

Implementing Carbon Capture and Storage: An Overview of the Plains CO₂ Reduction Partnership

**10th CO₂GeoNet Open Forum
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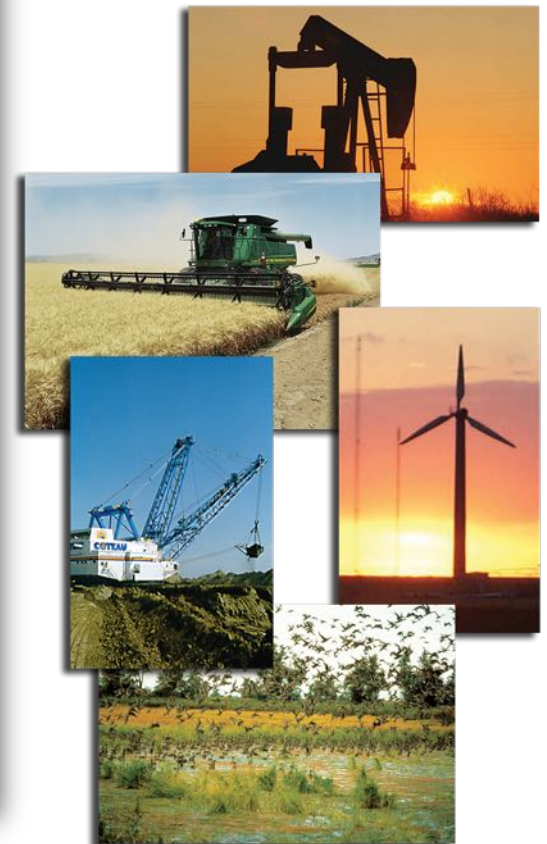
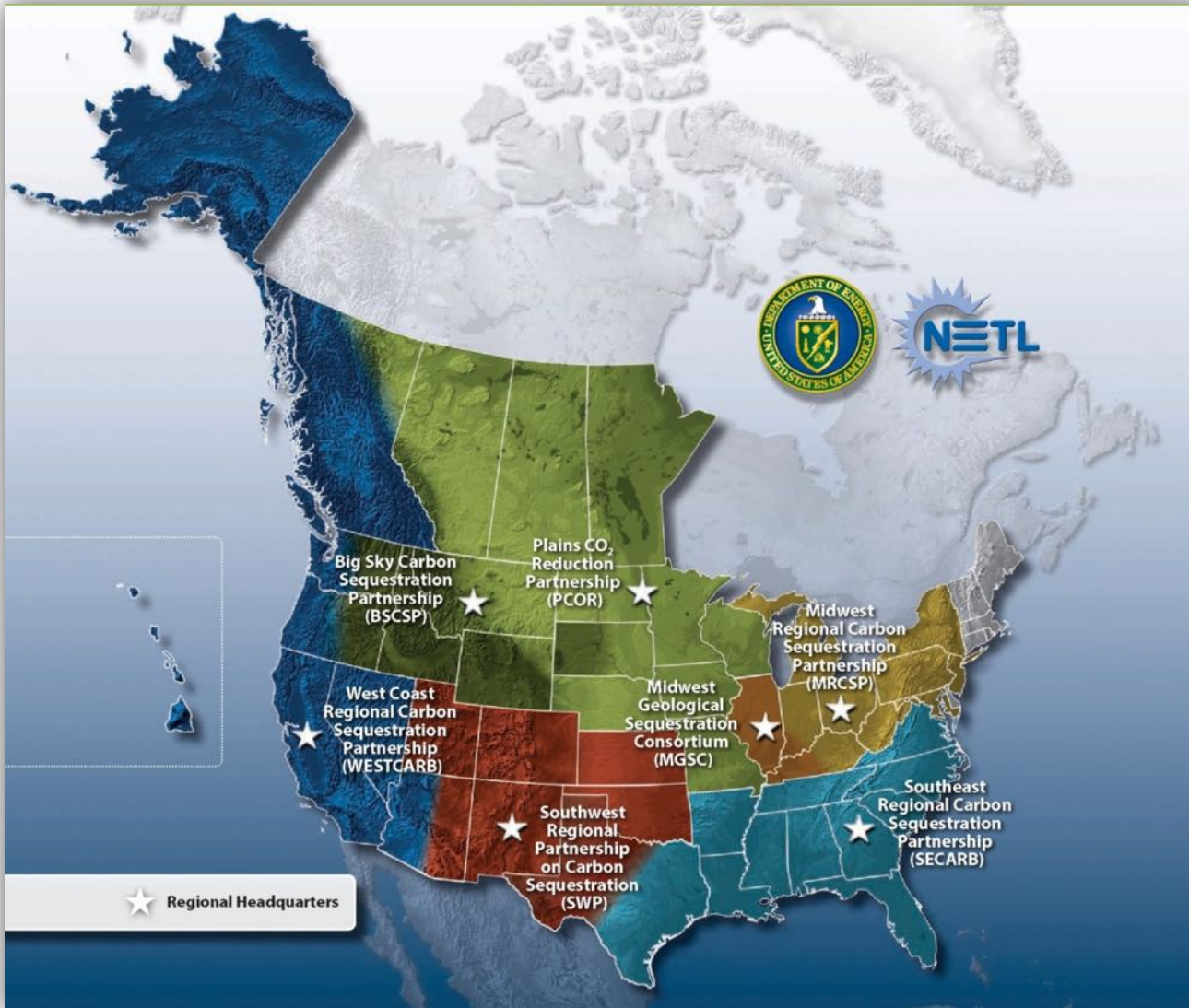
Presentation Outline

- Plains CO₂ Reduction (PCOR) Partnership
- Bell Creek project
- Aquistore project
- Basal Cambrian project
- Fort Nelson project
- Zama project
- Outreach activities
- Other PCOR Partnership activities



PCOR Partnership Region

- Nine states
- Four Canadian provinces
- 3,579,594 km²
(1,382,089 mi²)



