



REGION 9

SAN FRANCISCO, CA 94105

February 28, 2025

William Chessum
California Resources Corporation (CRC)
27200 Tourney Road, Suite 200
Santa Clarita, CA 913558

Sent via email only

Dear William Chessum:

The United States Environmental Protection Agency, Region 9 has identified information or clarification needed for continued evaluation of the site characterization and area of review (AoR) delineation modeling based on updated application materials provided on July 25, 2024. The comments are included in two (2) enclosures to this letter.

Please submit the information requested in the Site Characterization and Area of Review Delineation Modeling Evaluation Enclosures by March 31, 2025. If you have any questions about this letter and the Enclosures, please contact me at (415) 972-3971, or Kaylee Ball at (415) 972-3944.

Sincerely,

David Albright
Manager, Groundwater Protection Section

ENCLOSURES

1. Site Characterization Evaluation
2. Area of Review Delineation Modeling Evaluation

cc (via email): Faisal Latif, Carbon Terra Vault Holdings LLC
Chris Jones, CalGEM Central District
Alex Olsen, Central Valley Regional Water Control Board
Jason Dunn, CA State Water Resources Control Board
Janice Zinky, CA State Water Resources Control Board

ENCLOSURE
Request for Additional Information
Site Characterization Evaluation

Carbon TerraVault V
Underground Injection Control (UIC) Permit Application
Class VI Pre-Construction Permit Application No. R9UIC-CA6-FY23-6.1 to 6.6

On May 24, 2024, EPA sent questions about the geologic evaluation and data submitted by Carbon TerraVault Holdings LLC (CTV) in their permit application narrative dated September 12, 2023 for the CTV V Class VI Sequestration Project. CTV responded to the questions with an updated narrative, AoR and Corrective Action Plan, and pre-operational testing plan on July 25, 2024. The review below includes EPA's original questions which are bolded, CTV's responses in normal font, and EPA's comments on CTV's responses in italicized font. Previous responses that require no further information are not included in this enclosure.

1. Please explain why the Domengine Formation is referred to as a pressure dissipation zone.

Response:

Dissipation zone (aka dissipation interval), as defined by the California Air Resources Board CCS Protocol, is a stratigraphic interval with hydrogeologic properties sufficient to attenuate pressure created by CO₂ or formation fluid migration along an unidentified leakage pathway through the confining system.

EPA Comments:

CTV responded by providing the California Air Resources Board CCS Protocol definition of a dissipation interval, which they also added to the text of the narrative. The Domengine Formation is described as a porous and permeable sandstone interval above the Capay Shale, which is consistent with the CARB definition. CTV intends the Domengine to dissipate pressure increases in the specific event that fluid migrates past the Capay upper confining zone. Based on Section 2.10 (Site Suitability), CTV does not expect fluid migration through the Capay to occur and considers the Capay sufficient as a confining zone due to its regional continuity, thickness, and low permeability. This should be confirmed with the results of pre-operational testing to confirm available information on the integrity of the confining zone.

Please clarify if CTV intends to use the Domengine Formation as an injection zone. CTV has stated that fluid migration through the Capay will not occur. If the Domengine will not be used as an injection zone and fluid migration into the formation will not occur, the Domengine Formation should not be referred to in the UIC application as a pressure dissipation zone. Please revise the application documents accordingly.

2. For completeness and to satisfy the requirements of 40 CFR 146.82(a)(2), please add the faults shown on Figure 2.3-1 to Figure 2.2-11.

Response:

A risk-based AoR analysis was conducted and submitted to the EPA on 06-07-2024. The new risk-based AoR is equal to the extent of the CO2 plume areas where no faults are present, therefore the faults from Figure 2.3-1 were not added to Figure 2.2-11.

EPA Comments:

CTV did not add regional faults to their map in Figure 2.2-11. CTV's response cites a risk-based AoR analysis submitted to EPA on June 7, 2024, which concluded that none of the identified faults occur within this revised risk-based AoR. The risk-based AoR delineation method used by the applicant is not the recommended method for a storage reservoir system that is under-pressured. Page 39 of EPA's UIC Class VI Well AoR and Corrective Action Guidance¹ (the Guidance) lists Method 1 as the recommended method for calculating the threshold or critical pressure that defines the pressure front used to delineate the AoR for under pressured systems. For additional details, see the AoR Delineation Enclosure. Please reconsider this question once the AoR has been delineated according to the four steps described in Box 3-2 on pages 56-60 of the Guidance.

3. **Based on Figure 2.3-1, 3D seismic coverage appears to be lacking on the eastern boundary of the AoR. EPA requests that CTV perform additional 3D seismic surveys as part of pre-operational testing to address this uncertainty.**

Response:

The new risk-based AoR is equal to the extent of the CO2 plume areas which lie within the 3D seismic coverage. Therefore, no additional 3D seismic surveys during the pre-operational testing period are necessary.

