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

DE-FE0031890

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National Energy Technology Laboratory

Carbon Management Project Review Meeting

August 15 - 19, 2022

Presentation Outline

- Project overview
- Project Objectives
- Accomplishments
- Geology of San Juan Basin
- Technical Approach
- Synergy Opportunities
- Summary

Program Overview

- Funding Profile
- Overall Project Performance Dates

October 2020 – September 2023

	BP 1		BP 2		Total	
	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share
NMIMT	12,372,219	578,070	1,064,448	52,268	13,436,668	630,338
University of Utah	502,730	125,683	247,270	61,817	750,000	187,500
University of New Mexico	134,117	-	49,423	-	183,540	-
University of Wyoming	200,000	-	-	-	200,000	-
Wheaton College	30,322	-	15,847	-	46,170	-
Los Alamos National Laboratory	1,333,334	-	466,774	-	1,800,107	-
Sandia National Laboratories	502,539	-	233,256	-	735,794	-
Enchant Energy Corporation		675,988	-	337,994	-	1,013,982
Schlumberger		2,388,999	-	131,001	-	2,520,000
Total ($)	15,075,260	3,768,739	2,077,018	583,080	17,152,278	4,351,820
Total Cost Share %		20.00		21.92		20.24

Project Objectives/ Technical Approach

The overall objective of this proposed 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 at the San Juan Generating Station (SJGS).

- 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
- Retrofit the San Juan Generating Station with 6-7 MMT/yr CO_2 capture technology, locally store within San Juan Basin.
- Characterization target located ~17 miles from SJGS
- We anticipate to submit initial application in 2022
- Community and stakeholder outreach on CCS technology and its benefits
- Submitted EIV to NEPA

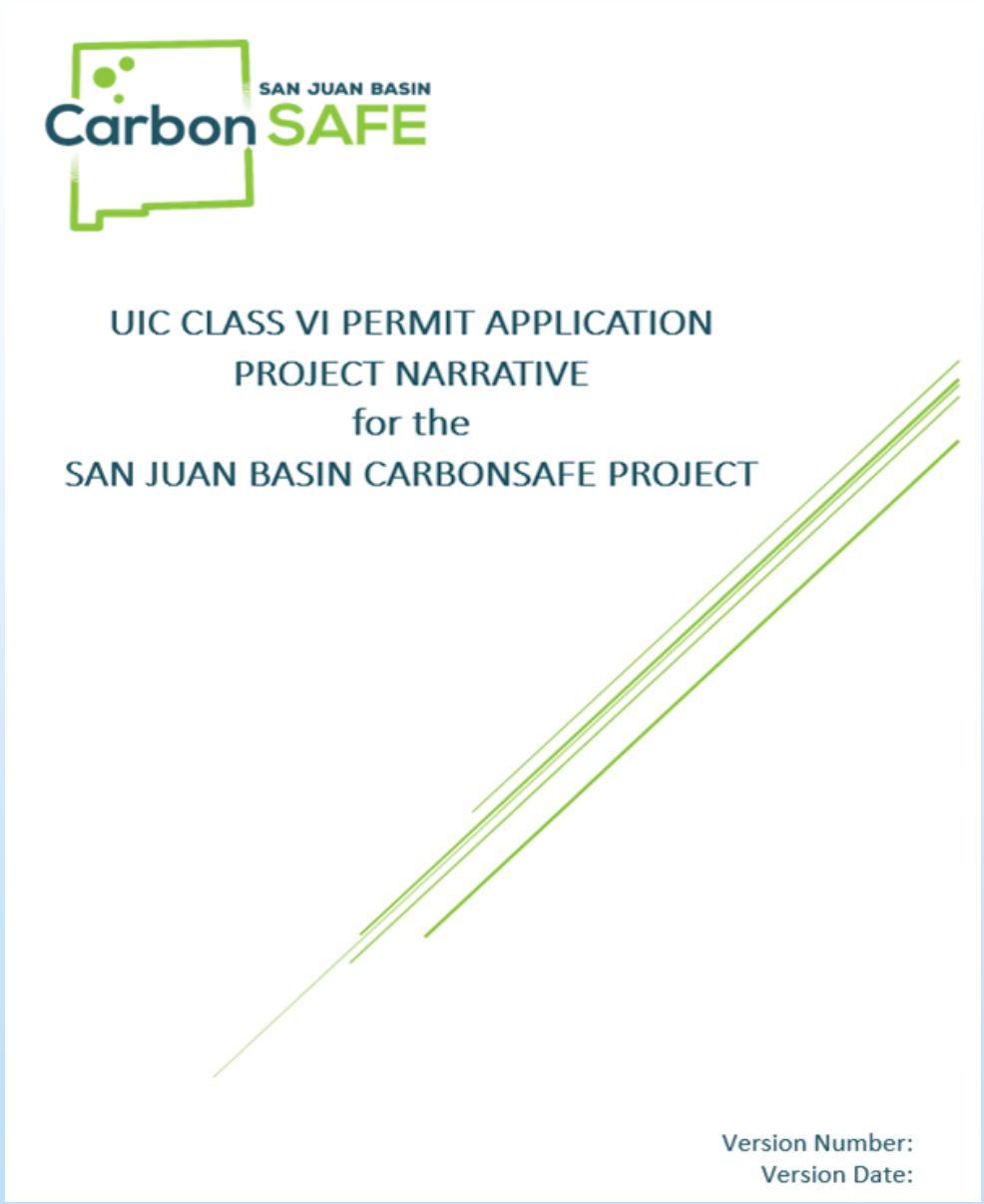
Characterization Plan

- Drill characterization well [Summer/ Fall 2022], perform injectivity tests on Private land
- Perform suites of laboratory experiments and numerical models
- Purchased 100 sq.miles 3D seismic, acquire 3D VSP,
- Install DAS/DTS/DSS Optical fiber behind casing

Technical Approach/Project Scope

Task/ Subtask	Milestone Title & Description	Planned Completion Date
1.0	Project Kick-off meeting	
2.3	NEPA documentation progress	3/31/2023
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	12/31/2022
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	8/31/2022
5.3	Complete initial Risk assessment for UIC permit application	8/31/2022
6	Complete documentation to submit UIC class VI application	9/30/2022
6.10	Progress report on submitted UIC class VI application	3/30/2023
6.10	Progress and/or receiving approval for UIC class VI application	9/30/2023

UIC Class VI Permit Application Plans Update



- 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

Accomplishments on the UIC Application - Plans

- **Subtask 6.2: Site Characterization (Permit's Project Narrative)**

- Status: Complete with few map edits from final AoR

- **Subtask 6.2: Area of Review and Corrective Action Plan**

- Status: Plan in progress now that final AoR delineation is complete.

- **Subtask 6.3: Well Construction Plan**

- Status: Plan complete

- **Subtask 6.4: Proposed Well Operation Plan**

- Status: Plan complete

- **Subtask 6.5: Proposed Testing and Monitoring Plan**

- Status: Plan in progress now that final AoR delineation is complete.

- **Subtask 6.6: Proposed Injection Well Plugging Plan**

- Status: Plan complete

Accomplishments on the UIC Application- Plans

- **Subtask 6.7: Proposed Post-Injection Site Care and Site Closure Plan**

- Status: Plan in progress now that final AoR delineation is complete.

- **Subtask 6.8: Emergency and Remedial Response Plan**

- Status: Plan complete except for updates required due to change in AoR.

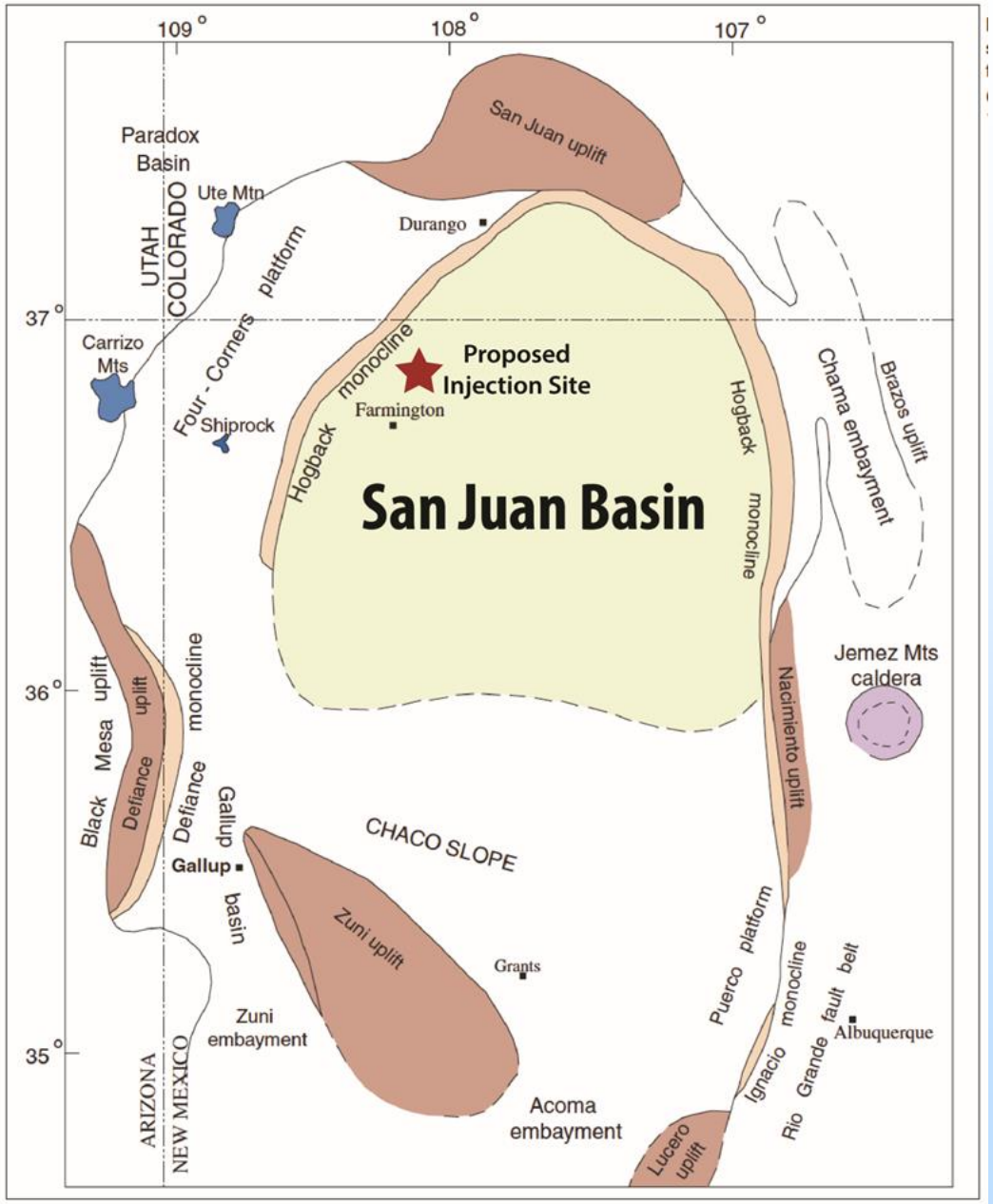
- **Subtask 6.9: Financial Responsibility**

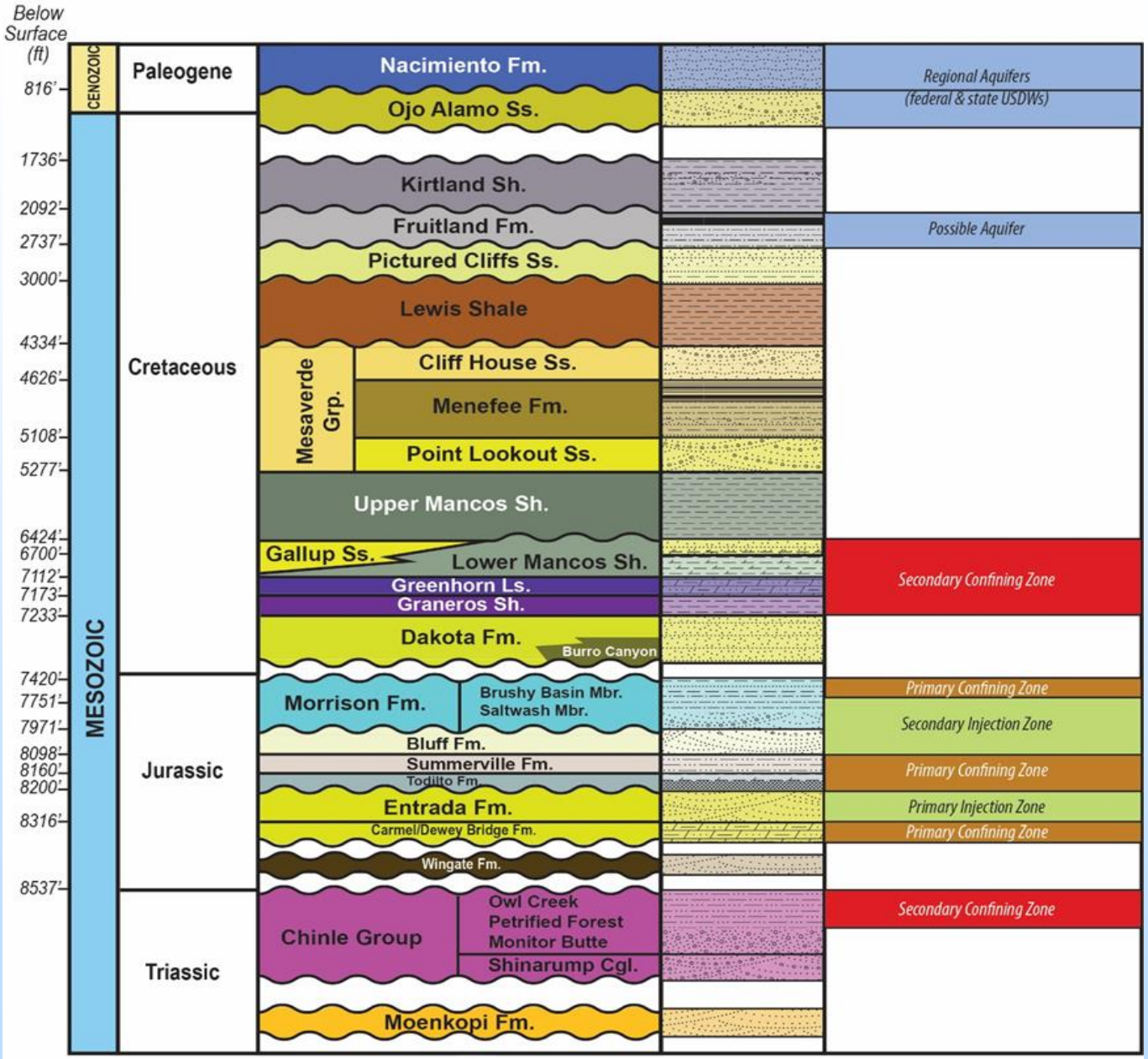
- Status: Work in progress

- **Pre-Operational Logging and Testing Plan –**

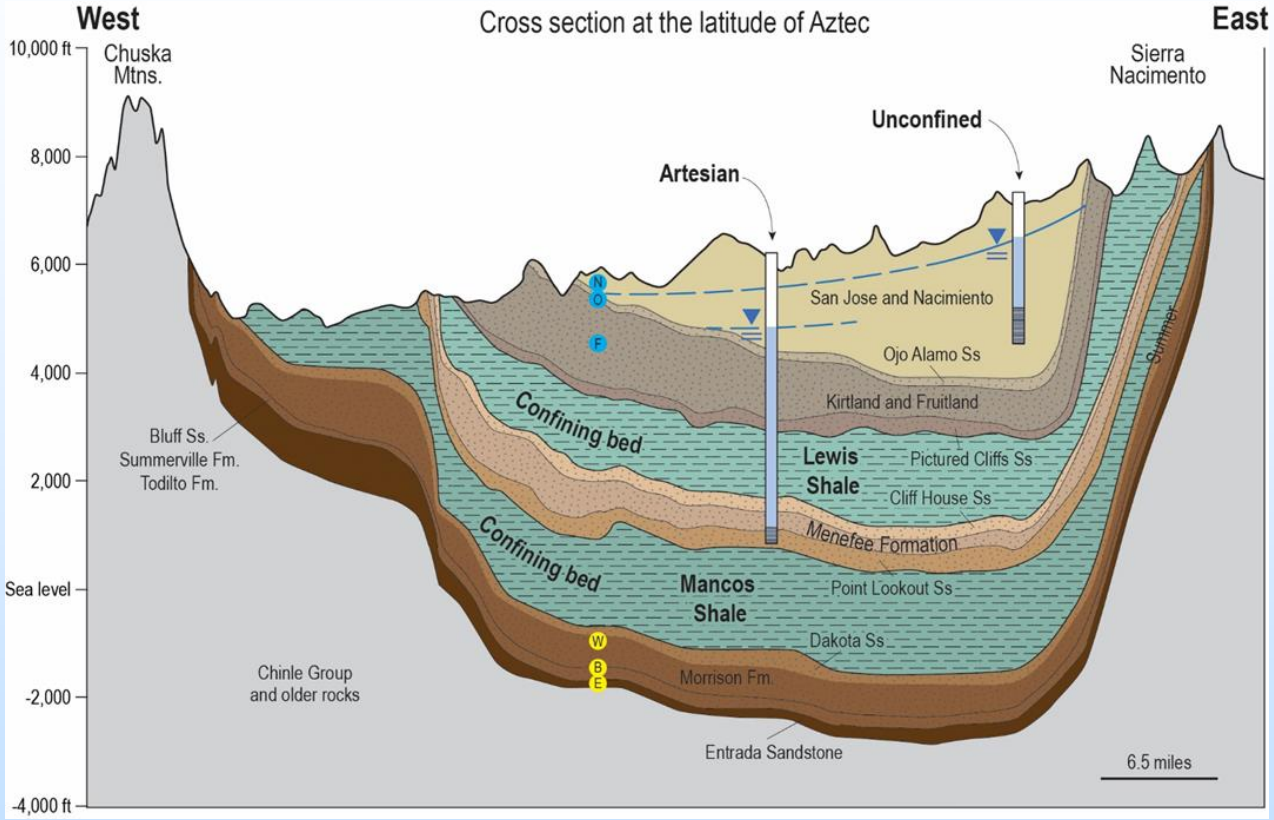
- Status: Plan complete.

