FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

Partnership Name	Southwest Regional Partnership on Carbon Sequestration
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Field Test Information: Field Test Name	San Juan Basin, New Mexico: Enhanced Coalbed Methane-Sequestration Test
Test Location	Near Navajo City, New Mexico
Amount and Source of CO_2	Tons: 20,000 – 35,000 tons; Source: CO2 sourced from McElmo Dome, CO
Field Test Partners (Primary Sponsors)	ConocoPhillips
	KinderMorgan CO_2 Company, L.P.

Summary of Field Test Site and Operations

General Geology and Target Reservoirs:

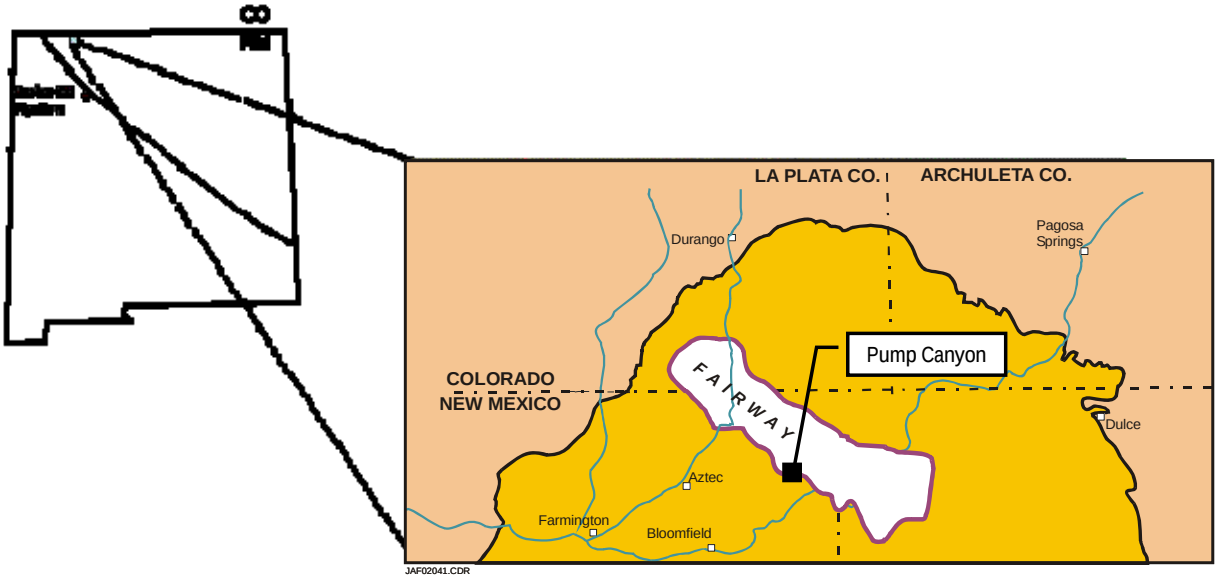

Figure 1: Location of SJB ECBM (Pump Canyon) demonstration test in the San Juan Basin, NM.

The San Juan basin (SJB) is one of the top ranked basins in the world for CO_2 coalbed sequestration because it has: 1) advantageous geology and high methane content; 2) abundant anthropogenic CO_2 from nearby power plants, 3) low capital and operating costs; 4) well-developed natural gas and CO_2 pipeline systems; and 4) local companies, e.g., ConocoPhillips, with coalbed methane (CBM) and enhanced CBM (ECBM) expertise. ConocoPhillips has

agreed to operate a project in collaboration with the SWP, specifically to examine ECBM efficacy with CO_2 sequestration. Because of its enormous coal resource, the San Juan offers a tremendous sequestration opportunity with value-added natural gas production. An extensive CO_2 infrastructure is already in place, making the area ready for future operations. In addition to the ECBM pilot test, a terrestrial pilot test will be conducted. ECBM operations are notorious for producing huge volumes of water. We desalinated produced water from our ECBM pilot and used this water for irrigating stressed riparian areas near the injection site, forming a combined ECBM – terrestrial

