# FACTSHEET FOR PARTNERSHIP FIELD VALIDATION TEST

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| **Partnership Name** | Midwest Geological Sequestration Consortium | | |
| **Contacts:** | Name | Organization | E-Mail |
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| **Field Test Information:** Field Test Name | Task 9: Enhanced Oil Recovery 2 – Well Conversion | | |
| Test Location | To be determined | | |
| Amount and Source of $CO_2$ | Tons: 2500 | Source: Air Liquide (refinery or ethanol plant) | |
| Field Test Partners (Primary Sponsors) | Petco Petroleum Corp. (pending) | | |

**Summary of Field Test Site and Operations:**

Five different oilfields were screened and evaluated based on depth, formation pressure, temperature, stratigraphic importance, and operator support. Currently, a water injection pattern is being considered for a well conversion EOR pilot within the Loudon Oil Field in Fayette County, Illinois. Geologically, the field is a very large anticlinal structure that was discovered in 1938 and has produced nearly 400 million barrels of oil. The Mississippian Weiler or Cypress Sandstones are the target reservoirs at an average depth of 1,550 feet. The Weiler is a deltaic deposit consisting of fine- to very fine-grained, well-cemented quartzose sandstone having good well-to-well continuity. Extensive well information gathered from geophysical logs and core descriptions was used to characterize the Weiler Sandstone. The average reservoir temperature is $78^{o}$F ($25.6^{o}$C) with an average thickness of 15.6 feet, average porosity of 19.5% and average horizontal permeability of 154 md. The formation water has been tested at 104,000 mg/L total dissolved solids (TDS). The oil field lies beneath a combination of forested and rural agricultural land that is generally flat lying (> 2% slope) and is dissected by small stream or rivers.

In situ pressure and temperature of the geologic formation for this test is desired to be in the liquid region of the $CO_2$ phase diagram. The liquid region is expected to provide reservoir conditions such that $CO_2$ injection will perform like a miscible flood, but at much lower temperatures and slightly lower pressures. The Illinois Basin has unique formation pressures and temperatures in the oil reservoirs where waterfloods occur such that a liquid $CO_2$ flood is possible. The liquid flood may be possible because the minimum miscible oil/$CO_2$ pressure is lower than commonly found in oil reservoirs due to the reservoir temperature being less than the critical temperature of $CO_2$. Consequently, this EOR flood pattern pilot will attempt a liquid $CO_2$ flood. However, if operationally it is impossible to sustain liquid $CO_2$ in the subsurface, an immiscible $CO_2$ gas flood will be conducted and a liquid flood will be attempted in a future EOR pilot.

Over seventy locations have been reviewed at Loudon Field in Fayette County, Illinois for this test. A number of criteria were used for screening locations. For example, surface features including access to wells, ability to locate equipment and offload $CO_2$, wells in flood plain, proximity to residences, structures, industry, roads, and water bodies were considered. Wells were evaluated for the ability to isolate and inject into the Mississippian age Cypress Sandstone reservoir within a standard five spot, ten-acre spaced water injection well pattern. Reservoir and injection pressures and temperatures were screened for a $CO_2$ liquid phase test pilot. Six prospective injection patterns were identified after screening. Geologic and stochastic models were developed for the six prospective locations. These models were developed on a square grid of seven by seven well spacings for a total of approximately 49 wells over an area of roughly 500 acres. The primary candidate is the Martin McClain #8-W injector well and four offset producers in Section 4, T7N R3E.  Geologic maps local to this injection well are shown below.

