Assessment of CO_2 Leakage into USDW during CCS project operations

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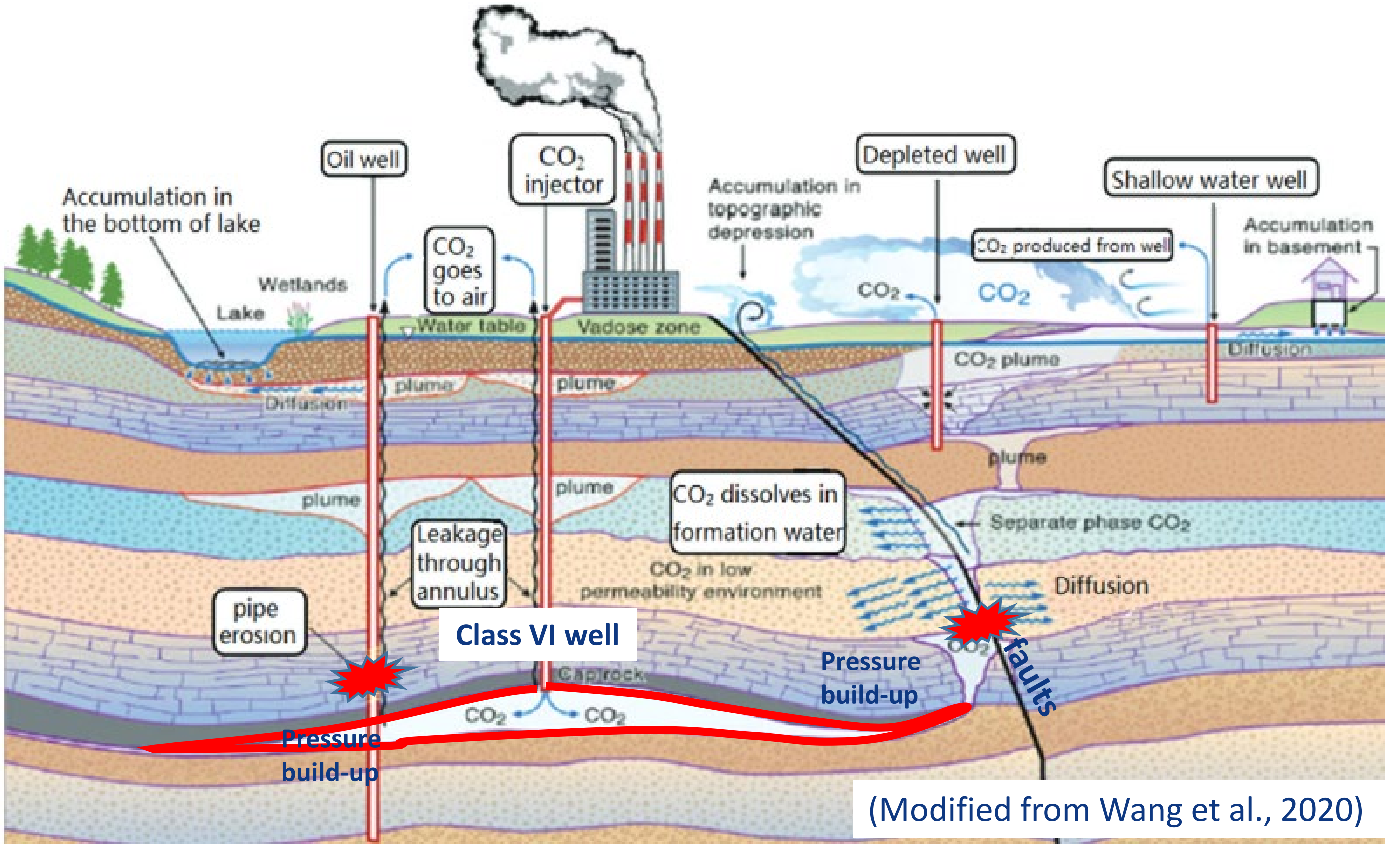
Contents

