ANNUAL ASSESSMENT REPORT

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

(for the period October 1, 2016, through September 30, 2017)

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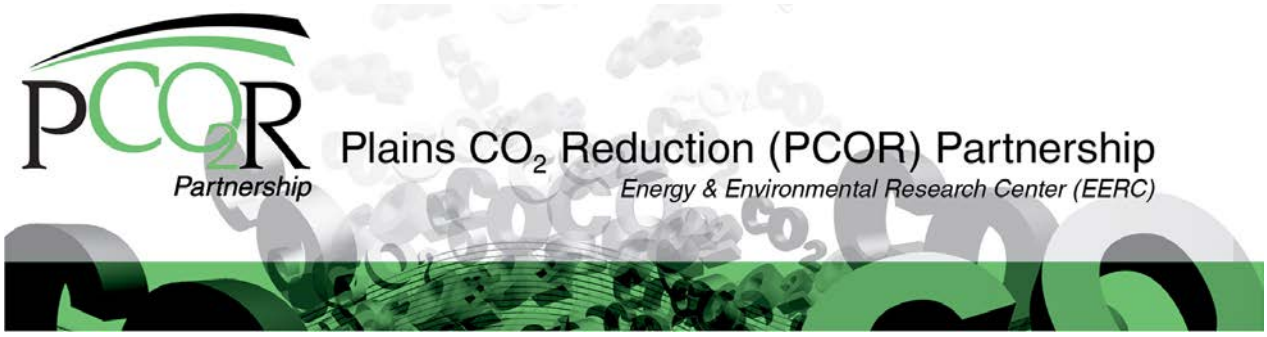

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EXECUTIVE SUMMARY

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 since inception in 2003 has included more than 120 stakeholders from the public and private sector. The PCOR Partnership region includes all or part of nine U.S. states and four Canadian provinces.

Phase III, the development phase (2007–2018), 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) 10 (October 1, 2016 – September 30, 2017) included 1) evaluating monitoring strategies for CO_2 storage incidental to commercial enhanced oil recovery (EOR) operations at Denbury Resources Inc.'s Bell Creek oil 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.

Significant progress continued in PY10 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 storage was recorded. **CO_2 injection continued, and as of September 2017, over 4.24 million cumulative tonnes of associated CO_2 storage has been recorded!** Efforts were focused on continued collection and investigation of oil and purchase/recycle gas, an enhanced pulsed-neutron logging campaign, interpretation of an expanded baseline and time-lapse 3-D survey, initial processing and analysis of historic InSAR data, life cycle analyses for primary and secondary EOR, continuing training for and development of models and simulation activities, and the initial stages of field-based operations decommissioning.

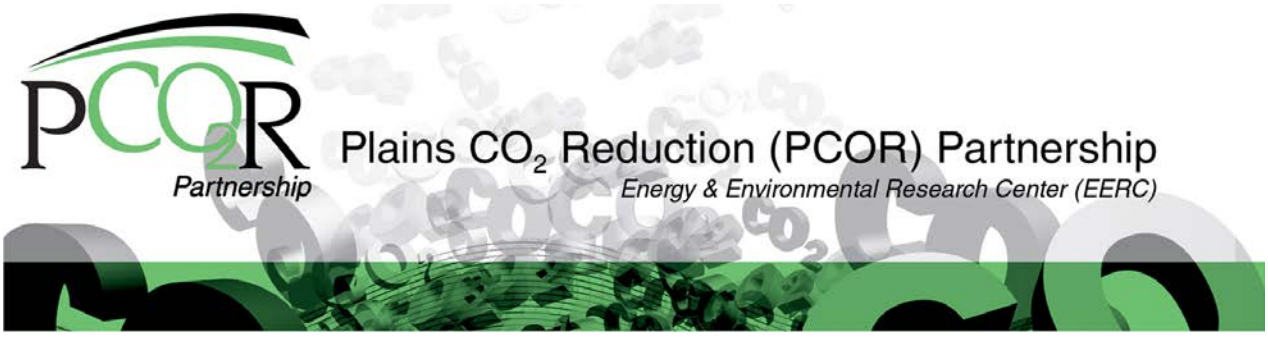
The PCOR Partnership submitted four abstracts, published four papers, gave 35 presentations, achieved 13 milestones, completed 25 deliverable/milestone reports (23 were finalized), and prepared three value-added products and 16 progress reports.

The PCOR Partnership continued the development of five best practices manuals (BPMs) specific to lessons learned through the PCOR Partnership Program. The adaptive management approach was revised based on comments from PCOR Partnership Technical Advisory Board members. Three other BPMs were completed on the topics of site characterization, modeling and simulation, and programmatic risk management. The fifth BPM, on monitoring for CO_2 storage and CO_2 EOR, was submitted October 31, 2017.

Overall, eleven tasks continued to support program goals in PY10. In addition to the foregoing, regional characterization continued, and 402 significant CO_2 sources (greater than 100,000 metric tons), producing 469 million tonnes annually, were verified within the region. Regional oilfield model development continued for simulation purposes to investigate fields that could store significant amounts of CO_2. Numerous activities in relation to the PTRC Aquistore project (near Estevan, Saskatchewan) continued, including updating the geologic model and running predictive simulations. Outreach activities included distribution of print materials, oral and poster presentations, Web site updates, and documentary broadcasts. "The Bell Creek Story – CO_2 in Action" documentary was broadcast on the Prairie Public Broadcasting television network on June 19, 2017. Since program inception, over 6500 PCOR Partnership atlases have been distributed, along with nearly 11,000 documentary DVDs. A full-field Version 3 geologic model was completed for the Bell Creek oil field. The RCSP Water Working Group was active, holding its ninth annual meeting in August 2017, and led the effort to create and edit a virtual special issue of the *International Journal of Greenhouse Gas Control* (IJGGC) focused on the issues at the nexus of water and CCS, which was published online in November 2016. The PCOR Partnership participated in the expert review of the RCSPs in January 2017. Efforts were initiated to develop and edit a virtual special issue of IJGGC on associated storage.

CO_2 injection at Bell Creek will continue in PY11. 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 PY11, ten tasks will continue to be implemented (Tasks 4, 5, 7, 8, 15, and 16 are completed). Seven tasks will be completed March 31, 2018 (Tasks 2, 3, 6, 9, 11, 12, and 14).

This report presents an update of Phase III PCOR Partnership activities from October 1, 2016, through September 30, 2017 (PY10) and planned activities for the following year.



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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 since inception in 2003 has included more 120 stakeholders from the public and private sector. The Phase III membership as of September 30, 2017, 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 (2007–2018): 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	Halliburton	Omaha Public Power District
UND EERC	Hess Corporation	Otter Tail Power Company
Abengoa Bioenergy New Technologies	Huntsman Corporation	Outsource Petrophysics, Inc.
Air Products and Chemicals, Inc.	Husky Energy Inc.	Oxand Risk & Project Management Solutions
Alberta Department of Energy	Indian Land Tenure Foundation	Peabody Energy
Alberta Department of Environment	Interstate Oil and Gas Compact Commission	Petro Harvester Oil & Gas
Alberta Innovates – Technology Futures	Iowa Department of Natural Resources	Petroleum Technology Research Centre
ALLETE	Lignite Energy Council	Petroleum Technology Transfer Council
Ameren Corporation	Manitoba Geological Survey	Pinnacle, a Halliburton Service
American Coalition for Clean Coal Electricity	Marathon Oil Company	Prairie Public Broadcasting
American Lignite Energy	MBI Energy Services	Pratt & Whitney Rocketdyne, Inc.
Apache Canada Ltd.	MEG Energy Corporation	Praxair, Inc.
Aquistore	Melzer Consulting	Ramgen Power Systems, Inc.
Baker Hughes Incorporated	Minnesota Power	Red Trail Energy, LLC
Basin Electric Power Cooperative	Minnkota Power Cooperative, Inc.	RPS Energy Canada Ltd.
BillyJack Consulting Inc.	Missouri Department of Natural Resources	Saskatchewan Ministry of Industry and Resources
Biorecro AB	Missouri River Energy Services	SaskPower
Blue Source, LLC	Montana–Dakota Utilities Co.	Schlumberger
BNI Coal, Ltd.	Montana Department of Environmental Quality	Sejong University
British Columbia Ministry of Energy, Mines, and Petroleum Resources	National Commission on Energy Policy	Shell Canada Limited
British Columbia Oil and Gas Commission	Natural Resources Canada	Spectra Energy
C12 Energy, Inc.	Nebraska Public Power District	Suncor Energy Inc.
The CETER Group, Ltd.	North American Coal Corporation	TAQA North, Ltd.
Computer Modelling Group Ltd.	North Dakota Department of Commerce Division of Community Services	TGS Geological Products and Services
Continental Resources, Inc.	North Dakota Department of Health	Tri-State Generation and Transmission Association, Inc.
Dakota Gasification Company	North Dakota Geological Survey	Tundra Oil and Gas
Denbury Resources Inc.	North Dakota Industrial Commission Department of Mineral Resources, Oil and Gas Division	University of Alberta
Eagle Operating, Inc.	North Dakota Industrial Commission Lignite Research, Development and Marketing Program	University of Regina
Eastern Iowa Community College District	North Dakota Industrial Commission Oil and Gas Research Council	WBI Energy, Inc.
Enbridge Inc.	North Dakota Natural Resources Trust	Weatherford Advanced Geotechnology
Encore Acquisition Company	North Dakota Petroleum Council	Western Governors' Association
Energy Resources Conservation Board/Alberta Geological Survey	North Dakota Pipeline Authority	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		
Great River Energy		

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 December 31, 2018:

BP3: October 1, 2007 – September 30, 2009
BP4: October 1, 2009 – March 31, 2016
BP5: April 1, 2016 – December 31, 2018

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) 10, CO_2 injection continued at the Bell Creek test site. As of March 31, 2016, corresponding to the end of BP4, an estimated 2.98 million cumulative tonnes of associated CO_2 storage was recorded. CO_2 injection continued, and as of September 2017, over 4.24 million cumulative tonnes of associated CO_2 storage has been recorded. Efforts were focused on continued collection and investigation of oil and purchase/recycle gas, 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 (EOR), continuing training for and development of models and simulation activities, and the initial stages of field-based operations decommissioning.

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.

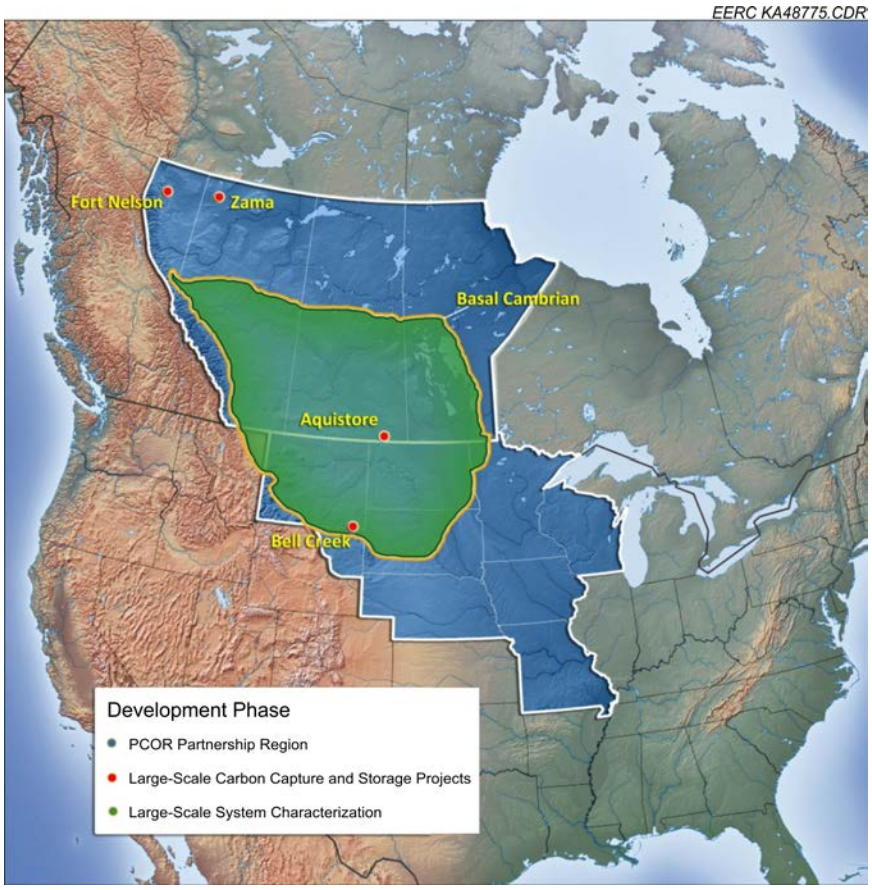

Figure 1. Location of large-scale sites with PCOR Partnership Phase III participation.

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 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 multiyear project, in three BPs, running from October 1, 2007, to December 31, 2018. This Annual Assessment Report summarizes the activities for PY10 (October 1, 2016 – September 30, 2017) 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 PY10. These included 18 required reports, achievement of mandatory milestones, and four quarterly progress reports.

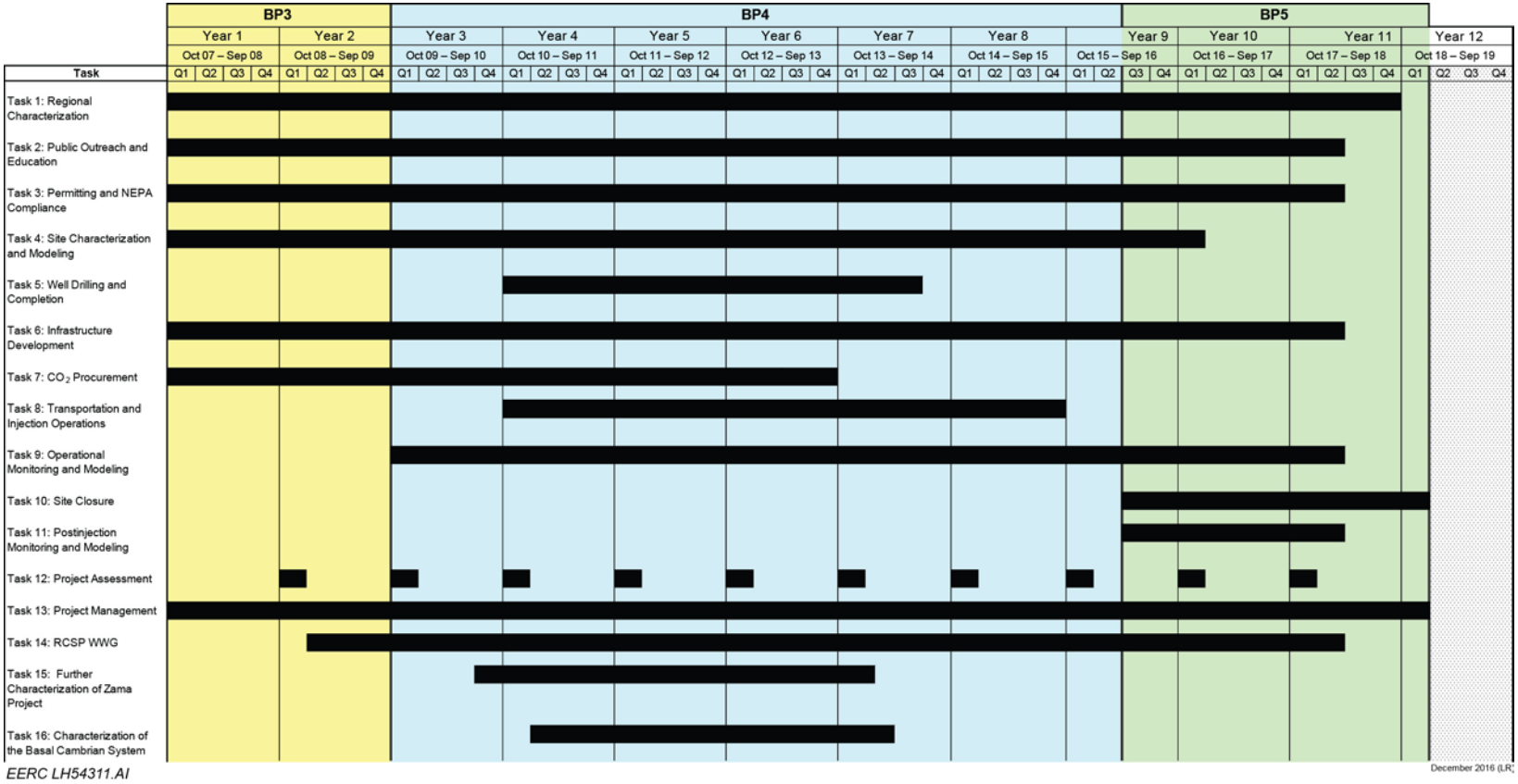

Figure 2. Phase III tasks.

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

The EERC Program Manager presented an overview and update of Phase III PCOR Partnership activities in November 2011 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. After the 2011 IEAGHG peer review, 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 PY10, the PCOR Partnership was represented at 49 meetings/conferences/ workshops and submitted four abstracts. The PCOR Partnership had four papers published, gave 33 oral presentations, and presented two posters. In addition, it completed 25 deliverable/milestone reports (23 were finalized), three value-added products, and 16 progress reports (monthlies and quarterlies combined) and prepared two 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 PY10. The PCOR Partnership distributed 360 documentary DVDs and 195 atlases in PY10. 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 have proven 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 oil 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 oil field, and as of September 30, 2017, at the end of PY10, 4.308 Mt of total gas (composition of approximately 98% CO_2) had been purchased for injection into the Bell Creek oil field, equating to an estimated 4.246 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.

The BP5 project wrap-up activities include the continued dissemination of information, particularly lessons learned. To accomplish this, the PCOR Partnership has worked on the creation of five BPMs specific to lessons learned through the PCOR Partnership program and has plans for a special issue of the *International Journal of Greenhouse Gas Control* (IJGGC) on associated storage. The BPMs are focused on the adaptive management approach (AMA), site characterization, modeling and simulation, programmatic risk management, and monitoring for CO_2 storage and CO_2 EOR.

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 PY10 BP5 (October 1, 2016 – September 30, 2017).
- Accomplishments achieved during PY10 BP5 (October 1, 2016 – September 30, 2017).
- Description of planned PY11 BP5 (October 1, 2017 – September 30, 2018) activities.

PY10 BP5 ACTIVITIES (2016–2017)

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 PY10 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, 2016, through September 30, 2017.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

Regional Characterization

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 402 significant (greater than 100,000 tonnes) CO_2 emission sources that emit 469 million tonnes on an annual basis. Figure 3 shows the locations of 15 new facilities that were found to be missing from the data set and were, therefore, added to it. Seven sources present in last year's data update did not produce the minimum quantity of CO_2 to be included in this data set (1).

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 (DSFs). 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 (2). 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 PY10 and will be finalized in PY11. Maps were modified, the structure/extent model of the Cedar Hills Formation was improved, the potential storage resource was recalculated, and internal review was initiated.

A value-added report on the geologic characterization and CO_2 storage potential of the Inyan Kara Formation continued in PY9 and PY10 and will be finalized in PY11.

Figure 3. Location of the new facilities identified during the 2017 database update.

Additional oilfield regional models were worked on for simulation purposes. These included models for the Beaver Creek Field and Gooseneck Field.

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 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, a value-added laboratory effort to determine key petrophysical attributes of these reservoirs was completed in PY9. 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.

A PCOR Partnership value-added report is under preparation and 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 PY10, regional characterization staff continued to work closely with the Montana Board of Oil and Gas (MBOG), the North Dakota Department of Mineral Resources (DMR), 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* (D81) 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 revised in PY6. A printing of 1250 copies of the *PCOR Partnership Atlas, 4th Edition, Revised*, was received in June 2013.

Modifications and updates to the information in the atlas continued into PY10. Updated information, including text, statistics, and figures, was incorporated on in all seven chapters. Some pages were rearranged for context reading ease. In addition, new pages were created to expand on the progress in the PCOR Partnership activities. These included pages to discuss the CO_2 EOR life cycle analysis; to extend Bell Creek information with pages on site characterization and on risk assessment, simulation, and modeling; to describe the Basal Cambrian project; to explore the Quest CCS project; and to describe the underground injection control program. This edition, *PCOR Partnership Atlas, 5th Edition*, was submitted to DOE NETL for approval on December 31, 2016, and approval was received February 1, 2017, with minor notes. Modifications were made based on the review notes and an initial printing from the vendor. A printing of 1008 atlases was received March 7, 2017. Copies were shipped to PCOR Partnership contacts.

Additional modifications and updates were made near the end of PY10. Changes included an update of the injection totals for the Bell Creek test site, an update of the text on Class VI primacy in North Dakota, and minor grammatical edits. The final version, *PCOR Partnership Atlas, 5th Edition Revised*, approved September 2017, is available on the public Web site and the partners-only Decision Support System (DSS) Web site. At this time, there is no plan to print hard copies.

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. 550 atlases were distributed in PY10 (compared to 194 distributed in PY9). Overall, since its first printing in 2005, over 6500 atlases have been distributed.

Updating the 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 PY10 are as follows:

- Updated content to the Bell Creek portion on site development, regional background, site operations, characterization, MVA, and modeling/simulation activities. Completed an initial internal review, placed content in the Web-based format, and continued additional review. Activities focused on refining the layout and presentation are ongoing.

- Updated links, thumbnails, and images related to the atlas to the *PCOR Partnership Atlas, 5th Edition.*

- Databases (oil fields, wells, gas plants) that populate the DSS with information were updated.

- Replaced the Fort Nelson fact sheet with the most recent version on the Demonstration Projects page.

- The 2016 PCOR Partnership Annual Membership Meeting pages went live August 25, 2017.

- New PCOR Partnership products are regularly added to the database once they are approved for release to partners. Currently, the database contains over 1370 products (an increase by over 50 products over PY9 [over 1320]) 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 PY10, 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.

Data Submitted to DOE's Energy Data eXchange (EDX). 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 demonstration project reporting system (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 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.

CO_2 injection data and oil/gas/water production data for the Bell Creek oil field were submitted to DOE's EDX on March 9, 2017. CO_2 injection began in the Bell Creek oil field in May of 2013. The data submitted include monthly values from the start of injection through December of 2016. Three Excel spreadsheets were included in the EDX submission. One spreadsheet contains monthly summary information for the oil field, while the other two spreadsheets provide the data on a well-by-well basis (one for injection, one production). The monthly summation data are provided in thousand standard cubic feet (Mscf), cubic meters, short tons, and metric tons. The well-by-well injection data and gas (CO_2) production data are reported in Mcf, the water and oil production in barrels. These data were obtained from MBOG (3).

Collaboration with 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 DSF. 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. A new contracting agreement regarding data sharing and an EERC–PTRC relationship with respect to modeling was signed and was effective as of May 30, 2017. Erik Nickel is the new Aquistore Program Manager.

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 have ranged up to 300 tonnes during injection periods this year. As of September 30, 2017, approximately 104,600 tonnes of CO_2 has been injected.

Aquistore Geologic Modeling and Simulation Activities. A new static model that better honors the geology and structure of the injection area was constructed. This is an improvement over the simplified, layer-cake model used by the previous simulation work. The horizons of the formations were interpreted from the baseline vibro seismic data and used to construct this static

model. Another update involves property distribution in the model. Porosity data for the current updated model were distributed based on seismic inversion methods. History matching was updated with injection data through June 1, 2017. A spinner survey carried out in April 2015 revealed that Perforation Intervals 1, 2, and 4 were taking about 10%, 45%, and 45% of injected CO_2, respectively, while Perforation Interval 3 was completely plugged, not taking any injected volume of CO_2. Moreover, CO_2 breakthrough has occurred at the observation well, according to the PNL data collected in February 2016. Hence, the simulation model was further calibrated with these data from the periodic monitoring well-logging events. The updated, history-matched simulation provides better predictive simulation scenarios. The results of this work were presented at the Aquistore Annual General Meeting held in Ottawa in August 2017. The work will also be reported in Geological Modeling and Simulation Report for the Aquistore Project (D93 Update 3), due October 2017 (PY11).

Training. EERC research staff attended the following training sessions:

- The Esri User Conference: Applying the Science of Where in San Diego, California, held July 10–14, 2017.

Additional Conference/Meeting Participation.

- Presented a poster entitled "Numerical Modeling of the Aquistore CO_2 Storage Project" at the 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13) held November 14–18, 2016, in Lausanne, Switzerland.

- Presented "A Numerical Simulation Update of the Aquistore CO_2 Storage Project" at the 2016 American Institute of Chemical Engineers (AIChE) Annual Meeting, held November 13–18, 2016, in San Francisco, California.

- Two representatives attended PTRC's Aquistore Project 2017 Annual General Meeting held September 12–13, 2017, in Ottawa, Ontario, Canada. A poster entitled "Updated Numerical Modeling and Simulation Study of the Aquistore CO_2 Storage Project" was presented. A PCOR Partnership representative presented as part of the Modeling Panel Discussion and Question-and-Answer Session.

DOE Carbon Storage Project BPMs. The PCOR Partnership played 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, continued in PY9, and completed in PY10. The revised DOE BPM was published July 2017.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

Meetings and Conferences

EERC employees attended 40 conferences/meetings and nine 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, scientists and researchers, regulators, and partners. Specifically, the PCOR Partnership peer and public outreach activities included 40 oral presentations, two new posters, one recycled poster, and two booths.

Outreach Material Distribution

The standard PCOR Partnership outreach packet contains some combination of the six 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 PY9, the PCOR Partnership distributed 360 documentary DVDs and 195 atlases. During PY10, the PCOR Partnership distributed 677 documentary DVDs and 561 atlases as follows:

- PCOR Partnership documentary entitled "Nature in the Balance: CO_2 Sequestration" – 9
- PCOR Partnership documentary entitled "Reducing Our Carbon Footprint: The Role of Markets" – 9
- PCOR Partnership documentary entitled "Out of the Air: Into the Soil" – 9
- PCOR Partnership documentary entitled "Managing Carbon Dioxide: The Geologic Solution" – 124
- PCOR Partnership documentary entitled "Global Energy and Carbon: Tracking Our Footprint" – 124
- PCOR Partnership documentary entitled "Installing a Casing-Conveyed Permanent Downhole Monitoring System" – 6
- PCOR Partnership documentary entitled "The Bell Creek Story: CO_2 in Action" – 396
- *PCOR Partnership Atlas, 4th Edition, Revised* – 35
- *PCOR Partnership Atlas, 5th Edition* – 526

Throughout the course of the program, the PCOR Partnership has distributed a total of 6511 copies of the various regional atlas editions and 10,998 copies of the five different documentary DVDs and one technical training video.

Data Acquisition and Management

The outreach data management system consists of several geographic information system (GIS)-compatible databases. During PY10, 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 has been and continues to be updated and expanded as appropriate, with major updates on a biennial basis. In PY10, Task 2 personnel began work on the D13 Public Web Site Update due January 31, 2018 (PY11). Intermediary changes provided for DOE review in PY10 included the following:

- Updates to several pages (What Is CO_2?, What Is CO_2 Sequestration?, Terrestrial Sequestration, and Technical Reports) and one new page (Partners-Only Landing Page) went live November 10, 2016, upon approval.

- The following changes occurred at the time of the PPB broadcast premiere of the D21 documentary *The Bell Creek Story: CO_2 in Action* (Milestone [M] 47) on June 19, 2017, at 7:00 PM CDT:
  - *The Bell Creek Story: CO_2 in Action* – new page
  - Documentaries page – updated to include the new documentaries
  - Home page – changed the Featured Documentary at the bottom of the page to *The Bell Creek Story*
  - Request Information form – Added *The Bell Creek Story* to the order form

Additionally, the 2016 PCOR Partnership Annual Membership Meeting and Workshop image and hyperlink on the home page were replaced with the 2017 PCOR Partnership Annual Membership Meeting and Workshop image and hyperlink. This went live June 9, 2017.

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. There were 37,973 sessions/visits to the public Web site in PY10, an increase of 21% over PY9 (31,326 sessions/visits). However, only 4800 of these visits interacted with more than one page. Approximately 30% of these visitors came to the site using a mobile device or tablet.

