

## FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

<b>Partnership Name</b>	Southwest Regional Partnership on Carbon Sequestration		
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<b>Field Test Information:</b> 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 <sub>2</sub>	Tons 20,000 – 35,000 tons;	Source CO <sub>2</sub> sourced from McElmo Dome, CO	
Field Test Partners (Primary Sponsors)	ConocoPhillips		
	KinderMorgan CO <sub>2</sub> Company, L.P.		

### Summary of Field Test Site and Operations

#### **General Geology and Target Reservoirs:**

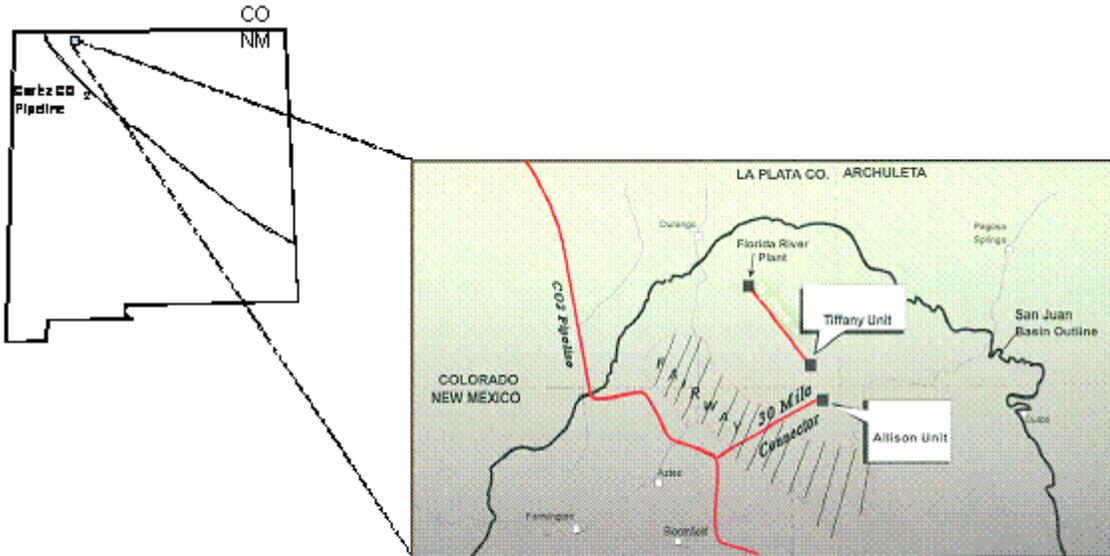
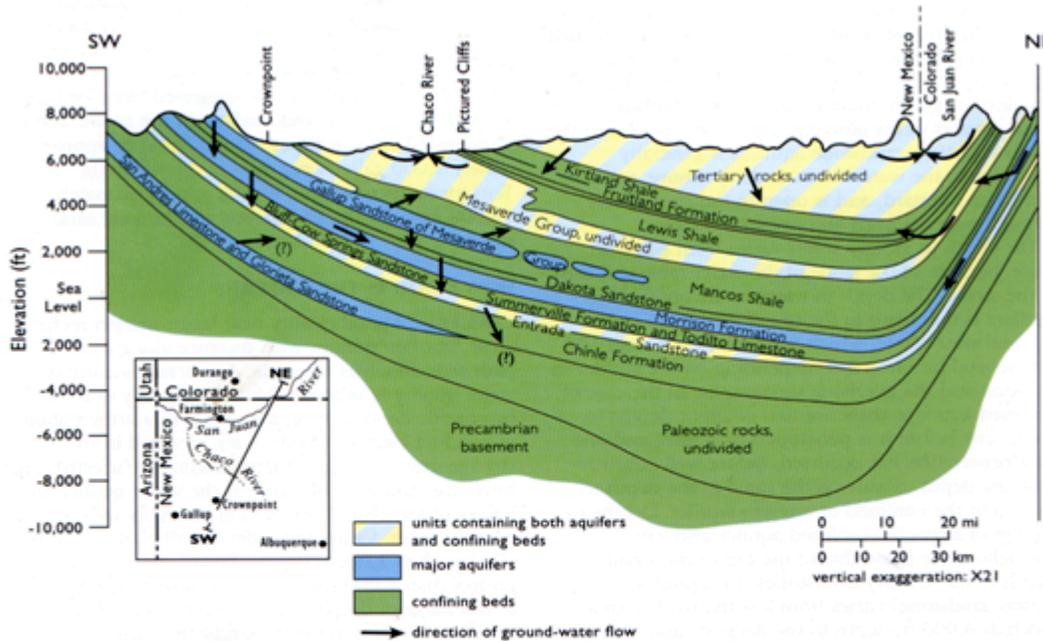


