Why did we do this project?

• The discharge of CO$_2$ to the atmosphere is under regulatory review, and subsurface storage may be required for existing facilities and the financing and construction of new facilities.

• Kentucky House Bill 1, passed in a special legislature session and signed into law in August 2007, appropriated $5 million funding for KGS to research the storage and use of CO$_2$ throughout the Commonwealth.

• House Bill 1 mandated that KGS drill a CO$_2$ storage research well in the Western Kentucky Coal Field by.

• The Hancock County drill site was chosen for its favorable geologic setting, shallowest drilling depths, and accessibility.
The Project

• The project proceeded in two phases:
  – Phase 1 (2009) got the well drilled and the first round of testing completed.
    • Acquired 24.1 miles of 2-D reflection seismic data
    • Drilled to 8,126 ft, cemented casing at 441 ft and 3,060 ft, and cut 395 ft of cores
    • Injected 18,454 barrels of brine and 323 tons of CO₂ (1,765 barrels) in the open wellbore below 3,060 ft
  – Phase 2 (2010) completed a second round of testing and abandoned the injection zone.
    • Plugged the well at 5,268 – 5,545 ft, abandoning the lower 2858 ft of the well, and constructed a 230-ft test interval at 5,038 – 5,268 ft
    • Injected 4,265 barrels of brine and 367 tons of CO₂ (2,000 barrels)
    • Plugged and abandoned the test interval at 5,037 – 5,275 ft
    • Plugged the well at 3,942 – 3,477 ft and abandoned the Knox Dolomite interval, and plugged the casing at 800 ft with a cast iron bridge plug
Western Kentucky Project Timeline

2008 - Organization
2009 - Site Characterization
2010 - EPA Permitting
2011 - Drilling
2011 - Testing
2012 - Evaluation and Reporting
2012 - Abandonment
2012 - Monitoring
Prior to drilling, 24.1 mi of new, high-quality 2D seismic data (Lines A-D) were acquired to provide subsurface structural and stratigraphic control at the wellsite, and to supplement existing older, lower-quality data (Line 7).
Phase 1

- Drilling commenced on April 24, 2009, and was finished on June 14 after 63 days of drilling.
  - Casing cemented at 441 ft and 3,660 ft
  - The hole was left open hole casing to the bottom of the well at 8,126 ft for injection testing

- Seven cores, totaling 395 ft, were cut to test the reservoir and seal properties
  - Reservoir seals
    - New Albany Shale (30 ft)
    - Maquoketa Shale (31 ft)
    - Black River Limestone (61 ft)
  - CO₂ storage reservoirs
    - Knox Group (three cores, 243 ft total)
    - Precambrian Middle Run Sandstone (30 ft)
Injection Testing

- Testing began on July 25, 2009, and was completed on August 22
  - Two formation water samples were collected
  - Initial injection of brine was into 285 ft intervals isolated by inflatable straddle packers on tubing
    - Seven tests attempted
    - Results were mixed due to leaks and communication around the packers through the formation porosity system
  - Program revised to full-wellbore injection of brine and CO₂ below a single packer in casing
CO₂ Injection

- Injected a total of 323 tons of CO₂ (1,765 barrels) below a packer set in casing at 3,603 ft
- After injection of CO₂ the well bore was flushed with 4,568 barrels of brine
- Long-term downhole pressure gauge was left in place to monitor pressure fall-off pending re-entry for Phase 2 testing
Phase 2

- Phase 2 testing took place on August 30 – September 30, 2010.
  - Cut 20 rotary sidewall cores through the injection interval to determine reservoir rock properties
  - Plugged the well at 5,268 – 5,545 ft, abandoning the lower 2,858 ft of the well
  - Constructed a 230-ft test interval at 5,038 – 5,268 ft by cementing a 5½-inch liner at 4,820-5033 ft
- Injected 4,265 barrels of brine and 367 tons of CO₂ (2,000 barrels)
  - Recorded pressure during injection and falloff to calculate reservoir permeability and volume
  - Recorded temperature logs before and after injection to determine which intervals were receiving the injected CO₂
- Recorded a 4-D vertical seismic program at more than 850 points around the well. Data was recorded both before and after CO₂ injection in an attempt to image the CO₂ plume.
- Abandoned the Knox Dolomite injection zone with cement plugs at 5,037 – 5,275 ft and 3,942 – 3,477 ft, exceeding EPA abandonment requirements (a single plug at 3,760 – 3,560 ft).
4-D VSP seismic data acquisition points
Seismic Survey Vibrator Truck
CO₂ Delivery
What we learned:

- The Knox Dolomite could serve as an effective CO$_2$ storage reservoir.
- There are excellent reservoir sealing strata in the Black River Limestone and overlying Maquoketa Shale, above the Knox Dolomite, that would prevent any CO$_2$ migration from the Knox Dolomite to the surface.
- Most of the West Kentucky Coal Field has Knox Dolomite, comparable to that in the KGS test well, that may be suitable for CO$_2$ storage.
- Additional evaluation of the Knox Dolomite will be necessary to fully determine its potential for CO$_2$ storage.
Knox Dolomite is too deep for economic CO$_2$ storage

Reservoir sealing rocks are too shallow to ensure CO$_2$ storage

The potential area for CO$_2$ storage in the Knox Dolomite in western Kentucky is about 6,400 mi$^2$. More research is needed to determine the actual extent.
Where did the CO$_2$ go?

- The Knox Dolomite, under just the 1 acre well drill site, holds about 1.7 million barrels (71.4 million gallons) of brine that is about 200 times saltier than what is allowed in drinking water by Federal regulations.

- We injected a total of 3,765 barrels of CO$_2$ (690 tons). This is about 0.25% of the volume of water in the Knox Dolomite under the drill site.
  - Most of the CO$_2$ dissolved in the formation water and dissipated.
  - A small amount of CO$_2$ reacted with the formation water and rock to make new minerals.

- Pepsi uses 0.35% CO$_2$ to carbonate their sodas, and a can of beer has about 0.5% CO$_2$ in it.
About 1.7 million barrels of brine are in the Knox Dolomite under the 1-acre drill site.

3,785 Barrels of CO₂ were injected in 2009 – 2010 *

*About 0.25% CO₂ (dissolved in the brine). A can of beer has about 0.5% CO₂ in it.
There are about 328 million barrels of brine in the Knox Dolomite under the Blan Farm

3,785 barrels of CO₂ injected
Acknowledgements

This research is being supported by a grant from the Commonwealth of Kentucky with additional contributions by the Energy and Environment Cabinet, the University of Kentucky, and a consortium of more than twenty industry partners. Principal contributors include:

Western Kentucky Carbon Storage Foundation
ConocoPhillips Company
Peabody Energy
E.ON U.S.
T.V.A.
Illinois Office of Coal Development
Illinois Geological Survey
US Department of Energy – National Energy Technology Laboratory
GEO Consultants, LLC
Schlumberger Carbon Services
Smith Management Company
Wyatt, Tarrant & Combs, LLP

Access to the drill site was graciously granted by Marvin and Brenda Blan, and without their cooperation this project would not have been possible.
If you have any questions about the project, please contact us:

Rick Bowersox – Lexington
(859) 323-0536
j.r.bowersox@uky.edu

Dave Williams – Henderson
(270) 827-3414 x22
williams@uky.edu