ATTACHMENT J –
POST-INJECTION SITE CARE AND SITE CLOSURE PLAN

GULF COAST SEQUESTRATION
PROJECT MINERVA

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FACILITY INFORMATION

Facility name: Project Minerva
Injector Well Nos. 1 – 4

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Well Locations: [redacted]

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 groundwater 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.

2.0 PRE- AND POST-INJECTION PRESSURE DIFFERENTIAL

[redacted]. Additional information on the projected post-injection pressure declines and differentials is presented in the "Area of Review and Corrective Action Plan 40 CFR 146.84(b)" permit document module and report.

Figure J.2.0-1 shows the grid cell pressures at the top perforations of the injection wells against time. [redacted]

[redacted], minus the corresponding pressure at the end of the injection period (following 30 years of injection), divided by the number of years between these dates ([redacted]).

[redacted].

The initial formation pressure is based on GCS's most likely initial formation pressure gradient of [redacted] Please see the "Area of Review and Corrective Action Plan 40 CFR 146.84(b)" permit document module and report for GCS methodology on most likely categorizations. The most likely fracture gradient in the simulation model is 90% of the most likely minimum horizontal stress gradient ([redacted] The induced seismicity pressure limit study was calculated [redacted]

Figure J.2.0-2 shows that the peak injection pressures are [redacted]

3.0 PREDICTED POSITION OF THE CO_2 PLUME AND ASSOCIATED PRESSURE FRONT AT SITE CLOSURE

Figure J.3.0-1) shows the predicted extent of the AoR at the end of the PISC timeframe, year 80 (50 years after injection ceases). Also shown, is the stable CO_2 plume and associated [redacted]

Please see discussion of modeling results in Section 6.2 (Predicted Position of the CO_2 Plume) of Attachment B (Area of Review and Corrective Action Plan).

4.0 POST-INJECTION MONITORING PLAN

A post-injection monitoring plan has been designed to ensure non-endangerment of the USDW via monitoring of the pressure front and CO_2 plume. The current monitoring network may be viewed in Figure J.4.0-1, and comprises:

[redacted]

GCS will assess the need to [redacted]

The results of all post-injection phase testing and monitoring will be submitted annually, as described in Section 4.3 (Schedule for Submitting Post-Injection Monitoring Results).

Monitoring is currently planned to take place over a post-injection period of 50 years. Monitoring data collected during the active injection period (30 years) will be used to history match the simulation model and update the predicted year of CO_2 plume stability [redacted] Dependent on the results of history matching, an updated PISC, containing a modified post-injection monitoring plan period, will be provided to the UIC Program Director 90 days prior to the cessation of injection. All activities will meet the requirements of 40 CFR 146.93(b)(1) (LAC 43:XVII.3633.A.2.a).

Information on the full Testing and Monitoring Plan may be found in "Attachment G - Testing and Monitoring Plan". The location of monitoring wells for direct sampling and the [redacted] setup for in-direct monitoring, may be found in Figure J.4.0-1. The monitor network will be extended in a phased approach, as operational data become available to validate the simulation model.

A Quality Assurance and Surveillance Plan ("QASP") for all testing and monitoring activities, required pursuant to 146.90(k), is provided as "Attachment H - Quality Assurance and Surveillance Plan (QASP)".

4.1 MONITORING ABOVE THE CONFINING ZONE

Table J.4.1-1 presents the monitoring methods, locations, and frequencies for monitoring above the confining zone. Table J.4.1-2 identifies the parameters to be monitored and the analytical methods Gulf Coast Sequestration will employ.

[redacted]

4.1.1.1 Monitoring location and frequency

Table J.4.1-1 shows the planned monitoring methods, locations, and frequencies for groundwater quality and geochemical monitoring in the [redacted]. The well location and sampling depths will be guided by [redacted] prior to commencement of injection operations.

Table J.4.1-2 shows representative diagnostic analytes to be evaluated.

