San Juan Basin CarbonSAFE Phase III: Ensuring Safe Subsurface Storage of CO_2 in Saline Reservoirs

DE-FE0031890

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New Mexico Tech

U.S. Department of Energy

National Energy Technology Laboratory

Carbon Management Project Review Meeting

August 28 – September 1, 2023

Presentation Outline

- Project overview
- Project Objectives
- Accomplishments
- Geology of San Juan Basin
- Technical Approach
- Summary
- Next Steps

Program Overview

- Funding Profile
- Overall Project Performance Dates

October 2020 – March 2025

Acknowledgements

The project would like to thank DOE for the award opportunity through DE-FE0031890 and our partners.

Project Objectives

- Perform a comprehensive site characterization of a storage complex located in northwest New Mexico to accelerate the deployment of CCS technology in the San Juan Basin

- The data and analysis performed will be used to prepare, submit and obtain UIC Class VI permit from the Environmental Protection Agency (EPA).

- Public awareness of CCS technology and its benefits

- Collaborate with regional partnerships and regional initiative projects to accelerate CCS technology deployment in the region

Project Objectives/ Technical Approach

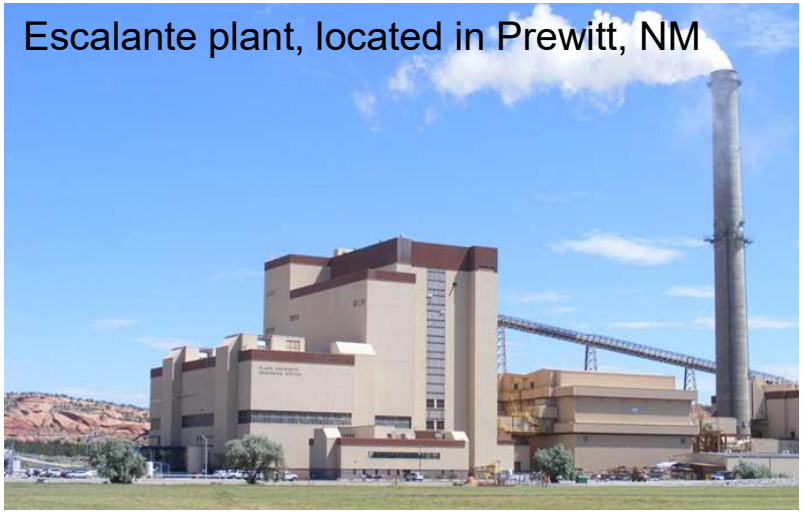
The overall objective of this project is to perform a comprehensive commercial-scale site characterization of a storage complex located within San Juan County, New Mexico to accelerate the deployment of integrated carbon capture and storage (CCS) technology

- Task 1.0 – Project Management and Planning
- Task 2.0 – National Environmental Protection Act (NEPA)
- Task 3.0 – Site Characterization
- Task 4.0 – Reservoir and Caprock Characterization
- Task 5.0 – Geologic Modeling and Simulation
- Task 6.0 – Underground Injection Control (UIC) Class VI Permit Application
- Task 7.0 – Integrated Assessment Modeling
- Task 8.0 – Stakeholder/Policymaker Outreach/Education and Engagement
- Task 9.0 – Coordination with other DOE Projects

Project Facts

Key Project Facts

- Perform Site Characterization of storage complex within San Juan Basin
- Source CO_2 from Escalante H_2 plant, located in Prewitt, NM.
- Initial UIC Class VI permit submitted in 2023
- Community and stakeholder outreach on CCS technology and its benefits
- Completed initial EIV, currently updating to reflect latest pipeline routing


Escalante plant, located in Prewitt, NM

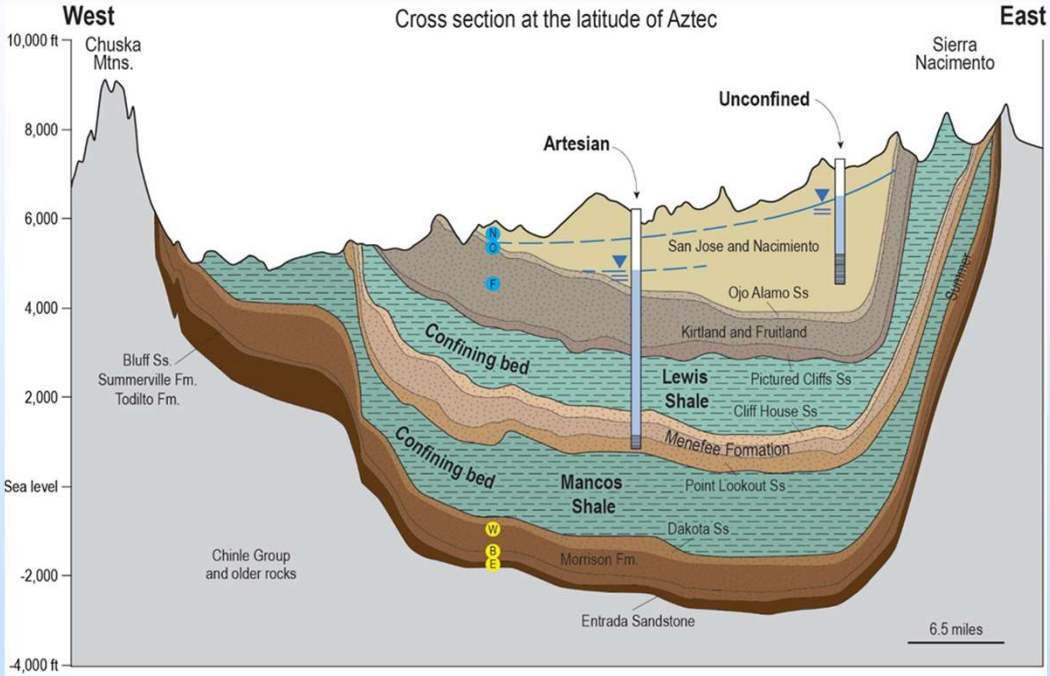
Characterization Plan

- Drilled characterization well, perform injectivity tests
- Recovered ~ 450 ft of Core, sampled drilling cuttings, advanced log suites measurements
- Purchased 100 sq.miles 3D seismic, acquire walk-away VSP,
- Installed DAS/DTS/DSS Optical fiber behind casing
- Perform suites of laboratory experiments and numerical models

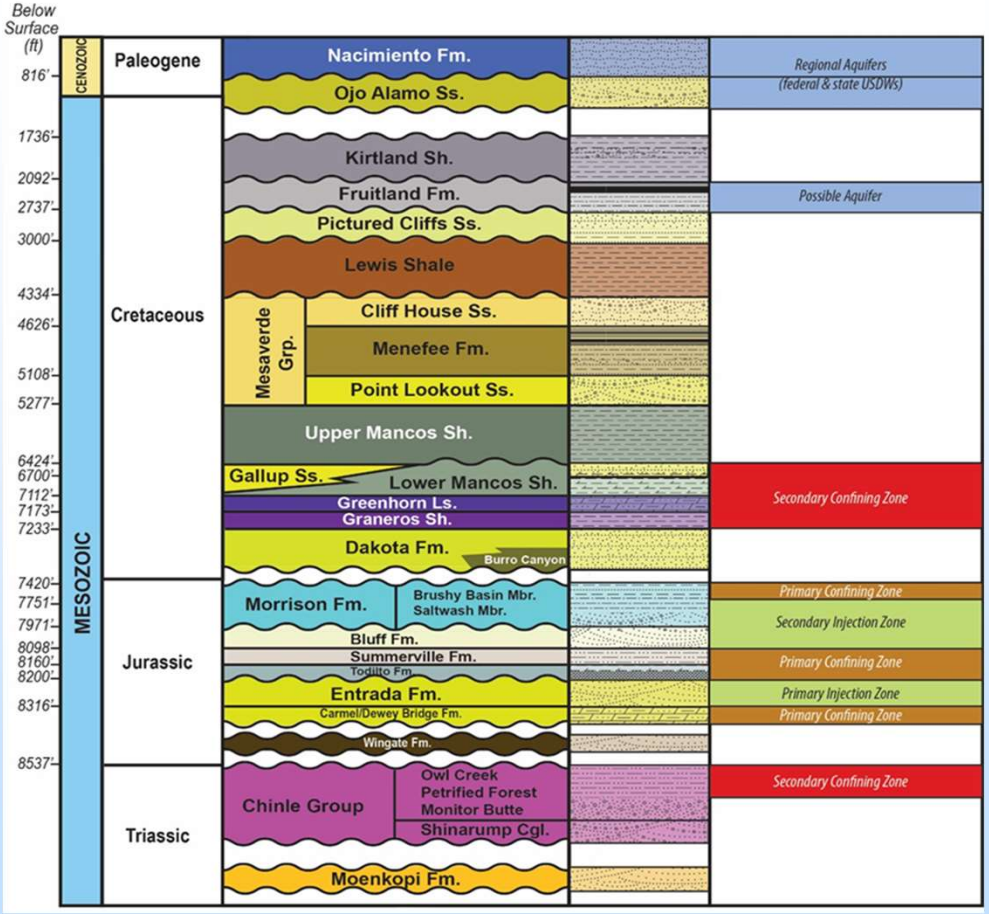
Technical Approach/Project Scope

Task/ Subtask	Milestone Title & Description	Status
1.0	Project Kick-off meeting	
2.3	NEPA documentation progress	Ongoing
3.1	Evaluation of available data such as seismic	Completed
3.3	Acquisition and processing of Seismic data	Completed
3.4.5	Stratigraphic well drilled	Completed
4	Complete needed Caprock and reservoir analysis for Modeling	Completed
5.2	Complete initial simulations for UIC permit application	Completed
5.2.8	Complete AOR modeling	Completed
5.3	Complete initial Risk assessment for UIC permit application	Completed
6	Complete documentation to submit UIC class VI application	Completed
6.10	Progress report on submitted UIC class VI application	Completed
6.10	Progress and/or receiving approval for UIC class VI application	Ongoing

San Juan Basin Geology



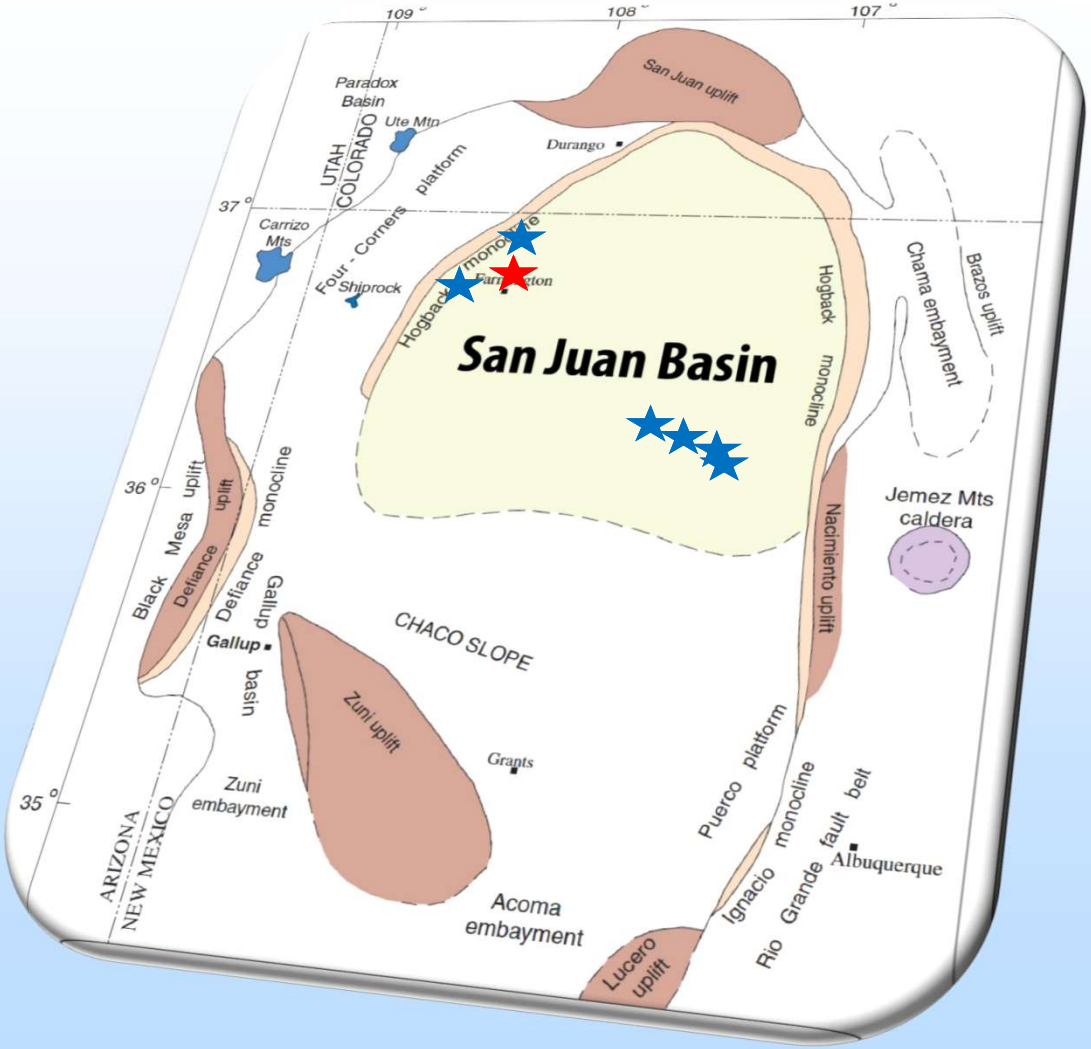
Schematic cross section of the San Juan Basin illustrating confining beds (blue units) and sandstone strata (brown, tan, and gray units).



