

# Field Testing for CO<sub>2</sub> Geologic Storage

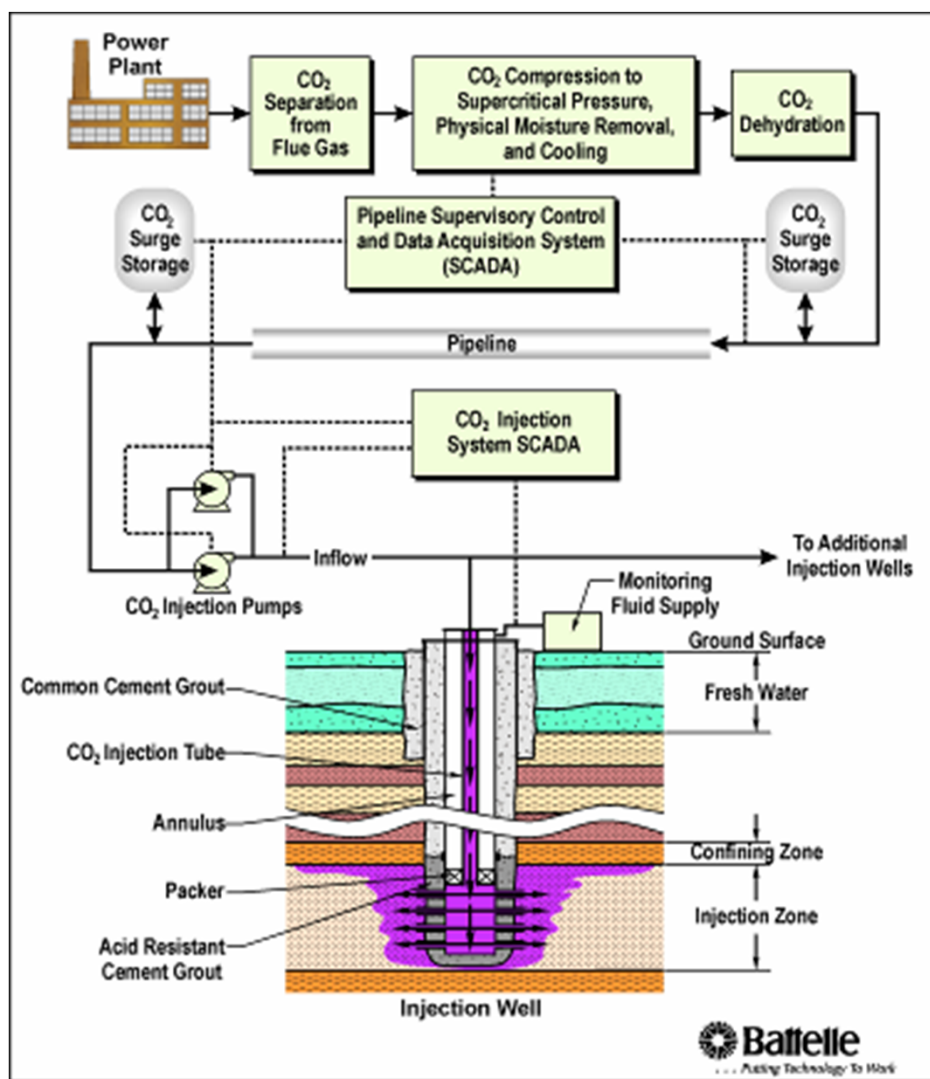
**Battelle**  
The Business of Innovation

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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 CO<sub>2</sub> transport properties
- Process optimization and integration
- System design support
  - Compression and processing
  - Pipeline transport
- Monitoring (inspection, corrosion analysis etc.)

