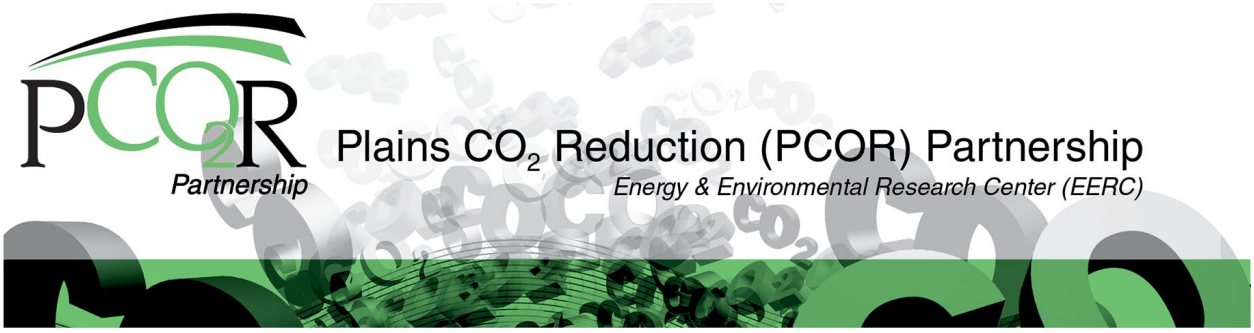

ANNUAL ASSESSMENT REPORT

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

(for the period October 1, 2015, through September 30, 2016)

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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 (DOE) National Energy Technology Laboratory (NETL) in 2003 as part of a national plan to mitigate greenhouse gas emissions. The PCOR Partnership is led and managed by the Energy & Environmental Research Center (EERC) at the University of North Dakota in Grand Forks, North Dakota, and includes over 100 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 development phase (2007–2017), 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, transport, 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 in Program Year (PY) 9 (October 1, 2015 – September 30, 2016) include 1) looking at the feasibility of developing a CO_2 storage program incidental to commercial enhanced oil recovery (EOR) operations at Denbury Resource Inc.'s Bell Creek Field in southeastern Montana, 2) assisting SaskPower and the Petroleum Technology Research Centre (PTRC) with CO_2 storage modeling and monitoring at the Aquistore site, 3) continuing to gather regional characterization data to verify the ability of target formations to store CO_2, 4) facilitating the development of infrastructure to transport CO_2 from sources to injection sites, 5) facilitating sensible development of the rapidly evolving North American regulatory and permitting framework, 6) developing opportunities for PCOR Partnership partners to capture and store CO_2, 7) continuing collaboration with other RCSPs, and 8) providing outreach and education for CO_2 capture and storage stakeholders and the general public. The EERC previously provided monitoring, verification, and accounting (MVA) and risk management support for Spectra Energy's Fort Nelson Carbon Capture and Storage (CCS) Feasibility Project, which would have involved the injection of CO_2 captured from one of the largest gas-processing plants in North America into a saline formation in northeastern British Columbia. While significant progress has been made with respect to project planning, MVA, and risk analysis, the Fort Nelson CCS Feasibility Project is currently lacking a commercial driver to move it forward and, as such, is on indefinite hold. In place of continued efforts at Fort Nelson, scope and budget have been allocated to continuing support of the Aquistore Project.

Significant progress was made in PY9 on the Bell Creek demonstration project. As of March 31, 2016, corresponding to the end of Budget Period 4, an estimated 2.98 million cumulative tonnes of associated CO_2 was recorded. **CO_2 injection continued, and as of September 2016, over 3.31 million cumulative tonnes of associated CO_2 storage was recorded!** Efforts were focused

on continued collection of oil, groundwater, soil gas chemistry data, minimum miscibility pressure evaluations, an enhanced pulsed-neutron logging campaign, interpretation of an expanded baseline and time-lapse 3-D survey, initial processing and analysis of historic InSAR (interferometric synthetic aperture radar) data, life cycle analyses for primary and secondary EOR, and continuing training for and development of models and simulation activities.

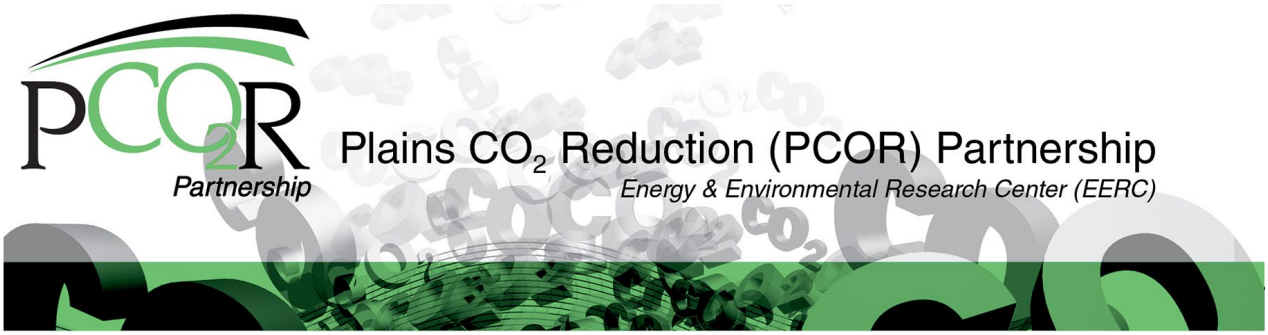
The PCOR Partnership submitted 16 abstracts, published two journal articles, gave 34 presentations, achieved 12 milestones, completed 20 deliverable/milestone reports (21 were finalized), and prepared four value-added products and 16 progress reports. The annual membership meeting was held in Grand Forks, North Dakota, and attracted 125 attendees representing 49 organizations.

The PCOR Partnership is playing an active part in the revision/redevelopment of DOE Carbon Storage Project best practices manuals (BPMs). PCOR Partnership personnel participated in conference calls and Webinars with the working groups tasked with updating each BPM. PCOR Partnership personnel worked on reviewing and commenting on the existing BPMs and preparing revisions. The PCOR Partnership completed the first of five BPMs specific to lessons learned through the PCOR Partnership program (Adaptive Management Approach).

Overall, eleven tasks continued to support program goals in PY9. In addition to the foregoing, regional characterization continued, and nearly 400 significant CO_2 sources (greater than 100,000 metric tons), producing 480 million tonnes annually, were verified within the region. CO_2/brine relative permeability testing on samples from the Williston Basin was completed. Outreach activities included distribution of print materials, oral and poster presentations, Web site updates, and documentary broadcasts. Production of two additional documentaries continued. Since program inception, over 5900 PCOR Partnership atlases have been distributed, along with over 10,000 documentary DVDs. The PCOR Partnership is assisting in understanding the U.S. Environmental Protection Agency's underground injection control rule related to transition of Class II enhanced oil or gas recovery wells to Class VI. The RCSP Water Working Group was active, holding its eighth annual meeting in August 2016, and is leading the effort to create and edit a special issue of the *International Journal of Greenhouse Gas Control* focused on the issues at the nexus of water and CCS. In addition, numerous activities in relation to the PTRC Aquistore project (near Estevan, Saskatchewan) continued, including updating the geologic model and running predictive simulations. A report detailing the development of a cost-effective long-term CO_2 monitoring strategy was completed.

CO_2 injection at Bell Creek will continue in PY10. 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. In PY10, eleven tasks will continue to be implemented (Tasks 5, 7, 8, 15, and 16 are completed).

This report presents an update of Phase III PCOR Partnership activities from October 1, 2015, through September 30, 2016 (PY9) 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 and managed by the Energy & Environmental Research Center (EERC) at the University of North Dakota (UND) in Grand Forks, North Dakota, and includes over 100 stakeholders from the public and private sector in Phase III. The Phase III membership as of September 30, 2016, 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 River Energy	North Dakota Pipeline Authority
UND EERC	Halliburton	Omaha Public Power District
Abengoa Bioenergy New Technologies	Hess Corporation	Otter Tail Power Company
Air Products and Chemicals, Inc.	Huntsman Corporation	Outsource Petrophysics, Inc.
Alberta Department of Energy	Husky Energy Inc.	Oxand Risk & Project Management Solutions
Alberta Department of Environment	Indian Land Tenure Foundation	Peabody Energy
Alberta Innovates – Technology Futures	Interstate Oil and Gas Compact Commission	Petro Harvester Oil & Gas
ALLETE	Iowa Department of Natural Resources	Petroleum Technology Research Centre
Ameren Corporation	Lignite Energy Council	Petroleum Technology Transfer Council
American Coalition for Clean Coal Electricity	Manitoba Geological Survey	Pinnacle, a Halliburton Service
American Lignite Energy	Marathon Oil Company	Prairie Public Broadcasting
Apache Canada Ltd.	MBI Energy Services	Pratt & Whitney Rocketdyne, Inc.
Aquistore	MEG Energy Corporation	Praxair, Inc.
Baker Hughes Incorporated	Melzer Consulting	Ramgen Power Systems, Inc.
Basin Electric Power Cooperative	Minnesota Power	Red Trail Energy, LLC
BillyJack Consulting Inc.	Minnkota Power Cooperative, Inc.	RPS Energy Canada Ltd.
Biorecro AB	Missouri Department of Natural Resources	Saskatchewan Ministry of Industry and Resources
Blue Source, LLC	Missouri River Energy Services	SaskPower
BNI Coal, Ltd.	Montana–Dakota Utilities Co.	Schlumberger
British Columbia Ministry of Energy, Mines, and Petroleum Resources	Montana Department of Environmental Quality	Sejong University
British Columbia Oil and Gas Commission	National Commission on Energy Policy	Shell Canada Limited
C12 Energy, Inc.	Natural Resources Canada	Spectra Energy
The CETER Group, Ltd.	Nebraska Public Power District	Suncor Energy Inc.
Computer Modelling Group Ltd.	North American Coal Corporation	TAQA North, Ltd.
Continental Resources, Inc.	North Dakota Department of Commerce Division of Community Services	TGS Geological Products and Services
Dakota Gasification Company	North Dakota Department of Health	Tundra Oil and Gas
Denbury Resources Inc.	North Dakota Geological Survey	University of Alberta
Eagle Operating, Inc.	North Dakota Industrial Commission Department of Mineral Resources, Oil and Gas Division	University of Regina
Eastern Iowa Community College District	North Dakota Industrial Commission Lignite Research, Development and Marketing Program	WBI Energy, Inc.
Enbridge Inc.	North Dakota Industrial Commission Oil and Gas Research Council	Weatherford Advanced Geotechnology
Encore Acquisition Company	North Dakota Natural Resources Trust	Western Governors' Association
Energy Resources Conservation Board/ Alberta Geological Survey	North Dakota Petroleum Council	Westmoreland Coal Company
Environment Canada		Wisconsin Department of Agriculture, Trade and Consumer Protection
Excelsior Energy Inc.		Wyoming Office of State Lands and Investments
General Electric Global Research Oil & Gas Technology Center		Xcel Energy
Great Northern Project Development, LP		

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 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 – March 31, 2016
BP5: April 1, 2016 – 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) facilitate the establishment of a technical framework to monitor, verify, and account for the storage of CO_2 in geologic formations, so that if carbon credit or other carbon-trading schemes are established in the future this stored CO_2 can be monitored; 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 approximately 1 million metric tons (Mt) of CO_2 per project. Each of the RCSP 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 participated in two large-scale demonstration projects. The sites are 1) the Denbury Onshore LLC (Denbury)-operated 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 (currently inactive) (Figure 1).

In Program Year (PY) 9, CO_2 injection continued at the Bell Creek test site. As of March 31, 2016, corresponding to the end of BP4, 3.034 Mt of total gas (composition of approximately 98% CO_2) had been purchased by Denbury for injection into the Bell Creek Field, equating to an estimated 2.979 Mt of CO_2 stored. By the end of PY9, September 30, 2016, this increased to 3.374 Mt of total gas purchased, with an estimated 3.318 Mt of associated CO_2 stored. Efforts were focused on continued collection of oil, groundwater, soil gas chemistry data, minimum miscibility pressure (MMP) evaluations, an enhanced pulsed-neutron logging (PNL) campaign, interpretation of an expanded baseline and time-lapse 3-D survey, initial processing and analysis of historic InSAR (interferometric synthetic aperture radar) data, life cycle analyses for primary and secondary enhanced oil recovery, and developing models and simulation activities. Over 3 years of near-surface assurance monitoring has now been completed. Ongoing work includes continued PNLs, passive seismic monitoring, casing-conveyed pressure and temperature monitoring, InSAR evaluation, and integration of commercial oil and gas data.

In collaboration with Spectra, the PCOR Partnership is supporting 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 northeastern British Columbia, Canada.

Figure 1. Location of large-scale sites with PCOR Partnership Phase III participation.

The Fort Nelson facility is one of the largest sour gas-processing plants in North America. The PCOR Partnership's monitoring, verification, and accounting (MVA) efforts will help Spectra determine whether deep underground saline reservoirs and associated infrastructure in the Fort Nelson area are appropriate for CCS. Although the Fort Nelson demonstration project was placed on indefinite hold until Spectra can establish a business case for the project, the PCOR Partnership prepared a comprehensive summary of its characterization, modeling and simulation, and risk assessment activities into a best practices manual (BPM), and the information acquired and analyzed suggests that the Fort Nelson area has sink and seal conditions that make it an exceptional candidate location for large-scale CCS.

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 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 Enhanced Oil Recovery (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 PY9 (October 1, 2015 – September 30, 2016) 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 purpose of CO_2 EOR and for the opportunity to study the associated storage of CO_2.

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 PY9. These included eleven required reports, achievement of mandatory milestones, and four quarterly progress reports.

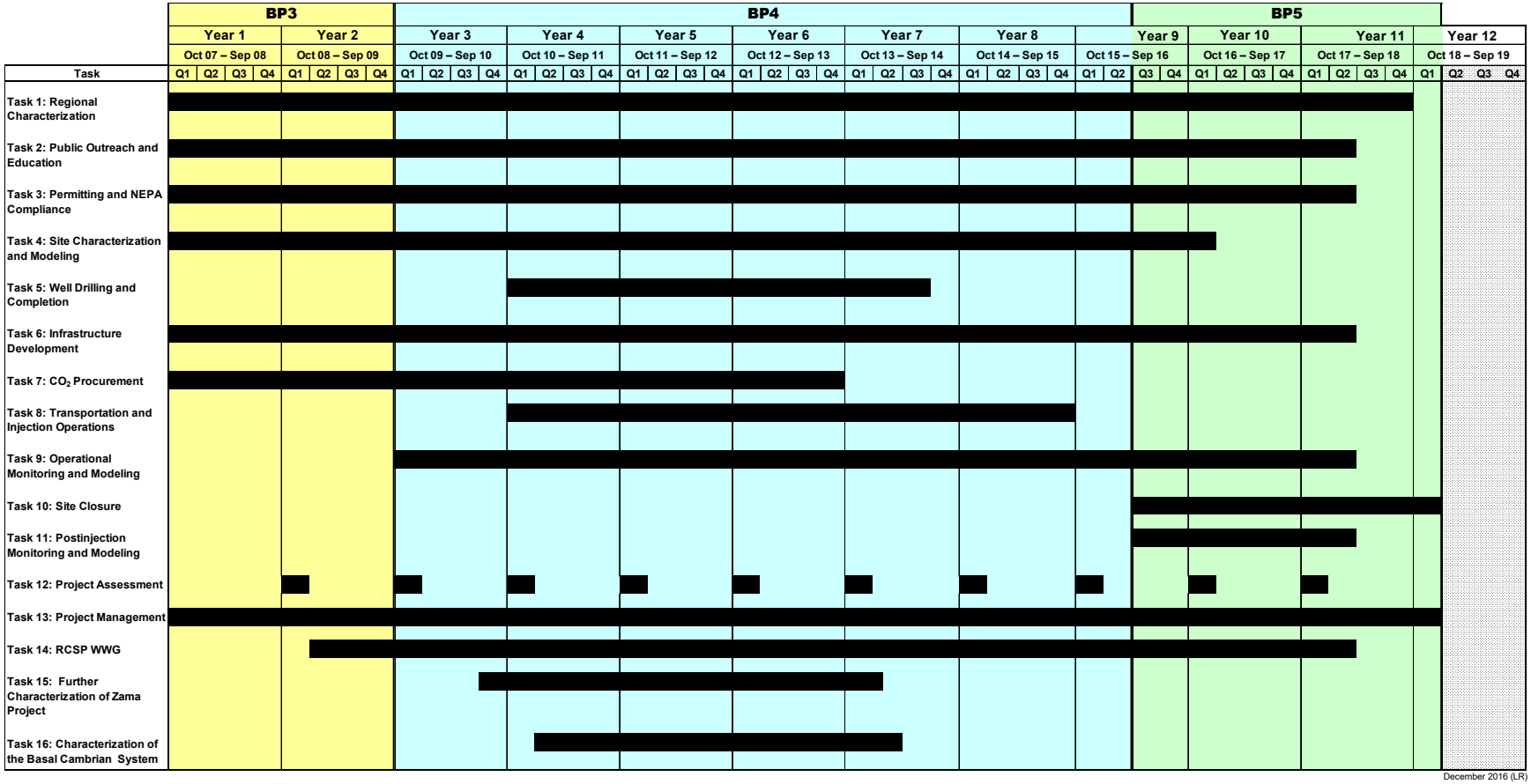


Figure 2. Phase III tasks.

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	Charles D. Gorecki
Task 4 – Site Characterization and Modeling	James A. Sorensen
Task 5 – Well Drilling and Completion (completed)	John A. Hamling
Task 6 – Infrastructure Development	Melanie D. Jensen
Task 7 – CO_2 Procurement (completed)	John A. Harju
Task 8 – Transportation and Injection Operations (completed)	Melanie D. Jensen
Task 9 – Operational Monitoring and Modeling	John A. Hamling and Lawrence J. Pekot
Task 10 – Site Closure	John A. Hamling
Task 11 – Postinjection Monitoring and Modeling	John A. Hamling and Lawrence J. Pekot
Task 12 – Project Assessment	Loreal V. Heebink
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 (completed)	Charles D. Gorecki
Task 16 – Characterization of the Basal Cambrian System (completed)	Wesley D. Peck

In August and September 2016, respectively, the PCOR Partnership participated in the RCSP annual project review meetings in Pittsburgh, Pennsylvania, and hosted the 2016 annual membership meeting in Grand Forks, North Dakota. The EERC program manager presented 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. Results of the review indicated unanimous agreement from the panel that the Bell Creek project has excellent scientific and technical merit combined with a comprehensive test program. It was also evident from the review that the project team covered each technical area comprehensively and was able to address all the technical points raised. Since the IEAGHG peer review in 2011, the PCOR Partnership established a Technical Advisory Board (TAB) to provide scientific and operational guidance that has aided the project. This was the only partnership that implemented this recommendation of the previous IEAGHG RCSP review. Other notable positive features were the wide-ranging public outreach program, proven relationships with the operators, and impressive reservoir characterization.

Throughout PY9, the PCOR Partnership was represented at 69 meetings/conferences/ workshops and submitted 16 abstracts. The PCOR Partnership had two journal articles published, gave 34 oral presentations, and presented four recycled posters (created during PY8). In addition, it completed 20 deliverable/milestone reports (21 were finalized), four value-added products, and 16 progress reports (monthlies and quarterlies combined) and prepared several conference call and meeting minutes.

The PCOR Partnership continued to post technical information about its program on its public Web site, which received over 31,000 site visits from 177 countries in PY9. The PCOR Partnership distributed 360 documentary DVDs and 195 atlases in PY9. In addition, nine telecasts of the documentaries were broadcast on public television, and over 110 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.

In BP4, the focus of the program was to inject CO_2 at commercial scale at the two demonstration sites. For each site, the critical steps/decision points were 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 were required in BP4 to move into the BP5 site closure and project wrap-up activities.

The CO_2 source was 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. CO_2 for the Bell Creek site comes from the ConocoPhillips Lost Cabin natural gas-processing and Shute Creek gas-processing facilities, 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 participate fully in Interstate Oil and Gas Compact Commission (IOGCC) efforts. 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. The PCOR Partnership hosted seven annual regulatory workshops, 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 mandates. These relationships will prove invaluable as the demonstration projects progress.

At 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 as of March 31, 2016, corresponding to the end of BP4, 3.03 Mt of total gas (composition of approximately 98% CO_2) had been purchased for injection into the Bell Creek Field, equating to an estimated 2.98 Mt of CO_2 stored, thereby surpassing a major RCSP Phase III metric of injection of 1 Mt of CO_2 per project. CO_2 injection has continued through the commercial operations at the Bell Creek Field, and as of September 30, 2016, the most recent month of record at the end of PY9, over 3.374 Mt of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated 3.318 Mt of CO_2 stored.

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 eleven tasks (Tasks 1–4, 6, and 9–14) that were active in PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016).

- Accomplishments achieved during PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016).

- Description of planned PY10 BP5 (October 1, 2016 – September 30, 2017) activities.

PY9 BP4 AND BP5 ACTIVITIES (2015–2016)

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 PY3 BP4. 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 2. Out of the 16 tasks, eleven tasks were active during PY9 BP4 and BP5 (Task 7 concluded at the end of PY6, Tasks 5, 15, and 16 concluded during PY7, and Task 8 concluded at the end of PY8). The progress update for the active tasks is presented within this section. This Annual Assessment Report (Deliverable [D] 57) details activities beginning October 1, 2015, through the end of PY9 BP4 and BP5 or September 30, 2016.

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

Accomplishments during PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) are addressed as follows.

Regional Characterization

The characterization of the region and its resources is vital to understanding the feasibility of moving from research to practice regarding storage of CO_2 in large-scale projects and implementation of practices regionwide. A necessary step toward the deployment of CCS is the development and understanding of the magnitude, distribution, and variability of the major stationary CO_2 sources and potential CO_2 storage targets. Using potential storage avenues available coupled with the understanding of both the regional significance as well as in-depth knowledge of their availability to test the storage of CO_2 into available resources gives the opportunity to greatly reduce the impact of anthropogenic CO_2 while also being an economically feasible option across the region.

A value-added report entitled "Characterization of the PCOR Partnership Region" details the individual components used to determine the underlying potential for CO_2 storage in the PCOR Partnership region as well as characterization of the region as a whole to better understand what potential steps forward should be taken for commercialization of CCS not only in our region but worldwide. CCS in geologic media is a technology that 1) is immediately applicable as a result of the experience gained in oil and gas exploration and production, deep waste disposal, and groundwater protection; 2) has large storage potential, although unevenly distributed; and 3) has retention times of centuries to millions of years (1). Geologic storage of CO_2 is actively pursued at several locations around the world, including in the PCOR Partnership region.

Geologic media that have been identified as suitable for CO_2 storage are uneconomical coal beds, oil and gas reservoirs, and deep saline aquifers. Storage of CO_2 in coal beds has the smallest potential in terms of storage potential and is an immature technology that has not yet been proven. Hydrocarbon reservoirs have the advantage of demonstrated storage potential and confinement properties, but they need to be produced and depleted first (unless CO_2 is being used in EOR), and they are penetrated by many wells, which may diminish storage security. Deep saline aquifers have the advantage of being much more widespread, of significantly larger storage resource potential, and generally present less risk of CO_2 leakage along existing wells because they are penetrated by fewer wells than hydrocarbon reservoirs (1).

Within the region, CO_2 storage resource potential amounts include 368–1220 billion tons in currently evaluated saline formations, 25 billion tons in depleted oil field reservoirs, 8 billion tons in unminable coal, and 1.71–10.26 billion tons in selected oil fields for EOR. Saline formations have the most significant storage potential, and with understanding each individual formation and its particular caveats, we can better understand how to utilize the information and create economically feasible plans for implementation of storage. By using both a broad and focused approach to characterization of these resources, we have the ability to look at the potential through a multistate/multiperspective as well as a site-specific approach.

The PCOR Partnership continues to refine the characterization of sources, geologic and terrestrial sinks, and infrastructure within the region. This continued regional characterization is refining CO_2 storage resource estimates for the project and providing context for extrapolating the results of the large-scale demonstrations (2).

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

The PCOR Partnership maintains a database of regional sources of CO_2 emissions and evaluates it on an annual basis. The database is an important part of assessing potential CO_2 capture–transportation–storage scenarios that could reduce greenhouse gas emissions in the PCOR Partnership region. The emission measurements compiled in this database are typically acquired through online databases of the U.S. Environmental Protection Agency (EPA) and Environment Canada. The updated database shows that there are 394 significant (greater than 100,000 metric tons) CO_2 emission sources that emit 483 Mt on an annual basis. Figure 3 shows the locations of 13 new facilities that were found to be missing from the data set and were, therefore, added to it (3).

Refine Storage Analogs for Specific Geologic Horizons Within the Regional Basins

Eight depositional basins lie fully or partially within the PCOR Partnership region. Efforts are under way to expand the number of assessed formations in these basins.

Through its close involvement with DOE and the international community with respect to the development and use of storage efficiency factors, the PCOR Partnership has accrued valuable insight into the methodologies for CO_2 storage resource and capacity estimations for deep saline formations. This insight has resulted in the development of a workflow that introduces intermediate storage efficiency factors that take into account increased levels of geologic reconnaissance (e.g., the geographic distribution of salinity and depth values) to generate refined CO_2 storage resource values for saline formations (4). This methodology is currently being applied to assess the Williston Basin.

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, continued in PY9 and should be finalized in PY10.

A value-added report on the geologic characterization and CO_2 storage potential of the Inyan Kara Formation continued in PY9 and should be finalized in PY10.

Relative Permeability of Williston Basin CO_2 Storage Sinks

Within the Williston Basin, multiple geologic formations have been identified as potential candidates for the injection and long-term storage of CO_2 captured from stationary industrial

Figure 3. Location of the new facilities identified during the 2016 database update.

sources. Of particular interest for advanced characterization are the Inyan Kara, Broom Creek, Charles, Lodgepole, and Deadwood Formations. These reservoirs represent both carbonate and clastic rock types. While each of these reservoirs has been evaluated with regard to its hydrocarbon resource, underground injection, or industrial process source water potential, there is little to no information specific to the response of the reservoir during the injection of CO_2.

To address this issue, the PCOR Partnership continued a value-added laboratory effort to determine key petrophysical attributes of these reservoirs. Laboratory activities were conducted to fully characterize existing samples with regard to mineralogy, porosity, pore-size distribution, permeability, and CO_2/brine relative permeability. The work will provide a comparison of reservoir properties and their relationship to CO_2/brine relative permeability. Specific attributes,

including pore size and distribution, air permeability, and fluid viscosities, will be compared from sample to sample to determine what similarities exist in the sample set as well as to existing results published in peer-reviewed literature. Results of this work will advance our understanding of the injectivity and storage potential of these reservoirs as well as provide baseline data for future geochemical evaluations.

Core intervals selected at the North Dakota Geological Survey Core Library from several wells were used for the laboratory characterization. Testing was completed in PY9. A PCOR Partnership value-added report will be submitted to DOE NETL, and a peer-reviewed journal article will be prepared and submitted for publication. PCOR Partnership partner Stefan Bachu, Alberta Innovates – Technology Futures (AITF), will be a coauthor on the peer-reviewed paper.

Work with Geological Surveys/Oil and Gas Divisions

In PY9, regional characterization staff continued to work closely with the Montana Board of Oil and Gas (MBOG), the North Dakota Department of Mineral Resources, 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.

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. The *PCOR Partnership Atlas, 4th Edition*, was updated in PY4, and 1200 atlases were printed in June 2012. A new printing of 1250 copies of the *PCOR Partnership Atlas, 4th Edition, Revised*, 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. 194 atlases were distributed in PY9 (compared to 318 distributed in PY8). Overall, since its first printing in 2005, nearly 6000 atlases have been distributed.

Modifications and updates to the information in the atlas continued. The *PCOR Partnership Atlas, 5th Edition*, is anticipated to be complete in PY10 (December 31, 2016). New pages are being added to expand on the progress in the PCOR Partnership activities. These will include pages to extend Bell Creek information, to describe the Basal Cambrian work, to explore the Aquistore project, and to develop the concept of green oil.

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

Modifications and refinement to the partners-only DSS are continually undertaken to ensure the timely dissemination of data and information as well as to help improve the quality and efficacy

for our partners for their carbon management decisions. Notable efforts directed to maintaining and updating the DSS in PY9 are as follows:

- A new server was brought online to address potential failure risks in the older equipment.
- CO_2 storage resource estimates for many of the oil fields in the PCOR Partnership region were updated based on a refined approach to applying efficiency factors. These new data were incorporated into the PCOR Partnership GIS (geographic information system).
- Usability improvements were implemented in the GIS interface.
- Databases (oil fields, wells, gas plants) that populate the DSS with information were updated.
- New PCOR Partnership products are regularly added to the database once they are approved for release to partners. Currently, the database contains over 1320 products (an increase by over 80 products over PY8 [1240]) produced by the PCOR Partnership since its inception in 2003.

It should be noted that the requirements for updated DSS reports (D9) in September 2013 and 2015 were deleted in September 2012. In PY9, updates to the DSS were reported in the quarterly technical progress reports rather than in stand-alone reports. 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.

Development of a Demonstration Project Reporting System (DPRS)

Collection of information specific to the demonstration sites is an ongoing effort. It was originally intended 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. With the development of DOE's Energy Data eXchange (EDX)—which has a wider application and functionality, a larger user base, and long-term viability beyond the project—data are submitted to this workspace.

It should be noted that the requirements for DPRS updates (D10) in September 2014 and 2016 were deleted in September 2012. Data and information for field demonstration projects, upon receipt of approval from the commercial site owner/operator, are provided in PowerPoint presentations at meetings and conferences. In PY9, an effort to compile these public data and information with annotations for the PCOR Partnership members continued. This will be completed in PY10 and provided to the members.

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. This CCUS project, formally known as Aquistore, is operated by SaskPower.

The PCOR Partnership is collaborating with PTRC and SaskPower, assisting in the site characterization, acting as advisor in the 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 and SaskPower to update the geologic model and perform predictive simulations.

The Aquistore project is part of the world's first commercial postcombustion CCUS project from a coal-fired power-generating facility, the SaskPower Boundary Dam, located in Saskatchewan, Canada, and is acting as a storage site for a portion of the captured CO_2 from the Boundary Dam power plant. The Aquistore site includes one injection well and a 152-meter offset observation well. Both wells were drilled and completed in the Deadwood and Black Island Formations.

Intermittent CO_2 injection commenced in April 2015. Injection quantities were limited by capture plant operating conditions and CO_2 sales obligations. Daily injection rates range from 300 to 500 tonnes during injection periods. As of September 30, 2016, approximately 84,000 tonnes of CO_2 has been injected.

During injection, multiple production logging, or spinner, surveys were performed in the injection well to help determine the flow distribution among the four perforation intervals in the well. In the observation well, several PNL runs were performed in anticipation of detecting the first arrival of CO_2 at the well. As of the survey performed in PY9 on February 24, 2016, CO_2 had arrived at the observation well. Cumulative injection to that date was 36,500 tonnes when breakthrough was observed. In PY9, a site work program was completed, which included surface seismic at the site with the permanent receiver system, PNLs in both wells, and spinner survey testing in the injection well.

Aquistore Geologic Modeling and Simulation Activities

To better understand the storage implications of injecting CO_2, history-match field pressure response, and predict CO_2 plume evolution at the Aquistore site, the EERC has constructed a simplified simulation model based on reservoir physical properties obtained from previous mean probability (P_{50}) static geologic model realization. Simulations have been conducted utilizing this model to better understand both operational and geologic uncertainties that may exist at the Aquistore site. The simulations are an update to those completed in the previous update of the original report entitled Geologic Modeling and Simulation Report for the Aquistore Project, D93, approved in 2014.

In D93 Update 2 (approved April 2016), a regional-scale model extends beyond the 34-square-kilometer PTRC 3-D seismic survey area. A local grid refinement system near both the

injection and observation wells was introduced for the history-matching and uncertainty analysis. Spinner log survey and pressure test data provided by partners were used and evaluated to adjust the near-wellbore local permeability in order to history-match the field pressure data. As of January 9, 2016, approximately 24,000 tonnes of CO_2 has been injected during a series of relatively short operating periods. However, the injection rate during these short operating periods increased near the end of year 2015 to a level of 300 to 500 tonnes per day, based on the quantity of CO_2 made available from the pipeline.

The two wells have been closely monitored, and history matching was performed while reconciling rate, pressure, temperature, variations in injectivity, and injection flow. The current data set is well replicated by the simulation. CO_2 breakthrough at the observation well was observed in February 2016, and geophysical imaging of the CO_2 plume has been completed, showing a CO_2 plume anomaly. However, mechanisms of important performance remain to be made, and additional reporting of project performance will be appropriate in the future. A new set of injection forecasts is presented, with some cases directly comparable to the previously published, pre-history match results (5–7).

Training

EERC research staff attended the following training sessions:

- The Research Experience in Carbon Sequestration (RECS) Course in Birmingham, Alabama, held June 12–20, 2016. The program offers graduate students and early career professionals hands-on field research experience in areas related to CCUS and is hosted by Southern Company and the Southeast Carbon Sequestration Partnership.

- The 2016 Esri GIS User Conference in San Diego, California, held June 27–30, 2016.