San Juan Basin Geology

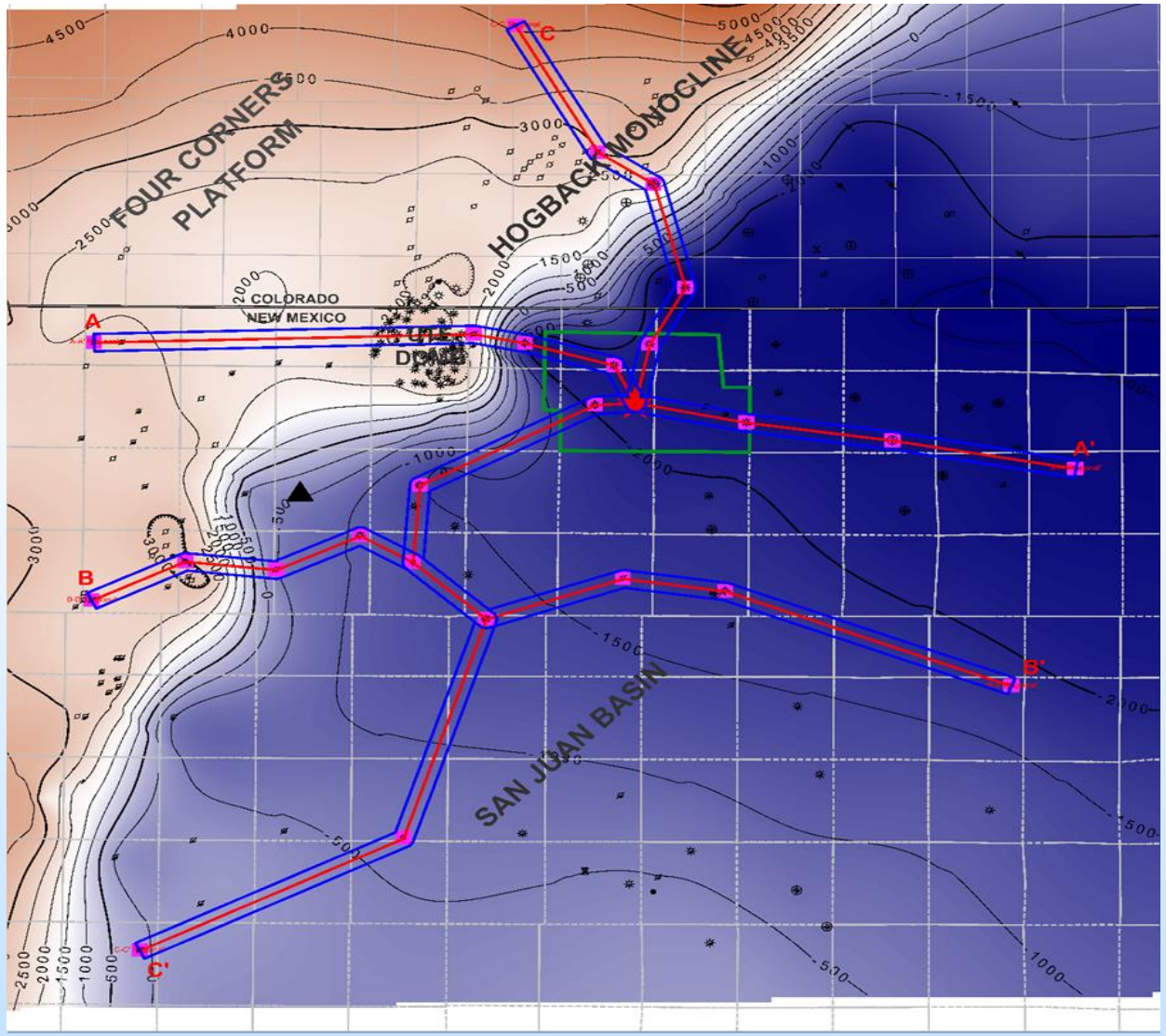


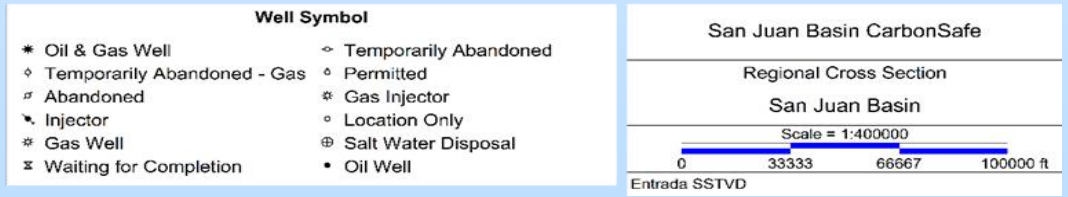


San Juan Basin Geology



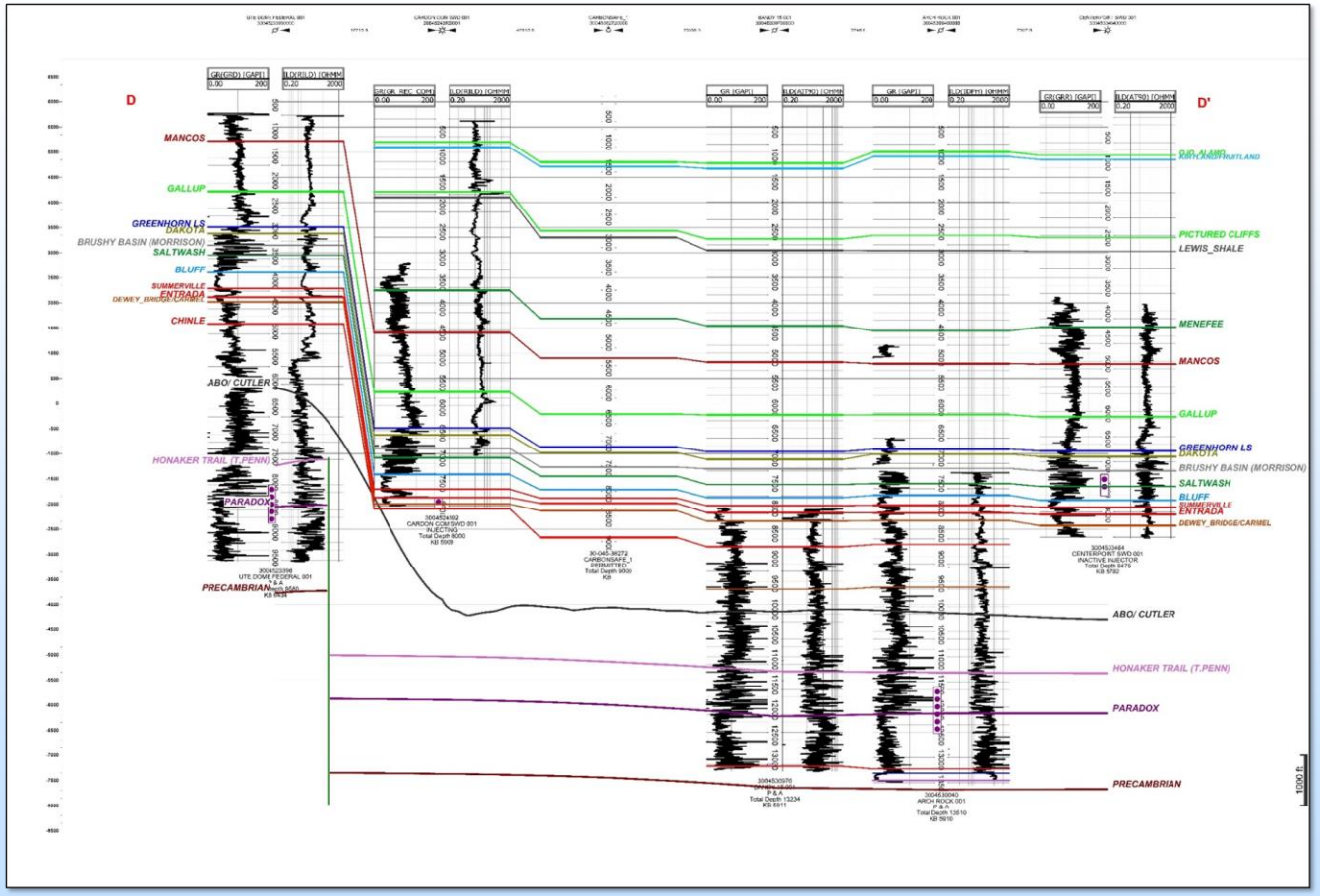
Schematic cross section of the San Juan Basin illustrating confining beds (blue units) and sandstone strata (brown, tan, and gray units).

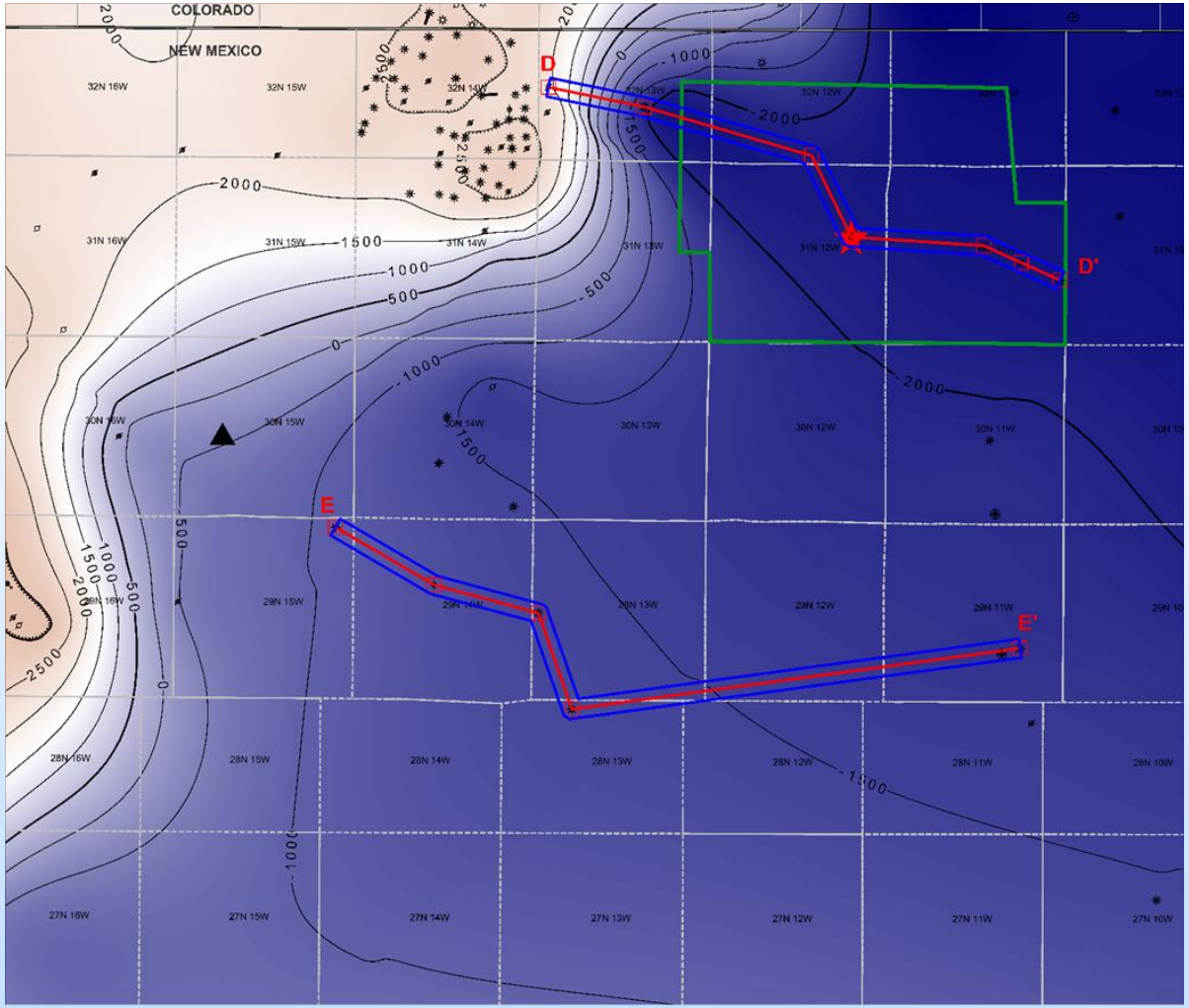




Structural contour map of the Entrada Formation

San Juan Basin Geology





Well Symbol

Gas Injector	Injector
Location Only	Plugged & Abandoned
Temporarily Abandoned - Oil	Temporarily Abandoned - Gas
Gas Well	Permitted
Salt Water Disposal	Waiting for Completion
Oil Well	Temporarily Abandoned
Unknown	

San Juan Basin CarbonSafe

Local Cross Sections

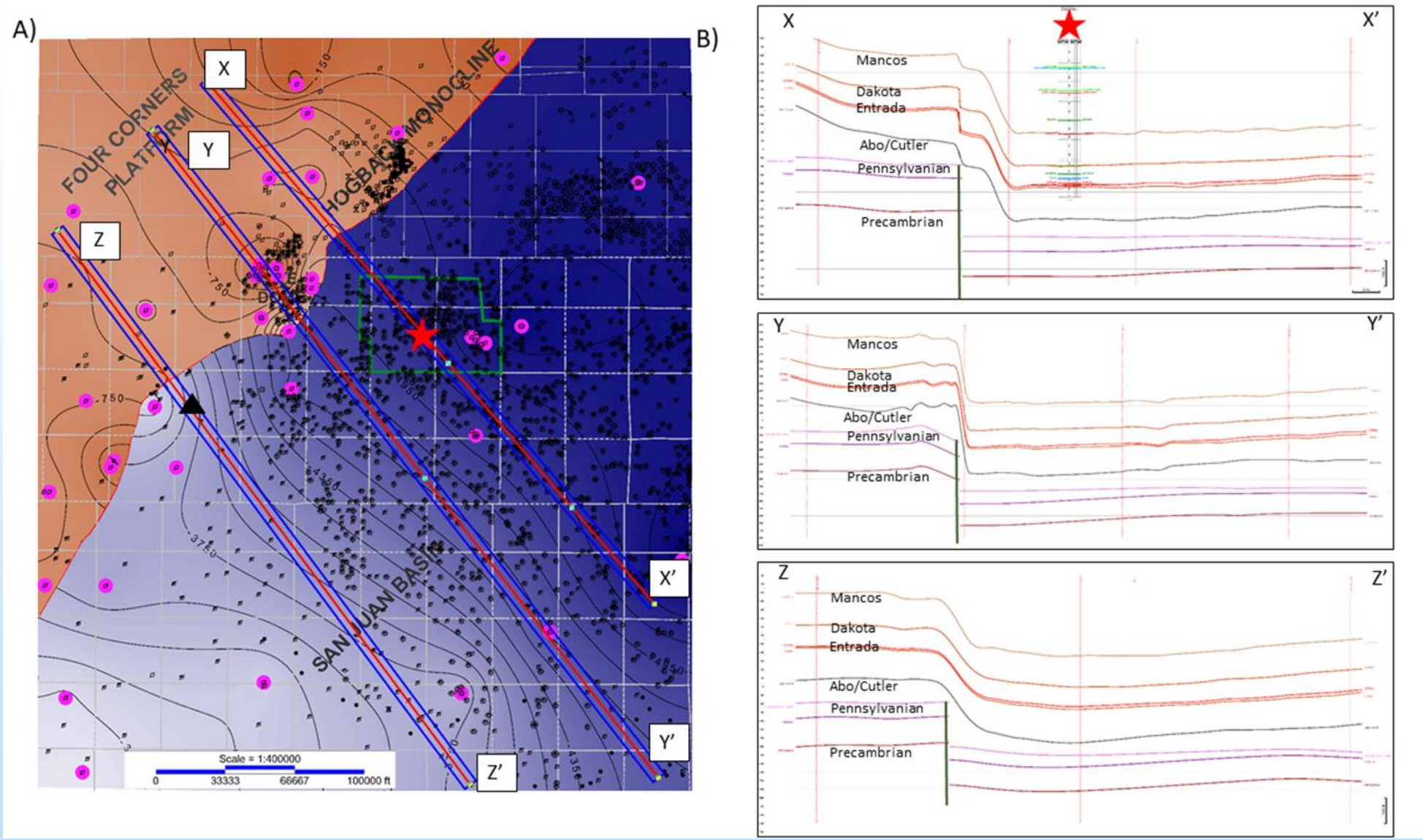
San Juan Basin

Scale = 1:200000

0 16667 33333 50000 ft

Grid: Entrada SSTVD

San Juan Basin Geology



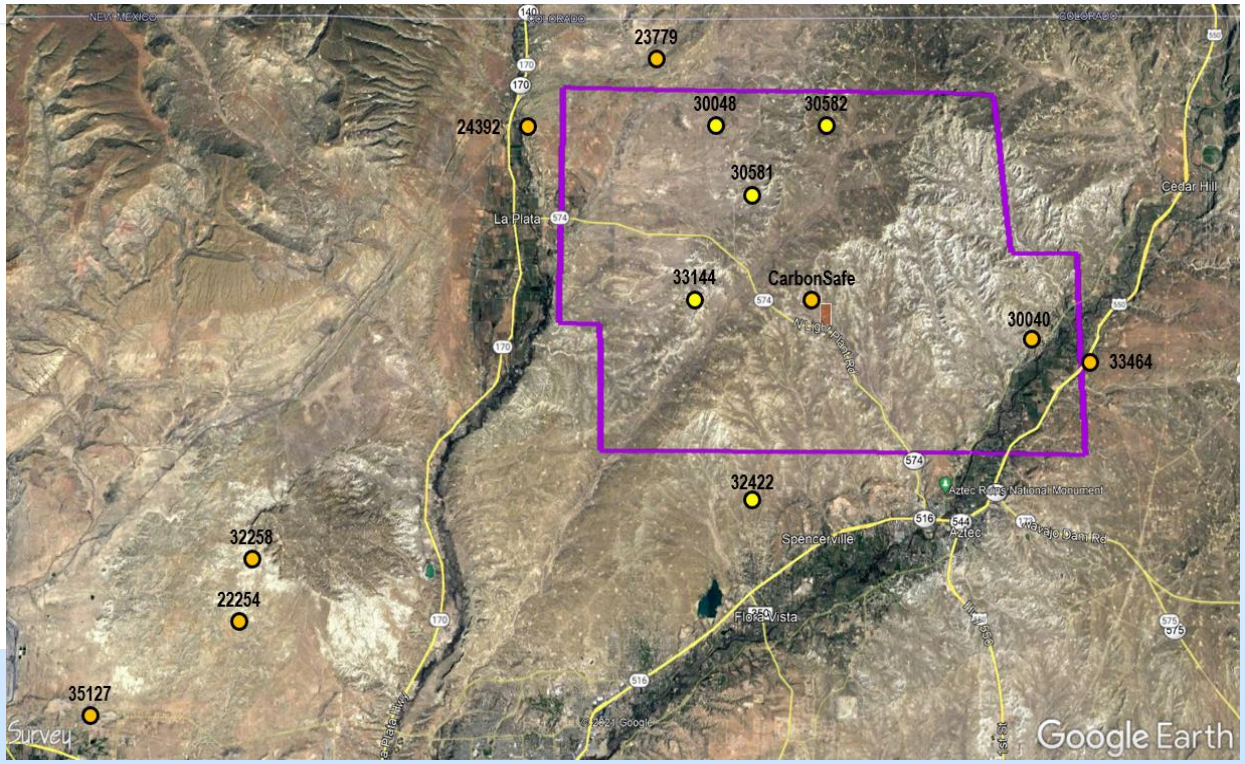
A) SSTVD structure map of the topo of the Honaker Trail Formation with locations of structural sections X, Y, and Z

B) Cross sections X, Y, Z (10x vertical exaggeration) with key formation grids visible

