

CCS Design and Long Term Storage Considerations

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Prepared for NASTL Conference: July 21, 2025



COLORADO

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Topic Outline

- What is a class VI well
- CCS Wellbore design
- Ownership matters
- Confusion with Class I/II wells
- Operation
- Long-term Maintenance
- Repurposing existing wells for CCS
- Site Closure and Abandonment
- Post-Closure Monitoring
- References

What is a Class VI Well?

Wells used to inject carbon dioxide into deep rock formations

- Reservoirs are simply *rocks*!
- Must have confining layer above it (usually shale)
- Must be deeper than any water aquifers
“Underground Sources of Drinking Water (USDWs)”
- Supercritical CO₂
 - Fluid with behaviors of both a gas and a liquid
 - Critical Temperature $\approx 31^{\circ}\text{C}$ (88°F)
 - Critical Pressure $\approx 7.4\text{ MPa}$ ($1,070\text{ psi}$)

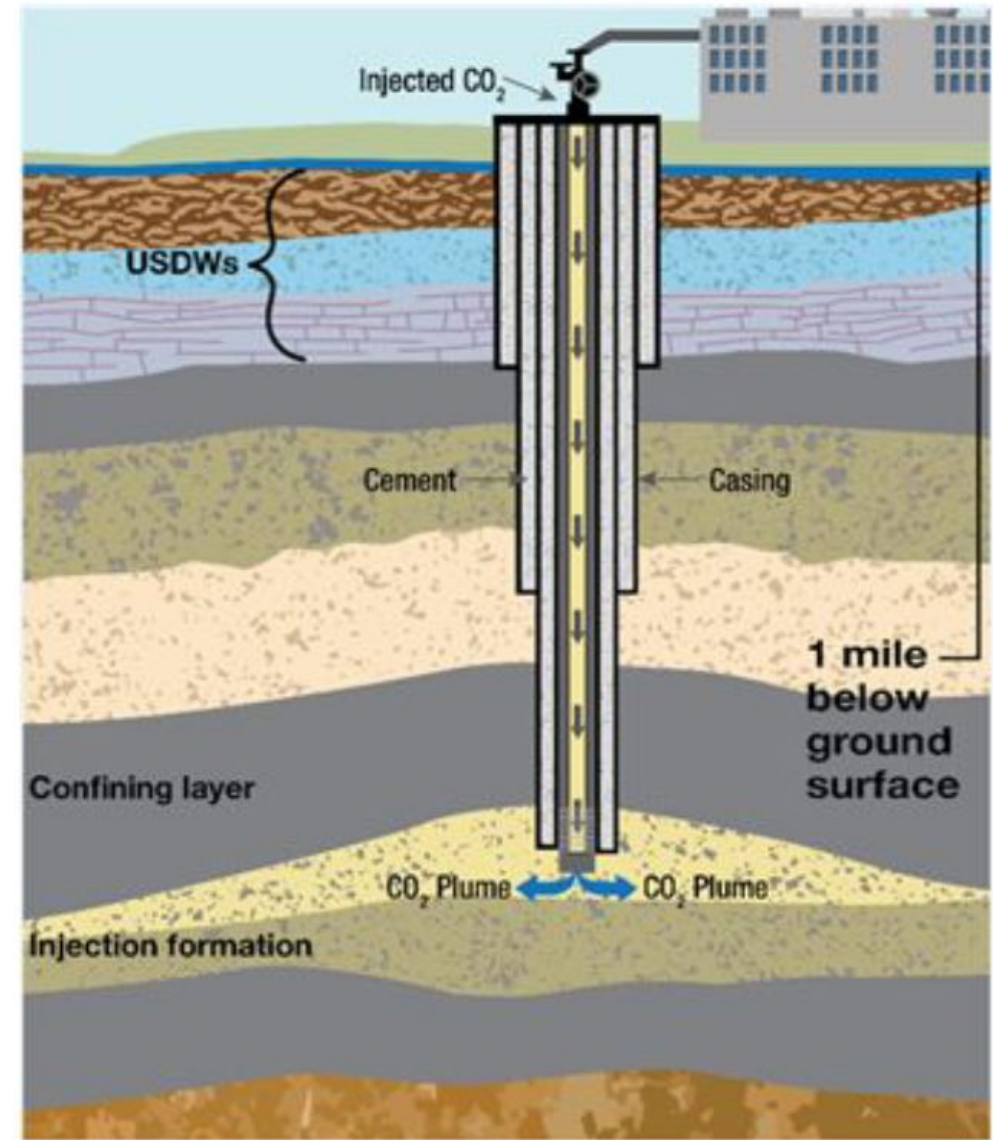
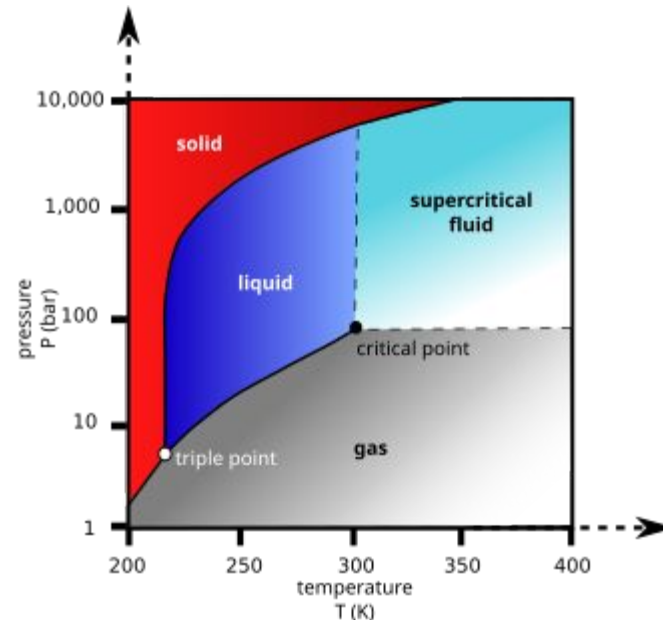


