
# PLAINS $CO_2$ REDUCTION PARTNERSHIP PHASE III

## Project Assessment Annual Report – Deliverable D57

*(for the period October 1, 2007 – September 30, 2008)*

*Prepared for:*

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## DOE DISCLAIMER



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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 RCSP Program is a government–industry effort tasked with determining the most suitable technologies, regulations, and infrastructure needs for carbon capture and storage (CCS) on the North American continent. The RCSP Program initiative is being implemented in three phases:

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

The PCOR Partnership is managed by the Energy & Environmental Research Center (EERC) at the University of North Dakota in Grand Forks, North Dakota. 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 goals and objectives of the PCOR Partnership Phase III program are to 1) build upon Phase I and II assessments on regional sequestration data to verify the ability of target formations to store $CO_2$, 2) develop the infrastructure required to transport $CO_2$ from the source to the injection site, 3) facilitate development of the rapidly evolving North American regulatory and permitting framework, 4) develop opportunities for PCOR Partnership partners to capture and sequester $CO_2$, 5) establish a means by which carbon markets can facilitate more recovery of oil and gas from the region, 6) develop a mechanism by which carbon credits can be monetized for $CO_2$ sequestered in geologic formations, 7) continue collaboration with the other RCSP Program partnerships, and 8) provide outreach and education for $CO_2$ sequestration stakeholders and the general public.

A long-range goal of the PCOR Partnership is to support the DOE FutureGen Initiative (Figure 1) and to mitigate risk to industries that rely on fossil fuels by taking a market- and incentive-based approach to carbon management. On February 27, 2003, the federal government announced FutureGen, the creation of a coal-based power plant focused on demonstrating innovative clean coal technology that produces hydrogen and electricity and mitigates greenhouse gas (GHG) emissions. Today, the DOE is working to restructure FutureGen by equipping multiple new clean coal power plants with advanced CCS technology.

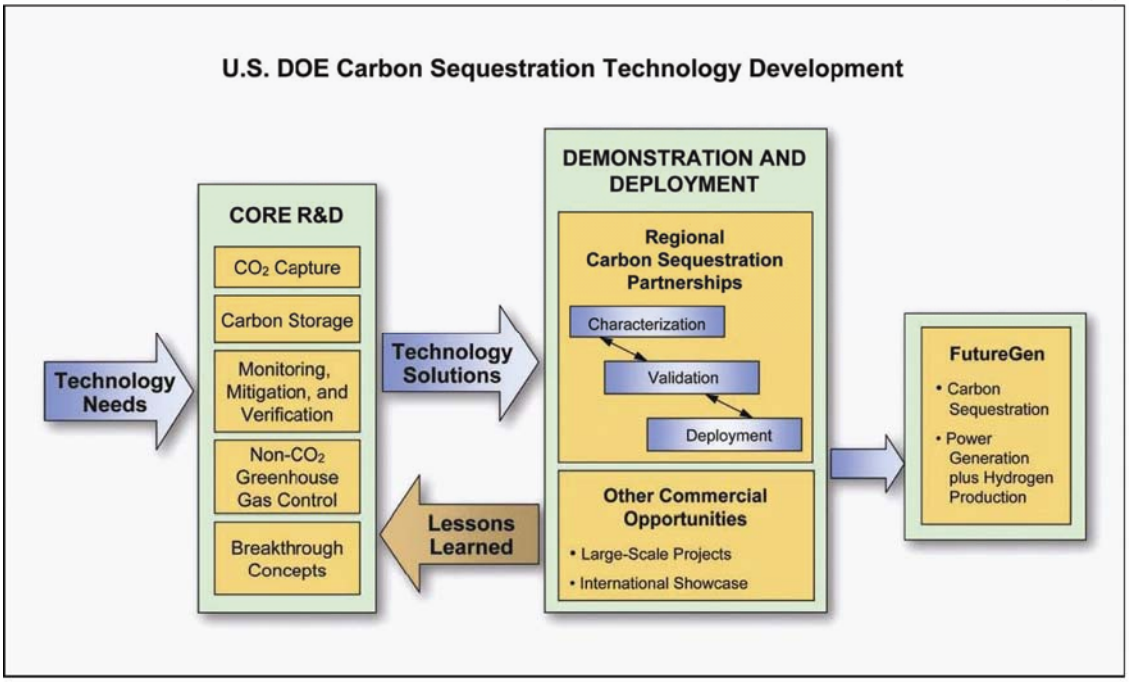



Figure 1. DOE Climate Change Technology Program (1).

## APPROACH

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

The EERC was awarded a contract for Phase III activities in late September 2007. Phase III is a 10-year project, in three budget periods (BPs), running from October 1, 2007, to September 30, 2017. This Project Assessment Annual Report summarizes the activities for the reporting period (October 1, 2007 – September 30, 2008) for Phase III.

The activities for Phase III of the PCOR Partnership include two large-volume sequestration demonstration tests (Figure 2) along with continued regional characterization and outreach. The PCOR Partnership Phase III objectives will be reached through a series of thirteen tasks. The project 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 (capture, purification, or purchase), 8) Transportation and Injection Operations, 9) Operational Monitoring and Modeling, 10) Site Closure, 11) Postinjection Monitoring and Modeling, 12) Project Assessment, and 13) Project Management. See Table 1 for the responsibility matrix of these thirteen tasks.

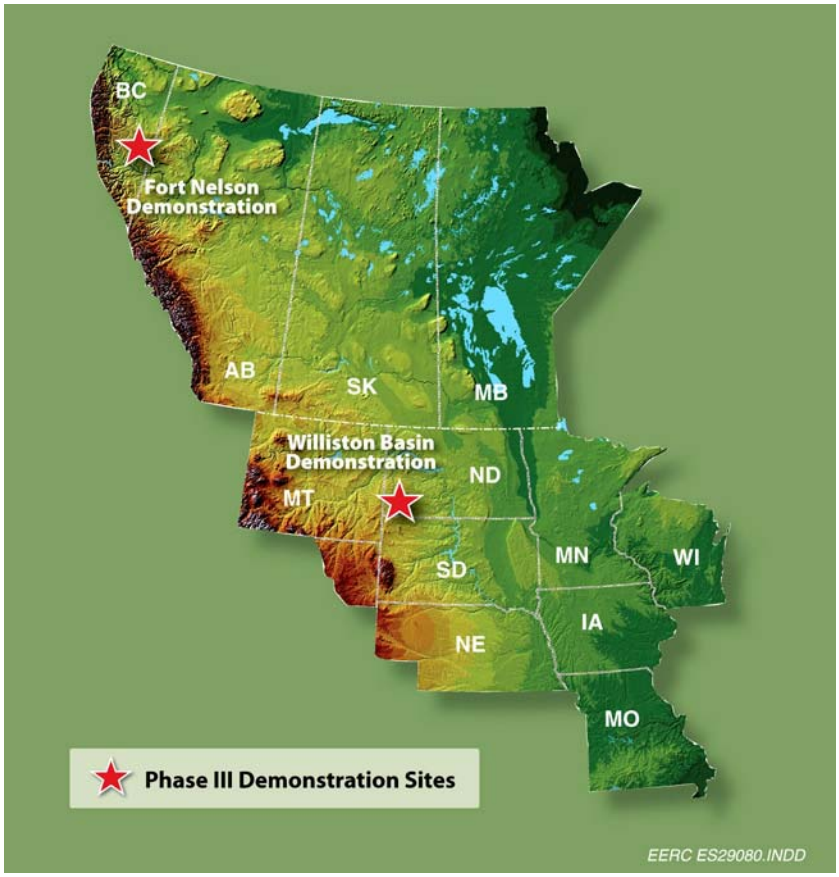



Figure 2. PCOR Partnership Phase III demonstration test sites.

**Table 1. Phase III Responsibility Matrix**

| Phase III Task Description | Responsible Party |
|---|---|
| Task 1 – Regional Characterization | Wes Peck |
| Task 2 – Public Outreach and Education | Dan Daly |
| Task 3 – Permitting and NEPA Compliance | Lisa Botnen |
| Task 4 – Site Characterization and Modeling | Jim Sorensen |
| Task 5 – Well Drilling and Completion | Steve Smith |
| Task 6 – Infrastructure Development | Melanie Jensen |
| Task 7 – $CO_2$ Procurement | John Harju |
| Task 8 – Transportation and Injection Operations | TBA |
| Task 9 – Operational Monitoring and Modeling | TBA |
| Task 10 – Site Closure | TBA |
| Task 11 – Postinjection Monitoring and Modeling | TBA |
| Task 12 – Project Assessment | Stephanie Wolfe |
| Task 13 – Project Management | Ed Steadman |

## RESULTS AND DISCUSSION

### Task 1 – Regional Characterization

Phase III regional characterization efforts over the past year (October 1, 2007 – September 30, 2008) have resulted in 1) the selection of three target areas for detailed geologic characterization work, 2) the development of a demonstration project reporting system (DPRS) to manage and report information on the Phase III demonstration sites, 3) a detailed review of the location of $CO_2$ sources in the PCOR Partnership region, 4) the rebuilding of the Decision Support System (DSS © 2007 EERC Foundation) on an improved platform, and 5) the addition of the Missouri Division of Geology and Land Survey (DGLS) as a subcontractor to gather baseline information on the geologic sequestration potential of Missouri.

Geologic characterization of oil fields in Phase II of the project focused on a reconnaissance-level effort using readily available data. Phase III activities will build on Phase II accomplishments by utilizing all sources of data available through the PCOR Partnership, including wire-line well logs, core analysis, production decline curves, drill stem tests, and produced fluid analyses to provide more detailed characterization. Site characterization activities will be conducted to develop predictive models, using industry standard software, that address three critical issues to determine the ultimate effectiveness of the target formation: 1) the capacity of the target formation, in this case, an oil reservoir within an established oil field; 2) the overall potential for enhanced resource recovery from the identified target; and 3) the mobility and fate of the $CO_2$ at near-, intermediate-, and long-term time frames. Key site characterization parameters that will be addressed include properties of the reservoir and seal rocks, properties of the fluids in the reservoir and overlying fluid-bearing formations, and the production and operational history of the target oil reservoir.

