

Planning the 'Yes-able' Permit – Insights from EPA Technical Reviews on Class VI Project Testing and Monitoring Approaches

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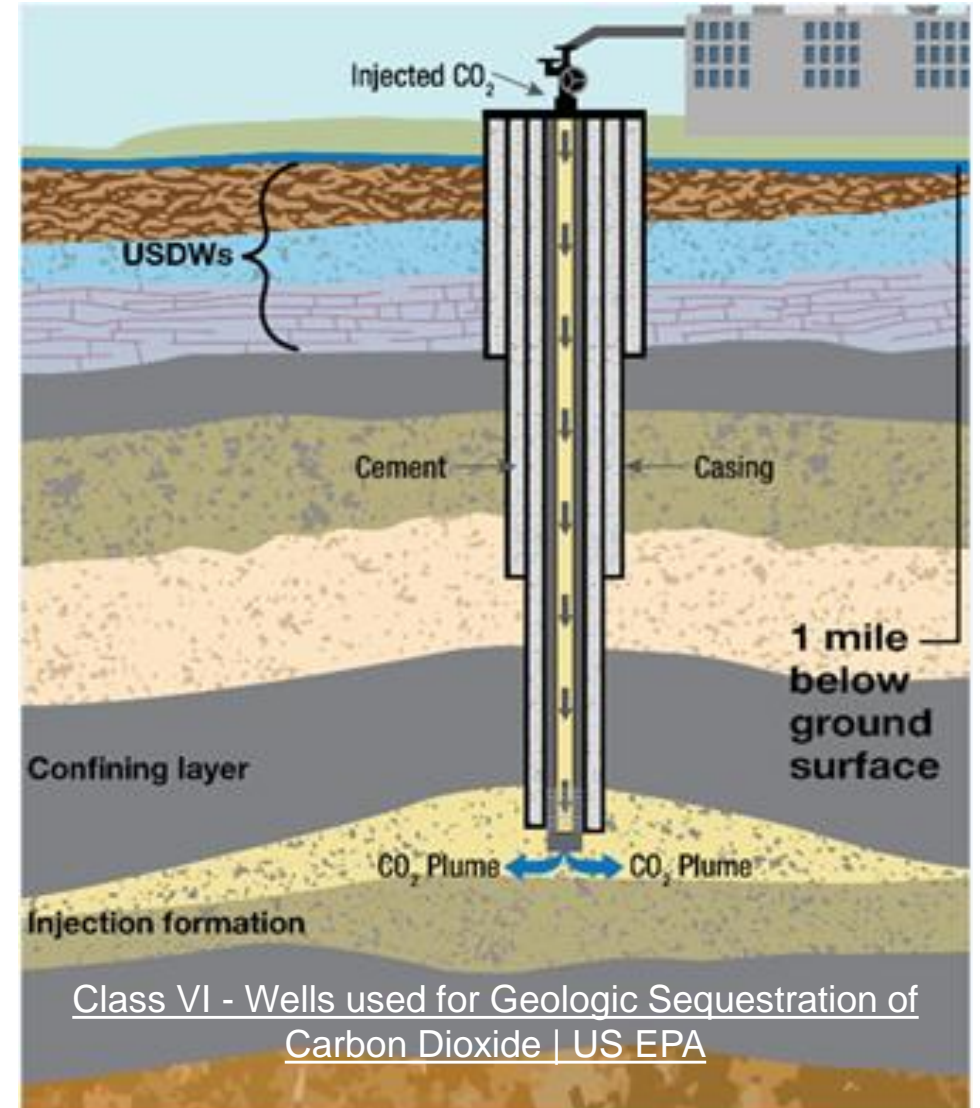
AGENDA

- Introduction
- Testing and Monitoring (T&M)
Regulations and Guidance
- EPA Permit Technical Reviews on
Proposed T&M
- Key Takeaways