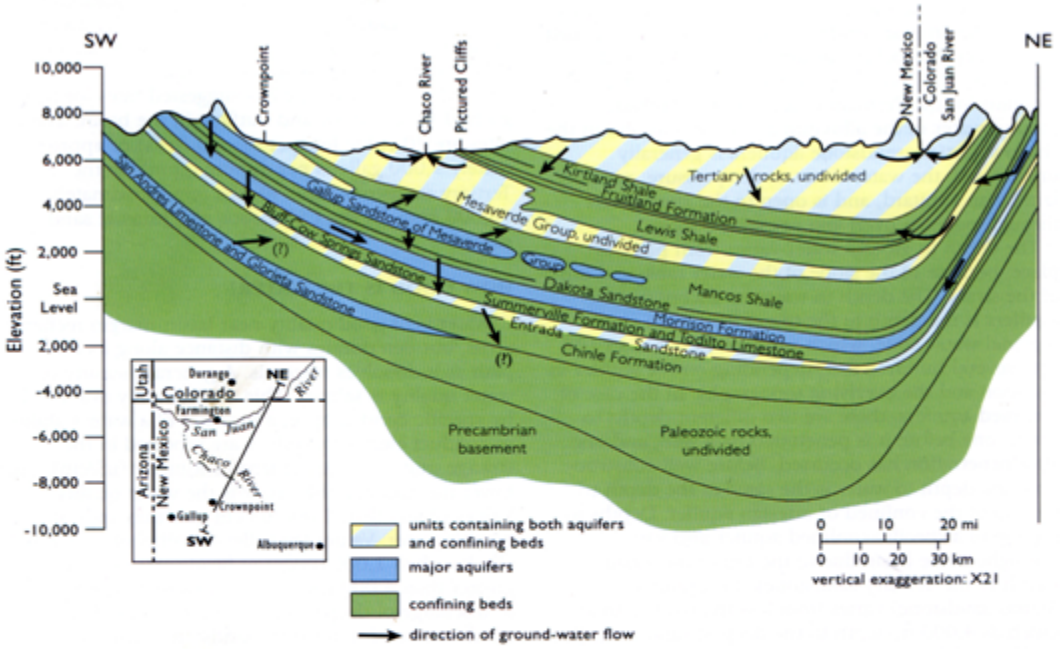

Figure 2. Generalized cross-section of San Juan basin, also showing large-scale hydrologic patterns. Adapted from Stone et al., "Hydrogeology and water resources of *San Juan* Basin, New Mexico," Hydrologic Report - New Mexico Bureau of Mines and Mineral Resources, vol.6, 70 pp., 1983.

sequestration project. The U.S. Bureau of Land Management and ConocoPhillips are both interested in making beneficial and environmentally-friendly use of the produced water.

The coals in the SJB fairway area are of exceptionally high permeability—100s of millidarcies. Due to the tendency of coal to swell when in contact with CO_2, high initial coal permeability is required to maintain high CO_2 injection rates over time. Maintaining high injectivity is an important requirement for large-scale, low-cost CO_2 sequestration in coal, and demonstrating this is an important DOE carbon sequestration program goal (as stated in DOE's 2007 Technology Roadmap and Program Plan). This demonstration represents an ideal opportunity to achieve that goal.

The injection site included three nearby CBM producing wells. The primary gas-producing horizons in this area are coal beds in the Upper Cretaceous Fruitland Formation. The coals, which occur at depths of approximately 3,000 ft, are about 75 ft thick, split among three seams over a 175-ft gross interval. This area of the San Juan coalbed fairway has undergone significant CBM production, and reservoir pressure at the test site is less than 100 psi. Coal matrix shrinkage is significant at these low pressures, contributing to the high coal permeabilities observed. In addition, CO_2 injection pressures were low, eliminating any potential CO_2 compression needs for the pilot project.

Brief Summary of Target Reservoirs and Seals:

- **Producing Formations:** Fruitland Formation coals (Figure 2) are the primary sequestration test target reservoir.
- **Deepest fresh water aquifer**: Probably the deepest freshwater zone to consider is the Dakota sandstone.
- **Type of trap and reservoir geometry:** The Fruitland coals are capped structurally and stratigraphically by the Kirtland shale (Figure 2).
- **Potential leakage points**: The region of the San Juan Basin where the injection well is located contains no major tectonic elements. However, in outer sections of the basin, particularly the southern and eastern stretches, some fracture zones are evident. Additionally, the injection site is approximately 40 miles from the Four Corners platform, which is separated from the central basin by a hogback monocline feature. Extension fractures are observed in the greater Cuba Mesa area as well minor northwest trending faults. We suggest that none of these structural features will affect the sequestration test, but must be considered prior to longer-term geological sequestration.
- **Pay zone thickness:** The Fruitland Formation approaches 250 ft thickness in some areas.
- **Porosity and Permeability:** Porosity of the Fruitland is highly variable (<1 to over 20%), but permeability is generally hundreds of millidarcies in the area of the sequestration test.
- **Water saturation and water characteristics:** The coals are saturated with methane and/or groundwater of relatively low TDS in the area of the sequestration test.

Data Quality: Data in the immediate vicinity of our test site is fairly robust, given ConocoPhillips' previous analyses of the area.