During the past year, the PCOR Partnership has been identifying target areas in which to conduct enhanced oil recovery (EOR). The following sites have been selected as target areas for further evaluation with regard to the utilization of $CO_2$ for EOR:

- Rival Field – This field is located in northwestern North Dakota and is proximal to a gas-processing plant that currently disposes of acid gas into the subsurface. The field will be modeled in detail with respect to the geological framework and fluid flow regimes. This model will then be used to run injection scenarios that utilize the current volume of acid gas injected as a miscible fluid for EOR.
- Eland Field – This field is located in central North Dakota directly south of several major stationary point sources of $CO_2$. The site has been identified by industry partners and internal investigations by the PCOR Partnership as having potential for $CO_2$ EOR operations.
- Sleepy Hollow Field – This field is in southwestern Nebraska and has significant potential for $CO_2$ EOR operations. The field's $CO_2$ needs could be served by future ethanol plants and will be modeled using volumes of this magnitude. Each of these site investigations will address unique opportunities to utilize $CO_2$ obtained from a myriad of industrial applications and provide valuable information with regard to the economic impact of $CO_2$ EOR.

Information (e.g., reports, summaries, tables, maps, etc.) generated in conducting the Phase III demonstration tests will be managed and reported to DOE and partners through a DPRS. The DPRS will be a Web-based interface designed to provide structured access to data by all demonstration participants and other partners to facilitate communication and interpretation of these data and to allow for efficient replication of additional or related demonstration projects.

Information and products currently developed through the PCOR Partnership are disseminated to DOE and partners through the DSS – a database-driven, password-protected Web site containing both traditional static pages and an interactive geographic information system (GIS). The DPRS will be incorporated into the overall architecture of the DSS. During the past year, a prototype of the DPRS was designed. Currently, the proposed content of the DPRS will be arranged in the following main categories:

1) **Background Information**. This section will describe the objectives of the demonstration project and provide basic information about the effort.

2) **Baseline Characterization Data**. This section includes subsurface information on geological characteristics, overlying seal(s) and formations, and formation storage injectivity and capacity.
   a. Predictive models that address:
      i. Capacity
      ii. Mobility and fate of the $CO_2$ at near-, intermediate-, and long-term time frames
      iii. Potential for leakage of the injected $CO_2$ into overlying formations and/or the surface environment
   b. A geological model that incorporates local (oil field)-, subregional (i.e., Cedar Creek, Nesson, or Billings Anticlines)-, and regional (Williston Basin)-scale stratigraphy and architecture.
   c. A hydrogeological model that operates at the local and subregional scales.
   d. A reservoir dynamics model for the selected reservoir.

3) **Regulations and Permitting**. This section is a repository of regulatory and permitting forms that were needed to initiate and conduct the injection demonstration.

4) **$CO_2$ Capture and Transportation**. This section will include information on the capture system used at each demonstration site and details on the transportation of the compressed $CO_2$.

5) **Monitoring, Mitigation, and Verification (MMV)**. Data in this category will include the following:
   a. Monitoring plans
   b. Updates on pressure/temperature conditions during injection
   c. Results of remote sensing/downhole tool investigations

6) **Injection and operations**. Day-to-day operation of the demonstration sites will likely bring up an array of issues to be addressed. As these issues are overcome, documentation of the methodologies will be assembled for future reference.

7) **Products**. This section will contain items that relate directly to the demonstration project. Topical reports, final reports, posters, presentations, and fact sheets will also be linked to the new DSS Products Database which will house all PCOR Partnership products. Media-related information such as news releases, images, and videos will be linked to the new Multimedia Gallery contained within the DSS.

Currently, the entire PCOR Partnership DSS is undergoing a redesign to improve the nature and accessibility of the various data (see Figure 3). The development and inclusion of the DPRS is a significant part of the overall redesign and will greatly expand the Phase III content of the DSS.

The Regional Characterization task also entails the review, characterization, and update of an inventory of $CO_2$ sources across the region. A recent review of the locational accuracy of the various sources was undertaken. The objective of this task was to verify the reported latitude/longitude location of each $CO_2$ source in the current PCOR Partnership database. The original location information was obtained from federal, state, and provincial sources (e.g., the U.S. Environmental Protection Agency [EPA], Environment Canada). To meet this objective and ensure that the location information originally obtained from various public data sets was truly valid, work study students were assigned the task of verifying the latitude/longitude


Figure 3. Redesign concept for upcoming DPRS Web site homepage.

values of each source facility plotted on an appropriate feature in an aerial photograph through the use of online global mapping applications, such as Google Earth. If the plotted location on the Web application was nowhere near a facility, the students were instructed to search a relatively local area. If again, no facility could be found in the area, further online research was conducted to determine where the facility was located.

This effort resulted in the repositioning of 755 locations. Of these modified locations, 525 were shifted by more than 0.5 kilometers, the minimum offset distance that we considered to be significant. If, in the process of tracking down the location of a specific source, additional sources came to light, the new data were added to the database. If the same process revealed that a source was no longer in operation, it was then removed from the database. In the course of this exercise, 17 additional $CO_2$ sources were added to the data set, and 22 sources were removed. Through this source location verification process, the total number of inventoried sources in the PCOR Partnership region changed from 1545 to 1540. Although there was a slight loss in the number of sources, the total annual $CO_2$ output increased by 0.04% to 585,784,043 tons.

The Missouri DGLS was added as a PCOR Partnership member and subcontractor to provide baseline data and characterization regarding the potential geologic sequestration of $CO_2$ in Missouri. The following bullets highlight the major effort by the DGLS:

- Information on reported cumulative oil and gas production from individual fields in Missouri was compiled and provided to the EERC via an Excel spreadsheet in April 2008. The scanning of over 2300 oil/gas geophysical logs from Missouri has been completed and was provided to the EERC in June 2008.
- DLGS is working on a bibliographic and literature review of historic and current reports on saline formations in Missouri. An assessment of Missouri water quality data is also under way. These data include depth of well, casing amount, primary aquifer, geologic unit, and water quality. Parameters from these data being considered for the project include total dissolved solids, residue on evaporation, chloride, sulfate, calcium, sodium, pH, conductance, and temperature. Following the review and evaluation of data, an ACCESS database will be designed for data entry and then used to generate GIS layers.
- DGLS has compiled structural information geologic and outcrop maps for the Missouri portions of the Dyersburg, Harrison, Joplin, and Poplar Bluff 1° × 2° quadrangles. Work was completed on the west half of the Springfield 1° × 2° quadrangle and is under way on the east half. A total of 872 maps have been examined for structures. These maps contained 393 named structural features that comprise 1073 separate lines.
- GIS coverages of known oil/gas pools in Missouri were compiled. A preliminary summary of the 14 principal coal seams of Missouri has also been initiated. This summary will include the creation or update of several coal resource maps and the extraction of coal data from the National Coal Resources Data System.

The first PCOR Partnership Geologic Working Group meeting was organized and facilitated following the 2007 PCOR Partnership Annual Meeting. Partners and prospective partners discussed geologic characterization activities occurring in their respective regions. The

group held a similar meeting April 17, 2008, in Minneapolis, Minnesota, and at the 2008 PCOR Partnership Annual meeting in Maple Grove, Minnesota.

**Task 2 – Public Outreach and Education**

PCOR Partnership Phase II and III calls for public outreach and education activities. As a result, the priorities for Year 1 of Phase III were:

- The development of a Phase III Outreach Action Plan (OAP) that would integrate Phase II and III activities and lay the groundwork for future Phase III activities
- The development and timely distribution of basic information on scope and activities of Phase III
- The expansion of capabilities to support Phase III outreach activities
- The expansion of personnel levels to meet Phase III requirements

The Phase II OAP was in place for general public outreach at the regional level, as well as site-level plans to support outreach for individual verification projects, with the level to be determined by partners. The Phase III OAP (Deliverable D11) was developed during Year One and was submitted for review on schedule on March 31, 2008. The plan focused on regional outreach, but addressed the need to develop plans for site outreach as negotiations are completed for the commercial-scale demonstration projects. The report included information on demographics, audiences and messages, outreach materials, and outreach methods and protocols. The plan superseded the Phase II OAP, providing for the coordinated application of both Phase II and III outreach tools and capabilities activities during the period of Phase II and III overlap as well as future Phase III activities.

The need for basic information on the Phase III program was met by the immediate posting of a press release regarding the announcement of Phase III and links to other Phase III notices on the public Web site, the development and release of a Phase III overview fact sheet during the first quarter, the development of a fact sheet on the Phase III commercial-scale projects released during the second quarter, and a focused fact sheet for the Canadian (Fort Nelson) demonstration test released during the third quarter. This was supplemented by the development of pages for the public Web site for the third quarter that provided information on the commercial-scale tests and featured the three fact sheets mentioned above. In addition, PowerPoint slides were developed on the Phase III program and the commercial-scale projects for use in public presentations. The development of a fact sheet for the Williston Basin demonstration was postponed because of a holdup in negotiations.

Phase III is a 10-year effort; thus capabilities were expanded with respect to video, regional outreach characterization, and regional outreach tracking to keep our partners and the general public up-to-date during this period.

- The scope of work calls for broadcast quality documentaries by Prairie Public Broadcasting (PPB) on both commercial-scale demonstrations. In order to ensure optimal quality on these, the film efforts by PPB will be supplemented by high-quality video taken in the field by PCOR Partnership personnel. To this end, a videocamera and

supporting software and laptop were acquired, and personnel were provided with training in the use of the equipment.
- A GIS-capable database, termed the Outreach Information System (OIS), was initiated to enable efficient planning and assessment for outreach activities. The database contains fields on population, media outreach, media contacts, and other information to aid planning and assessment. The database is being populated as time allows.

**Task 3 – Permitting and NEPA Compliance**

The overall goal of Task 3 is to advance the regulatory and permitting framework for $CO_2$ sequestration projects in North America as well as to obtain all of the permits and approvals that are needed for the demonstration projects to comply with state, provincial, and federal requirements.

The NEPA document for the Fort Nelson demonstration test has been completed and submitted to DOE. Additionally, analysis of regulatory risks is currently being conducted for this project. The development of a NEPA document for the Williston Basin demonstration test has been initiated.

Over the last year, several reports, documents, and proposed rules and regulations have been reviewed and analyzed. One of particular note is the Interstate Oil and Gas Compact Commission (IOGCC) report entitled "Storage of Carbon Dioxide in Geologic Structures, A Legal and Regulatory Guide for States and Provinces." Knowledge of this comprehensive document has facilitated, and will continue to facilitate, numerous discussions with our partners and others as to the development of a regulatory framework for carbon sequestration activities. Additionally, an evaluation of EPA's draft rules for regulating GHG emissions under the Clean Air Act and a review of World Resources Institute's (WRI's) Guidelines for Carbon Capture and Sequestration were also completed. The information obtained from these reviews has initiated conversations and dialogue with partners and others as to the ongoing regulatory and policy frameworks that are developing around carbon management.

