Wyoming's CarbonSAFE Phase II Project at Basin Electric's Dry Fork Station

SCHOOL OF ENERGY RESOURCES

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UNIVERSITY OF WYOMING

Disclaimer

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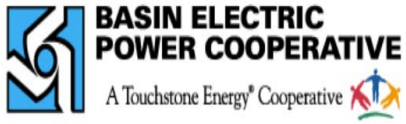
Presentation Outline

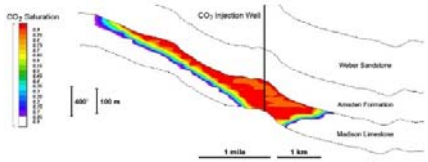
- **Introduction to the CarbonSAFE program**
- Project Study Area and Setting
- Update Wyoming CarbonSAFE

Meet the team

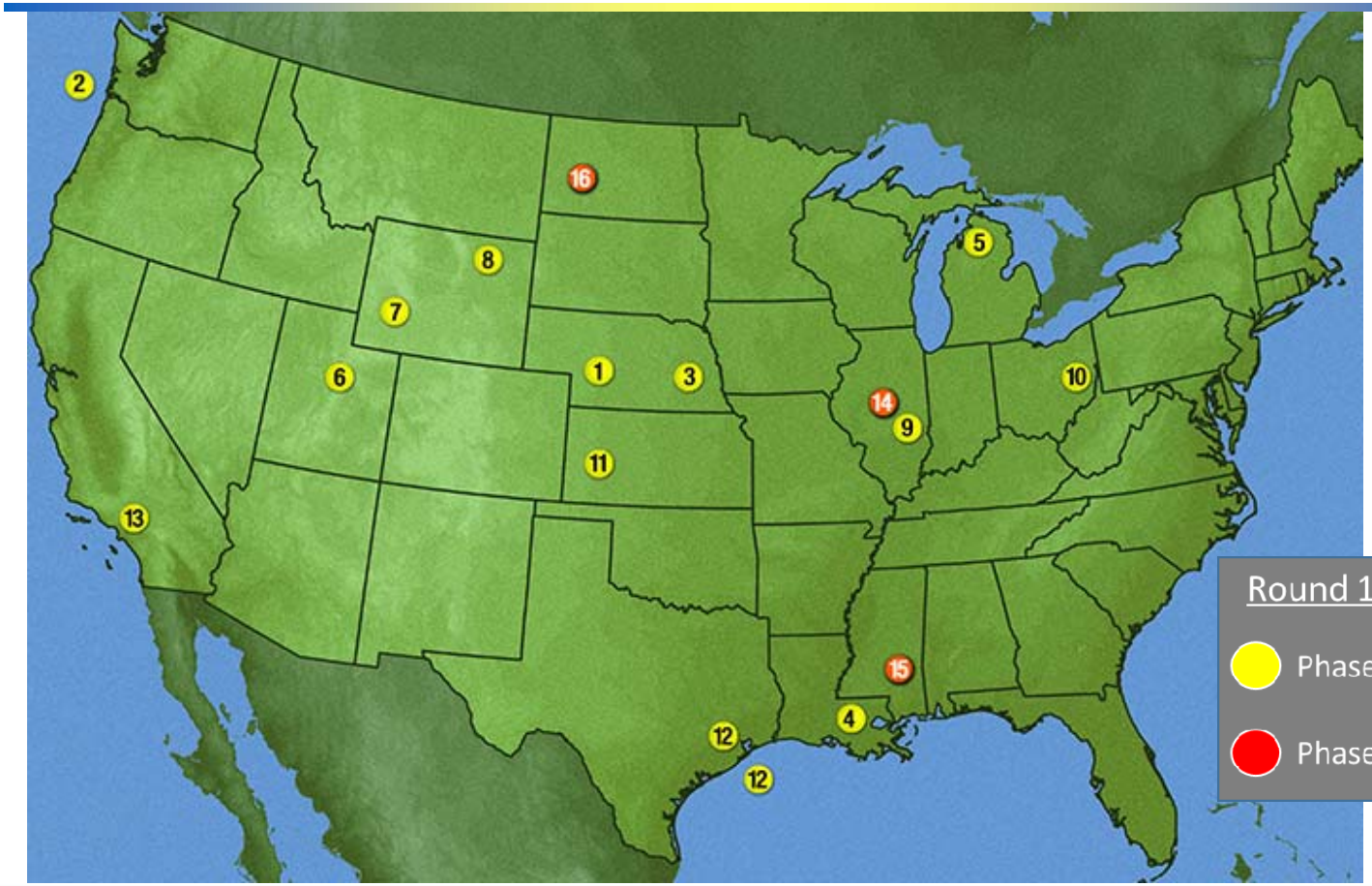


CarbonSAFE (Storage, Assurance, and Facility Enterprise)

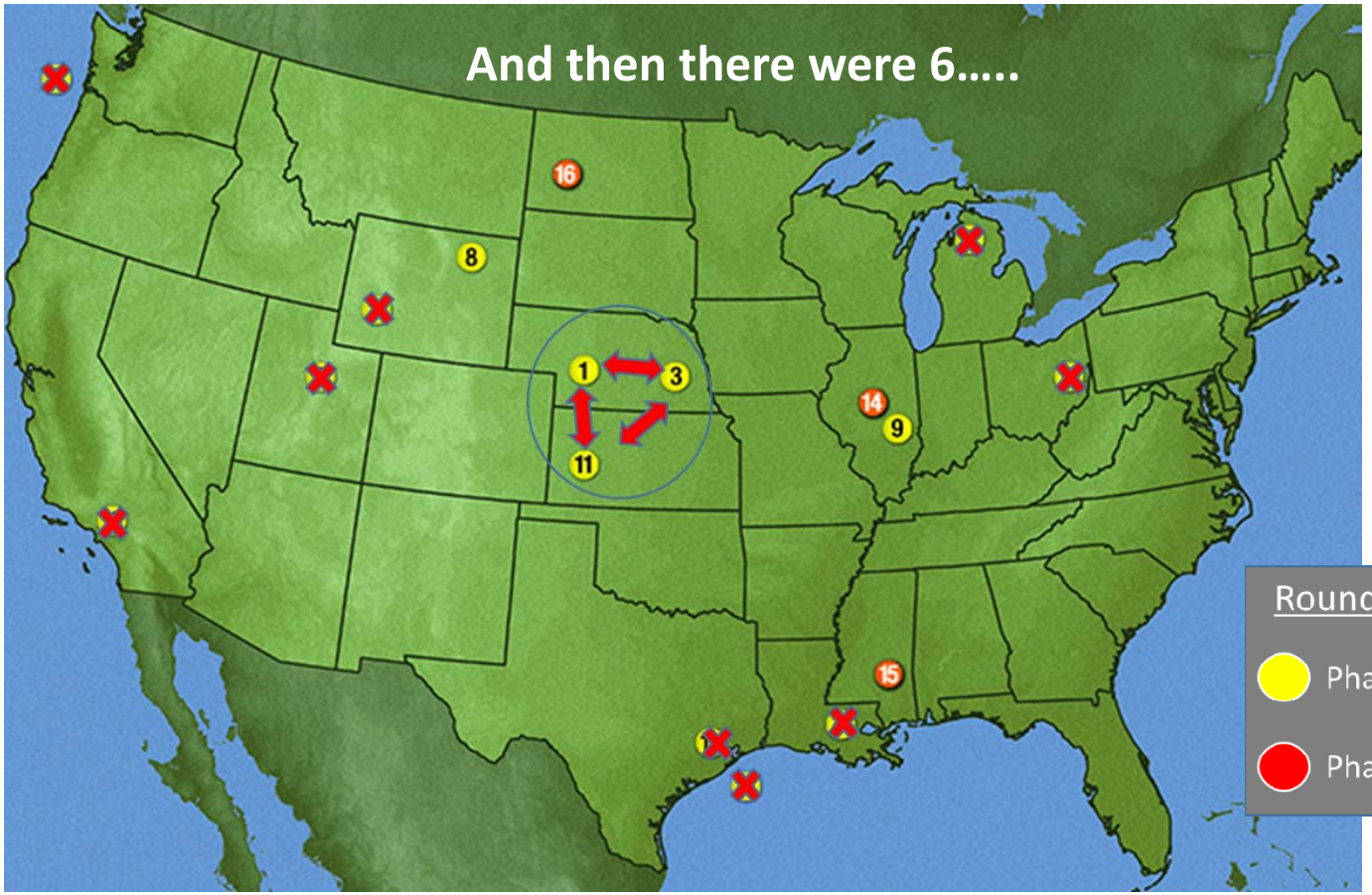
- Projects… will address **key research gaps** in the path toward the **deployment** of carbon capture and storage (CCS) technologies, including the development of **commercial-scale** (50+ million metric tons CO_2) **geologic storage sites for CO_2 from industrial sources…**
- Projects under CarbonSAFE aim to **develop integrated CCS complexes** that are **constructed and permitted for operation in the 2025 timeframe**
- **Get there through sequential Phases…**
  - ***Phase 1*** Integrated CCS Pre-Feasibility,
  - ***Phase 2*** **Storage Complex Feasibility,**
  - ***Phase 3*** Site Characterization,
  - ***Phase 4*** Permitting and Construction.
- **What about Carbon Capture?** That's a different DOE program