- The IEAGHG R&D Programme CCS Summer School held July 17–23, 2016, in Regina, Saskatchewan, Canada.

Additional Conference/Meeting Participation

- Attended and presented at the Esri Petroleum GIS Conference held April 26–27, 2016, in Houston, Texas. The presentation discussed and gave examples of how the EERC uses GIS technology in CCUS/CCS research activities.

- Presented "An Update of Aquistore CO_2 Storage Simulation" at Computer Modelling Group's (CMG's) 37th Technical Symposium, held June 13–14, 2016, in Calgary, Alberta, Canada.

- Presented "An Update of Aquistore CO_2 Storage Simulation" at PTRC's Annual Meeting, held August 16, 2016, in Ottawa, Ontario, Canada.

- Presented "Well Integrity" and served as a student mentor at the IEAGHG CCS Summer School held July 17–23, 2016, in Regina, Saskatchewan, Canada.

- Presented "Important Site Selection Traits" as part of the "Carbon Capture and Sequestration (CCS) Technical Discussion Series: Site Selection" Webinar to the California Air Resources Board on September 26, 2016.

DOE Carbon Storage Project BPMs

The PCOR Partnership is playing an active part in the revision/redevelopment of DOE Carbon Storage Project BPMs. The DOE BPM relevant to PCOR Partnership Task 1 activities is the Site Screening, Site Selection, and Site Characterization for Geologic Storage Projects BPM previously revised in 2013. Efforts were initiated in PY8; the following activities were performed in PY9. PCOR Partnership personnel participated in conference calls and Webinars with the working group tasked with updating this BPM. PCOR Partnership personnel continued work on reviewing and commenting on the BPM throughout the revision process. Five 1-page sidebars highlighting case studies from the PCOR Partnership's experience were developed and provided to the working group for consideration.

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 PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) are addressed as follows.

Meetings and Conferences

EERC employees attended 61 conferences/meetings and eight workshop/seminars (including internal) 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 34 oral presentations, four recycled posters, and two recycled and two new booths.

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 PY8, the PCOR Partnership

distributed over 700 documentary DVDs and 318 atlases. During PY9, the PCOR Partnership distributed 360 documentary DVDs and 195 atlases as follows:

- PCOR Partnership documentary entitled "Nature in the Balance: CO_2 Sequestration" – 16
- PCOR Partnership documentary entitled "Reducing Our Carbon Footprint: The Role of Markets" – 14
- PCOR Partnership documentary entitled "Out of the Air: Into the Soil" – 28
- PCOR Partnership documentary entitled "Managing Carbon Dioxide: The Geologic Solution" – 148
- PCOR Partnership documentary entitled "Global Energy and Carbon: Tracking Our Footprint" – 145
- PCOR Partnership documentary entitled "Installing a Casing-Conveyed Permanent Downhole Monitoring System" – 9
- *PCOR Partnership Atlas, 4th Edition, Revised* – 149

Throughout the course of the program, the PCOR Partnership has distributed a total of 5950 copies of the various regional atlas editions and 10,321 copies of the five different documentary DVDs and the technical training video.

Outreach Planning

An update to the PCOR Partnership outreach action plan (D11) was prepared in March 2010 and again in March 2016 (PY9). 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 PCOR Partnership region covers all or part of nine states and four Canadian provinces and has a total population of over 31 million in 11.9 million households. During Years 9–11 (BP5) of the Phase III U.S. DOE RCSP Program, the PCOR Partnership outreach team will continue to undertake activities and develop products intended to help raise awareness of the practice of sequestration as well as the PCOR Partnership and its role in the region. All of the outreach efforts will point to the public Web site, which is a 24/7, comprehensive source of information and downloadable materials for all audiences.

Audiences defined by geography include the general public across the region, select communities, and stakeholders in project locations. The general audiences at the regional level will continue to be served by periodic broadcasts of original documentaries on public television. Select communities will continue to be served by providing materials to local libraries. Depending on the CCS project in the region, the PCOR Partnership will serve as follows:

- For its collaborative project with Denbury, continue to interact with landowners in the course of sampling and monitoring activities, update customized outreach materials, and take part, as requested, in community meetings.

- For the Aquistore project, operated by SaskPower and the PTRC, continue to take part in outreach advisory meetings and site open houses and maintain and update customized materials as appropriate.

- For the other projects, continue to maintain and make available a combination of project fact sheets, pages in the regional atlas, and pages on the public Web site.

Select audiences include educators and opinion leaders. Outreach to educators will continue through presentations and the distribution of materials, the development of lesson plans by master teachers, and the production and distribution of original video materials. Outreach to opinion leaders will continue to involve senior project personnel and one-on-one meetings supplemented by outreach materials. For members or potential members, a subset of opinion leaders, outreach will be supplemented by periodic e-mails and attendance at the annual meeting or through one of the PCOR Partnership's other forums.

Documentation and planning will be facilitated by the continued maintenance and development of the Outreach Information System, including the Outreach Tracking Database. These components help characterize outreach material development, the distribution of materials, outreach activities including television broadcasts, and Web traffic. This plan will be assessed and updated under this structure through the completion of the PCOR Partnership project (8).

Data Acquisition and Management

The outreach data management system is envisioned as an addition to the DSS to consist of GIS-compatible databases. During PY9, this system was used to track outreach activities and product distribution and use for the Web site, PowerPoint presentations, fact sheets, and documentary products both at the regional level and for the areas of the demonstration projects.

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

Web Site Updates

The PCOR Partnership public Web site has been online since June 2004. This Web site will be updated and expanded as appropriate, with major updates on a biennial basis. The D13 Public Web Site Update report summarizes the 2016 contractual update to the PCOR Partnership public Web site for the period of July 1, 2014, through June 30, 2016. The central focus of this D13 consisted of an updated look to the Web site. This work features a black background, larger text, print-friendly pages, and shorter names on the left navigation for a more user-friendly experience. To make the public Web site more search-friendly, search engine optimization techniques were implemented in new and existing PDFs. In addition, several new Web pages were added, including Technical Publications landing page, Technical Posters, Permanent Downhole Monitoring, and Outreach Posters. Significant content and/or appearance modifications were made to nine existing

Web pages, the Home page being the most pronounced (Figure 4). Minimal updates were made to eleven other pages. A new section called Household Energy and Carbon Footprint replaced the Reduce Your Carbon Footprint page. The next contractual update is due in January 2018 (9).

Web Site Activity Tracking

The PCOR Partnership has used Google Analytics (GA) to track activity for the PCOR Partnership public Web site since April 2010. During PY7, Google upgraded from "classic" analytics to Universal Analytics (UA), which is designed to move away from session-based tracking to user-based tracking across all devices (e.g., desktop, mobile, tablet), thus improving tracking analytical potential. To accompany this change, Task 2 personnel updated the standard operating procedure (SOP) for Web tracking, including guidance on naming PDF, video, and Web pages as well as assigning URLs, and provided a search engine optimization protocol for PDFs (both in place and additions). In the wake of the transition from classic to UA, the PCOR Partnership is monitoring UA results closely in order to identify concrete examples of improved capability as well as potential issues.

The UA upgrade contains noticeable differences regarding the naming of two key metrics: 1) visits are now shown as sessions and 2) visitors are now referred to as users. Because of the renaming of these metrics, visits and visitors will be used along with sessions and users, respectively, in reporting.

As instituted in the beginning of PY6, the Advanced Segments feature in GA is used to exclude internal Web site traffic (project personnel and Web site maintenance visits), thus providing a reasonable starting point to gauge public activity. The results reported below are for public (external) traffic only.

Sessions/Visits

As shown in Figure 5, there were 31,326 sessions/visits to the public Web site in PY9, an increase of 27% over PY8 (24,589 sessions/visits). However, only 5000 of these visits interacted with more than one page. Approximately 26% of these visitors came to the site using a mobile device or tablet.

There were 26,834 unique visitors to the public Web site in PY9, representing a 29% increase from PY8 (21,144 visitors). Over 85% of these visitors were new to the Web site.

The PCOR Partnership public Web site received traffic from 177 countries from October 1, 2015, to September 30, 2016, as illustrated in Figure 6. There were visits from 10 new countries. Of the 31,326 sessions/visits, 43% of the Web traffic was domestic, and 57% was international. Table 3 lists the ten countries with the highest number of sessions/visits to the PCOR Partnership Web site. These included the United States, India, United Kingdom, Australia, Canada, Philippines, Malaysia, Pakistan, Kenya, and Netherlands.

Figure 4. Updated home page (www.undeerc.org/PCOR).

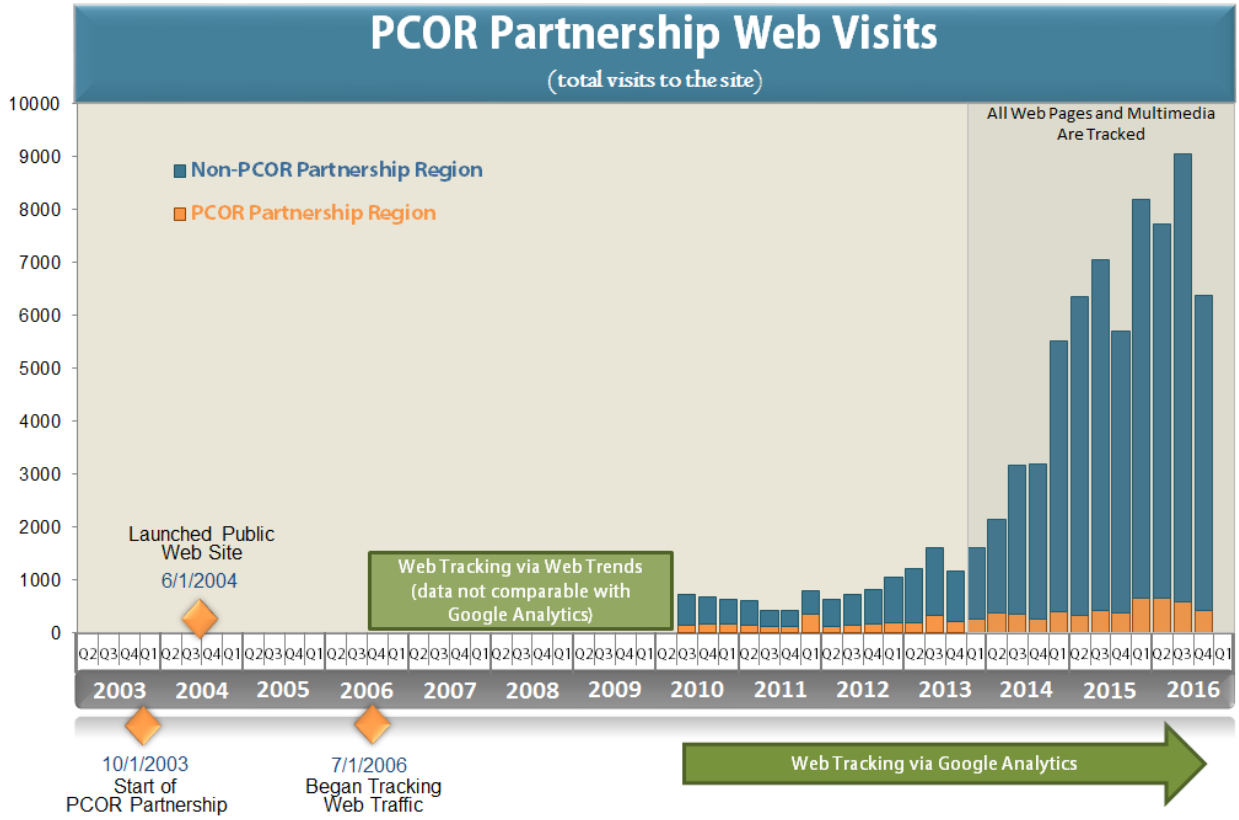


Figure 5. Cumulative bar graph of PCOR Partnership global Web traffic.

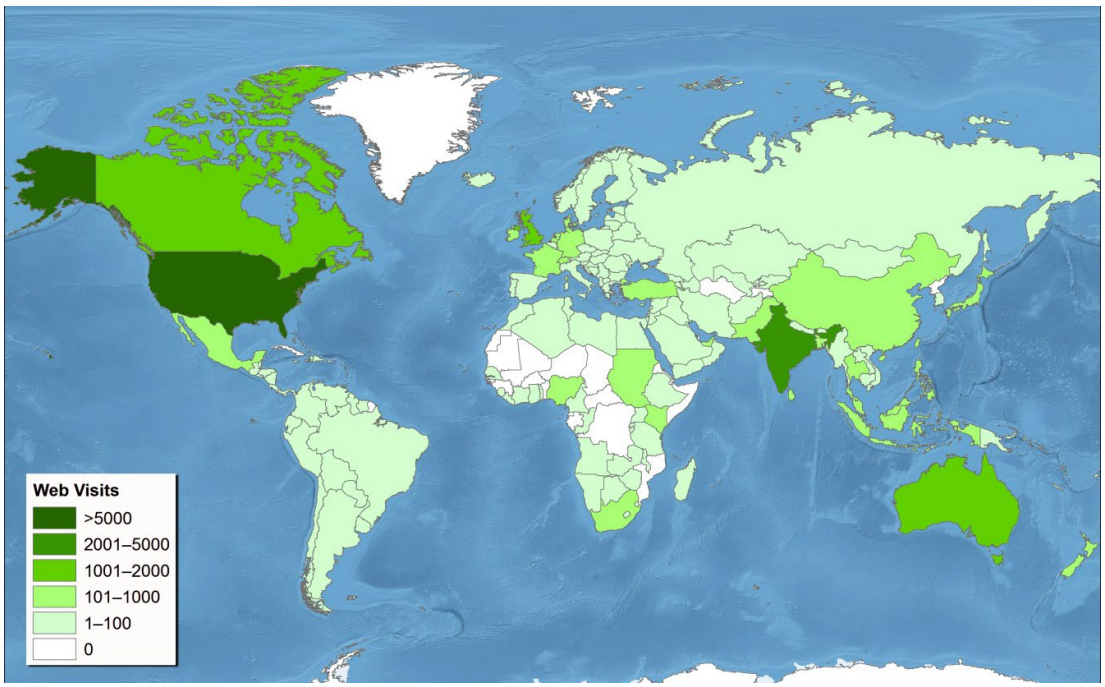


Figure 6. Map of PCOR Partnership global Web traffic for PY9.

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

	Country	Visits*	PCOR Partnership State/Province	Visits*
1.	United States	13,443		
			North Dakota	520
			Minnesota	330
			Wisconsin	215
			Missouri	155
			Iowa	12
			Montana	67
			Nebraska	66
			Wyoming	43
			South Dakota	36
2.	India	4276		
3.	United Kingdom	1943		
4.	Australia	1829		
5.	Canada	1742		
			Alberta	340
			British Columbia	273
			Saskatchewan	114
			Manitoba	40
6.	Philippines	604		
7.	Malaysia	466		
8.	Pakistan	365		
9.	Kenya	346		
10.	Netherlands	273		
	Other 167 countries	6039		
	Total Visits	**31,326**	**Total PCOR Partnership Visits**	**2320**

*Arranged by the number of visits to the site.

There were 2320 sessions/visits from within the PCOR Partnership Region. Approximately 67% of regional visits originated from the United States and 33% from Canada. Figure 7 illustrates Web sessions/visits to states and provinces within the region.

Sessions/visits from the PCOR Partnership region represent 7% of the total traffic to the public Web site. It should be noted that the totals may overestimate regional traffic to some degree because the visit location data were aggregated at the state and province level even though the PCOR Partnership region formally includes only portions of British Columbia, Montana, and Wyoming.

Traffic Sources

Traffic sources indicate how users/visitors came to the PCOR Partnership Web site. The three general categories of traffic sources include search, direct, and referral sites. Lesser traffic

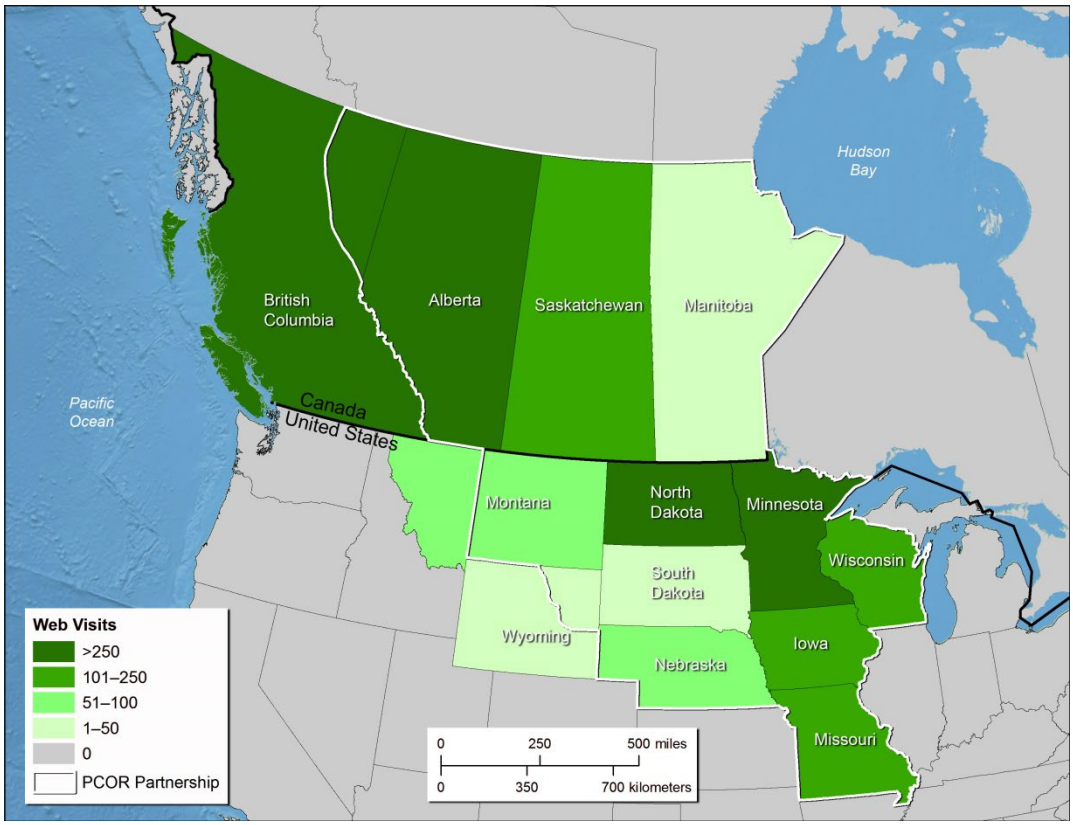


Figure 7. Map of PCOR Partnership regional Web site sessions/visits for PY9.

sources are acquired from social media and campaigns. These categories and their percentage of the total traffic sources are presented in Figure 8.

Search traffic refers to the use of search engines such as Google, Bing, and Yahoo. Search traffic accounted for almost 87% of the overall traffic that came to the public Web site. Google Analytics provides keywords visitors used to find the public Web site. The top three search phrases were "carbon sequestration," "what is CO_2," and "what is carbon sequestration."

Direct traffic consists of those visitors who bookmark or type a specific PCOR Partnership URL, e.g., www.undeerc.org/pcor, into a Web address bar. Direct traffic accounted for 9.5% of the overall traffic.

Referral traffic is traffic to the PCOR Partnership Web site from other sites via links. About 2.5% of external traffic resulted from referral sites. The top three referring Web sites were those from energy.gov, arthapedia.in, and globalccsinstitute.com.

Over 1% of Web traffic came from teacher campaigns and social interactions, such as e-mail, or from social media sources like Facebook or YouTube.

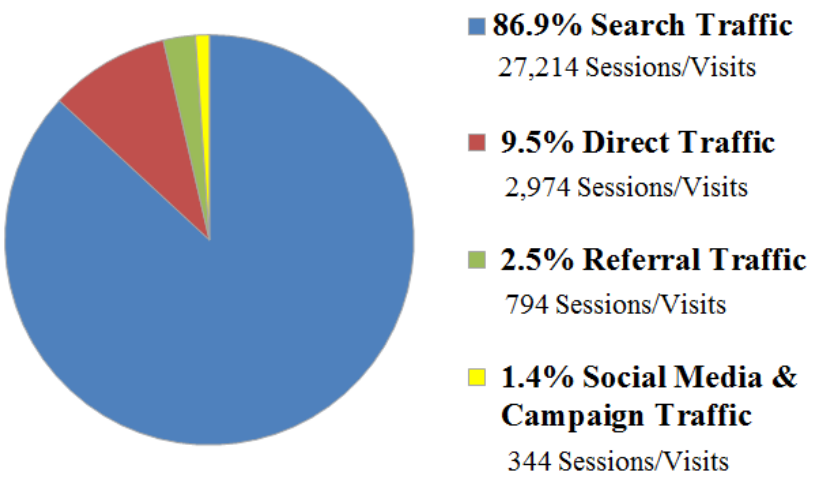


Figure 8. PCOR Partnership public Web site traffic in PY9.

Nature of Sessions/Visits

A total of 44,221 page views (a 29% increase from PY8) resulted from the 31,326 sessions/visits to the PCOR Partnership public Web site in PY9. The top five viewed Web pages (Table 4) accounted for about 74% of page views overall.

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.

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

Page Title	Page Views	% Page Views	Page URL
What Is CO_2 Sequestration?	22,234	50.3%	www.undeerc.org/pcor/sequestration/whatissequestration.aspx
What Is CO_2?	6467	14.6%	www.undeerc.org/pcor/sequestration/whatisco2.aspx
CO_2 Sequestration Projects	1527	3.5%	www.undeerc.org/pcor/co2sequestrationprojects/default.aspx
Home Page	1390	3.1%	www.undeerc.org/pcor/default.aspx
Terrestrial Sinks	1204	2.7%	www.undeerc.org/pcor/region/terrestrial

The general Phase III fact sheet (D14) was given approval in March 2016. The content of the existing text was updated as appropriate. Additional sections were added for the Aquistore Project and the WWG activities (http://undeerc.org/pcor/newsandpubs/pdf/FS14-PCOR-Partnership-Demonstrating-CO2-Storage-Northern-Great-Plains.pdf).

The fact sheet update entitled "Fort Nelson CCS Feasibility Project" (D16) was approved in September 2016. The fact sheet was completely redesigned to provide information on all activities that occurred over the project. Best practices from the experience gained were included. The fact sheet will be added to the public Web site in PY10.

The four Phase II project fact sheets are being updated as value-added products. This update includes alterations to content and the use of an expanded four-page format that features a first page highlighting key results and fast facts; inside-facing pages providing detail on approach and findings as well as a project time line; and a back page with frequently asked questions (FAQs), information on the PCOR Partnership, and contact information. The updated fact sheet entitled "CO_2 'Huff "n" Puff' Validation Test" was approved in April 2016 (http://undeerc.org/pcor/newsandpubs/pdf/FS12A-CO2-Huff-n-Puff-Validation-Test-NW-McGregor.pdf). The updated fact sheet entitled "CO_2 Sequestration Test in a Deep, Unminable Lignite Seam" was approved in September 2016. Updates for the terrestrial and Zama project fact sheets were near completion at the end of PY9. The full set of four Phase II fact sheet updates will be completed in PY10 and will be made available in hard copy and on the public Web site.

The Bell Creek fact sheet update was near completion at the end of PY9. It will be completed in PY10.

Three additional fact sheets were completed in PY9 for the PCOR Partnership Annual Meeting in September 2016: the PCOR Partnership Prospectus III, "What Is the PCOR Partnership?" and "PCOR Partnership Role in Aquistore."

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, DOE NETL approved 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, 34 oral presentations were given in PY9, and the majority included information on the Bell Creek project and other PCOR Partnership activities.

The general Phase III information PowerPoint presentation (D17) was updated for general use in May 2016. This update included three new slides to provide illustrations for future energy demand, top ten nations with major coal deposits, and CO_2 injection at Aquistore and seven slides with updated text, data, or images. This slide show serves as the basis for many of the general outreach presentations, including those given at teacher seminars.

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. The BPM is currently undergoing revision by the OWG.

The PCOR Partnership participated in six (October 17 and December 17, 2015, and March 17, April 28, June 16, and July 21, 2016) monthly OWG conference calls. In lieu of participation in monthly conference calls on November 19, 2015, and January 21, 2016, comments were provided by e-mail. The primary focus of the OWG conference calls in PY9 continued to be the review and preparation of the major revision to the DOE NETL outreach BPM.

Documentaries and Video Products

A spectrum of video products is developed to meet the needs of general and site-level outreach. 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. 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 entitled "The Bell Creek Story – CO_2 in Action" was near completion at the end of PY9. Interviews were conducted and minor location filming was done to complete the production phase of the documentary. The documentary will be submitted in October 2016 (PY10).

Interviews were conducted with the following individuals in PY9:

- Phil Rykhoek, President and Chief Executive Officer, Denbury
- Matt Dahan, Vice President of the North Region, Denbury
- Tom Doll, PCOR Partnership
- Representative Tom Richmond, Montana Legislator
- Nick Azzolina, The CETER Group

Coal in the Modern Age 60-minute Documentary Filming

A 60-minute documentary (D22) under development is due January 2017. Interviews and filming continued in PY9. Several trips to the PPB offices in Fargo, North Dakota, occurred to work on the documentary.

In October 2015, PCOR Partnership personnel and a PPB film crew traveled to Beulah, North Dakota, for an interview video shoot at Dakota Gasification Company and the Freedom Mine. On June 27–29, 2016, PCOR Partnership personnel and a PPB film crew traveled to the Gillette, Wyoming, area for filming, including aerial filming of surface coal mines and power plants. PCOR Partnership personnel and a PPB film crew traveled to northern California on July 12–15, 2016, to interview Dr. Julio Friedmann (Lawrence Livermore National Laboratory) and perform location filming. An interview was conducted with Sean Adams, University of Florida, in Gainesville, Florida, on August 17, 2016, with PCOR Partnership personnel and a PPB film crew.

The D22 documentary will be completed and submitted in PY10.

YouTube Exposure

In an effort to expand the PCOR Partnership outreach initiative, 50 video clips and five full-length documentaries (currently available on the public Web site) were uploaded to the EERC's YouTube channel on April 1, 2014 (www.youtube.com/user/undeerc/videos?sort=dd&shelf_id=1&view=0). Table 5 provides a summary of the top five viewed video items over PY9. Three PCOR Partnership full-length documentaries are also on the PPB YouTube Channel. The activity on the PPB site for PY9 is shown on Table 6.

Table 5. Top Five PCOR Partnership-Related YouTube Channel Videos Accessed

Video	Video Length, minutes	Views	Est. Minutes Watched
Reducing Our Carbon Footprint: The Role of Markets	26:49	3084	14,234
Reforestation in Brazil	4:41	2746	5969
The Phases of Oil Recovery – So Far	2:40	1420	2465
Household Energy Around the World	5:34	376	1059
Reservoir Geology 101: Fluid in the Rocks	1:50	322	407

Table 6. PCOR Partnership Documentaries Accessed on the PPB YouTube Channel

Video	Video Length, minutes	Views	Watch Time, minutes	Avg. View Duration
Global Energy and Carbon: Tracking Our Footprint	32:36	6210	50,797	13:03
Managing Carbon Dioxide: The Geologic Solution	31:40	975	11,445	11:40
Out of the Air – Into the Soil: Land Practices That Reduce Atmospheric Carbon Levels	26:45	46	183	15:00

Educational Web Site Exposure

In addition to the public Web site and YouTube, all 50 PCOR Partnership video clips and five documentaries have been uploaded to the North Dakota Studies and PBS Learning Media Web sites. These sites are available to educators. As with the public Web site, GA is used to obtain the number of views for each video. Table 7 and Table 8 list the top five videos watched for the PBS Learning Media (accessible by teachers across the United States) and North Dakota Studies (North Dakota educators) Web sites, respectively.

Broadcast of Documentaries

In PY9, the PCOR Partnership received public television exposure from documentaries broadcast in four states and one Canadian province. A total of nine broadcasts were aired. The number of telecasts by documentary are as follows: "Out of the Air: Into the Soil" (1), "Managing Carbon Dioxide: The Geological Solution" (3), and "Global Energy and Carbon: Tracking our Footprint" (5). All three documentaries were aired in the PCOR Partnership region.

Public Outreach Presentations

In PY9, the PCOR Partnership participated in three teacher training workshops and education conferences as well as university-level student and faculty presentations. These activities included introducing PCOR Partnership materials (DVDs, atlas, Web site awareness) to educators in K–12 schools. They included:

Table 7. Top Five PCOR Partnership Videos on the PBS Learning Media Web Site

Video	Video Length, minutes	Views
Household Electricity and Carbon Footprint	4:22	95
Out of the Air – Into the Soil: Land Practices That Reduce Atmospheric Carbon Levels	26:45	74
CO_2 Greenhouse Gas	1:40	46
Carbon-Based Fuels and Our Quality of Life	3:11	42
Humans CO_2 and Climate Change	2:34	42

Table 8. Top Five PCOR Partnership Videos on the North Dakota Studies Web Site

Video	Video Length, minutes	Views
CO_2 Sequestration: Geologic Sequestration	9:34	10
Introduction to Energy Use and Environmental Challenges	2:32	8
Electricity	3:50	6
Energy and Carbon: The Big Picture	2:34	6
Carbon Use Reduction – Household and Societal Actions	7:32	5

- A 1-day science teacher conference hosted by the North Dakota Teachers Association 2016 Spring Collaborative Conference STEM (science, technology, engineering and mathematics) Networking Sessions (materials disseminated) on April 21, 2016, in Grand Forks, ND.

- A 4-day coal-focused workshop presented by the North Dakota Lignite Energy Council (LEC) (presentation given, materials disseminated) held June 14–17, 2016, in Bismarck, North Dakota.

The educator workshop presentations reached a total of 111 teachers representing 89 different school districts in four states (North Dakota, Montana, Minnesota, and South Dakota) in the PCOR Partnership region. Six of the teachers (5%) had previously heard a PCOR Partnership Outreach presentation at a different workshop.

Since 2006, the outreach team has presented to almost 1400 teachers in eight states from the PCOR Partnership region. Over 11% of teachers have attended multiple conferences. Figure 9 shows the geographic distribution of the teachers who received materials by their corresponding school districts. In North Dakota, outreach materials are available to 83% of the school districts' teachers and students.

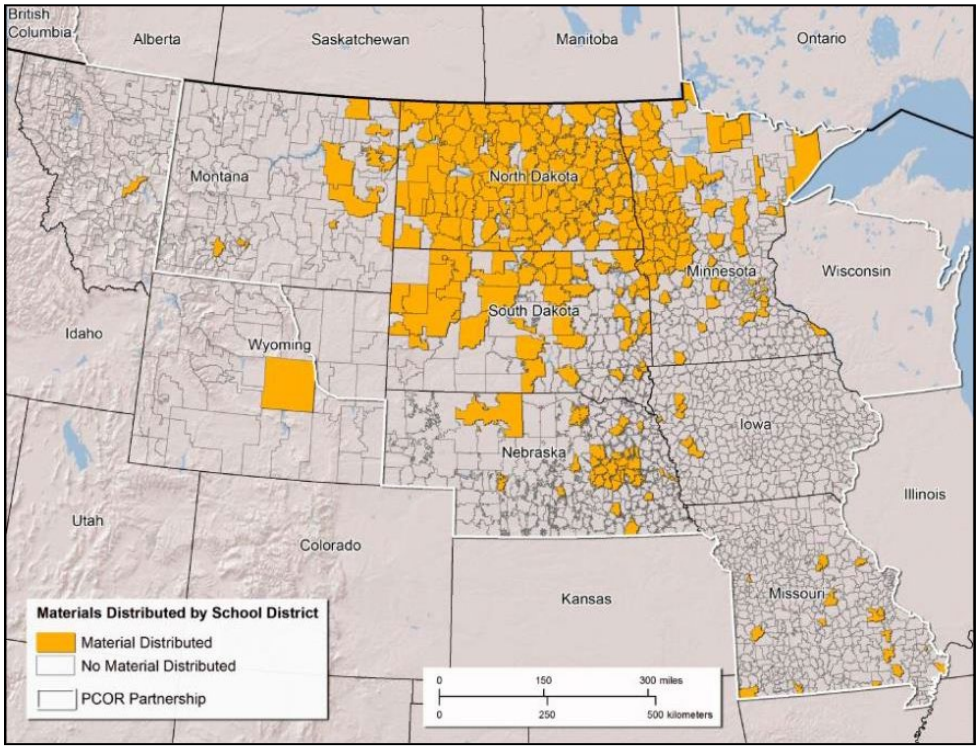


Figure 9. Distribution by school district of teachers who received outreach materials from 2006 to 2016.

The LEC workshop and the presentation to the audience at the university event involved the use of audience feedback systems or "clickers" that allowed individual real-time response by members of the audience. The use of "clickers" enhanced audience engagement, allowed the presenter to gauge the quality of information transfer and audience knowledge, and resulted in feedback that can be used to improve future presentations.

Project-Related Outreach Activities

There were nine near-surface assurance-monitoring events at Bell Creek during PY9. Outreach for these events included periodic telephone and personal contact with the eight landowners controlling access to water wells and ponds slated for sampling. Follow-up to these events included verbal contact as well as written reports of sampling results provided to each of these landowners. Final landowner packages were distributed in July 2016. Key summaries and landowner letters were provided for each landowner.