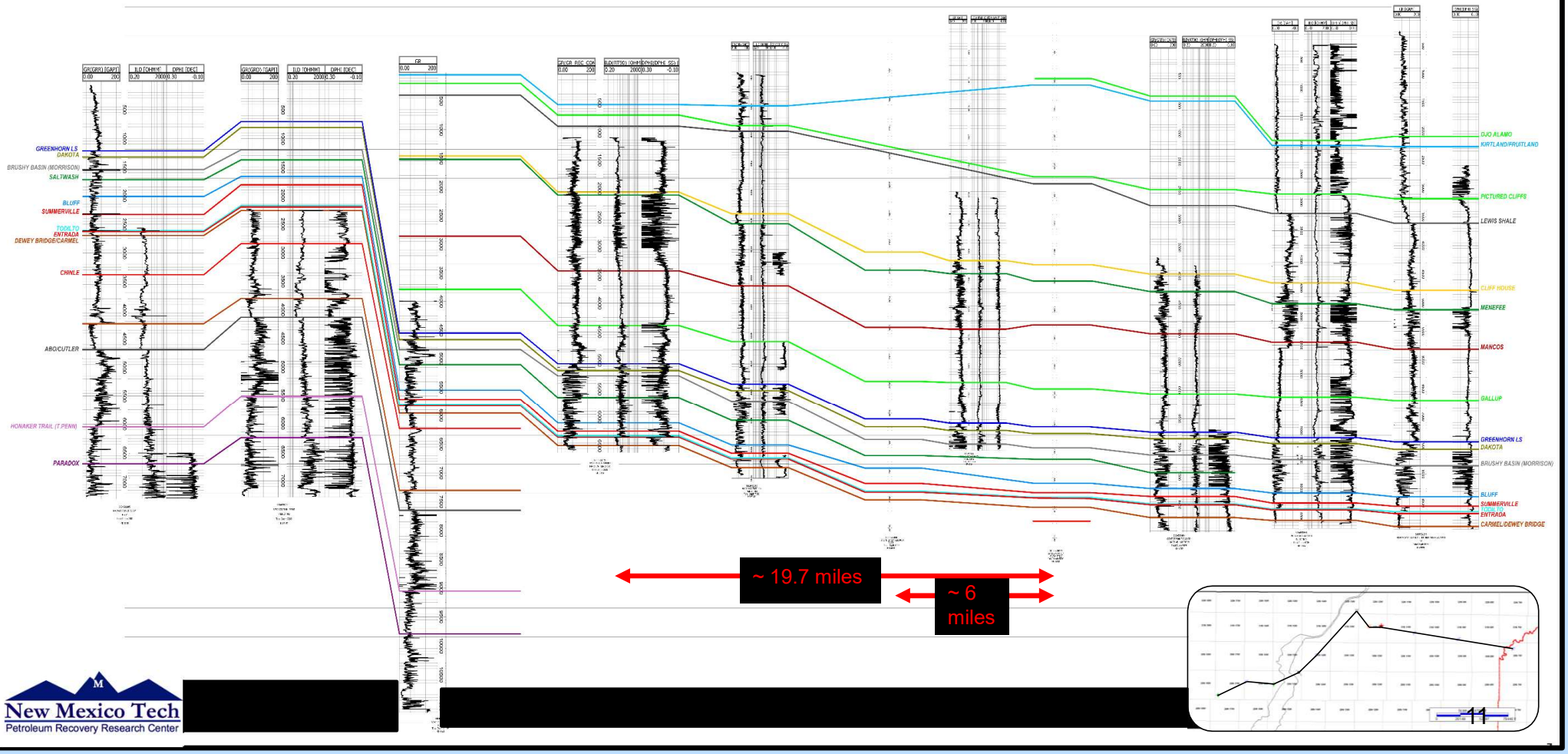
Stratigraphic column for San Juan Basin

SJB Basin Structural Elements

- Key Wells in the SJB:
  - SJB CARBON SAFE STRAT TEST #001 (30-045-38272)
  - State Strat 600 #001
  - Pathfinder AGI #001
  - Santa Fe H 20 #001
  - Federal 21 #002
  - EMU #001
  - San Luis Fed #001



Pathfinder AGI #001 State Strat 600 #001 SJB CarbonSafe Well

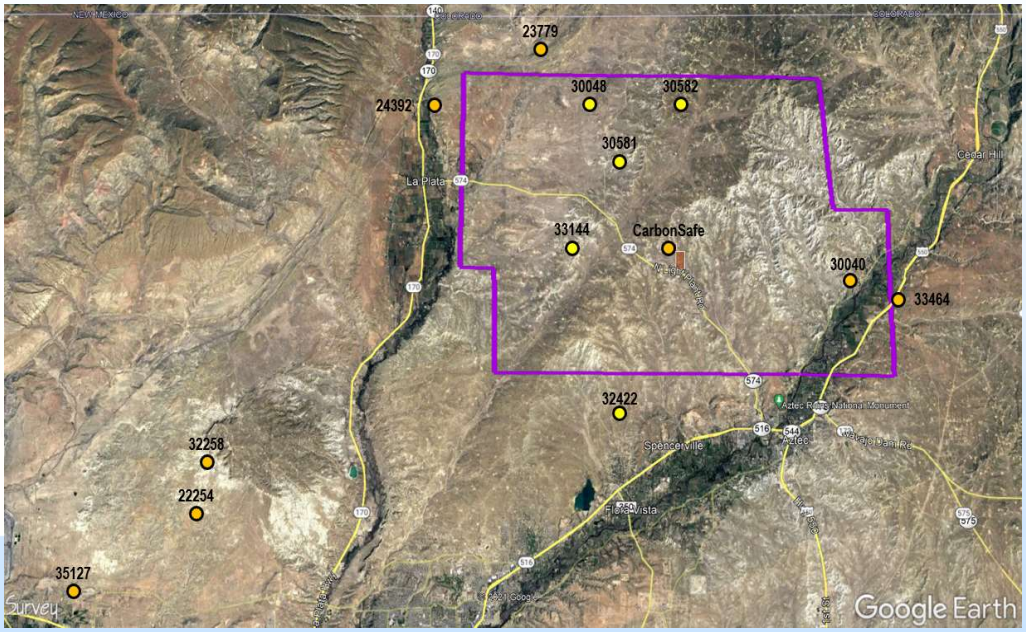


New Mexico Tech
Petroleum Recovery Research Center

Our Approach to Earth Modeling

	Seismic, Wellbore images	Triple-combo, Sonic, Core	Wellbore images, Sonic, Core	Petrophysics, Sonic, Core
Intrinsic properties	**Framework** Structure Faults Horizons	**Petrophysics** Lithology, Vcl Porosity, Sw Matrix Perm Elastic Moduli	**Mechanical** Strat Column Facies Support Fracture Attributes	**Rock Strength** Compressive & Tensile Strength Friction Angle
Extrinsic properties	**Vertical Stress** Overburden	**Pore Pressure** Pore Pressure	**Stress Direction** Maximum Horizontal Stress Direction	**Stress Magnitude** Minimum & Maximum Horizontal Stress
	Density log, Petrophysics	**Formation testing, Petrophysics, Mud logs**	**Wellbore images, Sonic, 4-Arm calipers**	**In-situ stress tests, Sonic**