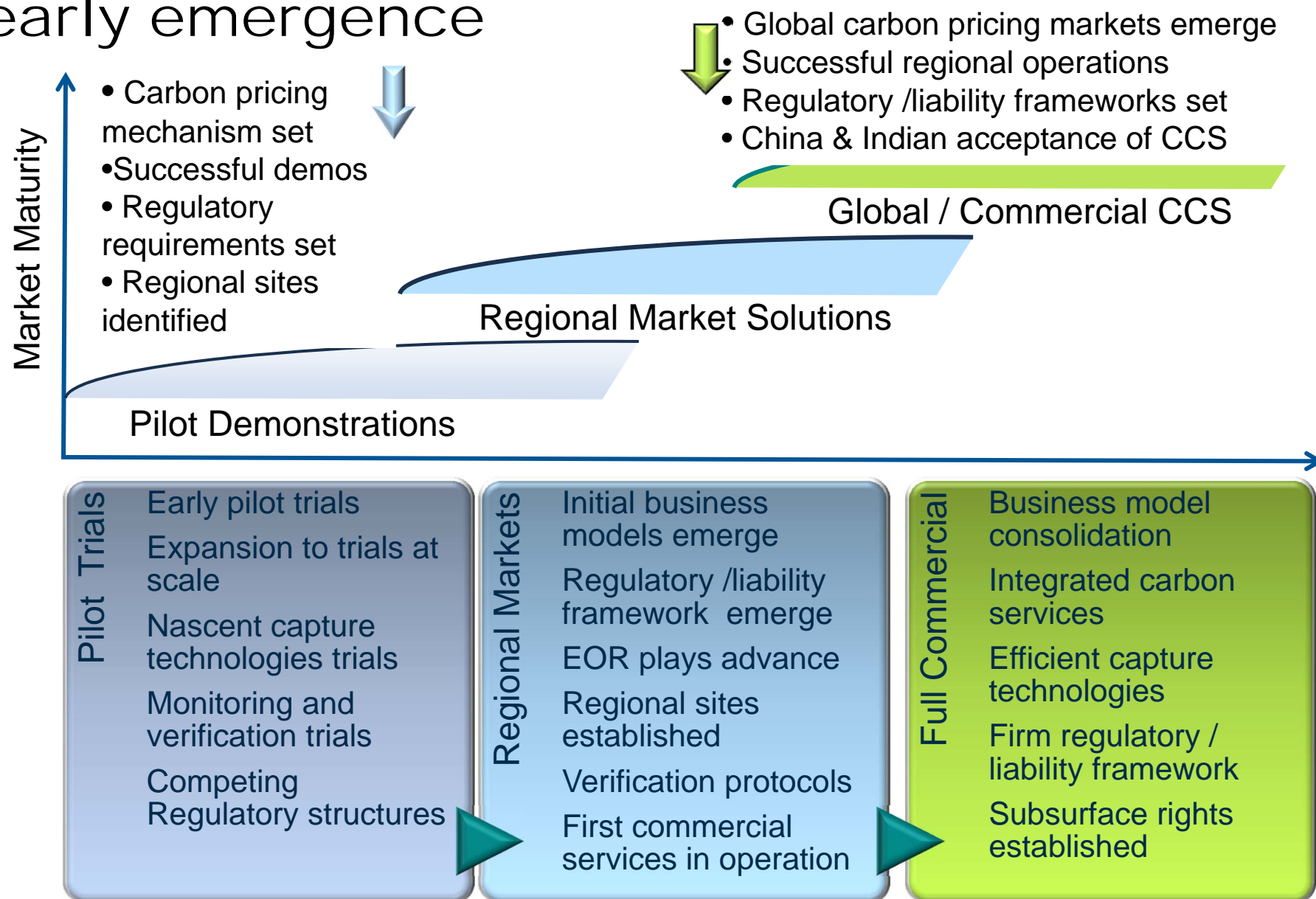
## Subsurface and Injection

- 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

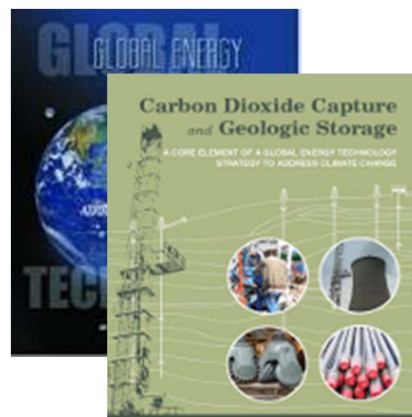
## Mountaineer



## FutureGen



## DOE Regional Partnership Program



## Global Energy Technology Strategy Program (GTSP)

## Direct Industry Support

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



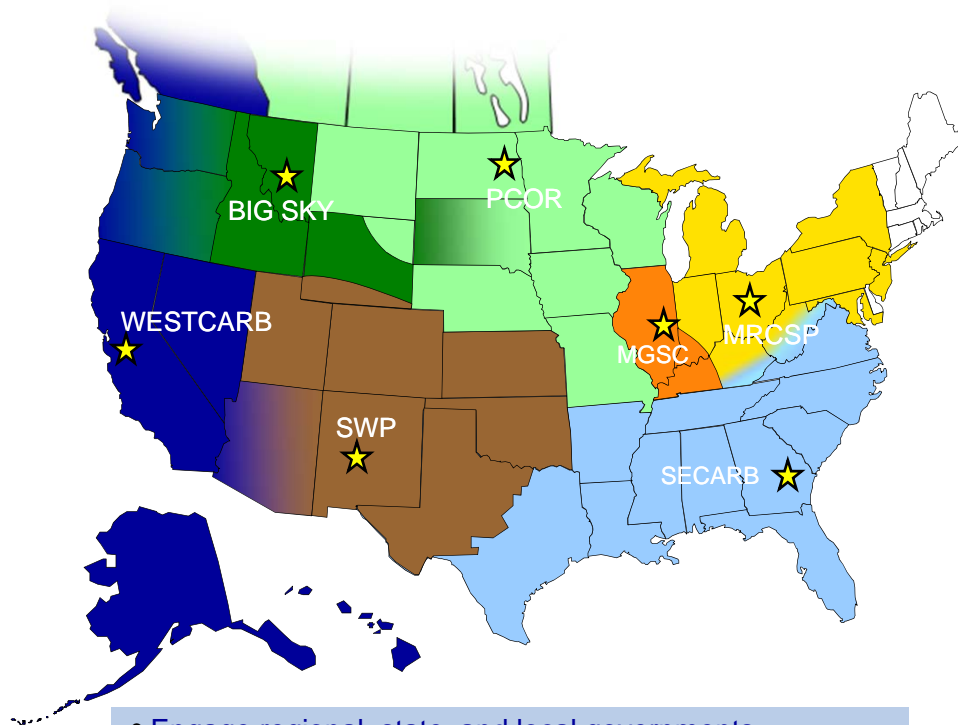
# Regional Carbon Sequestration Partnerships

## *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

#### Characterization Phase (2003-2005)

Search of potential storage locations and CO<sub>2</sub> sources