PCOR Partnership

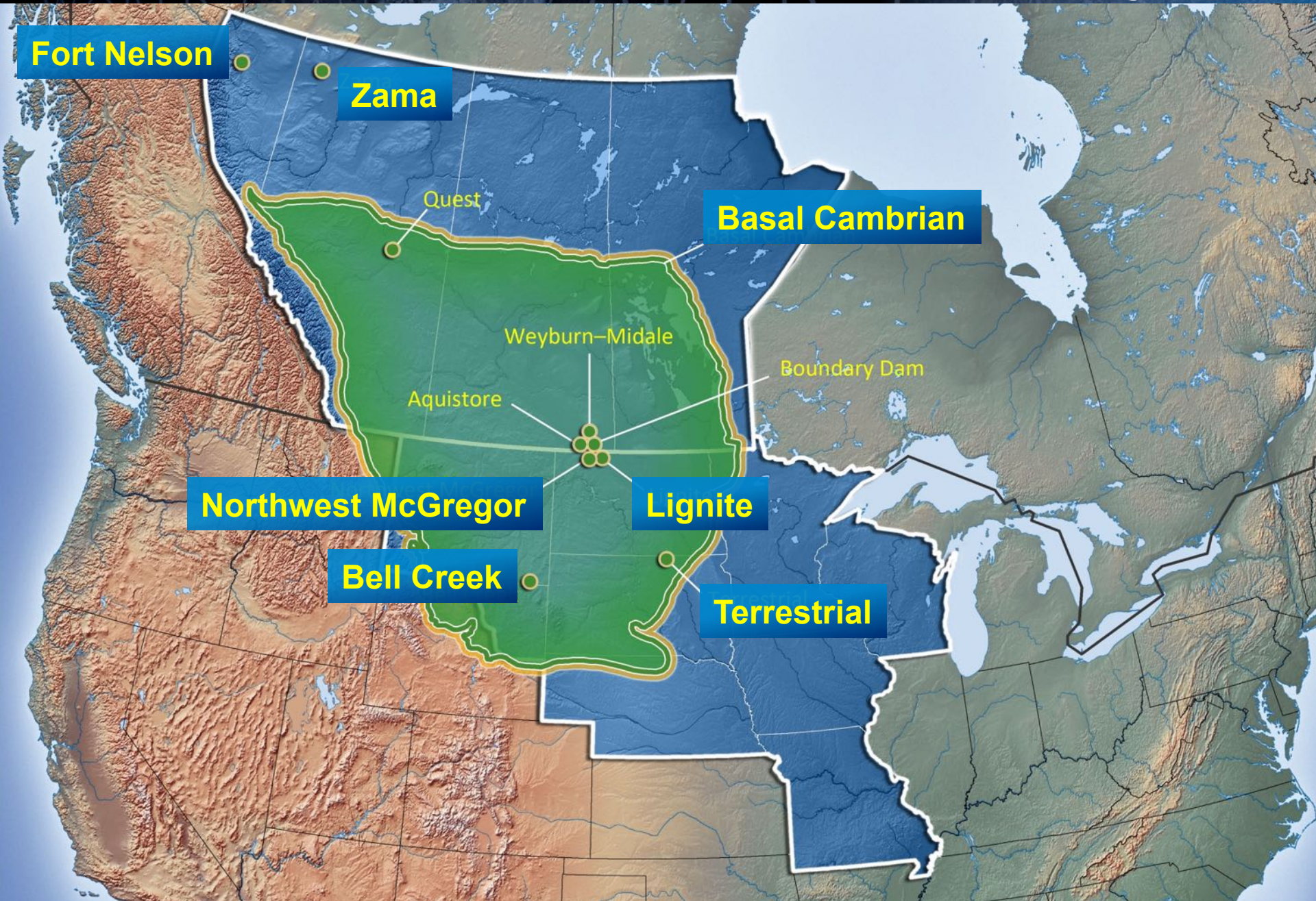


Commercial-Scale Demonstration Phase

- 1-million-tonnes CO₂/year-or-greater-scale demonstration.
- Ongoing and effective public outreach.
- Continued regional characterization.
- Continued involvement in other CO₂ storage projects in the region.
- Continued involvement in development of carbon capture and storage (CCS) and CO₂ enhanced oil recovery (EOR) regulations.

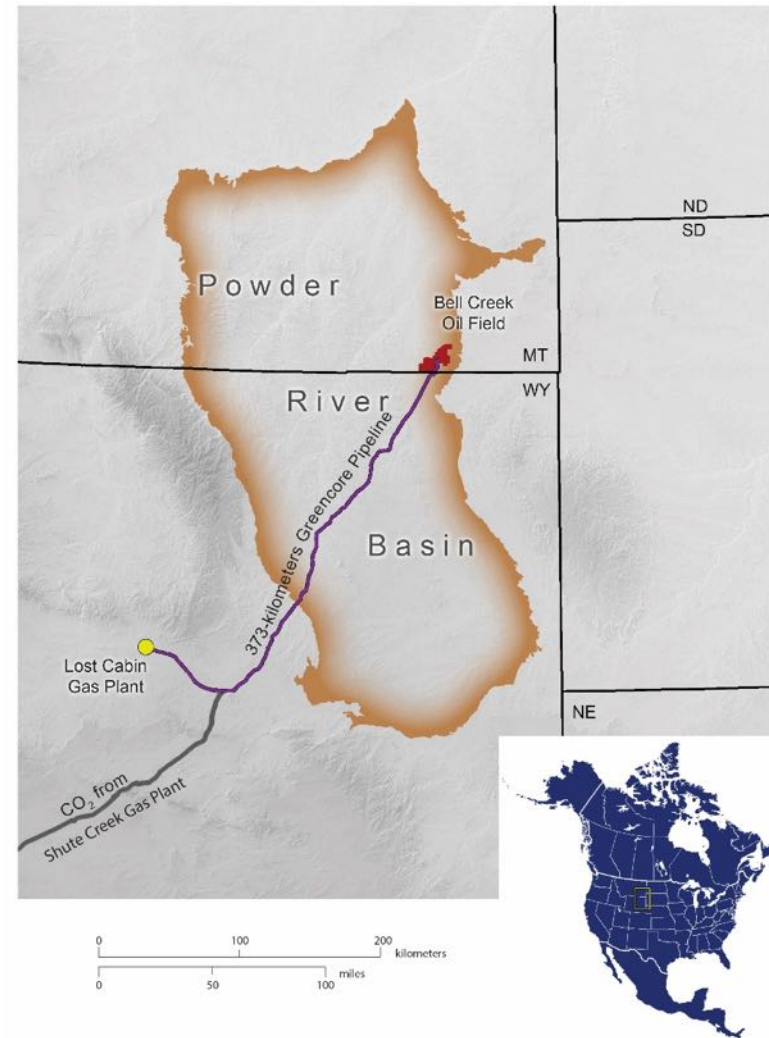
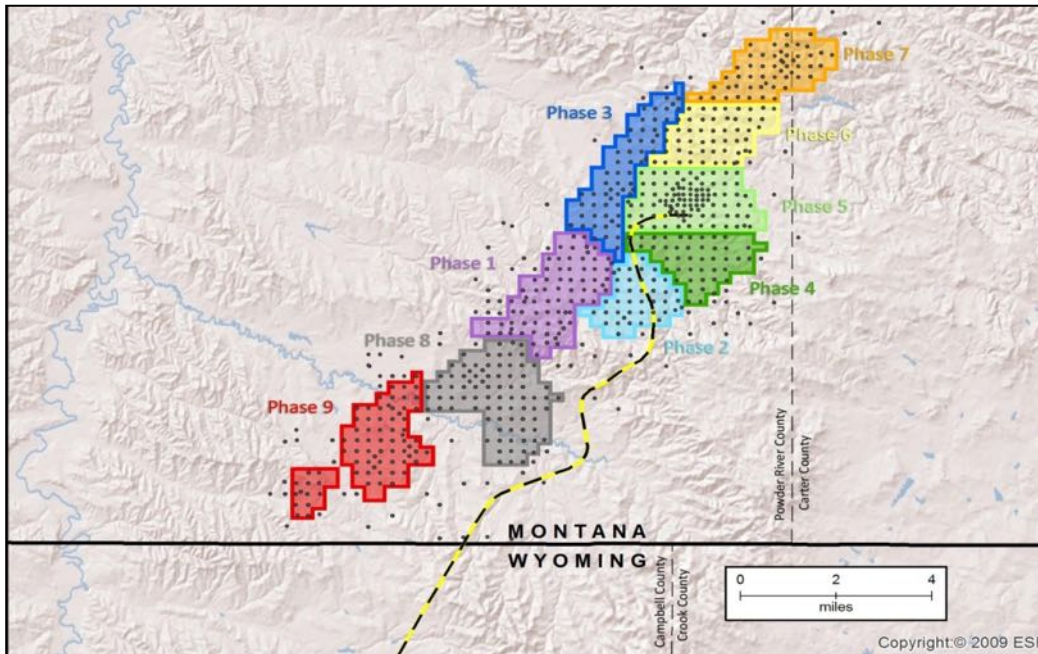


PCOR Partnership Field-Based Projects



Bell Creek Field

- The Bell Creek oil field is operated by Denbury Onshore LLC.
- CO₂ is sourced from ConocoPhillips' Lost Cabin natural gas-processing plant and Exxon's Shute Creek gas-processing plant.
- The EERC, through the PCOR Partnership, is studying associated CO₂ storage with regards to a commercial CO₂ EOR project.