There were 33,208 unique visitors to the public Web site in PY10, representing a 24% increase from PY9 (26,834 visitors). Over 87% of these visitors were new to the Web site.

The PCOR Partnership public Web site received traffic from 180 countries from October 1, 2016, to September 30, 2017, as illustrated in Figure 4. There were visits from ten new countries. Of the 37,973 sessions/visits, 46% of the Web traffic was domestic, and 54% was international. Table 3 lists the ten countries with the highest number of sessions/visits to the PCOR Partnership Web site: the United States, India, United Kingdom, Canada, Australia, Philippines, Nigeria, Malaysia, Pakistan, and New Zealand.

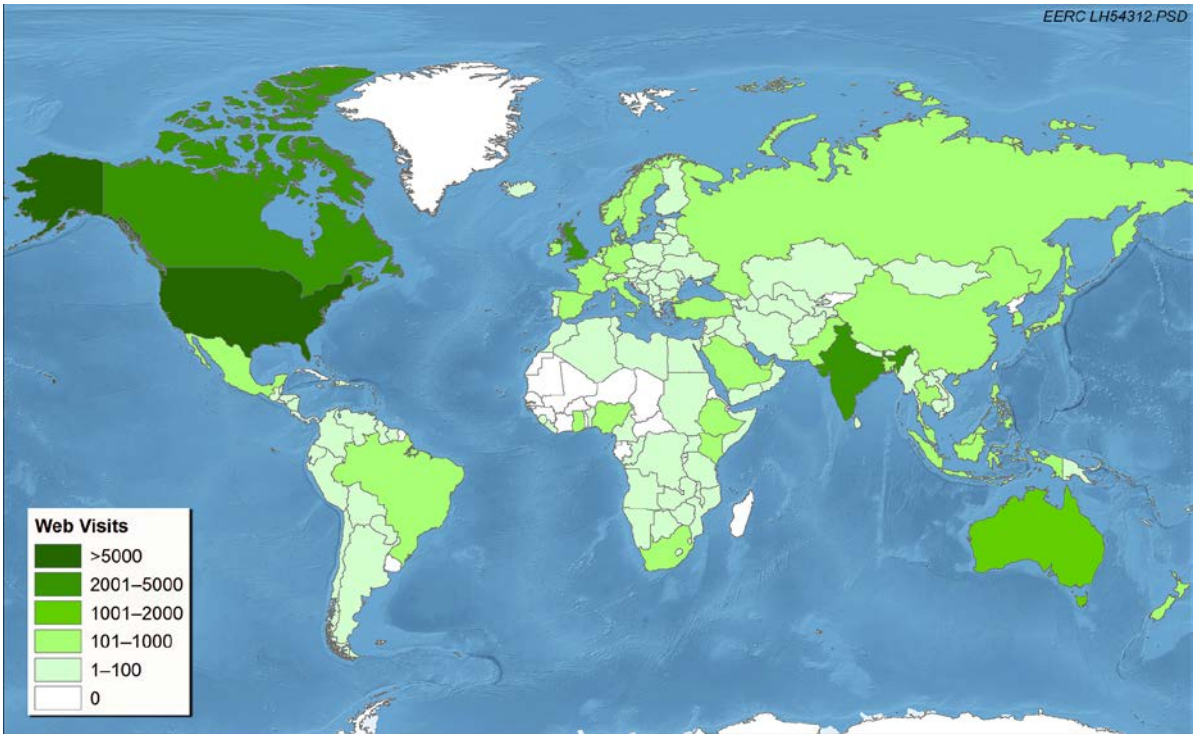

Figure 4. Map of PCOR Partnership global Web traffic for PY10.

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

	Country	Visits*	PCOR Partnership State/Province	Visits*
1.	United States	17,288		
			North Dakota	446
			Minnesota	392
			Wisconsin	333
			Missouri	222
			Iowa	156
			Montana	120
			Nebraska	111
			Wyoming	87
			South Dakota	40
2.	India	4278		
3.	United Kingdom	2406		
4.	Canada	2312		
			British Columbia	373
			Alberta	355
			Saskatchewan	108
			Manitoba	61
5.	Australia	1347		
6.	Philippines	814		
7.	Nigeria	640		
8.	Malaysia	426		
9.	Pakistan	385		
10.	New Zealand	340		
	Other 167 countries	7737		
	Total Visits	**37,973**	**Total PCOR Partnership Visits**	**2804**

*Arranged by the number of visits to the site.

There were 2804 sessions/visits from within the PCOR Partnership region. Approximately 68% of regional visits originated from the United States and 32% from Canada. Figure 5 illustrates Web sessions/visits to states and provinces within the region.

Sessions/visits from the PCOR Partnership region represent over 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 sources are acquired from social media and campaigns. These categories and their percentage of the total traffic sources are presented in Figure 6.

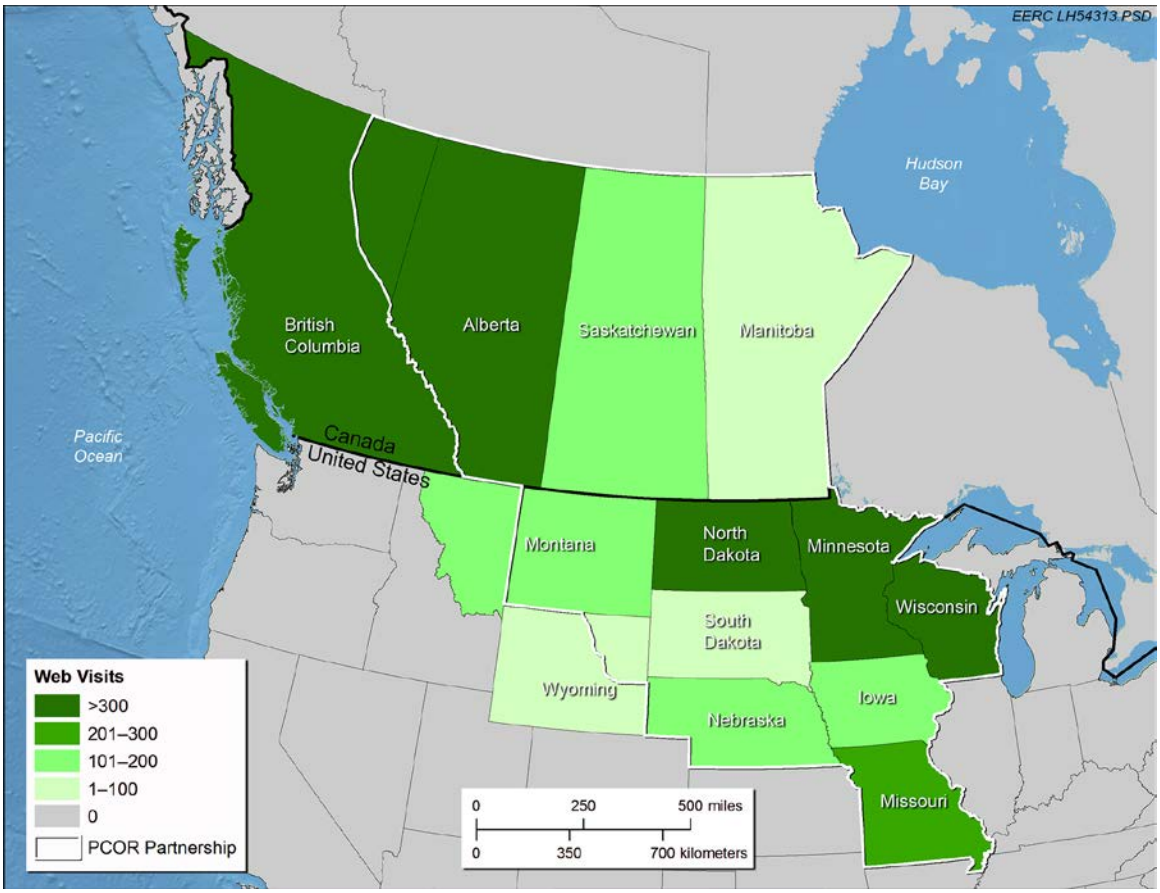

Figure 5. Map of PCOR Partnership regional Web site sessions/visits for PY10.

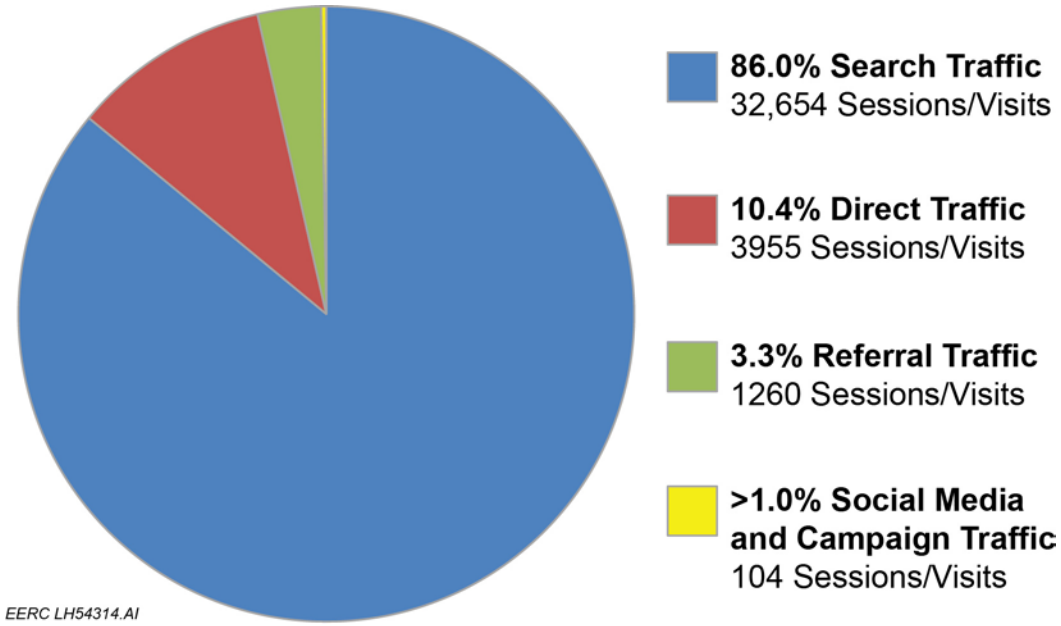

Figure 6. PCOR Partnership public Web site traffic in PY10.

Search traffic refers to the use of search engines such as Google, Bing, and Yahoo. Search traffic accounted for almost 86% 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 "CO_2," "carbon sequestration," and "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 over 10% of the overall traffic.

Referral traffic is traffic to the PCOR Partnership Web site from other sites via links. Over 3% of external traffic resulted from referral sites. The top three referring Web sites were those from undeerc.org, energy.gov, and arthapedia.in.

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

Nature of Sessions/Visits. A total of 60,402 page views (a 37% increase from PY9) resulted from the 37,973 sessions/visits to the PCOR Partnership public Web site in PY9. The top five viewed Web pages (Table 4) accounted for over 74% of page views overall.

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?	19,910	33.0	www.undeerc.org/pcor/sequestration/whatissequestration.aspx
What Is CO_2?	17,777	29.4	www.undeerc.org/pcor/sequestration/whatisco2.aspx
CCS	3108	5.1	www.undeerc.org/pcor/sequestration/ccs.aspx
Terrestrial	2608	4.3	www.undeerc.org/pcor/region/terrestrial/default.aspx
CO_2 Sequestration Projects	1766	2.9	www.undeerc.org/pcor/co2sequestrationprojects/default.aspx

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, are updated as needed. Other fact sheets may be developed as needed.

The four Phase II project fact sheets are continuing to be updated as value-added products. The updated "Terrestrial Carbon Sequestration Validation Test" was approved in May 2017 (http://www.undeerc.org/pcor/newsandpubs/pdf/FS11A-Terrestrial-Carbon-Sequestration-Field-Validation-Test.pdf). Updates to the Zama project fact sheet will be completed in PY11 and will be made available in hard copy and on the public Web site.

The 2016 Bell Creek fact sheet update (D15) was submitted to DOE for approval on November 30, 2016. The 2017 D15 update is in progress and will be submitted by the PY11 November 30, 2017, due date.

Updates to the general Phase III fact sheet (D14) were initiated. The fact sheet will be submitted by the PY11 October 31, 2017, due date.

Development of a value-added documentary fact sheet was initiated. This fact sheet will be submitted to DOE NETL for review and distributed at the 2017 PCOR Partnership Annual Membership Meeting and Workshop in October 2017.

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, 40 oral presentations were given in PY10, 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 2017. This update included one new slide to show the diversity of the projects involving PCOR Partnership members and 14 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, revised by the OWG, was released in June 2017.

The PCOR Partnership participated in 11 (October 20 and December 15, 2016, and January 19, February 16, March 23, April 20, May 18, June 22, July 20, August 24, and September 21, 2017) monthly OWG conference calls. No conference call was held in November 2016. The primary focuses of the OWG conference calls in PY10 were an OWG paper for the CCUS Conference held April 10–13, 2017, in Chicago, Illinois; the idea of engaging CarbonSAFE (Carbon Storage Assurance and Facility Enterprise) projects; the update of the DOE Outreach BPM; and the form of final products.

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.

"The Bell Creek Story – CO_2 in Action" Documentary. Production of the Bell Creek demonstration site documentary entitled "The Bell Creek Story – CO_2 in Action" (D21) in cooperation with PPB was completed. The documentary was submitted to DOE on October 31, 2016, and approved January 9, 2017.

The Bell Creek Test Site 30-minute video was broadcast on PPB television network on Monday, June 19, 2017, at 7:00 p.m. CDT and rebroadcast on Wednesday, June 21, 2017, at 1:00 a.m. CDT.

Table 5 outlines the publicity campaign to advertise the documentary, which was approved by DOE (4).

Table 5. PCOR Partnership Publicity Plan for *The Bell Creek Story* Broadcast Premiere

Date	Description	Content	Media
Monday, June 12	PPB adds *The Bell Creek Story* to its home page slide show.	*Boom and Bust "The Bell Creek Story: CO_2 in Action" is an original production from PPB that investigates how carbon dioxide from human activities is bringing the Bell Creek oil field back to life. Tune in for this PPB original production on Monday, June 19, at 7:00 p.m. CDT.*	Web site
Wednesday, June 14	PPB posts 20-second promo on social media.	*Boom and bust. It's the story of the frontier. For southeastern Montana, boom times came with cattle in the 1880s and with oil in the 1960s. "The Bell Creek Story: CO_2 in Action" investigates how carbon dioxide from human activities is bringing the Bell Creek oil field back to life. Tune in for this PPB original production on Monday, June 19, at 7:00 p.m. CDT.*	Facebook, Twitter
Thursday, June 15	PPB reposts its June 14 Facebook post.	*In partnership with the Energy & Environmental Research Center (EERC), PPB presents its newest original production! Tune in Monday evening.*	Facebook
Friday, June 16	EERC reposts PPB's trailer on social media with info on premiere date and how to watch. Tags PPB on appropriate social media accounts.	*Watch "The Bell Creek Story" on PPB, premiering on Monday June 19, at 7:00 p.m. CDT. The documentary features research done by the EERC.*	Facebook, Twitter, LinkedIn, Google+

Continued . . .

Table 5. PCOR Partnership Publicity Plan for *The Bell Creek Story* Broadcast Premiere (continued)

Date	Description	Content	Media
Monday, June 19	PPB Facebook post.	*In partnership with the Energy & Environmental Research Center (EERC), PPB presents its newest original production! Tune in tonight at 7:00 p.m. CDT.*	Facebook
Monday, June 19	PCOR Partnership Web pages go live.	1. *The Bell Creek Story: CO_2 in Action – new page* 2. *Documentaries page – updated to include the new documentaries* 3. *Home page – changed the Featured Documentary at the bottom of the page to The Bell Creek Story* 4. *Request Information form – added The Bell Creek Story to the order form.*	Web site
Monday, June 19	PPB adds the documentary to its YouTube channel.	*Informative documentary takes a look at the remote Bell Creek oil and carbon sequestration site north of Gillette, Wyoming, in Southern Montana. Denbury Resources Inc. (Denbury) and others have been involved in oil drilling there, CO_2 enhancement, and eventual reclamation of the area. Gives viewers an in-depth look at carbon sequestration and what the Bell Creek project is doing to enhance our environment and energy future. The discovery of the Bell Creek site in 1967 led to many jobs in Montana. Since then, Denbury has not only drilled for oil, but has also performed carbon capture and carbon enhancement, which is very unusual for an oil company. Interviews with officials and others talk about the projects going on at Bell Creek, including fascinating video of drilling and carbon capture.*	YouTube
Tuesday, June 20	EERC posts link to the PCOR Partnership Bell Creek Story page.	*Did you miss the premiere of "The Bell Creek Story"? Watch it here: undeerc.org/pcor/Default.aspx*	Facebook
Wednesday, June 21	PPB Facebook post.	*Did you miss the television premiere of "The Bell Creek Story: CO_2 in Action"? You can watch online here. www.youtube.com/watch?v=Xl4jHo4Tg-c*	Facebook
Wednesday, June 21	PPB changes the text associated with *The Bell Creek Story* on its home page slide show.	*Boom and Bust* *"The Bell Creek Story: CO_2 in Action" is an original production from PPB that investigates how carbon dioxide from human activities is bringing the Bell Creek oil field back to life.*	Web site

DVDs were produced, with cover artwork printed by RelyMedia (see Figure 7). DVDs were provided to those in attendance at the annual PCOR Partnership TAB meeting held May 23–24, 2017. Copies were also shipped to PCOR Partnership contacts.

Discussions were initiated with PPB regarding regional and national distribution of "The Bell Creek Story – CO_2 in Action" to public television markets via the National Educational Telecommunications Association (NETA). PPB initiates the paperwork and prepares the materials for submittal to NETA. PCOR Partnership Task 2 personnel will contact partners to request they contact their local public television markets to request that the documentary be aired.

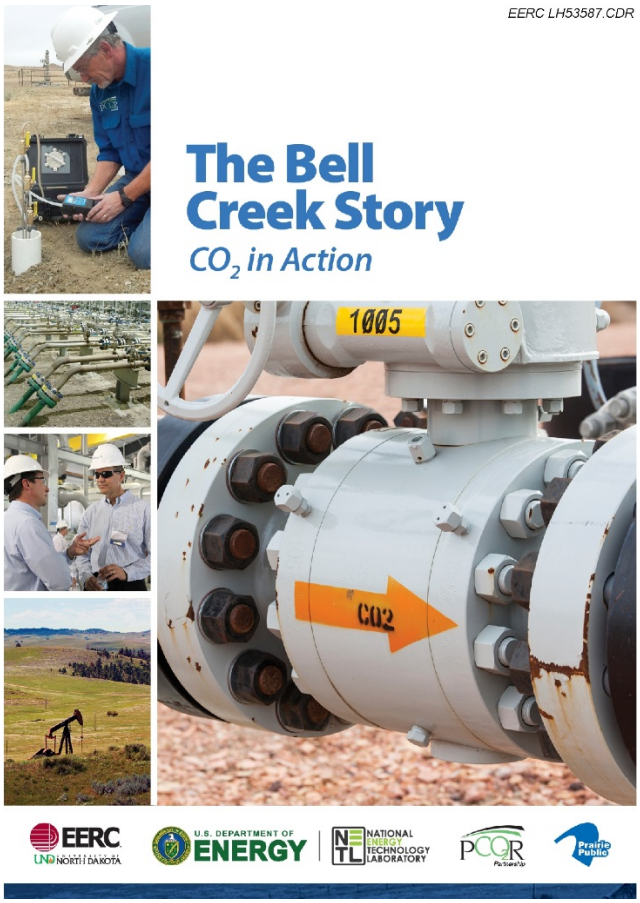

Figure 7. *The Bell Creek Story: CO_2 in Action* DVD cover.

"Coal Powered" 60-minute Documentary Filming. Development of a 60-minute documentary (D22) continued with additional interviews and filming in PY10. Several trips to the PPB offices in Fargo, North Dakota, occurred to work on the documentary.

On January 4, 2017, PPB personnel traveled to Grand Forks, North Dakota, to interview Ed Steadman, EERC Vice President for Research, and Roy Beard, EERC Principal Engineer, Director of Information Technology. Mr. Steadman was interviewed for his broad knowledge on coal utilization and coal-based technologies. Mr. Beard provided insight into the information perspective and advances in technology field taking the audience, from the stone age through the industrial age and into the electronic era.

The draft D22 documentary was submitted for DOE review on January 31, 2017, and comments were received. A screening of the draft documentary was presented to approximately 60 EERC staff members on September 12, 2017. Comments were solicited. All comments will be reviewed and addressed as appropriate in postproduction efforts. The final D22 documentary will be available in PY11.

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 6 provides a summary of the top five viewed video items over PY10. Two PCOR Partnership full-length documentaries are also on the PPB YouTube Channel. The activity on the PPB site for PY10 is shown on Table 7.

Table 6. Top Five PCOR Partnership-Related YouTube Channel Videos Accessed

Video	Video Length, minutes	Views	Est. Minutes Watched
Reforestation in Brazil	4:41	3323	7040
Reducing Our Carbon Footprint: The Role of Markets	26:49	2729	13,474
The Phases of Oil Recovery – So Far	2:40	2376	4051
Installing a Casing-Conveyed Permanent Downhole Monitoring System	19:19	575	2748
Household Energy Around the World	5:34	323	759

Table 7. Top Five PCOR Partnership-Related Documentaries and Video Clips Accessed on the PPB YouTube Channel

Video	Video Length, minutes	Views	Est. Minutes Watched
Global Energy and Carbon: Tracking Our Footprint	32:36	7993	60,665
Managing Carbon Dioxide: The Geologic Solution	31:40	800	8159
Clean Development Mechanism Projects	1:56	567	630
CO_2 and the Greenhouse Effect	1:40	408	468
CO_2 EOR and Geologic CO_2 Sequestration	3:13	345	620

Broadcast of Documentaries. In PY10, the PCOR Partnership received public television exposure from documentaries broadcast in four states and one Canadian province. A total of ten broadcasts were aired. The number of telecasts by documentary are as follows: "Reducing Our Carbon Footprint: The Role of Markets" (2), "Out of the Air: Into the Soil" (1), "Managing Carbon Dioxide: The Geological Solution" (2), "Global Energy and Carbon: Tracking our Footprint" (3), and "The Bell Creek Story – CO_2 in Action" (2). All four documentaries were aired in the PCOR Partnership region.

Public Outreach Presentations

In PY10, the PCOR Partnership participated in a 4-day coal-focused workshop presented by the North Dakota Lignite Energy Council (LEC) held June 12–15, 2017, in Bismarck, North Dakota. These activities included introducing PCOR Partnership materials (DVDs, atlas, Web site awareness) to educators in K–12 schools. This educator workshop presentation reached a total of

108 teachers representing 56 different school districts in six states (North Dakota, Montana, Minnesota, South Dakota, Iowa, and Wyoming) and one Canadian province (Saskatchewan) in and adjacent to the PCOR Partnership region.

Since 2006, the outreach team has presented to over 1500 teachers in eight states and one province from the PCOR Partnership region. Over 7% of teachers have attended multiple conferences. Figure 8 shows the geographic distribution of the teachers who received materials by their corresponding school districts. In North Dakota, outreach materials are available to 85% of the school districts' teachers and students.

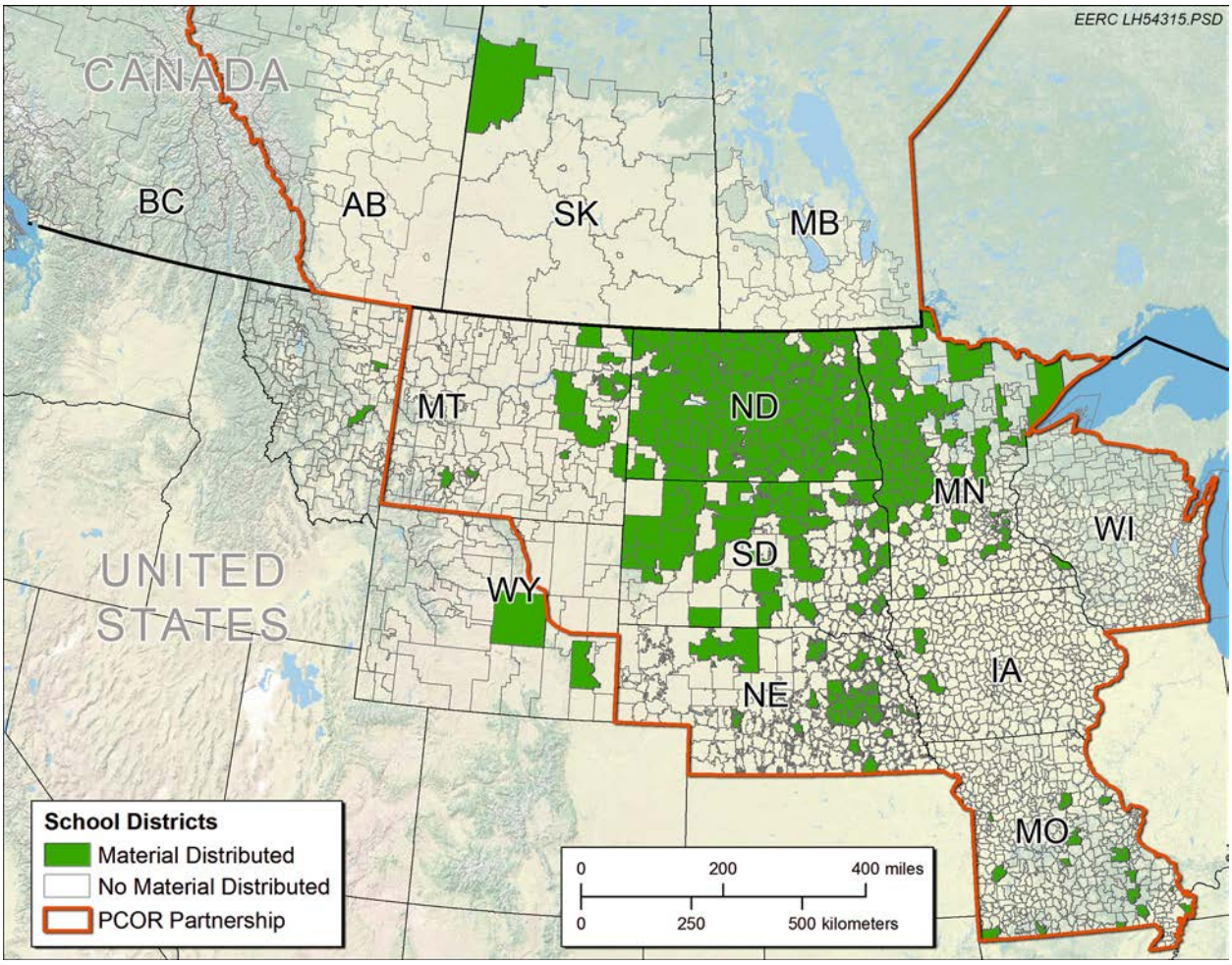

Figure 8. Distribution by school district of teachers who received outreach materials from 2006 to 2017.

Additional Conference/Meeting Participation

- PCOR Partnership personnel participated in a Webinar entitled "Part 5: Social Site Characterization" hosted by the Global CCS Institute on March 23, 2017. The focus of the

Webinar was social characterization as a basis for effective public engagement, education, and outreach for CCS.

Task 3 – Permitting and NEPA Compliance

The overall goal of Task 3 is to monitor 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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed 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 was summarized in D76 "Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region."

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

D76 (Regulatory Perspective Regarding the Geologic Storage of CO_2 in the PCOR Partnership Region), completed January 31, 2017, and approved March 23, 2017, provides a regulatory perspective regarding the dedicated and associated geologic storage of CO_2 in the PCOR Partnership region; it does not address legislation or regulations specific to the capture or transportation of the CO_2 to the storage site. The executive summary of the deliverable is included below.

The PCOR Partnership region covers a large geographic area that includes portions of the United States (i.e., Iowa, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming) and Canada (Alberta, British Columbia, Manitoba, and Saskatchewan).

This region has a diverse set of CO_2 emission sources, geologic formations, and a robust CO_2 EOR industry, making it ideal for implementing commercial CCS and CCUS greenhouse gas reduction strategies.

