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TESTING AND MONITORING PLAN
40 CFR 146.90

GULF COAST SEQUESTRATION
PROJECT GOOSE LAKE

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1.0 Introduction

This Testing and Monitoring Plan describes how Gulf Coast Sequestration ("GCS") will 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 underground sources of drinking water ("USDW"), 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 Area of Review ("AoR") reevaluations and a non-endangerment demonstration.

Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan 40 CFR 146.94(a).

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:	Calcasieu Parish, Louisiana – Datum WGS 1984 [redacted]

1.2 Overall Strategy and Approach for Testing and Monitoring

The Testing and Monitoring Plan is adapted to site area and considers the following site-specific parameters:

1. The Injection Zone (Upper Frio Formation) has been divided into 11 regionally correlated, geological sequences (alternating sandstone and mudstone intervals). Many of these sandstones function as separate flow units separated by intra-Frio flow barriers or baffles (mudstones). The thickness of the Upper Frio Formation ranges from 1,200 to 1,500 ft.
2. The performance of the Upper Frio Formation in accepting injected CO_2 is well understood:
    a. It has been used regionally as a target for Underground Injection Control ("UIC") Class 1 injection
    b. It has hosted an extensively monitored DOE-funded test injection project in Liberty County, Texas
    c. It has received CO_2 for CO_2 EOR in multiple fields. Two Upper Frio injection sites at Hastings Field and West Ranch Field received anthropogenic CO_2 and have been monitored as part of DOE-funded programs supporting CCUS projects
3. The performance of the shale-rich Anahuac Formation as a Confining Zone is well known:
    a. It retains hydrocarbons regionally
    b. Coring and testing programs conducted as part of the UIC Class 1 program have documented the quality of this thick, low permeability mudstone
    c. [redacted] Consequently, vertical leakage through the Anahuac Formation along faults or fractures is not considered a credible leakage pathway.
4. The Miocene interval overlying the Anahuac Formation is composed of >7,000 ft of highly transmissive sandstones, interbedded regional mudstone seals and local mudstone baffles. Regionally, the Miocene contains hydrocarbons and is used for Class 1 injection in both Louisiana and Texas. [redacted]
5. The Chicot aquifer within the AoR is hosted in the transmissive and multi-layered Beaumont Formation, which is regionally well known as a groundwater resource. However, locally it is sparsely used, and saline waters may be present because of natural salinization near salt domes or as a result of early oil and gas production activities that failed to protect USDWs. In addition, the Chicot aquifer system is locally charged with both biogenic and thermogenic methane. The monitoring program will document the initial condition of salinization of this aquifer system so that any changes resulting from failure to retain during injection can be recognized. [redacted]

[redacted]

6. Natural seismicity in the area is low and induced seismicity risk is also low because of high transmissivity and lack of brittle rocks within, above, or below the Injection Zone. Previous measurements of seismicity in Gulf Coast projects have not detected events resulting from injection. Therefore, seismicity will be monitored for change in frequency. Only if a change in frequency occurs will monitoring of local events be undertaken. Bottom seal is provided by thick mudstones of the Mid Frio Formation (Hackberry Shale). Brittle basement is greater than 6 miles (10 km) below the Injection Zone and will not be impacted in any way by the injection program.
7. GCS has set forth a robust proposal for characterizing surface monitoring over the life of the project. The primary objective of the proposed surface sampling and investigation workplan is to evaluate baseline conditions of surface water and ecological conditions within the AoR. [redacted]

Two injection wells will create a single CO_2 plume and area of elevated pressure that results in the Area of Review AoR. The injection wells have been sited so that the generated CO_2 plume intersects as few existing wells as possible over the life of the project. The AoR will grow over time and will intersect some existing wells. Validation of the magnitude and area of pressure increase during injection is, therefore, a monitoring focus, as well as documenting plume stabilization (described in the Alternative Post-Injection Site Care and Closure Plan 40 CFR 146.93(a) document submitted separately).

1.2.1 Project risk assessment

Monitoring is systematically designed to reduce project risk. This section outlines the site-specific risks and describes how the monitoring plan will systematically reduce them. Three prospective risk categories are identified:

1.2.1.1 Risk category 1: Within the planned CO_2 plume at stabilization or AoR a well lacks zonal isolation

The statistics below summarize the outcome of an exhaustive well records search detailed in the Area Of Review and Corrective Action Plan 40 CFR 146.84(b) document, Section 8.1 "Tabulation of Artificial Penetrations within the AoR" . All wells in the modeled 30-year (complete project length) CO_2 plume and AoR have been systematically reviewed to confirm if they present potential manmade conduits between the Injection Zone and USWD.

[redacted]

[redacted]

[redacted]

1.2.1.2 Risk category 2: The CO_2 plume or area of elevated pressure migrates preferentially in one zone or along one feature and becomes larger than the planned area of review

Injection for the project is placed down-dip, on a monocline to maximize isolation of the CO_2 from heavily drilled oil/gas fields to the north (Choupique) and northeast (Bayou Choupique), and salt domes to the northwest (Vinton Dome) and south (West Hackberry Field). The CO_2 plume and AoR have been modeled with best available approaches and the results indicate that the CO_2 plume and pressure elevation does not impinge on the areas of dense penetrations. [redacted]

1.2.1.3 Risk category 3: Induced seismicity as a result of injection is a risk commonly mentioned for injection projects

Calculation of risk for this project shows that this risk is negligible. See Class VI Permit Application Narrative 40 CFR 146.82(a) document, Section 3.3.3 Seismic Risk Analysis (submitted separately). The best practice in this situation is to monitor seismic magnitude and frequency to show that no unexpected change is occurring. Monitoring to assess plume migration will be augmented with a seismometer to provide basic seismic magnitude and frequency surveillance.

1.2.2 Design of the monitoring network to achieve risk management

The monitoring approaches selected to manage the risks described in the previous section are described for each of the categories listed above.

1.2.2.1 Risk category 1: A well in AoR lacks zonal isolation

[redacted]

[redacted] The main barrier used to detect out-of-zone migration along a well that may lack sufficient cement bond is *above-zone pressure monitoring*. [redacted] Pressure-based AZMI monitoring is widely used for protection via monitoring in settings including gas storage reservoirs and was tested for CO_2 storage projects at the SECARB Early Test at Cranfield Field, Mississippi. Additional storage projects using pressure based AZMI are associated with EOR at Hastings Field in Alvin, Texas and West Ranch Field in Vanderbilt, Texas.

Secondary to the AZMI, a *near-surface surveillance program* has been designed to be deployed as needed to provide assurance that no near-well leakage is occurring. The ecosystem monitoring program is described in #8 of Section 1.2.3 Monitoring Network below and includes a current "baseline" salinity profile based on a region-wide conductivity survey and a strategic water and gas sampling program with a natural tracer focus that will separate normal ecosystem variability from any leakage signal. This meets the expectation of baseline and ecosystem monitoring.

1.2.2.2 Risk category 2: CO_2 plume or area of elevated pressure becomes larger than the modeled area of review.

The extent of plume migration prior to stabilization and the extent of elevated pressure such that endangerment of USDW could occur have been modeled using the best available assumptions and data. If this was to occur, the CO_2 or elevated pressure could encounter wells or faults that have not been evaluated to determine that they are isolating, resulting in the same leakage signal as in Risk Category 1, but in areas outside of the modeled AoR. Monitoring will be used to increase confidence in modeled outcomes and avoid the potential damage that could occur if the CO_2 plume or area of elevated pressure becomes larger than modeled. Monitoring AoR extent includes three components:

1. Surveillance of the seismically detectable plume extent
2. Surveillance of the extent of pressure elevation
3. Salinity profile based on a region-wide conductivity survey that extends into areas of dense existing penetrations

This monitoring will meet the expectation of plume and pressure tracking and be conducted at intervals during the injection and post-injection site care and closure period (outlined in the Alternative Post-Injection Site Care and Site Closure Plan 40 CFR 146.93(a), or "PISC" document, submitted separately).

Surveillance of the seismically detectable plume extent will use time-lapse seismic measurements on selected transects that detect the substitution of CO_2 for brine in the injection intervals as the main confirmation that the CO_2 is accessing the pore volume following the pattern predicted by the modeling. [redacted]

A secondary surveillance that the USDW is not being impacted by pressure increase in the Injection Zone and brine leakage into USDW will be based on the salinity profile, which is based on a region-wide conductivity survey that extends into areas of dense existing penetrations. GCS expects that the areas around salt domes will have naturally elevated salinity and temperature profiles as is typical of these features. Past oilfield practices may also have added local salinization. The conductivity survey will map these pre-injection salinity anomalies. A repeat conductivity survey will show that the injection has not elevated salinity in the USDW in these areas.

1.2.2.3 Risk category 3: Induced seismicity as a result of injection

The frequency and magnitude of local microseismic events can be used to forecast the likelihood of felt or damaging earthquakes. A single installed direction microseismic sensor will confirm that injection into the Upper Frio Formation in this location has no detectable impact on seismicity in the magnitude 2 range.

1.2.3 Monitoring network

The monitoring network is composed of the following elements shown in [redacted]

1. Monitoring at the pipeline handoff to the injection site will determine the key parameters of mass and purity of CO_2 needed for accounting of mass injected and modeling of the subsurface response to injection.
2. Monitoring at injection wells will assure that the wells are performing as intended to deliver the CO_2 to the subsurface storage horizons and measure the pressure response at the reservoir intervals, a key model match parameter. Downhole pressure gauges and injection logging in the four injection wells will be used to assess within-plume reservoir response to injection.

[redacted]

[redacted]

1.2.4 Time-Lapse Monitoring Overview

Time-lapse seismic methods attempt to quantify the difference in the seismic response of the subsurface before and after human interference (mainly hydrocarbon production and fluid injection). Multiple theories and case studies have been published on this subject. The main aim is to interpret the temporal changes observed in the seismic response of the subsurface in terms of saturations, pore pressure, and temperature in order to ascertain bypassed pockets of fluids and, eventually, increase the recovery factor.

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1.2.5 Quality assurance procedures

A Quality Assurance and Surveillance Plan ("QASP") for all testing and monitoring activities, required pursuant to 146.90(k), is provided in Section 3.0 QASP.

1.2.6 Reporting procedures

GCS will report the results of all testing and monitoring activities to the EPA in compliance with the requirements under 40 CFR 146.91.