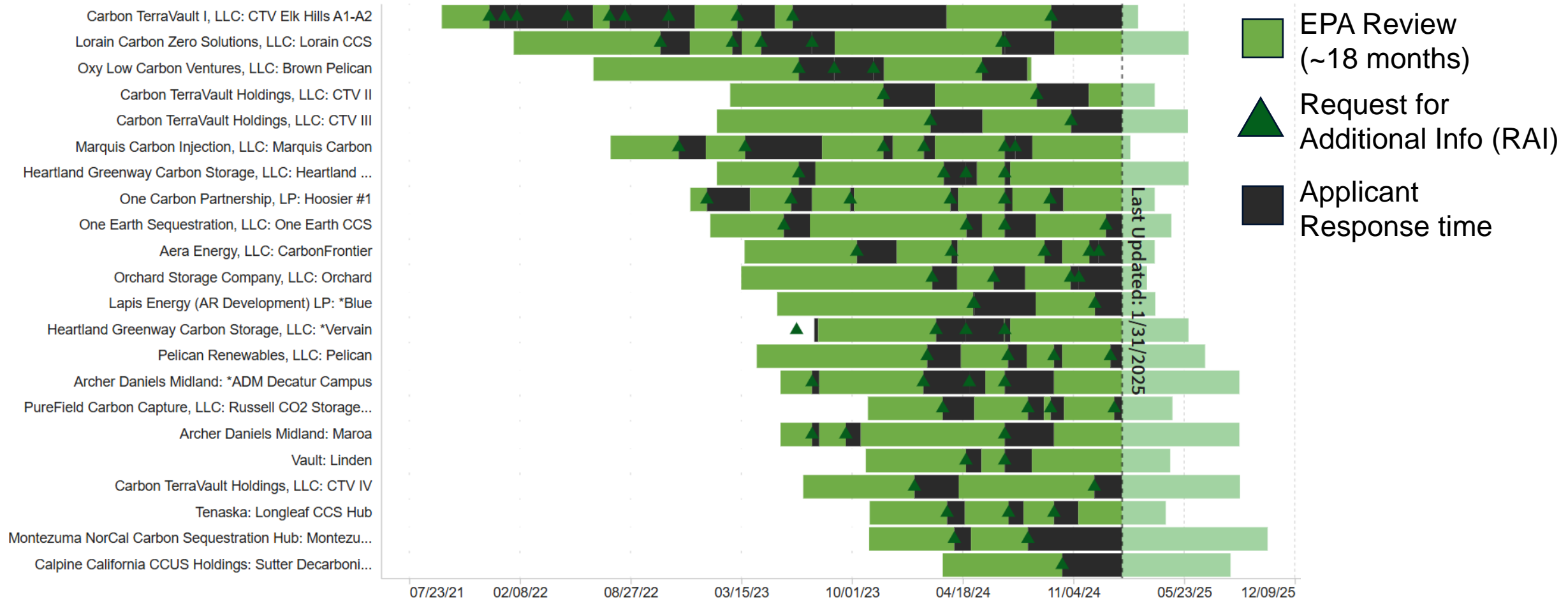
Class VI Wells for Carbon Sequestration

- **Underground Injection Control (UIC) Program**
 - Multiple well classes regulated
 - Goal to protect USDWs
- **Regulatory framework for safe and secure storage of CO₂**
- **Monitoring to account for unique chemistry**
 - Relative buoyancy and mobility
 - Corrosivity with water
 - Large injection volumes