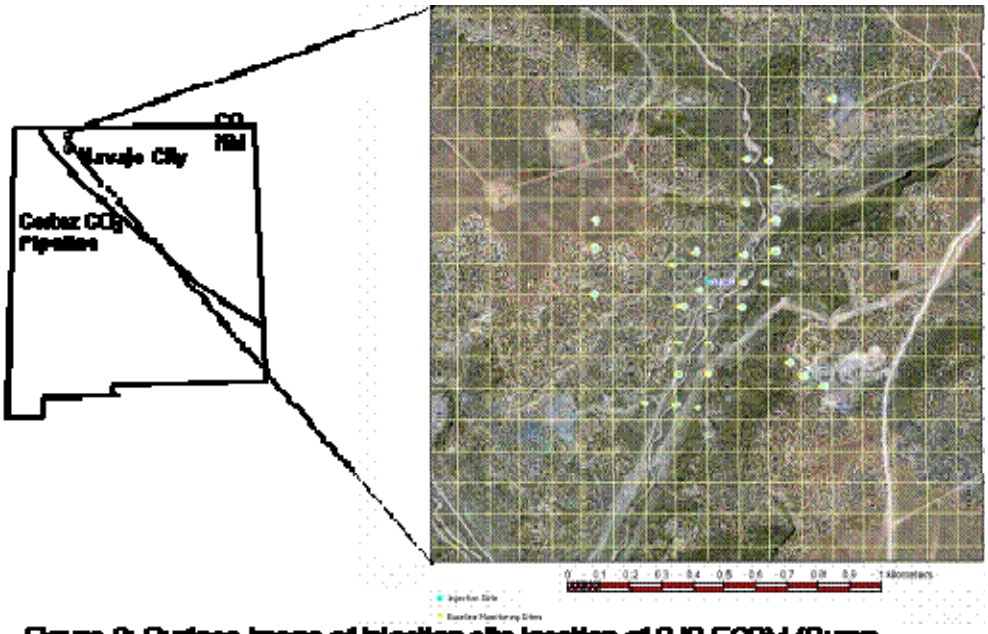

Figure 3: Surface image of injection site location of SJB ECBM (Pump Canyon) demonstration test in the San Juan Basin, NM.

Surface Description and Land Use: Much of the land in the area is maintained by the U.S. Bureau of Land Management. Topography is fairly rugged, with little grass but many shrubs and small trees. The injection site is close to a riparian corridor that is rich with grass, although drought, grazing, and other activities have stressed the riparian areas.

Research Objectives

ECBM-Sequestration Testing: Among primary goals of the SWP is to evaluate coalbed methane production efficiency with concomitant CO_2 storage efficacy. Pilot CO_2 injection began in July 2008, and continued for approximately 1 year; the total amount of CO_2 injected was just over 18,000 tons. ConocoPhillips owns and operates the field site, and drilled the injection well for the pilot in June 2008. This pilot is testing a suite of MVA

approaches tailored for its unique geology (coalbeds) and value-added benefit (methane production). Additional objectives include detailed risk assessment and mitigation plans, and to identify regulatory gaps for ECBM and CO_2 sequestration.

The SJB ECBM/CO_2 sequestration field test site is located in San Juan County, New Mexico, in the heart of the San Juan Basin (SJB) coalbed methane (CBM) fairway (Figures 1 and 3). The injection location, illustrated in Figure 3, is uniquely favorable for an ECBM/sequestration demonstration for several reasons. The results of the demonstration would be directly scalable to a large portion of the SJB for significant, low-cost sequestration. The SJB is a mature CBM play, and thus much of the infrastructure and services required to implement large-scale sequestration are already in place (e.g., wellbores, gathering and distribution systems, processing facilities, etc.). In addition, a well-established, reasonably-priced service capability to maintain and expand that infrastructure exists. Finally, and perhaps most importantly, the infrastructure to deliver CO_2 to the region exists—the Cortez pipeline that delivers (natural) CO_2 from McElmo Dome to West Texas passes directly through the SJB (Figure 1). If/when that pipeline begins transporting anthropogenic CO_2, the SJB will become a premier national sequestration site. Thus, the SJB represents an important near-term option for CO_2 sequestration.

Summary of Modeling and MVA Efforts

Table 1 below provides a summary of our ongoing and future monitoring activities for the San Juan Basin ECBM-sequestration testing. State-of-the-art reservoir models are being used for test design and engineering, and data from these monitoring activities are being used to parameterize these models. These models include coupling of multiphase CO_2-groundwater flow, coal-swelling and rock deformation, and relevant chemical reactions.

