Carbon Storage R&D Project Review Meeting
Pittsburgh, PA

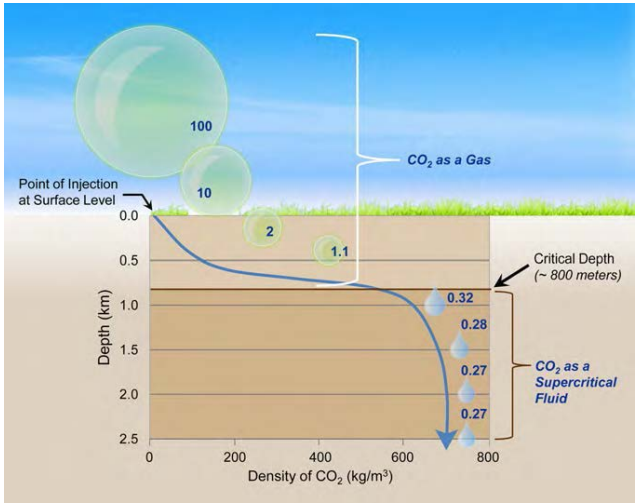
Bruce M. Brown

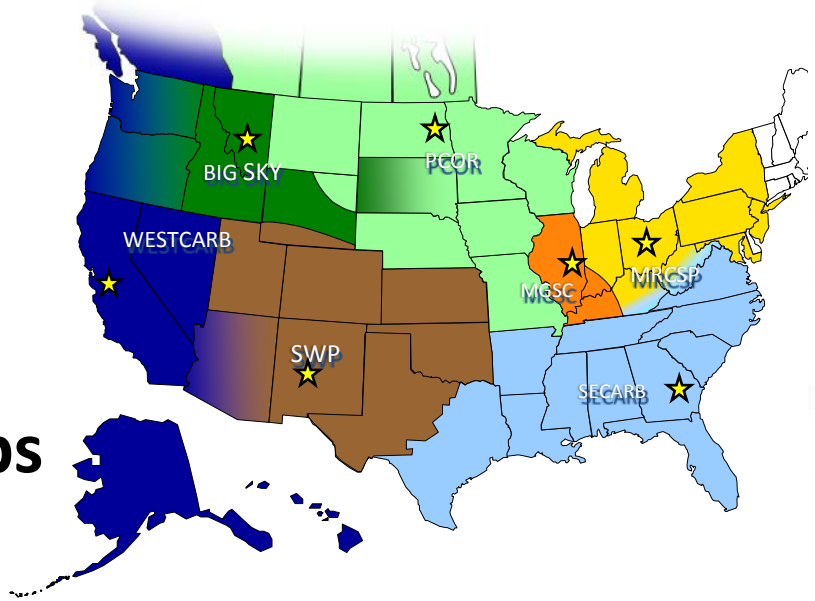
Infrastructure and Partnership Coordinator

August 20, 2013

Overview

- DOE Carbon Storage Program
- Core R&D
- Regional Partnerships





BIG SKY CARBON SEQUESTRATION PARTNERSHIP

MGSC

MRCSP MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

PCOR Partnership

SECARB Southeast Regional Carbon Sequestration Partnership

SWP

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP westcarb.org

SEC Office of Coal and Power R&D

Core Program Components Total FY 2013 Funding $317.5 Million

- **Carbon Capture - $65.6 Million**
- **Carbon Storage - $109.9 Million**
- **Advanced Energy Systems- $95.2 Million**
  - Advanced Combustion Systems - $15.2 Million
  - Gasification - $37.1 Million
  - Hydrogen Turbines - $14.3 Million
  - Solid Oxide Fuel Cells - $23.8 Million
  - Coal & Coal Biomass to Liquids - $4.8 Million
- **Cross Cutting Research - $46.8 Million**

FY13 total budget reflects Sequestration and

Across the Board Rescission

Carbon Storage Program

2013 Program Funding Statistics

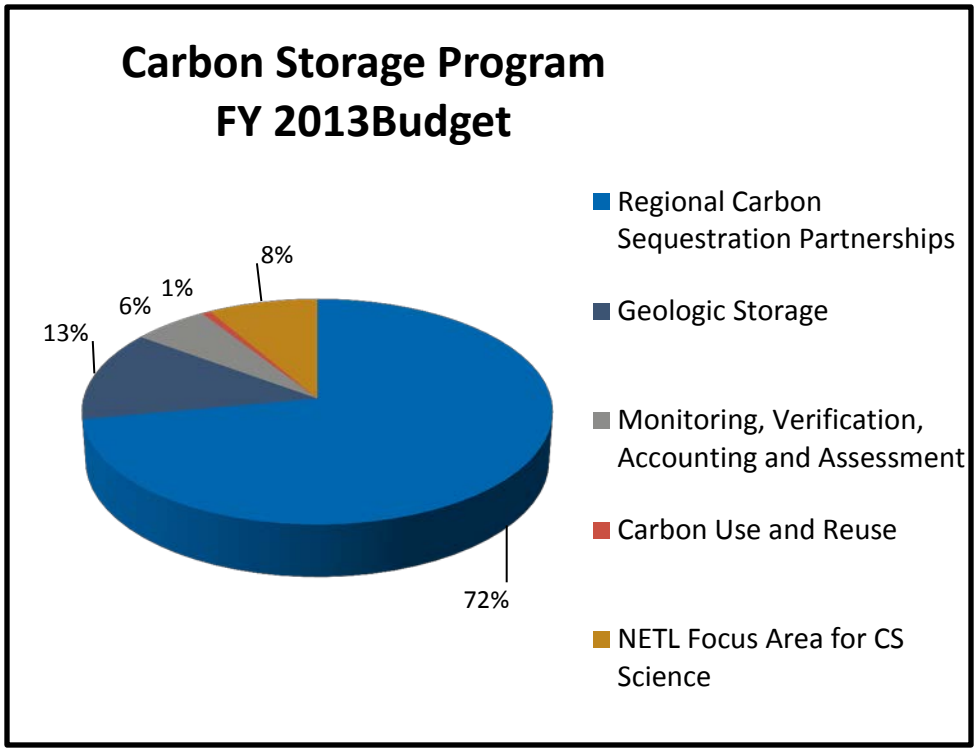
Regional Carbon Sequestration Partnerships* ($79.233M)

- *Large Scale Tests*
- *Small Scale Tests*
- *NATCARB*

Core R&D Research

- *Geologic Storage and Simulation Risk Technologies ($14.252M)*
- *MVA ($6.412M)*
- *CO_2 Use and Reuse ($0.740M)*