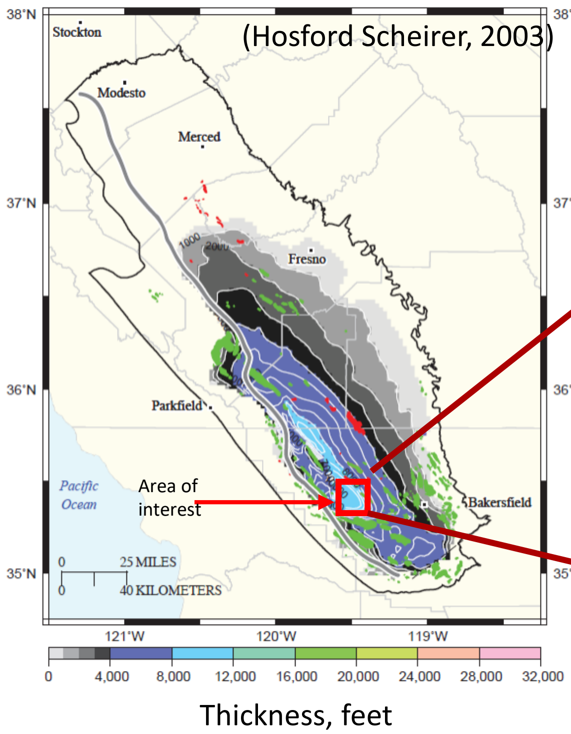
Potential Risks to USDW During GCS

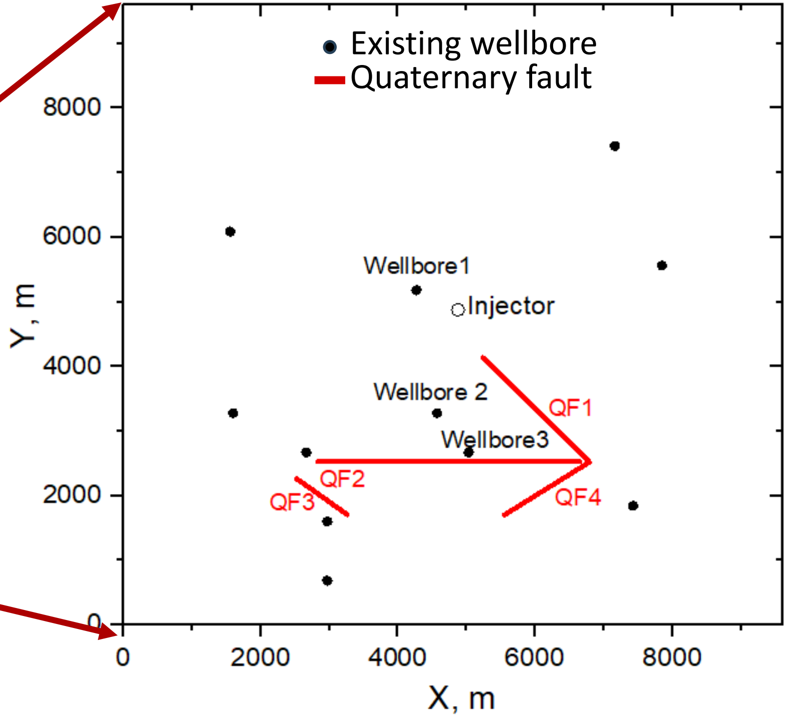


(Modified from Wang et al., 2020)

Overview of the CCS site

Target Storage formation: Etchegoin Formation





Objectives

- Evaluate the potential for CO_2 leakage along pre-existing wells and Quaternary faults
- Establish a repeatable methodology for CO_2 leakage risk assessment for CO_2 storage sites.

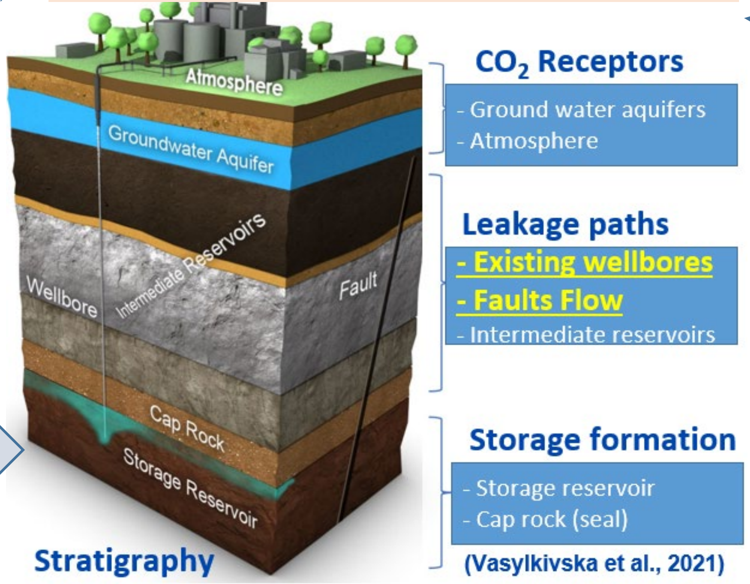
Leakage Risk Assessment Method

Develop a subsurface model & evaluate with a reservoir simulator

NRAP-OPEN-IAM

Assess leakage rates of brine and CO_2

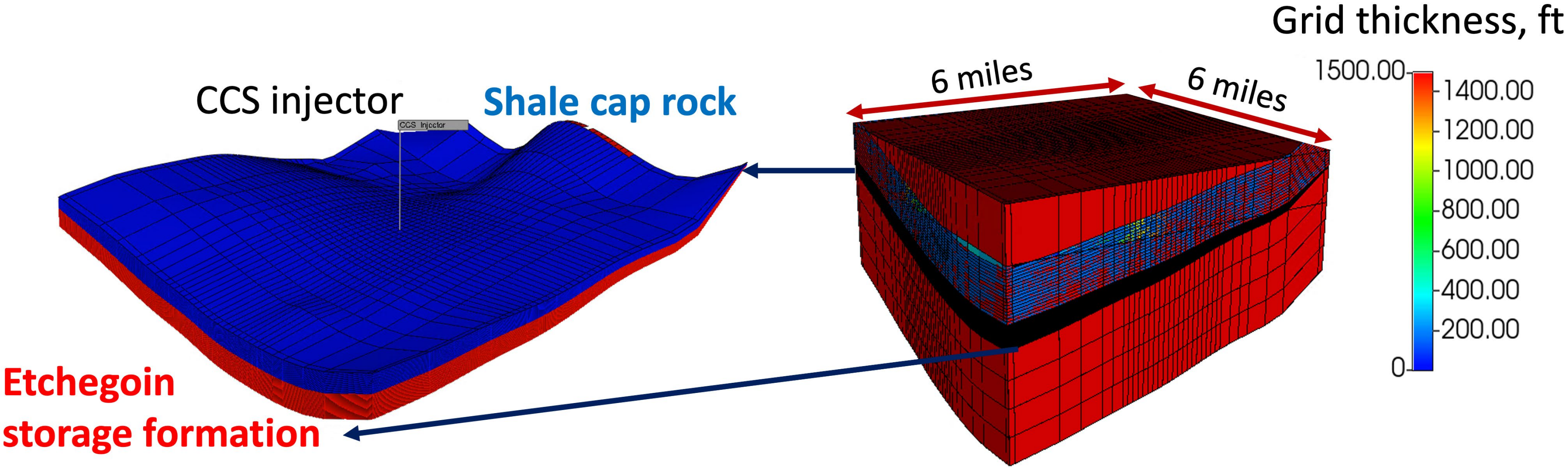
Investigate the impact on the USDW



https://edx.netl.doe.gov/nrap/nrap-open-iam/

Optimized CO_2 injection well trajectory (Li et al., 2024)

