Integrated Commercial Carbon Capture and Storage (CCS) Prefeasibility Study at Dry fork Station, Wyoming

Project Number: DE-FE0029375

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U.S. Department of Energy

National Energy Technology Laboratory
DE-FOA0001584 Project review

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SCHOOL OF ENERGY RESOURCES

Presentation Outline

- ❑Project Map
- ❑Source Transport and Storage Scenarios
- ❑Regional Stake Holder Analysis
- ❑Geologic Evaluation
- ❑Preliminary Modeling Efforts
- ❑Accomplishments
- ❑Research Gaps
- ❑Next Steps

Project Team

- University of Wyoming's (UW) Carbon Management Institute
- Energy & Environmental Research Center (EERC)
- Advanced Resources International, Inc. (ARI)
- Basin Electric Power Cooperative (Dry Fork Station)
- Wyoming Municipal Power
- Office of the Wyoming Governor
- Wyoming Infrastructure Authority (WIA)
- UW's Enhanced Oil Recovery Institute (EORI)
- UW's Center for Energy Economics & Public Policy (CEEPP)
- UW's College of Law
- Schlumberger
- KKR

Project Team at Dry Fork Station

Project Map: Methodology

Task 1: Scenario Generation	Source, Transport, and Storage
Task 2: Regional and stakeholder analysis	Regional Stakeholder analysis: Economic; Legal Assessment; Environmental Assessment; Community and Public Outreach
Task 3: Scenario Prioritization	Scenario ranking
Task 4: Geologic Evaluation	Geologic Evaluation
Task 5 and 6: Geologic Modeling	Geologic Model Development and simulation — NRAP Modeling and Validation

Project Goal: Identify ***Economic*** Saline Storage proximal to the Dry Fork Power Station

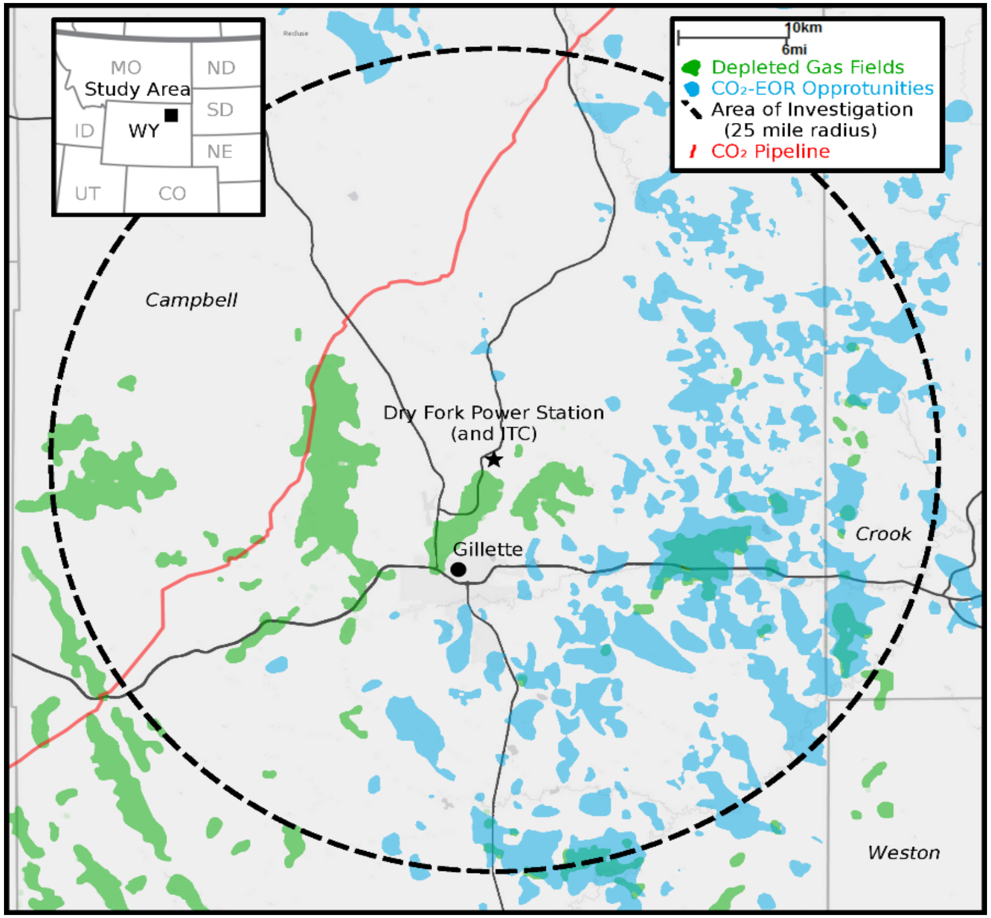
Project scenario:

Storage

- **Saline reservoirs**
- CO_2-EOR opportunities
- Depleted oil and gas fields

Favorable Economics

- Co-location of coal supplies CO_2 source, CO_2 transport, EOR, and CO_2 storage opportunities
- ITC
- Use of existing pipelines for utilization off-site



Primary Anthropogenic CO_2 Source

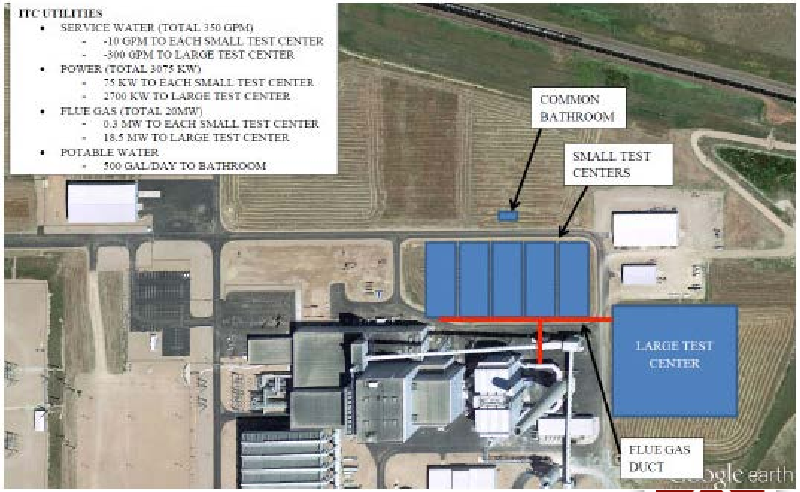
- Dry Fork Station (Basin Electric Power Coop)
- Wyoming Integrated Test Center (WY-ITC)

<u>Dry Fork Station</u>

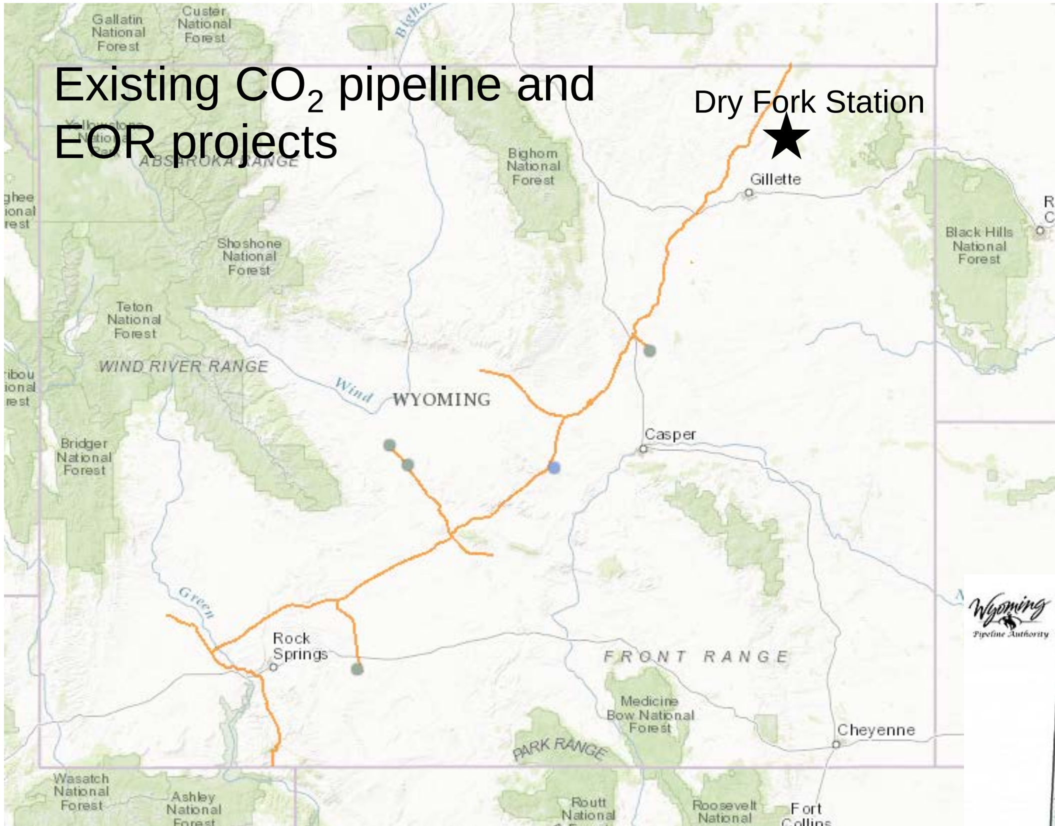
- ✓ Built in 2007
- ✓ 385 MW Power Plant
- ✓ 3.3 Million tons of CO_2/year

<u>WY-ITC</u>

- ✓ To be completed fall 2017
- ✓ Test CO_2 capture/CCUS technologies
- ✓ $20 Million public/private investment
- ✓ NRG COSIA Carbon XPRIZE ($20M global competition to develop breakthrough technologies for CO_2 emissions)



