

Field Testing for CO₂ Geologic Storage

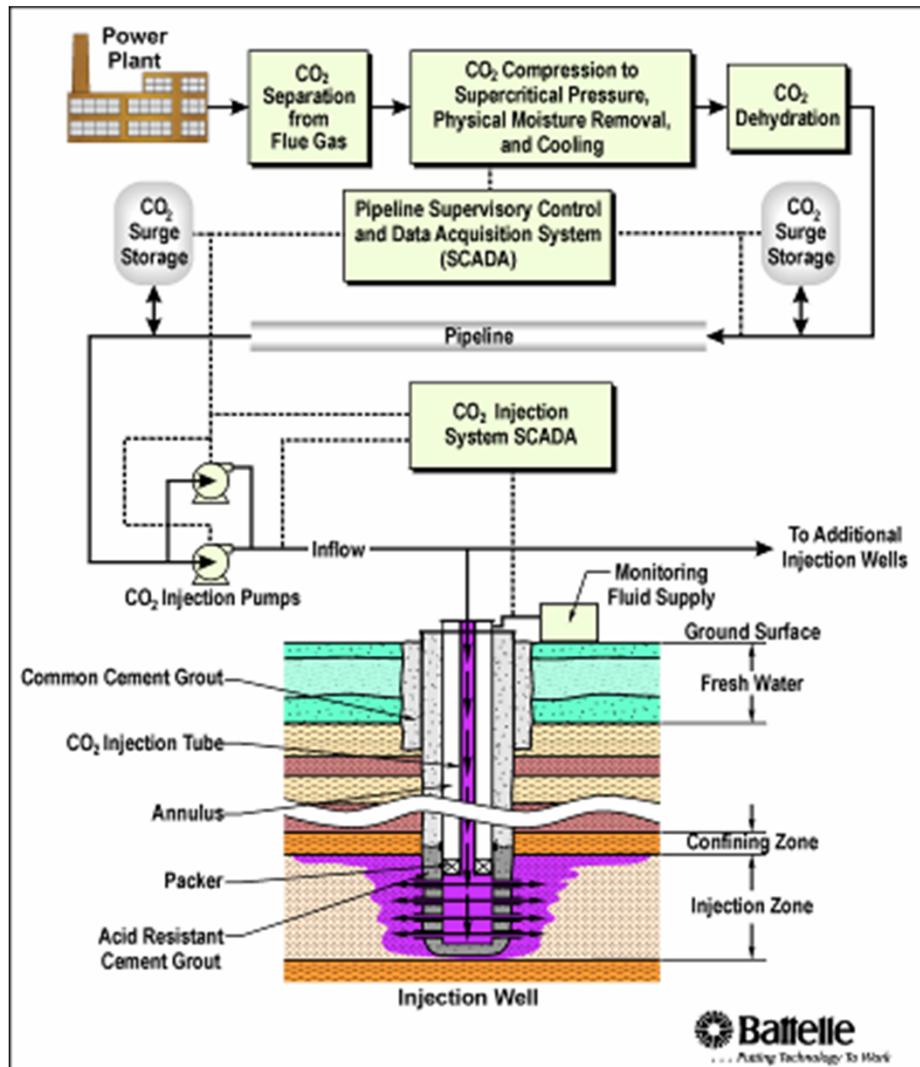
Battelle
The Business of Innovation

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Advanced Energy 2010 Conference, November 8, 2010, New York, New York

Major Components of CCS Value Chain



Enterprise Strategic Planning

- Carbon foot print analysis
- Source reduction analysis
- Asset opportunity screening

Capture

- Development of new capture concepts
- Applications screening
- Process optimization and integration

Surface Transport

- Analysis of CO₂ transport properties
- Process optimization and integration
- System design support
 - Compression and processing
 - Pipeline transport
- Monitoring (inspection, corrosion analysis etc.)

