeling and Simulation for the Aquistore Project		
D44	BC Test Site – Drilling and Completion Activities Report	D96	BC Test Site – 3-D Seismic Acquisition and Characterization Report		
D45	Report – Infrastructure Development	D99	Nexus of Water and CCS Fact Sheet		
D58	Quarterly Progress Report	D100	FN Test Site – Best Practices Manual– Feasibility Study		

PROJECT RECOGNITION/TRAVEL

Project Recognition

John Harju continued to serve on DOE's Unconventional Resources Technology Advisory Committee (URTAC), which provides advice to the U.S. Secretary of Energy on the development and implementation of activities related to unconventional natural gas and other petroleum resources.

The documentary "Global Energy and Carbon: Tracking Our Footprint," coproduced by PPB and the PCOR Partnership with support from DOE received a 2012 Platinum Best of Show Aurora Award—the highest honor awarded—in the nature/ environment documentary category.

Travel

Representatives from the PCOR Partnership attended and/or participated in the following 75 meetings/conferences, nine training opportunities, and 53 project management site trips in this reporting period:

- October 1–3, 2012: Participated in project meetings with service providers and Denbury in Plano, Texas.
- October 2, 2012: Participated in an MVA Knowledge-Sharing Workshop hosted by Denbury in Plano, Texas.
- October 2–5, 2012: Traveled to the Montana Board of Oil and Gas Conservation to collect well data in Billings, Montana.
- October 3–5, 2012: Hosted the IOGCC CGS Task Force meeting in Denver, Colorado.
- October 3–5, 2012: Hosted an exhibit booth at the 2012 SDLA Annual Meeting in Huron, South Dakota.
- October 6, 2012: Participated in a meeting regarding upcoming teacher training institutes at PPB offices in Fargo, North Dakota.
- October 6–8, 2012: Traveled to the Bell Creek oil field to download information from the PDM system located on the 0506OW monitoring well in southeastern, Montana.
- October 7–12, 2012: Remotely located staff traveled to the EERC for work plan discussions in Grand Forks, North Dakota.
- October 7–13, 2012: Modeling staff participated in Schlumberger software training entitled "Techlog Formation Evaluation Course" in Houston, Texas.
- October 8–11, 2012: Participated in focus group sessions with the OWG lead in Washington, D.C.
- October 15–19, 2012: Installed soil gas-profiling stations in the Bell Creek Field.
- October 16–19, 2012: Hosted an exhibit booth at the MPLA/NLA/NSLA 2012 Tri-Conference in LaVista, Nebraska.
- October 18, 2012: Visited the Lignite (Phase II) site near Kenmare, North Dakota.
- October 21–25, 2012: Modeling staff participated in Schlumberger software training entitled "Petrel Property Modeling" in Houston, Texas.
- October 24, 2012: Participated in a meeting regarding educational materials with PPB at its offices in Fargo, North Dakota.

- October 28 – November 2, 2012: Presented at the 2012 AIChE Annual Meeting in Pittsburgh, Pennsylvania.
- October 28 – November 3, 2012: Modeling staff participated in Schlumberger software training entitled "Techlog Formation Evaluation Course" in Houston, Texas.
- October 29–30, 2012: Attended the Midwest Regional Carbon Sequestration Partnership (MRCSP) Partners Meeting in Independence, Ohio.
- October 29 – November 2, 2012: Participated in and presented at the IOGCC 2012 Annual Meeting in San Antonio, Texas.
- October 30 – November 2, 2012: Traveled to the Montana Board of Oil and Gas Conservation to collect well data in Billings, Montana.
- November 1, 2012: Traveled to the Lignite Field site to inspect the site in Kenmare, North Dakota.
- November 1–13, 2012: Traveled to the Bell Creek oil field for site work near Gillette, Wyoming.
- November 4–9, 2012: Attended the SPE Novel Techniques for Reservoir Modeling Forum in Santa Fe, New Mexico.
- November 5–6, 2012: Traveled to the Bell Creek oil field to collect data near Miles City, Montana.
- November 5–7, 2012: Participated in meetings with PTRC in Calgary, Alberta.
- November 6–7, 2012: Traveled to the Bell Creek oil field for a site visit near Gillette, Wyoming.
- November 8–9, 2012: Traveled for a hotel site visit for a future PCOR Partnership annual meeting in Minneapolis, Minnesota.
- November 14–24, 2012: Attended and presented at GHGT-11 in Kyoto, Japan.
- November 15, 2012: Traveled to the Lignite Field site in Kenmare, North Dakota, to inspect the site.
- November 29, 2012: Traveled to the Lignite Field site in Kenmare, North Dakota, to inspect the site.
- December 2–7, 2012: Attended the CO_2 Conference Week activities in Midland, Texas.
- December 3–4, 2012: Participated in an reservoir saturation tool (RST) log review meeting at Denbury headquarters in Plano, Texas.
- December 3–6, 2012: Attended the National Groundwater Expo and Annual Meeting in Las Vegas, Nevada.
- December 9–22, 2012: Traveled to the Bell Creek oil field for site activities in southeastern Montana.
- December 10–11, 2012: Presented at the Electric Power Research Institute (EPRI) Annual Meeting in Mobile, Alabama.
- December 10–15, 2012: Met with landowners in the Bell Creek oil field and surrounding area.
- December 11, 2012: Participated in a meeting to discuss education materials at PPB headquarters in Fargo, North Dakota.
- December 13 and 27, 2012: Traveled to the Lignite Field validation site near Kenmare, North Dakota, to inspect the site.
- December 17–21, 2012: Participated in Schlumberger NExT Techlog Fundamentals software training in Houston, Texas.