Figure not to scale

Wellbore Design Requirements

Protection of USDWs

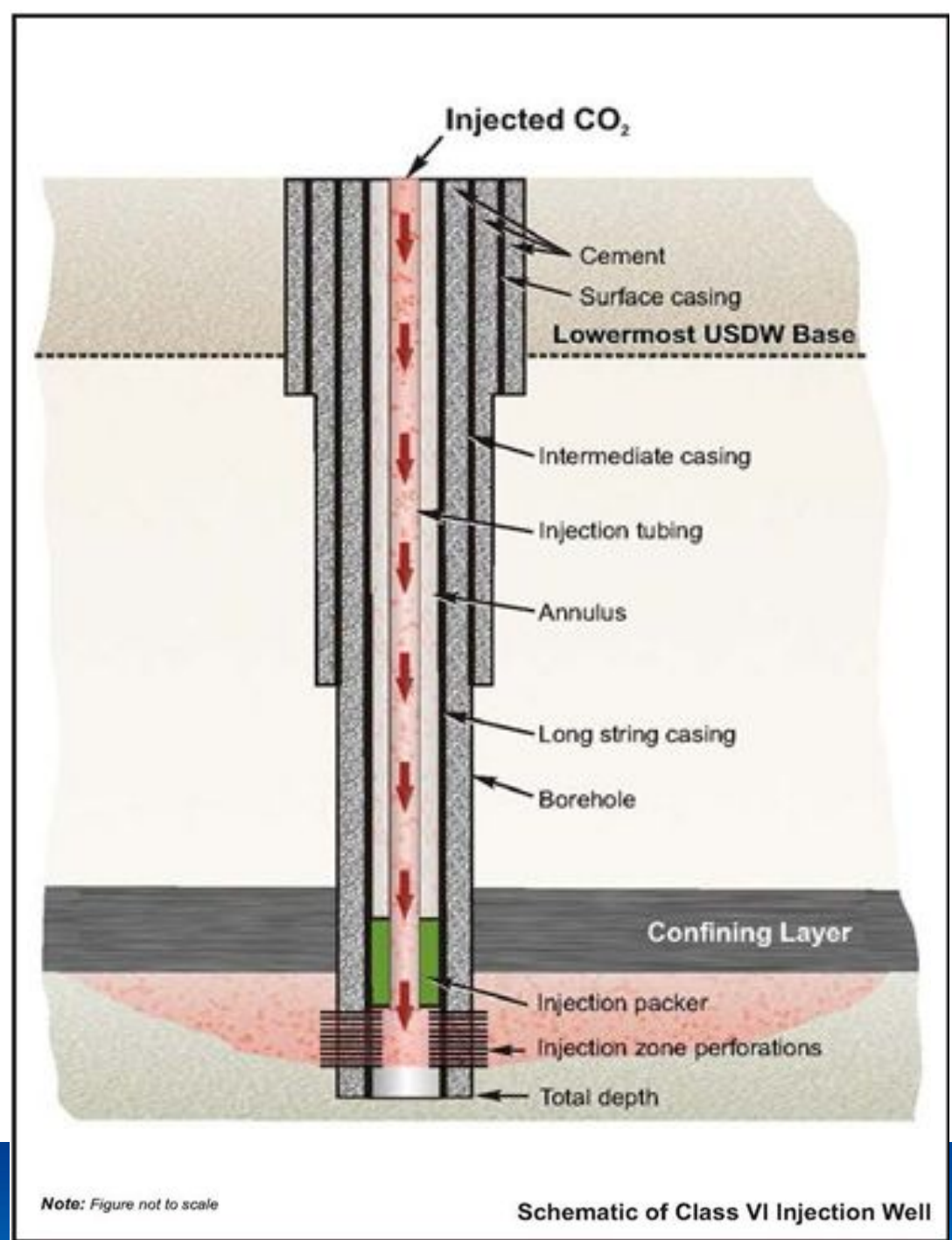
