TESTING AND MONITORING PLAN
40 CFR 146.90

Bluebonnet Sequestration Hub

1.0 Facility Information

Facility name: Bluebonnet Sequestration Hub (Bluebonnet Hub or the project)
Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS5, Bluebonnet CCS 6, and Bluebonnet CCS 7 wells

Facility contacts: Claimed as PBI [redacted]

Well location: Claimed as PBI [redacted]

Claimed as PBI [redacted]

This Testing and Monitoring Plan describes how the Bluebonnet Sequestration Hub, LLC, will monitor the Bluebonnet Hub pursuant to 40 CFR §146.90. In addition to demonstrating that the wells are operating as planned, the CO_2 plume and pressure front are moving as predicted, and that there is no endangerment to Underground Sources of Drinking Water (USDWs), the monitoring data will be used to validate and adjust the geological models used to predict the distribution of the CO_2 within the storage zone to support 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 attached to this application.

2.0 Overall Strategy and Approach of the Testing and Monitoring Plan

The testing and monitoring plan is designed to detect unforeseen CO_2 and/or brine leakage out of the injection zone that could endanger the USDW, migrate to a different stratus, or create a risk to human health or the environment.

This monitoring plan was tailored based on a qualitative risk assessment of the site that also was used to inform the Emergency and Remedial Response Plan for the Bluebonnet Hub. Table TM-1 summarizes the residual risk ranking, assuming the proposed controls and mitigations of the project design and monitoring plan are in place.

Table TM-1: Risk ranking for Bluebonnet Hub evaluation.

Claimed as PBI

[redacted]

Several components are integrated into the master monitoring plan for the Bluebonnet Hub, which are classified in the following categories:

1. Operational testing and monitoring during injection.
2. Mechanical integrity testing.
3. Groundwater quality and geochemical monitoring.
4. CO_2 plume and pressure-front tracking.
5. Near-surface and surface monitoring.
6. Induced seismicity.

Table TM-2 summarizes the different methods proposed to monitor the AoR, including the CO_2 plume and pressure front from the CO_2 injection wells proposed at the Bluebonnet Hub: Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6, and Bluebonnet CCS 7.

Table TM-2: Summary of Bluebonnet Hub Testing and Monitoring Plan.

Claimed as PBI

[redacted]

Table TM-2: Summary of Bluebonnet Hb Testing and Monitoring Plan (continued).

Claimed as PBI

[redacted]

Table TM-2: Summary of Bluebonnet Hub Testing and Monitoring Plan (continued).

Claimed as PBI

[redacted]

The methodology and frequency of testing and monitoring methods are expected to change throughout the project. Pre-injection monitoring and testing will focus on establishing baselines and ensuring that the site is ready to receive injected CO_2. Injection phase monitoring will be focused on collecting data that will be used to calibrate models and ensure the containment of CO_2. Post-injection phase monitoring and testing is designed to demonstrate CO_2 plume stabilization and ensure containment.

The proposed testing and monitoring plan will collect sufficient geospatial and monitoring data to validate the numerical simulation model, inform operational decisions on the quantity and rate of CO_2 injected, and trigger corrective or preventive maintenance actions, amongst others, to operate the site as designed, efficiently and safely. The monitoring results will allow the project to reevaluate the AoR and show that there is no endangerment to the USDW.

These methods and their applications in the proposed monitoring plan are discussed in the following sections. Results of the testing and monitoring activities described below may trigger action according to the Emergency and Remedial Response Plan.

The testing and monitoring plan will be reviewed at least once every five years and will be amended, if necessary, to ensure monitoring and storage performance is achieved and new technologies are appropriately incorporated. 40 CFR §146.90 (j).

2.1 Quality Assurance Procedures

A quality assurance and surveillance plan (QASP) for testing and monitoring activities, required pursuant to 146.90(k), is provided as a separate document in this permit.

2.2 Reporting Procedures

The Bluebonnet Sequestration Hub, LLC, will report the results of all testing and monitoring activities to EPA in compliance with the requirements under 40 CFR 146.91.

3.0 Well Monitoring Network Design

Bluebonnet Sequestration Hub, LLC, plans to drill six CO_2 injection wells: Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6, and Bluebonnet CCS 7, as part of the field development plan for the Bluebonnet Hub. The monitoring program proposed is designed based on the modeled CO_2 plume extension and propagation of the pressure front for the six wells injecting simultaneously according to the AoR delineation process.

The proposed monitoring plan includes a layout of four in zone (reservoir) monitoring wells, (Bluebonnet IZM FM1, Bluebonnet IZM FM2, Bluebonnet IZM M1, and [redacted]), and seven above-confining-zone/USWD monitoring wells (Bluebonnet USDW 1, Bluebonnet USDW 2, Bluebonnet USDW 3, Bluebonnet USDW 4, Bluebonnet USDW 5, Bluebonnet USDW 6, and Bluebonnet USDW 7).

The project team plans to drill two water production wells, Bluebonnet PRDW F1 and Bluebonnet PRDW F2, to extract formation water from the [redacted] Injection Zone as a technique to control reservoir pressure. The water production wells will be used as part of the monitoring system and will be equipped with pressure and temperature sensors on the surface as well as downhole gauges and sensors according to the artificial lift design.

The project team plans to permit one water disposal well, Bluebonnet DSW M2, to reinject the water produced from the [redacted] formation to the shallow sands of the [redacted] Confining Zone. Figure TM-1 and Figure TM-2 show the location of the monitoring wells, water production wells, and water disposal well relative to the CO_2 injection wells and predicted CO_2 plume.

Claimed as PBI

[redacted]

Figure TM-1: Location and layout of in-zone monitoring wells and water production wells relative to the CO_2 injector wells and the predicted CO_2 plume.

Claimed as PBI

[redacted]

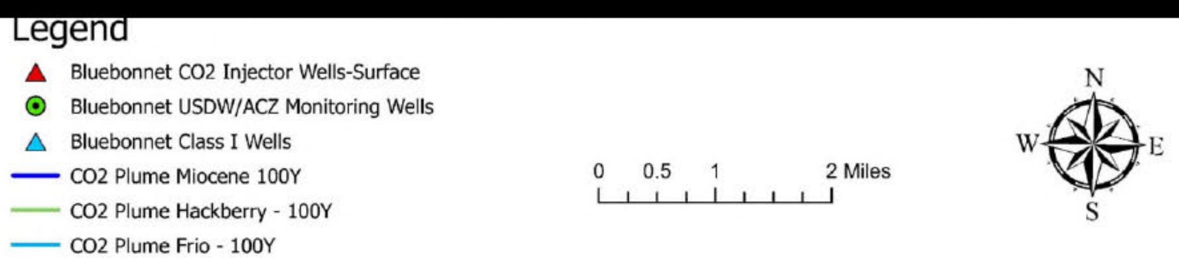

Figure TM-2: Location and layout of ACZ/USDW monitoring wells and water disposal water wells relative to the CO_2 injector wells and the predicted CO_2 plume.

The well locations show the approximate position of the monitoring wells, water production wells, and water disposal well. The exact locations might have a slight variation depending on the final design of the surface pads as well as the negotiations with the landowners when the locations are surveyed.

3.1 CO_2 Injector Wells (CCS)

The CO_2 injection wells Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6, and Bluebonnet CCS 7 are designed to maximize CO_2 injection rates and operate the site efficiently. The wells will be equipped with surface and downhole sensors to track reservoir behavior in real time, allowing the project team to validate the predictions of the numerical simulation model and optimize injection parameters.

The implementation of a pulse neutron/saturation log will evaluate the mechanical integrity of the CO_2 injection wells and provide information about the vertical conformance of the injected CO_2 in the injection zone and validate containment.

The project plans to install fiber optic alongside each CO_2 injection well from surface to top of the perforations to track in real time the vertical conformance of the CO_2 near the wellbore to identify any potential migration paths. The fiber will be used from the beginning of the injection period to image the development of the CO2 plume in 3D and validate the containment of CO_2 in the injection zones.

Details of the well construction and proposed schematics of the CO_2 injectors are included in the Injector Wells Construction Details Plan of this application.

3.2 In-Zone Monitoring Wells (IZM)

Figure TM-3, Figure TM-4 and Figure TM-5 show the location of the in-zone monitoring wells relative to the CO2 injection wells and development of the CO2 plume at different stages of the project. The location and completion design of the in-zone monitoring wells was defined with the objective of tracking the early development of the pressure front as it precedes the movement of the plume, to allow for history-matching of the model. The wells were located strategically to mitigate the main risks identified during the evaluation of the site and comply with 40 CFR §146.90 requirements. These areas included highly populated areas, faults, and high density of legacy wells, amongst others.

The in-zone monitoring well locations and completions (Bluebonnet IZM FM1, Bluebonnet IZM FM2, and Bluebonnet IZM M1) allow for the tracking of movement of the CO2 plume through the application of 3D vertical seismic profile (VSP), from early stages to the end of the injection period. If the surface seismometer network (described in the next sections) detects any activity related to induced seismicity due to the injection, these wells can acquire real time acoustic data to track downhole micro seismicity.

Claimed as PBI

[redacted]

Figure TM-3: Location of the in-zone monitoring wells, water disposal wells, and water production wells relative to the development of the CO_2 plume in the [redacted] Injection Zone for Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6 and Bluebonnet CCS 7.