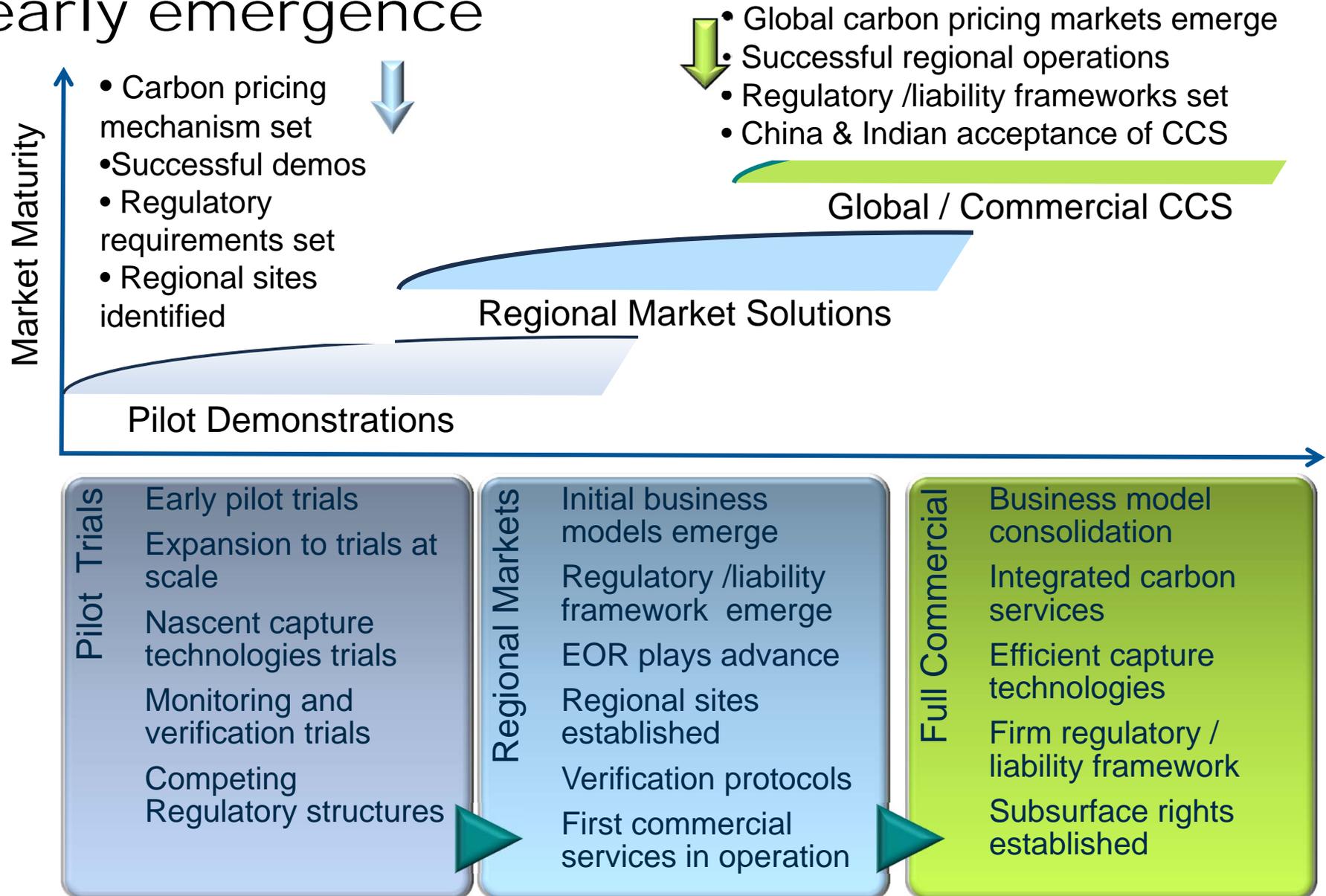
Subsurface and Injection

- Site characterization
- Permitting and NEPA
- Well field design and implementation
- Injection operations

Measurement Mitigation and Verification

- MMV design, implementation and operation
- Data analysis

Carbon technology markets are still in early emergence



Selected Battelle Programs in Carbon Management

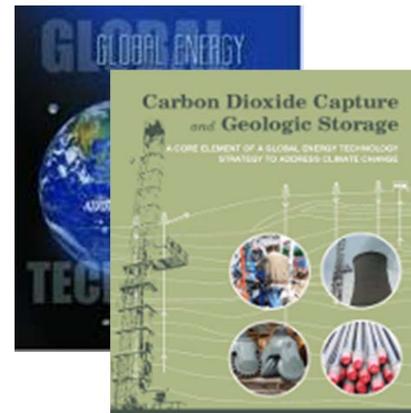
Mountaineer



DOE Regional Partnership Program



FutureGen



Global Energy Technology Strategy Program (GTSP)

Direct Industry Support

- AEP, Mountaineer
- RWE
- CRIEPI, Japan CCS
- BP, Shell, Conoco
- Major steel company
- Packaging company
- Others

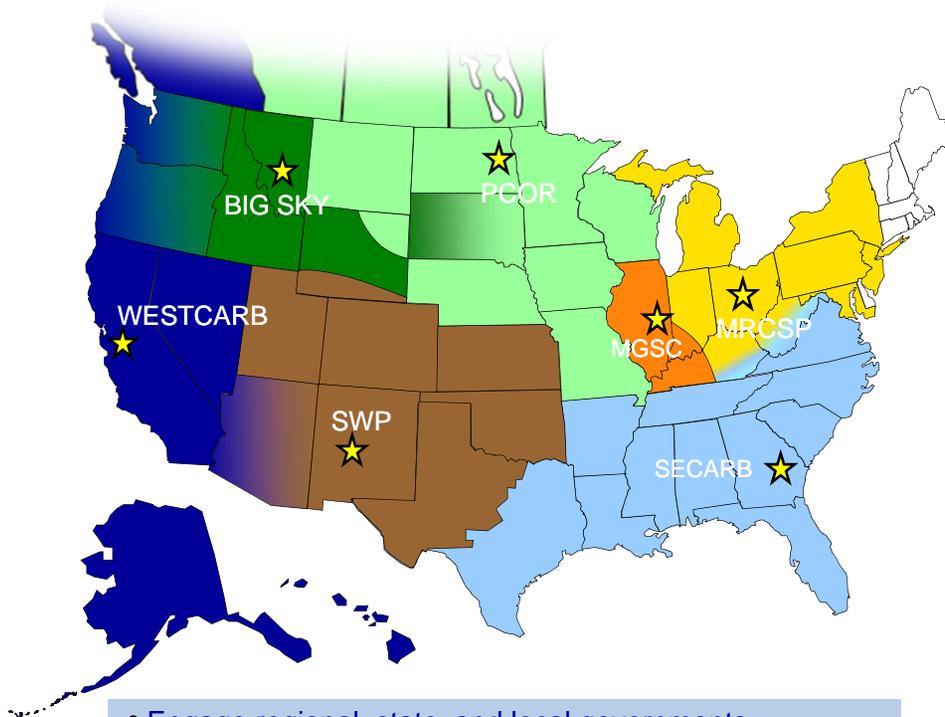
Regional Carbon Sequestration Partnerships