Wyoming CCUS Transportation Infrastructure

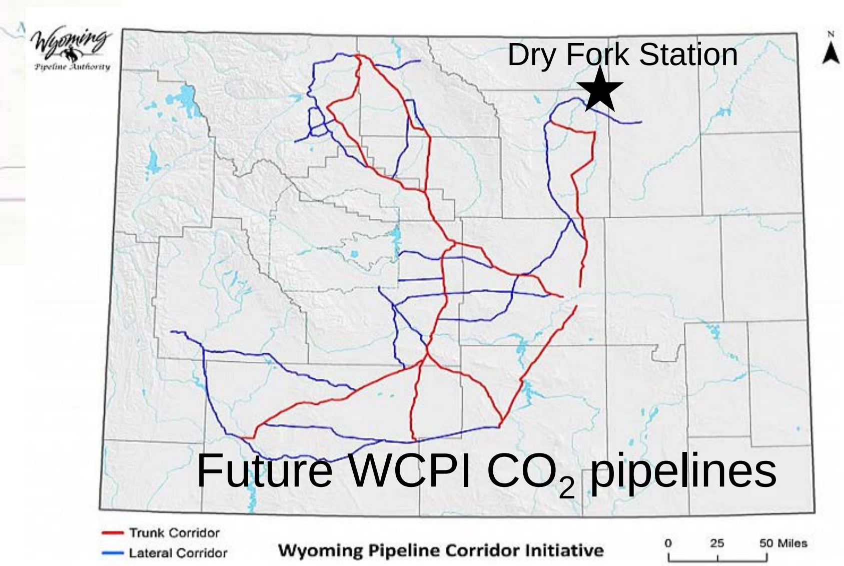


Existing and Pipeline ROWs

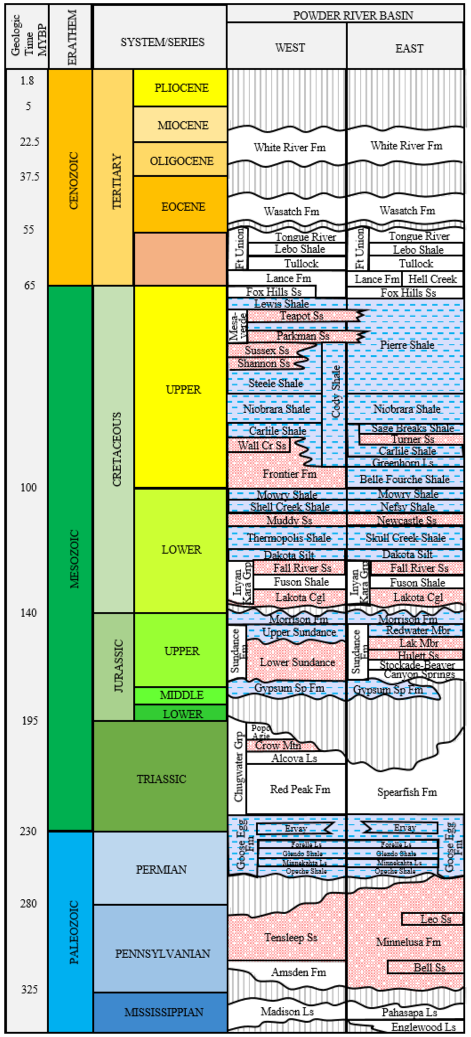
- ✓ Reduce Pipeline Construction Costs/Time
- ✓ Connect a Statewide source-sink combinations

The Wyoming Pipeline Corridor Initiative (WPCI) is a proposed pipeline ROW network designed to connect CO_2 sources to existing and future EOR oil fields

https://www.wyopipeline.com/projects/wpci/



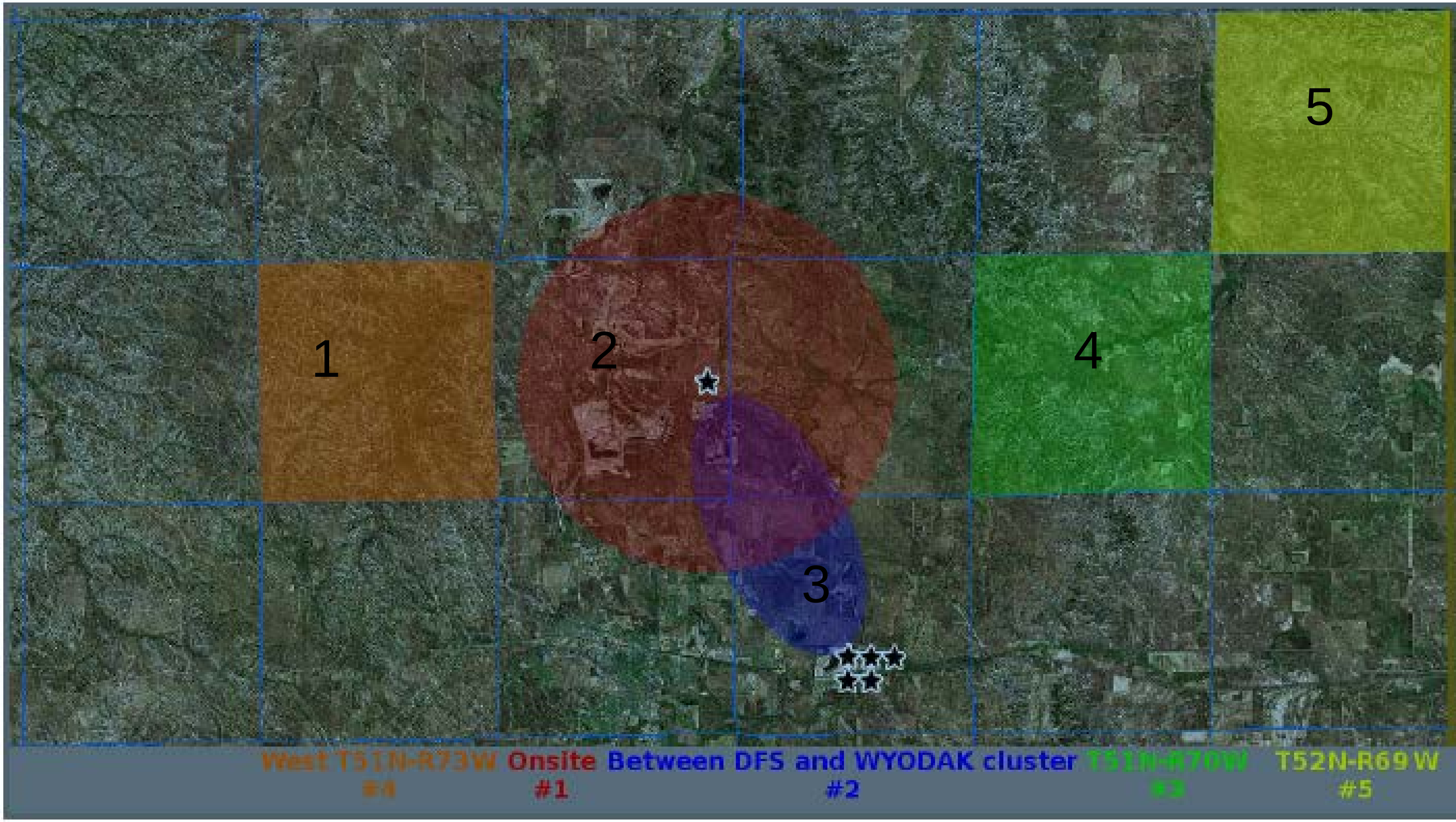
Storage Complex



Powder River Basin

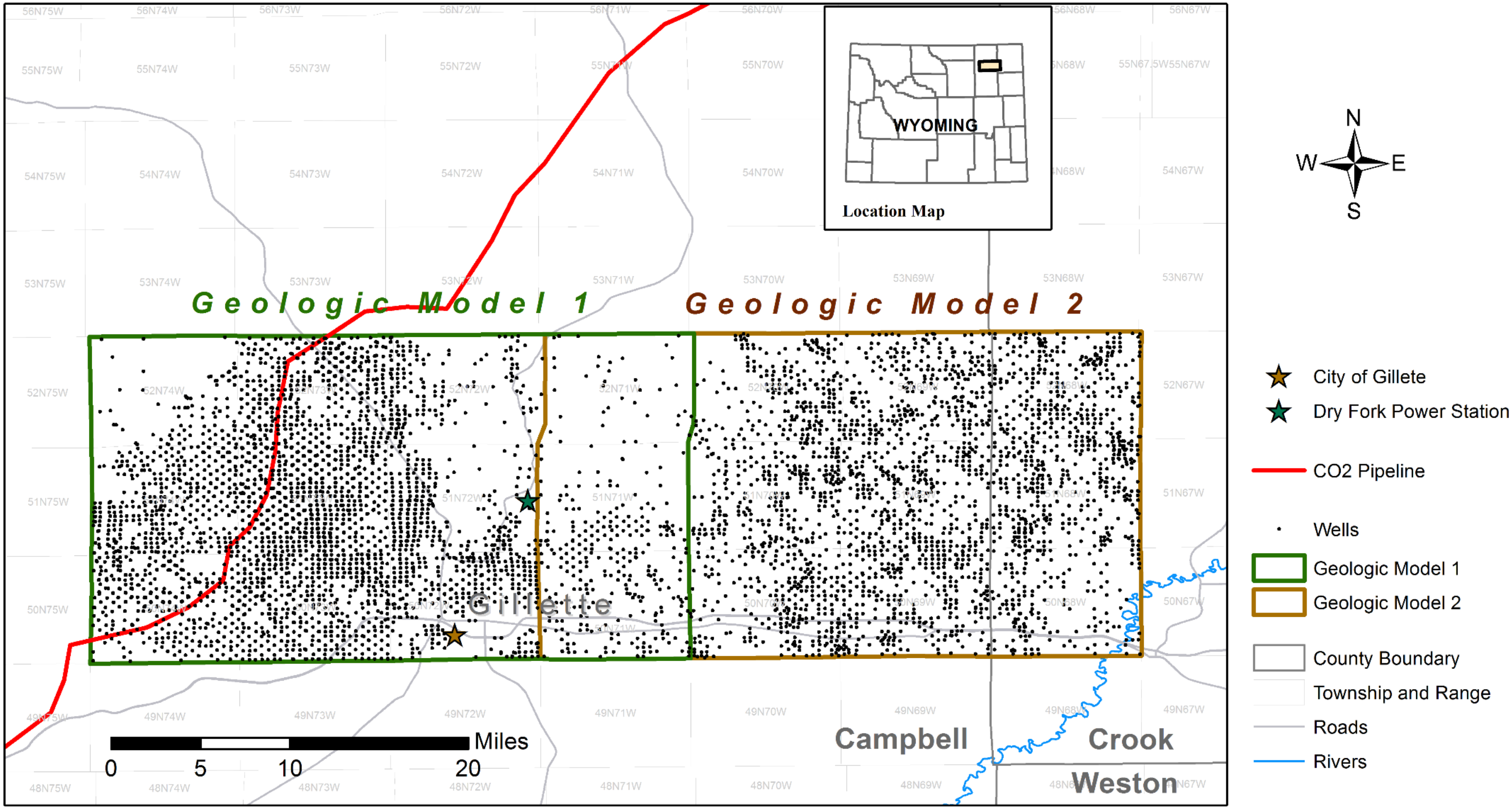
- ✓ 24,000 square miles in area and contains 17,000 feet of sedimentary rock
- ✓ Abundant oil and gas production
- ✓ The substantial hydrocarbons indicate significant pore space and sealing capacity of these formations
- ✓ NETL (2010) estimated the PRB to have 196 GT of storage capacity

Surface scenarios: Regional Stakeholder analysis (Task 2 &3)



Regional Stakeholder assessment: Economic, Legal, Environmental, Public Outreach

Subsurface evaluation (Task 4)