CarbonSAFE (Storage, Assurance, and Facility Enterprise)



CarbonSAFE (Storage, Assurance, and Facility Enterprise)



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CarbonSAFE Wyoming: Study Area

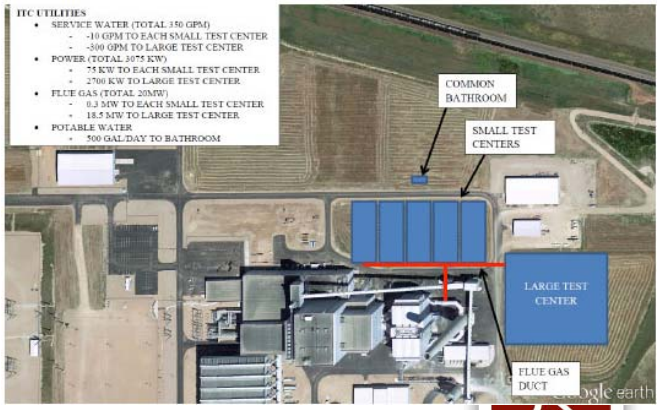
- Dry Fork Station (Basin Electric Power Coop)
- Wyoming Integrated Test Center (WY-ITC)

Dry Fork Station

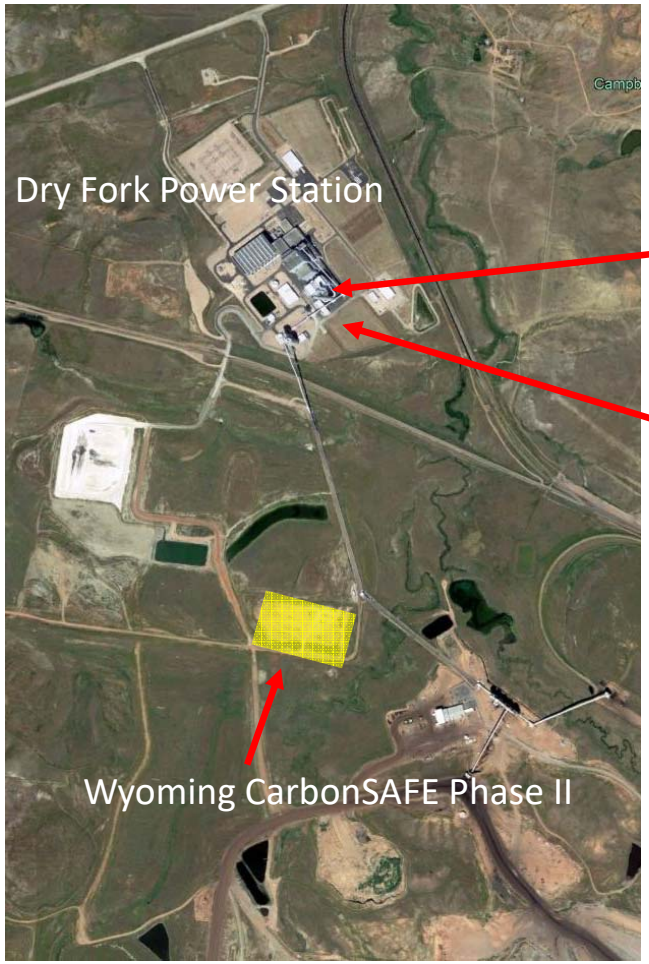
- ✓ Built in 2007
- ✓ 385 MW Power Plant
- ✓ 3.3 Million tons of CO_2/year

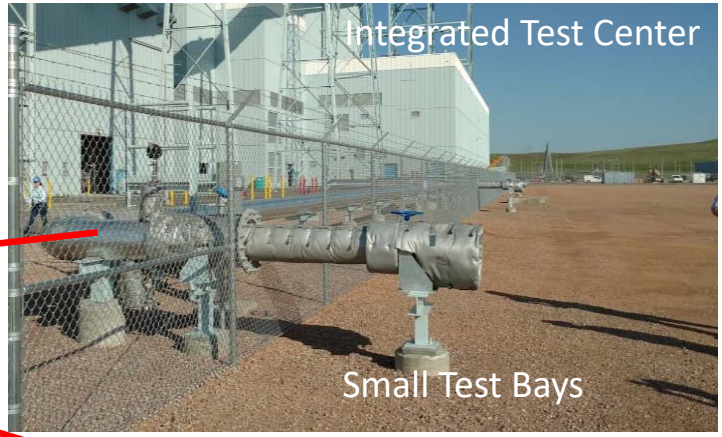
WY-ITC

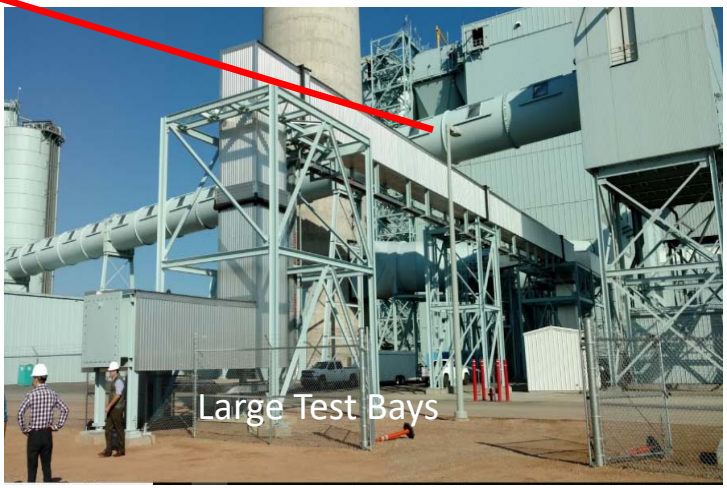
- ✓ Completed fall 2017
- ✓ Test CO_2 capture/CCUS technologies
- ✓ $20 Million public/private investment
- ✓ NRG COSIA Carbon XPRIZE ($20M global competition to develop breakthrough technologies for CO_2 emissions)