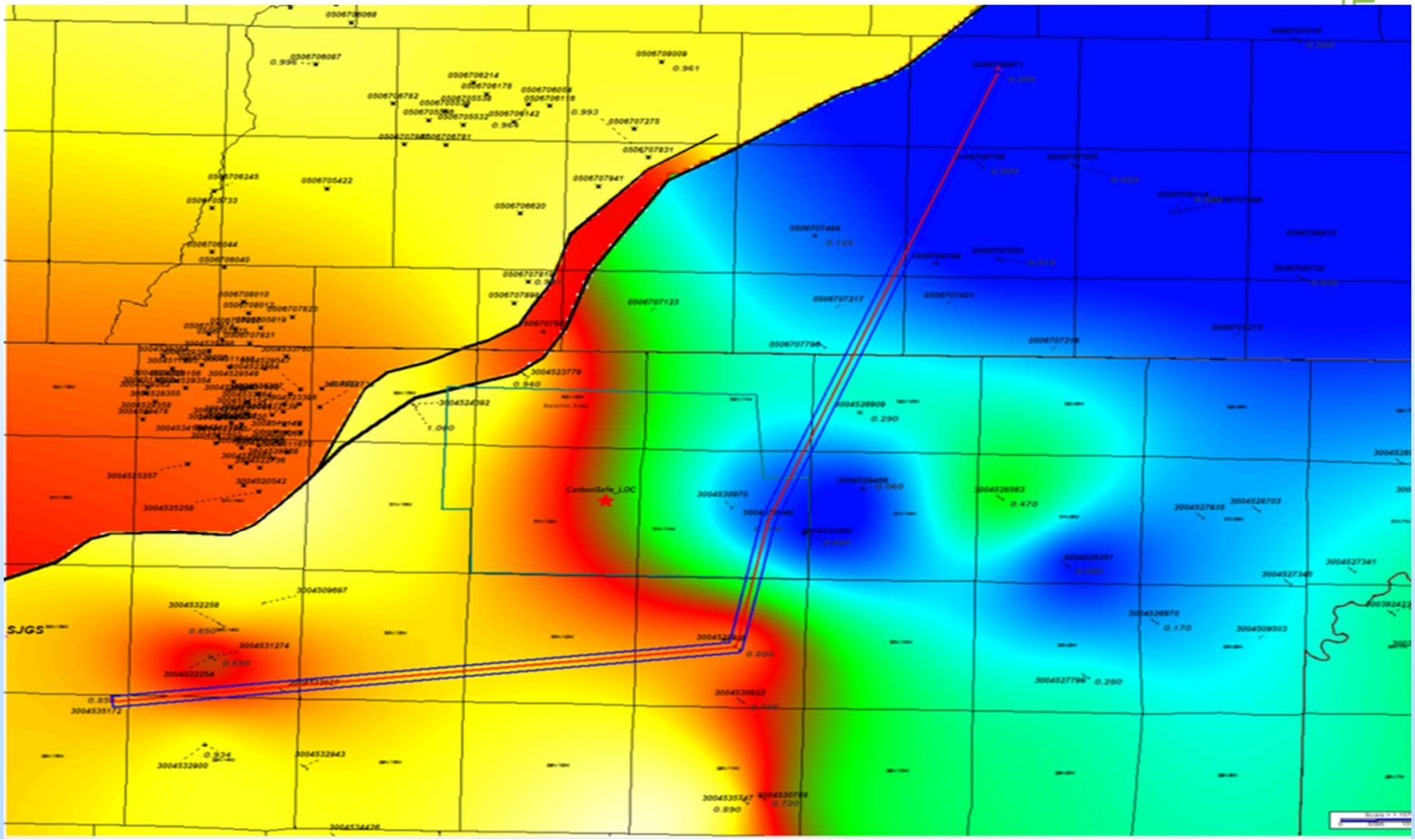
Brie and Bratton, 1994



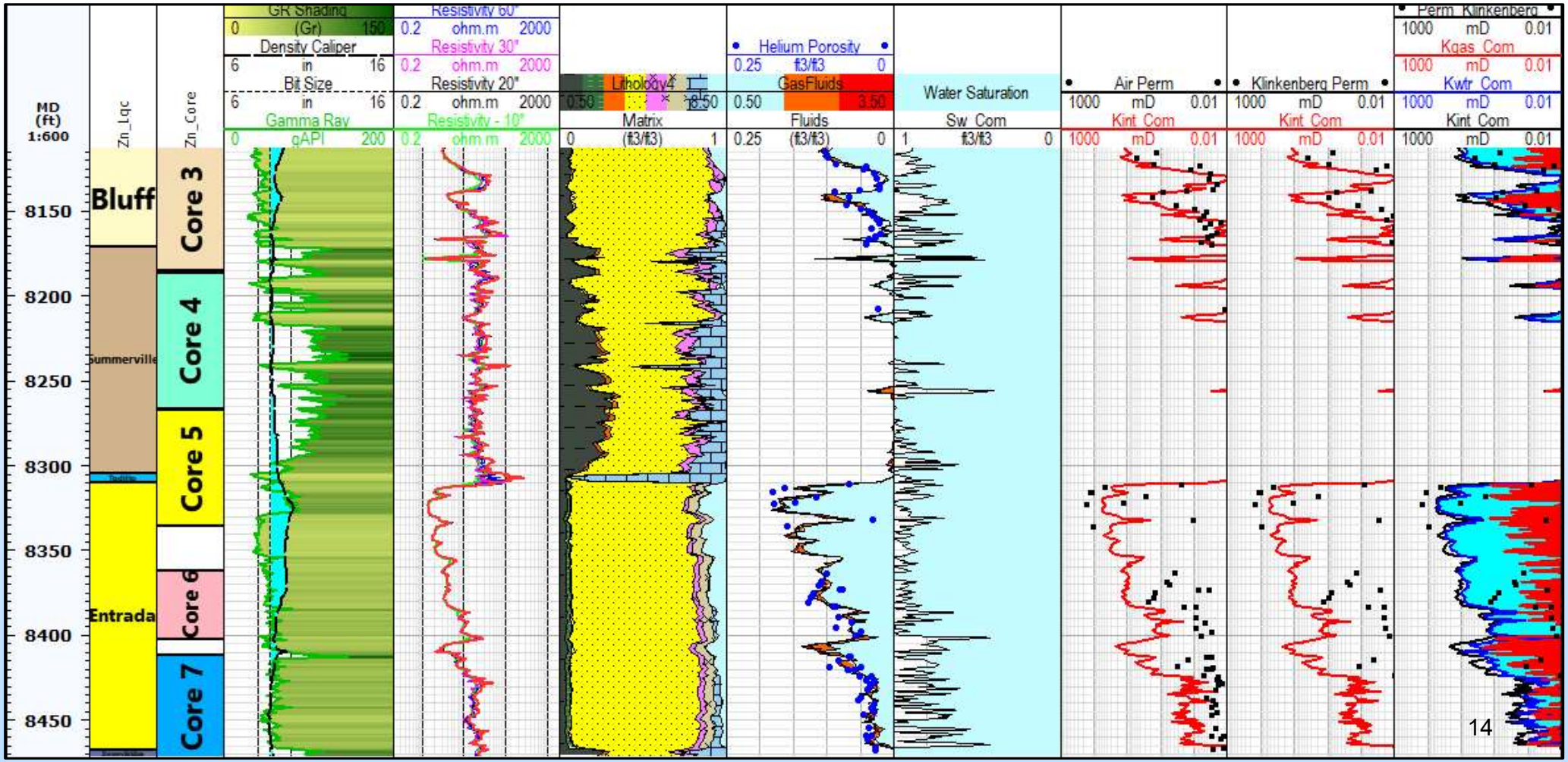
Wells used for Petrophysical analysis

A petrophysical analysis has been completed on 14 wells and a geomechanical analysis has been completed on a single well.