**Structure Map on the Base of the Barlow Limestone**

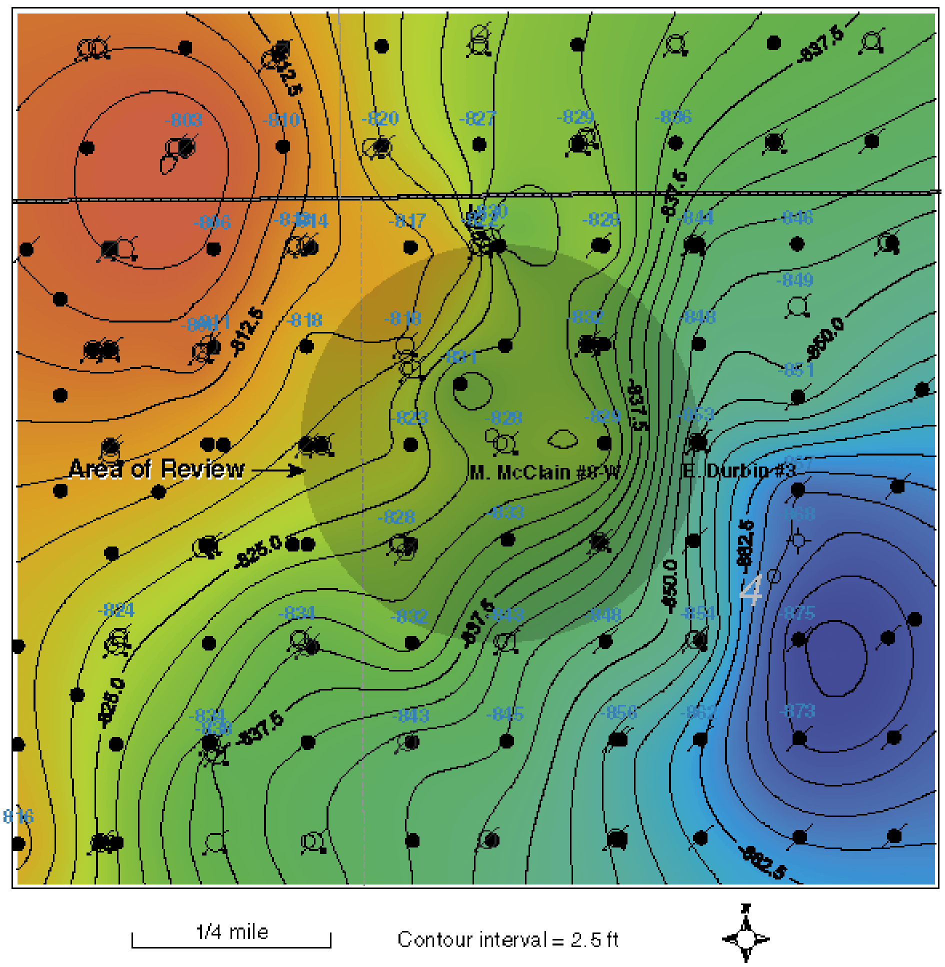


Figure 1.  Subsea structure map contoured on limestone marker bed located sixty feet above Weiler Sandstone injection target. Drilled on ten acre spacing, the McClain #8-W injector (labeled) and the four, north, south, east, and west offset producers included in the test flood pattern are located on the east flank of the Loudon Field structure in the northwest quarter of section 4. Area of Review, shaded, refers to well compliance review requirement included in the Illinois State permitting process.