Task 2 personnel represent the PCOR Partnership on the Aquistore Outreach and Advisory Working Group led by PTRC. During PY9 participation included the following:

- Participated in conference calls and e-mail correspondence.

- Collaborated with PTRC on the preparation of an abstract and paper for GHGT-13 entitled "Communicating about the Geological Storage of Carbon Dioxide – Comparing Public Outreach for CO_2 EOR and Saline Storage Projects."

Media Coverage

Media coverage is defined as articles related to the PCOR Partnership 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 PY9, three instances of coverage that included the PCOR Partnership were reported online as shown in Table 9.

Table 9. PCOR Partnership Media Coverage

Date	Headline	Media Organization/ Publication	City	Journalist, Author, or Source	Type
10/21/2015	2015 Pioneer Award Winners Announced	World Cement	Joseph Green	Online	10/21/2015
10/23/2015	EERC Announces 2015 Plains CO_2 Reduction Partnership Pioneer Award Winners	Sustainable Manufacturer Network	Staff report	Online	10/23/2015
11/5/2015	Hoeven Pushes for National Lab, University Partnerships for Clean Energy	Prairie Business Magazine	Staff Reporter	Online	11/5/2015

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 PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) 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. The information gathered through these efforts as well as lessons learned during Regulatory Roundup Meetings will be summarized in D76 "Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region," due January 2017.

Permitting Review – Update 3

On September 29, 2016, a third permitting review update was submitted. The first update was in 2013 (D6) and the second update was in 2015 (D8). The document provides a brief update on the requirements to conduct a geologic CO_2 storage project in the United States or Canada. Little has changed in the United States in the past year since the second permitting review was submitted in September 2015 (10). The information provided in the update gives a broad overview of the regulatory requirements and the authorities involved. As of this writing, the U.S. Environmental Protection Agency (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 Mandatory Reporting of Greenhouse Gases Rule (MRR) (11). In Canada, the provinces have the authority to permit geologic storage projects (12).

Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region

The gathering of information for "Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region" (D76) continued in PY9. Information on the rules, regulations, and statutes for various scenarios of CCS geologic storage and for CO_2 EOR for each of the PCOR Partnership states and provinces was obtained. The goal of this document is to help PCOR Partnership states and provinces through the permitting process. The report will be completed in PY10.

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, EERC Vice President for Strategic Partnerships John Harju is a past chair of IOGCC's Energy Resources, Research, and Technology Committee.

EERC staff members participated in the following IOGCC meetings in PY9:

- Witnessed the passing of a resolution presented by North Dakota regulators asking EPA to clarify the rules of Class VI wells at the IOGCC Annual Meeting in Oklahoma City, Oklahoma, September 26 – October 1, 2015.

- Attended the IOGCC Annual Business Meeting in Denver, Colorado, on May 16–17, 2016. Topics of interest included new and proposed rules and regulations, marginal wells and their challenges, and EOR and CO_2 storage in mature marginal oil wells.

Plug and Abandon Wells and Land Reclamation of Lignite Project Site

Reclamation of a carbon storage pilot field test that was conducted in 2009–2011 in Burke County, North Dakota, and included the injection of CO_2 into a 10-foot-thick seam of lignite at a depth of 1100 ft (the Lignite Project) was completed in PY9. The five wells on the site were

plugged and abandoned in September of 2011, and the site reclamation commenced and an electric fence was erected around the site 2 months later in November 2011. By May 2012, grass and other vegetation started to take root, and by September of that year, while some small areas were still bare, much of the lignite site saw grass and other vegetation up to 3 feet in height. By June 2013, with the electric fence removed, it was difficult to determine where the surrounding pasture began. In the fall of 2016, the electrical panels were removed from the reclamation site. A sundry notice for the reclamation of the lignite site in Burke County, North Dakota, was filed.

Additional Conference/Meeting Participation

- Attended the final North Dakota Department of Health public meeting on the Clean Power Plan on November 18, 2015, in Fargo, North Dakota.

- Attended a Webinar entitled "EPA's Proposed New Emission Rules and Impact on Oil & Gas Industry" presented December 8, 2015, by Jack Luellen, a partner with Fox Rothschild LLP, and hosted by the Association of Desk and Derrick Clubs (ADDC).

- Attended a Global CCS Institute Webinar entitled "Lessons Learned on CO_2 Storage from the Midwest Regional Carbon Sequestration Partnership Program," hosted by Battelle on December 8, 2015.

- Attended CO_2 Conference Week held December 8–11, 2015, in Midland, Texas, which included a field trip to the Seminole San Andres Unit (SSAU) project.

- Attended a presentation entitled "Smart Waterflood in Carbonates: A Promising IOR Method?" presented December 10, 2015, in Grand Forks, North Dakota, by Professor Hemanta Sarma, Oil and Gas Engineering, Department of Chemical & Petroleum Engineering, University of Calgary, Alberta, Canada.

- Participated in Shell Canada Webinar entitled "Building Social License and a Regulatory Framework: The Quest CCS Project" on October 20, 2015.

- Attended the Groundwater Protection Council 2016 Underground Injection Control Conference held February 23–25, 2016, in Denver, Colorado.

- Attended the Williston Basin Petroleum Conference (WBPC) Annual Meeting in Bismarck, North Dakota, on May 24–26, 2016.

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. The Bell Creek demonstration site work is continuing, but the Fort Nelson demonstration site work under Task 4 has been completed.

Activities and Results

Accomplishments during PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) are described as follows.

Fort Nelson Demonstration Site

The primary objective of the Fort Nelson project was 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 2014, this subtask was completed.

Bell Creek Demonstration Site

The Bell Creek oil field in southeastern Montana continued as a PCOR Partnership Phase III demonstration site. Detailed subsurface mapping and characterization were conducted in advance of a large-scale study of CO_2 storage associated with CO_2 injection for EOR. Site characterization activities continue to 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.

Bell Creek Test Site Baseline Geology Determination

The field data previously obtained through 3-D seismic acquisition, 3-D VSP (vertical seismic profile) survey, and PNL campaigns were utilized in geologic models. These data and models are used in conjunction with Task 9 – Operational Monitoring and Modeling data and models. The Task 4 activities were included in the August 2015 update to D66 (Bell Creek Test Site – Simulation Report). The review by Denbury was completed, comments were incorporated, and the report was finalized in August 2016. Additionally, the Task 4 activities were included in the August 2016 update. The updated report remains under review by Denbury and has not yet been finalized.

As part of the PCOR Partnership's adaptive management approach (AMA) to developing the CO_2 storage program, modeling and numerical simulation activities continue toward the goal of providing a comprehensive assessment of associated CO_2 storage behavior. This goal, while not a new objective at Bell Creek Field, has been guiding recent efforts discussed in the August 2016 update to D66 (work completed since August 2015). The overarching themes for the research discussed in the report include 1) increasing our understanding of the subsurface of Bell Creek Field through the acquisition of new data and 2) modeling and simulation activities to achieve predictions of fluid flow, pressure response, oil sweep and CO_2 storage efficiency, and determining the long-term fate of injected CO_2.

More specifically, discussion from this reporting period includes the 1) acquisition of new geologic characterization data, including PNLs and surface seismic data, to reduce uncertainty in model construction; 2) modeling of the reservoir and shallow subsurface aquifers, both within and surrounding the field, to provide the basis for numerical simulations of CO_2 injection; 3) development of a pressure, volume, and temperature (PVT) model (to be applied in compositional simulations) to predict the miscibility behavior of the system with varying injection gas compositions (i.e., recycled gas injection, CO_2 with varying amounts of impurities); 4) investigation of the effects of recycled gas injection on EOR and CO_2 storage performance; 5) history-matching of reservoir models; and 6) running of predictive simulations to aid in monitoring long-term behavior of injected CO_2.

Additional characterization data have been acquired in this reporting period to gain further insight into the static and dynamic nature of the Bell Creek Field subsurface environments. Seventeen PNLs were acquired in late 2015, providing baseline characterization data and delineation of fluid saturation changes (CO_2, water, and oil). Seismic data acquired in 2015 have enabled further geologic characterization and interpretation. The 2012, 2014, and 2015 surface seismic surveys show consistency and repeatability of geologic features (indicating the seismic data sets are reliable). Permeability barriers noted in amplitude summation maps (discussed in Burnison and others and Bosshart and others [13–14]) are shown clearly in time-lapse images of seismic difference volumes. The morphology of these features substantiates the revised interpretation of the erosional/depositional processes through which they were created. As noted in Bosshart and others (14), hydraulic connectivity appears to exist between Phase areas 1 and 2 (across the north–south incised channel permeability barrier) in 4-D seismic analyses. These analyses also suggest the presence of limited hydraulic connectivity between Phase Areas 1 and 3.

The data acquired over the last year have provided further verification of the revised understanding of Muddy Formation deposition at Bell Creek. Reservoir modeling efforts are focused on integrating this interpretation to create more accurate facies and petrophysical property distributions, enabling a better history match and more accurate predictive simulations (15).

Best Practices Manual – Site Characterization

The BPM for characterizing CO_2 storage targets (D35) has been extended to March 31, 2017, to include enhanced site characterization as approved on September 25, 2015. Work continued in PY9 on preparing the BPM with the current knowledge.

Training

EERC modeling staff attended the following training sessions:

- Attended the CMG-hosted Webinar on April 6, 2016, entitled "Advanced Parallelization Techniques to Optimize and Boost Simulator & Hardware Performance."

Task 5 – Well Drilling and Completion

The PCOR Partnership worked 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 was also evaluated.

The development of operational plans for the injection and recycling of CO_2 over the duration of the project was conducted. As 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 provided technical support for these activities; however, the actual drilling, completion, and/or reconditioning of injection and production wells was conducted by Denbury, while the EERC was 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 concluded in June 2014.

Activities and Results

The task concluded in BP4, PY7 (June 30, 2014).

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 the Bell Creek oil field for EOR. The infrastructure development for the Bell Creek test site will be performed by Denbury. EERC personnel will document the activities, interfacing with source facility engineers and vendors and providing assistance as requested.

Activities and Results

Accomplishments during PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) included the following.

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.

Regional CO_2 Emission Source Characterization

In September 2016, the annual update and quality assurance/quality control (QA/QC) of the CO_2 emission source master data spreadsheet were completed (performed in conjunction with Task 1).

Capture Technology Update

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 included 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 tree provides basic technical information about various capture technologies as well as development status, source type applicability, and economic information (when available). As a service to the PCOR Partnership partners, an update to the PCOR Partnership capture technologies overview report and its companion technology "tree" was initiated during PY7 and continued during PY8 and PY9. The update will be completed in PY10.

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 Manage 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* was the journal targeted for publication. Work on refining the manuscript continued throughout PY8. The draft article was included in a value-added report submitted and approved in October 2016 (PY9). The manuscript was submitted to *Energy & Environmental Science* in June 2016; however, the manuscript was rejected for publication. The manuscript is being retooled based on reviewer comments and will be submitted to another journal for possible publication. Currently, the most likely candidate journal is the *International Journal of Greenhouse Gas Control* (IJGGC).

The 2015 update to D85 "Opportunities and Challenges Associated with CO_2 Compression and Transport During CCS Activities" was completed in PY8. That update focused on the approaches to preparing CO_2 for transport (i.e., liquefaction followed by pumping, traditional gas compression techniques, or shockwave-based compression) and the efficient incorporation of compression into an integrated CCS system. The next update is due May 2017 (PY10).

Bell Creek Test Site Infrastructure Development

The EERC prepared a Bell Creek test site infrastructure development report in PY9 to summarize the key elements of infrastructure that are required to cost-effectively capture, compress, transport by pipeline, distribute, and inject CO_2 within an operating oil field as part of an EOR project with associated CO_2 storage. The EOR operation is a business activity, and much of the information is considered to be business-sensitive. With this in mind, the report was compiled exclusively using information that has previously been made public.

The CO_2 for the Bell Creek site is sourced from the ConocoPhillips Lost Cabin Gas Plant and the ExxonMobil Shute Creek Gas-Processing Facility. The Lost Cabin Gas Plant is located about 145 km (90 mi) west of Casper, Wyoming. The raw natural gas that is processed at the Lost Cabin plant comes from the Madden Field in the Wind River Basin in Wyoming. The raw natural gas contains approximately 67% methane, 20% CO_2, 12% hydrogen sulfide (H_2S), and 1% carbonyl sulfide (COS). A two-stage Selexol™ process is used to separate the acid gases H_2S and CO_2 from the methane, with the H_2S preferentially removed in the first stage and CO_2 removed in the second. The CO_2 stream that is produced by the Selexol process consists of roughly 1.4 million m^3/d (50 MMcfd) CO_2 with an average concentration of more than 98 vol% CO_2. This CO_2 was previously vented from the Lost Cabin Gas Plant but is now compressed to 15.2 MPa (2200 psi) and transported via Denbury's Greencore pipeline to the Bell Creek oil field.

The Shute Creek Gas-Processing Facility is located on the border between Lincoln and Sweetwater Counties in southwestern Wyoming. It processes raw natural gas produced from the LaBarge Madison Reservoir in Wyoming's Green River Basin that has a composition of approximately 65% CO_2, 22% methane, 7.4% nitrogen, 5% H_2S, and 0.6% helium. The raw natural gas is gathered at the nearby ExxonMobil Black Canyon facility where it is dehydrated to ensure safe pipeline transport over the 64 km (40 mi) to the Shute Creek Gas-Processing Facility. The Shute Creek Facility is the world's largest Selexol plant, containing two 2-stage Selexol trains in which the H_2S is removed in the first stage and the CO_2 is removed in the second stage. In addition to the Selexol process, the Shute Creek Gas-Processing Facility is the site of a commercial demonstration of the ExxonMobil Controlled Freeze Zone™ (CFZ™) CO_2 capture technology. The CFZ™ technology removes CO_2 and H_2S from natural gas in a distillation tower featuring a specially designed section in which CO_2 is allowed to freeze in a controlled manner. The Shute Creek Gas-Processing Facility produces about 65 MMcfd of CO_2 for compression to 12.1 MPa (1750 psi) and transport via the Anadarko and Greencore pipelines to the Bell Creek oil field in southeastern Montana. The average composition of this CO_2 stream is not publicly available.

The CO_2 from the Shute Creek Gas-Processing Facility is transported 258 km (160 mi) in the 324-mm (12.75-in.) Bairoil CO_2 pipeline until it ties into the 406-mm (16-in.) Anadarko pipeline for travel northeast 201 km (125 mi) to the Salt Creek Field near Casper, Wyoming. At the Salt Creek Field, the Anadarko pipeline ties into the Greencore pipeline. It is at this point that the CO_2 from the Shute Creek Gas-Processing Facility combines with the CO_2 from the Lost Cabin Gas Plant. The Greencore pipeline is approximately 373 km (232 mi) long. The pipeline was designed to be able to transport as much as 20.5 million m^3/d, or 38,150 t/d (725 MMcfd, or 42,053 short tons/d) of CO_2. The pipeline is 508 mm (20 in.) in diameter and was designed for a maximum operating pressure of 15.2 MPa (2200 psi). Steps taken when the pipeline was

constructed were standard pipeline construction sequence steps. Construction began in August 2011, and the pipeline was commissioned and started up in December 2012. The pipeline cost an estimated US$285 million.

Typical surface facilities at an oil field can produce oil, water, natural gas, CO_2, and H_2S. Each of these can be used on-site, injected or otherwise disposed of, or sold for use off-site. The specific products produced at any oil field depend on the level of processing. Initially, gas, oil, and water are separated from each other in a test separator. At the test separators and production separators, gas, oil, and water are separated and their flow rates monitored. Production separators separate the oil and water. Gas that is produced during the various separations is delivered to the CO_2 recovery plant. The level of processing of the recovered CO_2 varies based on economic and site-specific conditions, but there are three typical approaches: full-stream reinjection, which consists only of dehydration and compression; partial processing, which adds partial recovery of the C4+ hydrocarbons to full-stream reinjection; and full processing, in which natural gas liquids (NGLs) and methane are recovered and the CO_2 stream is recovered. Membranes can also be used in full processing, although CO_2 recovery from full processing typically involves cryogenic extractive distillation, also known as the Ryan–Holmes process. The most popular processing for CO_2 prior to reinjection is full-stream reinjection. The Bell Creek EOR facility follows a scheme in which the water and CO_2 that are separated from the oil are reinjected.

The methods used by Denbury to plan, construct, and operate the Greencore pipeline for EOR may also apply to CO_2 transport during a future CCS project. Likewise, the infrastructure utilized by the Bell Creek project and described in this report is the type of infrastructure required for any CCS project, although specific pieces may be different. While the Bell Creek project is a commercial EOR project rather than a CCS project, the data being collected during all of its phases will be invaluable in proving the usefulness of the CCS concept as a way to effectively decrease atmospheric CO_2 levels (16).

Conferences and Meetings

- Attended the American Institute of Chemical Engineers (AIChE) 2015 Annual Meeting held November 9–13, 2015, in Salt Lake City, Utah. Presented a talk entitled “The Effects of Variation in CO_2 Stream Composition and Flow Rate on Enhanced Oil Recovery and Geologic Storage” based on work that was originally performed under an IEAGHG R&D Programme contract with DOE cofunding, but the topic is also applicable to PCOR Partnership D45 (Bell Creek Test Site – Infrastructure Development Report). The information presented in Salt Lake City was updated for inclusion in D45. The DOE project manager for the IEAGHG–DOE project approved the presentation. At the conference, sessions on CO_2 capture and geologic storage were attended.

- By invitation, presented on CO_2 transport and worked as a mentor for the students at the IEAGHG CCS Summer School held July 17–23, 2016, in Regina, Saskatchewan, Canada.

- Attended the DOE NETL CO_2 Capture Technology Project Review Meeting on August 8–12, 2016, in Pittsburgh, Pennsylvania. Topics covered by the technical talks relevant to Task 6

included advances in technologies for pre- and postcombustion, oxycombustion, and compression.

Task 7 – CO_2 Procurement

This task documented CO_2 procurement procedures for CCS and EOR activities in the PCOR Partnership region. This task provided 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

The task concluded in PY6 BP4 (September 30, 2013).

Task 8 – Transportation and Injection Operations

This task consisted 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 did not cover activities for the Fort Nelson site.

Activities and Results

The task concluded in PY8 BP4 (September 30, 2015).

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 evaluating viable monitoring strategies for use in accounting for the injected CO_2 in conjunction with CO_2 EOR and storage projects.

Activities and Results

Accomplishments during PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) include the following.

Bell Creek Test Site

CO_2 Injection Continued

2.75 Mt of CO_2 Stored

Denbury is managing all injection, production, and recycle activities as part of its commercial CO_2 EOR operation. The EERC, through the PCOR Partnership, is studying the behavior of reservoir fluids and injected CO_2 to demonstrate safe and effective CO_2 storage associated with a commercial EOR project. The PCOR Partnership is developing practices and

technologies that will allow future commercial-scale CO_2 storage projects to make informed decisions regarding site selection, injection programs, operations, and monitoring strategies that maximize storage efficiency and effective storage capacity in clastic geologic formations.

Milestone (M) 58 marked that 2.75 Mt of associated CO_2 has been stored at the Bell Creek Field, which occurred in December 2015. The CO_2 is sourced from the Lost Cabin gas-processing facility, which processes gas from the Madden Field in the Wind River Basin of Wyoming, and the Shute Creek gas-processing facility, which processes gas from the LaBarge Field in the Green River Basin of Wyoming. Associated CO_2 storage volumes have been calculated on a monthly basis since the start of injection in May 2013 using custody transfer meter data supplied by Denbury and corrected using gas compositional data (17).

Injection and Production Data Acquisitions

Injection and production data are acquired and supplied separately from Denbury and are also made publicly available through the online MBOG database. The MBOG data are compiled, QA/QC-checked, and used to report CO_2 injection totals regularly to DOE. CO_2 injection and production data acquired from the Denbury database are used for data processing/interpretation for MVA-related activities and are integrated into Bell Creek simulation activities.

As of March 31, 2016, corresponding to the end of BP4, publicly available data were used to determine that cumulative total CO_2 gas injection was 4.86 Mt. This value represents the total gas volume injected, which includes purchase and recycle streams and is NOT corrected for a gas composition of approximately 98% CO_2.

As of March 31, 2016, corresponding to the end of BP4, 3.03 Mt of total gas (composition of approximately 98% CO_2) had been purchased for injection into the Bell Creek Field, equating to an estimated 2.98 Mt of CO_2 stored.

CO_2 injection continues at Bell Creek Field, and injection and storage numbers continue to be tracked. At the end of PY9, the publicly available data, through September 30, 2016, were used to determine that cumulative total CO_2 gas injection was 5.95 Mt. This value represents the total gas volume injected, which includes purchase and recycle streams and is NOT corrected for a gas composition of approximately 98% CO_2 (Table 10).

As of September 30, 2016, 3.37 Mt of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek Field, equating to an estimated 3.31 Mt of CO_2 stored (Table 11), with the difference comprising other trace gases in the purchase gas stream. A separate methodology from that used to calculate total gas injected was used to calculate a cumulative associated CO_2 storage volume estimate by correcting the gas purchase volume (approximately 98% CO_2) obtained from Denbury's custody transfer meter with gas compositional data. Cumulative CO_2 storage by month through September 2016 is shown in Figure 10.

Table 10. Bell Creek CO_2 Gas Injection Totals for September 2016 (cumulative totals May 2013 to July 2016)[1]

	September 2016 Injection
Total, Mscf	3,876,658
Total, tons[2]	221,739
Total, tonnes[2]	201,353
Cumulative Total, Mscf[2]	114,547,343
Cumulative Total, tons[2,3]	6,551,927
Cumulative Total, tonnes[2,3]	5,949,584

Source: MBOG database.

[1] There has been a lag in posting of injection/production volumes to the MBOG database. Total gas injection volumes are ***NOT CORRECTED*** for gas composition and include the combined purchased and recycled gas streams.

[2] This was calculated utilizing a conversion of 17.483 Mscf/ton and 19.253 Mscf/tonnes.

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

Table 11. Cumulative Total Gas Purchased and Estimated Associated CO_2 Storage Volumes for the Bell Creek Field[1]

	2016 Gas Volume
Monthly Total Gas Purchased, MMscf[2]	1613
Monthly Total Gas Purchased, million tons[2]	0.092
Monthly Total Gas Purchased, million tonnes[2]	0.084
Cumulative Total Gas Purchased, MMscf[2,3]	64,959
Cumulative Total Gas Purchased, million tons[2,3]	3.716
Cumulative Total Gas Purchased, million tonnes[2,3]	3.374
Cumulative Total CO_2 Stored, MMscf[3,4]	63,872
Cumulative Total CO_2 Stored, million tons[3,4]	3.653
Cumulative Total CO_2 Stored, million tonnes[3,4]	3.318

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

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

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

[4] Total CO_2 stored volumes are *CORRECTED* for gas composition.

Implementation of Monitoring Plan

Near-Surface Assurance Monitoring

Surface and shallow-subsurface water and soil gas chemistries, as well as the naturally occurring chemical variability within these systems, continued to be evaluated via collection and analysis of water and soil gas samples throughout the Bell Creek Field. The last planned full-field near-surface operational monitoring event was conducted October 26 – November 2, 2015.

The acquired data sets have provided key insight regarding how near-surface-research monitoring programs could be transitioned toward a more commercially viable long-term-assurance monitoring strategy. For example, workflows were developed to semiautomate the analysis and characterization process that could be adapted into site-specific intelligent monitoring

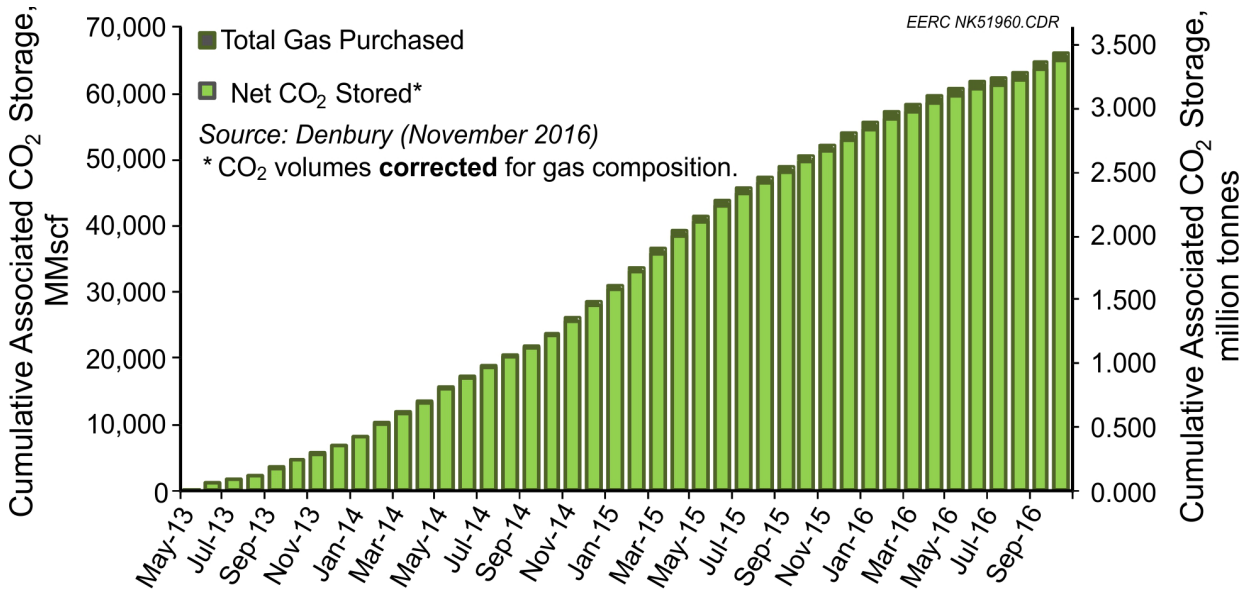


Figure 10. Cumulative total gas purchased and estimated associated CO_2 storage volumes for the Bell Creek Field.

approaches. Baseline data spanning an 18-month period prior to injection, supplemented by over 3 years of assurance monitoring data, have generated a defensible data set characterizing the natural variability of near-surface environments. The monitoring program has overall been sufficient to detect, characterize, and attribute multiple anomalies to naturally occurring processes and has successfully demonstrated no impact to near-surface environments. The methodology developed and lessons learned at Bell Creek will allow future CCUS operators to make informed decisions regarding site-specific monitoring programs at other commercial-scale injection sites throughout the region (18).

The team updated the internal, interactive database-driven map product with data from PY9 sampling events. Developed in PY7, the product is capable of querying, displaying, and enhancing rapid targeted comparison and interpretation of the large analytical data sets from near-surface monitoring data from both the baseline and operational monitoring periods to improve data accessibility and efficiency of analysis between project team members and stakeholders.

Year 4 of assurance monitoring tapered the frequency and samples with the Year 2 and 3 approaches of quarterly soil gas and water sampling and analysis. Within Phase 1 and the surrounding area, ten soil gas profile stations and two Fox Hills groundwater monitoring wells were sampled in May 2016 and July 2016. A release notification letter for the Fox Hills Formation monitoring wells was delivered to the landowner.

Working with Denbury, a plan was developed to collect periodic oil and gas samples from select wells in Phase Areas 1, 3, and 4. The plan was to collect an oil sample from select production wells approximately every 5–6 weeks for chemical compositional monitoring. Additional injection-phase near-surface monitoring activities included collection and analysis from the

incoming purchase supply as well as the recycled CO_2 streams to analyze gas composition. Specific collection dates of these samples are summarized in Table 12.

Minimum Miscibility Pressure Activities

A minimum miscibility pressure (MMP) paper entitled "Rapid and Simple Capillary-Rise/Vanishing Interfacial Tension Method to Determine Crude Oil Minimum Miscibility Pressure: Pure and Mixed CO_2, Methane, and Ethane" was formally accepted by *Energy and Fuels* after very minor revisions based on comments from the journal's reviewers. The paper provides a simplification and evaluation of the capillary-rise/vanishing interfacial tension method to measure MMP. Approximately 80 MMP values were measured and reported for Bell Creek and Bakken crude oil with pure and mixed CO_2, ethane, and methane. The paper has been formally published in the online and printed versions (19). The paper is also available via open access.

Deep MVA Program Activities

The primary purpose of deep subsurface monitoring is to track the movement of CO_2 in the subsurface in order to evaluate the performance of the reservoir with respect to CO_2 EOR and associated CO_2 storage and predict the ultimate fate of CO_2 injected into the storage reservoir. Additional benefits of the deep subsurface monitoring program include 1) early detection of

Table 12. Oil and CO_2 Gas Stream Sampling and Analyses[1]

		Production Stream by Development Phase, Well[1]							
		Phase 1				Phase 3			Phase 4
Date Sampled	Purchase/ Recycle	56-14R	32-02	05-06	04-04	28-02	21-10	21-14	34-09
Jan 2014		O	O	O					
Mar 2014		O	O						
May 2014	P	O	O	O					
Jun 2014	PR	O	O	O					
Jul 2014	PR	O	O	O					
Sep 2014	PR	OG	OG	O					
Oct 2014	PR	O	O						
Nov/Dec 2014		OG	OG	G					
Jan 2015[2]			O	OG					
Mar 2015		G	G	G					
Apr 2015	PR								
Jun 2015[2]		O	O	O					
Jul 2015	PR	G	G	G					
Sep 2015	PR								
Nov 2015[2]		O		O					
Jan 2016	PR								
Apr/May 2016[2]		O	O	O	O	O	O	O	
Jun/Jul 2016[2]	PR	O		O	O	O	O	O	
Aug/Sep 2016[2]		O	O		O	O	O	O	O

[1] P = purchase CO_2 gas stream, R = recycle CO_2 gas stream, O = produced oil stream, and G = produced CO_2 gas stream.
[2] Oil samples collected but not yet analyzed.

wellbore leakage or identification of potential leakage pathways that may require remediation; 2) identification of potential injectivity issues; and 3) the ability to monitor and account for injected CO_2 to monetize carbon credits, potentially offsetting project costs.

The PCOR Partnership deep subsurface MVA program utilizes a combination of technologies and techniques, such as pulsed-neutron tools, permanent downhole monitoring (PDM), 3-D VSP acquisition, InSAR, and production/injection data to measure reservoir changes during injection, track the vertical and lateral extent of fluid and CO_2 movement during the injection process, and account for injected CO_2. In PY9, the following activities were used to gather operational data for comparing to baseline data acquisitions and provide references in the field to monitor CO_2 as it moves between injectors and producers.

Injection-Phase PNL Activities

PNLs are acquired via wireline conveyance in conjunction with a crane truck. Logging operations require each well be sequentially taken off-line (production or injection) and take approximately 8 hours per well from rig up to rig down. Scheduling and acquisition are coordinated between Denbury, the EERC, and the logging service provider to allow for minimal impact to commercial CO_2 EOR operation (20).

PNLs provide a quantitative assessment of water, oil, and CO_2 saturations in the near-wellbore environment. PNL repeats were completed within and surrounding the Phase 1 development area to compare against baseline logs and monitor for vertical CO_2 migration in the near-wellbore environment and changes in water, oil, and gas saturations to evaluate conformance and storage efficiency as follows:

- Liquid–gas saturation from reservoir depth up to 200 ft of surface
- Water, oil, and CO_2 saturation over the Muddy Formation (storage reservoir)

An enhanced PNL campaign was proposed as part of a BP4 extension and completed in the fall of 2015. Logging was successfully completed in 17 of the 18 proposed wells in the Phase 1, 3, and 4 areas. Well 34-09 was planned but not logged because of an unknown restriction in the wellbore that was encountered, which prevented logging the zone of interest. Processed PNL data collected during the fall 2015 enhanced PNL campaign were received from Schlumberger. The PNL logs were imported into Petrel. Plans for a fall 2016 enhanced PNL campaign will be discussed with Denbury as part of the agenda of an October 17, 2016, update meeting in Plano, Texas.

Pressure and Temperature PDM Injection-Phase Activities

Real-time wellhead pressure, temperature, flow, and well test data (surface casing pressure, production casing pressure, flowline pressure, tubing pressure, mass flow, recycling volumes, and production volumes) were collected periodically for all active injection and production wells fieldwide. These measurements were accessed with permission from Denbury and will continue

to be collected during the operational phase of the project at the same frequency (20). The following activities were performed in PY9:

- Acquired and processed near-continuous data (5-minute intervals) since October 1, 2013, from three casing-conveyed downhole pressure and temperature gauges (05-06 OW):
  - Lower facies of the Muddy Sandstone
  - Upper facies of the Muddy Sandstone
  - Niobrara (thin sand lense within the primary seal)

- Acquired and processed near-continuous data (4-hour intervals) since October 1, 2013, from a fiber optic distributed-temperature system (05-06 OW):

  - 1-meter intervals from ~4700 ft to surface

- Details surrounding PDM data acquisition are summarized below:

  - Successfully installed replacement PROMORE 05-06 OW PTG interrogator (part of the PDM system), which was necessary because of persistent communication issues while downloading data. Sent the original interrogator that was replaced back to PROMORE as an exchange, and PROMORE will download and send the data from the replaced unit.