- Surface casing
- Surface cement

Corrosion Resistance

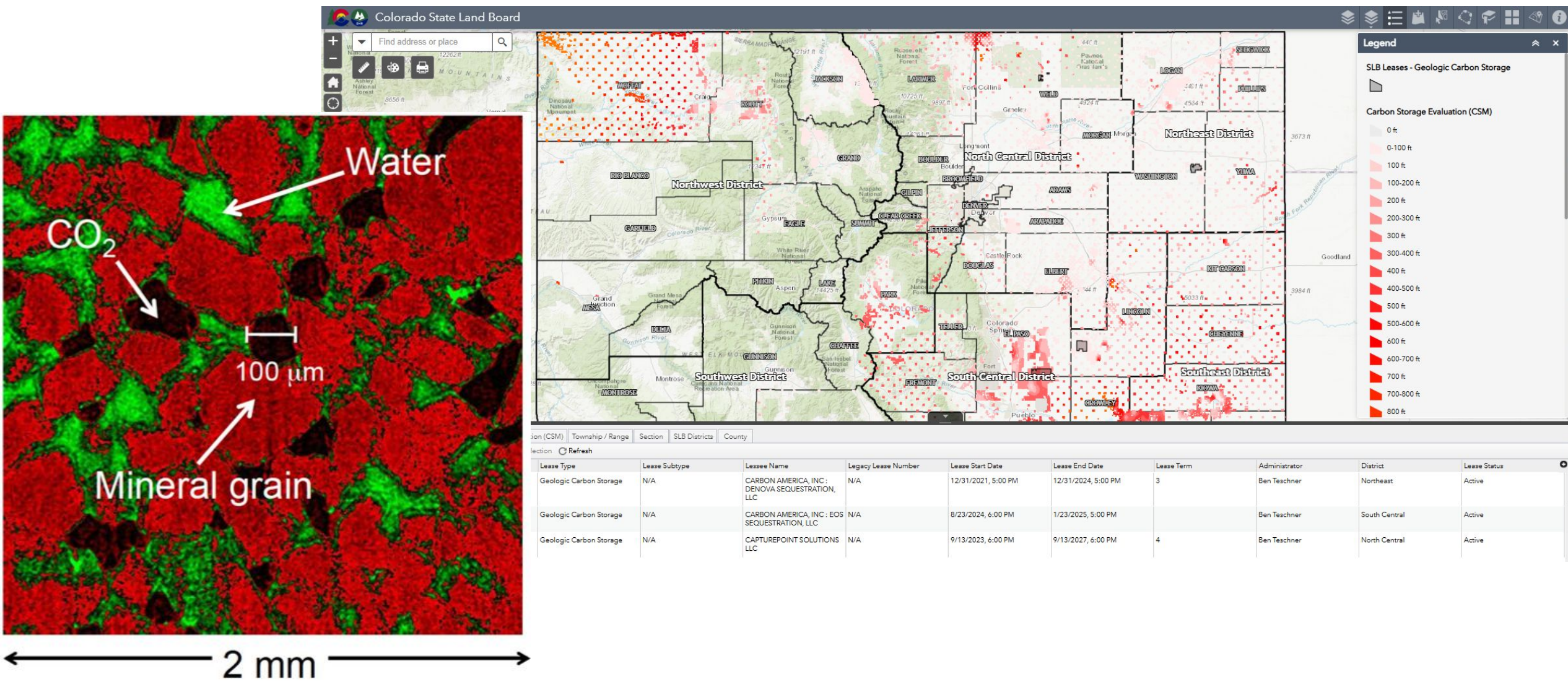
- Under pressure:



- Corrosion Resistant Alloys (CRAs)
API 5CT
- Appropriate cement selection
API 10A
- Cathodic protection



Whose CO₂ is it? Whose pore space is it? *These are different things!*



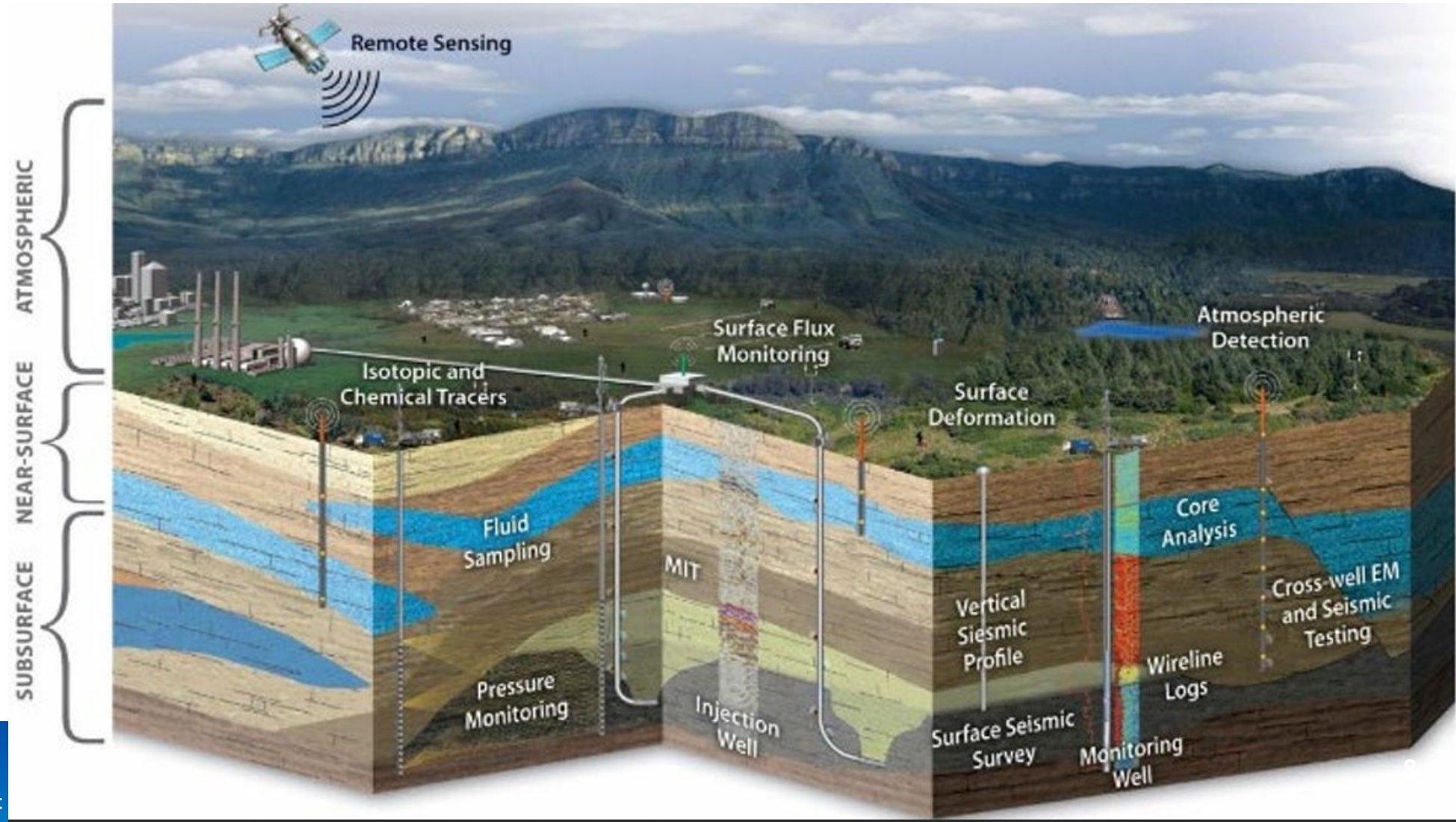
Avoid Confusion with Class I & II wells

- Class I Wells
 - Hazardous waste disposal
 - Non-hazardous waste disposal
- Class II Wells
 - Exploration & Production waste disposal
 - Enhanced Oil Recovery injection
 - Hydrocarbon storage
- Policy Consideration:
 - Avoid conflicts relating to regulatory/statutory pore space ownership between Class I, Class II, and Class VI

(see 2022 North Dakota Supreme Court case: *N.W. Landowners Assn. v. State*, 2022 ND 150)

Operational Considerations

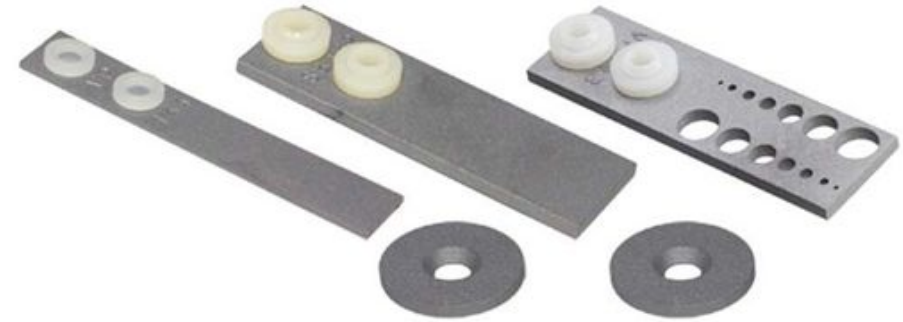
- Pressure Control
 - Continuous injection pressure monitoring
 - Immediate failure alerts and automatic shutdown systems
- Annular Pressure
 - Monitors casing integrity
 - Continuous monitoring
 - Radioactive tracer surveys
- Monitoring Wells
- Flow Measurement
 - Injection rate meters
 - Early identification of reservoir issues