GCS will conduct an [redacted].

[redacted] will be drilled and completed to sample the [redacted] The preliminary location of these wells has been mapped on Figure J.4.0-1. These wells fall into two location types:

[redacted]

[redacted]

Well construction will follow Louisiana monitoring well construction requirements. Well elevations will be surveyed. A logging program will be used to set screens over suitable intervals to sample and screen depths recorded.

[redacted]. Sample procedures will be optimized to quantify dissolved gases, which includes a flow-through apparatus for collection of interact samples with headspace gas. [redacted] Additional details on sampling procedures and standards can be found in Section 4.1 of Attachment H (QASP).

[redacted]

[redacted]

The number and location of USDW monitoring wells will be adapted to ensure effective monitoring and non-endangerment of the USDW over the injection and post-injection

monitoring period. Monitoring data collected during the injection period will be used to history match the simulation model and define if and where any additional USDW water wells are required.

4.1.1.2 Sampling methods

All sample containers will be labeled with durable labels and indelible markings. A unique sample identification number and sampling date will be recorded on the sample containers. The sample container will be sealed and sent to an authorized laboratory.

4.1.1.3 Laboratory to be used/chain of custody and analysis procedures

Samples will be analyzed by a Louisiana Environmental Accreditation Program (LELAP) laboratory. LELAP is the program responsible for assessing and accrediting environmental laboratories that generate data that is submitted directly or indirectly to the Department of Environmental Quality. LELAP also assesses and accredits laboratories that generate data for the Department of Natural Resources with regards to Method Manual 29B. LELAP monitors laboratories to ensure compliance with state regulation and national standards. LELAP maintains a database that includes contact information, physical location, and matrix/method/analytes for each accredited laboratory. LELAP is one of 14 National Environmental Laboratory Accreditation Program (NELAP) recognized Accreditation Bodies.

For additional details, see Section 4.0 (Data Generation and Acquisition) of Attachment H (QASP).

[redacted]

The preliminary location of these wells has been mapped on Figure J.4.0-1.

4.1.2.1 Monitoring location and frequency

Table 1.6.6-1 Table J.4.1-3 shows the planned monitoring methods, locations, and frequencies for monitoring the [redacted]. Table J.4.1-4 identifies the parameters to be monitored and the analytical methods Gulf Coast Sequestration will employ.

[redacted]

[redacted]

The number and location of AZ monitoring wells will be adapted to ensure effective monitoring and non-endangerment of the USDW over the injection and post-injection monitoring period. Monitoring data collected during the injection period will be used to history match the simulation model and define if and where any additional AZ water wells are required. Additional AZ wells may be added to if it is determined they are necessary to monitor wells with potential corrective action.

4.1.2.2 Sampling methods (AZ)

[redacted]

4.1.2.3 Laboratory to be used/chain of custody and analysis procedures

Samples will be analyzed by a Louisiana Environmental Accreditation Program (LELAP) laboratory. LELAP is the program responsible for assessing and accrediting

environmental laboratories that generate data that is submitted directly or indirectly to the Department of Environmental Quality. LELAP also assesses and accredits laboratories that generate data for the Department of Natural Resources with regards to Method Manual 29B. LELAP monitors laboratories to ensure compliance with state regulation and national standards. LELAP maintains a database that includes contact information, physical location, and matrix/method/analytes for each accredited laboratory. LELAP is one of 14 National Environmental Laboratory Accreditation Program (NELAP) recognized Accreditation Bodies.

For additional details, see Section 4.0 (Data Generation and Acquisition) of Attachment H (QASP).

4.2 CARBON DIOXIDE PLUME AND PRESSURE FRONT TRACKING

Gulf Coast Sequestration will employ direct and indirect methods to track the extent of the carbon dioxide plume and the presence or absence of elevated pressure. The timeframe of these monitoring efforts will encompass the entire life cycle of the injection site, which includes the pre-operational (baseline), operational, and post-operational periods.