1.3 Carbon Dioxide Stream Analysis [40 CFR 146.90(a)]

GCS will analyze the CO_2 stream during the operation period to yield data representative of its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a).

1.3.1 Sampling location

CO_2 stream sampling will be conducted for all (two) injection wells at the storage facility transfer point co-located with the mass flow meter.

1.3.2 Sampling frequency

CO_2 stream sampling will be conducted every three months (quarterly) or when known changes to the injected stream occur (i.e., source changes and/or additions/deletions to the existing stream). Density measurements at the mass flow meter greater than normal variability and not correlated to thermal variations also will trigger sampling. The isotopic composition of carbon in CO_2 ($\delta C^{12}/C^{13}$ ratio and C^{14}) will be measured once and repeated only if new sources are added.

1.3.3 Analytical parameters

GCS will contract a vendor to analyze the CO_2 for the constituents identified in Table 1.3.3-1 using the methods listed. If the constituents are not found in initial analysis or are screened out at the source prior to CO_2 pipeline transport this will be documented and with the prior approval of the UIC Program Director, they will be removed from the list of analytical parameters.

1.3.4 Sampling methods

The sampling system will step down pressure from pipeline pressure to atmospheric pressure sample container without loss of minor impurities. The sampler will be purged with pipeline CO_2 to remove contaminants prior to sample collection. 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 shipped to a Louisiana authorized laboratory(s).

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

Samples will be analyzed by a third party laboratory accredited by the Louisiana Department of Environmental quality (https://internet.deq.louisiana.gov/portal/divisions/lelap/accredited-laboratories) using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization.

1.4 Continuous Recording of Operational Parameters [40 CFR 146.88(e)(1), 146.89(b) and 146.90(b)]

GCS will install and use continuous recording devices to monitor as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b) the CO_2 mass delivered to the project at the transfer point, the volume and temperature of CO_2 allocated to each well, the pressure at well head, the pressure on the injection tubing, the pressure at well head on the annulus between the tubing and the long string casing; the annulus fluid volume added.

1.4.1 Monitoring location and frequency

GCS will perform the activities identified in [redacted] to monitor operational parameters and verify internal mechanical integrity of injection wells. Monitoring will take place at the locations and frequencies shown in [redacted]

Following conventional practices at injection sites with multiple wells, Project Goose Lake will use a mass flow meter to measure CO_2 mass delivered to the project at the transfer point from the pipeline to the project (same location as CO_2 stream analysis so that any non-CO_2 impurities can be subtracted from the storage accounting). Calibration will be conducted following the manufactures instructions and reported.

Additional flow meters will be installed on flow lines prior to each well to record CO_2 volume and temperature which will serve to guide the allocation of the CO_2 on a per well basis. Calibration will be conducted following the manufactures instructions and reported.

The following equipment/meter types will be used to facilitate the required monitoring requirements:

Injection pressure

- Proposed equipment: pressure transmitter

- Expected accuracy: Rosemount brand (or similar) – example accuracy is ± 0.04% reference accuracy resulting in ± 0.15% total operating performance; Stability (5-yr): ± 0.125%

Temperature

- Proposed equipment: temperature transmitter
- Expected accuracy: Rosemount brand (or similar) – example accuracy is ± 0.02% of span D/A Accuracy, RTD Stability: ± 0.25% or 0.25 °C, whichever is greater for years

CO_2 Rate and Volume

- Proposed equipment: Mass flow computer, senior orifice meter with mass flow computer or Coriolis meter (TBD)
- Expected accuracy: Orifice meter - Differential Absolute Pressure: ± 0.05% of span (for spans between 10% and 90% of Upper Range Limit (URL); Digital Output (spans < 10% URL): ± (0.005) x (URL/Span)% of Span; Long Term Drift Stability: ± 0.05% of URL per year over 5 years; Temperature: ± 0.15°C (±0.27 °F) (not including RTD uncertainties). Coriolis meter – mass flow accuracy: 0.1% of rate ± (zero offset/mass flow rate) x 100%; repeatability 0.075% within the range of 10:1 of full-scale (FS) and 0.5% within the range of 100:1 of FS; rangeability up to 100:1

Annulus pressure

- Proposed equipment: ABB absolute pressure instrumentation.
- Expected accuracy: Base accuracy: ± 0.1 %

Annulus fluid volume

The annular fluid volume is a fixed value rather than dynamic (that would require a meter) and will be calculated by using the following formula:

Annular capacity in bbl/ft = $(Dh^2 - Dp^2) \div 1029.4$

Where;
Dh in inch
Dp in inch

The calculated volume is based on the inside diameter of wellbore casing and outside diameter of tubing string above the packers set in the wellbore.

1.4.2 Monitoring details

The mass flow meter will be protected against damage by lightning.

Each well will be completed with equipment needed to 1) account for per-well injection mass and pressure as inputs to fluid flow modeling to validate AoR predictions and 2) assure well integrity is maintained.

Wellhead pressure and temperature gauges will be installed to detect changes and record changes in tubing pressure filled with CO_2 and the casing-tubing anulus (filled with corrosion-inhibited fluid). Replenishment of corrosion-inhibited fluid will occur as needed, and the amounts added will be recorded. A more-rapid-than-normal change in casing-tubing anulus pressure will trigger shut-in of injection and inspection of well components until failure is identified.

Downhole quartz pressure gages on wireline readout will provide needed input to models and serve as opportunities for additional calibration of fluid flow models during injection fall-off tests and as injection is started at each injection well. Downhole pressure monitoring protects the project against over-injection as the near well environment is cooled and CO_2 becomes denser. The gauge location will be on tubing above the packer where the gauge is protected by corrosion inhibited fluid with a pass though into the tubing. Pressure gauges will be calibrated according to manufacturers instructions and corrected for drift by comparison to tubing deployed gauges during MIT.

Wireline logging to assess the injection profile will be conducted at a minimum six months and two years after the start of injection at each well to assess which zones are being used by CO_2 and input this into models. A commercial vendor will be selected to conduct this logging using any of the standard techniques. If the injection profile is not optimum, this log provides input to correct the strategy.

[redacted]

[redacted]

1.5 <u>Corrosion Monitoring</u>

To meet the requirements of 40 CFR 146.90(c), GCS will monitor well materials during the operation period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to ensure that the well components meet the minimum standards for material strength and performance.

GCS will monitor corrosion using coupons and collect samples according to the description below in all proposed monitoring wells put forth in this report.

1.5.1 Monitoring location and frequency

Analyzing coupons of the well construction materials used in the well casing and tubing (and any other well parts in contact with CO_2) and inspecting the materials in the coupons for loss of mass, thickness, cracking, pitting, and other signs of corrosion. Loop and coupon details to be specified as part of pipeline and well design. These tests will be performed by qualified vendors on a quarterly calendar basis starting at the end of the first quarter month (March, June, September, December) following authorization and start-up of injection.

1.5.2 Sample description

GCS anticipates that corrosion coupon (weight loss) technique will be used for monitoring purposes as is the best known and simplest of all corrosion monitoring techniques (alternative is to use flow line loops). The corrosion monitoring system will be located downstream of all process compression/dehydration/pumping equipment (i.e., at the beginning of the pipeline to the wellhead). This tray of coupons will operate any time injection occurs. No other equipment will act on the CO_2 past the location of the tray; therefore, this location will provide representative exposure of the samples to the CO_2 composition, temperature, and pressures that will be seen at the wellhead and injection tubing. The holders and location of the system will be included in the pipeline design and will allow for continuation of injection during sample removal. The coupon method involves exposing a specimen sample material (the coupon) to a process environment for a given duration, then removing the specimen for analysis. Coupons will include materials of construction for all elements in contact with the CO_2 stream (Table 1.5.2-1). Corrosion analysis will consist of:

1. Sample photography
2. Cleaning
3. Precision weight loss analysis
4. Corrosion rate evaluation
5. Localized corrosion (pitting) analysis

Methods for initial coupon preparation and analysis/evaluation of exposed coupons will follow ASTM G1 - 03(2017) and/or NACE Standard RP0775-2005 Item No. 21017 standards.

1.5.3 Monitoring details

Per 40 CFR 146.90, GCS will run a casing inspection log (internal and external) to determine the presence or absence of corrosion in the protection (long string) casing when the tubing is pulled from the well. The log(s) will be compared to those run during construction of the well (40 CFR

146.87). Additional inspection logging may be performed should the coupons show excessive corrosion in excess of design-life criteria.

Alternative testing other than those listed above may be conducted, with the written approval of the Administrator. To obtain approval for alternative testing, GCS will submit a written request to the Administrator setting forth the proposed test and all technical data supporting its use.

1.6 Above Confining Zone Monitoring

GCS will monitor two water-bearing zones in the AoR to meet the requirements of 40 CFR 146.90(d): the lower-most USDW of the Chicot Formation (fresh water) and the part of the Miocene interval above the Anahuac Formation Confining Zone (saline water). Leakage detection strategy is different in the two zones, so they are discussed separately.

1.6.1 USDW monitoring in the lower part of the Chicot freshwater aquifer

The following sections detail the monitoring methodology. Please refer to Figure 1.2.3-1.

1.6.2 Monitoring location and frequency

[redacted]

The goal of groundwater monitoring is to develop a strategy to detect either brine or CO_2 leakage from depth into the aquifer, should it occur, using a process known as attribution of signal. This is not simple because many factors are expected to impact groundwater quality in this project area over the coming decades, including change in water levels related to sea level change and climate changes, changes in water production in offsite industrial areas, gradual natural mitigation and dilution of likely past oilfield water contamination events, natural migration of deep basin brines toward the surface in response to basin compaction, change in freshwater chemistry related to salt dissolution at salt domes, and land use changes. The same techniques will be used, if needed, to quantify leakage, assess impacts and validate remediation

Attribution requires:

1. Characterization of injected fluids (described in Section 1.3 Carbon Dioxide Stream Analysis)
2. Characterization of potential deep fluids in the Injection Zone and overburden that might migrate to the USDW (described below in Section 1.6 Above Confining Zone Monitoring and Section 1.9 Carbon Dioxide Plume and Pressure Front Tracking)
3. Characterization of the ambient areal and seasonal variability of the USDW (described in this section)
4. Modeling the signal that would allow identification of a mixture of injected fluids and Injection Zone fluids, and separation from naturally driven changes (also described in this section).