CarbonSAFE Wyoming: Study Area



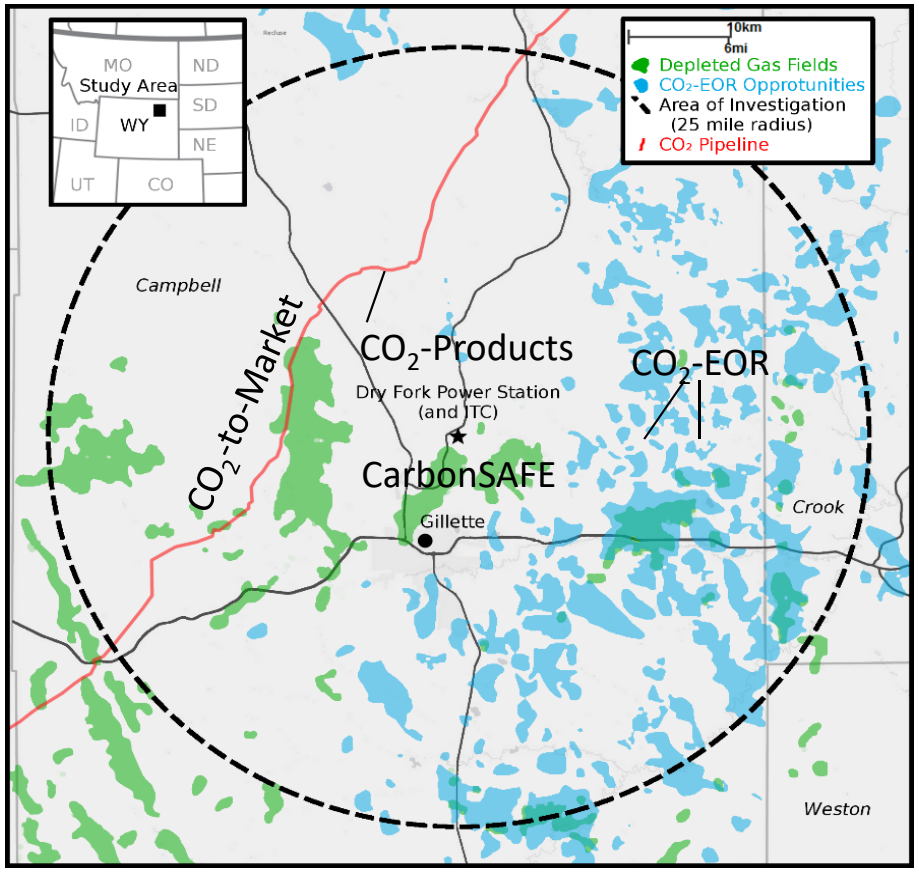




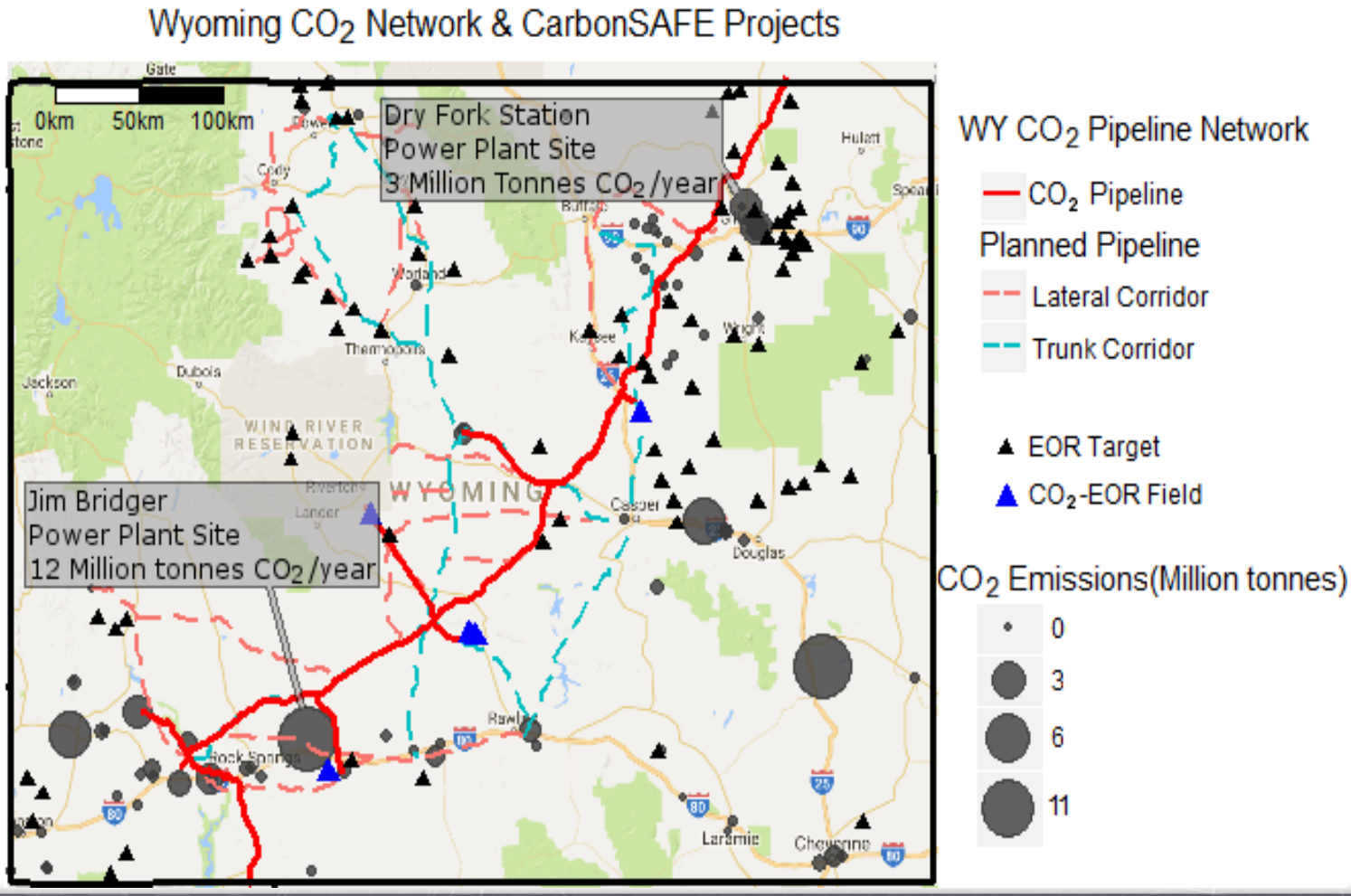
CarbonSAFE Wyoming: Study Area

Gillette WY "Carbon Valley"

- Storage: Saline reservoirs (Wyoming CarbonSAFE)
  - Located below Dry Fork Station
- Utilization: CO_2-EOR opportunities
  - Proximal EOR fields & CO_2 pipeline
- Capture/Utilization: WY Integrated test Center
  - Breathe (Bangalore, India)-common fuel and petrochemical feedstock
  - C4X (Suzhou, China) –chemicals and bio-composite foamed plastics
  - Carbon Capture Machine (Aberdeen, Scotland) –solid carbonates and building materials
  - CarbonCure (Dartmouth, Canada) –stronger, greener concrete
  - Carbon Upcycling UCLA (Los Angeles, CA, USA) – CO_2 absorbing concrete replacements
  - JCOAL & Kawasaki Heavy Industry (Japan) – CO_2 Capture
  - MTR/UK (CA/KY) Capture



CarbonSAFE Wyoming: Study Area



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Feasibility study

Wyoming CarbonSAFE is investigating the feasibility of practical, secure, permanent, geologic storage of carbon dioxide (CO_2) emissions from coal-based electricity generation facilities near Gillette, WY

Research questions/gaps for Phase II Feasibility Study:

- Is there sufficient volume in the subsurface to store commercial quantities of CO_2?
- Can the CO_2 be injected safely?
- Can the CO_2 be stored permanently?
- What are the risks/costs/legalities?

