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

PROJECT GOOSE LAKE

TABLE OF CONTENTS

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 Goose Lake Wells 1-2
Facility contact:	Benjamin Heard, Principal 2417 Shell Beach Drive, Lake Charles, Louisiana 70601 (713) 320.2497; bheard@gcscarbon.com
Well location: (bottom hole)	Calcasieu Parish, Louisiana – Datum WGS84 [redacted] [redacted]

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

Based on the modeling of the pressure front as part of the Area of Review ("AoR") delineation, pressure at the injection well is expected to decrease to pre-injection levels as given in [redacted] Additional information on the projected post-injection pressure declines and differentials are presented in the "Area of Review and Corrective Action Plan 40 CFR 146.84(b)" permit document module and report.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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

Figure 2.1-1 shows the predicted extent of the plume, AoR and pressure front at the end of the [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

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

A Testing and Monitoring Plan has been designed to monitor the Project Goose Lake 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 Injection Zone. This will allow AoR re-evaluations and a non-endangerment demonstration.

A full overview of the Testing and Monitoring Plan may be found in the Testing and Monitoring Plan 40 CFR 146.90 report and accompanying files.

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 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).

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 Goose Lake 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:

4.1 Introduction and Overview

A summary of relevant background information will be provided, including the operational history of Project Goose Lake, the date of the non-endangerment demonstration relative to the post-injection period outlined in this Post-Injection Site Care and Site Closure Plan 40 CFR 146.93(a), and a general overview of how monitoring and modeling results will be used together to support a demonstration of USDW non-endangerment.

4.2 Documentation of Wells within the AoR

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

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

4.3 Summary of Existing Monitoring Data

A summary of all previous monitoring data collected at Project Goose Lake, pursuant to the Testing and Monitoring Plan 40 CFR 146.90 and this Post-Injection Site Care and Site Closure Plan 40 CFR 146.93(a), 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.

4.4 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 using a variety of data sources (see bibliography 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.

4.5 Evaluation of Reservoir Pressure

There will be regular pressure build-up tests (to determine reservoir pressure and monitor 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 reservoir simulation 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.

4.6 Evaluation of Carbon Dioxide Plume

There will be regular VSP surveys, the timing of such surveys will be based on based on the mass injected and validated with the VSP vendor to determine the presence of CO_2 in the vicinity of the VSP line. These data measurements will be used as history matching data for future versions of the reservoir simulation 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. VSP monitoring is discussed in:

- Testing and Monitoring Plan 40 CFR 146.90
  - Section 1.2.4 Time-Lapse Monitoring Overview

4.7 Evaluation of Emergencies or Other Events

The wells where this data is to be collected will be modelled in the reservoir 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 reservoir simulation model. Having calibrated the reservoir model, it can be used to predict the risk that mobilized fluids pose a danger to USDWs.

5.0 Site Closure Plan

GCS will conduct site closure activities to meet the requirements of 40 CFR 146.93(e). 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 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.

5.1 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. The 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) has 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 it to the years-old baseline log could provide bonus information to participants.

If tubing exists 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 inch tubing is approximately 2.7 in^2, and the force exerted on the cement top would be approximately 10,000 lbs ÷ 2.7 $in^2 \approx$ 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:

- Top of the Anahuac Formation, the Confining Zone directly 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.

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.

5.2 Site Closure Report

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

- Plugging of all injection and testing and monitoring wells
- 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
- 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
- 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.

6.0 Quality Assurance and Surveillance Plan ("QASP")

The Quality Assurance and Surveillance Plan is presented in Section 3.0 of the Testing and Monitoring Plan 40 CFR 146.90.

7.0 References

(Juanes et al, 2006): Juanes, R., Spiteri, E.J., Orr, F.M. and Blunt, M.J., "Impact of relative permeabilities on geological CO_2 storage", Water Resources Research, Vol.42 W12418, 2006.

(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.