



NATIONAL ENERGY TECHNOLOGY LABORATORY

***March 12, 2013
Atlanta, GA***



2013 SECARB Stakeholders Meeting

Presenter: Bruce Brown, PG

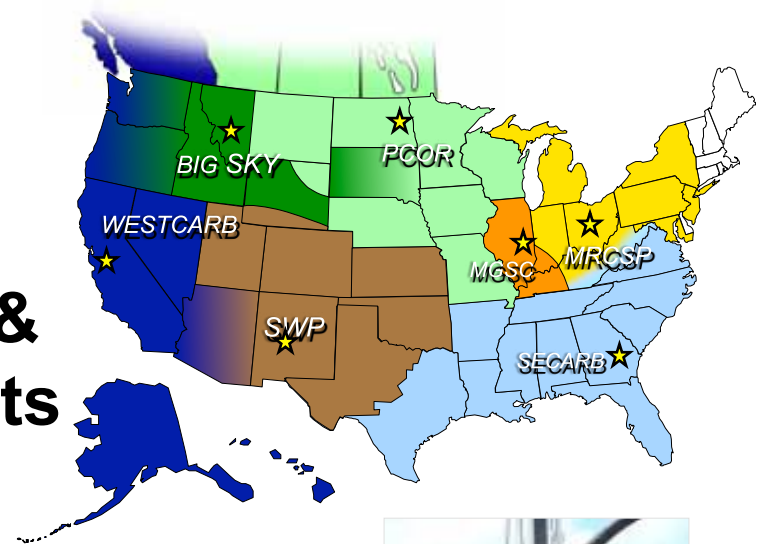
bruce.brown@netl.doe.gov

United States Department of Energy, National Energy Technology Laboratory,



Overview

- DOE Carbon Storage Program
- Core R&D
- Regional Partnerships
- Best Practices Manuals (BPM) & Other knowledge sharing products



Core Program Components

Office of Coal and Power R&D

Total FY 2012 Funding ~ \$333 Million

- **Carbon Storage - \$115.4 Million**
- **Carbon Capture - \$68.9 Million**
- **Advanced Energy Systems- \$99.9 Million**
 - Advanced Combustion Systems - \$15.9 Million
 - Gasification - \$39 Million
 - Turbines - \$15 Million
 - Fuel Cells - \$25 Million
 - Fuels - \$5 Million
- **Cross Cutting Research - \$49.1 Million**



Sequestration Program Total Funding (\$115.4 M)

2012 Program Statistics

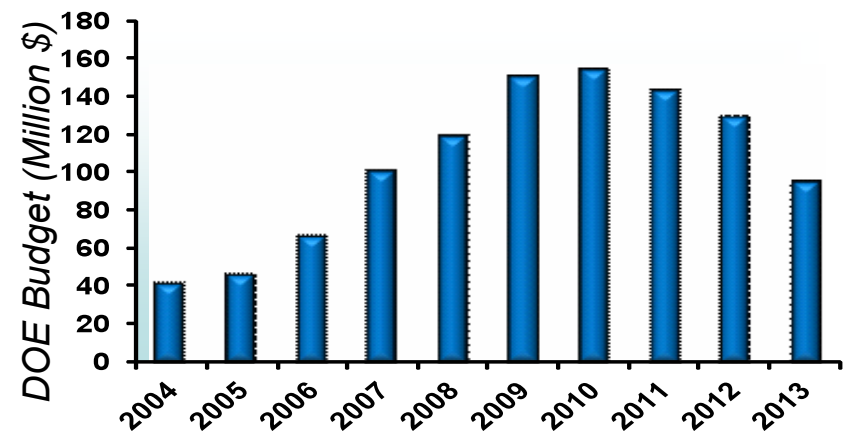
Regional Carbon Sequestration Partnership* (\$83.190 M)

- Large Scale Tests
- Small Scale Tests
- NATCARB

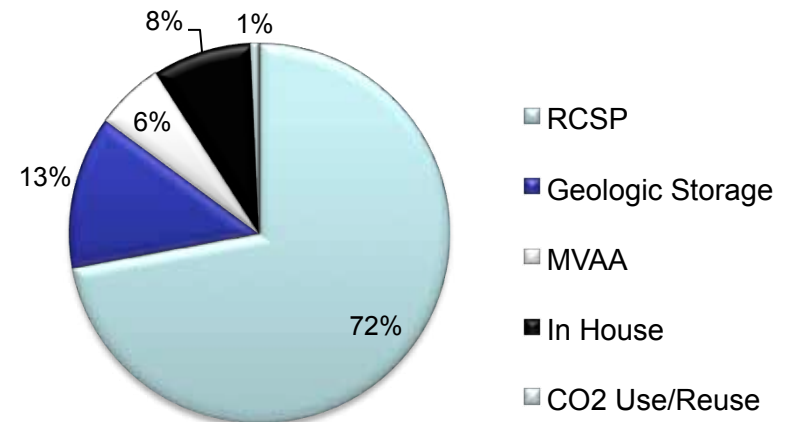
Core R&D Research

- Geologic Storage (\$14.978 M)
- MVA (\$6.738 M)
- CO₂ Use and Reuse (\$0.778 M)

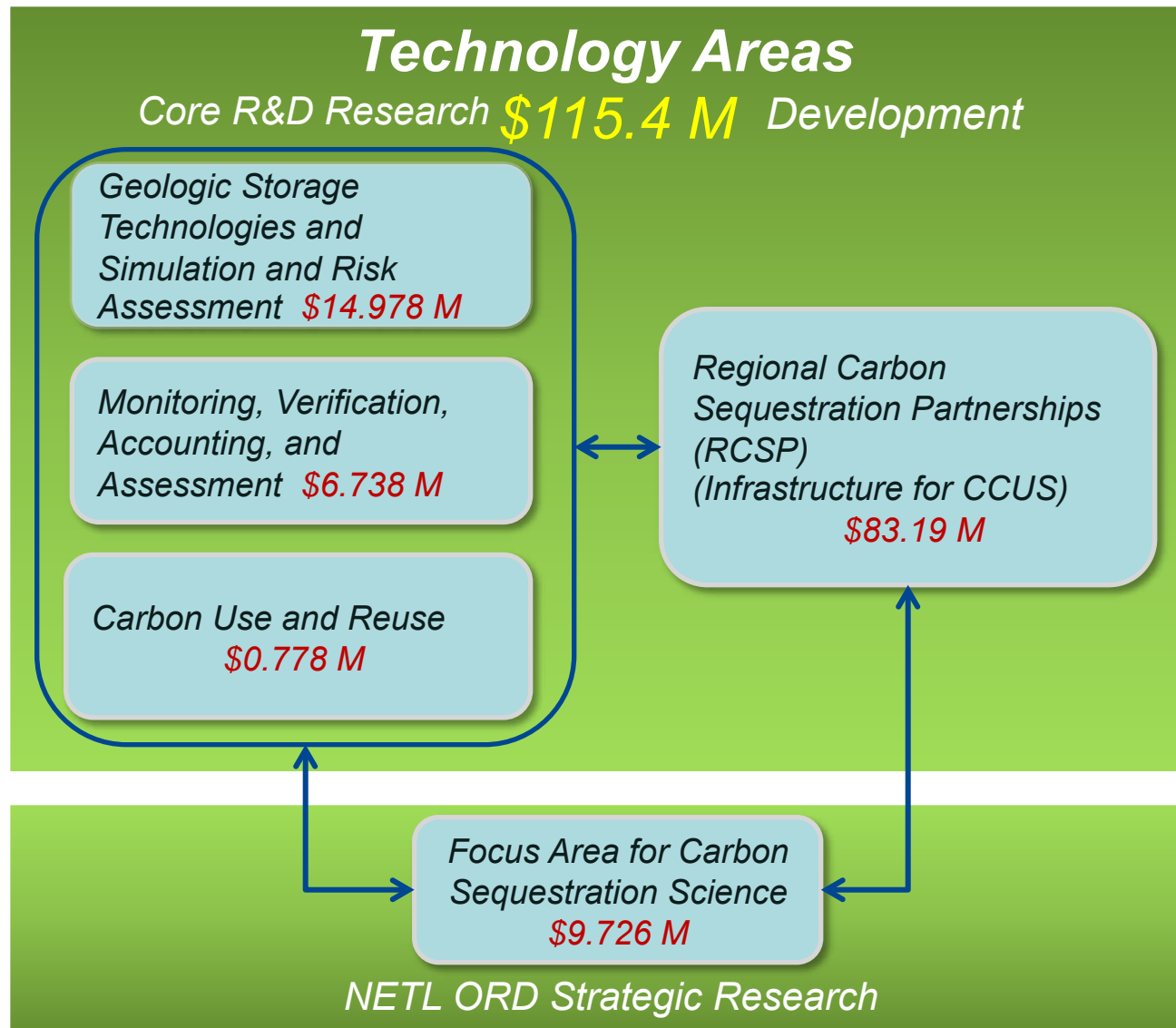
Focus Area for GHG Control (NETL ORD) (\$9.726M)