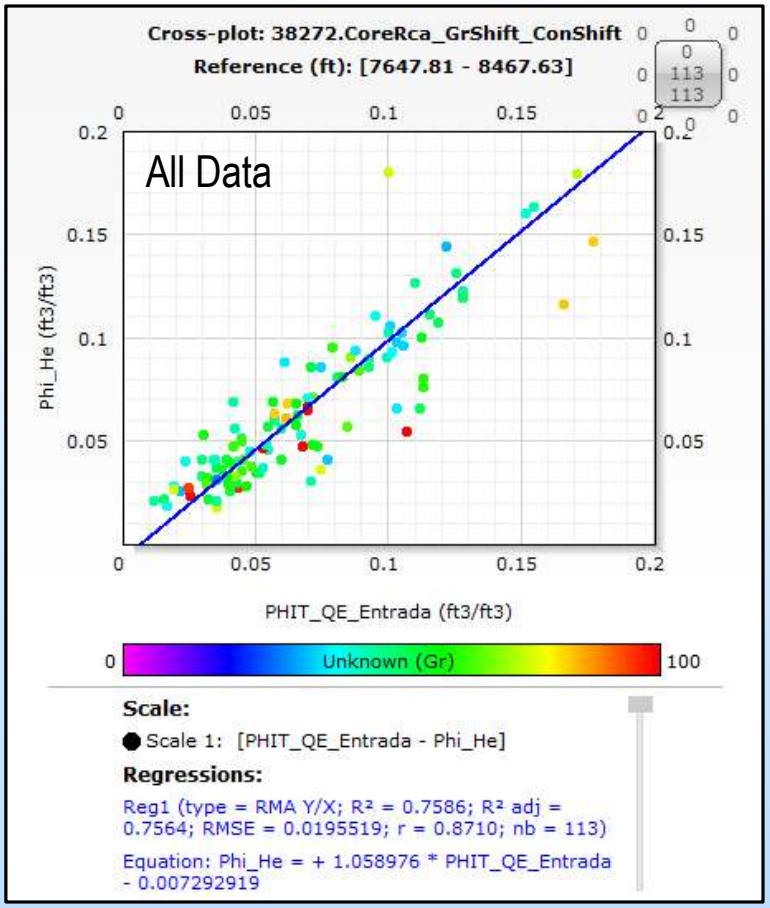
Site Selection

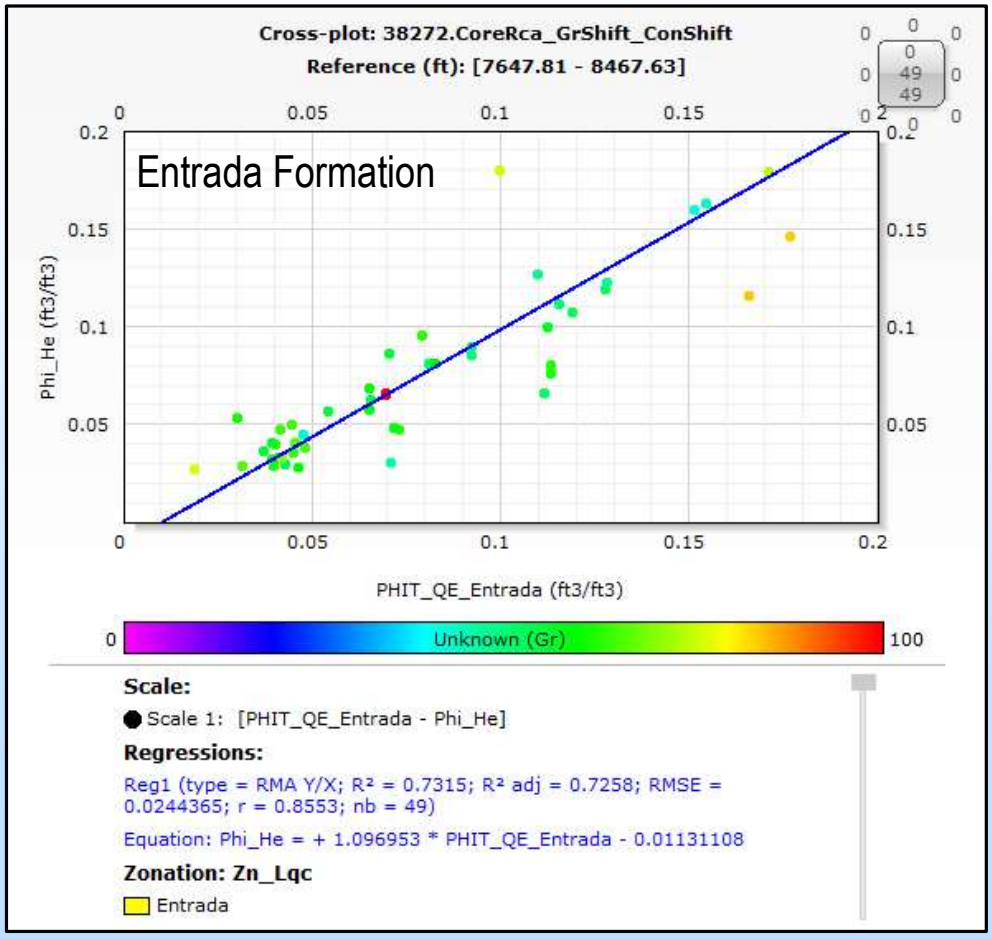


CarbonSAFE Well Routine core analysis

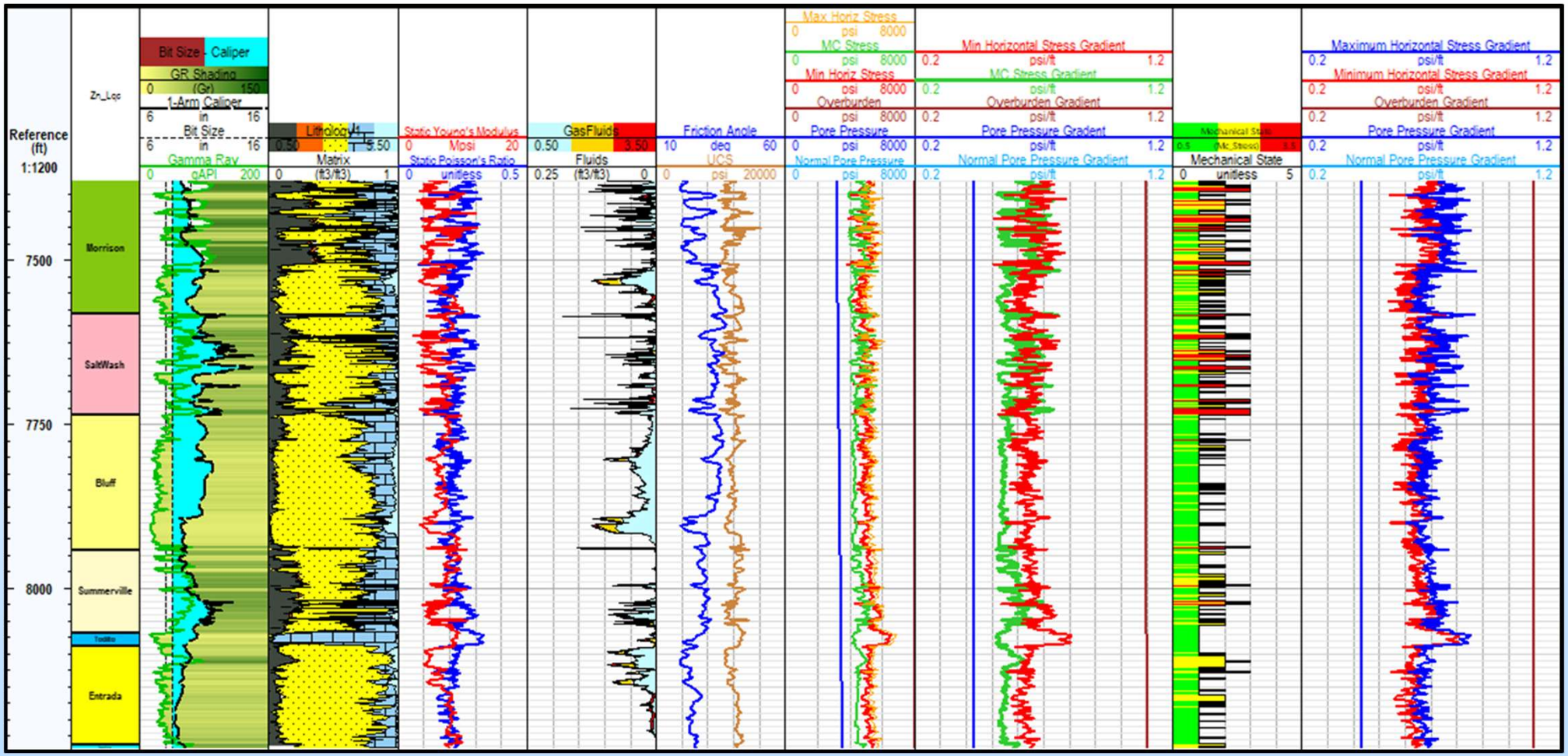


CarbonSAFE Well – Core He porosity vs. Log porosity





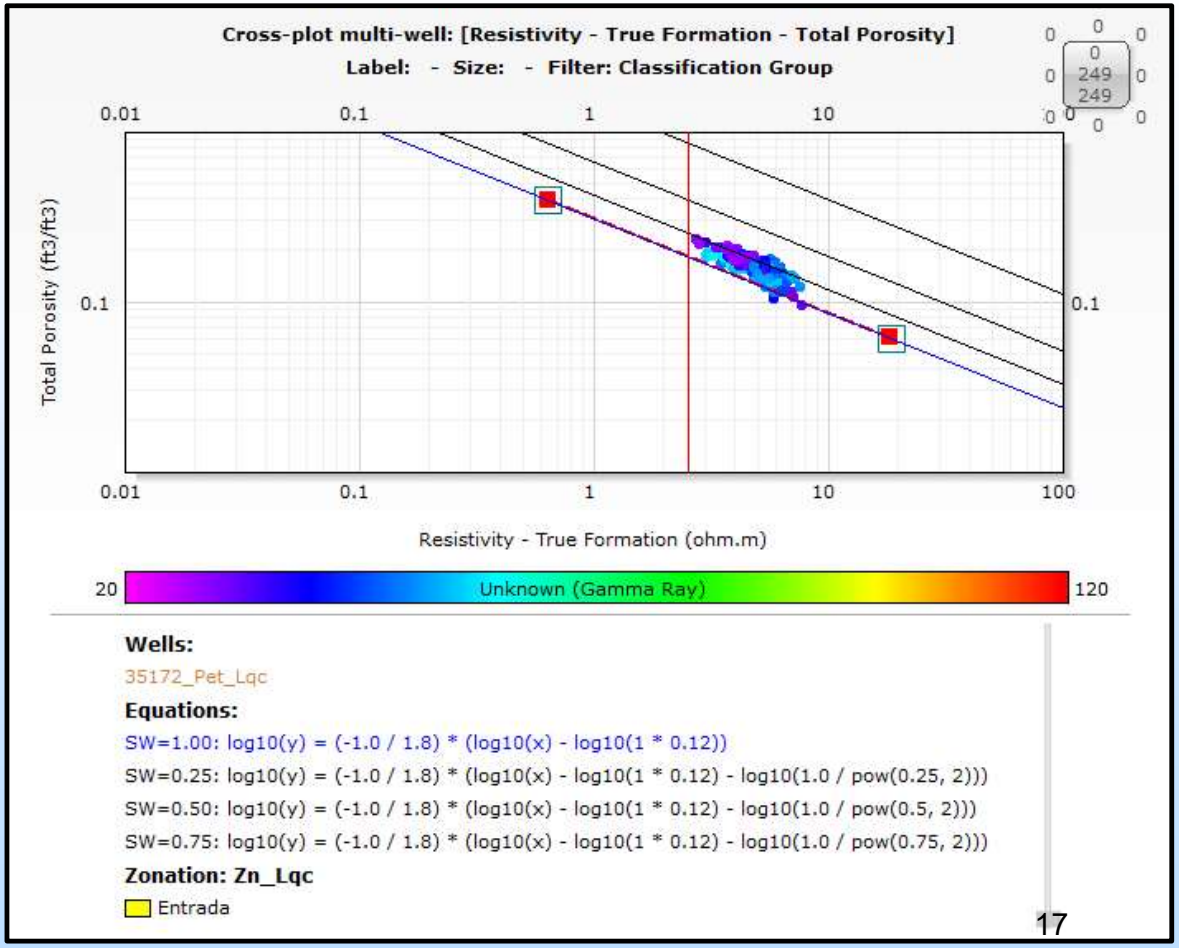
Geomechanics- 1D MEM



Entrada Salinity Estimation

- Pickett plot

- A=1
- M=1.8
- N=2.0
- Rw = 0.12
- Temp = 164 degF
- **Salinity = 24,102 ppm**



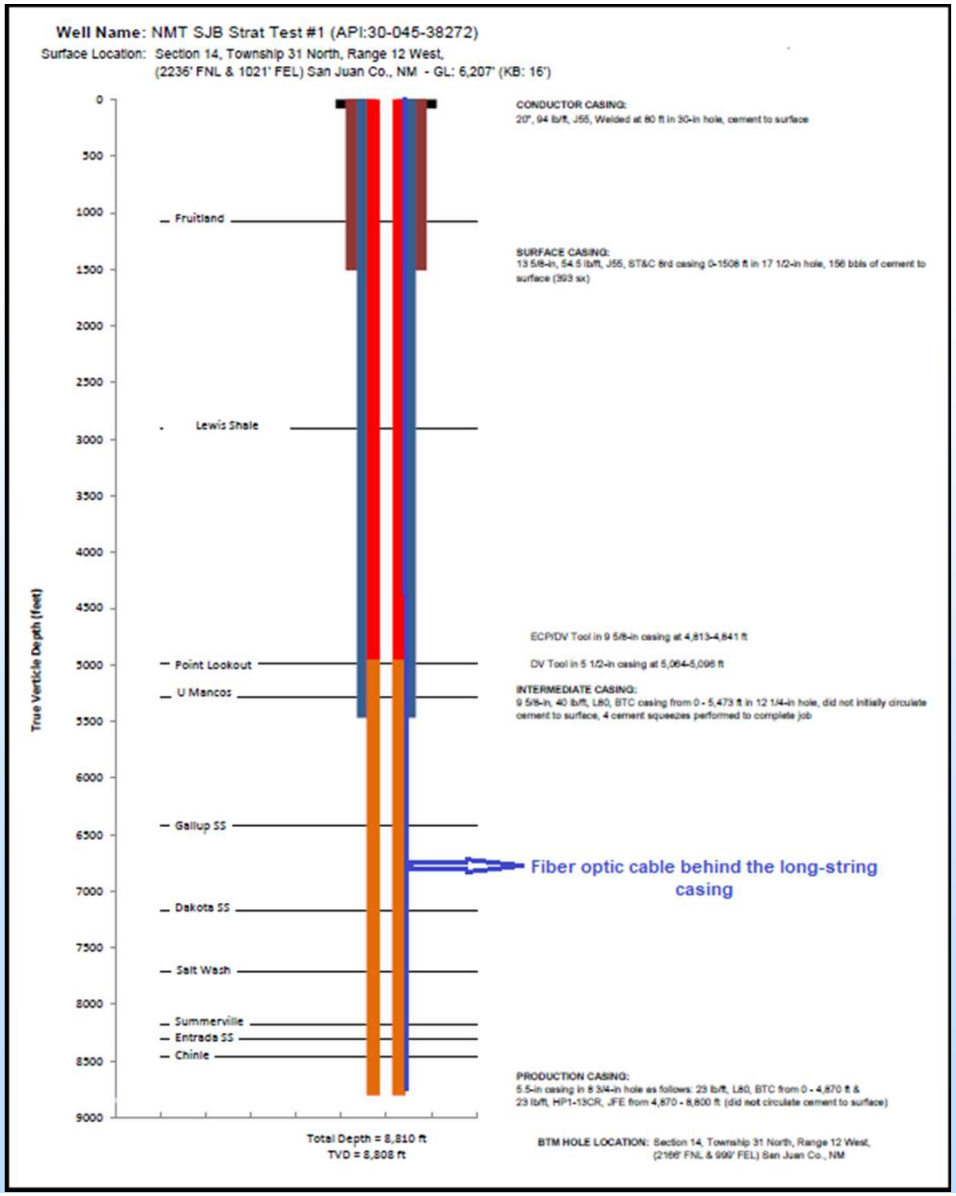
Other Salinity Estimations

Well	28563	30922	26909	30581	33464	32258	22254	33144	23779	24392	30030	35172
M factor	2	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Point Lookout				5								
Gallop				22.5								
L Mancos				13.9								
Dakota				23	13.2	26.8	38	32	26.4			26
Salt Wash	60.262	26.487	24.671					36	32	32	65	31
Bluff	281.392	30.014	61.859		68.4				67	65	65	28
Entrada	32.152	39.618	17.944		46.5	24.6		34	34	34	43	24

The results in *Kppm*

Field Operations

Stratigraphic Well Design

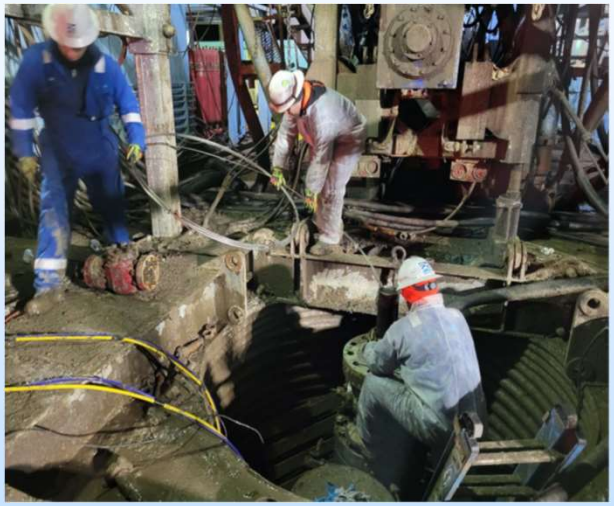


Field Operation
-Drilling

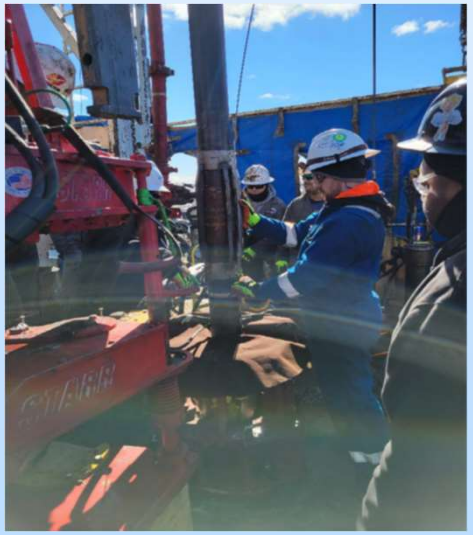
Field Operation – Coring

Field Operation - Logging

Field Operation - Fiber Installation



Silixa fiber optic cable deployment is part of DE-FE0032064 project.

