San Juan Basin CarbonSAFE Phase III

FWP-FE-1163-20-FY20

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U.S. Department of Energy

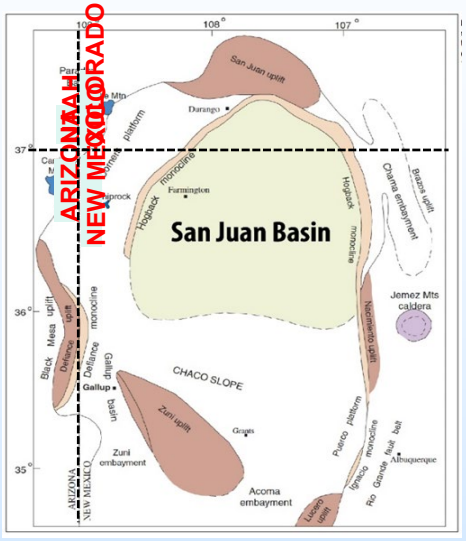
FECM/NETL

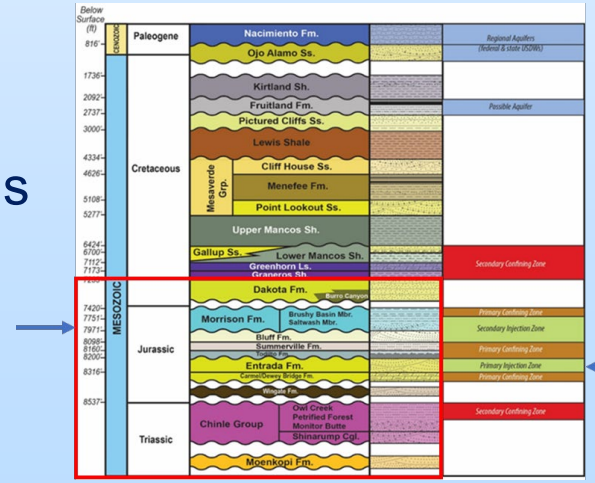
Carbon Management Research Project Review Meeting

August 28 – September 1, 2023

San Juan Basin CarbonSAFE

- Part of DOE's CarbonSAFE Phase-III program
  - Minimum project size requirement: 50 million tons cumulative CO_2 injection over 30 years
- Objective – Facilitate deployment of CCS technology
  - Develop and submit a Class-VI permit application
- Focused on the San Juan Basin
  - One of the major oil/gas producing basins in US
  - Multiple deeper saline reservoirs with significant potential storage capacity (SWRP analysis)





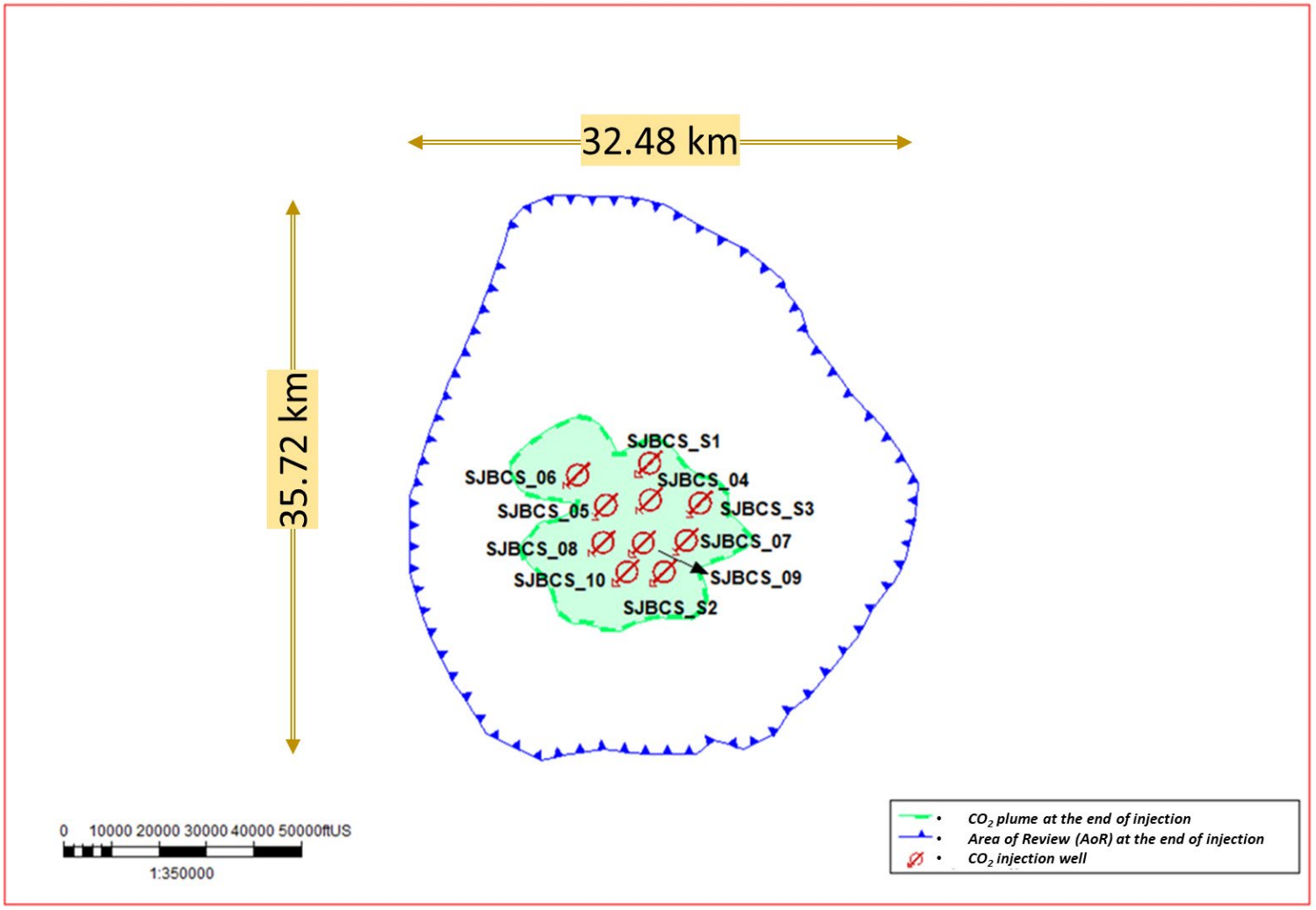
Major FY23 Accomplishments

- Leakage risk and corrective action (CA) for the legacy wells within the AoR
- Risk-based AoR delineation
- Induced seismicity risk
- Pipeline network modeling
- CO_2 source feasibility analysis
- Machine learning based fault detection