FY2012 Carbon Storage Budget



2012 Carbon Storage Program



Core R&D Research Areas

Geologic Storage \$14.978 M

- Wellbore construction and materials
- Mitigation technologies for wells and natural pathways
- Fluid flow, reservoir pressure, and produced brines
- Geochemical effects on formation, brine, and organisms
- Geomechanical effect on reservoirs & seals

CO2 Use and Reuse \$0.778 M

Chemicals

- Polycarbonate plastics
- Minerals and cements (building products)
- EOR, EGR, and geothermal

MVA Research Pathways \$6.738 M

- Atmospheric 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

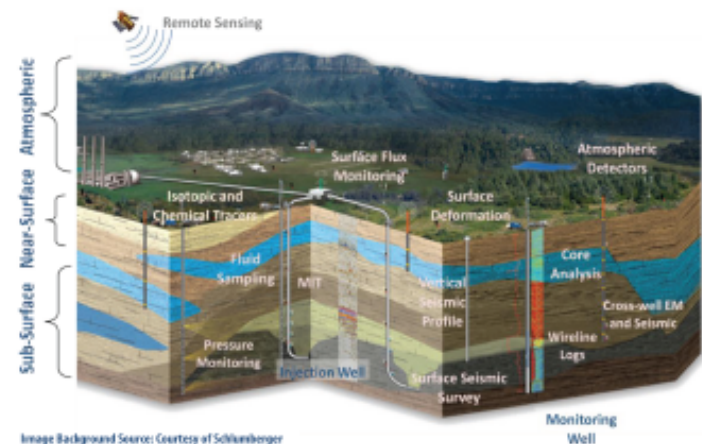


Image Background Source: Courtesy of Schlumberger

Monitoring Well

Carbon Storage Program Goals

Develop Technology Options That...

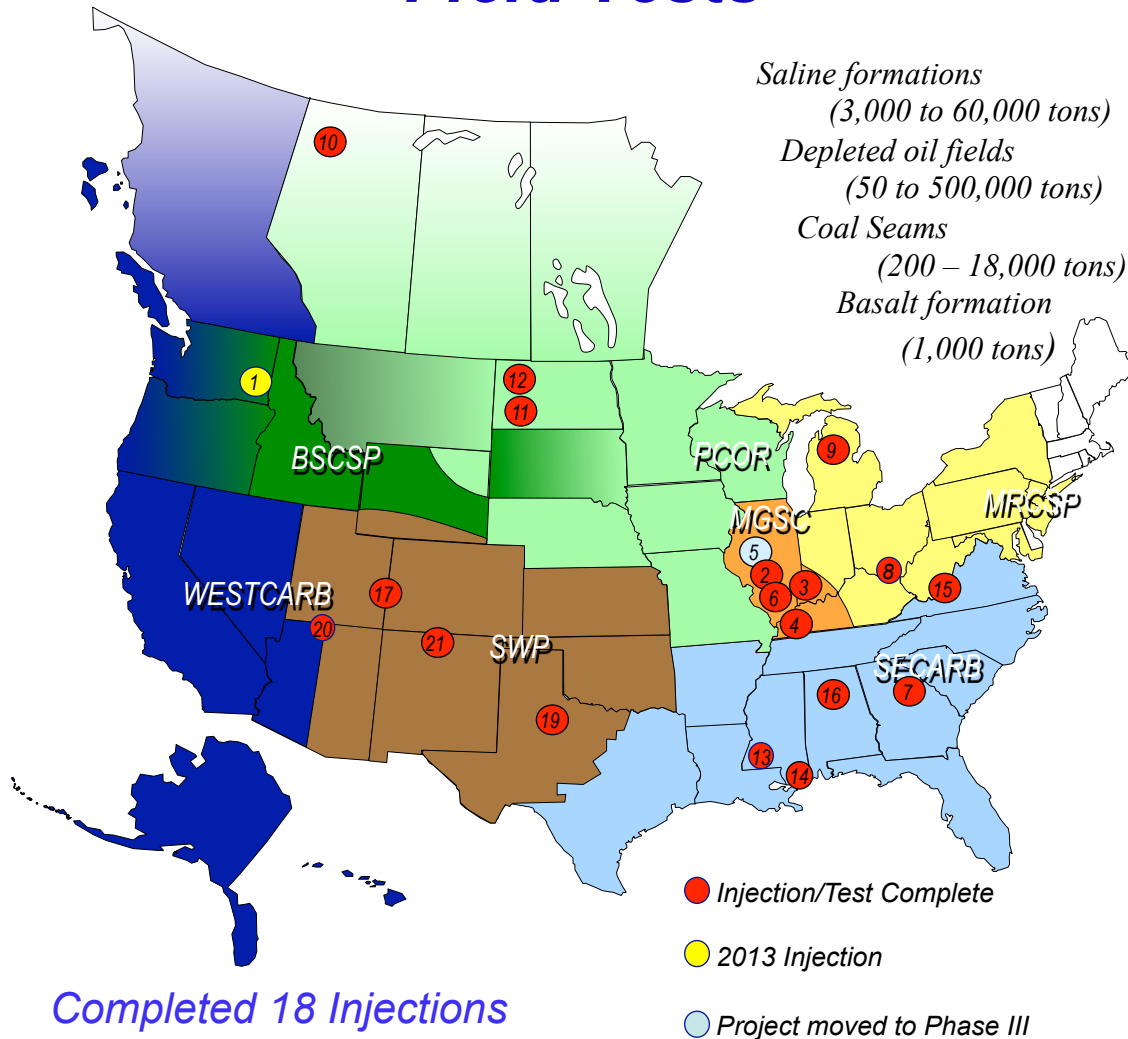
- **Deliver technologies & best practices that provide Carbon Capture Utilization and Storage (CCUS) with:**
 - 99% storage permanence
 - Best Practice Manuals for Storage
 - Improve Capacity Estimates and Storage Efficiency
- **Related Capture Goals**
 - 90% CO₂ capture at source
 - \$40/tonne by 2020 (*Requires market for carbon*)
 - \$10/tonne by 2030 (*Assumes climate policy driver*)