Found potential for 100's of years of storage

#### Validation Phase (2005-2010)

20 injection tests in saline formations, depleted oil, unmineable coal seams, and basalt

#### Development Phase (2008-2017+)

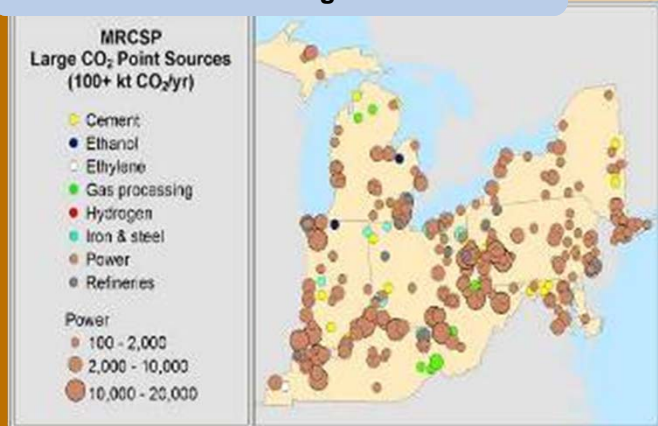
9 large scale injections (over 1 million tons each)

Commercial scale understanding

Regulatory, liability, ownership issues

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

## Quantifying CO<sub>2</sub> sources, demographics and economics in the region



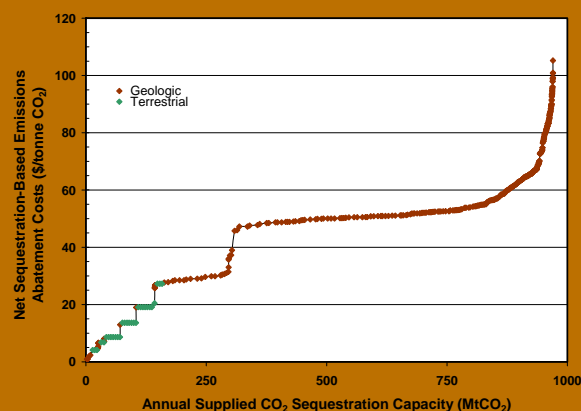
## Characterization, Phase I, 2003 - 2005