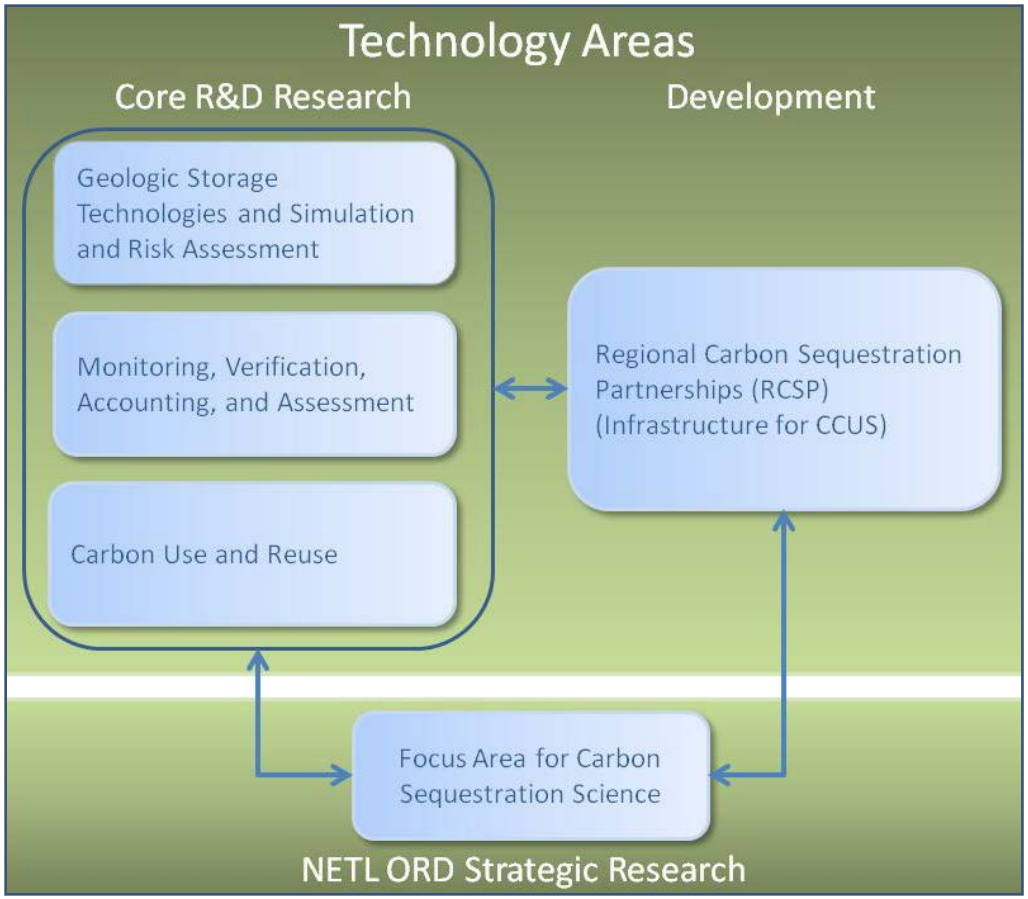
Focus Area for CS Science (NETL ORD) ($9.256M)



Carbon Storage Program

Total Base Program Value is $1.06 B – over 100 Projects

Additional Total Awarded ARRA Projects $160 M – 60 projects



Program Goals

99% Storage Permanence
Improve Storage Efficiency
Estimate Capacity +/- 30%
Best Practices Manuals

Benefits

Mitigate GHG Emissions
Credits for CO_2 Storage
Increased Oil/NG Recovery
Reduce Capital and O&M Costs
Reduce Environmental Footprint

Carbon Storage Program

Core R&D Key Technology Areas (TRL 2-5)

Geologic Storage Technology Area

(Storage Technologies and Simulation and Risk Assessment)

- **Wellbore** *construction and materials*
- **Mitigation** *technologies for wells and natural pathways*
- **Fluid flow, reservoir pressure, and water management**
- **Geochemical** *effects on formation, brine, and microbial communities*
- **Geomechanical** *impacts on reservoirs- seals and basin-scale coupled models; microseismic monitoring*
- **Risk Assessment** *databases and integration into operational design and monitoring*

MVAA Technology Area

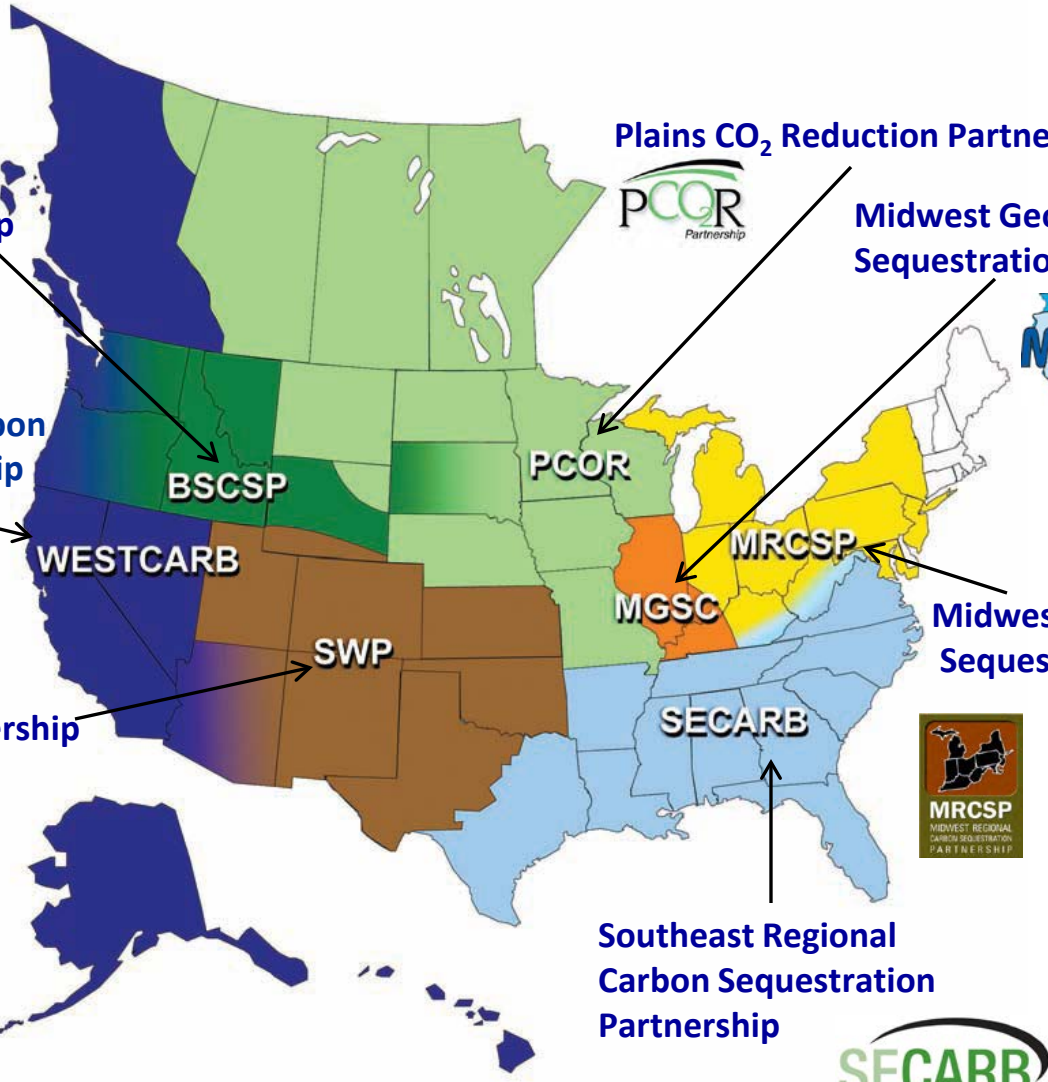
- **Atmospheric Monitoring** *and remote sensing technologies*
- **Near -Surface Monitoring** *of soils and vadose zone*
- **Subsurface Monitoring** *in and near injection zone*
- **Intelligent Monitoring Systems** *for field management*

CO_2 Use/Reuse Technology Area

- **Chemicals**
- **Polycarbonate plastics**
- **Minerals and cements (building products)**
- **EOR, EGR, and ECBM**