Program Overview - Driver

Storage Regulations and R&D Challenges

- **EPA Underground Injection Control Program**
 - Class VI Final Rule – 2010
 - U.S. EPA is the implementing organization Sept 2011
 - All new saline projects will be permitted as Class VI
 - Well Construction requirements (materials and cementing challenges)
 - Identifying faults/fractures and seal properties
 - Leak mitigation requirements – emergency response
 - Tracking CO₂ plume stabilization (50yrs) - Reducing uncertainty
 - Monitoring requirements (injection zone, above zone, near surface, atmospheric)
 - Impacts of geology on AOR (depositional environment)
 - Transition from Class II → VI
- **EPA Office of Air and Radiation**
 - CAA Supart UU and RR Rules issued December 2011
 - R&D exemption available but projects will likely comply
 - Quantifying air emissions for CCS projects from entire system

Small-Scale Geologic Field Tests



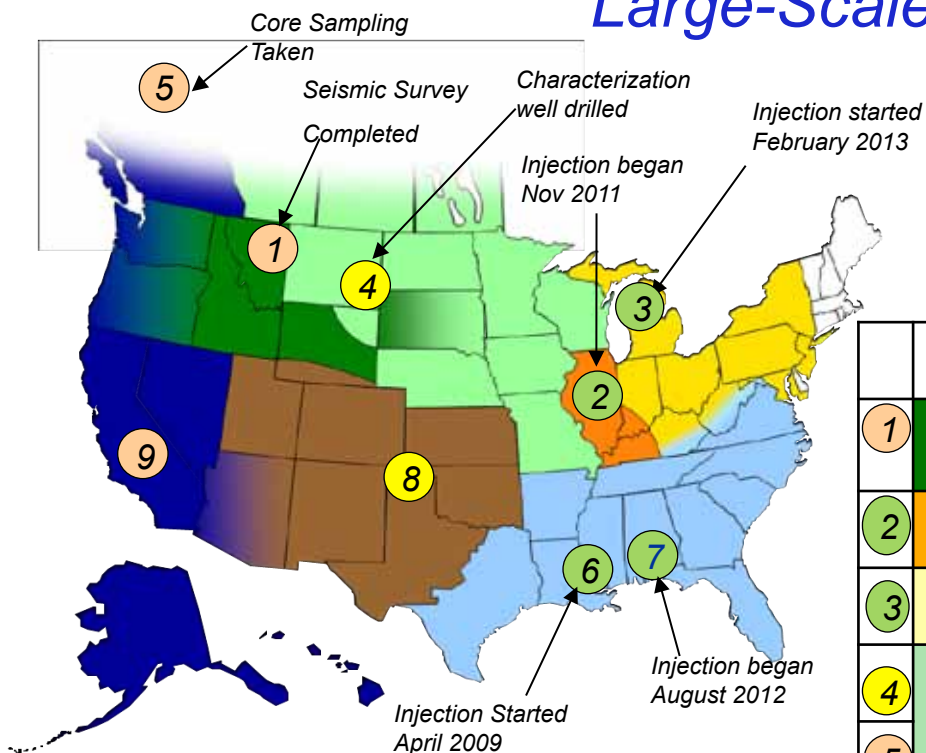
Completed 18 Injections

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

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

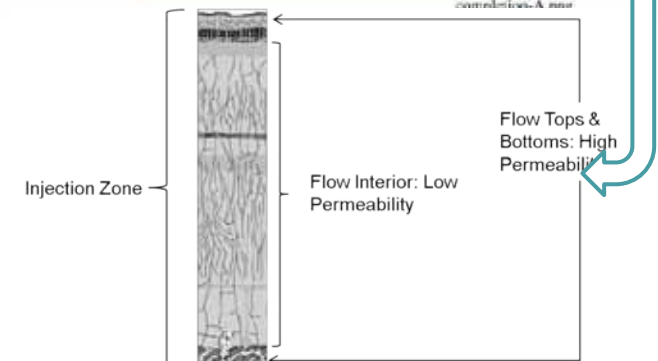
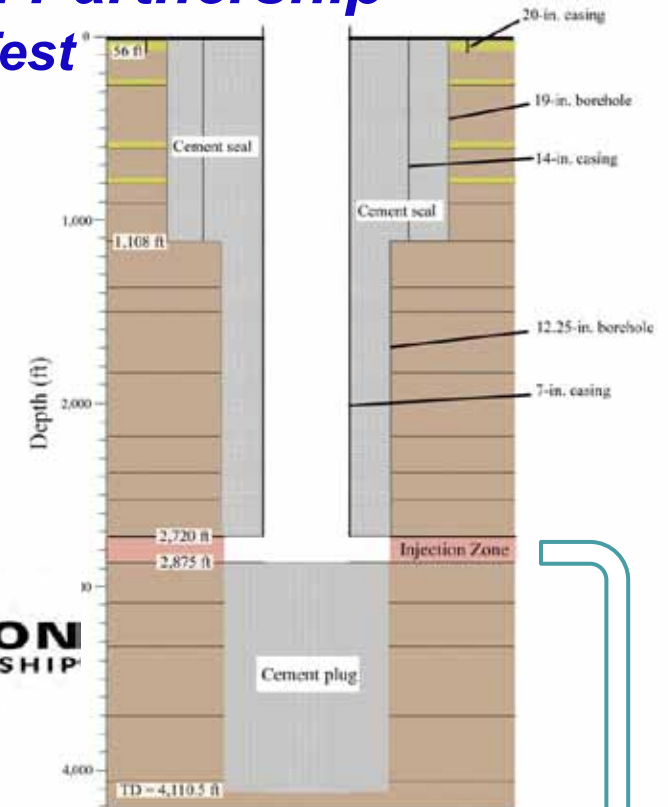
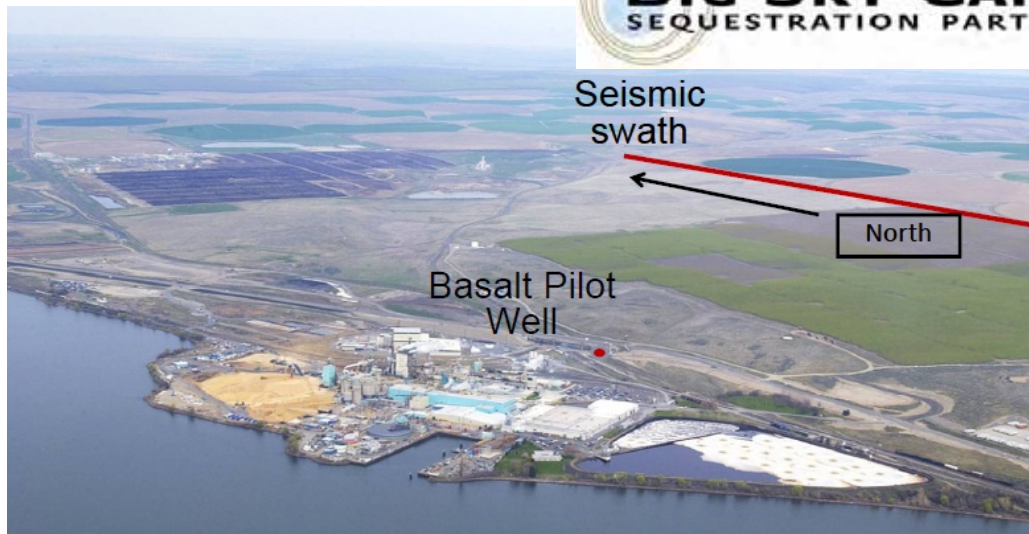
- ✓ Large-volume tests
- ✓ Three Partnerships currently injecting CO₂
- ✓ Remaining injections scheduled 2013-2015