### Reaching Out To and Educating Stakeholders

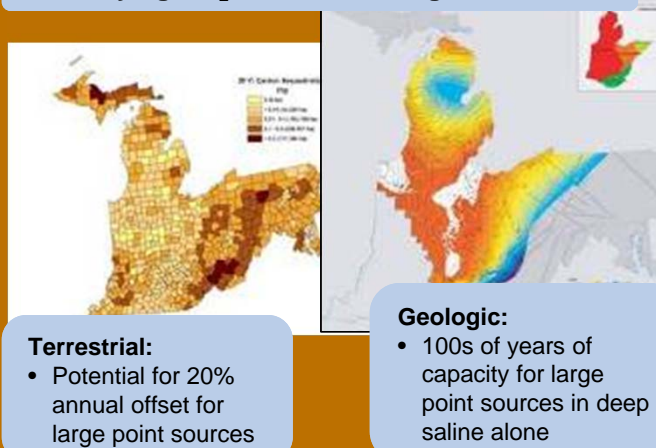


[www.mrcsp.org](http://www.mrcsp.org)

## Developing a Regional Model of the Economics of Sequestration

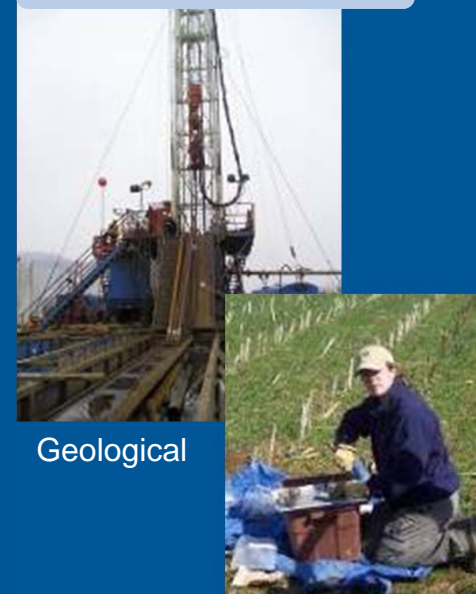


## Quantifying CO<sub>2</sub> Sinks in the Region



## Validation, Phase II, 2005 - 2009

### Implementation



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 CO<sub>2</sub>) Phase III Site**