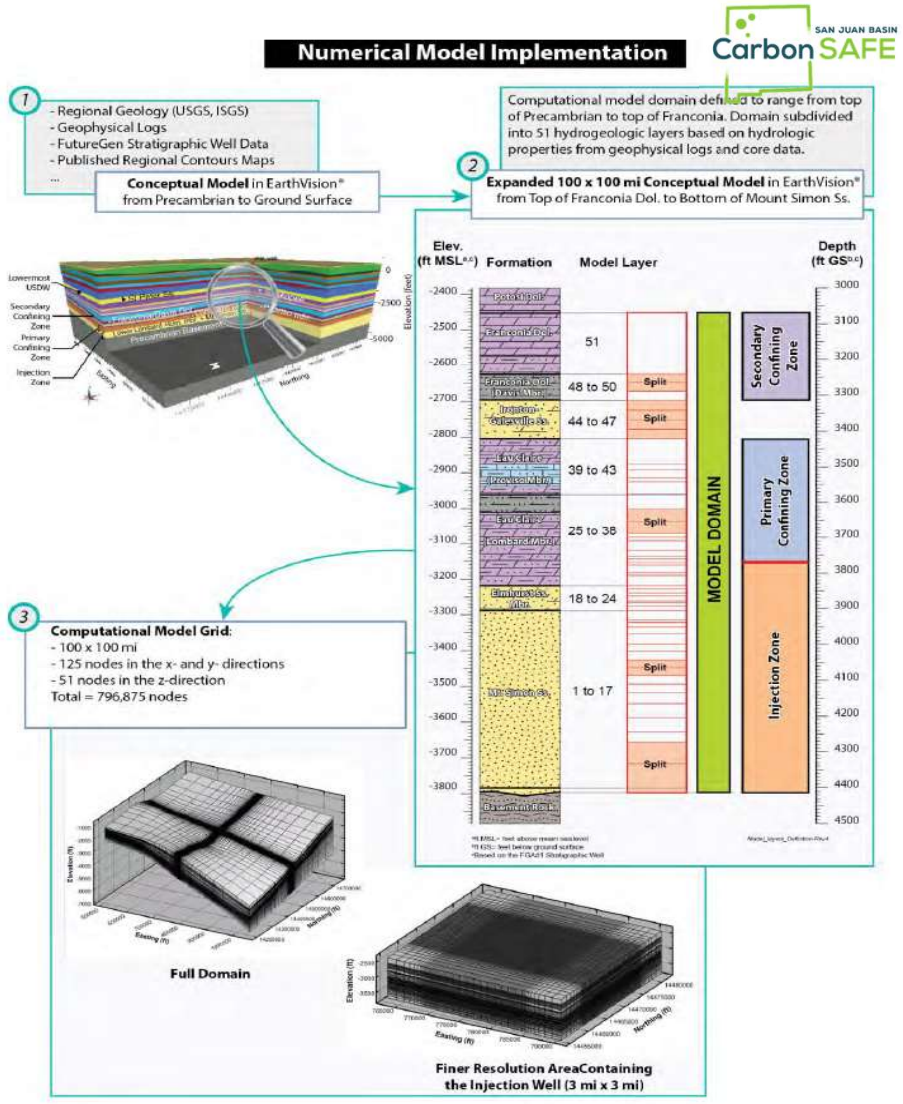


Field Operation-Casing and Cementing

Performing AoR modeling and delineation

- 146.82(a)(2)"A map showing the injection well for which a permit is sought and the applicable area of review consistent with § 146.84."

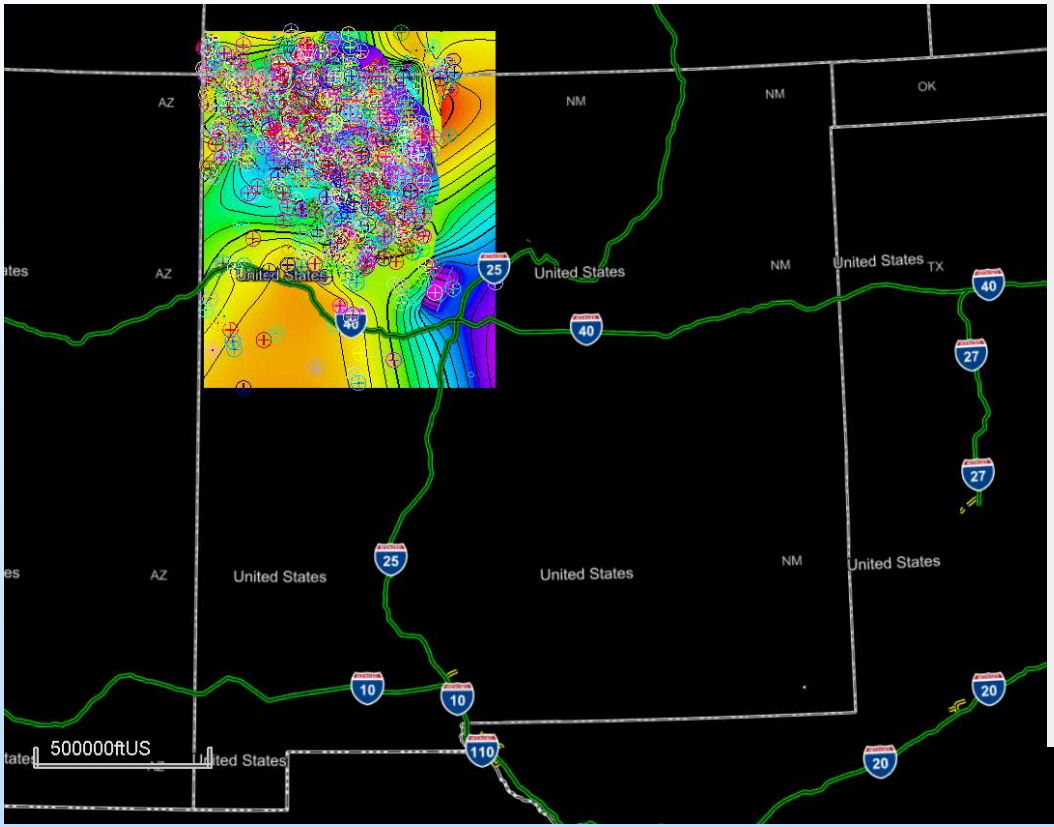
1. Model Development
   - Area encompasses proposed injection site
   - Determination of physical processes
   - Model design
     - Computational Code Determination
     - Model Spatial Extent, Discretization, and Boundary Conditions
     - Model Timeframe
     - Parameterization, etc …
2. Multiphase Numerical modeling
   - CO_2 saturation and pressure plume size thru time
3. Identify Area of Review
   - Area around injection zone where pressures are high enough to force fluid through open conduits into the overlying USDWs
   - Identify potential leaky well-bores
   - Identify potential open/high permeable faults
4. NRAP Tools to characterize endangerment of USDW due to well leakage

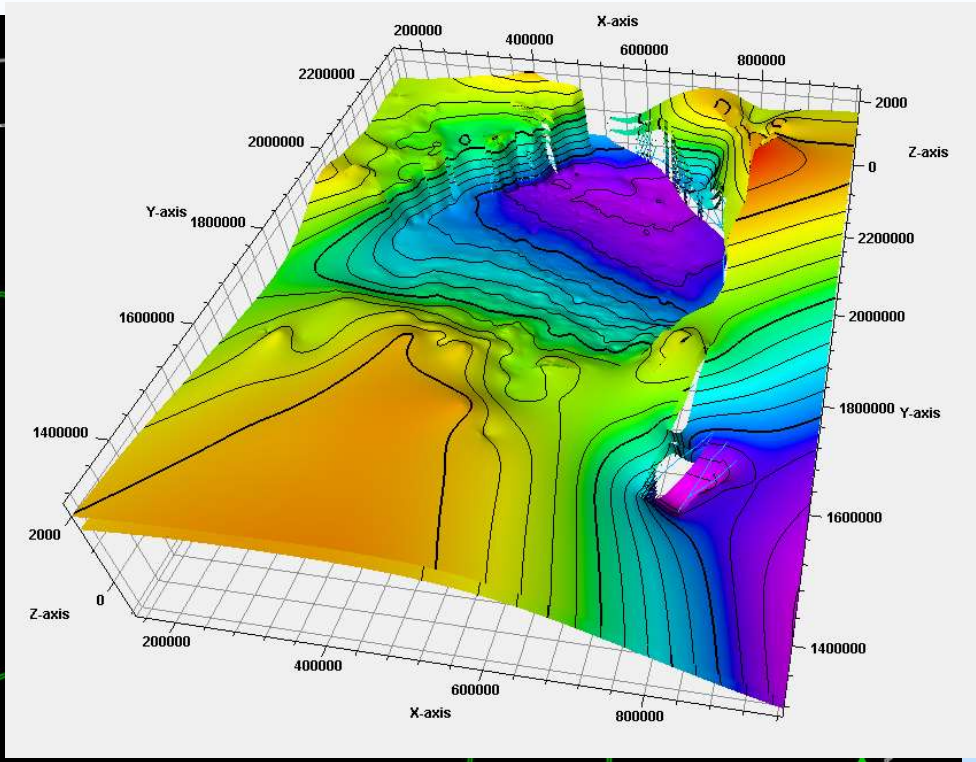


Implementation of the Numerical Model: From the Geological Conceptual Model to the Numerical Model

San Juan Basin Geological Modeling

- More than 2200 well tops so far





CO_2 Storage Estimation

$$S = Ah\phi\rho E_A E_h E_\phi E_V E_d,$$

where A is the area of the storage formation, h is the thickness of the storage formation, ϕ is the porosity of the storage formation, ρ is the density of the CO_2 (which depends on the pressure and temperature), E_A is the Net-to-total-area efficiency factor, E_h is the net-to-gross-thickness efficiency factor, E_ϕ is the effective-to-total porosity efficiency factor, E_V is the volumetric displacement efficiency factor, and E_d is the microscopic displacement efficiency factor.

Storage Formation	Entrada		Bluff		Saltwash	
Area (km^2)	9,571	0	9,571	0	9,571	0
Thickness (m)	47.4	4.74	55.7	5.57	103.5	10.35
Porosity (%)	10.9	0.4	9.7	0.3	7.9	0.2
Pressure (MPa)	17.2	1.72	15.0	1.50	15.3	1.53
Temperature (°C)	71.5	7.15	64.1	6.41	62.1	6.21

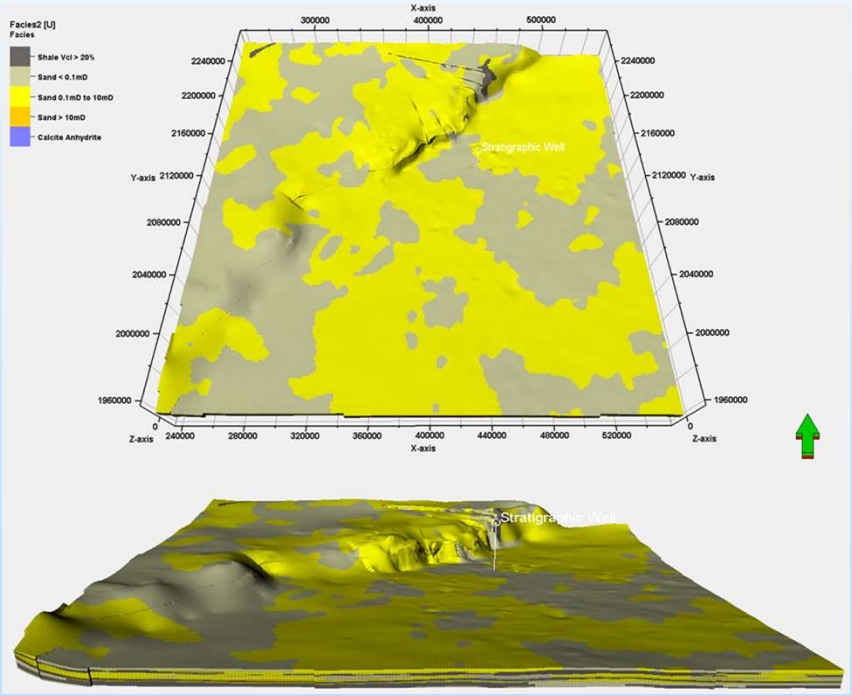
Input Parameters

Storage Formation	P_{10}	P_{50}	P_{90}	Mean
Entrada	**1,690**	**2,441**	**3,434**	**2,542**
Bluff	1,688	2,492	3,547	2,592
Satlwash	2,708	3,969	5,547	4,125
Total	6,086	8,901	12,527	9,259