	Partnership	Geologic Province	Target Injection Volume (tonnes)
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 II – Basalt Pilot Test

- Only basalt storage test in Continental U.S.
- Advantages of Basalt for CO₂ Storage
 - Extensive basalt formations in Pacific Northwest
 - Layered storage above and below basalt flows
 - Significant potential for CO₂ mineralization
- Host Site: Boise White Paper LLC - Wallula, WA
- CO₂ Injection Permit (WA Dept. of Ecology)
 - 1000 metric tons max.
 - 2,720 to 2,875 ft depth
- Target Injection Date: April 2013



Big Sky Carbon Sequestration Partnership

Phase III Kevin Dome Site Large-Scale Storage Project

Location

- Toole County, NW Montana

CO₂ Source

- Natural CO₂ at top of Kevin Dome

CO₂ Injection Amount

- 1 million metric tons over 4 years

Rationale

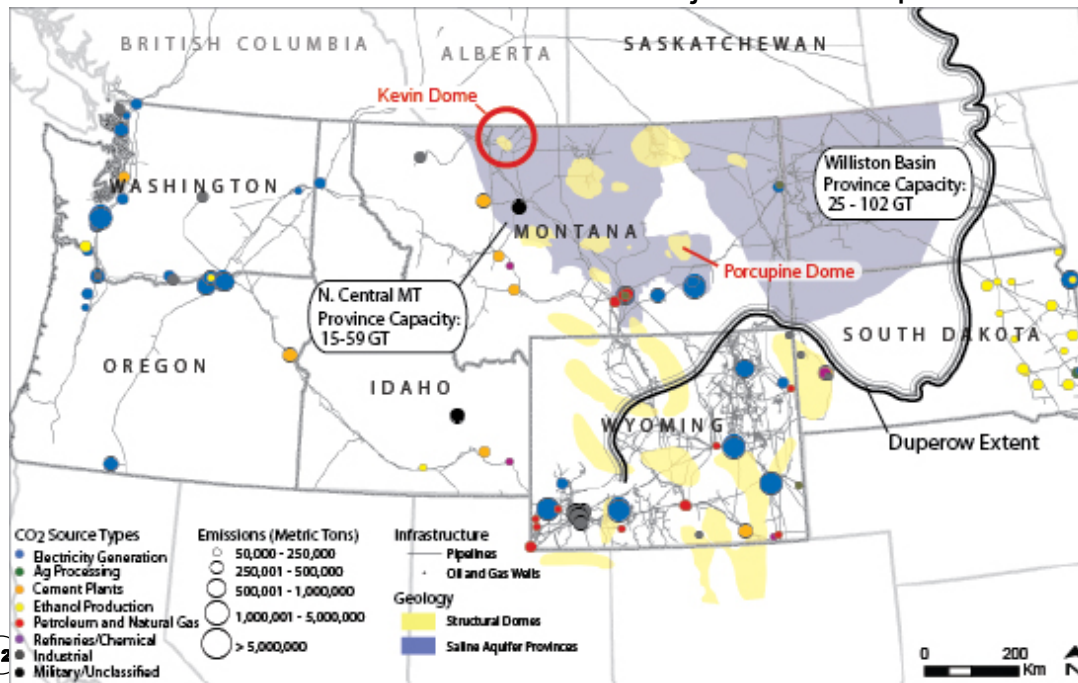
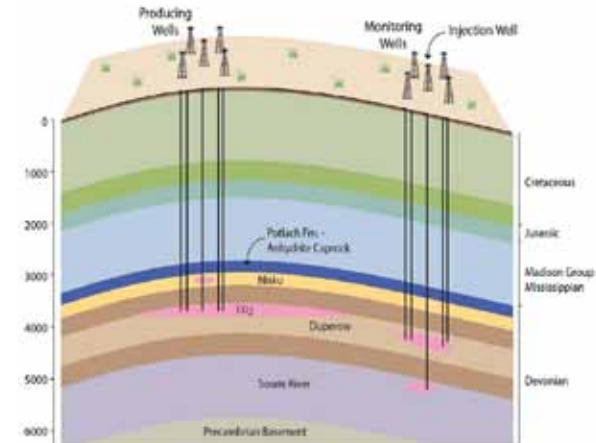
- Regional CO₂ Storage Hub

Target Formation

- Duperow Formation

Current Status

- Conducting NEPA Activities
- Preparing Permit Applications
- Injection anticipated



