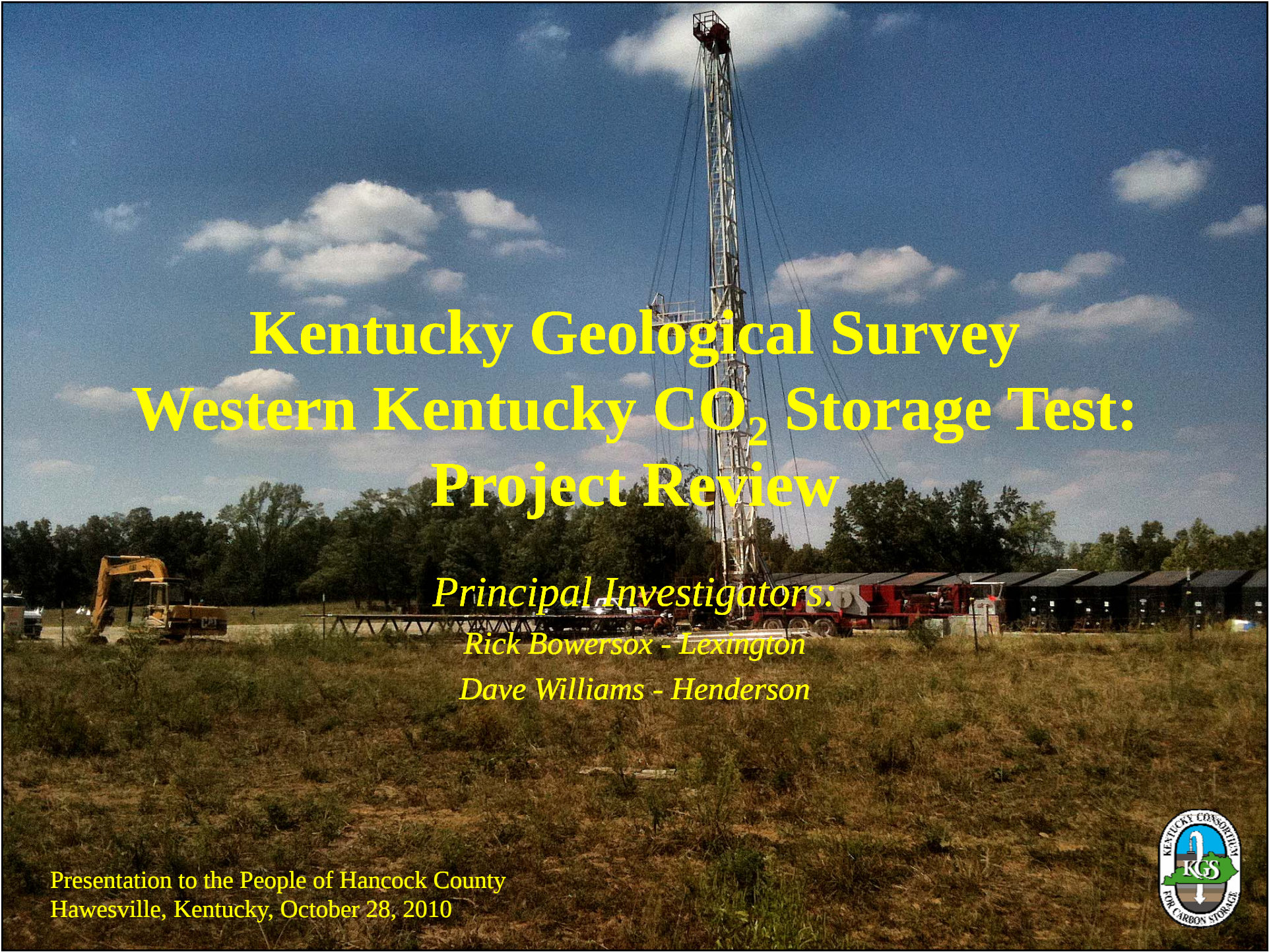




Kentucky Geological Survey Western Kentucky CO₂ Storage Test: Project Review

Principal Investigators:

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Presentation to the People of Hancock County
Hawesville, Kentucky, October 28, 2010