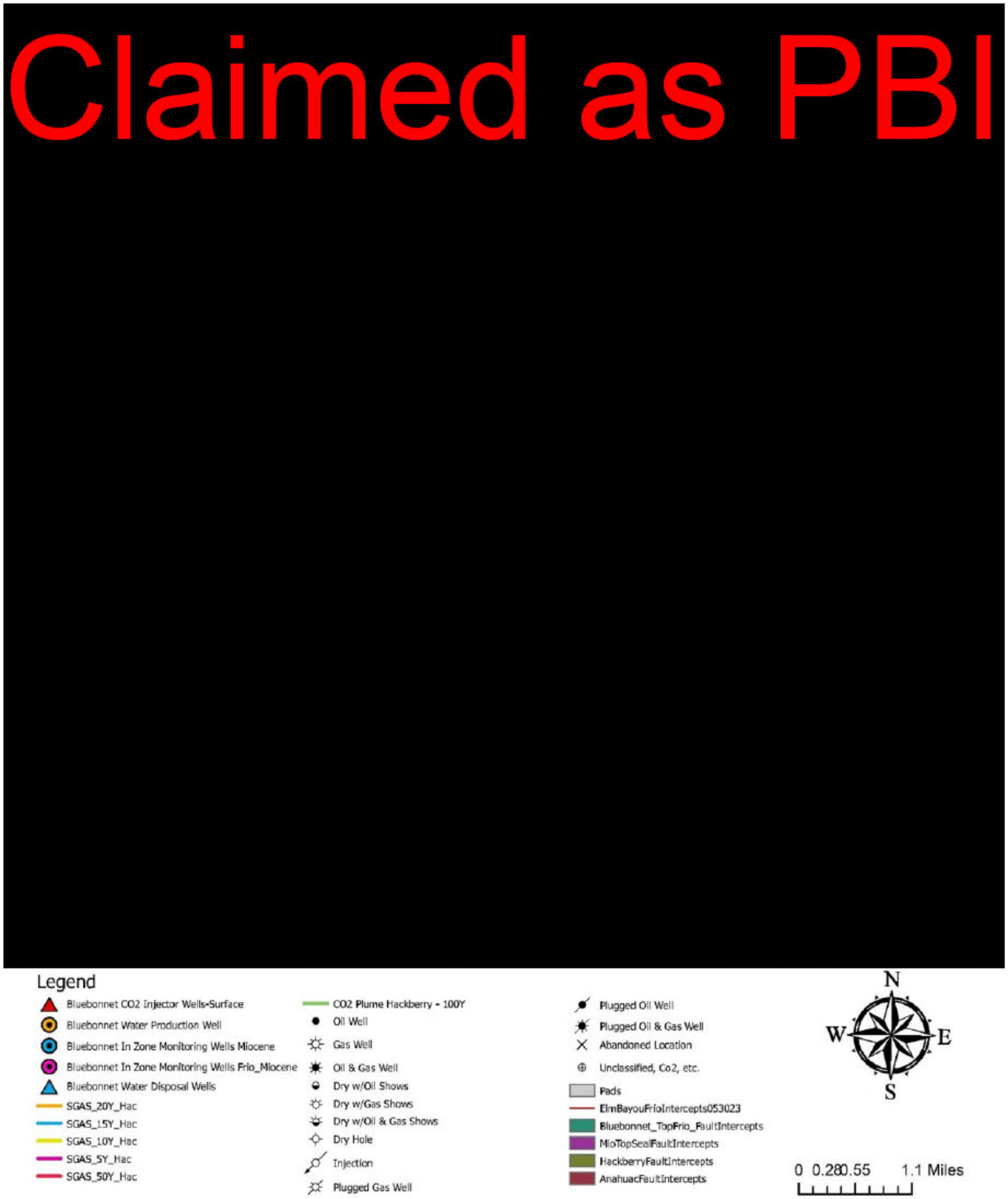

Figure TM-4: Location of the in-zone monitoring wells, water disposal wells, and water production wells relative to the development of the CO_2 Plume in the Claimed as PBI Injection Zone for Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6 and Bluebonnet CCS 7.

Claimed as PBI

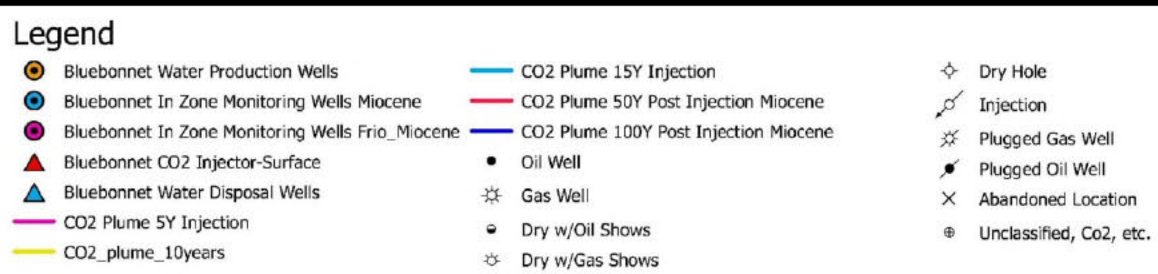

Figure TM-5: Location of the in-zone monitoring wells relative to the development of the CO_2 plume in the Claimed as PBI **Injection Zone for Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6 and Bluebonnet CCS 7.**

3.2.1 Bluebonnet IZM FM1

The Bluebonnet IZM FM1 will be drilled before the CO_2 injection starts or shortly thereafter. The well location was selected to track CO_2 movement and development of the pressure front to the northwest section of the AoR. This well will be located strategically in the updip direction and preferential path of the plume development. The well will serve to calibrate the simulation model and provide the capability to image the CO_2 plume with a 3D VSP, utilizing the fiber optic cable to be installed in the well, covering a radius 0.5 mile around the monitoring well to predict CO_2 plume migration rates.

The well will be completed in the [redacted] Injection Zones [redacted] and will be equipped with pressure and temperatures gauges downhole, ported to the tubing that will allow for tracking changes in the reservoir conditions. Pressure monitoring is extremely valuable to history-match the simulation model and improve accuracy in the prediction of the CO_2 plume movement.

Since the well will be drilled from the surface to the [redacted] Confining Zone, it will enable tracking any changes in CO_2 saturation around the wellbore, not only for the [redacted] Injection Zones, but also for the [redacted] Injection Zone and overburden.

If the surface seismometer network (described in the next sections) detects any activity that could be related to induced seismicity from CO_2 injection, the Bluebonnet IZM FM1 has the capability to acquire real-time acoustic data to track downhole micro seismicity.

The proposed schematic for this well is presented in Figure TM-6.

Claimed as PBI [redacted]

Figure TM-6: Well design and schematic for Bluebonnet IZM FM1.

3.2.2 Bluebonnet IZM FM2

The Bluebonnet IZM FM2 will be drilled before CO_2 injection starts or shortly thereafter. The well location was selected to track the development of the CO_2 plume and pressure front towards the east of the AoR. Claimed as PBI [redacted]

Claimed as PBI The well will be on the border of the CO_2 plume and placed strategically to track any abnormal development of the plume eastward.

The well will be completed in the Claimed as PBI Injection Zones Claimed as PBI and equipped with pressure and temperatures gauges downhole, ported to the tubing that will allow to tracking changes in the reservoir conditions. Pressure monitoring is extremely valuable to history-match the simulation model and improve accuracy in the prediction of the CO_2 plume movement.

Since the well will be drilled from surface to the Claimed as PBI Confining Zone, it will enable tracking any changes in CO_2 saturation around the wellbore, not only for the Claimed as PBI Injection zones, but also for the Claimed as PBI Injection Zone and overburden.

The well will be equipped with a fiber optic cable alongside the casing, providing the capability to image the CO_2 plume with a 3D VSP and covering a radius 0.5 mile around the monitoring well, to predict CO_2 plume migration rates.

If the surface seismometer network (described in the next sections) detects any activity that could be related to induced seismicity from injection, then Bluebonnet IZM FM2 can acquire real-time acoustic data to track downhole micro seismicity with the fiber optic cable installed in the well.

The proposed schematic for this well is presented in Figure TM-7.

[redacted]

Figure TM-7: Well design and schematic for Bluebonnet IZM FM2.

3.2.3 Bluebonnet IZM M1

The well location for Bluebonnet IZM M1 was selected to track the development of the CO_2 plume and pressure front towards the north section of the AoR in the [redacted] formation. The well will be completed in the [redacted] Injection Zone [redacted] allowing tracking variations in pressure and temperature in the reservoir above the [redacted] Confining Zone. The well will be equipped with a fiber optic cable alongside the casing that will provide the capability to image the

CO_2 plume in a 0.5 mile radius around the wells using 3D VSP technology, if required, to calibrate the model.

If the surface seismometer network (described in the next sections) detects any activity that could be related to induced seismicity from CO_2 injection, then the Bluebonnet IZM M1 can acquire real-time acoustic data to track downhole micro seismicity with the fiber optic cable installed in the well.

Implementing a pulse neutron survey in the Bluebonnet IZM M1 will allow monitoring of variations in the CO_2 saturation in the Claimed as PBI Injection Zone and overburden formations.

The proposed schematic for this well is presented in Figure TM-8.

Claimed as PBI

[redacted]

Figure TM-8: Well design and schematic for Bluebonnet IZM M1.

3.2.4 Encanto 01

The Claimed as PBI [redacted] well was drilled in 2022 as part of the stratigraphic well campaign to acquire site-based data for the project and is temporarily abandoned, pending recompletion as part of the project's monitoring network. The well is strategically placed to track any potential migration in the field to the north of the Bluebonnet CCS 1 and Bluebonnet CCS 2 injection wells and will provide monitoring capabilities to track the pressure and temperature changes in the reservoir since these will precede the movement of the CO_2 plume and will allow early calibration of the model. The well will be completed in the [redacted] Injection zones [redacted].

Since the well was drilled from the surface to the [redacted] Confining Zone, it will enable tracking any changes in CO_2 saturation around the wellbore, not only for the [redacted] Injection Zones, but also for the [redacted] Injection Zone and overburden.

The proposed schematic for this well is presented in Figure TM-9.

[redacted]

Figure TM-9: Well design and schematic for [redacted]

3.3 Above-Confining-Zone/USDW Monitoring Wells

The project team drilled the Bluebonnet USDW 1 well in 2024 with the objective of characterizing the shallow aquifers and validating the base of the USDW. The well was drilled to [redacted] Electric logs were run and water samples were collected to be used in the delineation of the AoR. The lower section of the well was abandoned from Claimed as PBI [redacted] with a cement plug and the well was completed in the sand below the base of USDW.

In addition to Bluebonnet USDW 1, the project team plans to construct six USDW monitoring wells across the AoR to closely monitor the above-confining zone/USDW by acquiring water samples and monitoring real time pressure and temperature. Bluebonnet USDW 2, Bluebonnet USDW 3, Bluebonnet USDW 4, Bluebonnet USDW 5, Bluebonnet USDW 6, and Bluebonnet USDW 7 will be drilled to the base of the USDW and completed in the lowest-most sand. The wells will be equipped with pressure and temperature sensors at the surface and downhole.

Figure TM-10 shows the well schematic for Bluebonnet USDW 1. Figure TM-11 to Figure TM-16 show the proposed construction for the additional five USDW monitoring wells.

Claimed as PBI [redacted]

Figure TM-10: Well design and schematic for Bluebonnet USDW 1.

Claimed as PBI

[redacted]

Figure TM-11: Well design and schematic for Bluebonnet USDW 2.

Claimed as PBI

[redacted]

Figure TM-12: Well design and schematic for Bluebonnet USDW 3.

Claimed as PBI

[redacted]

Figure TM-13: Well design and schematic for Bluebonnet USDW 4.

Claimed as PBI

[redacted]

Figure TM-14: Well design and schematic for Bluebonnet USDW 5.

Claimed as PBI

[redacted]

Figure TM-15: Well design and schematic for Bluebonnet USDW 6.

Claimed as PBI

[redacted]

Figure TM-16: Well design and schematic for Bluebonnet USDW 7.

3.4 Water Production and Water Disposal Wells

Bluebonnet Sequestration Hub, LLC, will construct two water production wells, Bluebonnet PRDW F1 and Bluebonnet PRDW F2, prior to CO_2 injection or shortly thereafter. The wells will serve to control the pressure increase in the [redacted] Injection Zone during the injection period and will be equipped with pressure and temperature sensors at the surface as well as downhole that will provide the capability to monitor real time the reservoir conditions.

The pressure monitoring data will direct operating parameter adjustments for the Hub and will provide information to validate the assumptions in the numerical simulation model, which will help validate the prediction of CO_2 plume and pressure development. These wells will not see CO_2 saturations during their operative period; however, the water will be monitored and tested to evaluate any changes in geochemistry. [redacted]

Figure TM-17 and Figure TM-18 show the proposed schematic and design for the water production wells Bluebonnet PRDW F1 and Bluebonnet PRDW F2.