Regional Carbon Sequestration Partnerships

Developing the Infrastructure for Wide Scale Deployment



Big Sky Carbon Sequestration Partnership

West Coast Regional Carbon Sequestration Partnership

Southwest Regional Partnership on Carbon Sequestration

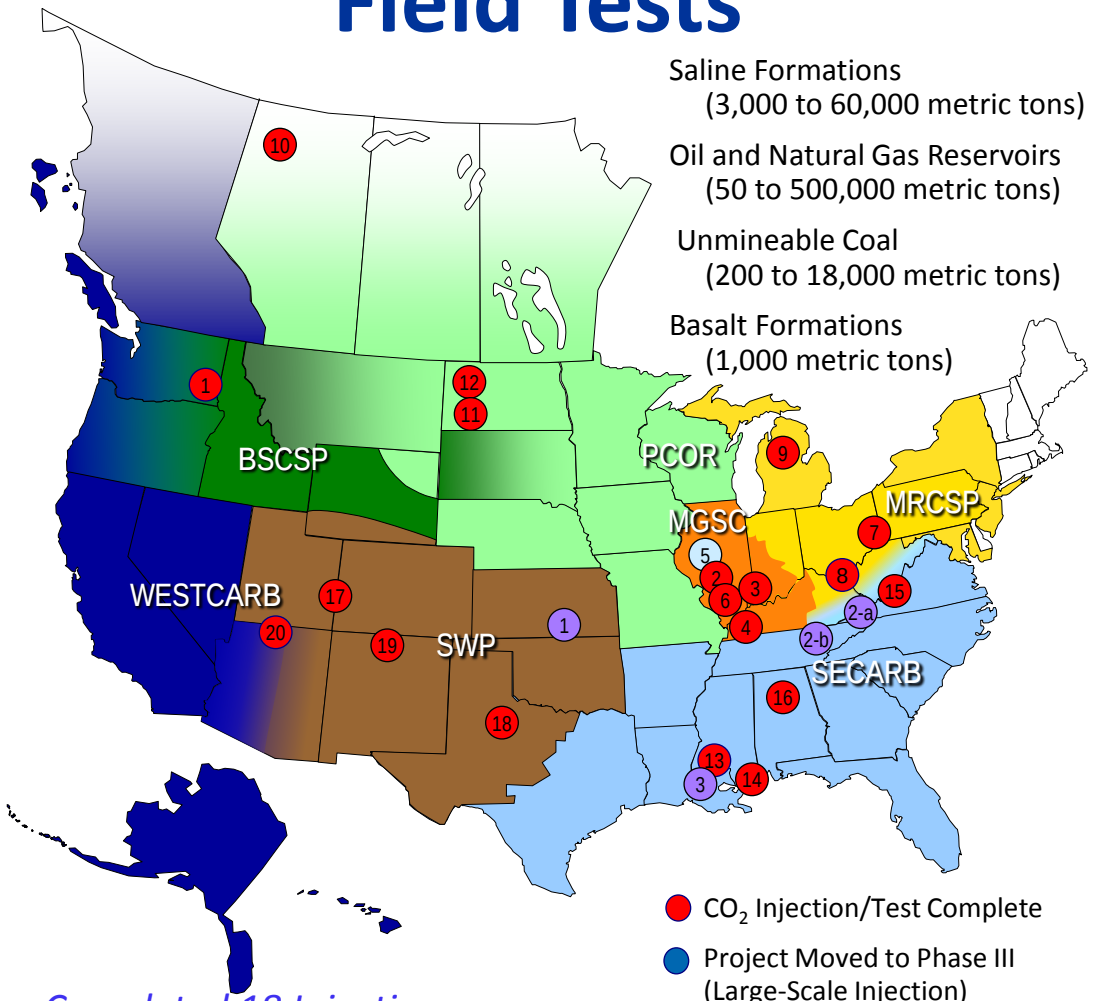
Plains CO_2 Reduction Partnership

Midwest Geological Sequestration Consortium

Midwest Regional Carbon Sequestration Partnership

Southeast Regional Carbon Sequestration Partnership

Small-Scale Geologic Field Tests



Completed 18 Injections

Over 1.35 M Tons injected

RCSP	Formation Type	Geologic Province
BIG SKY	SALINE 1	Columbia Basin
MGSC Midwest Geological Sequestration Consortium	OIL-BEARING 2 3 4 SALINE 5 COAL SEAM 6	Illinois Basin
MRCSP Midwest Regional Carbon Sequestration Partnership	SALINE 7 8 9	Cincinnati Arch, Michigan Basin, Appalachian Basin
PCOR The Plains CO_2 Reduction Partnership	OIL-BEARING 10 11 COAL SEAM 12	Keg River, Duperow, Williston Basin
SECARB Southeast Regional Carbon Sequestration Partnership	OIL-BEARING 13 SALINE 14 COAL SEAM 15 16	Gulf Coast, Mississippi Salt Basin, Central Appalachian, Black Warrior Basin
SWP Southwest Regional Partnership on Carbon Sequestration	OIL-BEARING 17 18 COAL SEAM 19	Paradox Basin, Aneth Field, Permian Basin, San Juan Basin
WESTCARB West Coast Regional Carbon Sequestration Partnership	SALINE 20	Colorado Plateau

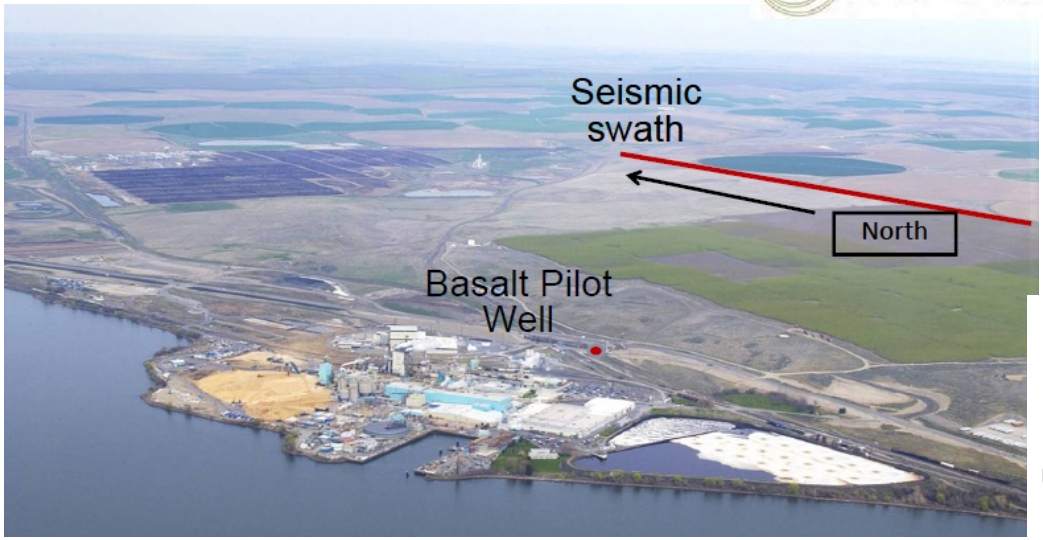
Other Small Scale Injections	Formation Type	Geologic Province
University of Kansas	OIL-BEARING & SALINE 1	Sedwick Basin
Virginia Tech	COAL SEAM 2-a ORGANIC SHALE 2-b	Appalachian Basin; Sourwood or Oakwood CBM fields
Blackhorse Energy, LLC	OIL-BEARING 3	Gulf Coast Basin; First Wilcox Sand

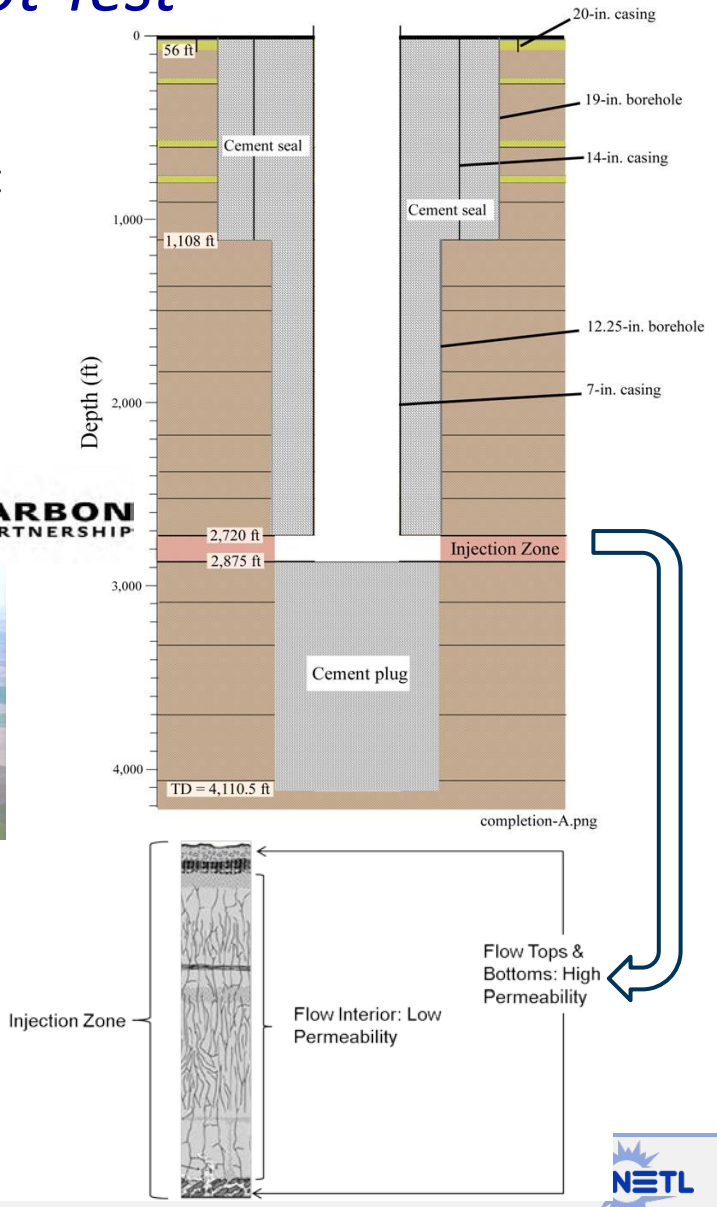
Big Sky Carbon Sequestration Partnership