Developing the Infrastructure for Wide Scale Deployment

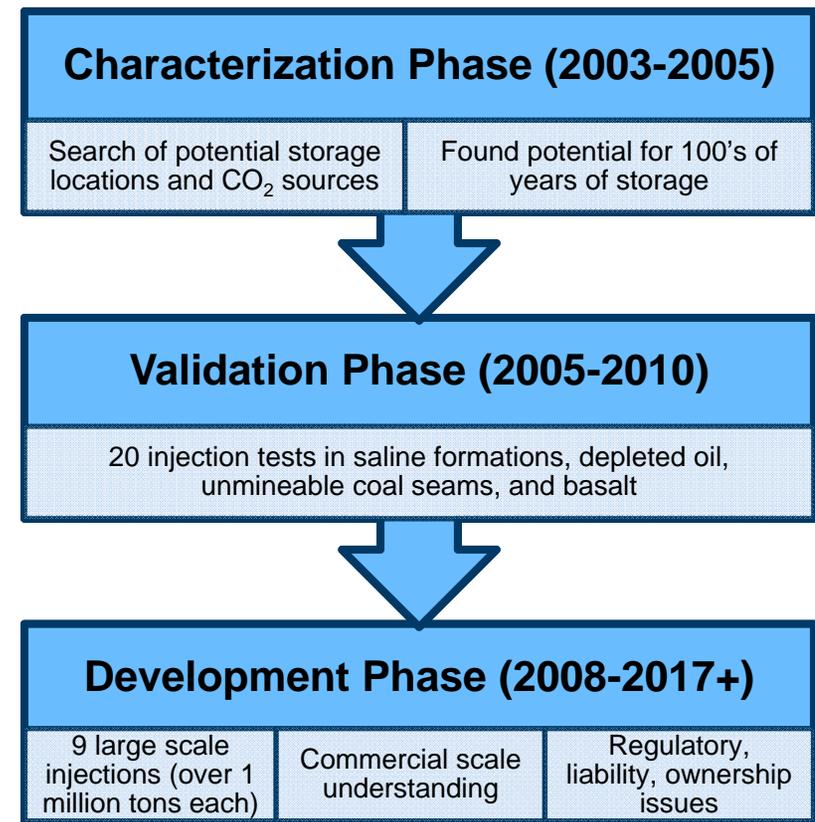
(Source : US DOE)

Seven Regional Partnerships

400+ distinct organizations, 43 states, 4 Canadian Provinces

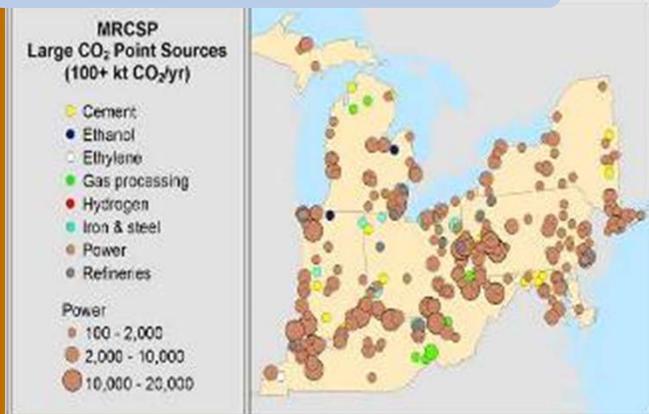


- Engage regional, state, and local governments
- Determine regional sequestration benefits
- Baseline region for sources and sinks
- Establish monitoring and verification protocols
- Address regulatory, environmental, and outreach issues
- Validate sequestration technology and infrastructure



MRCSP's mission: be the premier resource for sequestration knowledge in its region