Claimed as PBI

[redacted]

Figure TM-17: Well design and schematic for Bluebonnet PRDW F1.

Claimed as PBI

[redacted]

Figure TM-18: Well design and schematic for Bluebonnet PRDW F2.

The project also plans to construct one water disposal well, Bluebonnet DSW M2. This well will be permitted as Class I wells through the Texas Commission on Environmental Quality (TECQ) process.

Bluebonnet DSW M2 will be completed in the sands above the Claimed as PBI [redacted] Confining Zone in the dissipation zone. This well will be equipped with surface pressure and temperature sensors to track the reservoir conditions during the water disposal operation.

Figure TM-19 shows the proposed design for the water disposal wells.

Claimed as PBI

[redacted]

Figure TM-19: Well design and schematic for Bluebonnet DSW M2.

4.0 Operational testing and monitoring during injection

4.1 CO_2 Stream Analysis

Pursuant to 40 CFR 146.90(a), during the operation period, Bluebonnet Sequestration Hub, LLC, will analyze the CO_2 stream for its chemical and physical characteristics.

4.1.1 Sampling Location and Frequency

The CO_2 stream sampling will occur quarterly during operation either upstream or downstream of the custody transfer flowmeter that measures the flow rate of the injectant at the site. Multiple samples will be acquired during the startup period of the project (first injection) to validate that the CO_2 stream complies with the required minimum specifications. After the startup period, a sample will be taken 3 months after the start of injection, at 6 months, at 9 months, and at 12 months, as a minimum frequency, continuing every quarter. The sampling period could be increased and slightly shifted in timing, depending on the operations.

The project has developed a minimum standard CO_2 specification, as shown in Table TM-3, to be enforced with the emitters and distribution channels that control the quality of the CO_2 injected at the site. The project will install a gas analyzer at the custody transfer meter located in the sequestration site to monitor CO_2 quality continuously before it is distributed to each well in the site, to detect any major deviation from the contractual specifications. The project could require additional components to be limited and analyzed based on final contractual terms with the emitters.

Table TM-3: CO_2 Stream specifications.

Claimed as PBI

[redacted]

The CO_2 composition will be monitored continuously at each receipt point into the pipeline network along with at the delivery point to the sequestration site. In addition, samples will be collected and analyzed periodically at each receipt point and delivery point.

If the inline analyzers or sample results indicate a deviation from the CO_2 specification, the sampling frequency for the relevant receipt point(s) will be increased until the sampling results return to normal for a specified period.

If the CO_2 delivered to a receipt point does not meet the CO_2 specification, the project team will notify the CO_2 source facility and either shut in the source facility or increase the sample frequency, depending on the risk associated with the out-of-specification component.

If a CO_2 source facility is shut in, offtake will only resume from that facility once it has demonstrated the resumption of in-specification product for an agreed period between 12 and 48 hours.

4.1.2 Analytical parameters

The Bluebonnet Sequestration Hub, LLC, will analyze the CO_2 for the constituents identified in Table TM-4 as a minimum (but not limited to) requirement.

Table TM-4: CO_2 stream analysis.

Claimed as PBI

[redacted]

The project team may deem it necessary to test additional elements to ensure the CO_2 delivered to the Bluebonnet Hub complies with contractual specifications.

Isotopes will be analyzed during the first year of operation and after any major change of CO_2 source composition to fingerprint the stream.

4.1.3 Sampling Methods

A sampling station will be installed with the ability to purge and collect samples into a container that will be sealed. All sample containers will be labeled with durable labels and indelible markings. A unique identification number and sampling date will be recorded on the sample containers. The sample containers will be sent to the third-party authorized laboratory contracted for testing.

Sampling procedures will follow the third-party authorized laboratory protocols to ensure the sample is representative of the injectant and samples will be processed, packaged, and shipped to the contracted laboratory, following standard sample handling and chain-of-custody guidance. Sampling methods are described in the QASP.

4.1.4 Laboratory to be Used/Chain-of-Custody and Analysis Procedures

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Analytic methods and chain-of-custody procedures are described in the QASP.

4.2 Monitoring and Recording of Operating Parameters in CO_2 Injector Wells

The Bluebonnet Sequestration Hub, LLC, will install and use continuous recording devices to monitor injection pressure, rate, and volume, including the pressure on the annulus between the tubing and long string casing and the temperature of the injected stream in the CO_2 injector wells (Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, Bluebonnet CCS 5, Bluebonnet CCS 6 and Bluebonnet CCS 7) as required by 40 CFR 146.88(e)(1), 146.89(b), and 146.90(b).

The project will record any changes in annular fluid volumes during daily or weekly inspections, as needed. Additionally, the project plans to install a downhole gauge above the packer, ported to the annulus, to track in real time changes of pressure above the packer in the annulus.

Injection operations will be continuously monitored and controlled by the operations staff, using the process control system. The system will continuously monitor, control, record, and set alarms for critical system parameters of pressure, temperature, and flow rate.

The process control system will limit maximum flow according to the operation parameters for each well.

The system will initiate a shutdown if specified control parameters deviate from the intended operating range and will allow for remote shutdown under emergency conditions. Trend analysis will help evaluate the performance (e.g., drift) of the instruments, suggesting the need for maintenance or calibration.

4.2.1 Monitoring Location and Frequency

Real-time monitoring activities will begin during the startup of the wells for first injection. The injection pressure and temperature will be continuously measured at the surface via real-time pressure and temperature (P/T) instruments installed in the CO_2 injection line near the interface with the wellhead. The pressure will be measured by an electronic pressure transducer with analog output mounted on the CO_2 line associated with the injection well. The temperature will be measured by an electronic temperature transducer mounted in the CO_2 line near the pressure transducer, with both transducers mounted near the wellhead.

The flow rate of CO_2 injected into the well will be measured by flowmeter skids with a Coriolis type flowmeter in the CO_2 injection line near the interface with the wellhead. Piping and valving will be configured to permit flowmeter calibration/verification. The flow transmitter will be connected to a remote terminal unit (RTU) on the flowmeter skid.

A P/T gauge will be installed downhole as part of the upper completion and will be ported into the tubing to continuously measure CO_2 injection pressure and temperature at the reservoir. The downhole gauges will be the point of compliance for maintaining injection pressure below 90% of formation fracture pressure and for evaluating the reservoir performance and history-matching the operation with the projection of the model.

If the downhole gauge stops working between scheduled maintenance events, then the surface pressure limit approved for this permit will be used as a backup until the downhole gauge is repaired or replaced. For calibration purposes, in lieu of removing the injection tubing, the accuracy of the downhole gauges will be demonstrated by using a second pressure gauge with current certified calibration lowered into the well at the same depth as the permanent downhole gauge.

Electronic pressure and temperature transducers will be used to continuously monitor the pressure and temperature of the annulus between the tubing and long-string casing at the surface. Gauges and sensors will be connected to the automation system to provide continuous data analysis and alarms for malfunctioning events when the values deviate from the intended operating range.

A minimum of 100 psi differential will be maintained across the packer with the addition of packer fluid volume. Changes in pressure will be noted by the operator in the field and recorded in the project well databases daily. A pressure gauge and temperature sensor will be installed downhole as part of the upper completion and will be ported into the annulus above the packer to continuously measure the pressure in the annular space and identify any potential loss of mechanical integrity. If a major variation of pressure is observed in the annular gauges (surface/downhole), then the field operator will proceed to troubleshoot the well.

A fiber optic cable will be attached along the side of the casing and a distributed temperature sensing (DTS) interrogator will be installed on the surface, which will provide a distributed temperature profile while injecting. This system will continuously record the temperature to assist in monitoring the CO_2 behavior and identifying any unforeseen mechanical integrity issue in the well.

Automated shutoff devices will be installed at each exit of the flowlines in the wellhead and will be connected to the control system. If the operational parameters deviate from the program operational limits, the system will send an alarm to the operators to evaluate and correct the situation, which might include starting the shutdown protocol if the parameter exceeds the maximum operating limits [40 CFR 146.88 (e)(2)]. The Bluebonnet Sequestration Hub, LLC, will perform the activities identified in Table TM-5 to monitor operational parameters. All monitoring will take place at the locations and frequencies shown in the table.

Table TM-5: Monitoring devices, locations, and frequencies for continuous monitoring during injection operations in the CO_2 injector wells.

Claimed as PBI

[redacted]

4.2.2 Monitoring Devices Description and Technical Specifications

Technical specifications for the tools to use for real-time data acquisition, monitoring, and shut down are described in the QASP.

4.3 Corrosion Monitoring

To meet the requirements of 40 CFR 146.90(c), the Bluebonnet Sequestration Hub, LLC, 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.

The Bluebonnet Sequestration Hub, LLC, will monitor corrosion using coupons and collect samples according to the description below. The project team will complement the corrosion coupons with casing inspection logs, visual inspection of the facilities, a robust leak detection and repair program, the use of optical gas imaging cameras (OGI), and the data collected in real time from the fiber optic cable installed in the injector wells.

During well material selection, the Bluebonnet Sequestration Hub, LLC, simulated the chemical reactions of the selected material, formation waters, and proposed CO_2 stream at downhole conditions. The project team proceeded to test the selected metallurgy to the maximum limits of the specification and operating parameters to validate the correct selection for downhole materials that will be exposed to the injection stream and formation waters.

4.3.1 Monitoring Location and Frequency

Table TM-6: Monitoring location and frequency of corrosion coupon testing.

Claimed as PBI [redacted]

4.3.2 Corrosion Coupon Analysis Description

Samples of selected materials in the wells and facilities (coupons) will be exposed to the injected CO_2 stream and monitored for signs of corrosion to verify that the selected materials meet the minimum standards for material strength and performance and to identify well maintenance needs.

Coupons shall be collected and sent quarterly to a third-party company for analysis, conducted in accordance with NACE Standard SP-0775-2018-SC, to determine and document corrosion wear rates based on mass loss. The project will begin corrosion coupon monitoring after the start of injection and will continue quarterly until the end of injection period.

Table TM-7: Summary of methods to evaluate corrosion coupons.

Claimed as PBI [redacted]

Table TM-8: List of equipment with materials of construction.

Claimed as PBI [redacted]

Claimed as PBI

[redacted]

4.4 Visual Inspection and Leak Detection and Repair (LDAR) Program using Optical Gas Imaging Camera (OGI)

The project will perform visual inspection of the facilities and wells as part of the maintenance and mechanical integrity program, as summarized in Table TM-9. Inspection will start from the commissioning date and will continue weekly after the site is injecting steadily. Leak detection and repair (LDAR) field inspections will be performed quarterly after the start of injection and continue until injection ceases, using optical gas imaging (OGI) cameras.

During visual inspections, the field operator will be provided with handheld devices to measure explosive gases, H_2S, and CO_2 as part of the safety requirements of the site.

Table TM-9: Monitoring locations and frequency of visual inspections and LDAR program.

Claimed as PBI

[redacted]

4.5 Pressure Falloff Testing in CO_2 Injector Wells

The Bluebonnet Sequestration Hub, LLC, will perform pressure falloff tests in the CO_2 injection wells during the injection phase as described below to meet the requirements of 40 §CFR 146.90(f).