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**

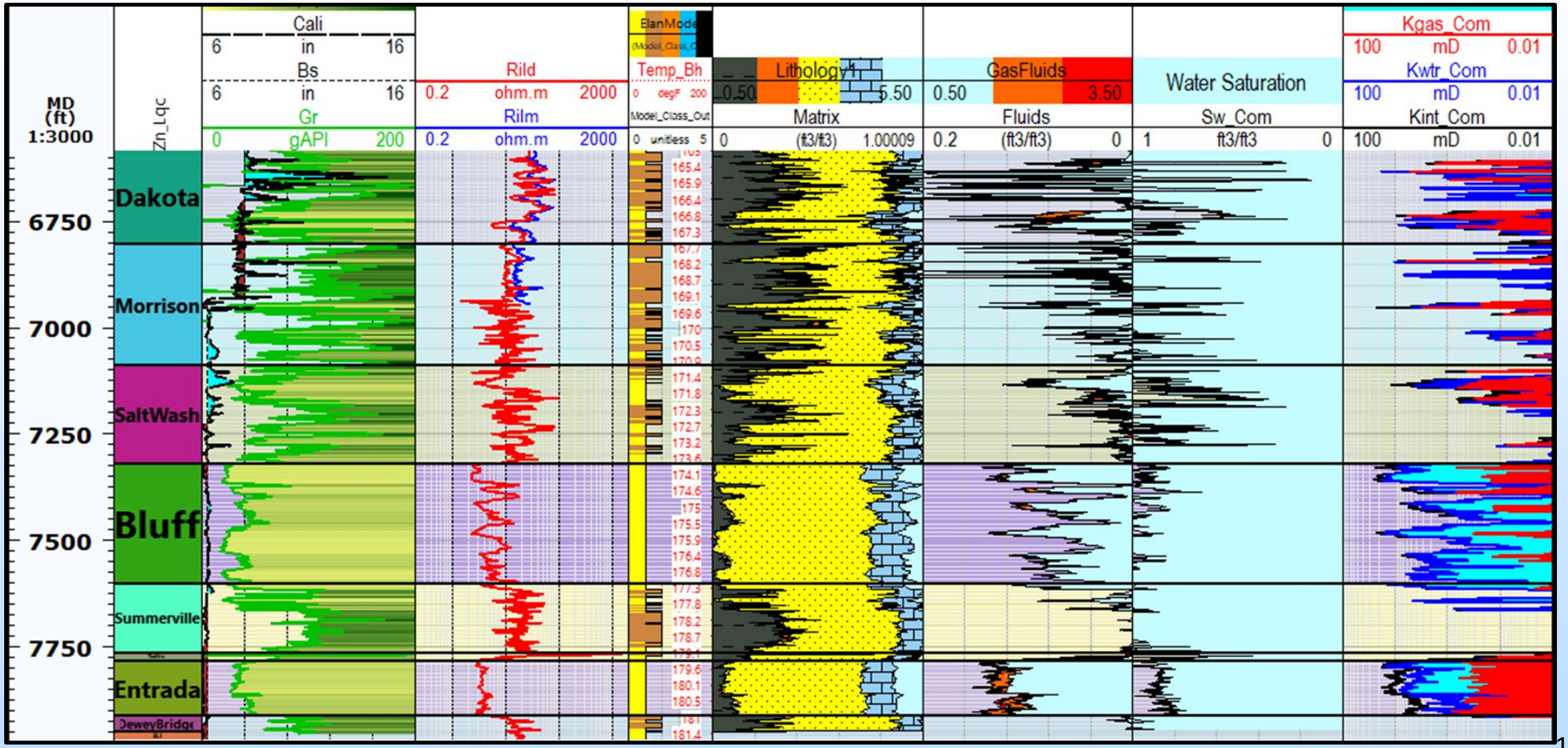
Brie and Bratton, 1994



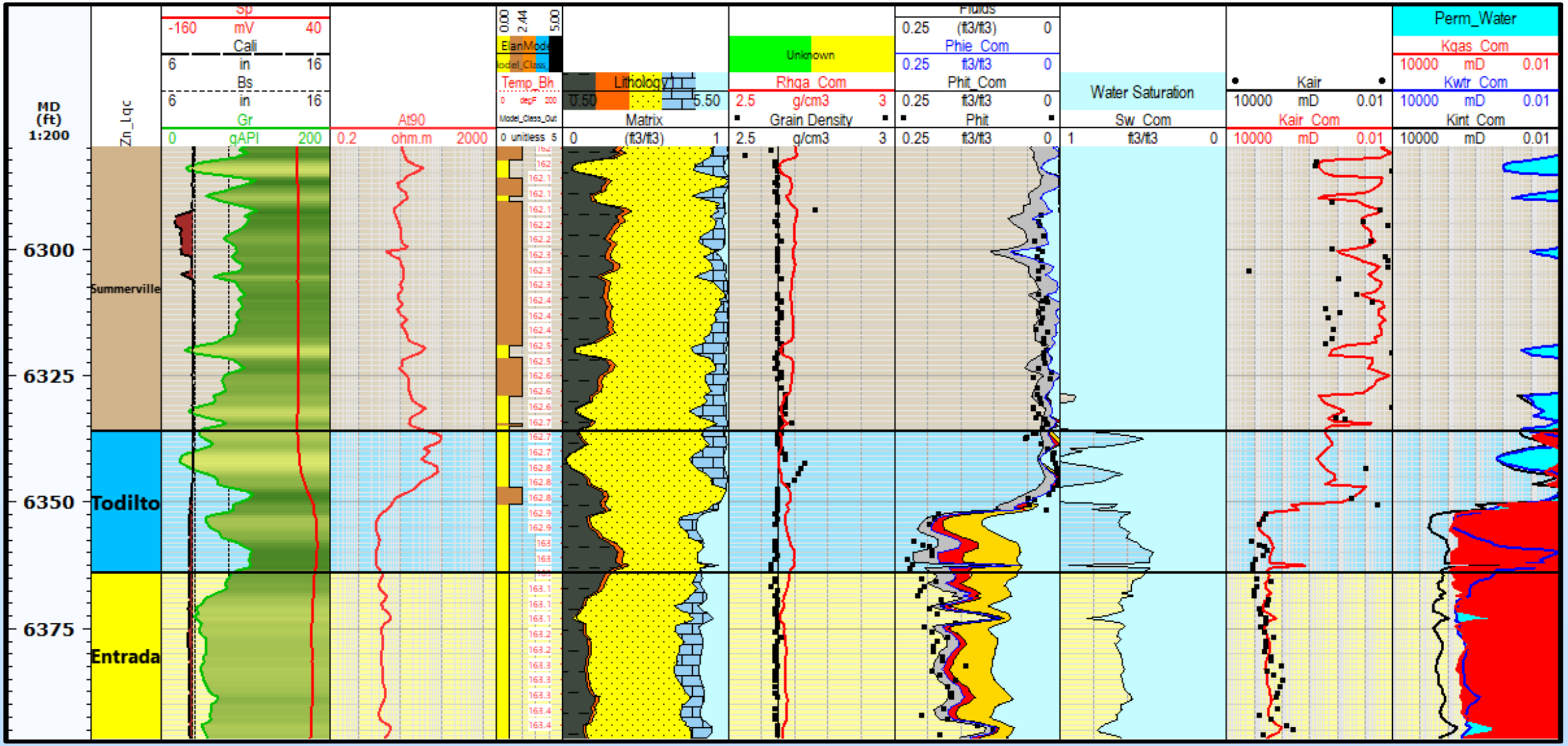
Wells used for Petrophysical analysis

Advanced petrophysical analysis (ELAN) has been completed on 12 wells and a geomechanical analysis has been completed on a single well.

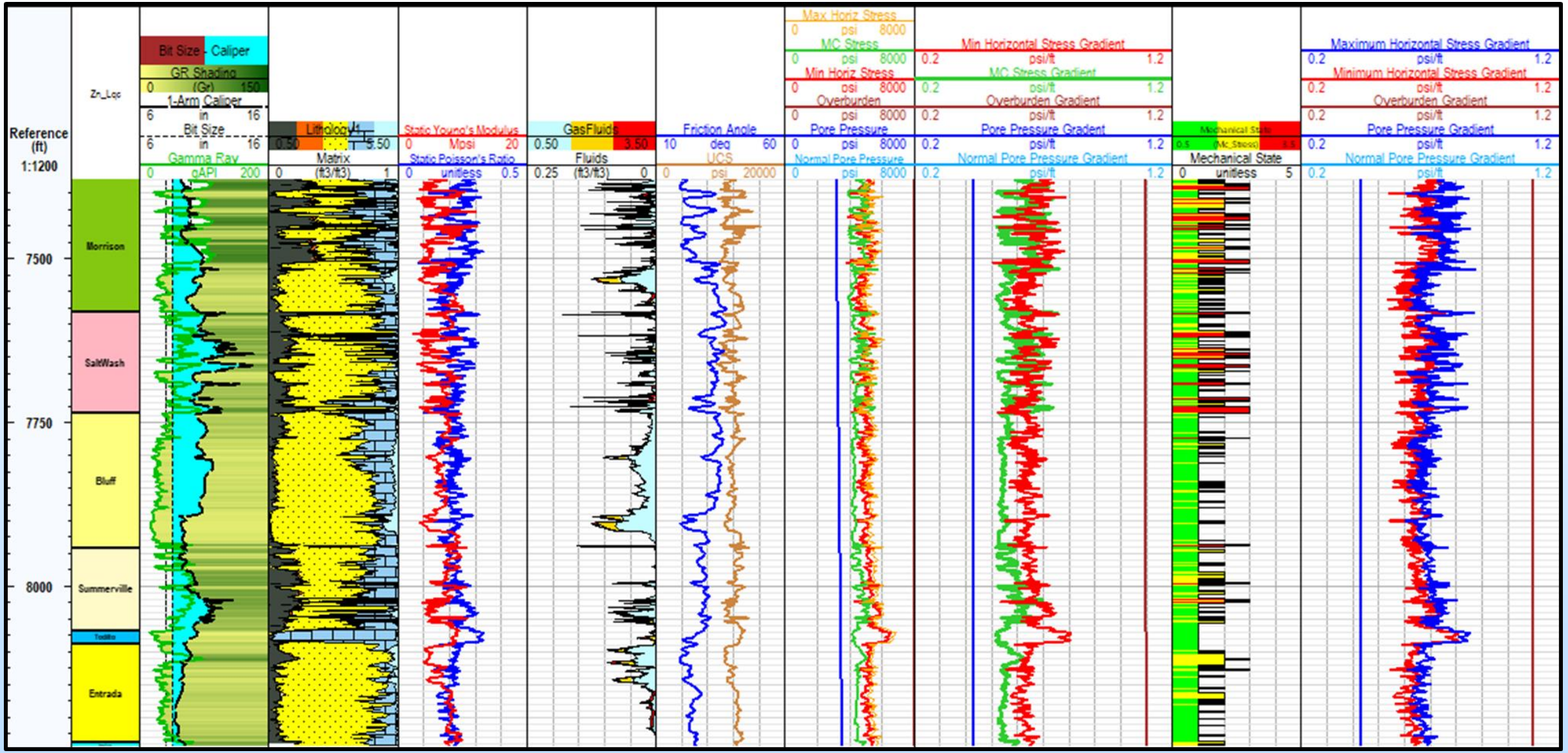
Petrophysics



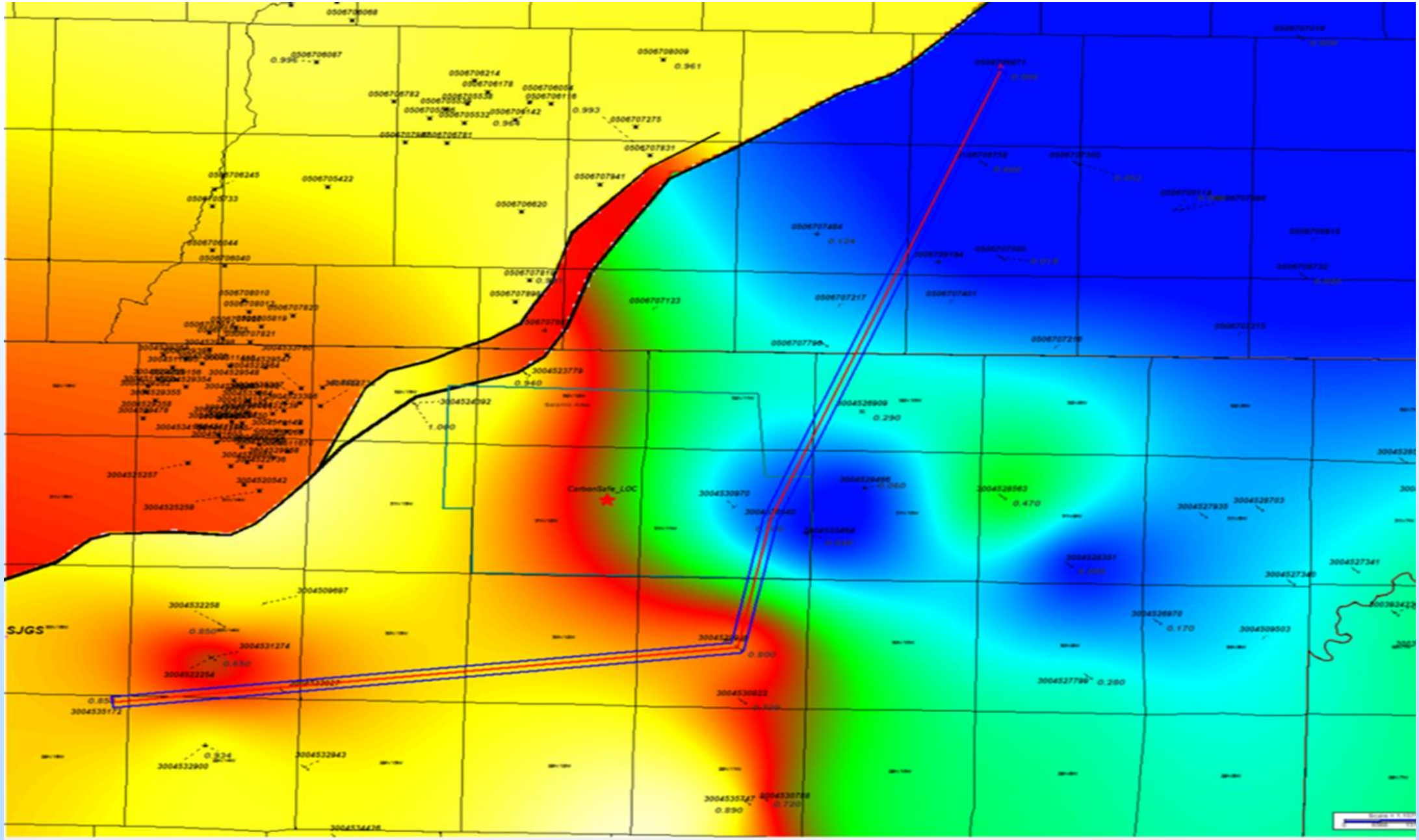
Elan Results compared with core- Pathfinder AGI#1 well