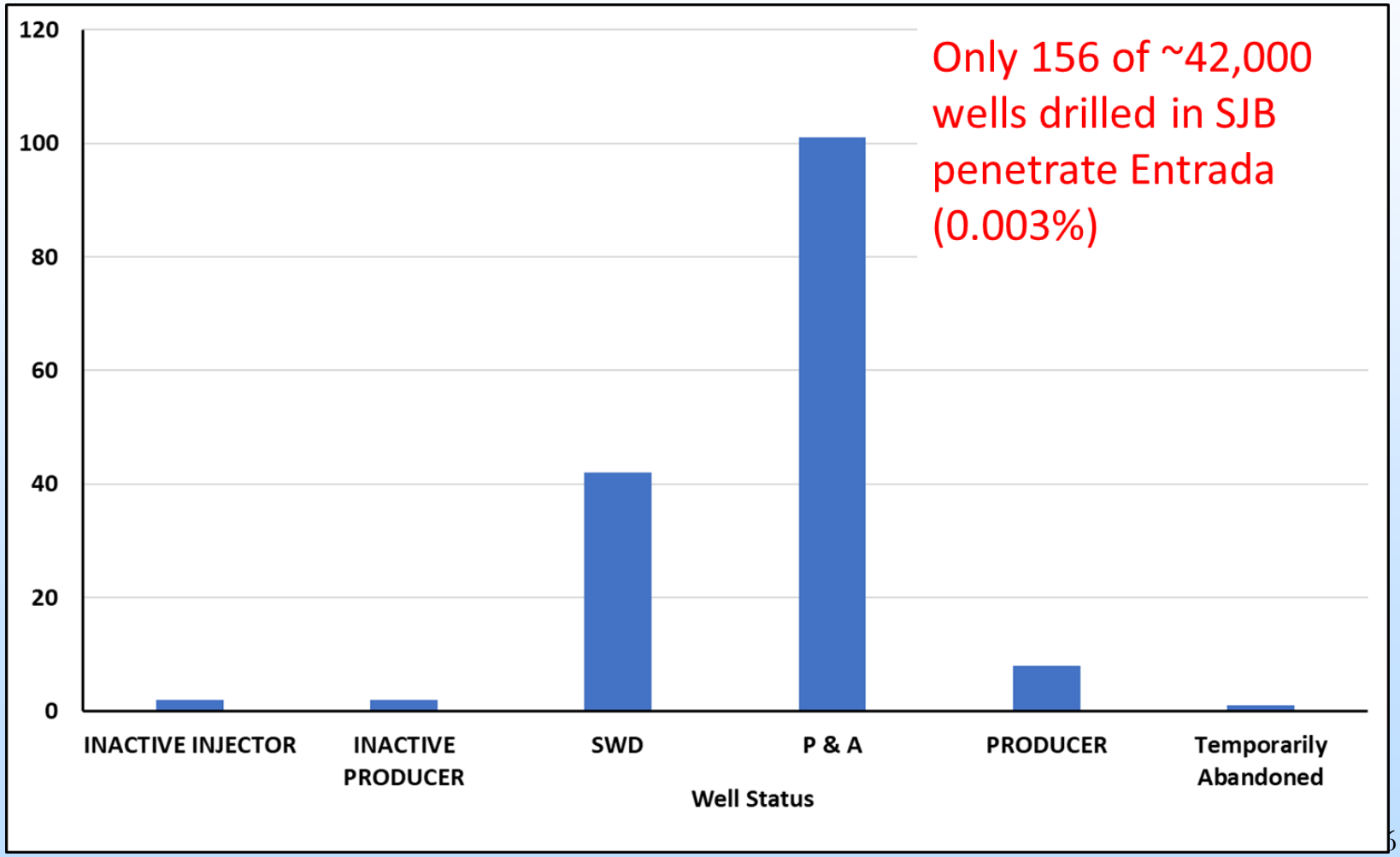
Technical Progress 1:

Leakage risk and corrective action

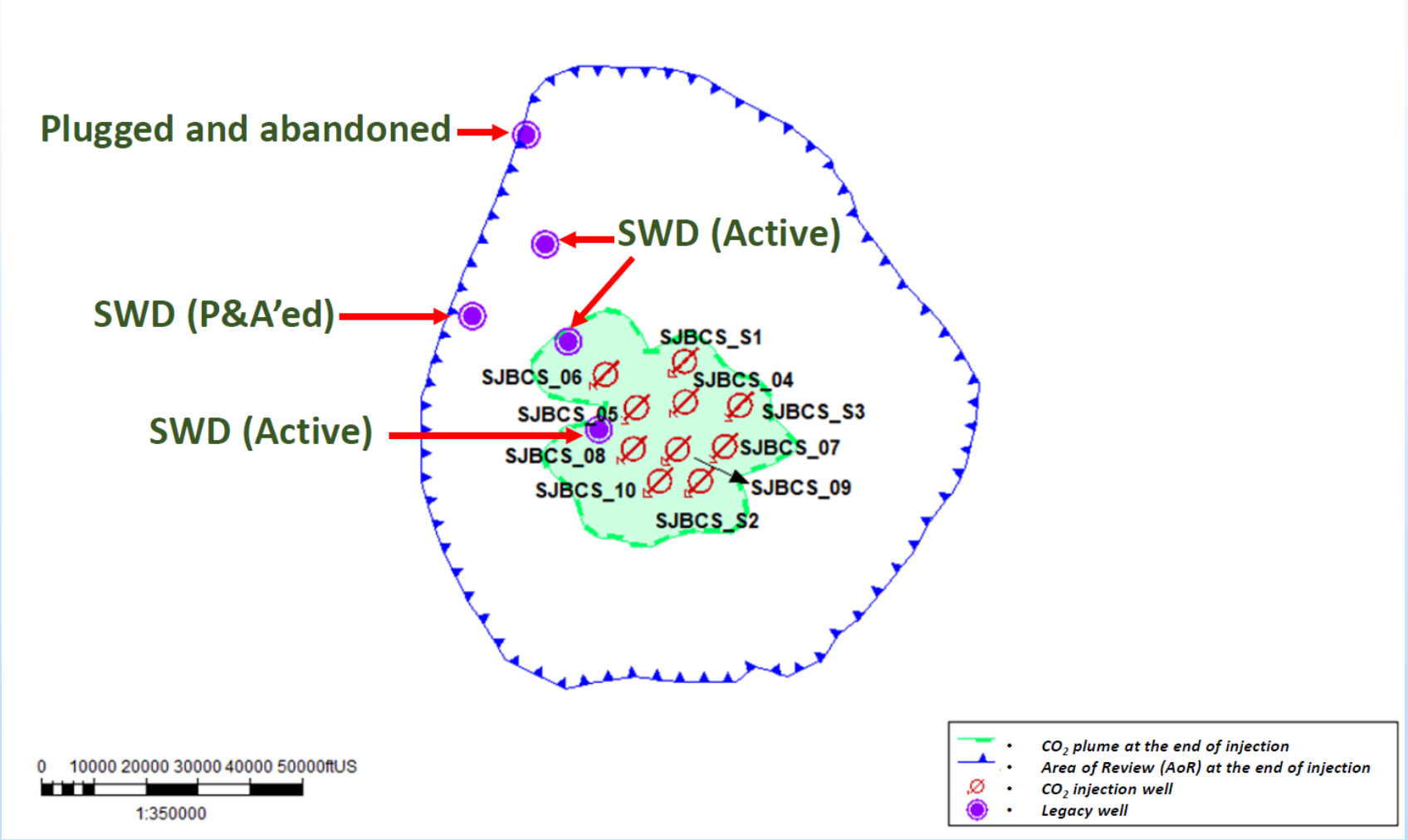
Area of Review



Legacy Wells Penetrating Entrada Formation



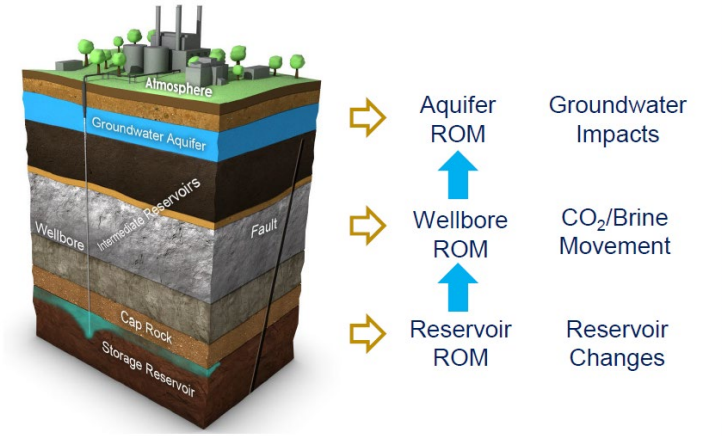
Legacy Wells within the AoR



Will the Legacy Wells Pose Leakage Risks to USDW?