Storage Capacity Estimation millions of metric tons of CO_2

SJB CarbonSAFE 7th Model Description

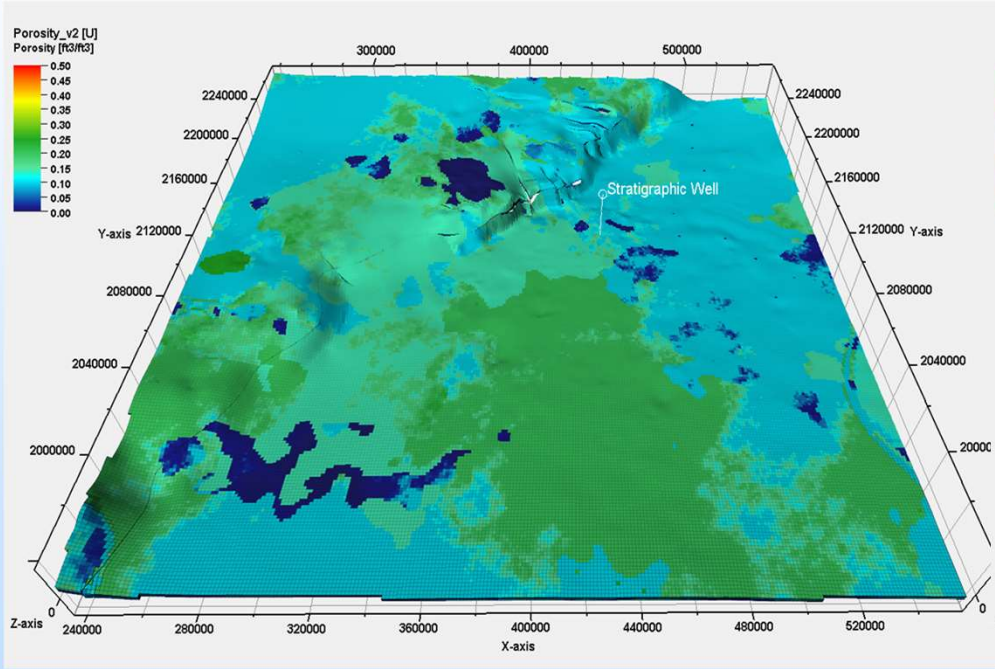
- Grid cells (nI x nJ x nK): 244 x 247x 59
- Total number of grid cells: 3,555,812
- X (ft): 235227.51 ~ 556067.02 ->320839.50ft (60.77 miles)
- Y (ft): 1957130.54 ~ 2278759.08-> 321628.55 ft (60.91 miles)
- CRS: NM-W:NAD27 New Mexico State Planes, Western Zone, US Foot



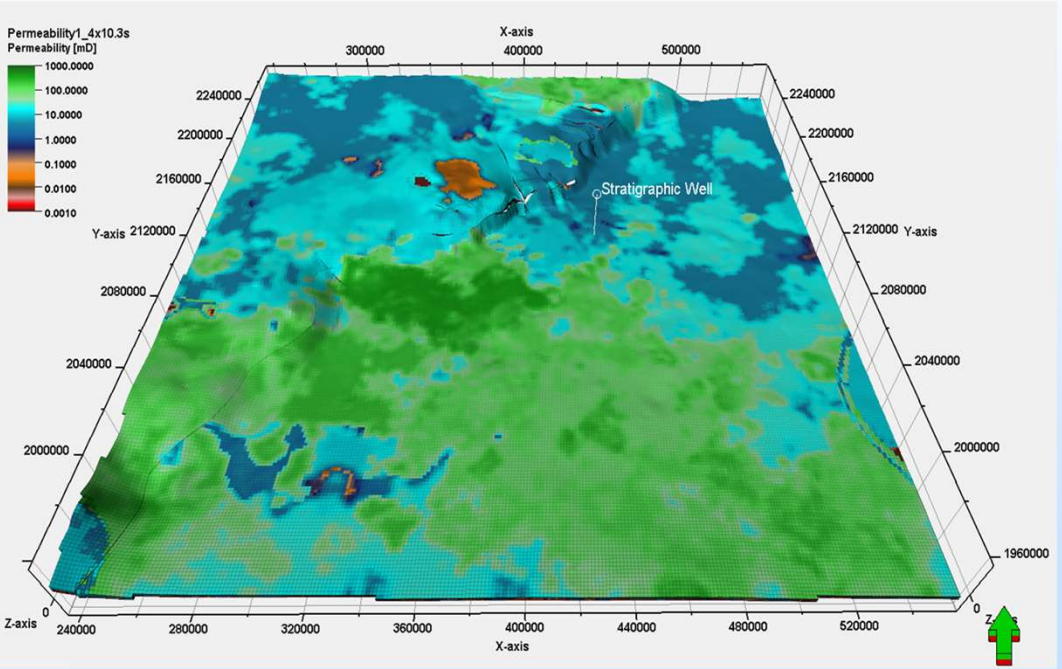
Layer No.	Formation
1	Dakota
2	Brushy Basin
3	
4	
...	
29	
30	
31	
32	Salt Wash
33	
34	
35	
36	
37	
38	Bluff
39	
40	
41	
42	
43	Summerville
44	
45	
46	
47	Todilto
48	
49	Entrada
50	
51	
52	
53	
54	Camel
55	
56	Wingate
57	
58	
59	

Reservoir Property Distribution

	Name	UNITS	Min	Max	Delta	N	Mean	Std
Entrada	Porosity	dec.	0	0.39	0.39	1781435	0.08	0.06
	Perm	mD	4.46E-10	641.0212	641.0212	1781435	9.3095	30.2975



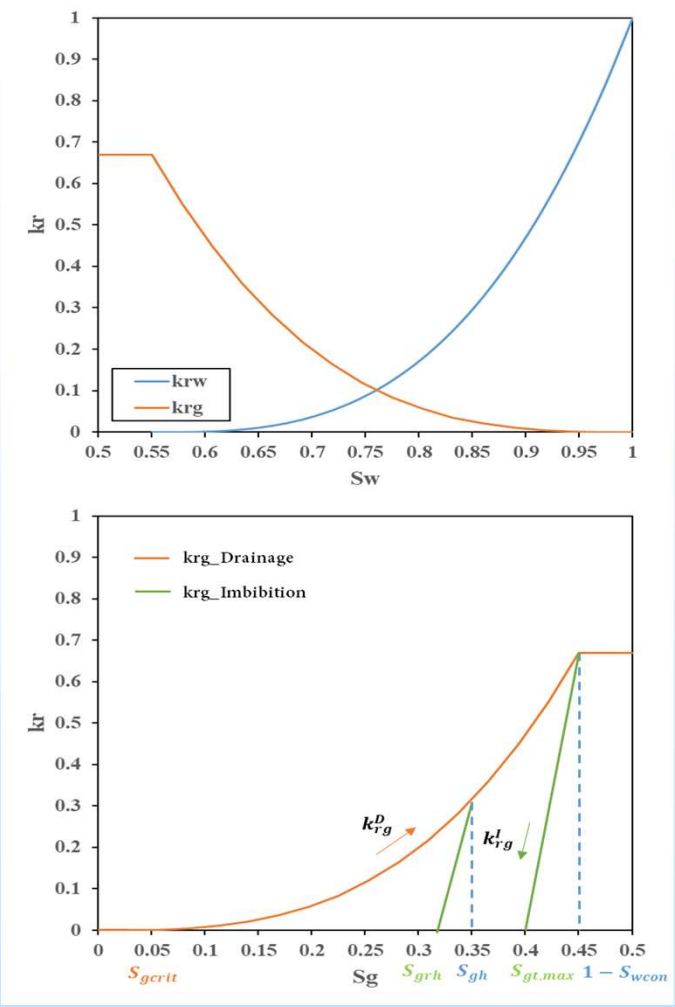
Porosity



Permeability

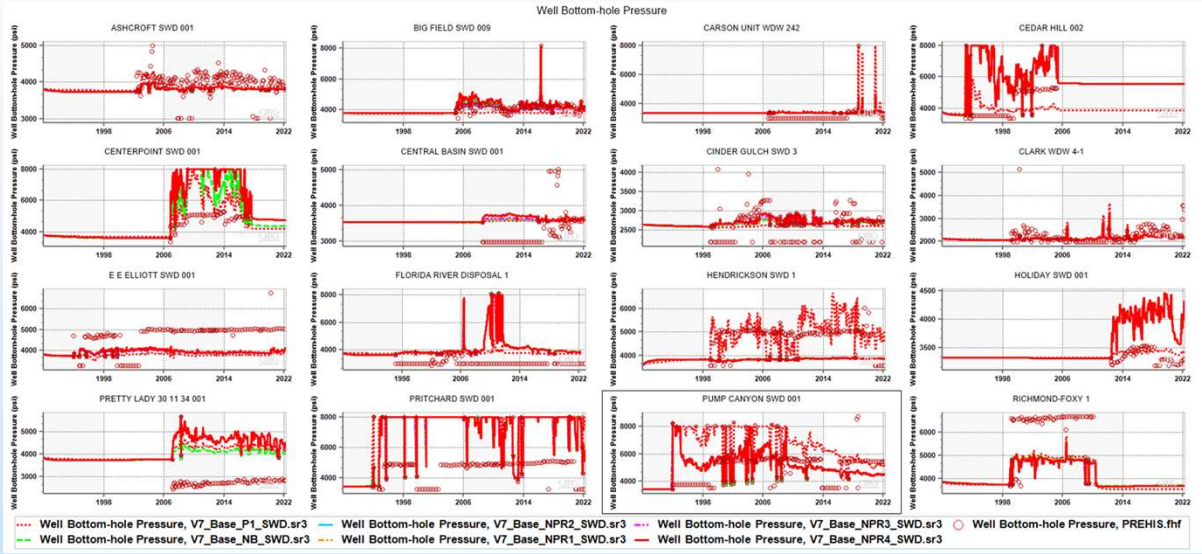
Rock and Fluid properties

- Relative Permeability
  - Lab measured irreducible water saturation
  - Residual gas trapping modeled through Land and Larsen's Correlation
- Fluid Model
  - Initial 100% water saturation
  - 50,000 ppm assumption from wellhead sample database
  - CO2 solubility is calculated at reservoir conditions
- Temperature:
  - 60F surface pressure and 0.0163 degree/ft
  - Entrada @ stratigraphic well location: ~ 194 F
- Pore pressure:
  - 0.427 psi/ft pore pressure gradient is assumed
  - Entrada @ stratigraphic well location: ~3361.71 psi
  - Entrada @ SJGS injection area: ~3017.76 psi
- Boundary Condition:
  - 200 times of volume multiplier is used at the edge of the model
  - Equivalent to 140 sq. miles

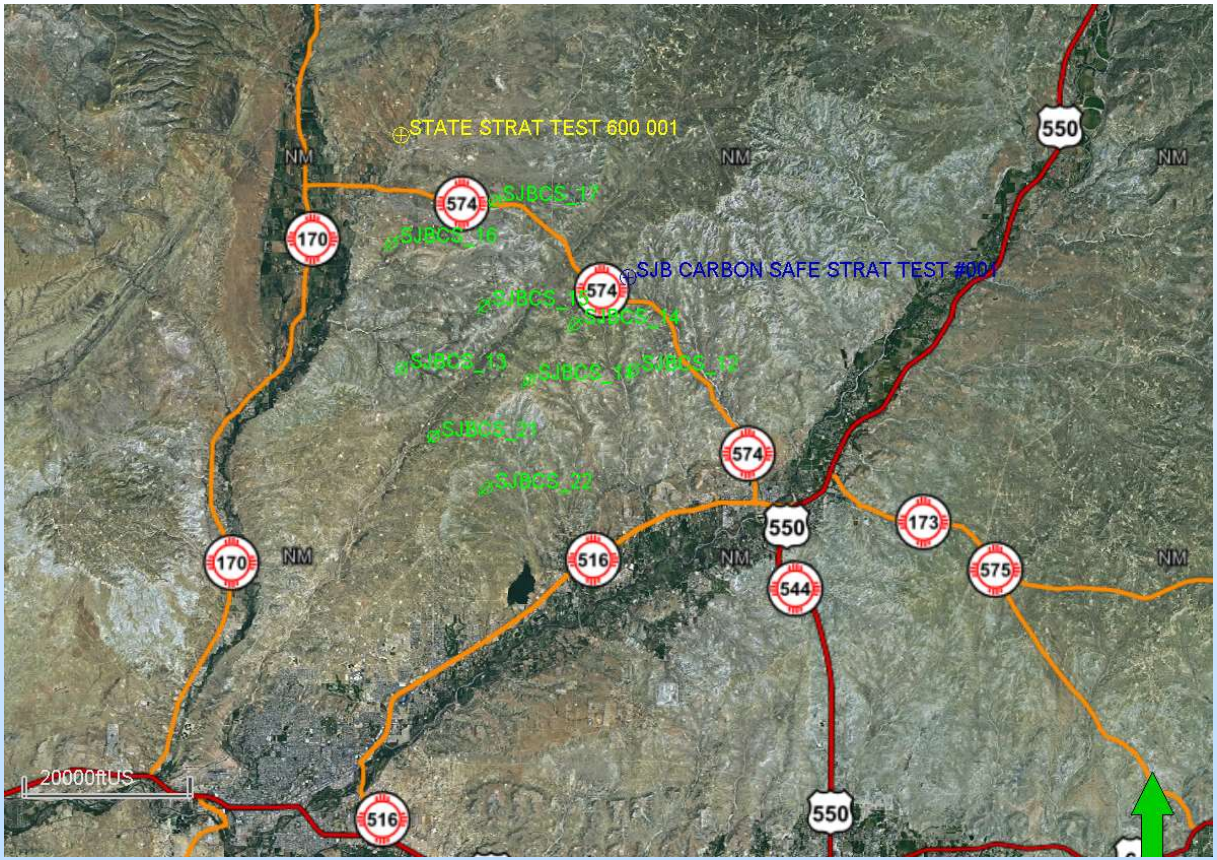


Saltwater Disposal Injection History Match

- A total of 35 Saltwater Disposal (SWD) wells penetrate the Entrada with historical water injection data within our study area
- One treated acid gas (TAG) injection well, Pathfinder AGI #001 injected TAG into Entrada
- The wellhead injection pressure limit and historical wellhead pressure are converted to bottom hole pressure through an in-house program for SWDs.
- History matching was performed to validate our preliminary porosity – permeability distributions and establish initial conditions prior to CO_2 injection