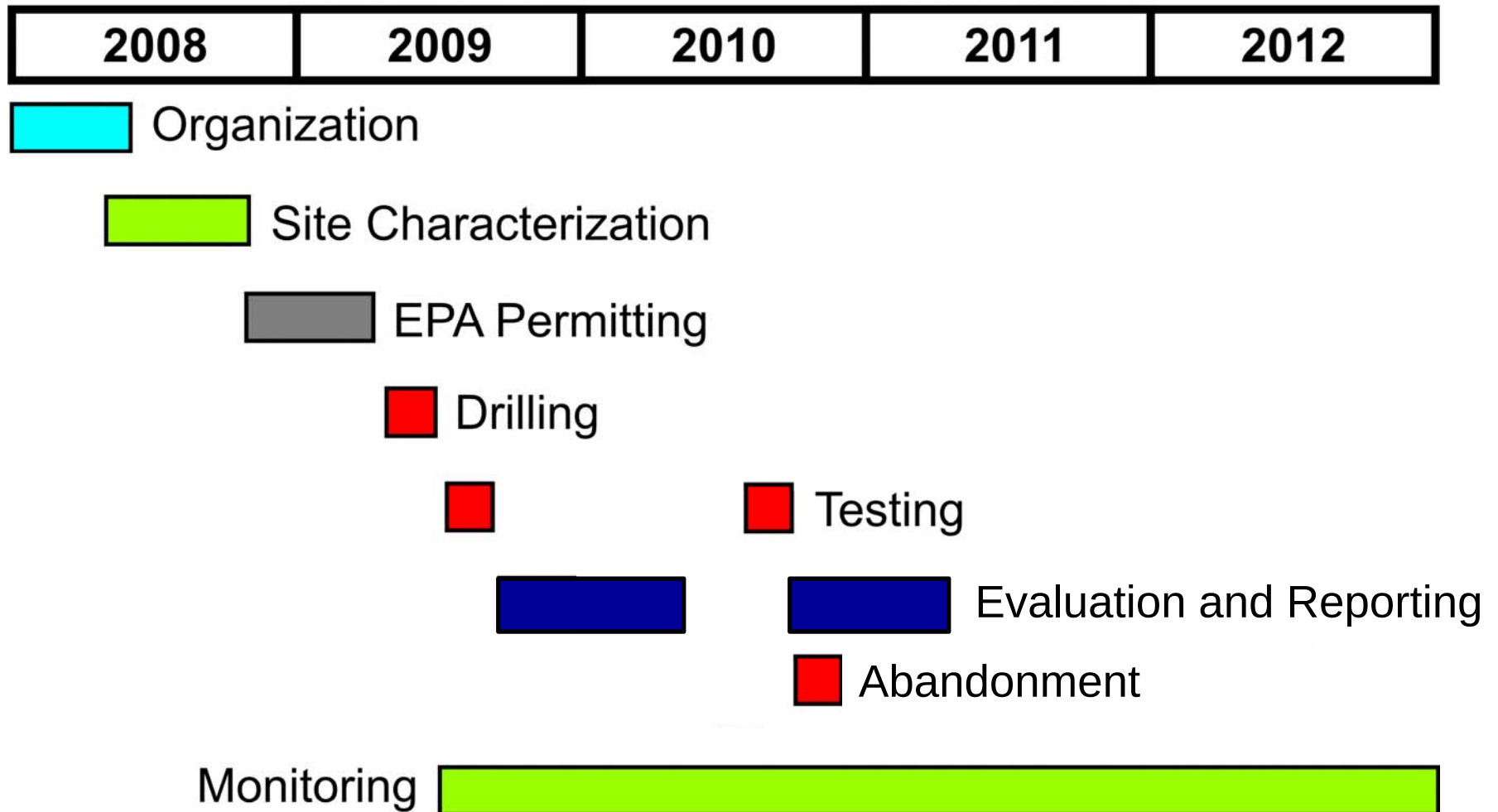
Why did we do this project?

- The discharge of CO₂ 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 CO₂ throughout the Commonwealth.
- House Bill 1 mandated that KGS drill a CO₂ storage research well in the Western Kentucky Coal Field by.
- The Hancock County drillsite was chosen for its favorable geologic setting, shallowest drilling depths, and accessibility.