One of the most important accomplishments of the PCOR Partnership this year has been the complete and thorough review of EPA's proposed rules for regulating geological sequestration under the underground injection control (UIC) program. Draft comments on EPA's proposed rules were developed and submitted to an ad hoc committee of PCOR Partnership members. As input from this committee was received, the comments were refined. The document was then distributed to the entire PCOR Partnership membership for comment. Remarks from the membership are being considered, and final comments were submitted to EPA on December 23, 2008.

The following activities have also transpired over the last year:

- PCOR Partnership staff attended the PGS Energy Training Phone and Web Seminar, "Carbon Market Developments."
- The PCOR Partnership staff continues to stay abreast of legislative actions occurring in Congress and follow the developments of various state 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, MMV issues, and carbon market developments.

- PCOR Partnership staff met with representatives from Spectra Energy and the British Columbia government to discuss regulatory issues in British Columbia, Canada, and in the United States. Additionally, actions of the province of British Columbia are followed for the effect they may have on the Fort Nelson demonstration project.
- The PCOR Partnership staff participated on a task force that is working on geologic sequestration legislation for the state of North Dakota.
- Frequent updates are provided to task leaders with regard to federal, state, and provincial actions.
- A review of the regulatory and economics section of the International Energy Agency's (IEA's) "Draft Aquifer Storage – Development Issues" document was completed.

**Task 4 – Site Characterization and Modeling**

The overall goals of Task 4 are to develop baseline site characterization data, petrophysical models, and plans for MMV for two field-based large-scale demonstrations of the geological storage of $CO_2$. Activities will be conducted at two sites: one a saline aquifer formation near Fort Nelson, British Columbia, Canada, and the other an oil reservoir in the U.S. portion of the Williston Basin. The task will include 1) the gathering of baseline characterization data, 2) rigorous modeling to predict the transport and fate of the injected $CO_2$ within the reservoir, 3) extensive laboratory tests and modeling to determine the geomechanical and geochemical properties of the reservoir and overlying seals, 4) the systematic application of technically appropriate and cost-effective monitoring techniques over the course of the study period, and 5) the development of best management practices for $CO_2$ flood EOR and storage in carbonate saline aquifers that lead to the monetization of carbon credits.

With respect to the Fort Nelson demonstration, a site in close proximity to the Fort Nelson natural gas-processing plant (within 15 km), which will be serving as the $CO_2$ source, has been selected, and specific well locations have been identified. A site Geological Characterization Experimental Design Package (Deliverable D37) has been completed, and the collection of baseline geological data has been initiated. Data gathered by the research team during the first year of the project includes historical seismic survey data, geophysical well log data, drill stem test data, and regional hydrogeologic regime data. A Geomechanical Experimental Design Package (Deliverable D38) for the Fort Nelson demonstration has also been developed, and early-stage laboratory-based experiments to develop an understanding of the geomechanical properties of key rocks in the area have been initiated.

With respect to the Williston Basin demonstration, the final selection of a site has been delayed while negotiations for the sale and transportation of the $CO_2$ continue between the owner/operator of the $CO_2$ source (Basin Electric Power Cooperative [BEPC]) and the owner/operator of the oil reservoir (Encore Acquisition Company). A Geological Characterization Experimental Design Package (Deliverable D31) is being developed, and although a specific site has not been chosen, the collection of baseline geological data at the regional and subregional scale has been initiated. Specific areas of interest within the Williston

Basin for which baseline data have been obtained include the Dickinson area, the Cedar Creek Anticline, the Nesson Anticline, and the Northeast Flank (Figure 4).

Data gathered by the research team during the first year of the project include publicly available geophysical well log data, drill stem test data, and regional hydrogeologic regime data. The development of petrophysical models has also been initiated for oil fields that are known to be under consideration as host sites for the project. A Geomechanical Experimental Design Package (Deliverable D30) for the Williston Basin demonstration has been developed, and early-stage laboratory-based experiments to develop an understanding of the geomechanical properties of key rocks in the area have been initiated. A series of experiments to examine the geochemical interactions between reservoir and seal rocks, formation fluids, and $CO_2$ under relevant reservoir conditions have also been initiated, with preliminary results being summarized in a paper that was presented as a poster at the 9th Greenhouse Gas Technology (GHGT-9) Conference.

Several other activities conducted as part of the Williston Basin baseline characterization activities resulted in papers being presented at GHGT-9. The results of these activities are being used to develop an effective and appropriate MMV plan and as part of the risk assessment process for the Williston Basin demonstration. The following activities have also transpired over the last year:

- PCOR Partnership staff met regularly with representatives from Spectra Energy, the British Columbia government, and the Canadian federal government to discuss the

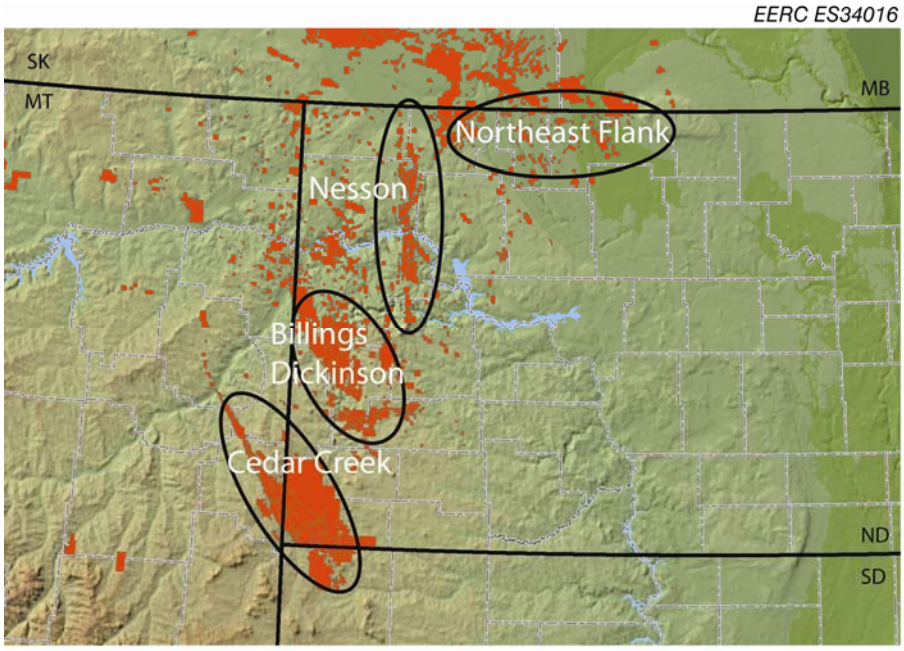



Figure 4. Likely locations for the Williston Basin demonstration, in four structurally and/or stratigraphically defined areas.

direction and progress of baseline characterization, modeling, and MMV plan development for the Fort Nelson project.
- PCOR Partnership staff met regularly with representatives from BEPC the North Dakota Oil and Gas Research Council; the North Dakota Department of Mineral Resources; and key oil companies, including Encore Acquisition, to discuss the direction and progress of baseline characterization, modeling, and MMV plan development for the Williston Basin demonstration.

Problems that have been encountered over the past year, and actions taken to resolve them, include the following:

- The original specific well location for the Fort Nelson demonstration, which was located approximately 3 km south of the gas-processing plant, had to be moved to a location approximately 15 km west of the plant. The reason for the move was the fact that the potential target injection zone at the original well location is overlain by a producing natural gas reservoir. Early characterization work conducted by Spectra suggested that the target injection zone and the overlying gas reservoir were separated by a thick, competent seal and were not in hydraulic communication with one another. However, previously unavailable data were provided to Spectra by the owner/operator of the overlying gas reservoir which cast doubt on this assumption. Based on the significant liability associated with potential leakage of $CO_2$ into the natural gas reservoir and subsequent degradation of the natural gas resource, Spectra decided it was prudent to move the injection well location to an area that is still relatively close to the plant, but does not underlie an operating natural gas field. While this decision did postpone the drilling of the exploration well from autumn 2008 to spring 2009, the drilling and baseline characterization plan had enough flexibility built into it so that subsequent key milestones such as installation of compression systems, pipeline construction, and initiation of injection in late 2010 or early 2011 will not be delayed.
- The final selection of a site location for the Williston Basin demonstration has been delayed while negotiations for the sale and transportation of the $CO_2$ continue between the owner/operator of the $CO_2$ source (BEPC) and the owner/operator of the oil reservoir (Encore Acquisition Company). This has resulted in the postponement of several activities and deliverables that are site-specific. The PCOR Partnership is working diligently with the key stakeholders in the Williston Basin demonstration to develop a solution to the challenges facing this demonstration.

**Task 5 – Well Drilling and Completion**

This task has not begun (begins Quarter 2 – BP3, Year 2). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

**Task 6 – Infrastructure Development**

Task 6 will develop the infrastructure associated with the capture, dehydration, compression, and pipeline required to move the $CO_2$ from the demonstration project source to the sequestration site. This task has been delayed while the plans for the $CO_2$ capture and

geologic sequestration for the demonstration projects are finalized. Once the specific carbon capture and sequestration strategy for the demonstration project has been finalized, planned task activities related to $CO_2$ capture, compression, and pipeline design and routing can begin. In the interim, activities are being undertaken in support of the planned actions.