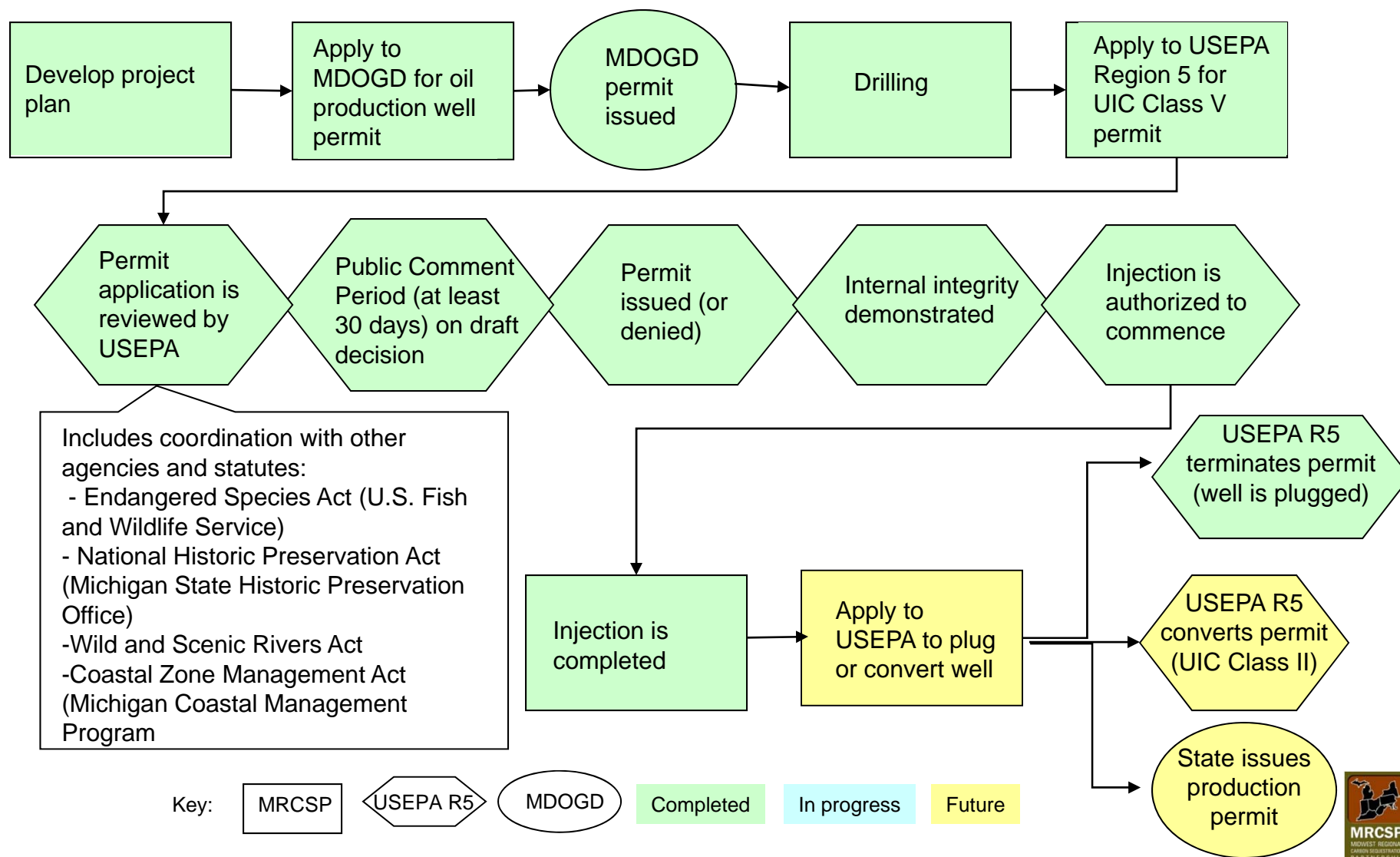
- Candidate site under evaluation

\* All deep saline tests





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



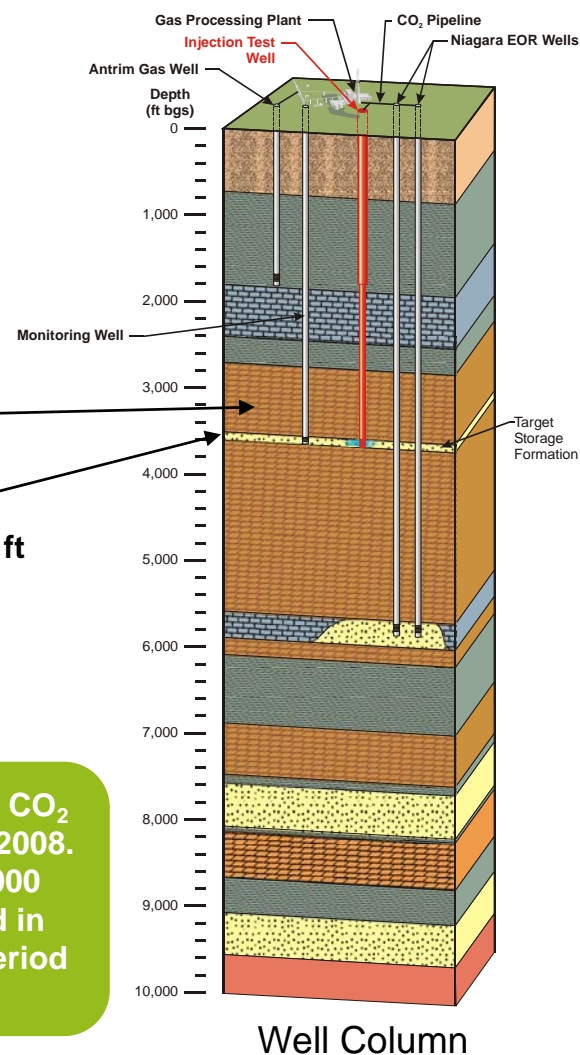
# Michigan Basin, Gaylord, Michigan

Leverages existing EOR infrastructure from DTE and Core Energy