Site Characteristics

Bell Creek Properties

- Cretaceous Muddy Sandstone Formation
- Nearshore marine/strand plain (barrier bars)
- Approximately 4300–4500-ft depth
- Overlain by more than 3000 ft of siltstones and shales
- Average thickness 30–45 ft
- Average porosity range
 - 25%–35%
- Average permeability range
 - 150–1175 mD
- Low reservoir water salinity ~5000 ppm total dissolved solids (TDS)
- Oil gravity 32°–41° API

EERC CG41198.CDR

Age Units		Seals, Sinks, and USDW	Powder River Basin
Cenozoic	Quaternary	USDW	
	Tertiary	USDW	Fort Union Fm
Mesozoic	Cretaceous	USDW	Hell Creek Fm
		USDW	Fox Hills Fm
		Upper Seal	Bearpaw Fm
			Judith River Fm
			Claggett Fm
			Eagle Fm
			Telegraph Creek Fm
		Upper Seal	Niobrara Fm
			Carlile Fm
			Greenhorn Fm
		Upper Seal	Belle Fourche Fm
		Upper Seal	Mowry Fm
		Sink	Muddy Fm
		Lower Seal	Skull Creek Fm

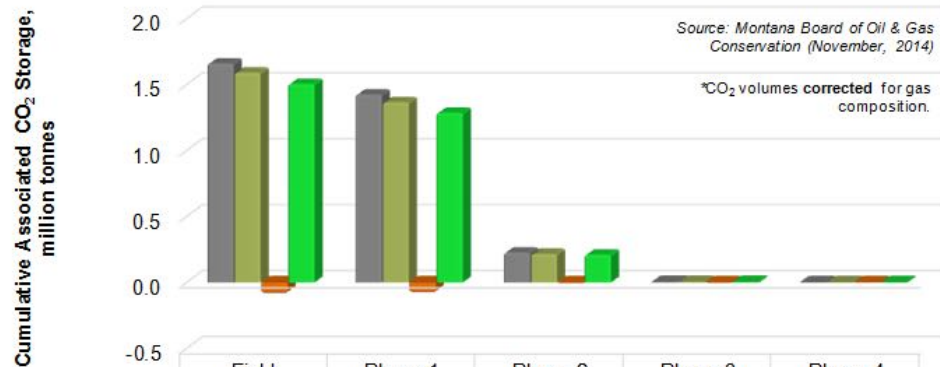
CO₂ Injection Is Ongoing!!!

- Pipeline completed November 2012
- Pipeline filled February/March 2013
- First injection May 2013
- Facilities commissioned August 2013
- **1.60 million tonnes of CO₂ injected through November 2014**
- **1.51 million tonnes of CO₂ stored through November 2014**

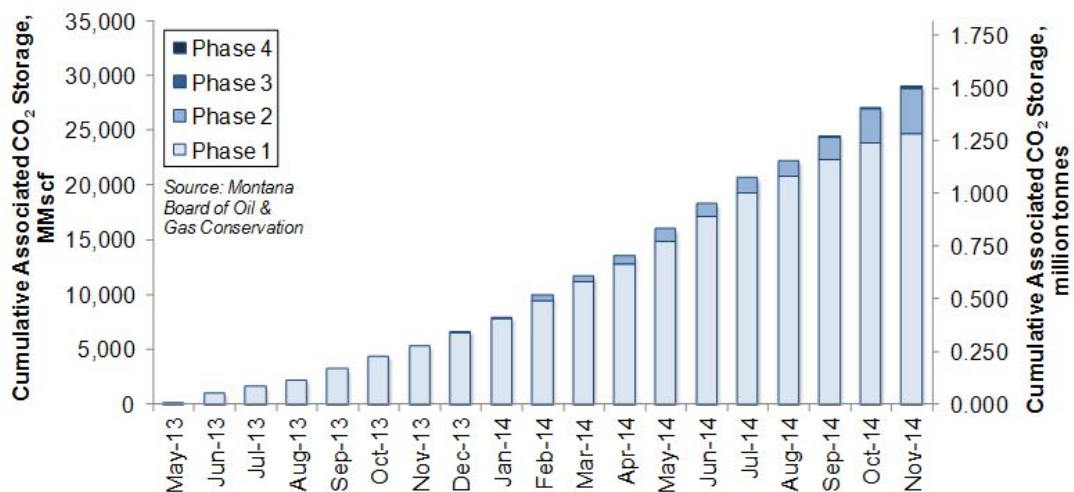
(source: Montana Board of Oil and Gas Database)

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- An estimated 40–50 million incremental bbl of oil will be recovered.
 - An estimated 12.7 million tonnes of CO₂ will be stored.