Phase II – Basalt Pilot Test

- **Only basalt storage test in continental U.S.**
- **Advantages of Basalt for CO_2 storage**
  - Extensive Basalt Formations in Pacific Northwest
  - Layered storage above and below basalt flows
  - Significant potential for CO_2 mineralization
- **Host Site: Boise White Paper LLC - Wallula, WA**
- **CO_2 Injection Permit (WA Dept. of Ecology)**
  - Inject 1,000 metric tons max
- **Injection Started: July 17, 2013**

BIG SKY CARBON SEQUESTRATION PARTNERSHIP



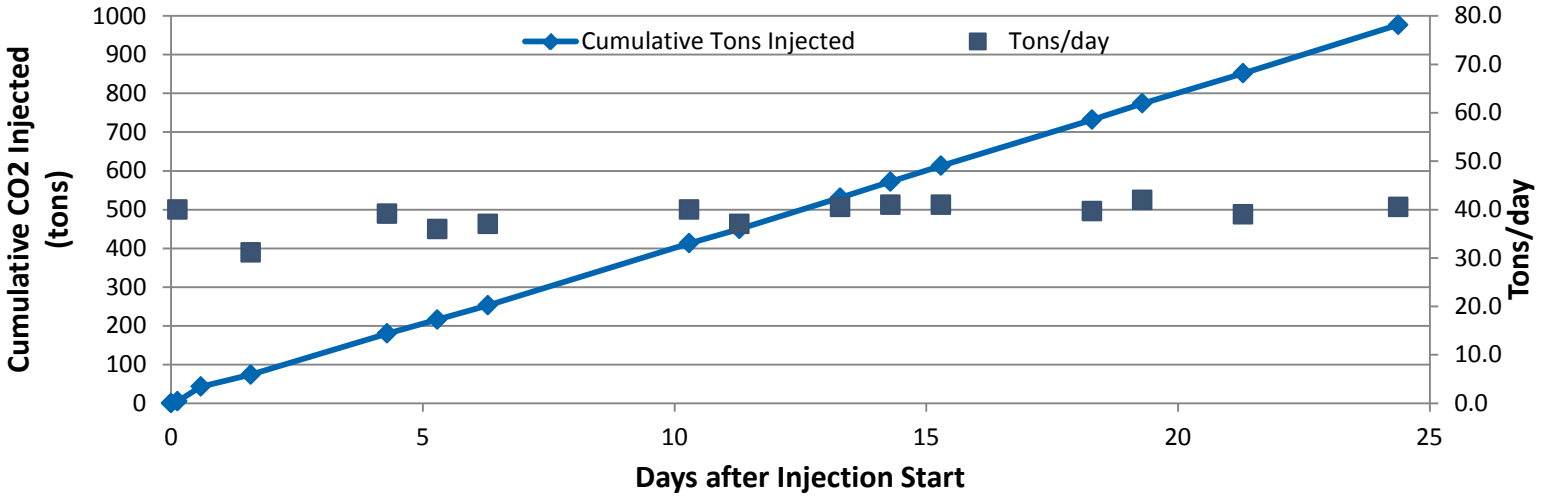


Big Sky Carbon Sequestration Partnership

Phase II – Basalt Pilot Test

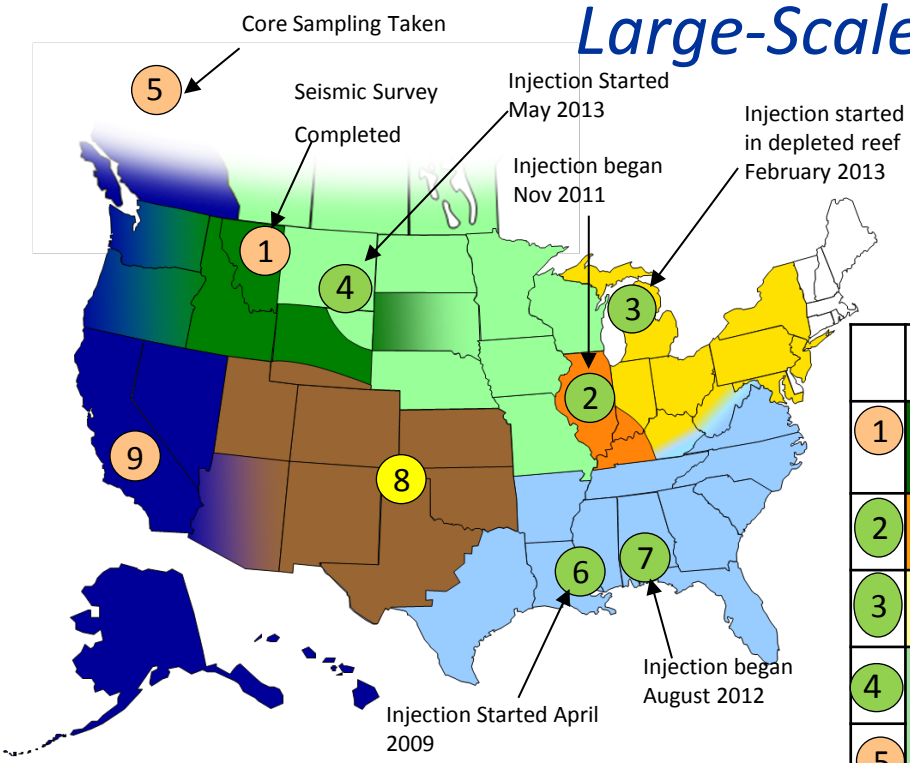
- **Injection completed August 11, 2013**
- **Total mass injected: 977 Metric Tons**
  - Intentional cutoff to avoid exceeding permit limit after final adjustments for Pressure and Temperature
- **Average injection rate ~ 40 Tons/day**
- **Downhole pressure maintained within 400 psi above baseline**
- **No operational problems or unexpected events**
- **MVA activities will continue through September 2014**

BIG SKY CARBON SEQUESTRATION PARTNERSHIP



RCSP Phase III: Development Phase

Large-Scale Geologic Tests



- Injection Ongoing
- 2013 Injection Scheduled
- Injection Scheduled 2013-2015

Note: Some locations presented on map may differ from final injection location

- ✓ *Large-volume tests*
- ✓ *Four Partnerships currently injecting CO_2*
- ✓ *Remaining injections scheduled 2013-2015*

	Partnership	Geologic Province	Injected to date
1	Big Sky	Nugget Sandstone	1,000,000
2	MGSC	Illinois Basin-Mt. Simon Sandstone	1,000,000
3	MRCSP	Michigan Basin-Niagaran Reef	1,000,000
4	PCOR	Powder River Basin-Bell Creek Field	1,500,000
5		Horn River Basin-Carbonates	2,000,000
6	SECARB	Gulf Coast – Cranfield Field- Tuscaloosa Formation	3,400,000
7		Gulf Coast – Paluxy Formation	250,000
8	SWP	Regional CCUS Opportunity	1,000,000
9	WESTCARB	Regional Characterization	

