ALTERNATIVE
POST-INJECTION SITE CARE AND SITE CLOSURE PLAN
40 CFR 146.93(a)

PROJECT MINERVA

1.0 Introduction

This Post-Injection Site Care and Site Closure ("PISC") plan describes the activities that Gulf Coast Sequestration ("GCS") will perform to meet the requirements of 40 CFR 146.93. GCS will monitor ground water quality and track the position of the carbon dioxide plume and pressure front as they stabilize. GCS may not cease post-injection monitoring until a demonstration of non-endangerment of underground sources of drinking water ("USDW") has been approved by the Underground Injection Control ("UIC") Program Director pursuant to 40 CFR 146.93(b)(3). Following approval for site closure, GCS will plug all monitoring wells, restore the site to its original condition, and submit a site closure report and associated documentation.

1.1 Facility Information

Facility name: Project Minerva
Wells 1-4

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[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

2.0 Pre- and Post-Injection Pressure Differential [40 CFR 146.93(a)(2)(i)]

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

2.1 Predicted Position of the CO_2 Plume and Associated Pressure Front at Site Closure [40 CFR 146.93(a)(2)(ii)]

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

3.0 Post-Injection Monitoring Plan [40 CFR 146.93(b)(1)]

A Testing and Monitoring Plan has been designed to monitor the Project Minerva site pursuant to 40 CFR 146.90. In addition to demonstrating that the well is operating as planned, the carbon dioxide plume and pressure front are moving as predicted, and that there is no endangerment to USDWs, the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO_2 within the storage zone to support AoR reevaluations and a non-endangerment demonstration.

Information on the Testing and Monitoring Plan may be found in the following document:

- Testing and Monitoring Plan 40 CFR 146.90

A Quality Assurance and Surveillance Plan ("QASP") for all testing and monitoring activities, required pursuant to 146.90(k), is provided as an appendix to the Testing and Monitoring Plan 40 CFR 146.90 document.

4.0 Alternative Post-Injection Site Care Timeframe [40 CFR 146.93(c)]

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).]

4.1 Computational Modeling Results – 40 CFR 146.93(c)(1)(i)

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

Additional detail and example vertical cross sections through the reservoir simulation model may be found in the following document:

- Area of Review and Corrective Action Plan 40 CFR 146.84(b)
    - Section 6.0 Modeling Results

4.1.1 Sensitivity Study

A Sensitivity Study has been conducted for Project Minerva and was presented in v3 of the Area of Review and Corrective Action Plan 40 CFR 146.84(b) report (Section 7.2) submitted to EPA in July 2022. It has been provided again in the latest report submission in January 2023 ("B.12.1 AoR Corrective Action Plan Report CBI – Rev No. 5 Jan 2023").

4.1.2 Predicted Timeframe for Pressure Decline – 40 CFR 146.93(c)(1)(ii)

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).] No site-specific pressure monitoring data are available at present.

4.2 Predicted Rate of Plume Migration – 40 CFR 146.93(c)(1)(iii)

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

4.3 Site-Specific Trapping Processes – 40 CFR 146.93(c)(1)(iv)-(vi)

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

4.4 Confining Zone Characterization – 40 CFR 146.93(c)(1)(vii)

The Confining Zone is the shale-rich Anahuac Formation directly overlying the Injection Zone (Upper Frio Formation). A detailed overview may be found in the following document:

- Area of Review and Corrective Action Plan 40 CFR 146.84(b)
    - Section 2.2.2 Porosity
    - Section 2.2.3 Permeability

  - Section 2.2.4 Mineralogy and Geochemistry
  - Section 2.2.5 Rock Compressibility

- Class VI Permit Application Narrative 40 CFR 146.82(a)
  - Section 2.4 Hydrogeology

4.4.1 Modelling the Anahuac Formation in the Simulation Model

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).]

4.5 Assessment of Fluid Movement Potential – 40 CFR 146.93(c)(1)(viii)-(ix)

4.5.1 AoR Well Integrity Review

A full overview of the AoR well integrity review may be found in the following document:

- Area of Review and Corrective Action Plan 40 CFR 146.84(b)
  - Section 8.0 Corrective Action

4.5.2 Summary of Artificial Penetrations Deeper than the Confining Zone Anahuac Formation) within the Area of Review

A full summary of all wells (artificial penetrations) determined to have been drilled deeper than the top of the Confining Zone (Anahuac Formation) may be found in the following document:

- Area of Review and Corrective Action Plan 40 CFR 146.84(b)

  - B.11.2 Corrective Action Summary
  - Section 8.4 Migration Potential of Assessment of Artificial Penetrations

4.5.3 Summary of Potential Corrective Action

A full overview of the AoR well integrity review may be found in the following document:

- Area of Review and Corrective Action Plan 40 CFR 146.84(b)
  - Section 8.0 Corrective Action

A list of all wells and accompanying schematics were submitted as supplements to the Area of Review and Corrective Action Plan 40 CFR 146.84(b) document.