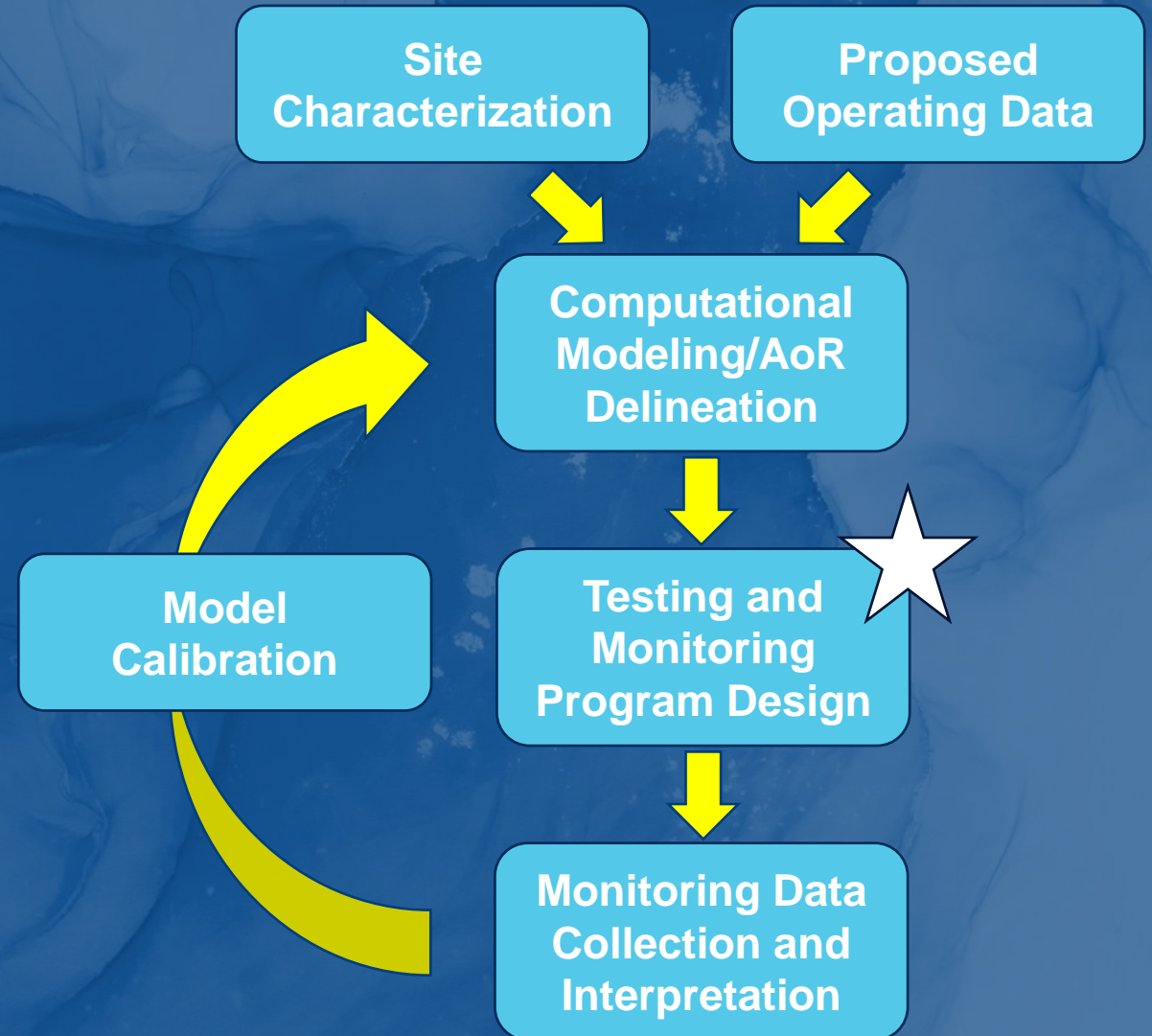
Why the 'Yes-able' Permit?

Class VI Permit EPA Technical Review Timeline



Testing and Monitoring

Regulations and Guidance



Adapted from Figure 4-1 of Class VI Testing and Monitoring Well Guidance

Class VI T&M Requirements – 40 CFR 146.90

Monitoring Component	Prescribed Method?
CO ₂ stream	No
Injection pressure, rate, and volume	Continuous Recording Devices
Corrosion monitoring	Coupons or flow loop
Groundwater quality and geochemical changes	No
Mechanical Integrity	<ul style="list-style-type: none"> Annulus pressure test (Internal) Tracer survey (e.g. oxygen-activation), temperature or noise log (External)
Pressure fall-off test	Pressure Fall-off test every five years
Carbon dioxide plume and pressure front	<ul style="list-style-type: none"> Direct methods Indirect methods, e.g. seismic, electrical, gravity, or electromagnetic surveys and/or down-hole carbon dioxide detection tool