Figure 1: Location of SJB ECBM (Pump Canyon) demonstration test in the San Juan Basin, NM.

The San Juan basin (SJB) is one of the top ranked basins in the world for CO<sub>2</sub> coalbed sequestration because it has: 1) advantageous geology and high methane content; 2) abundant anthropogenic CO<sub>2</sub> from nearby power plants, 3) low capital and operating costs; 4) well-developed natural gas and CO<sub>2</sub> 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<sub>2</sub> sequestration. Because of its enormous coal resource, the San Juan offers a tremendous sequestration opportunity with value-added natural gas production. An extensive CO<sub>2</sub> 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 will desalinate produced water from our ECBM pilot and use this water for irrigating stressed riparian areas near the injection site, forming



**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.**

a combined ECBM – terrestrial 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<sub>2</sub>, high initial coal permeability is required to maintain high CO<sub>2</sub> injection rates over time. Maintaining high injectivity is an important requirement for large-scale, low-cost CO<sub>2</sub> 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 includes 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<sub>2</sub> injection pressures will be low, eliminating any potential CO<sub>2</sub> 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.

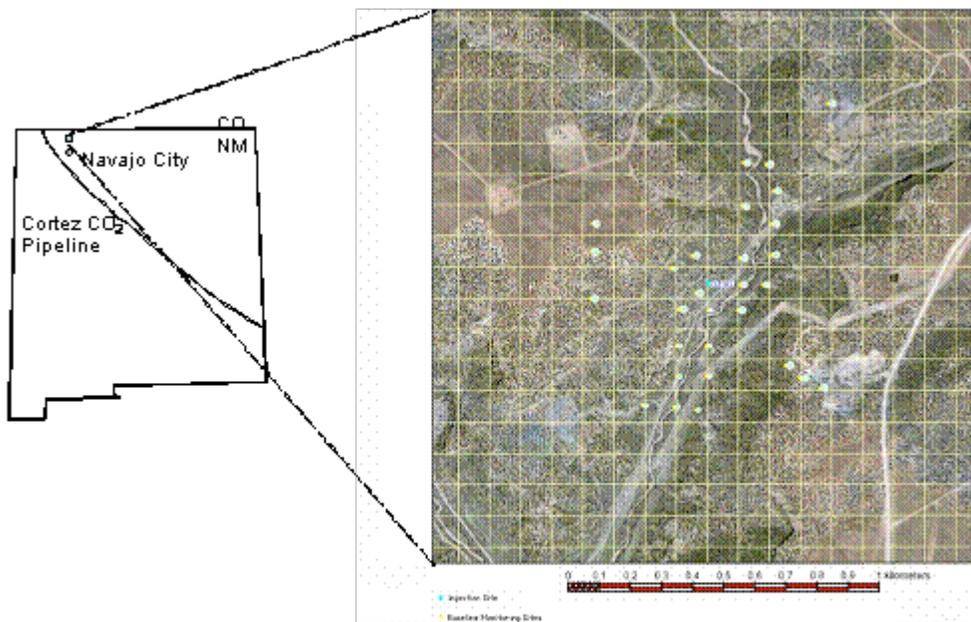


Figure 3: Surface image of injection site location of SJB ECBM (Pump Canyon) demonstration test in the San Juan Basin, NM.