0 200 Km N DNA



Midwest Geological Sequestration Consortium

Decatur Site Large-Scale Project

Target Formation

- Mt. Simon Sandstone

CO₂ Source

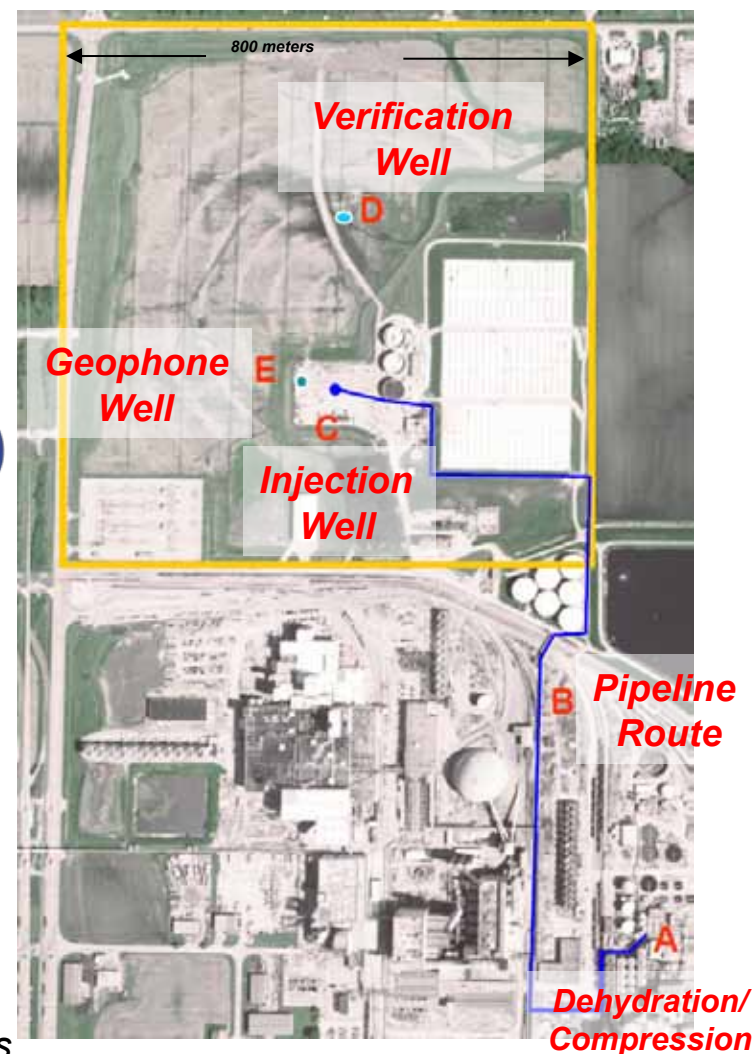
- ADM's Ethanol Production Facility

CO₂ Injection Amount

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

Current Status

- Completed 4 square mile 3D seismic survey
- Completed drilling injection well, groundwater monitoring wells, geophone well, and verification well.
- CO₂ Pipeline installed and connected to injection wellhead.
- Installed all subsurface monitoring equipment.
- Completed commission of compression/dehydration facility
- Completed baseline fluid samples from verification well.
- Completed satellite interferometry (InSAR) baseline imaging data collection.
- UIC Permit finalized in March, 2011. Approval from IEPA to begin injection granted November 4, 2011.
- As of February 28, 2013 cumulative CO₂ injection volume is over 422,000 metric tons



Plains CO₂ Reduction Partnership

Fort Nelson Site Large-Scale Project

Target Formation

- Elk Point Group

CO₂ Source

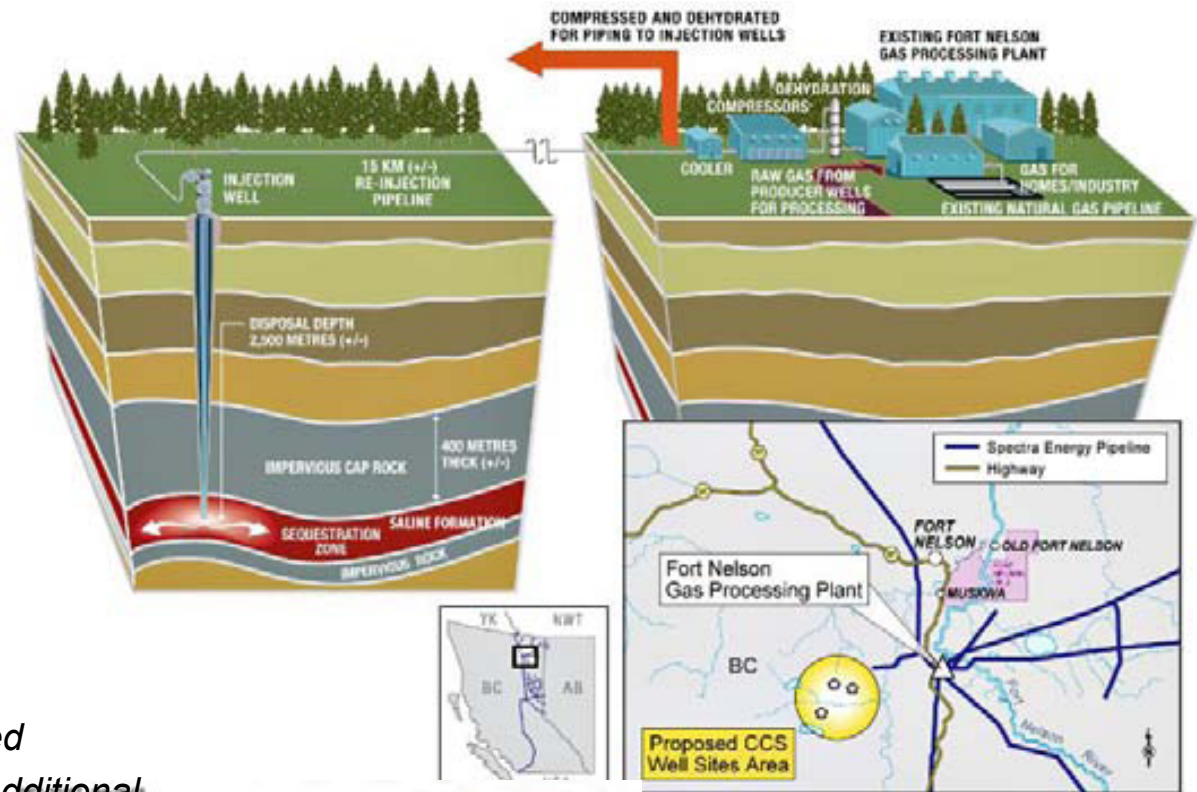
- Spectra Energy's Fort Nelson Natural Gas Processing Plant

CO₂ Injection Amount

- Up to 2 million tons/year

Current Status

- Drilling of exploration well completed
- Conducted "side-track" to acquire additional reservoir data
- Developing integrated Risk Management Plan (RMP), Modeling and MVA Program



Plains CO₂ Reduction Partnership

Bell Creek Site Large-Scale Project

Target Formation

- Colorado Group/Muddy Sandstone Formation

CO₂ Source

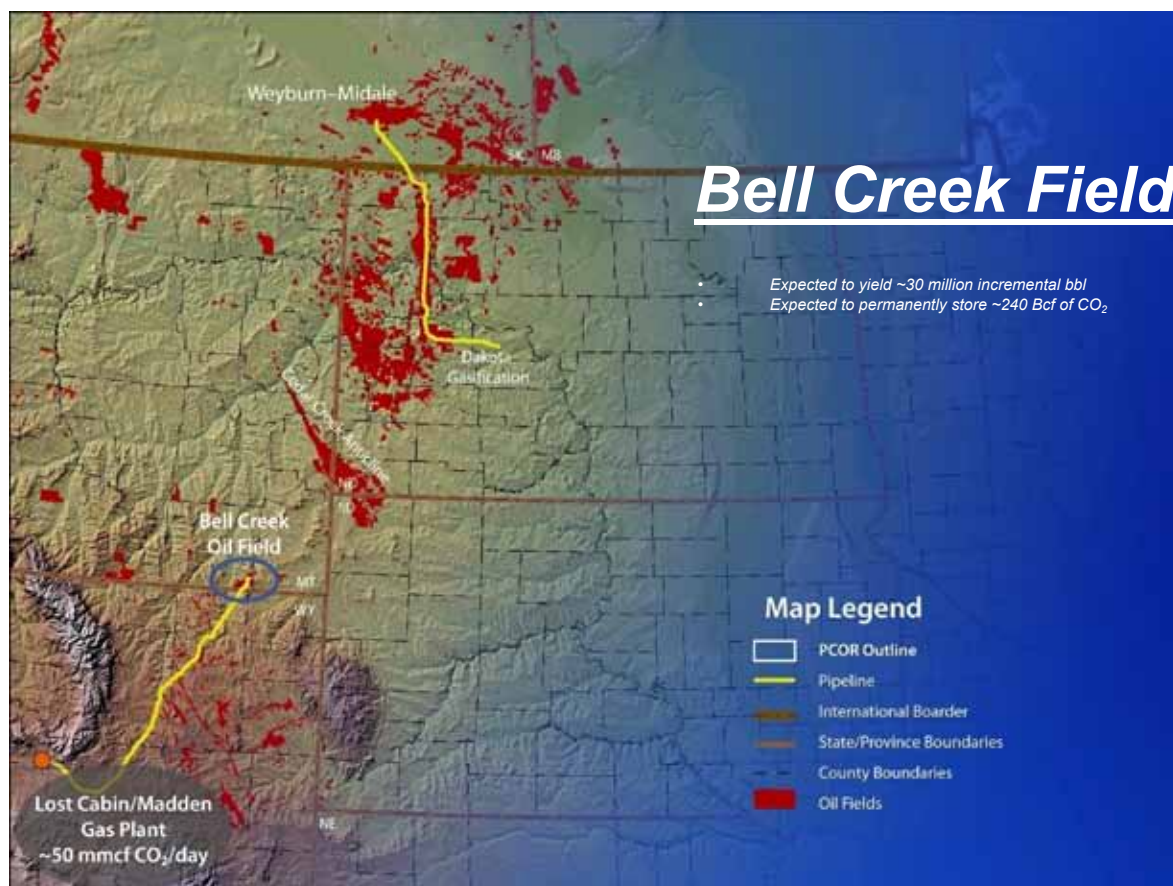
- Lost Cabin/Madden Gas Plant operated by ConocoPhillips