It is important to collect and analyze components that will be diagnostic, this will depend on the outcomes of initial characterization and monitoring, but Table 1.6.2-2 shows representative analytes to be evaluated.

[redacted]

Approximately five wells will be drilled and completed to sample fresh water in the USDW. A freshwater sampling point will be located at the injection well pad. Four other freshwater wells will be placed at areas of anomaly or leakage concern, based on the interpretation of the airborne conductivity survey (provisional groundwater well locations shown in [redacted] These wells fall into two location types:

1. **<u>Injection Site Specific USDW Monitoring wells</u>**

A USDW sampling point will be located at the injection well pad in order to validate that the injection wells are not leaking saline formation water or CO_2 into the USDW. This well is located where the modelled pressure and CO_2 concentrations are highest over the life of the project.

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1.6.3 Sampling methods

The sampling system will be used to sample and quantify free and dissolved gases and the aqueous phases in equilibrium with theme. Water samples will be collected from groundwater wells according to EPA method SESDPROC-301-R4 after purging three well volumes with a pump. Temperature, pH, specific conductivity, and dissolved oxygen and temperature will be measured in the field. Samples for isotopic analysis of DIC will be collected in 100-ml amber glass bottles with minimized headspace, and one drop of biocide (benzalkonium chloride) to eliminate biologic alteration of the sample. Samples will be immediately stored on ice and mailed overnight to a contracted laboratory for analysis of analytes listed in Table 1.6.2-2. All samples will be filtered in the field with a 0.45µm filter. Conditions during groundwater sampling will be recorded in the field.

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.

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

Samples will be analyzed by a third party laboratory accredited by the Louisiana Department of Environmental quality (https://internet.deq.louisiana.gov/portal/divisions/lelap/accredited-laboratories) using standardized procedures for gas, major, minor and trace element compositions..

[redacted]

1.6.6 Monitoring location and frequency

[redacted]

[redacted]

1.6.7 Sampling methods

The sampling system used to sample and quantify free and dissolved gases and the aqueous phases in equilibrium with these gases will be supplied by a vendor using Kuster sampler or equivalent tool. Deep brine sampling protocols are needed and all gases, not just hydrocarbons will be assessed. Methods are:

1. Purge the casing volume to bring fresh fluids that have not reacted with casing and tubing to the sample point
2. Deploy commercial downhole sampler on slickline to collect a fluid sample at pressure and then close to retain gas phases as sample is transported to the surface
3. Conserve gas volumes as samples are stepped to atmospheric pressure for shipping and analysis
4. Filter and conserve samples following protocols for brine sampling. 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

[redacted]

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

Samples will be analyzed by a third party laboratory accredited by the Louisiana Department of Environmental quality (https://internet.deq.louisiana.gov/portal/divisions/lelap/accredited-laboratories) using standardized procedures for gas, major, minor and trace element compositions..

1.7 External Mechanical Integrity Testing ("MIT")

GCS will conduct at least one of the tests presented in Table 1.7-1 annually during the injection phase to verify external mechanical integrity as required at 146.89(c) and 146.90.

1.7.1 Testing location and frequency

GCS will perform an annual external mechanical integrity log on each injection well. Preferred testing will be performed using a temperature survey. The principal requirement for running temperature logs is that the well be shut-in long enough so that temperature effects related to well construction can dissipate, leaving a relatively simple temperature profile. Experience has shown that 36 hours is usually sufficient for the shut-in time period. Temperature survey data will be developed from the optical fiber attached to each injection well protection (longstring) casing.

Should the optical fiber not be functioning, the survey will be performed via a wireline truck and the temperature survey will be run over the entire interval of cemented casing. Note that to be effective, temperature logging tools must have good thermal coupling to the borehole environment, which means that they are not generally useful in gas or air-filled boreholes. Depending on phase of the carbon dioxide in the well, this may require that the wellbore be displaced with water or bine and allowed to thermally stabilize prior to logging. When possible, the sonde will be calibrated to know temperature, such as in a bucket of ice water and in a bucket of water with a thermometer. The injection well will be logged from the surface downward, lowering the tool at a rate of no more than 30 feet per minute, which represents a practical balance between the tool response time and normal field time constraints. Note that slower logging speeds provide increasing detail. The temperature log should include both an absolute temperature curve and a differential temperature curve. A correlation log(s) should be recorded in track 1 (such as casing collar locator or gamma ray), and the two temperature curves recorded in tracks 2 and 3. The temperature log should be scaled at or about 20° F or 10° C degrees per track and the differential curve scaled in any manner appropriate to the logging equipment design, but it must be sensitive enough to readily indicate thermal anomalies.

Testing will be scheduled to be performed on an approximate annual basis, within +/- 45 days of the prior years' test. GCS will notify the Director ahead of testing should a testing event fall outside of the +/- 45-day window. Note that should a wireline truck be needed to run the surveys, testing for each well may be consolidated to a common timetable.

Alternate logging will consist of either a tracer survey, such as either a radioactive tracer or oxygen-activation log, or noise log. GCS will notify the Director ahead of testing should an alternate testing method be employed in one or more of the injection wells.

1.7.2 Testing details

Using temperature survey data from the optical fiber attached to each injection well protection (longstring) casing in each injection well is the simplest and preferred testing methodology for the demonstration of external integrity. Data from the optical fiber will be collected starting at cessation of injection and then accrued at increasing time intervals out to approximately 36 hours of shut in. Should the optical fiber not be functioning, the temperature survey will be performed via a wireline truck.

Subsequent temperature surveys will be compared to the baseline and prior surveys in each injection well. Deviations from a predictable geothermal gradient (initial survey), indicate the effects of injection. Within the Upper Frio Formation, deviations will occur in those sands receptive to flow. Deviations above the Anahuac Shale are anomalies. These may take the form of a nearly constant temperature between strata separated over a significant interval. In the case of the optical fiber temperature data, or if more than one log is run from a wireline truck, these anomalies are likely to "grow" as the other parts of the temperature profile return toward the natural geothermal gradient. In addition, those areas with active flow will reach a stable temperature more quickly than other areas (zones of historical flow).

If there are unresolved temperature anomalies that cannot be explained, a failure of mechanical integrity of the injection well may be indicated. In such a case, additional logging may be necessary to show whether a loss of mechanical integrity is occurring in that injection well. Depending on the nature of the suspected movement, radioactive tracer, noise, oxygen activation, or other logs approved by the Director may be required to further define the nature of the fluid movement. Identification of flow behind the casing is always made from long-term shut-in logs. The resolution of long-term shut-in logs for identifying the presence of flow is greater than that of logs made during injection. The temperature gradient from top to bottom within a well which has been injecting for some time is very shallow. The temperature at the Injection Zone may be only a few degrees different from that at the surface. The presence of a flow behind the casing will result in a fractional change in this gradient which will be proportional to the ratio of the flow rates within and outside the tubing. Therefore, only a rather substantial flow can be identified using logs made during injection.

1.8 Pressure Fall-Off Testing

GCS will perform pressure fall-off tests during the injection phase as described below to meet the requirements of 40 CFR 146.90(f). Special considerations will be made for pressure fall-off testing, as injection at one well will influence the pressure fall-off curve at other wells. For the offset wells (i.e., those not being tested), injection will cease prior to the test for a period of time exceeding the planned shut-in period, and injection rates will be held constant and continuously recorded during the test.

1.8.1 Testing location and frequency

GCS will perform a baseline pressure falloff test using brine or water mixed with a clay stabilizer in each injection well. This will allow for baseline characterization of the transmissibility of the Upper Frio at each injection well. The initial pressure falloff testing will be repeated using carbon dioxide within the first 60 days of injection operations. This will allow for comparison to the baseline test with the change in the injection fluid from brine water to carbon dioxide.

A subsequent pressure falloff test will be performed within +/-45 days of the 2-1/2-year anniversary of the start of carbon dioxide injection and within +/-45 days of the 5-year anniversary of the startup of injection. Thereafter, a pressure falloff test will be performed in each injection well within +/-45 days of each subsequent 5-year anniversary of the previous pressure test throughout the duration of the injection project. A final pressure falloff test will be run at the cessation of injection into each injection well.

1.8.2 Testing details

Testing procedures will follow the methodology detailed in EPA Region 6 UIC Pressure Falloff Testing Guideline-Third Revision (USEPA, 2002). Bottomhole pressure measurements near the perforations are preferred due to phase changes within the column of carbon dioxide in the tubing. A surface pressure gauge may also serve as a monitoring tool for tracking the test progress.

The downhole pressure gauge can be either installed as part of the completion or can be deployed via a wireline truck. If a wireline truck deployed gauge is used, the wireline should be corrosion resistant (such as MP-35 line), and the deployed gauges should consist of a surface read-out gauge with a memory backup. Gauge specifications should be as follows or similar to those shown in Table 1.8.2-1.

General testing procedure is as follows (presumes that a wireline deployed unit is used for the testing, note that dedicated downhole monitoring gauge may be used if installed on the injection well).

1. Mobilize wireline unit to the injection well and rig up on wellhead.
2. Rig up a wireline lubricator containing a calibrated downhole surface-readout pressure gauge ("SRO") with memory gauge installed in the tool string as a backup, to the adapter above the crown valve. Each gauge should have an operating range of 0-10,000 psi.

Reference the gauge to kelly bushing ("KB") reference elevation and the elevation above ground level.

3. Open crown valve, record surface injection pressure, and run-in hole with SRO to just above the shallowest perforations in the completion while maintaining injection at a constant rate. Steady rates of injection should be maintained for at least 24 hours ahead of the planned shut-in of the injection well. Any offset injection well should be either shut-in or maintaining a constant rate of injection for the entire duration of the testing. This will minimize any cross-well interference effects.
4. With the SRO positioned just above the perforations, monitor the bottom-hole injection pressure response for ±1 hour to allow the gauge to stabilize (temperature and pressure stabilization). Ensure that the injection rate and pressure are stable.
5. Cease injection as rapidly as possible (controlled quick shut-in); close the control valve and the manual flowline valve at well site (start with the valve closest to the wellhead so that wellbore storage effect in early time is minimized). Conduct the pressure fall-off test for approximately 24 hours, or until bottomhole pressures have stabilized.
6. Lock out all valves on the injection annulus pressure system so that annulus pressure cannot be changed during the falloff period. Ensure that valves on flow line to the injection well are closed and locked to prevent flow to the well during the falloff period.
7. After 24 hours, download data and make preliminary field analysis of the falloff test data with computer-aided transient test software to estimate if or when radial flow conditions might be reached. If sufficient data acquisition is confirmed, end falloff test. If additional data is required, extend falloff test until radial flow conditions are confirmed. After confirmation of sufficient data acquisition, end falloff test.
8. Pull SRO tool up out of the well at 1,000 ft increments and allow the gauge to stabilize (five minutes each stop). Record stabilized temperature and pressure. Repeat the process to collect stabilized pressure data (five-minute stops) at 1,000 ft intervals and in the lubricator.