The status of the legislative and regulatory progress of each state/province to regulate CCS operations varies significantly. The states of North Dakota, Wyoming, and Montana and the provinces of Alberta and Saskatchewan have legislation and regulations in place, and these two Canadian provinces have permitted and initiated commercial CCS and CCUS projects. North Dakota is the only state within the PCOR Partnership region that has applied for primacy over the rules of the U.S. EPA for UIC (underground injection control) Class VI wells. The remaining states, along with the province of Manitoba, have no legislative or regulatory frameworks in place. In the absence of state primacy, the regulation of a commercial CCS project will be led by one of three EPA Regions, (5, 7, or 8), each with its own interpretation of the Class VI regulations.

North Dakota has embraced the guidance provided by the IOGCC Model Statute/General Rules and Regulations for CCS by adopting two basic principles: 1) it is in the public interest to promote the geologic storage of CO_2 to reduce anthropogenic CO_2 emissions and 2) the pore space of the state or province should be regulated and managed as a resource under a resource management philosophy. A resource management philosophy ensures that pore space ownership and postoperational liability are incorporated into the CCS/CCUS regulatory process, which is not possible using EPA's UIC regulations.

In general, three legal/regulatory obstacles have inhibited the commercial deployment of CCS technology to varying degrees throughout the PCOR Partnership region: 1) access to and use of pore space, 2) the permitting of CCS/CCUS projects, and 3) site closure and management of long-term, postoperational liability. Two different legislative/regulatory approaches have been taken in the PCOR Partnership region to address these obstacles: one in Canada and one in the United States.

Generally speaking, Canada, which has made significant government investments in commercial-scale facilities, has attempted to maximize the use of the existing legislative and regulatory framework of the oil and gas industry to regulate this new industry and has deferred the authority to do so to the provincial governments, with Alberta being an exception as it has moved forward with the development of CCS-specific regulations. The Canadian approach represents the resource management philosophy recommended by the IOGCC in that pore space ownership (e.g., in general, the Crown has been designated as the owner of pore space in Canada) and postoperational liability are incorporated into the regulatory process. This legislative/regulatory approach has proven to be successful, as Canada currently has four commercial-scale CCS/CCUS facilities under construction and/or in operation, including the first integrated CCS operation involving a coal-fired, thermoelectric power plant (SaskPower Boundary Dam).

In contrast, the nature and uncertainty of the regulation of CCS/CCUS in the United States have inhibited the deployment of commercial facilities. The regulatory process is led by EPA at the federal level. EPA has created a new injection well class (Class VI) for the geologic storage of CO_2 and employs a waste management philosophy that does not recognize or manage pore space as a resource and does not adequately manage the postoperational liability of a storage project.

These rules also inhibit the use of the existing CO_2 EOR operations for geologic storage of CO_2 by potentially forcing their transition from Class II injection wells to the new Class VI injection wells. To improve the legal/regulatory process for CCS/CCUS in the United States, it is recommended that legislation/regulation governing the subsurface storage of CO_2 be adopted at the state level, with the states of the PCOR Partnership region securing primacy of the Class VI rules of EPA and incorporating them into a resource management philosophy that is compatible with their existing oil and gas regulatory frameworks (5).

EPA created a new UIC well classification, Class VI, for the geologic storage of CO_2 and employs a waste management philosophy that does not recognize or manage pore space as a resource and does not adequately manage the postoperational liability of a storage project. These rules also inhibit the use of the existing CO_2 EOR operations for geologic storage of CO_2 by potentially forcing their transition from Class II injection wells to the new Class VI injection wells. To date, only North Dakota has filed for and received primacy for the Class VI program (actual program approval expected January 2018).

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 PY10:

- Attended the IOGCC Annual Meeting in Little Rock, Arkansas, held October 2–4, 2016.

- On May 7–9, 2017, a Task 3 representative appointed by North Dakota served as the Vice Chairman of the Environment and Safety Committee at the IOGCC Annual Business Meeting held in Oklahoma City, Oklahoma.

Additional Conference/Meeting Participation

- Participated in the Webinar entitled "Environmental Regulations under the Trump Administration: What They Mean for Your Business" on January 10, 2017.

- Attended a meeting in Bismarck, North Dakota, on July 7, 2017, with representatives from the North Dakota Industrial Commission (NDIC) DMR Oil & Gas Division and PCOR Partnership partner Red Trail Energy (RTE) to discuss the status of North Dakota's Class VI primacy application and the implications of CCS permitting in North Dakota and how it will affect RTE's CCS project.

- Attended the Wyoming Petroleum Section of the Society of Petroleum Engineers (SPE) meeting and met with Denbury staff in attendance to discuss CO_2 delivery operations and pipeline right-of-way permitting.

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 PY10 BP5 (October 1, 2016 – March 31, 2017) are addressed as follows. The task concluded in PY10 BP5 (March 31, 2017).

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

Modeling Activities. 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 2016 update to D66 (Bell Creek Test Site – Simulation Report), with the portion of the executive summary relevant to Task 4 included below. The updated report remains under review by Denbury and has not yet been finalized.

Specific modeling and simulation activities discussed in this report include 1) updating the Bell Creek reference model with 11 new repeat/monitor PNLs and InSAR data, 2) completing the Version 3 (V3) geologic model, 3) developing a dynamic simulation model for the Phase 4 area, 4) conducting production/injection performance analyses for individual wells, 5) conducting history matching and predictive simulations with different injection/production constraints, 6) analyzing possible CO_2 transport and trapping mechanisms in the reservoir, 7) comparing simulation results with 4-D seismic monitoring and predicting long-term CO_2 trapping behavior, and 8) determining CO_2 relative permeability hysteresis curves and integrating them into a five-spot model.

A full-field V3 geologic model was completed based on a revised depositional interpretation (6), enabled by the integration of 3-D and 4-D seismic data, PNLs, legacy well logs, and core analysis. The model was developed by 1) partitioning the reservoir into seven areas for focused facies distributions, each area having distinct geologic characteristics; 2) determining the vertical and lateral facies associations within each of these areas through interpretation of well logs and seismic attributes; 3) creating facies logs for wells to serve as control points; 4) creating training images from interpreted facies associations; 5) using multiple point statistics to interpolate the

distribution of facies in interwell areas, drawing upon measurable relationships provided by the training images while honoring control points; and 6) conditioning petrophysical properties (porosity, permeability, and fluid saturations) to the facies model using variogram-based geostatistical methods. These efforts were conducted to enable better simulation history matching and increased accuracy of predictive forecasts (7).

PCOR Partnership BPMs

Best Practices Manual for Site Characterization. The purpose of BPM D35 (approved June 2017, executive summary provided here) is to describe lessons learned and best practices for site characterization of CO_2 geologic storage (herein "storage") projects. Information presented is derived from field and laboratory storage project activities conducted by the PCOR Partnership. Site characterization is one of four technical elements of the AMA formalized by the PCOR Partnership for storage project development. The other technical elements are modeling and simulation, risk assessment, and MVA of injected CO_2.

Site characterization is defined here as the acquisition and analysis of data to develop an understanding of critical properties and characteristics of storage project-relevant surface and subsurface environments. Lessons learned and recommended best practices are applicable to both dedicated storage (typically in DSFs) and associated storage (most commonly resulting from CO_2 EOR) projects. This document is intended to 1) provide guidance to nontechnical specialists including project developers, regulators, and others interested in evaluating and developing CO_2 storage opportunities and 2) serve as a reference for CO_2 storage technical specialists.

During screening of candidate storage sites, integration of existing information and data such as geologic maps and reports, well records, and seismic surveys is typically the main site characterization activity. Data acquired that describe potential storage formations and project sites are compared to generic or project-specific criteria to identify, screen, and rank sites with the potential capacity, injectivity, and containment to meet project requirements. Recommended best practices for screening-phase site characterization include:

- Early establishment of a rigorous data management system capable of handling data from all life cycle phases of a project.

- Understanding the project area regulatory environment, since regulations may affect the selection of storage targets.

- Working with regional geologic knowledge centers and/or government–industry storage characterization programs to access data and information. Available geologic data (and often information regarding regional sociopolitical issues and attitudes) can be of sufficient relevance and quality to use as a basis for early project investment decisions.

As a project moves from site screening to feasibility assessment of one or more selected candidate sites, increasing requirements for data to support progressive iterations of modeling/ simulation and risk assessment may require new data acquisition via exploration wells, seismic surveys, and other fieldwork. As a project advances to the design phase, site characterization data

will be used to develop detailed plans for CO_2 injection, infrastructure installation, and MVA to support permit applications and final investment decisions. Modeling and simulation will be used to determine an optimum injection plan, with predictions of CO_2 migration and pressure effects used to inform definition of the storage complex and area of review (AOR). Risk assessments will be refined to demonstrate that the project will have an acceptable risk profile and to provide context for the MVA plan. Key feasibility assessment- and design-phase recommended best practices derived from PCOR Partnership experience include the following:

- The cost-effectiveness and risk of any new data acquisition efforts should be carefully evaluated and methods for their execution strategically planned. With good planning, new site characterization data can be incorporated into an MVA program, and low-cost data acquisitions can often be used to derisk or optimize subsequent higher-cost data acquisitions.

- Because operations associated with injecting and monitoring CO_2 are closely analogous to and/or derived from oil and gas operations, site characterization exercises should—to the extent possible—follow oil and gas industry standard protocols. In addition to offering significant economic and reliability benefits, oil/gas industry methods are generally well understood and accepted by regulatory communities.

- A screening-level assessment of all wellbores within a project AOR is a key feasibility assessment component. In addition to identifying potential leakage pathways and associated risks, the assessment will serve as the basis for estimating level of effort and cost associated with further evaluation and/or mitigation/remediation plans.

- Seismic survey data are often critically important to accurately assessing the viability of a candidate storage complex, but seismic data acquisition is a major undertaking in terms of logistics, cost, and time. If affordable, hiring a qualified expert to act as a general contractor to assemble the required participants and coordinate the overall work effort is the most convenient, efficient, and effective way to execute a seismic survey.

- Because of high budget and schedule impacts, well-drilling decisions have the potential to be disruptive to feasibility- or design-phase activities. If site screening has indicated that a candidate project site will likely need one or more wells drilled, the project team should develop a set of criteria and guidelines for 1) assessing the need for each new well, 2) establishing the type of well needed (exploration or infrastructure), and 3) siting each new well.

The scope and intensity of site characterization activities will tend to progressively diminish during the construction/operation and closure/postclosure phases of a project as routine MVA, history matching of predictive models, and updating of risk assessments become the main technical elements. However, installation of wells during construction activities is likely to yield considerable characterization data that should be used as appropriate to inform the other technical elements. Similarly, any unexpected behavior of injected CO_2 or other operational anomalies detected by the MVA program may require additional site characterization to support development of mitigation strategies (8).

Training

EERC modeling staff attended the following training sessions:

- PCOR Partnership member Eric Pasternack, Outsource Petrophysics, led a 2-day petrophysics training event February 7–8, 2017, at the EERC and the North Dakota Core Library. The training used PCOR Partnership data sets and focused on ongoing PCOR Partnership activities.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

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 2017, 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 was initiated during PY7 and continued during PY8, PY9, and PY10. The update will be completed in PY11.

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.

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 May 2017 update (approved June 2017) is summarized below.

CCS can potentially reduce CO_2 emissions from large stationary sources, such as power plants and industrial facilities, thereby helping to achieve national and international CO_2 reduction goals. Large scale (>1 Mt per year CO_2), integrated CCS projects have been deployed over the last two decades using established and nascent technologies for each element of the CCS chain: capture, transport, and storage. The majority of the research to date has focused on either capture processes, representing the most expensive element of typical CCS projects, or storage, as the most uncertain element. The D85 report assesses factors affecting pipelines, the predominant means of transporting CO_2 at large scale, and considers the potential for a universal CO_2 pipeline specification that is applicable to the majority of capture technologies. Topics studied included the quality of CO_2 streams produced by selected industries and capture processes, the purity requirements for various utilization options for CO_2, the processes required to meet purity requirements, and the effects of impurities on transport infrastructure.

Solvent-based methods currently are the most common means to capture CO_2 from industrial processes and are especially well-suited to retrofit situations. Despite the range of processes amenable to solvent-based methods and their greater range of impurities, once separated and dehydrated the product CO_2 streams of these solvent-based methods are remarkably similar. Such product streams comprise at least 98% CO_2, with only low levels of residual N_2, O_2, water, and other impurities. Some commercial processes, such as ethanol production, produce very pure streams of CO_2 without purification other than dehydration. The quality of CO_2 stream that is produced by an ethanol plant or would be captured using amine scrubbing is sufficient for most end uses unless very low O_2 levels are required. If that is the case, additional processing to remove the O_2 would be needed.

The largest current beneficial use of CO_2 is EOR. Captured CO_2 from most commercial processes is sufficiently pure for use in EOR, as long as moisture levels are reduced to levels of less than 630 ppm and N_2 and O_2 levels are reduced appropriate to the needs of the oil reservoir. Other theoretical utilization options include the production of fuels or chemicals, although CO_2 specifications for the associated processes are typically not yet defined.

Depending on the end use, additional purification may be needed for the CO_2 to meet specific quality requirements. Purification could occur at distributed locations (e.g., points of capture or use) or in advantageous centralized locations. Centralized sites that receive CO_2 from multiple capture sites have the advantage of economy of scale because of the larger process quantities. Distributed locations possess major advantages related to the ability to customize and handle limited ranges of impurities and volumes of CO_2.

Composition standards have been developed to ensure transport safety of CO_2 and structural integrity of pipelines. CO_2 quality specifications are not based strictly upon physical and chemical considerations relative to the pipeline, but also health, safety, use, cost, and other considerations. These considerations can be competitive and complicate the development of quality specifications.

Pipeline design and construction must account for any potential corrosion that could result from impurities in the CO_2 stream. Three obvious approaches to address any issues created by impurities are to upgrade the pipe metal and/or thickness, adopt lined pipe, or switch to organic polymer composite pipe. Composite pipelines are flexible and offer an opportunity to transport

lower-purity CO_2 that might otherwise damage steel pipelines and, by so doing, potentially reduce capture and purification costs. Because of limitations with larger-diameter composite pipelines, steel would be the most economical choice for the larger main transmission pipelines, with spoolable composite pipe a less expensive alternative for gathering and distribution pipelines.

The potential variety of CO_2 sources, capture processes, and end uses makes formulation of a single, optimal-cost CO_2 quality specification difficult. D85 presents an integrative, total-systems perspective from which to consider CO_2 quality and its implications on pipeline design and operation (9).

Conferences and Meetings

- A PCOR Partnership representative served as an invited mentor at the 2017 IEAGHG CCS Summer School held July 17–23, 2017, in Regina, Saskatchewan, Canada, and presented "CO_2 Transport."

- On August 21–25, 2017, a representative attended the DOE NETL CO_2 Technologies Conference held in Pittsburgh, Pennsylvania.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

Bell Creek Test Site

CO_2 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 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 oil field, equating to an estimated 2.98 Mt of CO_2 stored.

CO_2 injection continues at the Bell Creek oil field, and injection and storage numbers continue to be tracked. At the end of PY10, the publicly available data, through September 30, 2017, were used to determine that cumulative total CO_2 gas injection was 8.480 Mt. This value represents the total gas injected, which includes purchase and recycle streams and is NOT corrected for a gas composition of approximately 98% CO_2 (Table 8).

Table 8. Bell Creek CO_2 Gas Injection Totals for September 2017 (cumulative totals May 2013 to September 2017)[1]

	September 2017 Injection
Total, Mscf	4,671,545
Total, tons[2]	267,205
Total, tonnes[3]	242,640
Cumulative Total, Mscf[4]	163,257,731
Cumulative Total, tons[2,4]	9,338,084
Cumulative Total, tonnes[3,4]	8,479,600

Source: MBOG database.

[1] Total gas injection quantities are ***NOT CORRECTED*** for gas composition and include the combined purchased and recycled gas streams.

[2] Calculated utilizing a conversion of 17.483 Mscf/ton.

[3] Calculated utilizing a conversion of 19.253 Mscf/tonne.

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

As of September 30, 2017, 4.308 Mt of total gas (composition of approximately 98% CO_2) has been purchased for injection into the Bell Creek oil field, equating to an estimated 4.246 Mt of CO_2 stored (Table 9), with the difference comprising other trace gases in the purchase gas stream. A separate method from that used to calculate estimated total gas injected was used to calculate a cumulative associated CO_2 storage 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 2017 is shown in Figure 9.

Table 9. Cumulative Total Gas Purchased and Estimated Associated CO_2 Storage for the Bell Creek Oil Field[1]

	September 2017 Gas Totals
Monthly Total Gas Purchased, MMscf [2]	1700
Monthly Total Gas Purchased, million tons[2]	0.097
Monthly Total Gas Purchased, million tonnes[2]	0.088
Cumulative Total Gas Purchased, MMscf [2,3]	82,944
Cumulative Total Gas Purchased, million tons[2,3]	4.744
Cumulative Total Gas Purchased, million tonnes[2,3]	4.308
Cumulative Total CO_2 Stored, MMscf [3,4]	81,748
Cumulative Total CO_2 Stored, million tons[3,4]	6.676
Cumulative Total CO_2 Stored, million tonnes[3,4]	4.246

[1] Conversion factors of 17.483 Mscf/ton and 19.253 Mscf/tonne were used to calculate equivalent purchase and storage quantities.
[2] Total gas purchased *NOT CORRECTED* for gas composition.
[3] Cumulative totals are for the period from May 2013 to the month listed.
[4] Total CO_2 stored *CORRECTED* for gas composition.

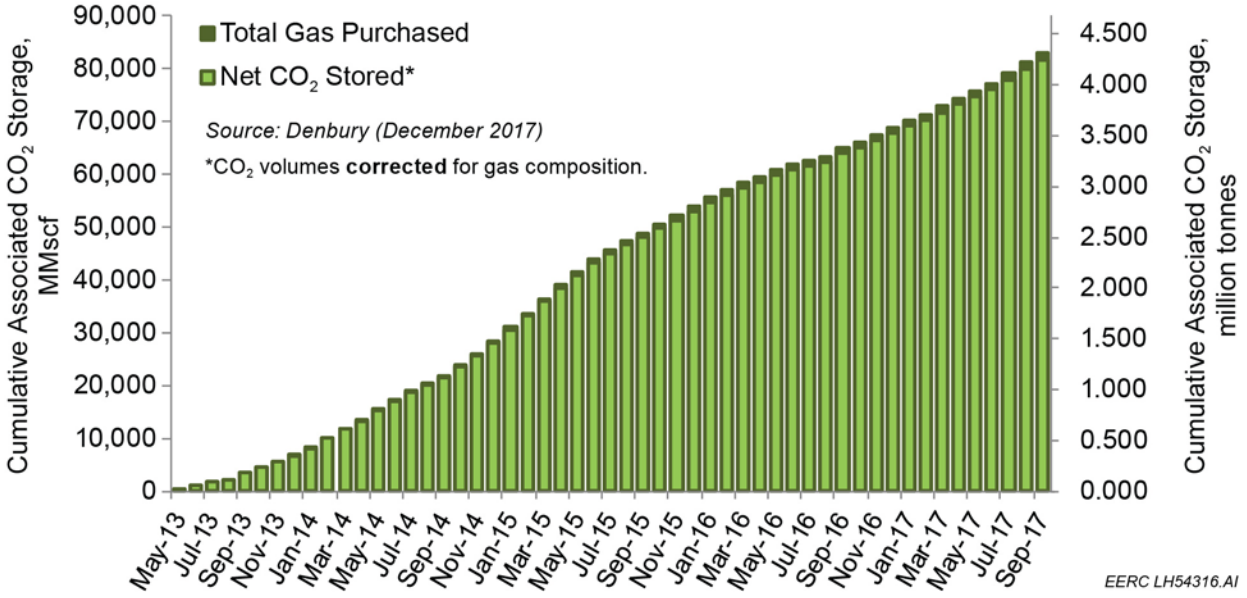

Figure 9. Cumulative total gas purchased and estimated associated CO_2 storage volumes for the Bell Creek oil field.

Near-Surface Monitoring. 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 improve storage efficiency and effective storage capacity in clastic geologic formations. 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 10.

Investigation of Crude Oil Compositional Changes During CO_2 EOR. Progress on the task to investigate the effect on the molecular weight distribution of produced oil during CO_2 EOR and associated CO_2 storage and, by extension, the composition of crude oil hydrocarbons left in the reservoir is described in M55 (Investigation of Crude Oil Compositional Changes During CO_2 EOR), which was submitted to and approved by DOE NETL in September 2017. The executive summary of the milestone is included below.

Two experimental approaches have been (and will be) utilized, including 1) the temporal collection and analysis of the produced crude oil before and after CO_2 injection and appearance at the production wells and 2) laboratory-based sampling and analysis of the hydrocarbon composition found in the CO_2-dominated "miscible" phase when Bell Creek crude oil is exposed to CO_2 at reservoir temperature and pressures.

A total of 90 produced crude oil samples have been collected beginning in 2013 from six wells in development Phase Area 1, three wells in development Phase Area 3, and five wells in development Phase Area 4, as shown in Table 10 and Figure 10. Initial analyses of the molecular weight distributions in the earlier samples of produced crude oil have indicated that program goals will be better met the longer the sample collections can occur. Therefore, we presently plan to continue the produced crude oil collection activities until the beginning of 2018 (PY11). At that time, all of the crude oil samples will be analyzed as a single batch to minimize the analytical variability so that subtle changes in crude oil molecular weight distributions before and after CO_2 enhanced oil production can best be monitored. We anticipate a total of 110–130 crude oil samples will be analyzed and final reporting via a technical paper or journal article completed by March 2018. The results will be correlated with field activities (e.g., the appearance of CO_2 in production wells).

When CO_2 is equilibrated with crude oil, the upper CO_2-dominated phase is deemed the "miscible" phase, assuming that the pressure is above the minimum miscibility pressure (MMP) of the crude oil at the relevant reservoir temperature. For Bell Creek, the experimentally determined MMP values have been 1400–1450 psi at the 42°C reservoir temperature. In order to allow quantitative sampling of the CO_2-dominated miscible phase, a high-pressure view cell was

Table 10. Oil and CO_2 Gas Stream Sampling

Date Sampled	Purchase/ Recycle[1]	Production Stream by Development Phase Area, Well[1]													
		Phase Area 1						Phase Area 3			Phase Area 4				
		56-14R	32-02	05-06	05-04	33-12	04-04	28-02	21-10	21-14	34-09	34-07	34-03	35-03	35-13
Nov 2013		O				O									
Jan 2014		O	O	O											
Mar 2014		O	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			O	OG											
Mar 2015		G	G	G											
Apr 2015	PR														
Jun 2015		O	O	O											
Jul 2015	PR	G	G	G											
Sep 2015	PR														
Nov 2015		O		O											
Jan 2016	PR														
Apr/May 2016		O	O	O			O	O	O	O					
Jun/Jul 2016	PR	O		O			O	O	O	O					
Aug/Sep 2016		O	O				O	O	O	O	O				
Oct 2016				O											
Nov/Dec 2016	PR	O	O	O			O	O	O	O	O	O	O		
Feb 2017		O	O				O	O	O	O	O	O	O		
May 2017	PR	O	O	O			O	O	O	O	O	O	O		
July 2017		O					O	O	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.

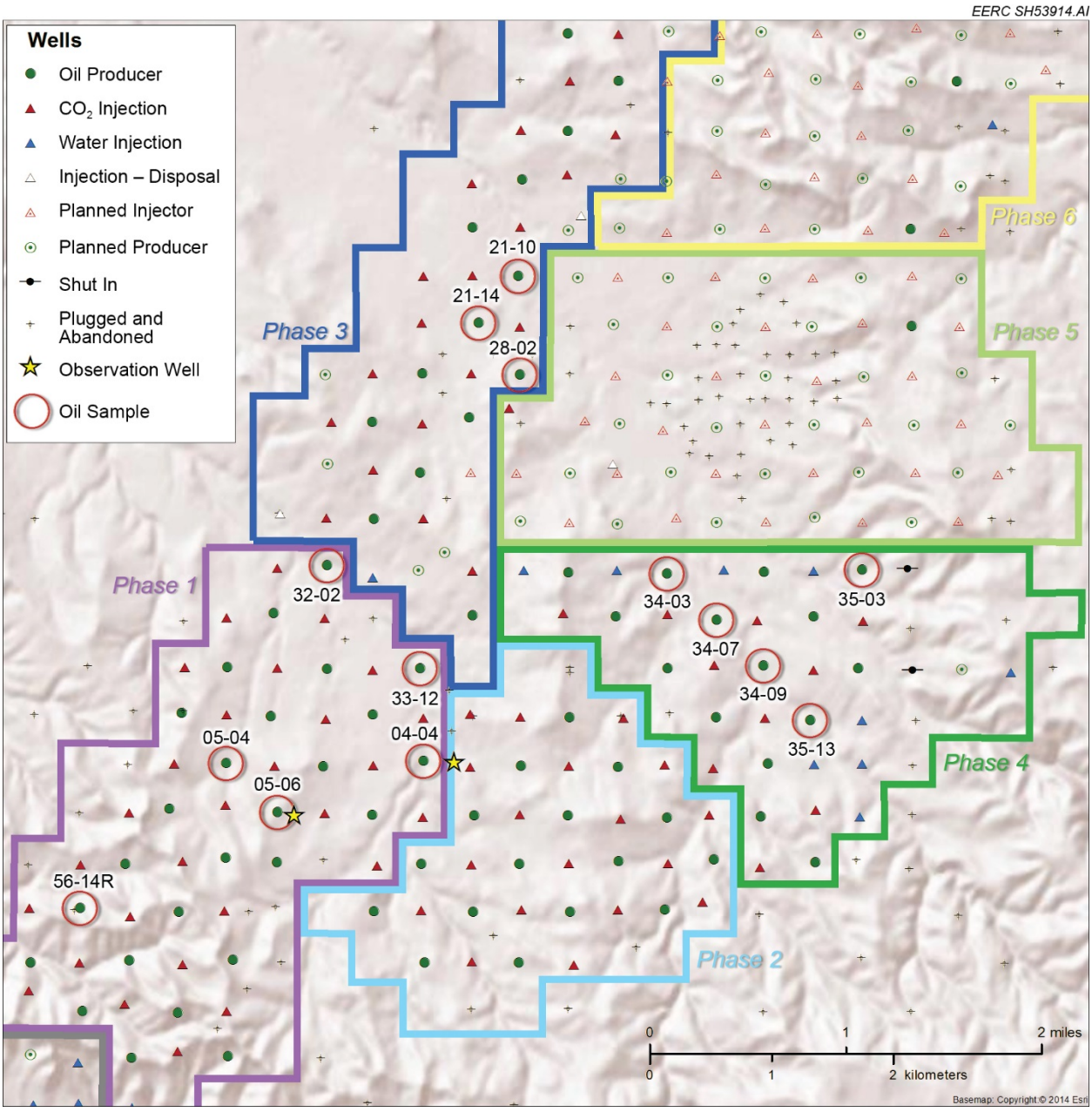

Figure 10. Produced crude oil sample well locations.

modified to allow small sample volumes of the CO_2-mobilized crude oil to be collected without disturbing either the cell pressure or temperature. These samples then flow through a small heated restrictor orifice and are directly purged into methylene chloride to collect the crude oil hydrocarbons that were present in the miscible phase, as well as to vent the CO_2. This allows direct analysis using capillary gas chromatography coupled with flame ionization detection of both the total concentration of crude oil mobilized into the CO_2-dominated miscible phase as well as the molecular weight distribution of the mobilized crude oil hydrocarbons.

The results of these investigations clearly demonstrate that both the quantity of CO_2-mobilized crude oil and its molecular weight distribution are heavily dependent on the CO_2 pressure, regardless of if the CO_2 pressure is below, at, or significantly above MMP; that is, the total mass of crude oil mobilized by CO_2 increases greatly with higher pressures (whether below, at, or above MMP). In addition, the ability to mobilize higher molecular weight crude oil hydrocarbons also increases with higher CO_2 pressures. These results are presently being prepared for review and publication (10).