Commercial quantities = 50 million tons over 25 years (i.e. 2 million tons per year)

Project outline – 3 Major Tasks

Field Operations

- Public outreach
- Test well
  - -Coring
  - -Fluid Sampling
  - -Logging
- 3D seismic data
- Field work

Experiments, analytics, & modeling

- Reservoir characterization
  - Geochemistry
  - Geomechanics
  - Petrology
  - Seismic interpretation
- Geologic modeling
- Economic Analysis
- Legal analysis

Phase 3 Recommendations

- Site development
- Techno economics
- Legal/Permitting
- Plan for MVA
- Risk assessment
- Community outreach

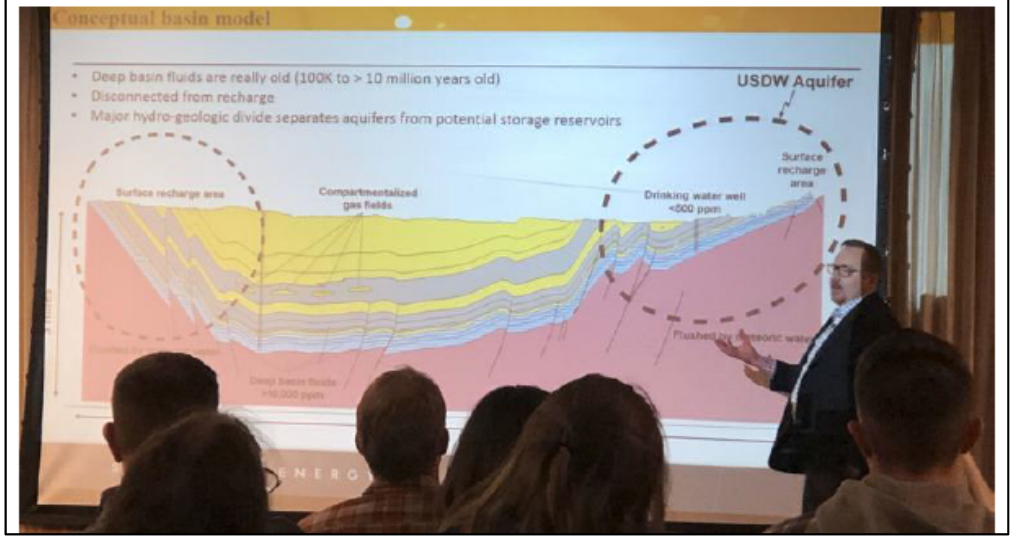
Public Outreach

Community and public outreach: February 21st and 23rd

Carbon research earning a 'social license' in Gillette

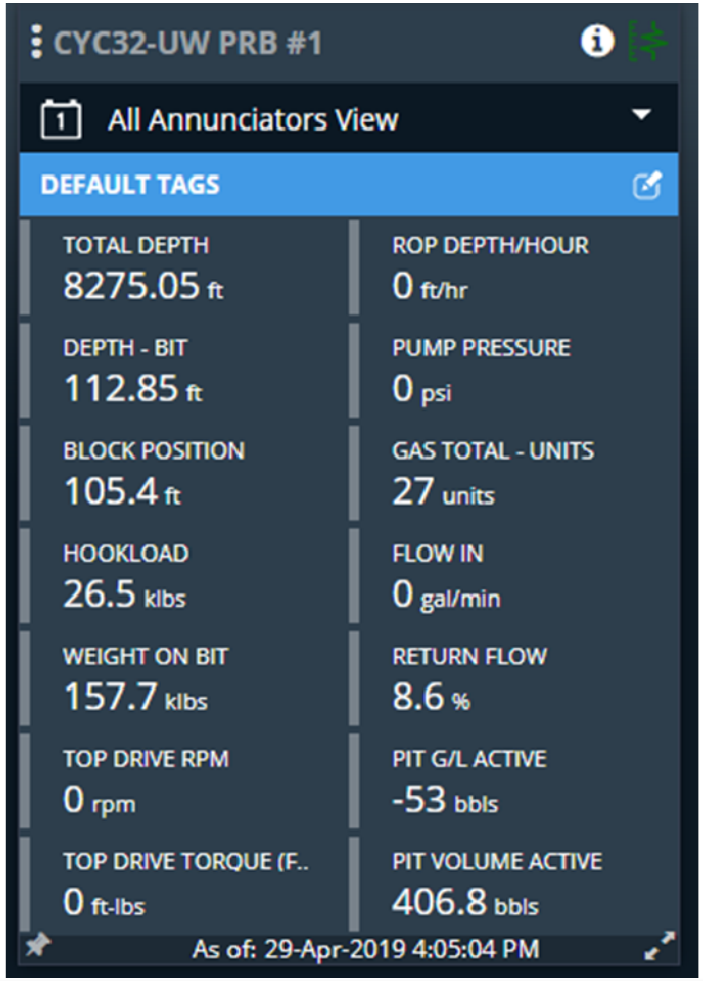
UW CarbonSAFE project will drill more than 10,000 feet into the Powder River Basin

By GREG JOHNSON NEWS RECORD MANAGING EDITOR gjohnson@gillettenewsrecord.net Feb 22, 2019



Field Operations – Site Preparation

Drilling


CYC32-UW PRB #1
All Annunciators View
DEFAULT TAGS
TOTAL DEPTH
8275.05 ft
ROP DEPTH/HOUR
0 ft/hr
DEPTH - BIT
112.85 ft
PUMP PRESSURE
0 psi
BLOCK POSITION
105.4 ft
GAS TOTAL - UNITS
27 units
HOOKLOAD
26.5 klbs
FLOW IN
0 gal/min
WEIGHT ON BIT
157.7 klbs
RETURN FLOW
8.6 %
TOP DRIVE RPM
0 rpm
PIT G/L ACTIVE
-53 bbls
TOP DRIVE TORQUE (F..
0 ft-lbs
PIT VOLUME ACTIVE
406.8 bbls
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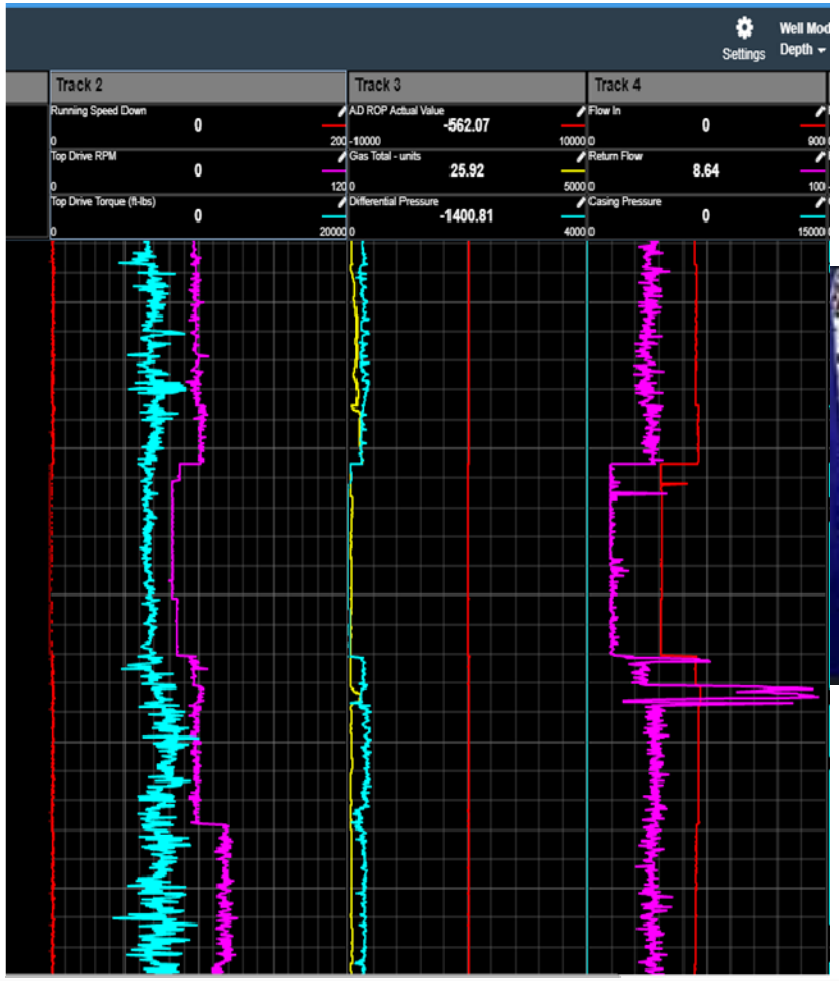