Reservoir Candidates

Muddy Reservoir: Challenges

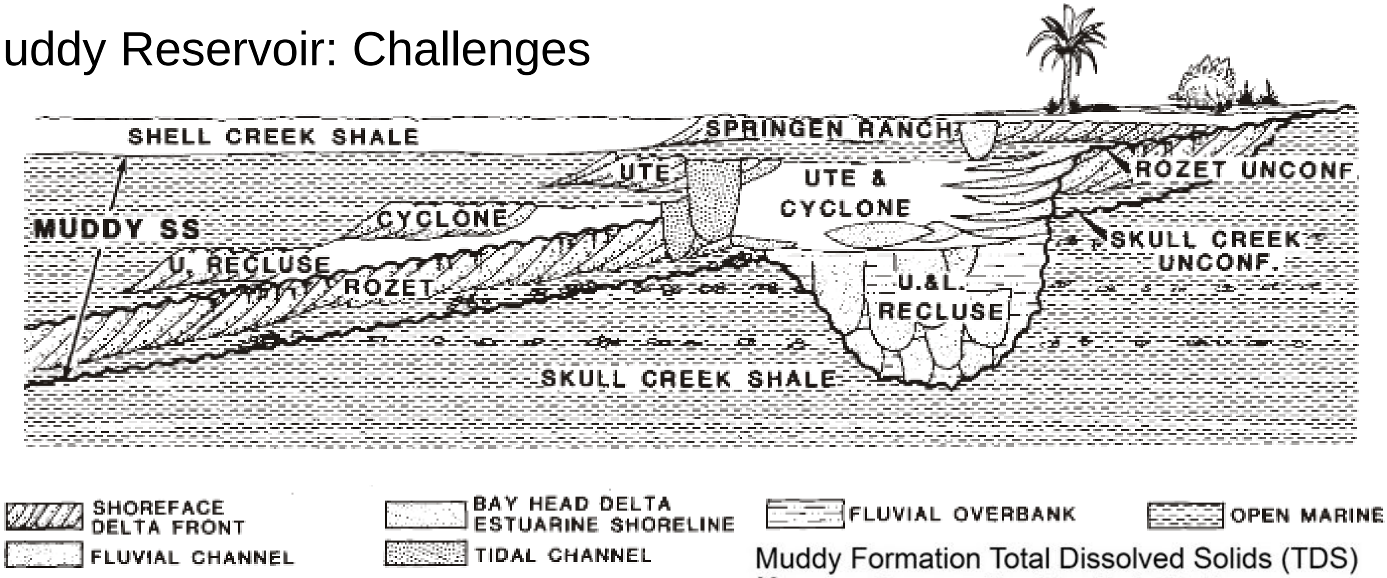
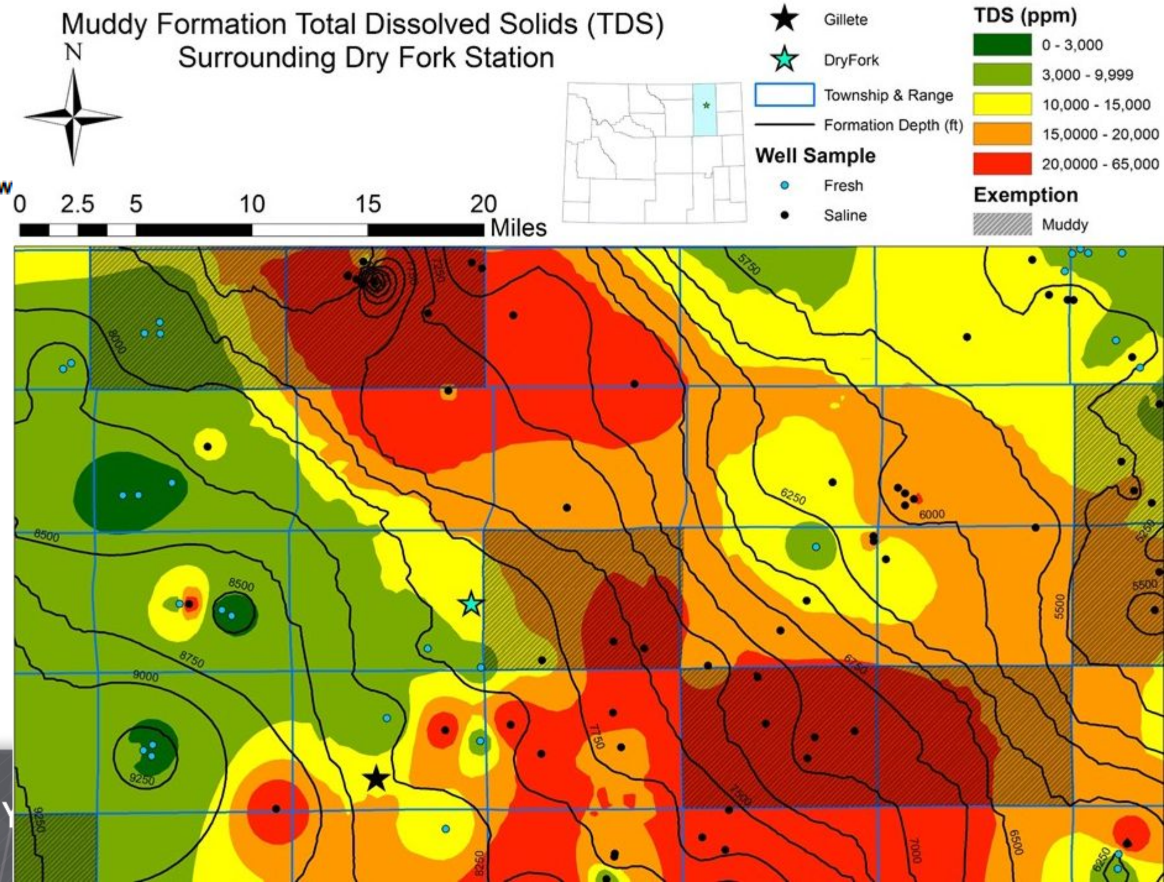
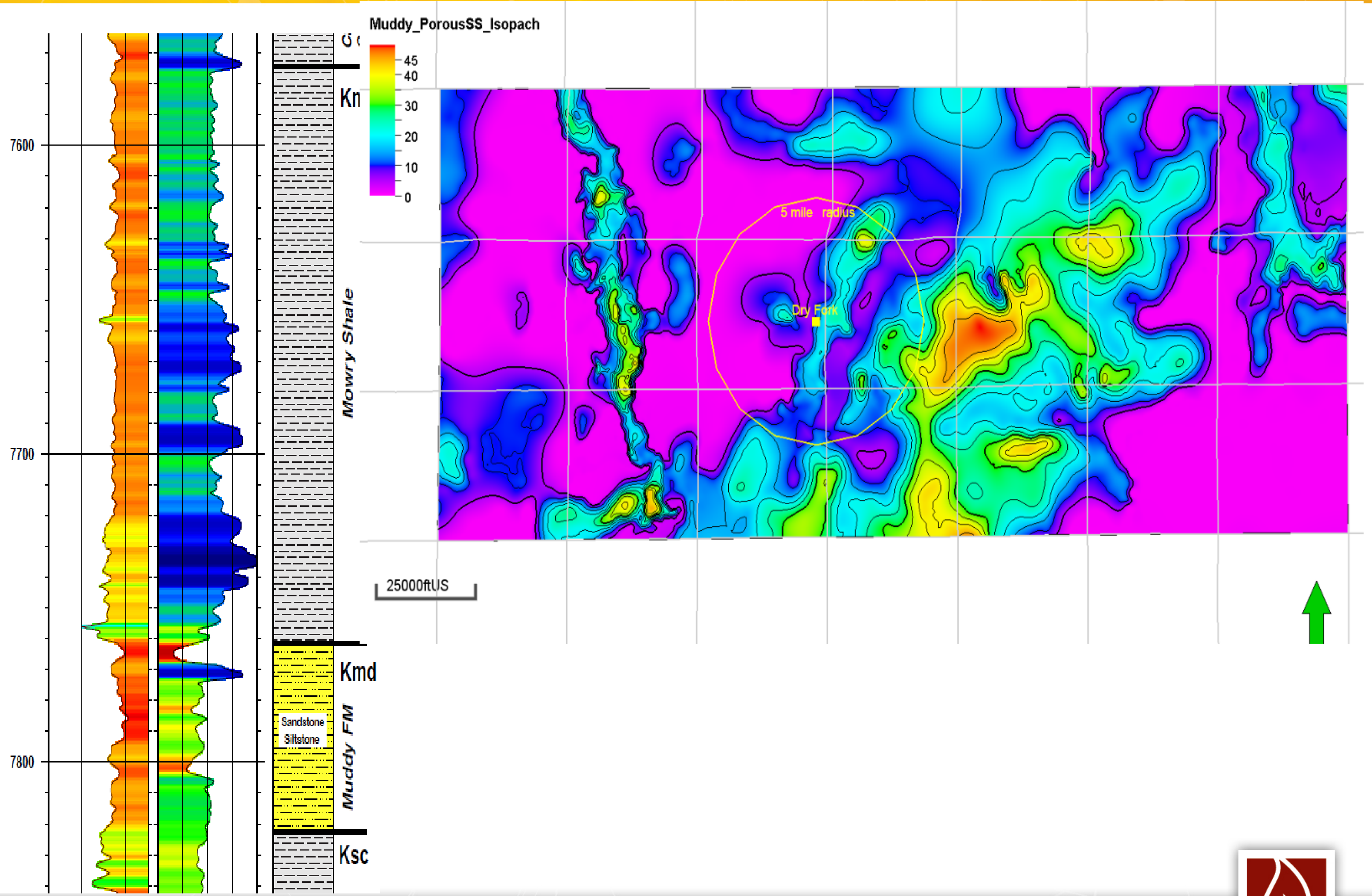