1.9 Carbon Dioxide Plume and Pressure Front Tracking

GCS will employ direct and indirect methods to track the extent of the carbon dioxide plume and the magnitude of elevated pressure during the operation period to meet the requirements of 40 CFR 146.90(g).

1.9.1 Plume monitoring location and frequency

[redacted]

1.9.2 Plume monitoring details

1.9.2.1 In-direct monitoring - VSP

Substitution of CO_2 for brine in the Upper Frio Formation at project depths is well documented to produce a strong change is acoustic impendence that can be detected by many time-lapse seismic methods. [redacted]

1.9.2.2 Direct monitoring – geochemical sampling

[redacted]

1.9.3 Pressure-front monitoring location and frequency

[redacted]

[redacted]

One fluid sampling event is planned. The same methods will be used, and the same analytes will be sampled in the Frio as in the Miocene (Table 1.6.6-2).

1.9.4 Pressure-front monitoring details

One in-zone well will be sparsely perforated over the major permeable zones of the Upper Frio [redacted]

[redacted]

1.10 Environmental monitoring at the surface

The primary objective of the proposed surface sampling and investigation workplan is to evaluate baseline conditions of surface water and ecological conditions within the AoR. Initial characterization and sampling program will be carried out prior to CO_2 injection. Baseline conditions will be established where possible over multiple seasons to quantify the natural background variability of these systems and to establish action levels (threshold concentrations). In contrast with deep subsurface monitoring, the chemical compositions of surface water/sediment sampling and near-surface atmosphere are subjected to strong seasonal effects and are influenced by a range of natural processes and human activities.

The duration of the baseline, operational and post-operational surface monitoring and the frequency of data sampling are shown in Table 1.10-1 for ground surface and atmospheric monitoring.

1.10.1 Atmospheric Monitoring

GCS proposes to carry out fixed-point CO_2 monitoring to measure CO_2 at fixed locations, with routine sampling for CO_2 and tracer gas concentrations. Tracer gases will provide improved leak-detection capability.

The monitoring method will consist of CO_2 point monitoring and analysis performed four times during the one-year baseline monitoring, quarterly during the first three years of injection period, and quarterly every 5 years to injection is complete. The post-injection atmospheric monitoring will be performed quarterly every five years up to 50 years of post-injection.

It is important to note that the inclusion of atmospheric monitoring there is undoubtedly the potential for false positives due to climate change affecting CO_2 concentration in the atmosphere using this approach. There may be a high degree of false positives as increased concentration of CO_2 in the atmosphere will likely result from a changing climate or human activities surrounding the AoR. All results from atmospheric monitoring will be correlated to other monitoring methods to minimize potential false positives.

1.10.2 Ecological Monitoring

GCS proposes to carry out 4 baseline ecological surveys as the pre-operational monitoring and characterization to establish baseline conditions for comparisons with operational monitoring results. Included in the ecological monitoring is surface-water monitoring (measurement of pH, temperature, electrical conductivity, and dissolved oxygen content of nearby surface waters). In conjunction with surface water monitoring, a visual vegetation condition assessment to characterize vegetation conditions and detect subtle changes in normal plant growth processes and relative vegetation stress will be performed. For broader coverage across the area of the project, ecosystem stress monitoring is required and can be attained with remote methods such as satellite imagery, aerial photography, and spectral imagery.

The monitoring methods consist of the ecological survey for baseline, followed by surface water monitoring, and vegetation conditions, as indicated. The ecological survey will be performed 4 times, in different seasons, during the one-year period of baseline monitoring, before injection commences. During the operation, the ecological survey will be performed annually during the first three years of injection period, and the next ones will be performed at 5-year intervals until injection is complete. The post-injection ecological monitoring will be performed every five years up to 50 years of post-injection. There may be a high degree of false positives as vegetation changes due to stress from drought, possible infestations or diseases that may result from a changing climate. Therefore, ecological monitoring results will always be correlated to other monitoring methods.

A 1/2-mile by 1/2-mile grid was placed on the AoR and sampling points were selected to ensure all waterbodies and individual ecological systems were accounted for, [redacted]

1.10.3 Surface Sampling Standard Operating Procedures (SOP)

1.10.3.1 Surface Water

SOP describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing or for offsite laboratory analysis. Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative samples are obtained from mid-channel at a stream depth of 0.5 ft in a well-mixed stream. In these conditions direct sampling with sample container is most efficient. Barring other considerations like physical access limitations or cross-contamination by contact of the outside of the container with the water body, direct collection by submerging the sample container is the preferred method for collecting a surface water sample, when possible. Samples from shallow depths should be collected by submerging the sample container. This method is advantageous when the sample might be significantly altered during transfer from a collection vessel into another container. This method should not be used for sampling lagoons or surface impoundments where contact with contaminants is a potential concern or if sampling for volatile organic compounds (VOC) or other analytical parameters requiring pre-preserved sample containers.

The following procedure describes the effective sampling of surface water. Figure 1.10.3.1-1 provides an example of a water sampling log, for reference:

1. Place all equipment on plastic sheeting next to the sampling location. Sample containers should be selected in accordance with the requirements specified in the project-specific field work plan, field sampling plan, or quality assurance project plan (QASP).
2. If required by the project, measure field parameters (such as temperature and pH) using procedures in relevant specific SOPs and project-specific field sampling plans. Record this information on the field data sheet or in the logbook.
3. A visual check for visible surface material (pond scum or ice) should be performed before sampling. If present, surface water samples should be collected by directly submerging the sample container (with lid still on) into the surface water at the specified sampling location. Avoid contacting the bottom of the water body with the sample container because this will disturb sediment that may interfere with the surface water sample. Once submerged, the lid should be removed to allow the container to fill with water below any visible material on the surface of the water. A visual check should be conducted during and after sample collection to ensure sample integrity. If no surface materials are present, sample as instructed below.
4. For stream sampling, sample the location farthest downstream first. In general, work from zones suspected of low contamination to zones of high contamination. Orient the mouth of the sample container facing upstream while standing downstream so as not to stir up any sediment that would contaminate the sample. Avoid contacting the bottom of the water body with the sample container because this will disturb sediment that may interfere with the surface water sample.
5. For a larger body of surface water, such as a lake, collect samples near the shore, unless boats are feasible and permitted. Collect samples from shallow depths by submerging the sample container. Avoid contacting the bottom of the water body with the sample container because this will disturb sediment that may interfere with the surface water sample. If sampling from a boat, collect the sample as far away as possible from the outboard engine to avoid possible fuel contamination.
6. If sediment samples are to be collected with surface water samples, collect surface water samples at each location before collecting sediment samples to avoid contaminating the water samples with excess suspended particles generated during sediment sampling.
7. Allow the water to fill the container until it is almost full.
8. Add preservative to the sample in accordance with requirements specified in the project-specific field work plan, field sampling plan, or QASP. Secure the cap tightly and affix a completed sample label to the container.
9. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

1.10.3.2 Sediment Sampling

Sediment samples will be collected at the same locations and at the same frequency as the associated surface water samples[redacted] If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites.

Samples collected for VOC analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

A bottom-material sample may consist of a single scoop. A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. Figure 1.10.3.2-1 provides an example of a soil sampling log, for reference.

A typical scoop sampling procedure is as follows:

1. Place all equipment on plastic sheeting next to the sampling location. S ample containers should be selected in accordance with the requirements specified in the project-specific field work plan, field sampling plan, or QAPP.
2. Reach over or wade into the water body
3. While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.
4. Complete all chain-of-custody documentation, field logbook entries, and sample packaging requirements.

2.0 Procedures

The following sections describe the procedures adhered to while handling data.

2.1 Data Review and Validation

Data will be reviewed by the project operator or designee on an ongoing basis as the data are collected in the field and as results are received from the laboratory. Data review will consist of (for example):

- Verifying that data collection and calibrations/QC checks are complete and fully documented
- Examining raw data values and trends for consistency and reasonableness
- Making comparisons between related measured parameters and calculated values for agreement within reasonable expectations
- Flagging incomplete, invalid or suspect data and documenting the reason for the flag
- Initiating investigative or corrective actions as needed.

All valid data will be included in the data analysis and reflected in the reported results. Suspect data may or may not be considered or may receive special treatment as will be specifically indicated. The impact on data quality of any problems or issues that arise will be fully assessed, documented and reported. Any limitations on the use of the resulting data will be fully assessed and reported.

2.2 Sample Handling and Custody

2.2.1 Chain-of-Custody ("COC")

Proper sample handling and custody procedures ensure the custody and integrity of samples beginning at the time of sampling and continuing through transport, sample receipt, preparation, and analysis. The COC is used to document sample handling during transfer from the field to the laboratory. The sample number, location, date, changes in possession and other pertinent data will be recorded in indelible ink on the form. The sample collector will sign the COC and transport it with the sample to the laboratory. At the laboratory, samples are inventoried against the accompanying COC. Any discrepancies will be noted at that time and the COC will be signed for acceptance of custody.

2.2.2 Sample Handling and Labeling

Samples will be labeled on the container with an indelible, waterproof marker. Label information will include site identification, date, sampler's initials, and time of sampling. The COC form will accompany all sets of sample containers. Following collection, samples will be preserved and transported to the appropriate analytical laboratory for analysis.

2.3 Audits, Quality Assessment and Response Action

The technical systems audit is intended to ensure that the sampling, data collection and analysis, QA/QC measures, and documentation are executed in accordance with this plan and that the quality impact of any deviations from the plan is fully assessed and documented. To this end, the internal reviewer will prepare an audit checklist including all key elements of this plan and, to the extent possible, systematically verify in the field that each key element is conducted according to plan.