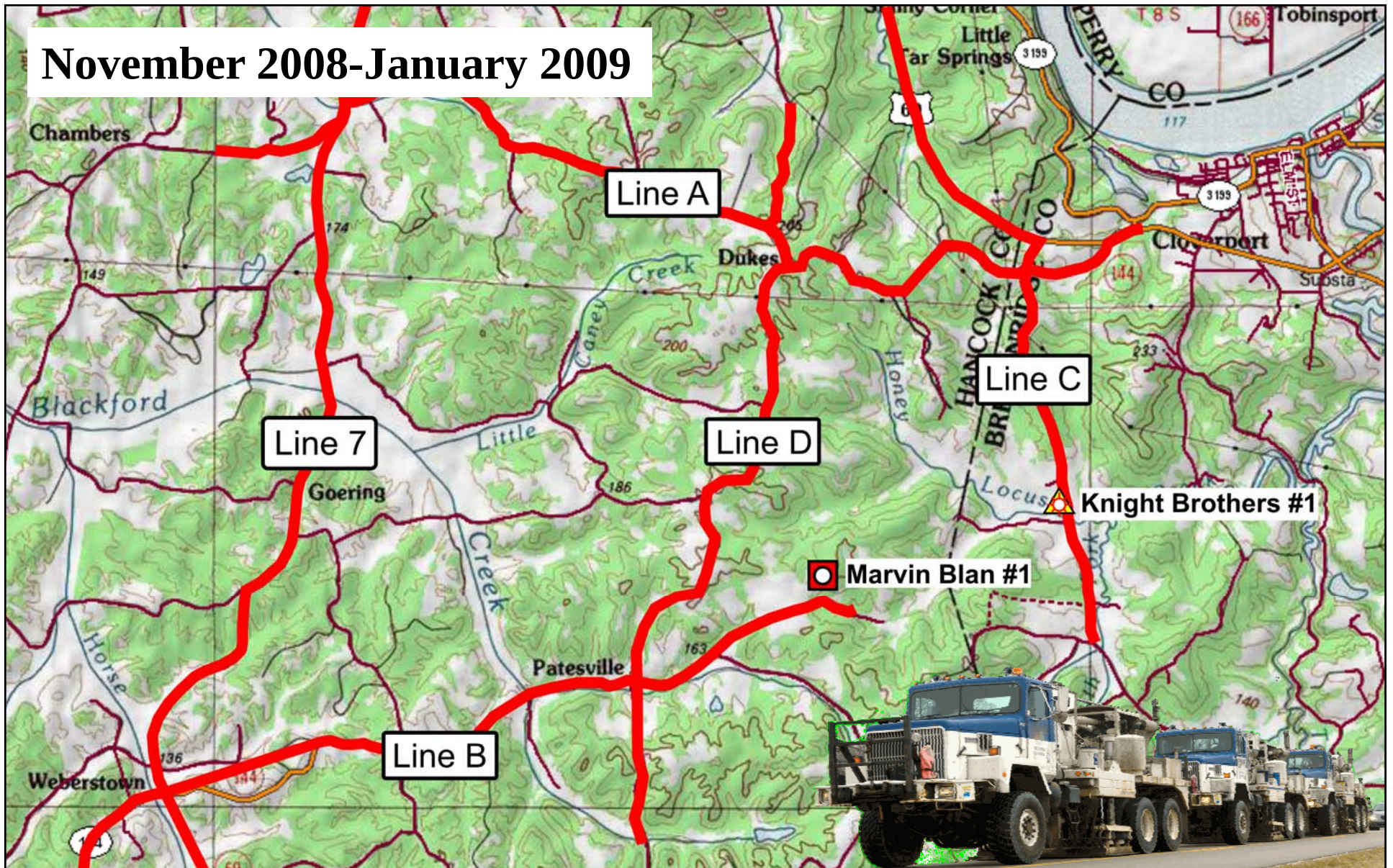
The Project

- 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



November 2008-January 2009



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).