Associated CO₂ Storage

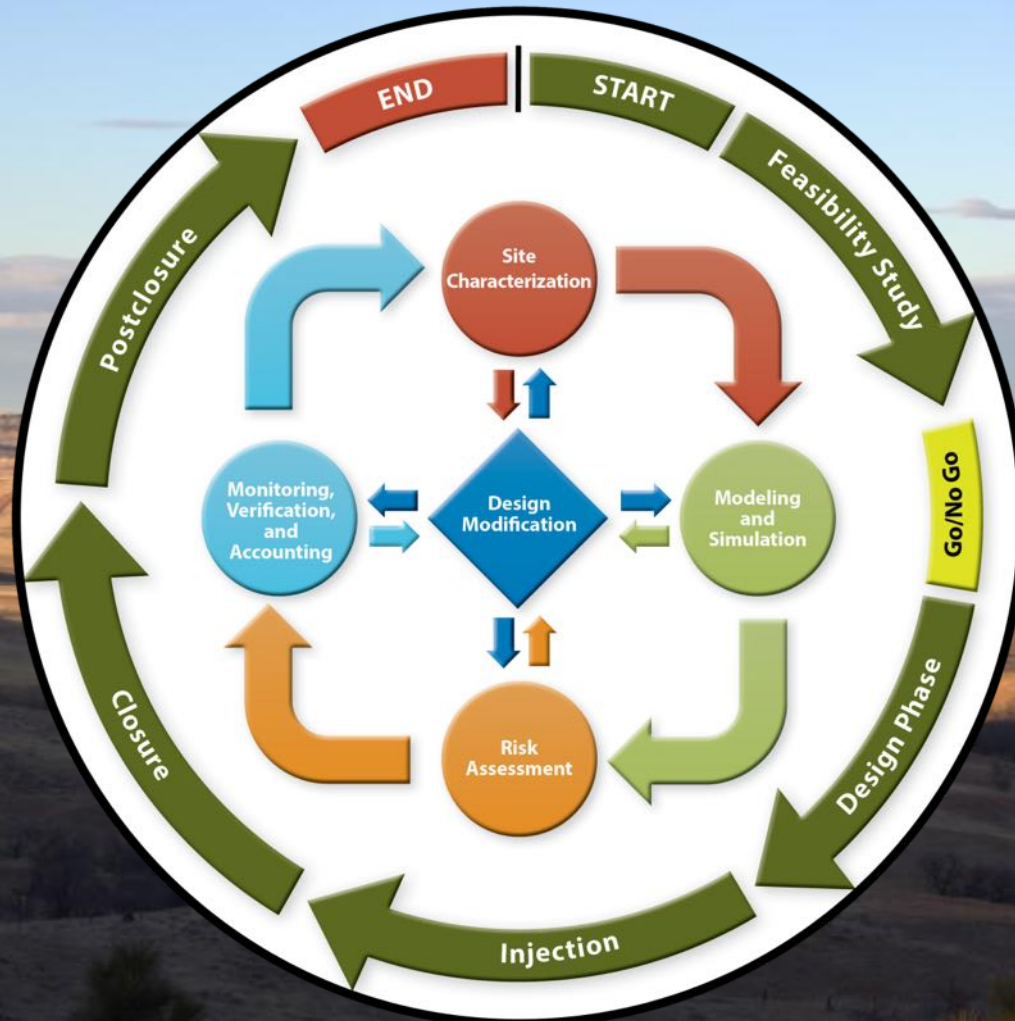


	Field	Phase 1	Phase 2	Phase 3	Phase 4
Total Gas Injected	1.661	1.426	0.228	0.006	0.0002
CO ₂ Injected*	1.593	1.368	0.218	0.006	0.0002
CO ₂ Produced/Recycled*	-0.087	-0.080	-0.006	-0.0003	0
Net CO ₂ Stored*	1.506	1.288	0.212	0.006	0.0002



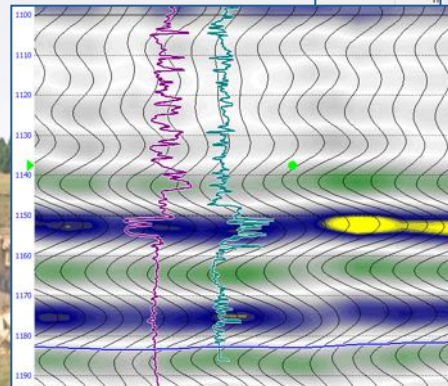
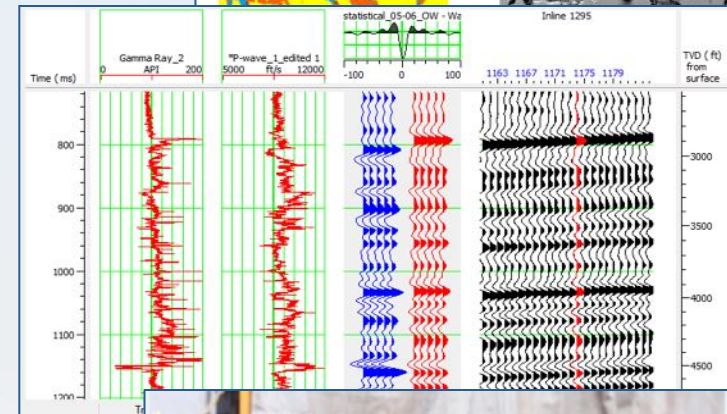
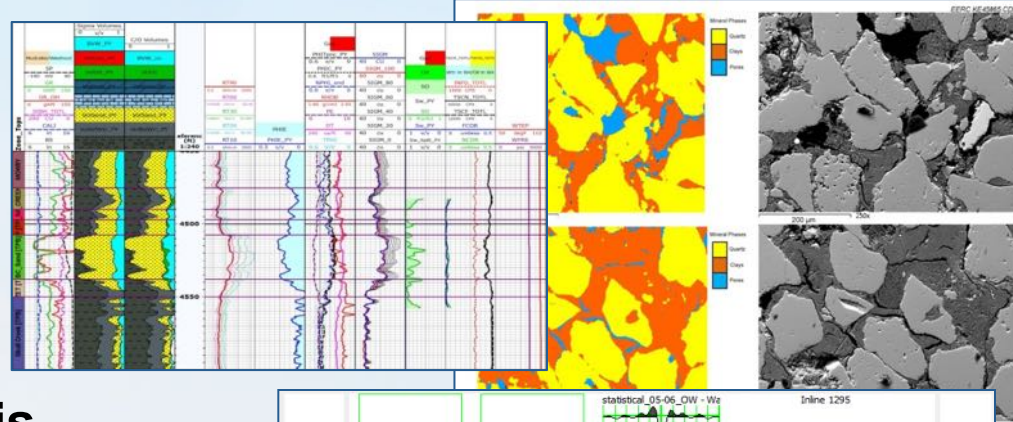
The PCOR Partnership's Integrated Approach to Program Development

Focused on Site Characterization, Modeling and Simulation, and Risk Assessment to Guide Monitoring, Verification, and Accounting (MVA) Strategy



Site Characterization

- Well file integration
- Lidar (light detection and ranging) collection
- Outcrop investigations
- Drilling characterization wells
- New core collection and analysis
- SCAL (special core analysis) and pressure–volume–temperature (PVT) testing
- Existing core analysis
- 104-km² (40-mi²) baseline 3-D seismic survey
- Baseline 3-D vertical seismic profiles (VSPs)
- Pulsed-neutron logs (PNLs)



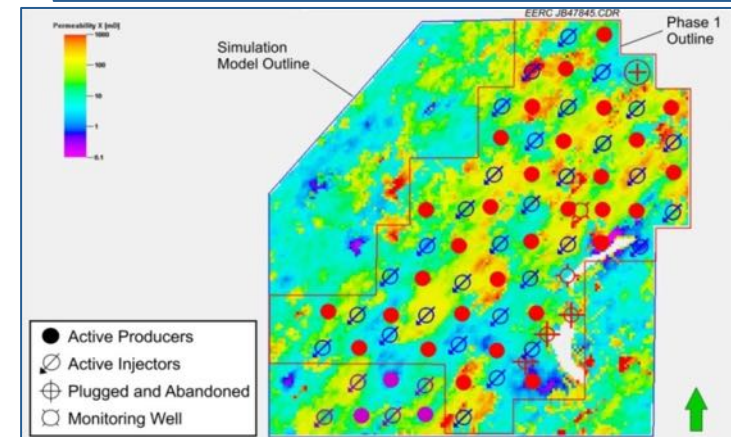
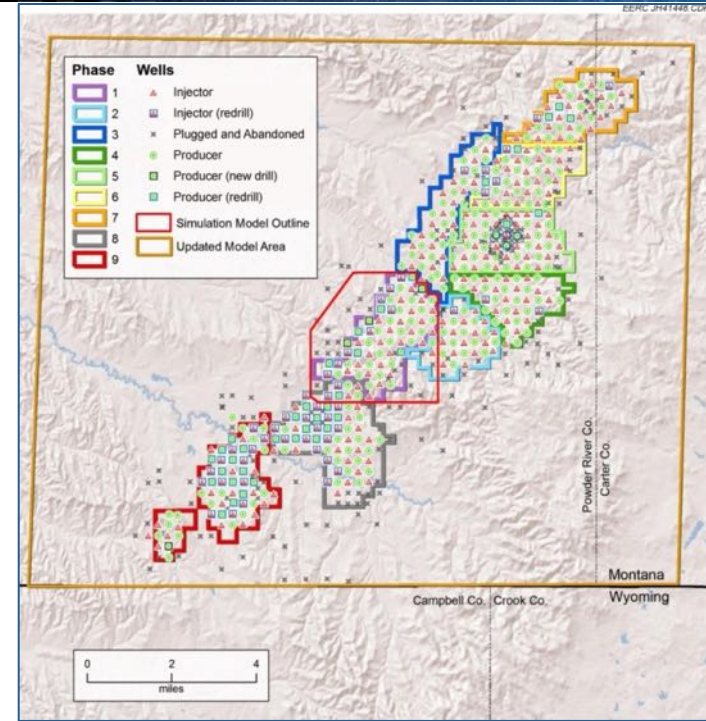
Modeling and Simulation

Models

- 518-km² (200-mi²) domain models
- 20-km² (7.75-mi²) multiphase flow numerical simulation models
- PVT and equation-of-state modeling
- 1-D and 3-D mechanical earth model
- Shallow-subsurface geochemical modeling
- Near-surface flow model

Simulation

- Phases 1 and 2 (separate) history matching and predictive simulation complete.
- Phases 1 and 2 combined history matching is under way.