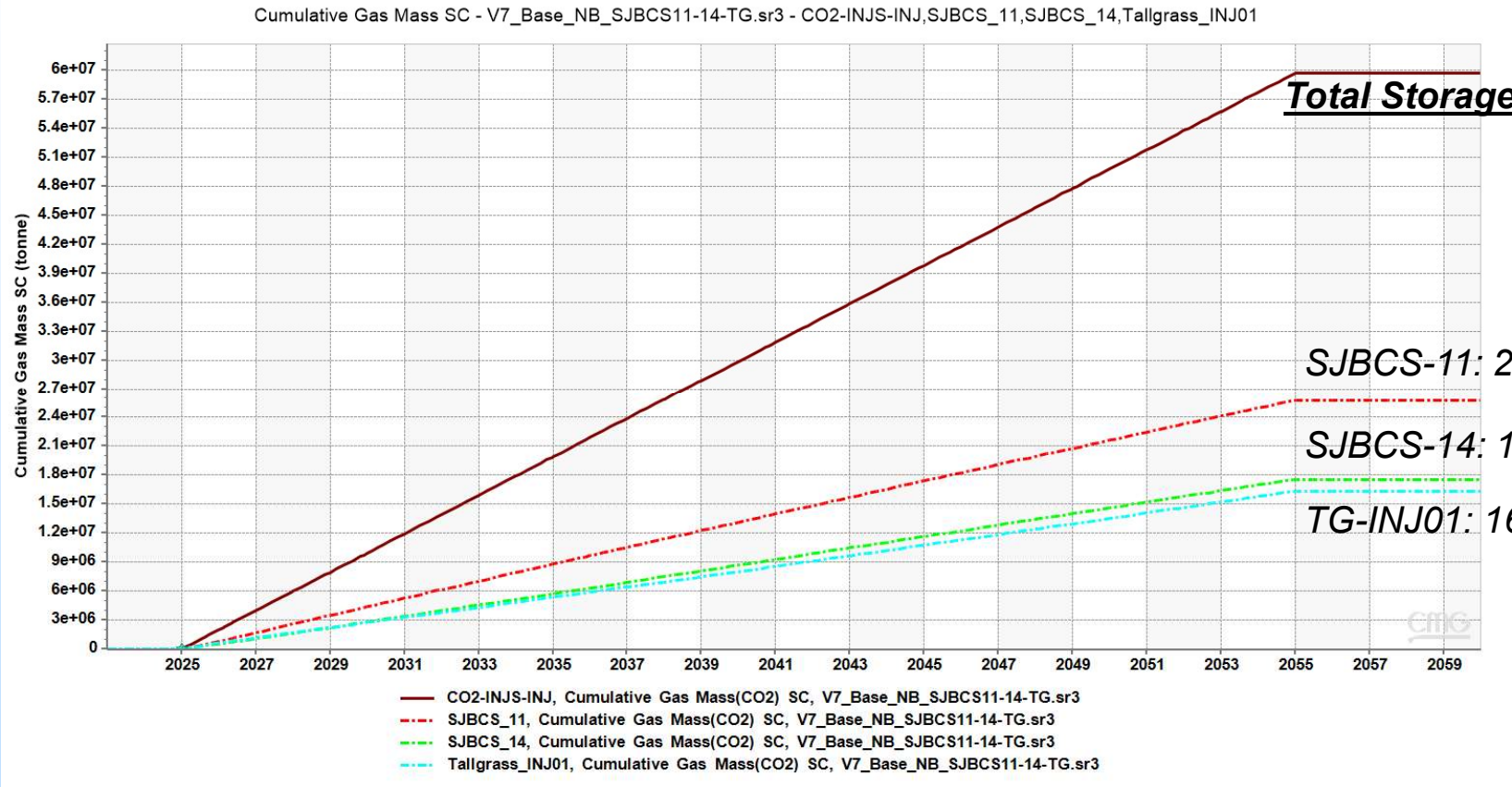


Well Injection Scenario



- *The BHP limits of each injector are set to 90% of the formation fracture gradient of 0.63 psi/ft*
- *The max rate cap of each Class VI injector is set to 1.5 MMt/year*
- *A group max rate cap of 2.0 MMt/year was imposed.*

Well Injection Profile



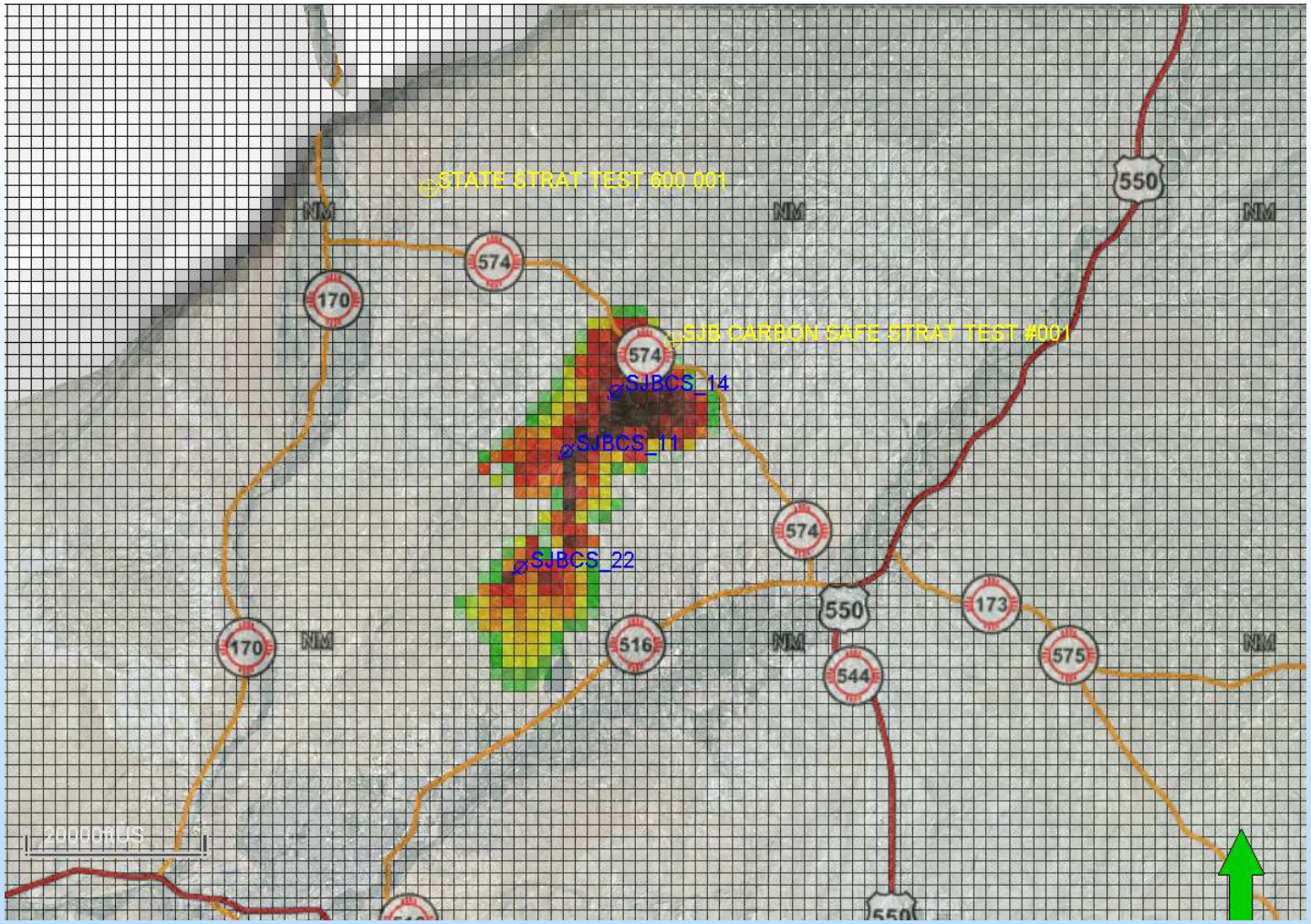
Total Storage: 60 MMt

SJBCS-11: 25.9 MMt

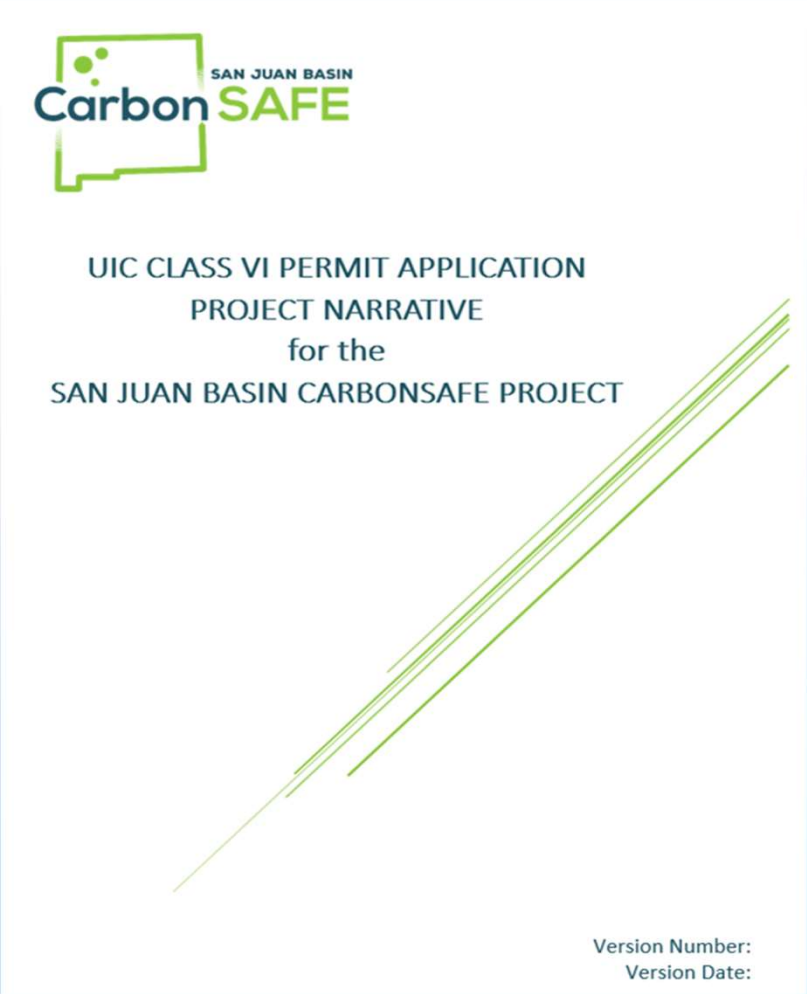
SJBCS-14: 17.6 MMt

TG-INJ01: 16.5 MMt

Plume Modeling



Accomplishments on the UIC Class VI Plans



- Site Characterization
- Area of Review (AoR) Delineation
- Corrective Action
- Injection Well Construction
- Testing and Monitoring during Operation
- Plugging, Post-Injection Site Care (PISC), and Site Closure
- Financial Responsibility

Summary- Next Steps

- Drilled stratigraphic well and completed to UIC Class VI standard.
- Successfully installed Silixa fiber optic behind casing
- Submitted first part of UIC Class VI Permit documentation to EPA.
- Commence NEPA documentation after DOE-NEPA determination
- Continue environmental justice analysis unto completion and ensure inputs are appropriately aligned with economic assessment inputs and analysis
- Complete core analysis and injectivity test
- Obtaining UIC Class VI permit for submitted permit

Acknowledgements

The project would like to thank DOE for the award opportunity through DE-FE0031890 and our partners.