- January 7–18, 2013: Traveled to the Bell Creek oil field for site activities in southeastern Montana.
- January 10 and 24, 2013: Traveled to the Lignite Field Validation Test site near Kenmare, North Dakota, to inspect the site.
- January 16, 2013: Attended a meeting at PPB headquarters in Fargo, North Dakota.
- January 20–25, 2013: Attended the 2013 UIC Conference in Sarasota, Florida.
- January 26 – February 1, 2013: Participated in the 2013 Energy, Utility & Environment Conference (EUEC) in Phoenix, Arizona.
- February 5–9, 2013: Traveled to Gillette, Wyoming, for sampling work near the Bell Creek Field.
- February 7 and 21, 2013: Traveled to the Lignite Field validation site near Kenmare, North Dakota, to inspect the site.
- February 10–18, 2013: Attended Schlumberger NExT software training entitled "Petrel Property Modeling" in Houston, Texas.
- February 16–20, 2013: Attended the SPE 2013 Reservoir Simulation Symposium and premeeting training courses entitled "Fundamentals of Reservoir Simulation" and "Reservoir Simulation for Practical Decision Making" in The Woodlands, Texas.
- February 19–22, 2013: Visited NETL offices in Morgantown, West Virginia, and Pittsburgh, Pennsylvania, to discuss project activities.
- February 19–23, 2013: Participated in a meeting of the Steering Committee of the Basal Aquifer Technical Group in Berkeley, California.
- February 20–23, 2013: Traveled to view proposed geophone installation in the Bell Creek Field.
- February 24 – March 1, 2013: Attended Schlumberger's NExT software training entitled "Techlog Formation Evaluations" in Houston, Texas.
- February 26–28, 2013: Participated in the IOGCC CGS Subgroup meeting in Minneapolis, Minnesota.
- February 27, 2013: Traveled to PPB headquarters to discuss educational materials in Fargo, North Dakota.
- February 27 – March 1, 2013: Presented at the Rice 2013 Oil & Gas High-Performance Computing (HPC) Workshop in Houston, Texas.
- March 2–10, 2013: Provided technical advice during 56-14R core collection in the Bell Creek Field.
- March 4–7, 2013: Hosted the 2nd annual TAB meeting in Orlando, Florida.
- March 7 and 21, 2013: Traveled to the Lignite Field validation site near Kenmare, North Dakota, to inspect the site.
- March 11–12, 2013: Participated in a logging review meeting with Denbury and Schlumberger in Denver, Colorado.
- March 11–13, 2013: Presented at the Southeast Regional Carbon Sequestration Partnership (SECARB) 8th Annual Stakeholders' Briefing in Atlanta, Georgia.
- March 15–22, 2013: Provided technical advice during 33-14R core collection in the Bell Creek Field.
- March 18–22, 2013: Traveled to the Bell Creek Field for sampling activities.
- March 20, 2013: Filmed preliminary version of the education presentation at PPB in Fargo, North Dakota.

- March 20–23, 2013: Presented at the CanGEA 2013 Geothermal Conference in Calgary, Alberta, Canada.
- March 22–29, 2013: Presented at the 6th International Petroleum Technology Conference (IPTC) in Beijing, China.
- April 1–5, 2013: Traveled to the Bell Creek Field for sampling work.
- April 2–12, 2013: Traveled to the Bell Creek Field for geophone installation.
- April 4, 2013: Traveled to inspect Lignite site reclamation near Kenmare, North Dakota.
- April 4–11, 2013: Traveled to the Bell Creek Field for project work.
- April 10–13, 2013: Attended Schlumberger NExT software training entitled "Petrel Workflow Editor and Uncertainty Analysis" in Houston, Texas.
- April 10–14, 2013: Traveled to the Bell Creek Field for project work.
- April 13–20, 2013: Presented at the CSLF meetings in Rome, Italy.
- April 14–18, 2013: Attended Schlumberger OFM software training entitled "OFM Using Oil and Waterflood Examples" and "OFM Forecast Analysis & Mapping Applications Fundamentals Combined Course" in Denver, Colorado.
- April 21 – May 1, 2013: Traveled to the Bell Creek Field for site sampling.
- April 22–25, 2013: Presented at the U.S.–Canada Clean Energy Dialogue II meeting in Champaign, Illinois.
- April 29 – May 3, 2013: Attended the Williston Basin Petroleum Conference (WBPC) in Regina, Saskatchewan, Canada.
- April 30, 2013: Met with PPB at its offices in Fargo, North Dakota.
- April 30 – May 3, 2013: Supervised core sampling at TerraTek Labs in Calgary, Alberta, Canada.
- May 7, 2013: Met with PPB at its offices in Fargo, North Dakota.
- May 7–8, 2013: Participated in meetings with Denbury in Plano, Texas.
- May 7–9, 2013: Participated in the IOGCC subgroup meeting in Minneapolis, Minnesota.
- May 8–10, 2013: Traveled to the Bell Creek Field for site work.
- May 13–19, 2013: Attended and participated in CCUS-12 in Pittsburgh, Pennsylvania.
- May 15–18, 2013: Traveled to the Bell Creek Field for site sampling.
- May 18, 2013: Attended American Association of Petroleum Geologists (AAPG) short courses entitled "Quality Control for Subsurface Maps," and "Sequence Stratigraphy Analysis of Shales: Key to Paleoclimate Archive, Subsurface Fluid Flow and Hydrocarbon Source" in Pittsburgh, Pennsylvania.
- May 18–22, 2013: Attended the IOGCC Midyear Issues Summit in Point Clear, Alabama.
- May 19–22, 2013: Presented at the AAPG Convention and Exhibition in Pittsburgh, Pennsylvania.
- May 19–23, 2013: Traveled to the Bell Creek Field for site work.
- May 28–30, 2013: Traveled to the Bell Creek Field to observe pump installation and to meet with area landowners.
- May 28–31, 2013: Traveled to the Bell Creek Field for sampling and site work.
- June 2–7, 2013: Participated in TOUGH2-EGS and TOUGH2-CSM workshops at the Colorado School of Mines in Golden, Colorado.