- B.11.2 Corrective Action Summary
- APPDX 2 – APs in AoR

4.5.4 Planned Injection Well Construction

Injection wells will be constructed with mechanical integrity to meet-or-exceed the EPA UIC program Class VI guidance, with both internal and external components working together to ensure prevention of fluid movement into USDW. [The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

4.5.5 Planned Testing and Monitoring of Barriers Between the Injection Zone and USDW

The ability of the internal barriers to protect USDW will be confirmed by initial and subsequent testing. An example of initial tests is a pressure test of the casing string in-place after cementing, to confirm no leakage through connections, and taking the baseline caliper survey inside the casing walls for comparison to subsequent surveys. Subsequent tests, besides the caliper survey mentioned, include continuous pressure monitoring of the annulus between the tubing string and the long string; this single annulus monitors the integrity of the tubing, the packer, and the long string.

4.5.6 Limited Risk to Well Integrity Through CO_2 Interaction with Wellbore Cement

The long-term degradation of cement by contact with CO_2 has been observed, but the external mechanical integrity of the injection well will be ensured by the continuous column of cement from base to surface. This length of cement will necessarily extend the full length of the confining layer, namely the Anahuac formation, several hundred feet thick. The CO_2 injectate, plus CO_2-contaminated formation brine in the Frio, will be confined at the Anahuac/Frio boundary. Cement around the casing string(s) through the confining Anahuac will not be subjected to contact with CO_2.

4.5.7 Evaluation of the distance between the Injection Zone and the nearest USDW

GCS has conducted detailed geological mapping for the base of the USDW and the injection zone using all available data sources. Please see Figure 2.26 in the Application Narrative 40 CFR 146.82(a) submitted January 2023 ("A.4.1 C6 Per App Narr CBI Rev No.5 Jan 2023").

4.6 <u>Location of USDWs – 40 CFR 146.93(c)(1)(x)</u>

A detailed overview of the USDW in relation to Project Minerva may be found in the following document:

- Class VI Permit Application Narrative 40 CFR 146.82(a)
    - Section 2.4 Hydrogeology

5.0 <u>Non-Endangerment Demonstration Criteria</u>

Prior to approval of the end of the post-injection phase, GCS will submit a demonstration of non-endangerment of USDWs to the UIC Program Director, per 40 CFR 146.93(b)(2) and (3).

GCS will issue a report to the UIC Program Director. This report will make a demonstration of

USDW non-endangerment based on the evaluation of the Project Minerva site monitoring data used in conjunction with the project's computational model. The report will detail how the non-endangerment demonstration evaluation uses site-specific conditions to confirm and demonstrate non-endangerment. The report will include all relevant monitoring data and interpretations upon which the non-endangerment demonstration is based, model documentation and all supporting data, and any other information necessary for the UIC Program Director to review the analysis. The report will include the following sections:

5.1 Introduction and Overview

A summary of relevant background information will be provided, including the operational history of Project Minerva, the date of the non-endangerment demonstration relative to the post-injection period outlined in this PISC Plan, and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

5.2 Documentation of Wells within the AoR

A full summary of all wells (artificial penetrations) drilled within the AoR may be found in the following document:

- Area of Review and Corrective Action Plan 40 CFR 146.84(b)
    - Section 8.0 Corrective Action

GCS will recalculate the AoR every 5 years during the injection period using operational data from the injection wells and monitoring wells. Any change in the predicted AoR will initiate a redetermination of the wells within the AoR and the corrective action workflow as set out in the Area of Review and Corrective Action Plan 40 CFR 146.84(b). A final AoR determination will be made as part of the final non-endangerment demonstration at the end of the injection period.

5.3 Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at Project Minerva, pursuant to the Testing and Monitoring Plan and this PISC Plan, including data collected during the injection and post-injection phases of the project, will be submitted to help demonstrate non-endangerment. Data submittals will be in a format acceptable to the UIC Program Director (40 CFR 146.91(e)), and will include a narrative explanation of monitoring activities, including the dates of all monitoring events, changes to the monitoring program over time, and an explanation of all monitoring infrastructure that has existed at the site. Data will be compared with baseline data collected during site characterization in satisfaction of 40 CFR 146.82(a)(6) and 146.87(d)(3).

Currently, there is no existing monitoring data.