Settings
Track 2
Track 3
Track 4
Running Speed Down
AD ROP Actual Value
-562.07
Flow In
Top Drive RPM
Gas Total - units
25.92
Return Flow
8.64
Top Drive Torque (ft-lbs)
Differential Pressure
-1400.81
Casing Pressure

Coring

Mowry ⬆ Muddy ⬇

Age		Formation/Member
Recent		alluvium and stream terraces
Paleocene		Fort Union Formation
		Lance Formation
		Fox Hills Sandstone
Upper Cretaceous		Pierre (Lewis) Shale
		Niobrara Formation
		Carlile Shale
		Belle Fourche Shale
		Mowry Shale
		Muddy Sandstone
Lower Cretaceous		Skull Creek Shale
		Fall River (Dakota) Formation
		Lakota Formation
		Morrison Formation
Upper Jurassic	Upper Sundance	Redwater Shale member
	Lower Sundance	Hulett Sandstone member
		Stockade Beaver Shale member
		Canyon Springs Sandstone member
Middle Jurassic		Gypsum Spring Formation
Triassic		Spearfish Formation
Permian	Goose Egg Formation	Ervay Salt member
		Minnekahta Limestone
		Opeche Formation
Pennsylvanian		Minnelusa Formation
Mississippian		Madison Limestone

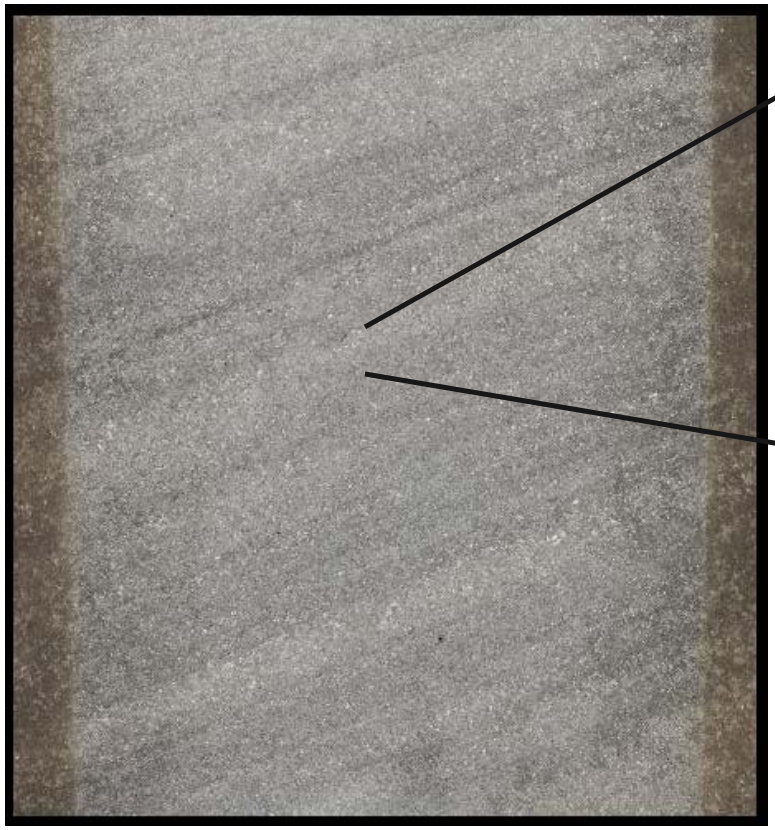
Regional data: USGS Core Research Center ~6 mile radius of DFS. 900' from geological units of interest including 595' of Muddy core, 206' of Minnelusa core, 67' of Opeche core and 55' of Mowry core.

Core: 100' Muddy/Mowry combined, 130' of combined Fall River/Dakota and Skull Creek,
Fluid: Muddy and Fall River

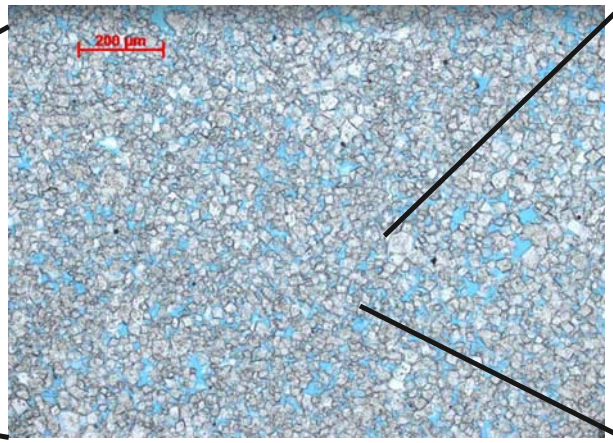
Core: 180' of combined reservoir/seal
Fluid: Hulett

Core: 180' Minnelusa/Opeche combined
Fluid: Minnelusa sample

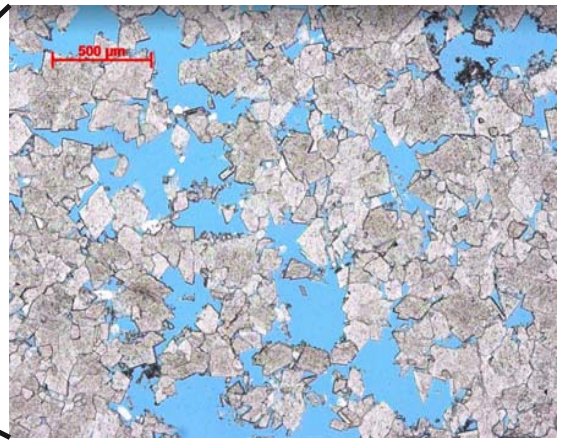
Exploring for pore space and permeability….



The rock…



The rock, but closer…



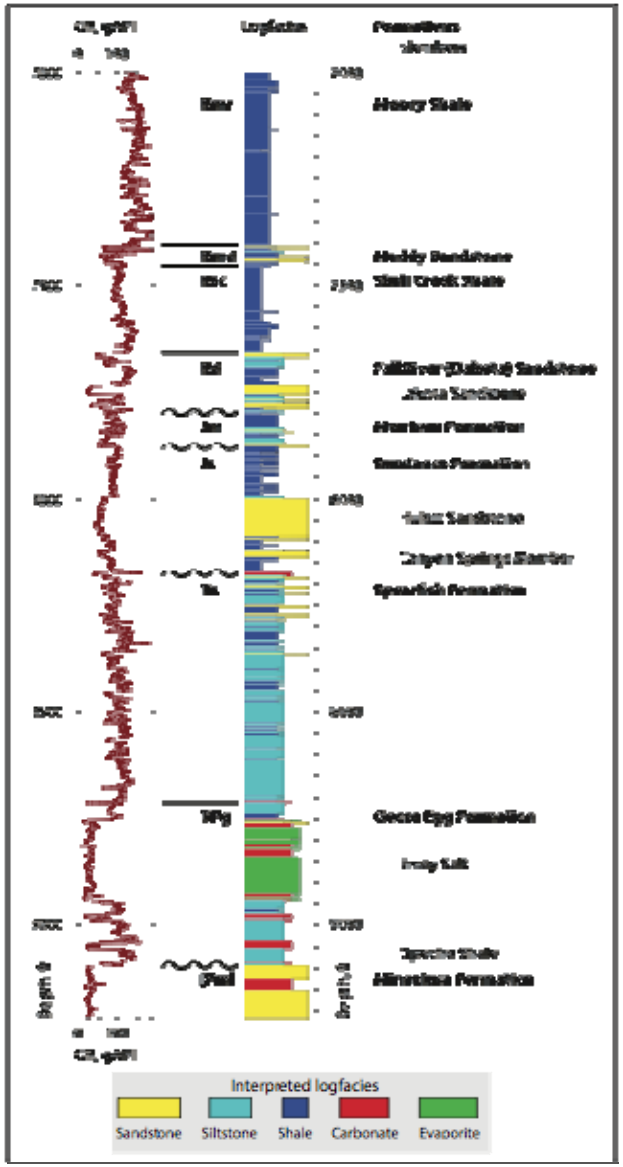
The rock, but even closer…

Core analytical work: petrography, petrology, geochemistry, porosity and permeability and other physical properties

Expected outcomes: porosity architecture, rock mechanics, diagenetic history, fluid history, relative permeability, displacement pressure, sealing history and capacity, multi-phase fluid injection response, CO_2 retention, magnetic resonance, tie-in to petrophysical, modeling and geophysical data.