Big Sky Carbon Sequestration Partnership

Phase III Kevin Dome Site Large-Scale Storage Project

Location
- Toole County, NW Montana

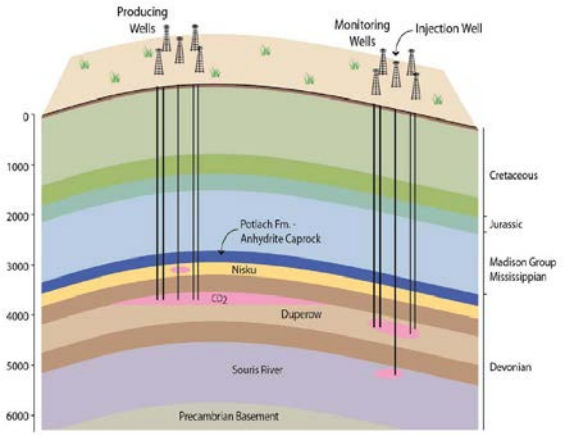
CO_2 Source
- Natural CO_2 at top of Kevin Dome

CO_2 Injection Amount
- 1 million metric tons over 4 years

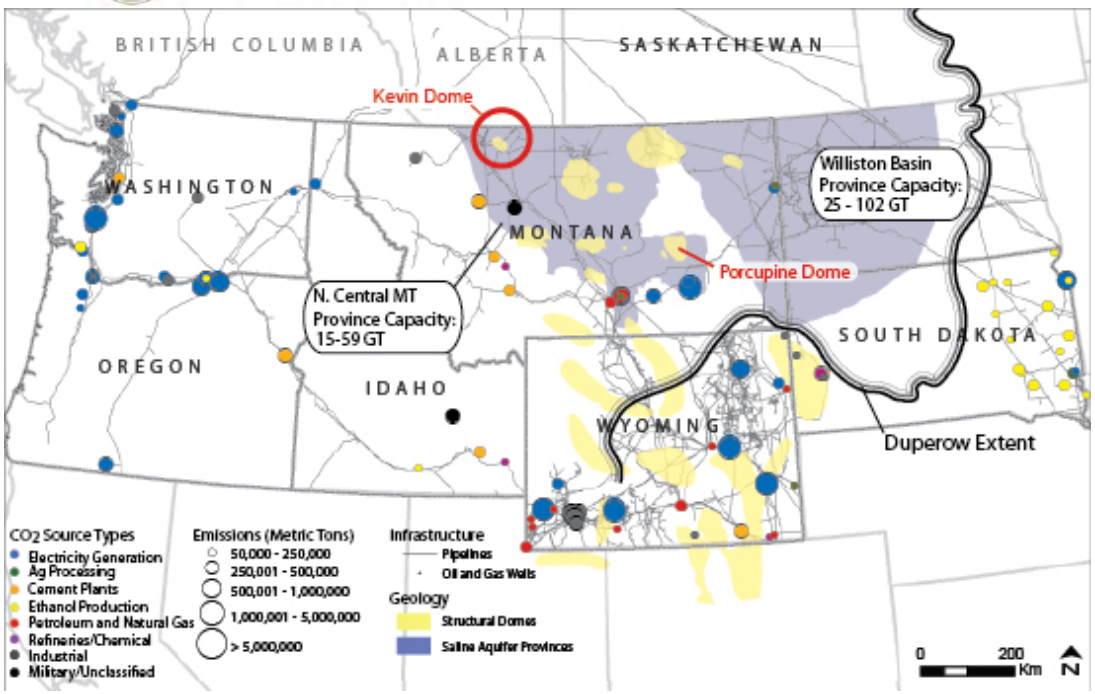
Rationale
- Regional CO_2 Storage Hub

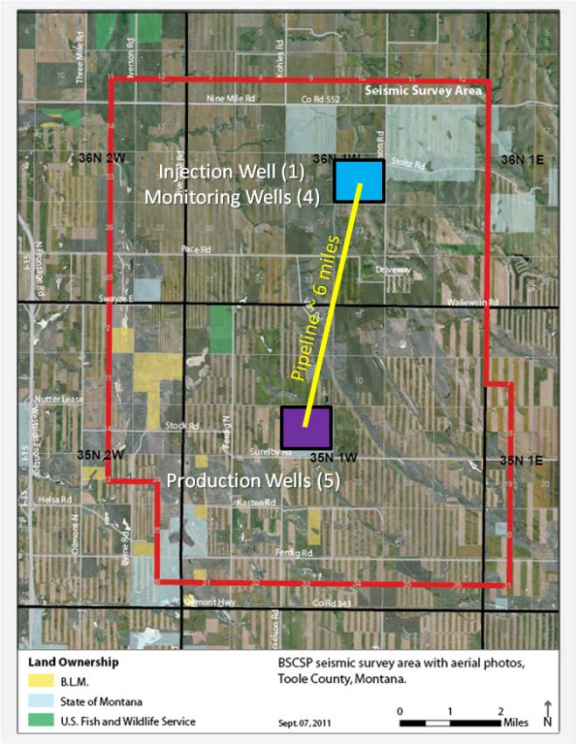
Target Formation
- Duperow Formation

Current Status
- Resolving NHPA Issues
- Preparing Permit Applications
- Injection anticipated (2013/2014)



BIG SKY CARBON SEQUESTRATION PARTNERSHIP





Midwest Geological Sequestration Consortium

Decatur Site Large-Scale Project

Target Formation

- Mt. Simon Sandstone at ~7,000 ft depth

CO_2 Source

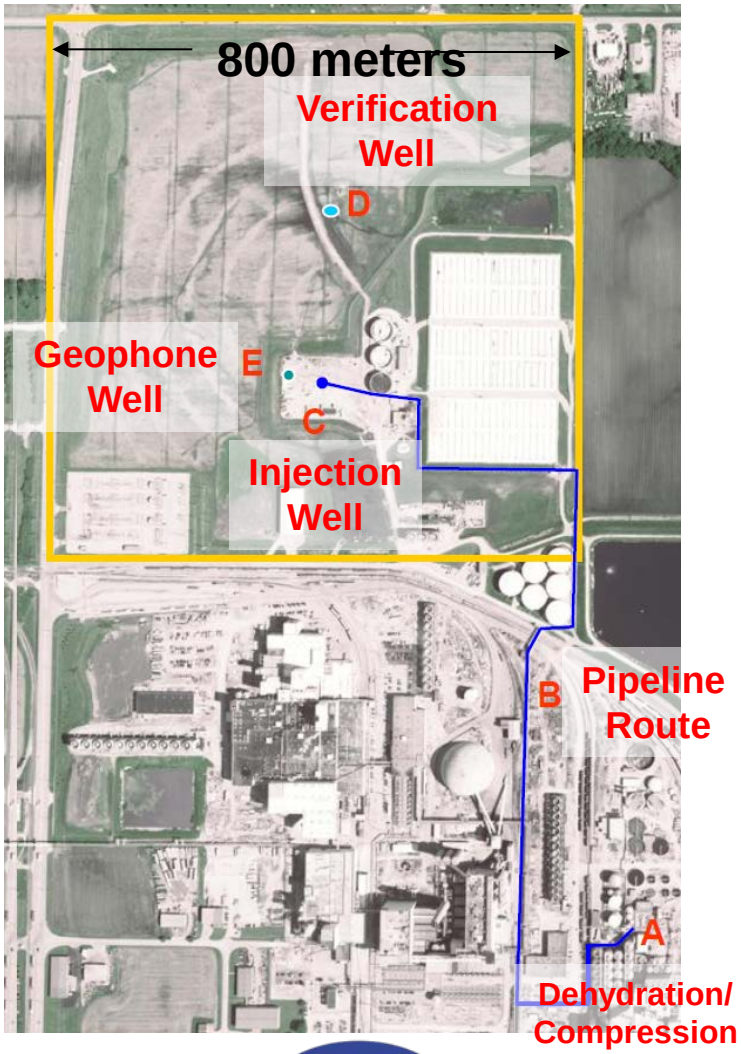
- ADM's Ethanol Production Facility

CO_2 Injection Amount

- 1 million metric tons over 3 years (17 Nov 2011 start)

Current Status

- UIC Permit finalized in March, 2011. Approval from IEPA to begin injection granted November 4, 2011.
- Class VI application submitted to EPA Region 5 in December 2011.
- Performed multiple fluid sampling from verification well.
- Performed baseline and multiple 3D Vertical Seismic Profile surveys to image CO_2 plume migration.
- Currently installing five surface seismic monitoring stations within the AoR.
- As of August 2013, cumulative CO_2 injection volume is over 570,000 metric tons.