Table J.4.2-1 presents the direct and indirect methods that Gulf Coast Sequestration will use to monitor the CO_2 plume and pressure front, including the activities, locations, and frequencies Gulf Coast Sequestration will employ. The parameters to be analyzed as part of fluid sampling and associated analytical methods, are presented in Table J.4.2-2. Fluid sampling and quality control will be performed as described in Section 4.1 of the QASP.

[redacted] Should amendments to the Testing and Monitoring Plan be necessary, they will be incorporated into the permit following

approval by the EPA or LDNR. Over time, monitoring methods and data collection may be supplemented or replaced as advanced techniques are developed.

[redacted]

4.2.1 *Direct Monitoring*

4.2.1.1 In-zone monitoring (IZ) details

[redacted]. Figure J.4.0-1 demonstrates the provisional locations of in-zone wells. All wells will be drilled on GCS-controlled land with confirmed access.

[redacted] Well design will enable geochemical sampling of the Injection Zone and wireline logging.

[redacted]

4.2.1.2 CO_2 Plume Tracking

[redacted]

[redacted]

[redacted]

[redacted]

4.2.1.3 Potential modifications to CO_2 plume monitoring over project life

Additional in-zone monitoring wells will be added, if necessary, to effectively track the CO_2 plume and demonstrate non-endangerment.

New technological advances in direct pressure monitoring methods will be assessed throughout the life of the project to determine if implementation improves non-endangerment demonstration.

4.2.1.4 Pressure Front Tracking

Table J.4.2-1 presents the well-based methods that GCS will use to monitor the magnitude of any pressure change and validate the modeled pressure front, to meet the requirements of 40 CFR 146.90(g). Pressure will be measured continuously and will be recorded; a record will be kept for a minimum of 10 years after site closure and be made available upon request.

4.2.1.5 Potential modifications to pressure front monitoring over project life

[redacted]

New technological advances in direct pressure monitoring methods will be assessed throughout the life of the project to determine if implementation improves non-endangerment demonstration.

4.2.2 *Indirect Monitoring*

4.2.2.1 CO_2 Plume Tracking

The following considerations lead to selection of this method for plume tracking:

[redacted]

These measurements can be plotted against equivalent model outputs and be used to validate or correct as needed the fluid flow model and plume tracking predictions to satisfy the requirements at 40 CFR 146.90(g).

4.2.2.2 Vertical Seismic Profile (VSP)

A safety concern and monitoring challenge is verifying that injected CO_2 does not leak from the Injection Zone into the USDW and atmosphere. Seismic monitoring methods offer the most effective, cost-efficient solution.

An additional goal is to passively monitor for any seismic events induced by injection activities. These seismic events may indicate CO_2 leakage pathways.

[redacted]

A VSP is a measurement in which a seismic signal generated at the surface of the earth is recorded by geophones secured at various depths within a well borehole or Distributed Acoustic Sensing ("DAS") fiber optic cable (Stewart, 2001).

[redacted]

[redacted]

4.2.2.3 Potential modifications to in-direct monitoring over project life

Monitoring data collected throughout the injection period and post-injection period will be used to determine if the VPS needs expanding to effectively track the CO2 plume and confirm non-endangerment of the USDW.

New technological advances in in-direct methods will be assessed throughout the life of the project to determine if implementation improves non-endangerment demonstration.

4.3 SCHEDULE FOR SUBMITTING POST-INJECTION MONITORING RESULTS

GCS will provide the reports detailed in the following sections to the UIC Program Director.