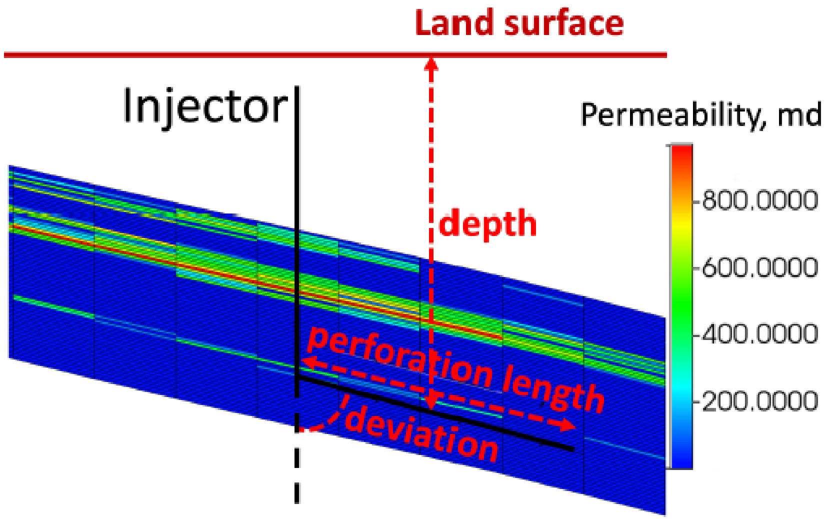
Reservoir Model Overview



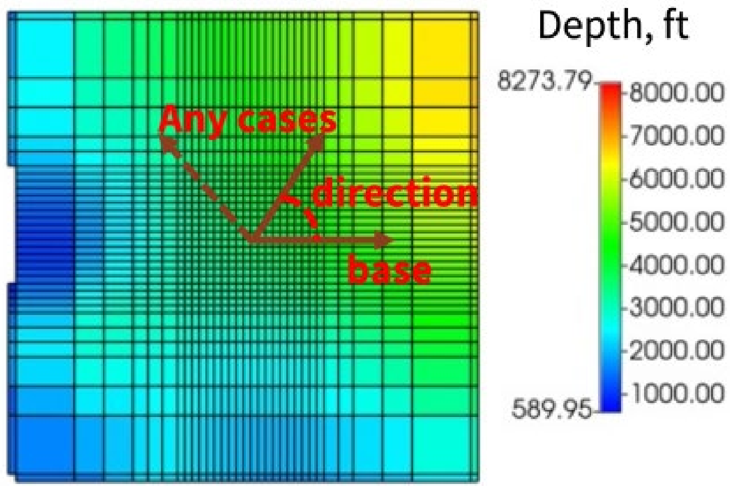
Etchegoin Formation
- Gridblocks: 33 by 33 by 75

(Li et al., 2024)

Optimized Well design with parameters



Deviated trajectory

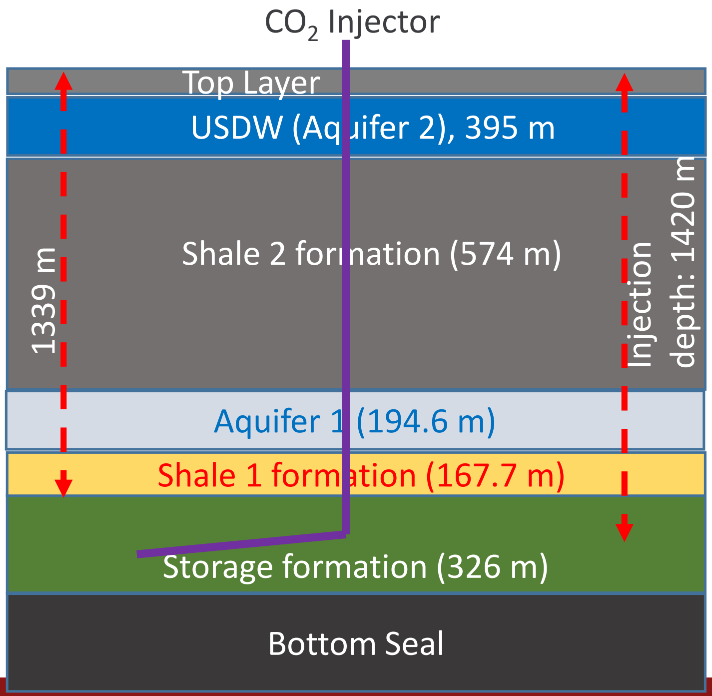


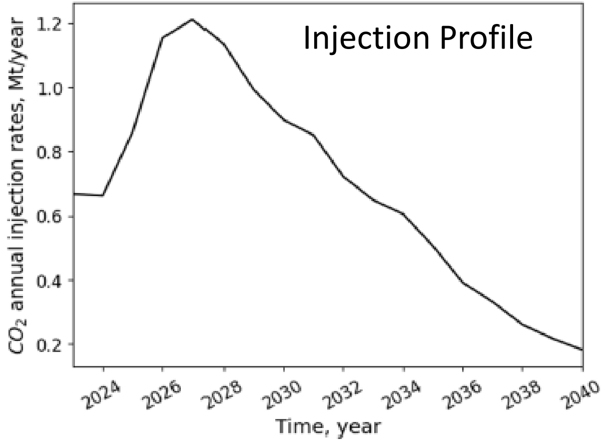
Base direction is defined to East

(Li et al., 2024)

Leakage Risk Assessment Parameters

- Injection: 0.683 Mt CO_2/y for 18 years injection and 100-year monitoring
- Injection trajectory: deviated injector