4.5.1 Testing Location and Frequency

Pressure falloff testing will be conducted upon completion of the injection well to characterize reservoir hydrogeologic properties, aquifer response model characteristics, and changes in near-well/reservoir conditions that may affect operational CO_2 injection behavior.

Pressure falloff testing will be conducted in the CO_2 injection wells at least once every five years during injection for the AoR until the wells are plugged. The objective of the periodic pressure falloff testing is to determine whether any significant changes in the near-wellbore conditions have occurred that may adversely affect the well or reservoir performance.

4.5.2 Testing Details

Detailed procedure and analytics proposed for the falloff test are described in the QASP.

4.6 Tracking and Recording Pressure and Temperature in In-Zone Monitoring Wells

The Bluebonnet Sequestration Hub, LLC, will continuously measure pressure and temperature in the in-zone monitoring wells at the surface via real-time P/T instruments installed in the wellhead. Table TM-10 summarizes the monitoring locations of P/T gauges and frequency of testing.

A pressure and temperature (P/T) gauge will be installed downhole as part of the upper completion and will be ported into the tubing to continuously measure pressure and temperature in the reservoir. These measurements will allow the project team to calibrate and verify the model, improve predictive capability for confirming CO_2 containment, and evaluate the development of the pressure front.

Since the changes in reservoir pressure precede the movement of the CO_2 plume, in-zone monitoring wells will provide data to history-match the model and calibrate the response expected from the reservoir regarding the development of pressure front and CO_2 plume migration.

Table TM-10: Monitoring locations and frequency of pressure and temperature measurement in in-zone monitoring wells.

Claimed as PBI

[redacted]

In the event the downhole sensor fails before a planned well maintenance operation, the project will continue monitoring the pressure with the surface transducers and might implement measurement of fluid levels in the well to calculate the bottomhole pressure while the equipment is replaced and repaired. The project team might install temporary pressure gauges in the well and limit the collection of data to one sample per day.

4.7 Tracking and Recording Pressure and Temperature in Water Production Wells

The project team plans to install P/T sensors in the water production wells. These sensors and gauges will be included as part of the upper completion and artificial lift system to continuously measure conditions in the reservoir. Since the changes in reservoir pressure are interrelated with the water extraction process and propagation of the pressure front, the measurements in the water production well will provide data to history-match the model.

This well will be equipped as well with pressure and temperature sensors at the surface, installed in the flowline.

In the event the downhole sensor fails before a planned well maintenance operation, the project team will continue monitoring the pressure with the surface transducers and might implement measurement of fluid levels in the well to calculate the bottomhole pressure while the equipment is replaced and repaired.

Table TM-11 summarizes the monitoring locations and frequency of pressure and temperature testing in the water production wells.

Table TM-11: Monitoring locations and frequency of pressure and temperature measurements in water production wells.

Claimed as PBI

[redacted]

4.8 Tracking and Recording Pressure in Above-Confining-Zone/USDW Monitoring Wells

The Bluebonnet Sequestration Hub, LLC, will continuously measure pressure and temperature in the above-confining-zone/USDW monitoring wells at the surface via real-time P/T instruments installed in the wellhead.

The project team plans to install P/T gauges in the upper completion of the above-confining-zone/ USDW monitoring wells to track changes in the downhole conditions. Bluebonnet USDW 6 will not be equipped with P/T gauge but will be sample for geochemical changes.

4.8.1 Monitoring Location and Frequency

Table TM-12: Monitoring locations and frequency of pressure and temperature measurement for above-confining-zone/USDW monitoring wells.

Claimed as PBI

[redacted]

4.9 Tracking and Recording Pressure in Water Disposal Wells

The Bluebonnet Sequestration Hub, LLC, will continuously measure pressure and temperature in the water disposal well, Bluebonnet DSW M2, at the surface via real-time P/T instruments installed in the wellhead.

Table TM-13: Monitoring location and frequency of pressure and temperature measurement for water disposal wells.

Claimed as PBI

<u>5.0 Mechanical Integrity Testing</u>

5.1 External Mechanical Integrity Testing

The Bluebonnet Sequestration Hub, LLC, will perform a cement logging evaluation with one or more of the following tools to validate zonal isolation between the injection zones, confining and dissipation zones, and overburden formations after installation of the long string casing during construction of the CO_2 injector, water production wells, water disposal well, and in-zone monitoring wells [40 CFR 146.87 (a)(2)(ii) 40 CFR 146.87 (a)(3)(ii)]:

a) Cement bond logging
a) Ultrasonic cement evaluation tool
a) Variable density log (VDL)

The project team will run a pulse neutron log (PNL) in the CO_2 injection wells after initial installation of the completion equipment, and at least once a year to evaluate external mechanical integrity (40 CFR 146.89(c) and 40 CFR 146.90(e)).

The project team will install a fiber optic cable alongside the long-string casing in the CO_2 injection wells with the capability of continuously monitoring temperature changes from the top of the perforations to the surface, exceeding the requirements in 40 CFR 146.89(e) and 40 CFR 146.90(e).

Additionally, during well maintenance operations or workovers for the CO_2 injection well, an ultrasonic casing inspection tool will be run to evaluate casing thickness and conditions.

The project team will run a PNL in the in-zone monitoring wells, water production wells, and water disposal well after initial installation of the completion equipment to set the baseline for mechanical integrity evaluation as well as for CO_2 plume tracking in the reservoir.

The project team will also install a fiber optic cable alongside the casing in the in-zone monitoring wells, Bluebonnet IZM FM1, Bluebonnet IZM FM2, and Bluebonnet IZM M1, that will allow tracking of mechanical integrity in real time as well as changes in reservoir conditions.

If a fiber optic cable fails in any of the in-zone monitoring wells, Bluebonnet IZM FM1, Bluebonnet IZM FM2, and Bluebonnet IZM M1, the project team will run one of the following tools at least every five years or during well maintenance operations or workovers to evaluate external mechanical integrity:

a) Pulse neutron through tubing
b) Electromagnetic casing inspection log
c) Temperature log

The project team will also install a fiber optic cable alongside the casing in the water production wells, Bluebonnet PDRW F1 and Bluebonnet PRDW F2, that will allow tracking of mechanical integrity in real time as well as changes in reservoir conditions.

If a fiber optic cable fails in any of the water production wells, the project team will run one of the following tools at least every five years or during well maintenance operations or workovers to evaluate external mechanical integrity:

a) Pulse neutron through tubing
b) Electromagnetic casing inspection log
c) Temperature log

For [redacted] stratigraphic well and Bluebonnet DSW M2, which do not have fiber optic cable installed on the long string, the project team will run one of the following tools at least every five years or during planned well maintenance or workover activities to demonstrate external mechanical integrity:

a) Pulse neutron through tubing
b) Electromagnetic casing inspection log
c) Temperature log

5.1.1 Testing Location and Frequency

Table TM-14 below provides a summary of the external mechanical integrity tools.

Table TM-14: Corrosion monitoring and surface leak detection tools.

Claimed as PBI

[redacted]

5.1.2 Testing Details

The logging industry has made impressive advancements in tools that provide images of and data identifying the quality of the cement bond behind the casing after cementing jobs are complete. The casing inspection tool and multi-finger calipers can provide information about ovality, collapse, and/or damage in the casing, as well as estimations of wall thickness to evaluate wearing and corrosion effects.

The most advanced tools can evaluate up to five concentric tubulars to measure changes in thickness that could be related to corrosion or wearing effects.

The tools described below are readily available technologies on the market and the basis of the project's master monitoring program for mechanical integrity. No specific provider has been selected. In the future, new technologies or tools may be proposed for further discussion with regulators.

5.1.2.1 Cement Bond Log and Variable Density Log

Cement bond log (CBL) is a basic method to evaluate cement quality in the annulus. It is an acoustic wave measurement. The tool usually includes a transmitter and receiver, separated by 3 ft. The acoustic wave is emitted by the transmitter, propagated down and across the annulus, and recorded by the receiver. The attenuation of the wave is analyzed to interpret the bonding behind the pipe. Signal coming from a properly cemented casing will be more attenuated than the signal coming from a poorly cemented one.

The arriving signal recorded by the receiver is a mixed signal coming from casing, cement, mud, and formations. Each signal has its own pathway because they travel at different velocities through each medium. The signal through the casing is the fastest, as sound travels the quickest through steel. As a result, it is the first signal detected on the receiver. The second signal most likely to arrive is the signal through the formation and last one is the drilling fluid signal because sound travels slower in a liquid.

Variable density log (VDL) is commonly used as an adjunct to the cement bond log and offers better insights with its interpretation. In most cases, micro annulus and fast-formation-arrival effects can be identified using this additional display.

Figure TM-20 and Figure TM-21 show examples of CBL and VDL output.