Logging

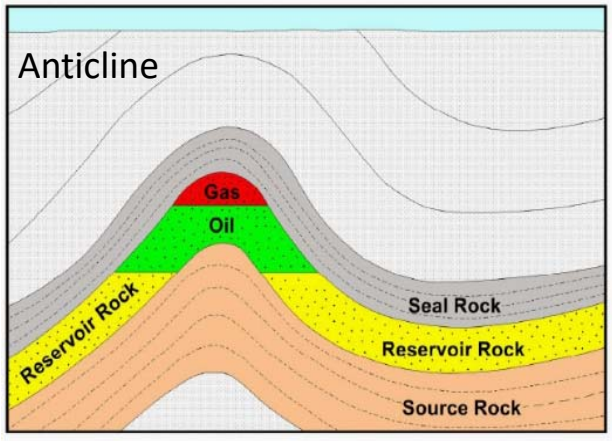
- **Petrophysical analytical work:** spectral gamma ray (GR), triple combination, dipole sonic, nuclear magnetic resonance (NMR), pulsed neutron (PNL/PNX), fullbore formation microimager (FMI) and cement bond (CBL). Downhole testing will utilize modular formation dynamics testing (MDT)
- **Expected outcomes:** expand geologic heterogeneity within the property models, scale-up core analysis data to over the length of the vertical section, determine rock and fluid properties for targeted intervals, tie well data to the 3-D seismic data to make realistic, high resolution property models for simulations.

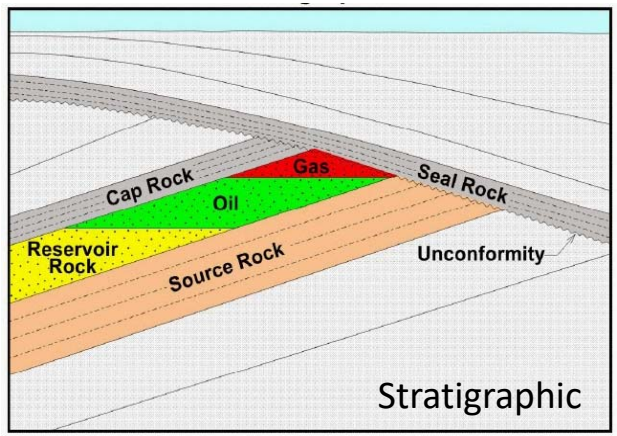


Can CO_2 be held safely? Permanently?

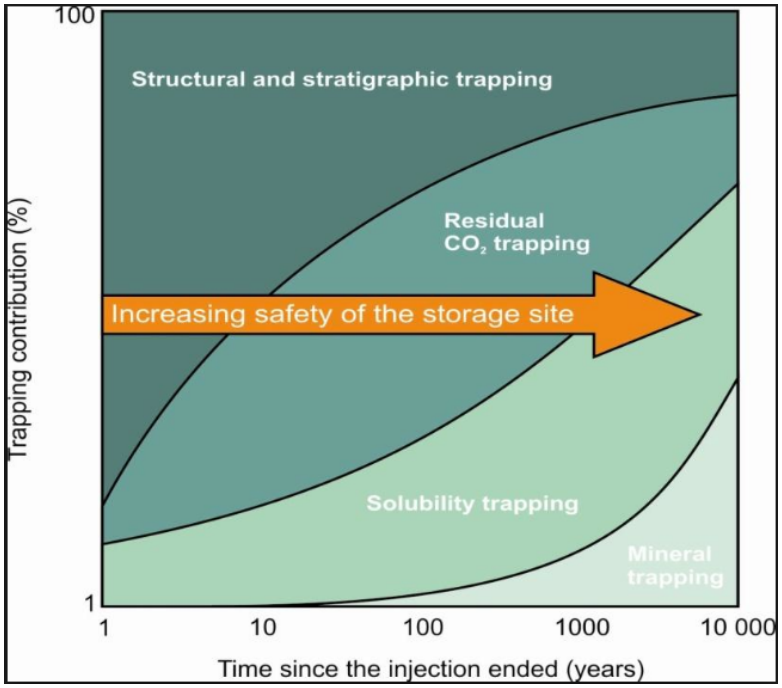
The seals…..