CO₂ Injection Amount

- As much as 1 million tons/year
- Injection anticipated early 2013

Current Status

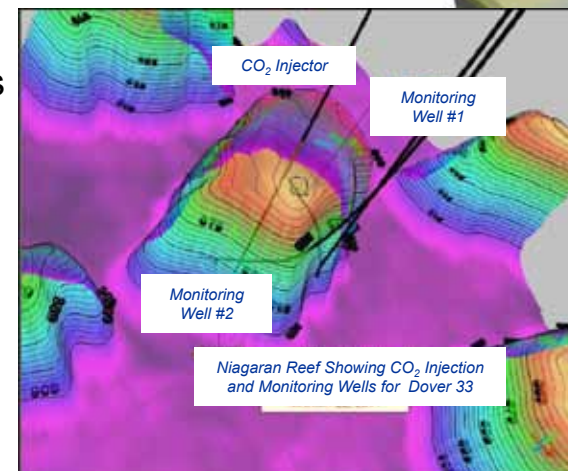
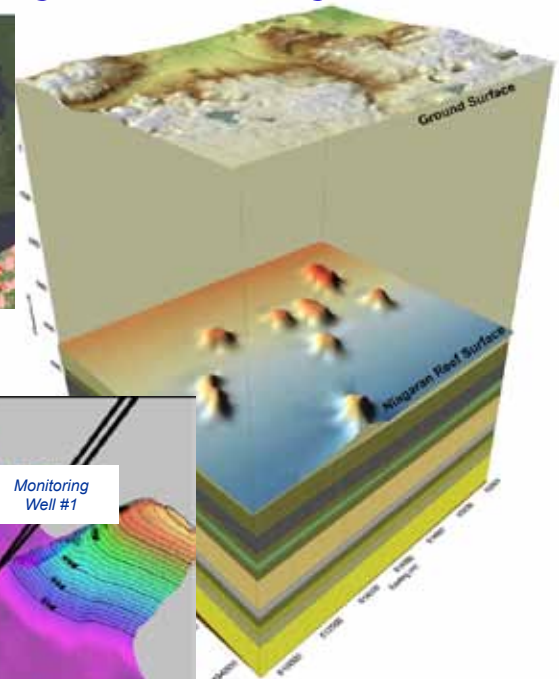
- Working with commercial partner (Denbury Resources Inc.)
- Developing integrated modeling and MVA plan
- Completed installation of the monitoring well



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
- **CO₂ Source**
 - Core Energy – Natural Gas Processing Plant
 - Antrim Shale Gas ~ 15% CO₂ content
- **CO₂ Injection Amount**
 - 1 million metric tons, over 4 years, 3 categories of reefs
 - Depleted Reef (Dover 33)- Spring 2013
 - Active Reefs – February 2013
 - New Production Reefs – Fall 2014
 - Anticipate 25,000+ metric tons per month
- **Current Status**
 - Dover 33 – Reservoir testing completed with brine injections; preliminary reservoir characterization completed; 3D seismic completed; field preparations and permitting being completed for InSAR monitoring and VSP
 - Active Reefs – data on temperature, pressure, and flow rate being collected and analyzed



Gas Processing Plant



Southeast Regional CS Partnership

Cranfield Site Large-Scale Project (Early Test)

Target Formation

- Lower Tuscaloosa

CO₂ Source

- Jackson Dome (natural source) delivered via Denbury Resources' Sonat CO₂ pipeline

CO₂ Injection Amount (Current)

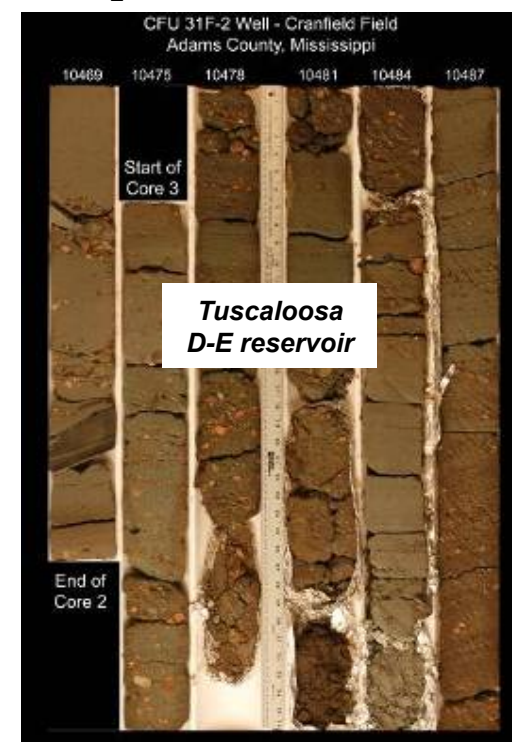
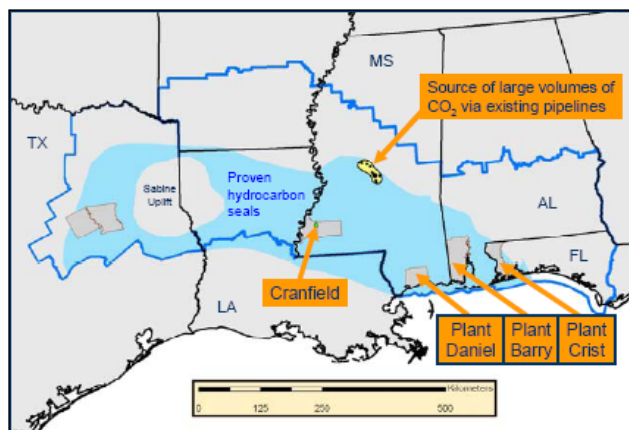
- > 3.4 million metric tons (P3 only)
- > 3.8 million metric tons (combined P2 and P3)

Current Status

- Injection began on 04/01/2009
- Injection rate was ~ 432 metric tons/day, now < 100 metric tons/day
- Over 3,400,000 metric tons stored in Phase III

MVA

- 4-D geophysics (VSP, ERT)
- Geochemical (U-Tube sampling)
- Field pressure monitoring
- Distributed Temperature
- Wireline logging



NATIONAL ENERGY TECHNOLOGY



Southeast Regional CS Partnership Plant Barry Site Large-Scale Project

Largest fully integrated PC plant capture and saline storage project in the U.S.