Midwest Regional Carbon Sequestration Partnership

Michigan Niagaran Reef Trend – Large Scale Injection Project

Target Formation

- Niagaran Reefs – Northern Michigan
- Closely-spaced, highly compartmentalized, oil and gas fields

CO_2 Source

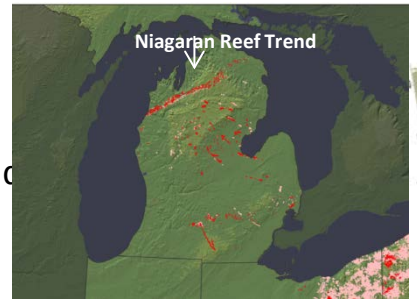
- Core Energy LLC
- Natural Gas Processing Plat from Antrim Shale Gas
- ~ 15% CO_2 content

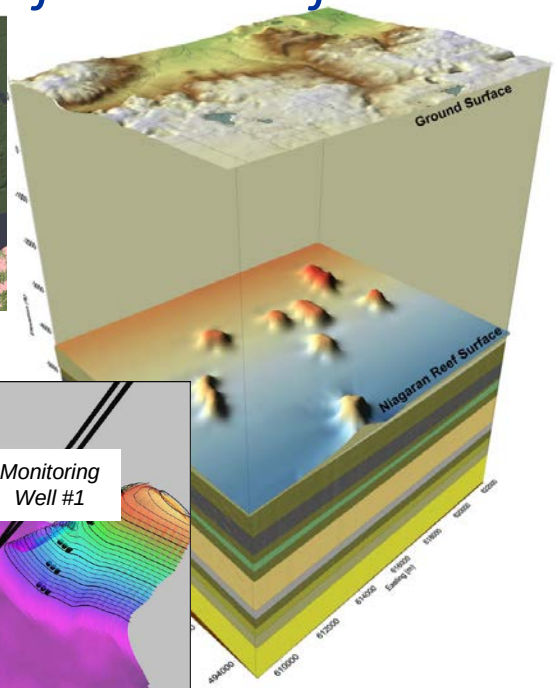
CO_2 Injection Amount

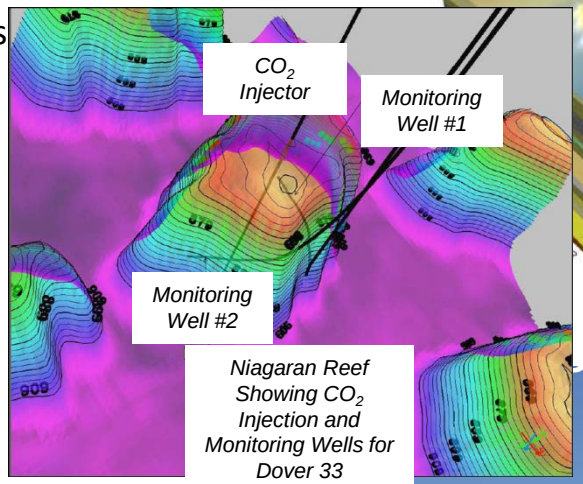
- 1 million metric tons, over 4 years, 3 categories of reefs
  - Depleted Reef (Dover 33)- April 2013
  - Active Reefs – February 2013
  - New CO_2 Injection Reefs – Fall 2014

Current Status

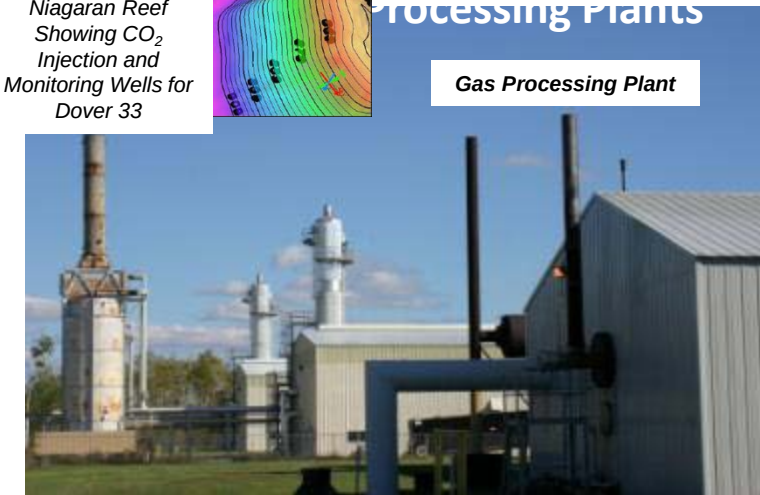
- Dover 33 – Injected >80,000 metric tons CO_2; monitoring and modeling underway
- Active Reefs – Injected >137,000 metric tons CO_2; data on temperature, pressure, and flow rate being collected and analyzed







Niagaran Reef Showing CO_2 Injection and Monitoring Wells for Dover 33



Plains CO_2 Reduction Partnership

Bell Creek Site Large-Scale Project

Target Formation

- Colorado Group/Muddy Sandstone Formation

CO_2 Source

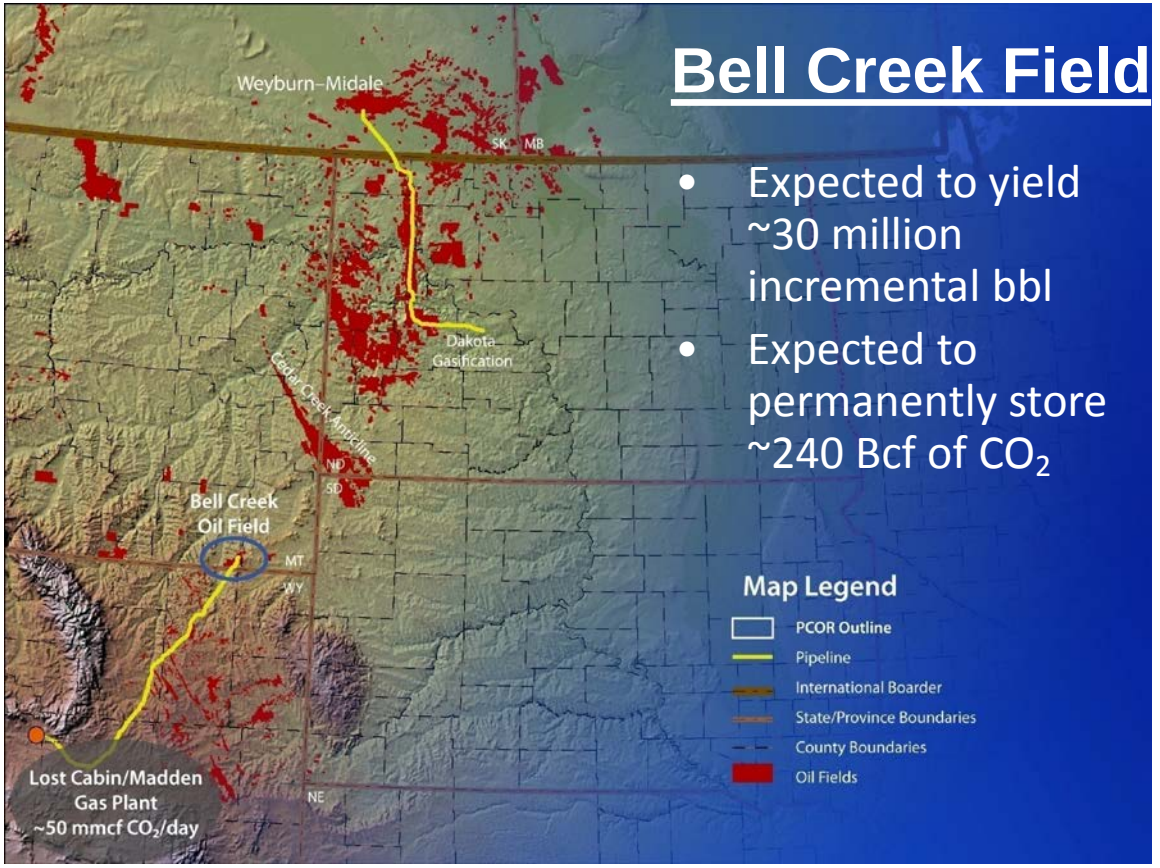
- Lost Cabin/Madden Gas Plant operated by ConocoPhillips