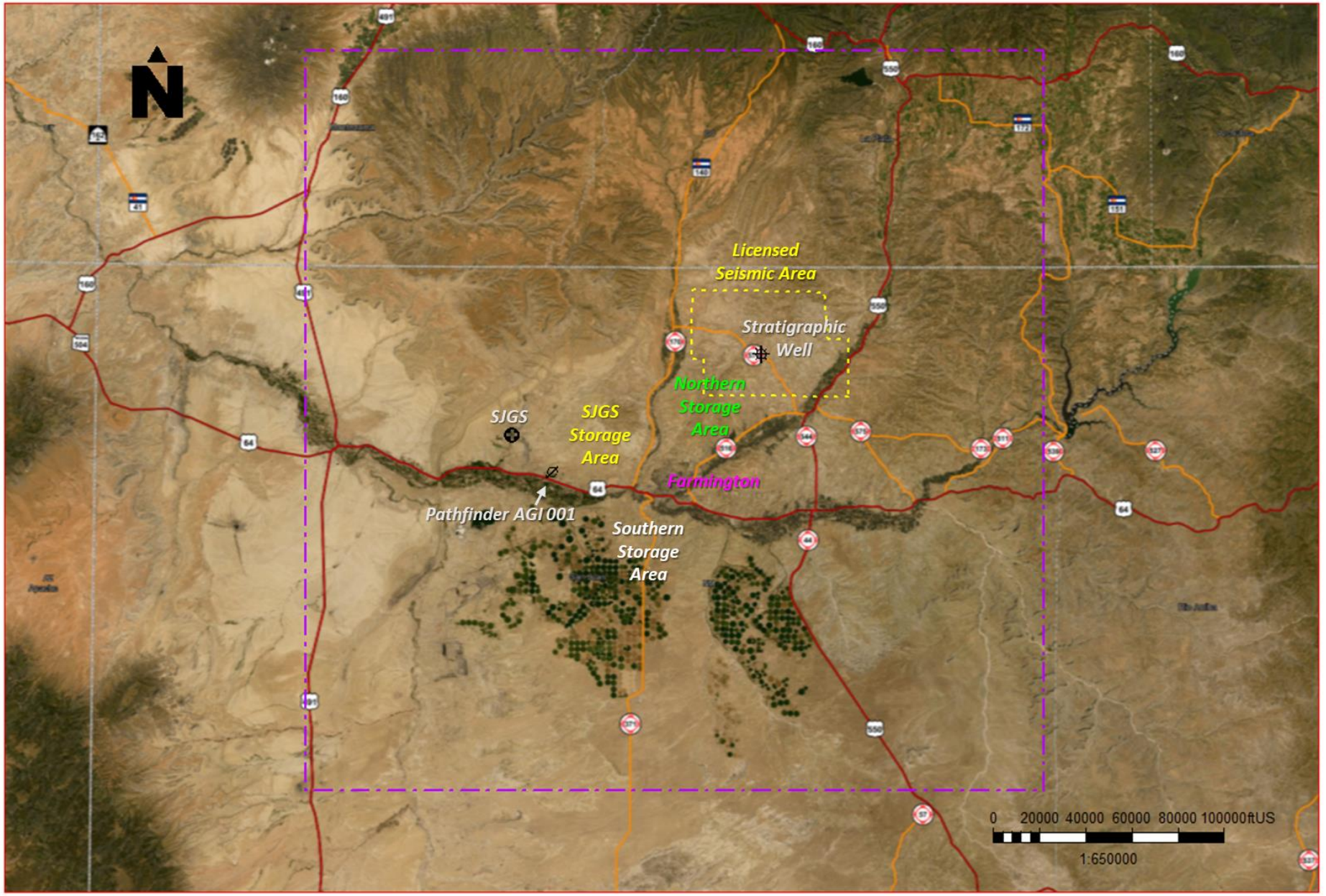
Geomechanics - 1D MEM



Site Selection



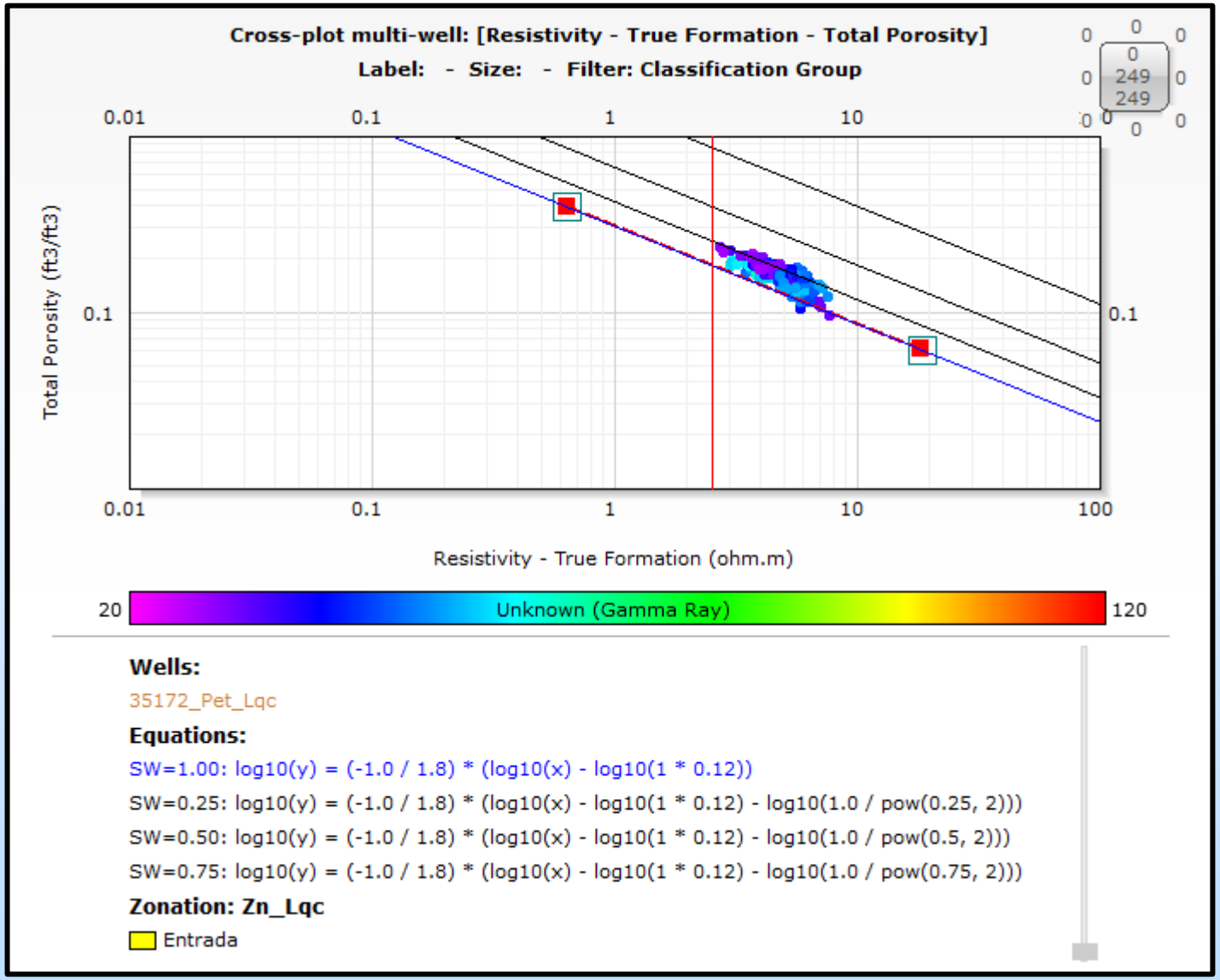
Site Selection



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*

Stratigraphic Well

Key Notes

- **Completion to Class VI standard**

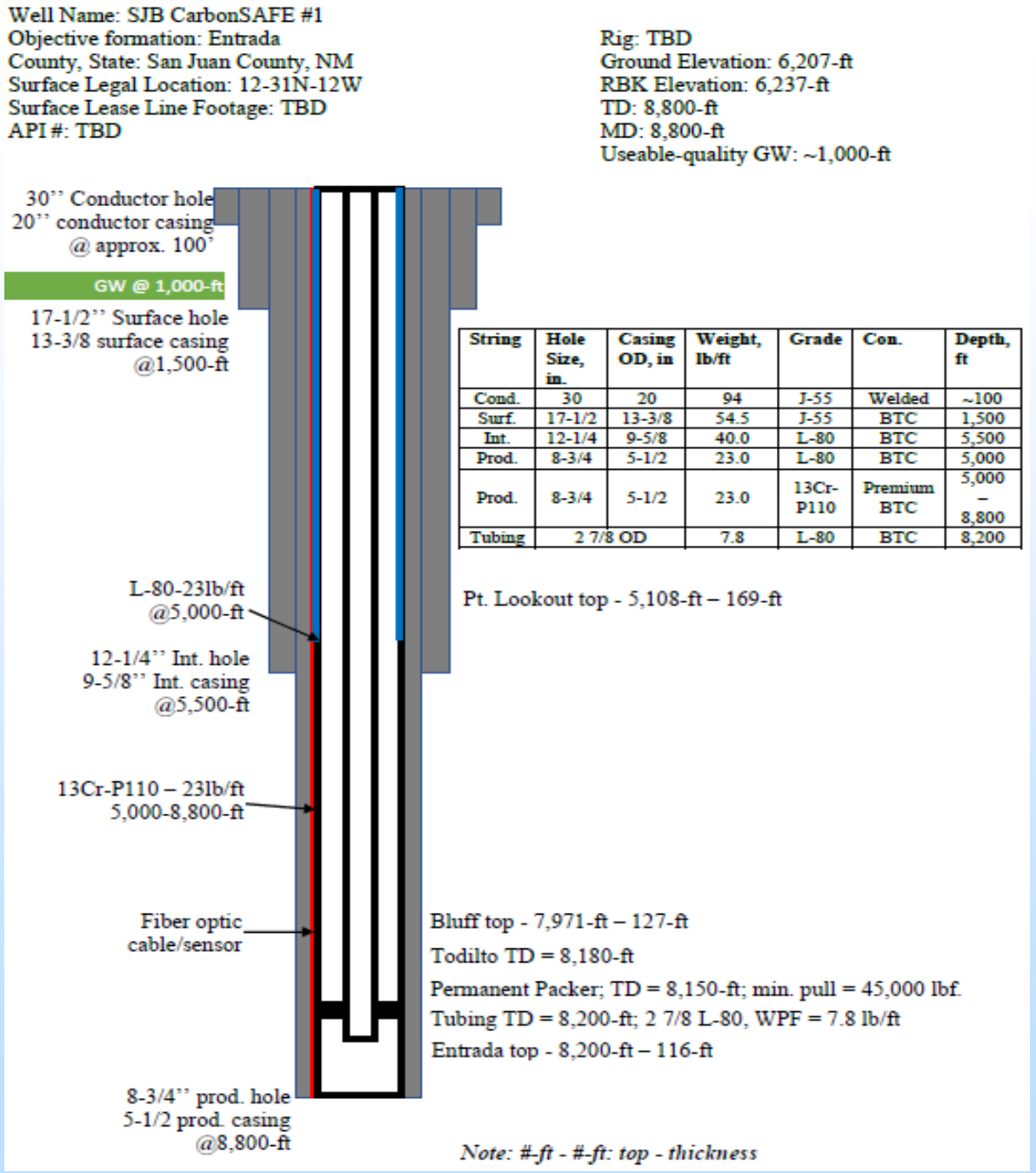
The strat well even though permitted as class II, we plan to complete it to a class VI standard for potential future use

- **Surface and Long-String Logging**

Openhole and cased-hole logging will be performed at the surface and long-string sections as regulator-required.

- **Fiber Optic Line**

Fiber optic line will be attached, along with downhole gauges, to the outside of the 5-1/2” casing to monitor the stress, pressure and temperature profiles along the wellbore.

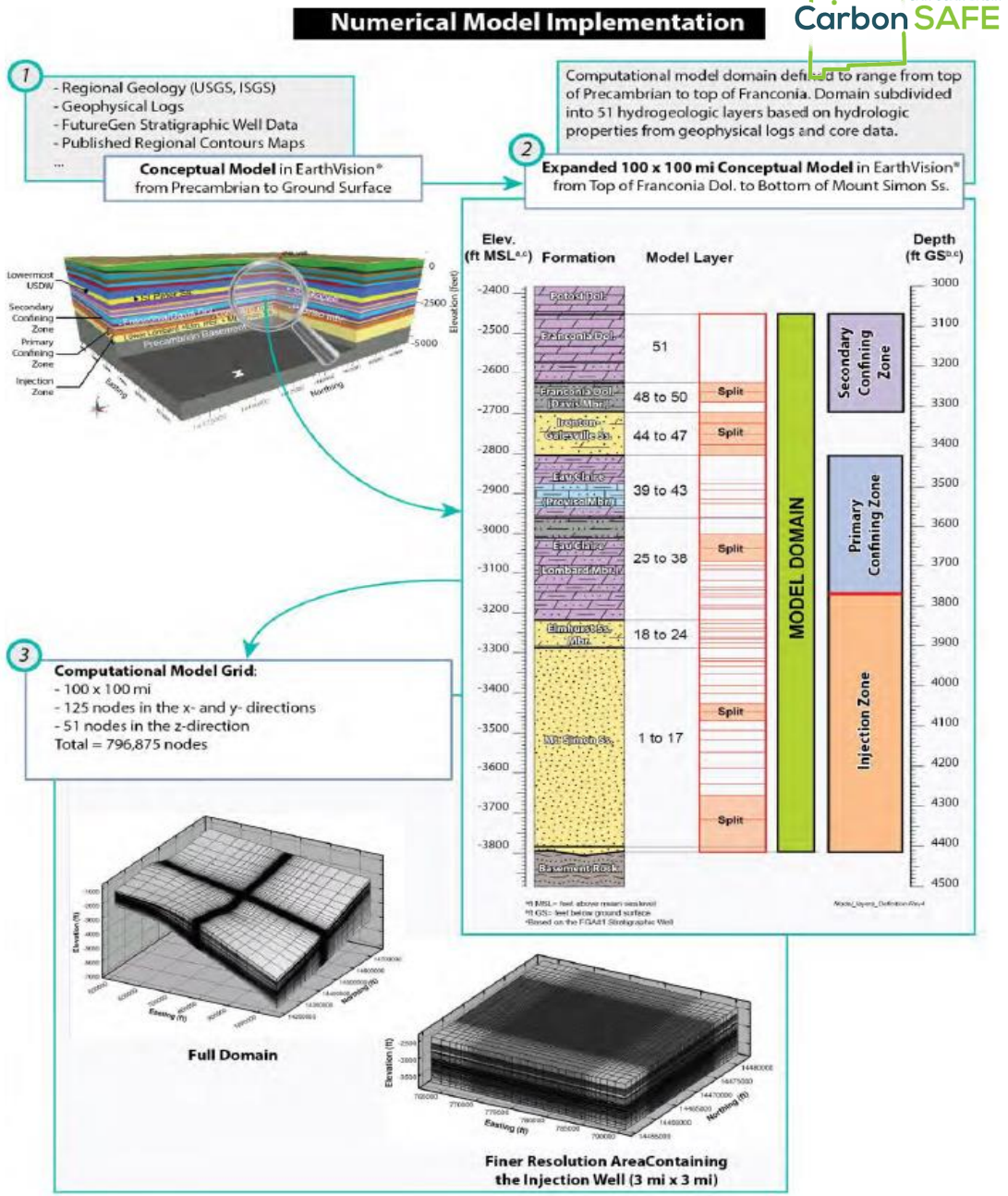


String	Hole Size, in.	Casing OD, in	Weight, lb/ft	Grade	Con.	Depth, ft
Cond.	30	20	94	J-55	Welded	~100
Surf.	17-1/2	13-3/8	54.5	J-55	BTC	1,500
Int.	12-1/4	9-5/8	40.0	L-80	BTC	5,500
Prod.	8-3/4	5-1/2	23.0	L-80	BTC	5,000
Prod.	8-3/4	5-1/2	23.0	13Cr-P110	Premium BTC	5,000 – 8,800
Tubing	2 7/8 OD		7.8	L-80	BTC	8,200

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."

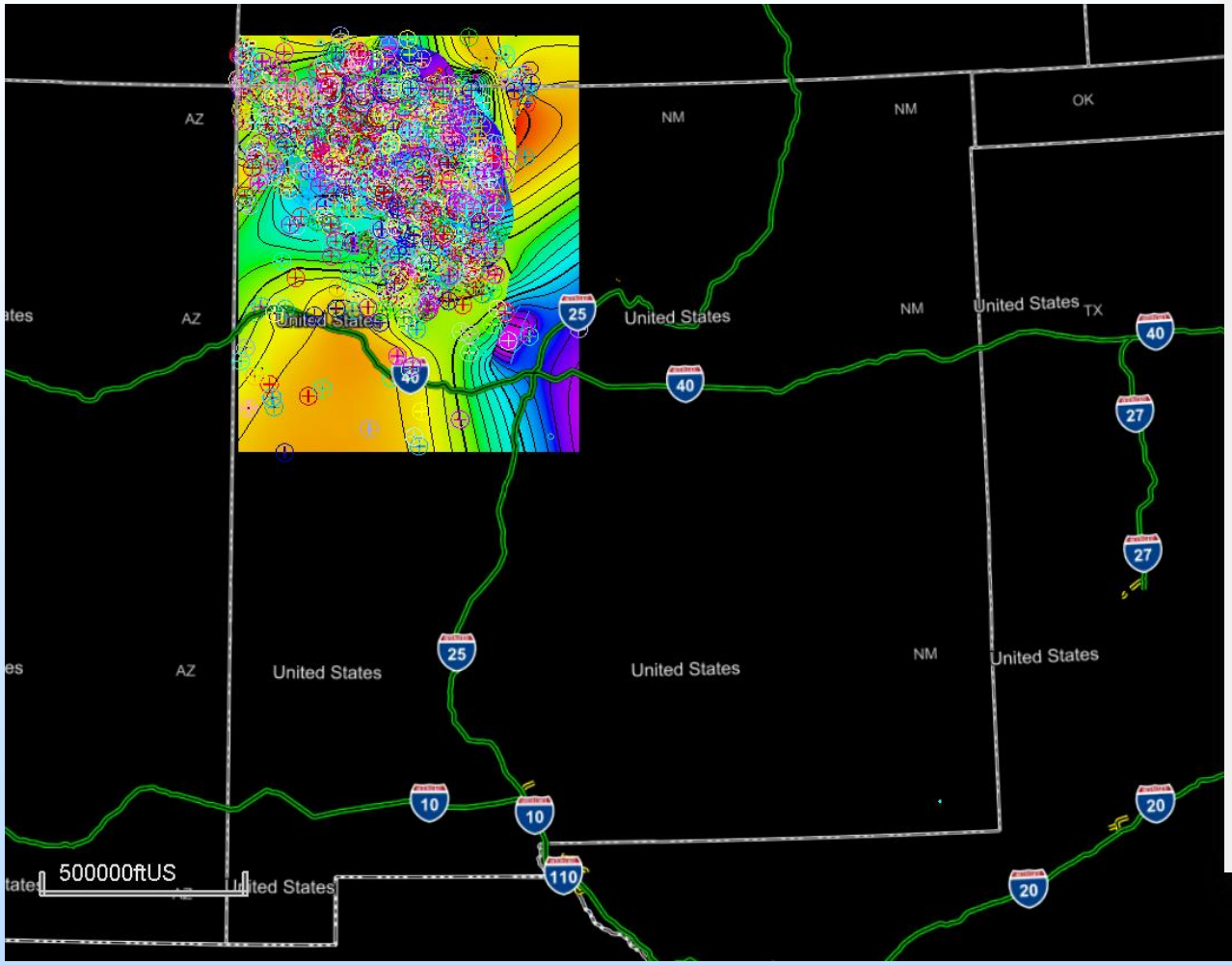
1. Model Development
   - Area encompasses proposed injection site
   - Determination of physical processes
   - Model design
     - Computational Code Determination
     - Model Spatial Extent, Discretization, and Boundary Conditions
     - Model Timeframe
     - Parameterization, etc …
2. Multiphase 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

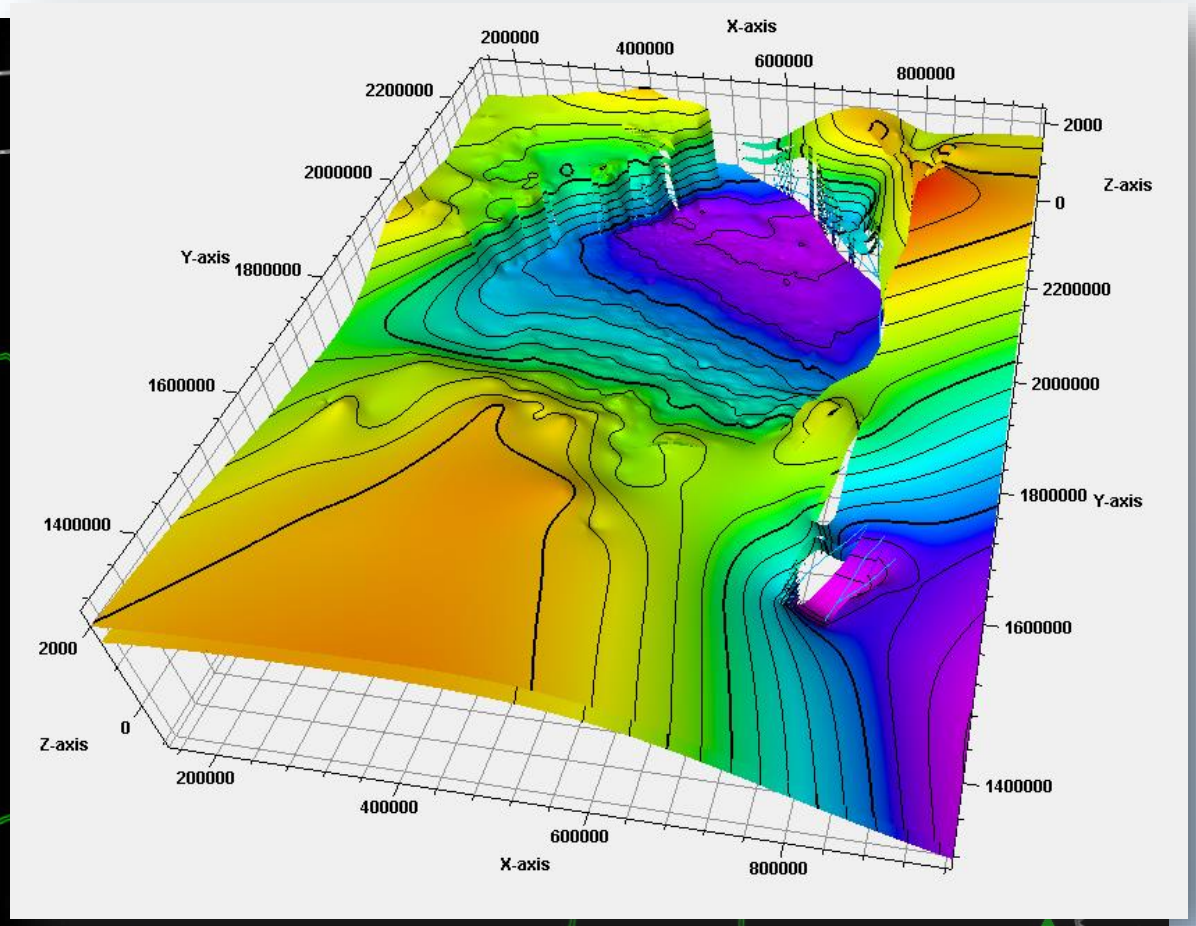


Implementation of the Numerical Model: From the Geological Conceptual Model to the Numerical Model

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 (km²)	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