Quantifying CO₂ sources, demographics and economics in the region



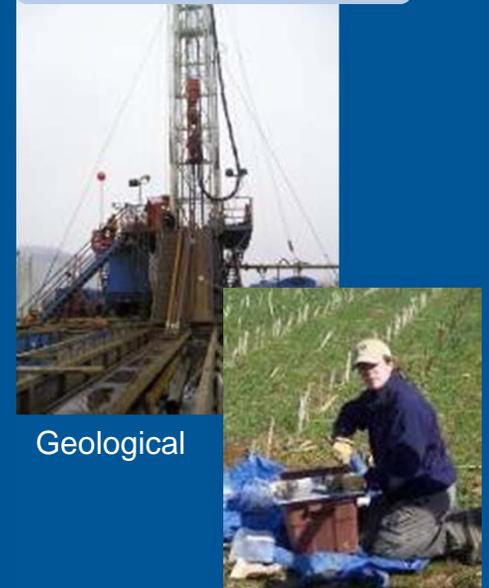
Characterization, Phase I, 2003 - 2005

Reaching Out To and Educating Stakeholders

www.mrcsp.org

Validation, Phase II, 2005 - 2009

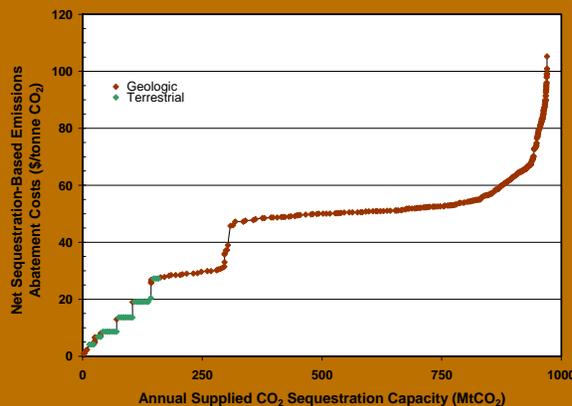
Implementation



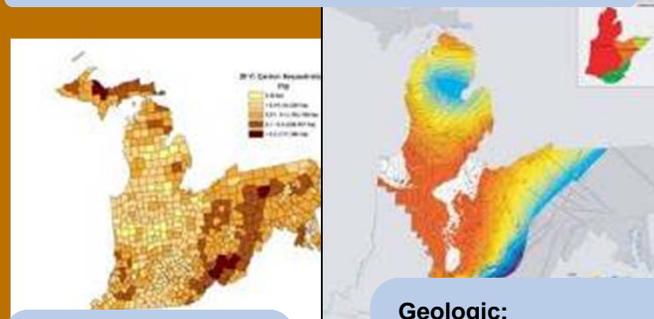
Geological

Terrestrial

Developing a Regional Model of the Economics of Sequestration



Quantifying CO₂ Sinks in the Region



Terrestrial:

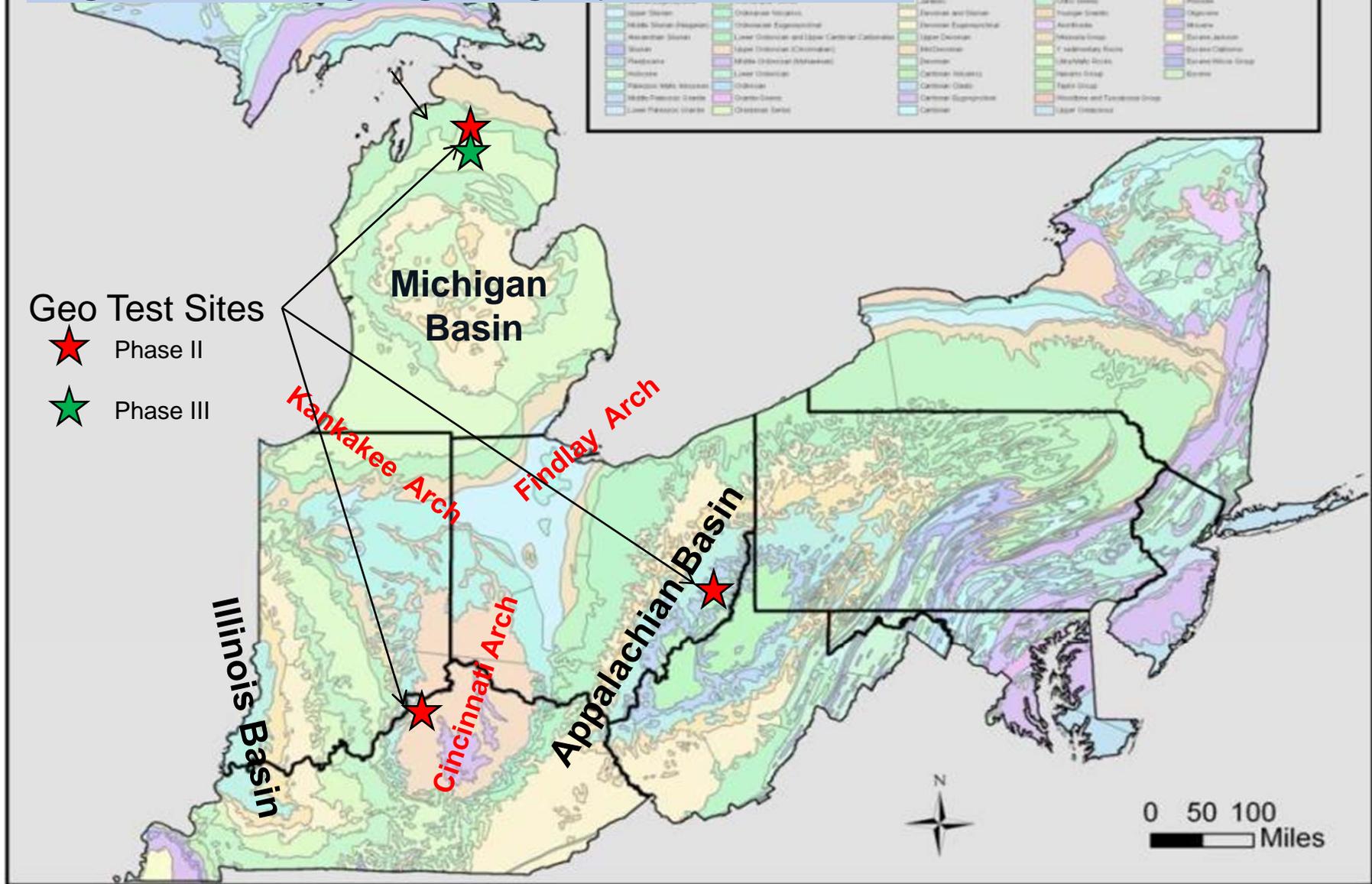
- Potential for 20% annual offset for large point sources