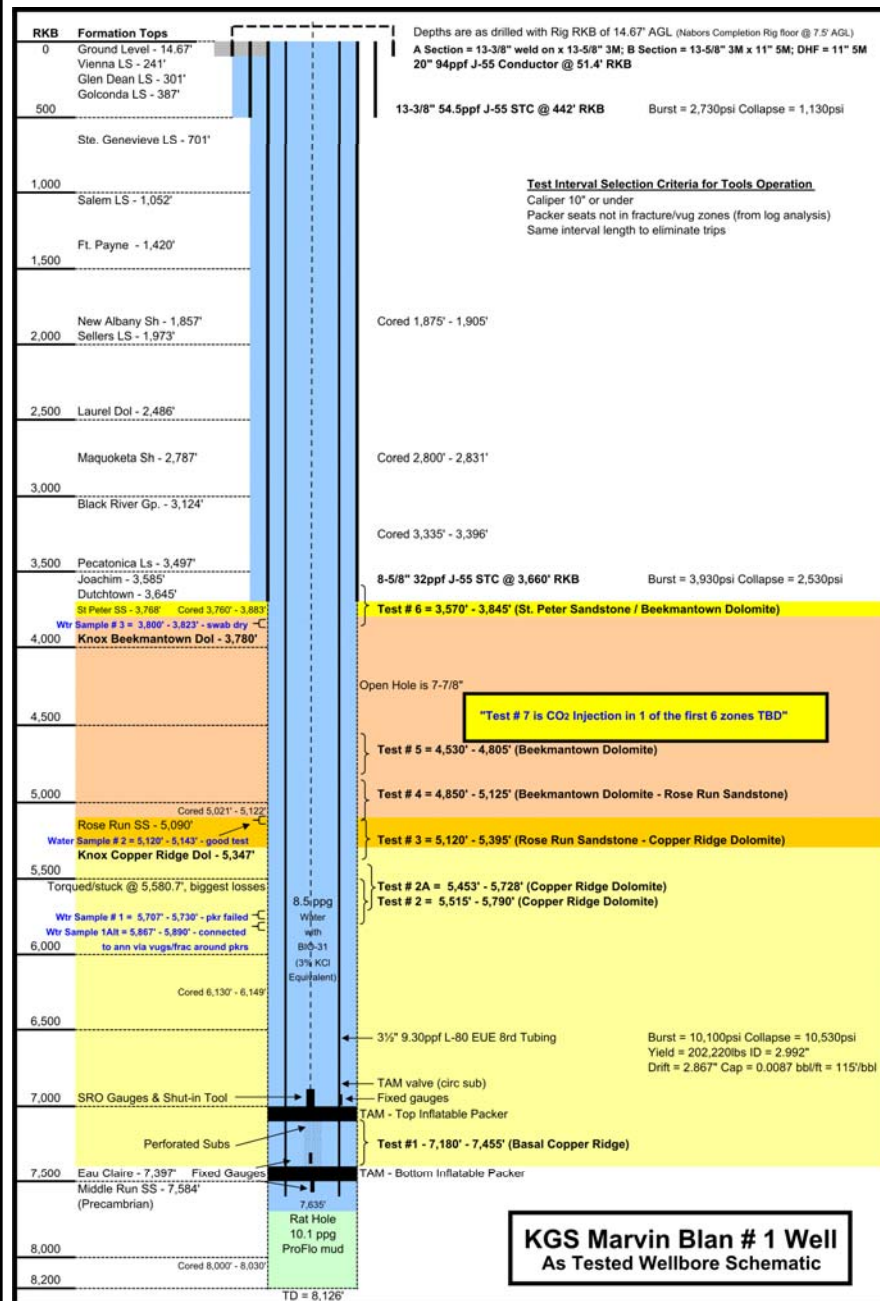
Phase 1

- 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

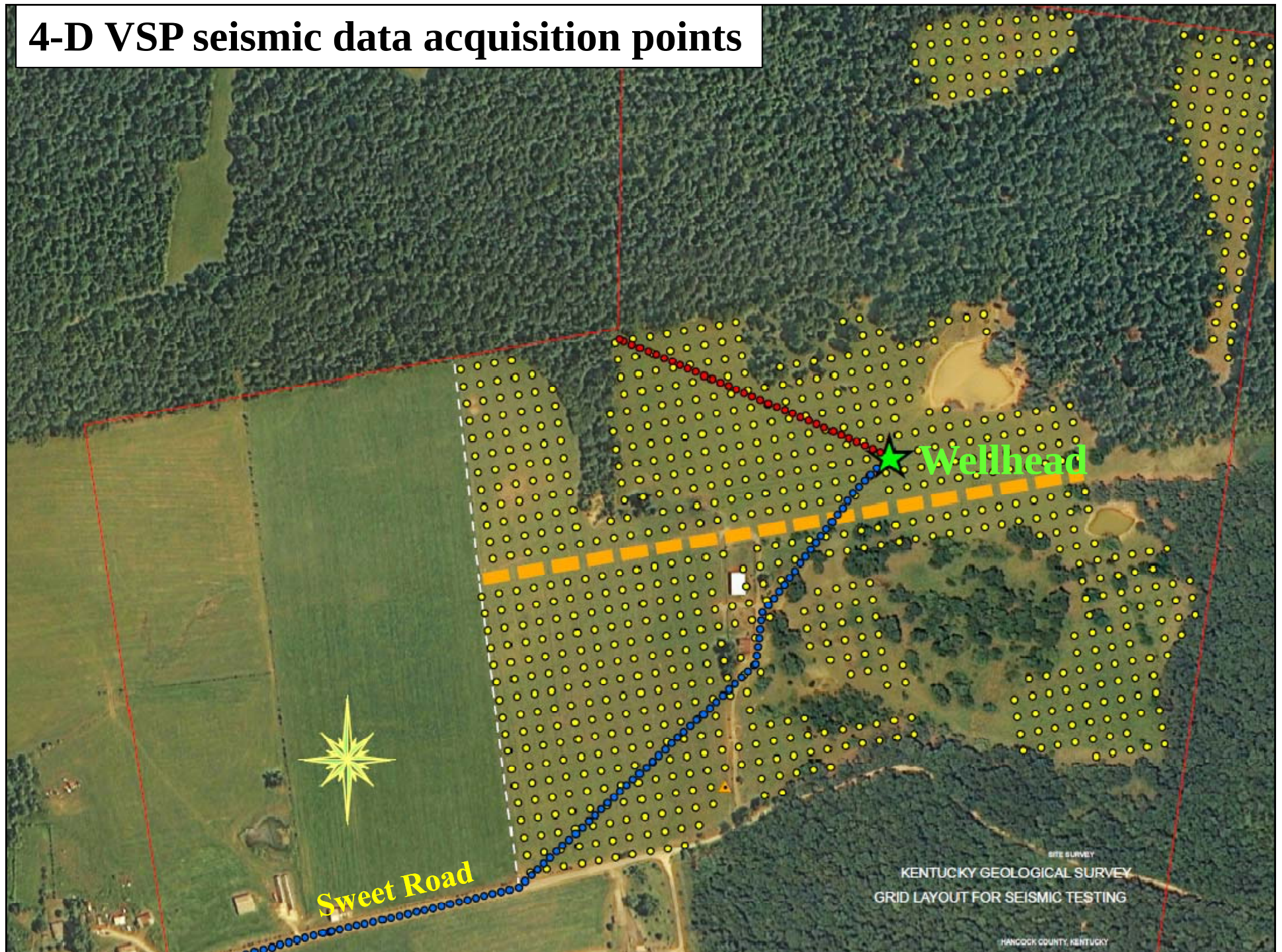
- Injected a total of 323 tons of CO₂ (1,765 barrels) below a packer set in casing at 3,603 ft
- After injection of CO₂ the well bore was flushed with 4,568 barrels of brine
- Long-term downhole pressure gauge was left in place to monitor pressure fall-off pending re-entry for Phase 2 testing