Gas processing plant,  
source of pure CO<sub>2</sub>



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

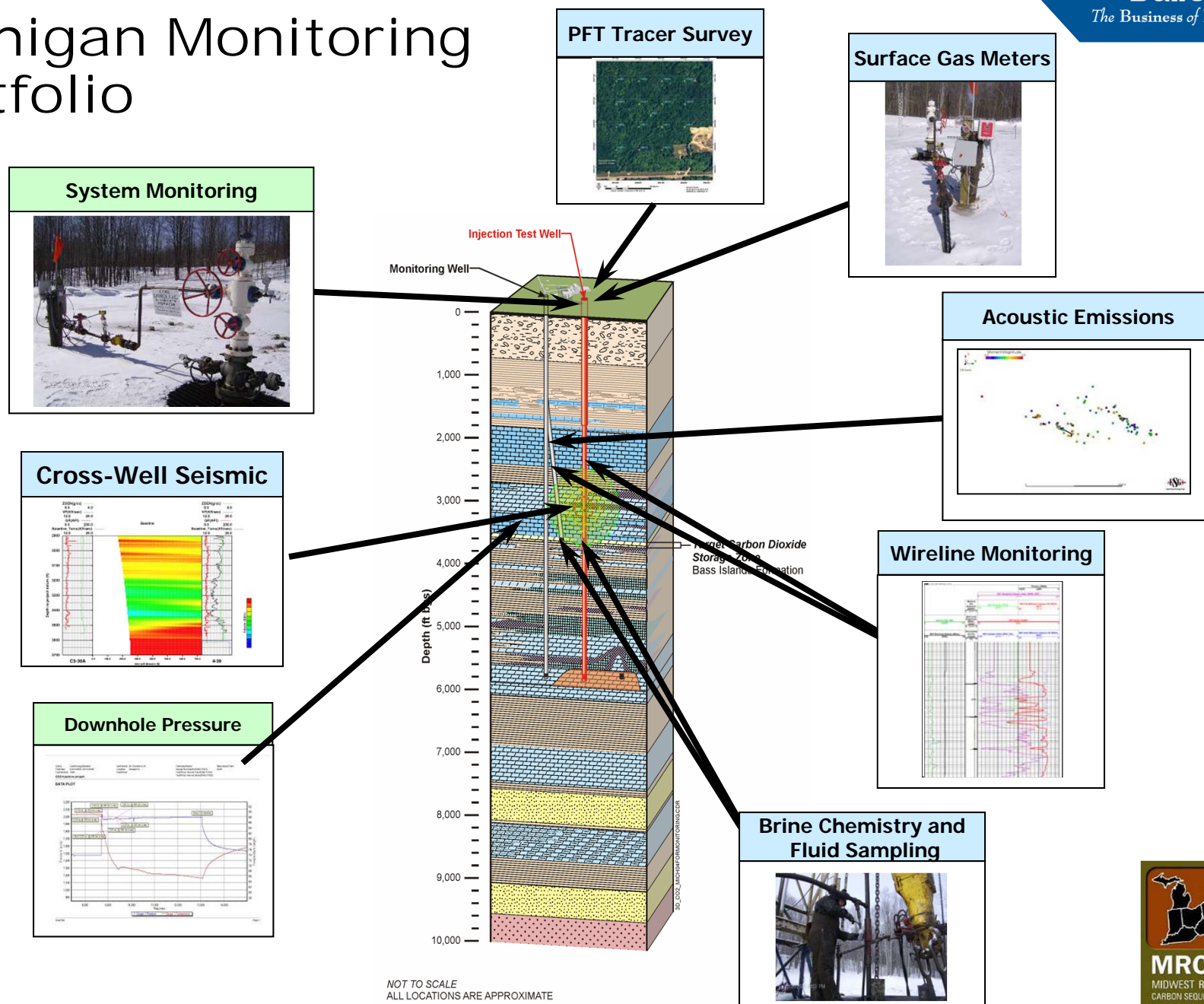


10,000 tonnes of CO<sub>2</sub>  
injected in early 2008.  
Additional 50,000  
tonnes injected in  
February-July period  
of 2009.