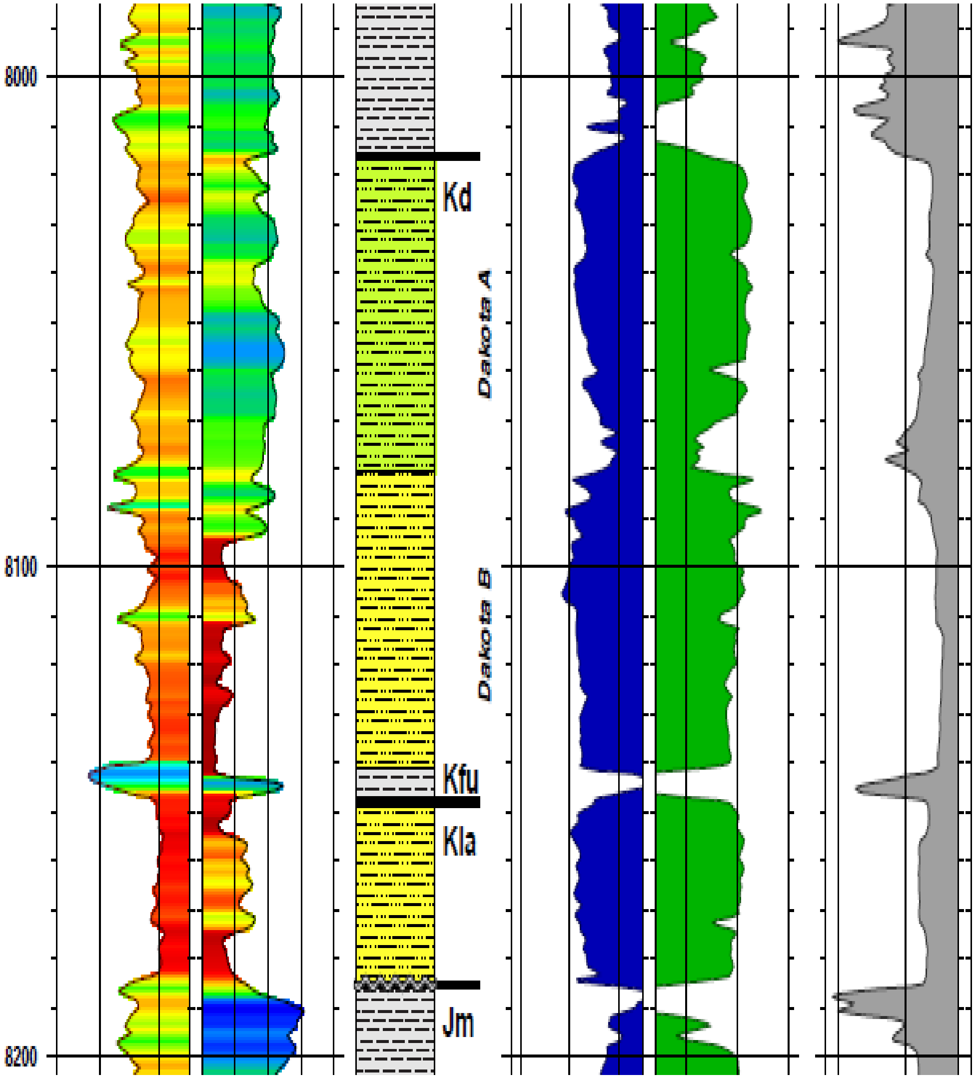
Figure E.1. Diagrammatic northwest-southeast cross section show relationships between members recognized in this study.