**Average of Permeability Distribution**
**between 60 to 65 feet Below the Barlow Limestone**

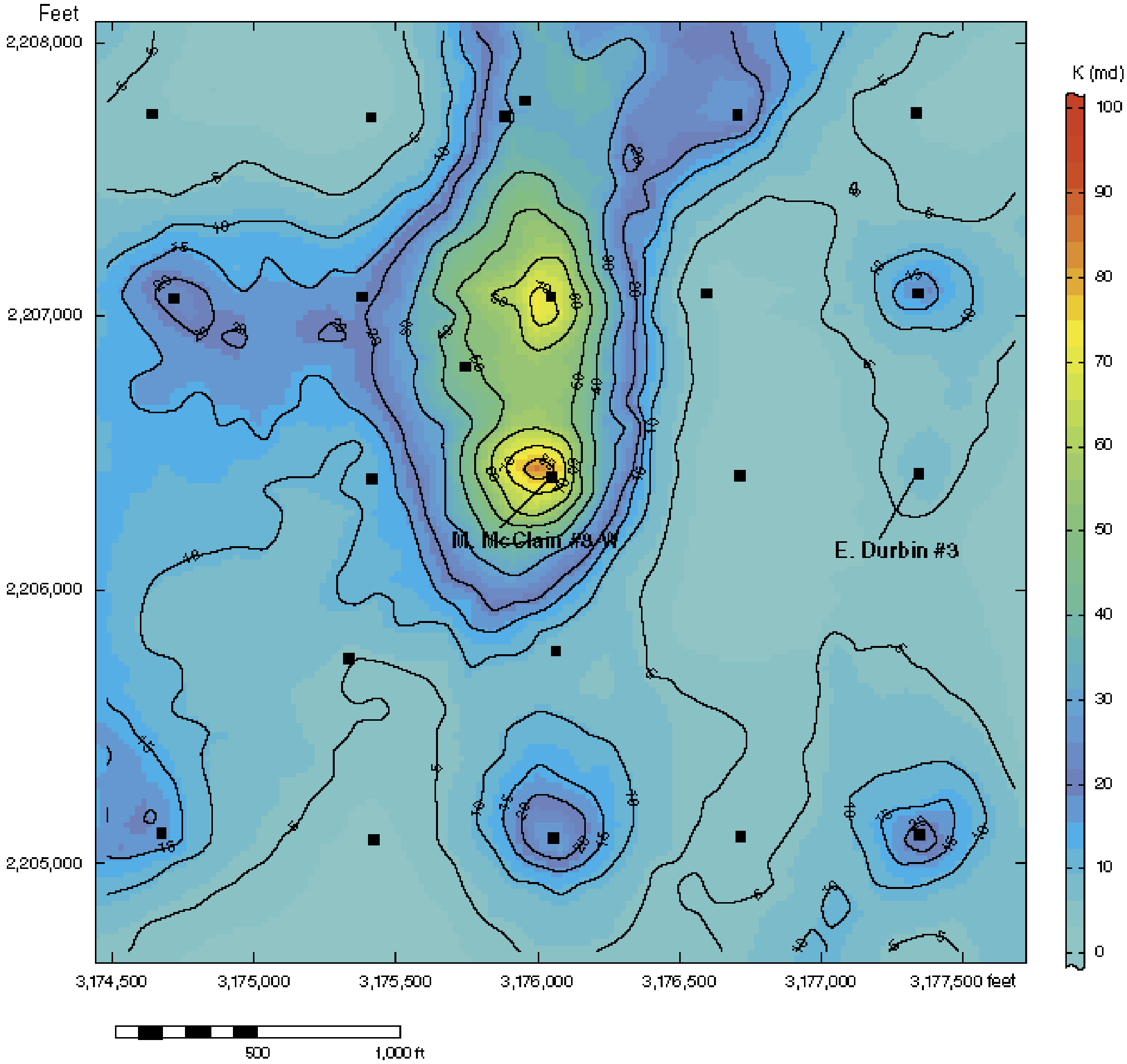


Figure 2. Geologic model of permeability averaged over a portion of the injection zone in the McClain #8-W well. The depositional and flow zone trend of the Weiler tidal shoal sandstones in this area of Loudon Field are commonly north-south to northeast-southwest as shown by the trend of permeability development on this map.

**Research Objectives:**

The goal of this pilot is to demonstrate that geologic sequestration is a safe and permanent method to mitigate GHG emissions. This EOR project will evaluate the potential for a combined geological sequestration of $CO_2$ and enhanced oil recovery method in mature Illinois oil reservoirs. In Phase I, the establishment of a demand for $CO_2$ in EOR projects are important to building infrastructure necessary for a $CO_2$ sequestration industry.

**Summary of Modeling and MMV Efforts: (Use the table provided for MMV)**

- ***Geophysical methods*:**

Electromagnetic Induction **(EMI)** and High Resolution Electrical Earth Resistivity **(HREER)** are being evaluated as techniques to measure conductivity and resistivity to indicate changes in soil moisture that maybe caused by migrating $CO_2$. If used, these methods will be run in pre- and post injection stages (P/P).

- ***Geochemical methods:***

Monitoring the changes in major and trace constituents as well as pH, alkalinity, stable and radioactive isotopes, gases, and chemical composition of ground water will be used to elucidate the impact of $CO_2$ migration.