180 feet of core taken

# Michigan Monitoring Portfolio

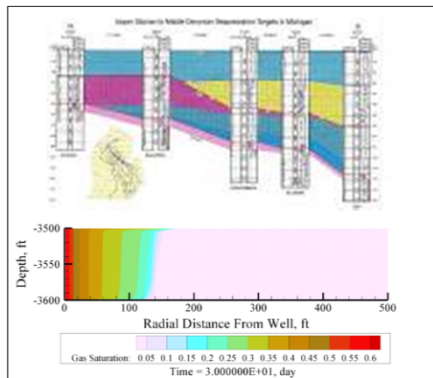




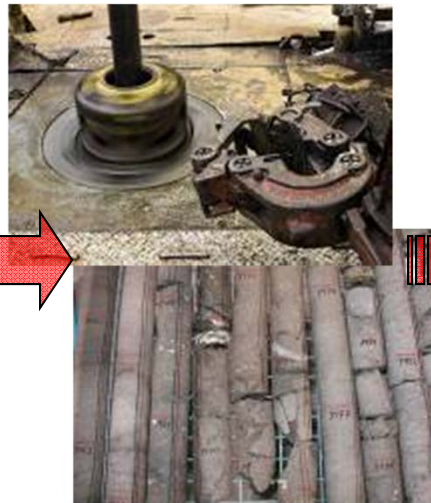
# MRCSP Michigan Site, Simulation and Monitoring

*STOMP<sub>CO2</sub> simulations were calibrated to test data to improve model capabilities and demonstrate confidence in reservoir models.*

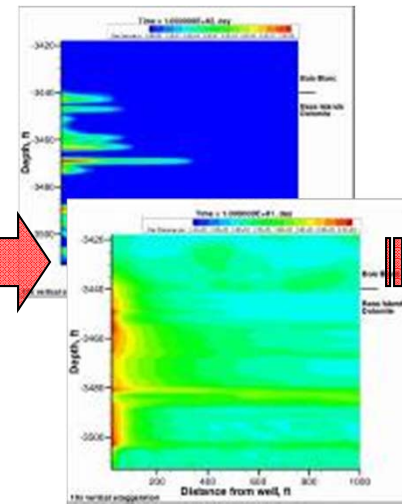
## Preliminary Modeling Based on Regional Data