Primary among these activities is the completion of the first year of the Ramgen Power Systems (Ramgen) subcontract. Current plans call for Ramgen's novel shockwave-based $CO_2$ compression technology (called the Rampressor) to be evaluated during one of the PCOR Partnership demonstration projects. The following activities were performed under the subcontract and lay the groundwork for evaluation of the Rampressor:

- Ramgen engineers have identified the specific parameters and characteristics that must be measured during a small-scale, single-stage, high-pressure-ratio Rampressor demonstration at a coal-fired power plant. These requirements, which Ramgen considers to be proprietary at this time, will serve as guidelines for setting up the testing infrastructure as well as developing the test plan at the demonstration site.
- Ramgen also began identifying the success criteria for demonstration at a coal-fired power plant. Because system integration and controls are very site- and condition-specific, the implications of a partial or total closed-loop test configuration are the focus of this effort. Other areas of investigation include heat exchanger limitations, seals, and demonstration requirements.
- The offerings of competitive compressors sold by MANTurbo, a commonly used $CO_2$ compressor, were evaluated. Ramgen personnel have determined that the dollar-per-horsepower metric can only be used to compare compressors with identical conditions as the results will be misleading when different conditions are evaluated. This finding enabled Ramgen to show improved cost savings that can be achieved by its technology when compared with the competition.
- Ramgen personnel also completed and verified a compression cost model that estimates increases in cost of electricity (COE) that would occur because of $CO_2$ capture and compression activities. Ramgen's cost model is based upon the simplified DOE calculations for COE, as referenced in a number of DOE publications. The model was validated through comparison of the cost penalties calculated by the model with the results of several pulverized coal studies with and without CCS capability. Ramgen then enhanced the model to differentiate the financial penalty of CCS between the contribution from capture and compression and capital and operating costs. The model indicates that compression contributes one-third of the cost penalty and capture contributes the other two-thirds. Operating costs and efficiency are widely believed to drive COE more than capital outlay. The Ramgen model shows that capital costs make up roughly 40%–43% of the increase in COE while operating costs make up 57%–60% of the increase in COE.
- Ramgen also developed a computer model animation of a notional Rampressor demonstration unit. The animation helps to explain the technology and identifies critical features and installation requirements of the proposed demonstration unit.
- Aaron Koopman, Ramgen's Chief Operating Officer, presented material about both $CO_2$ compression in general and the Rampressor technology at the 2008 PCOR

Partnership Annual Meeting and its associated capture workshop held in Maple Grove, Minnesota, on September 16–18, 2008.

- Other activities that have been performed under Phase III, Task 6 include:
  - Verification of locations of each of the stationary sources contained in the PCOR Partnership $CO_2$ source emission database using Google Earth. The latitude and longitude coordinates for each source were input into Google Earth and adjusted as necessary to fall on the center of the source site. When the Google Earth images were not clear, no changes were made to the location coordinates in the database.
  - Interfacing of Phase III, Task 6 personnel with EERC researchers who are setting up a $CO_2$ capture technology test bed/demonstration facility. The lessons learned from the $CO_2$ technology testing on the demonstration facility will be of benefit to PCOR Partnership members.

**Task 7 – $CO_2$ Procurement**

Numerous discussions with potential $CO_2$ suppliers have taken place, although some specifics cannot be shared at the present time because of the business-sensitive nature of the negotiations. The results of Phase I and II activities indicate that our region is poised to be a world leader in the sequestration of $CO_2$ based on the capture and use of anthropogenic $CO_2$ for EOR. This vision is based on the collective wisdom and experience of our partners and the geologic, socioeconomic, and cultural aspects of our region. Significant cost share and other support have been provided by our regional partners in the Williston Basin. These groups are interested in the development of a commercial $CO_2$ sequestration/EOR project that will set the stage for vibrant coal-fired utility and oil and gas industries in the likely event of a carbon-managed future. As such, we developed a Phase III Williston Basin demonstration that includes the capture of $CO_2$ from the BEPC Antelope Valley Station and the transport of that $CO_2$ to a commercial EOR flood operated by Encore Acquisition Company. Both companies provided letters documenting their commitment to this demonstration.

The first year of the PCOR Partnership Phase III operation efforts in Task 7 have focused on facilitating the negotiations between BEPC and Encore. Although these negotiations continue, they have not yet resulted in an agreement that has allowed us to identify a specific site. This has resulted in several of our deliverables being delayed. We are currently working to resolve this issue and remain committed to the original demonstration plan, although we are also exploring a set of options that will allow DOE to meet overall Phase III goals and objectives, including potential alternative arrangements and/or projects that could be considered as contingencies.

**Task 8 – Transportation and Injection Operations**

This task has not begun (begins Quarter 1 – BP4, Year 3). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

**Task 9 – Operational Monitoring and Modeling**

This task has not begun (begins Quarter 1 – BP4, Year 3). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 10 – Site Closure

This task has not begun (begins Quarter 1 – BP5, Year 9). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 11 – Postinjection Monitoring and Modeling

This task has not begun (begins Quarter 1 – BP5, Year 9). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 12 – Project Assessment

Project Assessment entails the communication and dissemination of all Phase III activities detailed in the quarterly and annual progress reports. Annual reports summarize project progress, accomplishments, project recognition (travel), planned activities, and goals. Assessment was conducted for all 13 Phase III tasks for October 1, 2007 – September 30, 2008, and has been illustrated in this report, Project Assessment Annual Report (Deliverable 57).

### Task 13 – Project Management

Project management involves the development and distribution of required project reports, as well as overall project management duties. The project manager (PM) and task leaders meet on a monthly basis to report the progress of their tasks and discuss any issues and corrective actions necessary. Each task leader is also responsible to communicate and keep track of any subcontractors they may have in their respective tasks. Task leaders are also responsible to provide the PM 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.

The PCOR Partnership has been fortunate to have great support and participation from its partners in Phases I and II. Phase III is no exception to this; there are currently 80 partners supporting Phase III activities. The membership, as of September 30, 2008, is listed in Table 2. Please note that Phase II members in good standing are automatically members of Phase III for the first BP that overlaps with the last 2 years of Phase II (October 1, 2007 – October 1, 2009).

The following activities have transpired over the preceding year (October 1, 2007 – September 30, 2008):

- Phase III commenced with an internal Project Initiation Briefing to ensure that all EERC personnel involved in the project understand the scope, goals, budget, milestones, deliverables, quality objectives, and contractual requirements of the project.
- A special session of the North Dakota Lignite Research Council was held to discuss the PCOR Partnership Phase III proposal. The meeting was held January 24, 2008, in Bismarck, North Dakota.

**Table 2. PCOR Partnership Phase II and Phase III Partners* (80, including the EERC)**

| | |
|---|---|
| 1) | U.S. Department of Energy National Energy Technology Laboratory |
| 2) | University of North Dakota Energy & Environmental Research Center |
| 3) | Abengoa Bioenergy New Technologies |
| 4) | Air Products and Chemicals |
| 5) | Alberta Department of Energy |
| 6) | ALLETE |
| 7) | Ameren Corporation |
| 8) | American Coalition for Clean Coal Electricity |
| 9) | American Lignite Energy (ALE) |
| 10) | Apache Canada Ltd. |
| 11) | BEPC |
| 12) | Biorecro AB |
| 13) | Blue Source, LLC |
| 14) | BNI Coal, Ltd. |
| 15) | British Columbia Ministry of Energy, Mines and Petroleum Resources |
| 16) | Carbozyme, Inc. |
| 17) | Computer Modelling Group, Inc. |
| 18) | Dakota Gasification Company |
| 19) | Ducks Unlimited Canada |
| 20) | Ducks Unlimited, Inc. |
| 21) | Eagle Operating, Inc. |
| 22) | Eastern Iowa Community College District |
| 23) | Enbridge Inc. |
| 24) | Encore Acquisition Company |
| 25) | Energy Resources Conservation Board/Alberta Geological Survey |
| 26) | Environment Canada |
| 27) | Excelsior Energy Inc. |
| 28) | Fischer Oil and Gas, Inc. |
| 29) | Great Northern Power Development, LP |
| 30) | Great River Energy |
| 31) | Hess Corporation |
| 32) | Huntsman Corporation |
| 33) | Interstate Oil and Gas Compact Commission |
| 34) | Iowa Department of Natural Resources – Geological Survey |
| 35) | Lignite Energy Council |
| 36) | Manitoba Geological Survey |
| 37) | Marathon Oil Company |
| 38) | MEG Energy Corporation |
| 39) | Melzer Consulting |
| 40) | Minnesota Power |
| 41) | Minnkota Power Cooperative, Inc. |
| 42) | Missouri Department of Natural Resources |
| 43) | Missouri River Energy Services |
| 44) | Montana–Dakota Utilities Co. |
| 45) | Montana Department of Environmental Quality |

* Phase II members in good standing are automatically enrolled in Phase III for the first BP that overlaps with the last 2 years of Phase II (October 1, 2007 – September 30, 2009).

Continued . . .

**Table 2. PCOR Partnership Phase II and Phase III Partners* (80, including the EERC), continued**

| |
|---|
| 46) National Commission on Energy Policy |
| 47) Natural Resources Canada |
| 48) Nexant, Inc. |
| 49) North American Coal Corporation |
| 50) North Dakota Department of Commerce Division of Community Services |
| 51) North Dakota Department of Health |
| 52) North Dakota Geological Survey |
| 53) North Dakota Industrial Commission Department of Mineral Resources, Oil and Gas Division |
| 54) North Dakota Industrial Commission Lignite Research, Development and Marketing Program |
| 55) North Dakota Industrial Commission Oil and Gas Research Council |
| 56) North Dakota Natural Resources Trust |
| 57) North Dakota Petroleum Council |
| 58) North Dakota State University |
| 59) Otter Tail Power Company |
| 60) Petroleum Technology Transfer Council |
| 61) Prairie Public Broadcasting |
| 62) Pratt & Whitney Rocketdyne, Inc. |
| 63) Ramgen Power Systems, Inc. |
| 64) RPS Energy Canada Ltd. – APA Petroleum Engineering Inc. |
| 65) Saskatchewan Industry and Resources |
| 66) SaskPower |
| 67) Schlumberger |
| 68) Shell Canada Energy |
| 69) Spectra Energy |
| 70) Strategic West Energy Ltd. |
| 71) Suncor Energy Inc. |
| 72) TAQA NORTH, Ltd. |
| 73) TGS Geological Products and Services |
| 74) University of Alberta |
| 75) U.S. Geological Survey Northern Prairie Wildlife Research Center |
| 76) Weatherford Advanced Geotechnology |
| 77) Western Governors' Association |
| 78) Westmoreland Coal Company |
| 79) Wisconsin Department of Agriculture, Trade and Consumer Protection |
| 80) Xcel Energy |

* Phase II members in good standing are automatically enrolled in Phase III for the first BP that overlaps with the last 2 years of Phase II (October 1, 2007 – September 30, 2009).