- June 8–14, 2013: Participated in the IEAGHG Combined Modelling and Risk Management Network Meeting in Trondheim, Norway.
- June 10–12, 2013: Presented at the Introduction to CO_2 EOR Workshop in Houston, Texas.
- June 10–14, 2013: Visited the Muddy Outcrop and area landowners near Hulett, Wyoming.
- June 11–14, 2013: Performed maintenance on equipment installed at the Bell Creek site.
- June 17–18, 2013: Presented at the 2013 Lignite Education Seminar: Energy, Economics, and Environment in Bismarck, North Dakota.
- June 18–21, 2013: Hosted and presented at the IOGCC CGS Task Force meeting held in Denver, Colorado.
- June 19, 2013: Traveled to inspect Lignite site reclamation near Kenmare, North Dakota.
- June 20–27, 2013: Attended the American Rock Mechanics Association (ARMA) 47th U.S. Rock Mechanics/Geomechanics Symposium, as well as the 3rd Geomechanics Solutions for Environmental and Technical Challenges in Unconventional Resources Workshop and the 2nd Workshop on Petroleum Geomechanics Testing in San Francisco, California.
- June 24–27, 2013: Conducted sampling work at the Bell Creek Field near Gillette, Wyoming.
- June 25–26, 2013: Gave a presentation entitled "Integrating Regional History, Culture, Science and the Arts" at the PPB Teacher Training Institute in Moorhead, Minnesota.
- June 25–27, 2013: Attended a meeting with Denbury personnel at the Bell Creek Field near Hulett, Wyoming.
- June 25–28, 2013: Met with area landowners and observed well pump installation at the Bell Creek Field near Gillette, Wyoming.
- July 1–3, 2013: Toured the Hastings oil field and met with Denbury personnel near Pearland, Texas.
- July 7–11, 2013: Participated in the 2013 CO_2 Capture Technology Meeting in Pittsburgh, Pennsylvania.
- July 9–12, 2013: Attended the 7th Annual Wyoming CO_2 Conference in Casper, Wyoming.
- July 9–12, 2013: Participated in the Aquistore Risk Assessment Workshop and SERC meeting in Regina, Saskatchewan, Canada.
- July 16, 2013: Attended the WBI Energy Customer Meeting in Bismarck, North Dakota.
- July 23, 2013: Inspected the Phase II Lignite Field Validation Test site near Kenmare, North Dakota.
- July 29 – August 1, 2013: Performed oil and gas sampling at the Bell Creek oil field in southeastern Montana.
- July 30–31, 2013: Hosted and participated in the 5th Annual PCOR Partnership Regulatory Meeting in Deadwood, South Dakota.
- July 31 – August 1, 2013: Toured the Bell Creek oil field in southeastern Montana.

- August 6–8, 2013: Traveled to the Bell Creek oil field in southeastern Montana for site maintenance.
- August 6–8, 2013: Downloaded monitoring data at the Bell Creek site in southeastern Montana.
- August 8, 2013: Attended the SPE Williston Basin Section open meeting in Minot, North Dakota.
- August 9, 2013: Reviewed education video Parts 1 and 2 at PPB offices in Fargo, North Dakota.
- August 10–16, 2013: Hosted an outcrop field trip for Denbury personnel near Hulett, Wyoming.
- August 14, 2013: Traveled to PPB offices for project discussions in Fargo, North Dakota.
- August 16, 2013: Attended the Bell Creek CO_2 EOR Project Commissioning Event (Ribbon Cutting) at the Bell Creek site in southeastern Montana.
- August 19, 2013: Participated in the WWG Open House in Pittsburgh, Pennsylvania.
- August 19, 2013: Hosted and participated in the WWG Annual Meeting in Pittsburgh, Pennsylvania.
- August 20–23, 2013: Presented at and participated in the Carbon Storage Project R&D Project Review Meeting in Pittsburgh, Pennsylvania.
- August 23 – September 1, 2013: Presented at the IEAGHG Combined Monitoring and Environmental Research Network meeting in Canberra, Australia.
- August 25–28, 2013: Observed the repeat logging activities at the Bell Creek oil field in southeastern Montana.
- August 26–29, 2013: Performed sampling activities at the Bell Creek oil field in southeastern Montana.
- September 9–14, 2013: Met with landowners in or near the Bell Creek oil field in southeastern Montana.
- September 10–12, 2013: Attended the North Dakota GIS Users Conference in Grand Forks, North Dakota.
- September 10–12, 2013: Attended a meeting with partner, Suncor, in Calgary, Alberta, Canada.
- September 16–18, 2013: Attended and distributed PCOR Partnership outreach materials at the NDPC Annual Meeting in Grand Forks, North Dakota.
- September 22–25, 2013: Attended the Groundwater Protection Council Annual Meeting in St. Louis, Missouri.
- September 23–25, 2013: Attended the 58th Annual Midwest Groundwater Conference in Bismarck, North Dakota.
- September 23–26, 2013: Hosted and presented at the 2013 PCOR Partnership Annual Membership Meeting in Minneapolis, Minnesota.
- September 24, 2013: Inspected the Phase II Lignite Field Validation Test site near Kenmare, North Dakota.
- September 24, 2013: Hosted and participated in the Bell Creek Baseline PNL Review Meeting in Minneapolis, Minnesota.
- September 24, 2013: Hosted and participated in the PCOR Partnership TAB Meeting in Minneapolis, Minnesota.