- Specific logs or tests for some monitoring areas
- Multiple possibilities for monitoring to meet requirements in other areas
 - Tailored to site- and project-specific factors

Class VI T&M Guidance (2013)

Monitoring Component	Guidance
CO ₂ stream	Flue gas analysis methods or laboratory analysis
Injection pressure, rate, and volume	Suggested meters
Groundwater quality and geochemical changes	Suggested locations and number of wells based on AoR and plume migration
Carbon dioxide plume and pressure front	<ul style="list-style-type: none">• Many listed seismic, gravity, and electrical methods• Rated as primary, secondary, or potential monitoring technologies

Guidance documents available for many different areas of Class VI projects, including T&M.

<https://www.epa.gov/uic/final-class-vi-guidance-documents>

EPA Permit Technical Reviews of Proposed T&M

Based on public
documents

EPA Region 9 – Pacific Southwest

15 Class VI Well Permit Applications

3

**Withdrawn (2)
Administratively
Incomplete (1)**

7

In Technical Review

4

**Administratively
Complete**

1

Permit Issued

Permits for four
individual wells under
one project

Application Project Overviews

CO₂ sources

- Refinery/oilfield operations
- Ethanol plant
- Natural gas plant
- Hydrogen plant
- Direct air capture
- Multi-source (Hub)

Injection formations

- Mix of depleted oil and gas formations and saline aquifers

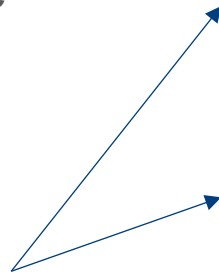
Key for reservoir modeling,
less focus for determining T&M

Above Injection Zone Monitoring

Monitoring Methods

- Pressure (gauge) and Temperature (gauge or Distributed Temperature Sensing, DTS)
- Direct fluid sampling
 - All – first permeable zone above the confining zone
 - Some – lowermost USDW
 - Some – shallow, utilized groundwater

CO₂ stream, too!



Key Comments

- Consistency requested in well monitoring
 - Consistent monitoring at different wells
 - Consistent fluid parameters across different formations
- Specific fluid parameters
 - Carbon isotopes (¹³C) (some instances)
- Method and QC information
 - RAIs include requests to provide and justify particular methods

Pressure Front Monitoring

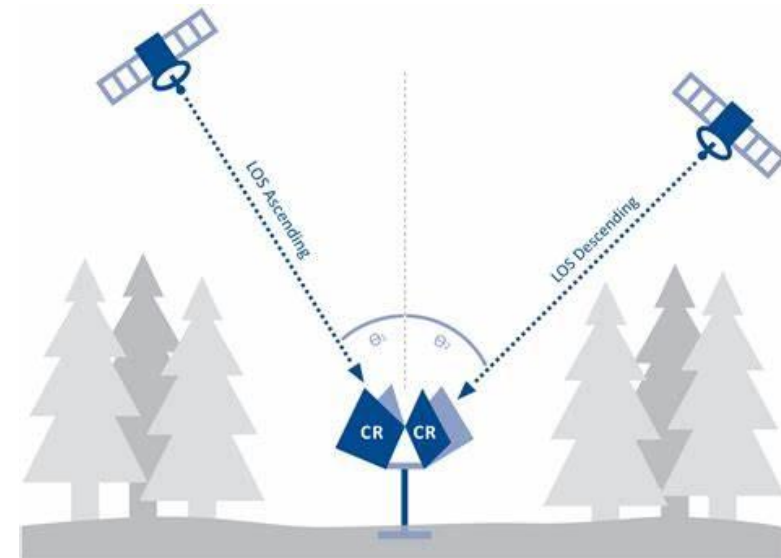
Monitoring Methods

- Direct Pressure (gauge) and Temperature (gauge and DTS)
- DAS/DSS
 - Distributed acoustic sensing
 - Distributed strain sensing
 - Usually, multi-functional for mechanical integrity monitoring and passive seismicity