- In March 2008, the PCOR Partnership reviewed and submitted comments on the draft Science Protocol: Carbon Storage for Facilitating 21st Century Energy Systems, which was developed for the Regional Carbon Sequestration Partnership Phase III Initiative.
- The Partnership for $CO_2$ Capture, an 18-month project that complements PCOR Partnership activities and examines the feasibility of different $CO_2$ capture technologies, is being run simultaneously with and will complement various PCOR Partnership activities. The Partnership for $CO_2$ Capture kickoff meeting took place on March 26, 2008, at the EERC.
- The PCOR Partnership took part in the 7th Annual Carbon Capture & Sequestration Conference in Pittsburgh, Pennsylvania, May 5–8, 2008.
  - The PCOR Partnership submitted two abstracts.
  - A booth (Phases II and III) was on exhibit.
- Work has begun on the Risk Management Plan (RMP) outline. The draft outline will be submitted to DOE during BP3 for review. The RMP was originally laid out in the Project Management Plan ([PMP], Deliverable D63) submitted in December 2007. The RMP is a living document, and more progress will be made as each Phase III demonstration project evolves.
- The PMP (Deliverable D63) has been revised to include updates on deliverable/milestone submissions and planned risk management activities. The PMP and statement of project objectives were originally submitted to DOE in December 2007; they were both updated and submitted on September 26, 2008.
- The PCOR Partnership was selected by the IOGCC's Stewardship Award Subcommittee as the winner in the 2008 Environmental Partnership category. Announced earlier, the award was presented to the PCOR Partnership on Monday, November 17, 2008, during the general session of the IOGCC Annual Meeting in Santa Fe, New Mexico.

## COST STATUS

The approved BP3 budget along with actual costs incurred and in-kind cost share reported is shown in Table 3. An expected spending plan by quarter of cash funds for BP3 is provided in Figure 5 and Table 4.

**Table 3. Phase III Budget – BP3**

| Organization | Approved Budget | Actual Costs Incurred |
|---|---|---|
| DOE Share – Cash | $5,300,000 | $1,516,008 |
| Nonfederal Share – Cash | $2,808,847 | $204,037 |
| Nonfederal Share – In-Kind | $5,577,212 | $0 |
| Total | $13,686,059 | $1,720,045 |

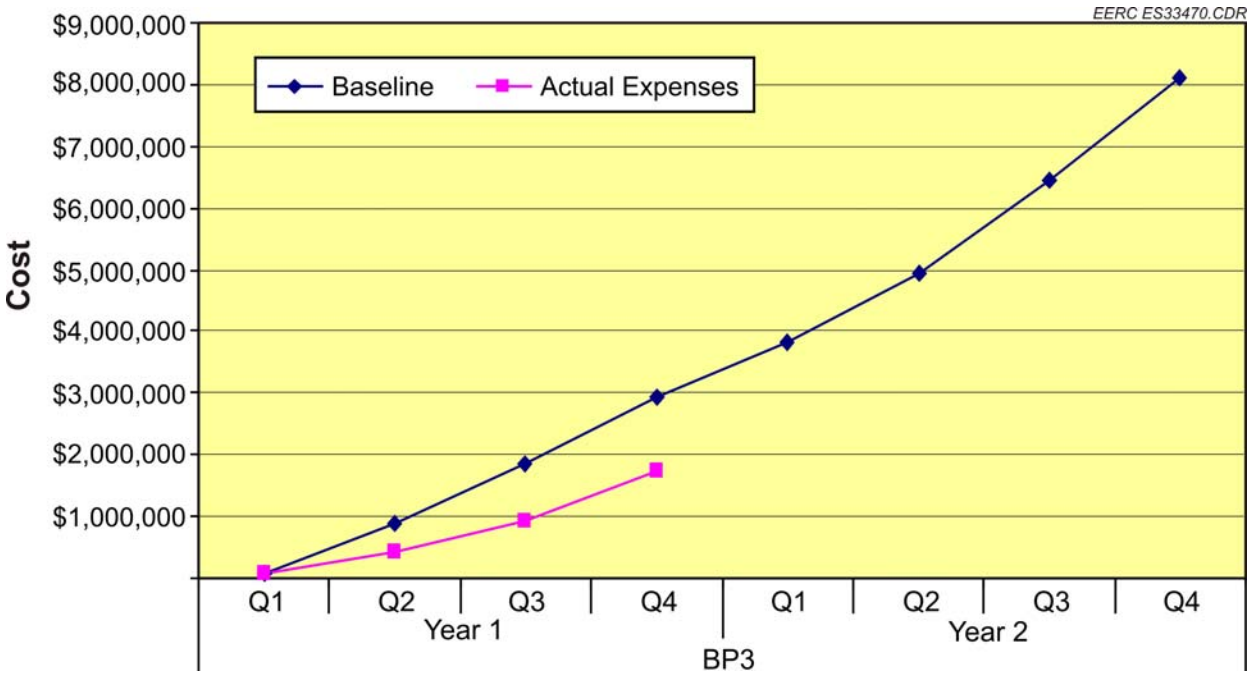



Figure 5. PCOR Partnership Phase III BP3 funding (cash only).

## SCHEDULE STATUS

Table 5 contains all of the Phase III deliverables, milestones, and submission dates for the reporting period. See Table 6 for a listing of deliverables and milestones by quarter for BP3.

## PRODUCTS OR TECHNOLOGY TRANSFER ACTIVITIES

### Task 1 – Regional Characterization

During this first year of Phase III, a prototype version of a DPRS was conceived. This product will be incorporated into the newest version of the DSS which is currently under development.

Information-sharing activities were the focus of the PCOR Partnership Geologic Work Group meetings that were held in the past year. Representatives from most of the states/provinces of the PCOR Partnership region were in attendance to discuss geologic sequestration capacity approaches, as well as hurdles in data management and data availability issues.

# Table 4. BP3 Spending Plan

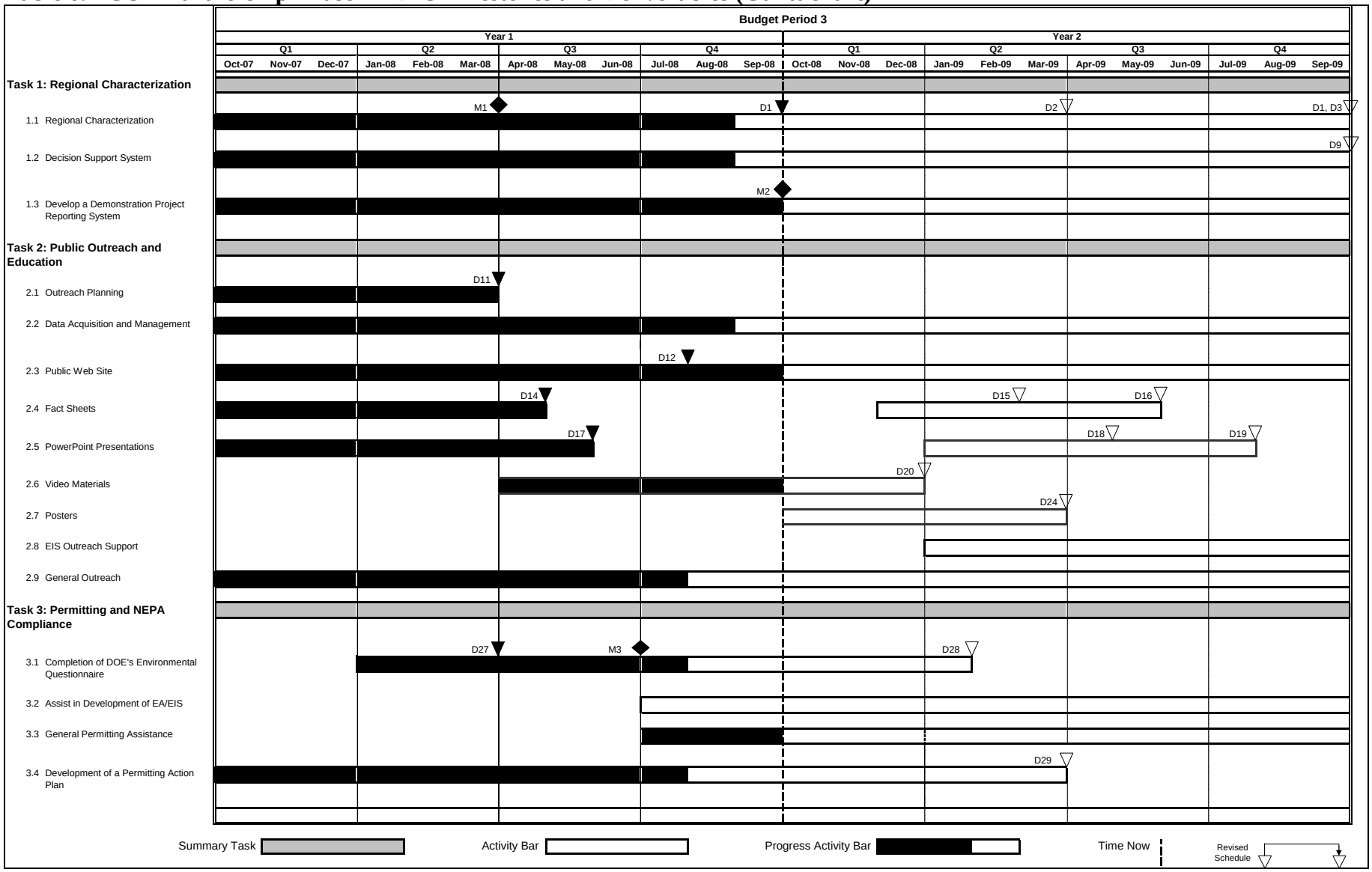
Budget Period 3

| Baseline Reporting Quarter | Year 1 | | | | | | | | Year 2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | | Q2 | | Q3 | | Q4 | | Q1 | | Q2 | | Q3 | | Q4 | |
| | Q1 | Cum. BP Total | Q2 | Cum. BP Total | Q3 | Cum. BP Total | Q4 | Cum. BP Total | Q1 | Cum. BP Total | Q2 | Cum. BP Total | Q3 | Cum. BP Total | Q4 | Cum. BP Total |
| **Baseline Cost Plan** | | | | | | | | | | | | | | | | |
| Federal Share | $ 88,728 | $ 88,728 | $ 318,976 | $ 407,704 | $ 510,620 | $ 918,324 | $ 600,000 | $ 1,518,324 | $ 567,251 | $ 2,085,575 | $ 756,335 | $ 2,841,911 | $ 1,134,503 | $ 3,976,413 | $ 1,323,587 | $ 5,300,000 |
| Non-Federal Share | $ - | $ - | $ 467,179 | $ 467,179 | $ 467,180 | $ 934,359 | $ 467,180 | $ 1,401,539 | $ 351,827 | $ 1,753,366 | $ 351,827 | $ 2,105,193 | $ 351,827 | $ 2,457,020 | $ 351,827 | $ 2,808,847 |
| Total Planned | $ 88,728 | $ 88,728 | $ 786,155 | $ 874,883 | $ 977,800 | $ 1,852,683 | $ 1,067,180 | $ 2,919,863 | $ 919,078 | $ 3,838,941 | $ 1,108,162 | $ 4,947,104 | $ 1,486,330 | $ 6,433,433 | $ 1,675,414 | $ 8,108,847 |
| **Actual Incurred Cost** | | | | | | | | | | | | | | | | |
| Federal Share | $ 88,728 | $ 88,728 | $ 318,976 | $ 407,704 | $ 510,620 | $ 918,324 | $ 597,684 | $ 1,516,008 | | | | | | | | |
| Non-Federal Share | $ - | $ - | $ - | $ - | $ - | $ - | $ 204,037 | $ 204,037 | | | | | | | | |
| Total Incurred Cost | $ 88,728 | $ 88,728 | $ 318,976 | $ 407,704 | $ 510,620 | $ 918,324 | $ 801,721 | $ 1,720,045 | | | | | | | | |
| **Variance** | | | | | | | | | | | | | | | | |
| Federal Share | $ (0) | $ (0) | $ (0) | $ (0) | $ (0) | $ (0) | $ 2,316 | $ 2,316 | | | | | | | | |
| Non-Federal Share | $ - | $ - | $ 467,179 | $ 467,179 | $ 467,180 | $ 934,359 | $ 263,143 | $ 1,197,502 | | | | | | | | |
| Total Variance | $ (0) | $ (0) | $ 467,179 | $ 467,179 | $ 467,180 | $ 934,359 | $ 265,459 | $ 1,199,818 | | | | | | | | |