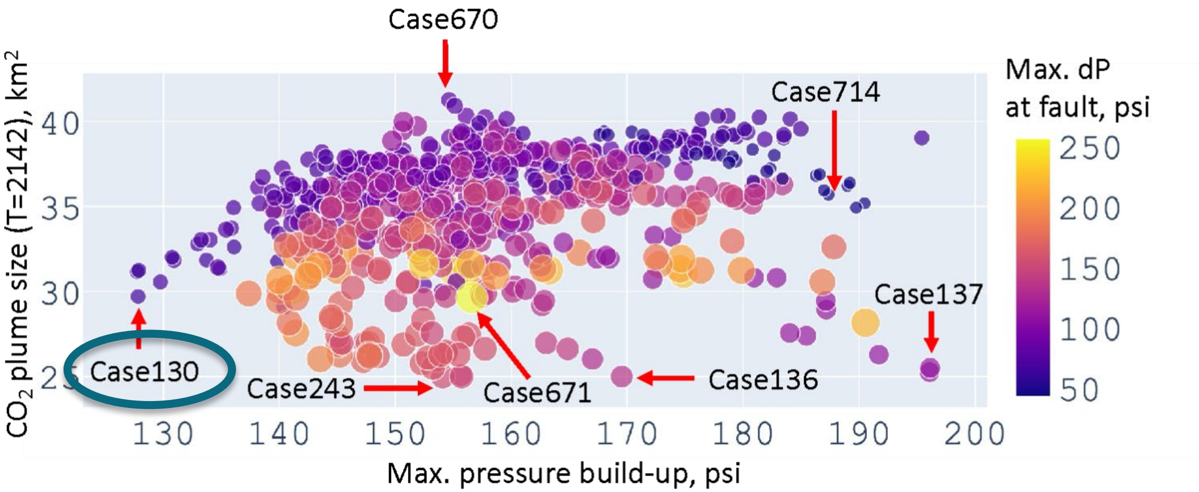
- Wellbore Perm.: 1- 10 mD (Kim et al., 2023)
- Perm. of Storage formation: 30 mD
- Perm. of Shale 1 and 2: 0.02 mD, 0.01 mD
- Fault effective aperture: 1E-4 – 2.5 cm

Results of Leakage Risk Assessment

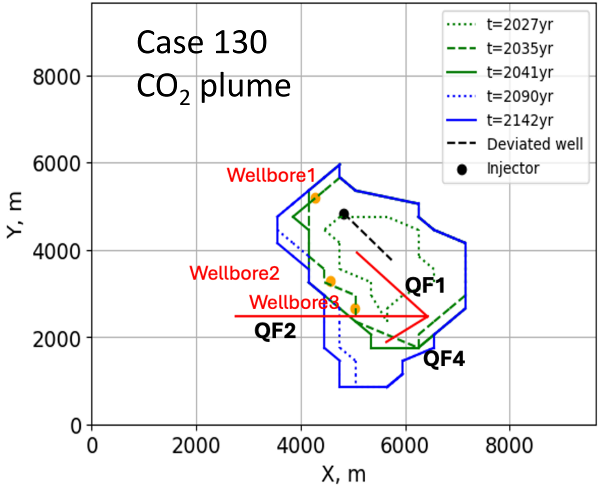
- Optimized Plume Migration
- Results of Leakage Risk Assessment

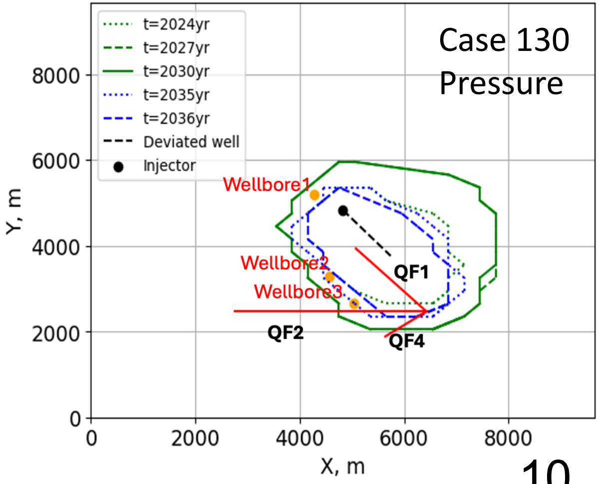
  - Existing Wellbores & Quaternary faults

Optimized injector controls pressure build-up (< 10%) and CO_2 plume migration

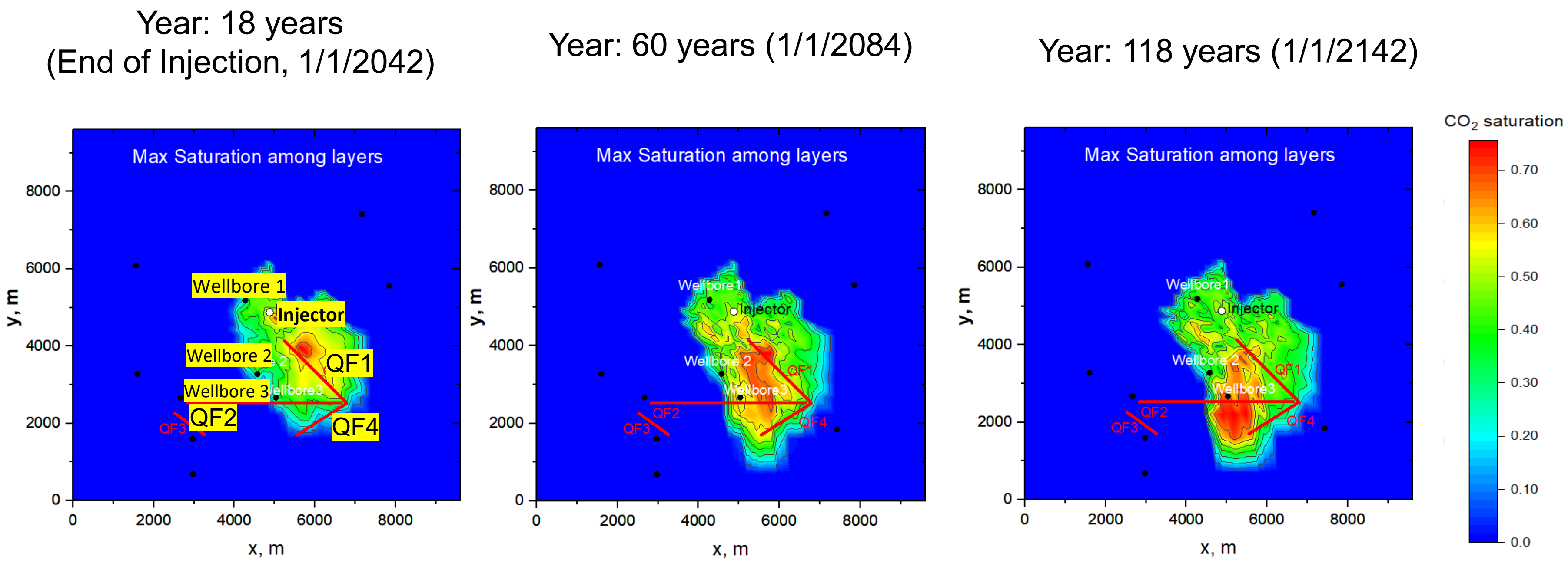


(Li et al., SPE WRM 2024)