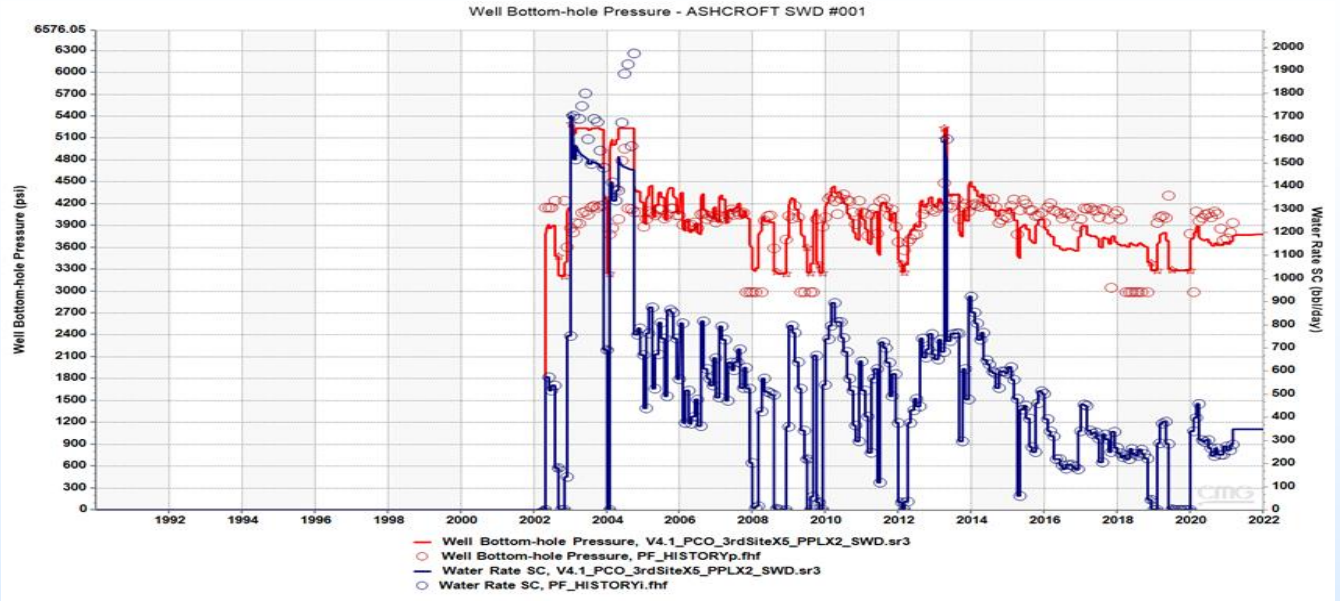
Input Parameters

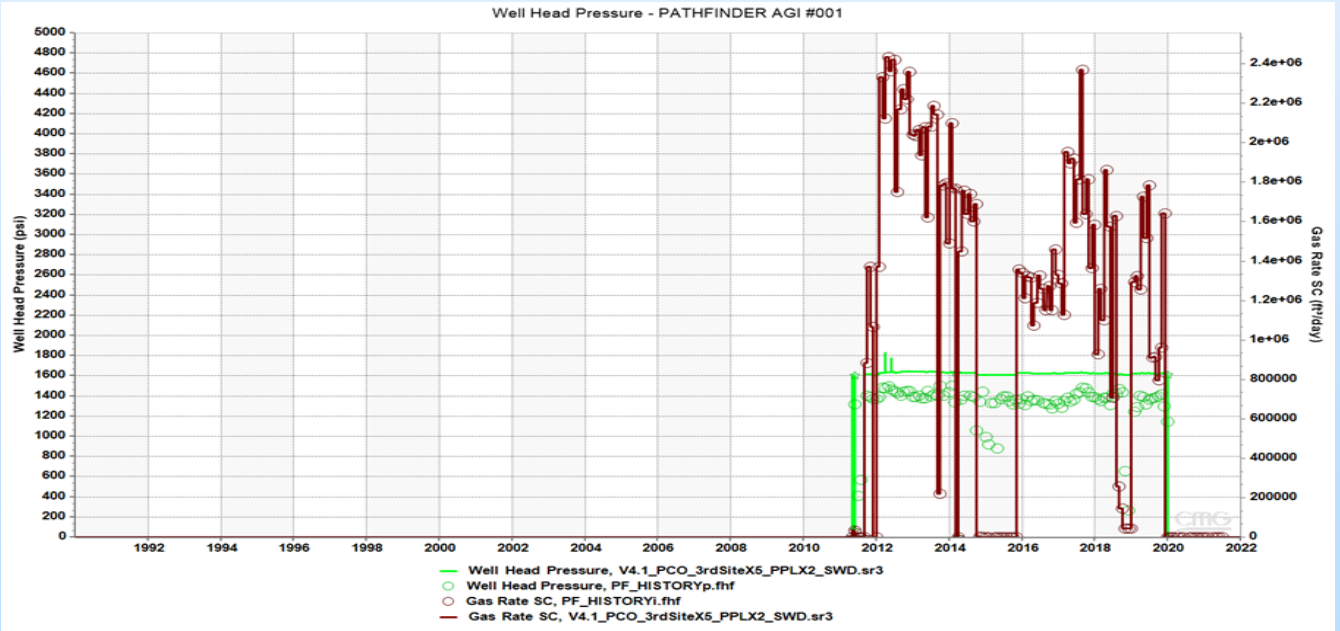
Storage Formation	P_{10}	P_{50}	P_{90}	Mean
Entrada	1,690	2,441	3,434	2,542
Bluff	1,688	2,492	3,547	2,592
Satlwash	2,708	3,969	5,547	4,125
Total	6,086	8,901	12,527	9,259

Storage Capacity Estimation millions of metric tons of CO_2

Salt Water Disposal Injection History Match

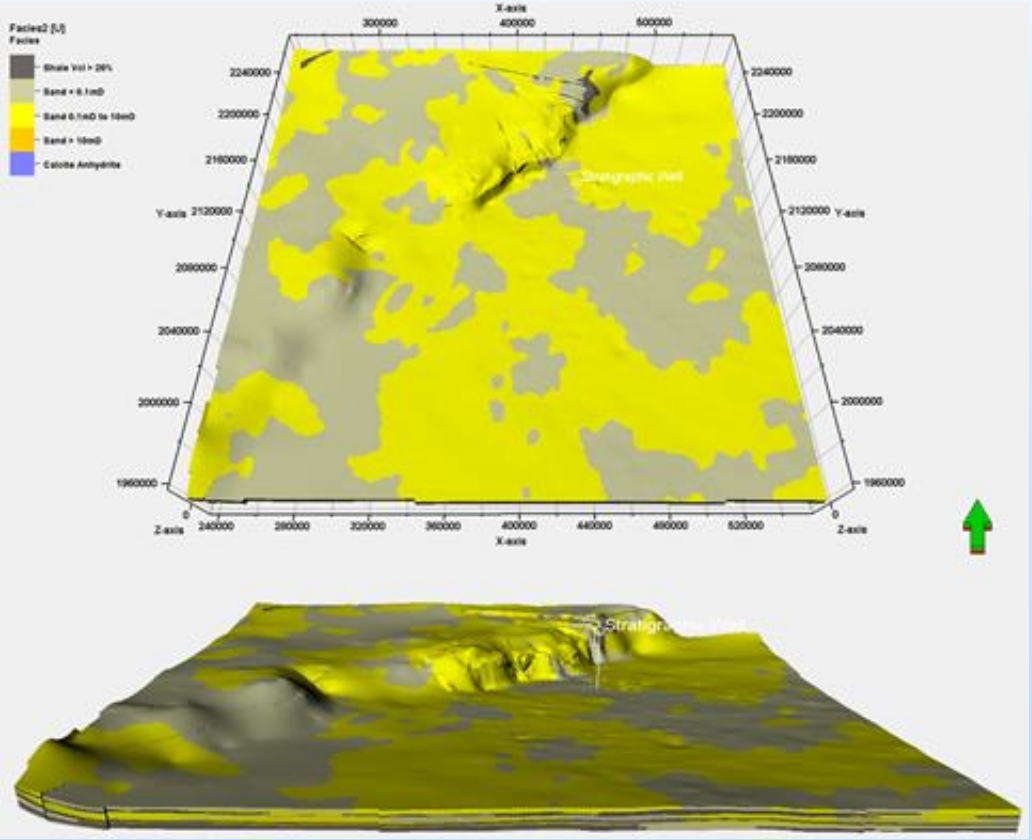
- A total of 34 Saltwater Disposal (SWD) wells penetrate the Entrada with historical water injection data within our study area
- One treated acid gas (TAG) injection well, Pathfinder AGI #001 injected TAG into Entrada
- The wellhead injection pressure limit and historical wellhead pressure are converted 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





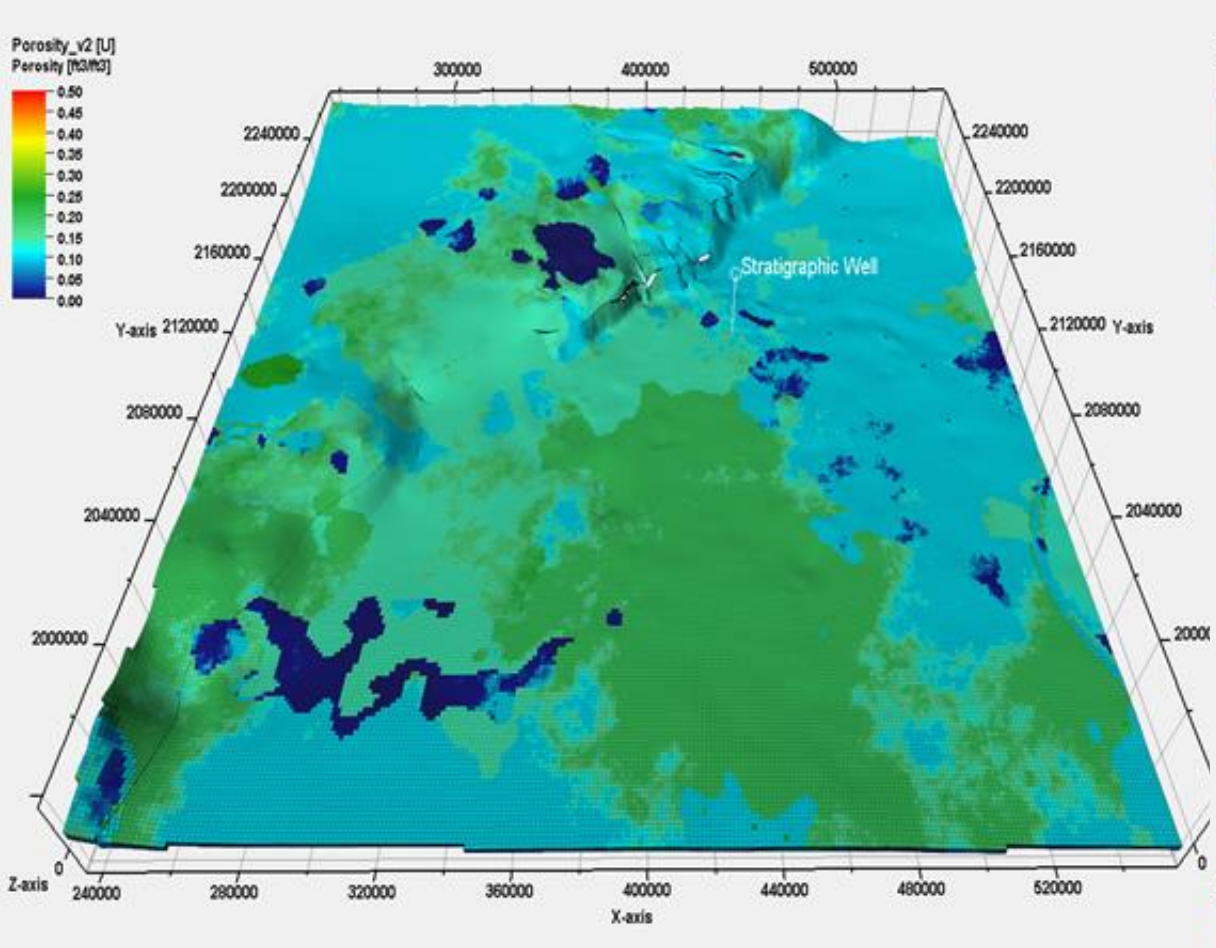
SJB CarbonSAFE 6th Model Description

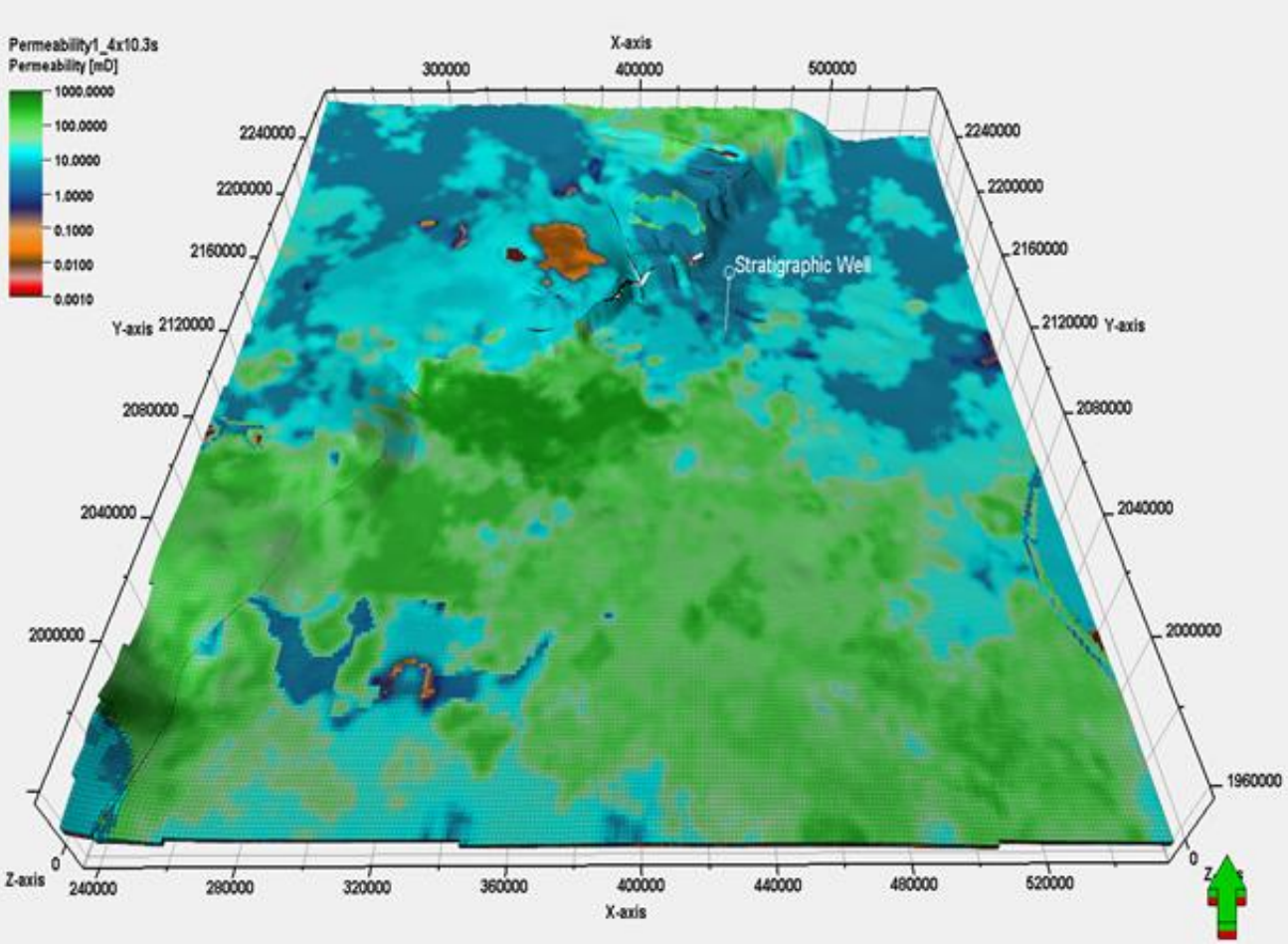
- Grid cells (nI x nJ x nK): 244 x 247x 59
- Total number of grid cells: 3,555,812
- X (ft): 235227.51 ~ 556067.02 ->320839.50ft (60.77 miles)
- Y (ft): 1957130.54 ~ 2278759.08-> 321628.55 ft (60.91 miles)
- CRS: NM-W:NAD27 New Mexico State Planes, Western Zone, US Foot



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



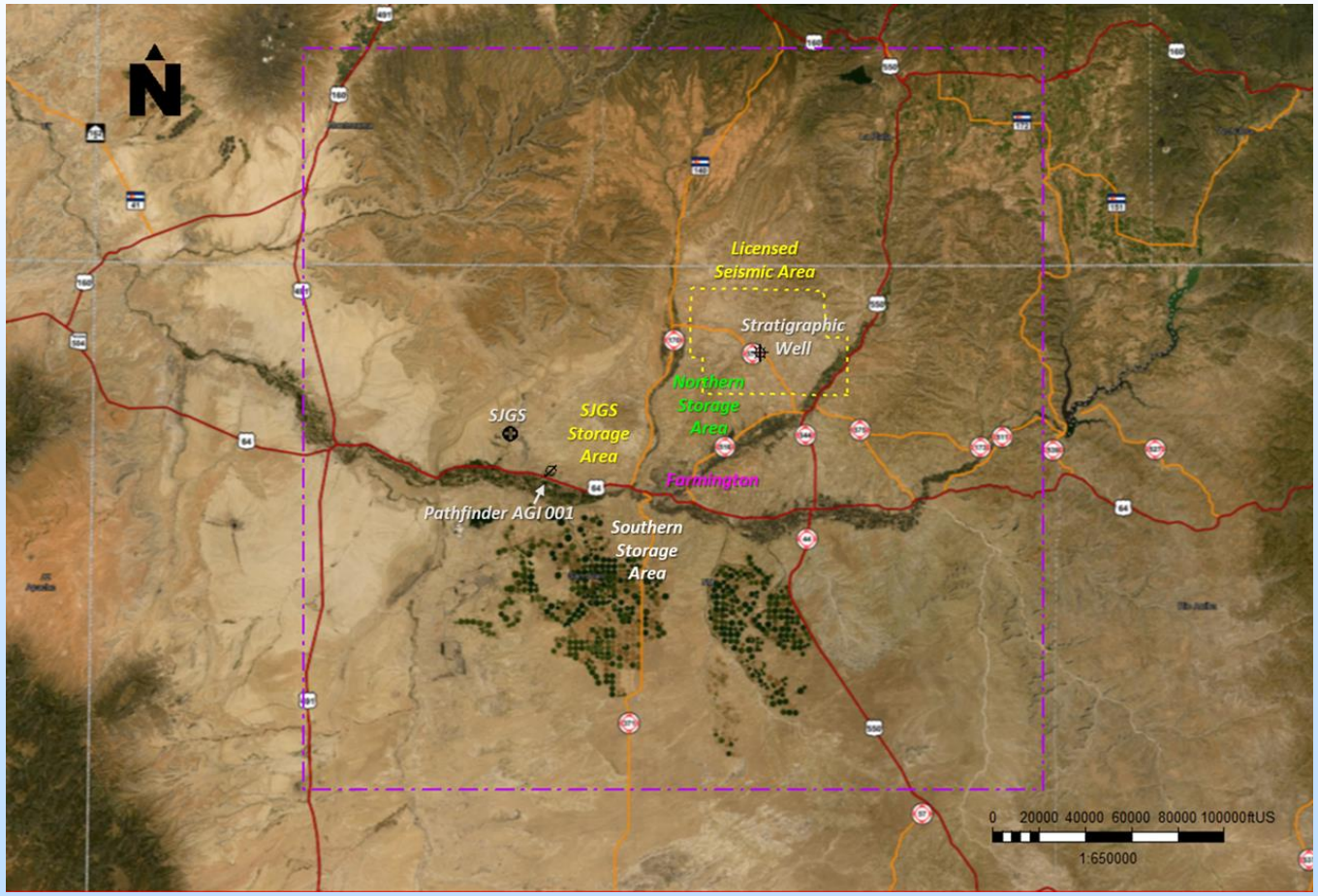


Porosity ***Permeability***

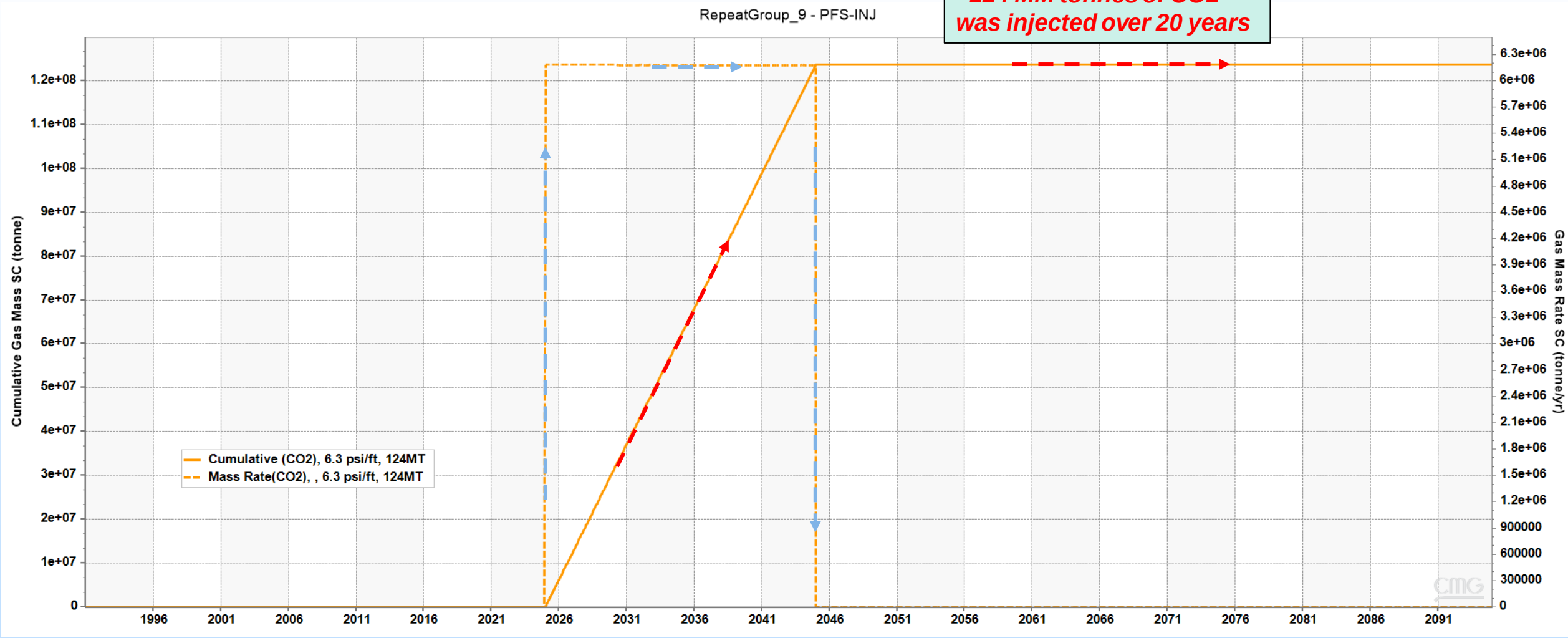
Well Injection Scenario

Injection schedule:

- **Maximum of 10** injectors near the SJGS storage area
- **Primary group control:**
  - Target 6.2 MM tonnes/year
- **Primary well control:**
  - 1.5 MM tonnes/year/well
- **Secondary well control:**
  - Max BHP calculated by 90% 0.62 psi/ft gradient
  - Entrada @ SJGS injection area: ~3567.67 psi

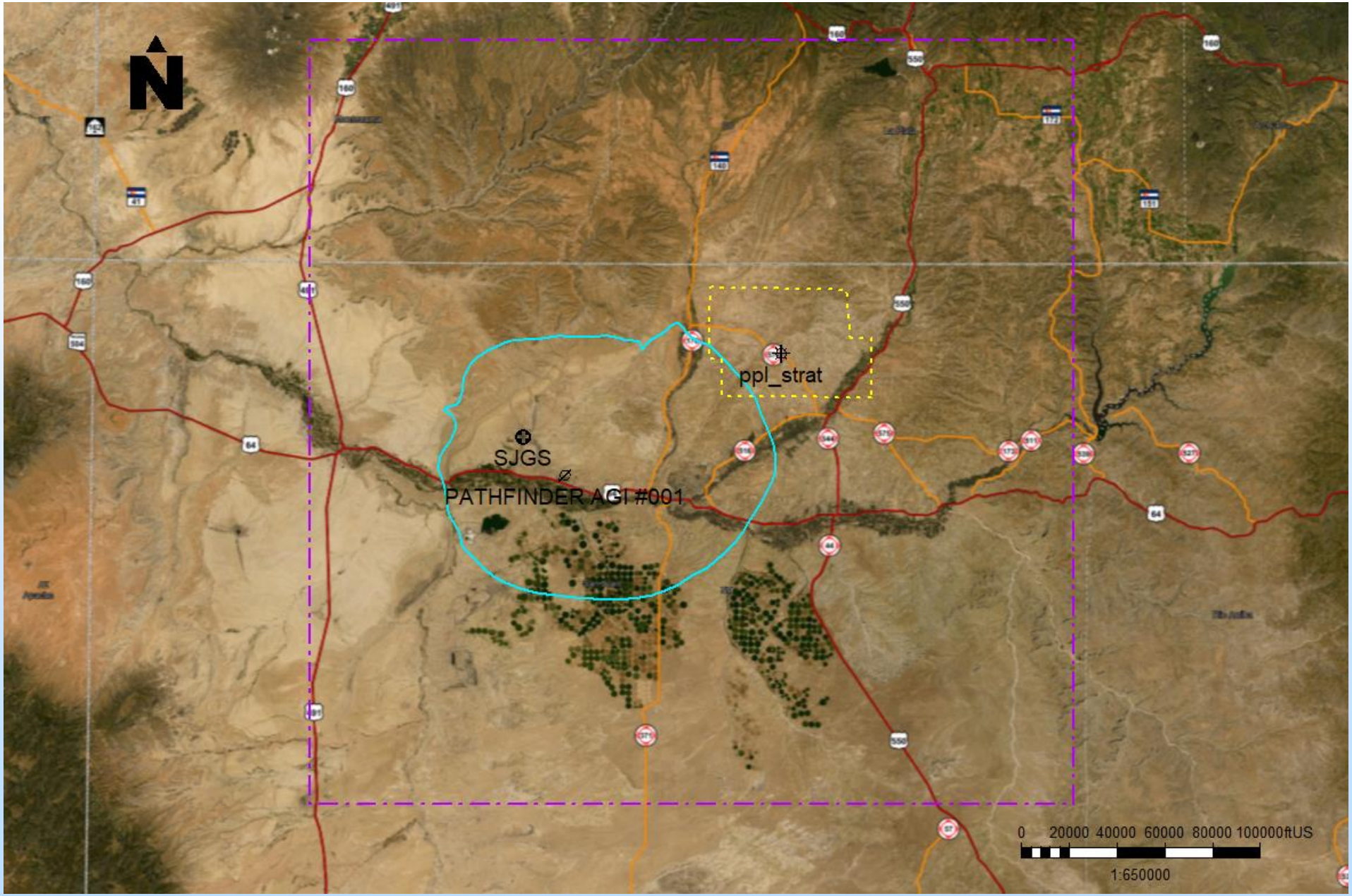


Injection Profile

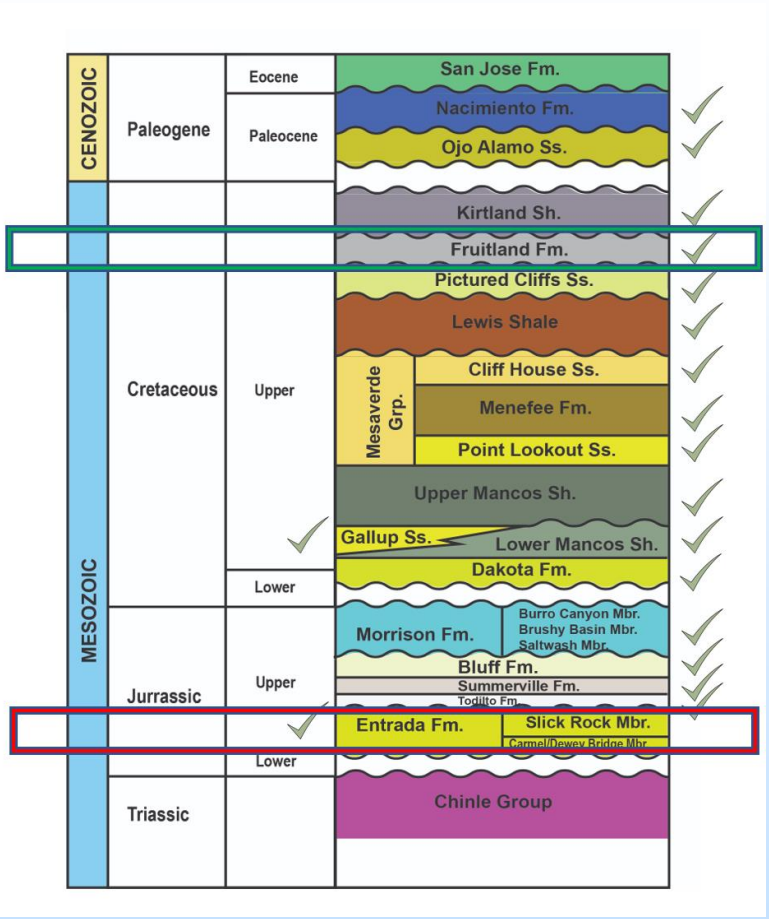


~6.2 MM tonnes/year rate sustained for the entire 20 years.

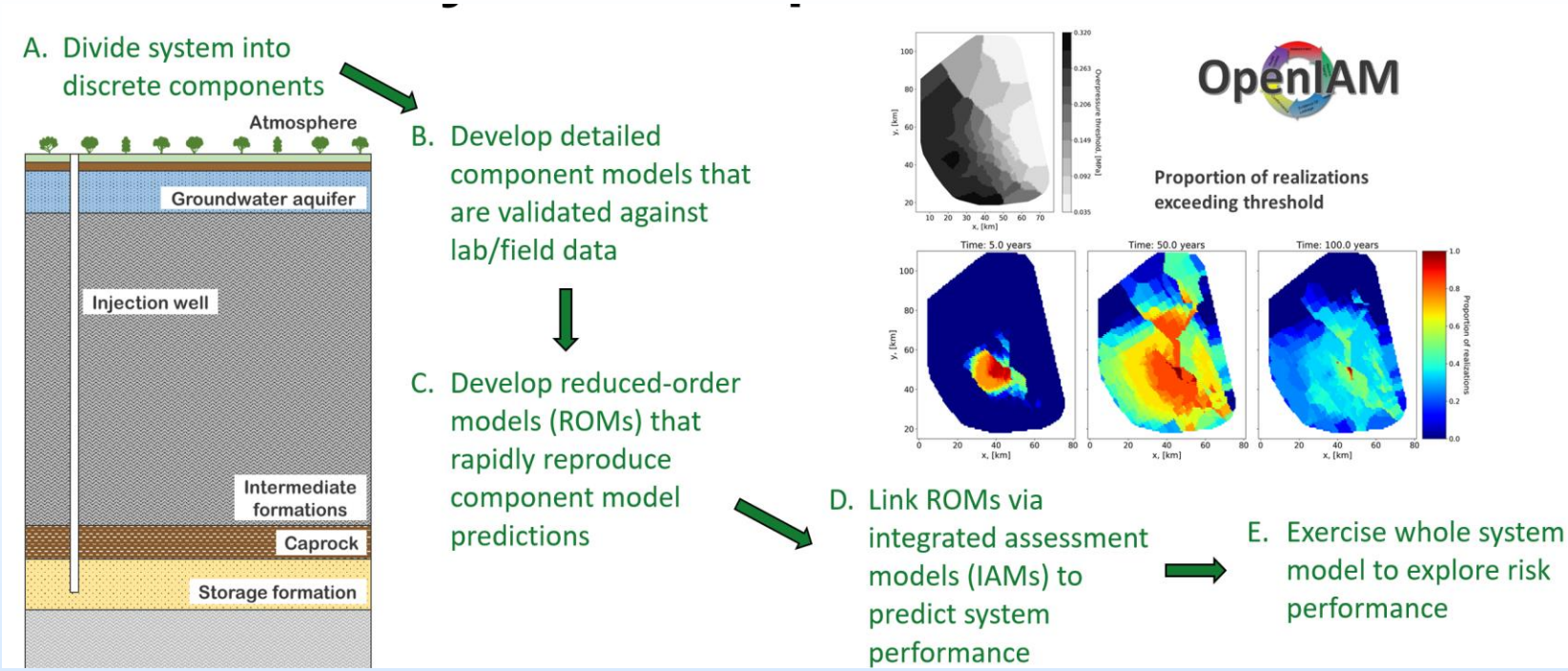
AoR Modeling



NRAP's approach for rapid prediction of whole-system risk performance



Calculation of upper formation thickness and depth ranges according to well drilling data at the research area.

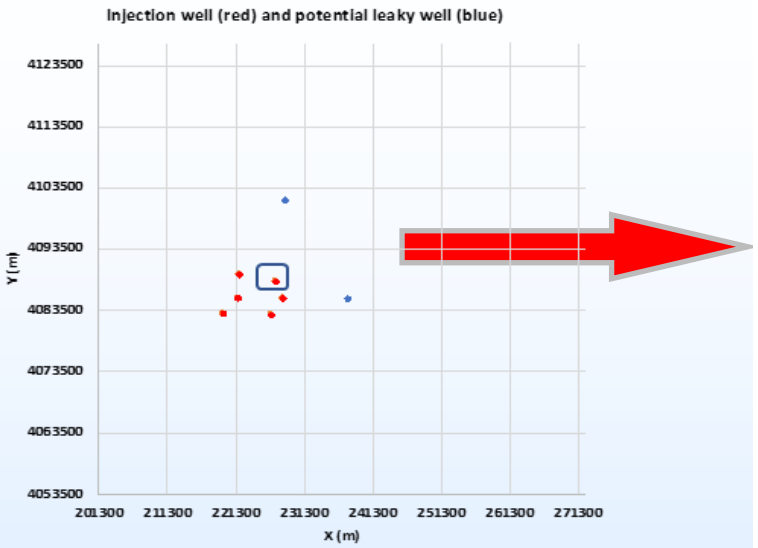


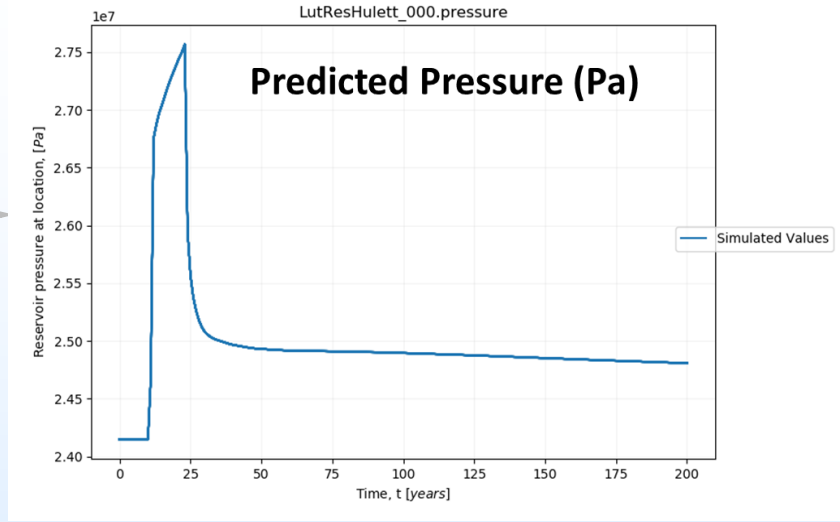
- Workflow has been developed importing physics-based reservoir simulator (CMG) pressure and CO_2 saturation results into NRAP Integrated Assessment Model (NRAP-Open-IAM)
- NRAP-Open-IAM was applied to quantify CO_2 and brine leakage
- The numerical simulations consider an ~70km x 70km area with six CO_2 injection wells penetrating the Entrada storage formation
- Preliminary study for two existing wells in the domain shows promising result with no CO_2 leakage and minimal brine leakage

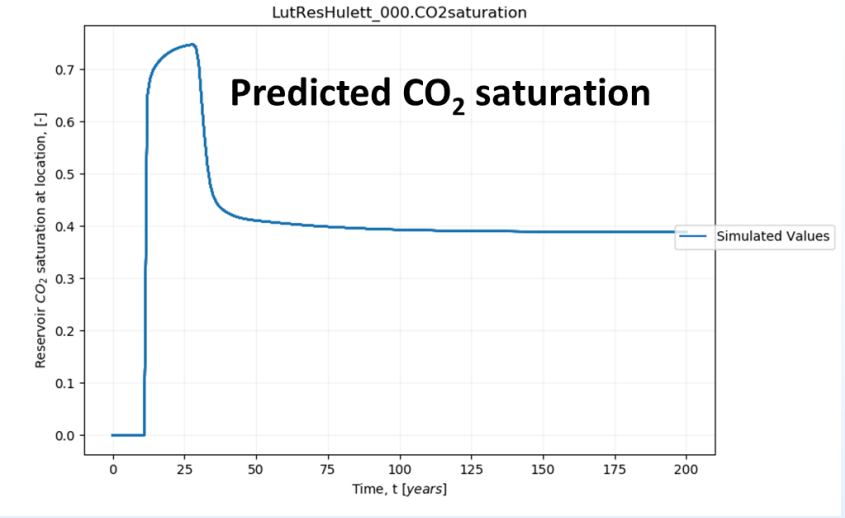
Simulation scenarios:

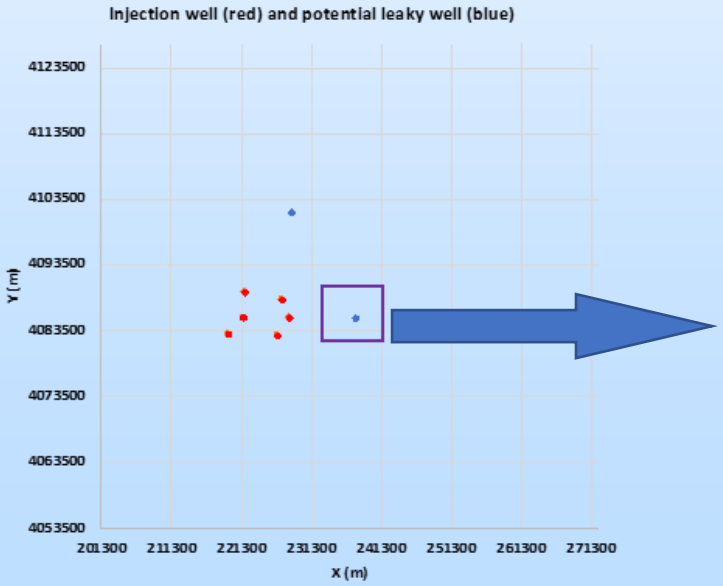
- 22 years of CO_2 injection to Entrada formation
- 200 years of post injection monitoring period