**Table 5. Phase III Milestones and Deliverables**

| Title/Description | Due Date | Actual Completion Date |
|---|---|---|
| **Year 1 – Quarter 1 (October–December 2007)** | | |
| M17: Task 4 – Fort Nelson Test Site Selected | 12/31/07 | 12/28/07 |
| D37: Task 4 – Fort Nelson Test Site – Site Geological Characterization Experimental Design Package | 12/31/07 | 12/28/07 |
| D63: Task 13 – Project Management Plan | 12/31/07 | 12/28/07 |
| **Year 1 – Quarter 2 (January–March 2008)** | | |
| D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report | 1/31/08 | 1/31/08 |
| D38: Task 4 – Fort Nelson Test Site – Geomechanical Experimental Design Package | 1/31/08 | 1/31/08 |
| 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 |
| D11: Task 2 – Outreach Plan | 3/31/08 | 3/31/08 |
| D30: Task 4 – Williston Basin Test Site – Geomechanical Experimental Design Package | 3/31/08 | 3/31/08 |
| D27: Task 3 – Environmental Questionnaire – Fort Nelson Test Site | 3/31/08 | 4/2/08 |
| **Year 1 – Quarter 3 (April–June 2008)** | | |
| D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report | 4/30/08 | 4/30/08 |
| D14: Task 2 – General Phase III Fact Sheet | 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)** | | |
| D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report | 7/31/08 | 7/31/08 |
| D12: Task 2 – Demonstration Web Pages on the Public Site | 7/31/08 | 7/31/08 |
| M2: Task 1 – Demonstration Project Reporting System (DPRS) Prototype Completed | 9/30/08 | 9/26/08 |
| D1: Task 1 – Review of Source Attributes | 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 |
| M4: Task 4 – Williston Basin Test Site Selected | 12/31/08 | 12/31/08 |
| M5: Task 4 – Data Collection Initiated for Williston Basin Test Site | 12/31/08 | 12/31/08 |
| 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 |

## Table 6. PCOR Partnership Phase III BP3 Milestones and Deliverables (Gantt chart)




Continued…

# Table 6. PCOR Partnership Phase III BP3 Milestones and Deliverables (Gantt chart), continued


**Key for Phase III Deliverables (D)**

| | |
|---|---|
| D1 | Review of Source Attributes |
| D2 | First Target Area Completed |
| D3 | Permitting Review – One State and One Province |
| D9 | Updated DSS |
| D11 | Outreach Plan |
| D12 | Demonstration Web Pages on the Public Site |
| D14 | General Phase III Fact Sheet |
| D15 | Williston Basin (WB) Test Site Fact Sheet |
| D16 | Fort Nelson Test Site Fact Sheet |
| D17 | General Phase III Information PowerPoint Presentation |
| D18 | WB Test Site PowerPoint Presentation |
| D19 | Fort Nelson (FN) Test Site PowerPoint Presentation |
| D20 | Video Support to PowerPoint and Web Site |
| D24 | PCOR Region Sequestration General Poster |
| D27 | FN Test Site – Environmental Questionnaire |
| D28 | WB Test Site – Environmental Questionnaire |
| D29 | Permitting Action Plan |
| D30 | WB Test Site – Geomechanical Experimental Design Package |
| D31 | WB Test Site – Site Geological Characterization Experimental Design Package |
| D37 | FN Test Site – Site Geological Characterization Experimental Design Package |
| D38 | FN Test Site – Geomechanical Experimental Design Package |
| D40 | FN Test Site – Geomechanical Final Report |
| D42 | WB Test Site – Injection Experimental Design Package |
| D43 | WB Test Site – Monitoring Experimental Design Package |
| D47 | Topical Report on the Preliminary Design of Advanced Compression Technology |
| D57 | Project Assessment Annual Report |
| D58 | Quarterly Progress Report |
| D59 | Milestone Quarterly Report |
| D60 | Site Development, Operations, and Closure Plan |
| D61 | Site Commercialization Plan |
| D63 | Project Management Plan |
| D64 | WB Test Site – Site Characterization Report |
| D65 | FN Test Site – Site Characterization Report |
| D66 | WB Test Site – Simulation Report |
| D67 | FN Test Site – Simulation Report |
| D77 | Risk Management Plan Outline |

**Key for Phase III Milestone (M)**

| | |
|---|---|
| M1 | Three Target Areas Selected |
| M2 | DPRS Prototype |
| M3 | Start Environmental Questionnaire for WB Test Site |
| M4 | WB Test Site Selected |
| M5 | Data Collection Initiated for WB Test Site |
| M6 | WB Test Site Geochemical Work Initiated |
| M7 | WB Test Site Geological Characterization Data Collection Initiated |
| M8 | WB Test Site Wellbore Leakage Data Collection Initiated |
| M9 | WB Test Site B - Version Geological Model Development Initiated |
| M10 | WB Test Site Wellbore Leakage Data Collection Completed |
| M11 | WB Test Site Baseline Hydro Data Collection Completed |
| M12 | WB Test Site Geochemical Work Completed |
| M17 | FN Test Site Selected |
| M18 | FN Test Site Geochemical Work Initiated |
| M19 | Capture, Dehydration, and Compression Technology Selected |

## Task 2 – Public Outreach and Education

During Phase III, Year One, Task 2 focused on updating the OAP, the public Web site, fact sheets on Phase III activities, PowerPoints of Phase III activities, and laying the groundwork for future relations with education networks such as science teachers and the Agricultural Extension Service. Activities included expanding the application and capabilities for obtaining high-quality video for use on the Web and in outreach presentations.

### *Outreach Planning*

The Phase II OAP was in place for general public outreach at the regional level, as well as site-level plans to support outreach for individual verification projects, with the level to be determined by partners. The Phase II plan was supplemented and superseded by a Phase III OAP (Deliverable D11) that was submitted on schedule on March 31, 2008, and subsequently approved. The plan focused on regional outreach but addressed the need to develop plans for site outreach as negotiations are completed for the commercial-scale demonstration projects. The OAP included information on demographics, audiences and messages, outreach materials, and outreach methods and protocols.

### *Public Web Site*

The OAP identifies the public Web site, available from two-thirds of the households in the region as well as schools and public libraries, as a major potential information source for sequestration in the region. As such, Phase III activities were added to the Web site in Year 1.

A major public Web site update, including the DOE documentary short on sequestration, updated links, updated information on Phase II projects, and the Phase III announcement, went live on October 10, 2007. Web pages for the Phase III field demonstrations for the public Web site (Deliverable D12) were completed, submitted on schedule at the end of July, and approved. This activity included an updated field test page in the Web site, new geologic columns, and an updated map.

### *Fact Sheets*

The general Phase III fact sheet (Deliverable D14) was submitted to DOE on schedule in April 2008 and was subsequently approved.

### *PowerPoint*

A public outreach PowerPoint was prepared for the Phase III field demonstrations (Deliverable D17). The PowerPoint was submitted to DOE on schedule at the end of May and was approved.

### *Public Television Documentary*

"Nature in the Balance," the first documentary produced by PPB and the PCOR Partnership, was updated with respect to the PCOR Partnership region, partnership members, and select map products in order to support partner outreach efforts for the Phase III demonstration in the Canadian portion of the PCOR Partnership region. A preliminary list of video clips was prepared based on the documentary products and other materials. The clips range from a half minute to 5 minutes in length and are intended to supplement the PowerPoints and public Web site.

### *Outreach Information System*

Efforts continued to populate the OIS, which is designed to contain a record of outreach activities as well as provide a basis for assessing audience exposure to outreach activities. Demographic information was obtained for the U.S. portion from the region, and an information request was developed and submitted for the Canadian portion of the area; information on school districts and contacts was obtained; information on public broadcasting market areas was obtained; and extension service contacts and meeting schedules were obtained. These provided the basis for draft thematic map products. In addition, an assessment of specific portions of the outreach activities (visits to public Web site, newspaper articles, broadcasts on public television, and other outreach activities) was conducted for the period July 1, 2007, to June 30, 2008. The assessment revealed:

- Over 370,000 hits and over 70,000 visits to the PCOR Partnership Public Web site
- Over 60 news articles in the North Dakota portion of the PCOR Partnership region
- Each public television documentary is viewed in all public television markets across the PCOR Partnership region, and as a result, each documentary is viewed in approximately 140,000 households (1.4%) in the PCOR Partnership region. Further, the viewership represents a cross section of the regional population. This characterization is based on viewing habits and audience character from the Neilson rating service (the viewership for the documentaries is probably conservative for the PCOR Partnership region based on viewer information from individual public television stations; further, the shows are broadcast on multiple occasions in the region, and the PCOR Partnership is unable to track all of these showings at this point).