5.4 Summary of Computational Modeling History

To date there has been no CO_2 injection or wells drilled for data collection. Hence, there is no data for history matching. A reservoir simulation model has been built in the simulation model using a variety of data sources (see Section 10.0 "References" for the Area of Review and Corrective Action Plan 40 CFR 146.84(b)) to predict the development of the AoR, pressure and CO_2 plumes in time.

5.5 Evaluation of Reservoir Pressure

There will be regular pressure build-up tests (to determine reservoir pressure and injectivity) and continuous monitoring of downhole pressures and temperatures during injection, together with measurement of injection rates, tubing head pressures, temperatures and composition. These will be used as history matching data for future versions of the dynamic model. After calibration (history matching) the model will be used to update its predictions of the development of the AoR, pressure and CO_2 plumes.

5.6 Evaluation of Carbon Dioxide Plume

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

5.7 Evaluation of Emergencies or Other Events

The wells where this data is to be collected will be modelled in the dynamic simulation model and the calculated pressures, CO_2 saturations and other relevant data compared with the corresponding measured values to determine the accuracy and fidelity of the dynamic simulation model. Having calibrated the dynamic model, it can be used to predict the risk that mobilized fluids pose a danger to USDWs.

6.0 Site Closure Plan

GCS will conduct site closure activities to meet the requirements of 40 CFR 146.93(e) as described below. GCS will submit a final Site Closure Plan and notify the permitting agency at least 120 days prior of its intent to close the site. Once the permitting agency has approved closure of the site, GCS will plug the monitoring wells and submit a site closure report to EPA. The activities, as described below, represent the planned activities based on information provided to EPA. The actual Site Closure Plan may employ different methods and procedures. A final Site Closure Plan will be submitted to the UIC Program Director for approval with the notification of the intent to close the site.

6.1 Plugging Monitoring Wells

Methods to plug monitoring wells will follow the guidance for plugging Class VI injection wells. Sixty-day notice will be provided prior to plugging operations. Adjustments to the plugging plan will be incorporated to meet the Director's guidance.

It is unlikely or uncertain that a homogenous liquid will exist from the surface wellhead gauge down to the perforations (or screen in the case of a pure monitoring well). The homogenous liquid is required to accurately determine the downhole pressure at the perforations; a mixture of gas and super-critical phase CO_2 cannot yield accurate pressure calculations. Consequently, a wireline unit will deploy a tubing downhole pressure gauge with either surface read-out or recorded memory data, and the pressure at the perforations/screen will be measured directly.

After determining the downhole pressure at perforations, the equivalent density of fluid to balance this pressure will be calculated using the equation: Density = Pressure ÷ .052 ÷ TVD, where density is in pounds-per-gallon, pressure is psi, and TVD is feet.

A work fluid with the density calculated as above from the downhole pressure will be mixed from a freshwater base, with bentonite added for viscosity and barite added for weight. This fluid is robust at the expected temperatures and is compatible with common cement spacers and cements.

If the monitoring well does not have an existing tubing string installed, a work string likely consisting of 2-7/8 inch tubing will be run into the well using a workover rig. If the well has an existing tubing string with packer, the workover rig will make up a work joint to the existing tubing, pull tension to unseat the tubing hanger from the wellhead, and pull further tension to unseat the packer. With the tubing work string or the existing tubing/packer unseated, the work fluid will be slowly pumped down the tubing towards the perforations. If fluid returns do not arrive back at surface, it may be necessary to add lost circulation material ("LCM") to the work fluid to plug the formation porosity at the perforations until fluid returns do arrive at surface. Pumping rate will be low so that undue friction pressures are not exerted on the formation open at the perforations; the volume to be pumped will be on the order of 200 bbls.

Note: this step should be considered as a bonus step, to be performed at the discretion of the owner/operator management and/or the Director. When the work fluid has been placed into the well and proven to balance formation pressure, and the tubing (either original or work string) have been pulled, a casing caliper log should be run on the long string. A baseline caliper log was taken when the casing was installed many years before, and possibly subsequent caliper logs have been run during the life of the well. A final caliper log would be run to determine the final condition of the long string's internal walls. It is likely that these walls have been continuously bathed by a non-corrosive fluid in the annulus between tubing and casing but obtaining the data and comparing to the years-old baseline log could provide bonus information to participants.

If the tubing existed in the wellbore with a packer attached, the tubing will be pulled, and the packer removed; it is likely that any tubing joints connected to seating nipples will also be removed. The goal is to install in the wellbore a tubing work string from surface to plugged-back total depth ("PBTD"), which is usually the float collar of the casing long string. At this point, with no packer obstacle in the annulus, circulation will be repeated until it is confirmed that the work fluid has balanced downhole pressure at the perforations.