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 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 PY10, 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. Initial Analysis of Extended Pulsed-Neuton Logging Campaign Data Complete (M52) was submitted to DOE NETL for review November 30, 2016, and approved December 6, 2016. The executive summary is included below.

PNL provides data important in understanding the subsurface environment during CO_2 injection. PNLs have been acquired with Schlumberger Carbon Services' (Schlumberger's) Reservoir Saturation Tool in Bell Creek for the purposes of 1) providing baseline characterization data (lithology/mineralogy, porosity, and water and oil saturations) for the Muddy Formation reservoir interval and overlying strata, 2) monitoring for time-lapse changes in fluid saturations (water, oil, and CO_2) both within the reservoir and in the overlying strata, and 3) providing an evaluation of the utility of PNLs as a commercially viable MVA technology.

PNL acquisition began in June 2013 in Bell Creek Phase Areas 1 and 2. The PNL campaign was extended into Bell Creek Phase Areas 3 and 4 in October 2015 to 1) monitor CO_2 saturation response in two geologically compartmentalized regions of the field (not hydraulically linked to existing injection in Phase Areas 1 and 2) in which CO_2 injection was beginning and 2) expand monitoring of overlying zones to additional development areas. The extended PNL campaign also included the acquisition of 13 repeat/monitor PNLs in Bell Creek Phase Area 1 in continuation of monitoring activities and assessment of near-wellbore saturation response to water alternating gas (WAG) injection.

The acquisition of 11 additional repeat/monitor PNL logs in Bell Creek Phase Areas 1 and 3 occurred in January 2017. An acquisition of three additional repeat/monitor PNL logs in Bell Creek Phase Area 4 will occur in 2018, which will complete the expanded PNL campaign. With this pending campaign, a total of eight PNL campaigns will have been undertaken in the Bell Creek oil field (Table 11, Figure 11). Forty-five wells will have been logged, each having at least a baseline PNL but variable numbers of repeat/monitor PNLs, with a total of 95 PNLs acquired.

Table 11. PNL Campaign Completion Dates and Number of PNLs Acquired in Each Campaign

Accomplishment	Date	PNLs Acquired
1st PNL Campaign Complete	June 2013	33
2nd PNL Campaign Complete	October 2013	4
3rd PNL Campaign Complete	January 2014	4
4th PNL Campaign Complete	August 2014	19
5th PNL Campaign Complete	November 2014	4
Extended PNL Campaign: 6th PNL Campaign Complete	October 2015	17
Extended PNL Campaign: 7th PNL Campaign Complete	January 2017	11
Extended PNL Campaign: 8th PNL Campaign Complete	Pending	3
Total		**95**

Initial analysis of extended PNL campaign data has been completed. Initial analysis suggests no vertical out-of-zone migration. Porosity and fluid saturation data from baseline PNLs have provided direct modeling inputs. Repeat PNLs are being compared with numerical simulation results to enable better history matching and achievement of more accurate predictive simulation results. Comparison of baseline and repeat PNLs in producing wells have verified suspected CO_2 breakthrough. With the field's injection following a WAG scheme, comparisons of successive repeat PNLs in injection wells cycling from CO_2 to water injection have given insight into irreducible CO_2 saturation (Figure 12). Preferential fluid flow zones have been identified. A comparison of PNL data from the October 2015 campaign, acquired in conjunction with a repeat 3-D seismic survey, indicated that an average CO_2 saturation of 3%–4% over a thickness interval of approximately 20 feet may produce a noticeable change in seismic amplitude (in a minimum measurement sense). Statistical analyses have been developed to assess the repeatability of PNLs between surveys, from reservoir to surface, in an attempt to illuminate any anomalies needing further investigation. Each of these efforts will continue to be developed and refined (11).

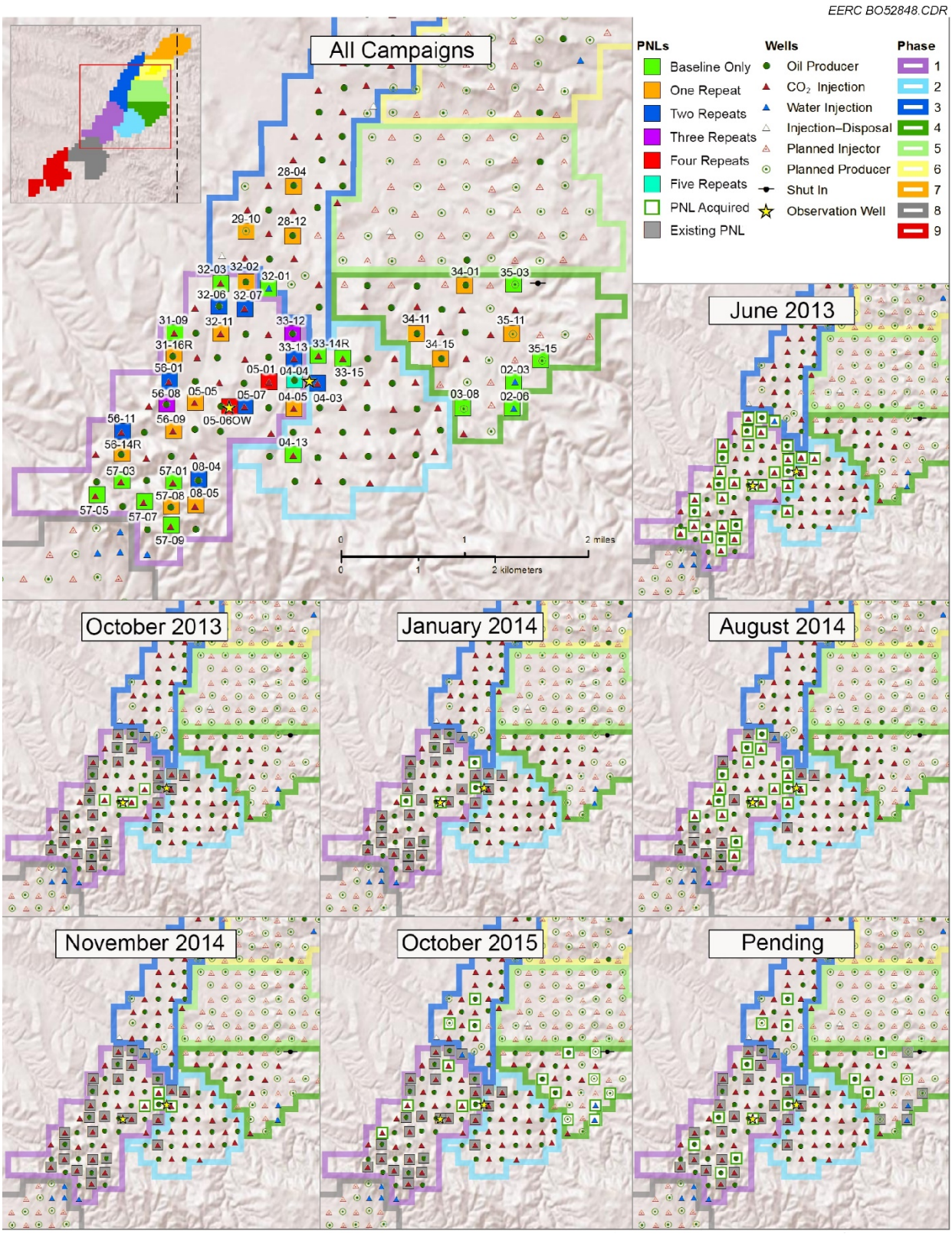

Figure 11. Bell Creek oilfield map showing all PNL campaigns.

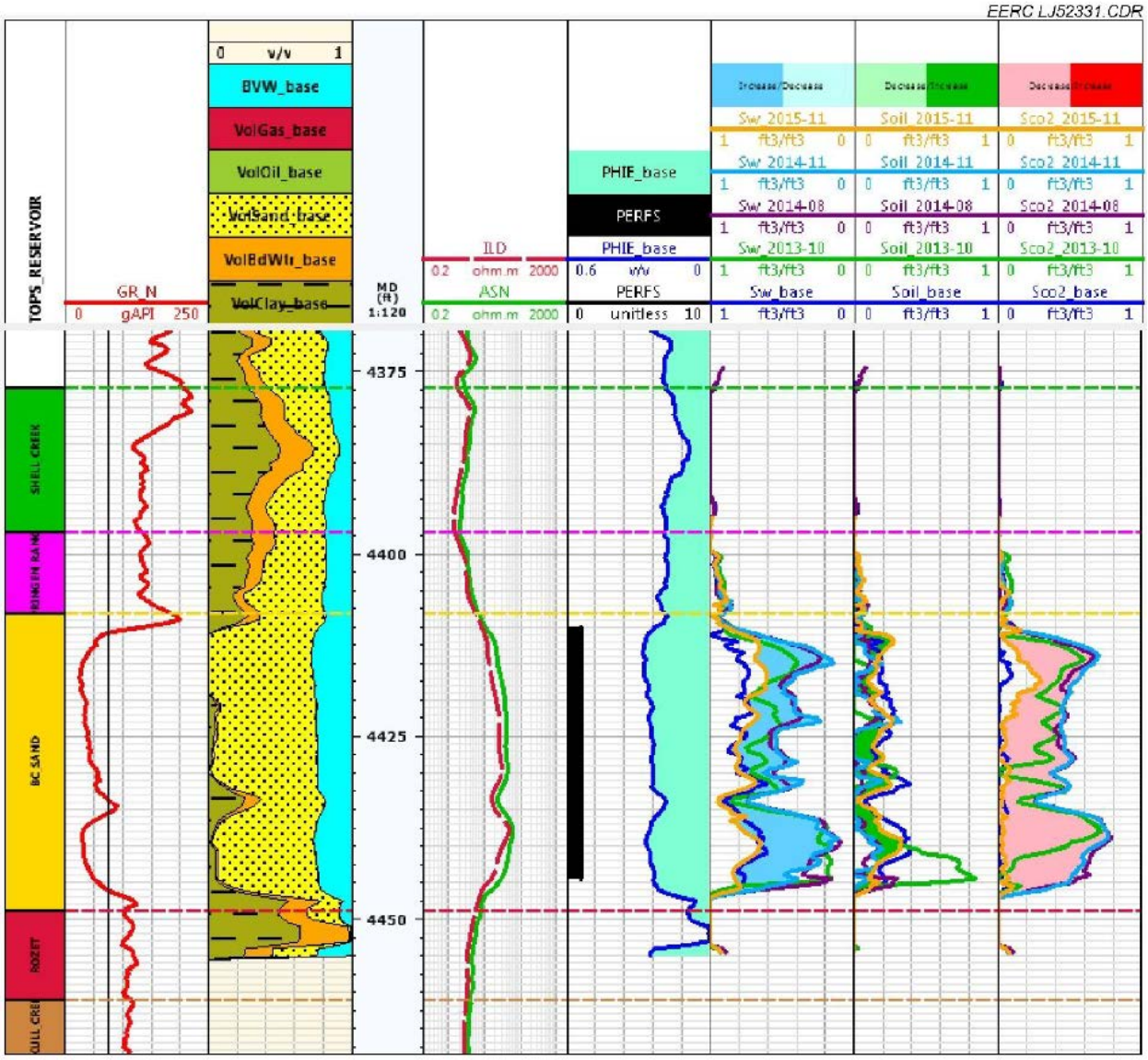

Figure 12. 05-01 injection well (Phase Area 1) PNL display within the Muddy Formation. Track descriptions are (from left to right) Muddy Formation subintervals (members), gamma ray (GR) log, component volumes, measured depth reference track (feet), resistivity log, perforations and effective porosity, water saturation, oil saturation, and CO_2 saturation. Regarding the saturations, color fill is indicative of increase or decrease in repeat PNL measurement (from November 2014 to November 2015). Interval tops shown are (from bottom to top) Skull Creek, Rozet, Bell Creek sand, Springen Ranch, and Shell Creek shale. This well was undergoing water injection at the time of measurement (note the decrease in CO_2 saturation and increase in water saturation). Irreducible CO_2 saturation to water appears to range from 2% to 5% in the lower perforation interval but increasing upward, reaching as high as 25% near the top of the perforation interval.

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) are 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. The following activities were performed in PY10:

- Acquired and processed near-continuous data (5-minute intervals) since April 2012 from three casing-conveyed downhole pressure and temperature (P–T) gauges (05-06 OW [observation well]):
  - 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 April 2012 from a fiber optic distributed-temperature system (DTS) (05-06 OW):
  - 1-meter intervals from ~4700 ft to surface
- Details surrounding PDM data acquisition performed during this reporting period are summarized below:
  - Traveled to Bell Creek oil field February 22–24, 2017, to download data from the PDM system.
    - DTS data: July 11, 2016, to February 23, 2017
    - P–T data: July 29, 2016, to February 23, 2017 (Note: P–T data lost July 11, 2016, to July 29, 2016, because of data acquisition overflow error.)
  - Traveled to Bell Creek oil field August 15–17, 2017, to download data from the PDM system. Updated the sampling rate and software recording P–T data to prevent future data overflow issues.
  - Completed processing and evaluation of downloaded PDM data through August 16, 2017.

Injection-Phase Seismic Efforts: Expanded Seismic Campaign. The EERC has provided support for site characterization, modeling and simulation, and risk assessment and will aid in the development of the MVA plan. As part of this effort, a 3-D surface seismic survey was acquired in 2012 prior to the start of CO_2 injection. This baseline survey provided detailed information that enhanced the characterization of the reservoir and served as a benchmark comparison for two subsequent surface monitor surveys acquired in 2014 and 2015. The monitor surveys, acquired after CO_2 injection had been implemented in different field development phases, were used to create “difference images” to track where the injected CO_2 had migrated to within the reservoir at

the time of the survey. Maps of the seismic amplitude changes associated with injected CO_2 produce powerful images that allow for detailed interpretation of the injection zone, providing significant additional information on permeability barriers and flow channels that were used to refine the characterization, update the geologic models to improve predictive simulations, and help determine the ultimate fate of injected CO_2 (Figure 13).

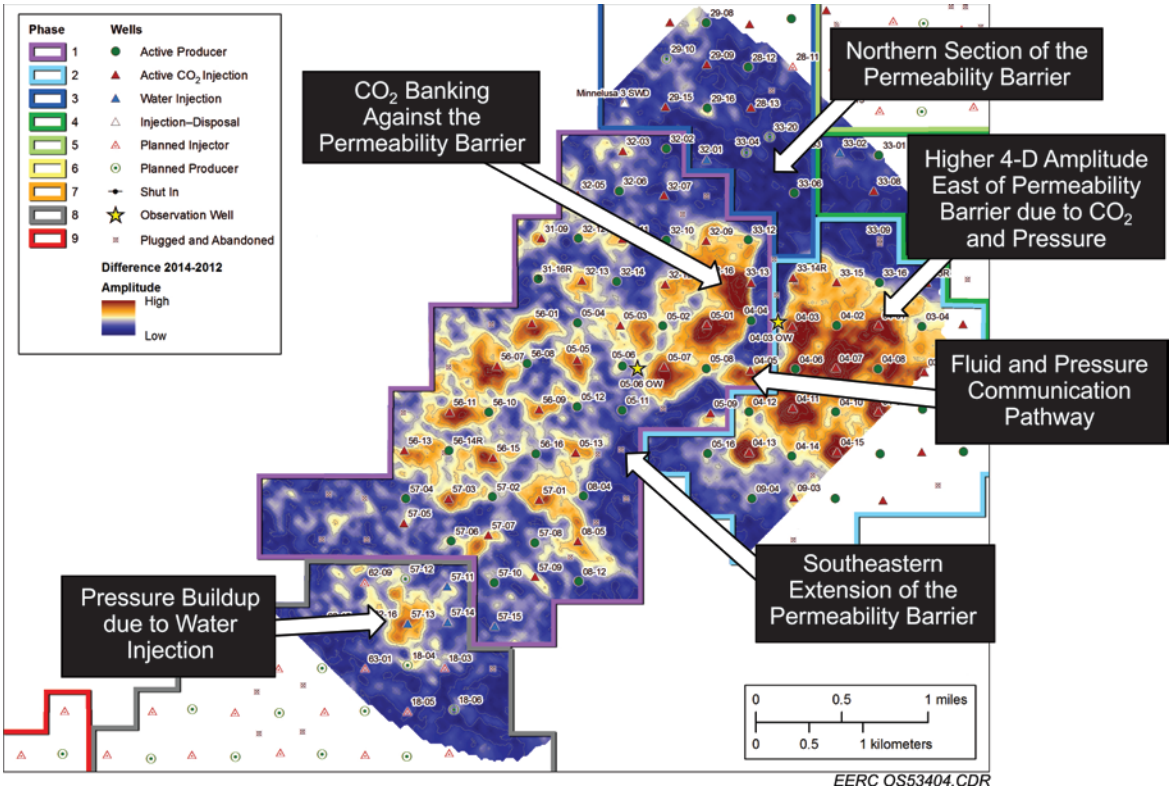

Figure 13. Summary of the 2014–2012 4-D amplitude difference map interpretation.

In addition to the 3-D surface seismic surveys, several other geophysical studies have been done or are currently being conducted at Bell Creek as part of the expanded seismic campaign. These include a 2-D test line to assess different sources for use in the baseline 3-D survey that later became instrumental in proving that CO_2 could be observed in the reservoir. 3-D VSPs were acquired, processed, and are being interpreted from two observation wells. One observation well, 04-03 OW, contains a 50-level seismic geophone array that was permanently installed. The permanent array was connected to a recording system on the surface, and data were recorded passively and continuously for 3 years in order to detect microseismic events that occurred during the time period when field development Phase Areas 1 and 2 were prepared and brought online with CO_2 flooding. Figure 14 shows a time line of the geophysical studies that were a part of the PCOR Partnership project's expanded seismic program at Bell Creek.

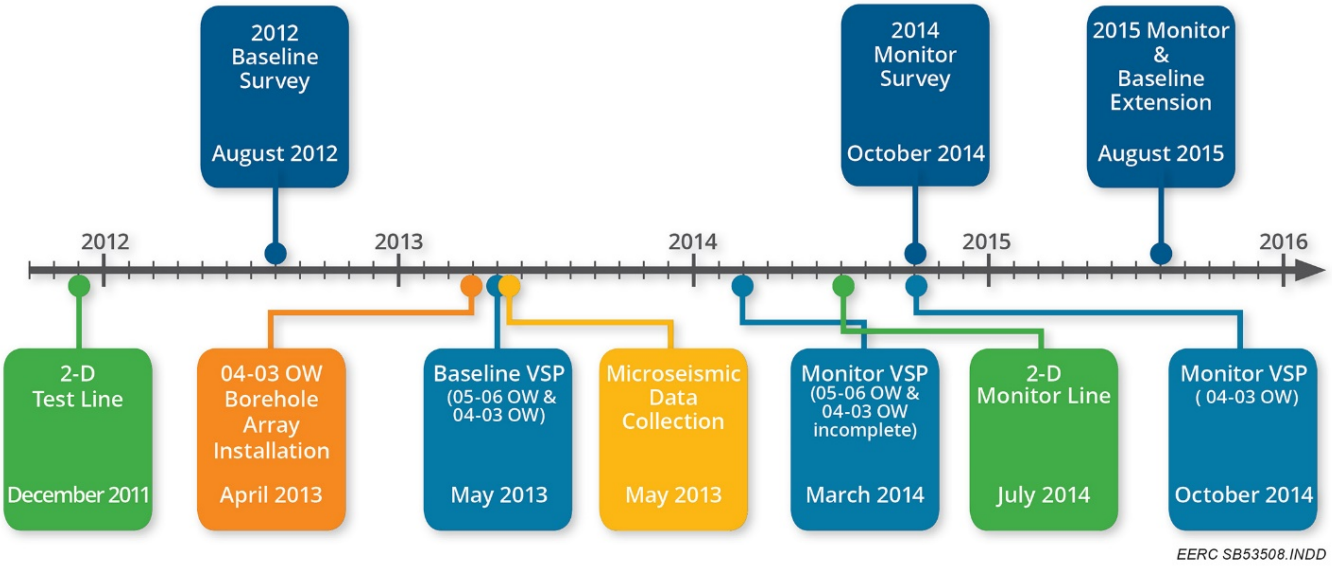

Figure 14. Time line showing the different components of the expanded seismic campaign.

Key Results and Conclusions from the Bell Creek Expanded Seismic Campaign

- The expanded seismic campaign has been instrumental in gaining a better understanding of incidental CO_2 storage associated with CO_2 EOR. It has provided a means to measure and image physical properties throughout the geologic section on a fine grid over the field that has aided geologic characterization.

- 4-D analysis improved the understanding of the reservoir heterogeneity and improved the geologic model that was generated using interpretation results from the 2012 baseline data.

- CO_2 acted as a tracer that illuminated geobodies in the 4-D data by delineating permeability barrier boundaries that were not resolved with 3-D baseline data. This illumination gave better insight about the location, extent, and effectiveness of these permeability barriers.

- Understanding and incorporating the newly illuminated features and their geometrical dimensions into the static model significantly improved dynamic simulation of well performance and improved reservoir history matching and forecasting.

- 4-D analysis indicated updip migration of CO_2 in the south–east direction and apparent accumulation of CO_2 against the permeability barrier.

- Inversion of 3-D data was used to calculate volumes of geomechanical properties that were used in the construction of a 3-D mechanical earth model (MEM) so that geomechanical responses due to injection operations could be modeled in the reservoir and surrounding strata.

The results of the expanded seismic campaign have contributed to the PCOR Partnership's development of practices and technologies that will allow future commercial-scale CO_2 storage

projects to make informed decisions regarding site selection, injection operations, and monitoring strategies. This analysis has also led to a greater understanding of monitoring best practices, which will be reported in BPM D51 "Monitoring for CO_2 Storage and CO_2 EOR," due to DOE the end of October 2017 (PY11). Work on the expanded seismic campaign data will continue with in-house processing and interpretation of the passive data to better understand changes in reservoir conditions associated with phase development. New methods of pre- and poststack inversion of 3-D surface data are planned to gain more information about reservoir compartmentalization. Additional efforts may include quantitative 4-D seismic analysis and inversion to independently estimate the amount of CO_2 stored in the reservoir and separate the CO_2 seismic response from the pressure response (12, 13).

Passive Seismic Monitoring. In PY10, the EERC worked with a representative from Denbury to set up several check shots with a trailer-mounted weight-drop source (source purchased for use on a separate DOE project) to aid in calibration and interpretation of passive seismic data collected using the permanent borehole array in 04-03 OW. EERC representatives traveled to Bell Creek oil field July 10–13, 2017, for borehole array reactivation and check shot acquisition. The upper 25 sensors powered up for recording; the lower 25 channels would not respond to power. Data acquisition was completed successfully from several check shot locations using the 25 active sensors. The borehole array system was powered down, and surface computer and acquisition equipment was returned to the EERC.

InSAR Processing and Analysis. 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 executive summary of M63, submitted and approved March 30, 2017, is included below.

The objectives for InSAR analysis at the Bell Creek oil 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 is being completed in two stages. The first stage consisted of historical processing of lower resolution from an Advanced Land Observing Satellite (ALOS) data set prior to field pressurization. This phase determined that ground deformation can be sufficiently detected and identified natural historical ground movement. Based on those data, it was decided to proceed with a second stage of data collection and analysis using higher-resolution COSMO-SkyMed

(CSK) satellite data during and after field pressurization. Initial processing and analysis of the CSK InSAR data were provided by TRE Canada in June 2016.

Initial processing and analysis of Stage 2 CSK InSAR data have been completed. The area of interest (AOI) for the InSAR work is the Bell Creek oil field in southeastern Montana, covering an area of 143 sq mi. Land cover is mostly bare or lightly vegetated ground with oilfield infrastructure and sparse agricultural fields. The topography is hilly, with elevation ranging from 3274 to 4409 ft above sea level. The current monitoring analysis used high-resolution CSK imagery to compare with the ALOS baseline results and identify ground response to CO_2 injection. The data were analyzed using TRE's proprietary SqueeSAR algorithm. Sixteen CSK radar images were collected from September 11, 2015, to May 8, 2016.

Figure 15 shows the average ground deformation rates within each phase boundary during the historical (ALOS) and current (CSK) imaging periods. Deformation rates within each phase boundary range between −0.09 to +0.60 in./yr during the injection period, compared to −0.06 to 0.05 in./yr in the baseline period. The most notable change between the two periods was observed in Phase Area 4, where uplift started in January 2016 and cumulative deformation reached +0.37 in. in May 2016. This uplift is in agreement with the start of CO_2 injection (December 8, 2015) in Phase Area 4. Mild uplift of +0.18 in. was also detected in Phase Area 2, beginning in early 2016. The data indicate a positive correlation between ground deformation within a 300-foot radius of the wells and cumulative injected fluid (gas and water) volume.

Based on the results of this work, it was decided to continue collecting CSK data through June 2017. The current data in house are from June to December 2016. Pertinent results will be reported in BPM D51 "Monitoring for CO_2 Storage and CO_2 EOR," which will be submitted to DOE by the end of October 2017 (14).

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 oilfield simulations was prepared in August 2011 and updated in August 2012, August 2013, August 2014, August 2015, August 2016, and August 2017 (D66). The 2016 and 2017 updates remain under review by Denbury and have not yet been finalized. The executive summary of the 2017 update is provided below.

Specific modeling and simulation activities discussed in this report include 1) updating the Bell Creek reference model with 11 new repeat/monitor PNLs and InSAR data, 2) completing the V3 geologic model, 3) developing a dynamic simulation model for the Phase 4 area, 4) conducting production/injection performance analyses for individual wells, 5) conducting history matching and predictive simulations with different injection/production constraints, 6) analyzing possible CO_2 transport and trapping mechanisms in the reservoir, 7) comparing simulation results with 4-D seismic monitoring and predicting long-term CO_2 trapping behavior, and 8) determining CO_2 relative permeability hysteresis curves and integrating them into a five-spot model.

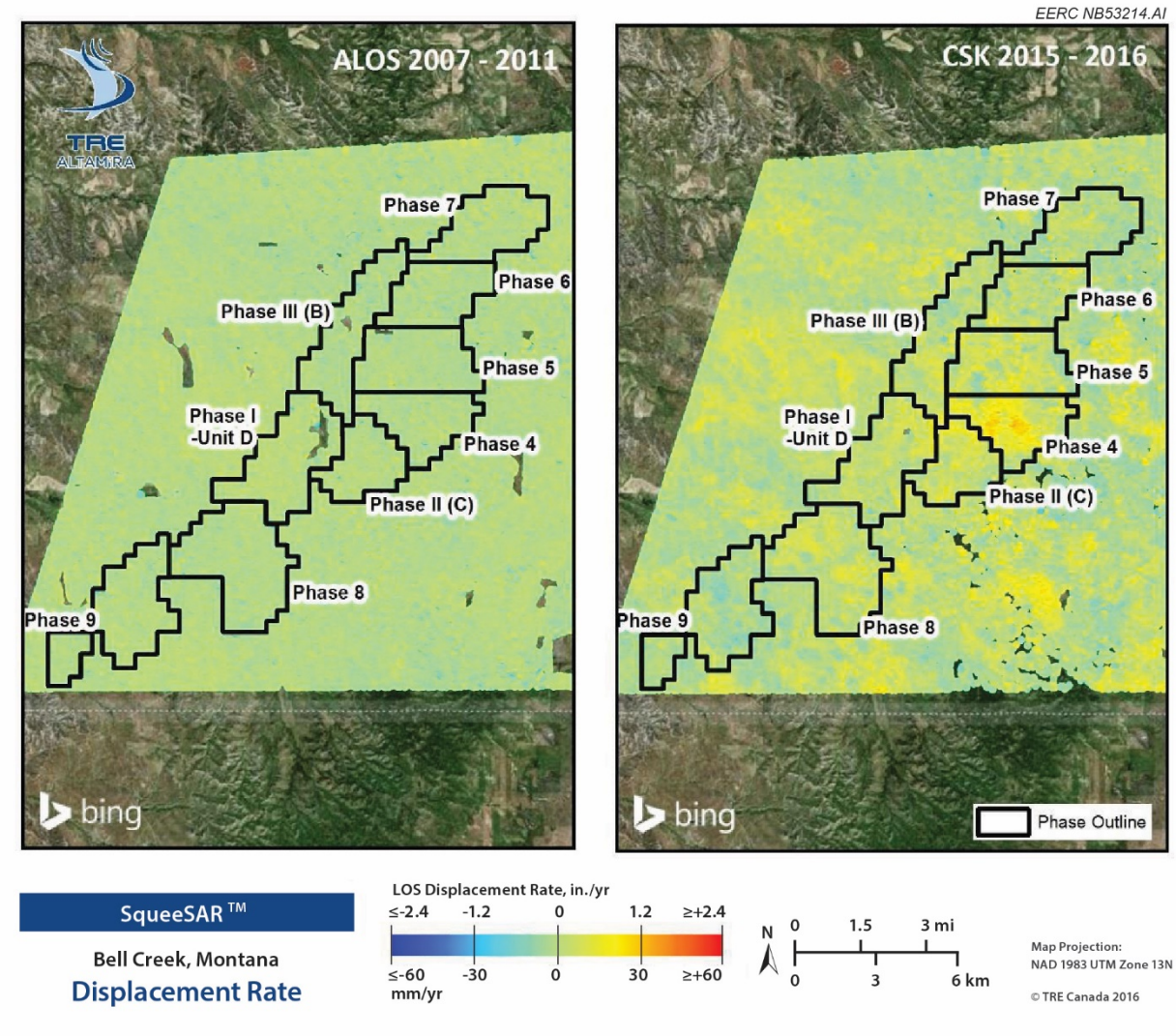

Figure 15. Historical deformation within the injection phase boundaries from 2007 to 2011 compared to deformation from September 2015 to May 2016.