  - During maintenance of the Qorex system, a fault was identified in the interrogator system that appears to have been caused by an electrical short resulting in the system becoming nonoperational on November 4, 2015. The fiber-optic DTS (distributed temperature sensor) unit was repaired and returned to the EERC. The repaired unit was installed on March 23, 2016.

  - Traveled to the Bell Creek Field on July 11–13, 2016, to download DTS unit and MOREVision data, which included the following:

    - DTS data: March 23 – July 11, 2016 (these are the first acquired data since the unit was repaired March 23, 2016).
    - MOREVision data: October 31, 2015 – February 29, 2016 and March 23 – July 11, 2016.

  - QA/QC and data processing will continue into PY10.

    Injection-Phase Seismic Efforts

Preinjection baseline seismic surveys were acquired at Bell Creek in PY5 and PY6. An approximately 40-square-mile 3-D surface seismic survey was completed in September 2012. The main focus of this survey was for reservoir characterization and to provide a baseline for subsequent postinjection time-lapse surveys. Baseline 3-D VSPs were conducted in the 05-06 OW and 04-03 OW wells in May 2013. The VSPs were acquired with equipment consisting of a 60-level retrievable geophone array in the 05-06 OW well and a permanently installed 50-level

geophone array cemented into the 04-03 OW well. The VSP data were acquired to study the usefulness of VSPs in a CO_2 EOR context, provide a detailed subsurface characterization of the permeability barrier between Phase Areas 1 and 2, and as a baseline for subsequent time-lapse surveys that would provide seismic images of CO_2 saturation changes. Between seismic surveys, the permanently installed geophone array was used for passive seismic monitoring of the field starting in May 2013 (PY6) to May 2016 (PY9). Monitoring after May 2016 was periodic because of frequent equipment failures of the system.

Passive seismic monitoring using the borehole array at 04-03 OW continued into PY9. Passive monitoring involves recording 24 hours a day, 7 days a week to detect microseismic events that may occur within the field as a geomechanical response due to injection processes or larger seismic events originating outside the field. Routine hard drive swaps occurred every 6–8 weeks, as needed, when data drives filled. Periodic equipment failures interrupted continuous monitoring after May 2016.

To provide useful information, the passive monitoring data need to be sifted for the time, location, and magnitude of microseismic events. The first 13 months of passive data collected were processed by the contractor that installed the system. To address the volume of data collected since then, the EERC purchased a SuperMicro workstation with multiple hot-swap drive bays to handle the large amount of data collected and GeoTomo MiVu software capable of sifting for events and calculating their locations and magnitudes. A graduate student intern worked on processing the data for part of PY8, and a full-time staff person has been working on the data in PY9.

Expanded Baseline and Time-Lapse 3-D Surface Seismic Survey Completed

A campaign of 3-D surface seismic surveys was conducted at Bell Creek Field, consisting of three overlapping surveys to date. The initial 40-square-mile preinjection baseline survey was acquired in late 2012 and covered a large part of the oil field, including a significant buffer area outside the field boundary and was used to enhance the geologic characterization of the field. Two subsequent surveys have been acquired. The first was a 10.4-square-mile time-lapse survey shot in October 2014 and was primarily focused on obtaining a visualization of the CO_2 that had been injected in the Phase 1 area and the western part of the Phase 2 area. The result proved that CO_2 could be seen clearly in the relatively thin Muddy Formation reservoir using surface seismic and established that surface seismic at Bell Creek would serve a useful role as part of an overall MVA strategy to better understand CO_2 sweep efficiency, effective storage capacity, and vertical and lateral flow boundaries in the field. With this successful result, a subsequent survey was designed to expand the preinjection baseline to include the entirety of the Phase 4–6 areas and provide time-lapse coverage of the Phase 3 area and all of the Phase 2 area (Figure 11). The M53 report marked the completion of the expanded baseline and time-lapse 3-D surface seismic survey.

An expanded baseline and time-lapse 3-D survey was acquired by Geokinetics on August 20, 2015, and completed September 6, 2015. The survey consisted of 6622 receiver locations and 7512 source locations. Source energy was from two AHV-IV 60,000-pound Vibroseis units (Figure 12). Receivers were Sercel Unite nodes using three-component, 10-hertz geophones (Figure 13). Sweep and recording parameters matched previous surveys. The survey was acquired without incident. The field data were delivered (21). Interpretable data volumes were delivered in 2016.

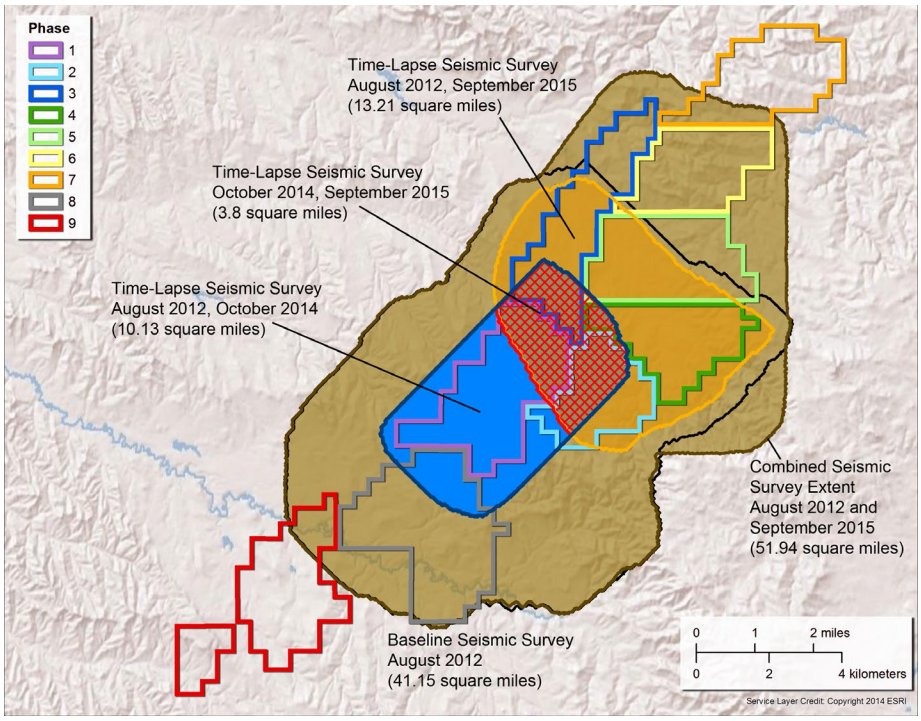


Figure 11. 3-D surface seismic surveys acquired at the Bell Creek Field as of September 2015.

Figure 12. Vibrators working in the southern portion of the expanded baseline survey area.

Figure 13. Nodal geophone assembly on station. From the top, a pin flag marking the surveyed receiver location, three-component geophone with leveling bubble, field battery, and Sercel Unite digital acquisition unit with GPS (global positioning system) antenna dome.

InSAR Processing and Analysis

Initial Processing and Analysis of Historic InSAR Data Completed

InSAR satellite data provide a series of images that can be used to detect subtle movements of the ground surface, known as deformation. Ground elevation measurements from InSAR data have the potential to detect changing reservoir pressure conditions by observing the deformation at the overlying surface.

The objectives for InSAR analysis at the Bell Creek Field are to 1) determine naturally occurring deformation rates prior to the start of field pressurization, 2) determine if deformation has occurred as a result of the injection of CO_2 and/or pressure maintenance prior to CO_2 injection, 3) attempt to identify swept and unswept areas of the field, 4) provide an estimate of injection volumes or pressure differentials required to produce measurable surface deformation, 5) evaluate the potential to use ground deformation and ground motion obtained from InSAR to calibrate geologic models, 6) identify fault activation or reactivation if present, 7) evaluate the applicability of InSAR as an areal monitoring technique with regard to unique challenges imposed by the environment and EOR activities, and 8) compare with data from existing and planned time-lapse 3-D seismic monitoring surveys and passive seismic monitoring as validation and to investigate InSAR as a technique to delineate field compartmentalization and monitor subsurface pressure plumes over large areas.

The InSAR analysis will be completed in two phases. The first phase consists of historical processing of lower resolution from an Advanced Land Observing Satellite (ALOS) data set prior to field pressurization. This phase will determine that ground deformation can be sufficiently detected and will identify natural historical ground movement. Pending proof of concept, the second phase will consist of using higher-resolution COSMO-SkyMed (CSK) satellite data during the operational phase during and after field pressurization. Initial processing and analysis of InSAR data are being provided by TRE Canada.

Initial processing and analysis of historic InSAR data have been completed, satisfying M54. Historical preinjection data covering an area of approximately 143 square miles, spanning the time period between January 13, 2007, through January 24, 2011, and incorporating 21 frames of archived InSAR data have been processed and analyzed to investigate naturally occurring ground deformation rates prior to the start of pressurization of the Bell Creek oil field. The objective of this work is to determine if the predicted ground deformation during field pressurization will likely be within the measurement resolution of the InSAR data. Initial analysis indicates regional stability with an average ground deformation during the preinjection period of −5.6 mm. Multiple anomalies with higher-than-average ground deformation were identified. Each of the anomalies was investigated and determined to be a direct result of agricultural soil tilling practices. Hence, these areas were cropped from the InSAR data set (Figure 14) and will not be included in further analysis. It is expected that fully processed, interpreted, and analyzed results for the baseline data set will be completed in February, followed by a determination of whether or not to proceed with the subsequent phase of operational monitoring (22).

A report outlining specific activities over the course of the Bell Creek demonstration project will be compiled into a monitoring for CO_2 storage and CO_2 EOR BPM (D51). This document will be developed as an effort to validate the CO_2 injected throughout the project as being safely stored with little risk of natural release. In PY9, the outline and structure of the BPM were developed. A list of lessons learned that will serve as the basis for further development of the BPM was compiled.

Reservoir Modeling

Attributes such as injectivity, fluid production, and reservoir dynamics are being 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 and updated in August 2012, August 2013, August 2014, August 2015, and August 2016 (D66). The 2016 update remains under review by Denbury and has not yet been finalized.

As part of the PCOR Partnership's AMA to developing the CO_2 storage program, modeling and numerical simulation activities continue toward the goal of providing a comprehensive assessment of associated CO_2 storage behavior. This goal, while not a new objective at Bell Creek Field, has been guiding recent efforts discussed in the 2016 update to D66 (work completed since August 2015). The overarching themes for the research discussed inthis report include 1) increasing our understanding of the subsurface of Bell Creek Field through the acquisition of new data and 2) modeling and simulation activities to achieve predictions of fluid flow, pressure

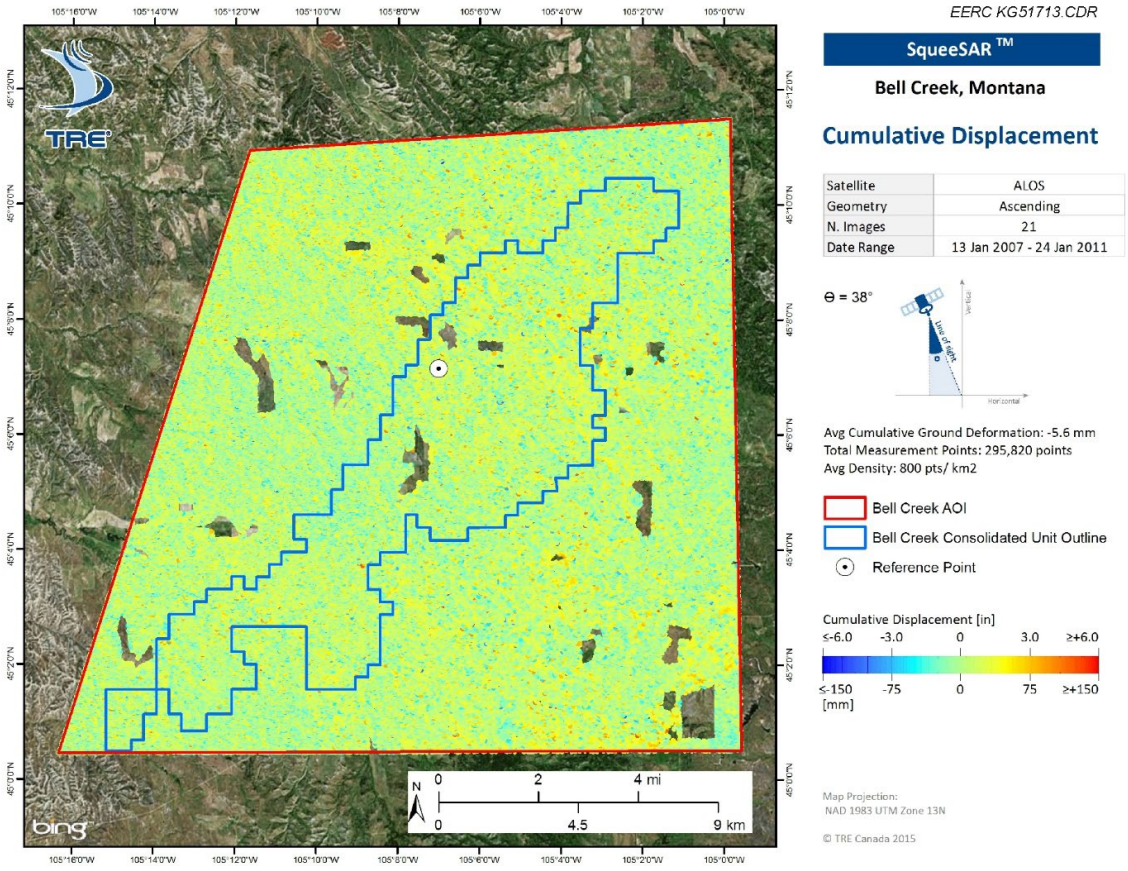


Figure 14. Map illustrating ground deformation based on historic InSAR data prior to start of pressurization of the Bell Creek Field (image source: TRE Canada).
Site Characterization, Modeling, and Monitoring Report

response, oil sweep and CO_2 storage efficiency, and determining the long-term fate of injected CO_2.

More specifically, discussion from this reporting period includes the 1) acquisition of new geologic characterization data, including PNLs and surface seismic data, to reduce uncertainty in model construction; 2) modeling of the reservoir and shallow subsurface aquifers, both within and surrounding the field, to provide the basis for numerical simulations of CO_2 injection; 3) development of a PVT model (to be applied in compositional simulations) to predict the miscibility behavior of the system with varying injection gas compositions (i.e., recycled gas injection, CO_2 with varying amounts of impurities); 4) investigation of the effects of recycled gas injection on EOR and CO_2 storage performance; 5) history-matching of reservoir models; and 6) running of predictive simulations to aid in monitoring long-term behavior of injected CO_2.

Additional characterization data have been acquired in this reporting period to gain further insight into the static and dynamic nature of the Bell Creek Field subsurface environments. Seventeen PNLs were acquired in late 2015, providing baseline characterization data and delineation of fluid saturation changes (CO_2, water, and oil). Seismic data acquired in 2015 have

enabled further geologic characterization and interpretation. The 2012, 2014, and 2015 surface seismic surveys show consistency and repeatability of geologic features (indicating the seismic data sets are reliable). Permeability barriers noted in amplitude summation maps (discussed in Burnison and others and Bosshart and others [13–14]) are shown clearly in time-lapse images of seismic difference volumes. The morphology of these features substantiates the revised interpretation of the erosional/depositional processes through which they were created. As noted in Bosshart and others (14), hydraulic connectivity appears to exist between the Phase 1 and 2 areas (across the north–south incised channel permeability barrier) in 4-D seismic analyses. These analyses also suggest the presence of limited hydraulic connectivity between the Phase 1 and 3 areas.

The data acquired over the last year have provided further verification of the revised understanding of Muddy Formation deposition at Bell Creek. Reservoir modeling efforts are focused on integrating this interpretation to create more accurate facies and petrophysical property distributions, enabling a better history match and more accurate predictive simulations.

Regional-scale, basin-scale, and near-surface (shallow aquifer) models were constructed to determine the long-term CO_2 migration potential in the greater Bell Creek Field region. The regional- and basin-scale models were developed to assess CO_2 migration potential in the reservoir interval, while the near-surface model was developed to investigate CO_2 migration potential in Bell Creek's shallow aquifers (Fox Hills and Hell Creek Formations). To clarify, there is no evidence of unintended CO_2 saturation in shallow aquifer units or any regions outside of the field, nor any reason to believe this will ever be the case. These investigations aim to inform where MVA efforts may best be implemented for rapid detection and response. These models have not yet been subjected to simulation efforts.

Three simulation models with different scales (quarter five-spot, subphase-, and phase-scale) and a nine-component PVT model were developed to simulate the impact of impurities on recycled gas EOR and CO_2 storage performance. Impurities in Bell Creek produced gas samples were analyzed to provide data necessary for these simulations. Results showed methane (CH_4) was the main impurity, which varied from 1 to 4 mol%, and the quantity of impurities appears to be decreasing as the CO_2 flood continues. A series of MMP measurements were conducted for the Bell Creek oil and CH_4–CO_2 mixtures under reservoir conditions using the vanishing interfacial tension (VIT) method, which produced similar results to the slim-tube method (but the testing was faster and more cost-effective). The measured MMPs of the Bell Creek oil increased from 1403 to 4085 psi as the CH_4 mol% increased from 0% to 100% in the solvent phase (19). The recycled gas EOR simulations performed with the new PVT model discussed above indicated a range of impurities (up to 30 mol%) can be tolerated in the recycled gas without significant impairment of EOR efficiency or CO_2 storage performance.

A simulation model encompassing the Phase 3–7 areas was also constructed for investigation of long-term CO_2 migration behavior. Two case studies were simulated considering the effects of fluid density differences (buoyancy) within the reservoir's geologic structure. These cases simulated a 5000-year interval and showed that CO_2 migration (under the effects of buoyancy only) would be a slow process in the Bell Creek Field, around 3 ft/year to the east–southeast. However, these simulations excluded the effects of mineral trapping, the pinchout of reservoir quality sand updip of the field, and natural hydrodynamics operating in the direction opposite to

the CO_2 migration vector. These additional factors would likely further hinder CO_2 migration potential, suggesting that injected CO_2 is likely to remain contained within the field for thousands of years (15).

Life Cycle Assessments

Life cycle assessments (LCAs) of crude oils, also known as net carbon negative oil assessments, will be performed on 1) the oil being produced at Bell Creek during EOR activities and 2) oil produced during primary and secondary recovery (either from Bell Creek or a comparable field). A broad view of environmental issues will be assessed through the compilation of an inventory of relevant material and energy inputs and releases to the environment, evaluation of potential impacts, and interpretation of results. The results of these assessments will be presented in a topical report (D105).

Life Cycle Analysis for Primary and Secondary Recovery Oil

The EERC worked with the CETER Group, Inc., through the PCOR Partnership to apply LCA methodology in determining if oil produced by EOR using anthropogenic CO_2 omits less CO_2 than conventionally produced oil. LCAs evaluate the environmental impacts associated with each stage of a product's life, from raw material procurement and processing to distribution, use, and disposal or recycling.

Using information provided by Denbury Resources Inc. as well as in-house PCOR Partnership data, an LCA of oil produced during primary and secondary recovery (i.e., conventional oil production) is being performed. A second LCA will be performed for oil produced during EOR activities at the Bell Creek Field in southeastern Montana. The Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model, known as the GREET model, will be used for both LCAs. The resulting CO_2 footprints will then be compared to highlight any differences between conventional oil production and EOR.

Published literature has shown that other LCA methodologies result in cost and/or emission results that are not the same as those obtained using the GREET model. Therefore, a different methodology is being used to repeat the LCAs for the two oil production scenarios to assess any variances in the models' results. This approach will also provide an indication of the range of CO_2 emissions that could be expected for the two scenarios.

This project originally intended to construct two simulations based upon default information contained within the GREET model. The first simulation was to mimic representative North American natural gas processing and U.S. primary and secondary petroleum recovery and processing, while the second simulation was to depict representative North American natural gas processing with CO_2 capture and U.S. EOR and processing using the captured CO_2. Each simulation was to consist of three major steps: 1) natural gas recovery and processing; 2) petroleum recovery and processing; and 3) transportation, storage, and refining of petroleum and petroleum products. The GREET model posed a few challenges to its use for performing LCAs for these situations:

- The structure of and defaults within the GREET model do not permit linkage of natural gas-processing rates with petroleum recovery and processing rates, other than small amounts consumed by oil equipment when recovering and processing crude oil.

- The model's structure does not provide for production of simultaneous multiple main products (CO_2, sulfur, and pipeline-quality natural gas) from processing of the raw natural gas.

- The model lacks predefined pathways, processes, and default values that would allow CO_2 captured from raw natural gas to feed directly to an EOR petroleum recovery operation.

The result of these challenges was that default EOR crude oil recovery and processing simulation information did not exist within the GREET model; thus it was not possible to construct the second simulation.

The first simulation that was constructed contains processes describing emissions related to U.S. crude oil recovery, processing, transportation, and refining into six major U.S. petroleum refinery products. The simulation also contains emissions related to North American recovery and processing of conventional and shale natural gas. Default values contained within GREET were adopted to estimate emissions. The GREET model contained pathways for six refined products (residual oil, petroleum coke, liquefied petroleum gas, low-sulfur diesel, gasoline blendstock, and conventional jet fuel) that are representative of U.S. refined products. Additional GREET-related activities initiated during this reporting period were focused on preparing resources and processes that would be incorporated into the Lost Cabin- and Bell Creek-specific emission models.

To provide a comparison to the GREET results, a second model was built for the two natural gas and oil production systems that are the subject of the GREET modeling effort. This model is Microsoft Excel® spreadsheet-based, and it works from upstream to downstream segments using line-by-line calculations in an accounting-style ledger to estimate the emissions of the greenhouse gases CO_2, methane, and nitrous oxide.

The first spreadsheet model, called the System 1 model, includes conventional natural gas extraction and processing as well as conventional crude oil extraction, transport, refining, and combustion. In this model, natural gas leaves the system boundary, so its end use is not part of the accounting. Rather, the model accounts for the natural gas as a coproduct in the natural gas–oil system. The second model, called the System 2 model, includes conventional natural gas extraction and processing; capture of CO_2 during natural gas processing; transport of the CO_2 to the CO_2 EOR field by pipeline; CO_2 EOR gate-to-gate processes for crude oil extraction; and downstream segments for crude oil transport, refining, and combustion.

The spreadsheet model totals the GHG emissions for the components from each system and compares the total GHG emission between System 1 and System 2. The difference, or "delta," between Systems 1 and 2 represents the change in life cycle GHG emissions between conventional oil production and a system of CO_2 EOR where the CO_2 is sourced from a natural gas-processing facility by capturing vented CO_2. Preliminary results indicate that sourcing the CO_2 from a natural

gas-processing facility for EOR results in an overall emission reduction of approximately 15% (about 477 million kg CO_2 from a total of 3.15 billion kg CO_2) when compared to conventional oil production (23).

Life Cycle Analysis for Primary and Secondary Enhanced Oil Recovery at the Bell Creek Field

Using information provided by Denbury as well as in-house PCOR Partnership data, two LCAs are being performed: the first of oil produced during primary and secondary recovery (i.e., conventional oil production) and the second for oil produced during EOR activities at the Bell Creek Field in southeastern Montana. The Argonne National Laboratory GREET model is being used for both LCAs. Published literature has shown that other LCA methodologies result in cost and/or emission results that are not the same as those obtained using the GREET model. Therefore, a different methodology is being used to repeat the LCAs for the two oil production scenarios to assess any variances in the models' results. The resulting CO_2 footprints will then be compared to highlight any differences between the two scenarios (i.e., conventional oil production vs. EOR). The information will be invaluable to the U.S. DOE and Denbury because it offers an objective determination of the CO_2 emission differences between oil produced during EOR and non-EOR activities.

Specific information for the Lost Cabin and Shute Creek gas-processing plants and the Bell Creek Field operation was collected for incorporation into the LCA framework that was developed in GREET and a spreadsheet model for M56. The integration of Bell Creek-specific information will produce an estimate of the actual CO_2 emission advantages associated with EOR using anthropogenic CO_2 at the Bell Creek Field (24). The results are being compiled into LCA topical report entitled "Comparison of Non-EOR and EOR Life Cycle Assessments" (D105) to be submitted in October 2016 (PY10).

International Journal of Greenhouse Gas Control LCA Article

The work performed under the LCA task was published in an IJGCC journal article entitled "How Green Is My Oil? A Detailed Look at Greenhouse Gas Accounting for CO_2 Enhanced Oil Recovery (CO_2 EOR) Sites" on June 21, 2016 (25). The authors include Nicholas A. Azzolina and David V. Nakles of CETER; Wesley D. Peck, John A. Hamling, Charles D. Gorecki, Scott C. Ayash, and Thomas E. Doll of the EERC; and L. Stephen Melzer of Melzer Consulting. A CO_2 EOR LCA model for the article submitted to the IJGCC was added as a page to the public PCOR Partnership Web site, which went live July 21, 2016.

Fort Nelson Test Site

Spectra has currently suspended activities on the Fort Nelson CCS Feasibility Project pending the development of an economically viable business model for implementation. The Fort Nelson test site subtask was eliminated, effective October 2015.

Modeling Training Courses

EERC modeling staff attended the following training sessions:

- Linux training led by Guru Labs at the EERC November 2–6, 2015. The purpose of this training was to better understand the Linux operating system that is installed on the geophysics processing workstation, improving efficiency when using the workstation. Several staff members working on the Bell Creek project attended.

- The CMG Webinar "The Role of Coupled Geomechanical Modelling in Reservoir Simulation" on Wednesday, November 18, 2015.

- The 2015 IEAGHG R&D Carbon Capture and Storage Summer School held December 6–12, 2015, in Perth, Australia.

- The American Rock Mechanics Association (ARMA) Symposium in Houston, Texas, June 26–29, 2016, as well as workshops June 24–25, 2016.

- The IEAGHG International Interdisciplinary Carbon Capture & Sequestration Summer School in Regina, Saskatchewan, July 16–24, 2016.

Additional Conference/Meeting Participation

- Participated in the Research Partnership to Secure Energy for America (RPSEA) Interactive Workshop Focusing on Induced Seismicity held November 3–5, 2015, in Houston, Texas.

- Attended and presented at the AIChE 2015 Annual Meeting held November 9–13, 2015, in Salt Lake City, Utah.

- Attended the Carbon Management Technology Conference held November 17–19, 2015, in Sugar Land, Texas.

- Attended the Global CCS Institute Webinar "Lessons Learned on CO_2 Storage from the Midwest Regional Carbon Sequestration Partnership Program," hosted by Battelle on December 8, 2015.

- Attended CO_2 Conference Week held December 8–11, 2015, in Midland, Texas, and presented "Laboratory Studies of MMP and Hydrocarbon Mobilization in Conventional and Bakken Plays Using CO_2, Methane, and Ethane" during Theme Session 3: "CO_2 Flooding Case Histories."

- Attended the WBPC Annual Meeting in Bismarck, North Dakota, on May 24–26, 2016. Attendance was focused on PCOR Partnership outreach, identifying CCS opportunities within the PCOR Partnership region, and identifying technology providers and vendors with applications to CCS.

- Attended CMG's 37th Technical Symposium held June 13–14, 2016, in Calgary, Alberta, Canada. Presented on Bell Creek simulation and history matching in a presentation entitled "A Systematic Simulation Study of CO_2 Flooding in the Bell Creek Oil Field."

- Presented "Adaptive Approach to Modeling and Monitoring 5 million tonnes of CO_2 Injection at the Bell Creek Oil Field" at the IEAGHG Modelling and Monitoring Network Meeting held July 7–8, 2016, in Edinburgh, Scotland.

- Presented at the IEAGHG International Interdisciplinary Carbon Capture & Sequestration Summer School in Regina, Saskatchewan, July 16–24, 2016.

DOE Carbon Storage Project BPMs

The PCOR Partnership is playing an active part in the revision/redevelopment of DOE Carbon Storage Project BPMs. Three DOE BPMs are relevant to PCOR Partnership Task 9 activities. These BPMs are expected to be completed in 2016 or 2017. The following activities were performed in PY9.

PCOR Partnership personnel participation continued for the update of the DOE Best Practices for Monitoring, Verification, and Accounting of CO_2 Stored in Deep Geologic Formations (last updated in 2012). Personnel participated in conference calls discussing the BPM. An image and caption illustrating a Bell Creek 4-D seismic amplitude test were sent for inclusion in this BPM. PCOR Partnership personnel submitted five call-out boxes (or sidebars) based on PCOR Partnership project experiences for possible inclusion in this BPM:

- Pulsed-Neutron Log Use Within an MVA Program

- Using Near-Real-Time History Matching to Guide MVA Deployment

- Designing an MVA Program to Reduce Risk and Meet Regulatory Requirements

- PNL and Seismic Monitoring Integration for Risk Reduction

- Periodic Surface 3-D Seismic Surveys

PCOR Partnership personnel participation continued for the DOE Carbon Storage Systems and Well Management Systems BPM. Personnel participated in conference calls discussing the BPM. Revisions to the BPM were reviewed and commented upon. The PCOR Partnership revised and submitted Chapter 5 – Injection Operations. Included were three PCOR Partnership-related call-out boxes entitled Formation Pressure Testing for Reservoir Analysis; Landowner Relations; and Consideration of Wildlife During CCS Project Planning. Final revisions were submitted to the BPM lead on April 1, 2016. Cover photo selections were submitted to the BPM lead on June 15, 2016.

PCOR Partnership personnel participated in Webinars and conference calls for the DOE Risk Analysis and Simulation for Geologic Storage of CO_2 BPM, which was last updated in 2013.

PCOR Partnership participants reviewed and provided comments on the BPM as revisions continued. Suggestions for cover images were provided.

Task 10 – Site Closure

Because demonstration tests are expected to be performed at ongoing commercial operations, it is anticipated that site closure will occur beyond the scope of the Phase III effort. However, research will be conducted with regard to site closure practices that would be applicable for this type of operation.

Activities and Results

Task 10 was initiated on April 1, 2016, with the start of BP5. A report that outlines the procedures that would be necessary to close a site similar to this project will be prepared. The report will include postinjection monitoring techniques, mitigation summaries, methods to evaluate project effectiveness, and final abandonment procedures.

Task 11 – Postinjection Monitoring and Modeling

Commercial CO_2 injection and oil production operations will continue at the test sites beyond the scope of the Phase III effort. Monitoring and modeling of the sites should also continue beyond that time frame, if possible. To maximize the effectiveness of such a program, this task will use the data generated by the site characterization and monitoring activities to provide 1) the technical interpretation of the Bell Creek monitoring plan results; 2) the long-term strategy for monitoring the site; and 3) verification and applicability of selected monitoring techniques for the site.

Activities and Results

Task 11 was initiated on April 1, 2016, with the start of BP5. Accomplishments during BP5 (April 1, 2016 – September 30, 2016) are addressed as follows.

Development of a Cost-Effective, Long-Term Monitoring Strategy

The Bell Creek oil field is operated by Denbury as a commercial EOR project which provides an opportunity to improve the understanding of associated CO_2 storage that occurs as a natural part of the EOR process as well as provides a large-scale CO_2 injection site that can be used to inform carbon storage in deep saline formations (DSFs). The PCOR Partnership Bell Creek project, which is conducted in collaboration with the commercial project, provides a substantive opportunity for the validation of viable MVA strategies with applicability to both large-scale carbon storage in DSFs and associated carbon storage through EOR. In collaboration with Denbury, a 5-year research MVA program was conducted to demonstrate 16 MVA techniques with applications to geologic CO_2 storage scenarios. The program represents 1.5 years of preinjection and over 3 years of operational MVA activities coinciding with the first 3.2 million tons of associated CO_2 storage.

Every carbon storage project presents unique technical, operational, and performance conditions. However, typical monitoring criteria are likely to include demonstration of secure storage; tracking the vertical and lateral migration of fluids and pressure; improving long-term performance forecasts of storage capacity, efficiency, and utilization; informing operational improvements; and understanding of the long-term distribution and containment of injected CO_2. The research MVA program was designed to evaluate the adequacy of monitoring techniques for addressing identified technical risks common to nearly all CO_2 storage applications. An AMA was used to integrate components of the MVA program with site characterization, modeling and simulation, and technical risk assessment. This integration provided experience and insights regarding the additional ancillary value that each demonstrated MVA technique provides to a commercial injection project.

Established CO_2 injection projects, whether via EOR or in DSFs, are expected to operate for decades. The Bell Creek project, with a significant production and CO_2 injection history, comprehensive characterization of the field, extensive MVA program, and validated robust performance forecast capabilities, now serves as an excellent representation of an established commercial-scale CO_2 injection project. Established projects are characterized by a reduction in technical risks and a resulting shift in MVA focus to guiding cost-effective performance improvements and conformance monitoring. This rare combination of features provides an opportunity to demonstrate the cost–benefit of viable long-term MVA strategies applicable to commercial carbon storage. Insights derived from the research MVA program regarding the value and limitations of MVA data integration along with the process and concepts that will be used to develop these long-term strategies are described.