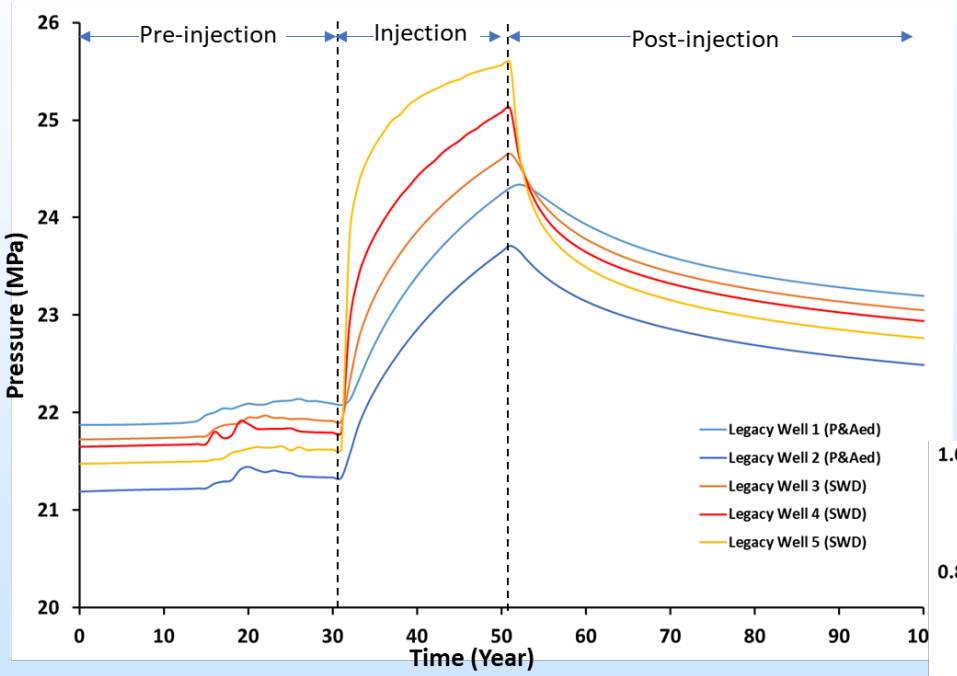
- Leakage risk assessment using NRAP's 'NRAP-Open-IAM' model
- Model setup for each legacy well within the AoR
- Reservoir simulation results utilized: time-dependent pres. & sat.
- Wellbore modeled using cemented wellbore ROM
- USDW modeled using aquifer ROM

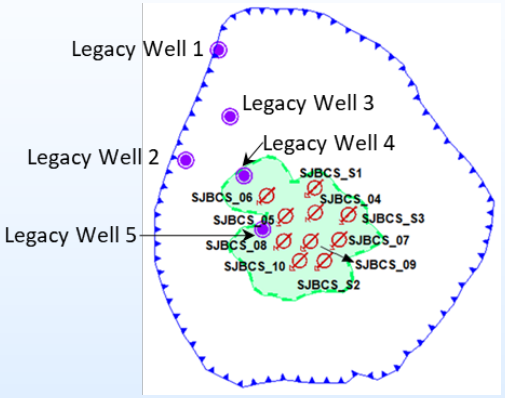
'NRAP open IAM' simulates behavior of a CO_2 storage site through an integrated assessment model combining reduced order models for multiple components including reservoir, leakage pathways and receptors (groundwater)

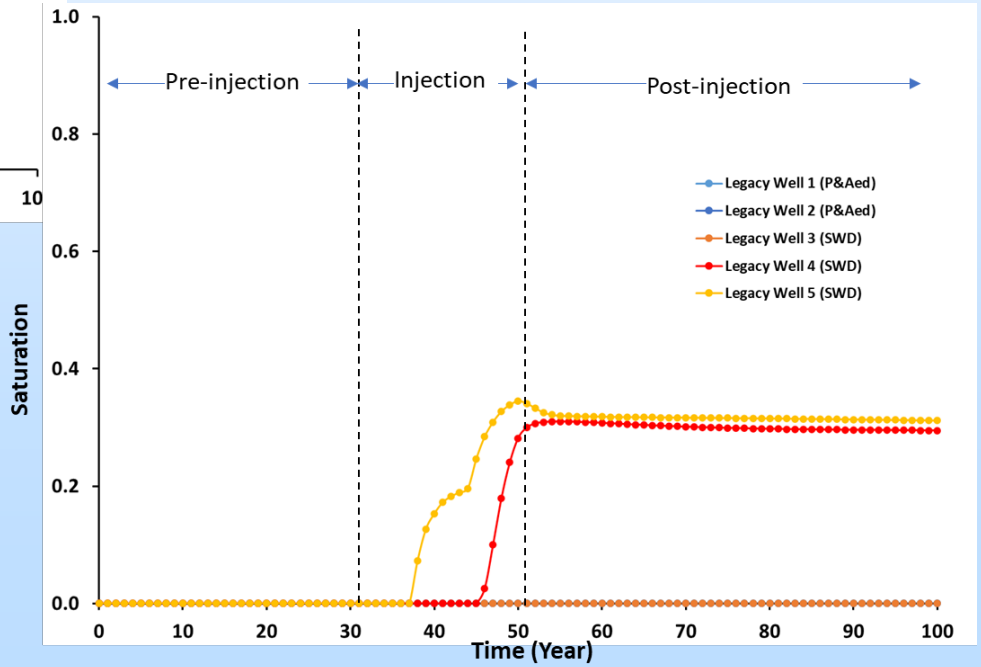


Vasylkivska et al, Env. Mod. Soft., 2021, Pawar et al, IJGGC, 2016

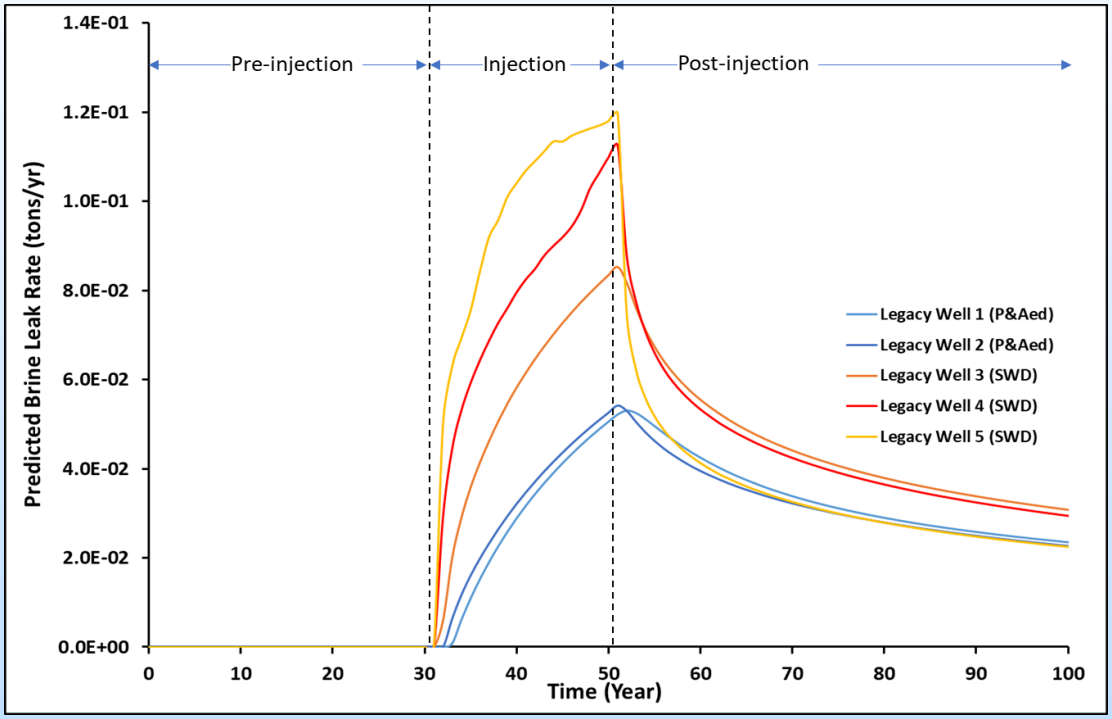
Predicted Pressures and Saturations at Locations of the Legacy Wells