- September 27 – October 3, 2013: Attended the SPE Annual Technical Conference and Exhibition (ATCE) and short course in New Orleans, Louisiana.
- September 29 – October 6, 2013: Performed sampling at the Bell Creek site.
- September 30 – October 6, 2013: Met with landowners in and near the Bell Creek oil field.

Materials presented at these meetings are available to partners on the PCOR Partnership DSS Web site (www2.undeerc.org/website/pcorp/ProductsDB/Default.aspx).

PHASE III PRODUCTS/PUBLICATIONS

During PY6, the PCOR Partnership submitted 18 abstracts, all but one of which was accepted; the author declined three and one is currently in review. The PCOR Partnership had nine journal articles published (in two separate journals), gave 76 presentations (oral and poster combined). In addition, it completed 21 deliverable reports (ten of which were finalized), ten milestone reports (seven of which were finalized), one value-added product, and 16 progress reports (monthlies, quarterlies, and annual combined), and prepared several conference call and meeting minutes.

Abstracts

Submitted (1)

Bosshart, N.W., Braunberger, J.D., Gorecki, C.D., and Steadman, E.N., 2013, Using multiple-point statistics in the modeling of a Winnipegosis Formation pinnacle reef for enhanced oil recovery and CO_2 storage applications [abs.]: American Association of Petroleum Geologists Annual Convention and Exhibition 2014, Houston, Texas, April 6–9, 2014.

Submitted, Accepted, and Declined by Author (3)

Ostadhassan, M., Braunberger, J.R., Hamling, J.A., and Gorecki, C.D., 2012, Post-stack processing and seismic inversion of 2-D line Bell Creek Field, Powder River Basin, Montana [abs.]: 2013 AAPG Annual Convention & Exhibition, Pittsburgh, Pennsylvania, May 19–22, 2013.

Saini, D., Gorecki, C.D., Hamling, J.A., Bailey, T.P., and Sorensen, J.A., 2012, Mechanism of subnormal pressure generation in the Bell Creek oil field and the implications to CO_2 storage [abs.]: International Petroleum Technology Conference, Beijing, China, March 26–28, 2013.

Schlasner, S.M., Jensen, M.D., and Steadman, E.N., 2013, Assessing temporary storage options to attenuate variable-rate CO_2 emissions for use during enhanced oil recovery [abs.]: Carbon Management Technology Conference, Alexandria, Virginia, October 21–23, 2013.

Submitted and Accepted for Presentation (6)

Braunberger, J.R., Peck, W.D., Bailey, T.P., Bremer, J.M., Huffman, B.W., and Gorecki, C.D., 2012, Subsurface core and analogous outcrop characterization of the Muddy/Newcastle Formation for the Bell Creek oil field, Powder River County, Montana [abs.]: 2013 AAPG Annual Convention & Exhibition, Pittsburgh, Pennsylvania, May 19–22, 2013.

Burnison, S.A., Ditty, P., Gorecki, C.D., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2013, Integrated geophysical monitoring program to study flood performance and incidental CO_2 storage associated with a CO_2 EOR project in the Bell Creek Oil Field [abs.]: American Geophysical Union Fall Meeting, San Francisco, California, December 9–13, 2013.

Dotzenrod, N.W., Braunberger, J.R., and Gorecki, C.D., 2013, Geospatial workflow optimization using ModelBuilder for visualizing subsurface CO_2 plume footprint predictions derived from

numerical simulation cases [abs.]: North Dakota GIS Users Conference, Grand Forks, North Dakota, September 10–12, 2013.

Liu, G., Gorecki, C.D., Braunberger, J.R., Bailey, T.P., and Landsverk, K.R., 2012, Integrated reservoir modeling and simulation optimization workflow based on a high-performance parallel computing cluster [abs.]: 2013 Rice Oil & Gas HPC Workshop, Houston, Texas, February 28, 2013.

Ostadhassan, M., Braunberger, J.R., Ge, J., Hamling, J.A., and Gorecki, C.D., 2012, Geomechanical modeling and in situ stresses around the wellbore, Bell Creek Field, Powder River Basin, Montana [abs.]: 47th US Rock Mechanics Geomechanics Symposium, San Francisco, California, June 23–26, 2013.