The research-monitoring program conducted at Bell Creek has resulted in several key insights into cost-effective, long-term monitoring for commercial-scale CO_2 storage projects. No single monitoring technique is capable of addressing all monitoring criteria throughout the stratigraphic column from the storage complex to the surface. However, when techniques are combined into a monitoring strategy that is integrated as part of an AMA, the resulting strategy can not only address the required monitoring criteria but also provide a means of evaluating and enhancing project performance.

Techniques that avoid adverse operational or health, safety, and environmental impacts and/or possess streamlined processing and interpretation that can inform near-real-time operational decisions are preferred. Monitoring techniques that allow data to be acquired and interpreted autonomously or remotely and with minimal technical field personnel are also desirable. Techniques that can improve storage or utilization performance and can cost-efficiently complement, replace, or guide more robust but less timely solutions also hold an advantage.

A long-term, cost-effective strategy for MVA of associated CO_2 storage at the Bell Creek Field that leverages commercial data, insights provided by the research-monitoring program, and the AMA are being evaluated. Several new and established low-impact and/or high-value techniques will be demonstrated to better define specific benefits, impacts, and costs associated with MVA at an established commercial CO_2 injection site. These techniques include PNL fluid saturation profiles, time-lapse seismic surveys, InSAR (ground deformation monitoring), produced fluid sampling, pressure/temperature, and production/injection data.

Insights provided through the Bell Creek project and investigation into a long-term monitoring plan have resulted in an ongoing field demonstration of two emerging geophysical techniques, the Krauklis seismic wave (K-wave) and scalable, automated, semipermanent seismic array (SASSA), through complementary projects. These techniques show promise for providing more cost-efficient, lower-impact, near-real-time solutions for long-term monitoring. If proven successful, these techniques will provide additional techniques compatible with long-term monitoring strategies. While the development of a long-term monitoring plan for the Bell Creek project will take into consideration specific operations and benefits to the project, the case study will provide recommendations that are expected to be broadly applicable for commercial carbon storage projects throughout the PCOR Partnership region and the wider deployment of CCS (26).

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 PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) include the following.

An assessment was conducted for the tasks during the period October 1, 2014 – September 30, 2015. A project assessment annual report (D57) was submitted on December 31, 2015.

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 PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) 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 PY9, one modification to the contract was issued.

The EERC received DOE Cooperative Agreement Amendment 34 effective March 31, 2016. The amendment authorized the following:

- Provided authorization to proceed with BP5 from April 1, 2016, to September 30, 2017.
- Awarded and funded an additional amount of $9,668,307 for work to be completed during BP5.
- Increased the originally projected cost share to be received for BP5 by $3,294,118, from $2,417,076, to $5,711,194.
- Incorporated a revised budget for BP5.
- Incorporated a revised Statement of Project Objectives as follows:
  - Modified Objective 5.
  - Updated the Statement of Work to reflect the discontinuation of the Fort Nelson site as the second demonstration site. It also noted that efforts were transitioned to the Aquistore project.
  - Modified terminology.
  - Added M60 (Data Submitted to EDX) to report the EDX submissions due February 2017 and September 2018.
  - Updated Subtask 4.32 – Bell Creek Test Site Baseline Geology Determination to reflect baseline work being performed in Phases 1–4, not limited to Phase 1.
  - Modified the overall goal for Task 9 to correlate with the modified objective.
  - Eliminated the Fort Nelson test site Subtask 9.2.2 – Implementation of Monitoring Plan, effective October 2015, since the demonstration was suspended.
  - Modified Subtask 9.2.3 – Site Characterization, Modeling, and Monitoring Report to reference that modeling efforts were initiated and reported, but the remainder of the task could not be performed under the circumstances.
  - Modified the Task 10 introductory paragraph.

- Changed the Task 11 introduction paragraph to reflect the updated scope of work.

- Changed the Subtask 11.1 title from Bell Creek Test Site to Postinjection Monitoring and Modeling.

- Changed the Subtask 11.1.1 title from Interpretation of Phase III Monitoring for the Bell Creek Test to Interpretation of Phase III Modeling Results.

- Removed the phrase "for the Bell Creek Test" from the Subtask 11.1.2 title, leaving it as Development of Cost-Effective Long-Term Monitoring Strategy.

- Changed the Subtask 11.1.3 title from Testing of Cost-Effective Long-Term Monitoring Strategy for the Bell Creek Test Site to Evaluation of Long-Term Monitoring Strategies.

- Altered the text of Subtask 11.1.3 to encompass the change of scope.

- Eliminated Subtask 11.2 – Fort Nelson Test Site, effective October 2015.

- Removed "BC Test Site –" from the title of D73.

- Added a conversion from monthly to quarterly conference calls in BP5 in Subtask 14.1.1 – Coordinate Monthly Conference Calls.

- Added Subtask 14.1.5 – Publication of Special Issue of *International Journal of Greenhouse Gas Control*. Added the associated deliverable (D106, Special Issue of IJGCC – Nexus of Water and Carbon Capture and Storage) due December 2016.

- Noted the stop of Subtask 14.5 – Best Practice Manual in September 2015 and the removal of D80.

- Added Subtask 14.6 – Major Research Focuses for Water and CCS. Added D107 (Journal Article of Topical Report – Major Research Focuses for Water and CCS) due February 2018.

Project Management Plan

Revisions to the plan are under way and will be submitted in PY10.

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 PY9, the 14th partner meeting (the 13th meeting that included project results) was held.

The 2016 PCOR Partnership Annual Membership Meeting was held September 14 and 15, 2016, in Grand Forks, North Dakota, at the EERC. A Premeeting Workshop was held prior to the meeting on September 13, 2016. The workshop and meeting attracted 125 attendees (64 partners, presenters, or guests and 61 EERC employees) representing 49 organizations from 10 states, the District of Columbia, and four Canadian provinces (Figure 15). The workshop featured presentations on CO_2 capture technology and laboratory-based geologic characterization for CO_2 storage and provided tours to highlight the EERC's CO_2 capture pilot facility, mineralogy/core characterization, geomechanical characterization, and gas/fluid characterization capabilities. The meeting presentations pertained to current PCOR Partnership activities and lessons learned from the PCOR Partnership Program. PCOR Partnership partners presented on related CO_2 storage activities in the region. The presentations from the meeting and workshop are now available in the Products Database of the Partners-Only Web site. As shown in Table 13, the PCOR Partnership still garners significant interest from its varied members. Hosting the annual meeting at the EERC allowed for the participation of a greater number of PCOR Partnership team members and EERC employees.

Figure 15. Attendees at the PCOR Partnership 2016 Annual Membership Meeting held September 14 and 15, 2016, in Grand Forks, North Dakota.

Table 13. Participation Numbers, Including the Average, from the Past Eight Annual Meetings

Year	2009	2010	2011	2012	2013	2014	2015	2016	Average
Attendees	84	74	83	84	88	86	71	125	87
Organizations	50	45	42	51	46	52	40	49	47
U.S. States	14	15	12	15	15	14	13	10	14
District of Columbia	Y	Y	Y	Y	Y	Y	Y	Y	Y
Canadian Provinces	5	4	4	4	3	3	2	4	4
Other Foreign Countries	Sweden			England					

Best Practice for the Commercial Deployment of Carbon Dioxide Geologic Storage: Adaptive Management Approach

The RCSP Program is focused on advancing the state of the science of carbon capture and storage. To that end, the PCOR Partnership has spent over 10 years developing, testing, and validating the best methods and technologies to conduct the activities required for the geologic storage of CO_2. Through this effort, the PCOR Partnership has formalized an AMA for the commercial development of CO_2 geologic storage projects (Figure 16). The use of this approach, which draws upon the collective experience and lessons learned of the PCOR Partnership, represents a best practice for advancing CO_2 geologic storage projects toward commercial deployment.

At the heart of the AMA are four primary technical activities necessary for any successful CO_2 storage project, namely, site characterization, modeling and simulation, risk assessment, and MVA. Each of these activities plays a key role in gathering site-specific data unique to the development of each project. Collectively, these data contribute to an overall knowledge and understanding of the storage site and its performance. While each of the four technical activities provide useful data in their own right, it is their integration through the AMA that yields a streamlined, fit-for-purpose strategy for the commercial deployment of the geologic storage of CO_2. Key to this successful integration and the best practice are feedback loops

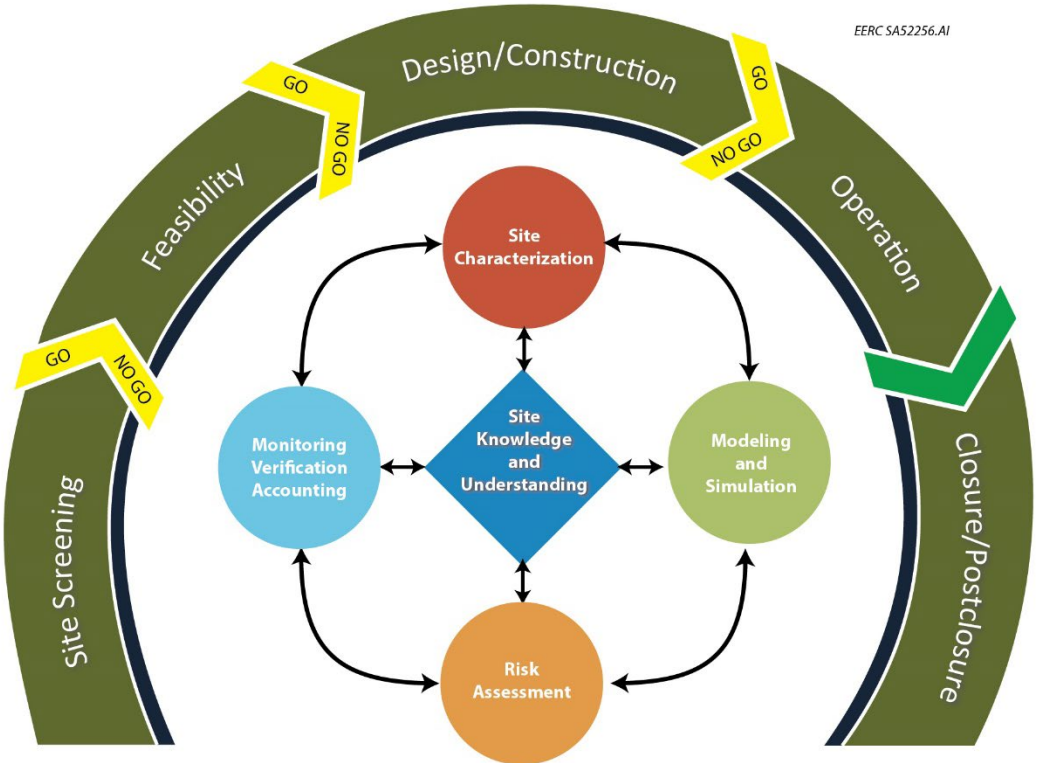


Figure 16. The PCOR Partnership's AMA for the development of CO_2 geologic storage (GS) projects.

that allow the results of each activity to serve as inputs to the others. Each iteration of the AMA creates an improved understanding of the overall storage complex and thus more targeted and accurate application of the technical activities. In order to move a potential CO_2 geologic storage project down the pathway to commercial-scale implementation, the AMA must incorporate a series of development phases. These phases consist of site screening, feasibility, design, construction/operation, and closure/postclosure. Each phase has specific questions guided by technical, economic, and regulatory factors that should be addressed in order to advance to the next stage of development. The early development phases (site screening, feasibility, and design) are separated by go/no-go decision points that allow the project's developer to determine if the project should advance to the next phase. The AMA provides the necessary framework to gather the data needed to answer the questions at each phase and move the project to commercial deployment.

Currently, CO_2 geologic storage is focused on two primary applications: CO_2 storage in saline formations and storage associated with commercial CO_2 EOR. Although some key differences exist between these applications, the PCOR Partnership's AMA can be used to successfully advance projects in either application. Examples of this versatility can be seen by looking at two of the PCOR Partnership's large-scale (target injection of 1 Mt of CO_2 or more) demonstration projects: the Fort Nelson feasibility study and the Bell Creek Project. The Fort Nelson project, which sought to inject up to 2 Mt per year into a saline formation, clearly demonstrates the value of the AMA's integrated approach. The first round of the AMA for this project highlighted the fact that the original project design created a high risk of impacting nearby commercial gas production. As a result, the preliminary design was modified based on the increased site knowledge and understanding that resulted from applying the AMA. A second iteration of the AMA revealed that the revised project design successfully lowered the risk profile to acceptable levels. The ongoing Bell Creek Project is using the AMA to direct the investigation of CO_2 geologic storage associated with an oil field undergoing CO_2 EOR. The PCOR Partnership's application of the AMA at Bell Creek has been implemented at the design and operation phases of the project.

The examples provided by these case studies, as well as the completion of other, related work by the PCOR Partnership, highlights the successful application of the AMA as a best practice for implementing an integrated, fit-for-purpose approach for the commercial deployment of geologic CO_2 storage (27).

A copy of the BPM (D102/M59) was sent to each TAB member for concurrent review with DOE. Once all comments from TAB have been received, a revised version of the document will be issued.

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 OWG and WWG took part in scheduled conference calls.

- PCOR Partnership personnel attended a regional partnership annual meeting, the 2016 Midwest Carbon Sequestration Science Conference in Champaign, Illinois, May 16–17, 2016. The PCOR Partnership program manager presented a "Lessons Learned" PowerPoint presentation in a panel discussion.

- On December 2–3, 2015, a task manager attended the North American Energy Ministers (NAEM) Climate Change and Energy Collaboration meeting held in Austin, Texas (Figure 17). The meeting was part of the North American Energy Ministers' Working Group on Climate Change and Energy created in 2014 by Mexican Secretary of Energy Pedro Joaquin Coldwell, U.S. Secretary of Energy Ernest J. Moniz, and then Canadian Minister of Natural Resources Greg Rickford (since replaced by James Carr). "Practical Learnings about CO_2 Storage in North America?" was presented.

- On December 2–3, 2015, project personnel attended the Intelligent Monitoring Systems Project Kickoff Meeting and provided an update on the PCOR Partnership Program in Pittsburgh, Pennsylvania.

- On May 24–26, 2016, project personnel attended WBPC held in Bismarck, North Dakota. Work performed under multiple tasks was presented.

- On June 5–7, 2016, the PCOR Partnership program manager and a researcher attended this conference and presented at the 5th U.S.–China Symposium on CO_2 Emission Control held in Hangzhou, China. The presentation "The Plains CO_2 Reduction (PCOR) Partnership—Demonstrating Geologic Storage of Carbon Dioxide" gave an overview of the PCOR Partnership's CO_2 storage activities.

Figure 17. Attendees at the NAEM Climate Change and Energy Collaboration meeting held December 2–3, 2015, in Austin, Texas.

- On June 14–16, 2016, project personnel presented an overview of the PCOR Partnership program in a presentation entitled "The Plains CO_2 Reduction (PCOR) Partnership: Guiding CCS Deployment in Central North America" at the Annual CCUS Conference held in Tysons, Virginia.

- On August 31, 2016, a project researcher presented a PCOR Partnership overview entitled "The Plains CO_2 Reduction Partnership: Developing Technologies for CCS Deployment in Central North America" at the 35th International Geological Congress held August 27 – September 4, 2016, in Cape Town, South Africa.

- An project member presented a PCOR Partnership overview entitled "The Plains CO_2 Reduction Partnership: Carbon Management Through the Development of Technologies for CCS Deployment" at the second U.S.–China Clean Coal Industry Forum (CCIF) in Ordos, Inner Mongolia, China, held September 9–10, 2016.

National Risk Assessment Partnership

The National Risk Assessment Partnership (NRAP)—an initiative within DOE's Office of Fossil Energy and led by NETL—applies DOE's core competency in science-based prediction for engineered–natural systems to the long-term storage of CO_2. The science-based prediction of engineered–natural systems is a core competency that crosscuts many of today's energy challenges. Over decades, DOE has built a unique set of resources for predicting how these complex and heterogeneous systems behave under extreme conditions and over large ranges in time. NRAP has joined international efforts to develop the risk assessment tools needed for safe, permanent geologic CO_2 storage. NRAP members include five national DOE laboratories that have been conducting collaborative research for the Office of Fossil Energy's Carbon Sequestration Program for many years. The NRAP Program receives input from industry, government, nongovernment organizations, and academia regarding research needs for large-scale CO_2 storage deployment. The NRAP collaborative also keeps abreast of international developments by participating in collaborations like the IEAGHG Risk Assessment Network (28).

In PY9, the PCOR Partnership provided input to NRAP as follows:

- Participated in NRAP beta tool Webinars (IAM-CS model, NSealR, REV tool, Design for Risk Evaluation and Monitoring, Wellbore Leakage Analysis Tool, Aquifer Impact Model, Short-Term Seismic Forecasting Tool, and RROM-Gen tools).

- Participated in a Webinar on June 20, 2016, hosted by DOE NETL to introduce the newest NRAP tools on the EDX workspace: the Multiple Source Leakage Reduced-Order Model (MSLR) and the Ground Motion Prediction Applications to Potential Induced Seismicity (GMPIS).

- Downloaded and evaluated the NRAP DREAM (Designs for Risk Evaluation and Monitoring) tool to determine its use with PCOR Partnership MVA data. The DREAM tool will not fit the objectives the PCOR Partnership is trying to accomplish.

- Attended the NRAP Risk Assessment Tools Workshop in Pittsburgh, Pennsylvania, on August 15, 2016.

Mastering the Subsurface Through Technology Innovation & Collaboration: Carbon Storage & Oil & Natural Gas Technologies Review Meeting

Twelve staff members attended and presented on numerous projects at the Mastering the Subsurface Through Technology Innovation & Collaboration: Carbon Storage & Oil & Natural Gas Technologies Review Meeting held August 16–18, 2016, in Pittsburgh, Pennsylvania. The PCOR Partnership project manager presented "Plains CO_2 Reduction Partnership: Bell Creek Field Project." A booth backdrop was displayed the conference that included PCOR Partnership materials.

PCOR Partnership Partners

The PCOR Partnership has significant support and participation from its partners. As of September 30, 2016, over 100 partners are supporting Phase III activities. Since the onset of BP5 in PY9, four new companies joined the PCOR Partnership as paying members, as follows:

- Petro Harvester Oil & Gas, LLC
- Red Trail Energy, LLC
- Tundra Oil and Gas
- General Electric Global Research Oil & Gas Technology Center

Task Leader Meetings

Approximately once a month, internal EERC meetings are held with all 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

The 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 also received recognition in 2007.

On June 27–30, 2016, project personnel attended the 2016 CSLF Mid-Year Meeting held in London, United Kingdom.

Also in PY9, 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. The PCOR Partnership has greatly benefited from TAB recommendations and guidance since its inception. The annual face-to-face meetings, combined with shorter Webinars throughout the year, provide regular opportunities for TAB to comment on the PCOR Partnership's activities from both technical and strategic perspectives. This consistent feedback provides an independent review by industry-leading experts and contributes to a more scientifically sound and robust research program. From the PCOR Partnership's perspective, these meetings have been invaluable in guiding the technical components of the PCOR Partnership's work. For example, during a Webinar on soil gas- and groundwater-monitoring activities at Bell Creek, TAB recommended that the PCOR Partnership drill two deep groundwater-monitoring wells. The Bell Creek Field operator took this recommendation seriously and implemented it, resulting in a stronger overall monitoring program for the project.

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

- Bill Jackson, BillyJack Consulting, Inc. (Chair)
- Stefan Bachu, AITF
- Ray Hattenbach, Blue Strategies
- Lynn Helms, North Dakota Industrial Commission (NDIC)
- Mike Jones, LEC
- Steve Melzer, Melzer Consulting
- Tom Olle, Lonestar Resources, Inc.
- Steve Whittaker, CSIRO (Commonwealth Scientific and Industrial Research Organization)
- Neil Wildgust, Global CCS Institute

In 2015, Dr. Steve Whittaker accepted a position with the Illinois State Geological Society, causing a potential conflict of interest with participating on TAB. Dr. Whittaker was replaced by Dr. Jim Erdle of CMG.

The fifth annual TAB meeting was held April 5–6, 2016, in New Orleans, Louisiana. Topics discussed included ongoing work at the Bell Creek and Aquistore projects, outreach activities (including Bell Creek documentaries), BPMs, and the concept of a PCOR Partnership regional vision for inclusion in the next version of the atlas. TAB members in attendance included James Erdle, Lynn Helms, Ray Hattenbach, Steve Melzer, Neil Wildgust, Stefan Bachu, and Bill Jackson. Mike Jones, while not able to attend the meeting in person, was able to participate in the discussion

on April 6, 2016, via phone. Other meeting attendees included Dave Nakles (facilitator) and EERC personnel Charles Gorecki, Jim Sorensen, Ed Steadman, John Harju, and Scott Ayash.

Additionally, a TAB WebEx was held on July 26, 2016. This format was preferable to the TAB members to accommodate their busy travel schedules. An update on the Aquistore injection, field activities, and modeling and simulation work was presented. Seven of the nine TAB members were able to participate and provided feedback on the work presented.

In 2016, TAB member Neil Wildgust became a staff member of the EERC. This new position presented a conflict of interest with serving as an independent advisor, and Mr. Wildgust stepped down from his role on TAB. An invitation to join the TAB was extended to Ms. Stacey Dahl of Minnkota Power Cooperative, which she accepted. Ms. Dahl is an attorney-at-law and has valuable experience and knowledge in the power utility sector, especially related to regulatory and policy matters surrounding CO_2 emissions. The following are the current PCOR Partnership TAB members:

- Bill Jackson, BillyJack Consulting, Inc. (Chair)
- Stefan Bachu, AITF
- Ray Hattenbach, Industry Expert
- Lynn Helms, NDIC
- Mike Jones, LEC
- Steve Melzer, Melzer Consulting
- Tom Olle, Lonestar Resources, Inc.
- Jim Erdle, CMG
- Stacey Dahl, Minnkota Power Cooperative

A face-to-face TAB meeting was hosted in Grand Forks, North Dakota, on September 13, 2016, prior to the PCOR Partnership Premeeting Workshop. TAB members attending the PCOR Partnership Annual Membership Meeting participated. Seven of the nine members of TAB attended. Topics discussed included PCOR Partnership BPMs, regulatory permitting deliverables, and the upcoming peer review.

Task 14 – RCSP WWG Coordination

In order to investigate the relationship between water and CCS, members of the RCSPs 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 PY9 BP4 (October 1, 2015 – March 31, 2016) and BP5 (April 1, 2016 – September 30, 2016) include the following.

Monthly Conference Calls

A total of 66 monthly conference calls (M23) have taken place since the inception of this task, two of which were completed in PY9, as follows: October 29, 2015, and January 27, 2016. DOE NETL waived the requirement for conference calls during the months of December 2013, 2014, 2015, and 2016 as well as August 2013, July 2015, August 2015, November 2015, February 2016, and March 2016. The November 2015 call was waived because of unavailability of participants, and the February and March 2016 calls were waived based on limited work required by the WWG at that time. Minutes of the calls are submitted to the WWG members in the month following a call.

Beginning in BP5, the monthly conference calls were converted to quarterly conference calls based on the reduced WWG effort. Two quarterly conference calls were completed in PY9, as follows: April 27, 2016, and September 28, 2016. Minutes of the calls are submitted to the WWG members in the month following a call.

Status of the WWG

The WWG has completed the following activities:

- Produced a white paper that identified a wide variety of nexus of water and CCS issues, 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 on the white paper. In March 2013, Fact Sheet No. 2 entitled "Carbon Capture and Storage: Protecting Freshwater Resources" was finalized. Fact Sheet No. 3, "Monitoring, Verification, and Accounting Plans for Protection of Water Resources During the Geologic Storage of Carbon Dioxide" was finalized October 31, 2013. In November 2014, Fact Sheet No. 4 entitled "Long-Term Protection of Freshwater Resources Following CO_2 Storage" was finalized. 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

The eighth annual WWG meeting (M24) was held on August 18, 2016, in Pittsburgh, Pennsylvania, during the NETL Mastering the Subsurface Through Technology Innovation &

Collaboration: Carbon Storage & Oil & Natural Gas Technologies Review Meeting. Fifteen individuals participated in the meeting, approximately one-half of whom were WWG members. Presentations were given on the recently awarded brine extraction and storage test (BEST) projects by Robert Trautz of the Electric Power Research Institute and John Hamling of the EERC. Challenges, potential solutions, and opportunities of both projects were discussed by the group. A novel water treatment technology for high-salinity brines was presented by Vikas Khanna of the University of Pittsburgh. Advantages, disadvantages, and economics of the methodology were discussed by the group.

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 then determined the topics for three fact sheets.

In November 2014, the final fact sheet of the series, entitled "Long-Term Protection of Freshwater Resources Following CO_2 Storage" was completed. This 2-page fact sheet identifies the primary physical and chemical mechanisms that are being relied upon to ensure the long-term containment of CO_2 in a storage reservoir following injection. The fact sheet is available on the PCOR Partnership public Web site at http://undeerc.org/pcor/newsandpubs/pdf/FSWWG4-Long-Term-Projection-Freshwater-Resources-Following-CO2-Storage.pdf.

Web Site Content Development

In order to more effectively engage stakeholder groups and address stakeholder concerns, the WWG has developed a Web site that is hosted on NETL's Web site as part of the Carbon Dioxide Storage Program description. In PY8, DOE NETL officially released the WWG Web site (www.netl.doe.gov/research/coal/carbon-storage/wwg). Key Logic Systems, a NETL contractor, updates the Web site.

The Web site content was updated in PY8 and PY9 to include the following:

- Text on the "Water and CCS" page was revised to be more concise.
- The presentation from the August 2015 WWG Annual Meeting was uploaded.
- The fourth fact sheet in a series of WWG fact sheets was added, entitled "Long-Term Protection of Freshwater Resources Following CO_2 Storage."

As new works are produced or made available by the WWG or its members, the material will be added to the WWG Web site and noted in the next update in May 2017 (D101, PY10). Likewise, any revisions to the current content will be noted in the update as well.

Currently, the WWG is working on a virtual special issue of IJGGC. When this virtual special issue is completed in PY10, the link to the issue and a brief description of the effort will be added to the WWG Web site (29).

Special Issue of the International Journal of Greenhouse Gas Control

A BPM (D80) on the nexus of water and carbon storage activities was scheduled to be completed November 2016. Permission was received to drop the "BPM" title from D80 because of a lack of research leading to "best practices" in the field of water and CCS. The WWG group consensus was that the deliverable of a specific WWG BPM would be largely redundant of DOE's efforts to refresh the CCS BPMs and that the efforts should be redirected. PCOR Partnership representatives are working with DOE BPM authors to incorporate water-related case studies as needed. The BPM subtask was stopped September 30, 2015, and D80 was deleted. A request to change the scope of work from working on a BPM (D80) to create and edit a special issue of IJGGC (D106) focused on the issues at the nexus of water and CCS under a new subtask was approved in November 2015.

This subtask will result in production of all the materials necessary for Elsevier B.V. to publish the special issue. On June 15, 2015, the formal announcement of the Special Issue on the "Nexus of Water and Carbon Capture and Storage" was distributed to various stakeholders. Articles were received from prospective authors and vetted through the peer-review process. Development of a draft journal article on behalf of the WWG continued. A formal agreement was made with Elsevier B.V. to complete the IJGGC Special Issue as a digital version.

Major Research Focuses for Water and CCS

A new subtask was added through the BP5 continuation application. An update on the state of the science of research projects and learning related to the nexus of water and CCS will be summarized. The focus will be the issues of water extraction, treatments, water quality, regulations, and related topics. The final product will be either a journal article or a topical report (D107). A draft outline was created in PY9.

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 (D86), an updated regional technology implementation plan for the Zama project, which was completed in February 2014.

Activities and Results

The task concluded in PY7 BP4 (February 28, 2014).

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 was performed, 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 had 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 was conducted by the EERC in cooperation with AITF as a binational effort. The EERC worked closely with key partners in the United States to evaluate the American portion of the Basal Cambrian system. AITF led a multiprovince team to conduct a similar evaluation for the Canadian portion of this system.

Activities and Results

The task concluded in PY7 BP4 (March 31, 2014).

COST STATUS

The currently approved budget for Phase III is shown in Table 14.

On September 30, 2015, the PCOR Partnership completed its ninth year of Phase III activities (PY9, October 1, 2015 – September 30, 2016). Actual cash expenditures of DOE and nonfederal sources as well as noncash cost share reported through the end of BP4 (March 31, 2016) are listed in Table 15. Actual cash expenditures of DOE and nonfederal sources as well as noncash cost share reported for BP5 through September 30, 2016, are listed in Table 16.

SCHEDULE STATUS

Table 17 contains all of the Phase III deliverables, milestones, and submission dates for the reporting period. Tables 18–21 provide Gantt charts for BP4, including the reporting period (PY9 BP4 and BP5) and the next program year.

Table 14. PCOR Partnership Phase III Budget as of Modification 34

	BP3		BP4		BP5		Total	
DOE Share	$4,209,149	54.6%	$65,123,437	63.0%	$9,668,307	62.9%	$79,000,893	62.5%
Nonfederal Share								
Cash*	$887,428		$2,411,971		$0		$3,299,399	
In-Kind	$2,613,890		$35,766,276		$5,711,194		$44,091,360	
Total	$3,501,318	45.4%	$38,178,247	37.0%	$5,711,194	37.1%	$47,390,759	37.5%
Total	**$7,710,467**	**100.0%**	**$103,301,684**	**100.0%**	**$15,379,501**	**100.0%**	**$126,391,652**	**100.0%**

* Cash as recognized by DOE.

Table 15. BP4 Funding and Actual Costs as of March 31, 2016

Organization	Approved Budget,* $	Actual Costs Incurred, $
DOE Share – Cash	65,123,437	60,477,018
Nonfederal Share – Cash	2,411,971	3,002,296
Nonfederal Share – In-Kind	35,766,276	36,100,731
Total	103,301,684	99,580,045

*As of Modification No. 33.

Table 16. BP5 Funding and Actual Costs as of September 30, 2016

Organization	Approved Budget,* $	Actual Costs Incurred, $
DOE Share – Cash	9,668,307	3,460,140
Nonfederal Share	5,711,194	5,612,385
Total	15,379,501	9,072,525

*As of Modification No. 34.

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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 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 Sequestration 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	Not applicable	Not required
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 (DOE) 8/21/09 (WWG)
M23: Task 14 – Monthly WWG Conference Call Held	8/31/09	8/25/09
D1: Task 1 – Review of Source Attributes	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 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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	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 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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	12/13/10
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 (update)	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 CCS 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 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 Final Report	5/31/11	5/31/11

Continued…

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 4 – Quarter 3 (April–June 2011) (continued)		
M23: Task 14 – Monthly WWG Conference Call Held	5/31/11	5/5/11
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	7/31/11	8/31/11
M23: Task 14 – Monthly WWG Conference Call Held	8/31/11	8/24/11
D1: Task 1 – Review of Source Attributes	9/30/11	9/21/11
D4: Task 1 – 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 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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
M23: Task 14 – Monthly WWG Conference Call Held	1/31/12	1/19/12
M29: Task 4 – Fort Nelson Site Characterization Report Completed	1/31/12	1/31/12
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
M36: Task 13 – Annual Advisory Board Scheduled	3/31/12	3/28/12
M23: Task 14 – Monthly WWG Conference Call Held	3/31/12	3/27/12
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 CCS	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 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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	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
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
Year 6 – Quarter 2 (January–March 2013)		
D32: Task 4 – Bell Creek Test Site – Geomechanical Final 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	2/28/13
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCS Activities	3/31/13	Waived by DOE (journal article)
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	3/28/13
M36: Task 13 – Annual Advisory Board Meeting Scheduled	3/31/13	3/27/13

Continued . . .

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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
M23: Task 14 – Monthly WWG Conference Call Held	6/30/13	6/27/13
M26: Task 9 – Bell Creek Test Site – CO_2 Injection Initiated	6/30/13	May 2013 – sent 6/25/13
M37: Task 3 – IOGCC Task Force Subgroup Meeting 2 Held	5/9/13	5/29/13
M42: Task 3 – Findings and Recommendations of the Operational and Postoperational Subgroups Presented to the Carbon Geologic Storage (CGS) Task Force	6/30/13	6/20/13 – sent 6/28/13
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 – Geochemical Final Report	7/31/13	7/31/13
M12: Task 4 – Bell Creek Test Site 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 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) 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	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 CGS Task Force	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 – sent 9/5/13
M39: Task 3 – IOGCC Task Force Editing Subgroup Meeting Held	9/30/13	6/3/13 – sent 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
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
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- Soil Gas-Monitoring Program Completed	12/31/13	11/15/13 – sent 12/13/13
Year 7 – Quarter 2 (January–March 2014)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/14	1/31/14
D57: Task 12 – Project Assessment Annual Report	1/31/14	1/31/14
M23: Task 14 – Monthly WWG Conference Call Held	1/31/14	1/28/14
M41: Task 6 – Decision to Incorporate Ramgen Compression Technology into Bell Creek Project	1/31/14	1/29/14

Continued . . .