Geologic:

- 100s of years of capacity for large point sources in deep saline alone

MRCSP Geologic Test Sites

Aligned with major geologic provinces



MRCSP Geologic Test Sites*



Michigan Basin: DTE and Core Energy gas and oil operations, Gaylord, Michigan

- Permitting: EPA Region 5, Class V, Granted Jan 2007.
- Target: Bass Islands Dolomite, ~3500 ft
- Status: Injected 10,000 tonnes 2008. Additional 50,000 tonnes injected February-July 2009
- Host: DTE Energy, Core Energy

Appalachian Basin: FirstEnergy's RE Burger Power Plant, Shadyside, Ohio

- Permitting: Ohio EPA, Class V, Granted Sep 2008
- Target: Oriskany, Salina, and Clinton, 6500-8000 ft
- Status: Injection testing completed, reporting underway
- Host: FirstEnergy

Cincinnati Arch -- Mount Simon: Duke's East Bend Power Station, Rabbit Hash, Kentucky

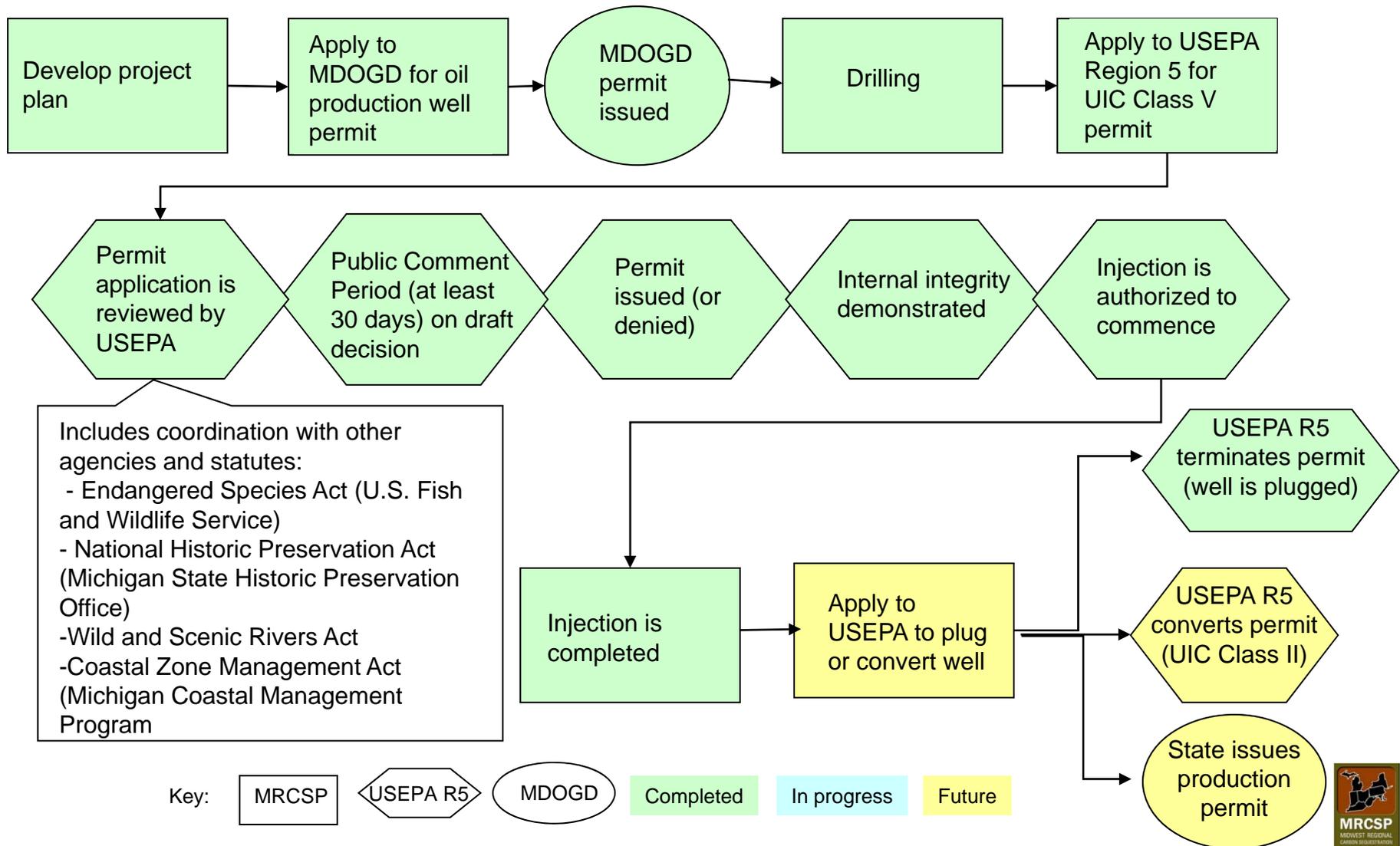
- Permitting: EPA Region 4, Class V, Granted Feb 2009.
- Target: Mt. Simon Sandstone, 3,500 ft
- Status: Drilling Jun 2009, Injection completed Sep 2009
- Host: Duke Energy