Ostadhassan, M., Braunberger, J.R., Hamling, J.A., and Gorecki, C.D., 2012, Post-stack processing and seismic inversion of 2-D line Bell Creek Field, Powder River Basin, Montana [abs.]: 2013 AAPG Annual Convention & Exhibition, Pittsburgh, Pennsylvania, May 19–22, 2013.

Submitted and Accepted for Poster (7)

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., and Steadman, E.N., 2013, PCOR Partnership outreach—a decade of achievement [abs.]: Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Gao, P., Gorecki, C.D., Braunberger, J.R., Shah, J., Klenner, R.C.L., Steadman, E.N., and Harju, J.A., 2013, Acid gas injection for enhanced oil recovery and long-term storage in Zama pinnacle reefs [abs.]: Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Gorecki, C.D., Steadman, E.N., Harju, J.A., Hamling, J.A., and Ayash, S.C., 2013, CO_2 enhanced oil recovery (EOR)—the Plains CO_2 Reduction Partnership's approach to carbon capture and storage [abs.]: International Petroleum Technology Conference, Doha, Qatar, January 20–22, 2014.

Hamling, J.A., 2013, Baseline MVA at the Bell Creek combined CO_2 enhanced oil recovery and CO_2 storage project [abs.]: IEAGHG Combined Monitoring and Environmental Research Network Meeting, Canberra, Australia, August 27–30, 2013.

Klapperich, R.J., Gorecki, C.D., Steadman, E.N., Harju, J.A., McNemar, A.N., and Nakles, D.V., 2013, Regional Carbon Sequestration Partnership Water Working Group [abs.]: Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Liu, G., Peck, W.D., Braunberger, J.R., Klenner, R.C.L., Gorecki, C.D., and Steadman, E.N., 2013, Large-scale CO_2 storage exploration in a basal saline system in Canada and the United States [abs.]: Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Watson, K., Cumming, L., Daly, D.J., and Wade, S., 2013, Message mapping – field testing message to enhance CCS communications: Draft abstract for the 12th Annual Conference on Carbon Capture Utilization & Sequestration, Pittsburgh, Pennsylvania, May 13–16, 2013.

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Hamling, J.A., and Gorecki, C.D., 2013, Characterization and time-lapse monitoring of a combined CO_2 EOR and CO_2 storage project at the Bell Creek oil field utilizing pulsed neutron well logging [abs.]: Carbon Management Technology Conference, Alexandria, Virginia, October 21–23, 2013.

Klapperich, R.J., Gorecki, C.D., Sorensen, J.A., Steadman, E.N., Harju, J.A., McNemar, A.T., and Nakles, D.V., 2013, Regional Carbon Sequestration Partnership Water Working Group white paper on the nexus of water and carbon capture and storage [abs.]: Carbon Management Technology Conference, Alexandria, Virginia, October 21–23, 2013.

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Steadman, E.N., Harju, J.A., Gorecki, C.D., Botnen, L.S., Daly, D.J., Jensen, M.D., Peck, W.D., Sorensen, J.A., Smith, S.A., Hamling, J.A., Klapperich, R.J., and Anagnost, K.K., 2012, The Plains CO_2 Reduction (PCOR) Partnership—a Regional Carbon Sequestration Partnership in the interior plains of North America [abs.]: EUEC 2013: Energy, Utility & Environment Conference, Phoenix, Arizona, January 28–30, 2013.

Accepted for Poster Presentation (1)

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Botnen, L.S., Daly, D.J., Hamling, J.A., Sorensen, J.A., Peck, W.P., Saini, D., Kurz, B.A., Ayash, S.C., Steadman, E.N., Harju, J.A., Nakles, D., and Jackson, B., 2012, PCOR Partnership Technical Advisory Board meeting: Confidential presentation for the PCOR Partnership Technical Advisory Board meeting, Orlando, Florida, March 5–6, 2013.

Braunberger, J.R., 2012, A geospatial overview in the PCOR Partnership: Lecture for Introduction to GIS presented at North Dakota State University, Fargo, North Dakota, December 7, 2012.

Burnison, S.A., and Peck, W.D., 2012, CO_2 EOR opportunities on the Cedar Creek Anticline: Presented to Denbury Resources personnel, Grand Forks, North Dakota, November 13, 2012.

Burnison, S.A., Peck, W.D., and Doll, T.E., 2013, Cedar Creek Anticline: Presented to Denbury Resources Inc. personnel, Plano, Texas, May 8, 2013.

Daly, D.J., 2013, Energy and carbon—the big picture: Presented at the Integrating Regional History, Culture, Science, and the Arts Prairie Public Broadcasting Teacher Training Institute, Moorhead, Minnesota, June 25–26, 2013.

Daly, D.J., 2013, Energy and CO_2 management—carbon capture and storage: Presented at the 2013 Lignite Education Seminar: Energy, Economics & Environment, Bismarck, North Dakota, June 17–20, 2013.

Daly, D.J. Managing CO_2—carbon capture and storage: Presented at the Prairie Public Broadcasting Master Teacher Meeting, Fargo, North Dakota, October 6, 2012.

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Dotzenrod, N.W., Braunberger, J.R., and Gorecki, C.D., 2013, Geospatial workflow optimization using ModelBuilder for visualizing subsurface CO_2 plume footprint predictions derived from numerical simulation cases: Presented at the North Dakota GIS Users Conference, Grand Forks, North Dakota, September 10–12, 2013.