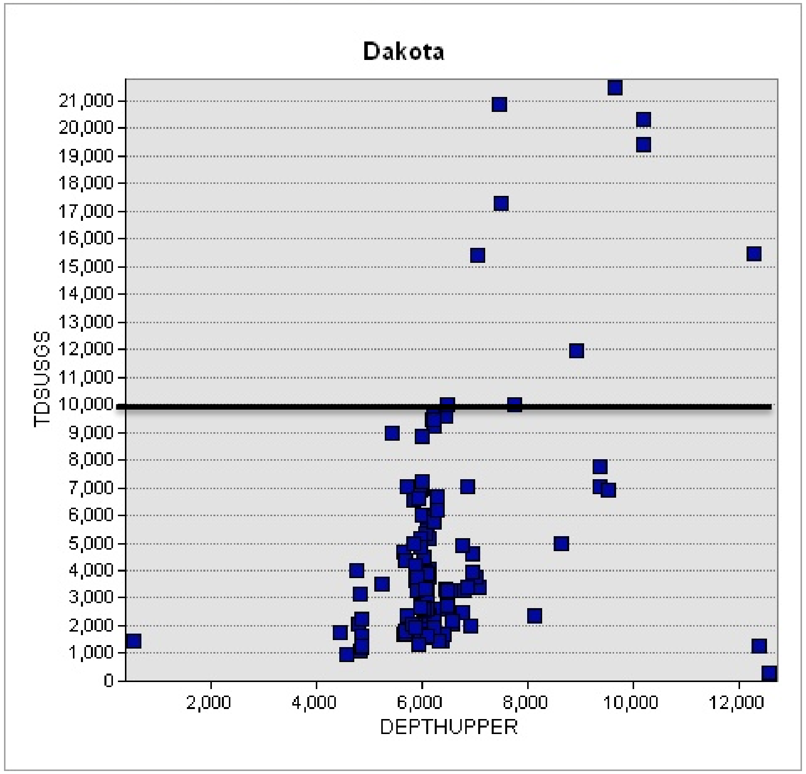


Muddy Formation: Sand Distribution

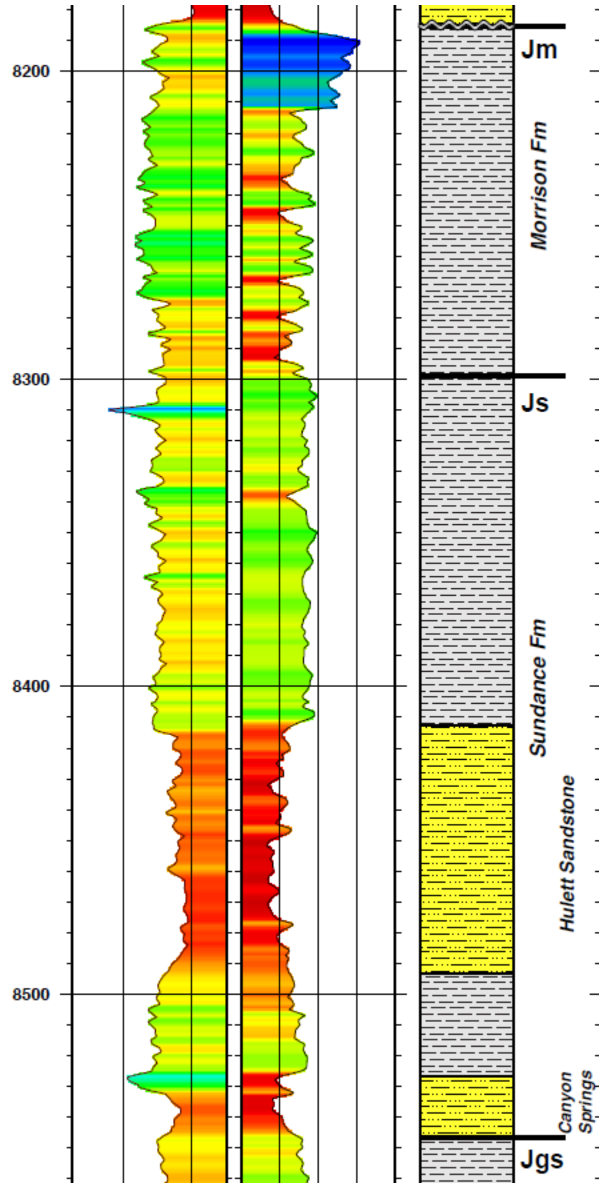


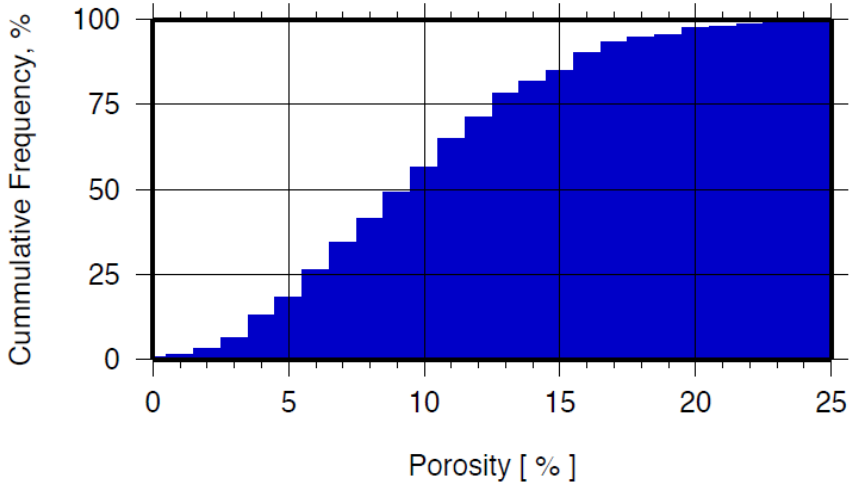
Dakota and Lakota

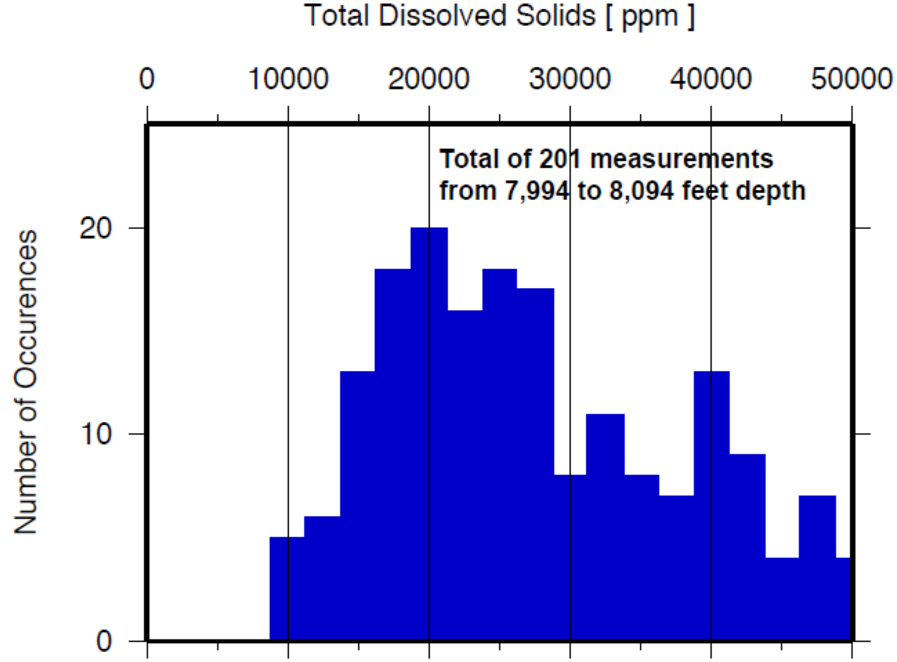




Lower Sundance



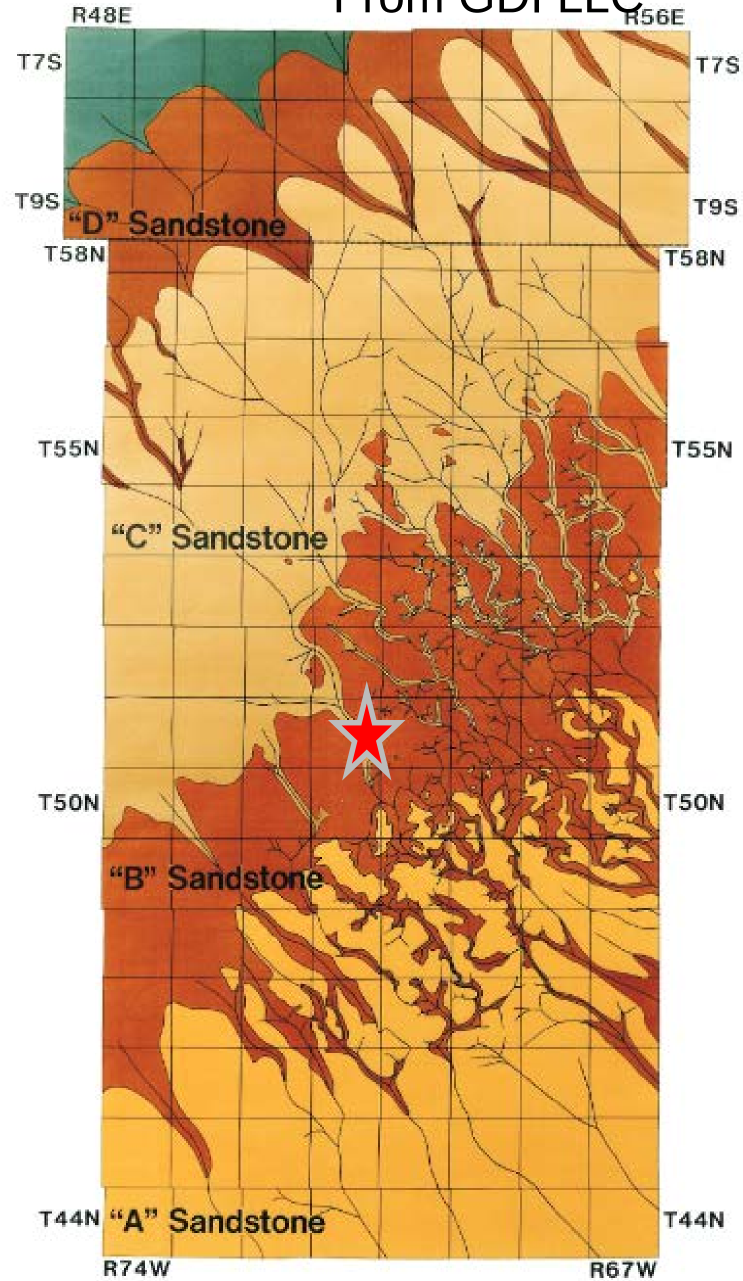




Minnelusa

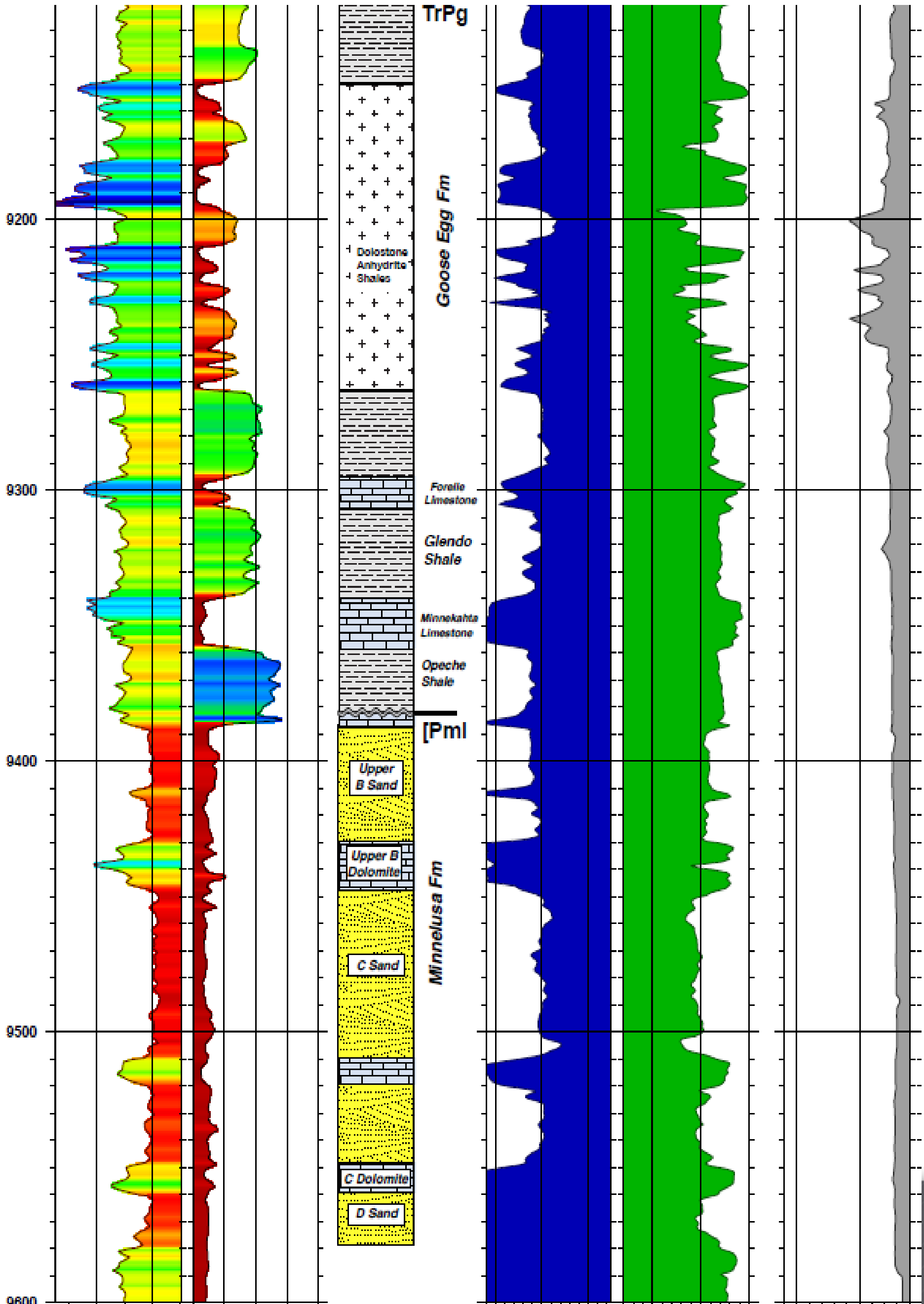
	UNIT DIVISION	INTERVAL DIVISION	INTERVAL SUBDIVISION	STAGE
UPPER MEMBER MINNELUSA FORMATION	"A" UNIT	A Dolomite	A Dolomite	WOLFCAMPIAN
		A Sandstone	A1 Sandstone	
			A′ Dolomite	
			A2 Sandstone	
	"B" UNIT	B Dolomite	B Dolomite	
		B Sandstone	B1 Sandstone	
			B′ Dolomite	
			B2 Sandstone	
	"C" UNIT	C Dolomite	C Dolomite	
		C Sandstone	C′ Sandstone	
			C′ Dolomite	
			C2 Sandstone	
	"D" UNIT	D Dolomite	D Dolomite	
		D Sandstone	D1 Sandstone	
			D′ Dolomite	
			D2 Sandstone	