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



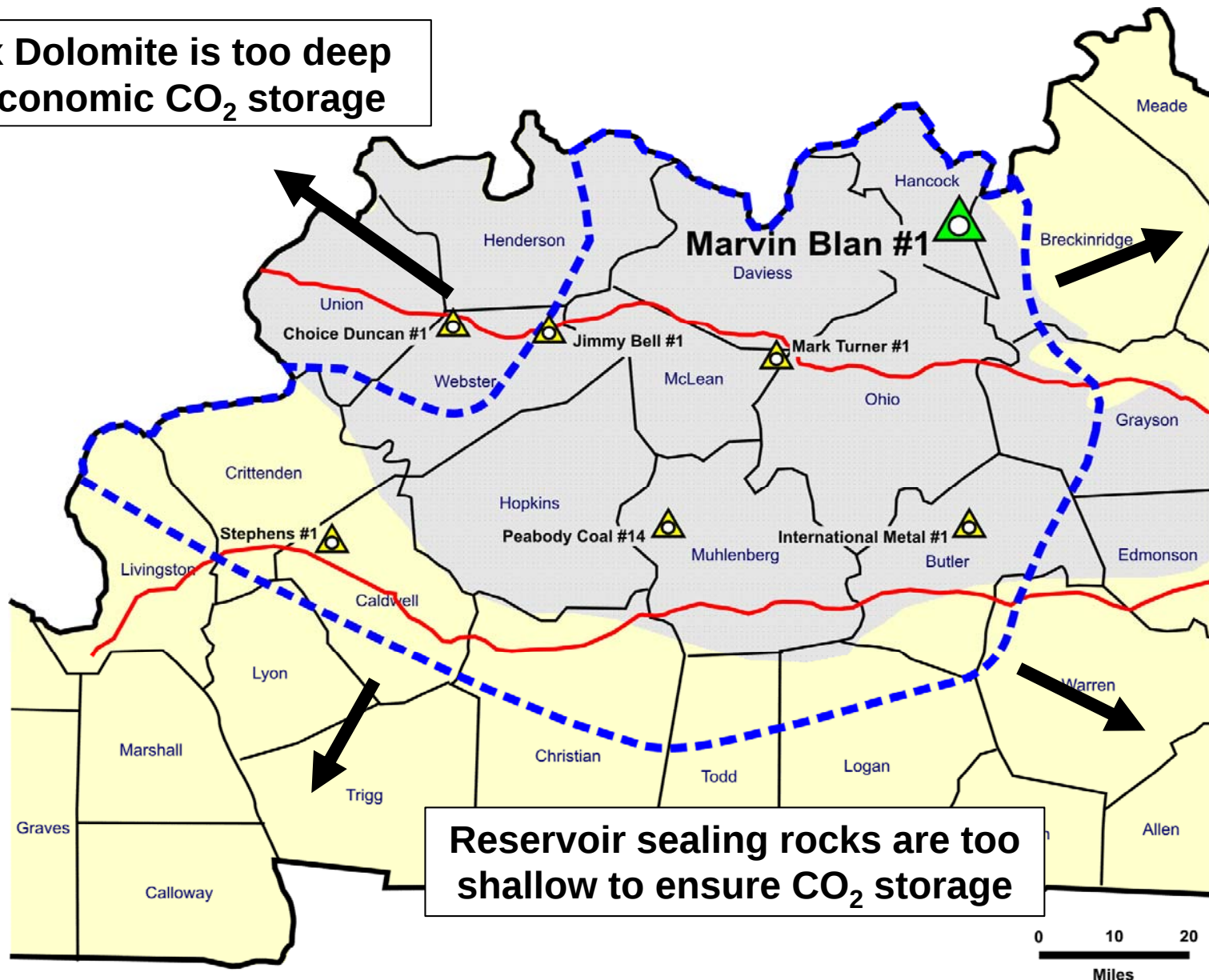
CO₂ Delivery



What we learned:

- The Knox Dolomite could serve as an effective CO₂ 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 CO₂ 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 CO₂ storage.
- Additional evaluation of the Knox Dolomite will be necessary to fully determine its potential for CO₂ storage.

**Knox Dolomite is too deep
for economic CO₂ storage**



**Reservoir sealing rocks are too
shallow to ensure CO₂ storage**

The potential area for CO₂ storage in the Knox Dolomite in western Kentucky is about 6,400 mi². More research is needed to determine the actual extent.

Where did the CO₂ 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 CO₂ (690 tons). This is about 0.25% of the volume of water in the Knox Dolomite under the drill site.
 - Most of the CO₂ dissolved in the formation water and dissipated.
 - A small amount of CO₂ reacted with the formation water and rock to make new minerals.
- Pepsi uses 0.35% CO₂ to carbonate their sodas, and a can of beer has about 0.5% CO₂ 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**



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