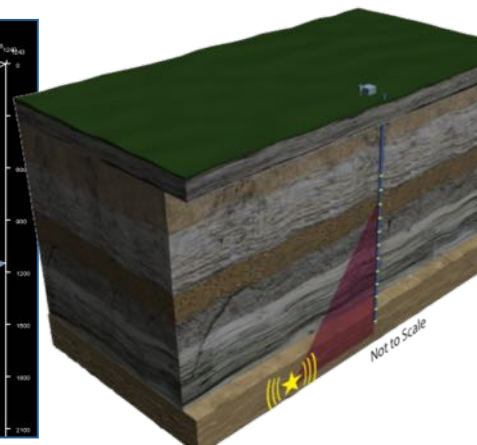
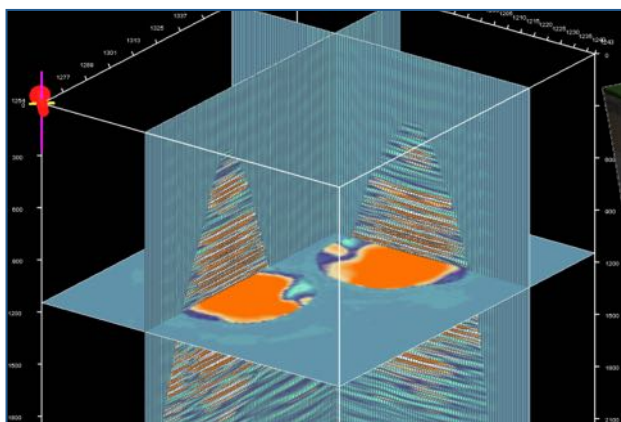
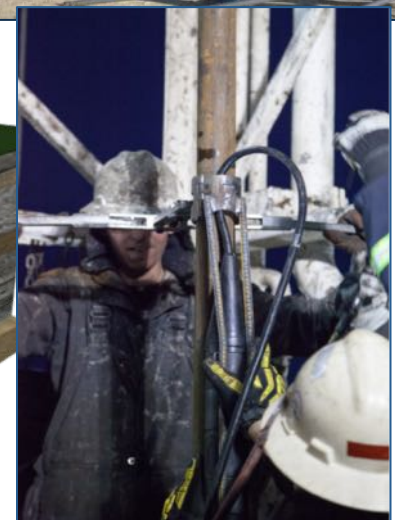
MVA

Surface and Near-Surface Activities

- Baseline soil gas and water monitoring are complete.
- Regular sampling events are under way.

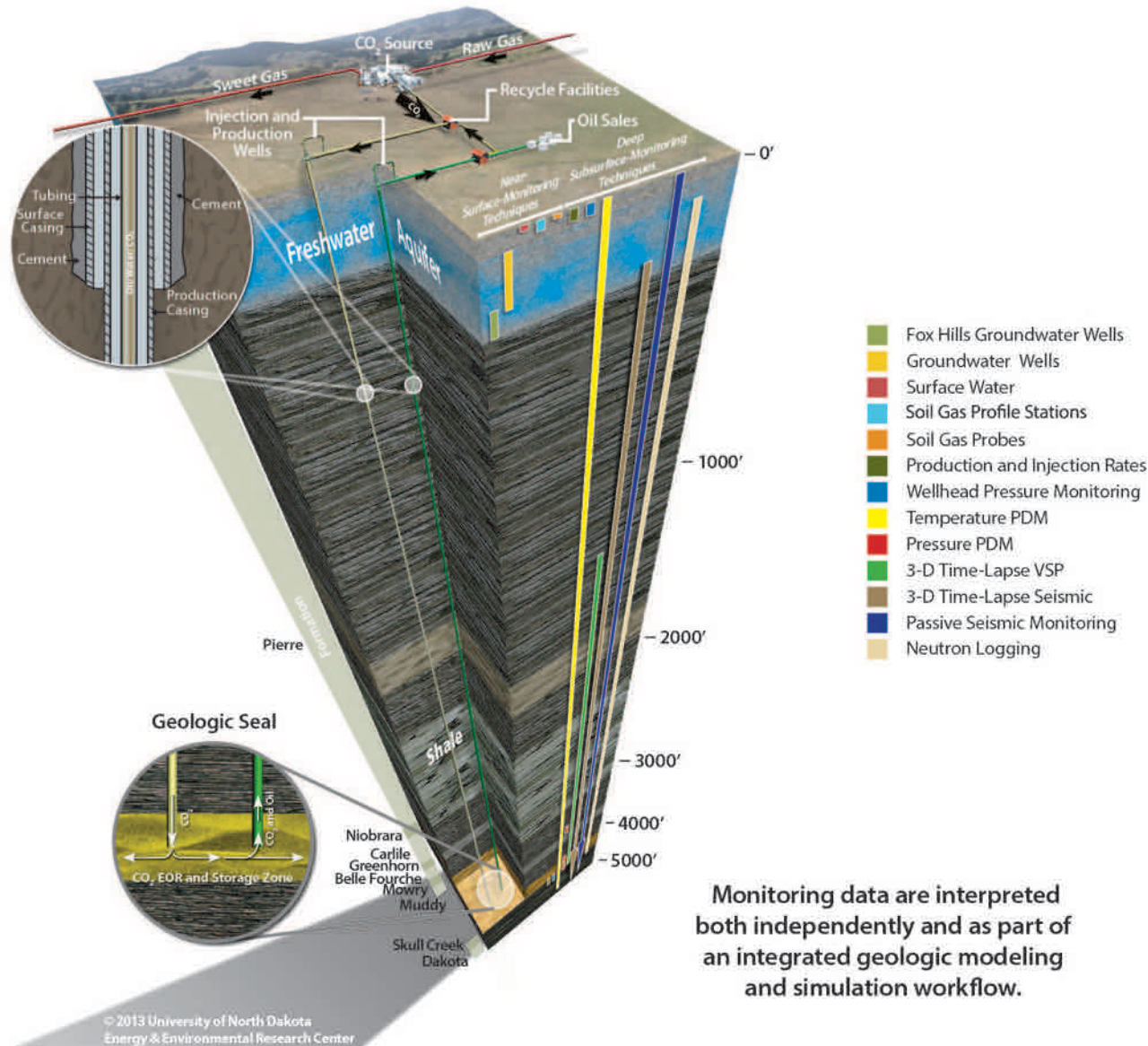
Subsurface Activities

- Repeat PNLs collected (31 to date)
- Passive seismic monitoring (nearly 2 years complete)
- Downhole pressure and temperature monitoring
- Time-lapse seismic collected (surface and VSP)



Path Forward – Operational Monitoring

- Update risk analysis with monitoring data.
- Time-lapse seismic surveys.
- Pulsed-neutron logging.
- Reduced sampling interval for soil gas and groundwater.