From GDI LLC



Upper Minnelusa Sandstone Distribution and Opeche Channels

Minnelusa



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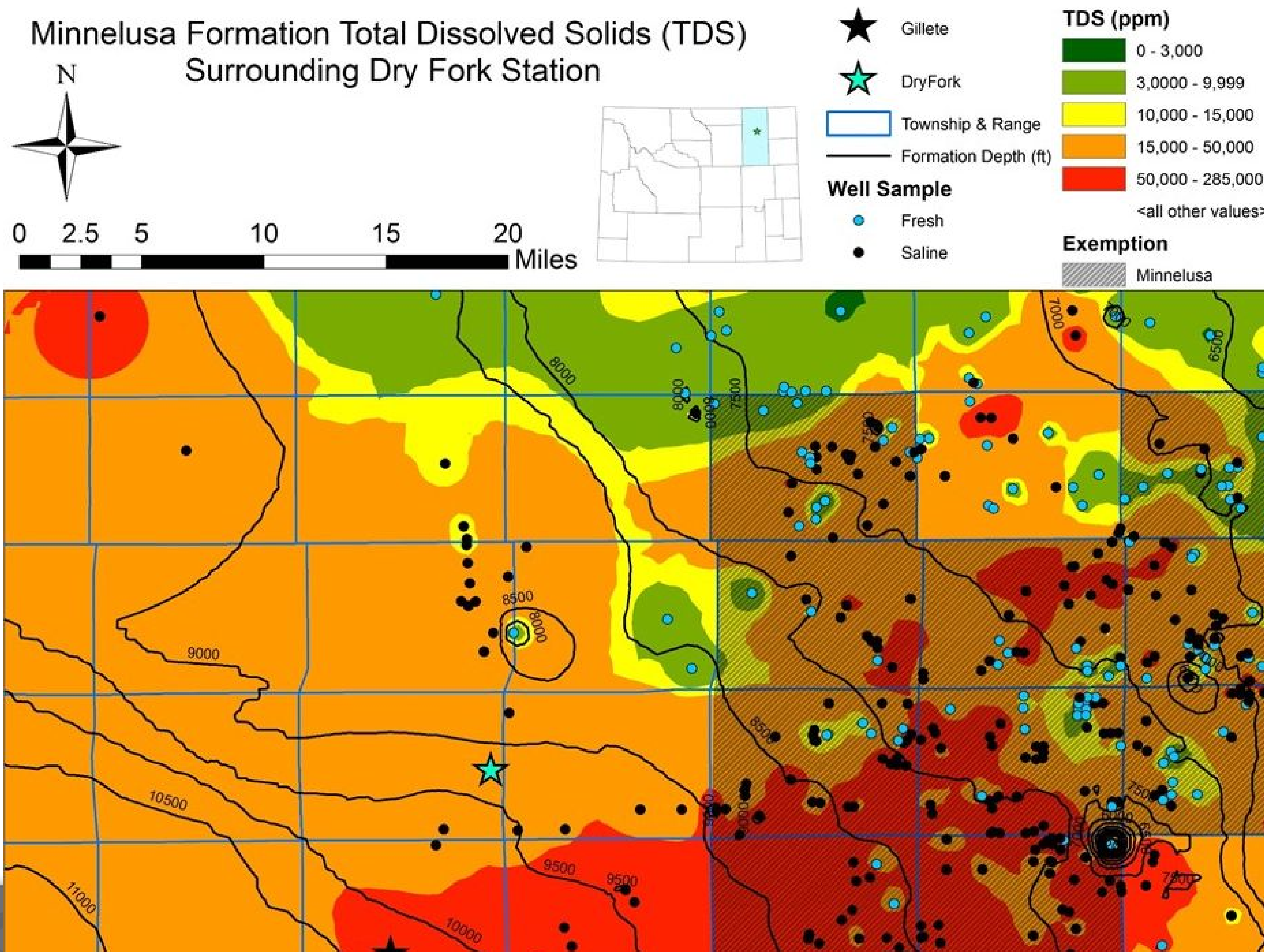
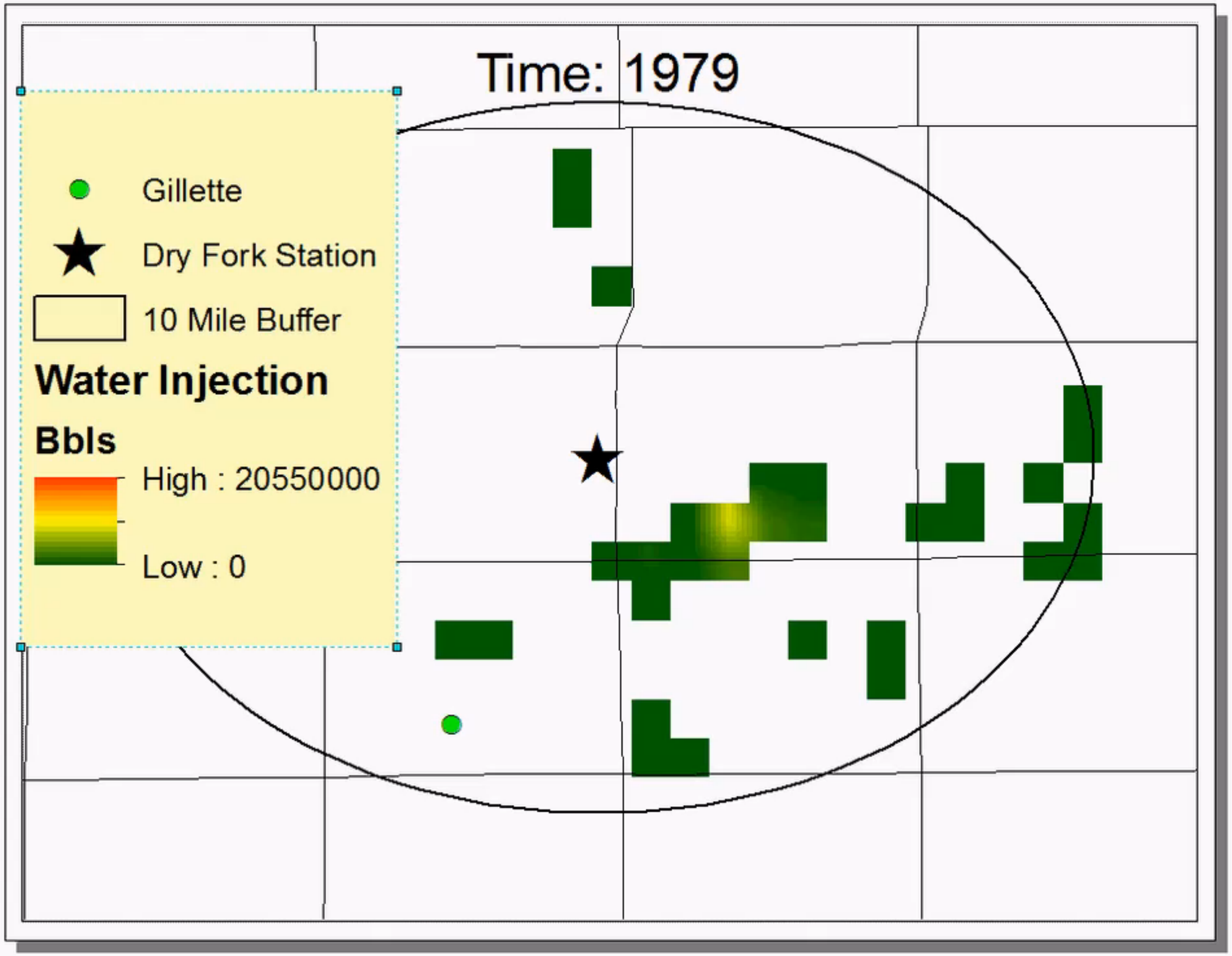
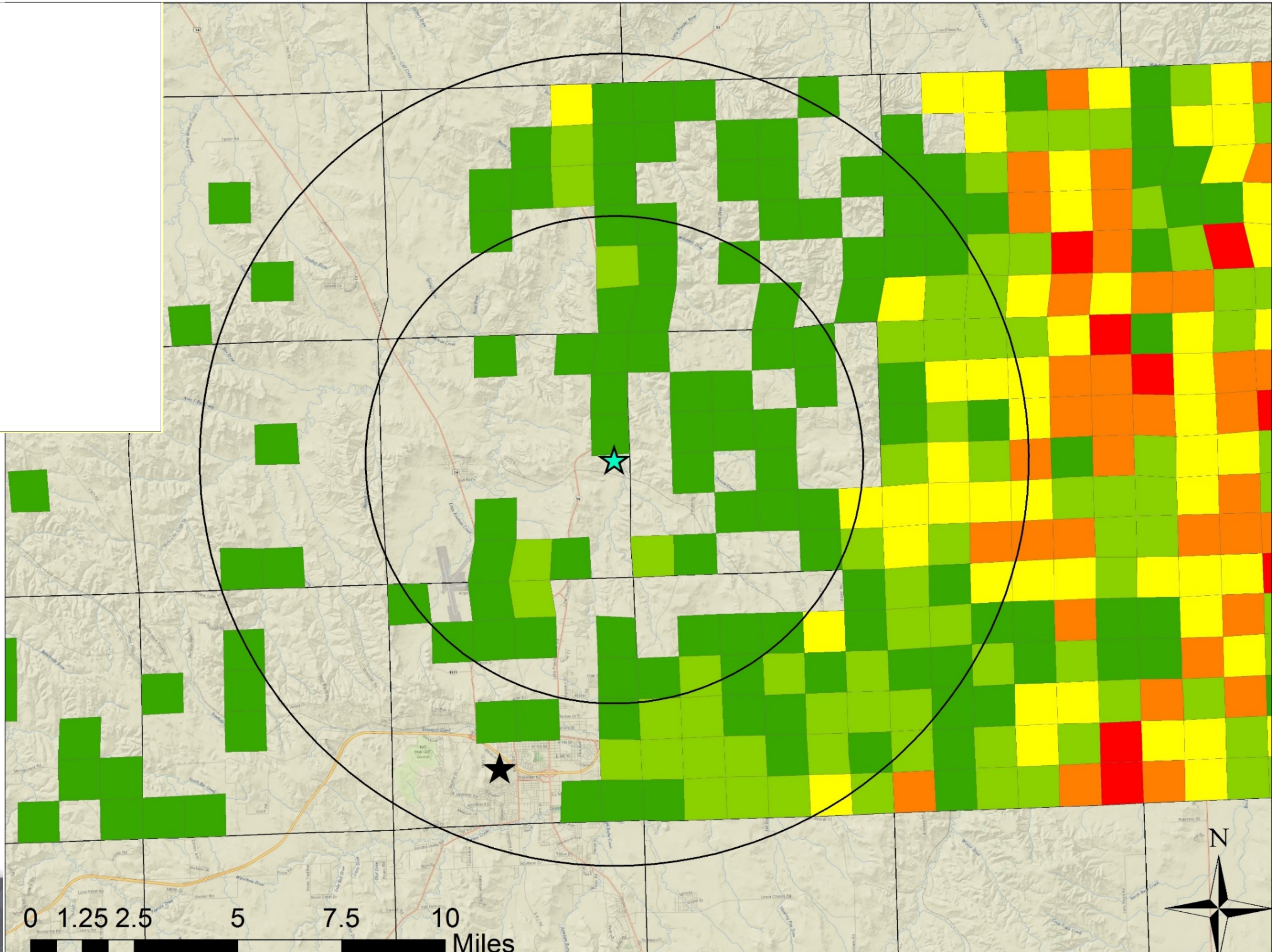
Minnelusa Formation Salinity



Minnelusa waste water injection



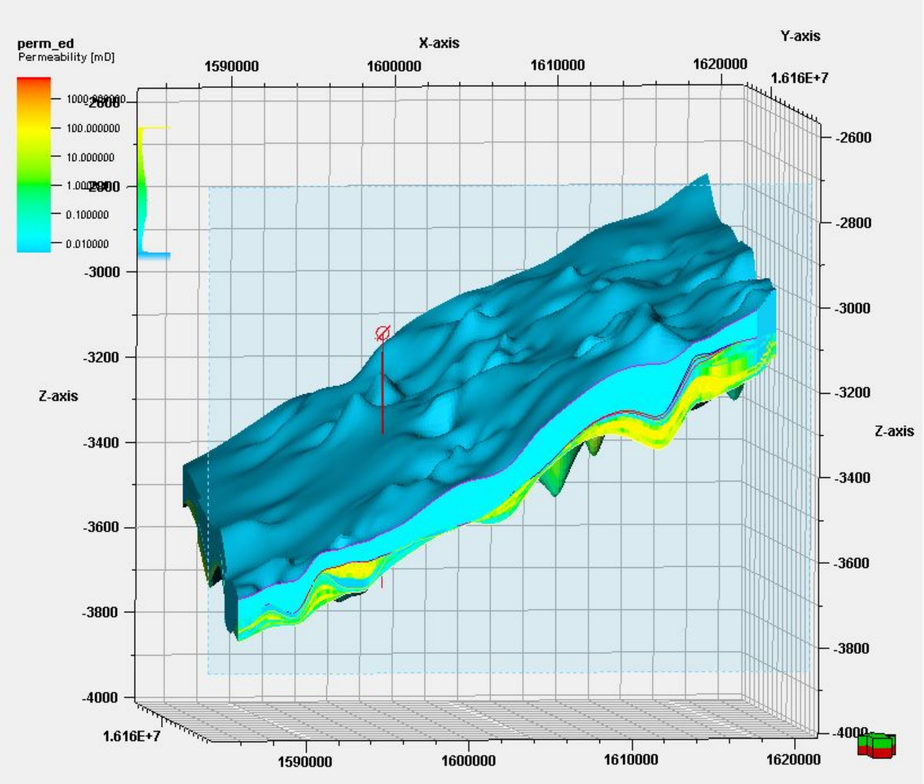
Opeche: Minnelusa Seal



Property Modeling of the Minnelusa Formation (Task 5)

The property model:

- T52 N and R69 W (6x6 miles)
- Depth from 6982 to 7837 ft
- Opeche Shale Seal
- Minnelusa Formation: 7 stratigraphic intervals within the Minnelusa
- B Sand primary target
- There is one CO_2 injection well.