MHI KS1 amine process

UIC Class V permit with Class VI requirements

Target Formation

- **Upper Paluxy Formation within the Citronelle Field**

CO₂ Source

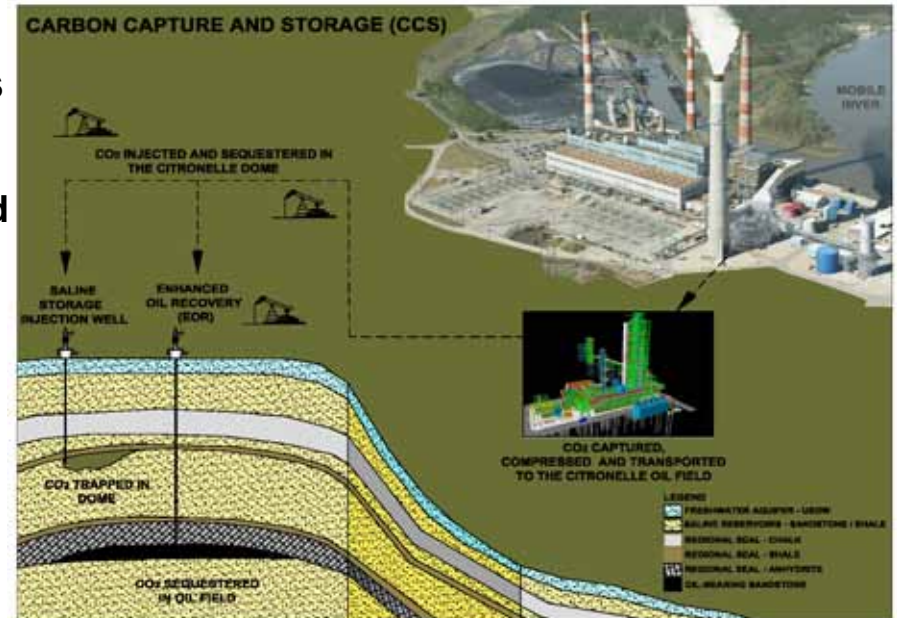
- **Southern Company's Plant Barry Power Station**

CO₂ Injection Amount

- **~ 250,000 metric tons over 2 years (August 2012)**

Current Status

- **Characterization well drilled January 2011**
- **Final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) signed March 2011**
- **Pipeline construction completed (November 2011)**
- **Injection well drilling completed (December 2011)**
- **UIC Class V Injection well permit (July 2012)**
- **CO₂ injection started August 20, 2012. >50,000 metric tons to date**



SECARB

Southwest Regional Partnership on CS Phase III Farnsworth Unit

Farnsworth unit (FWU) is an existing CO₂-EOR site operated by Chaparral Energy. CO₂ injection began in 2010 and will be expanding through 2015.

Target Formation

- Morrow Sandstone

Anthropogenic CO₂ Sources

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

Farnsworth Unit

CO₂ Injection Amount

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

Current Status

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



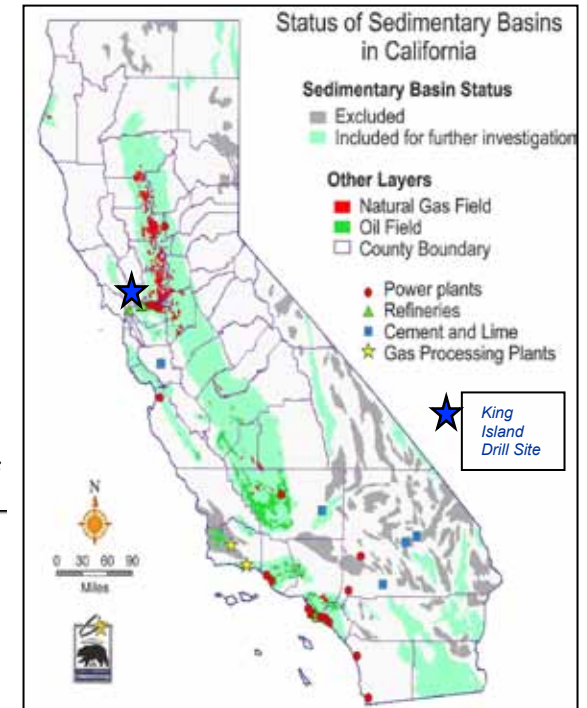
West Coast Regional CS Partnership

Regional Characterization Efforts

Colorado Plateau and Sacramento Basin

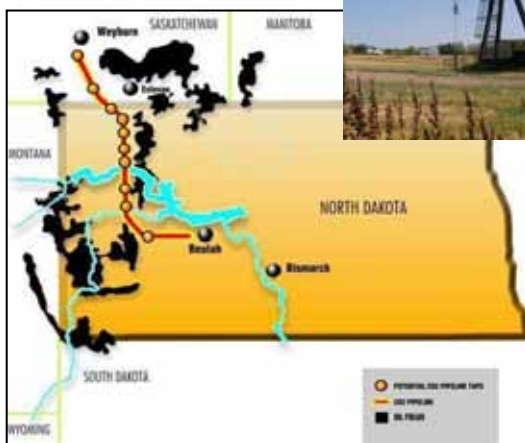
Current Status

- The WESTCARB Phase III effort is currently being negotiated. Selected Phase II carryover tasks were authorized during the negotiation process.
- Drilled a stratigraphic test well, at risk, in the southern Sacramento Basin (King Island Site) to characterize CO₂ storage targets in a depleted natural gas reservoir.
- Completing a California state wide Natural Gas Combined Cycle study, reviewing individual power plants, to determine if they are capture ready. Additionally, they are identifying potential geologic storage formations and their relationship to the power plant locations, identifying potential pipeline locations, and ranking the power plants in order of their CCS readiness.
- Collecting existing Arizona characterization data to identify potential CO₂ storage formations. used to help down select a drilling location for a future Phase III characterization well.
- WESTCARB is continuing to collect regional geologic characterization and CO₂ source data as well as performing outreach activities.



Global Collaborations

Leveraging International Geologic Storage R&D Projects



Dakota Gasification CO₂ pipeline and Weyburn EOR field



Iceland CarbFix CO₂ pilot basalt injection

- DOE sponsorship of multi-national carbon storage R&D including Canadian Weyburn-Midale, Australian Otway, Iceland CarbFix, and North Sea Sleipner projects.
- North American Carbon Storage Atlas and IEA GHG Weyburn-Midale projects selected for inclusion in IEA CCS Roadmap and case studies.
- **IEA GHG Weyburn-Midale project published Best Practices for Validating CO₂ Geological Storage – Observations and Guidance from the IEA GHG Weyburn – Midale CO₂ Monitoring and Storage Project.**
- **Carbon Sequestration Leadership Forum** honored with Global Achievement Awards: Canadian Weyburn-Midale, Algerian In Salah, and North Sea Sleipner projects.