Long-term Maintenance

Periodic/Continuous assessment of corrosion/integrity is critical

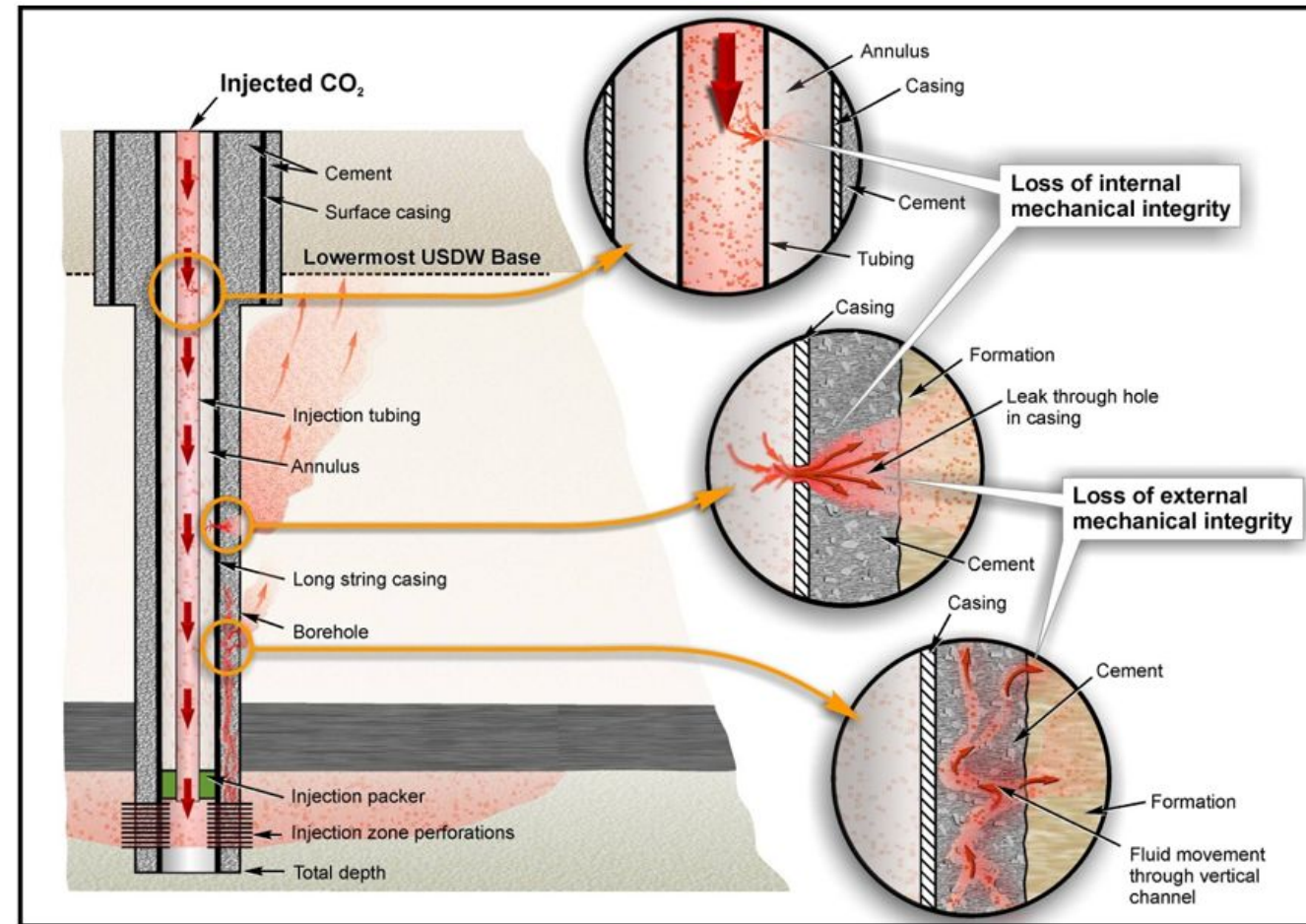
- Downhole
 - Caliper logging
 - Radioactive Tracer Surveys
 - Tubing replacements as needed
- Surface facilities
 - Corrosion coupon monitoring
 - Regular turnarounds
- Supply/Pipeline
 - Commonly a different operator
 - Different regulation (PHMSA)



Can an O&G Well be Repurposed for CCS?

It's Highly Improbable!

- Class VI wells are designed for their purpose from the start
- Existing wells must have all design components in place or easily installable
 - Corrosion resistance
 - Monitoring capability
 - Capable reservoir
- Existing integrity is critical, and is difficult:
 - Age of well and permanent elements
 - Potential for reservoir interference
 - Maintenance/ownership history



Plugging & Abandonment (P&A) of Class VI Wells vs. Oil & Gas

Similarities

- Subsurface leakage into water aquifers is a main concern
- Secured advance funding is *critical*
 - Avoid passing off costs on to taxpayers