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 7 – Quarter 2 (January–March 2014) (continued)		
D86: Task 15 – Updated Regional Implementation Plan for Zama	2/28/14	2/28/14
M23: Task 14 – Monthly WWG Conference Call Held	2/28/14	2/27/14
D24: Task 2 – PCOR Partnership Region Sequestration General Poster (update)	3/31/14	3/27/14
D36: Task 4 – Bell Creek Test Site – Wellbore Leakage Final Report	3/31/14	3/19/14
D92: Task 16 – Report – Storage Capacity and Regional Implications for Large-Scale Storage in the Basal Cambrian System	3/31/14	3/27/14
D93: Task 1 – Geological Modeling and Simulation Report for the Aquistore Project	3/31/14	3/25/14
D96: Task 4 – Bell Creek Test Site – 3-D Seismic and Characterization Report	3/31/14	3/27/14
M23: Task 14 – Monthly WWG Conference Call Held	3/31/14	3/25/14
M36: Task 13 – Annual Advisory Board Meeting Scheduled	3/31/14	3/4/14 – sent 3/25/14
M44: Task 9 – Bell Creek Test Site – First 3-D VSP Repeat Surveys Completed	3/31/14	3/1/14 – sent 3/25/14
Year 7 – Quarter 3 (April–June 2014)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/14	4/30/14
M23: Task 14 – Monthly WWG Conference Call Held	4/30/14	4/24/14
D17: Task 2 – General Phase III Information PowerPoint Presentation (update)	5/31/14	5/30/14
D101: Task14 – WWG Web Site Content Update	5/31/14	5/30/14
M23: Task 14 – Monthly WWG Conference Call Held	5/31/14	5/21/14
D44: Task 5 – Bell Creek Test Site – Drilling and Completion Activities Report	6/30/14	5/30/14
M23: Task 14 – Monthly WWG Conference Call Held	6/30/14	6/26/14
M45: Task 9 – Bell Creek Test Site – First Full-Repeat of Pulsed Neutron Logging Campaign Completed	6/30/14	6/9/14
M46: Task 9 – Bell Creek Test Site – 1 Year of Injection Completed	6/30/14	6/26/14

Continued . . .

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 7 – Quarter 4 (July–September 2014)		
D13: Task 2 – Public Site Updates	7/31/14	7/29/14
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/14	7/31/14
M23: Task 14 – Monthly WWG Conference Call Held	7/31/14	7/17/14 WebEx
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/14	8/27/14 Exec. Sum.
M23: Task 14 – Monthly WWG Conference Call Held	8/31/14	Waived by DOE
D1: Task 1 – Review of Source Attributes	9/30/14	9/24/14
D7: Task 1 – Third Target Area Completed	9/30/14	9/26/14
D93: Task 1 – Geological Modeling and Simulation Report for the Aquistore Project	9/30/14	9/30/14
D100: Task 9 – Fort Nelson Test Site – Best Practices Manual – Feasibility Study	9/30/14	9/30/14
M23: Task 14 – Monthly WWG Conference Call Held	9/30/14	9/30/14
Year 8 – Quarter 1 (October–December 2014)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/14	10/31/14
D99: Task 14 – Water/CCS Nexus-Related Fact Sheet	10/31/14	10/31/14
M23: Task 14 – Monthly WWG Conference Call Held	10/31/14	10/28/14
M48: Task 9 – Bell Creek Test Site – 1 Million Metric Tons of CO_2 Injected	10/31/14	10/29/14
M23: Task 14 – Monthly WWG Conference Call Held	11/30/14	11/25/14
D57: Task 12 – Project Assessment Annual Report	12/31/14	12/30/14
M24: Task 14 – WWG Annual Meeting Held	12/31/14	8/11/14
Year 8 – Quarter 2 (January–March 2015)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/15	1/30/15
D32: Task 4 – Bell Creek Test Site – Geomechanical Report (Update 1)	1/31/15	1/28/15
M23: Task 14 – Monthly WWG Conference Call Held	1/31/15	1/27/15
M23: Task 14 – Monthly WWG Conference Call Held	2/28/15	2/26/15
D25: Task 2 – Bell Creek Test Site Poster (update)	3/31/15	2/5/15
M23: Task 14 – Monthly WWG Conference Call Held	3/31/15	3/25/15
M36: Task 13 – Annual Advisory Board Meeting Scheduled	3/31/15	3/31/15

Continued . . .

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 8 – Quarter 3 (April–June 2015)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/15	4/29/15
M23: Task 14 – Monthly WWG Conference Call Held	4/30/15	4/28/15
D17: Task 2 – General Phase III Information PowerPoint Presentation (update)	5/31/15	6/1/15
M23: Task 14 – Monthly WWG Conference Call Held	5/30/15	5/28/15
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS (carbon capture, utilization, and storage) Activities (update)	5/31/15	5/29/15
M23: Task 14 – Monthly WWG Conference Call Held	6/30/15	6/23/15
M49: Task 9 – Bell Creek Test Site – 1.5 Million Metric Tons of CO_2 Injected	6/30/15	6/30/15
Year 8 – Quarter 4 (July–September 2015)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/15	7/31/15
M23: Task 14 – Monthly WWG Conference Call Held	7/31/15	Waived by DOE
M50: Task 9 – Bell Creek Test Site – 2 Years of Near-Surface Assurance Monitoring Completed	7/31/15	7/21/15
D66: Task 9 – Bell Creek Test Site – Simulation Report	8/31/15	8/27/15 Exec. Sum.
M23: Task 14 – Monthly WWG Conference Call Held	8/31/15	Waived by DOE
M51: Task 9 – Bell Creek Test Site – Initial Analysis for First Large-Scale Repeat Pulsed-Neutron Logging Campaign Post-Significant CO_2 Injection Completed	8/31/15	8/31/15
D1: Task 1 – Review of Source Attributes (update)	9/30/15	9/23/15
D8: Task 3 – Permitting Review – Update 2	9/30/15	9/30/15
D49: Task 8 – Bell Creek Test Site – Transportation and Injection Operations Report	9/30/15	9/29/15
M23: Task 14 – Monthly WWG Conference Call Held	9/30/15	9/30/15
Year 9 – Quarter 1 (October–December 2015)		
D59/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/15	10/31/15
M23: Task 14 – Monthly WWG Conference Call Held	10/31/15	10/29/15
M23: Task 14 – Monthly WWG Conference Call Held	11/30/15	Waived by DOE
D57: Task 12 – Project Annual Assessment Report	12/31/15	12/31/15
M24: Task 14 – WWG Annual Meeting Held	12/31/15	8/20/15
M53: Task 9 – Expanded Baseline and Time-Lapse 3-D Surface Seismic Survey Completed	12/31/15	12/17/15

Continued . . .

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 9 – Quarter 2 (January–March 2016)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/16	1/31/16
M23: Task 14 – Monthly WWG Conference Call Held	1/31/16	1/27/16
M54: Task 9 – Initial Processing and Analysis of Historic InSAR Data Completed	1/31/16	1/26/16
D14: Task 2 – General Phase III Fact Sheet (update)	2/29/16	2/26/16
D93: Task 1 – Geological Modeling and Simulation Report for the Aquistore Project (Update 2)	2/29/16	2/29/16
M23: Task 14 – Monthly WWG Conference Call Held	2/29/16	Waived by DOE
D11: Task 2 – Outreach Plan (update)	3/31/16	3/28/16
D45: Task 6 – Bell Creek Test Site – Infrastructure Development Report	3/31/16	3/31/16
M23: Task 14 – Monthly WWG Conference Call Held	3/31/16	Waived by DOE
M36: Task 13 – Annual Advisory Board Meeting Scheduled	3/31/16	3/31/16
M56: Task 9 – Life Cycle Analysis for Primary and Secondary Recovery Oil Completed	3/31/16	3/31/16
M58: Task 9 – Bell Creek Test Site – Completion of 2.75 Million Metric Tons of CO_2 Stored	3/31/16	3/22/16
Year 9 – Quarter 3 (April–June 2016)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/16	4/29/16
D17: Task 2 – General Phase III Information PowerPoint Presentation (update)	5/31/16	5/31/16
D101: Task 14 – WWG Web Site Content Update 1	5/31/16	5/31/16
M57: Task 9 – Life Cycle Analysis for EOR at the Bell Creek Field Completed	5/31/16	5/26/16
M23: Task 14 – Monthly WWG Conference Call Held	6/30/16	4/27/16
Year 9 – Quarter 4 (July–September 2016)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/16	7/29/16
D13: Task 2 – Public Site Updates	7/31/16	7/21/16
D16: Task 2 – Fort Nelson Test Site Fact Sheet (update)	8/31/16	8/29/16
D66: Task 9 – Bell Creek Test Site – Simulation Report (update)	8/31/16	8/31/16
D102: Task 13 – Best Practices Manual – Adaptive Management Approach	8/31/16	8/31/16
M59: Task 9 – Completed the PCOR Partnership Adaptive Management Approach Best Practices Manual	8/31/16	8/31/16

Continued . . .

Table 17. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2016) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 9 – Quarter 4 (July–September 2016) (continued)		
D1: Task 1 – Review of Source Attributes (update)	9/30/16	9/29/16
D8: Task 3 – Permitting Review – Update 3	9/30/16	9/29/16
D55: Task 11 – Bell Creek Test Site – Cost-Effective Long-Term Monitoring Strategies Report	9/30/16	9/30/16
M23: Task 14 – Monthly WWG Conference Call Held	9/30/16	9/28/16

Table 18. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4)

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Table 18. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4) (continued)

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Table 18. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4) (continued)

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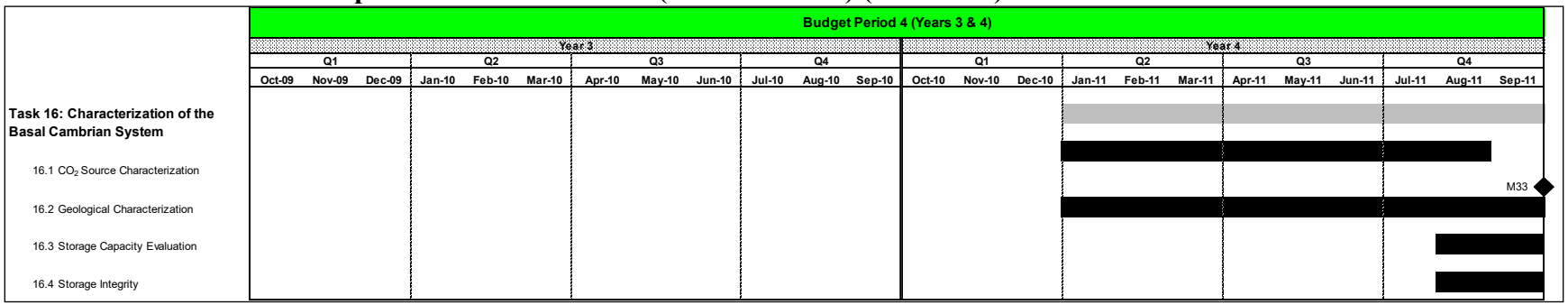
Table 18. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4) (continued)



Summary Task | Activity Bar | Progress Activity Bar | Time Now | Deliverable | Milestone

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 19. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4)

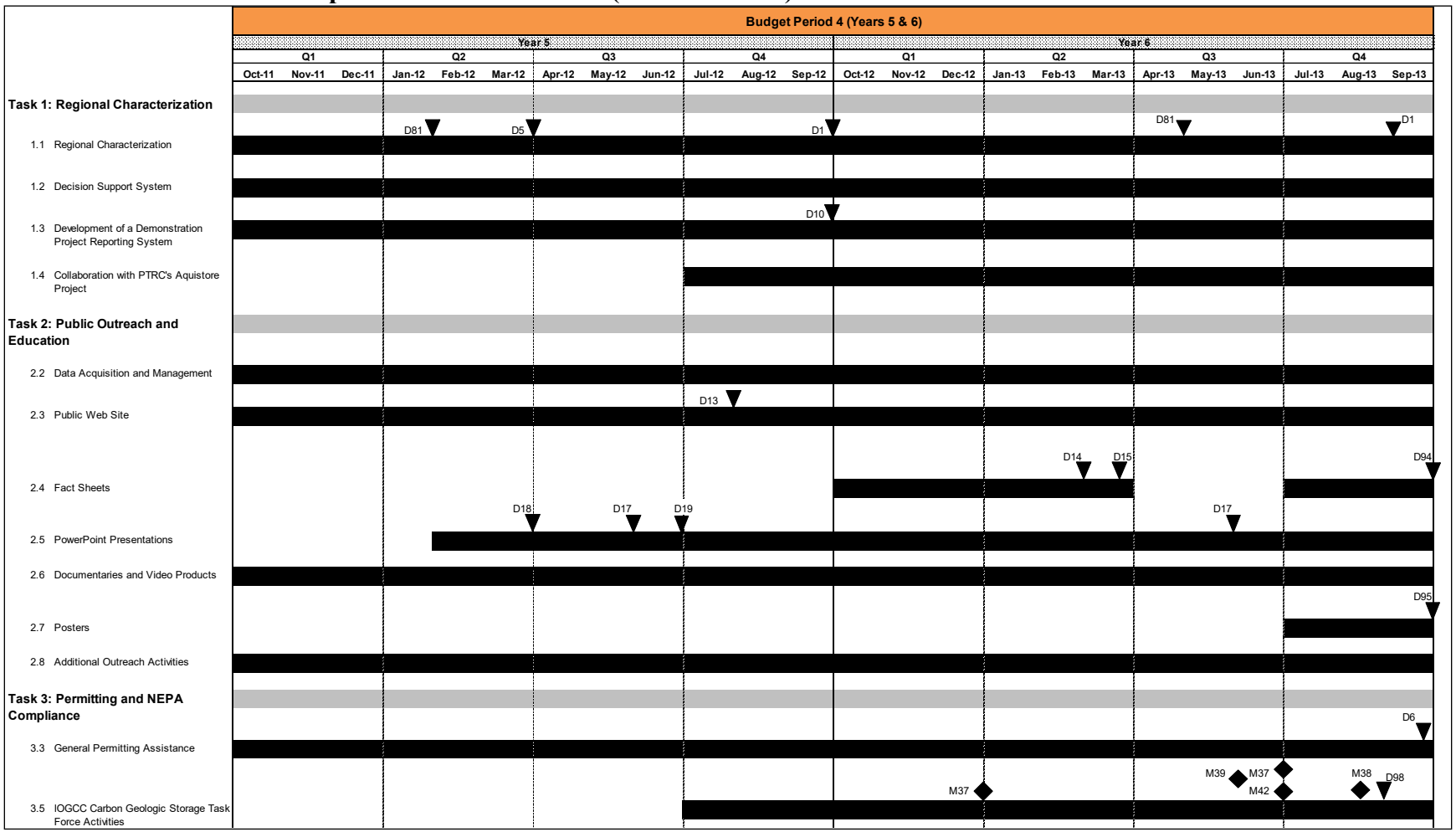


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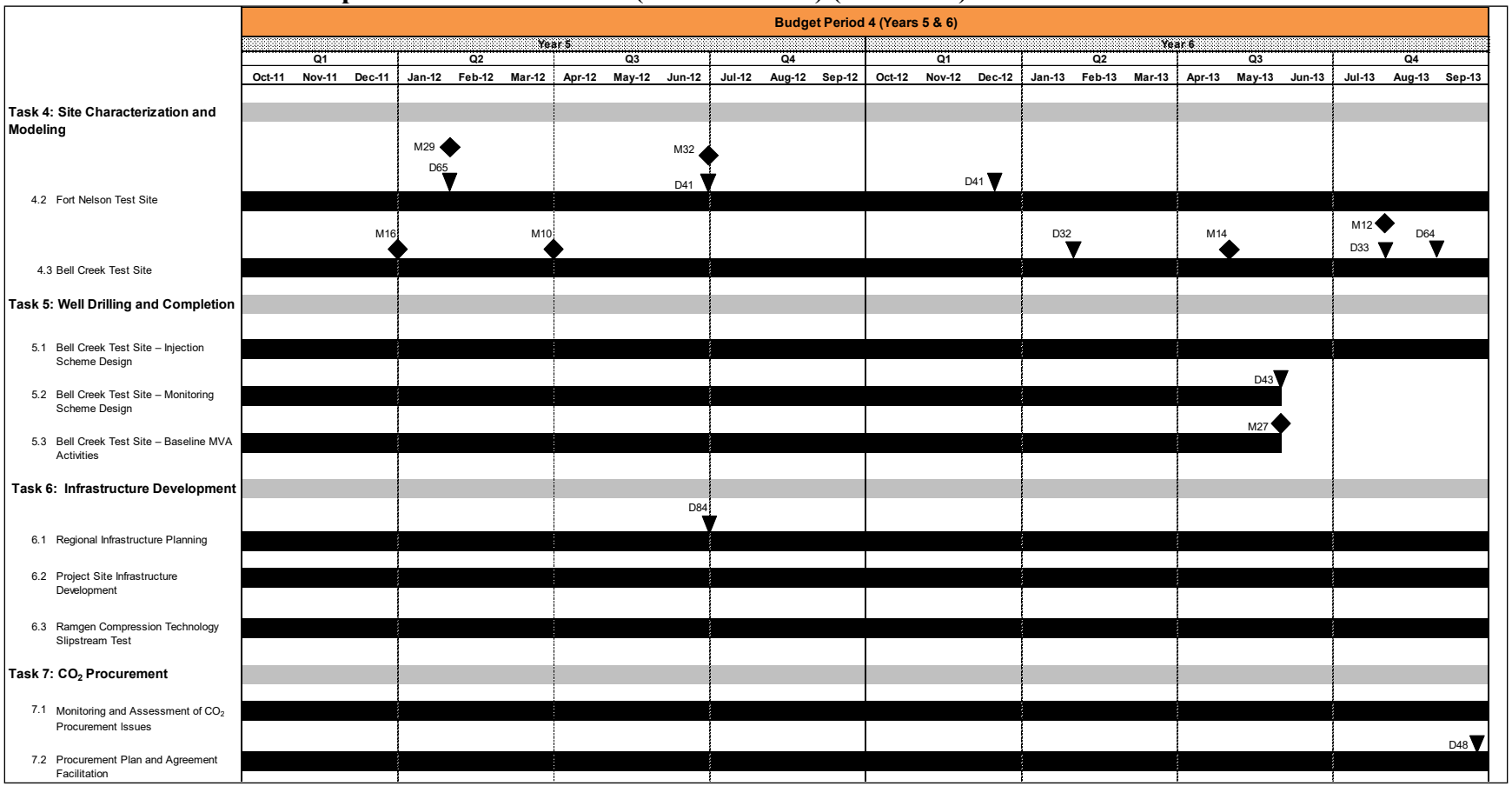
Table 19. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)



Summary Task | Activity Bar | Progress Activity Bar | Time Now | Deliverable | Milestone

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Table 19. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)

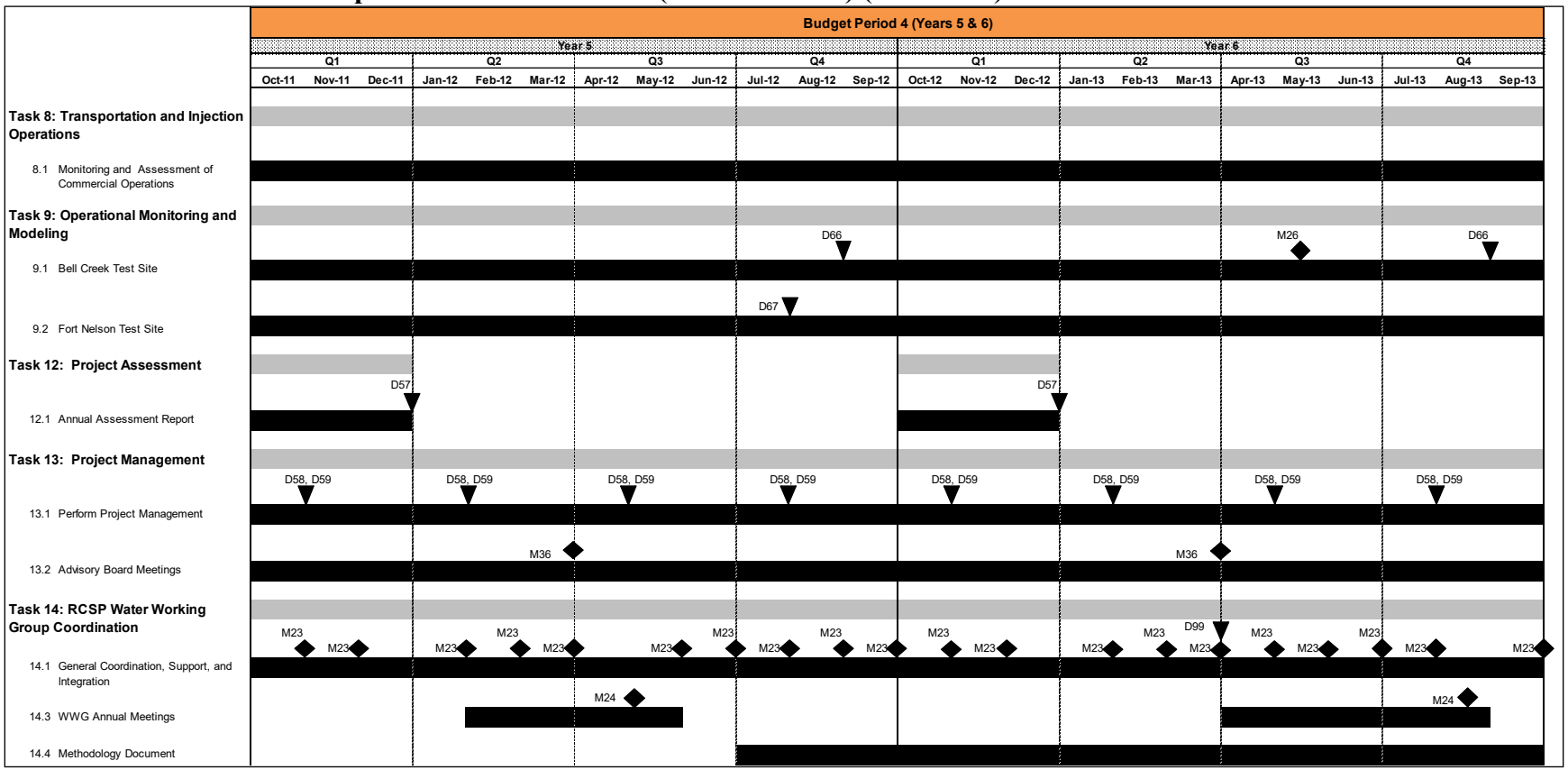

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Table 19. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)

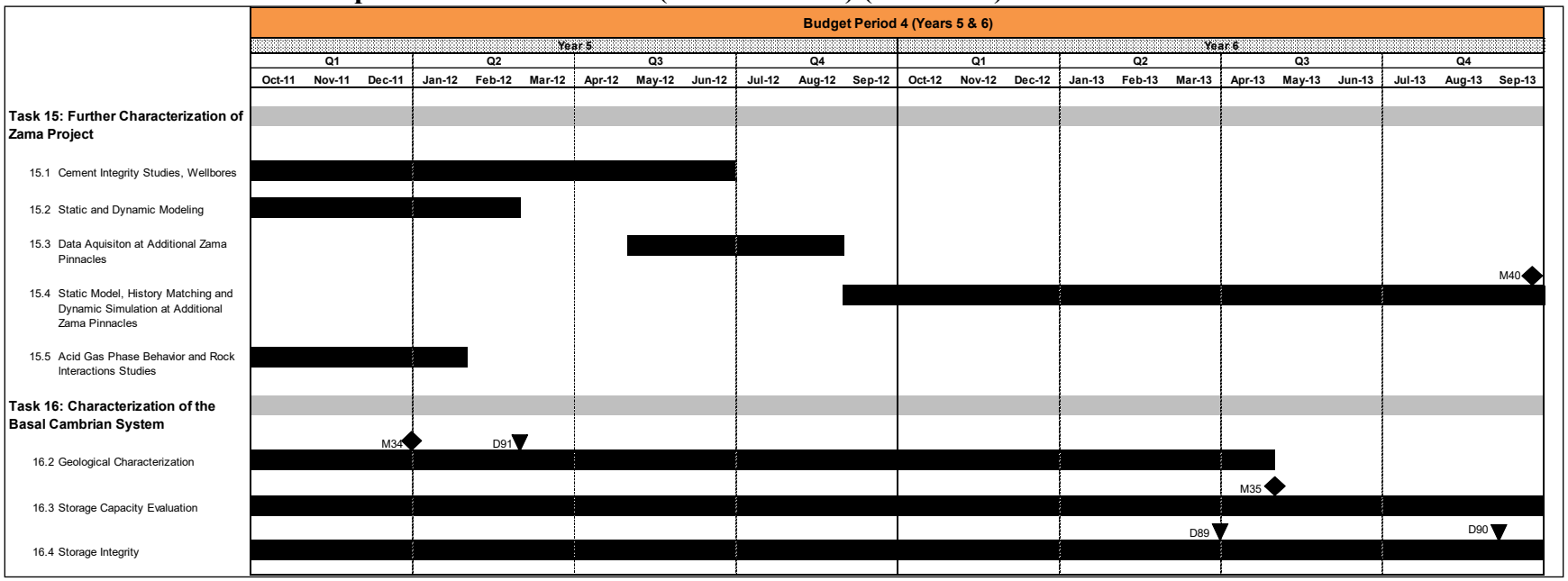

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Table 19. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)

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				

Table 20. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4)

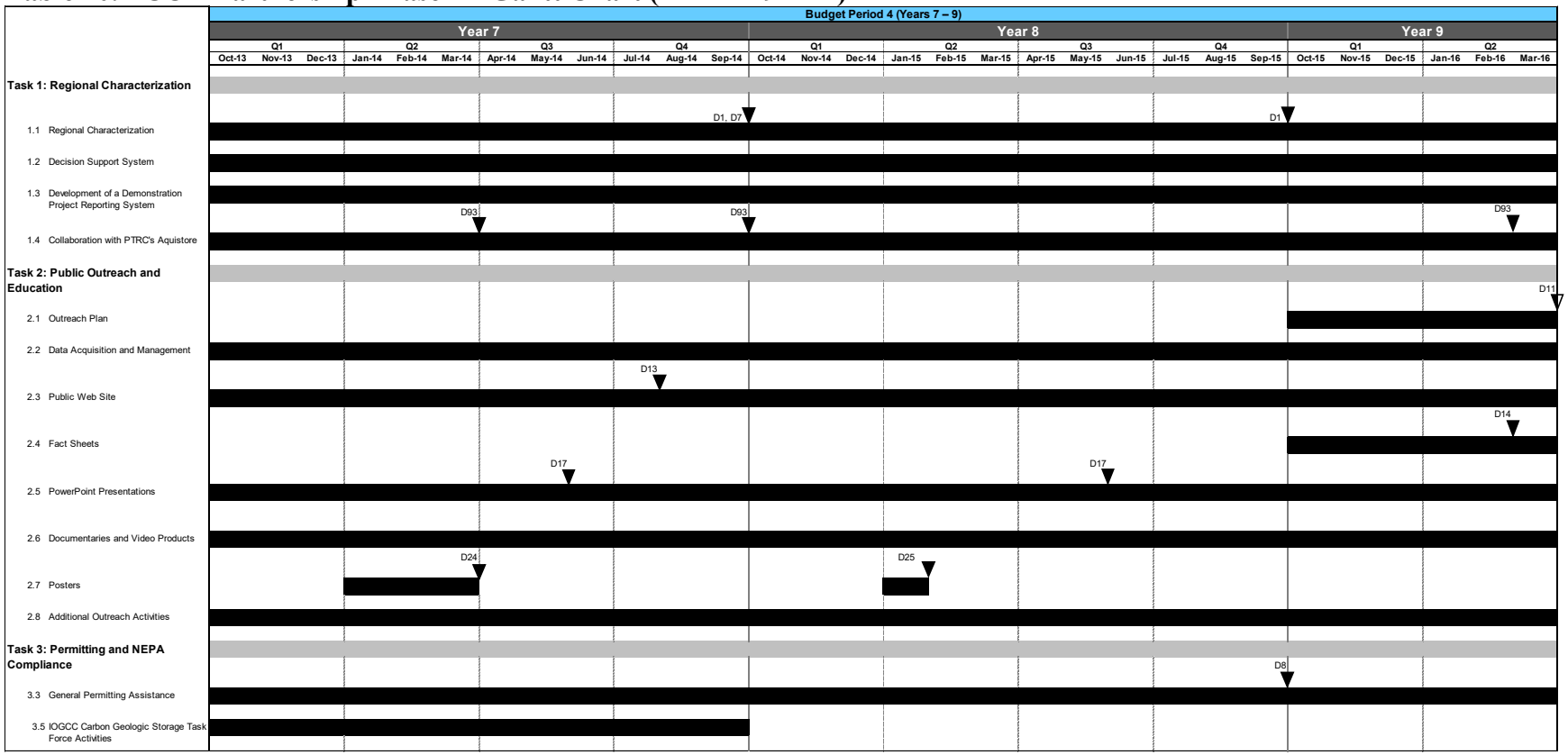

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Table 20. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4) (continued)

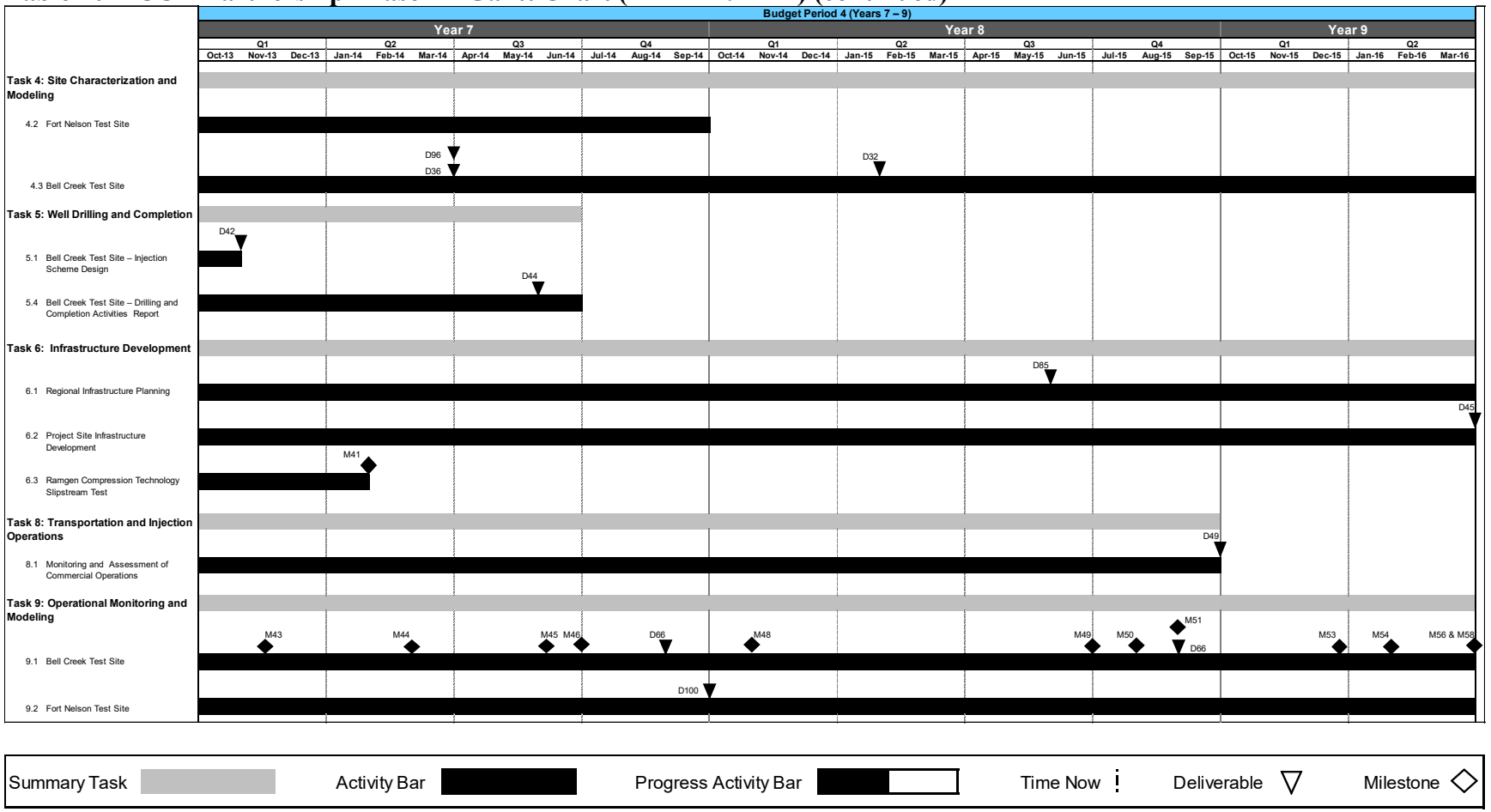

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Table 20. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4) (continued)