The audit of data quality will consist of verifying that reported results are fully supported by the data collected by tracing each result back to its sources in the raw data and verifying that all required QA/QC is complete and documented for each data source, and that calculations are correct, and results and uncertainties are correctly reported.

2.4 Data Management and Records

GCS will be responsible for ensuring that all electronic and hard copy data, forms and logs are accounted for, properly completed and stored in project files.

Documentation will be sufficient that a third party can reproduce the results from the raw data. This requires that all necessary information will be documented, and that the documents are organized and maintained such that the information may be practically retrieved and made use of.

Documentation will consist of instrument and other digital files, hard copy field log sheets, calibration certificates, laboratory reports, etc. All of these documents will ultimately be stored in electronic form; however, hard copy log sheets will be retained on file. An electronic data package will be compiled containing project documentation sufficient to allow a third party to reproduce the results and organized in such a manner that this may be done without undue effort.

2.5 Management of Change

Changes or deviations from this plan may be necessitated by field conditions, unexpected events, observations, or opportunities to improve the results as determined by the project operator. In such events, the reason for the change, and the new measures implemented will be documented in a note to the project log (if the change is minor) or deviations memorandum. This will include an assessment of the impact of the change on data quality. Verification of this will be part of the internal field and data audits.

A comprehensive deviations memorandum will be prepared including an overall assessment of all changes in data quality. Any new or revised procedures will be documented. Significant deviations and their impact on data quality will also be addressed in the final report.

3.0 QASP

This Quality Assurance and Surveillance Plan (QASP) describes how GCS will monitor the Project Goose Lake site pursuant to 40 CFR 146.90(k). [redacted]

3.1 Title and Approval Sheet

This Quality Assurance and Surveillance Plan (QASP) is approved for use and implementation at Project Goose Lake. The signatures below denote the approval of this document and intent to abide by the procedures outlined within it.

Signature	Date
INSERT TYPED NAME	
INSERT TITLE: Chief Operating Officer	

Signature	Date
INSERT TYPED NAME	
INSERT TITLE: Chief Engineer	

Signature	Date
INSERT TYPED NAME	
INSERT TITLE: Senior Executive	

3.2 Distribution List

The following project participants will receive the completed QASP and all future updates for the duration of Project Goose Lake. The following project participants should receive the completed QASP and all future updates for the duration of the project. The GCS Site Manager will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved Quality Assurance and Surveillance Plan. Names in bold are the primary points of contact with addresses listed below:

1. Field Manager
   2417 Shell Beach Drive
   Lake Charles, LA 70601

2. 24-7 Control Room Operations
   5599 San Felipe Drive
   Houston, Texas 77056

3. Safety Manager
   5599 San Felipe Drive
   Houston, Texas 77056

4. Audit/Risk Manager
   5599 San Felipe Drive
   Houston, Texas 77056

3.3 Project/Task Organization

3.3.1 Key Individuals and Responsibilities

Project Goose Lake is led by GCS and includes participation of several subcontractors. The testing and monitoring responsibilities will be shared between GCS and designated subcontractors and include the following activities:

1. CO_2 stream analysis surface sampling
2. Continuous recording of operational parameters
3. Corrosion monitoring
4. Above confining zone monitoring
5. External mechanical integrity testing (MIT)
6. Pressure fall-off testing
7. CO_2 plume and pressure from tracking
8. Environmental monitoring at the surface

3.3.1.1 Independence from Project Quality Assurance (QA) Manager and Data Gathering

The majority of the physical samples collected, and data gathered as part of the Testing and Monitoring Plan will be analyzed, processed, or witnessed by third parties independent from and outside of the project management structure.

3.3.1.2 QASP Responsibility

GCS is responsible for maintaining and distributing an official, approved QASP. GCS will periodically review the QASP and consult with the EPA and Louisiana Department of Natural Resources (LDNR) to determine whether changes to the plan are warranted.

3.3.1.3 Organizational Chart for Key Project Personnel

Figure 3.3.1.3-1 shows the organization structure of the project. GCS will provide the Region 6 EPA Underground Injection Control (UIC) Program Director and LDNR a contact list of individuals fulfilling these roles.

3.3.2 Problem Definition / Background

3.3.2.1 Reasoning

The Testing and Monitoring Plan for Project Goose Lake is responsive to the requirements of the Class VI specifications and employs best practices developed in similar CO_2 storage projects.

3.3.2.2 Reasons for Initiating the Project

The goal of Project Goose Lake is to demonstrate the ability of the Upper Frio Formation to accept and retain industrial-scale volumes of CO_2 for permanent geologic storage thus reducing atmospheric concentrations of CO_2.

3.3.2.3 Regulatory Information, Applicable Criteria, Action Limits

The Class VI rule requires owners or operators of Class VI wells to perform several types of activities during the lifetime of the project to ensure that the injection well maintains mechanical integrity, that fluid migration and the extent of pressure elevation are within the limits described in the permit application, and that USDWs are not endangered. These monitoring activities include MITs, injection well testing during operation, monitoring of groundwater quality, and tracking of the CO_2 plume and associated pressure changes. This document details both the measurements that will be taken as well as the steps to ensure that the quality of all the data can be used with confidence in making decisions during the life of the project, based on requirements stipulated in EPA Requirements for Quality Assurance Project Plans (EPA QA R-5, USEPA, 2011).

3.3.3 Project / Task Description

3.3.3.1 Summary of Work to be Performed.

Table 3.3.3.1-1 provides a summary of the testing and monitoring activities planned at Project Goose Lake. Table 3.3.3.1-2 provides an instrumentation summary.

3.3.3.2 Geographic Locations

Figures 1.2.3-1 and 1.2.3-2 illustrate the locations of all Testing and Monitoring Plan elements.

3.3.3.3 Resource and Time Constraints

No additional resources or time constraints have been identified for the Testing and Monitoring Plan beyond project funding levels and the proposed timeline.

3.3.4 Quality Objectives and Criteria

The overall objective of the QASP is to provide the standards and procedures necessary to validate the overall integrity of the sampling methods discussed in the Testing and Monitoring Plan and ensure results of sampling and testing will meet the characterization and non-endangerment goals of Project Goose Lake. The QASP is the mechanism by which the UIC Program Director, and by extension the public, has confidence in the rigor of the Testing and Monitoring Plan.

3.3.4.1 Performance / Measurement Criteria

Tables 3.3.4.1-1, 3.3.4.1-2, 3.3.4.1-3, 3.3.4.1-4, and 3.3.4.1-5 will be completed as vendor selection and onboarding proceeds and relevant scopes of work are adopted and implemented.

Ground water monitoring will be conducted during the injection phase of the project. Shallow and deep ground water monitoring wells will be used to gather water-quality samples and pressure data. All the ground water analytical and field monitoring parameters and outputs are listed in Table 1.9.2.2-1. Table 3.3.4.1-6 shows gauge specifications. The list of analytes may be reassessed periodically and adjusted to include or exclude analytes based on their effectiveness to the overall monitoring program goals.

Key testing and monitoring areas include:

1. Shallow Ground Water Sampling
   a. Aqueous chemical concentrations
2. Deep Formation Fluid Sampling
   a. Aqueous chemical concentrations
3. Well Logging
   a. Pulse neutron logging
4. Mechanical Integrity Tests (MITs)
   a. Pressure test casing inspection logging (internal)
   b. Noise or oxygen activation logging or other Director-approved logging process (external)
5. Pressure/Temperature Monitoring
   a. Pressure/temperature from in-situ gauges
   b. Pressure/temperature from surface gauges
6. Geophysical Monitoring

a. Seismic data files
b. Processed time-lapse report.

3.3.4.2 Precision

For ground water sampling, data accuracy will be assessed by the collection and analysis of field blanks to test sampling procedures and matrix spikes to test lab procedures. Field blanks will be taken no less than one per sampling event to spot check for sample bottle contamination. Laboratory assessment of analytical precision will be the responsibility of the individual laboratories per their standard operating procedures. Tables 3.3.4.1-6, 3.3.4.2-1, 3.3.4.2-2, 3.3.4.2-3, 3.3.4.2-4 and 3.3.4.2-5 summarize the specifications, which may be tool-dependent, of each monitoring method for pressure, temperature, and logging. GCS is currently in the process of finalizing the monitoring equipment that will be utilized.

3.3.4.3 Bias

Field blanks assess potential bias from the combined processes of sample handling, processing, and laboratory analysis. A field blank is prepared in the field by filling a clean container with deionized water and appropriate preservative, if any, using the same techniques as the specific sampling activity being undertaken. A field equipment blank is a sample of analyte-free media that has been used to rinse common sampling equipment to detect potential bias introduced through the use of the sampling apparatus.

Laboratory bias is determined through the analysis of laboratory control samples and limit of quantitation check samples prepared in the sample matrix (e.g., laboratory grade water, sand, commercially available tissue) using verified and known amounts of all target analytes and by then calculating percent recovery of those analytes. Results are compared to control limits and used during evaluation of analytical performance.

Laboratory assessment of analytical bias will be the responsibility of the individual laboratories per their SOPs and analytical methodologies. Direct pressure and logging measurements are considered to have no bias.

3.3.4.4 Representativeness

For groundwater sampling, data representativeness expresses the degree to which data accurately and precisely represent a characteristic of a sample population, parameter variations at a sampling point, a process condition, or an environmental condition. The sampling network has been designed to provide data representative of site conditions. For results of individual groundwater sample analysis, representativeness will be estimated by ion and mass balances. Ion balances with ±10% error or less will be considered valid. A mass balance assessment will be used in cases where the ion balance is greater than ±10% to help determine the source of error. For a sample and its duplicate, if the relative percent difference is greater than 10%, the sample may be considered non-representative.

3.3.4.5 Completeness

For groundwater sampling, data completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. It is anticipated that data completeness of 90% for groundwater sampling will be acceptable to meet monitoring goals. For direct pressure and temperature measurements, it is expected that data will be recorded no less than 90% of the time.

3.3.4.6 Comparability

Data comparability expresses the confidence with which one data set can be compared to another. The data sets to be generated by this project will be very comparable to future data sets because of the use of standard methods and the level of QA/ QC effort. If historical ground water quality data becomes available from other sources, their applicability to the project and level of quality will be assessed prior to use with data gathered on this project. Direct pressure, temperature, and logging measurements will be directly comparable to previously obtained data.