Gorecki, C.D., 2013, Overview of the PCOR Partnership Program: Presented at the Plains CO_2 Reduction (PCOR) Partnership Regulatory Meeting, Deadwood, South Dakota, July 30, 2013.

Gorecki, C.D., 2013, Overview of the PCOR Partnership Program: Presented to Korean CCS R&D Center, Korea Institute of Energy Research, Kyung Hee University, and Korea Research Institute of Chemical Technology personnel, Grand Forks, North Dakota, May 20, 2013.

Gorecki, C.D., 2013, PCOR Partnership Program—accomplishments and path forward: Presented at the PCOR Partnership Annual Membership Meeting, Minneapolis, Minnesota, September 25–26, 2013.

Gorecki, C.D., 2013, PCOR Partnership Technical Advisory Board (TAB) side meeting: Presented at the Plains CO_2 Reduction (PCOR) Partnership Technical Advisory Board (TAB) Meeting, Minneapolis, Minnesota, Sept 24, 2013.

Gorecki, C.D., 2013, PCOR Partnership's approach to MVA for CO_2 EOR projects: Presentation and panel discussion for Onshore Monitoring, Verification, Accounting, and Assessment: Lessons Learned at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Gorecki, C.D., 2013, PCOR Partnership's approach to MVA for CO_2 EOR and storage projects in remote locations: Presented at the Joint U.S.–Norway Workshop on CO_2 Storage Demonstration Projects: The Value of Monitoring Technology, Pittsburgh, Pennsylvania, August 19, 2013.

Gorecki, C.D., 2012, Plains CO_2 Reduction Partnership—CO_2 EOR and MVA update: Presented at the 2012 Joint CoalFleet for Tomorrow & CO_2 Capture and Storage Technical Meeting, Mobile, Alabama, December 11, 2012.

Gorecki, C.D., 2013, Plains CO_2 Reduction (PCOR) Partnership overview: Presented at the Partnership for CO_2 Capture Phase II Project Update Meeting, Grand Forks, North Dakota, March 8, 2013.

Gorecki, C.D., 2012, The Plains CO_2 Reduction (PCOR) Partnership—Bell Creek focus: Presented to Denbury Resources Inc. personnel, Grand Forks, North Dakota, November 13, 2012.

Gorecki, C.D., and Harju, J.A., 2013, PCOR Partnership – partnering with industry: Presented at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Gorecki, C.D., and Liu, G., 2013, Overview of the PCOR Partnership Program and other EERC-led CO_2 storage-related projects: Presented at the Division of Engineering Geology and Water Resources, Institute of Geology and Geophysics, Beijing, China, March 27, 2013.

Gorecki, C.D., and Hamling, J.A. EERC–Bell Creek MVA overview: Presented at the MVA Knowledge Sharing Workshop, Plano, Texas, October 2, 2012.

Hamling, J.A., 2012, Overview of the Bell Creek combined CO_2 storage and CO_2 enhanced oil recovery project: Presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Hamling, J.A., and Gorecki, C.D., 2013, Bell Creek Project update meeting: Presented at the Bell Creek Project Update Meeting, Plano, Texas, May 7–8, 2013.

Harju, J.A., and Botnen, L.S. 2012, IOGCC carbon storage task force operation and postoperational liability: Presented at the Interstate Oil and Gas Compact Commission (IOGCC) Annual Meeting, Council of State Oil and Gas Attorneys, San Antonio, Texas, October 30, 2012.

Harju, J.A., and Steadman, E.N., 2013, The Plains CO_2 Reduction (PCOR) Partnership: Presented to Statoil personnel, Houston, Texas, March 7, 2013.

Harju, J.A., and Steadman, E.N., 2013, The Plains CO_2 Reduction (PCOR) Partnership: Presented to U.S. Department of Energy National Energy Technology Laboratory personnel, Morgantown, West Virginia, February 20–21, 2013.

Jensen, M.D., Heebink, L.V., Pei, P., and Snyder, A.C., 2012, A phased approach to developing a hypothetical pipeline network for CO_2 transport during CCUS: Presented at the 2012 AIChE Annual Meeting, Pittsburgh, Pennsylvania, October 28 – November 2, 2012.

Klapperich, R.J., 2013, RCSP Water Working Group meeting: Presented at the Regional Carbon Sequestration Partnership Water Working Group annual meeting, Pittsburgh, Pennsylvania, August 19, 2013.

Klenner, R.C.L., and Peck, W.D., 2013, North American CO_2 storage atlas—a comparable model: Presented at the CanGEA 2013 Geothermal Conference, Calgary, Alberta, March 20–22, 2013.

Liu, G., Gorecki, C.D., Braunberger, J.R., Bailey, T.P., and Landsverk, K.R., 2013, Integrated reservoir modeling and simulation optimization workflow based on a high-performance parallel computing cluster: Presented at the 2013 Rice Oil & Gas HPC Workshop, Houston, Texas, February 28, 2013.

Peck, W.D., 2013, Basal Cambrian project update: Presented via WebEx to the PCOR Partnership Technical Advisory Board, Grand Forks, ND, August 23, 2013.

Peck, W.D., 2013, The Plains CO_2 Reduction (PCOR) Partnership—a Regional Carbon Sequestration Partnership in the interior plains of North America: Presented at EUEC 2013: Energy, Utility & Environment Conference, Phoenix, Arizona, January 28–30, 2013.