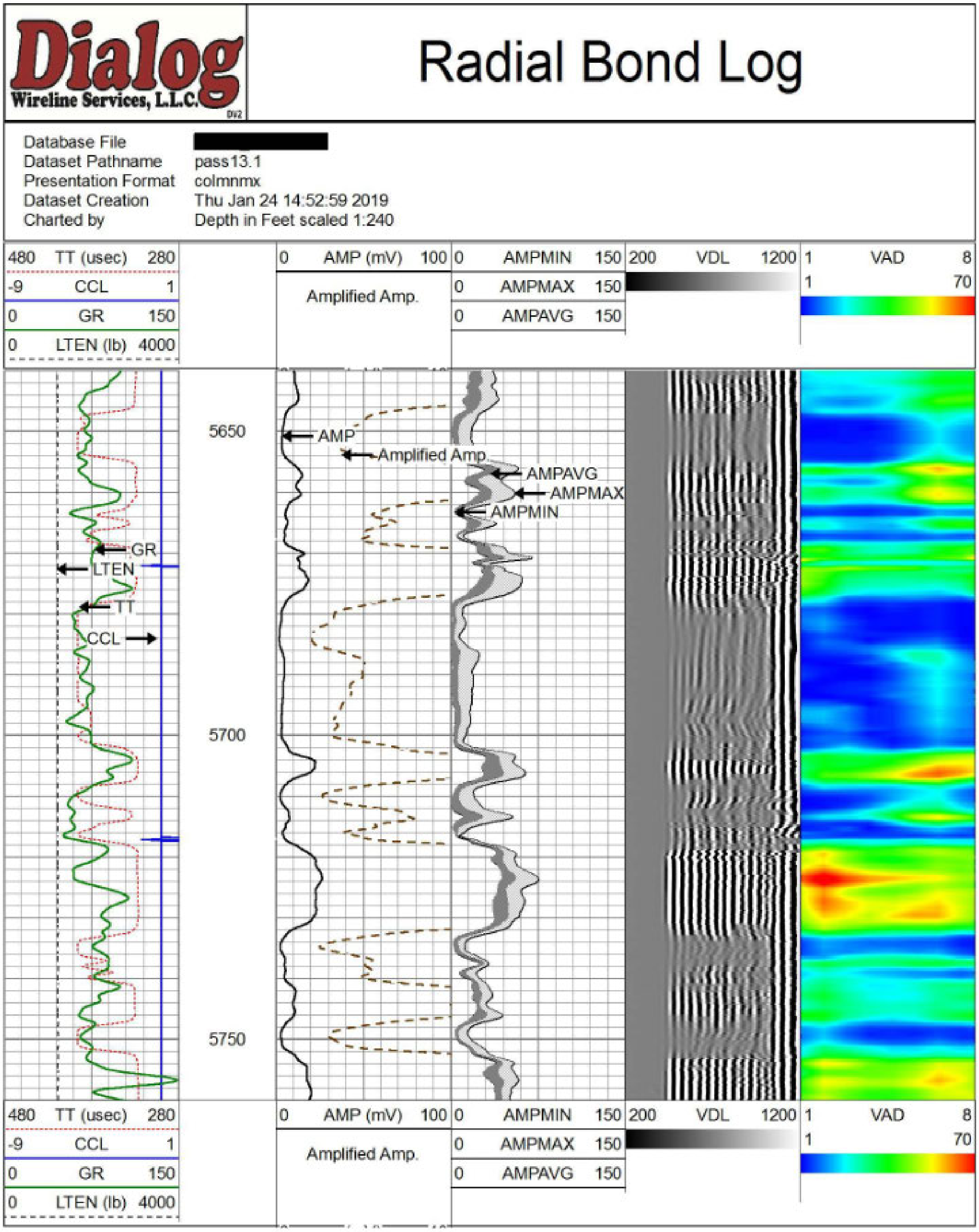

Figure TM-20: **CBL and VDL example from dialog wireline services web page.**

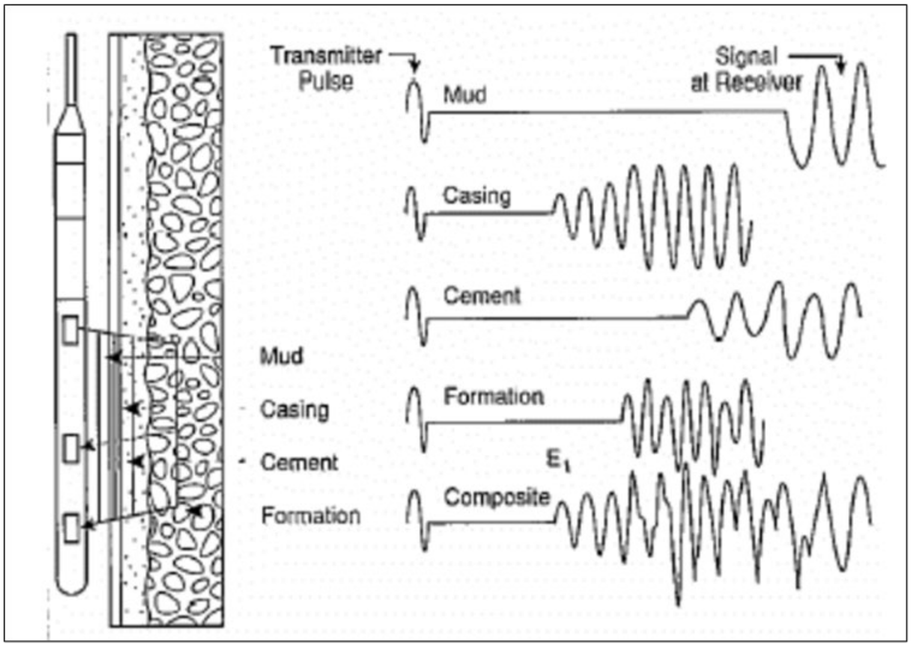

Figure TM-21: Signal received by CBL-VDL.

5.1.2.2 Ultrasonic Cement and Casing Evaluation Tools

USIT (SLB technology) is an example of an ultrasonic imager that delivers an accurate, comprehensive, and high-resolution confirmation of the pipe-to-cement bond quality and downhole pipe condition in real time. Casing inspection and monitoring applications include corrosion detection, identification of internal and external damage or deformation, and casing thickness analysis for collapse and burst pressure calculations.

The rate of decay of the waveforms received indicates the quality of the cement bond at the cement-casing interface and the resonant frequency of the casing provides the casing wall thickness required for pipe inspection. The resulting 360° data coverage enables evaluation of the quality of the cement bond and determination of both the internal and external condition of the casing.

Isolation Scanner™ (SLB Technology) is a combination of independent measurements that fully characterizes the annular environment, differentiating low-density solids from liquids to distinguish lightweight and contaminated cements from liquids. Its azimuthal coverage provides results around the entire circumference of the casing, pinpointing any channels in the cement and confirming the effectiveness of the annular barrier for zonal isolation.

The Isolation Scanner™ tool also identifies corrosion or drilling-induced wear through measurement of the inside diameter and thickness of the casing. The flexural wave measurement produces entirely new information from the third-interface echoes (TIEs) between the annulus and borehole or outer casing. The TIEs image the borehole shape, define the position of the casing within the borehole or outer casing, and image the outer string to reveal corrosion and damage.

5.1.2.3 Distributed Temperature Sensing

Distributed temperature sensing (DTS) technology uses fiber optic sensor cables, typically several kilometers in length, that function as linear temperature sensors. The result is a continuous temperature profile along the entire length of the sensor cable. DTS uses the Raman effect to measure temperature. An optical laser pulse sent through the fiber results in some scattered light reflecting to the transmitting end, where the information is analyzed. The intensity of the Raman scattering is a measure of the temperature along the fiber. The Raman anti-Stokes signal changes its amplitude significantly with changing temperature, while the Raman Stokes signal is relatively stable. The position of the temperature reading is determined by measuring the arrival timing of the returning light pulse like a radar echo.

The fiber optic cable is run alongside the casing as an umbilical and is protected with clamps and centralizers to avoid any damage while deploying it into the well. The fiber is connected on the surface to an interrogator that converts the signal to temperature values and transmits the data to the monitoring platform in real time for surveillance purposes.

The equipment maintenance and calibration will be performed according to the manufacturer's manuals and will be the technology provider's responsibility. Technical specifications are available in the QASP.

5.1.2.4 Electromagnetic Casing Inspection Tool

Electromagnetic Pipe Xaminer® V (EPX™ V) (Halliburton technology) is an example of a proprietary electromagnetic tool. The operating principle of the tool is to induce a high-definition frequency (HDF) electromagnetic energy into the surrounding pipe, which propagates through the concentric well strings with no wellbore fluid influences. The interaction with the metal of the pipe returns a signal to the tool, yielding information on the metal loss present in the tubulars. The magnitude and location of corrosion-induced defects are identified using HDF variance algorithms of the returning electromagnetic waves. This information leads to a quick total thickness calculation determining the overall condition of the pipe structure. This technology enables examination of the whole well in one trip, for up to five concentric strings of pipe.

5.1.2.5 Temperature Log

Temperature logs are used to locate gas entries, detect casing leaks, and evaluate fluid movement behind casing (see example in Figure TM-22). They are also used to detect lost-circulation zones and cement placement. Temperature logs are used as a basic diagnostic tool and are usually paired with other tools like acoustics or multi-arms calipers, if more in-depth analysis is required.

Temperature instruments used today are based on elements with resistances that vary with temperature. The variable resistance element is connected to bridge circuitry or a constant current circuit, so that a voltage response is proportional to temperature. The voltage signal from the temperature device is then usually converted to a frequency signal that is transmitted to the surface, where it is converted back to a voltage signal and recorded. The absolute accuracy of temperature logging instruments is not high (in the order of +- 5°F), but the resolution is good (0.05°F or better) although this accuracy can be compromised by present day digitalization of the signal on the surface. The temperature instrument can usually be included in the string with other tools, such as radioactive tracer tools or spinners flowmeters. Temperature logs are run continuously, typically at cable speeds of 20 to 30 ft/min. (A. Daniel Hill 2021).

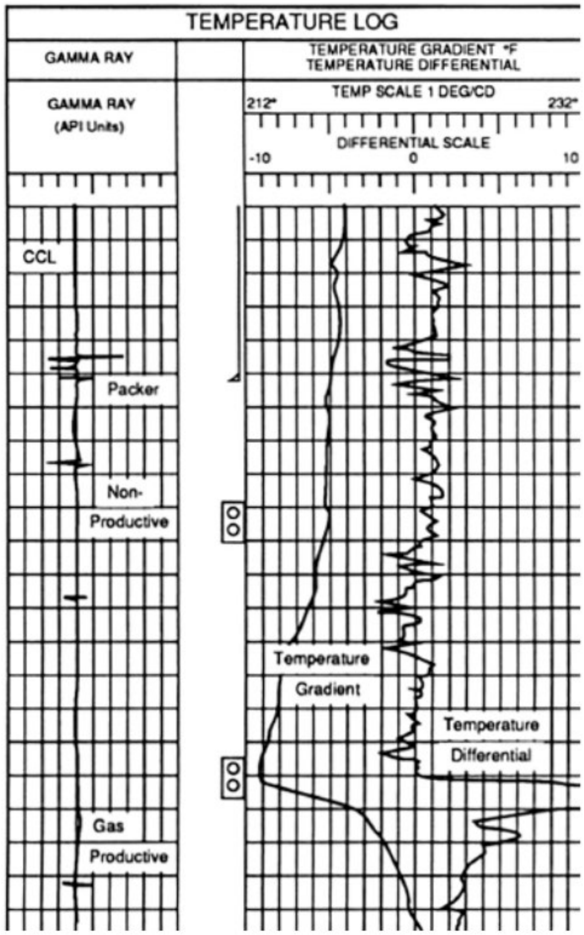

Figure TM-22: Example of temperature log output.

5.1.2.6 Pulse Neutron Log

Pulse neutron log (PNL) provides formation evaluation and reservoir monitoring in cased holes. The PNL is deployed as a wireline logging tool with an electronic pulsed neutron source and one or more detectors that typically measure neutrons or gamma rays. High-speed digital signal electronics process the gamma ray response and its time of arrival relative to the start of the neutron pulse. Spectral analysis algorithms translate the gamma ray energy and time relationship into concentrations of elements. Each logging company has its own proprietary designs and improvements on the tool.

SLB's Pulsar multifunction spectroscopy service (PNX) pairs multiple detectors with a high-output pulsed neutron generator in a slim tool with an outer diameter (OD) of 1.72 in. for through-tubing access in cased hole environments. The housing is corrosion-resistant, allowing deployment in wellbore environments such as CO_2. The tool's integration of the high neutron output and fast detection of gamma rays, with proprietary pulse processing electronics, allows differentiation and quantification of gas-filled porosity from liquid-filled and tight zones. The tool can accurately determine saturation in any salinity of formation water, across a wide range of well conditions, mineralogy, lithology, and fluid contents profile at any inclination. Detection limits for CO_2 saturation for the PNX tool vary with the logging speed as well as the formation porosity. Detailed measurement and mechanical specifications for the PNX tool are provided in the QASP document. The wireline operator will provide QA/QC procedures and tool calibration for their equipment.