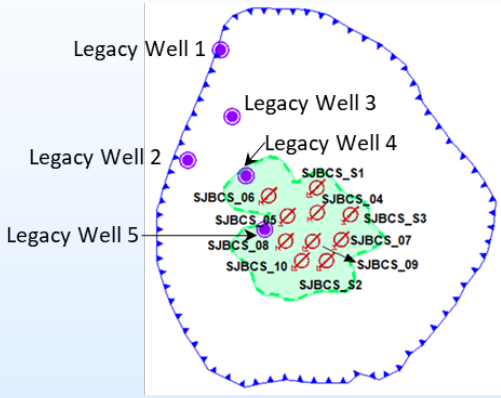






NRAP-Open-IAM Predictions

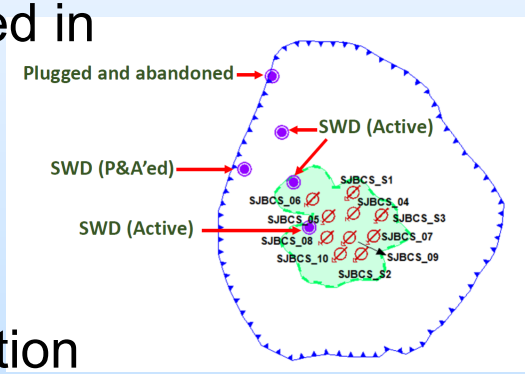




- Leakage simulations indicate:
  - ✓ No CO_2 leakage
  - ✓ Extremely low (negligible) brine leakage
  - ✓ No USDW impact

Status of Legacy Wells in the AoR

- Plugged & Abandoned wells:
  - ✓ Plugged with multiple cement plugs
  - ✓ Local USDW protected by surface casing with annular cement to the surface
  - ✓ One non-active salt water disposal well abandoned in 2020
  - ✓ No reported failures
- Active Salt Water Disposal wells:
  - ✓ Wells completed using UIC Class-II well construction requirements
  - ✓ UIC Class-II requirements for internal and external MIT
  - ✓ Periodic inspection
  - ✓ No loss of integrity to date or reported failures



Evaluation of the Need for Corrective Actions

- Wells within the predicted CO_2 plume are active SWD wells:
  - ✓ Demonstrated integrity through periodic tests (UIC Class-II requirements)
  - ✓ Localized pressure barrier
  - ✓ CO_2 arrival expected only 7 years after the beginning of injection
  - ✓ Conservative leakage risk predictions show no CO_2 and brine leakage risks (no impact to groundwater quality)
- Wells outside CO_2 plume include 1 active SWD well, 1 plugged SWD well and 1 plugged well:
  - ✓ Two wells close to AoR boundary
  - ✓ Conservative leakage risk predictions show no brine leakage risks (no impact to groundwater quality)
- A phased approach can be utilized – supported by quantitative leakage risk assessment

Technical Progress 2:

Risk-based AoR delineation

Risk-based AoR Delineation

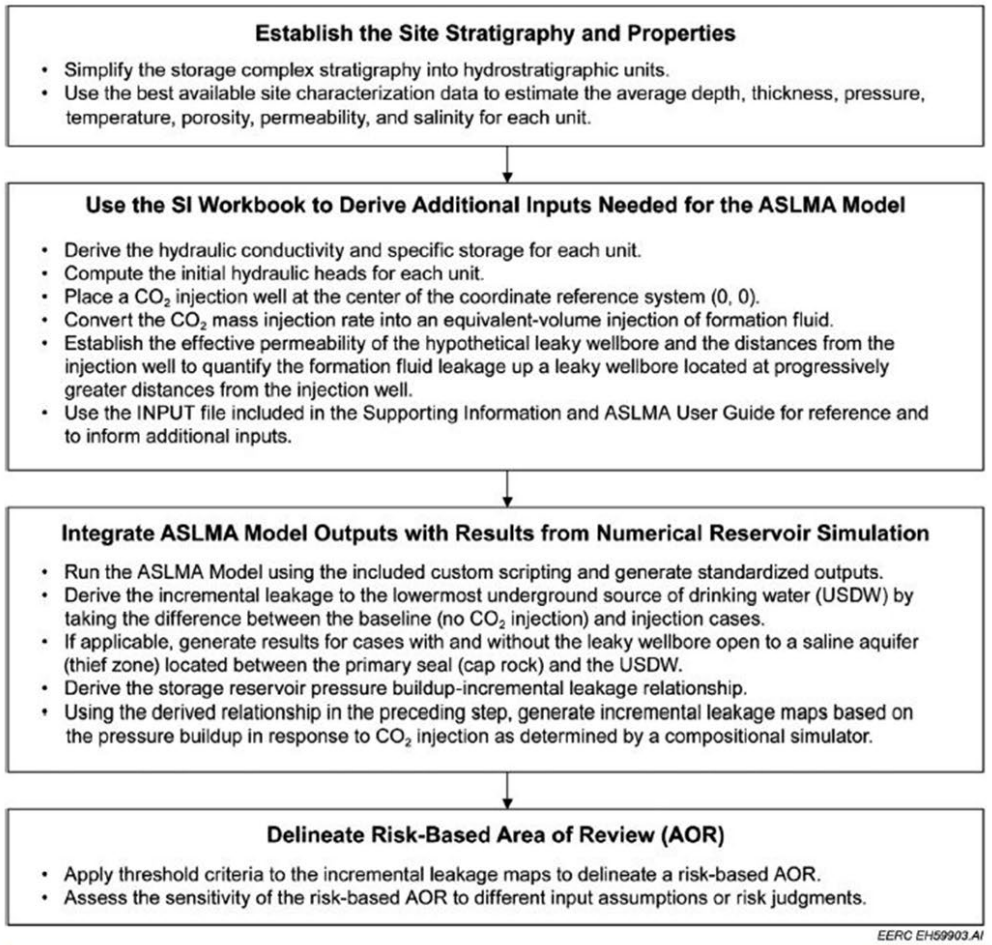


Figure 1. Workflow for delineating a risk-based AOR for a storage facility permit.