Our reservoir-modeling objective currently underway was to match injection rates and pressures and reproduce the loss in injectivity due to coal swelling. Once this was accomplished, "what-if" scenarios were conducted to evaluate the impact of stimulation on the injection well or a different well configuration (horizontal or multi lateral).

Table 1. Measurement Technologies Employed at the San Juan Basin, New Mexico Test Site

Measurement technique	Measurement parameters	Applications
Tracers	- Travel time - Partitioning of CO_2 into brine or oil - Identification of sources of CO_2	- Tracing movement of CO_2 - Quantifying solubility trapping - Tracing leakage
Water composition	- CO_2, HCO_3, CO_3^{2-} - Major ions - Trace elements - Salinity	- Quantifying solubility & mineral trapping - Quantifying CO_2-water-rock interactions - Detecting leakage into shallow groundwater aquifers
Subsurface pressure	- Formation pressure - Annulus pressure - Groundwater aquifer pressure	- Control of formation pressure below fracture gradient - Wellbore and injection tubing condition - Leakage out of the storage formation
Well logs	- Brine salinity - Sonic velocity - CO_2 saturation	- Tracking CO_2 movement in and above storage formation - Tracking migration of brine into shallow aquifers - Calibrating seismic velocities for 2D seismic surveys

Vertical seismic profiling	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Detecting detailed distribution of CO_2 in the storage formation - Detection leakage through faults and fractures
Visible and infrared imaging from satellite	- Hyperspectral imaging of land surface	- Detect vegetative stress
CO_2 land surface flux monitoring using flux chambers or eddy covariance	- CO_2 fluxes between the land surface and atmosphere Atmosphere	- Detect, locate and quantify CO_2 releases
Soil gas sampling	- Soil gas composition Isotopic analysis of CO_2	- Detect elevated levels of CO_2 - Identify source of elevated soil gas CO_2 - Evaluate ecosystem impacts
Land surface deformation	- Tiltmeters - Vertical and horizontal displacement using interferometry and GPS	- Detect geomechanical effects on storage formation and caprock - Locate CO_2 migration pathways

Accomplishments to Date

- CO_2 injection began July 30, 2008 and ended on July 29, 2009. A total of approximately 18,400 tons of CO_2 v injected.

The well will be plugged and abandoned in the coming weeks.

- Post-injection VSP was completed in September 2009 and is currently being analyzed
- CO_2 concentration at the 3 closest offset wells is being monitored through CO_2 sensors. They have not shown any breakthrough so far. However, N_2 concentration has increased at two of the wells and could be an early sign of breakthrough.
- Tiltmeters are monitoring the ground deformation and do not show any sign of deformation. The results are consistent with the GPS data. The tiltmeters will be removed from the site at the beginning of November.
- Tracers were injected in the 3 offset wells (to separate in-situ CO_2 from injected CO_2) and breakthrough was noticed at 2 offset wells (same wells as N_2 breakthrough)
- The previous history-match is being updated to include injection data, nitrogen concentration and allow different permeability by layer. The model is currently running.
- A multi-scale investigation of sealing behavior of the overlying Kirtland shale is being conducted and shows good sealing quality so far. The study is not complete yet.

Summary of Target Sink Storage Opportunities and Benefits to the Region

The San Juan Basin has been previously assessed by Advanced Resources International (ARI) under the DOE-sponsored Coal-Seq project as one of the nation's top coal basins for sequestration in terms of potential storage capacity (12 Gt of CO_2, 12% of U.S. total), ECBM potential (16 TCF, 10% of U.S. total), and potential cost of storage (at a predicted net profit of \$4-8/ton of CO_2).

In addition to gaining a better understanding of ECBM and sequestration potential, another benefit to the region is evaluation and application of new, alternative, beneficial use of produced water: irrigation of stressed riparian areas will not only take up additional carbon, but will also help restore the local ecosystems in general.

Cost:

Total Field Project Cost: Approximately $5.5M

DOE Share: Approximately $4.4M or 80%

Non-DOE Share: Approximately $1.1M or 20%

Field Project Key Dates:

Baseline Completed: May 2007

Drilling Operations Begin: May 2008

Injection Operations Begin: July 2008
Injection Operations End: July 2009

MVA Events: July 2008

Total CO_2 Injected as part of SWP Demonstration Purposes: 318,856 Mcf or approximately 18,430 tons over 1 year.

Field Test Schedule and Milestones

Major field operations, including well-drilling, pipeline planning, reservoir engineering and baseline MVA operations, began in winter and spring of 2006. Safety training, initial reservoir model grids, and other essential SWP activities were also completed that year. First injection began in July 2008, and ceased one year later. A general summary of the SWP's schedule for the New Mexico project is provided in the Gantt chart below.