A simulation model of the Phase 4 area was created from the V3 geologic model (as discussed in Task 4). A history match was achieved for 49 years of field records, including primary production, waterflooding, and CO_2 EOR stages. Individual wells' production performance in the Phase 4 development area was analyzed to evaluate boundary conditions and water saturation in the reservoir. WAG and continuous CO_2 injection predictive simulations with different pressure settings were conducted for the Phase 4 area to assess oil recovery and associated CO_2 storage performance. Compared to development Phase Areas 1 and 2, Phase Area 4 has a higher ratio of production wells to injection wells (nearly 1:1 ratio in Phase Areas 1 and 2 versus 1.8:1 in Phase Area 4) and a historically lower average CO_2 injection rate per injection well (54.8 Mscf/day/injector in Phase Areas 1 and 2 versus 24.6 Mscf/day/injector in Phase Area 4). The production/injection activities of this development phase have resulted in a lower estimated

sweep efficiency and oil recovery factor (13%–14% OOIP [original oil in place] in Phase Areas 1 and 2 versus 6.5%–7% OOIP in Phase Area 4) when compared to prior development phases.

Steady-state relative permeability tests were performed using a clean sandstone core sample collected from 05-06 OW to derive gas-phase relative permeability curves. A hysteretic effect was identified from the drainage and imbibition CO_2 relative permeability curves. The curves were integrated in simulation models, and simulations were conducted to investigate the effects of CO_2-trapping mechanisms, including residual, solubility, and structural/stratigraphic trapping. The effectiveness of residual and solubility trapping mechanisms is continually changing because WAG injection causes fluid saturations within the reservoir to change continually, ultimately affecting associated CO_2 storage. The effects of both structural and stratigraphic trapping are widespread in the Bell Creek oil field because of the complex geologic characteristics of the reservoir. A five-spot model and a model of Phase Areas 1 and 2 combined were used to investigate the effects of these trapping mechanisms on CO_2 EOR and associated storage performance.

Simulation results from the five-spot model, taking into account Bell Creek fluid properties and reservoir conditions, showed that residual trapping may not have a significant effect on oil recovery factor. The results also showed increasing residual CO_2 saturation yields increased associated CO_2 storage. The simulation results quantitively predicted the effect, showing a difference of approximately 40,000 tonnes of associated CO_2 storage between a case without hysteresis applied and a case with hysteresis applied and an assumed residual CO_2 saturation of 0.3. With regard to solubility trapping, simulation results predicted more CO_2 is dissolved when the residual CO_2 saturation is higher, as more CO_2 is available to interact with oil and water in the pore space. Additionally, the simulation results suggest CO_2 solubility in Bell Creek oil is much greater ($\geq$5 times) than in water.

A series of seismic monitoring activities have been conducted to monitor CO_2 saturation and pressure changes. 4-D seismic amplitude differencing identified no evidence of out-of-zone CO_2 migration, supporting effective containment of injected CO_2 within the reservoir under the effects of structural/stratigraphic trapping. Time-lapse seismic analysis enabled detailed interpretation of fluid and pressure communication pathways in the reservoir. Amplitude difference maps were used to calibrate the geologic and simulation models to improve long-term performance forecasts for the injected CO_2 in development Phase Areas 1 and 2 (12). Results of predictive simulation showed that CO_2 is effectively trapped in the Muddy Formation within the Bell Creek oil field. CO_2 is not expected to migrate from the area for at least 1000 years (the simulation was terminated after 1000 years) following the end of field operation, providing additional support to the long-term effectiveness of structural and stratigraphic trapping mechanisms within the field (7).

PCOR Partnership BPMs

Best Practices for Modeling and Simulation of CO_2 Storage. The purpose of BPM D69 is to describe lessons learned and best practices for modeling and simulation of CO_2 geologic storage (herein “storage”) projects. The executive summary is included below.

Modeling is defined in D69 as the collation of subsurface data into a 3-D representation of the subsurface geology and hydrogeology of a CO_2 storage site and surrounding area. Simulation refers to the quantitative prediction within a geologic model of the dynamic effects of CO_2

injection, including migration of CO_2 and other formation fluids; pressure and temperature effects; geomechanical and geochemical responses; and the long-term fate of injected CO_2. Modeling and simulation can be undertaken at a variety of scales, from regional to site-specific, and levels of complexity and should be developed according to the "fit-for-purpose" philosophy that is central to the AMA.

A typical geologic (or static) model being constructed to support simulation of injection will depict the storage reservoir formation(s) and confining zones (seals), together with structural features such as faults, fractures, and folds. The basis for model construction, invariably in digital form, is a combination of measured subsurface characteristics and geological interpretation. In the sedimentary rock sequences that host dedicated and associated storage projects, geological interpretation would include knowledge of the typical spatial relationships between various rock types caused by relevant depositional processes.

A general workflow for model construction applicable to storage projects comprises 1) literature review and data compilation; 2) data review (quality assurance and control), formatting, and input to modeling software; 3) well data interpretation; 4) geophysical analysis; 5) structural framework and geocellular grid construction; 6) property distribution and uncertainty analysis; and 7) grid upscaling and preparation for numerical simulation.

A key lesson learned through PCOR Partnership experience is that data availability to inform model construction, especially during early stages of a project, can vary widely between dedicated and associated storage projects. Dedicated storage projects that target DSFs often have sparse well control or other characterization data. In contrast, associated storage with CO_2 EOR projects typically allows access to production history and an extensive network of wells and associated records.

Key best practices recommended for modeling include:

- Creating thorough documentation of modeling objectives, methods, and accumulated knowledge as the project progresses.

- Conducting interpretation of seismic data, where available, with a multidisciplinary team, including geophysicists, geologists, and reservoir engineers.

- Selecting grid cell sizes with consideration of the geologic setting, allowing the best chance of capturing the anticipated degree of heterogeneity.

- Using uncertainty analyses to highlight data gaps and guide data acquisition in future characterization activities.

Simulation is a valuable tool for supporting engineering judgment and decision-making processes such as technical and economic feasibility studies, optimization of operations, or development of effective MVA. A clear definition of objectives should be developed to frame simulations in support of overall storage project goals. The accuracy and reliability of simulation

outputs depend heavily on the quality of data input, including the geologic model. An understanding of underlying uncertainties is essential to constrain simulation results.

A general workflow for undertaking storage simulation comprises the following activities: 1) selecting an appropriate domain size and grid system from the geologic model, 2) developing fluid characterization properties tailored to the storage process, 3) integrating rock and fluid properties, 4) estimating initial and boundary conditions for the reservoir, 5) incorporating well settings, 6) performing numerical tuning for computational efficiency and accuracy, 7) undertaking production/injection performance analysis, 8) history matching of production/injection data where available, 9) assessing storage performance with various operational methods, and 10) predicting long-term CO_2 migration.

Key best practices recommended for simulation include the following:

- A rigorous data management system should be maintained for ease of future reference.
- Geomechanical modeling should be undertaken to contribute to predictions of seal integrity for dedicated storage projects.
- Simulation data should be calibrated with downhole and wellhead temperature data to detect injectivity issues related to thermal effects.
- Sensitivity analysis should be used to screen the relative importance of input parameters for simulation and history matching (15).

"Best Practices for Modeling and Simulation of CO_2 Storage" (D69) was submitted on May 31, 2017. Based on mutual agreement with the DOE Program Manager, the PCOR Partnership plans to submit an update to the document that incorporates additional reviewer perspectives and findings. Revisions to lessons learned, recommended best practices, case studies, and text were ongoing in PY10.

Best Practices Manual – Monitoring for CO_2 Storage and CO_2 EOR. Writing, an initial internal review, and modifications to D51 (Best Practices Manual – Monitoring for CO_2 Storage and CO_2 EOR) were performed in PY10. D51 will be submitted to DOE in PY11, due the end of October 2017. BPM D51 will be focused on the monitoring strategies and technologies that support the verification of storage. Lessons learned and recommended best practices to be presented are applicable to dedicated storage (typically in DSFs) and associated storage (most commonly resulting from CO_2 EOR) projects. Monitoring programs for dedicated and associated storage projects may share many common objectives, but the design of monitoring programs may be influenced by markedly varying circumstances and risk profiles.

Comparison of Non-EOR and EOR Life Cycle Assessments

Life cycle assessments (LCAs) of crude oils, also known as net carbon negative oil assessments, were 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 was 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 (16, 17). The results of these assessments are compiled into LCA topical report entitled "Comparison of Non-EOR and EOR Life Cycle Assessments" (D105) (executive summary included below).

The PCOR Partnership evaluated whether life cycle GHG emissions associated with incremental oil produced by EOR using anthropogenic CO_2 are less than GHG emissions associated with conventional oil production because of the significant amount of CO_2 that is permanently stored in the oil reservoir during CO_2 EOR (approximately ½ ton [450 kg] of CO_2 per barrel of incremental oil produced [18]).

D105 assesses a cradle-to-grave system boundary to quantify the full life cycle GHG emissions associated with the extraction of crude oil, pipeline transport of crude oil to a refinery, refining of crude oil into fuels, transportation of fuels to the point of sale and, finally, combustion of the fuels. In this report, four different scenarios were modeled and compared:

Scenario NA1: North American natural gas processing and U.S. primary and secondary petroleum recovery and processing.

Scenario NA2: North American natural gas processing with CO_2 capture and U.S. EOR and processing using the captured CO_2.

Scenario BC1: LaBarge (Shute Creek) natural gas processing and Bell Creek-like conventional oil production (because Bell Creek does not currently produce oil conventionally).

Scenario BC2: LaBarge (Shute Creek) natural gas processing with CO_2 capture and Bell Creek incremental oil production via EOR using the captured CO_2.

Two different tools were used to conduct the LCA: 1) customized programming of the Argonne National Laboratory Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model, known as the GREET model and 2) Microsoft Excel® spreadsheet models using emission factors from the peer-reviewed literature and DOE NETL publications.

A set of spreadsheet models was constructed for all four scenarios using Microsoft Excel® spreadsheets and emission factors from the peer-reviewed literature and NETL publications. Spreadsheet models are easy to use, are accessible to a broad array of practitioners, and allow the integration of emission factors from multiple literature sources. Each spreadsheet model contained three segments: natural gas extraction, processing, and transport; crude oil extraction, also called gate-to-gate processing; and downstream processing of the oil. The spreadsheet model segments were integrated into each of the four scenarios. To permit fair comparisons across scenarios, the natural gas and oil production for all four scenarios was normalized to the forecasted Bell Creek performance over 25 years.

The GREET model was also used to construct segments similar to those of the spreadsheet model. The GREET model is quite complex. For example, the GREET conventional crude oil recovery and processing model contains seven pathways, 13 technologies, and 23 processes that describe emissions related to U.S. crude oil recovery, processing, transport, and refining into six major U.S. petroleum refinery products. Unfortunately, a default EOR crude oil recovery and processing pathway does not exist within the GREET model. Therefore, the Scenario NA2 and Scenario BC2 simulations were constructed outside of GREET. Ultimately, default GREET modules, GREET modules modified with site-specific inputs, and spreadsheet models had to be combined to derive a final life cycle emission for a particular scenario.

The results of the LCA spreadsheet model indicated that the scenarios with CO_2 capture and CO_2 EOR produce both natural gas and oil with lower emissions. For example, the life cycle emission for Scenario NA1 is 10.62 Mt CO_2eq and for Scenario NA2 is 9.54 Mt CO_2eq, or approximately 10% lower. Similarly, the life cycle emission for Scenario BC1 is 11.78 Mt CO_2eq and for Scenario BC2 is 8.67 Mt CO_2eq, or approximately 26% lower. Preliminary sensitivity analysis of the spreadsheet model shows that the model results are sensitive to the net CO_2 utilization, which directly impacts the purchased CO_2 requirement and, therefore, dictates the upstream emissions associated with raw natural gas extraction and processing.

Analogous to the spreadsheet modeling results, the GREET scenarios with CO_2 capture and CO_2 EOR also produce gas and oil with less emission of CO_2. For example, the life cycle emissions for Scenario BC1 are 13.86 Mt CO_2eq and for Scenario BC2 are 10.22 Mt CO_2eq, or approximately 26% lower. The life cycle emissions for Scenarios BC1 and BC2 modeled using GREET differ from the spreadsheet model results by approximately 15% (11.78 vs. 13.86 Mt CO_2eq for NA2 and 8.67 vs. 10.22 Mt CO_2eq for BC2).

The results highlight the uncertainty in the estimates. However, when comparing scenarios within one modeling approach (i.e., all spreadsheet or all GREET), the internally consistent approaches yield the same result: there is a net reduction in life cycle CO_2 emissions when processing natural gas and producing incremental oil via EOR using captured CO_2.

While considerable effort was put into acquiring necessary detail for accurate models, much of the data used were obtained from secondary sources. Significantly greater detail and more rigorous treatment would be required to produce an LCA for use as proof of CO_2 emission reduction (19).

Fort Nelson Test Site

Spectra has 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.

Data Preparation for DOE's EDX

The PCOR Partnership initiated the development of a strategy and plan for a PCOR Partnership data set to be submitted to DOE's EDX in 2018 (PY11).

Modeling Training Courses

EERC modeling staff attended the following training sessions:

- Schlumberger led a geophysical logging training workshop at the EERC October 31 – November 4, 2016. It covered tools, principles, applications, and processing of various geophysical logging techniques that can be used to collect data for modeling and MVA. Several staff members working on the Bell Creek project attended.

- A Linux Sysadmin Workshop was held in El Segundo, California, February 9–10, 2017. This was a hands-on training workshop on Linux system administration, which will allow more efficient use of the dedicated geophysics workstation. This workstation is used for processing and analysis of seismic data.

- Two researchers attended the Schlumberger NExT Training "Practical Seismic Interpretation with Petrel" held February 27 – March 3, 2017, in Houston, Texas.

- Researchers attended a Schlumberger short course entitled "Geomechanics Applications in Shale Gas" in Grand Forks, North Dakota, on March 28–29, 2017. The course covered several relevant topics, including introduction to petroleum geomechanics, construction of a MEM, wellbore stability control, and shale anisotropy and heterogeneity. The knowledge will aid in the modeling process.

- A representative attended the American Rock Mechanics Association (ARMA) Symposium and Hydraulic Fracturing Workshop held June 25–28, 2017, in San Francisco, California.

Additional Conference/Meeting Participation

- A representative presented "Lessons Learned in Near-Surface Monitoring for Large-Scale CO_2 Storage" at the AIChE Conference held November 13–18, 2016, in San Francisco, California.

- A The PCOR Partnership Program Manager attended the 79th European Association of Geoscientists & Engineers (EAGE) Conference & Exhibition 2017 held June 12–15, 2017, in Paris, France, and presented "The Value of 4-D Seismic Monitoring at Bell Creek – A Mature Oil Field Undergoing CO_2 Enhanced Oil Recovery."

- The PCOR Partnership task leader attended the IEAGHG Monitoring and Network Meeting held June 13–15, 2017, in Traverse City, Michigan, and presented "Integrating Monitoring Data: Understanding Reservoir Behavior and CO_2 Movement at the Bell Creek Commercial CO_2 EOR Project." The task leader also participated in the Near-Surface/Surface Baseline Monitoring – Commonalities/Site-Specific Subtleties and Leakage Monitoring panel session, presenting information on the Bell Creek project.

- A PCOR Partnership representative served as an invited mentor at the 2017 IEAGHG CCS Summer School held July 17–23, 2017, in Regina, Saskatchewan, Canada, and presented "Wellbore Integrity."

DOE Carbon Storage Project BPMs

The PCOR Partnership played an active part in the revision/redevelopment of DOE Carbon Storage Project BPMs. Three DOE BPMs are relevant to PCOR Partnership Task 9 activities. Efforts were initiated in PY8, continued in PY9, and completed in PY10. The DOE BPMs were published 2017.

NETL's revised *Best Practices: Monitoring, Verification, and Accounting (MVA) for Geologic Storage* (last updated in 2012) was published August 2017. NETL's revised *Best Practices: Operations for Geologic Storage Projects* was published August 2017. NETL's revised *Best Practices: Risk Management and Simulation for Geologic Storage Project*, which was last updated in 2013, was published June 2017.

Task 10 – Site Closure

Because Bell Creek PCOR Partnership demonstration activities are being performed at a commercial EOR site, it is anticipated that site closure will occur far beyond the scope and time frame of the PCOR Partnership Phase III effort (i.e., at the end of commercially viable EOR). However, the research and activities being conducted through the PCOR Partnership Bell Creek Phase III activities will be informative and applicable to site closure for both dedicated and associated CO_2 storage projects.

Activities and Results

Accomplishments during PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

A site closure report (D54) is being compiled that provides a summary of field-based demonstration, research, and monitoring activities that were conducted as part of PCOR Partnership Phase III efforts at Bell Creek. The report, due December 31, 2017, will provide a closure/decommissioning plan and anticipated time line for field-based operations and data collection activities.

Closure activities related to research efforts began in PY10. Satellite Internet service and portable facilities to support field operations were canceled and removed. The passive seismic array was powered down and idled in anticipation of decommissioning. A decommissioning plan/schedule for EERC mobile operations support trailers located in the field was developed.

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

Accomplishments during PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

The Monitoring and Modeling Fate of Stored CO_2 report (D73) was initiated. This paper will assess and report the relevant learnings and results of modeling and monitoring efforts demonstrated the PCOR Partnership Bell Creek Phase III activities, with particular focus on commercial viability to future associated and dedicated storage projects. The relevancy of techniques and strategies applicable to commercial sites during the injection, post injection, and post closure period will be considered.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

An assessment was conducted for the tasks during the period October 1, 2015 – September 30, 2016. A project assessment annual report (D57) was submitted on December 30, 2016.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

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 Program Manager shortly after month's end and are posted on the partners-only Web site. Informal weekly updates are e-mailed to the DOE NETL Program Manager.

DOE Contract (DE-FC26-05NT42592) Modifications

During PY10, three modifications to the contract were issued.

The EERC received DOE Cooperative Agreement Amendment 35 effective November 30, 2016. The amendment authorized the following:

- Recognized the final, calculated carryover figure of $4,277,905 of unexpended funding from BP4 is carried forward into BP5 (Phase III).
- Recognized an increase in the recipient's (EERC's) share of $1,823,269, which represented the final, actual cost share received for BP4 (Phase III).
- Incorporated revised project budgets for BP4 and BP5 (Phase III).
- Corrected an administrative error within the summary cost-share table relating to the percentage calculation of the recipient's (EERC's) share.

The EERC received DOE Cooperative Agreement Amendment 36 effective June 8, 2017. The amendment updated the DOE Award Administrator from Kellyn Cassell to Anne Cary.

The EERC received DOE Cooperative Agreement Amendment 37 effective October 1, 2017. The amendment authorized the following:

- Updated the current approved period of performance from September 30, 2018, to December 31, 2018, which reflects DOE's approval of the extension request.
- Corrected an administrative error in Modification 35.

PCOR Partnership Partners

The PCOR Partnership has significant support and participation from its partners. As of September 30, 2017, over 120 partners are supporting Phase III activities. Efforts continued to expand the PCOR Partnership's membership base as inquiries continue.

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.

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 oilfield operator took this recommendation seriously and implemented it, resulting in a stronger overall monitoring program for the project.

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, Computer Modelling Group, Ltd.
- Stacey Dahl, Minnkota Power Cooperative

The sixth annual TAB meeting was held May 23–24, 2017, in San Francisco, California. Several topics were discussed, including updates on Bell Creek and Aquistore projects, PCOR Partnership BPM development, and other ongoing CCS projects in the PCOR Partnership region. TAB members provided feedback and guidance on the activities presented. TAB members in attendance included Stefan Bachu, Stacey Dahl, Jim Erdle, Bill Jackson, Ray Hattenbach, Mike

Jones, and Steve Melzer (see Figure 16). Attending from the EERC were Scott Ayash, Charlie Gorecki, John Harju, Dave Nakles, Ed Steadman, and Neil Wildgust.

Two Webinar meetings discussing TAB activities took place between October 2016 and September 2017. The first Webinar occurred on July 26, 2016, with the EERC presenting an update on the ongoing predictive simulation and history-matching efforts related to the Aquistore project. The second Webinar meeting was held December 13, 2016, and discussion focused on the PCOR Partnership's presentation to be given at the next January 2017 RCSP peer review. Plans were made to hold a TAB meeting in conjunction with the PCOR Partnership Annual Membership Meeting and Workshop in Plano, Texas, in October 2017.

Figure 16. Attendees at the annual TAB meeting.

Project Management Plan

Revisions to the project management plan continued in PY10 and will be submitted in PY11.

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. Because of scheduling conflicts, the 15th partner meeting (the 14th meeting that included project results) was scheduled outside of PY10. The 2017 PCOR Partnership Annual Membership Meeting is scheduled for October 25–26,

2017, in Plano, Texas. A premeeting workshop is scheduled prior to the meeting on October 24, 2017.

IEAGHG Expert Review of the RCSPs

DOE requires that an independent technical review of the Phase III program be periodically conducted; IEAGHG has been selected to undertake the expert review each time. IEAGHG has extensive experience with CO_2 injection projects worldwide and has organized a number of independent technical reviews. One outcome of note stemming from one expert panel's review was the recommendation to create a TAB to provide scientific and/or operational guidance to the PCOR Partnership Program, including both demonstration sites.

In PY10, an expert review was scheduled for January 23–27, 2017. The required Project Technical Summary was completed and submitted to the PCOR Partnership Program Manager on December 9, 2016, for DOE to upload to a SharePoint site for transfer to the peer review panel. The required PowerPoint presentation was submitted to the PCOR Partnership Program Manager on December 21, 2016. Following review, the final presentation was submitted on December 22, 2016, for DOE to upload to a SharePoint site for transfer to the peer review panel. Additional required project information was selected and submitted on December 1, 2016, including three technical documents highlighting the PCOR Partnership's work to the peer review panel:

- PCOR Partnership Atlas, 4th Edition, Revised
- Fort Nelson Carbon Capture and Storage Feasibility Study – A Best Practices Manual for Storage in a Deep Carbonate Saline Formation
- How Green Is My Oil? A Detailed Look at Greenhouse Gas Accounting for CO_2 Enhanced Oil Recovery (CO_2 EOR) Sites

The 45-minute presentation was given by the PCOR Partnership Program Manager before the expert panel on January 24, 2017, in Pittsburgh, Pennsylvania, presenting an update on PCOR Partnership activities, including how these activities are meeting the goals of the RCSP Program. This was followed by a question-and-answer session and deliberation by the panel. Several staff members from the EERC participated via phone. Recommendations from the peer review panel will be addressed when received.

RCSP Program Support

- The PCOR Partnership was asked to coordinate the RCSP WWG. This task began in January 2009 and is ongoing through March 2018.
- Members of the OWG and WWG took part in scheduled conference calls.
- PCOR Partnership personnel reviewed and provided comments on a DOE NETL RCSP poster for the GHGT-13 conference.

- The PCOR Partnership hosted a meeting with Richard Esposito, Southeast Regional Carbon Sequestration Partnership (SECARB), to discuss updates related to PCOR Partnership and SECARB among other research projects on October 25, 2016, at the EERC.

- PCOR Partnership personnel attended the Midwest Regional Carbon Sequestration 2016 Annual Partners Meeting held November 2, 2016, in Columbus, Ohio.

- The PCOR Partnership Program Manager attended a site visit to Southern Company in Birmingham, Alabama, hosted by Richard Esposito, SECARB, on January 5–6, 2017, to discuss potential areas of collaboration.

- The PCOR Partnership hosted an Energy Roundtable at the EERC on January 20, 2017. Key PCOR Partnership partners discussed the primary focus of current energy topics and gave brief updates from their companies' perspective. This information will be used to help inform PCOR Partnership activities.

- PCOR Partnership personnel attended the SECARB 12th Annual Stakeholders' Briefing held March 8–9, 2017, in Atlanta, Georgia. Presented "Lasting Impacts of the Plains CO_2 Reduction (PCOR) Partnership Program" on March 8, 2017.

- On March 28–30, 2017, a task manager attended the CCUS Working Group at the North American Energy Ministers Trilateral (NAEMT) Meeting/Workshop held in Pittsburgh, Pennsylvania. 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). "The Plains CO_2 Reduction (PCOR) Partnership Program Update" was presented.

- On April 10–13, 2017, project personnel attended the CCUS Conference in Chicago, Illinois. A task leader participated in the "Making History – Major CCUS Projects in the U.S." panel discussion. Another task leader presented "The Plains CO_2 Reduction Partnership: CO_2 Injection Update and Results of Adaptive Management Approach."

- The PCOR Partnership Program Manager presented "An Adaptive Management Approach for Monitoring CO_2 Storage" at the U.S.–Taiwan International CCS Conference in Taipei, Taiwan, April 17–21, 2017, as a representative of the U.S.–Taiwan CCS Delegation to Taipei (invited by DOE). The presentation contained lessons learned through the PCOR Partnership. The draft version of *The Bell Creek Story: CO_2 in Action* documentary (D21, Task 2) was also shown.

- A representative attended GeoConvention 2017 held May 15–19, 2017, in Calgary, Alberta, Canada, and presented "Demonstration of Secure CO_2 Geological Storage in the PCOR Partnership Region."

- On May 26, 2017, a representative attended the 2017 Stanford Center for Carbon Storage (SCCS) Affiliates Meeting & Workshop at Stanford University in Metro Park, California, and

presented "The Plains CO_2 Reduction Partnership: CO_2 Injection Update and Results of Adaptive Management Approach."

- The PCOR Partnership Assistant Program Manager attended the 2nd International Workshop on Offshore Geologic CO_2 Storage held June 19–20, 2017, in Beaumont, Texas.

- The PCOR Partnership Assistant Program Manager presented a poster entitled "Reducing Greenhouse Gas Emissions – Energy with a Smaller Carbon Footprint" at the Bureau of Economic Geology (BEG) Open House held June 21, 2017, in Beaumont, Texas.

- A review of text from the Global Carbon Capture and Storage Institute (GCCSI) Web site regarding Bell Creek was completed as requested by DOE. The information was updated using publicly accessible information and input from a Denbury representative. The revised text was submitted to DOE on June 22, 2017.

- On July 13, 2017, two PCOR Partnership representatives attended the DOE NETL RCSP PI Meeting in Morgantown, West Virginia.

- A representative attended the Carbon Management Technology Conference 2017 (CMTC 2017) held July 17–20, 2017, in Houston, Texas. Presented "Demonstration of Secure CO_2 Geological Storage Associated with Enhanced Oil Recovery in the PCOR Partnership Region."