Stratigraphy & Properties

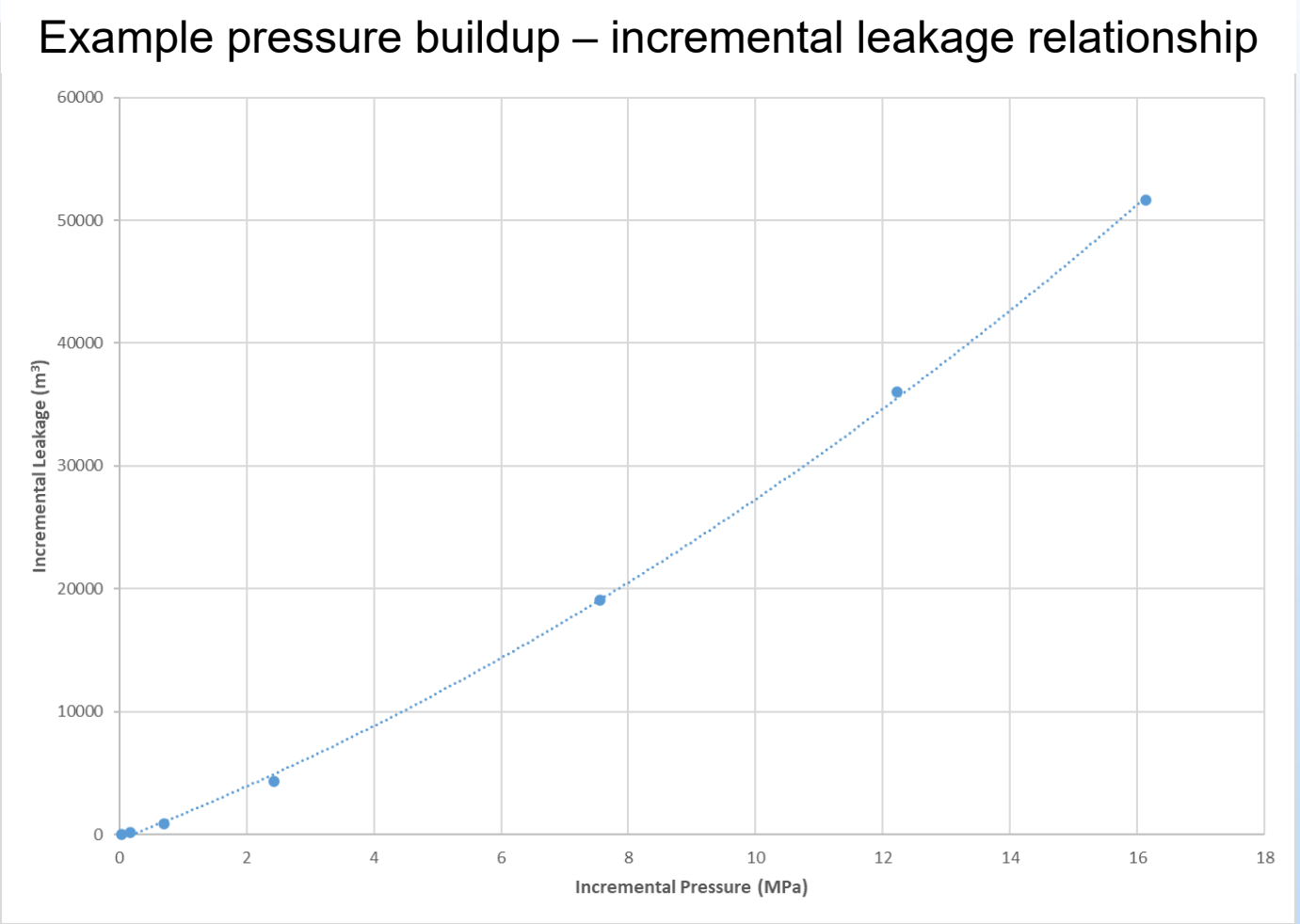
Derived Inputs for SALSA

Compute Incremental Leakage as Function of Incremental Pressure

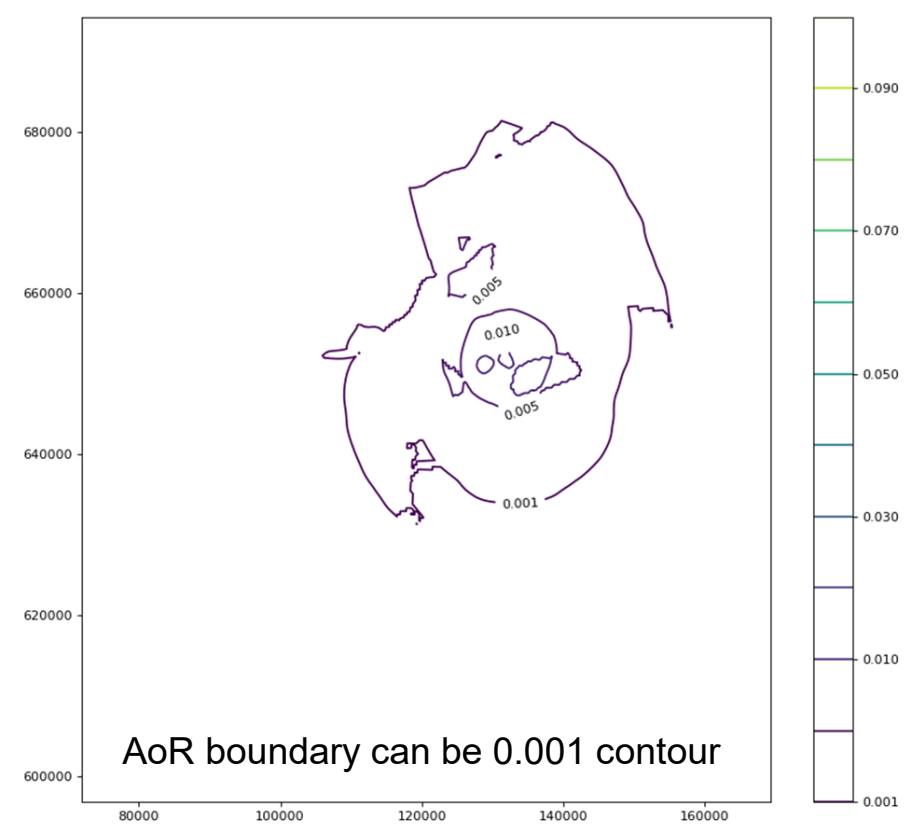
Delineate AoR

Reference: Burton-Kelly et al., 2021

Incremental Pressure – Leakage Relationship



Risk-based AoR



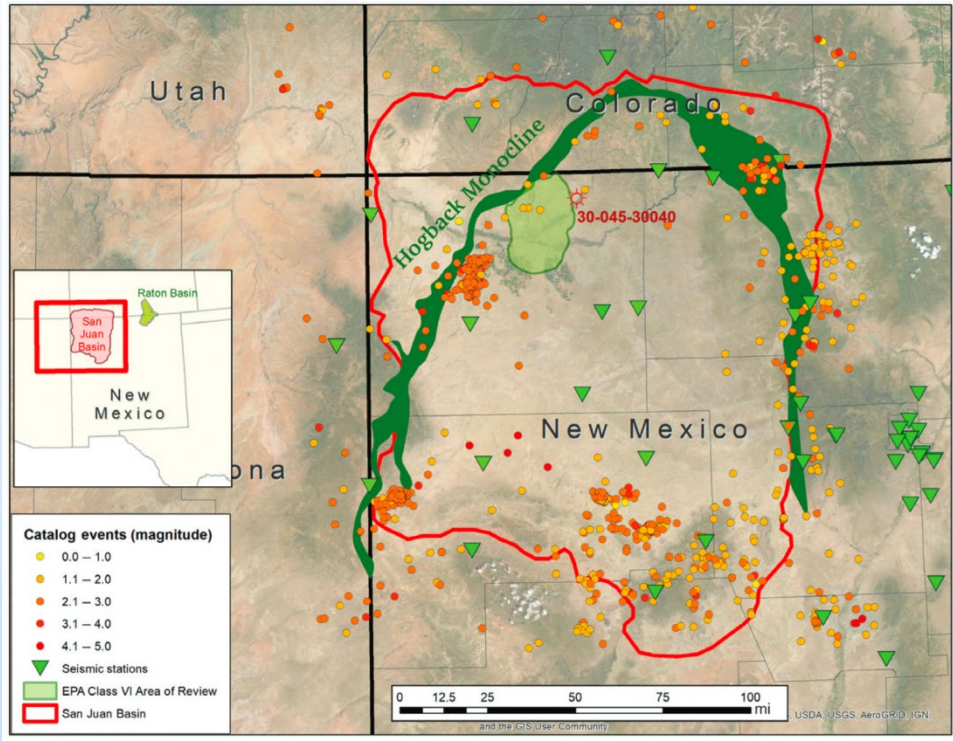
- Define a threshold criterion to the incremental leakage maps which reflects an acceptable impact to the USDW
- Defining a site-specific threshold criterion is a matter of risk judgment under uncertainty