CO_2 Injection Amount

- As much as 1 million tons/year
- Injection initiated May 2013

Current Status

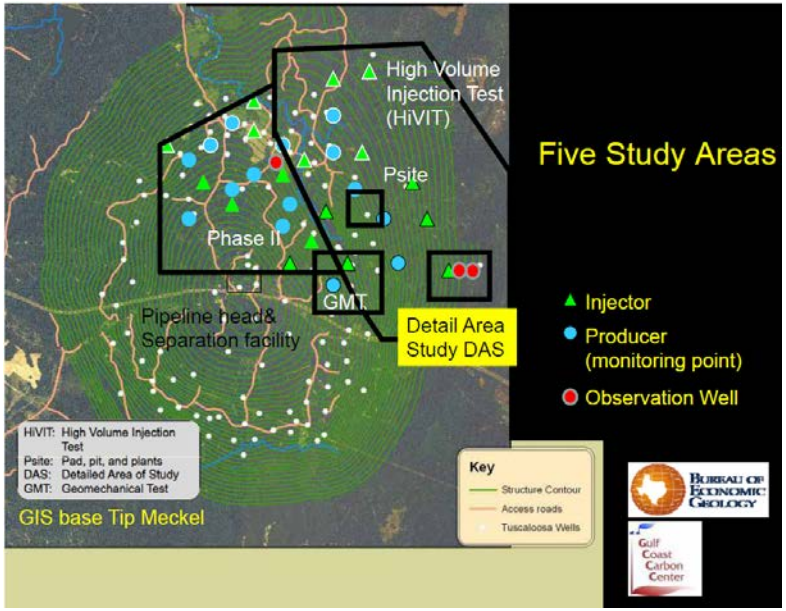
- Working with commercial partner (Denbury Resources Inc.)
- Performing integrated characterization, simulation, risk assessment, and MVA activities
- Transitioning from pre-injection characterization to injection monitoring

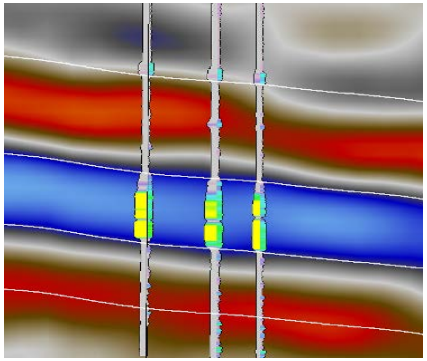


PCO2R Partnership

Southeast Regional Carbon Sequestration Partnership

Cranfield Field Project





First large scale storage project

In collaboration with Denbury Resources

Target Formation:

- Tuscaloosa

CO_2 Source:

- Jackson Dome

Injection Amount

- Over 3.6 MMT injected for storage
- Injection rate was 432 MT/day, now <100 MT/day

Extensive MVA plan to account for stored CO_2 in the injection zone:

- *4-D geophysics (ERT, VSP)*
- *Geochemical (U-tube technology)*
- *Field pressure monitoring*
- *Distributed temperature*
- *Wireline logging*

Southeast Regional Carbon Sequestration Partnership

Citronelle-Plant Barry Field Project

Target Formation:

- Paluxy Formation

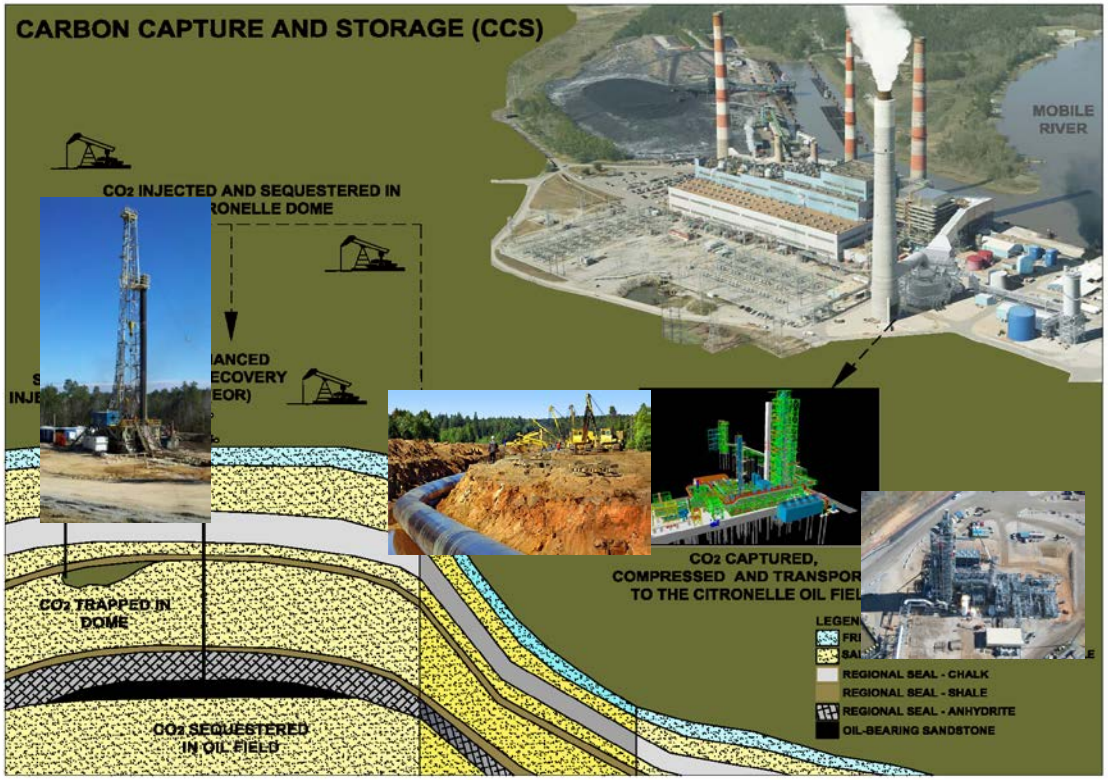
CO_2 Source:

- Southern Company's Plant Barry Power Station
- Largest fully integrated capture (25MW) and saline storage project in the U.S
- MHI KS1 amine process

Injection Amount:

- CO_2 injection started August 20,2012. >70,000 MT injected to date

- **UIC Class V permit with Class VI requirements**
- **Projected CO_2 Injection Amount ~250,000 MT over 2 years**



carbon sequestration leadership forum

SECARB

Southwest Regional Partnership on Carbon Sequestration

Phase III Farnsworth Unit

Farnsworth unit (FWU) is an existing CO_2 -EOR site. CO_2 injection began in 2010 and will be expanding through 2015.

Target Formation

- Morrow Sandstone

Anthropogenic CO_2 Sources

- Agrium (Fertilizer Plant) – Borger TX
- Arkalon (ethanol plant)- Liberal KS

CO_2 Injection Amount

- 1 million metric tons over 5 years
- Injection starting in 2013

Current Status

- Full Project mod early Feb. 2013
- Completed all NEPA Activities
- Completed 3D seismic survey on Feb. 4, 2013

West Coast Regional Carbon Sequestration Partnership

Regional Characterization Efforts

California

- Completed a California state-wide Natural Gas Combined Cycle study reviewing individual power plants, and identifying potential geologic storage.