3.3.4.7 Method Sensitivity

Additional details on gauge specifications and sensitivities will be provided once decided upon.

3.3.4.8 Specialized Training and Certifications

The geophysical survey equipment and wireline logging tools will be operated by trained, qualified, and certified personnel, according to the service company which provides the equipment. The subsequent data will be processed and analyzed according to industry standards. No specialized certifications are required for personnel conducting ground water sampling, but field sampling will be conducted by trained personnel. Ground water sampling will be conducted by personnel trained to understand and follow the project specific sampling procedures. Upon request GCS will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method. GCS will include the technician's training certification with the annual report.

3.3.4.9 Training Provider and Responsibility

Training for personnel will be provided by GCS or by the subcontractor responsible for the data collection activity.

3.3.5 Documentation and Records

3.3.5.1 Report Format and Package Information

Reporting will follow the outlines contained within the Testing and Monitoring Plan and will contain all required project data, as specified by the UIC Class VI permit. Data will be provided in electronic or other formats as required by the EPA Region 6 and/or LDNR UIC Program Director.

3.3.5.2 Other Project Documents, Records, and Electronic Files

Other documents, records, and electronic files such as well logs, test results, or other data will be provided as required by the EPA Region 6 UIC Program Director and/or LDNR.

3.3.5.3 Data Storage and Duration

All data and project records will be stored electronically on secure servers and will have routine backups. Reporting will comply with Class VI UIC requirements.

3.3.5.4 QASP Distribution Responsibility

GCS will be responsible for ensuring that all those on the distribution list will receive the most current copy of the approved QASP.

3.4 Data Generation and Acquisition

This plan will establish a standardized program for data acquisition and validation methods. The program will verify that collected data are reasonable, processed and analyzed correctly, and free of errors. Peer reviews or third-party consultants will serve as a QC mechanism. Issues identified during a peer review will be addressed and corrected by the data owner. Errors identified in the data via validation will be corrected, and affected users will be notified. Corrective actions will be coordinated to ensure the impact of any error is fully addressed.

3.4.1 Sampling Process Design

This section is focused on ground water and fluid sampling and does not address monitoring methods that do not gather physical samples (e.g., logging, seismic monitoring, and pressure/temperature monitoring). Ground water sampling is planned to include an extensive set of chemical parameters to establish aqueous geochemical reference data. Parameters will include selected constituents that: (1) have primary and secondary EPA drinking water maximum contaminant levels, (2) are the most responsive to interaction with CO_2 or brine, (3) are needed for quality control, and (4) may be needed for geochemical modeling. The full set of parameters for each sampling interval is given in Table 1.6.2-1 and 1.6.2-2. After a sufficient baseline is established following commencement of monitoring, monitoring scope may shift to a subset of indicator parameters that are (1) the most responsive to interaction with CO_2 or brine and (2) are needed for quality control. Implementation of a reduced set of parameters would be done in consultation with the EPA. Isotopic analyses will be performed on baseline samples to the degree that the information helps verify a condition or establish an understanding of non-project related variations. For non-baseline samples, isotopic analyses may be reduced in all monitoring wells if a review of the historical project results or other data determines that further sampling for isotopes is unneeded. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the full set of monitoring parameters. The USDW ground water samples will be analyzed using a laboratory meeting the requirements under the EPA Environmental Laboratory Accreditation Program. All other samples will be analyzed by the operator or a third-party laboratory. Dissolved CO_2 will be analyzed by methods consistent with Test Method B of ASTM D 513-06, "Standard Test Methods for Total and Dissolved Carbon Dioxide in Water" or equivalent. Isotopic analysis will be conducted using established methods.

3.4.1.1 Design Strategy

The following sections set forth the design strategy.

3.4.1.2 CO_2 Stream Monitoring Strategy

GCS will analyze the CO_2 stream during the operation period to determine its chemical and physical characteristics and to meet the requirements of 40 CFR 146.90(a). See Section 1.3 of the Testing and Monitoring Plan for further information.

3.4.1.3 Corrosion Monitoring Strategy

To meet the requirements of 40 CFR 146.90(c), GCS will monitor well materials during the operation period for loss of mass, thickness, cracking, pitting, and other signs of corrosion to ensure that the well components meet the minimum standards for material strength and performance.

GCS will monitor corrosion using coupons and collect samples according to the description below in all proposed monitoring wells put forth in this report.

3.4.1.4 Shallow Groundwater Monitoring Strategy

GCS will conduct groundwater quality and geochemical monitoring above the Confining Zone to meet the requirements of SWO 29-N-6 §625. A.3 [40 CFR §146.90(c)]. Water wells drilled at each injection well pad will be completed as long-term monitoring points to document changes in water chemistry. Groundwater wells will be drilled to characterize anomalous salinity to deal with the expected complex salinity signal detected with airborne conductivity.

3.4.1.5 Deep Groundwater Monitoring Strategy

Monitoring in the AZMI (lower Miocene saline aquifer) will be used for early leakage detection in formations that are much closer to the injection reservoir. Fluid sampling in combination with pressure monitoring, temperature monitoring, and pulse neutron logging will be used to determine if leakage is occurring at or near the injection well. The Upper Frio Formation has sufficient permeability (over 100 mD, average) such that pressure monitoring at the monitor wells would detect a failure of the confining zone should it occur. MI testing and DTS monitoring at the injection well will also provide data to ensure the mechanical integrity of the well is maintained. With the planned sampling and monitoring frequencies, it is expected that baseline conditions can be documented, natural variability in conditions can be characterized, unintended brine or CO_2 leakage could be detected if it occurred, and sufficient data will be collected to demonstrate that the effects of CO_2 injection are limited to the intended storage reservoir.

3.4.1.6 Type and Number of Samples/Test Runs

Table 1.6.2-1 shows the planned monitoring methods, logic behind selecting locations, and frequencies for groundwater quality and geochemical monitoring in the freshwater of the Lower Chicot Aquifer. Seasonal sampling including field parameters, dissolved and free gasses, and water level monitoring will be conducted four times a year for 3 years for characterization, after which sampling frequency will be decreased and targeted to chemical species that are indicative of leakage. Refer to Section 1.6.1 for further details.

3.4.1.7 Site/Sampling Locations

[redacted]

3.4.1.8 Sampling Site Contingency

[redacted]

3.4.1.9 Activity Schedule

The freshwater wells will be sampled quarterly for 3 years to detect seasonal variations.

3.4.1.10 Critical/Informational Data

During both ground water sampling and analytical efforts, detailed field and laboratory documentation will be taken. Documentation will be recorded in field and laboratory forms and notebooks. Critical information will include time and date of activity, person/s performing activity, location of activity (wellfield sampling) or instrument (lab analysis), field or laboratory instrument calibration data, field parameter values. For laboratory analyses, much of the critical data are generated during the analysis and provided to end users in digital and printed formats. Noncritical data may include appearance and odor of the sample, problems with well or sampling equipment, and weather conditions.

3.4.1.11 Sources of Variability

Potential sources of variability related to monitoring activities include (1) natural variation in fluid quality, formation pressure and temperature and seismic activity; (2) variation in fluid quality, formation pressure and temperature, and seismic activity due to project operations; (3) changes in recharge due to rainfall, drought, and snowfall; (4) changes in instrument calibration during sampling or analytical activity; 5) different staff collecting or analyzing samples; (6) differences in environmental conditions during field sampling activities; (7) changes in analytical data quality during life of project; and (8) data entry errors related to maintaining project database.

Activities to eliminate, reduce, or reconcile variability related to monitoring activities include (1) collecting long-term baseline data to observe and document natural variation in monitoring parameters, (2) evaluating data in a timely manner after collection to observe anomalies in data that can be addressed by being resampled or reanalyzed, (3) conducting statistical analysis of monitoring data to determine whether variability in a data set is the result of project activities or natural variation, (4) maintaining weather-related data using on-site weather monitoring data or data collected near project site (such as from local airports), (5) checking instrument calibration before, during and after sampling or sample analysis, (6) thoroughly training staff, (7) conducting laboratory quality assurance checks using third party reference materials, and/or blind, and/or replicate sample checks, and (8) developing a systematic review process of data that can include sample-specific data quality checks (i.e., cation/anion balance for aqueous samples).

3.4.2 Sampling Methods

Logging, geophysical monitoring, and pressure/temperature monitoring do not apply to this section and are omitted.

3.4.2.1 Sampling SOPs

The sampling SOPs will include carefully planned and consistently applied procedures that produce accurate and defensible data. The procedures and plans presented in the SOP should be considered as minimum sampling process guidelines to maintain sample integrity and identity. Samples should be collected according to the approved project and site-specific SOP.

3.4.2.2 In-situ Monitoring

In-situ monitoring of ground water chemistry parameters is not currently planned.

3.4.2.3 Continuous Monitoring

GCS will install and use continuous recording devices to monitor as required at 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b) the CO_2 mass delivered to Project Goose Lake at the transfer point, the volume and temperature of CO_2 allocated to each well, the pressure at the wellhead, the pressure on the injection tubing, the pressure at the wellhead on the annulus between the tubing and the long string casing, and the annulus fluid volume added. Injection pressure and temperature will be continuously measured at the surface via real-time pressure/temperature (P/T) instruments installed at the primary meter station and at the allocation meters at each wellhead. Pressure will be measured using electronic pressure gauges with analog data transmitters, installed at the primary meter station and at each allocation meter/wellhead. Temperature will similarly be measured using electronic temperature sensors with data transmitters installed in close proximity to the pressure gauges both at the primary meter station and at each allocation station.

3.4.2.4 Sample Homogenization, Composition, Filtration

Mixing of the sample is necessary to create a representative sample media. It is extremely important that solid samples be mixed as thoroughly as possible to ensure that the sample is as representative as possible of the sample location. The mixing technique will depend on the physical characteristics of the solid material (e.g., particle size, moisture content, etc.). The mixing container should be large enough to hold the sample volume and accommodate the procedures without spilling. Both the mixing container (generally a bowl or tray) and the mixing implement should be properly decontaminated before use. Samples should be homogenized according to procedures listed in the project-specific SOP (EPA-540-R-09-03 or equivalent, USEPA, 2011).