CCS Best Practices Manuals

*Critical Requirement For Significant Wide Scale Deployment -
Capturing Lessons Learned*



Best Practices Manual	Version 1 (Phase II)	Version 2 (Phase III)	Final Guidelines (Post Injection)
Monitoring, Verification and Accounting	2009/ 2012	2016	2020
Public Outreach and Education	2009	2016	2020
Site Characterization	2010	2016	2020
Geologic Storage Formation Classification	2010	2016	2020
**Simulation and Risk Assessment	2010	2016	2020
**Carbon Storage Systems and Well Management Activities	2011	2016	2020
Terrestrial	2010	2016 – Post MVA Phase III	

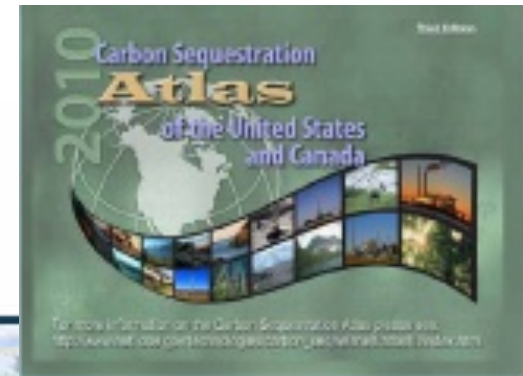
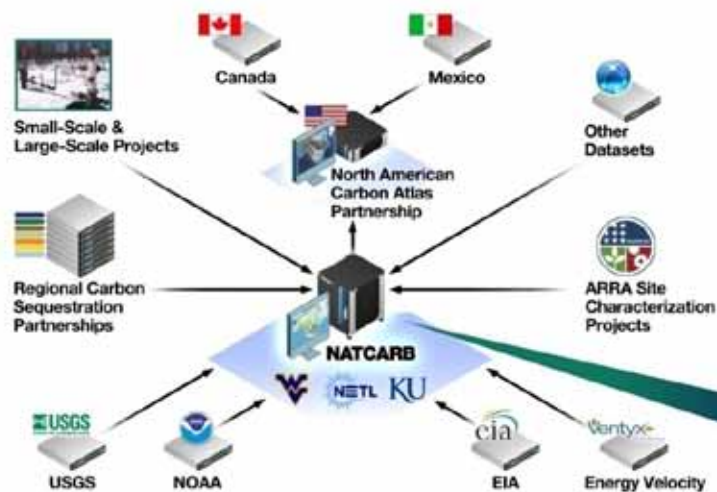
***Regulatory Issues will be addressed within various Manuals*

NATIONAL ENERGY TECHNOLOGY LABORATORY

http://www.netl.doe.gov/technologies/carbon_seq/refshelf/refshelf.html

Knowledge Sharing Products

North American Carbon Atlas and NATCARB



**Oil and Gas Fields
143 GT CO₂
Storage Resource**

ARRA Regional Technology Training

RCSPs Working Groups

- Geological and Infrastructure
- Monitoring, Verification, Accounting
- Simulation and Risk Assessment
- Capture and Transportation
- GIS and Database
- Water
- Public Outreach and Education



Worldwide CCS Project Database



Visit our website: www.NETL.DOE.GOV

NATIONAL ENERGY TECHNOLOGY LABORATORY

North American Carbon Atlas Partnership (NACAP)

First coordinated effort between Canada, Mexico, and the United States to jointly publish a resource of data and information on CCS technologies, pressing issues, and current progress toward solutions

- **NACAP's Objective:**
 - Identify, gather, and **share** data of CO₂ sources and geologic storage potential
- **Development of this GIS-based CO₂ sources and storage database supports:**
 - Carbon Storage Program in DOE's Office of Fossil Energy
 - North American Energy Working Group
 - Canada-US Clean Energy Dialogue
 - Mexico-US Bilateral Framework on Clean Energy and Climate Change
- **3 North American Products:**
 - Hard copy Atlas
(North American Carbon Storage Atlas - NACSA)
 - NACSA online viewer
(Web mapping application for dynamic display & analysis of data)
 - NACSA website (<http://www.nacsap.org/>) – online version of NACSA, links to resources (English, Spanish, and French)



Carbon Sequestration Atlas of the United States and Canada



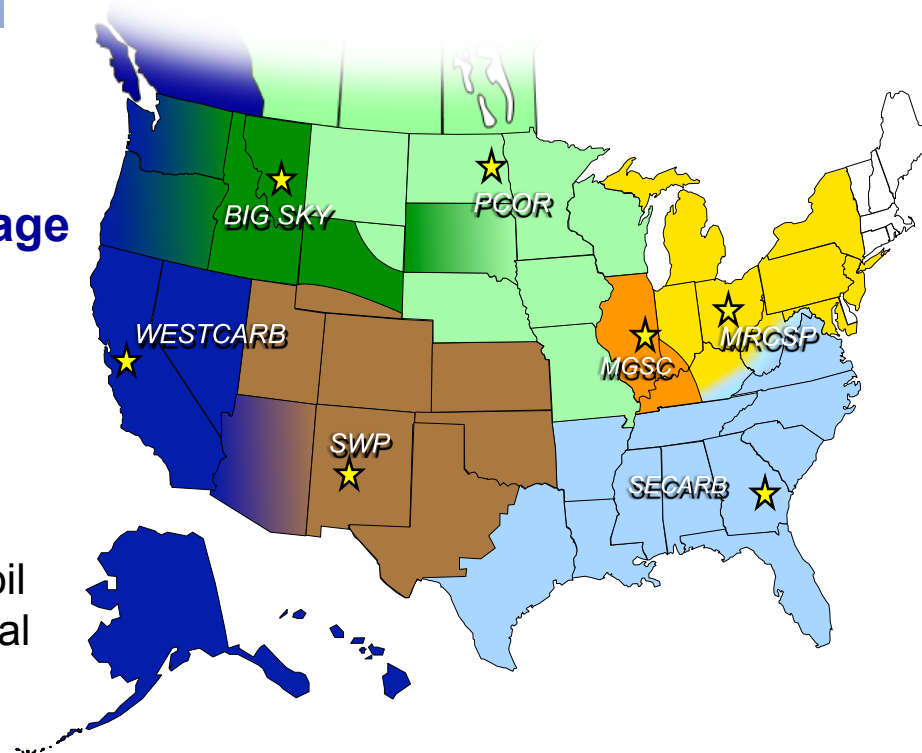
Atlas I - March 2007
Atlas II - November 2008
Atlas III - November 2010

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

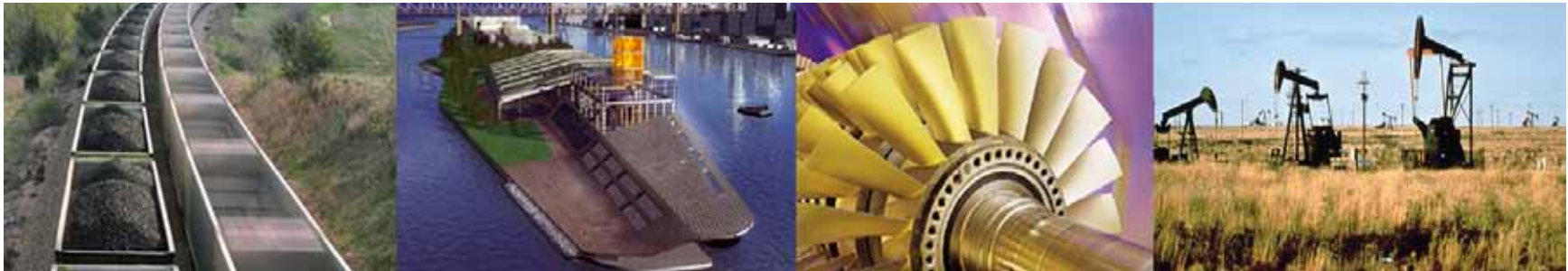
- Comparison of publically available methodologies for regional and site specific assessments

ATLAS V (Nov. 2014)

- Revised / Improved methodology for oil and gas formations and unconventional reservoirs (shale, unmineable coal, basalts)



Thank you



Questions?