Halliburton's Reservoir Monitor Tool 3-Detector™ (RMT-3D) is a pulsed-neutron tool that solves for water, oil, and gas saturations within reservoirs using three independent measurements (Sigma, C/O, and SATG). This provides the ability to uniquely solve simple or complex saturation profiles in reservoirs, while eliminating phase-saturation interdependency. The RMT-3D provides gas phase analysis to identify natural gases, nitrogen, CO_2, steam, and air. The tool has 2.125 in. OD that allows it to be run through tubing.

5.1.3 Description and Technical Specifications of the Tools for External Mechanical Integrity Evaluation

Detailed information and technical references of these tools are provided in the QASP.

5.2 Internal Mechanical Integrity Testing

The Bluebonnet Sequestration Hub, LLC, will perform an annular pressure test in the CO_2 injection wells and in the in-zone monitoring wells and water disposal well to demonstrate internal mechanical integrity, according to 40 CFR 146.89(b).

Annular pressure testing is used to validate mechanical integrity. Tests will be performed according to the frequency presented in Table TM-15.

Table TM-15: Annular pressure testing frequency.

Claimed as PBI

[redacted]

If the additional monitoring systems indicate a potential mechanical integrity issue, the Bluebonnet Sequestration Hub, LLC, will perform troubleshooting and perform an annular pressure test as part of the protocol, if needed.

An example overview of the procedure is as follows (actual procedures may vary based upon operating conditions at the well and other safety or technical considerations):

1. First, shut in the well to stabilize the pressures in the injectors and validate static conditions in the monitoring wells.

2. Connect the testing equipment to the annular valves and test surface lines to 1,500 psi above the testing pressure.

3. Verify that there are no surface leaks from the pumping unit to the wellhead valve. Bleed off any air in the system. If needed, fill the annular space with packer fluid and corrosion inhibitor (if needed, it should require only a minimal amount). Record the initial tubing and casing pressure.

4. Test the well to 1,000 psi in the annular space for the CO_2 injection wells and 500 psi in the annular for in-zone monitoring wells. The pressure should not decrease more than 10% in 30 minutes.

5. Continuously monitor the tubing and casing pressures. Record the final tubing and casing pressure. If the pressure decreases more than 10%, bleed the pressure completely, test the surface connection, and repeat the test.

6. If there is an indication of mechanical failure, the operator will prepare a plan to repair the well and discuss it with the Director.

7. Document and store the test results in the centralized database of the project for reporting and documentation.

Note: Surface gauges should be calibrated according to manufacturer recommendations. There should be a pressure range that will allow the test pressure to be near the gauge's mid-range. Additionally, the gauge must be of sufficient accuracy and scale to allow an accurate reading of 5% change to be read.

6.0 Groundwater Quality and Geochemical Monitoring

The Bluebonnet Sequestration Hub, LLC, will monitor groundwater quality and geochemical changes above the confining zones during the operation period to meet the requirements of 40 CFR 146.90(d).

The groundwater monitoring locations were selected based on the original screening of the AoR for existing legacy wells, results of the numerical simulation for CO_2 plume and pressure front, and risk assessment performed by the project. The location, techniques, and frequency were optimized, taking into consideration the complementary techniques proposed in this monitoring plan for direct and indirect measurements, such as 2D seismic surveys, 3D time lapse VSP, pulse-activated neutron logs, soil gas analysis, and others that are explained in additional sections of this document.

The Bluebonnet Sequestration Hub, LLC, selected [redacted] legacy shallow water wells distributed around the AoR to sample and test the freshwater aquifer in the area. These wells targeted the [redacted] Aquifer to provide water for domestic, public, stock, and irrigation uses. Some of these wells could be replaced or eliminated after the project performs a mechanical integrity assessment on the wells.

Additionally, the project team drilled Bluebonnet USDW 01 in May 2024 to characterize the different zones between surface and base of the USDW. The well was completed in the first permeable zone below the base of the USDW and will serve to monitor geochemical and pressure changes in the sands underlying the base of USDW.

The project team plans to drill six additional USDW monitoring wells that will be completed in the base of the USDW to track pressure and temperature changes as well as geochemical changes in the aquifers across the AoR.

Figure TM-23 shows the proposed well network for groundwater and above-confining-zone/USDW monitoring wells.

Claimed as PBI

[redacted]

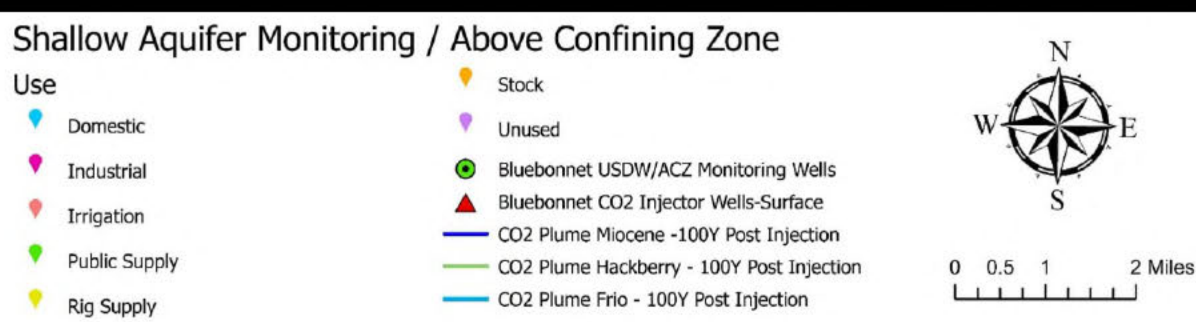

Figure TM-23: Proposed well network for groundwater and above-confining-zone/USDW monitoring.

6.1 Freshwater Shallow Aquifer Water Sampling and Testing

Claimed as PBI [redacted]

Candidate wells for sampling and testing were selected to cover an extensive area inside and around the defined AoR. Candidate wells were evaluated using publicly available data for installation age, use, depth, and relative location to the AoR and other monitoring wells. Field evaluations are planned for each proposed candidate well to assess mechanical integrity and accessibility. Selected wells will be identified and reported upon completion of field evaluations and access confirmation.

Shallow freshwater aquifer sampling and characterization is planned to commence a minimum of one year prior to the start of injection (Table TM-17). Detailed analytical suite for water samples is shown in Table TM-20, which includes characterization of physical and chemical compositions as well as analysis of dissolved gases and major isotope systems.

6.1.1 Monitoring Location and Frequency

Table TM-16 shows the proposed locations for sampling the freshwater shallow aquifer and Table TM-17 shows the frequencies proposed (40 CFR §146.90(d)(1) and 40 CFR §146.90(d)(2)).

Table TM-16: Location of the freshwater shallow water wells selected for sampling in the AoR.

Claimed as PBI [redacted]

[redacted]

Table TM-17: Sampling frequency for existing shallow freshwater wells (40 CFR §146.90(d)(1) and 40 CFR §146.90(d)(2)).

[redacted]

6.2 USDW/Above-Confining-Zone Monitoring Wells Water Sampling and Testing

Recent field investigations conducted onsite supported publicly available data that showed base USDW (<10,000 mg/l TDS) is in the [redacted] Aquifer, at depths [redacted] within the AoR. Bluebonnet USDW 01 was recently drilled and completed, and six additional USDW/ACZ monitoring wells are planned. USDW/ACZ monitoring wells will be sampled prior to injection to establish geochemical baselines, and during the injection period for water quality monitoring. The detailed analytical suite for water samples collected from USDW/ACZ monitoring wells is shown in Table TM-20 and is identical to the analytical suite used for the existing shallow freshwater wells. Pressure transducers will be deployed in USDW/ACZ monitoring wells for the high frequency of sampling fluid levels and temperature during injection required by 40 CFR §146.90(d).

6.2.1 Monitoring Location and Frequency for Water Sampling in Above-Confining-Zone/USDW Wells

Tables TM-18 and TM-19 show the location, monitoring interval, monitoring formation, and frequency of sampling for the above-confining-zone/USDW in the USDW monitoring wells Bluebonnet USDW 1, Bluebonnet USDW 2, Bluebonnet USDW 3, Bluebonnet USDW 4, Bluebonnet USDW 5, Bluebonnet USDW 6, and Bluebonnet USDW 7 (40 CFR §149.90(d)(1) and 40 CFR §149.90(d)(2)).

Table TM-18: Planned and drilled USDW/ACZ wells for water sampling and testing.

Claimed as PBI

[redacted]

Table TM-19: Location and frequency of the water sampling and testing in the USDW wells.

Claimed as PBI

[redacted]

6.3 Analytical Parameters for Water Testing in Groundwater and USDW/Above-Confining Zone

The Bluebonnet Sequestration Hub, LLC, has proposed an extensive water quality characterization program using natural tracers and unique fluid chemical characteristics to define reservoirs within the storage complex (in-zone reservoir, above-confining-zone/USDW, and freshwater aquifers). The sampling and analysis protocol will be used to establish baseline geochemical characteristics and differentiate changes in water quality between natural and anthropogenic influences.

The pre-injection baseline analytical suite will include detailed characterization of the chemical composition and major isotope systems. Following baseline characterization, a reduced analytical suite will be developed from baseline characterization results to focus on primary indicators of potential leakage. Isotopic compositions will likely not be routinely conducted during injection unless required for source attribution. Proposed changes to the analytical suite will be discussed with the UIC Director after the baseline data is collected and the routine testing protocol is finalized. Table TM-20 outlines the analytical suite for water quality samples collected from existing shallow freshwater wells and USDW/ACZ monitoring wells.

Field sampling methods and chain of custody procedures for water quality sampling are described in the QASP. All field and laboratory analytical tests will be performed by third-party certified laboratories and will follow applicable EPA or industry standard methods.

Table TM-20: Measured parameters and analytical methods summary for existing shallow freshwater wells and USDW/ACZ monitoring wells.

Claimed as PBI

[redacted]

6.4 Sampling Methods for Groundwater and Above-Confining-Zone/USDW Water Samples

Water sampling will be performed by personnel of a certified laboratory, following the specific methods approved by the EPA or other standards. Operators might audit the procedures and results of the selected laboratory with a third party to improve quality control.

Sampling procedures and technical specification of the tools are provided in the QASP.

6.5 Laboratory to be Used/Chain of Custody Procedures

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Sampling methods and chain of custody procedures are described in the QASP.

7.0 CO_2 Plume and Pressure-Front Tracking

7.1 Summary of Direct and Indirect Methods to Monitor CO_2 Plume and Pressure Front Development

Table TM-21 presents methods that Bluebonnet Sequestration Hub, LLC, will use to monitor the position of the CO_2 plume and development of the pressure front, including the activities, locations, and frequencies for the Bluebonnet Hub to comply with 40 CFR 146.90(g).

Table TM-21: Summary of methods for monitoring of CO_2 plume extension and pressure front.

Claimed as PBI

[redacted]

Claimed as PBI

[redacted]

7.2 Pressure and Temperature Measurement in the Reservoir

The use of pressure and temperature gauges and transducers for monitoring the CO_2 Injectors, monitoring wells, and water producer wells was explained in Sections 3 and 4 of this document.

Table TM-22: Summary of the sampling frequency for downhole pressure measurements in CO_2 injectors, in-zone monitoring wells, and water producer wells.