Technical Progress 3:

Induced seismicity

Seismic History

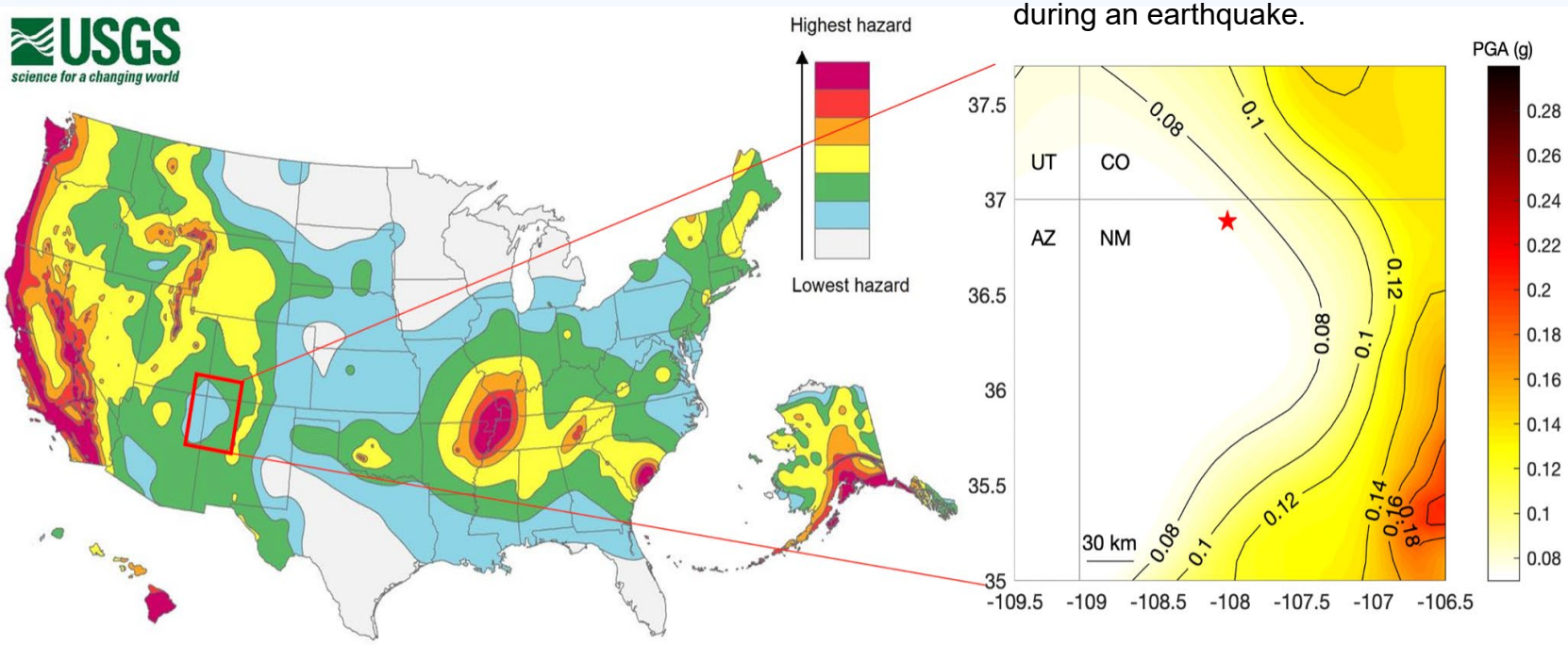
- Compiled an earthquake catalog for San Juan Basin region
  - ✓ USGS (1966-2021)
  - ✓ ANF from USArray (mostly 2007-2009)
  - ✓ Literature
    - Historical (pre-1962)
    - Instrumental (1962-2009)
- Low seismicity region (max M=4.8, less than 1 M3+ per year)
- Most events surround the basin where more tectonic structures are present
- Few seismic events within the area of interest



(McCormack et al., 2022)

Earthquake Hazard

Peak acceleration is a measure of the maximum force experienced by a small mass located at the surface of the ground during an earthquake.



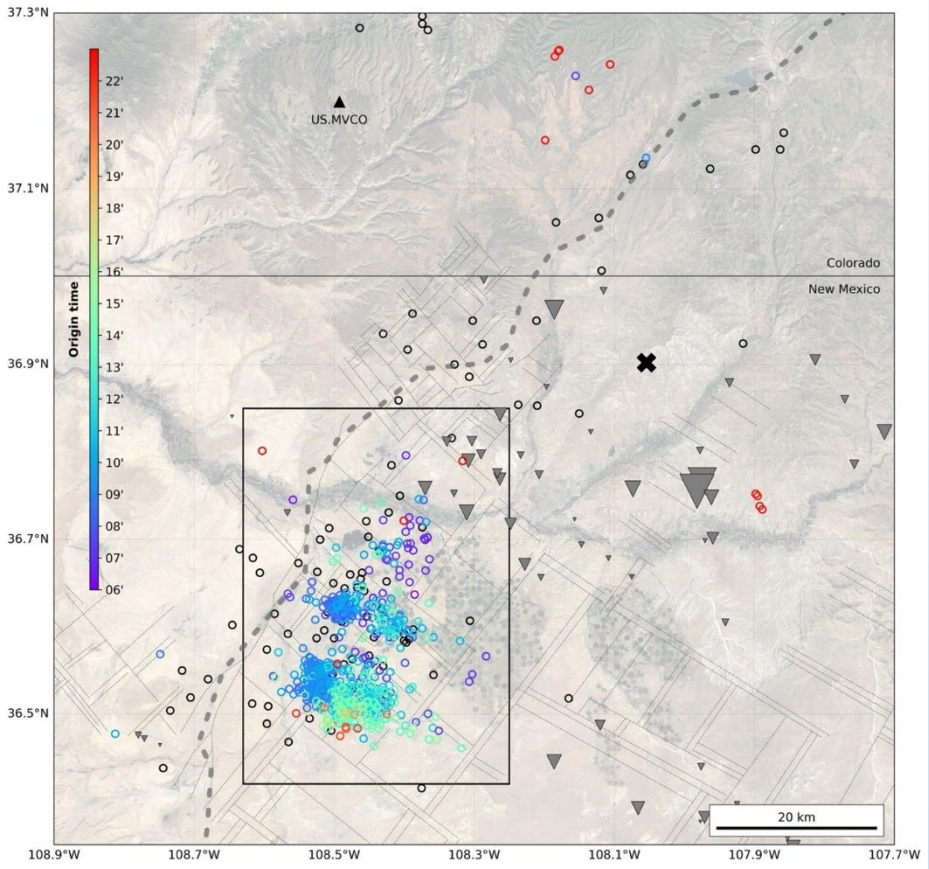
Earthquake hazard based on US Geological Survey estimation

- The proposed injection site (red star) has low earthquake hazard, showing low peak ground accelerations (PGA) with a 2% probability of exceedance in 50 years.

Low Earthquake Hazard

- **Low earthquake hazard in the proposed San Juan Basin site is confirmed by a synergistic study** funded by DOE base program, which involves local seismic monitoring using a temporary seismic network deployment.