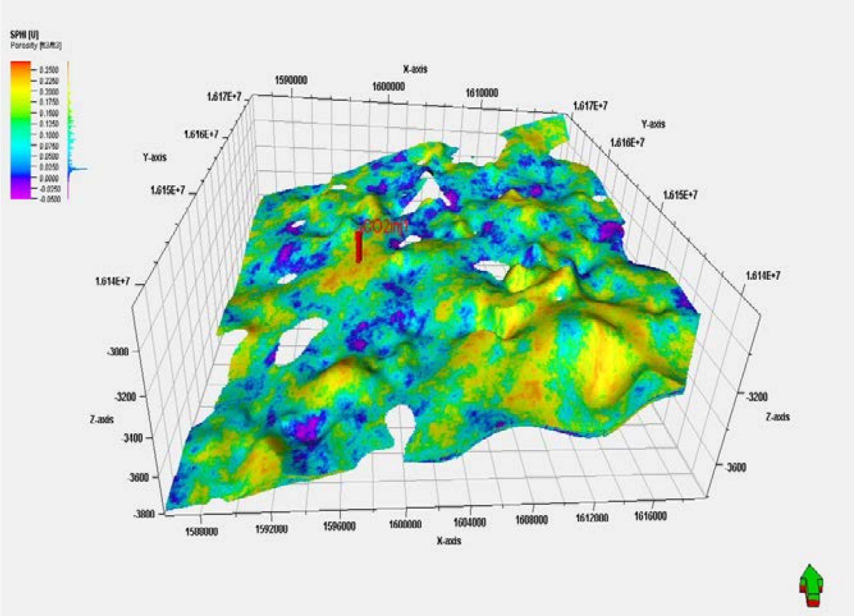


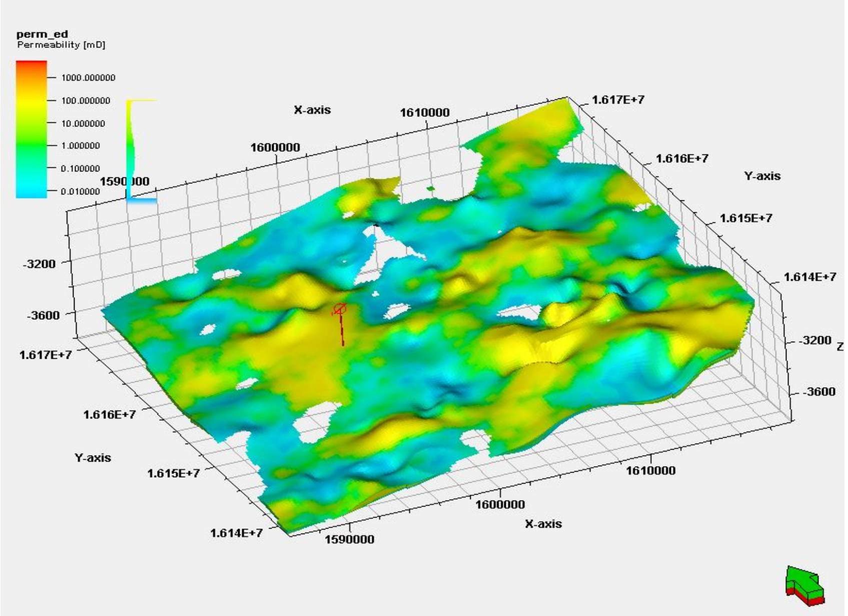
- Correlations: S. Fryberger and N. Jones
- Permeability (perm pore function): using Jiao et al., 2013
- Grid cells: is 451,584 (168x168x16), and X&Y:200 ft and Z=10 ft

Porosity and Permeability Distributions of B Sandstone

The porosity of B sandstone ranges from 0.01% to 0.27% with mean of 11%

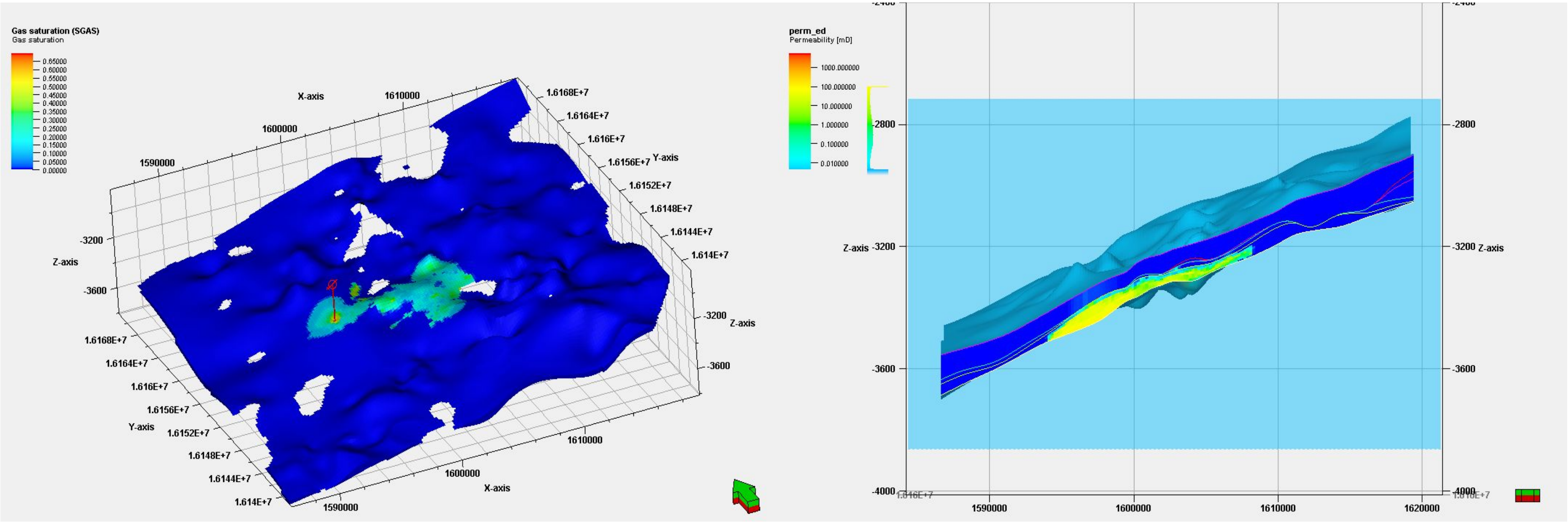
The permeability of B sandstone ranges from 0.004 to 100 mD with mean of 15.7 mD





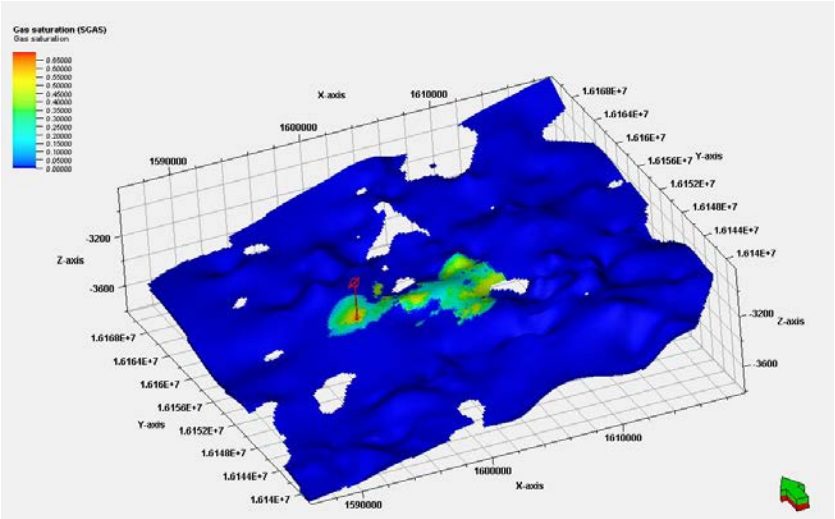
CO2 Injection to B Sandstone

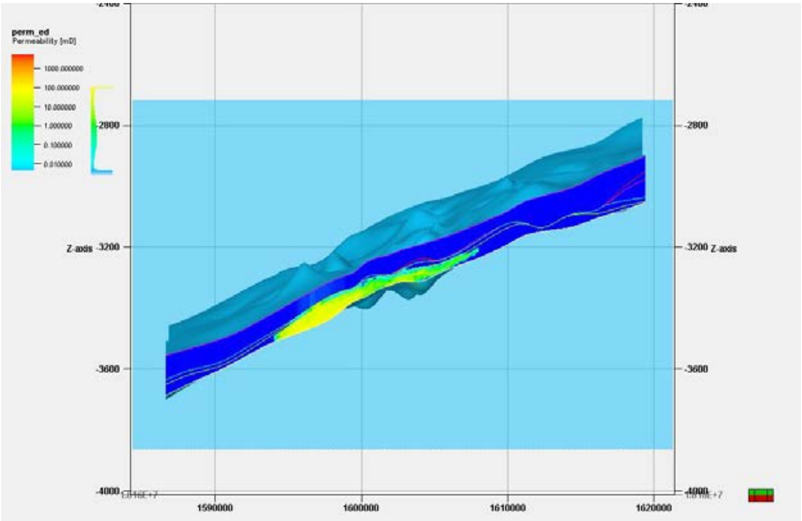
- CO_2 plume after **50 year injection**
- The farthest front of the **CO_2 plume** from the injection well is **1.5 miles.**
- The injected **CO_2 moved** through **Upper B dolostone** to Unconformity and reached the **bottom of the Opeche Shale**.



CO2 Injection to B Sandstone

The distribution of CO2 plume after 50 year of post injection. The expanding CO2 only occurs at upper dip direction. The saturation of the CO2 decreases slightly through post injection time, and the reservoir pressure is reduced significantly after 10 year of post injection.