EPA Comments:

CTV states that the boundary of the revised risk-based AoR falls within the lateral extent of the existing 3D seismic coverage. The risk-based AoR delineation method used by the applicant is not the recommended method for a storage reservoir system that is under-pressured. Page 39 of EPA's UIC Class VI Well AoR and Corrective Action Guidance¹ (the Guidance) lists Method 1 as the recommended method for calculating the threshold or critical pressure that defines the pressure front used to delineate the AoR for under pressured systems. For additional details, see the AoR Delineation Enclosure. Please reconsider this question once the AoR has been delineated according to the four steps described in Box 3-2 on pages 56-60 of the Guidance.

4. **Are the two faults within the AoR influenced by any increased pressure? If so, please include a discussion of the pressure increase at the locations of the faults, particularly the one to the east of the injectors.**

Response:

No faults lie within the new risk based AoR. Refer to the response to EPA question 8 for discussion on pressure and fault stability.

EPA Comments:

CTV responded to EPA's question in their response to Question 8 in CTV's response document (removed from this letter). CTV notes that these faults do not occur within the revised risk-based AoR. The risk-based AoR delineation method used by the applicant is not the recommended

method for a storage reservoir system that is under-pressured. Page 39 of EPA's UIC Class VI Well AoR and Corrective Action Guidance¹ (the Guidance) lists Method 1 as the recommended method for calculating the threshold or critical pressure that defines the pressure front used to delineate the AoR for under pressured systems. For additional details, see the AoR Delineation Enclosure. Please reconsider this question once the AoR has been delineated according to the four steps described in Box 3-2 on pages 56-60 of the Guidance.

5. EPA requests the following revisions to the pre-operational testing plan to improve data collection:

- a. Perform direct in-situ formation stress testing to confirm the minimum and maximum horizontal stress conditions that were referenced in Section 2.5.2 using published data.**

Response: Direct in-situ formation stress testing will consist of SRT/DFIT of select intervals in the confining layer and injection zones. This will give direct measurement of the minimum horizontal stress. The maximum horizontal stress cannot be measured directly, and therefore must be inferred from a combination of wellbore failure (as observed through image logs) and rock failure criteria (determined from rock mechanics testing on core) (Zoback MD. Reservoir Geomechanics. Cambridge University Press; 2007.). Because of this, CTV will acquire core and logs that can be used to help estimate the magnitude of the maximum horizontal principal stress. These include core rock mechanics, dipole sonic logs, and formation microimaging logs. See the following paper for a detailed explanation of stress magnitude determination from wellbore failure: Zoback, M.D., Barton, C.A., Brudy, M., Castillo, D.A., Finkbeiner, T., Grollmund, B., Moos, D., Peška, P., Ward, C.D., & Wiprut, D.J. (2003). Determination of stress orientation and magnitude in deep wells. International Journal of Rock Mechanics and Mining Sciences, 40, 1049-1076.

EPA Comments:

CTV indicated that minimum horizontal stress will be measured through SRT and Diagnostic Fracture Injection Testing (DFIT) performed on select intervals in the injection and confining zones. CTV asserts that the maximum horizontal stress cannot be measured directly and will be inferred from a combination of well and rock failure criteria as determined by core rock mechanics testing. To accomplish this, CTV will collect rock core samples and perform dipole sonic and microimaging logging to acquire the data necessary to determine maximum horizontal stress using the method in Zoback, et al. (2003). However, this logging is not included in the Pre-Operational Testing Plan. Please include dipole sonic logging and microimaging logging in the Pre-Operational Testing Plan.

ENCLOSURE
Request for Additional Information
Area of Review Delineation Modeling Evaluation
Carbon TerraVault V
Underground Injection Control (UIC) Permit Application
Class VI Pre-Construction Permit Application No. R9UIC-CA6-FY23-6.1 to 6.6

This Computational and Static Modeling Evaluation for the proposed Carbon TerraVault V (CTV V) Class VI geologic sequestration project summarizes EPA's review of the computational modeling as described in the Area of Review and Corrective Action Plan (AoR CAP) (Attachment B Version 2, submitted July 25, 2024) of the permit application. Previous responses that require no further information are not included in this enclosure. Please note that modifications to the model parameters may be needed if pre-operational testing yields results that are significantly different than the model inputs described in the initial permit application.