CO_2 Plume Migration (Case 130)



CO_2 and Brine Leakage Through Existing Wellbores

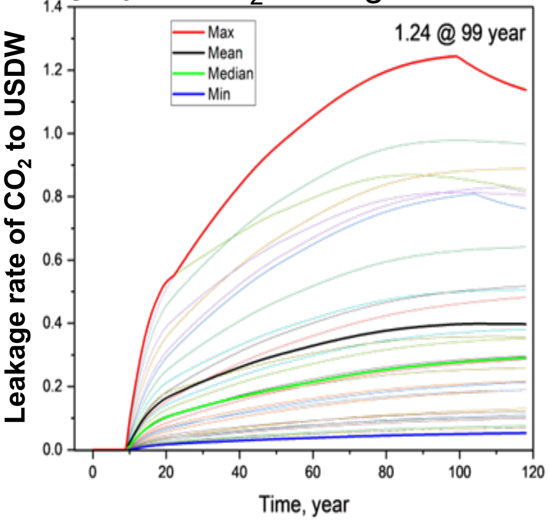
Wellbore 1 is main leakage path.

Cumulative CO_2 leakage ratio (CLR) into USDW

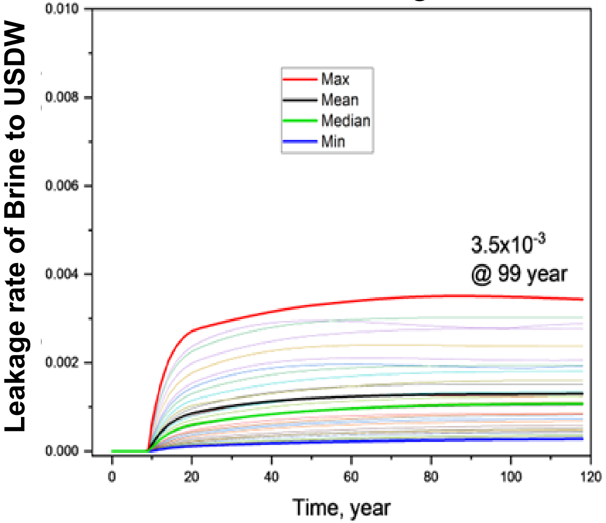
$$= \frac{Cumulative\ leakage\ of\ CO_{2,mass}\ into\ USDW}{Total\ injected\ CO_{2,mass}\ in\ storage\ formation}$$

Leakage of Wellbore 1+2 = $2.8 \times 10^{-6} \sim 1.44 \times 10^{-5}$ (0.0003 – 0.0014 %)