Claimed as PBI

[redacted]

7.3 Pulse Neutron/Saturation Log for CO_2 Plume Tracking

The implementation of PNL was described in Section 3 as well as in Section 5 of this document.

Table TM-23: Location and frequency of pulse neutron or saturation log implementation for CO_2 plume monitoring in CO_2 injector wells and in-zone monitoring wells.

[redacted]

7.4 Geophysical Methods for CO_2 Plume Extension Monitoring Details

A multi-scale approach will be employed for plume migration, CO_2 saturation monitoring, and potential leak detection with multiple seismic methods.

A baseline acquisition program consisting of surface 2D seismic, surface 3D seismic, and 3D VSP will be acquired prior to injection and is designed to calibrate the in-situ seismic response across multiple scales of investigation and model the predicted seismic response resulting from injection.

During the injection period, 3D VSP timelapse surveys will be acquired and analyzed annually, to provide high quality imaging and temporal resolution of plume movement proximal to injection wells Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, and Bluebonnet CCS 6, and monitoring wells Bluebonnet IZM FM1, Bluebonnet IZM FM2, and Bluebonnet IZM M1. Injection wells Bluebonnet CCS 5 and Bluebonnet CCS 7 are not planned for 3D VSP since they share well pads with Bluebonnet CCS 1 and Bluebonnet CCS 3, respectively. Monitoring well Encanto 01 will not encounter a modeled plume during injection period and is not included in the VSP program. Modeling indicates that the plume extents will be detectable from the injection well VSPs from the start of injection but will move beyond the radius of investigation by as early as year 5 of injection in the respective injection zone. Modeled plumes and VSP radius of investigation may be seen in Figure TM-24 for the [redacted] injection, Figure TM-25 for the [redacted] injection, and Figure TM-26 for the [redacted] injection.

A 2D timelapse surface seismic will be acquired and analyzed every five years during injection to monitor plume movement and saturation on an AoR-wide scale. The 2D timelapse monitoring will be repeated at the end of injection period and before site closure to demonstrate non-endangerment to USDW. If any aspect of the monitoring system indicates unfavorable plume movement at any point during the injection and post-injection periods, the project team will evaluate the need for additional geophysical surveys. The proposed 2D program is conceptual and will be refined as needed to suit monitoring needs.

The combined 3D VSP and 2D seismic program is designed to leverage the high-resolution of 3D VSP (particularly at the injection well) to understand the early plume development in detail, with the broader scope of the timelapse 2D to monitor for long-term movement.

[redacted]

Figure TM-24: Proposed geophysical monitoring program for the [redacted] injection.

Claimed as PBI

Figure TM-25: Proposed geophysical monitoring program for the Claimed as PBI Injection.

[redacted]

Figure TM-26 Proposed geophysical monitoring program for the [redacted] injection.

7.3.1 3D Surface Seismic Baseline Survey

A 3D surface seismic baseline survey will be acquired covering the AoR prior to injection. Notional acquisition parameters for the survey are specifically designed to provide full-fold coverage of the storage complex and strata above. The 3D baseline will be acquired with Vibroseis. The survey will utilize a high density of sources and receivers designed to increase the definition of shallow horizons above the confining zone. The 3D baseline has a large surface footprint encompassing the AoR and is designed to image from surface to basement on a broad frequency band. The outline of planned 3D is seen in Figure TM-27. The processing sequence will include state-of-the-art onshore preprocessing and depth imaging (pre-stack depth migration and velocity model building), followed by complete post-migration processing. Survey results will be used to update the structure, faulting (if any), and stratigraphy for input into an updated static model prior to injection.

Survey results will also be integrated with rock-physics studies to determine the expected timelapse 2D surface seismic response given predicted CO_2 saturation values.

Figure TM-28 and Figure TM-29 show examples of a modeled seismic response to CO_2 saturation performed using the [redacted] well. The model included the AoR document tested CO_2 saturations of 3%, 10%, and 20% within the Frio injection zone. No discernable seismic response was seen with 3% saturation, but 10% and 20% saturations resulted in detectable acoustic impedance signal deflection. Similarly, the [redacted] injection zone was modeled and a similar detectable alteration to seismic response is expected within the CO_2 plumes. This modeling indicates that acoustic monitoring techniques, such as the planned 2D seismic and 3D VSPs, are valid for the Bluebonnet Project.

Claimed as PBI

[redacted]

Figure TM-27: Planned baseline 3D seismic acquisition covering ~87 sq. miles of the Bluebonnet Project area.

Claimed as PBI [redacted]

Figure TM-28: Example modeled seismic response from CO_2 saturation Claimed as PBI [redacted]. The right-most track, ΔAI, demonstrates the acoustic impedance signal change from baseline due to 10% and 20% CO_2 saturation; the red shading between curves is the difference between the two test cases.

Claimed as PBI

[redacted]

Figure TM-29: Example modeled seismic response from CO_2 saturation for a pseudo well within the CCS 6 Miocene plume utilizing well data Claimed as PBI. As in the previous figure, the right-most track demonstrates acoustic impedance signal change due to CO_2 saturation. substitution

7.3.2 2D Surface Seismic Base Line and Timelapse Surveys

Approximately 48 miles of 2D surface seismic will be acquired prior to injection to establish a baseline (see Figure TM-24, Figure TM-25, and Figure TM-26). The 2D layout is designed to cover the extent of the AoR and beyond, with 2D lines positioned along low-traffic roads as much as possible to minimize disruption and allow for frequent and cost-effective repeat surveys. The 2D baseline design in Figures TM-24, Figure TM-25, and Figure TM-26 is conceptually based upon the modeled plume and AoR, and may change according to subsequent model refinements.

Once the baseline 2D program is acquired, the design will become static so that repeatability of the monitoring surveys is achieved. The 2D baseline will be acquired primarily with Vibroseis. The survey will use a high density of sources and receivers designed to increase the definition of shallow horizons above the confining zone. The baseline 2D data will be processed with state-of-the-art 2D preprocessing and pre-stack migration, followed by complete post-migration processing. Survey results will be integrated with rock-physics studies to determine the expected timelapse 2D surface seismic response, given predicted CO_2 saturation values.

Repeat 2D timelapse surveys will be acquired (using the same acquisition parameters as the 2D baseline) every five years during injection. The 2D timelapse monitoring will be repeated at the end of the injection period, and before site closure to demonstrate non-endangerment to the USDW. The 2D timelapse data will be processed with state-of-the-art joint parallel 2D timelapse preprocessing of the baseline, current, and previous monitor surveys, followed by pre-stack time migration and complete post-migration processing. Seismic amplitude changes observed between the current and previous surveys will be evaluated against the rock-physics model to determine changes in CO_2 saturations. These results will be checked against and integrated into the predictive models.

7.3.3 3D VSP baseline and timelapse surveys

The 3D baseline vertical seismic profile (VSP) surveys will be acquired at the injection wells, Bluebonnet CCS 1, Bluebonnet CCS 2, Bluebonnet CCS 3, and Bluebonnet CCS 6, and monitoring wells, Bluebonnet IZM FM1, Bluebonnet IZM FM2, and Bluebonnet M1, using permanent DAS fiber optic cables installed in the wellbores with Vibroseis surface sources. The VSP survey will use state-of-the-art VSP preprocessing and depth imaging (pre-stack depth migration), followed by post-migration processing. The imaging radius for the 3D VSP survey is assumed to be 0.5 mile (see Figures TM-24, Figure TM-25, and Figure TM-26). Within this radius, high-resolution seismic imaging (exceeding that of surface seismic) is expected, along with accurate time-depth control. Structure and stratigraphy from the 3D baseline VSP surveys will be evaluated and integrated into the geomodel. Survey results will be integrated with rock-physics studies to determine the expected timelapse VSP seismic response given predicted CO_2 saturation values.

Repeat timelapse VSP surveys will be acquired on an annual basis (using the same acquisition parameters as the VSP baseline surveys) until a time when the plume is determined to have moved beyond the imaging radius for a particular location. The timing of plume movement into or out of the 3D VSP radius of influence varies according to the injection or monitoring well location and timing of injection into respective storage zones and may be seen in Figure TM-24, Figure TM-

25, and Figure-26. The timelapse surveys will be processed using state-of-the-art joint parallel VSP timelapse preprocessing of baseline, current, and previous monitor surveys, followed by pre-stack depth migration and complete post migration processing. Seismic amplitude changes observed between the current and previous surveys will be evaluated against the rock-physics model to infer changes in CO_2 saturations. The high-resolution imaging and frequent (annual) acquisition of repeat VSP surveys are intended to provide detailed information on the early evolution of the CO_2 plume, including (but not limited to) the response to heterogeneity within the injection reservoir, the integrity of the confining zones, the rate of CO_2 movement, and the fidelity of the subsurface geomodel and resulting simulation.

8.0 Surface and Near Surface Monitoring

8.1 Soil Gas Monitoring and Isotopic Fingerprinting

The Bluebonnet Sequestration Hub, LLC, will install soil gas sample stations and collect soil gas samples. The project plans to characterize the soil gas samples using a methodology developed by Dr. Katherine Romanak from the Gulf Coast Carbon Center (GCCC) 40 CFR §146.90 (h).

The samples will be analyzed by a certified commercial laboratory to determine gas composition and isotopic signatures of carbon and hydrogen elements. This data will be used to inform process-based soil gas monitoring (Romanak 2012) to monitor for ecological stress and distinguish a leakage signal from natural vadose-zone CO_2, providing for attribution at the site. Modeling and additional geochemical data from the subsurface overburden will be used to define diagnostic parameters for attribution in soil gas.

Soil gas assessment will consist of characterization of soil gas CO_2, CH_4, O_2, and N_2 ratios within a process-based framework and, if thresholds are ever exceeded, collection of additional isotopic parameters for further assessment.

For a minimum of one year prior to injection, soil gas will be analyzed quarterly for CO_2, O_2, N_2, CH_4, C1-C5 hydrocarbons, δ13C and 14C of CO_2, and CH_4 and δD of CH_4 (Table TM-25). At the end of characterization period, protocols for detection of leakage signal will be tailored to site base data.

As part of the process for designing the soil gas stations and selecting locations, an airborne electromagnetic survey will be conducted over the AoR. The aerial electromagnetic (EM) data will be used to identify and map the extent of near-surface and surface salinization. This environmental determination will inform additional parameters for groundwater monitoring to complement soil gas as part of the near-surface monitoring strategy.

8.1.1 Sampling Location and Frequency for Soil Gas

For soil-gas sampling, 8 cm boreholes will be drilled with a hollow-stem auger by a contracted drilling company to a depth of 3 to 5 ft, depending on the thickness of the vadose zone. Sampling stations will be installed in permeable soil layers. Sample tubes will be comprised of 3 mm diameter stainless steel tubing fitted at one end with Geoprobe® 15 cm vapor implant screens.