Project Objectives

- Perform a comprehensive site characterization of a storage complex located in northwest New Mexico to accelerate the deployment of CCS technology in the San Juan Basin

- The data and analysis performed will be used to prepare, submit and obtain UIC Class VI permit from the Environmental Protection Agency (EPA).

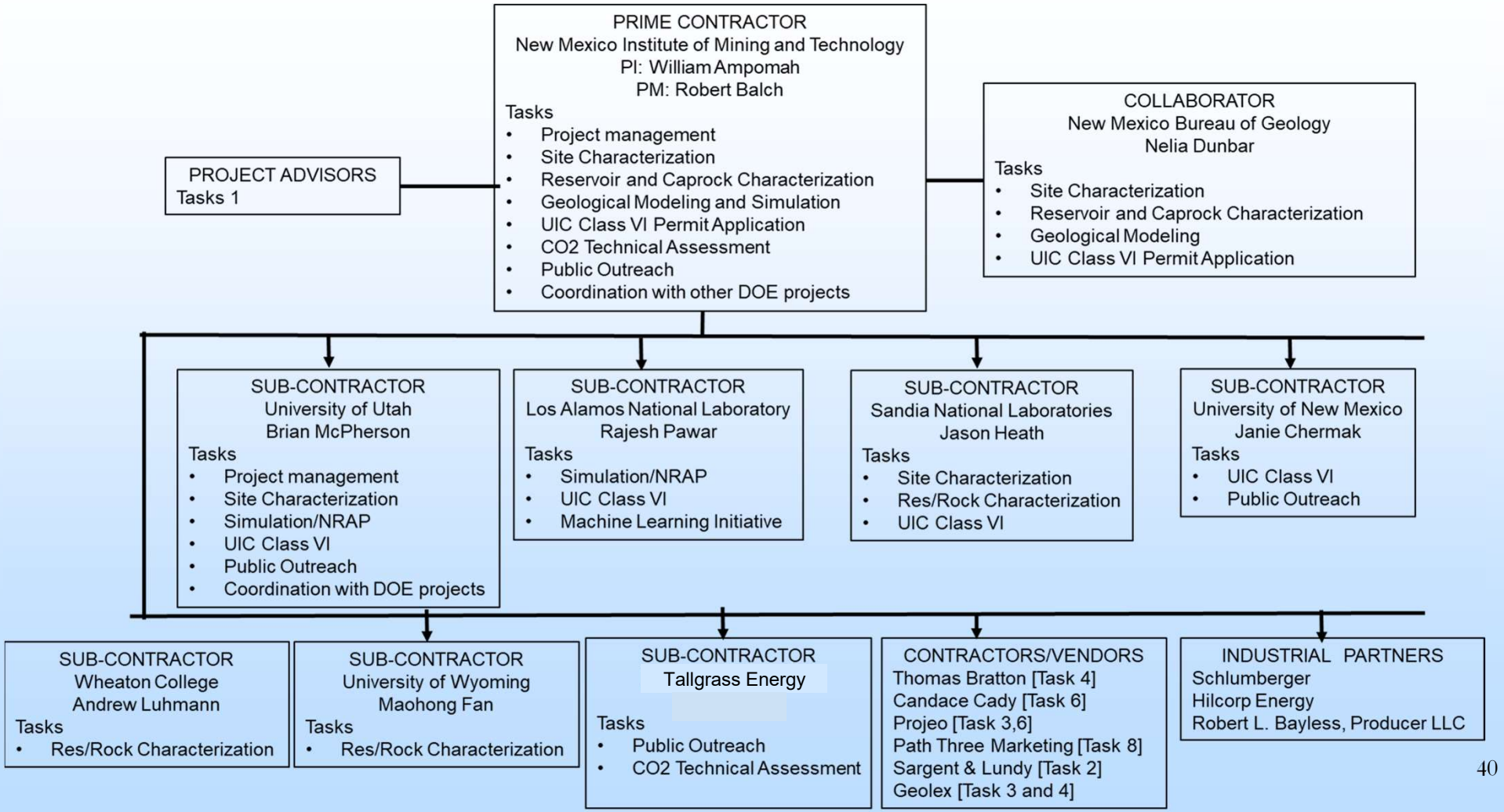
- Public awareness of CCS technology and its benefits

- Collaborate with regional partnerships and regional initiative projects to accelerate CCS technology deployment in the region

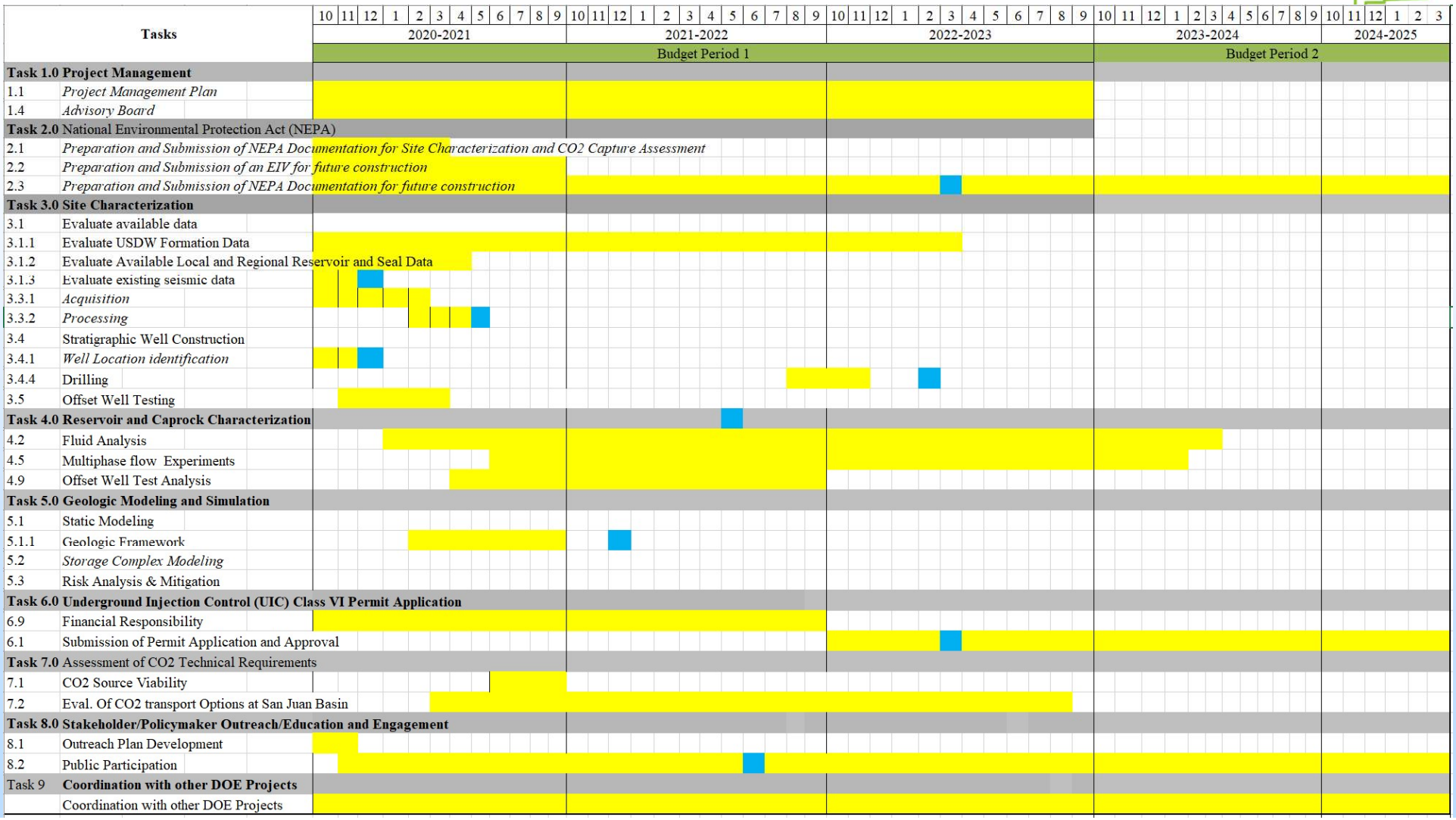
Appendix

– These slides will not be discussed during the presentation, but are mandatory.

Organization Chart



Gantt Chart


Tasks
10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3
2020-2021
2021-2022
2022-2023
2023-2024
2024-2025
Budget Period 1
Budget Period 2
Task 1.0 Project Management
1.1 Project Management Plan
1.4 Advisory Board
Task 2.0 National Environmental Protection Act (NEPA)
2.1 Preparation and Submission of NEPA Documentation for Site Characterization and CO2 Capture Assessment
2.2 Preparation and Submission of an EIV for future construction
2.3 Preparation and Submission of NEPA Documentation for future construction
Task 3.0 Site Characterization
3.1 Evaluate available data
3.1.1 Evaluate USDW Formation Data
3.1.2 Evaluate Available Local and Regional Reservoir and Seal Data
3.1.3 Evaluate existing seismic data
3.3.1 Acquisition
3.3.2 Processing
3.4 Stratigraphic Well Construction
3.4.1 Well Location identification
3.4.4 Drilling
3.5 Offset Well Testing
Task 4.0 Reservoir and Caprock Characterization
4.2 Fluid Analysis
4.5 Multiphase flow Experiments
4.9 Offset Well Test Analysis
Task 5.0 Geologic Modeling and Simulation
5.1 Static Modeling
5.1.1 Geologic Framework
5.2 Storage Complex Modeling
5.3 Risk Analysis & Mitigation
Task 6.0 Underground Injection Control (UIC) Class VI Permit Application
6.9 Financial Responsibility
6.1 Submission of Permit Application and Approval
Task 7.0 Assessment of CO2 Technical Requirements
7.1 CO2 Source Viability
7.2 Eval. Of CO2 transport Options at San Juan Basin
Task 8.0 Stakeholder/Policymaker Outreach/Education and Engagement
8.1 Outreach Plan Development
8.2 Public Participation
Task 9 Coordination with other DOE Projects
Coordination with other DOE Projects

(Project Success Criteria)

Objective/ Decision point	Success Criteria
NEPA assessment of selected project location(s) [Task 2]	The selected locations meet NEPA requirements. If not successful we move to a new location.
Obtain permits and drill a stratigraphic well at the selected suitable location. [Task 3]	Successful drilling, logging, and coring of well. If not successful we change location.
Purchasing of available seismic in the selected area [Task 3]	Purchase of existing seismic. If none available, we will acquire a new survey
Detailed site characterization to determine viability of selected storage complex [Task 3 and 4]	Site is found to have suitable geology for large scale CO_2 injection and storage
Modeling results from reservoir model and NRAP used to determine storage potential [Task 5]	Results show selected complex is able to securely store more than 50 million tons of CO_2 in the long term.
Complete application for UIC class VI application [Task 6]	Successful submission of UIC class VI application to EPA.
Secure approval on submitted UIC class VI application [Task 6]	Receiving approval to construct from EPA or the project cannot move forward

Project risks and mitigation strategies

Technical/Scope Risks:	Probability/Impact/Overall			Mitigation
Delays when drilling well	med	High	med	Appropriate management and well design should prevent this from happening. We will monitor drilling activities daily.
Unsuitable geology in identified area	low	High	low	Site location was chosen after a feasibility study by expert geologists with years of experience in the San Juan Basin. This study identified other potential sites in the area that could be used.
Lack of data	low	High	low	The project has identified several sources of commercial data. The New Mexico Bureau of Geology has offered access to databases and well logs for well information throughout the San Juan Basin.
ES&H Risks:				
Safety and environmental Risk	low	High	low	Experienced personnel with appropriate levels of expertise and safety will be handling field operations in the study.
External Factor Risks:				
Site access	low	High	low	We have a letter committing to site access from the operator and surface lessee (Hilcorp Energy) and additional letter from Robert L. Bayless, Producer LLC to use their site as well.
Regulatory Issues	med	High	med	New Mexico does not have a precedent for Class VI CO2 injection so issues of pore space and mineral rights may arise. However, the team has expertise from previous CarbonSAFE projects, regional partnerships and industry to overcome any potential barriers.