3.4.2.5 Sample Containers and Volumes

The analytical protocol(s) to be used for sample analysis often requires the use of a particular type of sample container. The type of container also may depend on the sample matrix and analysis. The use of borosilicate glass containers, which are inert to most materials, is recommended. Conventional polyethylene is recommended when sampling for metals because of the lower cost and absorption rate of metal ions. Using the wrong container may result in breakage, gathering of an insufficient volume needed to perform sample analysis, or interference of the container material with the analysis. Therefore, the correct sample containers for each sampling event will be identified using Sample Container Type Specifications as outlined in EPA-540-R-09-03 or equivalent.

3.4.2.6 Sample Preservation

Degradation of some contaminants may occur naturally. Some water samples will require chemical preservation for certain analytes before the samples are shipped to the laboratory. Any visible reaction between the sample and added chemical preservative will be noted in the field record. Water samples will be preserved and immediately cooled to 4°C (±2°C) upon collection, and samples should remain cooled until the time of analysis (the water samples will not be frozen). Preservation techniques will align with EPA-540-R-09-03 or equivalent.

3.4.2.7 Cleaning/Decontamination of Sampling Equipment

Dedicated pumps will be installed in each ground water monitoring well to minimize potential cross contamination between wells. GCS is still in the process of determining the types of pumps that will be utilized. These pumps will remain in each well throughout the project period except for maintenance. Prior to installation, the pumps will be cleaned on the outside with a non-phosphate detergent. Pumps will be rinsed a minimum of three times with deionized water and a minimum of 1 L of deionized water will be pumped through pump and sample tubing. Individual clean pumps and tubing will be placed in plastic garbage bags for transport to the field for installation. All field glassware (pipets, beakers, filter holders, etc.) are cleaned with tap water to remove any loose dirt, washed in a dilute nitric acid solution, and rinsed three times with deionized water before use.

3.4.2.8 Support Facilities

For sampling of ground water, the following are required: air compressor, vacuum pump, generator, multi-electrode water quality sonde, analytical meters (pH, specific conductance, etc.). Field activities are usually completed in field vehicles and portable laboratory trailers located on site. Field gauges will be removed from the injection well and verification well utilizing existing standard industry tools and equipment. Deployment and retrieval of verification well gauges will be done using procedures and equipment recommended by the vendor, subcontractor, or is standard per industry practice.

3.4.2.9 Corrective Action, Personnel, and Documentation

Field staff will be responsible for properly testing equipment and performing corrective actions on broken or malfunctioning field equipment. If corrective action cannot be taken in the field, then equipment will be returned to the manufacturer for repair or replaced. Significant corrective actions affecting analytical results will be documented in field notes. Sample holding times will be consistent with those described in US EPA (1974, America Public Health Association (2005), Wood (1976), ASTM Method D6517-00 (2005). Once the samples are analyzed, the laboratory will be responsible for disposing of the containers and residues properly.

3.4.2.10 Maximum Hold Time/Time Before Retrieval

Daily shipment of samples to laboratories will be the preferred method whenever possible. If samples cannot be shipped on a daily basis, they will be properly preserved and maintained to meet ASTM Method D6517-00 (or equivalent) temperatures, holding times, and custody requirements. The technical holding times are the maximum time allowed between a sample collection and the completion of the sample extraction and/or analysis. In contrast, contractual holding times are the maximum lengths of time that a laboratory can hold the sample prior to extraction and/or analysis. Samples will be processed, packaged, and shipped to the contracted laboratory, following standard sample handling and chain-of-custody guidance (EPA 540-R-09-03, or equivalent). Once the samples are analyzed, the laboratory will be responsible for disposing of the containers and residues properly.

3.4.2.11 Sample Transportation

Samples will be shipped to an accredited Louisiana Environmental Laboratory Accreditation Program (LELAP) laboratory with chain-of-custody documentation. Shipping and handling shall be in accordance with laboratory recommendations for the specific analytical method. The contracted laboratory will employ EPA-approved or other industry standard analytical methods and have a documented QA/QC program in place.

3.4.2.12 Sampling Documentation

Collected samples will be properly documented for analysis in order to uniquely identify each sample and ensure adequate chain-of-custody procedures. If sampling on privately owned property, the property owner will be provided with a receipt for samples collected and removed from that owner's property. These types of documentation help ensure proper sample identification and provide additional chain-of-custody records.

3.4.2.13 Sample Identification

The use of a sample label, sample tag, or field operations will record documenting information such as daily activities, equipment and materials used, personnel involved, site security, etc. may also be utilized.

3.4.2.14 Sample Chain-of-Custody Record

For ground water samples, chain-of-custody will be documented using a standardized form. A typical form is shown in Figure 3.4.2.14-1, and it or a similar form will be used for all ground water sampling. Copies of the form will be provided to the person/lab receiving the samples as well as the person/lab transferring the samples. These forms will be retained and archived to allow simplified tracking of sample status. The chain-of -custody form and record keeping are the responsibility of ground water sampling personnel.

3.4.3 Analytical Methods

Logging, geophysical monitoring, and pressure/temperature monitoring do not apply to this section and are omitted.

3.4.3.1 Analytical SOPs

Analytical SOPs are referenced in Table 1.9.2.2-1. Other laboratory specific SOPs utilized by the laboratory will be determined after a contract laboratory has been selected. Upon request GCS will provide the agency with all laboratory SOPs developed for the specific parameter using the appropriate standard method. Each laboratory technician conducting the analysis on the samples will be trained on the SOP developed for each standard method.

3.4.3.2 Equipment/Instrumentation Needed

Equipment and instrumentation are specified in the individual analytical methods referenced in Table 1.9.2.2-1.

3.4.3.3 Method Performance Criteria

Nonstandard method performance criteria are not anticipated for this project.

3.4.3.4 Analytical Failure

Each laboratory conducting analyses in Table 1.9.2.2-1 will be responsible for analytical failure according to their SOPs.

3.4.3.5 Sample Disposal

Each laboratory conducting the analyses will be responsible for appropriate sample disposal.

3.4.3.6 Laboratory Turnaround

Laboratory turnaround will vary by laboratory, but generally turnaround of verified analytical results within one month will be suitable for project needs.

3.4.3.7 Method Validation for Nonstandard Methods

Nonstandard methods are not anticipated for this project. If nonstandard methods are needed or proposed in the future, the EPA will be consulted on additional appropriate actions to be taken.

3.4.4 QC

As part of the quality control process during testing and surveillance, most of the samples collected and the data gathered will be analyzed, processed, validated, or witnessed by third parties independent of the operations staff. For specialized data such as seismicity and DTS, Project Goose Lake will have additional support from the providers of the selected technologies in quality control, verification of the data, and system calibration.

QC of the sampling and results will follow the protocols established in the standard analytical method used for testing. The operator reserves the right to audit the laboratory procedures and protocols to validate that the methods are being followed and results are accurate.

3.4.4.1 QC activities

3.4.4.1.1 Blanks

Trip blanks for QA/QC purposes will be collected and used to validate test results and ensure samples are free of contamination.

3.4.4.1.2 Duplicates

Duplicate samples and for QA/QC purposes will be collected and used to validate test results and ensure samples are free of contamination.

3.4.4.1.3 Exceeding Control Limits

If the sample analytical results exceed control limits (i.e., ion balances > ±10%), further examination of the analytical results will be done by evaluating the ratio of the measured total dissolved solids (TDS) to the calculated TDS (i.e., mass balance) per APHA method (or equivalent). The method indicates which ion analyses should be considered suspect based on the mass balance ratio. Suspect ion analyses are then reviewed in the context of historical data and interlaboratory results, if available. Suspect ion analyses are then brought to the attention of the analytical laboratory for confirmation and/or reanalysis. The ion balance is recalculated, and if the error is still not resolved, suspect data are identified and may be given less importance in data interpretations.

3.4.4.2 Calculating Applicable QC Statistics

3.4.4.2.1 Charge Balance

Titration methods will be based on standard protocols from Standard Methods 2320B-2011. Laboratories shall have standard operating procedures for the analytical methods performed.

The analytical results are evaluated to determine correctness of analyses based on anion-cation charge balance calculation. Because all potable waters are electrically neutral, the chemical analyses should yield equally negative and positive ionic activity. The anion-cation charge balance will be calculated using the formula:

$$\% \, difference = 100 \frac{\sum cations - \sum anions}{\sum cations + \sum anions} \qquad \text{Eq. 1}$$

where the sums of the ions are represented in milliequivalents (meq) per liter and the criteria for acceptable charge balance is ±10%.

3.4.4.2.2 Mass Balance

The ratio of the measured TDS to the calculated TDS will be calculated in instances where the charge balance acceptance criteria are exceeded using the formula:

$$1.0 < \frac{\text{measured TDS}}{\text{calculated TDS}} < 1.2 \qquad \text{Eq. 2}$$

example equation, where the anticipated values are between 1.0 and 1.2.

3.4.4.2.3 Outliers

Outliers may result from random variation or may indicate something scientifically interesting. In any event, we typically do not want to simply delete the outlying observation. However, if the data contains significant outliers, we may need to consider the use of robust statistical techniques.

3.4.5 Instrument/Equipment Testing, Inspection, and Maintenance

Logging tool equipment will be maintained as per wireline industry best practices.

For ground water sampling, field equipment will be maintained, factory serviced, and factory calibrated per manufacturer's recommendations. Spare parts that may be needed during sampling will be included in supplies on-hand during field sampling.

For all laboratory equipment, testing, inspection and maintenance will be the responsibility of the analytical laboratory per standard practice, method-specific protocol, or LELAP requirement.

3.4.6 Instrument/Equipment Calibration and Frequency

All field equipment will be visually inspected and tested prior to use. Spare instruments, batteries, etc., will be stored in the field support trailer.

Pressure gauges used to conduct fall-off tests will be calibrated in accordance with the manufacturers' recommendations. In lieu of removing the injection tubing to recalibrate the downhole pressure gauges, their accuracy will be demonstrated by comparison with a second pressure gauge with current certified calibration, which will be lowered into the well to the same depth as the permanent downhole gauge. Calibration curves for the downhole gauge, based on annual calibration checks using the second calibrated gauge, can be used for the fall-off test. These calibration curves (showing all historic pressure deviations) will accompany the fall-off test data.