- The PCOR Partnership Program Manager attended the EAGE Technical Programme of the Fourth Sustainable Earth Sciences Conference held September 3–7, 2017, in Malmö, Sweden, and presented "The Plains CO_2 Reduction (PCOR) Partnership: Successes Leading to New Innovation."

- On September 19–20, 2017, a representative attended the 2017 Midwest Carbon Sequestration Science Conference in Champaign, Illinois, and presented "The Plains CO_2 Reduction (PCOR) Partnership."

- The PCOR Partnership Assistant Program Manager attended the Mission Innovation Carbon Capture Utilization and Storage Experts' Workshop held September 25–29, 2017, in Houston, Texas.

- The PCOR Partnership Program Manager attended the North Dakota Petroleum Council Annual Meeting held September 26–28, 2017, in Bismarck, North Dakota.

- The PCOR Partnership continued to keep abreast of National Risk Assessment Partnership (NRAP) developments.

GHGT-13

The GHGT conference series was formed in 1997 following the merger of the earlier series of the International Conference on Carbon Dioxide Removal and the Greenhouse Gas: Mitigation Options Conference. IEAGHG is the guardian of the conference series. The GHGT conferences

are held every 2 years in IEAGHG member countries. The conference series rotates between North America, Europe, and Asia.

The GHGT conference series has established itself as the principal international conference on GHG mitigation technologies, especially CCS. Each conference is a forum for technical discussions related to the field of GHG control technology. This field can be defined, broadly, as technologies that allow us to continue using our large fossil energy reserves while reducing their associated GHG emissions.

The PCOR Partnership gave nine oral presentations and one poster presentations at the GHCT-13 conference held November 14–18, 2016, in Lausanne, Switzerland. The following presentations were given and published in the conference proceedings in *Energy Procedia* (v. 114):

- Oral presentations:
  - "Relative Permeability of Williston Basin CO_2 Storage Targets"
  - "Numerical Modeling of the Aquistore CO_2 Storage Project"
  - "Regionwide Outreach in a Project-level World—Lessons from the PCOR Partnership"
  - "Communicating about the Geological Storage of Carbon Dioxide – Comparing Public Outreach for CO_2 EOR and Saline Storage Projects" (via OWG)
  - "Monitoring 3.2 million tons of CO_2 at the Bell Creek oil field"
  - "4-D Seismic Monitoring of Injected CO_2 Enhances Geological Interpretation, Reservoir Simulation, and Production Operations"
  - "Impact of CO_2 Impurity on MMP and Oil Recovery Performance of Bell Creek oil field"
  - "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"
  - "A Life Cycle Analysis of Incremental Oil Produced via CO_2 EOR"
- Poster presentation:
  - "A Numerical Simulation Update of the Aquistore CO_2 Storage Project"

In addition, the PCOR Partnership Program Manager and three additional PCOR Partnership representatives served as chairs or cochairs for sessions at the conference.

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 March 10, 2017, a form that gives a brief overview of some of the PCOR Partnership program highlights was submitted to CSLF, upon request from DOE. On April 30 – May 4, 2017, project personnel attended the CSLF Mid-Year Meeting held in Abu Dhabi, United Arab Emirates (UAE).

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

Eleven EERC 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 1–3, 2017, in Pittsburgh, Pennsylvania. The PCOR Partnership Program Manager presented "Bell Creek Oilfield Project – Plains CO_2 Reduction Partnership." A booth backdrop was displayed at the conference and included PCOR Partnership materials.

PCOR Partnership BPMs

Best Practice for the Commercial Deployment of Carbon Dioxide Geologic Storage: Adaptive Management Approach. The PCOR Partnership BPM (D102/M59) was originally submitted in August 2016 (PY9), and a copy was sent to each TAB member for concurrent review with DOE. Once all comments from TAB were received, a revised version of the document was submitted on May 23, 2017, for additional DOE review and received approval on May 25, 2017. The executive summary of the BPM is included below.

The RCSP initiative is focused on the safe and long-term storage of CO_2 to support the commercial deployment of CCS. To that end, the PCOR Partnership has spent over 10 years developing, testing, and validating the best methods and technologies to conduct the geologic storage of CO_2 (hereafter referred to as CO_2 storage). Through this effort, the PCOR Partnership has formalized an AMA for the commercial development of CO_2 storage projects (Figure 17). The use of this approach, which draws upon the collective experience and lessons learned from the PCOR Partnership, represents best practices for advancing CO_2 storage projects toward commercial deployment.

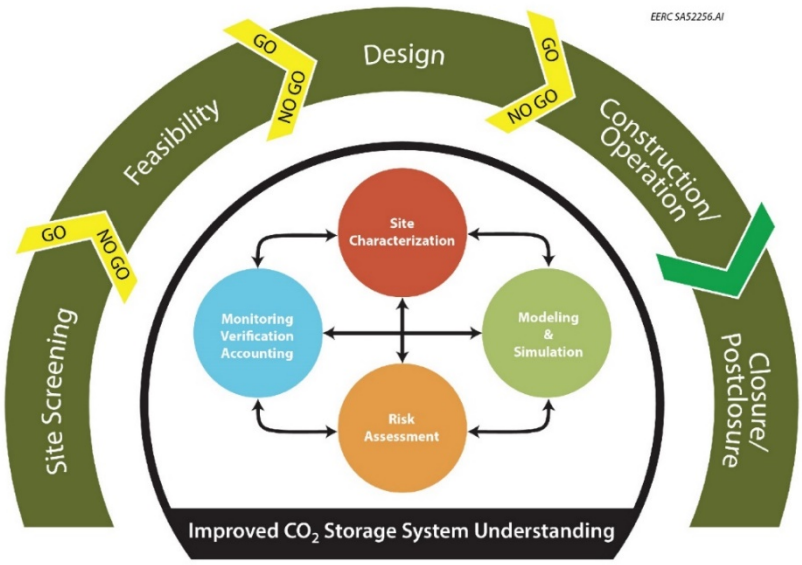

Figure 17. The PCOR Partnership's AMA.

At the heart of the AMA are four technical elements necessary for any successful CO_2 storage project: 1) site characterization, 2) modeling and simulation, 3) risk assessment, and 4) MVA (Figure 17). Each of these elements plays a key role in gathering and assessing site-specific data that provide a fundamental understanding of the storage complex and its performance. While each of the four technical elements can provide useful data independently, integrating them through the AMA yields a streamlined, fit-for-purpose strategy for the commercial deployment of CO_2 storage. Key to this integration and resulting best practice are feedback loops that allow the results of each element to serve as inputs to the others. Each iteration of the AMA creates an improved understanding of the storage complex and thus more targeted and efficient applications of the technical elements. For the purpose of establishing an adaptive management framework, hard lines have been drawn between the technical elements of the AMA. However, in practice, the rapid and seamless interaction between the elements can blur these lines. For example, to aid in the analysis and interpretation of site characterization data, a static geocellular model is often required. While this model development is part of the technical element, modeling and simulation, it is an integral part of the site characterization effort. Likewise, much of the monitoring data collected as part of the MVA technical element can be used to inform site characterization. The back-and-forth flow of data and use of models between the technical elements continue throughout the project.

A CO_2 storage project will advance through a series of life cycle phases—screening, feasibility, design, construction/operation, and closure/postclosure—with the AMA applied during each phase (Figure 17). As part of each phase, specific questions, which are guided by technical, economic, and regulatory factors, need to be answered prior to advancing to the next project phase. Following each of the pre-operational development phases of the project (i.e., site screening, feasibility, and design) are go/no-go decision points that allow the project developer to determine if advancement of the project to the next phase is warranted. The AMA provides the necessary framework to gather data needed to answer the questions at each project phase and facilitate

commercial deployment; however, the exact boundary or scope of a particular life cycle phase may vary from project to project, with the various phases potentially overlapping one another based on the perspective and needs of the individual project operators.

Currently, CO_2 storage is focused on two primary approaches: 1) dedicated storage in saline formations and depleted oil and gas field and 2) associated storage that occurs primarily during commercial CO_2 EOR operations. Although some key differences exist between these approaches, the PCOR Partnership AMA can be used to successfully advance commercial projects in either case. Examples of this versatility have been demonstrated at two of the PCOR Partnership's large-scale (i.e., target injection of 1 million Mt of CO_2 or more) demonstration projects: the Fort Nelson CCS project and the Bell Creek CO_2 EOR project. The AMA was applied to a dedicated CO_2 storage project in Fort Nelson, British Columbia, with the goal of injecting up to 2 million Mt of CO_2 per year into a saline formation. The project advanced to the feasibility phase (Figure 17), where the first iteration of the technical elements of the AMA (i.e., site characterization, modeling and simulation, and risk assessment) indicated that the original project design posed unacceptable risks to nearby commercial gas production. As a result, the preliminary design of the CO_2 injection scheme (i.e., the location of the CO_2 injection well) was modified. A second iteration of the technical elements of the AMA using the new location of the CO_2 injection well indicated that the risk profile of the project had been successfully reduced to acceptable levels. In addition to the Fort Nelson CCS project, the PCOR Partnership is applying the AMA during the design and operation phases of the ongoing Bell Creek CO_2 EOR project to investigate associated CO_2 storage that occurs during CO_2 EOR. These examples, as well as other work completed by the PCOR Partnership, highlight the successful application of the AMA as a best practice for implementing an integrated, fit-for-purpose approach for the commercial deployment of both dedicated and associated CO_2 storage (20).

PCOR Partnership Best Practices Manual for Subsurface Technical Risk Assessment of Geologic CO_2 Storage Projects. The PCOR Partnership wrote a BPM on conducting subsurface technical risk assessments for CCS projects (D103), which was submitted for DOE review on August 29, 2017. The executive summary is included below.

The PCOR Partnership is publishing a series of BPMs for each of the four PCOR Partnership-defined primary technical elements of a storage site: site characterization; modeling and simulation; risk assessment; and monitoring, verification, and accounting. The D103 document describes the risk assessment process for evaluating subsurface technical risks associated with a CO_2 storage project.

Risk assessment is the iterative process of identifying, analyzing, and evaluating individual project risks. In the context of a CO_2 storage project, risk is the combination of the severity of consequences (negative impacts) of an event and the associated likelihood of its occurrence. Risks can affect the operational performance and long-term safety of CO_2 storage. The focus of D103 is on establishing the context of the risk assessment and conducting a risk assessment through identification, analysis, and evaluation. Risk treatment, communication, and monitoring are outside the scope of D103 and are not included.

The PCOR Partnership has conducted a series of risk assessments as part of its RCSP activities. This experience includes two Phase III demonstration projects (large-scale projects with

a target of storing 1 million Mt or more total CO_2) involving dedicated CO_2 storage in a deep-saline formation and associated CO_2 storage incidental to CO_2 EOR. Additional subsurface technical risk assessments were also conducted for other storage projects within the PCOR Partnership region. In addition to the Phase III demonstration projects, there are many completed and ongoing CCS-related projects within the PCOR Partnership region. Collectively, this experience was used to develop a best practice for conducting risk assessments for implementing CO_2 storage projects, with a focus on subsurface technical risks related to injection into a storage complex.

This BPM identifies the key elements comprising a risk assessment for a CO_2 storage complex and defines important risk management terminology and technical factors that are unique to the geologic storage of CO_2. It also provides best practices for implementing a risk assessment based on lessons learned from conducting risk assessments for storage complexes within the PCOR Partnership region (Figure 18). Case studies of these real-world examples, which highlight key aspects of applying the risk assessment process to storage projects, are provided to support the proposed best practices.

The development of a best practice requires the execution of multiple projects where the knowledge gained and lessons learned are accumulated over time and integrated to yield a best practice. This development progression is an adaptive management process whereby best practices constantly evolve over time in response to knowledge gained and lessons learned. D103 encompasses the current body-of-knowledge and best practices for applying a standardized risk assessment approach within risk management for storage projects. Application of these best practices will provide reliable and consistent standards for identifying project-related risks, analyzing the probabilities and potential impacts of these risks, evaluating which risks require treatment, and determining priority for treatment implementation. These best practices will continue to evolve and be refined over time as commercialization of the CO_2 storage industry proceeds (21).

Special Issue of IJGGC

Efforts were initiated in PY10 to compile a virtual special issue (VSI) of the IJGGC on associated storage. Team members began drafting outlines and writing text for potential papers. A list of proposed papers with lead author is shown in Table 12.

DOE Carbon Storage Project BPMs

The PCOR Partnership played an active part in the revision/redevelopment of DOE Carbon Storage Project BPMs. Efforts through PCOR Partnership Task 13 were initiated in PY8, continued in PY9, and completed in PY10. PCOR Partnership representatives continued to assist with *Best Practices: Risk Management and Simulation for Geologic Storage Projects* by revising case studies and providing comments. The revised DOE BPM was published June 2017.

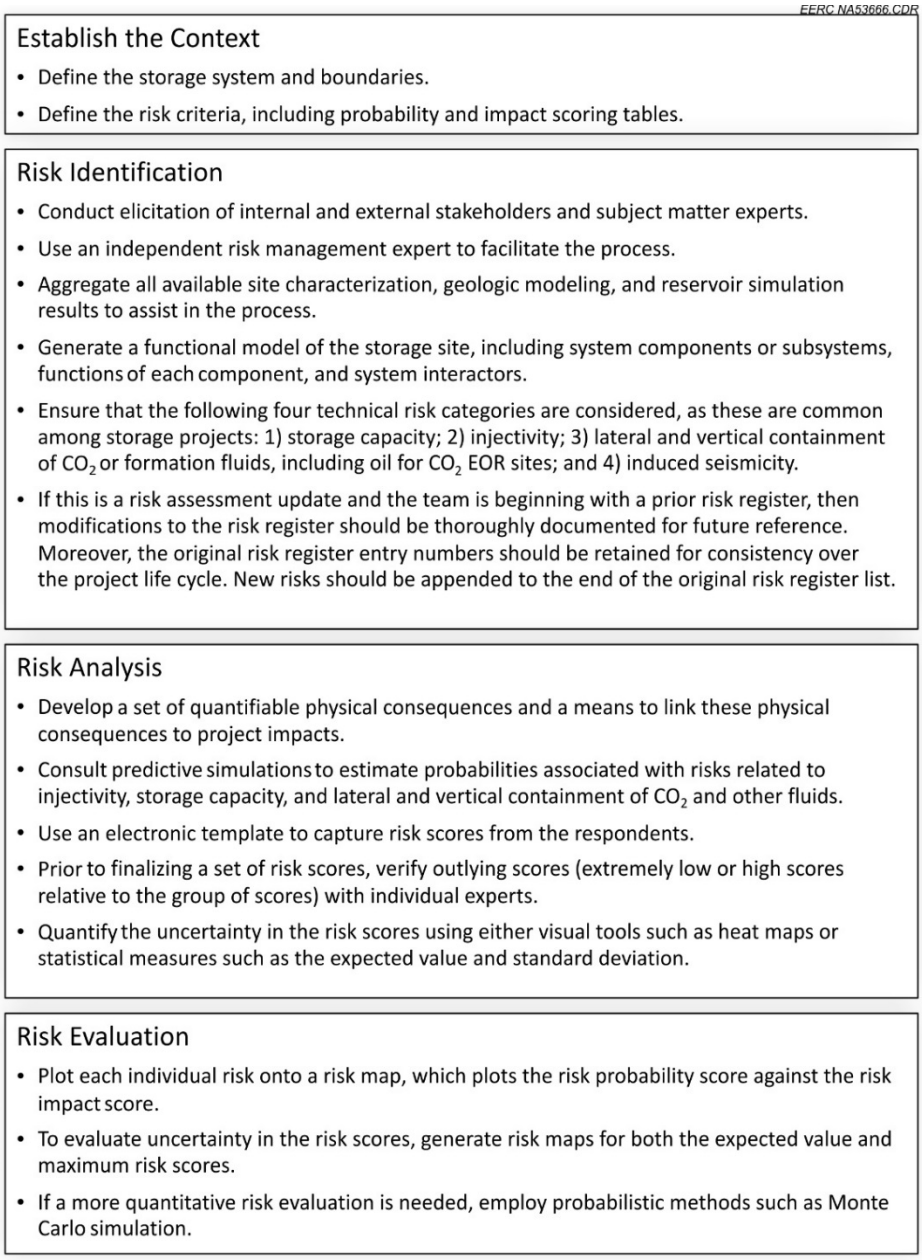

Figure 18. A best practice workflow for conducting risk assessments for storage projects.

Table 12. Proposed Papers for PCOR Partnership IJGGC Special Issue

Title	Lead Author
Introduction: The Plains CO_2 Reduction (PCOR) Partnership Program and Large-Scale Demonstration of Associated CO_2 Geological Storage	Neil Wildgust, David Nakles, and Ryan Klapperich (editors)
CO_2 Storage Associated with CO_2 Enhanced Oil Recovery: A Statistical Analysis of Historical Operations. International Journal of Greenhouse Gas Control, 2015, v. 37, p. 384–397.[1,2]	
Characterization of a Case Study CO_2 EOR Project to Support the Assessment of Associated CO_2 Storage	Nick Bosshart
Quantifying CO_2 Storage Efficiency Factors in Hydrocarbon Reservoirs: A Detailed Look at CO_2 Enhanced Oil Recovery[1]	Wes Peck and others
Using Pulsed-Neutron Lifetime (PNL) Logs to Monitor Wellbore Integrity at a CO_2 Storage Site: Lessons Learned from Field Deployment by the PCOR Partnership	Nick Bosshart
Laboratory Measurements of CO_2 Draining Oil Relative Permeability and Hysteresis Effects for a Conventional Clastic Reservoir	Steven Smith
Evaluation of Recycle Gas Injection and Associated Impurities on Performance of Associated Storage	Lu Jin
Lessons Learned and Best Practices Derived from Environmental Monitoring at a Large-Scale CO_2 Injection Project	Kerryanne Leroux
Effects of Gas Relative Permeability Hysteresis and Solubility on Associated CO_2 Storage Performance	Lu Jin
Detection of Subsurface CO_2 Migration Using 4-D Seismic Monitoring to Update History Matching and Improve Reservoir Simulation	Lu Jin
Comparison of Saturation Values from PNLs and Seismic	Shaughn Burnison
Application of 4-D Seismic Inversion to Improve Seismic Amplitude Interpretation of a Reservoir Undergoing CO_2 Injection	Olarinre Salako
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, 2016, v. 51, p. 369–379.[1,2]	
Life Cycle Analysis: Case Study of Associated Storage with Enhanced Oil Recovery	Melanie Jensen

[1] These papers were developed under separate funding and are either in press or have already been published. These papers are planned to be included in the special issue because of the relevant subject matter.

[2] This paper has already been published by the journal.

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 PY10 BP5 (October 1, 2016 – September 30, 2017) are addressed as follows.

Quarterly Conference Calls

A total of 66 monthly conference calls (M23) took place since the inception of this task. 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. Calls were waived because of such reasons as unavailability of participants and limited work required by the WWG at that time. Minutes of the calls were 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. A total of five quarterly conference calls have taken place since the start of BP5. Three quarterly conference calls were completed in PY10, as follows: November 16, 2016; March 30, 2017; and June 28, 2017. The annual meeting took the place of the final quarterly conference call in PY10. The primary focus of the calls was discussion regarding the development of the final product for the task entitled "Journal Article or Topical Report – Major Research Focuses for Water and CCS" (D107).

Annual Meetings

The ninth annual WWG meeting (M24) was held on August 2, 2017, in Pittsburgh, Pennsylvania, during the NETL Mastering the Subsurface Through Technology Innovation & Collaboration: Carbon Storage & Oil & Natural Gas Technologies Review Meeting. The meeting hosted two guest speakers. Dale Skoff, Tetra Tech, discussed potential wastewater injectivity in western Pennsylvania, and Omkar Lokare, University of Pittsburgh, discussed quantity and quality of produced waters generated in western Pennsylvania and how these change over a well's life cycle.

Special Issue of IJGGC

The mission of the RCSP WWG is to address stakeholder concerns regarding emerging CCS technology and potential interactions with local and regional water resources. As part of that mission, the WWG worked with the IJGGC to develop a Special Issue dedicated to the nexus of water and CCS. Research papers were solicited, edited, and subsequently published in IJGGC. These articles were then submitted to IJGGC on December 29, 2016, to be published online in a VSI (listed below). The articles published in the VSI build upon the research that has previously

been published in IJGGC over the previous 4 years to complete a more comprehensive understanding of water issues associated with CCS. The articles listed in the special issue and these previous works are provided in D106, which was submitted to DOE on December 29, 2016, and approved January 3, 2017 (22). The VSI entitled "Nexus of Water and CCS," edited by Ryan J. Klapperich, Charles D. Gorecki, and David V. Nakles, can be found at http://www.sciencedirect.com/science/journal/17505836/vsi/101VWKM4QT4:

Buscheck, T.A., Bielicki, J.M., White, J.S., Sun, Y., Hao, Y., Bourcier, W.L., Carroll, S.A., and Aines, R.D., 2016, Pre-injection brine production in CO_2 storage reservoirs—an approach to augment the development, operation, and performance of CCS while generating water: International Journal of Greenhouse Gas Control, v. 54, p. 499–512.

Dastgheib, S., Knutson, C., Yang, Y., and Salih, H., 2016, Treatment of produced water from selected oilfields and coal mines in the Illinois Basin: International Journal of Greenhouse Gas Control, v. 54, p. 513–523.

Kobos, P.H., Klise, G.T., Malczynski, L.A., and Walker, L.T., 2016, Parametric analysis of technology costs for CO_2 storage in saline formations: International Journal of Greenhouse Gas Control, v. 54, p. 574–587.

Martin, C., Folkedahl, B., Dunham, D., and Kay, J., 2016, Application of liquid desiccant dehumidification to amine-based carbon capture systems: International Journal of Greenhouse Gas Control, v. 54, p. 557–565.

Schroeder, J., Harto, C., and Clark, C., 2016, Analysis of state and federal regulatory regimes potentially governing the extraction of water from carbon storage reservoirs in the United States: International Journal of Greenhouse Gas Control, v. 54, p. 566–573.

Pan, F., McPherson, B.J., Esser, R., Xiao, T., Appoid, M.S., Jia, W., and Moodie, N., 2016, Forecasting evolution of formation water chemistry and long-term mineral alteration for GCS in a typical clastic reservoir of the Southwestern United States: International Journal of Greenhouse Gas Control, v. 54, p. 524–537.

Ziemkiewicz, P., Stauffer, P., Sullivan-Graham, J., Chu, S., Bourcier, W.L., Buscheck, T.A., Carr, T., Donovan, J., Jiao, Z., Lin, L., Song, L., and Wagoner, J.L., 2016, Opportunities for increasing CO_2 storage in deep, shale aquifers by active reservoir management and treatment of extracted formation water—case study at the GreenGen IGCC Facility, Tianjin, PR China: International Journal of Greenhouse Gas Control, v. 54, p. 538–556.

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 following updates have been sent to NETL site support in PY10 for inclusion in the WWG Web site:

- Text was developed to represent the effort to produce the VSI: Nexus of Water and CCS in conjunction with the IJGGC. A link to the journal was also provided. This text will be included on the "Products" page and is included below.

- The presentation from the August 2016 WWG Annual Meeting was uploaded.

- Minor edits were made across the site to improve readability.

"In 2016, members of the Water Working Group worked with the International Journal of Greenhouse Gas Control (IJGGC) to develop a 'virtual special issue,' or online publication, of research on subjects related to the nexus of water and CCS. These peer-reviewed papers discuss a variety of issues important to understanding the challenges and opportunities related to water that are likely to come with implementation of CCS methodologies. Subjects covered included enhancement of CO_2 storage volumes through water extraction, water extraction designs for enhanced CO_2 storage, treatment technologies applicable to extracted water, economic analysis of CCS water extraction, and analysis of regulatory regimes related to water extraction for CCS. The entire virtual issue is available from IJGGC on its Web site."

The updates, as submitted in D101 to DOE for review on May 23, 2017, were approved on May 25, 2017. As new works are produced or made available by the WWG or its members, said material will be added to the Web site. In addition, previous WWG documents that are not currently on the Web site will be reviewed for their potential inclusion. There are no additional formal update documents planned for the Web site, but any future updates made will be noted in the updates provided by the PCOR Partnership. Likewise, any revisions to the current content will be noted in these updates as well (23).

Major Research Focuses for Water and CCS

The WWG is currently developing its final product entitled Major Research Focuses for Water and CCS. It will provide a time line of the overall activities of the WWG, a description of the specific stakeholder outreach activities that were completed, and a summary of the WWG findings and observations related to 1) characterization of water availability and supply, 2) assessment of the cost/benefit of extracting formation water, 3) the treatment and beneficial reuse of extracted water, 4) regulatory and long-term monitoring considerations, and 5) overarching economic considerations that have the potential to influence the water management activities associated with CCS. Finally, a path forward for continuing to examine and optimize water management during the capture and geologic storage of CO_2 will also be presented.

A literature review has been conducted in order to update our understanding of the current state of knowledge of water and CCS issues. This information is being incorporated into the draft D107 – Report of Major Research Focuses for Water and CCS. In addition, after the August WWG Annual Meeting, a request was made of WWG members to provide any additional information or

products their partnerships have produced over the past several years that may also contribute to this effort.

The outline for D107 has been approved by Andrea McNemar, and work is commencing on writing D107. The plan is to prepare D107 such that it can be submitted as a paper for GHGT-14. An abstract to GHGT-14 will be submitted before the December 2017 abstract deadline (24). Once D107 is completed in PY11, it will be posted to the WWG Web site.

Additional Conference/Meeting Participation

- A researcher participated as a panelist for the "Science Challenges to Improve Industrial Water Use" at the DOE workshop: Basic Research Needs for the Energy–Water Nexus: New Approaches to Ensure Robust and Secure Energy and Water Systems on January 4–6, 2017, in Bethesda, Maryland. Over 150 participants and observers representing the national labs, academia, and industry were invited and tasked with providing an assessment of the basic science bottlenecks and gaps in the fundamental understanding of issues related to the energy–water nexus. Priority research directions were established for improving water use in industrial applications, reducing water use in energy production, challenges to increase fit-for-purpose water availability, and crosscutting basic science in the energy–water nexus.

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., 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 the 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 13.

Table 13. PCOR Partnership Phase III Budget as of Modification 36

	BP3		BP4		BP5		Total	
DOE Share	$4,209,149	54.6%	$60,845,532	60.3%	$13,946,212	71.0%	$79,000,893	61.6%
Nonfederal Share								
Cash*	$887,428		$3,002,602		$0		$3,890,030	
In-Kind	$2,613,890		$36,998,914		$5,711,194		$45,323,998	
Total	$3,501,318	45.4%	$40,001,516	39.7%	$5,711,194	29.0%	$49,214,028	38.4%
Total	**$7,710,467**	**100.0%**	**$100,847,048**	**100.0%**	**$19,657,406**	**100.0%**	**$128,214,921**	**100.0%**

* Cash as recognized by DOE.

On September 30, 2017, the PCOR Partnership completed its tenth year of Phase III activities (PY10, October 1, 2016 – September 30, 2017). Actual cash expenditures of DOE and nonfederal sources as well as noncash cost share reported for BP5 through September 30, 2017, are listed in Table 14.

Table 14. BP5 Funding and Actual Costs as of September 30, 2017

Organization	Approved Budget, $*	Actual Costs Incurred, $
DOE Share – Cash	13,946,212	9,108,375
Nonfederal Share	5,711,194	5,759,054
Total	19,657,406	14,867,429

*As of Modification No. 36.

SCHEDULE STATUS

Table 15 contains all of the Phase III deliverables, milestones, and submission dates for the reporting period. Tables 16–19 provide Gantt charts for Phase III BP4 and BP5, including the reporting period (PY10 BP5) and the next program year.