Other PCOR Partnership Program Components

- Aquistore project
- Basal Cambrian project
- Fort Nelson project
- Zama project
- Public outreach
- Regional characterization
- Regulatory involvement
- Water Working Group



Aquistore Project



- CO₂ from the Boundary Dam power plant in southeastern Saskatchewan will be injected into a saline formation:
 - Target zone is Deadwood Formation, 3200 m (10,500 ft) deep, >50 m (>150 ft) thick.
 - PCOR Partnership activities include:
 - Core analysis.
 - Static and dynamic modeling.
 - Public outreach.
 - Participation in Aquistore Science and Engineering Research Council (SERC).



ptrc

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Aquistore

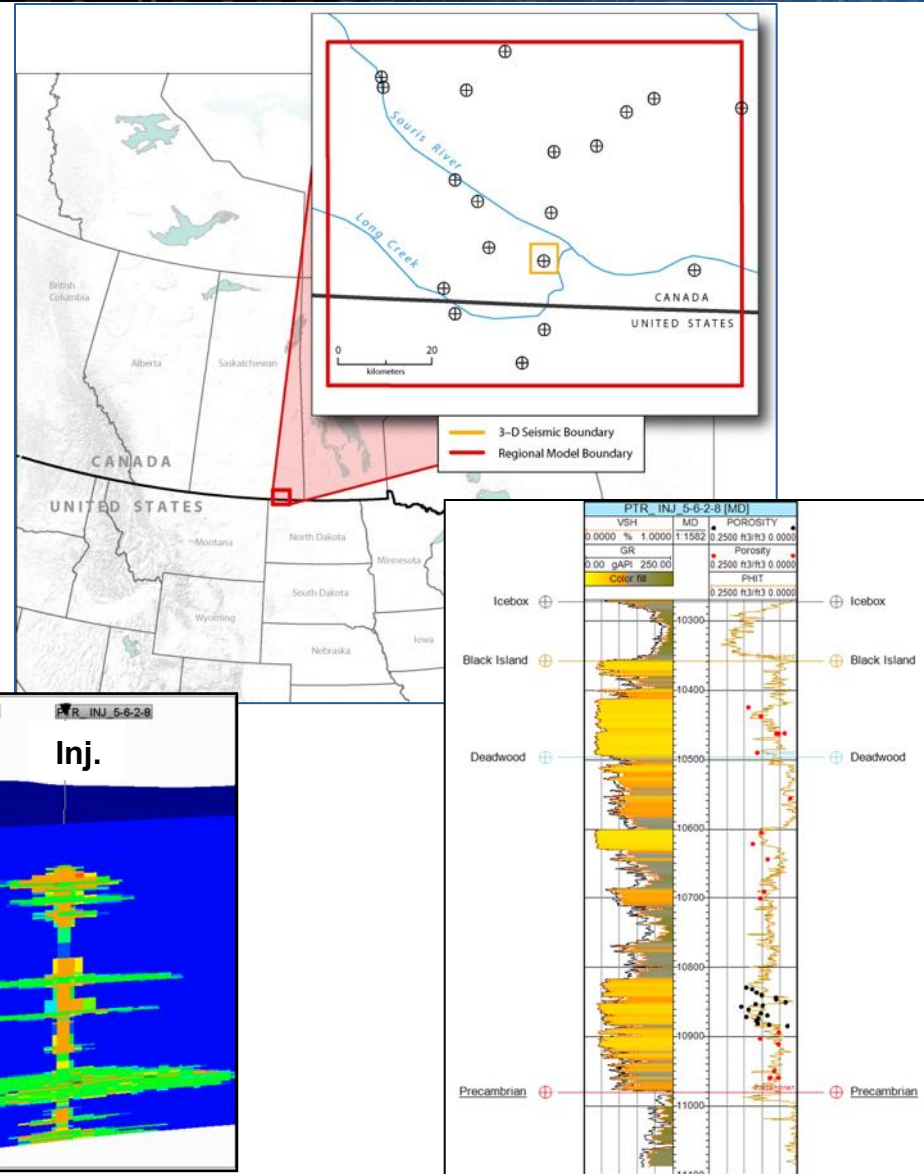


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PCOR
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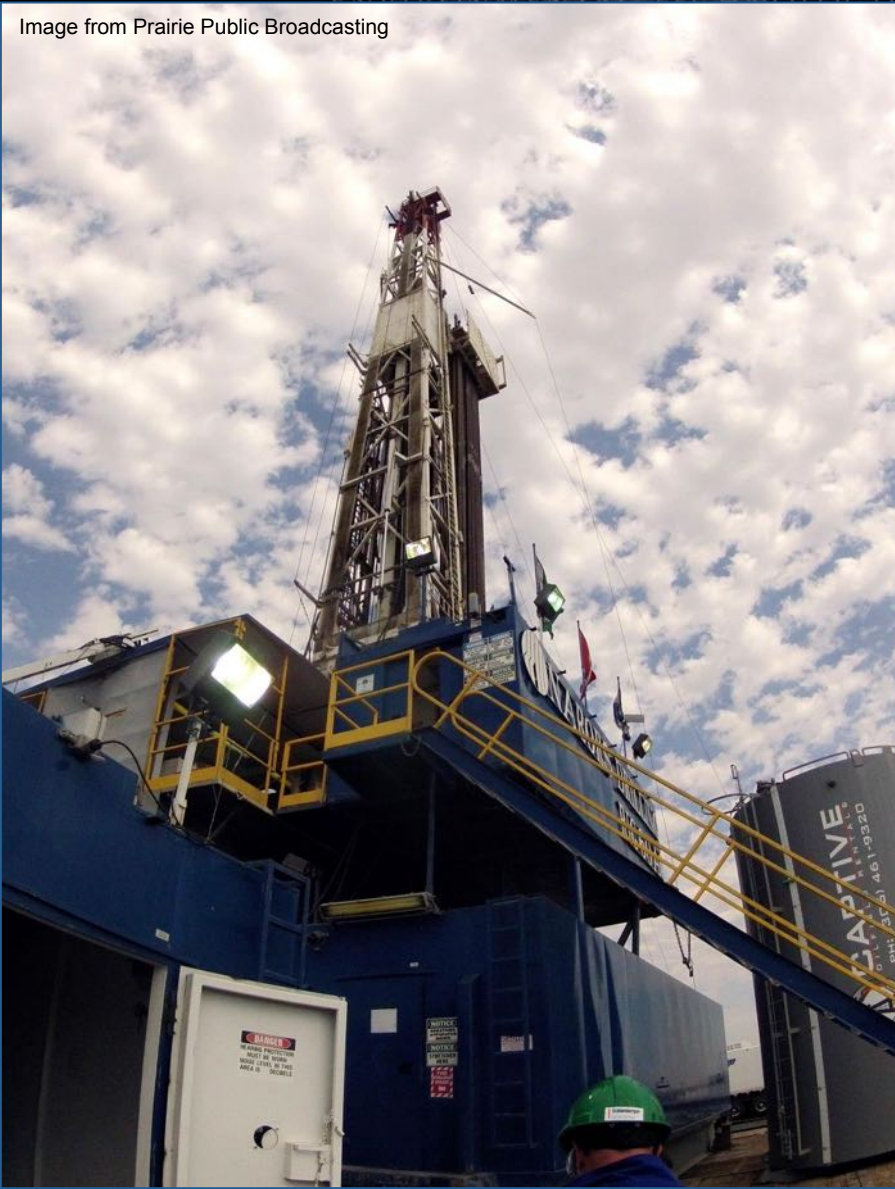
Aquistore Modeling and Simulation

- Initial phase of modeling and simulation completed.
 - Coarse and fine-scaled geocellular models centered on the injection and observation wells.
 - Multiple injection scenarios simulated based on three realizations.