During laboratory analysis, the calibration, testing, maintenance, and inspection of laboratory equipment shall be the responsibility of the contracted analytical laboratory. Equipment calibration shall be in accordance with the approved method-specific protocols for the analytical method and the laboratory's QA program. The laboratory QA program shall be reviewed and approved prior to the contract award.

3.4.6.1 Calibration and Frequency of Calibration

Equipment used for field sampling will be calibrated, serviced, and maintained according to the manufacturer's recommendations.

3.4.6.2 Calibration Methodology

Equipment used for field sampling will be calibrated, serviced, and maintained according to the manufacturer's recommendations.

3.4.6.3 Calibration Resolution and Documentation

Equipment used for field sampling will be calibrated, serviced, and maintained according to the manufacturer's recommendations.

3.4.7 Inspection/Acceptance for Supplies and Consumables

3.4.7.1 Supplies, Consumables, and Responsibilities

Both field operations and laboratory operations need supplies and consumables. The focus of this section is the management of laboratory and field sampling supplies and consumables. For information on the actual field/lab supplies and consumables needed for any specific method, see the reference method in 40 CFR Part 50, the general guidance methods and technical assistance documents on AMTIC and the manufacturer's operations manuals. From this information, monitoring organizations, as part of the QASP requirements, will develop specific SOPs for its monitoring and analytical methods. One section of the SOPs requires a listing of the acceptable supplies and consumables for the method. Pollutant parameters are measured using electronic (e.g., continuous emission monitors, FTIRs, etc.), wet chemical techniques, or physical methods. Chemical analysis always involves the use of consumable supplies that must be replaced on a schedule consistent with their stability and with the rate at which samples are taken. Currently used physical methods require adequate supplies of chemicals for operation for three months so that the supplier can comply with the delivery schedules. In some cases, analytical reagents for specific air contaminants deteriorate rapidly and need protective storage. The following information may be helpful when considering the use of these consumable items. Much of the information presented below is derived from the document Quality Assurance Principles for Analytical Laboratories (Garfield et al 2000).

3.4.8 Nondirect Measurements

3.4.8.1 Data Sources

For time lapse seismic surveys, repeatability is paramount for accurate differential comparison. Therefore, to ensure survey quality, the locations for the shots and acquisition methodology of sequential surveys will be consistent. Once these surveys are conducted, they will be compared to a baseline survey to track and monitor plume development. [redacted]

3.4.8.2 Relevance to Project

Time lapse seismic surveys will be used to track changes in the CO_2 plume in the subsurface. Processing and comparing subsequent surveys to a baseline will allow project managers to monitor plume growth, as well as to ensure that the plume does not move outside of the intended storage reservoir. Numerical modeling will be used to predict the CO_2 plume growth and migration over time by combining the processed seismic data with the existing geologic model. In-zone pressure monitoring data will be used in numerical modeling to predict plume and pressure front behavior and confirm the plume stage within the AoR.

3.4.8.3 Acceptance Criteria

Following standard industry practices will ensure that the gathered seismic data will be used for accurate modeling and monitoring. Similar ground conditions shot points located within tolerable limits, functional geophones, and similar seismic input signal will be used from survey to survey to ensure repeatability. When processing seismic data, several QA checks will be done in accordance with industry standards including reformatting to structured files, geometry application, amplitude compensation, predictive deconvolution, elevation statics correction, RMS amplitude gain, velocity analysis every 2 km, NMO application using picked velocities, CMP stacking, random noise attenuation, and instantaneous gain.

3.4.8.4 Resources/Facilities Needed

GCS will subcontract all necessary resources and facilities for seismic monitoring, in-zone pressure monitoring, and ground water sampling.

3.4.8.5 Validity Limits and Operating Conditions

For seismic surveys and numerical modeling, intraorganizational checks between trained and experienced personnel will ensure that all surveys and numerical modeling are conducted conforming to standard industry practices.

3.4.9 Data Management

3.4.9.1 Data Management Scheme

GCS will be responsible for ensuring that all electronic and hard copy data, forms and logs are accounted for, properly completed and stored in project files.

Documentation will be sufficient that a third party can reproduce the results from the raw data. This requires that all necessary information will be documented, and that the documents are organized and maintained such that the information may be practically retrieved and made use of.

Documentation will consist of instrument and other digital files, hard copy field log sheets, calibration certificates, laboratory reports, etc. All of these documents will ultimately be stored in electronic form; however, hard copy log sheets will be retained on file. An electronic data package will be compiled containing project documentation sufficient to allow a third party to reproduce the results and organized in such a manner that this may be done without undue effort.

3.4.9.2 Recordkeeping and Tracking Practices

All reports, submittals and notifications will be submitted to both the EPA and the LDNR. All records will be retained by GCS throughout the life of the project and for 10 years following site closure. Data on the nature and composition of all injected fluids collected will be retained as well for 10 years after site closure. The records will be delivered to the Director after the retention period if required by the director. Monitoring data as described in the Testing and Monitoring Plan will be retained for 10 years after it is collected. Well plugging reports, post-injection site care data and the site closure report itself will be retained for 10 years following site closure.

3.4.9.3 Data Handling Equipment/Procedures

GCS will be responsible for ensuring that all electronic and hard copy data, forms and logs are accounted for, properly completed and stored in project files. All data and project records will be stored electronically on secure servers and will have routine backups. Reporting will comply with Class VI UIC requirements.

3.4.9.4 Responsibility

GCS will be responsible for ensuring that all electronic and hard copy data, forms and logs are accounted for, properly completed and stored in project files. All data and project records will be stored electronically on secure servers and will have routine backups. Reporting will comply with Class VI UIC requirements.

3.4.9.5 Data Archival and Retrieval

GCS will be responsible for ensuring that all electronic and hard copy data, forms and logs are accounted for, properly completed and stored in project files. All data and project records will be stored electronically on secure servers and will have routine backups. Reporting will comply with Class VI UIC requirements. All reports, submittals and notifications will be retained by GCS throughout the life of the project and for ten (10) years following site closure. Data on the nature and composition of all injected fluids collected will be retained as well for ten (10) years after site closure. The records will be delivered to the Director after the retention period if required by the director. Monitoring data as described in the Testing and Monitoring Plan will be retained for 10 years after it is collected. Well plugging reports, post-injection site care data and the site closure report itself will be retained for ten (10) years following site closure.

3.4.9.6 Hardware and Software Configurations

All GCS and vendor hardware and software configurations will be appropriately interfaced.

3.4.9.7 Checklists and Forms

Checklists and forms will be procured and generated as necessary.

3.5 Assessment and Oversight

3.5.1 Assessments and Response Actions

3.5.1.1 Activities to be Conducted

Assessments of each of the QASP elements:

I) CO_2 stream analysis surface sampling
II) Continuous recording of operational parameters
III) Corrosion monitoring
IV) AZMI
V) External MIT
VI) Pressure fall-off testing
VII) CO_2 plume and pressure from tracking
VIII) Environmental monitoring at the surface

After completion of sample analysis, results will be reviewed for QC criteria as noted in Section 3.3.4. If the data quality fails to meet criteria set in Section 3.3.4, samples will be reanalyzed, if still within holding time criteria. If outside of holding time criteria, additional samples may be collected or sample results may be excluded from data evaluations and interpretations. Evaluation for data consistency will be performed according to procedures described in the EPA 2009 Unified Guidance (USEPA, 2009).

3.5.1.2 Responsibility for Conducting Assessments

GCS or its designated subcontractors gathering data will be responsible for conducting their internal assessments. All stop work orders will be handled internally within individual organizations.

3.5.1.3 Assessment Reporting

GCS will coordinate reporting of assessments.

3.5.1.4 Corrective Action

All corrective action affecting only an individual organization's data collection responsibility should be addressed, verified, and documented by the individual project managers and communicated to the other project managers as necessary. Corrective actions affecting multiple organizations should be addressed by all members of the project leadership and communicated to other members on the distribution list for the QASP. Assessments may require integration of information from multiple monitoring sources across organizations (operational, in-zone monitoring, above-zone monitoring) to determine whether correction actions are required and/or the most cost-efficient and effective action to implement. GCS will coordinate multiorganization assessments and corrective actions as warranted.

3.5.2 Reports to Management

3.5.2.1 QA Status Reports

QA status reports should not be needed. If any testing or monitoring techniques are changed, the QASP will be reviewed and updated as appropriate in consultation with EPA. Revised QASPs will be distributed by GCS to the full distribution list at the beginning of this document.

3.6 Data Validation and Usability

3.6.1 Data Review, Verification, and Validation

3.6.1.1 Criteria for Accepting, Rejecting, or Qualifying Data

As part of the QC process, during testing and surveillance, most of the samples collected and data gathered will be analyzed, processed, validated, or witnessed by third parties independently, outside of the operator staff.

For specialized data such as seismicity, the project will have additional support from the provider of the selected technologies to perform QC and verification of the data as well as calibration of the systems as needed.

All EPA-reportable data will be formatted appropriately and uploaded to the GSDT at the required frequency.

3.6.2 Verification and Validation Methods

3.6.2.1 Data Verification and Validation Processes

The project will establish a standardized program to validate the data and acquisition methods. The program will verify that collected data are reasonable, were processed and analyzed correctly, and are free of errors. Peer reviews or third-party consultant will be used as a QC mechanism to verify the information.

3.6.2.2 Data Verification and Validation Responsibility

If an error is identified in data under validation, in addition to correcting the error, affected work products and management decisions will be identified, affected users will be notified, and corrective actions will be coordinated to an extent of the error's impact is fully addressed.

3.6.2.3 Issue Resolution Process and Responsibility

GCS or its designee will overview the data handling, management, and assessment process. Contractors involved in these processes will consult with GCS to determine actions required to resolve issues.

3.6.2.4 Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements. These will be detailed as site-specific design advances.

3.6.3 Reconciliation with User Requirements

3.6.3.1 Evaluation of Data Uncertainty

Statistical software will be used to determine data consistency using methods consistent with region 6 UIC Program Director guidance and/or LDNR.

3.6.3.2 Data Limitations Reporting

The organization-level project managers will be responsible for ensuring that data developed by their respective organizations is presented with the appropriate data-use limitations. GCS will use the current operating procedure on the use, sharing, and presentation of results and/or data for Project Goose Lake. This procedure has been developed to ensure quality, internal consistency and facilitate tracking and record keeping of data end users and associated publications.

4.0 References

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