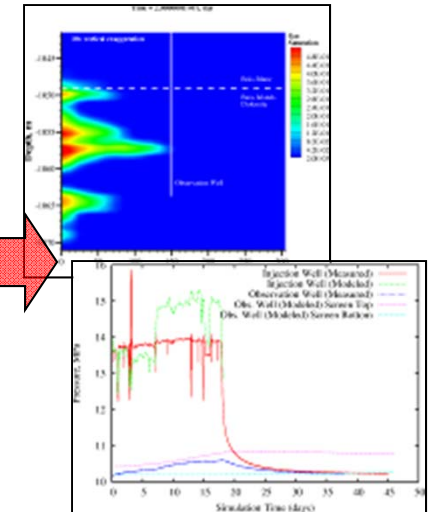
## Site Drilling & Testing



## Site Specific Modeling



## Calibration to Monitoring Data



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

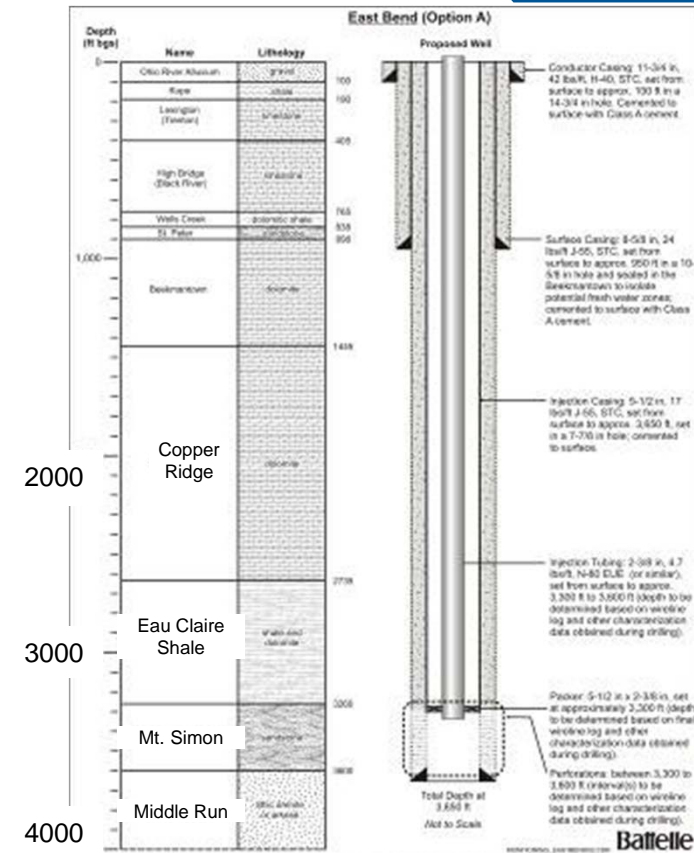
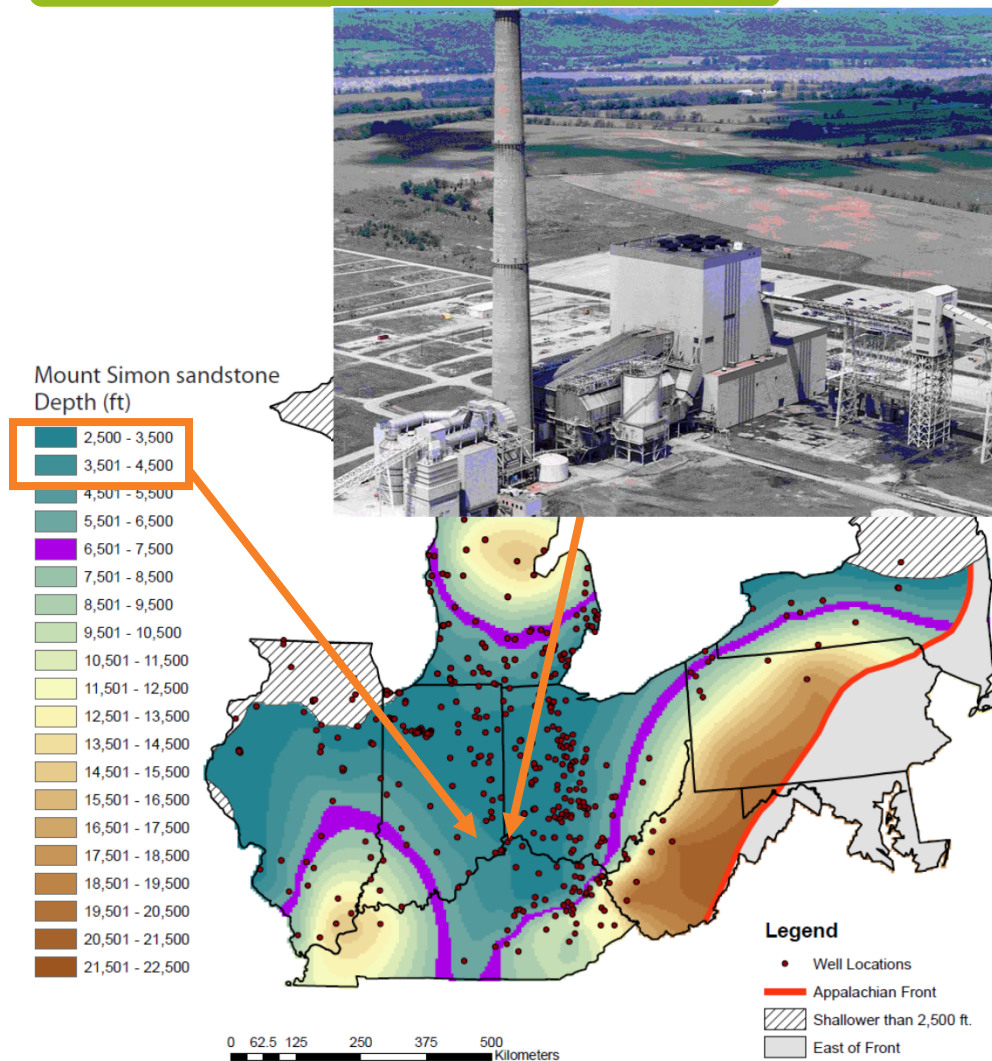
Measured vs predicted  
results from falloff test



# Cincinnati Arch Site

## East Bend Station, Duke Energy

1,000 tonnes CO<sub>2</sub> injected in 2009.



# Proactive Outreach was Key to Successful Execution at Each Site