- Earthquake event detection magnitude threshold is lowered, but still **few earthquakes are found within the area of interest, suggesting low earthquake hazard.**

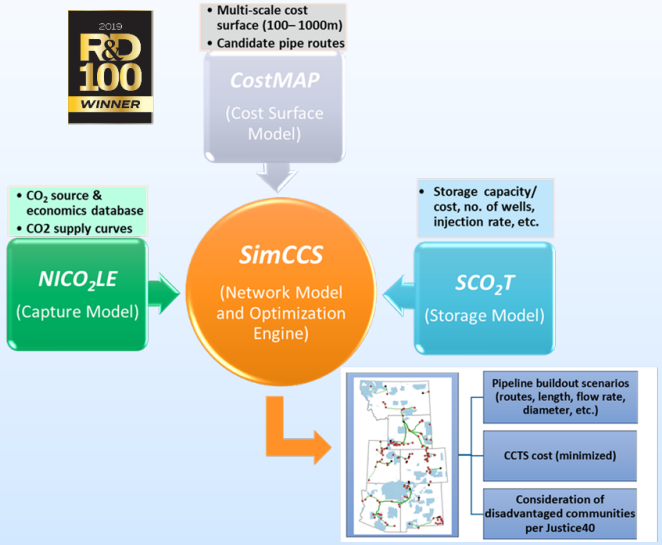


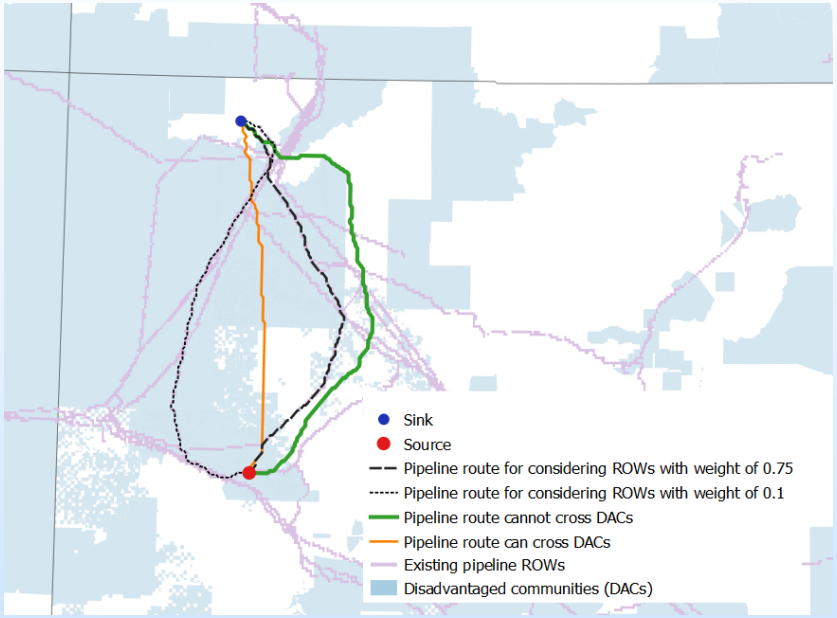
Most detections are mining events, not earthquakes

Technical Progress 4:

Pipeline Modeling

SJB CarbonSAFE Pipeline Routes (Preliminary)



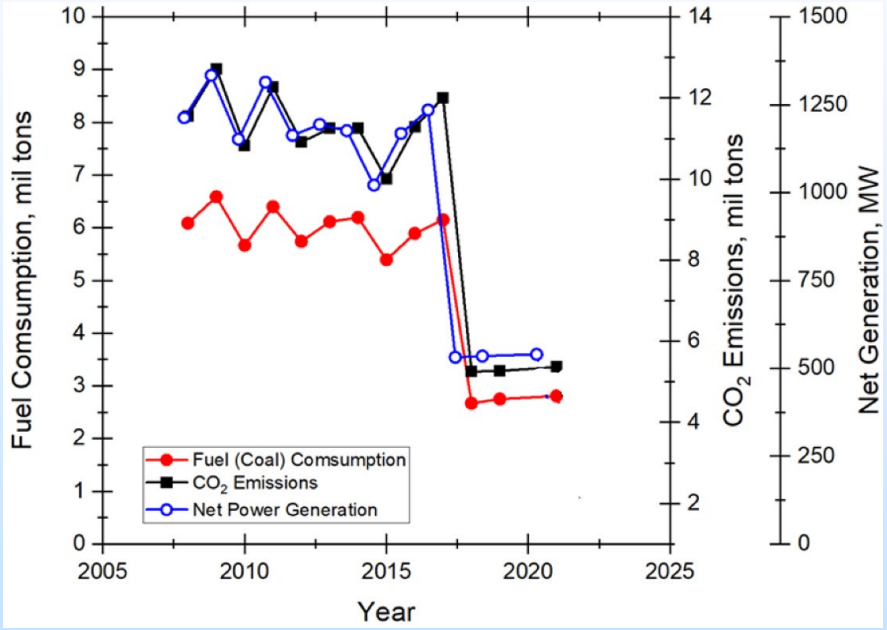


Scenario	Pipeline route length (miles)	Shared corridor length (miles)	ROWs utilization percentage
Pipeline route cannot cross DACs	142.9	10.6	7.39%
Pipeline route can cross DACs	102.2	10.6	10.33%
Pipeline route for considering ROWs with weight of 0.1	133.3	126.5	94.92%
Pipeline route for considering ROWs with weight of 0.75	121.2	94.1	77.62%

Technical Progress 5:

Technical assessment of CO_2 source viability

San Juan Generating Station CO_2 Emissions



Yearly fuel coal consumption (red), CO_2 emissions (black), and net generation (blue)

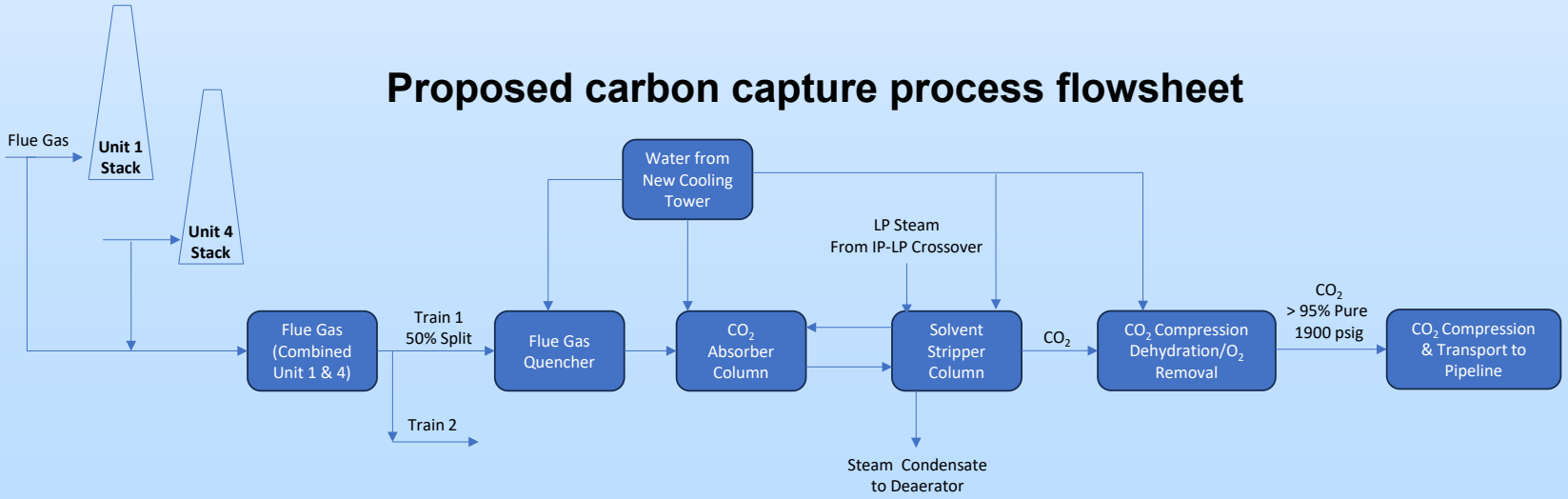
Parameter	Units	Unit 1 & 4 Combined Flow	
Temperature	°F	127	
Pressure [Note 1]	in.w.c.	-6	
	psia	11.788	
Volumetric Flow Rate	scfm at 68°F	2,846,302	
Flow Rate / Composition			
Nitrogen + Argon (N_2 + Ar)	lb/hr-vol.%	8,303,023	66.92
Oxygen (O_2)	lb/hr-vol.%	847,396	5,98
Water (H_2O)	lb/hr-vol.%	1,368,539	17.16
Carbon Dioxide (CO_2)	lb/hr-vol.%	1,936,347	9.93
Sulfur Dioxide (SO_2)	lb/hr-ppmv wet	523	18
Nitrogen Oxides (NOx)	lb/hr-ppmv wet	2,167	106