### *Education*

The OAP identifies schools as a primary conduit for reaching tomorrow's leaders and citizens. Two meetings were held in December 2007 with Scott Berge, a geology and field biology teacher at Red River High School in Grand Forks, North Dakota, and a recipient of a National Science Foundation grant for graduate study with a focus on carbon sequestration, to discuss an approach for outreach to schools in the region and to provide him with basic information on carbon sequestration, including the documentary "Nature in the Balance – $CO_2$ Sequestration," the PCOR Partnership Regional Atlas, and links for the RCSP Program. Follow-up meetings were held as a first step in developing a working advisory group for assessing outreach materials and planning outreach for schools. Discussions were held with Jeremy

Kranowitz of Keystone with respect to the potential of holding a Keystone Climate Change curriculum workshop in the region in Year 2. A scope of work was completed for the development of an education packet on sequestration in the region to be made available to teachers in the spring of 2009.

***PCOR Partnership Video Capability***

A pro-sumer-grade videocamera, capable of taking high-definition images, was purchased, along with supporting components. The camera will provide the capability to obtain video for use on the public Web site and to provide supplementary material to the PPB documentary productions.

**Task 3 – Permitting and NEPA Compliance**

Activities included the following:

- PCOR Partnership staff met with representatives from Spectra Energy and the British Columbia government to discuss regulatory issues in British Columbia and the United States.
- PCOR Partnership staff met with a representative from Blue Source, LLC, to discuss the $CO_2$ sequestration market and regulatory activities in the region.
- The deliverable entitled "D27: Task 3 – Environmental Questionnaire – Fort Nelson Test Site," was submitted to DOE for approval on March 31, 2008.
- A spreadsheet that compares and contrasts the EPA-proposed rules for geologic sequestration with WRI Guidelines and IOGCC model rules was developed and provided to PCOR Partnership members.
- Draft comments on EPA's proposed rules have been developed and submitted to PCOR Partnership members. Final comments will be submitted to EPA by the December 24, 2008, deadline.

**Task 4 – Site Characterization and Modeling**

Products and technology transfer activities for Task 4 included the following:

- Presentations on the overall goals, objectives, and technical approaches of the Fort Nelson and Williston Basin project were given by PCOR Partnership staff at several regional, national, and international meetings and conferences. Three papers summarizing some of the work conducted as part of Phase III – Task 4 were published in the proceedings of the GHGT-9 conference, one of which was presented orally and the other two as posters. The titles of those papers are as follows:
  - $CO_2$ Storage Risk Minimization Through Systematic Identification and Assessment of Faults: A Williston Basin Case Study
  - Probabilistic Approach to Evaluating Seismicity for $CO_2$ Storage Risk Assessment
  - Laboratory Experiments and Numerical Modeling of Geochemical of Geochemical Reactions in a Reservoir Used for $CO_2$ Storage

- The deliverable entitled "D37: Task 4 – Fort Nelson Test Site – Site Geological Characterization Experimental Design Package" was submitted to DOE for approval on December 28, 2007.
- The deliverable entitled "D38: Task 4 – Fort Nelson Test Site – Geomechanical Experimental Design Package" was submitted to DOE for approval on January 1, 2008.
- The deliverable entitled "D30: Task 4 – Williston Basin Test Site – Geomechanical Experimental Design Package" was submitted to DOE for approval on March 31, 2008.

**Task 5 – Well Drilling and Completion**

This task has not begun (begins Quarter 2 – BP3, Year 2). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

**Task 6 – Infrastructure Development**

Phase III, Task 6 personnel assisted in the preparation of a detailed overview of $CO_2$ capture technologies that can serve as the basis for future presentations. New information that was used in the presentation will be very useful when we work with the company that plans to provide the $CO_2$ for the Phase III Williston Basin demonstration.

A capture and transportation workshop was held in conjunction with the 2008 PCOR Partnership Annual Meeting. Workshop topics were gathered from the PCOR Partnership members through an e-mail survey and included an overview of capture technologies, with specific information on monoethanolamine (MEA) scrubbing, the chilled ammonia process, membrane technologies, and $CO_2$ capture from integrated gasification combined-cycle systems. The issues associated with applying $CO_2$ capture to a coal-fired power plant were discussed, as were both utility and nonutility perspectives on the need for $CO_2$ capture. Finally, information about $CO_2$ compression, pipelines, and the economics of $CO_2$ capture was presented. The workshop was held on September 16, 2008, in Maple Grove, Minnesota.

A table of capture technologies was prepared for inclusion in the PCOR Partnership DSS "Partners-Only" Web site. The table includes 45 $CO_2$ capture technologies. Each entry includes the status of the technology, the developers' names, a short description, and a few of the advantages and challenges associated with the technology. Many of the entries also include a link to Web-based information about the technologies. Following project management review, it will be placed on the DSS "Partners-Only" Web site. The detailed information gathered while the capture technologies table was prepared is being used to update the PCOR Partnership $CO_2$ capture technology overview prepared in 2005.

**Task 7 – $CO_2$ Procurement**

Numerous discussions with potential $CO_2$ suppliers have taken place. Because of the sensitive nature of negotiations, specifics cannot be shared at the present time.

### Task 8 – Transportation and Injection Operations

This task has not begun (begins Quarter 1 – BP4, Year 3). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 9 – Operational Monitoring and Modeling

This task has not begun (begins Quarter 1 – BP4, Year 3). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 10 – Site Closure

This task has not begun (begins Quarter 1 – BP5, Year 9). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 11 – Postinjection Monitoring and Modeling

This task has not begun (begins Quarter 1 – BP5, Year 9). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 12 – Project Assessment

Task 12 activities for October 1, 2007 – September 30, 2008, include the quarterly and annual progress reports. The Project Assessment Annual Report (Deliverable D57) summarizes project progress, accomplishments, and goals. This report is the Phase III Year One project assessment report.

### Task 13 – Project Management

Products and technology transfer activities for Task 13 included the following:

- The deliverable entitled "D63: Task 13 – PMP" was submitted to DOE for approval on December 28, 2007. The PMP was updated and submitted again on September 26, 2008
- The deliverable entitled "D58/D59: Task 13 – Quarterly Progress Report/Milestone Quarterly Report" was submitted to DOE for approval on January 31, 2008; June 30, 2008; and September 30, 2008.
- A value-added fact sheet entitled "$CO_2$ EOR and $CO_2$ Sequestration – The Case for Collaboration" was prepared and added to the PCOR Partnership public and private Web sites.

The PCOR Partnership prepared all required technical papers for the DOE NETL Contractor's review during this reporting period.

## PLANNED ACTIVITIES

### Task 1 – Regional Characterization

Activities that are planned for the October 2008 through September 2009 time frame include the following:

- Completion of the redesign to the DSS
- Addition of another state/province geological survey to conduct baseline regional characterization efforts
- Bringing the DPRS online
- Creation of the next PCOR Partnership Regional Atlas

### Task 2 – Public Outreach and Education

Activities that are planned for the October 2008 through September 2009 time frame include the following:

- Development of an education packet for use in the schools
- An educational advisory group
- Completion of fact sheets for each of the upcoming commercial demonstrations (Deliverables D15 and D16)
- Completion of PowerPoint presentations on the upcoming commercial demonstrations (Deliverables D18 and D19)
- Completion of a set of video materials for use on the Web and in PowerPoint presentations (Deliverable D20)
- A general poster on sequestration (Deliverable D24)

### Task 3 – Permitting and NEPA Compliance

Activities that are planned for the October 2008 through September 2009 time frame include the following:

- Completion of the NEPA document for the Williston Basin demonstration
- Completion of the Permitting Action Plan for the Williston Basin demonstration
- Continuing to monitor regulatory developments as they relate to carbon management
- Continuing to monitor the development of carbon markets

### Task 4 – Site Characterization and Modeling

Activities that are planned for the October 2008 through September 2009 time frame include the following:

- Drilling of the exploratory well at the Fort Nelson site and subsequent application of a variety of downhole geophysical logging tools, drill stem tests, and other analytical activities and tests associated with the new well.

- Continuing to gather and integrate baseline characterization data.
- Development of a petrophysical model of the target injection zone and overlying sealing formation at the Fort Nelson site.
- Development of an MMV plan using the results of baseline characterization activities and risk assessment.
- Execution of activities enumerated in the geomechanical experimental design package for Fort Nelson.
- Continuing to conduct laboratory experiments to determine the nature of interactions between reservoir and seal rocks, formations fluids, and $CO_2$–acid gas at relevant reservoir conditions.
- Finalizing the selection of a site for the Williston Basin demonstration.
- Initiating site-specific baseline geological characterization, geomechanical, and modeling activities for the Williston Basin demonstration.
- Initiating the development of an MMV plan for the Williston Basin demonstration.

**Task 5 – Well Drilling and Completion**

This task has not begun (begins Quarter 2 – BP3, Year 2). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

**Task 6 – Infrastructure Development**

Activities that are planned for the October 2008 through September 2009 time frame include:

- Finalizing the table of capture technologies on the PCOR Partnership DSS "Partners-Only" Web site.
- Updating the PCOR Partnership $CO_2$ capture technology overview.
- Performing an engineering review and analysis of the Powerspan $ECO_2$ technology. This was selected by the $CO_2$ supplier for the Williston Basin demonstration as the means by which the $CO_2$ will be captured. Having a more complete understanding of the technology will allow the Phase III, Task 6 personnel to better answer questions and assist the supplier with any interface or infrastructure issues.
- Expanding on the sections of a deliverable report prepared for Phase II, Task 9 that described a preliminary regional $CO_2$ pipeline network route. This summary document will examine how the Williston Basin demonstration fits within this context and how the lessons learned during the demonstration can be extrapolated to the broader context of the PCOR Partnership region.
- Selection of the capture, dehydration, and compression technologies needed for the Williston Basin demonstration should be finalized.
- A topical report will be prepared on the preliminary design of the Ramgen advanced compression technology that will be evaluated during the demonstration.

### Task 7 – $CO_2$ Procurement

Numerous discussions with potential $CO_2$ suppliers have taken place. Because of the sensitive nature of negotiations, specifics cannot be shared at the present time.

### Task 8 – Transportation and Injection Operations

This task has not begun (begins Quarter 1 – BP4, Year 3). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 9 – Operational Monitoring and Modeling

This task has not begun (begins Quarter 1 – BP4, Year 3). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 10 – Site Closure

This task has not begun (begins Quarter 1 – BP5, Year 9). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 11 – Postinjection Monitoring and Modeling

This task has not begun (begins Quarter 1 – BP5, Year 9). Once activities are initiated, the information will be communicated and detailed in the project assessment annual report.

### Task 12 – Project Assessment

Project assessment activities for October 2008 through September 2009 will continue to include quarterly and annual progress reports. Project assessment activities will continue to support those of Task 13 (Project Management) in order to manage Phase III task and subtask reports.