CO₂ Injection Is Under Way!

Image from Prairie Public Broadcasting

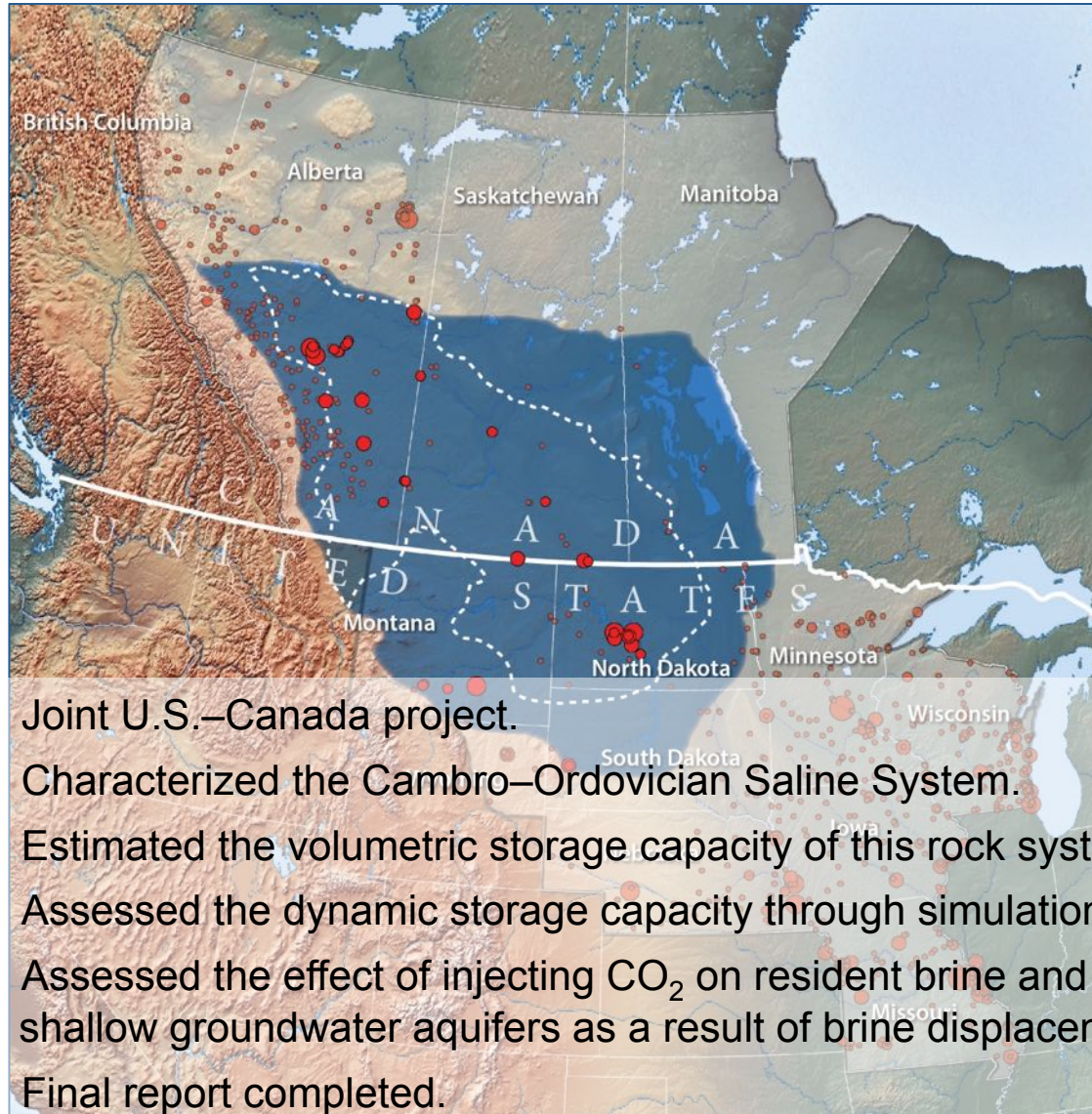
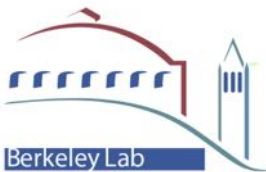


- Injection of CO₂ began in April, 2015.
- Downhole monitoring data are being collected from multiple zones.

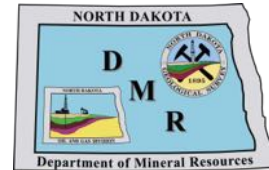
Future Work

- Update predictive simulations with actual injection data in an iterative fashion.
- Expand fine-scale model.
- Obtain better understanding of storage efficiency.

Basal Cambrian Project



- Joint U.S.–Canada project.
- Characterized the Cambro–Ordovician Saline System.
- Estimated the volumetric storage capacity of this rock system.
- Assessed the dynamic storage capacity through simulations.
- Assessed the effect of injecting CO₂ on resident brine and on shallow groundwater aquifers as a result of brine displacement.
- Final report completed.



CCS in Deep Saline Formations and Hydrocarbon Reservoirs

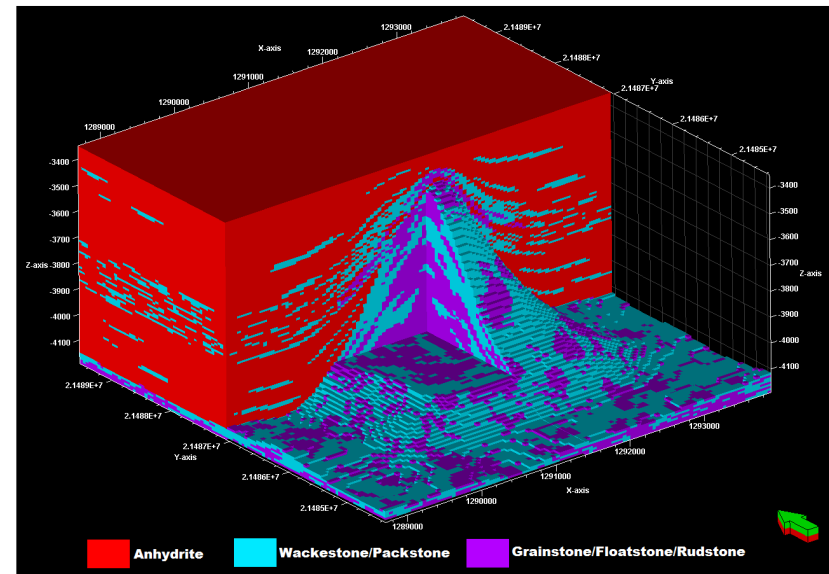
Fort Nelson CCS Feasibility Study

- CCS in a deep saline formation.
- Completed a best practices manual for MVA.