Research gaps

- Preliminary results show that formation TDS can heavily influence the site selection process. Some geologic formations have insufficient data to determine salinity
- Understand the role of pressure management
- Understanding geologic heterogeneity will be key going forward. Geologic heterogeneity has a direct impact on plume geometry, migration, area of review and storage efficiency
- Cost benefit of integrating CO2-EOR to multiple fields

Accomplishments to Date

Data Discovery:

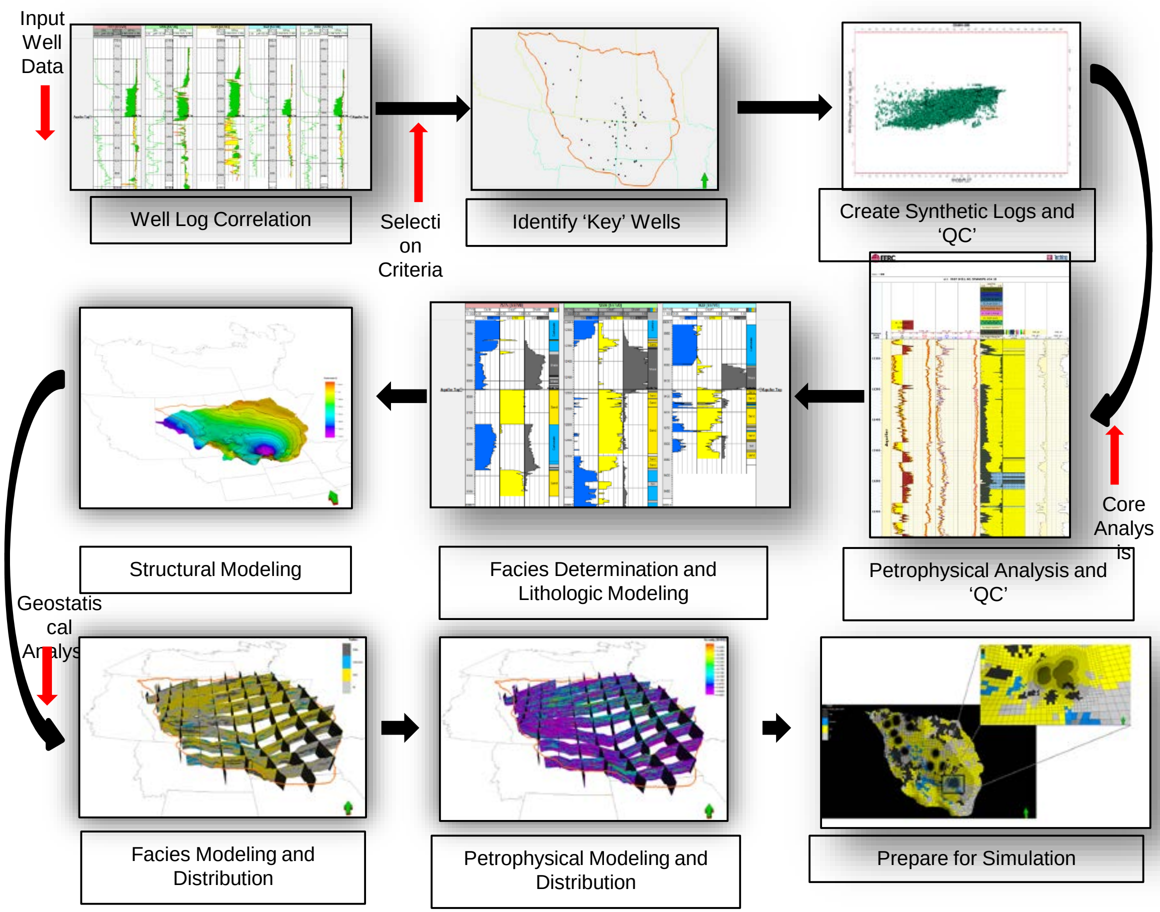
- Identified 3-4 potentially successful commercial scale Source, Transport and Storage scenarios
- Verified sufficient pore volume to store CO2
- Identified substantial subsurface data to conduct the geologic evaluation

Collaborative Efforts:

- Partnership with Industry
- Support from key regional stake holders (i.e Wyoming Legislature and state agencies)
- Development of a strong Coordination Team

Next Steps

- Refine and rank the source, storage and transportation scenarios
- Begin/refine geologic modeling for each of the identified scenarios
- Collect core and outcrop data to inform geologic models and sealing capacity
- Define storage potential for the highest priority reservoirs



Acknowledgements

Funding :

- DOE FE0029375

Industrial Partners:

- Basin Electric
- Wyoming Municipal Power Agency

Wyoming State Agencies

- Department of Environmental Quality
- State Engineers Office
- Infrastructure Authority
- Wyoming Legislature
- Oil and Gas Commission
- Pipeline Authority

Appendix Benefits Statement: (a) *Controlling CO_2 Emissions*: By taking advantage of the State of Wyoming's beneficial CCS legal and commercial environment, this Project should result in the capture and storage of 50+ million metric tons of CO_2 from one or more sources in the PRB, which supplies more coal than any other region of the United States.

(b) *Advancing the R&D Void Associated with the Characterization and Permitting of a Commercial-Scale CCS Project*. This Project will advance the development and permitting of commercial-scale saline CCS projects by leveraging numerous unique and existing Wyoming assets and attributes, including but not limited to the DFS (which already houses the ITC), an existing and expanding CO_2 pipeline network, and numerous favorable CO_2-EOR opportunities.

(c) *Advancing DOE's Carbon Storage R&D Program Goals*. The Project supports all four of DOE's Carbon Storage R&D Program's goals. Goal #1 (ensuring 99% storage permanence) will be primarily addressed by a robust monitoring program in later phases, and is also partially addressed by implementing stacked storage so that redundant competent confining units isolate and contain the injectate. Goal #2 (improving storage efficiency and containment effectiveness) will be addressed through preparation for pressure management, which will be implemented in a later phase. Goal #3 (supporting predicted storage capacity) will be supported by leveraging NETL's NRAP tool suite, traditional reservoir models, and appropriate characterization data. Goal #4 (best practices) will be supported by the activities of the Project's CCS Coordination Team, which plans to oversee (and along the way document for DOE and the public through Best Practices Manuals) the development, finance, permitting, and construction of a commercially feasible integrated CCS project at the PRB, a site that -- for the reasons of geology, State of Wyoming support, and existing CO_2 infrastructure -- stands as one of the most favorable locations in the United States to advance critically needed commercial-scale CCS technologies and projects.

Advancing DOE's Carbon Storage R&D Program Goals.

#1 Ensuring 99% storage permanence will be primarily addressed by a robust monitoring program in later phases, will be addressed through characterization of reservoir and seal systems.

#2 Improving storage efficiency and containment effectiveness addressed by implementing stacked storage so that redundant competent confining units isolate and contain the injectate.

#3 Supporting predicted storage capacity will be supported by leveraging NETL's NRAP tool suite, traditional reservoir models, and appropriate characterization data.

#4 Best practices will be supported by the activities of the Project's CCS Coordination Team, along the way document (for DOE and the public through Best Practices Manuals) the development, finance, permitting, and construction of a commercially feasible integrated CCS project at the PRB, a site that

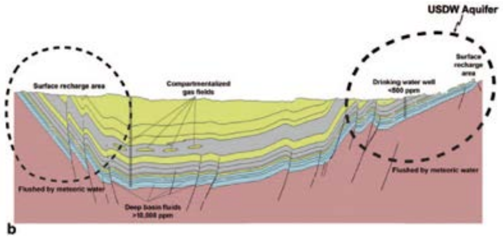
Project Overview: Goals and Objectives

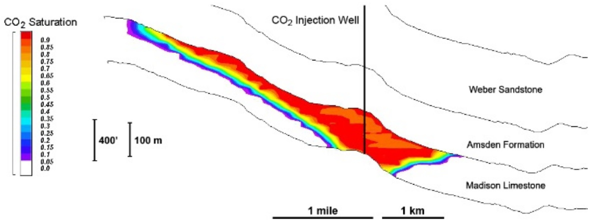
Identify (Economic) Saline Storage proximal to the Dry Fork Power Station

a. Establish a CCS Coordination Team

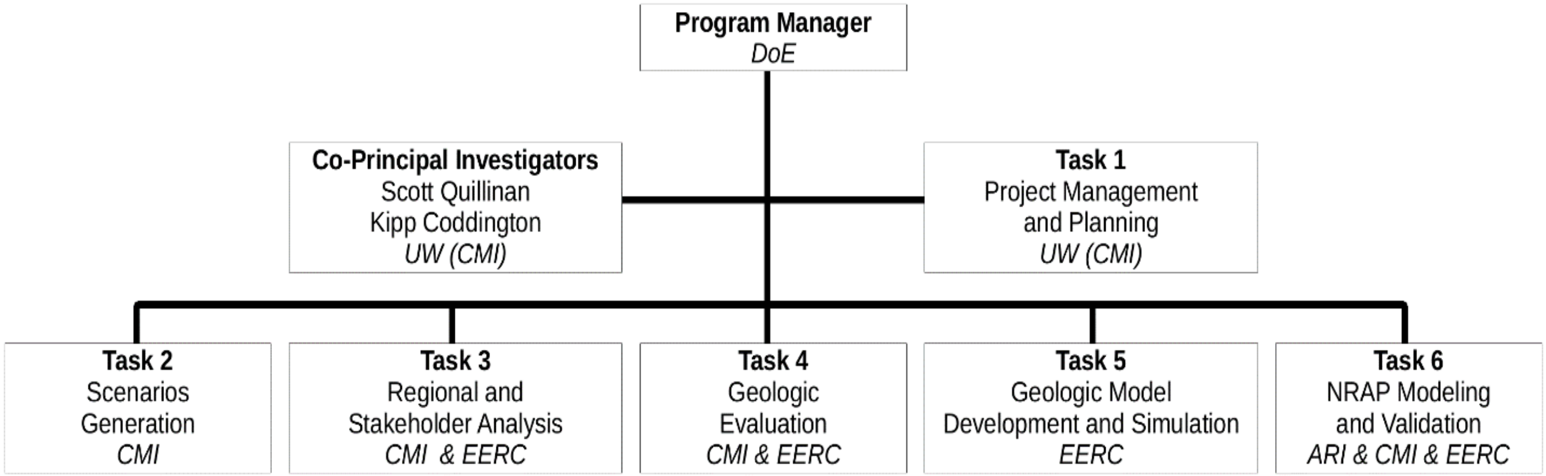
b. “Develop a Plan to Address Challenges of a <u>Commercial-Scale</u> CCS Project”

c. “High Level Technical Sub-Basinal Evaluation and CO_2 Source Assessment”





Organizational Plan and communication strategy



Quillinan (PI; CMI) and Coddington (CMI) will lead technical and non-technical decision-making, respectively.

Communications will be conducted via:

- ✓ Monthly online webinar and conference calls (to the extent possible).
- ✓ In-person meetings and planning/implementation sessions.
- ✓ Monthly (or as needed) updates to DOE project manager

To streamline intra-team communications, we have developed a structure, consistent with the tasks, to ensure single points of contact for key issues.

Outcomes

- Ranked list of integrated CCUS scenarios for the Dry Fork Station and ITC (technical, economics, policy)
- Identify coupled revenue streams for anthropogenic CO_2
- Characterization of storage potential in compartmentalized reservoirs

Summary

- ✓ Highly qualified multi-disciplinary CCS Coordination Team
- ✓ Source, Transportation, and Storage Components
- ✓ Economic and Policy Drivers
- ✓ Clear Project Map and Methodology
- ✓ Organizational Plan and Communication Strategy
- ✓ Clear and Well-described Tasks
- ✓ Attainable Deliverables/Milestones
- ✓ Project is low risk