Circulation will be continued until fluid returns at surface appear to be clear from any debris and pumping rates will be increased to determine the wellbore's tolerance for frictional pressures. Additions of LCM might be required to maintain circulation, and this will be the time to learn the behavior of the wellbore. Determination of this tolerance and behavior will allow detail planning of the rates to be used during cementing operations.

It is proposed to set a series of balanced cement plugs inside the long string, beginning with a 500 ft cement plug across the perforations. Each cement plug will be designed by the cementing contractor to utilize cement types and additives suitable for each placement in the well; the first plug across the perforations will contain non-Portland cement components such as Pozzolan-Lime, Gypsum, Resin, or Latex to reduce or eliminate degradation by CO_2. No cement retainer or bridge plug is proposed at the top of this plug, as this adds mechanical complexity in a place where a simple solid cement seal is required.

After displacing the cement plug to the balanced depth, the tubing work string will be slowly pulled to a point at least 500 ft above the top of cement, and the tubing work string will be circulated (the long way, down the tubing and up the annulus) to clear any excess cement out of the well; reciprocate and rotate the tubing continuously during this circulation. Wait-on-cement ("W.O.C.") for 24 hours, with periodic short circulations down the tubing to ensure it remains open-ended. After W.O.C. 24 hours (or such time recommended by cementing contractor for plug to achieve 100 Bc or 1,000 psi compressive strength), run tubing work string slowly into well to tag the top of cement. Circulate through the work string during the final 90 ft (three joints) to ensure that the tubing remains open-ended when it encounters cement. Tagging the cement top will determine the precise location of the cement compared to desired placement; additionally, set down 10,000 lbs of work string weight on top of the cement plug to prove its competency. The cross-sectional area of 2-7/8" tubing is approximately 2.7 in^2, and the force exerted on the cement top would be approximately 10,000 lbs ÷ 2.7 in^2 ≈ 3,700 psi.

After successfully tagging the cement plug top and proving its competency, immediately pick up the tubing work string and circulate through it to clear any cement from the open end. Mix and pump via the balanced method another 500 ft cement plug similar to the first plug, placing it on top of the first plug. Repeat the process of pulling at least 500 ft above the calculated top of cement, circulating out any excess cement, W.O.C. while periodically circulating, and tagging the top of second plug and proving its competency.

Subsequent 500 ft high cement plugs will be planned for:

- the top of Anahuac, the confining formation above Injection Zone
- 250 ft above-and-below the depth of the surface casing shoe
- 250 ft above-and-below the base USDW
- at surface, from 510 ft to 10 ft below ground level.

As a conservative approach, each of the plugs will be tagged using the method described earlier. Tagging each plug will prove its location and competency, thus removing doubt about the suitability of the plugging process. It will be a time-consuming process due to the W.O.C. intervals, but successfully placed cement plugs will protect USDW.

Volume calculations will be based upon established oilfield methods, using measured pipe diameters. The series of casing caliper logs run over the life of the long string will provide the real-time inside diameter of that pipe after many years of service. The actual outside and inside diameters of the tubing work string can be measured on-site with hand calipers. An example calculation for volume of an annulus is: $(OD^2 – ID^2) ÷ 1{,}029.4$ = volume in bbls per foot.

Prior to plugging, the internal competence of the long string will be tested by running a casing caliper log; this log will show remaining wall thickness. The external competence of the cement

sheath around the long string will be tested by running a temperature or noise log, to determine if any fluid is moving in that cemented annulus.

During the lengthy injection period and possible monitoring period after injection, it is likely that surface equipment and infrastructure will have been upgraded, modified or replaced several times. The plugged well would provide no usage to the owner/operator, so it is envisioned that all of the surface equipment will be removed piecemeal, and the location pad and access road would be left in place.

6.2 Site Closure Report

A site closure report will be prepared and submitted within 90 days following site closure, documenting the following:

- Plugging of the verification and geophysical,
- Location of sealed injection well on a plat of survey that has been submitted to the local zoning authority,
- Notifications to state and local authorities as required at 40 CFR 146.93(f)(2),
- Records regarding the nature, composition, and volume of the injected CO_2, and
- Post-injection monitoring records.

GCS will record a notation to the property's deed on which the injection well was located that will indicate the following:

- That the property was used for carbon dioxide sequestration,
- The name of the local agency to which a plat of survey with injection well location was submitted,
- The volume of fluid injected,
- The formation into which the fluid was injected, and
- The period over which the injection occurred.

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

7.0 Quality Assurance and Surveillance Plan ("QASP")

The Quality Assurance and Surveillance Plan is presented in the Appendix of the Testing and Monitoring Plan 40 CFR 146.90.

8.0 References

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