Table 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 Oilfield 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 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) 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 – WWG Conference Call Held	9/30/16	9/28/16
Year 10 – Quarter 1 (October–December 2016)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/16	10/27/16
D21: Task 2 – Bell Creek Test Site 30-minute Documentary	10/31/16	10/31/16
D105: Task 9 – Comparison of Non-EOR and EOR Life Cycle Assessments	10/31/16	10/31/16
D15: Task 2 – Bell Creek Test Site Fact Sheet (update)	11/30/16	11/30/16
M52: Task 9 – Initial Analysis of Extended Pulsed-Neutron Logging Campaign Data Completed	11/30/16	11/29/16
D57: Task 12 – Project Assessment Annual Report	12/31/16	12/30/16
D81: Task 1 – Regional Carbon Sequestration Atlas (update)	12/31/16	12/30/16
D106: Task 14 – Special Issue of IJGGC – Nexus of Water and Carbon Capture and Storage	12/31/16	12/29/16
M23: Task 14 – WWG Conference Call Held	12/30/16	11/16/16
M24: Task 14 – WWG Annual Meeting Held	12/31/16	8/18/16
M36: Task 13 – Annual Advisory Board Meeting Scheduled	12/31/16	12/28/16
Year 10 – Quarter 2 (January–March 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/17	1/31/17
D22: Task 2 – Energy from Coal 60-minute Documentary	1/31/17	1/31/17
D76: Task 3 – Regional Regulatory Perspective	1/31/17	1/31/17
D35: Task 4 – Bell Creek Test Site – Best Practices Manual – Site Characterization	3/31/17	3/31/17
M23: Task 14 – WWG Conference Call Held	3/31/17	3/30/17
M60: Task 1 – Data Submitted to EDX	3/31/17	3/7/17
M63: Task 9 – Initial Analysis of Processed InSAR Data Completed	3/31/17	3/31/17

Continued . . .

Table 15. PCOR Partnership Phase III, BP3, BP4, and BP5 (through 9/30/2017) Deliverables and Milestones (continued)

Title/Description	Due Date	Actual Completion Date
Year 10 – Quarter 3 (April–June 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/17	4/27/17
D17: Task 2 – General Phase III Information PowerPoint Presentation (update)	5/31/17	5/31/17
D69: Task 9 – Best Practices Manual – Simulation Report	5/31/17	5/31/17
D85: Task 6 – Report – Opportunities and Challenges Associated with CO_2 Compression and Transportation During CCUS Activities	5/31/17	5/31/17
D101: Task 14 – WWG Web Site Content Update 1	5/31/17	5/23/17
D104: Task 9 – Analysis of Expanded Seismic Campaign	6/30/17	6/30/17
M64: Task 9 – Initial Analysis of Expanded Seismic Campaign Data Completed	6/30/17	6/27/17
M23: Task 14 – WWG Conference Call Held	6/30/17	6/28/17
M47: Task 2 – Bell Creek Test Site 30-minute Documentary Broadcast	6/30/17	6/19/17
Year 10 – Quarter 4 (July–September 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/17	7/27/17
D66: Task 9 – Bell Creek Test Site – Simulation Report (Update 6)	8/31/17	8/30/17
D81: Task 1 – PCOR Partnership Atlas (update)	8/31/17	8/31/17
D103: Task 13 – Best Practices Manual – Programmatic Risk Management	8/31/17	8/29/17
D1: Task 1 – Review of Source Attributes (update)	9/30/17	9/27/17
M23: Task 14 – WWG Conference Call Held	9/30/17	8/2/17
M55: Task 9 – Investigation of Crude Oil Compositional Changes during CO_2 EOR Completed	9/30/17	9/25/17
M62: Task 14 – Research Related to Water and CCS Nexus Completed	9/30/17	9/25/17
Year 11 – Quarter 1 (October–December 2017)		
M24: Task 14 – WWG Annual Meeting Held	12/31/17	8/2/17

Table 16. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4)

Continued…

Table 16. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4) (continued)

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

Continued…

Table 16. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4) (continued)

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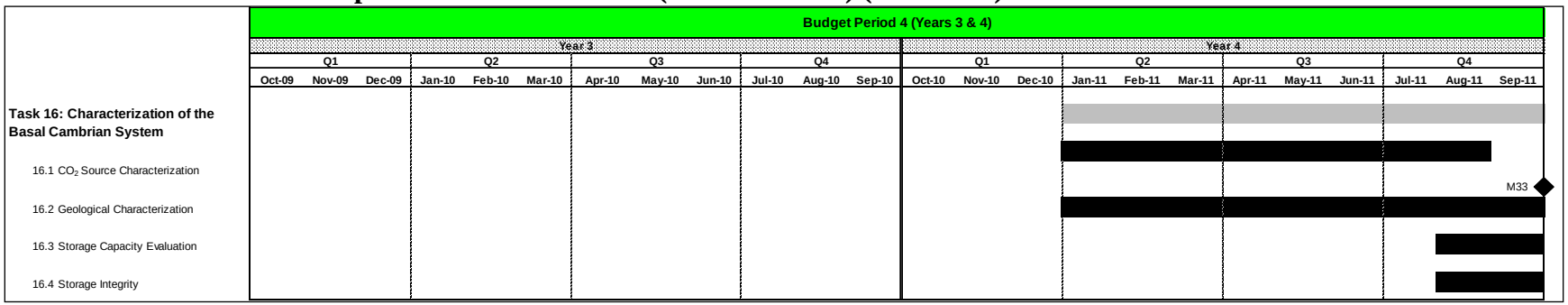
Table 16. PCOR Partnership Phase III Gantt Chart (PY3–PY4 BP4) (continued)



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

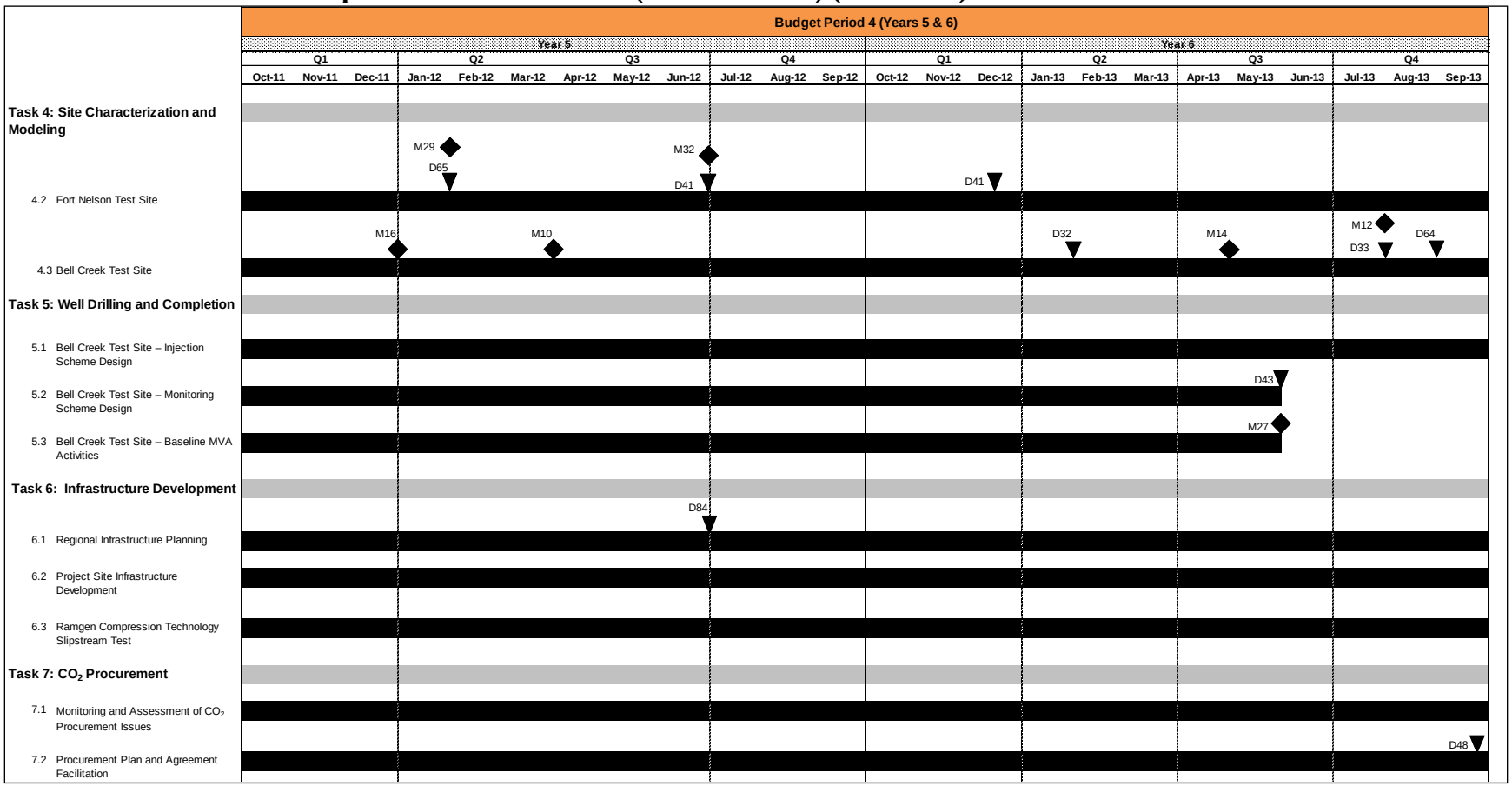
Key for Deliverables (D)			
D1	Review of Source Attributes	D29	Permitting Action Plan
D4	Permitting Review – Basic EPA Requirements	D31	BC Test Site – Geological Characterization Experimental Design Package
D9	Updated DSS	D34	BC Test Site – Baseline Hydrogeological Experimental Design Package
D10	DPRS 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 17. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4)

Continued…

Table 17. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)



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

Continued…

Table 17. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)

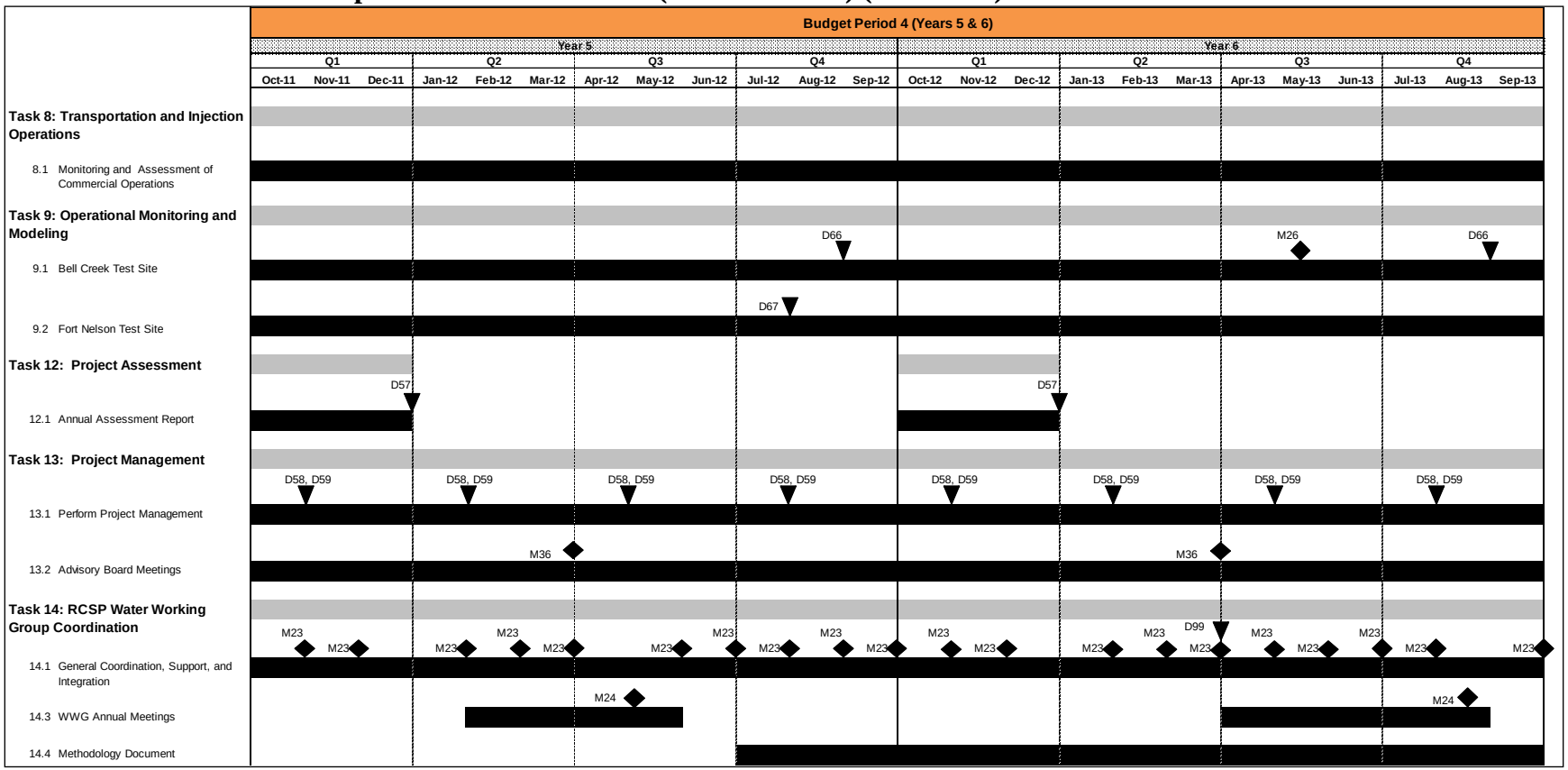


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Table 17. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)

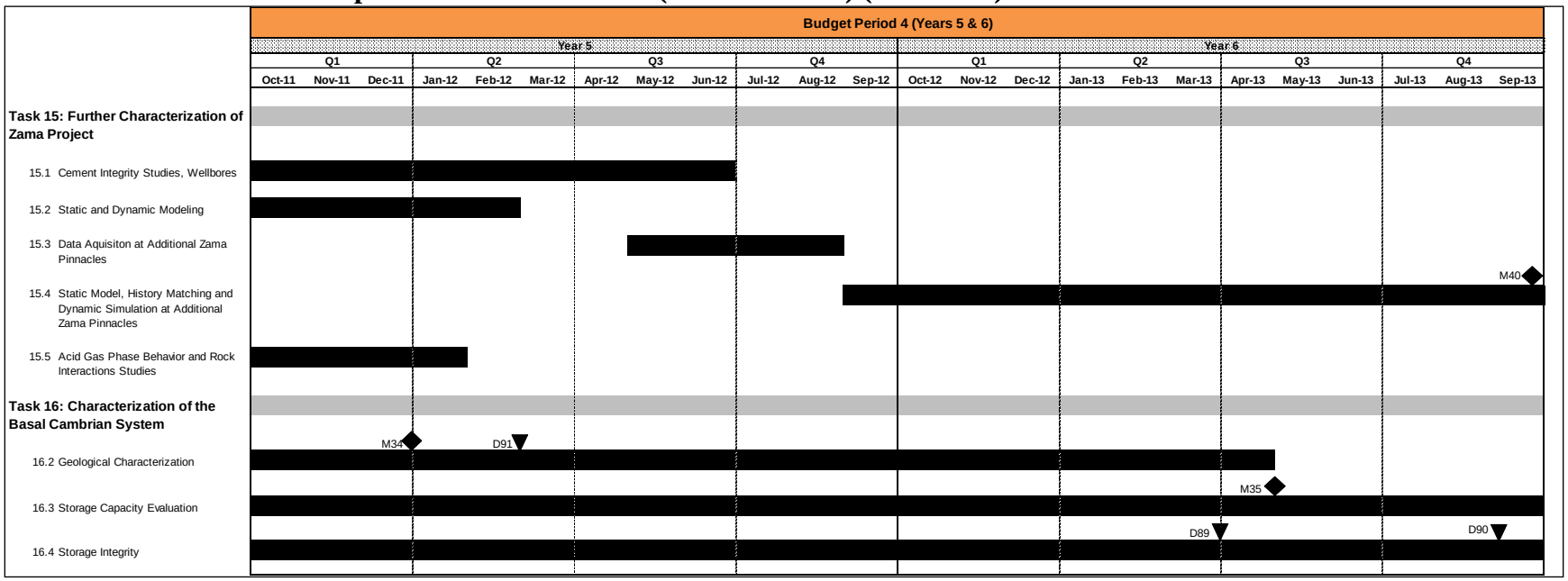

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Table 17. PCOR Partnership Phase III Gantt Chart (PY5–PY6 BP4) (continued)

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

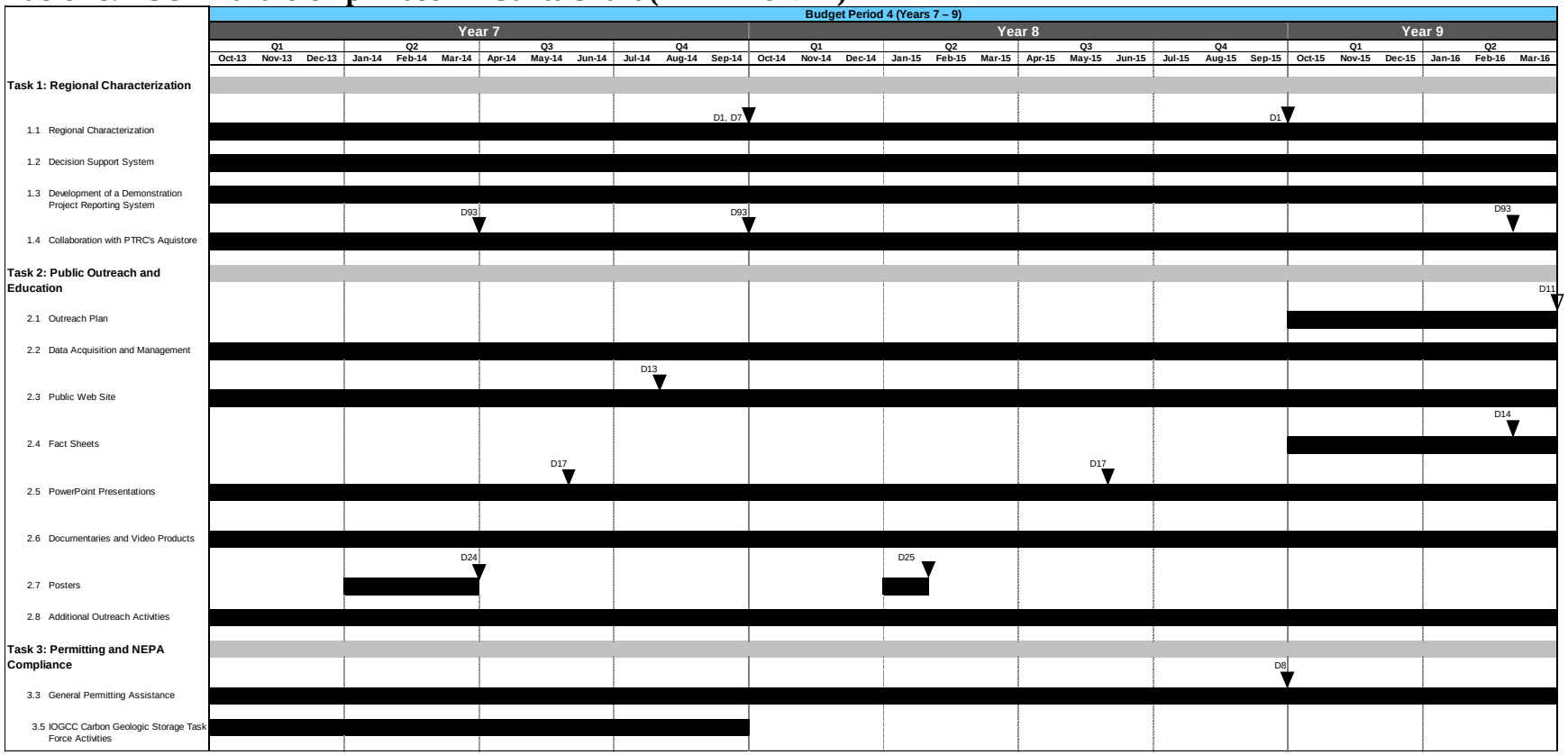

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Table 18. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4) (continued)

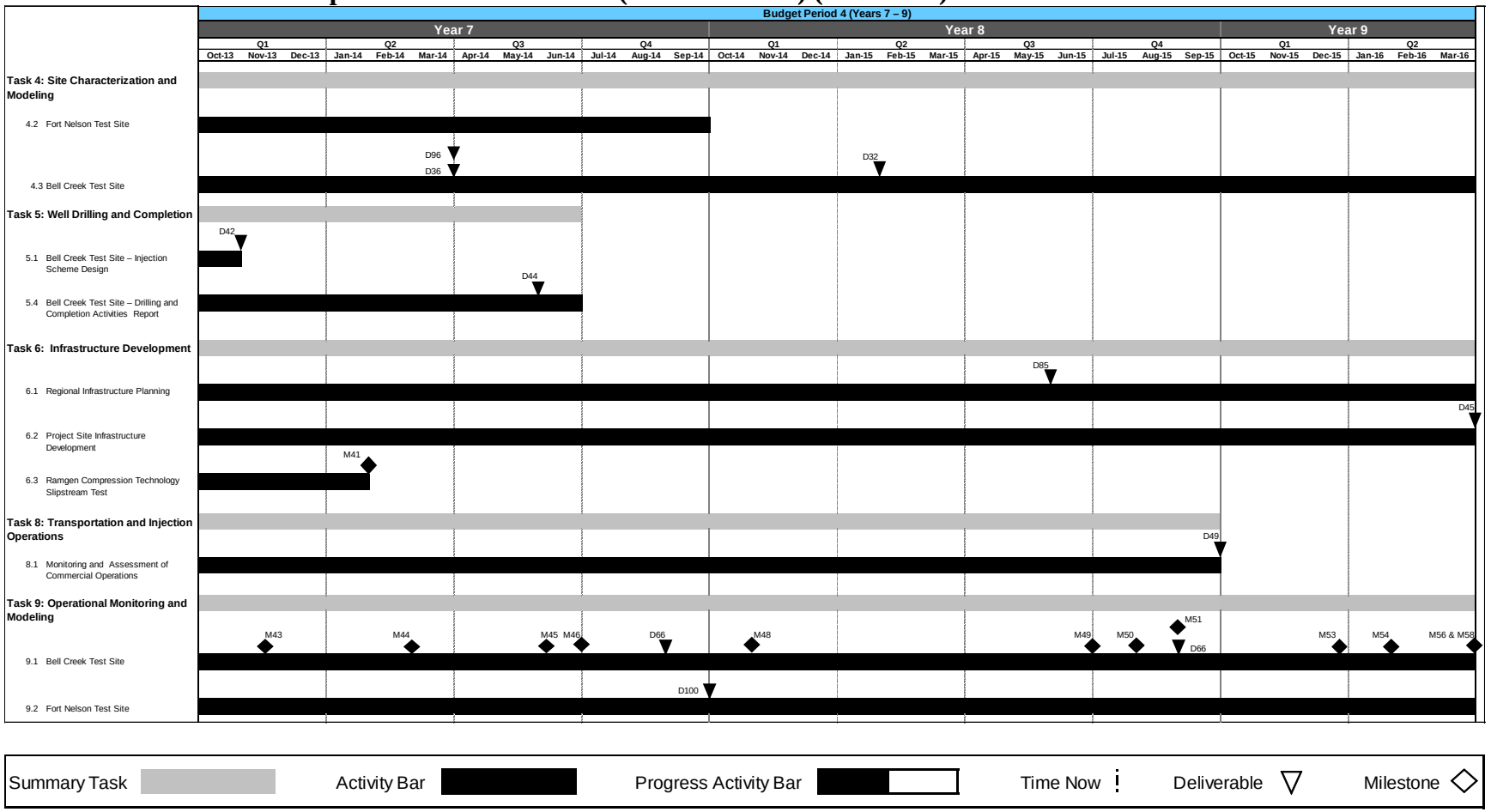

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Table 18. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4) (continued)

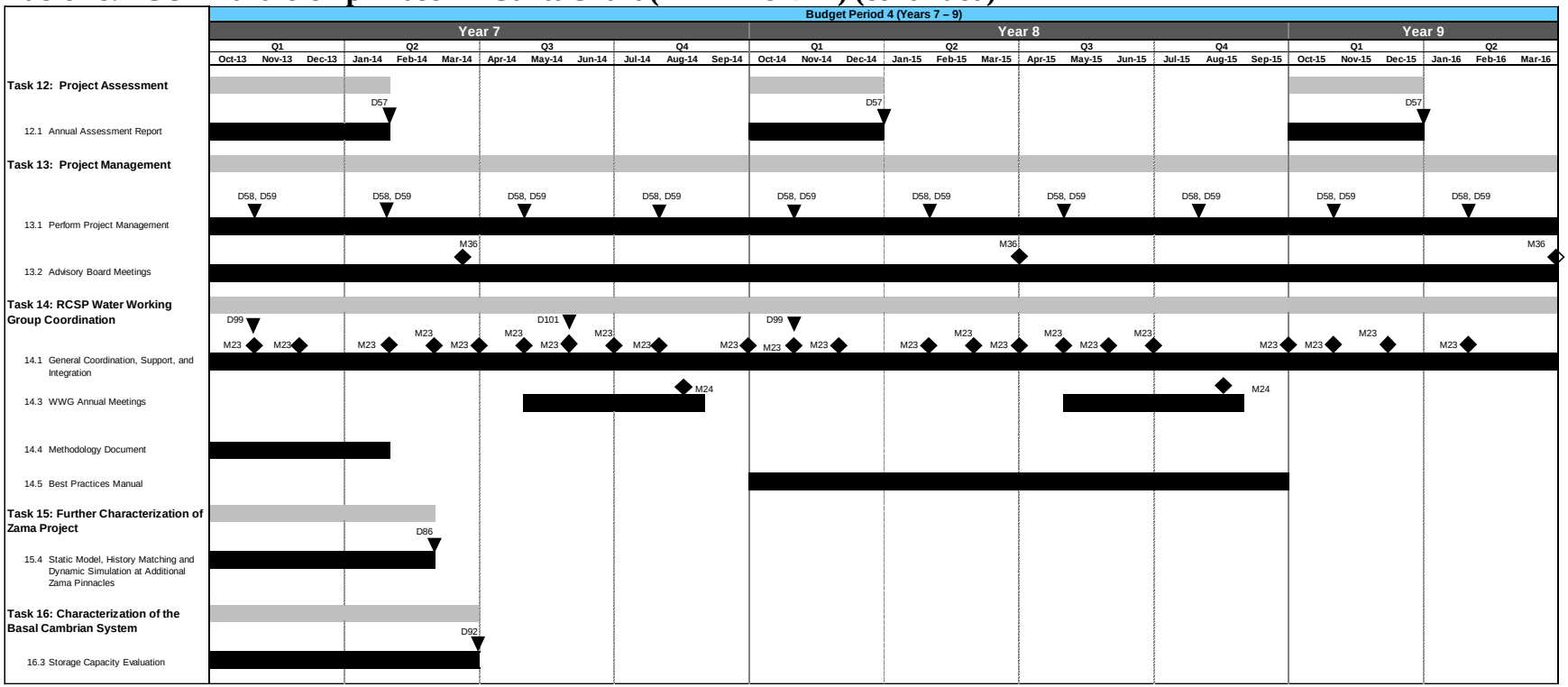

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Table 18. PCOR Partnership Phase III Gantt Chart (PY7–PY9 BP4) (continued)

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 19. PCOR Partnership Phase III Gantt Chart (PY9–PY12 BP5)

Continued . . .