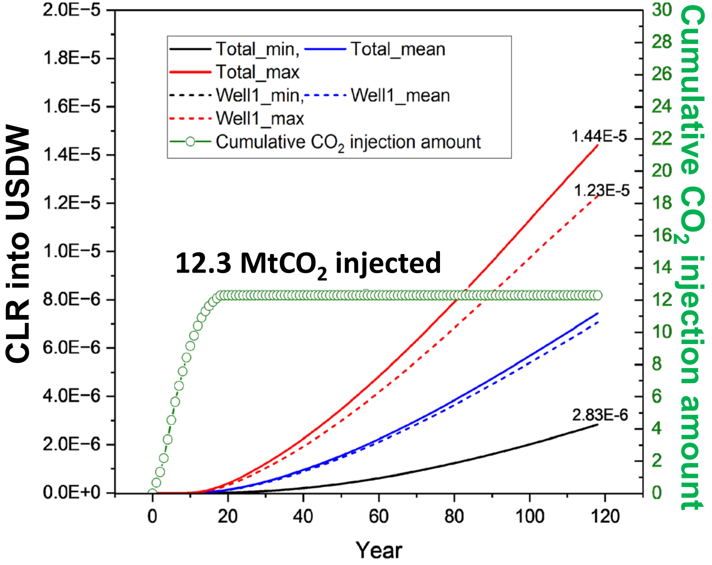
kg/day CO_2 leakage



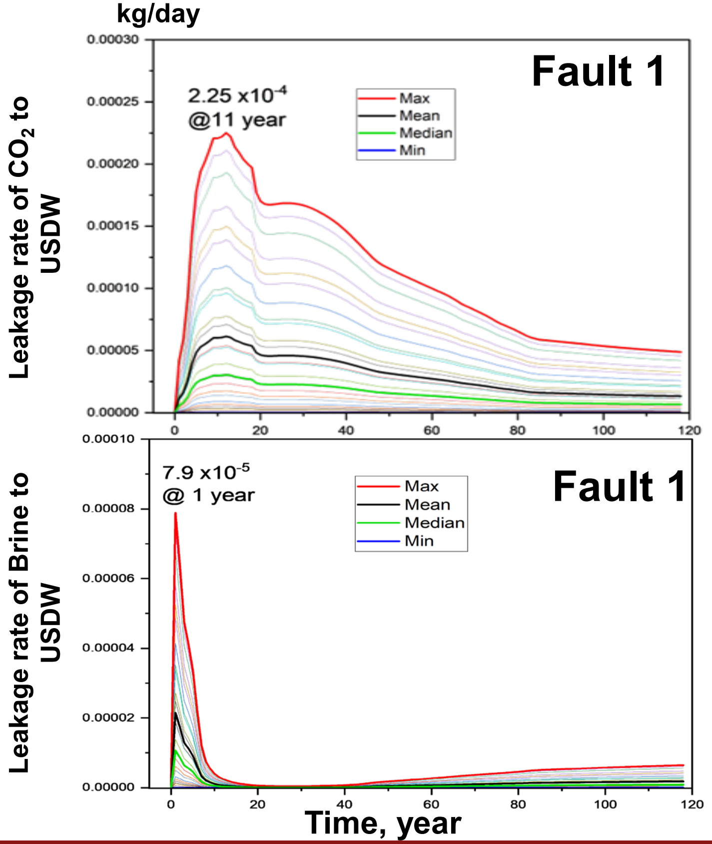
kg/day Brine leakage

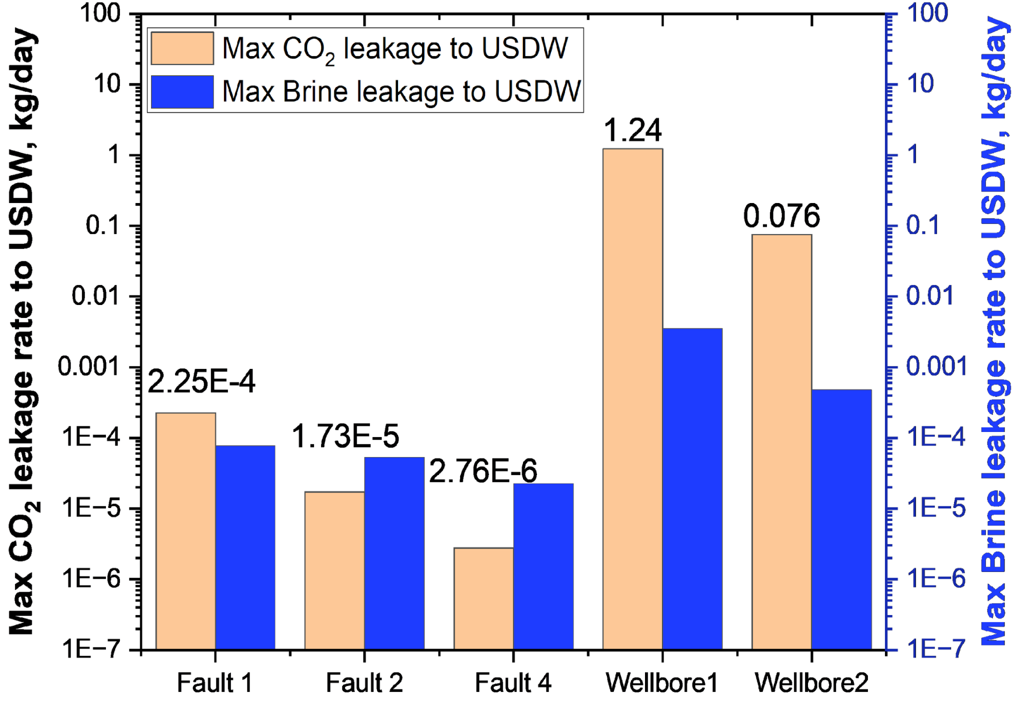


Wellbore 1



CO_2 and Brine Leakage to USDW Along Faults

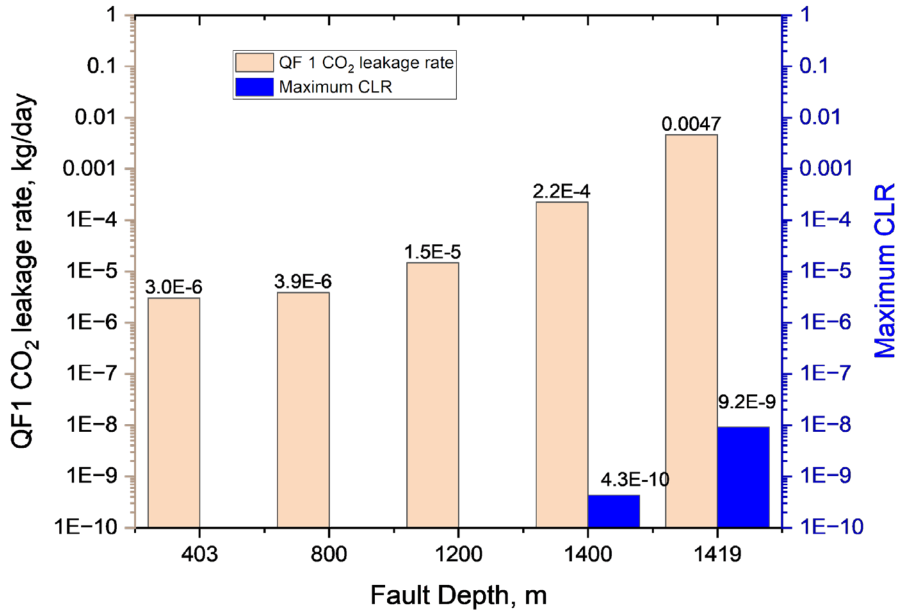




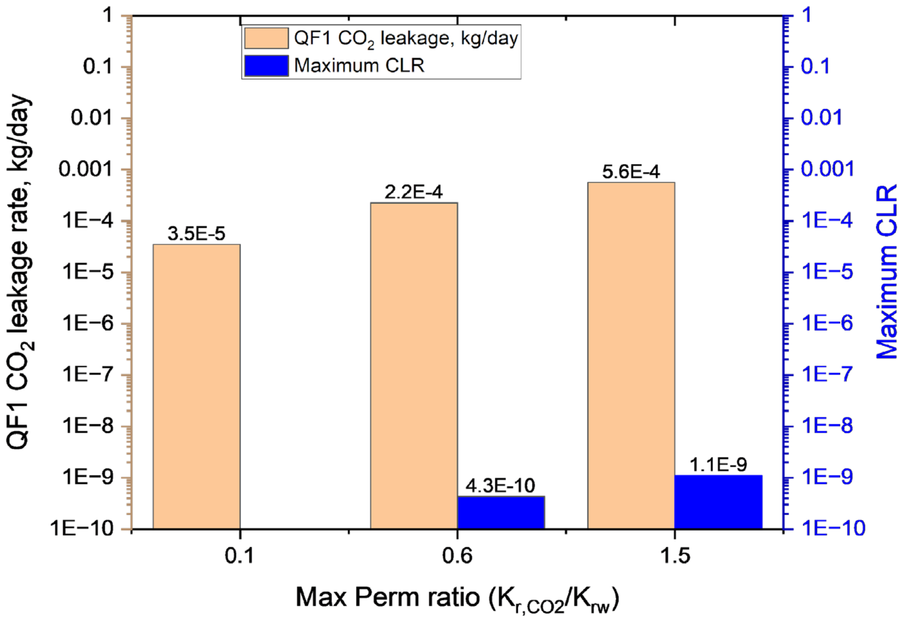
QF parameters: 1400 m Fault Depth, 4 Segments,
Max Perm ratio: 0.6, Aperture: 2E-4 – 2.5 cm