The traps…

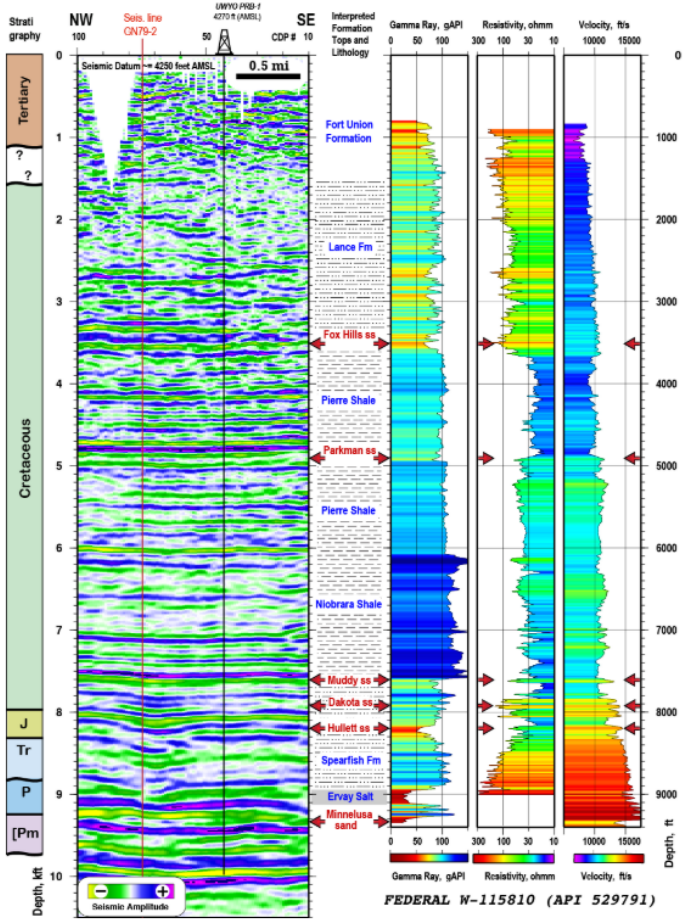


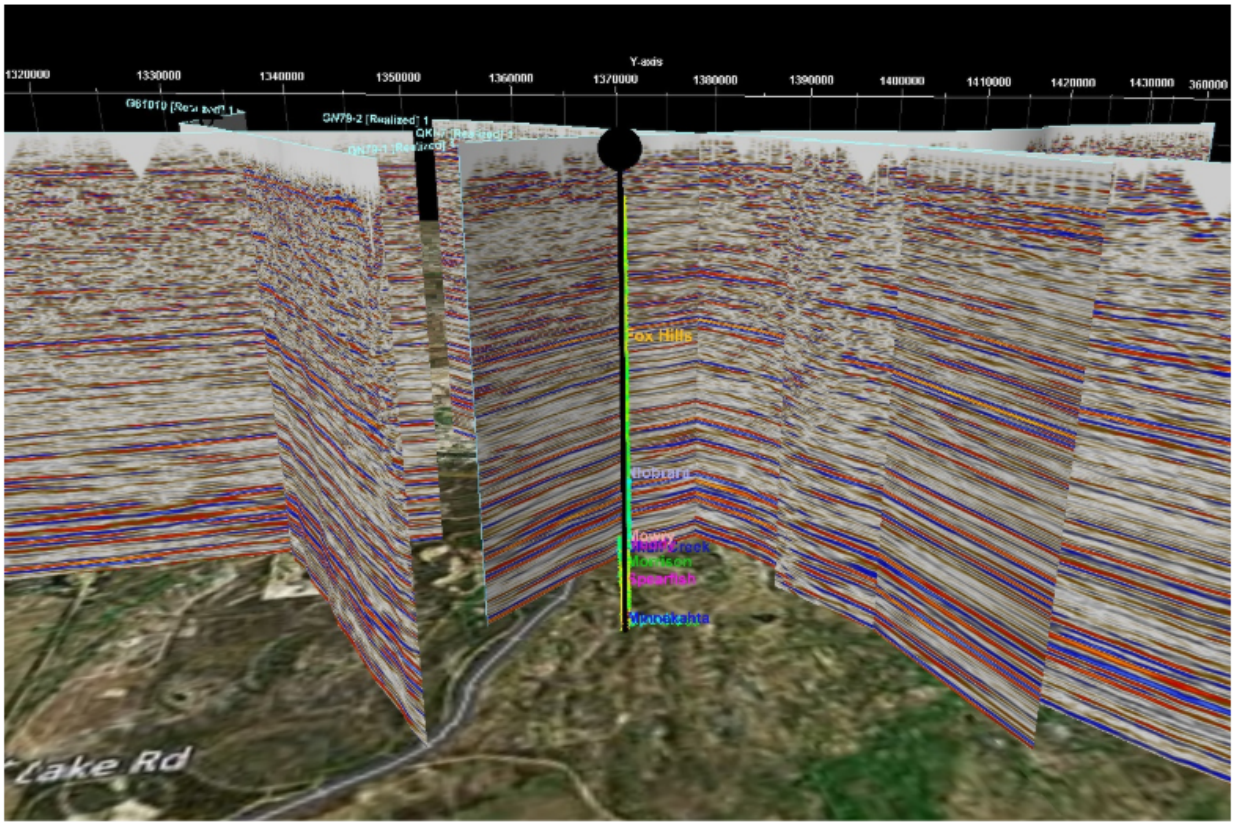


Mineralization…



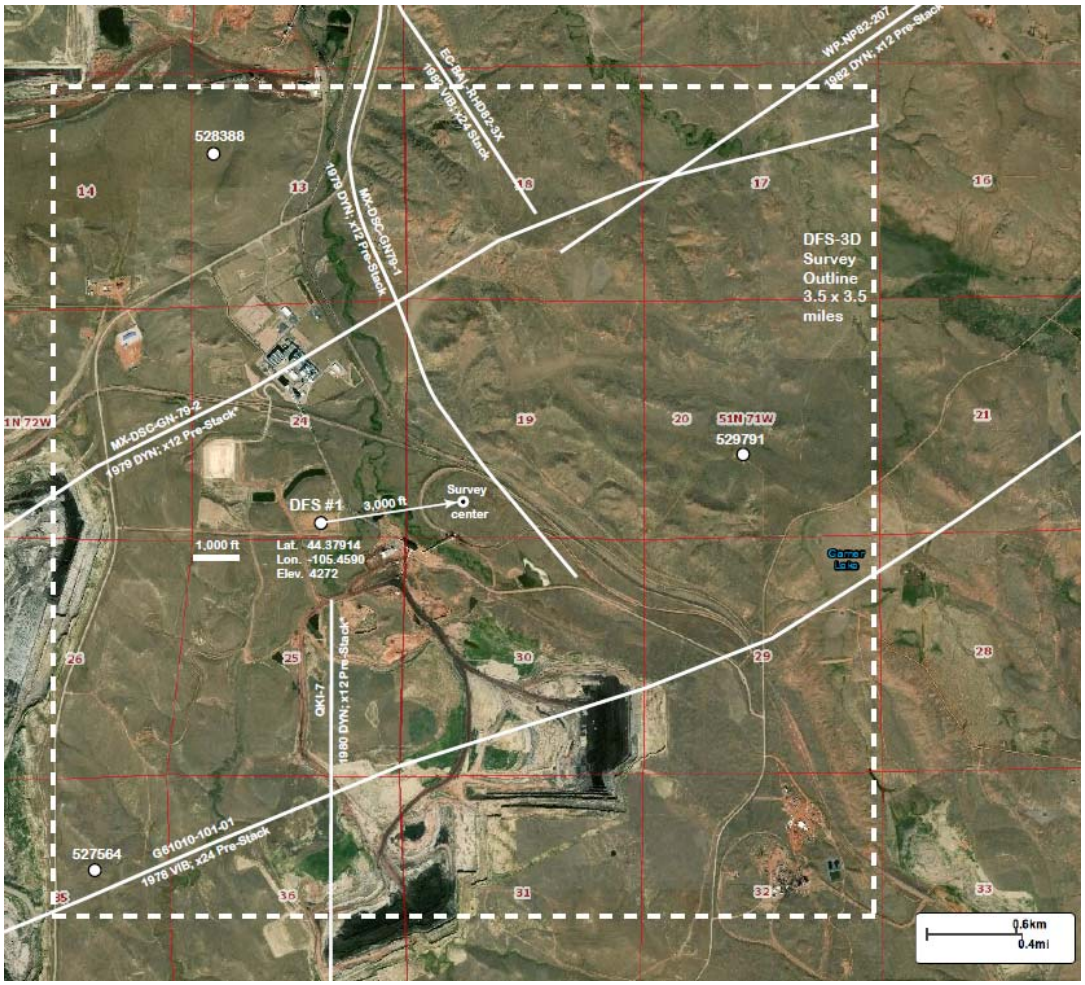
Seismic data can extend the vertical log data laterally





2D seismic data purchased for the project (109 miles total)

Seismic collection

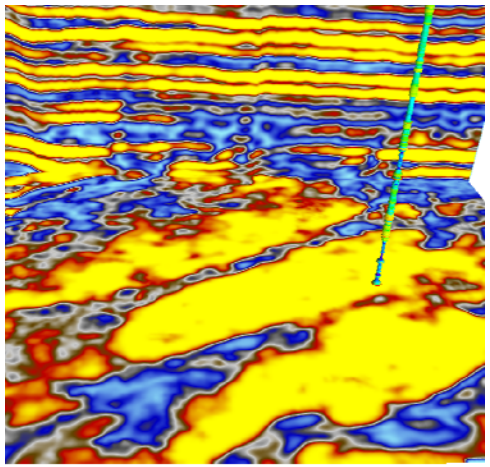


Seismic collection:

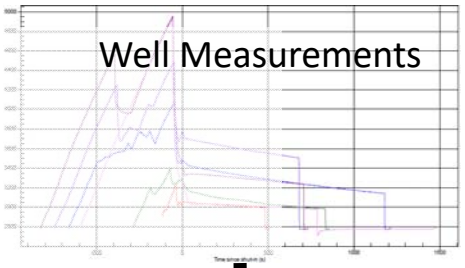
- Will begin later this calendar year
- 3.5 mile x 3.5 mile 3D coverage
- Purchase 2D seismic