Evaluation Summary

The risk-based AoR delineation method used by the applicant is not the recommended method for a storage reservoir system that is under pressured. Page 39 of EPA's UIC Class VI Well AoR and Corrective Action Guidance¹ (the Guidance) lists Method 1 as the recommended method for calculating the threshold or critical pressure that defines the pressure front used to delineate the AoR for under pressured systems. **Please delineate the Area of Review (AoR) according to the four steps described in Box 3-2 on pages 56-60 of the Guidance. Please re-run all the sensitivity analyses to assess the impact on the boundary of this AoR.**

General Questions

1. Figure 4.1 (Injection Zone (CO₂) plume development through time) shows significant plume growth from 65 to 115 yrs. If the simulated plume has stabilized by 115 yrs, more curves before 115 yrs should be added that show stabilization. If the plume is not stable at 115 yrs, it would be beneficial to carry the calculations farther out in time to ensure that you understand when the plume stabilizes. Please provide more curves, either before or after 115 yrs that define the time at which the CO₂ plume stops moving. Another way to do this would be to graph the map view total area of the CO₂ plume as a function of time, where the total area should reach a maximum then stabilize or even decrease.
2. Data sources for initial conditions were not cited specifically in the report (Table 3.3). Please add specific citations for the data used to build Table 3.3 and other initial conditions.
3. The project location contains several CCS projects, and it appears the applicant intentionally selected a lower injection volume to prevent the pressure front from overlapping with other Areas of Review (AoRs). The applicant shows that the AORs of the CTV V and Pelican Renewables projects are not overlapping. However, given the uncertainty of the southern pressure boundary condition, please include an assessment of the uncertainty in the CO₂ plume and the interaction of the Pelican and CTV-V CO₂ plumes and include how CTV plans to mitigate overlap during operations in the Corrective Measures section of the AoR report.

- a. Please add text to the Corrective Action section of the AoR report that discusses how the applicants will monitor for such potential interference.
4. The applicant states that two normal faults penetrate the model domain but do not explicitly model them. Please include stronger evidence to justify the removal of the normal faults. The current language on page 3 does not include citations to literature where the assumptions can be cross-checked.

Model Design

5. The applicant states that the normal faults are not active, but they do not provide evidence that they won't leak. They state, "These faults are classified as typical normal faults as seen in the extended area beyond the model domain". Stronger evidence that these normal faults are not a leakage risk should be provided, including citations to literature that supports this position.
6. Once a more rigorous uncertainty quantification is performed, please consider using a higher mesh resolution to capture geological heterogeneity.
7. Time stepping was not mentioned. Please add text stating what convergence criteria and time stepping parameters were used.
8. The CO₂ boundary seems to keep expanding even after 100 years of injection. The modelling time should be expanded until movement ceases.

Incorporation of Site-Specific Conditions

9. The initial condition was not derived from site-specific data. Instead, the applicants used a near equilibrium approximation. The model inputs should be updated once site-specific data are available.
10. Data sources for initial conditions were not cited specifically in the report (Table 3.3, on page 42 of the PDF). Please add specific citations for the data used to build Table 3.3 and other initial conditions.

Model Presentation

11. The resolution on Figure 4.1 adequately shows the plume growth. However, EPA would like to see more discrete time steps in the evolution of the plume up to and past 115 yrs if needed to ensure that the end of CO₂ migration has been simulated.

Model Calibration and Sensitivity Analysis

12. Table 4.1 (on page 45 of the PDF) shows that the applicants did a very simplistic uncertainty analysis. The single sensitivity simulations changed single parameters at a time within $\pm 10\%$ of the base case values. A more rigorous sensitivity should be undertaken to get a better idea of what could happen during injection. This is especially important to do once site-specific data are available. Permeability uncertainty is often a factor of $\pm 10x$. The applicant states only that "these scenarios and the comparison against previous work in the area provide us with confidence in the CO₂ plume extent and AoR".
 - a. The applicant only shows AoR changes due to different CO₂ concentrations at the injection wells. The changes to the AoR from a more rigorous sensitivity analysis should be provided in figures, including relative permeability and capillary pressure.
 - b. 10% porosity and permeability are not overly conservative estimations. In the next iteration of the application, it would be good to see a sensitivity analysis with all

parameters. The applicant should consider the standard deviation of parameters to capture full uncertainty ranges. Please use values from the tail ends of the probability distribution of each parameter. Then, run simulations for combinations of the selected parameters to understand the impact on AoR.

- c. No analysis was conducted on the sensitivity of the model results to mesh refinement. Please add a brief section on this in the next iteration of the application.

Additional Questions

13. Page 6 of Appendix 9: Flux is by definition a rate, so this sentence should be modified as follows: “The MODFLOW-predicted brine flux rate”. (See Stauffer 2006 Flux Flummoxed, Ground Water)
14. Please include page numbers for the figures. Additionally, please include a ‘Table of Figures’ and ‘Table of Tables’ at the beginning of the Attachment B AoR document.
15. A discussion of the CTV-III and Pelican pressure interference results should be included in the main Attachment B AoR document, perhaps directly adding this material from the ‘CTV V Interference Response Letter_060724.pdf’ file to the AoR document as an appendix with a short paragraph in the main text.
16. For future submissions, please use SI units with oil-patch units in parentheses.