Table 19. PCOR Partnership Phase III Gantt Chart (PY9–PY12 BP5) (continued)

Key for Deliverables (D)

D1	Review of Source Attributes
D8	Permitting Review
D13	Public Site Updates
D14	General Phase III Fact Sheet
D15	BC Test Site Fact Sheet
D16	Fort Nelson Test Site Fact Sheet
D17	General Phase III Information PowerPoint Presentation
D21	BC Test Site 30-minute Documentary
D22	Energy from Coal 60-minute Documentary
D35	BC Test Site – Best Practices Manual – Site Characterization
D51	BC Test Site – Best Practices Manual – Monitoring for CO_2 Storage and CO_2 EOR
D54	Report – Site Closure Procedures
D55	BC Test Site – Cost-Effective Long-Term Monitoring Strategies Report
D57	Project Assessment Annual Report
D58	Quarterly Progress Report
D59	Milestone Quarterly Report
D62	Final Report
D66	BC Test Site – Simulation Report
D69	BC Test Site – Best Practices Manual – Simulation
D73	Report – Monitoring and Modeling Fate of Stored CO_2
D76	Regional Regulatory Perspective
D81	Regional Carbon Sequestration Atlas
D85	Report – Opportunities and Challenges Associated with CO_2 Compression
D93	Report – Geological Modeling and Simulation for the Aquistore Project
D101	WWG Web Site Content Update
D102	Best Practices Manual – Adaptive Management Approach
D103	Best Practices Manual – Programmatic Risk Management
D104	BC Test Site – Analysis of Expanded Seismic Campaign
D105	Comparison of Non-EOR and EOR Life Cycle Assessment
D106	Special Issue of IJGGC – Nexus of Water and Carbon Capture and Storage
D107	Journal Article or Topical Report – Major Research Focuses of Water and CCS

Key for Milestones (M)

M23	WWG Conference Call Held
M24	WWG Annual Meeting Held
M36	Annual Advisory Board Meeting Scheduled
M47	BC Test Site 30-minute Video Broadcast
M52	BC Test Site – Initial Analysis of Extended Pulsed-Neutron Logging Campaign Data Completed
M55	Investigation of Crude Oil Compositional Changes During CO_2 EOR Completed
M57	Life Cycle Analysis for EOR Completed
M59	Adaptive Management Approach Best Practices Manual Completed
M60	Data Submitted to EDX
M61	Site Closure for Bell Creek Test Completed
M62	Research Related to Water and CCS Nexus Completed
M63	Initial Analysis of Processed InSAR Data Completed
M64	Initial Analysis of Expanded Seismic Campaign Data Completed

April-17

PLANNED ACTIVITIES

During the next program year (October 1, 2017 – September 30, 2018), Tasks 2, 3, 6, 9, 11, 12, and 14 will be completed on March 31, 2018. Tasks 1, 10, and 13 will continue through December 31, 2018.

Task 1 – Regional Characterization

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – September 30, 2018):

- 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.
- Upload the 2017 PCOR Partnership Annual Membership Meeting Web pages (planned to go live in December 2017).
- Provide an annual data submission to the EDX workspace (September 2018).
- 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

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- Continue to review, update, and upgrade the public PCOR Partnership Web site (D13) (January 2018).

- Complete development of broadcast documentary products; continue broadcasts and marketing of documentary products, development and placement of custom video products, and archiving video materials.

- 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

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- Complete the update to D8 "Permitting Review" (February 2018).

- 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, particularly IOGCC meetings.

- Continue attending appropriate regulatory meetings throughout BP5.

Task 4 – Site Characterization and Modeling

This task ended March 31, 2017. No further activity is anticipated.

Task 5 – Well Drilling and Completion

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

Task 6 – Infrastructure Development

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- Complete the value-added CO_2 capture technology overview document update.

- 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

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- Complete a BPM on monitoring for CO_2 storage and CO_2 EOR (D51) (October 2017).
- Revise the BPM for modeling and simulation of CO_2 storage (D69).
- 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 investigation of crude oil compositional changes during CO_2 EOR.
- Continue dynamic reservoir modeling.

Task 10 – Site Closure

During the next program year (October 1, 2017 – September 30, 2018), the following activities will be undertaken:

- Continue appropriate site closure activities to conclude project-specific activities.
- Complete D54, a report that outlines postinjection monitoring techniques, mitigation and site reclamation, and final abandonment procedures that would be necessary to close a site similar to Bell Creek (December 2017).

Task 11 – Postinjection Monitoring and Modeling

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- 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 commercial viability of the combined modeling and monitoring efforts.

- Prepare a report on the fate of stored CO_2 and the commercial applicability of the developed monitoring and modeling strategies for a commercial site (D73) (January 2018).

Task 12 – Project Assessment

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- Prepare the Annual Project Assessment Report (D57).

Task 13 – Project Management

During the next program year (October 1, 2017 – September 30, 2018), 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.

- Host the 2017 annual membership meeting in Plano, Texas.

- Plan the 2018 annual membership meeting.

- Continue to participate in and support RCSP efforts.

- Update the project management plan as necessary.

- Prepare and edit a virtual special issue of IJGGC on associated storage.

- Submit abstracts to the GHGT-14 conference.

- Complete the final report, D62 (September 2018).

Task 14 – RCSP WWG Coordination

The following activities will be undertaken to complete the task during the next program year (October 1, 2017 – March 31, 2018):

- Continue to conduct quarterly WWG conference calls.

- Update the WWG Web site content as appropriate.

- 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) (February 2018).

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 20 contains all of the Phase III deliverables, milestones, and submission dates for PY11 (October 1, 2017 – September 30, 2018).

Table 20. Phase III Milestones and Deliverables

Title/Description	Due Date	Actual Completion Date
Year 11 – Quarter 1 (October–December 2017)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	10/31/17	
D14: Task 2 – General Phase III Fact Sheet (update)	10/31/17	
D51: Task 9 – Best Practices Manual – Monitoring for CO_2 Storage and CO_2 EOR	10/31/17	
D93: Task 1 – Geological Modeling and Simulation Report for the Aquistore Project (Update 3)	10/31/17	
D15: Task 2 – Bell Creek Test Site Fact Sheet (update)	11/30/17	
D54: Task 10 – Report – Site Closure Procedures	12/31/17	
D57: Task 12 – Project Assessment Annual Report	12/31/17	
M23: Task 14 – WWG Conference Call Held	12/31/17	
M24: Task 14 – WWG Annual Meeting Held	12/31/17	8/2/17
M36: Task 13 – Annual Advisory Board Meeting Scheduled	12/31/17	
M65: Task 13 – 2017 PCOR Partnership Annual Membership Meeting and Workshop Held	12/31/17	
Year 11 – Quarter 2 (January–March 2018)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	1/31/18	
D13: Task 2 – Public Site Updates	1/31/18	
D73: Task 11 – Bell Creek Test Site – Monitoring and Modeling Fate of CO_2 Progress Report	1/31/18	
D8: Task 3 – Permitting Review – Update 4	2/28/18	
D107: Task 14 – Journal Article or Topical Report – Major Research Focuses for Water and CCS	2/28/18	
M23: Task 14 – Monthly WWG Conference Call Held	3/31/18	
M66: Task 13 – Submission of Draft Papers on Associated Storage to Special Issue of IJGGC	3/31/18	
Year 11 – Quarter 3 (April–June 2018)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	4/30/18	
M67: Task 13 – Annual PCOR Partnership Advisory Board Meeting Held	6/30/18	
Year 11 – Quarter 4 (July–September 2018)		
D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report	7/31/18	
M60: Task 1 – Data Submitted to EDX	9/30/18	
D62: Task 13 – Final Report	9/30/18	

TRAVEL

Representatives from the PCOR Partnership attended and/or participated in the following 46 external meetings/conferences/workshops, two training opportunities, and seven project management site trips in this reporting period. As the Phase III Program continued through BP5, travel decreased compared to that in PY9. Fewer meetings/conferences/workshops (46 compared to 56 in PY9) and site trips (seven versus 20) were made during the operational monitoring phase. The external training opportunities increased (two versus one in PY9); however, additional training was provided in-house and by Webinar.

- October 1–5, 2016: traveled to Little Rock, Arkansas, to attend the IOGCC Annual Meeting.
- October 16–18, 2016: traveled to Plano, Texas, to attend a meeting with Denbury and to attend the Society of Geophysicists Annual Meeting.
- October 26–28, 2016: traveled to Washington, D.C., to attend the U.S. Energy Association Panel Discussion on Carbon, Capture, Utilization, & Storage Act.
- November 1–3, 2016: traveled to Columbus, Ohio, to attend the Midwest Regional Carbon Sequestration Partnership 2016 Annual Partners Meeting.
- November 6–8, 2016: traveled to Plano, Texas, for meetings with Denbury regarding the PCOR Partnership Bell Creek documentary, PNL planning, geophysics and InSAR discussion, and Bell Creek-related GHGT-13 Conference presentations.
- November 9–19, 2016: traveled to Lausanne, Switzerland, to attend and present at the 13th Conference on Greenhouse Gas Control Technologies.
- November 13–18, 2016: traveled to San Francisco, California, to present at the AIChE Annual Meeting.
- December 5–6, 2016: traveled to Bismarck, North Dakota, to attend the Joint North Dakota Petroleum Council Legislative Reception.
- December 5–9, 2016: traveled to Midland, Texas, to attend and present at the 14th Annual CO_2 Conference Week.
- December 9–21, 2016: traveled to Gillette, Wyoming, to collect PNLs at the Bell Creek site.
- December 30, 2016: traveled to Fargo, North Dakota, to work on the PCOR Partnership coal documentary (D22) with PPB.
- January 3–6, 2017: traveled to Bethesda, Maryland, to participate as a panelist at the Basic Research Needs for Energy–Nexus Conference.
- January 4–8, 2017: traveled to Birmingham, Alabama, to visit Southern Company and tour project sites.
- January 4–13, 2017: traveled to Gillette, Wyoming, to collect PNLs at the Bell Creek site.
- January 10–17, 2017: traveled to Gillette, Wyoming, for Bell Creek project work.
- January 16–20, 2017: off-site staff traveled to Grand Forks, North Dakota, for project work and meetings.
- January 17–25, 2017: traveled to Gillette, Wyoming, for Bell Creek project work.
- January 23, 2017: traveled to Fargo, North Dakota, to work on the “Coal Powered” documentary with PPB.
- January 23–25, 2017: traveled to Pittsburgh, Pennsylvania, to attend and present at the FY17 Regional Sequestration Partnership Expert Review meeting.
- February 8–12, 2017: traveled to El Segundo, California, to attend 2-day Linux Sysadmin Training and Workshop.

- February 22–24, 2017: traveled to Glendive, Montana, for sampling at the Bell Creek site.
- February 26 – March 4, 2017: traveled to Houston, Texas, to attend Schlumberger's NExT Training "Practical Seismic Interpretation with Petrel."
- March 5–9, 2017: Traveled to Atlanta, Georgia, to attend the SECARB 12th Annual Stakeholders' Briefing.
- March 27–30, 2017: off-site staff traveled to Grand Forks, North Dakota, for project work and meetings.
- March 28–31, 2017: traveled to Pittsburgh, Pennsylvania, to attend the NAEMT CCUS Working Group Meeting and Energy Week 2017.
- April 3–7, 2017: off-site staff traveled to Grand Forks, North Dakota, to work on-site at the EERC on various projects.
- April 10–13, 2017: traveled to Chicago, Illinois, to present at and participate in the CCUS Conference.
- April 17–21, 2017: traveled to Taipai, Taiwan, to attend the U.S.–Taiwan International Carbon Capture & Sequestration Conference.
- April 18–19, 2017: traveled to Bismarck, North Dakota, to attend the LEC Annual Meeting.
- April 27 – May 4, 2017: traveled to Abu Dhabi, UAE, to attend the CSLF 2017 Mid-Year Meeting.
- May 6–10, 2017: traveled to Oklahoma City, Oklahoma, to attend the IOGCC Annual Meeting.
- May 13–21, 2017: traveled to Calgary, Alberta, Canada, to present at Geoconvention 2017.
- May 21–25, 2017: traveled to San Francisco, California, to host the PCOR Partnership TAB Annual Meeting.
- May 25–27, 2017: traveled from San Francisco, California, to Metro Park, California, to attend the 2017 SCCS Affiliates Meeting & Workshop at Stanford University.
- June 5–9, 2017: remote staff traveled to the EERC for project meetings.
- June 9–16, 2017: traveled to Paris, France, to present at the 79th EAGE Conference & Expo.
- June 12–13, 2017: traveled to Bismarck, North Dakota, to present at the LEC Teacher Seminar.
- June 12–16, 2017: traveled to Traverse City, Michigan, to attend the IEAGHG 11th Annual Network Meeting.
- June 18–22, 2017: traveled to Beaumont, Texas, to attend the 2nd International Workshop on Offshore Geologic CO_2 Storage.
- June 21, 2017: a staff member already in Beaumont, Texas, presented at the Lamar University Center for Innovation and Commercialization.
- June 24–28, 2017: traveled to San Francisco, California, to attend the ARMA Symposium and Hydraulic Fracturing Workshop.
- July 7, 2017: traveled to Bismarck, North Dakota, to attend a meeting with NDIC DMR and RTE.
- July 9–14, 2017: traveled to San Diego, California, to attend the ESRI User Conference.
- July 10–14, 2017: traveled to Gillette, Wyoming, for field work and to restart the borehole array.
- July 12–13, 2017: traveled to Morgantown, West Virginia, to attend a meeting at NETL.
- July 16–21, 2017: traveled to Houston, Texas, to present at CMTC 2017.
- July 17–22, 2017: traveled to Regina, Saskatchewan, to assist with the IEAGHG CCS Summer School.

- July 18–19, 2017: traveled to Bismarck, North Dakota, to attend the WBI Energy Customer Meeting and the Rainbow Gas Company Luncheon.
- July 31 – August 4, 2017: traveled to Pittsburgh, Pennsylvania, to attend and present at the Mastering the Subsurface: Carbon Storage & Oil & Natural Gas Technologies Review meeting and to host the WWG Annual Meeting.
- August 15–17, 2017: traveled to Miles City, Montana, for a Bell Creek site visit.
- August 20–25, 2017: traveled to Pittsburgh, Pennsylvania, to attend the DOE NETL Capture Technology Project Review Meeting.
- August 21–22, 2017: traveled to Plano, Texas, to conduct a hotel site visit and evening event venue site visits for the upcoming PCOR Partnership Annual Membership Meeting.
- September 2–7, 2017: traveled to Malmö, Sweden, to present at the EAGE 4th Sustainable Earth Sciences Conference.
- September 19–20, 2017: traveled to Champaign, Illinois, to present at the 2017 Midwest Carbon Sequestration Science Conference.
- September 25–28, 2017: traveled to Houston, Texas, to be a panelist for the CCUS Experts Workshop.

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 PY10, the PCOR Partnership submitted four abstracts (four were accepted). The PCOR Partnership gave 33 oral presentations and presented two posters. In addition, it completed 25 deliverable/milestone reports (23 were finalized), three value-added products, and 16 progress reports (monthlies and quarterlies combined); submitted four papers; and prepared two meeting minutes.

Abstracts

Submitted (2)

Wildgust, N., 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, Demonstration of secure CO_2 geological storage in the PCOR Partnership region [abs.]: GeoConvention 2017, Calgary, Alberta, May 15–19, 2017.

Hamling, J.A., 2017, Regional update of CCUS field projects within the PCOR Partnership region—improving the commercial viability of CO_2 storage through improved performance monitoring and operational management [abs.]: Carbon Capture, Utilization and Storage Conference, Nashville, Tennessee, March 19–22, 2018.

Submitted and Accepted for Presentation (2)

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—CO_2 injection update and results of adaptive management approach [abs.]: 2017 Carbon Capture, Utilization & Storage Conference, Chicago, Illinois, April 10–13, 2017.

Wildgust, N., 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., 2017, Demonstration of secure CO_2 geologic storage associated with enhanced oil recovery in the PCOR Partnership region [abs.]: Carbon Management Technology Conference 2017, Houston, Texas, July 17–20, 2017.

Accepted for Presentation (2)

Gorecki, C.D., Ayash, S.C., Wildgust, N., Peck, W.D., Hamling, J.A., Pekot, L.J., Sorensen, J.A., Jensen, M.D., Daly, D.J., Klapperich, R.J., and Heebink, L.V., 2017, The Plains CO_2 Reduction (PCOR) Partnership—successes leading to new innovation [abs.]: Near Surface Geoscience Conference & Exhibition 2017, Malmö, Sweden, September 3–7, 2017.

Nakles, D.V., Peck, W.D., Wildgust, N., Hamling, J.A., Gorecki, C.D., Steadman, E.N., and Harju, J.A., 2017, Geologic storage of carbon dioxide in the central plains of North America [abs.]: 2017 American Institute of Chemical Engineers (AIChE) Annual Meeting, Minneapolis, Minnesota, October 29 – November 3, 2017.

Presentations (33)

Azzolina, N.A., Hamling, J.A., Peck, W.D., Gorecki, C.D., Nakles, D.V., and Melzer, L.S., 2016, A life cycle analysis of incremental oil produced via CO_2 enhanced oil recovery (EOR): Presented at the 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

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

Daly, D.J., and Crocker, C.R., 2017, Energy and CO_2 management—carbon capture and storage: Presented at the 2017 Lignite Education Seminar, Bismarck, North Dakota, June 13, 2017.

Daly, D.J., Crocker, C.R., Gorecki, C.D. (authors), and Wildgust, N. (presenter), 2016, Regionwide outreach in a project-level world—lessons from the PCOR Partnership: Presented at the 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Glazewski, K.A., 2017, Wellbore integrity: Presented at the IEAGHG International CCS Summer School, Regina, Saskatchewan, July 17–23, 2017.

Glazewski, K.A., and Jensen, M.D., 2017, CO_2 transport: Presented at the IEAGHG International CCS Summer School, Regina, Saskatchewan, July 17–23, 2017.

Gorecki, C.D., and Ayash, S.C., 2016, The Plains CO_2 Reduction (PCOR) Partnership Program update: Presented to Southern Company personnel, Grand Forks, North Dakota, October 25, 2016.

Gorecki, C.D., and Ayash, S.C., 2017, A look at the Bakken's contributions to American energy: Presented at the North Dakota Petroleum Council Annual Meeting, Grand Forks, North Dakota, September 26, 2017.

Gorecki, C.D., and Ayash, S.C., 2017, An adaptive management approach for monitoring CO_2 storage: Presented at the US–Taiwan International CCS Conference, Taipei, Taiwan, April 17–21, 2017.

Gorecki, C.D., and Ayash, S.C., 2017, The Plains CO_2 Reduction (PCOR) Partnership—successes leading to new innovation: Presented at the Near Surface Geoscience Conference & Exhibition 2017, Malmö, Sweden, September 3–7, 2017.

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., 2017, The Plains CO_2 Reduction Partnership—CO_2 injection update and results of adaptive management approach: Presented at the Carbon Capture, Utilization & Storage Conference, Chicago, Illinois, April 10–13, 2017.

Gorecki, C.D., Ayash, S.C., Peck, W.D., and Wildgust, N., 2017, Plains CO_2 Reduction (PCOR) Partnership – Phase III: Presented at the 2017 Regional Carbon Sequestration Partnerships IEA Greenhouse Gas R&D Programme Expert Review – Development Phase (Phase III), Pittsburgh, Pennsylvania, January 23–27, 2017.

Gorecki, C.D., Ayash, S.C., and Wildgust, N., 2017, Bell Creek oilfield project – Plains CO_2 Reduction Partnership: Presented at Mastering the Subsurface Through Technology Innovation, Partnerships & Collaboration—Carbon Storage & Oil & Natural Gas Technologies Review Meeting, Pittsburgh, Pennsylvania, August 1–3, 2017.

Gorecki, C.D., Ayash, S.C., and Wildgust, N., 2017, PCOR Partnership Program Technical Advisory Board annual meeting 2017: Presented at the 2017 PCOR Partnership Technical Advisory Board Annual Meeting, San Francisco, California, May 23–24, 2017.

Hamling, J.A., 2017, Near-surface/surface baseline monitoring: Presented at the IEAGHG Monitoring Network Meeting, Traverse City, Michigan, June 13–15, 2017.

Hamling, J.A., Glazewski, K.A., Leroux, K.M., Kalenze, N.S., Bosshart, N.W., Burnison, S.A., Klapperich, R.J., Stepan, D.J., Gorecki, C.D., and Richards, T.L., 2016, Monitoring 3.2 million tonnes of CO_2 at the Bell Creek oil field: Presented at the 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Hamling, J.A., Stepan, D.J., and Klapperich, R.J., 2017, Integrating monitoring data—understanding reservoir behavior and CO_2 movement at the Bell Creek commercial CO_2 EOR project: Presented at the IEAGHG Monitoring Network Meeting, Traverse City, Michigan, June 13–15, 2017.

Harju, J.A., 2017, CO_2 enhanced oil recovery (EOR) in unconventional plays: Presented at the mid-year meeting of the Carbon Sequestration Leadership Forum, Abu Dhabi, United Arab Emirates, May 1, 2017.

Harju, J.A., Gorecki, C.D., Ayash, S.C., and Ensrud, J.R., 2017, Lasting impacts of the Plains CO_2 Reduction (PCOR) Partnership Program: Presented at the Southeast Regional Sequestration Partnership 12th Annual Stakeholders' Briefing, Atlanta, Georgia, March 8–9, 2017.

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: Presented at the 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

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

Klapperich, R.J., 2017, RCSP Water Working Group Annual Meeting: Presented at the RCSP Water Working Group Annual Meeting, Philadelphia, Pennsylvania, August 2, 2017.

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: Presented at the 2016 AIChE Annual Meeting, San Francisco, California, November 13–18, 2016.

Peck, W.D., 2017, EERC activities in oil and gas, and carbon management: Presented at the Wyoming Oil & Gas Fair, Casper, Wyoming, September 12–13, 2017.

Pekot, L.J., 2017, Modeling panel discussion and Q&A: Presented at the Aquistore Project 2017 Annual General Meeting, Ottawa, Ontario, September 12–13, 2017.

Salako, O., Jin, L., Burnison, S.A., Hamling, J.A., Gorecki, C.D., Reed, S., and Richards, T., 2017, The value of 4-D seismic monitoring at Bell Creek – a mature oil field undergoing CO_2 enhanced oil recovery: Presented at the 79th European Association of Geoscientists & Engineers (EAGE) Conference & Exhibition, Paris, France, June 12–15, 2017.

Smith, S.A., Beddoe, C.L., Mibeck, B.A.F., Heebink, L.V., Kurz, B.A., Peck, W.D., and Jin, L., 2016, Relative permeability of Williston Basin CO_2 storage targets: Presented at the 13th International Conference on Greenhouse Gas Control Technologies (GHGT-13), Lausanne, Switzerland, November 14–18, 2016.

Sorensen, J.A., 2016, Research to unlock the EOR potential of unconventional reservoirs: Panel talk presented at the 2016 CO_2/ ROZ Conference, Midland, Texas, December 6–8, 2016.

Steadman, E.N., 2017, Bell Creek oilfield project – Plains CO_2 Reduction Partnership: Presented at the 2017 Midwest Carbon Sequestration Science Conference Annual Meeting, Champaign, Illinois, September 19–20, 2017.

Wildgust, N., 2017, Reducing greenhouse gas emissions – energy with a smaller carbon footprint: Poster presented at the Bureau of Economic Geology (BEG) Open House, Beaumont, Texas, June 21, 2017.

Wildgust, N., 2017, The Plains CO_2 Reduction Partnership—CO_2 injection update and results of adaptive management approach: Presented at the SCCS Annual Workshop 2017, Stanford, California, May 26, 2017.

Wildgust, N., 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, Demonstration of secure CO_2 geological storage in the PCOR Partnership region: Presented at GeoConvention 2017, Calgary, Alberta, May 15–19, 2017.

Wildgust, N., 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., 2017, Demonstration of secure CO_2 geological storage associated with enhanced oil recovery in the PCOR Partnership region: Presented at the Carbon Management Technology Conference 2017, Houston, Texas, July 17–20, 2017.

Poster Presentations (2)

Dalkhaa, C., Pekot, L.J., Jiang, T., Oster, B.S., Bosshart, N.W., and Nickel, E., 2017, Updated numerical modeling and simulation study of the Aquistore CO_2 storage project: Poster presented at the Aquistore Project 2017 Annual General Meeting, Ottawa, Ontario, September 12–13, 2017.

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

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 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.

Azzolina, N.A., Nakles, D.V., Ayash, S.C., Wildgust, N., Peck, W.D., and Gorecki, C.D., 2017, PCOR Partnership best practices manual for subsurface technical risk assessment of geologic CO_2 storage projects: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D103 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.

Crocker, C.R., and Daly, D.J., 2017, Coal powered! [DVD]: Dambach, B., and Steadman, E.N., executive producers, Fargo, North Dakota, Prairie Public Broadcasting, and Grand Forks, North Dakota, Energy & Environmental Research Center, Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 2 Deliverable D22 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592.

Daly, D.J., Crocker, C.R., Crossland, J.L., Hamling, J.A., and Gorecki, C.D., 2016, Bell Creek integrated CO_2 EOR and storage project: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 2 Deliverable D15 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, November.

Jensen, M.D., Schlasner, S.A., Hamling, J.A., Leroux, K.M., Gorecki, C.D., and Azzolina, N.A., 2016, Comparison of non-EOR and EOR life cycle assessments: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D105 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.

Pekot, L.J., Bosshart, N.W., Wildgust, N., Torres Rivero, J.A., Jin, L., Ge, J., Jiang, T., Heebink, L.V., Kurz, M.C., Dalkhaa, C., Peck, W.D., Burnison, S.A., and Gorecki, C.D., 2017, Best practices for modeling and simulation of CO_2 storage: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D69 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.

Peterson, K.J., Jin, L., Bosshart, N.W., Pekot, L.J., Salako, O., Burnison, S.A., Smith, S.A., Mibeck, B.A.F., Oster, B.S., He, J., Peck, W.D., Ayash, S.C., Wildgust, N., and Gorecki, C.D., 2017, Bell Creek test site – simulation report: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D66 (Update 6) 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.

Salako, O., Livers, A.J., Burnison, S.A., Hamling, J.A., Wildgust, N., Gorecki, C.D., Glazewski, K.A., and Heebink, L.V., 2017, Analysis of expanded seismic campaign: Plains CO_2 Reduction (PCOR) Partnership Phase III draft Task 9 Deliverable D104 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, June.

Submitted and Approved (18)

Ayash, S.C., and Gorecki, C.D., 2016, Technical Advisory Board meeting scheduled: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 13 M36 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-01-02, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

Bosshart, N.W., Hurley, J.P., Hamling, J.A., and Gorecki, C.D., 2017, Bell Creek test site – initial analysis of processed InSAR data completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M63 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-03-13, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Burnison, S.A., Salako, O., Livers, A.J., Wildgust, N., Gorecki, C.D., Hamling, J.A., and Glazewski, K.A., 2017, Initial analysis of expanded seismic campaign data completed: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 9 Milestone M64 for U.S. Department of

Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-06-13, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Crocker, C.R., and Daly, D.J., 2017, The Bell Creek story – CO_2 in action [DVD]: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D21 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, Grand Forks, North Dakota, Energy & Environmental Research Center, January.

Crocker, C.R., Daly, D.J., Crossland, J.L., and Gorecki, C.D., 2017, Bell Creek Test Site – 30-minute documentary broadcast: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Milestone M47 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-07-08, Grand Forks, North Dakota, Energy & Environmental Research Center, June.

Daly, D.J., Crocker, C.R., Wildgust, N., and Gorecki, C.D., 2017, General audience CO_2 sequestration outreach PowerPoint presentation: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 2 Deliverable D17 (Update 8) 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., Aulich, T.R., Wildgust, N., Nakles, D.V., Hamling, J.A., Burnison, S.A., Livers, A.J., Salako, O., Sorensen, J.A., Ayash, S.C., Pekot, L.J., Bosshart, N.W., Gorz, A.J., Peck, W.D., and Gorecki, C.D., 2017, Best practices manual (BPM) for site characterization: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 4 Deliverable D35 for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-06-08, Grand Forks, North Dakota, Energy & Environmental Research Center, March.

Gorecki, C.D., Harju, J.A., Steadman, E.N., Heebink, L.V., Romuld, L., Hamling, J.A., Sorensen, J.A., Pekot, L.J., Daly, D.J., Jensen, M.D., Peck, W.D., Klapperich, R.J., Bosshart, N.W., Votava, T.F., Ayash, S.C., and Ensrud, J.R., 2016, Annual assessment report: Plains CO_2 Reduction (PCOR) Partnership Phase III Task 12 Deliverable D57 (October 1, 2015 – September 30, 2016) for U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-05NT42592, EERC Publication 2017-EERC-02-06, Grand Forks, North Dakota, Energy & Environmental Research Center, December.

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