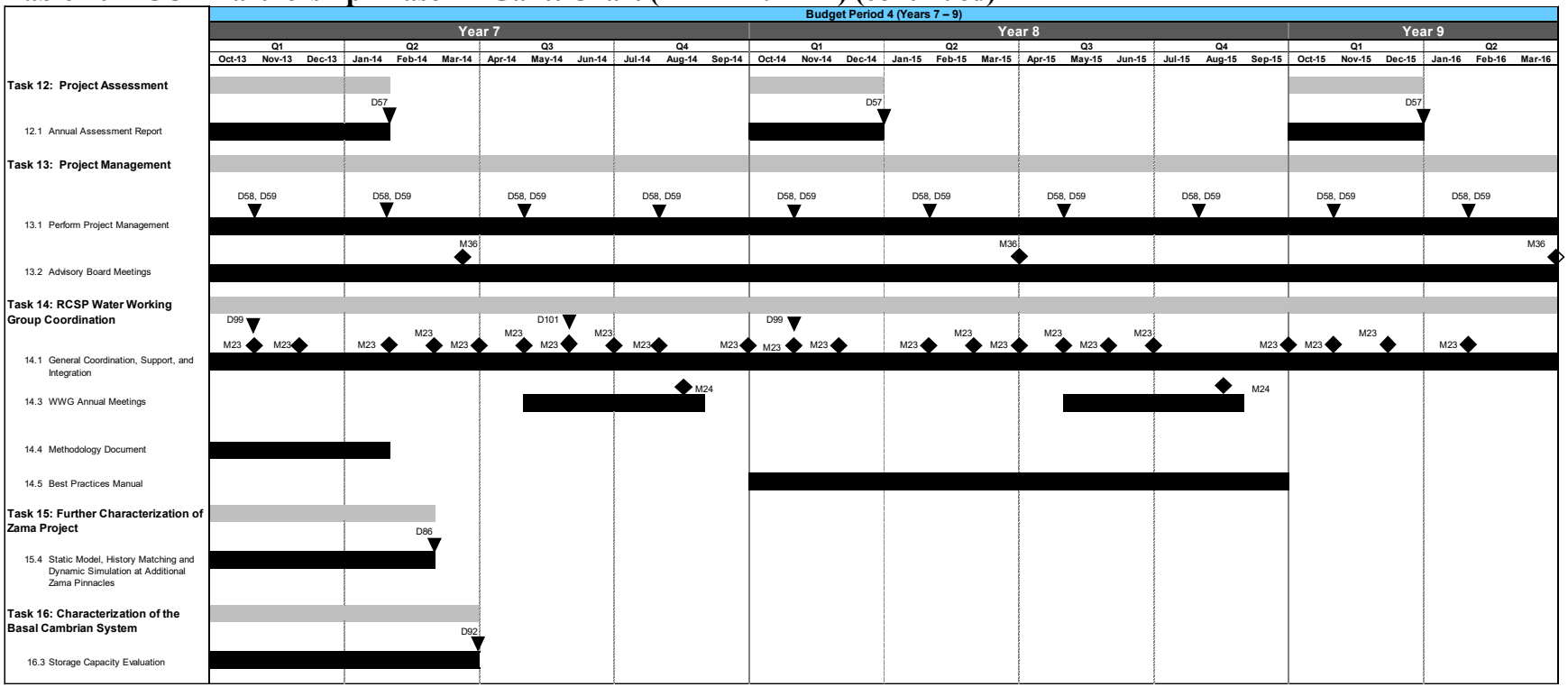

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Table 20. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4) (continued)

Key for Deliverables

D1	Review of Source Attributes
D7	Third Target Area Completed
D8	Permitting Review – Update 2
D11	Outreach Plan
D13	Public Site Updates
D14	General Phase III Fact Sheet
D17	General Phase III Information PowerPoint Presentation
D24	PCOR Partnership Region CO_2 Storage General Poster
D25	BC Test Site Poster (Update)
D32	BC Test Site – Geomechanical Report
D36	BC Test Site – Wellbore Leakage Final Report
D42	BC Test Site – Injection Experimental Design Package
D44	BC Test Site – Drilling and Completion Activities Report
D45	Report – Infrastructure Development
D49	BC Test Site – Transportation and Injection Operations Report
D57	Project Assessment Annual Report
D58	Quarterly Progress Report
D59	Milestone Quarterly Report
D66	BC Test Site – Simulation Report
D85	Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities
D86	Updated Regional Technology Implementation Plan for Zama
D92	Report – Storage Capacity and Regional Implications for Large-Scale Storage in the Basal Cambrian System
D93	Report – Geological Modeling and Simulation for the Aquistore Project
D96	BC Test Site – 3-D Seismic Acquisition and Characterization Report
D99	Nexus of Water and CCS Fact Sheet
D100	FN Test Site – Best Practices Manual– Feasibility Study
D101	WWG Web Site Content Update

Key for Milestones

M23	Monthly WWG Conference Call Held
M24	WWG Annual Meeting Held
M36	Annual Advisory Board Meeting Scheduled
M41	Decision to Incorporate Ramgen Compression Technology into BC Project
M43	BC Test Site – First Full-Repeat Sampling of the Groundwater- and Soil Gas- Monitoring Program Completed
M44	BC Test Site – First 3-D VSP Repeat Surveys Completed
M45	BC Test Site – First Full-Repeat of Pulsed-Neutron Logging Campaign Completed
M46	BC Test Site – 1 Year of Injection Completed
M48	BC Test Site – 1 Million Metric Tons of CO_2 Injected
M49	BC Test Site – 1.5 Million Metric Tons of CO_2 Injected
M50	BC Test Site – 2 Years of Near-Surface Assurance Monitoring Completed
M51	BC Tast Site – Initial Analysis for First Large-Scale Repeat Pulsed-Neutron Logging Campaign Post-Significant CO_2 Injection
M53	BC Test Site – Expanded Baseline and Time-Lapse 3-D Surface Seismic Survey Completed
M54	BC Test Site – Initial Processing and Analysis of Historic InSAR Data Completed
M56	BC Test Site – Life Cycle Analysis for Primary and Secondary Recovery Oil Completed
M58	BC Test Site – Injection of 2.75 Million Metric Tons of CO_2 Completed

January 2016

Table 21. PCOR Partnership Phase III Gantt Chart (PY9–PY12 BP4 and BP5)

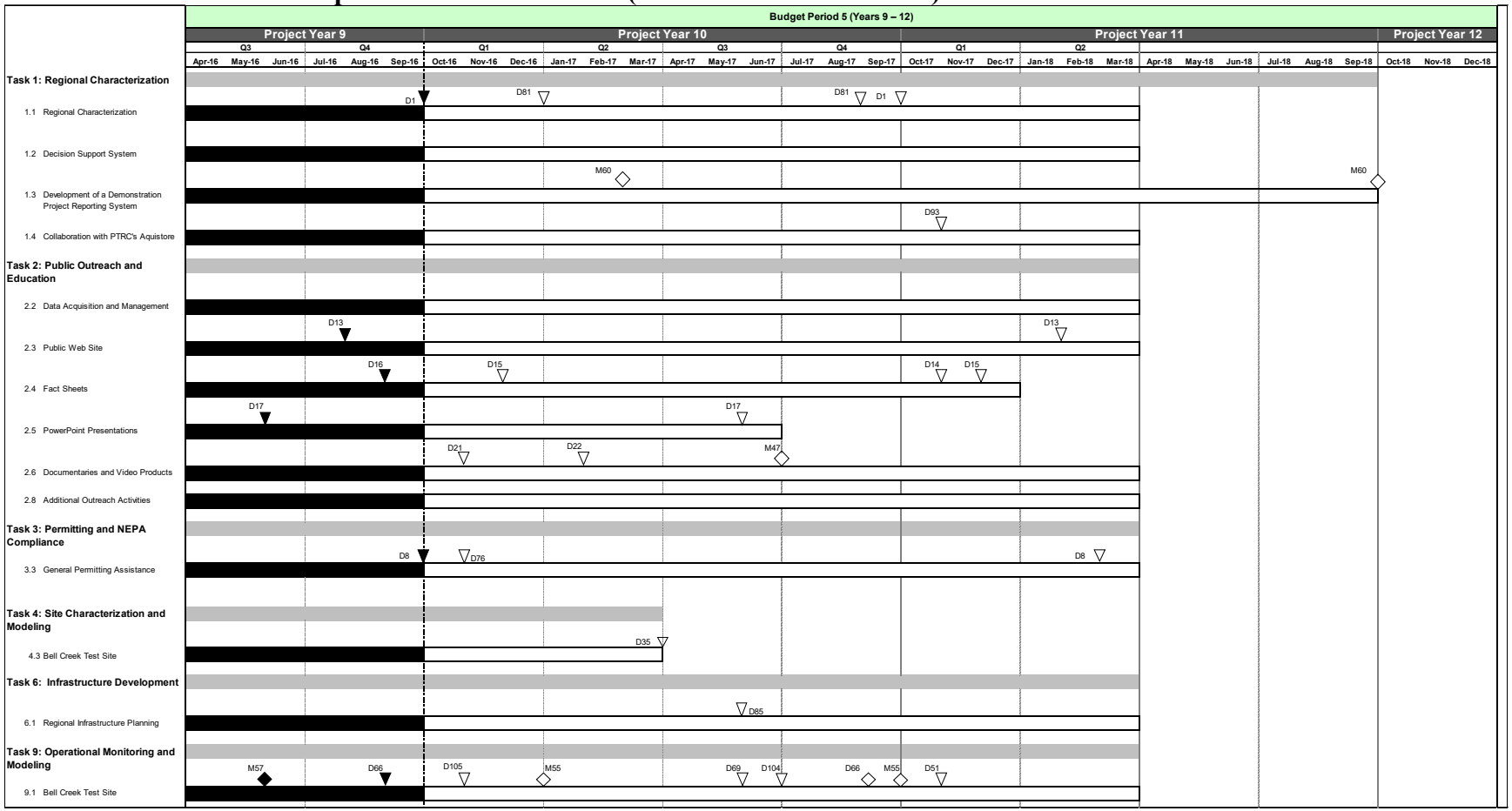

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Table 21. PCOR Partnership Phase III Gantt Chart (PY9–PY12 BP4 and BP5) (continued)

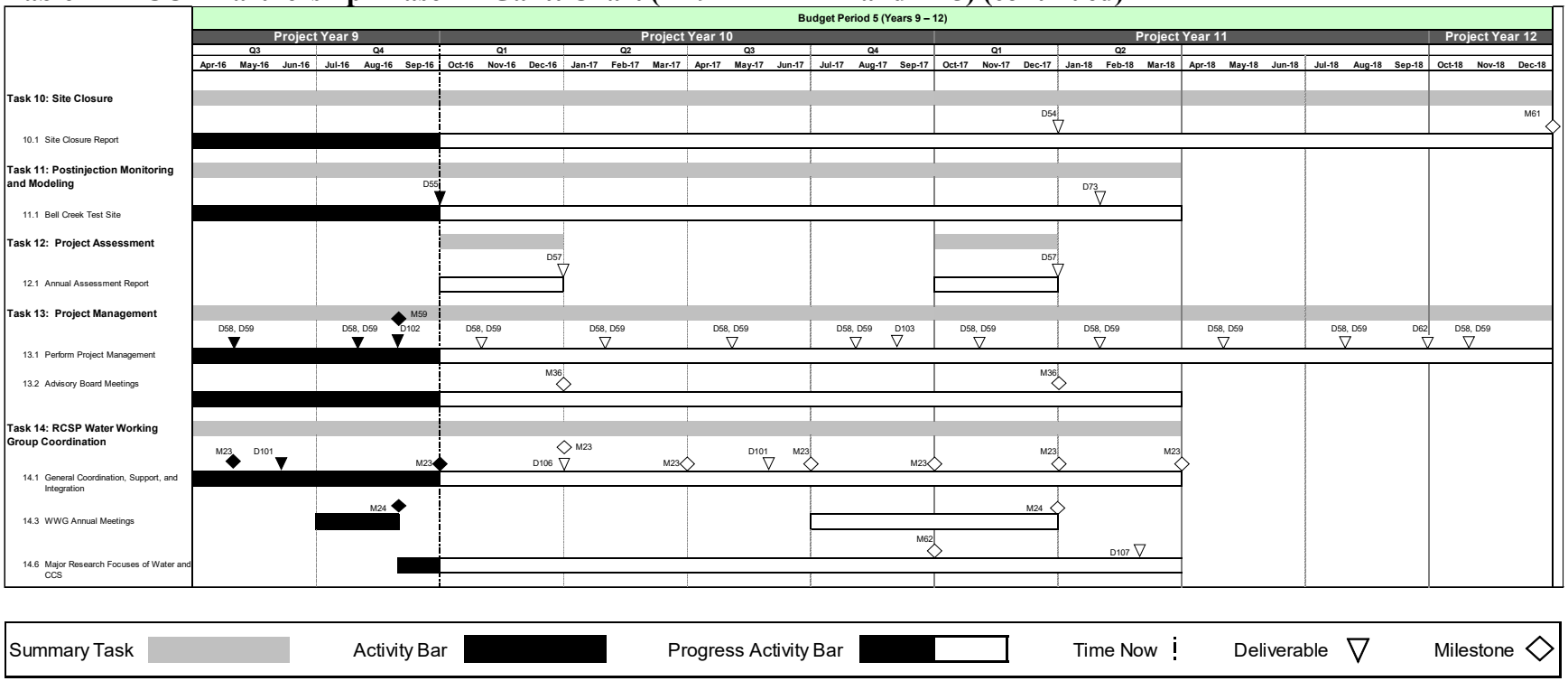

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Table 21. PCOR Partnership Phase III Gantt Chart (PY9–PY12 BP4 and BP5) (continued)

Key for Deliverables (D) ▼				Key for Milestones (M) ◆	
D1	Review of Source Attributes	D62	Final Report	M23	WWG Conference Call Held
D8	Permitting Review	D66	BC Test Site – Simulation Report	M24	WWG Annual Meeting Held
D13	Public Site Updates	D69	BC Test Site – Best Practices Manual – Simulation	M36	Annual Advisory Board Meeting Scheduled
D14	General Phase III Fact Sheet	D73	Report – Monitoring and Modeling Fate of Stored CO_2	M47	BC Test Site 30-minute Video Broadcast
D15	BC Test Site Fact Sheet	D76	Regional Regulatory Perspective	M52	BC Test Site – Initial Analysis of Extended Pulsed-Neutron Logging Campaign Data Completed
D16	Fort Nelson Test Site Fact Sheet	D81	Regional Carbon Sequestration Atlas	M55	Investigation of Crude Oil Compositional Changes During CO_2 EOR Completed
D17	General Phase III Information PowerPoint Presentation	D85	Report – Opportunities and Challenges Associated with CO_2 Compression	M57	Life Cycle Analysis for EOR Completed
D21	BC Test Site 30-minute Documentary	D93	Report – Geological Modeling and Simulation for the Aquistore Project	M59	Adaptive Management Approach Best Practices Manual Completed
D22	Energy from Coal 60-minute Documentary	D101	WWG Web Site Content Update	M60	Data Submitted to EDX
D35	BC Test Site – Best Practices Manual – Site Characterization	D102	Best Practices Manual – Adaptive Management Approach	M61	Site Closure for Bell Creek Test Completed
D51	BC Test Site – Best Practices Manual – Monitoring for CO_2 Storage and CO_2 EOR	D103	Best Practices Manual – Programmatic Risk Management	M62	Research Related to Water and CCS Nexus Completed
D54	Report – Site Closure Procedures	D104	BC Test Site – Analysis of Expanded Seismic Campaign		
D55	BC Test Site – Cost-Effective Long-Term Monitoring Strategies Report	D105	Comparison of Non-EOR and EOR Life Cycle Assessment		
D57	Project Assessment Annual Report	D106	Special Issue of IJGGC – Nexus of Water and Carbon Capture and Storage		
D58	Quarterly Progress Report	D107	Journal Article or Topical Report – Major Research Focuses of Water and CCS		
D59	Milestone Quarterly Report				

September-16

PLANNED ACTIVITIES

Task 1 – Regional Characterization

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Complete the next edition of the PCOR Partnership Atlas (D81) by December 31, 2016.
- 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.
- Investigate saltwater disposal as a proxy for CO_2 storage. Write a journal article.
- Develop storage coefficients for CO_2 storage in abandoned oil fields.
- Investigate CO_2 injection as a secondary oil recovery method. Examine oil production and CO_2 storage relationships without waterflood, and relate them to the concept of green oil.
- Finalize a value-added white paper on the characterization of relevant oil fields located in the Cedar Creek Anticline.
- Continue to update the DSS, and report changes in the quarterly progress reports.
- Provide an annual data submission to the EDX workspace. Report the submission in M60, "Data Submitted to EDX" by February 2017.
- Continue updating the Aquistore geologic model as appropriate with monitoring and characterization data (e.g., surface and passive seismic, PNLs) collected by PTRC.
- Continue history-matching simulations using Aquistore injection data.

Task 2 – Public Outreach and Education

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Continue to review and improve the public PCOR Partnership Web site.
- Update the PowerPoint presentation for Phase III general activities (D17). Develop other PowerPoint presentations as needed.

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

- Complete development of broadcast documentary products; continue broadcasts and marketing of documentary products, development and placement of custom video products, and archiving video materials (D21 – Bell Creek documentary: October 2016; D22 – energy from coal documentary: January 2017). Complete M47 – "BC Test Site 30-minute Video Broadcast" (June 2017).

- 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 and the Aquistore Project Communications Advisory Group.

Task 3 – Permitting and NEPA Compliance

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Complete D76 "Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region." (January 2017).

- Attend public and industry meetings related to the EPA Clean Power Plan, the underground injection control Class II well transition to Class VI, and other federal regulatory actions.

- Continue attending appropriate regulatory meetings throughout BP5.

Task 4 – Site Characterization and Modeling

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Bell Creek Test Site
  - Continue development of the V3 geologic model (full-field).
    - Incorporate the expanded baseline (Phases 5–7 of Bell Creek development) 3-D surface seismic survey data into the V3 geomodel.
    - Incorporate learnings from the new PNL campaigns within the V3 geomodeling efforts and MVA activities.
  - Hold an outcrop field trip for Denbury and EERC Bell Creek team members to evaluate, in context, new depositional environment interpretation.
  - Continue development of regional-scale and near-surface models. Use the near-surface model to inform or adapt MVA activities or assessment as fitting.
  - Complete D35 – Site Characterization BPM (March 2017). Important topics will include well log analyses, core viewing, lab analyses, and seismic data. The BPM will focus on how site characterization activities and data are used in selecting a storage project site and as part of the AMA.

Task 5 – Well Drilling and Completion

This task ended June 30, 2014. No further activity is anticipated.

Task 6 – Infrastructure Development

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Complete the value-added CO_2 capture technology overview document update.
- Update the CO_2 capture technology "tree" on the PCOR Partnership Partners-Only Web site to match the overview document.
- Develop a database of existing and emerging CO_2 compression technologies, and incorporate it into the PCOR Partnership Partners-Only Web site.
- Complete D85 "Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities" (May 2017).

- Continue to assist commercial partners with the activities required to develop any additional 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

This task ended September 30, 2015. No further activity is anticipated.

Task 9 – Operational Monitoring and Modeling

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Bell Creek Test Site
  - Complete a BPM for CO_2 EOR and storage modeling simulations (D69).
  - Complete the initial analysis of expended PNL campaign data (M52).
  - Complete another round of testing in the enhanced PNL campaign.
  - Continue to provide a quarterly summary of injection operations in the quarterly technical progress reports.
  - Complete an initial investigation of crude oil composition changes during CO_2 EOR (M55).
  - Complete the initial analysis of the expended seismic campaign (D104/M64).
  - Update the simulation report (D66) by August 31, 2017.
  - Complete the LCA final report (D105).
  - Complete an initial analysis of processed InSAR data (M63).

Task 10 – Site Closure

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Initiate site closure activities as appropriate.

Task 11 – Postinjection Monitoring and Modeling

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Compare early modeling results with actual field data regarding the size, shape, and nature of the injected CO_2.
- Conduct a final-stage, holistic modeling effort using the reservoir, hydrogeologic, geochemical, and geomechanical data generated during Phase III efforts to provide technical support for integrated MVA and risk management efforts.
- Evaluate results of Task 9 activities and Subtasks 11.1.1 and 11.1.2 to assess the viability of long-term CO_2 storage at a commercial site.
- Use a holistic approach to determine the cost-effectiveness and commercial viability of the combined modeling and monitoring efforts.

Task 12 – Project Assessment

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Prepare the Annual Project Assessment Report (D57).

Task 13 – Project Management

During the next program year (October 1, 2016 – September 30, 2017), 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.
- Complete Programmatic Risk Management Best Practices Manual, D103 (August 2017).

Task 14 – RCSP WWG Coordination

During the next program year (October 1, 2016 – September 30, 2017), the following activities will be undertaken:

- Continue to conduct quarterly WWG conference calls.
- Update the WWG Web site content as appropriate.
- Publish the special digital issue of IJGGC focused on the issues at the nexus of water and CCS (D106).
- Plan and conduct the 9th annual meeting of the WWG.
- Provide an update on the state of the science of research projects and learnings related to the nexus of water and CCS resulting in a final summary report (D107). Complete the associated milestone "Research Related to Water and CCS Nexus Completed" (M62).

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

This task ended February 28, 2014. No further activity is anticipated.

Task 16 – Basal Cambrian System Characterization

This task ended March 31, 2014. No further activity is anticipated.

PLANNED SCHEDULE

Table 22 contains all of the Phase III deliverables, milestones, and submission dates for PY10 (October 1, 2016 – September 30, 2017).

Table 22. Phase III Milestones and Deliverables

Title/Description	Due Date	Actual Completion Date
Year 10 – Quarter 1 (October–December 2016)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/16	
D21: Task 2 – Bell Creek Test Site 30-minute Documentary	10/31/16	
D76: Task 3 – Regional Regulatory Perspective	10/31/16	
D105: Task 9 – Comparison of Non-EOR and EOR Life Cycle Assessments	10/31/16	
D15: Task 2 – Bell Creek Test Site Fact Sheet (update)	11/30/16	
M52: Task 9 – Initial Analysis of Extended Pulsed-Neutron Logging Campaign Data Completed	11/30/16	
D57: Task 12 – Project Assessment Annual Report	12/31/16	
D81: Task 1 – Regional Carbon Sequestration Atlas (update)	12/31/16	
D106: Task 14 – Special Issue of IJGGC – Nexus of Water and Carbon Capture and Storage	12/31/16	
M23: Task 14 – Monthly WWG Conference Call Held	12/30/16	
M24: Task 14 – WWG Annual Meeting Held	12/31/16	
M36: Task 13 – Annual Advisory Board Meeting Scheduled	12/31/16	
Year 10 – Quarter 2 (January–March 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/17	
D22: Task 2 – Energy from Coal 60-minute Documentary	1/31/17	
M60: Task 1 – Data Submitted to EDX	2/28/17	
D35: Task 4 – Bell Creek Test Site – Best Practices Manual – Site Characterization	3/31/17	
M23: Task 14 – Monthly WWG Conference Call Held	3/31/17	
Year 10 – Quarter 3 (April–June 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/17	
D17: Task 2 – General Phase III Information PowerPoint Presentation (update)	5/31/17	
D69: Task 9 – Bell Creek Test Site – Best Practices Manual – Simulation Report	5/31/17	
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities (update)	5/31/17	
D101: Task 14 – WWG Web Site Content Update 1	5/31/17	
D104: Task 9 – Analysis of Expanded Seismic Campaign	6/30/17	
M23: Task 14 – Monthly WWG Conference Call Held	6/30/17	
M47: Task 2 – Bell Creek Test Site 30-Minute Documentary Broadcast	6/30/17	

Continued . . .

Table 22. Phase III Milestones and Deliverables (continued)

Title/Description	Due Date	Actual Completion Date
Year 10 – Quarter 4 (July–September 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/17	
D66: Task 9 – Bell Creek Test Site – Simulation Report (update)	8/31/17	
D81: Task 81 – Regional Carbon Sequestration Atlas (update)	8/31/17	
D103: Task 13 – Best Practices Manual – Programmatic Risk Management	8/31/17	
D1: Task 1 – Review of Source Attributes (update)	9/30/17	
M23: Task 14 – Monthly WWG Conference Call Held	9/30/17	
M55: Task 9 – Investigation of Crude Oil Composition Changes during CO_2 EOR Completed	9/30/17	
M62: Task 14 – Research Related to Water and CCS Nexus Completed	9/30/17	

TRAVEL

Representatives from the PCOR Partnership attended and/or participated in the following 48 external meetings/conferences, seven workshops, one training opportunity, and 20 project management site trips in this reporting period. As the Phase III Program moved into BP5, travel remained close to that in PY8. Slightly fewer meetings/conferences/workshops (56 compared to 60 in PY8) and site trips were made during the operational monitoring phase (20 versus 23). The external training opportunities decreased (one versus six in PY8); however, additional training was provided in-house and by Webinar.

- September 26 – October 1, 2015: traveled to Oklahoma City, Oklahoma, to attend the IOGCC Annual Meeting.
- September 27 – October 1, 2015: traveled to Southampton, United Kingdom, to present at the IEAGHG Risk Management & Environmental Research Combined Network Meetings.
- October 20–22, 2015: traveled to Columbus, Ohio, to attend the Midwest Regional Carbon Sequestration Partnership Partners Meeting.
- October 21–22, 2015: traveled to Beulah, North Dakota, for an interview and filming at the Dakota Gasification Company and the Freedom Mine.
- October 25 – November 1, 2015: traveled to Gillette, Wyoming, for site work at the Bell Creek Field.
- October 26 – November 5, 2015: traveled to Gillette, Wyoming, for SASSA project work at the Bell Creek Field.
- November 1–3, 2015: traveled to Gillette, Wyoming, for site work at the Bell Creek Field.
- November 3–5, 2015: traveled to Houston, Texas, for the Interactive Workshop Focusing on Induced Seismicity.
- November 8–13, 2015: traveled to Salt Lake City, Utah, to attend the AIChE Annual Meeting.
- November 16–19, 2015: traveled to Gillette, Wyoming, for site work at the Bell Creek Field.
- November 17, 2015: traveled to Fargo, North Dakota, to meet with PPB production staff to work on budgets, planning, and schedules for the upcoming documentaries.
- December 1–3, 2015: traveled to Austin, Texas, to attend the Carbon Capture Sequestration and the Carbon Capture Utilization Working Group meeting.
- December 1–4, 2015: traveled to Morgantown, West Virginia, to attend the PCOR Partnership continuation application meeting.
- December 6–12, 2015: traveled to Perth, Australia, to attend the 2015 IEAGHG R&D Carbon Capture and Storage Summer School.
- December 7–11, 2015: traveled to Gillette, Wyoming, to conduct maintenance on geophysics systems at the Bell Creek Field.
- December 8–11, 2015: traveled to Midland, Texas, to attend CO_2 Conference Week.
- December 13–15, 2015: traveled to Ottawa, Ontario, Canada, to attend Science and Engineering Research meetings.
- January 6–8, 2016: traveled to Plano, Texas, for project meetings with Denbury personnel.
- January 7–8, 2016: traveled to Gillette, Wyoming, for repairs to the borehole array network at the Bell Creek Field.
- January 25–29, 2016: Off-site staff member traveled to the EERC offices in Grand Forks, North Dakota, for meetings and work on state and provincial regulation flowcharts and crosswalk documents.

- January 25–29, 2016: traveled to Gillette, Wyoming, for purchase and recycle gas sample collection activities at the Bell Creek Field.
- February 17–19, 2016: traveled to Fargo, North Dakota, for meetings with PPB and to Plano, Texas, to conduct interviews at Denbury.
- February 22–26, 2016: traveled to Denver, Colorado, to attend the Ground Water Protection Council Underground Injection Control Meeting.
- March 9–10, 2016: traveled to Bismarck, North Dakota, to attend the North Dakota Carbon Management Industrial Working Group meeting.
- March 22–24, 2016: traveled to Glendive, Montana, for site work at the Bell Creek Field.
- April 3–6, 2016: traveled to New Orleans, Louisiana, to host, present, and participate in the TAB Annual Meeting.
- April 6–8, 2016: traveled to Washington, D.C., to attend the Carbon Capture Infrastructure Workshop.
- April 4–7, 2016: traveled to Miles City, Montana, for site work at the Bell Creek Field.
- April 11–15, 2016: traveled to Mexico City and Villahermosa, Mexico, to attend the North American Energy Ministers Trilateral Carbon Capture Utilization & Sequestration Working Group Meeting.
- April 18–22, 2016: Off-site staff member traveled to the EERC offices in Grand Forks, North Dakota, for meetings and work on state and provincial regulation flowcharts and crosswalk documents.
- April 19–21, 2016: traveled to Bismarck, North Dakota, to attend the LEC Spring Conference.
- April 22, 2016: traveled to Fargo, North Dakota, to participate in meetings with PPB.
- April 25–28, 2016: traveled to Houston, Texas, to attend the Esri Petroleum GIS Conference.
- May 10, 2016: traveled to Fargo, North Dakota, for planning and documentary script development meetings.
- May 14–18, 2016: traveled to Denver, Colorado, to attend the IOGCC Annual Meeting.
- May 16–17, 2016: traveled to Champaign, Illinois, to present at the 2016 Midwest Carbon Sequestration Science Conference.
- May 16–20, 2016: traveled to Gillette, Wyoming, for Bell Creek sample collections.
- May 18, 2016: traveled to Fargo, North Dakota, to work on the coal documentary with PPB.
- May 23–26, 2016: traveled to Bismarck, North Dakota, to attend the WBPC.
- May 23–27, 2016: traveled to Gillette, Wyoming, for sample collection and site maintenance at the Bell Creek Field.
- June 2-8, 2016: traveled to Hangzhou, China, to attend and present at the 5th U.S.–China Symposium on CO_2 Emission Control Science Technology conference.
- June 8–16, 2016: traveled to Tysons, Virginia, to attend and present at the Carbon Capture Utilization and Storage conference.
- June 10–19, 2016: traveled to Calgary, Alberta, Canada, to attend CMG's Technical Symposium.
- June 12–21, 2016: traveled to Birmingham, Alabama, to attend the Education in Carbon Capture, Utilization, and Storage training and conference.
- June 13–14, 2016: traveled to Bismarck, North Dakota, to present at the LEC Teacher Seminar.
- June 23–30, 2016: traveled to Houston, Texas, to attend the ARMA 50th U.S. Rock Mechanics Symposium and workshops.
- June 24–30, 2016: traveled to San Diego, California, to attend the Esri User Conference.

- June 27–29, 2016: traveled to Gillette, Wyoming, to film with PPB for the Bell Creek documentary.
- June 27–30, 2016: traveled to London, United Kingdom, to attend the 2016 CSLF Mid-Year Meeting.
- July 2–9, 2016: traveled to Edinburgh, Scotland, to attend the IEAGHG Modeling and Monitoring Network Conference and field trip.
- July 11–13, 2016: traveled to Glendive, Montana, for data download from MOREVision and DTS units at the Bell Creek observation well.
- July 12–15, 2016: traveled to San Francisco, California, for location shoots and to conduct interviews for the coal documentary.
- July 16–24, 2016: traveled to Regina, Saskatchewan, to attend and present at the IEAGHG International Interdisciplinary Carbon Capture & Sequestration Summer School.
- July 17–19, 2016: traveled to Calgary, Alberta, for meetings with Arcis.
- July 18–22, 2016: traveled to Miles City, Montana, to collect oil samples from Denbury staff.
- July 19–21, 2016: traveled to Bismarck, North Dakota, to attend the WBI Energy Customer Meeting and the NDIC Special Session.
- July 25–29, 2016: traveled to Gillette, Wyoming, to sample soil gas profile stations and Fox Hills Formation monitoring wells.
- August 7–12, 2016: traveled to Pittsburgh, Pennsylvania, to attend the DOE NETL CO_2 Capture Technology Project Review Meeting.
- August 14–19, 2016: traveled to Pittsburgh, Pennsylvania, to attend and present at the Mastering the Subsurface Through Technology Innovation and Collaboration: Carbon Storage & Oil and Natural Gas Technologies Review Meeting, to attend the associated NRAP Risk Assessment Tools Workshop, and to host the WWG Annual Meeting.
- August 15–17, 2016: traveled to Ottawa, Ontario, Canada, to attend the Aquistore Annual Technical Meeting.
- August 16–18, 2016: traveled to Gainesville, Florida, with PPB to conduct an interview with a coal historian for the coal documentary.
- August 22, 2016: traveled to Fargo, North Dakota, to the PPB offices to conduct an interview for the coal documentary.
- August 22–26, 2016: off-site staff member traveled to the EERC offices in Grand Forks, North Dakota, for meetings and to work on upcoming deliverables.
- August 27 – September 2, 2016: traveled to Cape Town, South Africa, to attend and present at the 35th International Geological Congress.
- September 6–13, 2016: traveled to Ordos, China, to present at the second U.S.–China CCIF.
- September 8–10, 2016: traveled to Billings, Montana, to conduct an interview with Tom Richmond for the Bell Creek documentary.
- September 12 and 19, 2016: traveled to Kenmare, North Dakota, to remove electrical panels still on-site.
- September 12–16, 2016: off-site staff member traveled to the EERC offices in Grand Forks, North Dakota, to attend the PCOR Partnership Annual Membership Meeting and Workshop and to work on upcoming deliverables.
- September 13, 2016: traveled to Fargo, North Dakota, to conduct an interview with Steve Melzer for the Bell Creek documentary (D21).
- September 19–21, 2016: traveled to Minot, North Dakota, to attend the North Dakota Petroleum Council's Annual Meeting.