Maximum Leakage Rate on QF Parameters

Leakage of CO_2 and brine through faults is negligible compared to existing wellbores



Max Perm ratio: 0.6, Frac. Aperture: 0.0002 - 2.5 cm



Fault depth: 1400 m, Frac. Aperture: 0.0002 - 2.5 cm

Conclusions

- Optimized injector controls pressure build-up (< 10%) and plume migration
- Main leakage pathways are

  - two existing wellbores

  - two Quaternary faults (QF1, QF2)
- CO_2 leakage through QF is negligible compared to the existing wellbores
- The cumulative leakage fraction to USDW compares to the total injection amount in the worst-case at existing wellbores was 1.44×10^{-5} (0.0014 %)

Acknowledgement

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References

CO_2 and Brine Leakage Through Existing Wellbore 2

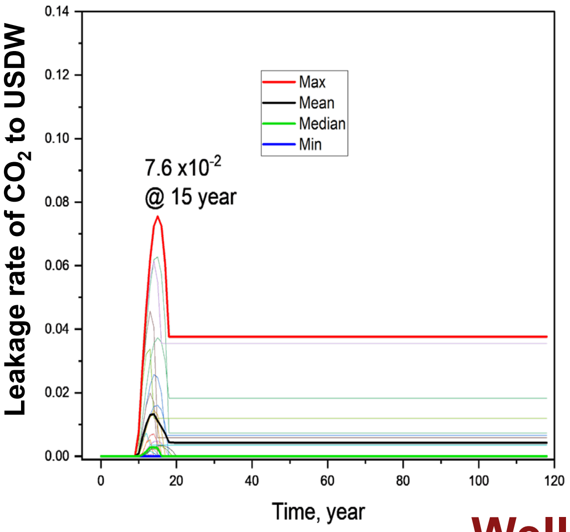
- Wellbore 2 is relatively small comparing Wellbore1.
- Brine leakage is relatively small amount

Cumulative CO_2 leakage ratio (CLR) into USDW

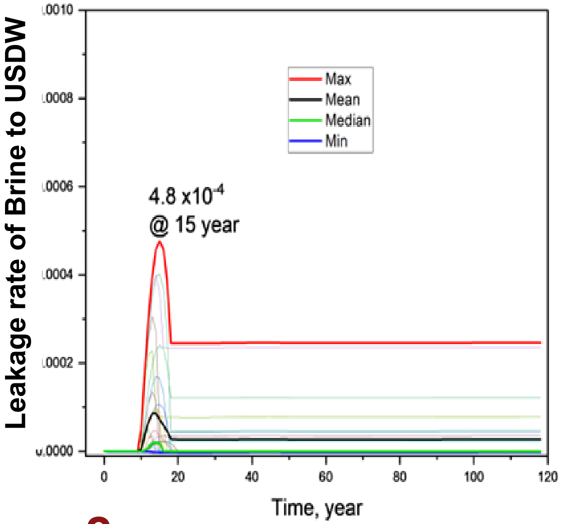
$$= \frac{Cumulative\ leakage\ of\ CO_{2,mass}\ into\ USDW}{Total\ injected\ CO_{2,mass}\ in\ storage\ formation}$$

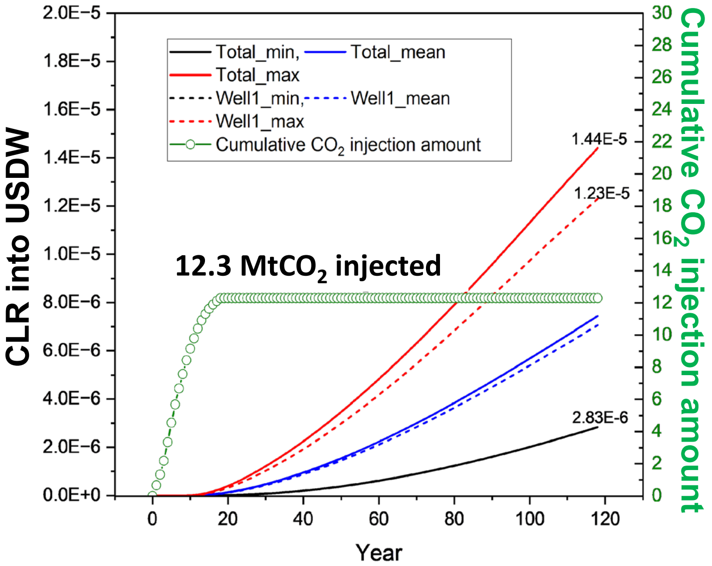
Leakage of Wellbore 1+2 = $2.8 \times 10^{-6} \sim 1.44 \times 10^{-5}$ (0.0003 – 0.0014 %)