Note 1 – Atmospheric pressure = 12.004 psia

Flue gas composition, volume and operating conditions used as design basis

CO_2 Capture System and Source Viability

- CO_2 capture system was designed based on Mitsubishi Heavy Industries Americas (MHIA)'s Kansai Mitsubishi (KM) Carbon Dioxide Recovery (CDR) Process.
- The advanced KM CDR process can capture more than 90% CO_2 with a purity of 99.9% by volume.
- Our analysis indicates that the CO_2 capture from SJGS using KM CDR technology would have been a viable CO_2 source to support San Juan basin storage complex.



Summary

- Class VI regulations require the delineation of AoR through computational modeling, identification of potential conduits for fluid flow within AoR and need for corrective actions

- Quantitative leakage risk assessment (e.g., with NRAP-Open-IAM) can be utilized to determine the potential for USDW endangerment due to leakage through legacy wells within AoR
  - ✓ Our analysis indicates no CO_2 leakage, negligible brine leakage, and no USDW impact

- No immediate corrective actions are required for the legacy wells within AoR; a phased approach can be utilized in a later stage

Summary

- Risk-based AoR was delineated for SJB over-pressured CO_2 storage system
- The proposed injection site has low earthquake hazard
- CO_2 pipeline transport options has been optimized by considering ROWs and disadvantaged communities
- The CO_2 capture from SJGS using KM CDR technology would have been a viable CO_2 source to support San Juan basin storage complex

Thank you

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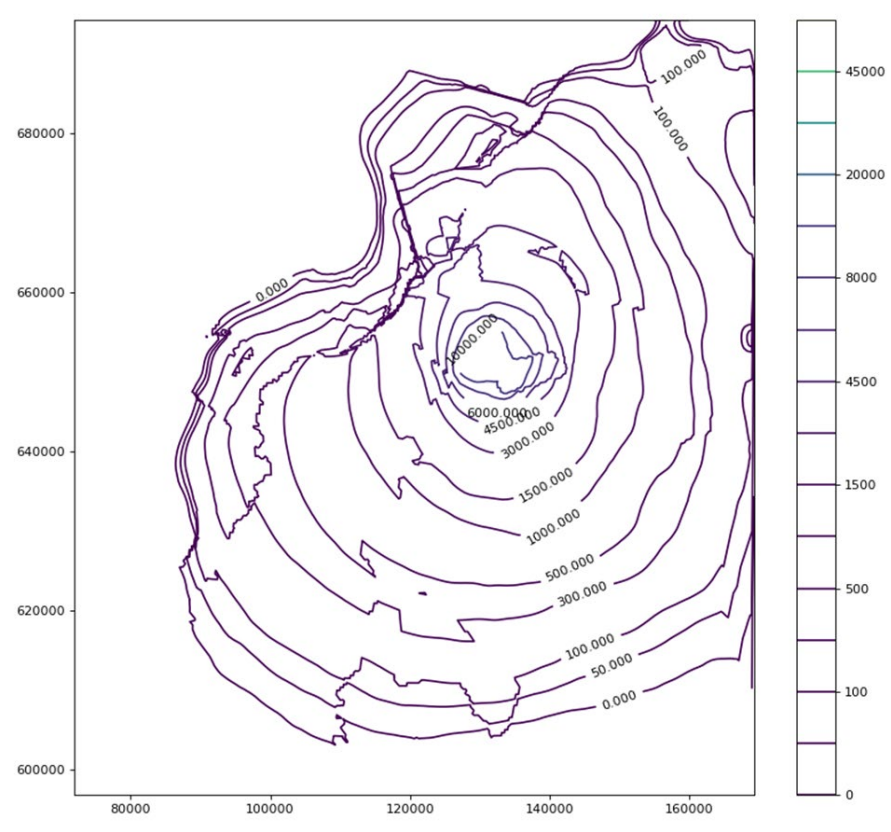
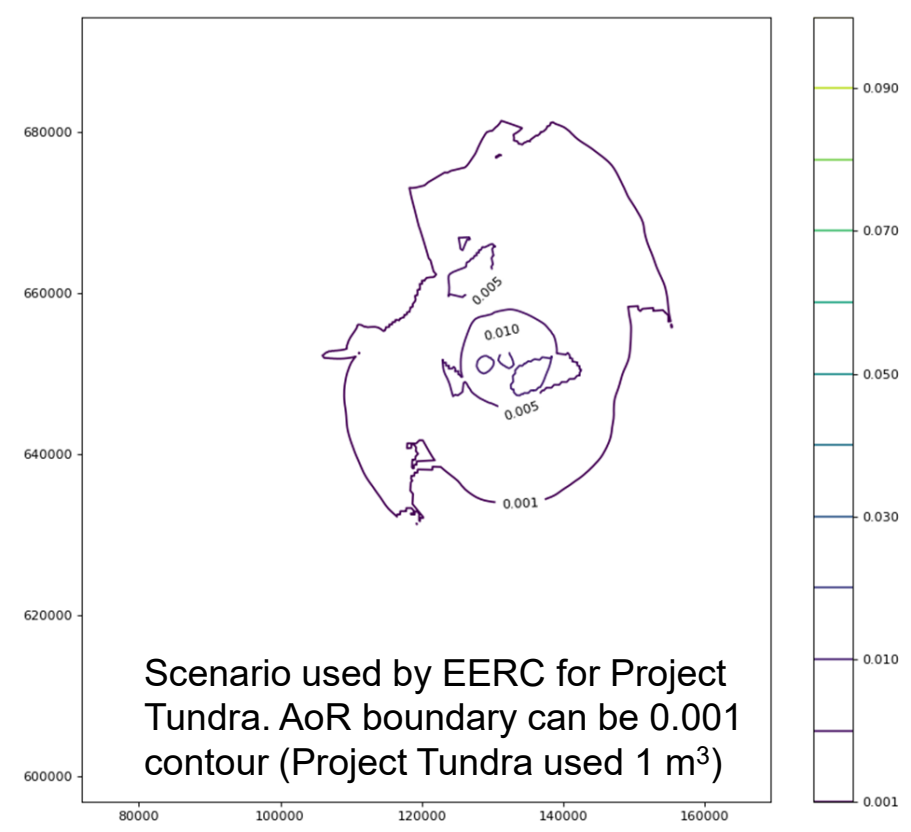
Risk-based AoR

Leaky Well Perm – 100 Darcy



Leaky Well Perm – 0.1 mD



Scenario used by EERC for Project Tundra. AoR boundary can be 0.001 contour (Project Tundra used 1 m^3)