Large Scale (1 million tonnes of CO₂) Phase III Site

- Candidate site under evaluation

* All deep saline tests

Battelle has Completed Injection Permits for Several Sites - MRCSP Michigan Example



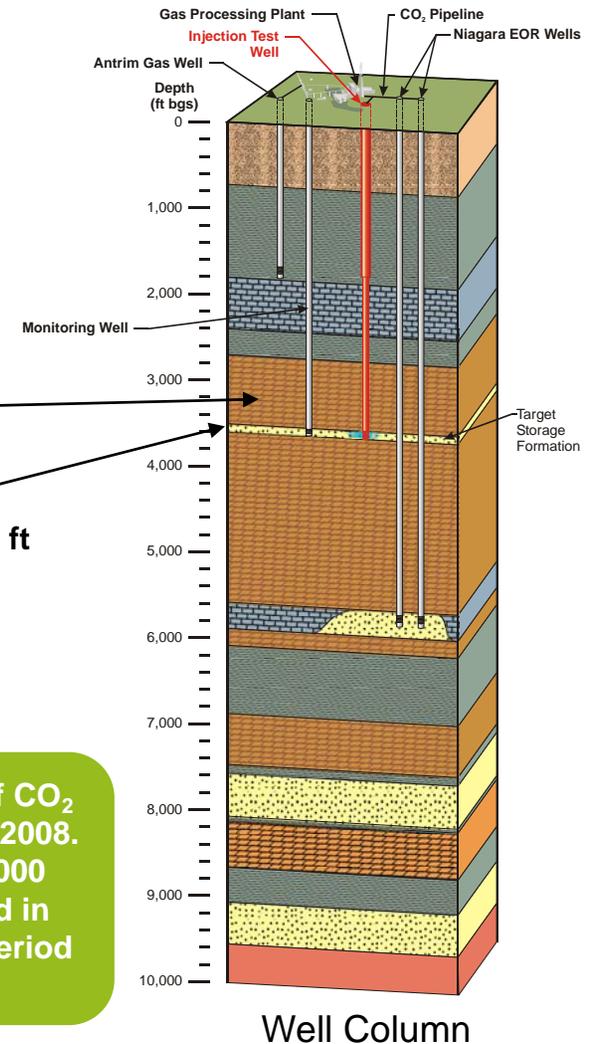
Michigan Basin, Gaylord, Michigan

Leverages existing EOR infrastructure from DTE and Core Energy

Gas processing plant,
source of pure CO₂



600 T/d Compressor



5000 Foot Deep Test Well
Drilled in November 2006

Confining Layer:
Amherstburg Limestone

Injection Target:
Bass Islands Dolomite 3,500 ft

Injection
well head

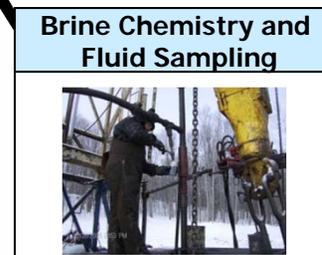
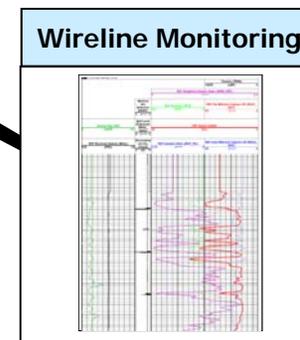
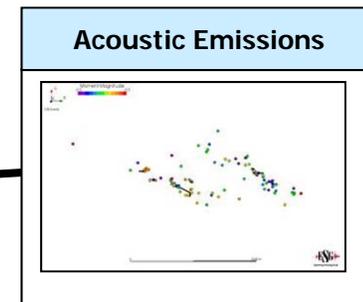
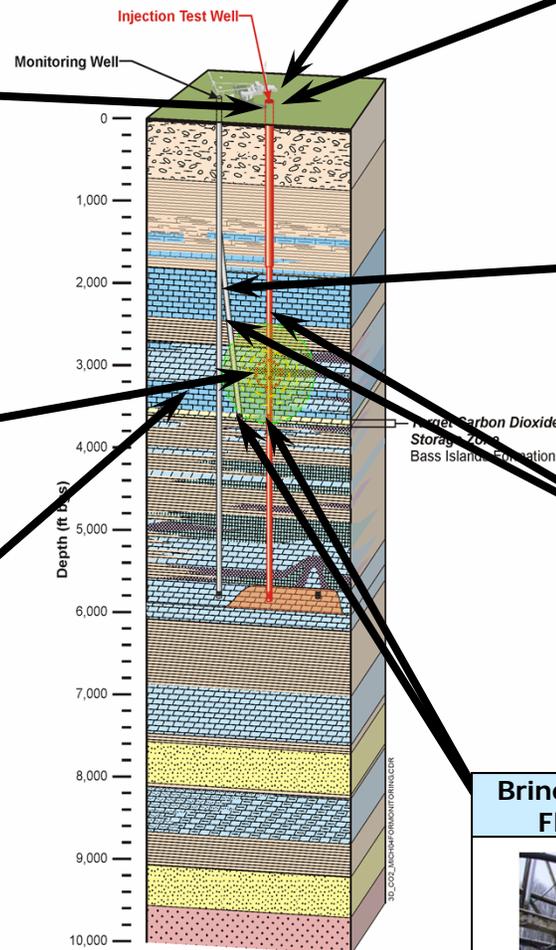
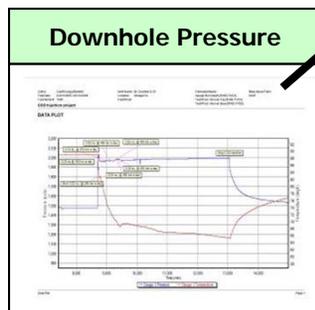