Peck, W.D., and Braunberger, J.R., 2013, Basal Cambrian project update meeting: Presented at the Basal Cambrian Project Meeting, Berkeley, California, February 21, 2013.

Saini, D., 2013, An update on completed static and dynamic modeling work (F Pool) and further characterization of Zama CO_2 EOR and storage project: Presented to Apache Canada personnel, Grand Forks, North Dakota, January 24–25, 2013.

Smith, S.A., 2013, The EERC and Zama past, present, and future: Presented to Apache Canada personnel, Grand Forks, North Dakota, January 24–25, 2013.

Sorensen, J.A., Peck, W.D., Smith, S.A., Gorecki, C.D., and Steadman, E.N., 2013, The role of the Plains CO_2 Reduction (PCOR) Partnership in the Aquistore Project: Presented at the Aquistore Annual Sponsors' Meeting, Regina, Saskatchewan, July 12, 2013.

Steadman, E.N., 2013, Lessons learned through RCSP activities – Plains CO_2 Reduction (PCOR) Partnership: Presented at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Steadman, E.N., 2013, The PCOR Partnership: Presented at the U.S.–Canada Bilateral National Conference, Champaign, Illinois, April 23, 2013.

Steadman, E.N., 2013, The Plains CO_2 Reduction (PCOR) Partnership: Presented at the 8th Annual Southeast Regional Carbon Sequestration Partnership (SECARB) Stakeholders' Briefing, Atlanta, Georgia, March 12, 2013.

Steadman, E.N., 2013, The Plains CO_2 Reduction (PCOR) Partnership: Presented to Konkuk University (Seoul, Korea) personnel, Grand Forks, North Dakota, March 1, 2013.

Steadman, E.N., Harju, J.A., and Gorecki, C.D., 2013, Bell Creek MVA overview: Presented at the Carbon Sequestration Leadership Forum CO_2 Monitoring Interactive Workshop, Rome, Italy, April 16–19, 2013.

Stepan, D.J., and Klapperich, R.J., 2012, Baseline monitoring, verification, and accounting (MVA) activities: Draft version presented via WebEx to Denbury Resources, Inc., personnel, Grand Forks, North Dakota, November 28, 2012.

Stepan, D.J., and Klapperich, R.J., 2013, Baseline monitoring, verification, and accounting (MVA) activities: Presented via WebEx to the PCOR Partnership Technical Advisory Board, Grand Forks, ND, January 3, 2013.

Poster Presentations, many of these posters were presented at more than 1 event (31)

Braunberger, J.R., Peck, W.D., Bailey, T.P., Bremer, J.M., Huffman, B.W., and Gorecki, C.D., 2013, Subsurface core and analogous outcrop characterization of the Muddy/Newcastle Formation for the Bell Creek oil field, Powder River County, Montana: Poster presented at the 2013 AAPG Annual Convention & Exhibition, Pittsburgh, Pennsylvania, May 19–22, 2013.

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, PCOR Partnership outreach—a decade of achievement: Poster presented at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Gao, P., Gorecki, C.D., Braunberger, J.R., Shah, J., Klenner, R.C.L., Steadman, E.N., and Harju, J.A., 2013, Acid gas injection for enhanced oil recovery and long-term storage in Zama pinnacle reefs: Poster presented at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Gorecki, C.D., 2013, The Plains CO_2 Reduction (PCOR) Partnership—CO_2 sequestration demonstration projects adding value to the oil and gas industry: ePoster presented at the International Petroleum Technology Conference, Beijing, China, March 26–28, 2013, No. IPTC-17089-MS.

Gorecki, C.D., Liu, G., Bailey, T.P., Sorensen, J.A., Klapperich, R.J., Braunberger, J.R., Steadman, E.N., and Harju, J.A., 2012, The role of static and dynamic modeling in the Fort Nelson CCS Project: Poster presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Grove, M.M., 2013, Bell Creek CO_2 Enhanced Oil Recovery Project: Poster presented at the Bell Creek CO_2 Enhanced Oil Recovery Project Commissioning Event, Bell Creek, Montana, August 16, 2013.

Hamling, J.A., 2013, Baseline MVA at the Bell Creek CO_2 enhanced oil recovery project: Poster presented at the IEAGHG Combined Monitoring and Environmental Research Network Meeting, Canberra, Australia, August 27–30, 2013.

Jensen, M.D., Pei, P., Snyder, A.C., Heebink, L.V., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2012, A phased approach to building a hypothetical pipeline network for CO_2 transport during CCUS: Poster presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Klapperich, R.J., Gorecki, C.D., Steadman, E.N., Harju, J.A., McNemar, A.T., and Nakles, D.V., 2013, Regional Carbon Sequestration Partnership Water Working Group: Poster presented at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Liu, G., Peck, W.D., Braunberger, J.R., Klenner, R.C.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Large-scale CO_2 storage exploration in a basal saline system in Canada and the United States: Poster presented at the Carbon Storage R&D Project Review Meeting, Pittsburgh, Pennsylvania, August 20–22, 2013.

Peck, W.D., 2013, Bell Creek unit CO_2 EOR process flow diagram: Poster presented at the Bell Creek CO_2 Enhanced Oil Recovery Project Commissioning Event, Bell Creek, Montana, August 16, 2013.