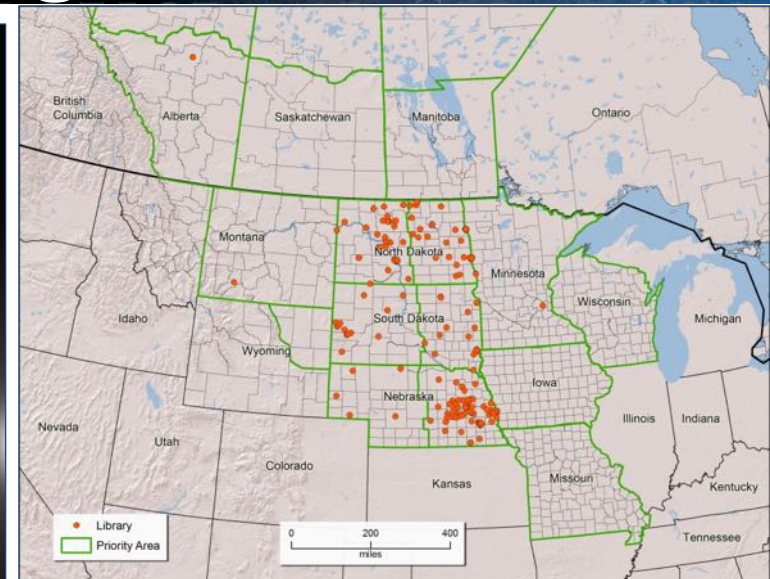
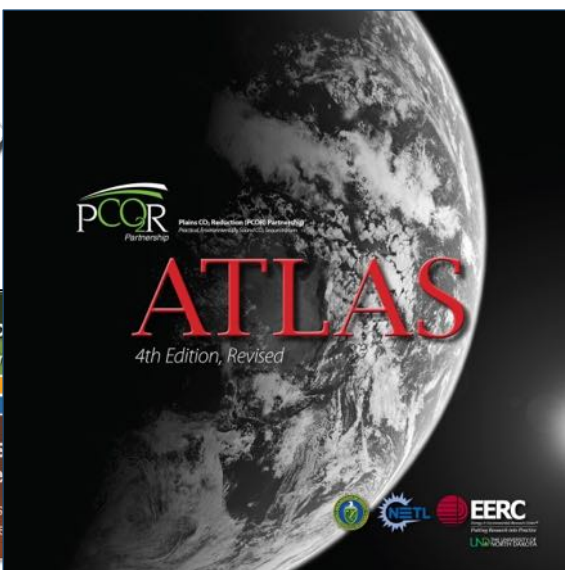


Zama Acid Gas EOR and Storage

- Operated by Apache Canada Ltd.
- Static and dynamic modeling activities completed.
- Regional technology implementation plan created.



PCOR Partnership Outreach Activities Occur at Local and Regional Levels



About the Partnership
Carbon Sequestration, Climate Change and CO₂

Carbon dioxide (CO₂) sequestration, the long-term storage of CO₂ either in geologic zones deep underground or at the earth's surface in plants and soils, is emerging as a major strategy to help address climate change concerns. But to be successful,

PCOR Partnership Features:

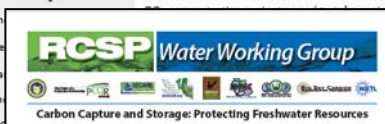
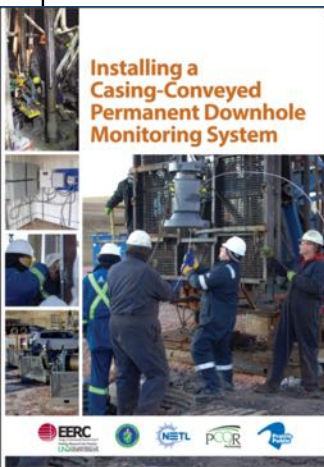
DOE Techlines

DOE-Sponsored Field Test Finds Potential for Permanent Storage of CO₂ in Lignite Seams

DOE Regional Partnership Successfully Demonstrates Terrestrial CO₂ Storage Practice in Great Plains Region of U.S. and Canada

Topical Report

Factors Affecting the Potential for CO₂ Leak from Geologic Sinks (PDF)



a collaboration is laying the und CO₂ America.

Introduction

The national goal of carbon capture and storage (CCS) to impact carbon dioxide (CO₂) that has been captured from a point source, with a power plant, into a closed underground storage formation and ensure that it remains there. Maintaining the security of that CO₂ and preventing any water resources. This report identifies the key to successful protection water resources during CCS and introduces the underlying regulatory framework set up for that purpose.

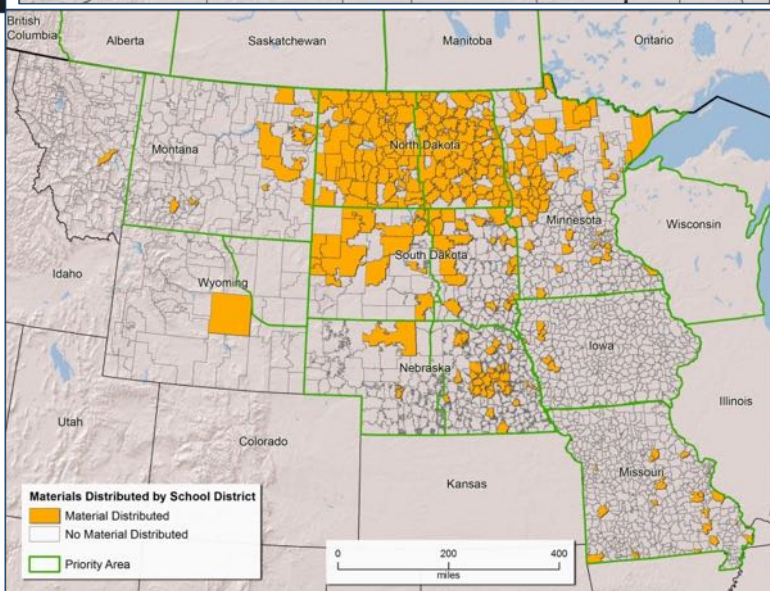
CCS and CO₂ Containment

The commercial geologic sequestration of CO₂ has been done only in the United States for decades and currently is not widely practiced. CCS is a complex technology that involves the capture, transport, and injection of CO₂ into a geologic formation. CCS involves the capture of CO₂ from a point source, its transport via pipeline or ship, and its injection into a geologic formation. CCS involves the capture of CO₂ from a point source, its transport via pipeline or ship, and its injection into a geologic formation.

Keys to Successful Protection of Water Resources

The keys to water resource protection during CCS include: (1) understanding the geology and hydrology of the storage formation; (2) understanding the behavior of CO₂ in the storage formation; (3) understanding the behavior of water in the storage formation; and (4) understanding the behavior of the storage formation during CCS.

State	Number of Wells	Comments
Alaska	1	One well in the North Slope region.
Colorado	1	One well in the Front Range region.
Illinois	1	One well in the St. Louis region.
Missouri	1	One well in the St. Louis region.
Nebraska	1	One well in the Lincoln region.
North Dakota	1	One well in the Bismarck region.
South Dakota	1	One well in the Pierre region.
Utah	1	One well in the Salt Lake City region.
Wyoming	1	One well in the Cheyenne region.



Other PCOR Activities

Regional Characterization

- Four value-added reports completed in the last year. Three in development.
- Paper submitted and accepted to a journal (*Environmental Science and Technology*).



Water Working Group

- Developing a BPM project capstone report (due November 2016)
- Publishing special edition of the *International Journal of Greenhouse Gas Control* (target mid-2016).
 - Special edition focused on “The Nexus of Water and CCS.”
 - Solicitation for papers is being prepared and will be released soon.

Regulatory

- 
- An aerial photograph of a town, likely Deadwood, South Dakota, showing a mix of red brick buildings and lush green trees. The image is used as a background for a list of activities.
- Participation in Interstate Oil and Gas Compact Commission activities.
 - 7th Annual PCOR Partnership Regulatory Roundup to be held in Deadwood, South Dakota, July 22–23, 2015.

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PROGRAMS, OPPORTUNITIES FOR
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Thank You!!!

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