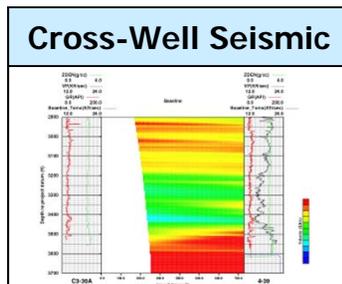
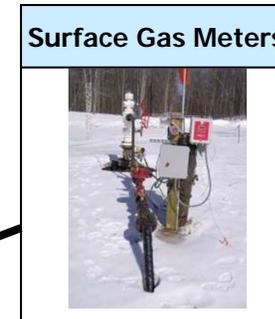
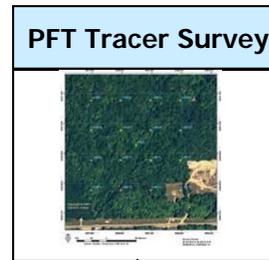
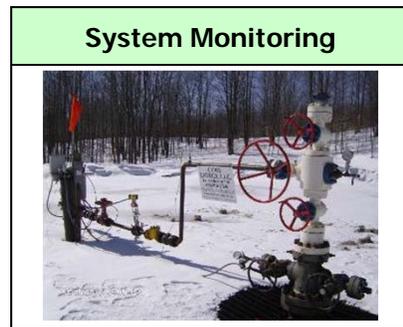


10,000 tonnes of CO₂
injected in early 2008.
Additional 50,000
tonnes injected in
February-July period
of 2009.



180 feet of core taken

Michigan Monitoring Portfolio



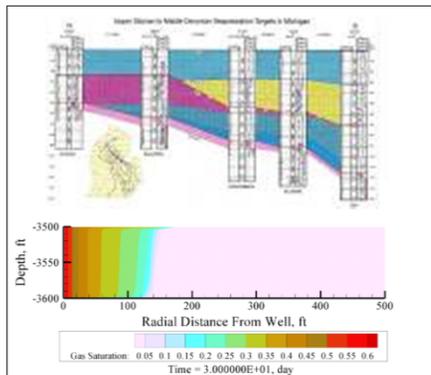
NOT TO SCALE
ALL LOCATIONS ARE APPROXIMATE



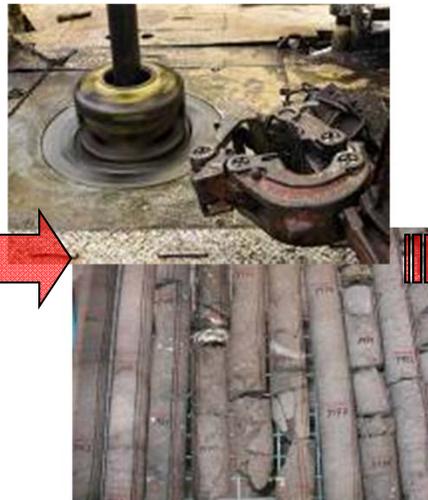
MRCSP Michigan Site, Simulation and Monitoring

STOMP_{CO2} simulations were calibrated to test data to improve model capabilities and demonstrate confidence in reservoir models.

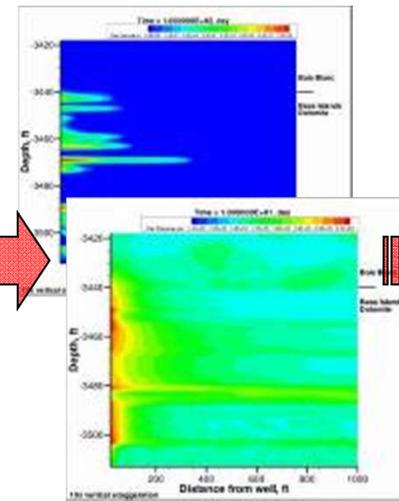
Preliminary Modeling Based on Regional Data