Validating Feasibility

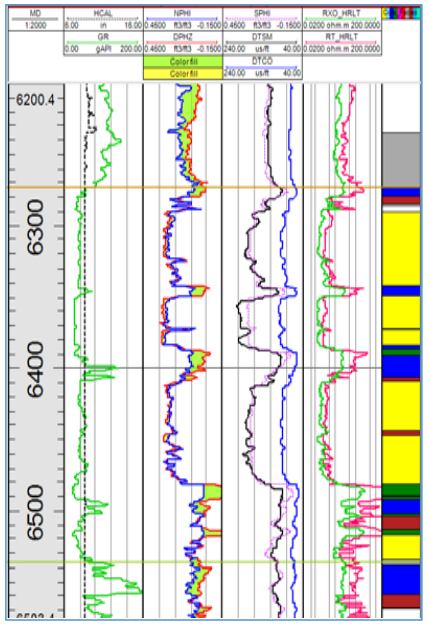
Geophysical Data Interpretations

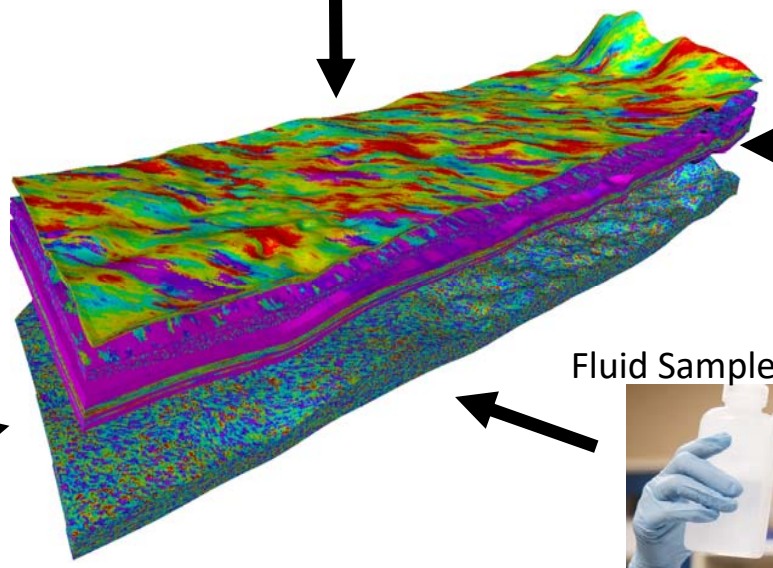


Well Measurements



Well Log Data





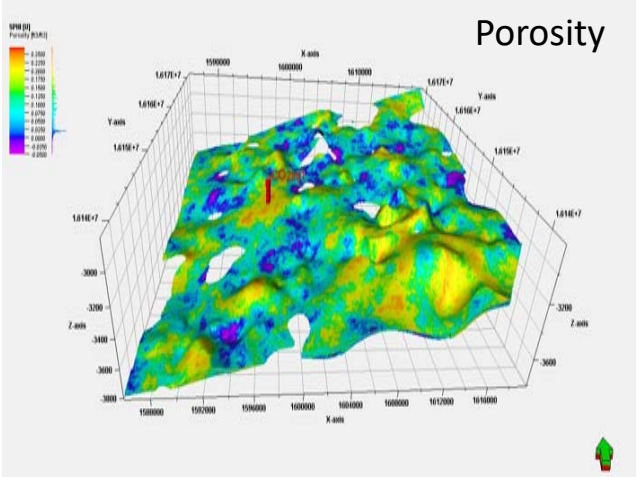
Core Sample Analyses

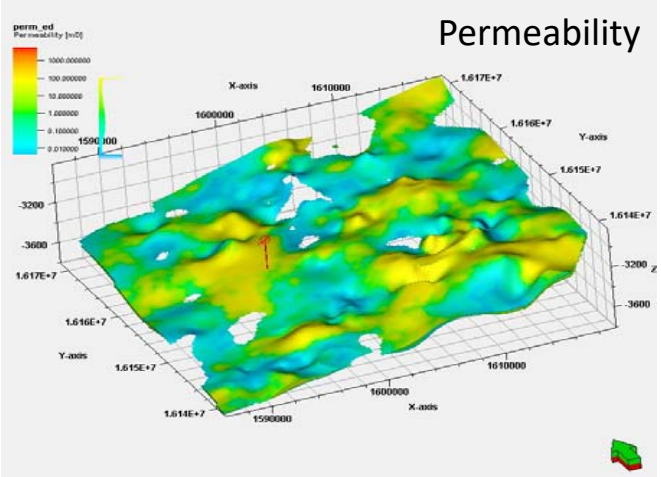
Fluid Sample Analyses

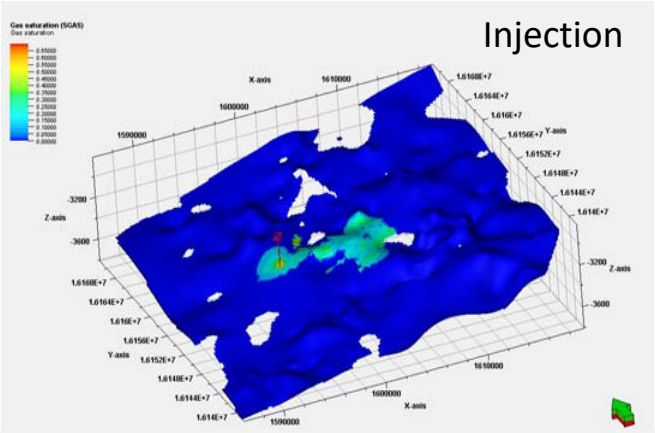
Validating Feasibility

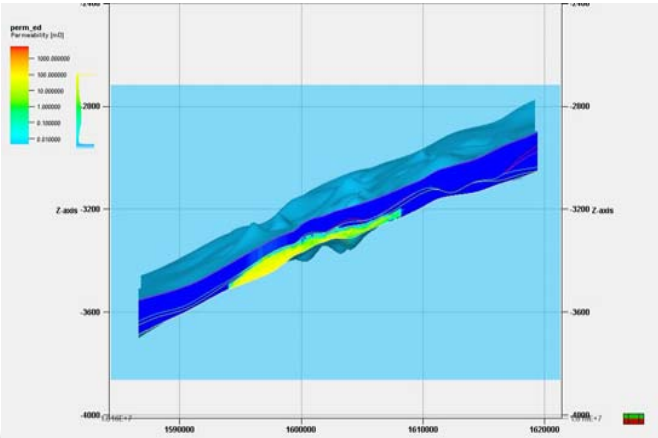
Develop strategies, methodologies and/or models for:

- *Economics of utilization and storage*
- *Storage assessments*
- *Additional permitting needs*
- *Long-term monitoring and validation*
- *Risk assessment*
- *Continued community outreach*
- *Statewide carbon management*









Advantages of CCUS in Wyoming

- ✓ **Capable Experienced Team:** Experienced and diverse coordination team (Academia, Industry & Regulatory)
- ✓ **CO_2 Source:** Engaged Industry Partner- Coal fired power plant & ITC CO_2 Capture and Utilization test facility
- ✓ **CO_2 Transport:** Existing statewide CO_2 pipeline and pipeline ROW's
- ✓ **Saline Storage:** Text book geologic reservoirs for storage
- ✓ **Pore Space Ownership:** Pore space ownership is defined
- ✓ **Regulatory:** CCUS friendly regulatory environment, pending application for WY Class VI primacy
- ✓ **Induced seismicity:** Low risk of induced seismicity
- ✓ **Public Awareness:** Energy educated community
- ✓ **Favorable Economics:** Proximal enhanced oil recovery and CO_2 transport opportunity
- ✓ **Trained Workforce:** CCUS industry jobs analogous to energy industry jobs

Thank you. Questions or comments.

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