**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<sub>2</sub> storage efficacy. Pilot CO<sub>2</sub> injection began in July 2008, and will continue for four to six months, as conditions permit. Plans include injection of about 75,000 tons of CO<sub>2</sub> during that year as conditions permit. 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 MMV 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<sub>2</sub> sequestration.

The SJB ECBM/CO<sub>2</sub> 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<sub>2</sub> to the region exists—the Cortez pipeline that delivers (natural) CO<sub>2</sub> from McElmo Dome to West Texas passes directly through the SJB (Figure 1). If/when that pipeline begins transporting anthropogenic CO<sub>2</sub>, the SJB will become a premier national sequestration site. Thus, the SJB represents an important near-term option for CO<sub>2</sub> sequestration.

### **Summary of Modeling and MMV 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<sub>2</sub>-groundwater flow, coal-swelling and rock deformation, and relevant chemical reactions.

Our first reservoir-modeling objective already underway is to determine optimum injection rates and potential breakthrough times to adjacent wells. The area’s CBM performance history was evaluated (matched) via reservoir simulation to calibrate unknown reservoir properties (e.g., relative permeability), which will become the primary basis for understanding subsequent pattern performance under CO<sub>2</sub> injection. Initial forecasting of pattern performance will be used to refine injection design and other operational plans (e.g., fine-tune injection rates, estimate optimum injection pressures, etc.).

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

Measurement technique	Measurement parameters	Applications
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Time-lapse 2-D seismic imaging	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Tracking CO <sub>2</sub> movement in and above storage formation
Vertical seismic profiling	- P and S wave velocity - Reflection horizons - Seismic amplitude attenuation	- Detecting detailed distribution of CO <sub>2</sub> in the storage formation - Detection leakage through faults and fractures
Passive seismic monitoring	- Location, magnitude and source characteristics of seismic events	- Development of microfractures in formation or caprock - CO <sub>2</sub> migration pathways
Electrical techniques	- Formation conductivity	- Tracking movement of CO <sub>2</sub> in and above the storage formation - Detecting migration of brine into shallow aquifers
Time-lapse microgravity techniques	- Density changes caused by fluid displacement	- Detect CO <sub>2</sub> movement in or above storage formation - CO <sub>2</sub> mass balance in the subsurface
Visible and infrared imaging from satellite	- Hyperspectral imaging of land surface	- Detect vegetative stress
CO <sub>2</sub> land surface flux monitoring using flux chambers or eddy covariance	- CO <sub>2</sub> fluxes between the land surface and atmosphere	- Detect, locate and quantify CO <sub>2</sub> releases
Soil gas sampling	- Soil gas composition Isotopic analysis of CO <sub>2</sub>	- Detect elevated levels of CO <sub>2</sub> - Identify source of elevated soil gas CO <sub>2</sub> - 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 <sub>2</sub> migration pathways

**Accomplishments to Date**

- Baseline surface fluxes measured with follow-up surveys ongoing
- Baseline reservoir groundwater (brine) compositions assessed
- 3-D reservoir model grids assembled and simulations underway
- History-match analysis of reservoir data completed
- Subsurface core collected, laboratory work ongoing
- Tiltmeter arrays installed and surveys ongoing
- Geophysical logging completed and analyses ongoing
- Desalination testing permits acquired
- Baseline logs and VSP completed
- CO<sub>2</sub> injection began July 30, 2008 and ongoing

**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<sub>2</sub>, 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<sub>2</sub>).

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**

**MMV Events: July 2008**

**Field Test Schedule and Milestones**

Major field operations, including well-drilling, pipeline planning, reservoir engineering and baseline MMV 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. A general summary of the SWP's schedule for the New Mexico project is provided in the Gantt chart below.