No major comments, through guidance calls fiber methods and InSAR “potential” technologies

- InSAR (one application)

- Satellite surface deformation with corner reflectors
- Permit NOT YET received technical feedback on T&M

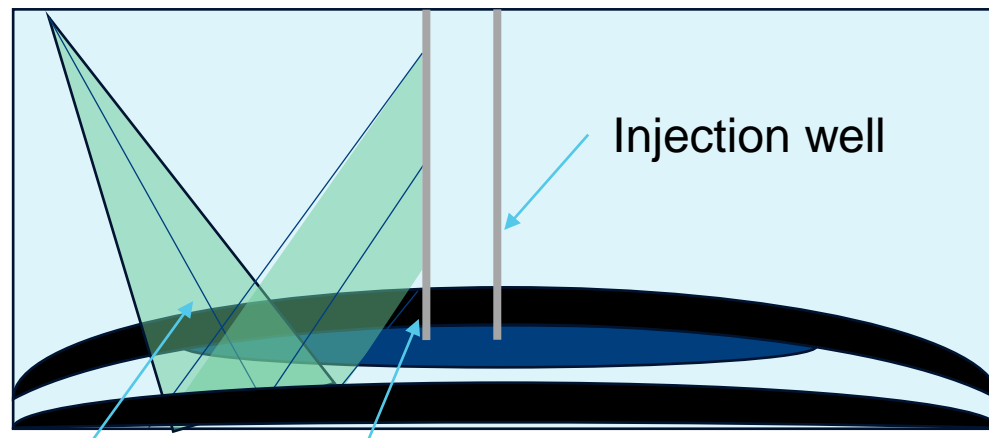


InSAR Corner Reflectors - TRE ALTAMIRA

Plume Monitoring

Monitoring Methods

- Direct fluid sampling
- Pulsed neutron capture logs
- 2D/3D seismic survey
- DAS VSP/Time-lapse VSP
 - Vertical Seismic Profiles



Offset VSP

DAS monitoring well

Key Comments

- Direct fluid sampling is required
- Consistent fluid parameters
 - To support above zone monitoring to detect leakage
- Seismic methods require baseline survey and description for repeatability
 - VSP is considered a “potential” technology
 - Typically combined with multiple methods

Monitoring Methods

- DAS
- Shallow borehole seismometers



Trillium 120 Borehole Seismometer |
Nanometrics

Key Comments

- Describe network specifications – design and threshold
- Specify period of baseline data collection
- Discuss how historical data will be used

Corrosion Monitoring Concerns

- Focus on corrosion monitoring due to identified corrosion of CCUS in-zone monitoring well
 - Mobilization of formation fluid above the confining zone at the ADM Decatur Project in Illinois
 - Identified in March 2024
- EPA RAIs include action levels, of what rates would indicate corrosion



Multi-finger caliper tools that can identify changes in casing thickness (Empire Wireline Special Services)

Comprehensive

- Individual monitoring tools can serve **multiple functions**
- Strategies serve **overall site characterization and leakage pathways**
- **Data method QC** verifies sequestration and confidence

Consistent

- Ensure monitoring details are internally consistent throughout **individual** plans and across **different** plans
 - Many inconsistencies in Tables
 - E.g., well construction materials and T&M corrosion monitoring of the same materials
- Following feedback, ensure **updates** are propagated

Key Takeaways

Key Takeaways for a 'Yes-able' T&M Plan

- Comprehensive and consistent
- Site- and project-specific across lifespan
 - Reservoir and geochemical modeling
 - Data to revise site models and adapt strategies
- **Multiple-lines of evidence**
 - Multiple GW wells for redundancy
 - Direct and indirect, innovative and well-tested
 - **Adaptable for new understanding with further guidance**

The better we make our permits, the more quickly and efficiently they can be approved

THANK YOU. QUESTIONS?

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