### Task 13 – Project Management

Activities that are planned for the October 2008 through September 2009 time frame include:

- Continuing to ensure timely production of deliverables and overall project management.
- Integrating all RCSPs.
- A PCOR Partnership Annual Meeting tentatively scheduled for September 2009 in St. Louis, Missouri.
- A regulatory workshop is being planned for June 2009 (tentatively).
- Current and pending $CO_2$-related projects within the PCOR Partnership region are continuously changing. To better inform our partners, a Web site will be developed to exhibit $CO_2$ projects by location, parties involved, and Web site links to learn more about them.

- For large-scale demonstrations, a database of features, events, and processes distinct in the considered environment will be created. A numerical model of the reservoir will be created, and a sensitivity analysis will be performed with respect to the factors listed in the database. The analysis will allow for the quantification of the risks associated with the factors. The numerical model will be constantly updated basing on the results of the monitoring program. As the model is updated, risks will be reassessed to ensure safety of the operations and storage. An RMP outline (Deliverable D77) is due in September 2009. The RMP outline will be developed to document program and individual project risks, consequences, and impacts.
- A Site Commercialization Plan (Deliverable D61) which describes the steps taken by our partners to commercialize the existing site and how those steps might be applicable to similar sinks in the region is due September 2009.
- Our partners will be provided with a topical report on past, present, and future carbon market activities.

## PROJECT RECOGNITION/TRAVEL

### Project Recognition

- The PCOR Partnership was represented at the 7th Annual Carbon Capture and Sequestration Conference in May 2008.
- An overview was presented of accomplishments and plans for Phase II and III activities at the PCOR Partnership Annual Meeting in September 2008.
- A presentation was given at the North Dakota Petroleum Council teacher education workshop in Bismarck, North Dakota, on June 11, 2008. Feedback was obtained from the attendees regarding potential products.
- The PCOR Partnership was selected by the IOGCC's Stewardship Award Subcommittee as the winner in the 2008 Environmental Partnership category. Announced earlier, the award was presented to the PCOR Partnership on Monday, November 17, 2008, during the general session of the IOGCC Annual Meeting in Santa Fe, New Mexico.

### RCSP Support

- Members of the GIS, Capture and Transportation, Geologic, Outreach, and Risk Assessment Working Groups took part in monthly conference calls.
- Members of the PCOR Partnership took part in initial discussions, reviewed, and provided input to the script and drafts of the NETL video on sequestration premiering at the booth at GHGT-9.
- The PCOR Partnership was represented at DOE NETL's 2008 RCSP Initiative Review Meeting in December 2007.
- The PCOR Partnership was represented at the GHGT-9 Conference in November 2008.

**Travel**

- October 18–19, 2007: PCOR Partnership Annual Meeting in Grand Forks, North Dakota
- October 26, 2007: Senate Energy Staff Briefing in Washington, D.C.
- October 31 – November 1, 2007: National Conference of State Legislatures Advanced Coal Technologies Energy Institute in Tampa, Florida
- November 6–8, 2007: International Energy Agency Meeting in Edmonton, Alberta
- November 7–9, 2007: Clean Power in the West Summit in San Francisco, California
- November 11–14, 2007: Society of Petroleum Engineers Annual Technical Conference in Anaheim, California
- November 12–14, 2007: Meeting with Spectra Energy, Natural Resources Canada, and the British Columbia government in Calgary, Alberta
- November 14–16, 2007: Carbon Reduction Project Development and Finance in Houston, Texas
- November 28, 2007: Presented to a graduate chemical engineering class at UND in Grand Forks, North Dakota
- December 3–5, 2007: Carbon Capture Status and Outlook Conference in Washington, D.C.
- December 11–13, 2007: POWER-GEN International in New Orleans, Louisiana
- December 12–14, 2007: Regional Carbon Sequestration Review Meeting in Pittsburgh, Pennsylvania
- January 17, 2008: Meeting with the North Dakota Industrial Commission in Bismarck, North Dakota
- January 23–31, 2008: Energy Generation Conference in Bismarck, North Dakota
- January 24–25, 2008: Platts Carbon Trading Conference in Houston, Texas
- January 27–30, 2008: 11th Annual Conference on Clean Air, Mercury, Global Warming, and Renewable Energy in Tucson, Arizona
- January 30, 2008: Energy Generation Conference in Bismarck, North Dakota
- February: Presented to the Minnesota State University in Moorhead, Minnesota.
- February 1–4, 2008: EUEC 2009 – Clean Air, Mercury, Global Warming & Renewable Energy in Phoenix, Arizona
- February 14, 2008: Missouri River Energy Services Board Meeting
- February 25–27, 2008: Environmental Systems Research Institute GIS Petroleum Users Group Meeting in Houston, Texas
- February 25–27, 2008: ESRI Petroleum User's Group Meeting in Houston, Texas
- February 26–27, 2008: U.S. EPA's second public workshop to discuss the development of proposed regulations for the underground injection of carbon dioxide for geologic sequestration under the Safe Drinking Water Act in Arlington, Virginia
- February 26–29, 2008: Attend a training class for developing GIS applications using .NET in GIS Server 9.2 in Phoenix, Arizona
- February 27, 2008: EmPower North Dakota Meeting in Minot, North Dakota
- February 29, 2008: Industrial Commission Meeting in Bismarck, North Dakota
- March 3–4, 2008: The Edison Foundation's Carbon Capture and Storage: Key Issues and Challenges in Washington, D.C.
- March 11–13, 2008: Coal Ash Professionals Training Course in San Antonio, Texas
- March 12–13, 2008: WRI CCS Stakeholder Workshop in Washington, D.C.

- March 12–14, 2008: Office of Science Basic Energy Sciences Annual Geosciences Symposium, Courtyard Marriott Gaithersburg Washingtonian Center, Maryland, located northwest of Washington, D.C.
- March 18, 2008: North Dakota Climate Change Dialogue in Fargo, North Dakota
- Week of March 24: IEA Greenhouse Gas Review in Washington, D.C.
- March 25, 2008: Met with Lynn Helms and UIC staff in Bismarck, North Dakota
- March 26, 2008: Hearing on the challenges to rapid deployment of carbon capture and storage technologies in Bismarck, North Dakota
- March 25–28, 2008: 2008 RCSP Peer Review (IEA GHG Review) in Washington, D.C.
- March 28, 2008: North Dakota Science Teacher Meeting in Minot, North Dakota
- April 6–10, 2008: 235th American Chemical Society National Meeting (Advances in $CO_2$ Management: $CO_2$ Sequestration, Utilization, Capture, and EOR) in New Orleans, Louisiana
- April 10–11, 2008: Sixth International Forum on Geologic Sequestration of $CO_2$ in Deep, Unminable Coal Seams, "Coal – Seq. VI" in Houston, Texas
- April 13–17, 2008: Carbon Sequestration Leadership Forum in Cape Town, South Africa
- April 17, 2008: $CO_2$ for Enhanced Oil Recovery Conference in Houston, Texas
- April 17, 2008: Attend the Geologic Characterization Meeting in Minneapolis, Minnesota
- April 20–23, 2008: American Association of Petroleum Geologists Annual Convention & Exhibition in San Antonio, Texas
- April 27–29, 2008: 16th Williston Basin Petroleum Conference & Expo in Minot, North Dakota
- April 30 – May 1, 2008: Carbon Capture and Storage in Houston, Texas
- April 30 – May 1, 2008: Rocky Mountain Coal Mining Institute Section Meeting in Grand Junction, Colorado
- May 1, 2008: UIC permit hearing in Bismarck, North Dakota
- May 5–8, 2008: 7th Annual Carbon Capture & Sequestration Conference in Pittsburgh, Pennsylvania
- May 6–8, 2008: 2008 Electric Power Conference in Baltimore, Maryland
- June 1–5, 2008: The 33rd International Technical Conference on Coal Utilization & Fuel Systems in Clearwater, Florida
- June 4–6, 2008: Carbon Finance North America 2008 – Risk and Opportunities in Emissions Markets in New York, New York
- June 9–12, 2008: teachers seminar in Bismarck, North Dakota
- June 10, 2008: SharePoint Seminar in Fargo, North Dakota
- June 15–20, 2008: documentary filming in New Mexico and Texas
- June 18–19, 2008: 9th Annual Western Canadian Sedimentary Basin Working Group Meeting in Winnipeg
- June 29 – July 2, 2008: 4th International Symposium on Energy, Informatics and Cybernetics: EIC '08 in Orlando, Florida
- July 5–8, 2008: Meeting with PCOR Partnership partners on the Fort Nelson and Zama Projects in Calgary, Alberta
- July 8–10, 2008: Meeting with Spectra Energy, Natural Resources Canada, and the British Columbia government in Calgary, Alberta
- July 8–11, 2008: Met with Spectra Energy, Natural Resources Canada, and Schlumberger in Calgary , Alberta
- July 8–11, 2008: Computer Modeling Group Ltd. Technical Symposium in Calgary, Alberta

- July 11–13, 2008: International Energy Agency-Greenhouse Gas Research Program in New York, New York
- August 4–8, 2008: attended the ESRI International Users Conference in San Diego, California
- August 5, 2008: Project meeting with Praxair in Minot, North Dakota
- August 5–6, 2008: met with Spectra Energy, Natural Resources Canada, and Schlumberger in Calgary, Alberta, Canada.
- August 13–15, 2008: Coal-Gen in Louisville, Kentucky
- August 25–28, 2008: attended the Power Plant Air Pollutant Control "Mega" Symposium in Baltimore, Maryland
- August 21, 2008: Carbon Management Council's Carbon Capture and Storage Webinar.
- September 16–18, 2008: PCOR Partnership Annual Meeting in Maple Grove, Minnesota
- September 23–24, 2008: Underground Injection Control and $CO_2$ Geosequestration Seminar in Cincinnati, Ohio
- September 24, 2008: UIC and $CO_2$ Geosequestration Seminar in Cincinnati, Ohio
- September 25, 2008: Presented to the North Dakota Association of Oil and Gas Producing Counties Annual Meeting in Minot, North Dakota.
- September 29–30, 2008: EPA's Public Hearings (Phases II and III) in Chicago, Illinois
- September 30, 2008: Attended EPA public meeting on proposed rules for geologic sequestration in Chicago, Illinois
- September 29 – October 2, 2008: Pittsburgh Coal Conference in Pittsburgh, Pennsylvania

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

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