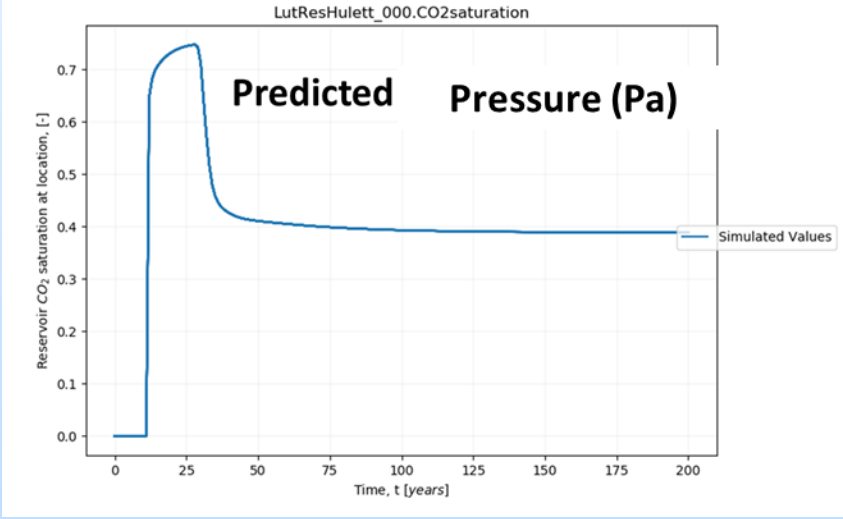
Preliminary Results and Analysis

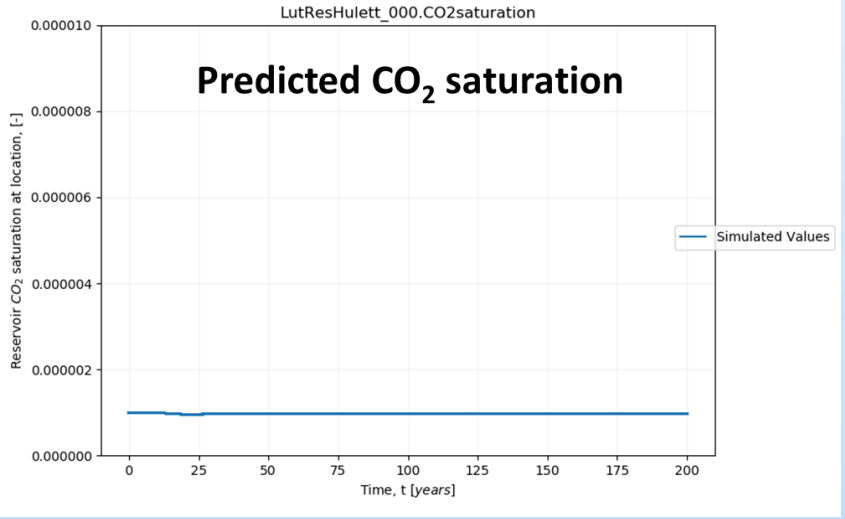






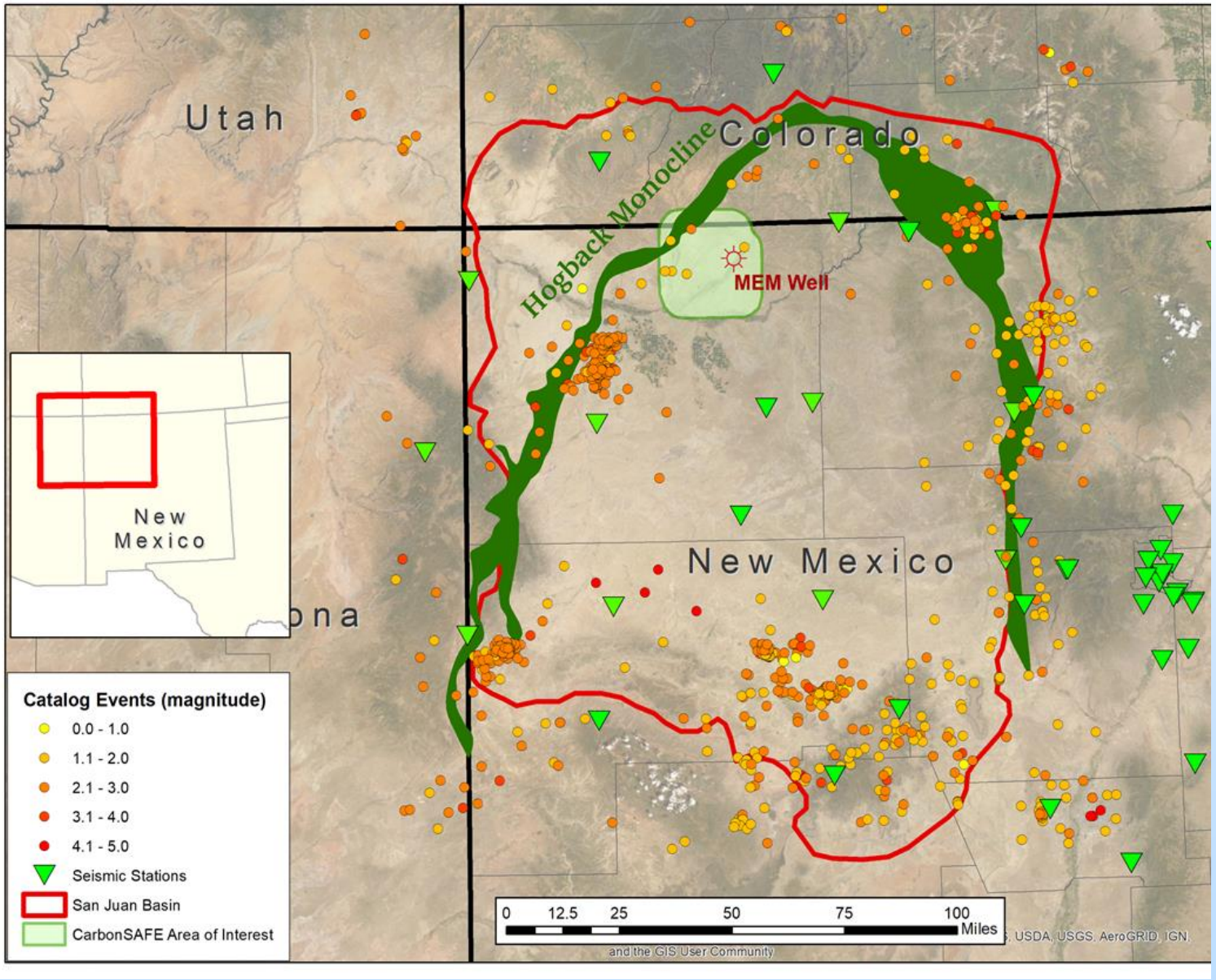






Previous Seismicity at SJB

- Compiled an earthquake catalog for San Juan Basin region
  - USGS (1966-2021)
  - ANF from USArray (mostly 2007-2009)
  - Literature
    - Historical (pre-1962)
    - Instrumental (1962-2009)
- Low seismicity region
- Most events surround the basin where more tectonic structures are present
- Few seismic events within the area of interest



Impacts and Considerations

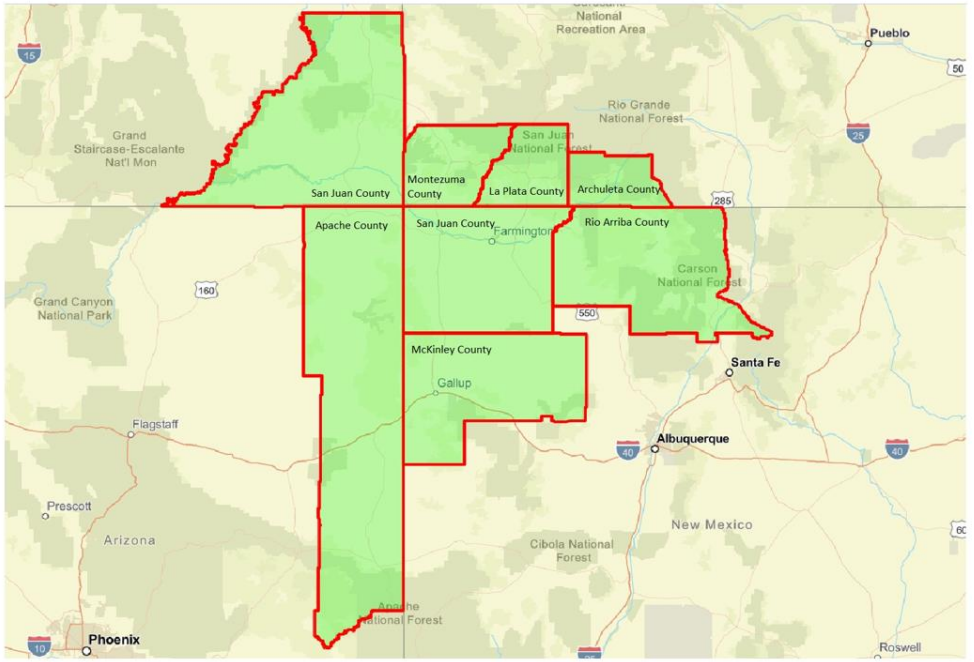
Environmental Justice

Social Justice

Economic Justice

Area of Interest

- San Juan County, NM
- NM
  - Rio Arriba
  - McKinley
- AZ
  - Apache
- CO
  - Montezuma
  - La Plata
  - Archuleta
- UT
  - San Juan
- NM



Benefit Cost Assessment

- Direct
- Indirect
- Externalities
- Assessed in monetary units (allows comparison)

Jobs, Labor Income, Value Added (SJC)*

San Juan County, NM Jobs, Labor Income, and Value Added by Scenario				
Event	Status Quo (annual)	Shut Down (annual)	CCUS (annual)	CCUS construction (one-time)
Jobs				
Direct	450	0	468	4,723
Indirect	313	0	443	738
Induced	263	0	318	2,165
Labor Income (million)				
Direct	$39.7	$0.0	$42.2	$488.3
Indirect	$24.3	$0.0	$34.9	$32.6
Induced	$10.7	$0.0	$13.0	$88.0
Value Added (million)				
Direct	$143.0	$0.0	$174.6	$711.6
Indirect	$77.1	$0.0	$111.7	$75.6
Induced	$21.7	$0.0	$26.3	$177.2

* Preliminary results

Synergy opportunities

- The team is leveraging on experiences from other CarbonSAFE projects, NETL-RIC, Regional partnerships such as SWP and Regional Initiatives to ensure success of proposed efforts

- Collaboration with Enchant Energy LLC and its partners to accelerate deployment of CCS technology at the SJGS

- Collaborating with other DOE sponsored project (DE-F0032064) to install the fiber behind casing in the proposed stratigraphic well at San Juan Basin

Summary - Next Steps

- To finalize UIC Class VI Permit documentation for submission to EPA.
- Commence NEPA documentation after DOE-NEPA determination
- To drill stratigraphic well in Fall 2022 and complete laboratory analysis
- To perform seismic inversion for reservoir properties to enhance property distribution into our geological model
- Continue environmental justice analysis unto completion and ensure inputs are appropriately aligned with economic assessment inputs and analysis

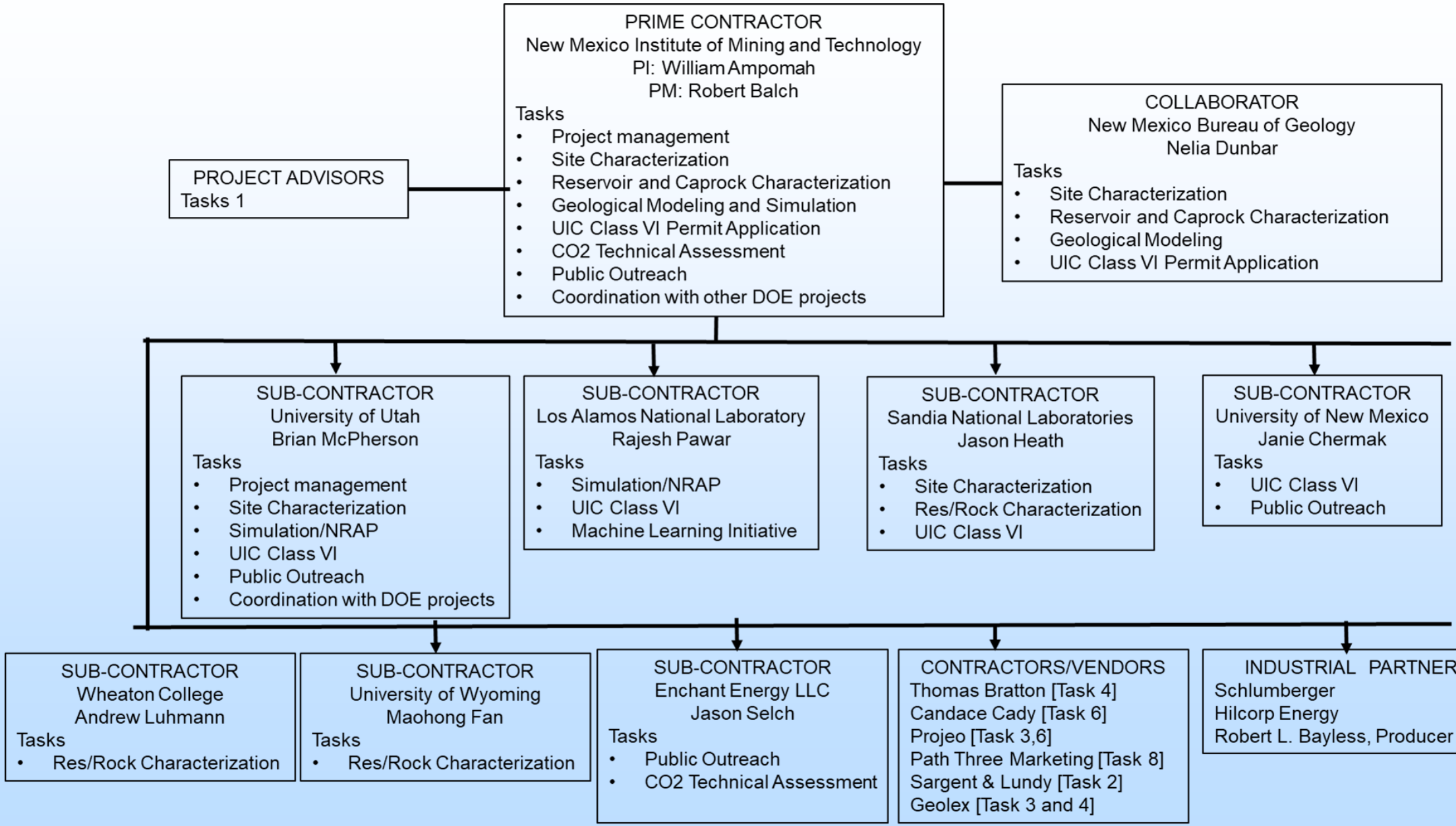
Acknowledgements

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

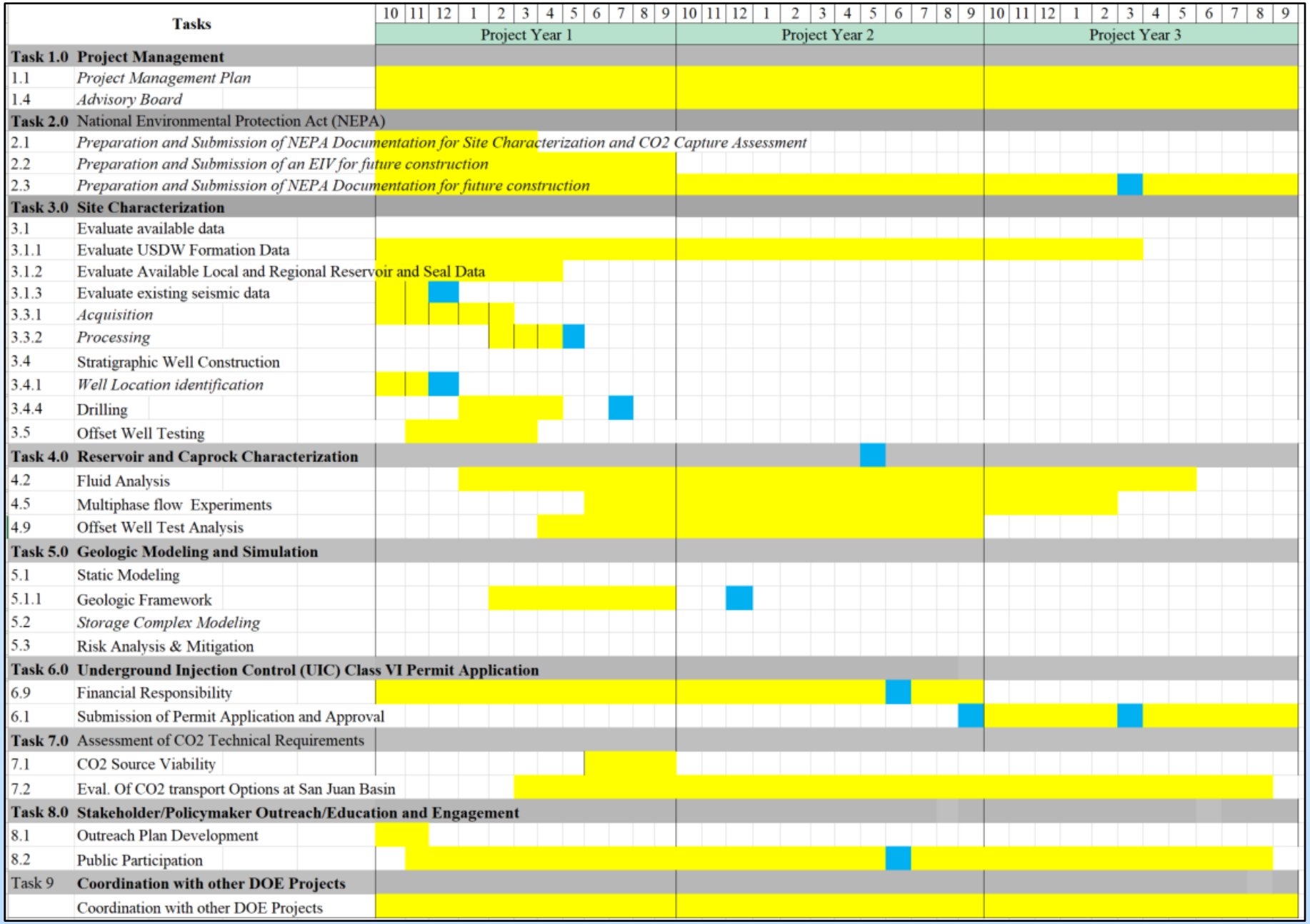
Appendix

– 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
Project Year 1
Project Year 2
Project Year 3
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 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

Technical Approach/Project Scope

Task/ Subtask	Milestone Title & Description	Planned Completion Date
1.0	Project Kick-off meeting	
2.3	NEPA documentation progress	3/31/2023
3.1	Evaluation of available data such as seismic	12/30/2020
3.3	Acquisition and processing of Seismic data	5/30/2021
3.4.5	Stratigraphic well drilled	9/30/2021
4	Complete needed Caprock and reservoir analysis for Modeling	5/31/2022
5.2	Complete initial simulations for UIC permit application	7/31/2022
5.2.8	Complete AOR modeling	8/31/2022
5.3	Complete initial Risk assessment for UIC permit application	8/31/2022
6	Complete documentation to submit UIC class VI application	9/30/2022
6.10	Progress report on submitted UIC class VI application	3/30/2023
6.10	Progress and/or receiving approval for UIC class VI application	9/30/2023

(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.