4.3.1 Semi-Annual Reports

Semi-annual reports will contain:

- Any changes to the physical, chemical, and other relevant characteristics of the carbon dioxide stream from the proposed operating data;
- Monthly average, maximum, and minimum values for injection pressure, flow rate and volume, and annular pressure;
- A description of any event that exceeds operating parameters for annulus pressure or injection pressure specified in the permit;
- A description of any event which triggers a shut-off device required pursuant to § 146.88(e) and the response taken;

- The monthly volume and/or mass of the carbon dioxide stream injected over the reporting period and the volume injected cumulatively over the life of the project;
- Monthly annulus fluid volume added; and
- The results of monitoring prescribed under §146.90. (LAC 43:XVII.3625.A)

4.3.2 Reporting (Within 30 Days)

Report to the UIC Program Director, within 30 days, the results of:

- Periodic tests of mechanical integrity;
- Any well workover; and
- Any other test of the injection well conducted by the permittee if required by the Director.

4.3.3 Reporting (Within 24 Hours)

Report to the UIC Program Director, within 24 hours, the results of:

- Any evidence that the injected carbon dioxide stream or associated pressure front may cause an endangerment to a USDW;
- Any noncompliance with a permit condition, or malfunction of the injection system, which may cause fluid migration into or between USDWs;
- Any triggering of a shut-off system (i.e., down-hole or at the surface);
- Any failure to maintain mechanical integrity; or
- Pursuant to compliance with the requirement at § 146.90(h) for surface air/soil gas monitoring or other monitoring technologies, if required by the Director, any release of carbon dioxide to the atmosphere or biosphere.

4.3.4 Notification (30 Days In Advance)

Owners or operators must notify the Director in writing 30 days in advance of:

- Any planned well workover;
- Any planned stimulation activities, other than stimulation for formation testing conducted under §146.82; and (LAC 43:XVII.3607.A)

- Any other planned test of the injection well conducted by the permittee.

5.0 NON-ENDANGERMENT DEMONSTRATION CRITERIA

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) (LAC 43:XVII.3633.A.2.b and LAC 43:XVII.3633.A.2.c)

GCS will issue a report to the UIC Program Director. This attachment 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: Introduction and Overview; Documentation of Wells within the AoR; Existing Monitoring Data Summary; Computational Modeling History Summary; Reservoir Pressure Evaluation; Carbon Dioxide Plume Evaluation; and Emergencies or Other Events Evaluation

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:

- Attachment B - Area of Review and Corrective Action Plan
    - 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 Attachment B (Area of Review and Corrective Action Plan). 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) (LAC 43:XVII.3607.C.2.e) and 146.87(d)(3) (LAC 43:XVII.3617.B.4.c)

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

[redacted]. This monitoring will occur in all injector wells and in-zone monitor wells. The data will be used to history match the simulation model. After calibration (history matching) the model will be used to update its predictions of the development of the AoR, pressure front and CO_2 plume.

5.6 EVALUATION OF CARBON DIOXIDE PLUME

[redacted]

These data measurements 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.

5.7 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 to its intent to close the site. Once the permitting agency has approved closure of the site, GCS will plug the monitoring wells, remove any VSP-related apparatus 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.

[redacted]

[redacted]

[redacted]

[redacted]

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 site closure report will be submitted to the permitting agency and maintained by GCS for a period of 10 years following site closure. Additionally, the owner or operator will maintain the records collected during the post-injection period for a period of 10 years after which these records will be delivered to the UIC Program Director.

7.0 QUALITY ASSURANCE AND SURVEILLANCE PLAN ("QASP")

The Quality Assurance and Surveillance Plan (QASP) is presented as Attachment H.

8.0 REFERENCES

(Gaus et al., 2005): Gaus, I., Azaroual, M., & Czernichowski-Lauriol, I., "Reactive transport modelling of the impact of CO_2 injection on the clayey cap rock at Sleipner (North Sea)", Chemical Geology, 217(3-4), 319-337, 2005

(Wesson and Nicholson, 1987): Wesson, R.L. and Nicholson, C., "Zero Cohesion Mohr-Coulomb failure criterion", method by E.I. du Pont de Nemours & Co., 1987.