Colorado

- WESTCARB acquired field data on the stratigraphy of the Colorado Plateau and analyzed groundwater samples from these strata; results confirm deep sandstone and carbonate strata offer promising locations for storing CO2 from the area's coal-fired power plants

Arizona

- WESTCARB completed their evaluation of carbon dioxide storage potential in Mohawk Basin, Gila River Trough, Southwestern Arizona.

Global Collaborations

Leveraging International Geologic Storage R&D Projects

International Demonstrations

– Sponsor multi-national R&D including Canadian Weyburn-Midale, Australian Otway, and Iceland CarbFix projects

Carbon Sequestration Leadership Forum

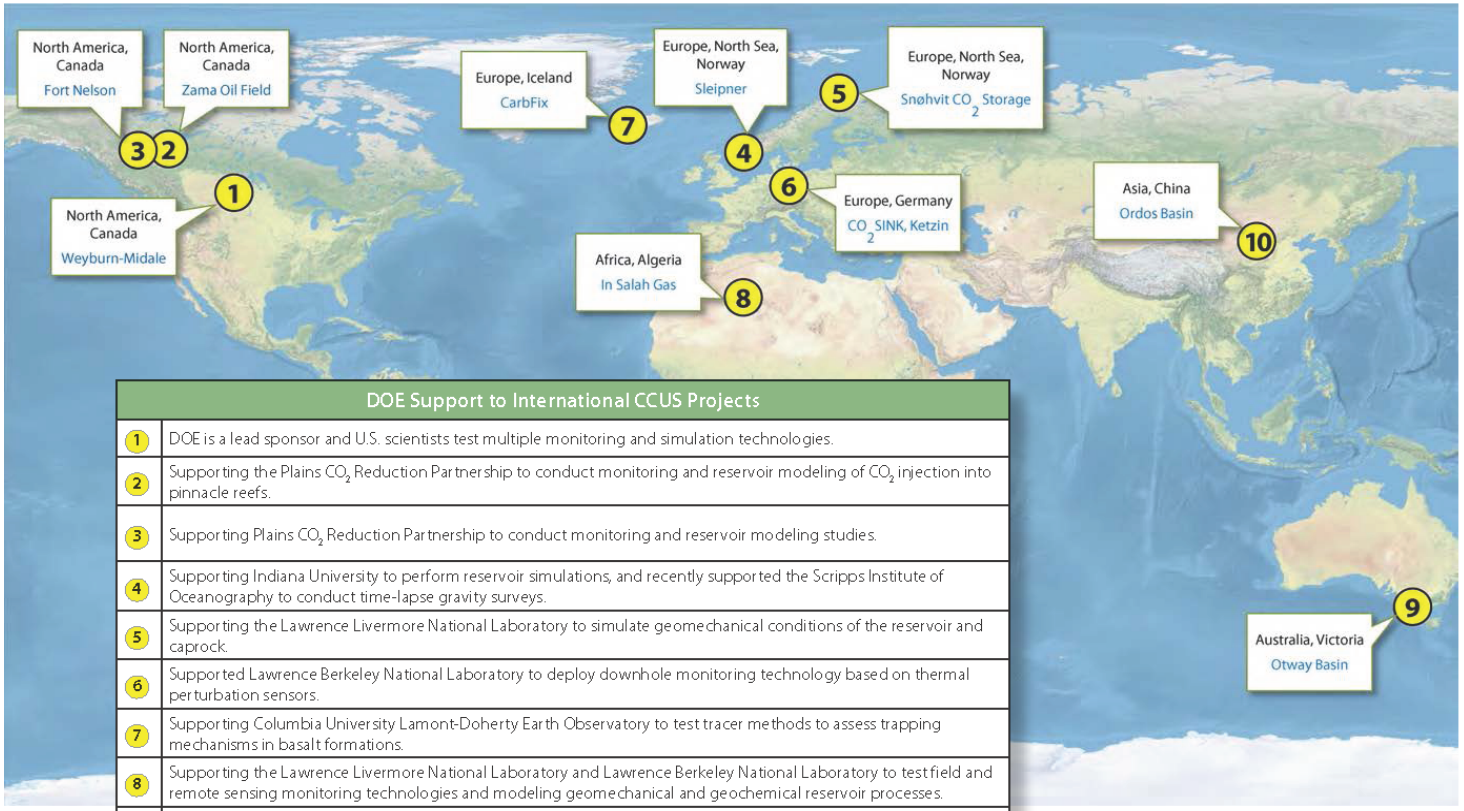
– International ministerial-level organization focused on improved CCS technologies

North American Carbon Atlas Partnership

– Joint initiative between U.S., Canada, and Mexico to map CO_2 sources and storage

Other International Activities

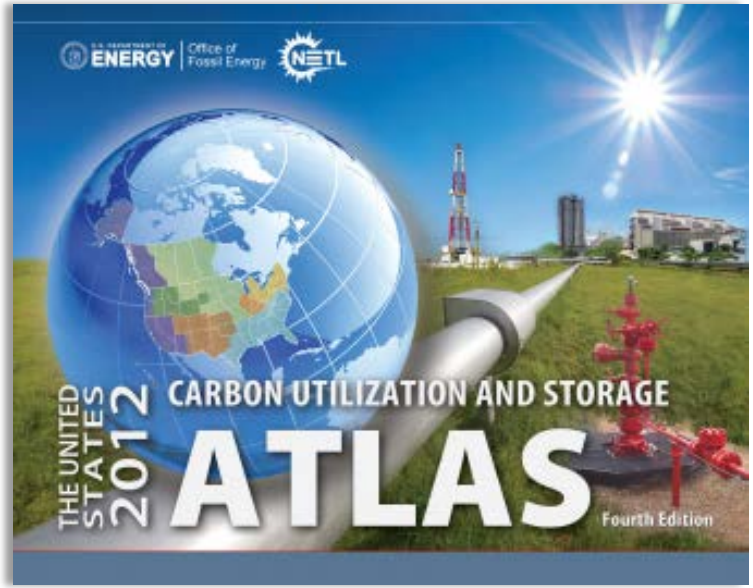
– Partnerships with IEA GHG R&D Programme, IEA, others



DOE Support to International CCUS Projects	
1	DOE is a lead sponsor and U.S. scientists test multiple monitoring and simulation technologies.
2	Supporting the Plains CO_2 Reduction Partnership to conduct monitoring and reservoir modeling of CO_2 injection into pinnacle reefs.
3	Supporting Plains CO_2 Reduction Partnership to conduct monitoring and reservoir modeling studies.
4	Supporting Indiana University to perform reservoir simulations, and recently supported the Scripps Institute of Oceanography to conduct time-lapse gravity surveys.
5	Supporting the Lawrence Livermore National Laboratory to simulate geomechanical conditions of the reservoir and caprock.
6	Supported Lawrence Berkeley National Laboratory to deploy downhole monitoring technology based on thermal perturbation sensors.
7	Supporting Columbia University Lamont-Doherty Earth Observatory to test tracer methods to assess trapping mechanisms in basalt formations.
8	Supporting the Lawrence Livermore National Laboratory and Lawrence Berkeley National Laboratory to test field and remote sensing monitoring technologies and modeling geomechanical and geochemical reservoir processes.
9	Supporting scientists at Lawrence Berkeley National Laboratory to test multiple monitoring technologies at depleted gas field and saline formations.
10	Supporting West Virginia University and Lawrence Livermore National Laboratory to assess capacity for storage, and simulating hydrogeologic and geochemical reservoir conditions.

Focus Area for Carbon Sequestration Science

U.S. 2012 Carbon Utilization and Storage Atlas (Atlas IV)



Released in December 2012

- **Updated CO_2 stationary source emission estimates and storage potential of various geologic storage types:**
  - *at least 2,400 billion metric tons total storage resource*
  - *3.3 billion metric tons annual CO_2 emissions*
- **Outlines DOE's Carbon Storage Program**
- **Showcases updated info about Regional Carbon Sequestration Partnership (RCSP) CO_2 storage activities**
- **New information from the ARRA Site Characterization projects**
- **Highlights CCS collaborations and worldwide CCS projects**

http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIV/Atlas-IV-2012.pdf

Thank you.
Questions ?