Peck, W.D., Knudsen, D.J., Bachu, S., Peterson, J., Sorensen, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A. 2012, CO_2 storage resource potential of the Cambro–Ordovician Saline System in the western interior of North America: Poster presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Saini, D., Knudsen, D.J., Sorensen, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2012, A simulation study of simultaneous acid gas EOR and CO_2 storage at Apache's Zama F Pool: Poster presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Sorensen, J.A., Gorecki, C.D., Botnen, L.S., Steadman, E.N., and Harju, J.A., 2012, Overview, status, and future of the Fort Nelson CCS project: Poster presented at the 11th International Conference on Greenhouse Gas Control Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012.

Deliverables/Milestones

Draft (14)

Anagnost, K.K., Harju, J.A., and Steadman, E.N., 2013, Bell Creek test site—carbon dioxide (CO_2) procurement efforts for a large-scale CO_2 storage and CO_2 enhanced oil recovery project: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 7 Deliverable D48 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Bengal, L.E., Bliss, K., and Connors, K., 2013, Guidance for states and provinces on operational and post-operational liability: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 3 Deliverable D98 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Botnen, L.S., Gorecki, C.D., and Steadman, E.N., 2013, Permitting review—update 1: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 3 Deliverable D6 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement

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Botnen, L.S., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, IOGCC Task Force editing subgroup meeting held: Plains CO_2 Reduction (PCOR) Partnership draft Phase III Task 3 Milestone M39 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Botnen, L.S., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, IOGCC Task Force wrap-up meeting held: Plains CO_2 Reduction (PCOR) Partnership draft Phase III Task 3 Milestone M38 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Braunberger, J.R., Pu, H., Gorecki, C.D., Bailey, T.P., Bremer, J.M., Peck, W.D., Gao, P., Ayash, S.C., Liu, S.C., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site—simulation report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D66 executive summary for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Daly, D.J., Crocker, C.R., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Aquistore—demonstrating carbon storage: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 2 Deliverable D95 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Daly, D.J., Crocker, C.R., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, PCOR Partnership Role in the Aquistore Project: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 2 Deliverable D94 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Gao, P., Ayash, S.C., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Further characterization of Zama acid gas EOR, CO_2 storage, and monitoring project completed: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 15 Milestone M40 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Glazewski, K.A., Hamling, J.A., Peck, W.D., Doll, T.E., Laumb, J.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Wellbore evaluation of the basal Cambrian system: Plains CO_2 Reduction (PCOR) Partnership draft Phase III Task 16 Deliverable D90 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Jensen, M.D., Haley, J.D., Peck, W.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Review of source attributes: Plains CO_2 Reduction (PCOR) Partnership draft Phase III Task 1 Deliverable D1 for U.S. Department of Energy National Energy Technology Laboratory

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Kalenze, N.S., Hamling, J.A., Klapperich, R.J., Braunberger, J.R., Burnison, S.A., Glazewski, K.A., Stepan, D.J., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site—site characterization report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 4 Deliverable D64 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Kalenze, N.S., Hamling, J.A., Klapperich, R.J., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site – monitoring experimental design package: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 5 Deliverable D43 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Kurz, B.A., Heebink, L.V., Eylands, K.E., Smith, S.A., Hamling, J.A., Klapperich, R.J., Thompson, J.S., Stepan, D.J., Botnen, B.W., Pu, H., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site—preinjection geochemical report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 4 Deliverable D33 Milestone M12 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

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Ayash, S.C., Gorecki, C.D., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site—geological characterization data collection completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Milestone M14 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-07-07, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Ayash, S.C., Gorecki, C.D., Sorensen, J.A., Steadman, E.N., and Harju, J.A., 2013, Technical Advisory Board meeting scheduled: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 13 Milestone M36 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-07-09, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Botnen, L.S., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Findings and recommendations of the operational and postoperational subgroups presented to the CGS Task Force: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 3 Milestone M42 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-07-04, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Botnen, L.S., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2012, IOGCC Task Force subgroup Meeting 1 held: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 3 Milestone M37 for U.S. Department of Energy National Energy Technology Laboratory

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Botnen, L.S., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, IOGCC Task Force subgroup Meeting 2 held: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 3 Milestone M37 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-07-06, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Crocker, C.R., Daly, D.J., Anagnost, K.K., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2012, Public site updates: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D13 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication No. 2013-EERC-01-05, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Daly, D.J., Crocker, C.R., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, PCOR Partnership – demonstrating CO_2 storage in the northern Great Plains: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D14 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Daly, D.J., Crocker, C.R., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Plains CO_2 Reduction (PCOR) Partnership general audience CO_2 sequestration outreach PowerPoint: Phase III Task 2 Deliverable D17 (update 4) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Gorecki, C.D., Harju, J.A., Steadman, E.N., Romuld, L., Hamling, J.A., Sorensen, J.A., Botnen, L.S., Daly, D.J., Jensen, M.D., Peck, W.D., Smith, S.A., Klapperich, R.J., Anagnost, K.K., and Votava, T.J., 2012, Annual assessment report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 12 Deliverable D57 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-01-16, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Hamling, J.A., Kalenze, N.S., Klapperich, R.J., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek test site—MVA equipment installation and baseline MVA activities completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 5 Milestone M27 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-07-03, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

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