CO_2 leakage



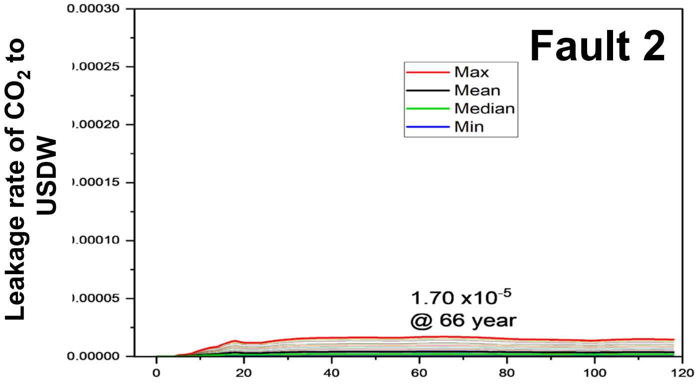
Brine leakage

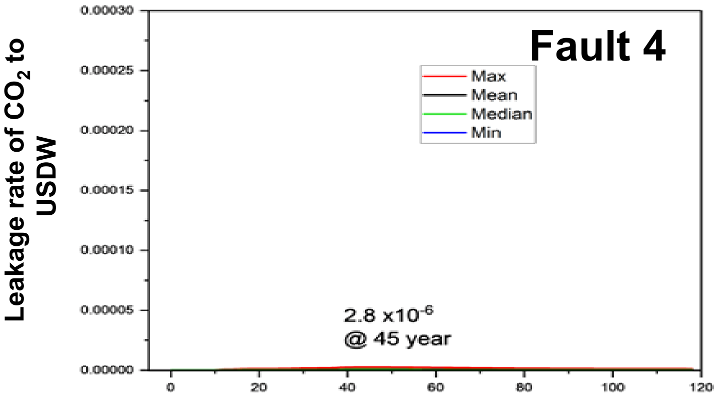


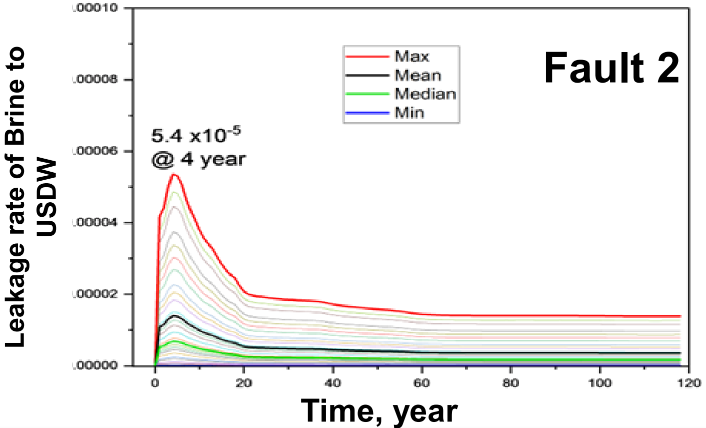


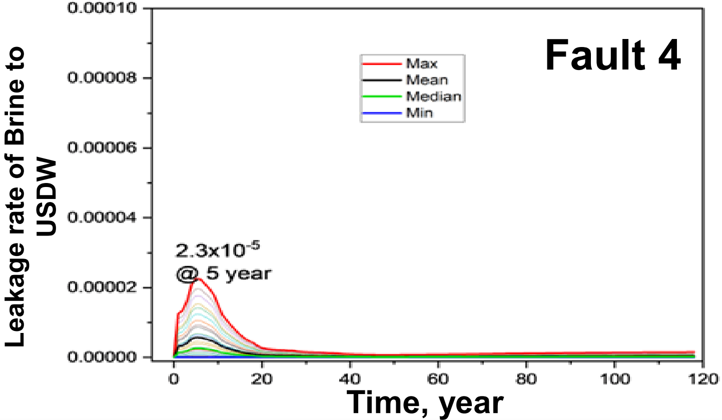
Wellbore 2

CO_2 and Brine Leakage Through QFs



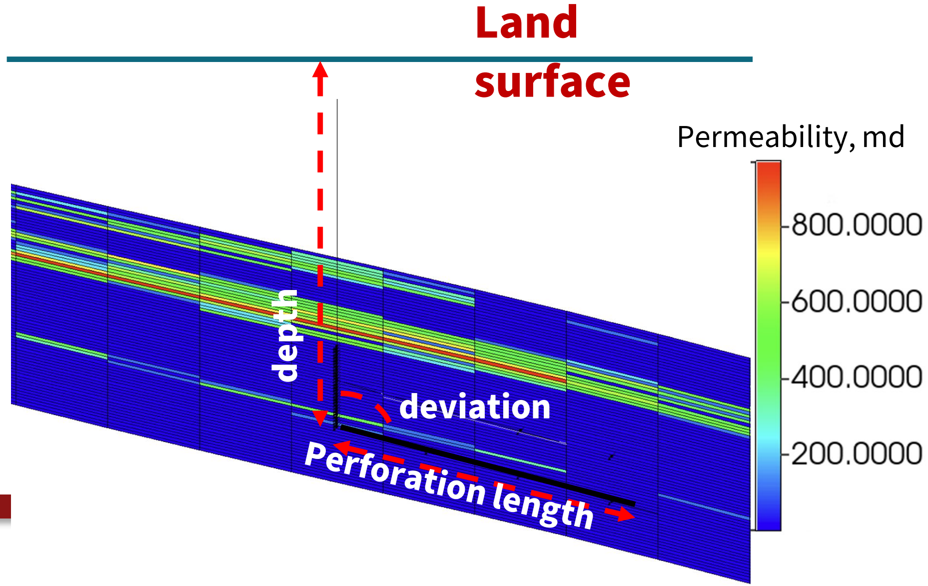


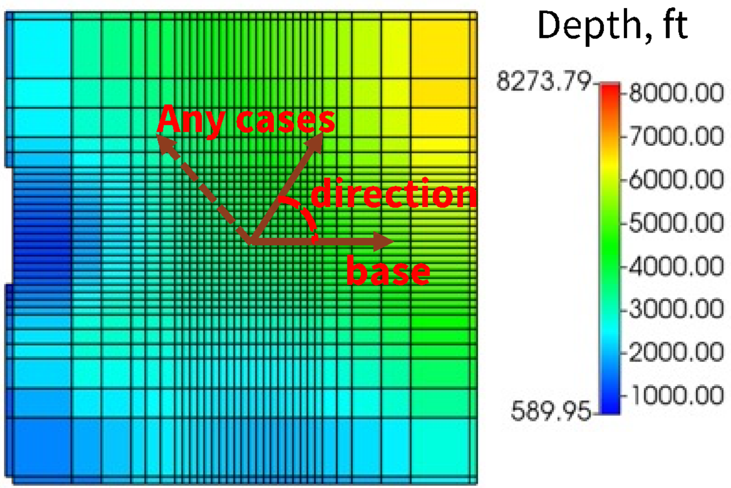




Realistic Geomodel and Well Optimization

- Deviated trajectory
- Depth: 4100 – 4900 ft
- Direction: 0^{o} – 360^{o}
- Deviation angle: 78^{o} – 98^{o}
- Perforation length: 100 ft – 5100 ft





Base direction is defined to East