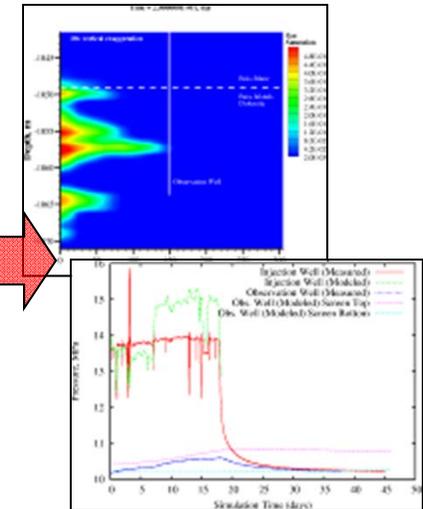
Site Drilling & Testing



Site Specific Modeling



Calibration to Monitoring Data



Measured vs predicted results from falloff test

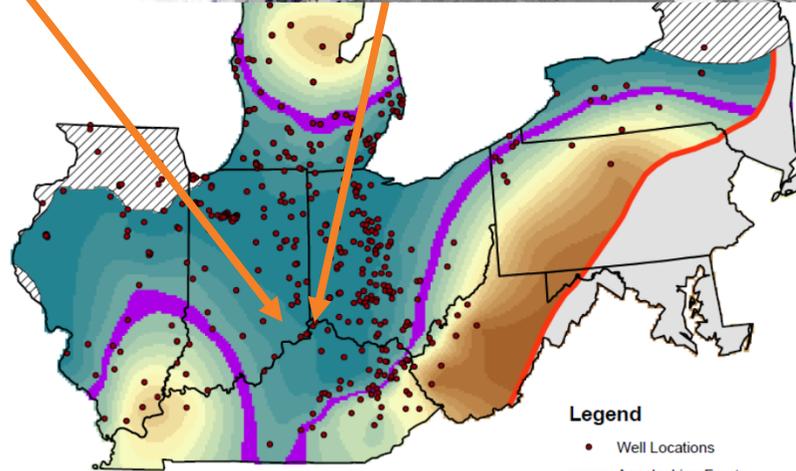
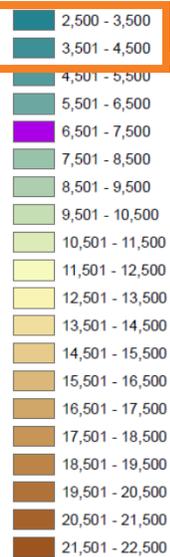
- Monitoring includes: Crosswell seismic, Microseismic, PFT tracers, Fluid sampling, Pressure and Temperature
- Measured results correlate well with model
- Permeability higher than predicted

Cincinnati Arch Site East Bend Station, Duke Energy

1,000 tonnes CO₂ injected in 2009.



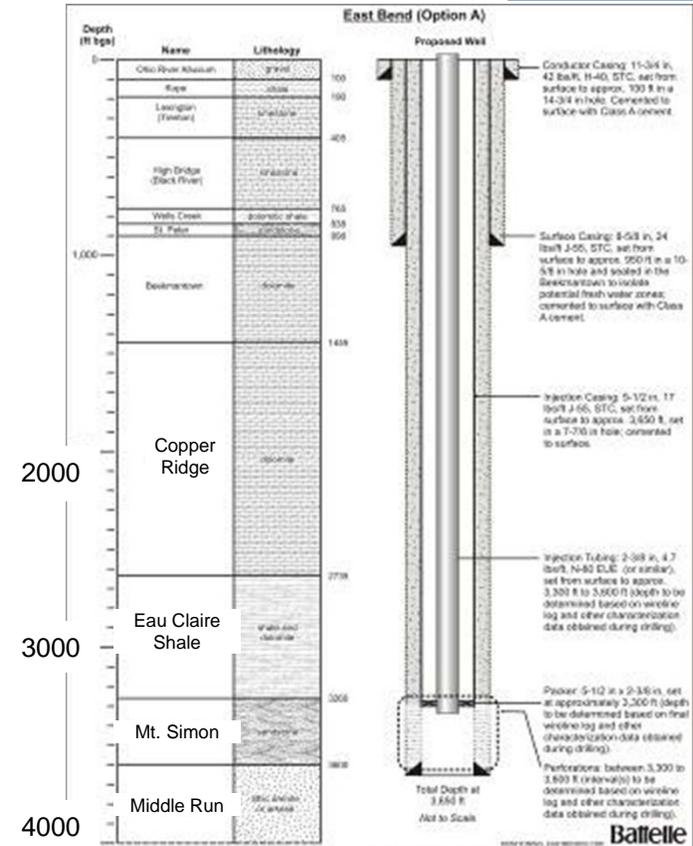
Mount Simon sandstone
Depth (ft)



0 62.5 125 250 375 500 Kilometers

Legend

- Well Locations
- Appalachian Front
- ▨ Shallower than 2,500 ft.
- ▭ East of Front



1 | Lithology below Ridge formation based on interpretation of log data from the Cecil Cove well, Boone County, KY, by Stiles-Arcos et al. (2005) and data from other wells in the area (Stiles, Snow, Collins). Depths were adjusted for difference in land surface elevation of the test site.

Proactive Outreach was Key to Successful Execution at Each Site