- ***Soil gas sampling:***

Also, concentrations of $CO_2$ and $CH_4$ will be attempted in the vadose zone (P/P) to detect elevated levels of $CO_2$, identify source of elevated soil gas, and evaluate ecosystem impacts. Previous experience has proven that the vadose zone is often too saturated for effective analysis to take place.

- ***Well Logging:***

The best tools to validate the integrity of the injection well, monitor storage formation and seal, and measure seismic velocities, moisture, gas content, salinity, and hydrocarbon content around well casing. Three different type of well logging methods will be considered: Gamma Ray log, Ultra Sonic Instrument **(USI)**, and Reservoir Saturation Tool **(RST)** which are run pre and post injection.

- ***Ground water monitoring:***

Ground water monitoring will be used to measure quality and flow direction in shallow ground water and in the production well, to monitor changes in water quality after $CO_2$ injection to validate integrity of the seal formation, injection well, and other potential migration pathways to the biosphere (P/P).

- ***Subsurface pressure and temperature, gas content and fluid chemistry:***

Gas content, fluid chemistry, and pressure of formation and temperature of wellhead, downhole and annulus zones will be monitored continuously to determine reactions of injected $CO_2$ to the formation matrix and fluid, provide a level of safety to operators, and to insure the integrity of the formation and seal (pre, during, and post injection).

- ***Measuring $CO_2$ injection rate, Volume, and isotopic composition:***

To validate the volume of $CO_2$ injected into the formation, the injection rate will be monitored. In addition, the isotopic composition of the injected $CO_2$ will be determined. The isotopic data may provide source tracking information that will help to trace $CO_2$ migration in order to validate injection well and formation integrity.

- ***Groundwater and Geochemical Modeling:***

A site specific groundwater model will be developed using **MODFLOW**, a widely accepted, finite-difference based, groundwater flow model. An analytical elements model, such as GFLOW, may be used to develop a conceptual model for groundwater flow. The results of the modeling effort will estimate the time for potential contaminants that could be associated with $CO_2$ injection to travel outside the area of the injection site. This estimate will help identify risks to nearby water supplies, should $CO_2$ leakage occur (P/P). Also the software **PHREEQCI** and/or Geochemist Workbench would be applied for thermodynamic modeling of shallow groundwater samples and injection-formation brine samples to gain experience in using water quality data and chemical modeling as a technique for detecting releases of injected $CO_2$ (P/P).

**Accomplishments to Date:**

Several sites were screened to identify those with highest probability of $CO_2$ response during operations. The project site has been selected and will begin pending contract approval. Geologic models and reservoir models were developed to help with this process. Equipment has been ordered to convert the surface producing equipment to accommodate the conversion of the water injector to a $CO_2$ injector and for data acquisition of the gas casing rates. The UIC Class II permit for this project is in progress. Contract negotiations with the operator will follow issuance of the permit.

**Summarize Target Sink Storage Opportunities and Benefits to the Region:**

This project evaluated the potential for geological sequestration of $CO_2$ in mature Illinois oil reservoirs as part of an enhanced oil recovery program. If deemed commercial, further development using this technology could be expanded by oil producers but is beyond the scope of this study area. This type stimulation can significantly boost short-term oil production and generate quick payouts, especially at attractive oil prices. The primary injected zone has basin-wide applicability having accounted for nearly 30% of the 4.1 billion barrels of produced oil. These EOR project treatments will provide information to numerous small lease operators that will consider starting their own $CO_2$ floods based on these test pilots.

| **Cost:** | **Field Project Key Dates:** |
|---|---|
| **Total Field Project Cost: $638,000** | **Baseline Completed:** **Sep 2008 – Oct 2008** |
| **DOE Share:** **$578,000** **91%** | **Well Conversion Begin:** **Oct 2008** |
| **Non-Doe Share:** **$ 60,000** **9%** | **Injection Operations Begin:** **Oct 2008** |
| | **MMV Events:** **Apr 2008 – Sep 2009** |

**Field Test Schedule and Milestones (Gantt Chart):**

Final Site Selection: Pending contract approval
Injection: Pending permit and contract approval