Latest update on the UIC Application- Project Narrative

1 – Facility Information: **Well names and locations to be finalized based on final AoR delineation and discussions with operator.**

2 – Project Background and Contact Information: **Section complete**

3 – Introduction: **Section complete.**

4 – Site Characterization

4.1 – Regional Geology, Hydrogeology, and Local Structure

4.1.1 – Regional Geology: **Section complete.**

4.1.2 - Regional Hydrogeology: **Section complete.**

4.1.3 – Local Structural Geology: **Section complete.**

4.2 – Maps and Cross Sections of the Area of Review: **Work in progress but nearing completion.**

Latest update on the UIC Application- Project Narrative

4.3 – Faults and Fractures: **A few remaining comments to address.**

4.4 – Injection and Confining Zone Details: **Section complete.**

4.5 – Geomechanical and Petrophysical Information: **Section complete except for the question of how many wells were used to construct the petrophysical model.**

4.6 – Seismic History: **Section complete.**

4.7 – Hydrologic and Hydrogeologic Information: **Section complete except for redrawing figures due to change in AoR delineation.**

4.8 – Geochemistry: **Section complete except for redrawing figures due to change in AoR delineation.**

4.9 – Other Information (including Surface Air and/or Soil Gas Data): **Section complete.**

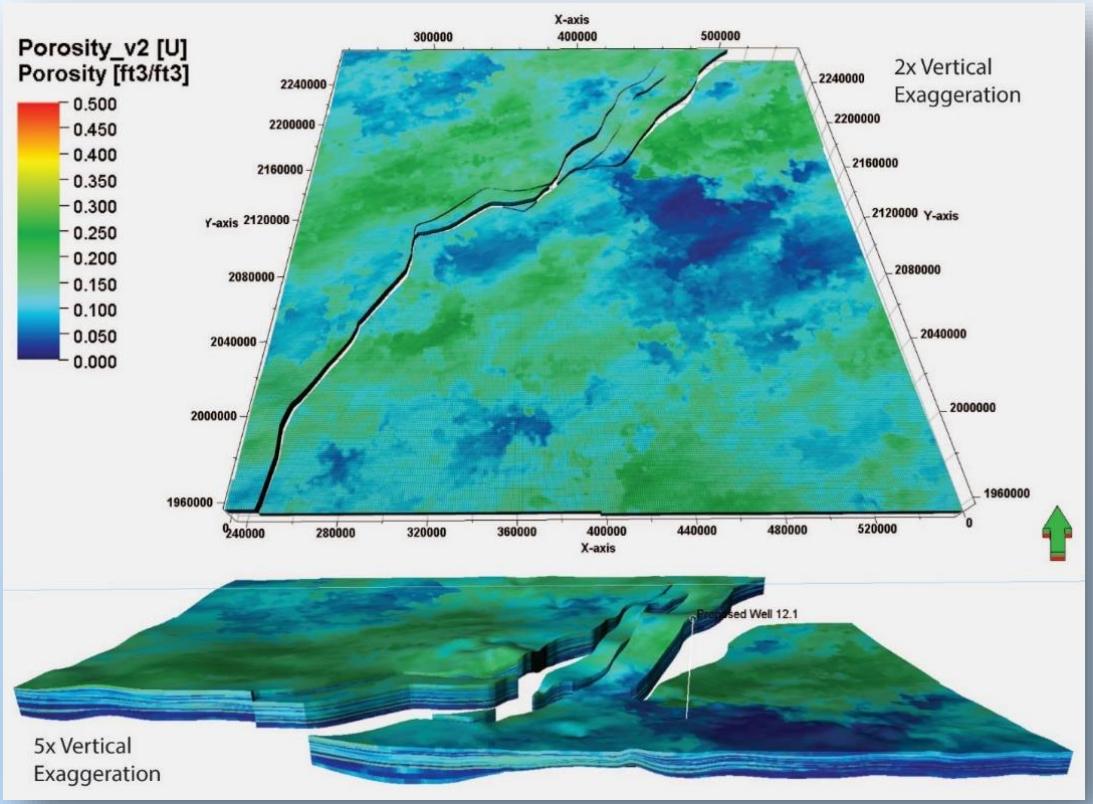
4.10 – Site Suitability: **Currently being completed by William and Luke**.

Latest update on the UIC Application- Project Narrative

- 5 – Injection Well Construction: **Section complete.**
- 6 – Well Operation: **Section complete**.
- 7 – Injection Depth Waiver and Aquifer Exemption Expansion: **Section complete.**
- 8 – Other Information: **Section complete.**
- 9 – 15 – Summaries: **Finalizing summaries of completed plans**
- 16 – References: **As they are completed, references for each subnarrative are added.**

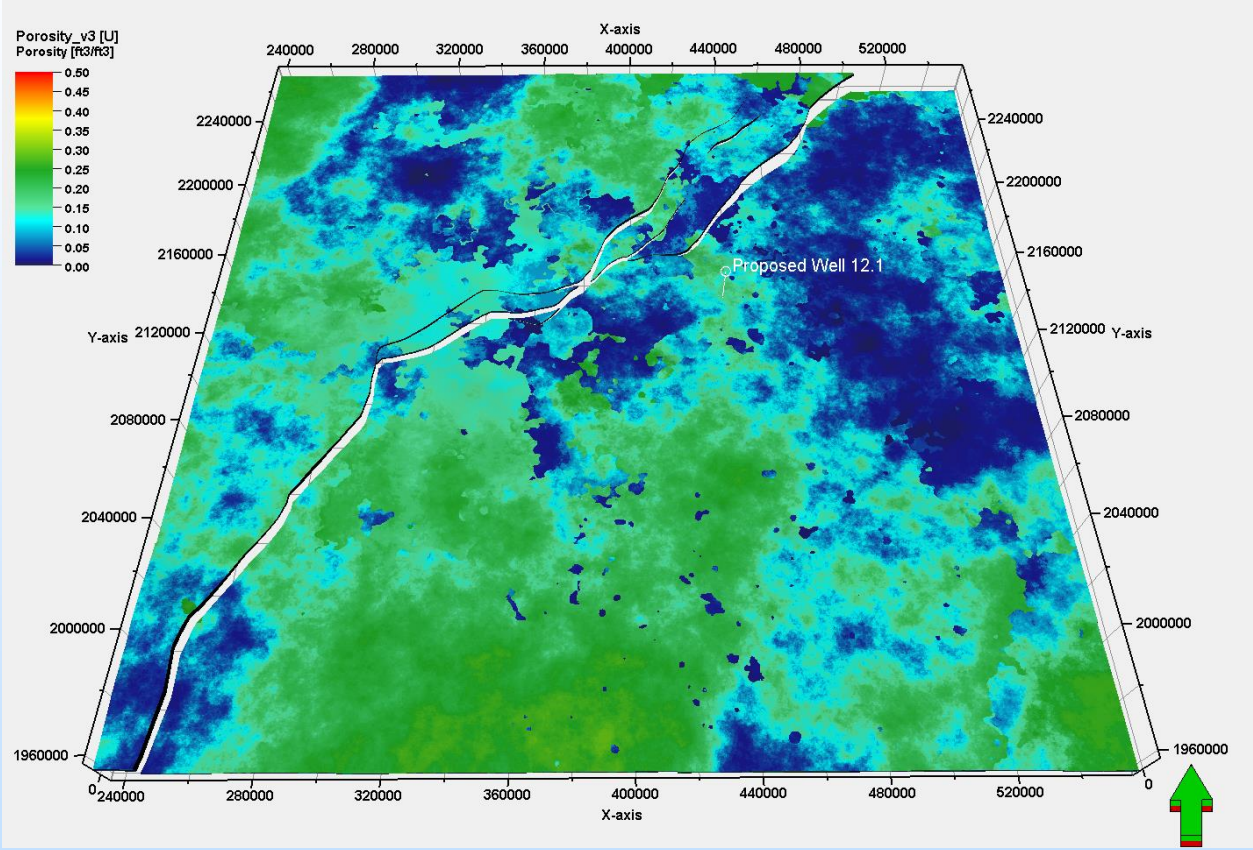
SJB CarbonSafe Model Description [Model 1]

- Grid cells (nI x nJ x nK): 322 x 321x 29
- Total number of grid cells: 2,886,660
- X (ft): 235356.12 ~ 555976.40 ->320620.28 ft (**60.72** miles)
- Y (ft): 1957320.33 ~ 2278308.71-> 320988.38 ft (**60.79** miles)
- CRS: NM-W:NAD27 New Mexico State Planes, Western Zone, US Foot

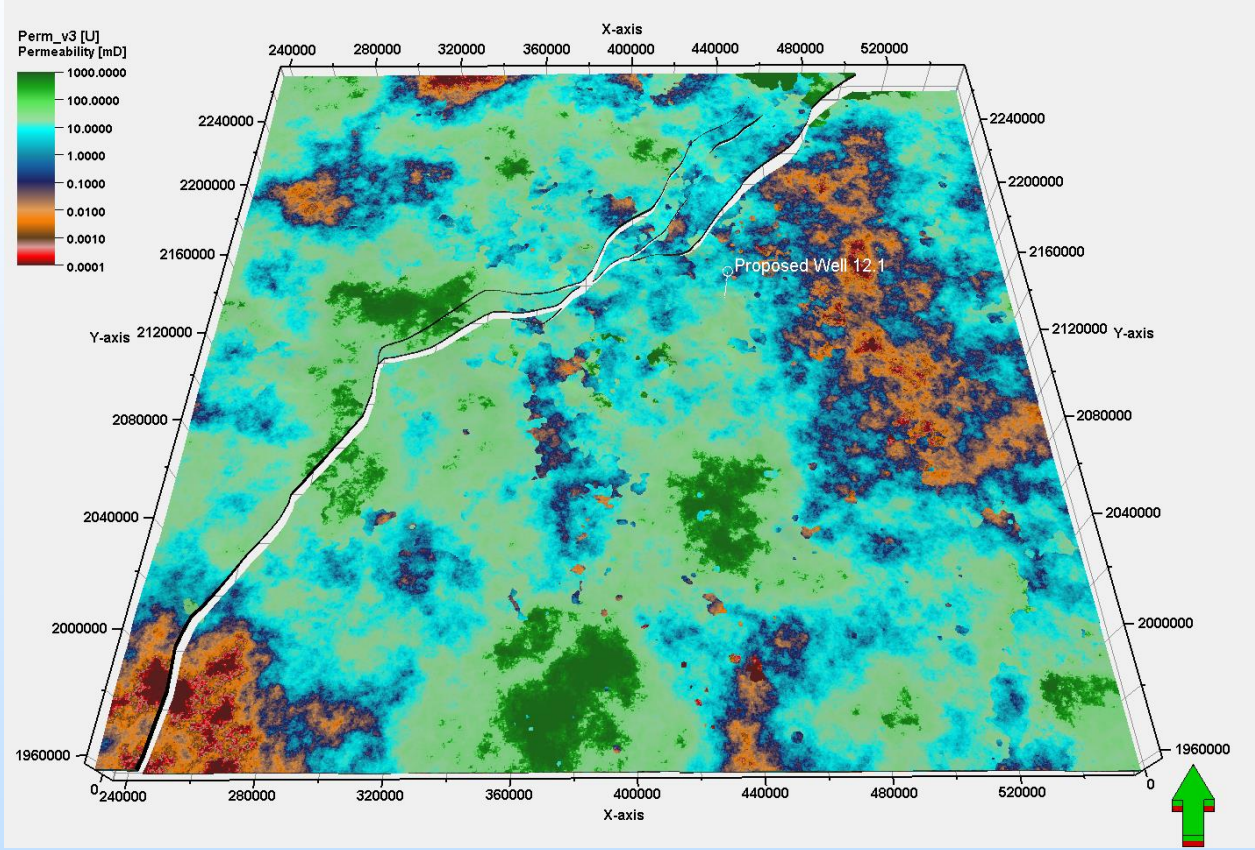


Layer No.	Formation
1	Dakota
2	Brushy Basin
3	
4	
5	
6	
7	Salt Wash
8	
9	
10	
11	
12	Bluff
13	
14	
15	
16	
17	Summerville
18	
19	
20	
21	Todilto
22	
23	Entrada
24	
25	
26	
27	Camel
28	
29	

Perm and Porosity Distribution at the top layer of Entrada [Model 1]



Permeability

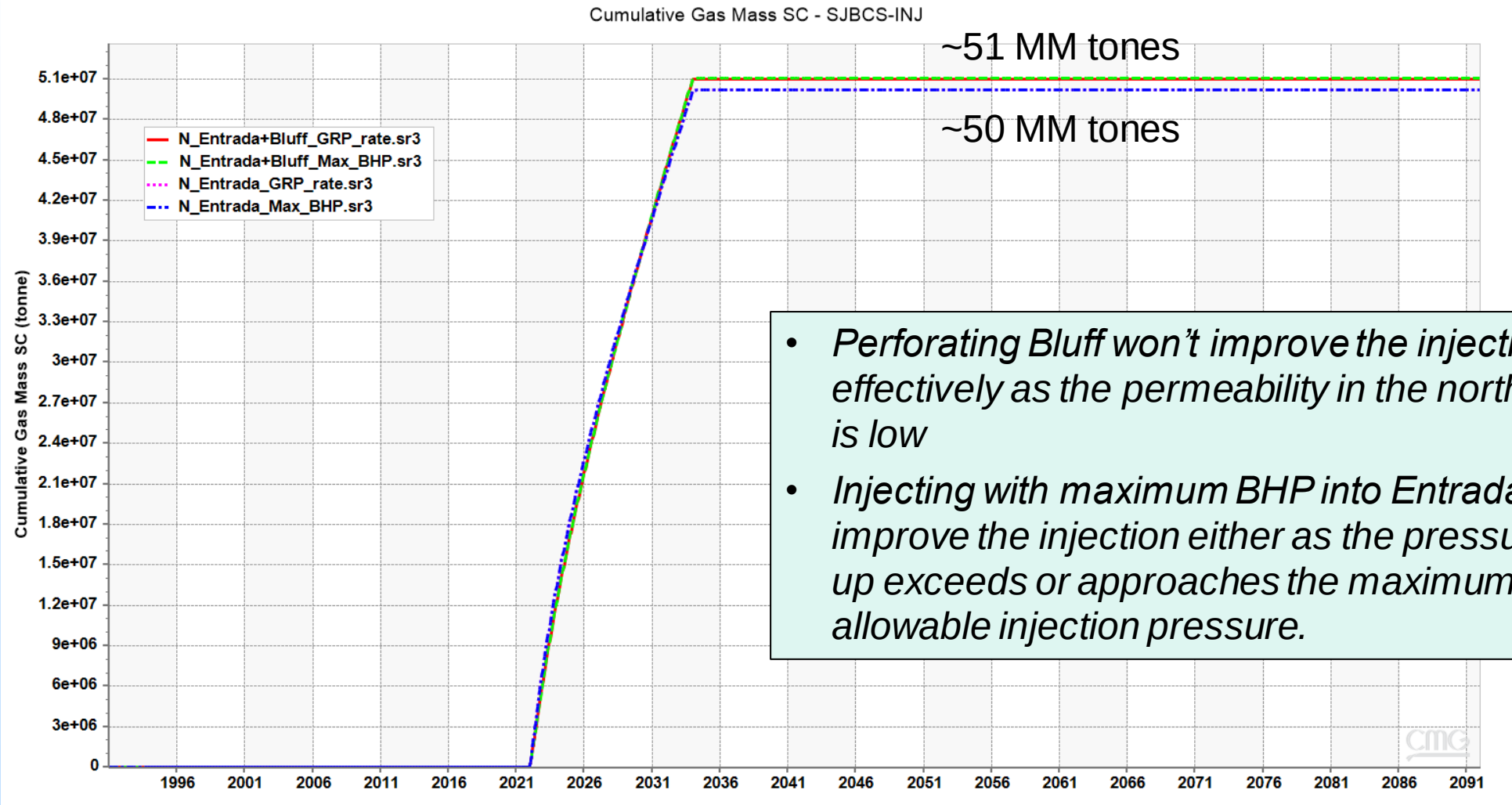


Porosity

Model 1- Injection Scenario 1 [Northern site]

- 10 Injectors in the North Site
- Perforated Zone: Entrada ***and/or*** Bluff
- Injection Rate:
  - Group Rate 6.2 tones/year for 12 years ***or***
  - Maximum BHP injection
- Max Rate limit: 1.5 tones/year/well
- Max BHP Limit: 0.54 psi/ft
  - 90% of the Formation Fracture Gradient (*40 CFR § 146.88 (a)*)

Cum injected CO2 (for 10 well scenarios)- Model 1



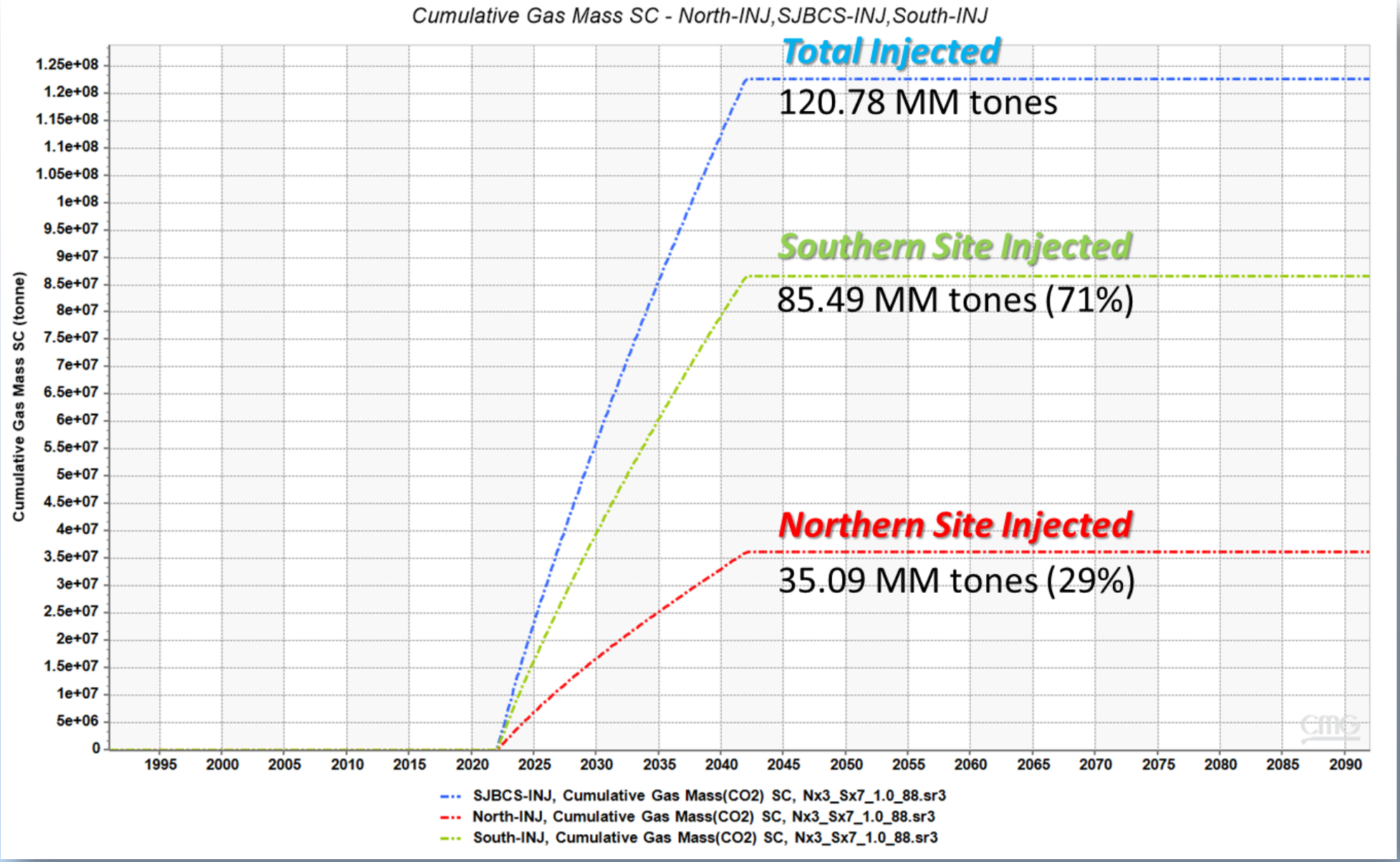
- *Perforating Bluff won't improve the injection effectively as the permeability in the north of Bluff is low*
- *Injecting with maximum BHP into Entrada won't improve the injection either as the pressure build-up exceeds or approaches the maximum allowable injection pressure.*

Model 1 - Injection Scenario 2

- Injection schedule:

- Primary group control:
  - Target 6.2 MM tonnes/year
- Primary well control:
  - 1.5 MM tonnes/year/well
- Secondary well control:
  - Max BHP calculated by 90% of 0.6 psi/ft gradient
  - @ the Northern Site ~ 4,400 psi
  - @ the Southern Site ~ 3,700 psi

Injection Profile [Scenario 2]



SJGS Site Scenario 3- Injection Profile