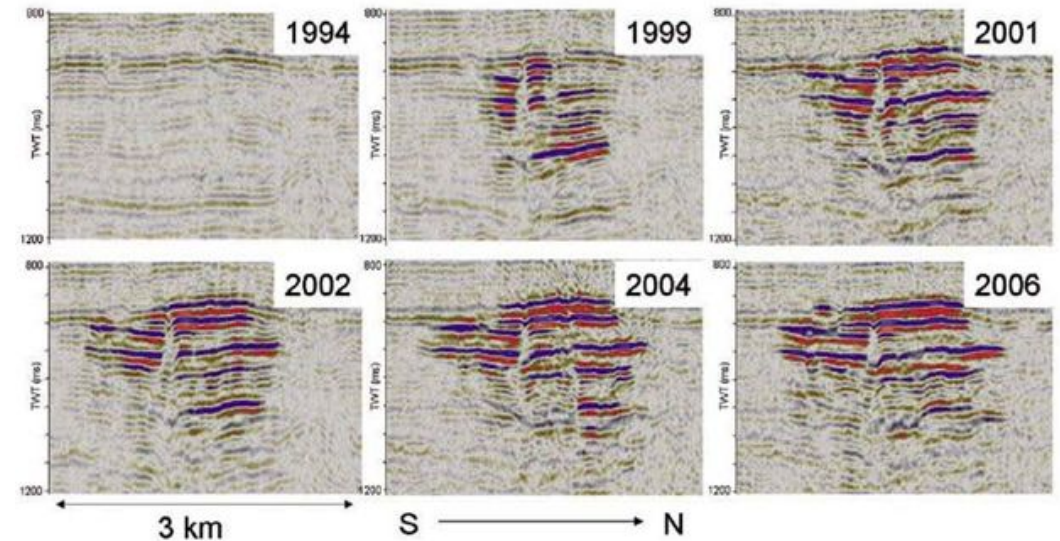
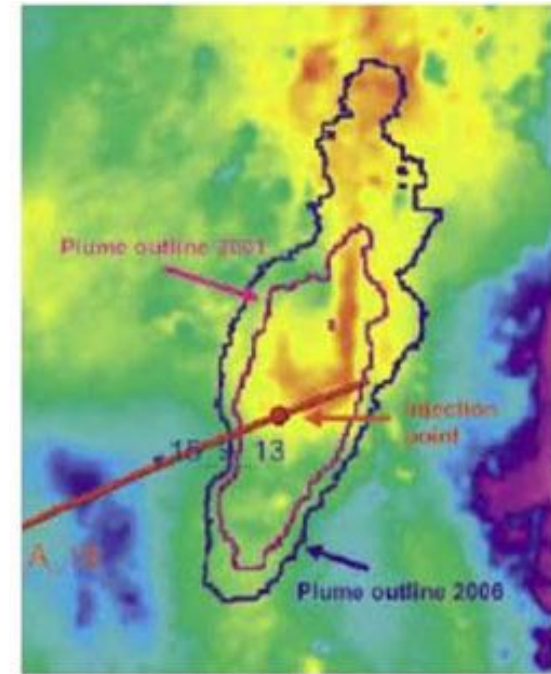
Differences

- CO2 leakage at surface is rarely an acute public health risk
- Releases impact climate
- Corrosion resistant materials required
- Long-term monitoring (50+ years)

Remember...Chemistry is Forever, Operators are Not

Post-Closure Monitoring

- Monitoring is a much longer-term affair
 - EPA default is 50 years
 - May be more or less - it depends!
- Carbon Dioxide Plume Monitoring
 - CO₂ keeps dissolving into formation fluids for a while
 - Effects of injection pressure buildup
 - Buoyant flow
 - Pressure declines over time
 - Ensure CO₂ plume stabilizes in reservoir
 - Physical samples (monitoring wells)
 - Geophysical surveys
- Final monitoring well plugging & abandonment



References & Image Sources

- Colorado State Land Board (Colorado Department of Natural Resources)
 - State Land Board Map Server
<https://gis.colorado.gov/trustlands/>
- Colorado Energy & Carbon Management Commission (Colorado Department of Natural Resources)
 - Creating Colorado's Carbon Sequestration Framework: A Legislative Proposal (2023)
https://ecmc.state.co.us/documents/library/Special_Projects/CCUS_Framework_Legislative_Proposal.pdf
 - Report from the Colorado Carbon Capture and Geological Sequestration Task Force (2010)
https://ecmc.state.co.us/documents/library/Technical/Miscellaneous/Final_Report-Colo_CCS_Task_Force.pdf
 - Energy & Carbon Management Commission Rulemakings
<https://ecmc.colorado.gov/hearings/rulemaking>
- United States Environmental Protection Agency
 - EPA 816-R-11-020: Class VI Well Construction Guidance
<https://www.epa.gov/sites/default/files/2015-07/documents/epa816r11020.pdf>
 - EPA 816-R-13-001: Class VI Well Testing and Monitoring Guidance
<https://www.epa.gov/sites/default/files/2015-07/documents/epa816r13001.pdf>
 - EPA 816-R-16-006: Class VI Well Plugging, PostInjection Site Care, and Site Closure Guidance
https://www.epa.gov/sites/default/files/2016-12/documents/uic_program_class_vi_well_plugging_post-injection_site_care_and_site_closure_guidance.pdf
 - Carbon Capture and Storage (Stakeholder Presentation)
https://www.epa.gov/system/files/documents/2022-09/August_2022_CCS_Information_Session.pdf

Questions?

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