- September 19–23, 2016: traveled to Gillette, Wyoming, for oil sampling at the Bell Creek Field.
- September 23, 2016: traveled to Fargo, North Dakota, for meetings with PPB to discuss the upcoming documentaries.
- September 29, 2016: traveled to Bismarck, North Dakota, to present at the North Dakota Building Trades Convention.

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

PHASE III PRODUCTS/PUBLICATIONS

During PY9, the PCOR Partnership submitted 16 abstracts (17 were accepted), and authors declined one. The PCOR Partnership gave 29 oral presentations and presented several recycled posters (created during PY8). In addition, it completed 20 deliverable/milestone reports (21 were finalized), four value-added products, and 16 progress reports (monthlies and quarterlies combined), submitted three journal articles (one rejected), and prepared several conference call and meeting minutes.

Abstracts

Submitted, Accepted, and Declined by Author (1)

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., and Steadman, E.N., 2016, Engaging teachers to facilitate learning—PCOR Partnership outreach in action [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Submitted and Accepted for Presentation (14)

Azzolina, N.A., Peck, W.D., Hamling, J.A., Gorecki, C.D., Melzer, L.S., and Nakles, D.V., 2015, How green is my oil? A detailed look at carbon accounting for CO_2 enhanced oil recovery sites (CO_2 EOR) [abs.]: Carbon Capture, Utilization & Storage Conference, Tyson, Virginia, June 14–16, 2015.

Daly, D.J., Crossland, J.L., Crocker, C.R., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, Regionwide and project-level outreach—the PCOR Partnership approach [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Gorecki, C.D., Ayash, S.C., Peck, W.D., Hamling, J.A., Sorensen, J.A., Daly, D.J., Jensen, M.D., Klapperich, R.J., Heebink, L.V., Pekot, L.J., Steadman, E.N., and Harju, J.A., 2016, The Plains CO_2 Reduction Partnership—developing technologies for CCS deployment in central North America [abs.]: 35th International Geological Congress, Cape Town, South Africa, August 27 – September 4, 2016.

Gorecki, C.D., Ayash, S.C., Peck, W.D., Hamling, J.A., Sorensen, J.A., Daly, D.J., Jensen, M.D., Klapperich, R.J., Heebink, L.V., Pekot, L.J., Steadman, E.N., and Harju, J.A., 2015, The Plains CO_2 Reduction Partnership—guiding CCS deployment in central North America [abs.]: Carbon Capture, Utilization & Storage Conference, Tyson, Virginia, June 14–16, 2015.

Gorecki, C.D., Steadman, E.N., Harju, J.A., Hamling, J.A., Sorensen, J.A., Peck, W.D., Daly, D.J., Jensen, M.D., Pekot, L.J., Klapperich, R.J., Heebink, L.V., and Ayash, S.C., 2016, The Plains CO_2 Reduction Partnership—demonstrating geologic storage of carbon dioxide [abs.]: 5th U.S.–China Symposium on CO_2 Emission Control, Hangzhou, China, June 5–7, 2016.

Hamling, J.A., Azzolina, N.A., Peck, W.D., Gorecki, C.D., Melzer, L.S., and Nakles, D.V., 2016, How green is my oil? a detailed look at carbon accounting for CO_2 enhanced oil recovery sites (CO_2 EOR) [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Hamling, J.A., Klapperich, R.J., Kalenze, N.S., Bosshart, N.W., Stepan, D.J., Burnison, S.A., Leroux, K.M., Glazewski, K.A., Gorecki, C.D., and Richards, T.L., 2016, Monitoring 2.5 million tonnes of CO_2 at the Bell Creek oil field [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Hamling, J.A., Leroux, K.M., Glazewski, K.A., and Bosshart, N.W., 2016, Adaptive approach to modeling and monitoring 5 million tonnes of CO_2 injection at the Bell Creek oil field [abs.]: 2nd Combined Meeting of the Modelling and Monitoring Networks, Edinburgh, United Kingdom, July 6–8, 2016.

Hawthorne, S.B., Miller, D.J., Sorensen, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, Effects of reservoir temperature and percent levels of methane and ethane on CO_2/oil MMP values as determined using vanishing interfacial tension/capillary rise [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Jiang, T., Pekot, L.J., Peck, W.D., Sorensen, J.A., and Gorecki, C.D., 2016, A numerical simulation update of the Aquistore CO_2 storage project [abs.]: 2016 AIChE Annual Meeting, San Francisco, California, November 13–18, 2016.

Jin, L., Pekot, L.J., Hawthorne, S.B., Gobran, B., Greeves, A., Bosshart, N.W., Jiang, T., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, Impact of CO_2 impurity on MMP and oil recovery performance of Bell Creek oil field [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Leroux, K.M., Glazewski, K.A., Kalenze, N.S., Botnen, B.W., Stepan, D.J., Klapperich, R.J., and Hamling, J.A., 2016, Lessons learned in near-surface monitoring for large-scale CO_2 storage [abs.]: 2016 AIChE Annual Meeting, San Francisco, California, November 13–18, 2016.

Salako, O., Burnison, S.A., Hamling, J.A., Reed, S., and Gorecki, C.D., 2016, 4-D seismic monitoring of injected CO_2 enhances geological interpretation, reservoir simulation, and production operations [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Smith, S.A., Beddoe, C.J., Zacher, E.J., Heebink, L.V., Kurz, B.A., Peck, W.D., and Gorecki, C.D., 2016, Relative permeability of Williston Basin CO_2 storage targets [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Submitted and Accepted for Poster (1)

Jiang, T., Pekot, L.J., Jin, L., Peck, W.D., Gorecki, C.D., and Worth, K., 2016, Numerical modeling of the Aquistore CO_2 storage project [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Accepted for Presentation (1)

Burnison, S.A., Gorecki, C.D., Ayash, S.C., Peck, W.D., Hamling, J.A., Sorensen, J.A., Daly, D.J., Jensen, M.D., Klapperich, R.J., Heebink, L.V., Pekot, L.J., Steadman, E.N., and Harju, J.A., 2016, The Plains CO_2 Reduction Partnership—carbon management through the development of technologies for CCS deployment [abs.]: 2nd Clean Coal Industry Forum (CCIF), Ordos, Inner Mongolia, September 9–10, 2016.

Presentations (29)

Ayash, S.C., and Gorecki, C.D., 2016, Lasting impacts of the Plains CO_2 Reduction (PCOR) Partnership Program: Presented at the 2016 Plains CO_2 Reduction (PCOR) Partnership Annual Membership Meeting and Workshop, Grand Forks, North Dakota, September 13–15, 2016.

Ayash, S.C., and Gorecki, C.D., 2016, Plains CO_2 Reduction (PCOR) Partnership, oil and gas activities, and other EERC projects: Presented to Petro Harvester personnel, Grand Forks, North Dakota, March 9, 2016.

Ayash, S.C., and Gorecki, C.D., 2016, Plains CO_2 Reduction (PCOR) Partnership Program Technical Advisory Board (TAB) meeting: Presented at the 2016 Plains CO_2 Reduction (PCOR) Partnership Annual Membership Meeting and Workshop, Grand Forks, North Dakota, September 13–15, 2016.

Ayash, S.C., Gorecki, C.D., Hamling, J.A., Peck, W.D., Pekot, L.J., and Nakles, D.V., 2016, 2016 PCOR Partnership Technical Advisory Board meeting: Presented at the 5th Annual Plains CO_2 Reduction Partnership Technical Advisory Board Meeting, New Orleans, Louisiana, April 4–5, 2016.

Azzolina, N.A., Peck, W.D., Hamling, J.A., Gorecki, C.D., Ayash, S.C., Doll, T.E., Nakles, D.V., and Melzer, L.S., 2016, How green is my oil? a detailed look at GHG accounting for CO_2 EOR sites: Plains CO_2 Reduction (PCOR) Partnership WebEx presentation to U.S. Department of Energy National Energy Technology Laboratory personnel, January 28, 2016.

Burnison, S., 2016, Geophysics at the EERC—overview of projects, status, and plans: Presented to Denbury Resources Inc. personnel, Plano, Texas, January 7, 2016.

Burnison, S.A., and Gorecki, C.D, 2016, The Plains CO_2 Reduction Partnership—carbon management through the development of technologies for CCS deployment: Presented at the 2nd Clean Coal Industry Forum (CCIF), Ordos, Inner Mongolia, September 9–10, 2016.

Daly, D.J., and Crocker, C.R., 2016, Climate change/carbon management: Presented at the North Dakota Science Teachers Association Spring 2016 Conference, Grand Forks, North Dakota, April 21, 2016.

Daly, D.J., and Crocker, C.R., 2016, Energy and CO_2 management—carbon capture and storage: Presented at the 2016 Lignite Education Seminar, Bismarck, North Dakota, May 9–10, 2016.

Gorecki, C.D., 2016, Panel discussion—lessons learned on Phase III activities: Presented at the Midwest Carbon Sequestration Science Conference, Champaign, Illinois, May 16–17, 2016.

Gorecki, C.D., 2016, Plains CO_2 Reduction Partnership—Bell Creek Field project: Presented at Mastering the Subsurface Through Technology Innovation and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting, Pittsburgh, Pennsylvania, August 16–18, 2016.

Gorecki, C.D., 2015, Plains CO_2 Reduction (PCOR) Partnership Budget Period 5 discussion: Presented at the Plains CO_2 Reduction (PCOR) Partnership Budget Period 5 discussion, Morgantown, West Virginia, December 4, 2015.

Gorecki, C.D., and Ayash, S.C., 2016, The Plains CO_2 Reduction (PCOR) Partnership—demonstrating geologic storage of carbon dioxide: Presented at the 5th U.S.–China Symposium on CO_2 Emission Control, Hangzhou, China, June 5–7, 2016.

Gorecki, C.D., Ayash, S.C., 2016, PCOR Partnership project review and updates: Presented to U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) personnel, Grand Forks, North Dakota, June 21, 2016.

Gorecki, C.D., Jin, L., and Pekot, L.J., 2016, A systematic simulation study of CO_2 flooding in the Bell Creek oil field: Presented at the Computer Modelling Group Technical Symposium, Calgary, Alberta, June 13–14, 2016.

Hamling, J.A., Leroux, K.M., Glazewski, K.A., and Bosshart, N.W., 2016, Adaptive approach to modeling and monitoring 5 million tonnes of CO_2 injection at the Bell Creek oil field: Presented at the 2nd Combined Meeting of the Modelling and Monitoring Networks, Edinburgh, United Kingdom, July 6–8, 2016.

Jensen, M.D., and Azzolina, N., 2016, Life cycle analysis (LCA) of oil produced by CO_2 EOR: Presented to Denbury Resources Inc. personnel, Plano, Texas, January 7, 2016.

Klapperich, R.J., 2016, EERC CO_2 EOR and saline storage research through the PCOR Partnership and other EERC projects: Presented to African Carbon Energy Africary – South Africa personnel, Grand Forks, North Dakota, May 17, 2016.

Klapperich, R.J., 2016, RCSP Water Working Group annual meeting: Presented at the Regional Carbon Sequestration Partnerships RCSP Water Working Group Annual Meeting, Pittsburgh, Pennsylvania, August 17, 2016.

Nakles, D.V., Azzolina, N., Peck, W.D., Hamling, J.A., Gorecki, C.D., Ayash, S.C., Doll, T.E., and Melzer, L.S., 2016, How green is my oil? A detailed look at GHG accounting for CO_2 EOR

sites: Presented at the Carbon Capture, Utilization & Storage Conference, Tysons, Virginia, June 14–16, 2016.

Peck, W.D., 2015, Plains CO_2 Reduction (PCOR) Partnership perspective: Presented at North American Energy Ministers Climate Change and Energy Collaboration—Advancing the Deployment of CCUS, Austin, Texas, December 1–3, 2015.

Peck, W.D., and Gorecki, C.D., 2016, Practical learnings about CO_2 storage in North America?: Presented at the North American Energy Ministers Trilateral (NAEMT) Meeting – Carbon Capture, Utilization and Storage, Mexico City, Mexico, April 12–13, 2016.

Peck, W.D., and Gorecki, C.D., 2016, The Plains CO_2 Reduction Partnership—developing technologies for CCS deployment in central North America: Presented at the 35th International Geological Congress, Cape Town, South Africa, August 27 – September 4, 2016.

Peck, W.D., Hamling, J.A., and Gorecki, C.D., 2016, Implementing carbon capture and storage—an overview of the Plains CO_2 Reduction Partnership's Bell Creek project: Presented at the North American Energy Ministers Trilateral (NAEMT) Meeting – Best Practices for CO_2-EOR with CCS Workshop, Villahermosa, Mexico, April 14, 2016.

Pekot, L.J., 2016, An update of Aquistore CO_2 storage simulation: Presented at the Aquistore Annual General Meeting, Ottawa, Ontario, August 16–17, 2016.

Pekot, L.J., 2016, An update of Aquistore CO_2 storage simulation: Presented at the Computer Modelling Group Technical Symposium, Calgary, Alberta, June 13–14, 2016.

Pekot, L.J., 2016, An update of Aquistore CO_2 storage simulation: Webinar for the Plains CO_2 Reduction (PCOR) Partnership Technical Advisory Board, July 26, 2016.

Steadman, E.N., 2016, What have we learned along the CCS trail? A different perspective: Presented at the 2016 Plains CO_2 Reduction (PCOR) Partnership Annual Membership Meeting and Workshop, Grand Forks, North Dakota, September 13–15, 2016.

Steadman, E.N., Gorecki, C.D., and Ayash, S.C., 2016, The Plains CO_2 Reduction (PCOR) Partnership—guiding CCS deployment in central North America: Presented at the Carbon Capture, Utilization & Storage Conference, Tysons,

Deliverables/Milestones

Draft (7)

Ayash, S.C., Nakles, D.V., Peck, W.D., Sorensen, J.A., Glazewski, K.A., Aulich, T.R., Klapperich, R.J., Azzolina, N.A., and Gorecki, C.D., 2016, Best practice for the commercial deployment of carbon dioxide geologic storage—adaptive management approach: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 13 Deliverable D102/Milestone M59 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, B.W., Kalenze, N.S., Leroux, K.M., Klapperich, R.J., Glazewski, K.A., Stepan, D.J., Hamling, J.A., and Gorecki, C.D., 2016, Bell Creek test site – development of a cost-effective, long-term monitoring strategy: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task

11 Deliverable D55 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., Kovacevich, J.T., Jensen, M.D., Peck, W.D., and Gorecki, C.D., 2016, Review of source attributes: Plains CO_2 Reduction Partnership Phase III draft Task 1 Deliverable D1 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., and Gorecki, C.D., 2016, Bell Creek test site – infrastructure development report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Subtask 6.2 Deliverable D45 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Jensen, M.D., Schlasner, S.A., Hamling, J.A., Gorecki, C.D., and Azzolina, N.A., 2016, Life cycle analysis for primary and secondary recovery oil completed: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Milestone M56 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Jin, L., Bosshart, N.W., Oster, B.S., Hawthorne, S.B., Peterson, K.J., Burton-Kelly, M.E., Feole, I.K., Jiang, T., Pekot, L.J., Peck, W.D., Ayash, S.C., and Gorecki, C.D., 2016, Bell Creek test site – simulation report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D66 (Update 5) 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.

Wilson IV, W.I., Doll, T.E., and Gorecki, C.D., 2016, Permitting review – Update 3: Plains CO_2 Reduction (PCOR) Partnership draft Phase III Task 3 Deliverable D8 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.

Submitted and Approved (13)

Burnison, S.A., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Bell Creek test site—expanded baseline and time-lapse 3-D surface seismic survey completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone 53 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-12-19; Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Crossland, J.L., Crocker, C.R., Daly, D.J., and Gorecki, C.D., 2016, 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 2016-EERC-08-12, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Daly, D.J., Crossland, J.L., Crocker, C.R., and Gorecki, C.D., 2016, Outreach action plan: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D11 (update 2) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-09-02, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, Fort Nelson CCS feasibility project: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D16 fact sheet 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., Crossland, J.L., Peck, W.D., Hamling, J.A., and Gorecki, C.D., 2016, PCOR Partnership—demonstrating CO_2 storage in the northern Great Plains: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D14 (update) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Daly, D.J., Crocker, C.R., and Crossland, J.L., 2016, General audience CO_2 sequestration outreach PowerPoint presentation: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D17 (update 7) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Glazewski, K.A., Hamling, J.A., and Gorecki, C.D., 2016, Bell Creek test site—initial processing and analysis of historic InSAR data completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M54 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-01-11, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Gorecki, C.D., Harju, J.A., Steadman, E.N., Heebink, L.V., Romuld, L., Hamling, J.A., Sorensen, J.A., Daly, D.J., Jensen, M.D., Peck, W.D., Klapperich, R.J., Votava, T.F., Pekot, L.J., Ayash, S.C., and Ensrud, J.R., 2015, Annual assessment report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 12 Deliverable D57 (October 1, 2014 – September 30, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-02-14, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Gorecki, C.D., Kalenze, N.S., and Hamling, J.A., 2016, Bell Creek test site—completion of 2.75M metric tons of CO_2 stored: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M58 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-03-12, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Heebink, L.V., Ayash, S.C., and Gorecki, C.D., 2016, 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 2016-EERC-04-01, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Jensen, M.D., Schlasner, S.A., Hamling, J.A., Leroux, K.M., Gorecki, C.D., and Azzolina, N.A., 2016, Life cycle analysis for primary and secondary enhanced oil recovery at the Bell Creek Field completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M57 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-06-02, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Jiang, T., Pekot, L.J., Jin, L., Peck, W.D., and Gorecki, C.D., 2016, Geologic modeling and simulation report for the Aquistore project: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 1 Deliverable D93 (Update 2) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-04-06, Grand Forks, North Dakota, Energy & Environmental Research Center, February.

Klapperich, R.J., and Gorecki, C.D., 2016, Water Working Group Web site content update: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 14 Deliverable D101 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-06-01, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

Approved (8)

Dotzenrod, N.W., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Bell Creek test site—initial analysis for first large-scale repeat pulsed-neutron logging campaign post-significant CO_2 injection completed: Plains CO_2 Reduction Partnership Phase III Task 9 Milestone M51 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-10-06, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

Ge, J., Klenner, R.C.L., Liu, G., Braunberger, J.R., Ayash, S.C., Pu, H., Gao, T., Bailey, T.P., Hamling, J.A., Sorensen, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2013, Bell Creek Field test site—geomechanical modeling report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Deliverable D32 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-02-18, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Heebink, L.V., Smith, S.A., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Bell Creek test site – drilling and completion activities report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 5 Deliverable D44 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-04-04, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Jensen, M.D., Hamling, J.A., and Gorecki, C.D., 2015, Bell Creek test site – transportation and injection operations report: Plains CO_2 Reduction Partnership Phase III Task 8 Deliverable D49 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-04-03, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

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 Task 4 Deliverable D64 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-02-15, Grand Forks, North Dakota, Energy & Environmental Research Center, August.

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 Task 4 Deliverable D33 Milestone M12 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-03-08, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Laumb, J.D., Klapperich, R.J., Hamling, J.A., Glazewski, K.A., Kalenze, N.S., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Bell Creek wellbore integrity study: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D36 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-04-05, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Wilson IV, W.I., Doll, T.E., and Gorecki, C.D., 2015, Permitting review—Update 2: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 3 Deliverable D8 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-10-09, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

Value-Added Products

Submitted and Approved (4)

Crossland, J.L., Daly, D.J., Crocker, C.R., and Gorecki, C.D., 2016, Household energy and carbon Web pages report value-added report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-06-03, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Crossland, J.L., Daly, D.J., and Gorecki, C.D., 2016, Household energy and carbon Web pages report: Plains CO_2 Reduction (PCOR) Partnership Phase III value-added report (April 1 – June 30, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-07-11, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, CO_2 "Huff 'n' Puff" validation test: Plains CO_2 Reduction (PCOR) Partnership Phase III value-added fact sheet for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Daly, D.J., Crocker, C.R., Crossland, J.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2016, CO_2 sequestration test in a deep, unminable lignite seam: Plains CO_2 Reduction (PCOR) Partnership Phase III fact sheet 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.

Progress Reports

Monthlies (12)

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Harju, J.A., Pekot, L.J., Heebink, L.V., Klapperich, R.J., and Ensrud, J.R., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (August 1–31, 2016) 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.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Harju, J.A., Pekot, L.J., Heebink, L.V., Klapperich, R.J., and Ensrud, J.R., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (July 1–30, 2016) 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.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Harju, J.A., Pekot, L.J., Heebink, L.V., Klapperich, R.J., and Ensrud, J.R., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (June 1–30, 2016) 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.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Harju, J.A., Pekot, L.J., Heebink, L.V., Klapperich, R.J., and Ensrud, J.R., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (May 1–31, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (April 1–30, 2016) 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., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (March 1–31, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (February 1–29, 2016) for U.S. Department of Energy

National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March 2016.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (January 1–31, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, February 2016.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Sorensen, J.A., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2016, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (December 1–31, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, February 2016.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Sorensen, J.A., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2015, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (November 1–30, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, December 2015.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Sorensen, J.A., Hamling, J.A., Jensen, M.D., Pekot, L.J., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2015, Plains CO_2 Reduction (PCOR) Partnership: Phase III monthly report (October 1–31, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, November 2015.

Gorecki, C.D., Steadman, E.N., Peck, W.D., Daly, D.J., Sorensen, J.A., Hamling, J.A., Jensen, M.D., Harju, J.A., Heebink, L.V., and Klapperich, R.J., 2015, Plains CO_2 Reduction (PCOR) Partnership: Phase III Monthly Report (September 1–30, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, October 2015.

Quarterlies (4)

Gorecki, C.D., Harju, J.A., Steadman, E.N., Romuld, L., Sorensen, J.A., Daly, D.J., Hamling, J.A., Jensen, M.D., Peck, W.D., Klapperich, R.J., Heebink, L.V., Pekot, L.J., Ensrud, J.R., and Votava, T.J., 2016, Plains CO_2 Reduction Partnership Phase III Task 13 Deliverable D58/D59 quarterly technical progress report (April 1 – June 30, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592 and North Dakota Industrial Commission Contract Nos. FY08-LX111-162 and G-015-030, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

Gorecki, C.D., Harju, J.A., Steadman, E.N., Romuld, L., Sorensen, J.A., Daly, D.J., Hamling, J.A., Jensen, M.D., Peck, W.D., Klapperich, R.J., Heebink, L.V., Pekot, L.J., Ensrud, J.R., and Votava, T.J., 2016, Plains CO_2 Reduction Partnership Phase III Task 13 Deliverable D58/D59 quarterly technical progress report (January 1 – March 31, 2016) for U.S. Department of Energy

National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592 and North Dakota Industrial Commission Contract Nos. FY08-LX111-162 and G-015-030, Grand Forks, North Dakota, Energy & Environmental Research Center, April.

Gorecki, C.D., Harju, J.A., Steadman, E.N., Romuld, L., Sorensen, J.A., Daly, D.J., Hamling, J.A., Jensen, M.D., Peck, W.D., Klapperich, R.J., Heebink, L.V., Votava, T.J., Pekot, L.J., and Ensrud, J., 2016, Plains CO_2 Reduction Partnership Phase III Task 13 Deliverable D58/59 quarterly technical progress report (October 1 – December 31, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592 and North Dakota Industrial Commission Contract Nos. FY08-LX111-162 and G-015-030, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Gorecki, C.D., Harju, J.A., Steadman, E.N., Romuld, L., Sorensen, J.A., Daly, D.J., Hamling, J.A., Jensen, M.D., Peck, W.D., Klapperich, R.J., Heebink, L.V., Votava, T.J., and Pekot, L.J., 2015, Plains CO_2 Reduction Partnership Phase III Task 13 Deliverable D58/59 Quarterly Technical Progress Report (July 1 – September 30, 2015) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592 and North Dakota Industrial Commission Contract Nos. FY08-LX111-162 and G-015-030, Grand Forks, North Dakota, Energy & Environmental Research Center, October.

Meeting Minutes (7)

Ayash, S.C., and Nakles, D., 2016, Minutes—summary of the 5th Annual Plains CO_2 Reduction Partnership Technical Advisory Board Meeting: New Orleans, LA, April 5–6, 2016.

Ayash, S.C., and Nakles, D., 2015, Minutes—summary of Plains CO_2 Reduction (PCOR) Partnership technical advisory board meeting: Chicago, Illinois, September 15, 2015.

Klapperich, R.J., and Tennyson, M., 2016, Minutes—Regional Carbon Sequestration Partnerships Water Working Group conference call: April 27, 2016.

Klapperich, R.J., 2016, Minutes—Regional Carbon Sequestration Partnerships Water Working Group conference call: January 27, 2016.

Klapperich, R.J., 2015, Minutes—Regional Carbon Sequestration Partnerships Water Working Group conference call: December 8, 2015.

Klapperich, R.J., 2015, Minutes—Regional Carbon Sequestration Partnerships Water Working Group conference call: October 29, 2015.

Klapperich, R.J., 2015, Minutes—Regional Carbon Sequestration Partnerships Water Working Group conference call: September 30, 2015.

Journal Articles Submitted and Accepted (2)

Azzolina, N.A., Peck, W.D., Hamling, J.A., Gorecki, C.D., Ayash, S.C., Doll, T.E., Nakles, D.V., and Melzer, L.S., 2016, How green is my oil? a detailed look at greenhouse gas accounting for CO_2 enhanced oil recovery (CO_2 EOR) sites: International Journal of Greenhouse Gas Control, v. 51, p. 369–379.

Hawthorne, S.B., Miller, D.J., Jin, L., and Gorecki, C.D., 2016, Rapid and simple capillary-rise/vanishing interfacial tension method to determine crude oil minimum miscibility pressure—pure and mixed CO_2, methane, and ethane: Energy & Fuels, v. 30, no. 8, p. 6365–6372.

Journal Article Submitted and Rejected (1)

Schlasner, S.M., Jensen, M.D., Nakles, D.V., and Azzolina, N.A., 2016, Assessing temporary storage options to manage variable-rate CO_2 emissions for use during enhanced oil recovery: Energy & Environmental Science [submitted for publication].

REFERENCES

1. Intergovernmental Panel on Climate Change, 2005, Special report on carbon dioxide capture and storage: Cambridge, United Kingdom, and New York, Cambridge University Press.
2. Glazewski, K.A., Grove, M.M., Peck, W.D., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Characterization of the PCOR partnership region: Plains CO_2 Reduction (PCOR) Partnership Phase III Value-Added Report for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-02-14, Grand Forks, North Dakota, Energy & Environmental Research Center, January.
3. Glazewski, K.A., Kovacevich, J.T., Jensen, M.D., Peck, W.D., and Gorecki, C.D., 2016, Review of source attributes: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 1 Deliverable D1 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-10-05, Grand Forks, North Dakota, Energy & Environmental Research Center, September.
4. Peck, W.D., Glazewski, K.A., Klenner, R.C.L., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Improvements in the application of CO_2 storage efficiency values for deep saline formations: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 1 Deliverable D7 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.
5. Jiang, T., Pekot, L.J., Jin, L., Peck, W.D., and Gorecki, C.D., 2016, Geologic modeling and simulation report for the Aquistore project: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 1 Deliverable D93 (Update 2) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-04-06, Grand Forks, North Dakota, Energy & Environmental Research Center, February.
6. Jiang, T., Pekot, L.J., Jin, L., Peck, W.D., Gorecki, C.D., and Worth, K., 2016, Numerical modeling of the Aquistore CO_2 storage project [abs.]: 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

7. Jiang, T., Pekot, L.J., Peck, W.D., Sorensen, J.A., and Gorecki, C.D., 2016, A numerical simulation update of the Aquistore CO_2 storage project [abs.]: 2016 AIChE Annual Meeting, San Francisco, California, November 13–18, 2016.

8. Daly, D.J., Crossland, J.L., Crocker, C.R., and Gorecki, C.D., 2016, Outreach action plan: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D11 (Update 2) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-09-02, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

9. Crossland, J.L., Crocker, C.R., Daly, D.J., and Gorecki, C.D., 2016, 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 2016-EERC-08-12, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

10. Wilson IV, W.I., Doll, T.E., and Gorecki, C.D., 2015, Permitting review—Update 2: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 3 Deliverable D8 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.

11. U.S. Environmental Protection Agency 40 CFR Parts 60, 70, 71, and 98 Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: www.epa.gov/airquality/cpp/cps-final-rule.pdf Electric Utility Generating Units (accessed July 2015).

12. Wilson IV, W.I., Doll, T.E., and Gorecki, C.D., 2015, Permitting review—Update 2: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 3 Deliverable D8 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-10-09, Grand Forks, North Dakota, Energy & Environmental Research Center, September.

13. Burnison, S.A., Burton-Kelly, M.E., Zhang, X., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2014, Bell Creek test site—3-D seismic and characterization report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D96 for U.S. Department of Energy National Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, March.

14. Bosshart, N.W., Jin, L., Dotzenrod, N.W., Burnison, S.A., Ge, J., He, J., Burton-Kelly, M.E., Ayash, S.C., Gorecki, C.D., Hamling, J.A., Steadman, E.N., and Harju, J.A., 2015, Bell Creek test site—simulation report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Deliverable D66 Update 4 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, August.

15. Jin, L., Bosshart, N.W., Oster, B.S., Hawthorne, S.B., Peterson, K.J., Burton-Kelly, M.E., Feole, I.K., Jiang, T., Pekot, L.J., Peck, W.D., Ayash, S.C., and Gorecki, C.D., 2016, Bell Creek test site—simulation report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D66 (Update 5) 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.

16. Jensen, M.D., and Gorecki, C.D., 2016, Bell Creek test site—infrastructure development report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Subtask 6.2 Deliverable D45 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

17. Gorecki, C.D., Kalenze, N.S., and Hamling, J.A., 2016, Bell Creek test site—completion of 2.75M metric tons of CO_2 stored: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M58 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-03-12, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

18. Gorecki, C.D., Leroux, K.M., Kalenze, N.S., Hamling, J.A., Glazewski, K.A., Stepan, D.J., Klapperich, R.J., Steadman, E.N., and Harju, J.A., 2015, Bell Creek test site—2 years of near-surface assurance monitoring completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M50 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-07-10, Grand Forks, North Dakota, Energy & Environmental Research Center, July.

19. Hawthorne, S.B., Miller, D.J., Jin, L., and Gorecki, C.D., 2016, Rapid and simple capillary-rise/vanishing interfacial tension method to determine crude oil minimum miscibility pressure—pure and mixed CO_2, methane, and ethane: Energy & Fuels, v. 30, no. 8, p. 6365–6372.

20. 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 Task 5 Deliverable D43 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2013-EERC-11-08, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

21. Burnison, S.A., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2015, Bell Creek test site—expanded baseline and time-lapse 3-D surface seismic survey completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone 53 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2015-EERC-12-19; Grand Forks, North Dakota, Energy & Environmental Research Center, December.

22. Glazewski, K.A., Hamling, J.A., and Gorecki, C.D., 2016, Bell Creek test site—initial processing and analysis of historic InSAR data completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M54 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-01-11, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

23. Jensen, M.D., Schlasner, S.A., Hamling, J.A., Gorecki, C.D., and Azzolina, N.A., 2016, Life cycle analysis for primary and secondary recovery oil completed: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Milestone M56 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

24. Jensen, M.D., Schlasner, S.A., Hamling, J.A., Leroux, K.M., Gorecki, C.D., and Azzolina, N.A., 2016, Life cycle analysis for primary and secondary enhanced oil recovery at the Bell Creek Field completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M57 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-06-02, Grand Forks, North Dakota, Energy & Environmental Research Center, May.

25. Azzolina, N.A., Peck, W.D., Hamling, J.A., Gorecki, C.D., Ayash, S.C., Doll, T.E., Nakles, D.V., and Melzer, L.S., 2016, How green is my oil? a detailed look at greenhouse gas accounting for CO_2 enhanced oil recovery (CO_2 EOR) sites: International Journal of Greenhouse Gas Control, v. 51, p. 369–379.

26. Botnen, B.W., Kalenze, N.S., Leroux, K.M., Klapperich, R.J., Glazewski, K.A., Stepan, D.J., Hamling, J.A., and Gorecki, C.D., 2016, Bell Creek test site—development of a cost-effective, long-term monitoring strategy: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 11 Deliverable D55 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.

27. Ayash, S.C., Nakles, D.V., Peck, W.D., Sorensen, J.A., Glazewski, K.A., Aulich, T.R., Klapperich, R.J., Azzolina, N.A., and Gorecki, C.D., 2016, Best practice for the commercial deployment of carbon dioxide geologic storage—adaptive management approach: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 13 Deliverable D102/Milestone M59 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.

28. U.S. Department of Energy National Energy Technology Laboratory, 2014, www.netl.doe.gov/research/coal/crosscutting/national-risk-assessment-partnership (accessed December 2014).

29. Klapperich, R.J., and Gorecki, C.D., 2016, Water Working Group Web site content update: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 14 Deliverable D101 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2016-EERC-06-01, Grand Forks, North Dakota, Energy & Environmental Research Center, May.