Each screen will be fitted to the well tubing with Swagelok® gas-tight connectors. Sample depth intervals will be filled with a quartz-sand filter pack placed in the well annulus and isolated with bentonite. The bentonite will be used to backfill between depth intervals, assuring the integrity of each sampling interval. Each well will be sealed at the top with a no-flow Swagelok® quick-connect stem, which restricts the exchange of gas between the soil gas well and atmosphere. The soil-gas wells will be protected at the ground surface and capped. General information for each sampling station location will be recorded, including project name, borehole designation, borehole total depth, date and time of completion, borehole Geographic Positioning System (GPS) location information, and field personnel information. There may be minor changes to the procedures for soil gas sampling based on actual technical, operational, or safety considerations at the time the sampling occurs. See Figure TM-30 for a schematic of a gas sampling station.

Figure TM-31 shows the proposed location for the soil gas probes installation relative to the AoR and CO_2 injectors.

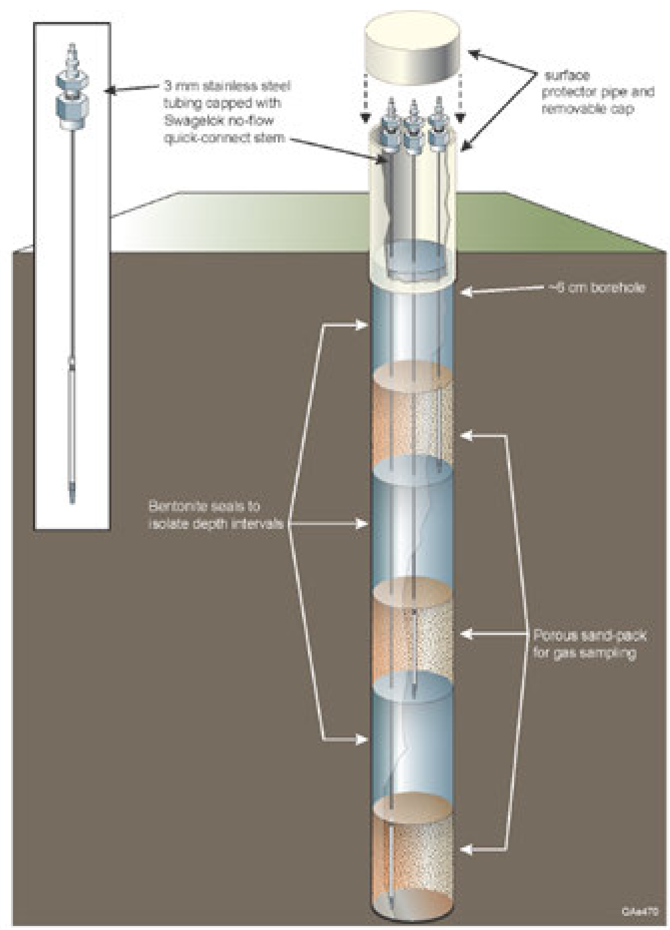

Figure 1. Schematic of gas sampling station construction showing individual gas wells set at different levels. Not to scale.

Figure TM-30: Schematic of soil gas sampling station.

Figure TM-31: Location of the proposed soil gas probes.

Table TM-24 shows the frequency proposed for soil gas sampling and testing.

Table TM-24: Soil gas sampling locations and frequencies.

Claimed as PBI

[redacted]

8.1.2 Parameters for Soil Gas Analysis

Table TM-25: Soil Gas Analysis Parameters.

Claimed as PBI

[redacted]

8.1.3 Sampling Soil Gas Analysis

Trained or specialized personnel will perform the sampling and the field operator will be trained in the process for taking samples and monitoring gas compositions with handheld devices as a routine operation. The samples are taken in specialized bags to collect the gas and will be sent to a third-party laboratory. Calibration of the field equipment will be performed per manufacturer protocol.

8.1.4 Laboratory to be Used/Chain of Custody and Analysis Procedures.

The samples will be analyzed by a third-party laboratory using standardized procedures for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Analytic methods and chain of custody procedures will follow the laboratory protocol.

8.2 CO_2 Sensors in Surface - Wellheads

The Bluebonnet Sequestration Hub, LLC, will install infrared gas detectors close to the wellheads of the injector, monitoring, and water production wells. These sensors will interface with the surveillance system to set alarms and identify potential leaks at the surface. The final selection of the technology will consider the integration of all the sensors and transducers in a unique surveillance system. Calibration and maintenance protocols will be based on the manufacturer specifications and performed by specialized professionals. Technical specifications for the CO_2 leak detector are provided in the QASP Plan.

Table TM-26: Atmospheric CO_2 sensor in wellhead.

Claimed as PBI

8.3 Airborne Electromagnetic Survey

The purpose of acquiring a baseline timelapse airborne time-domain electromagnetic (ATEM) survey is to identify and map the extent of surface and near-surface electrical resistivity distribution due to fluctuations of the water table and groundwater salinity. This data will be used along with soil gas and water sample data to provide a reference for environmental monitoring.

The airborne electromagnetic data will be acquired by a helicopter-mounted source and receiver at the ground clearance of approximately 30-40 m. The ATEM data acquisition systems vary depending on a provider, but can be summarized as one of the options shown in Figure TM-32. A large transmitter loop is towed by a helicopter and a receiver is above or inside it. The signal is transmitted in discrete time intervals. The transmitted signal induces electric current in the subsurface, and once the transmitter is turned off, the earth response is recorded by a receiver. This recorded signal is a function of electromagnetic properties of subsurface and time.

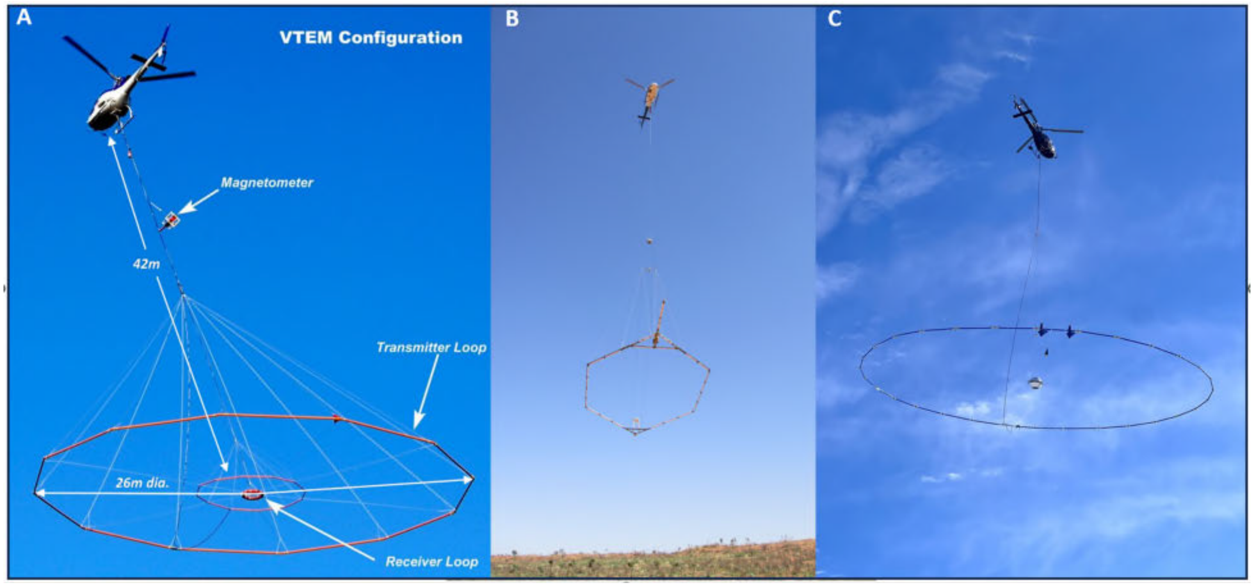

Figure TM-32: Different configurations of airborne time-domain electromagnetic systems: A. Geotech VTEM system, courtesy of Geotech (https://geotech.ca/papers/helicopter-electromagnetic-vtem-ztem-applications-gold-exploration); B. SkyTEM system, courtesy of SkyTEM; and C. HeliTEM system, courtesy of Xcalibur Multiphysics.

Claimed as PBI

[redacted]

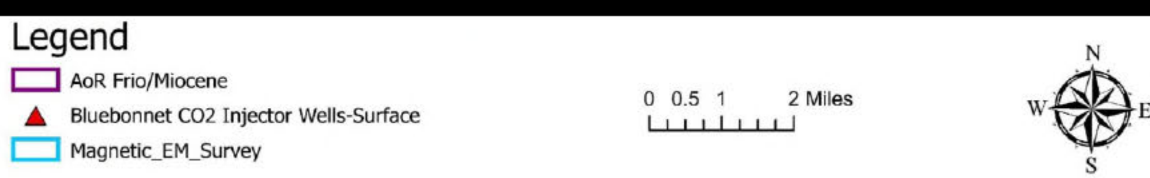

Figure TM-33: Location and the outline of the time-domain electromagnetic survey.

Note: Imagery courtesy of ESA contains modified Copernicus Sentinel data processed by Sentinel Hub.

Claimed as PBI [redacted] The data will be acquired at an average loop elevation of 30-40 m above the ground. Data lines will be spaced at regular intervals, depending on the data acquisition system, approximately 100-150 m apart.

The Bluebonnet Sequestration Hub, LLC, will contract a third-party to conduct the survey using a heliborne ATEM data acquisition system. Data acquisition systems can have various configurations depending on the acquisition provider. Regardless of system configuration, all types of heliborne electromagnetic data acquisition systems are equipped with a GPS electronic navigation system and laser and radar altimeters to ensure accurate positioning of the data. The data acquisition systems are also equipped with airborne video. The data will be processed by a contractor using a system-specific workflow.

Different data inversion techniques can be used to obtain electrical resistivity distribution in the subsurface. For this initial survey, a 1D data inversion will be utilized. In addition, the Bluebonnet Sequestration Hub, LLC, will provide data from nearby USDW wells to the third party to calibrate the inversion procedure.

Table TM-27: Airborne electromagnetic survey.

Claimed as PBI

[redacted]

8.4 Airborne Magnetic Survey

Airborne magnetics is a proven, established technology for detection of near-surface steel-cased wellbores and wellheads. The project team will use this technology to acquire heliborne magnetic data to identify and/or confirm locations of legacy wellbores or pipelines within the AoR.

8.4.1 Methodology to Acquire and Process Airborne Magnetic Survey.

Based on experience with in-house airborne magnetic surveys, the Bluebonnet Sequestration Hub, LLC, determined that magnetic anomalies resulting from steel-cased wells and wellheads would be detectable and resolvable by an airborne acquisition system, if the magnetometer height is 20 – 40 m above ground level and with line spacing not larger than 20 m. The Bluebonnet Sequestration Hub, LLC, will engage a third party to conduct the survey using a heliborne magnetic data acquisition system. In such a system, a magnetometer or an ensemble of magnetometers is attached or towed beneath a helicopter (Figure TM-34).

Data acquisition systems can have various configurations depending on the provider. However, regardless of the magnetic system configuration and provider, all types of heliborne magnetic data acquisition systems are equipped with GPS navigation system and laser and radar altimeters to ensure accurate positioning of the data. The data acquisition systems are also equipped with video recording capabilities, which will be used in data interpretation for a real-time visual aid in detecting magnetic anomaly sources.

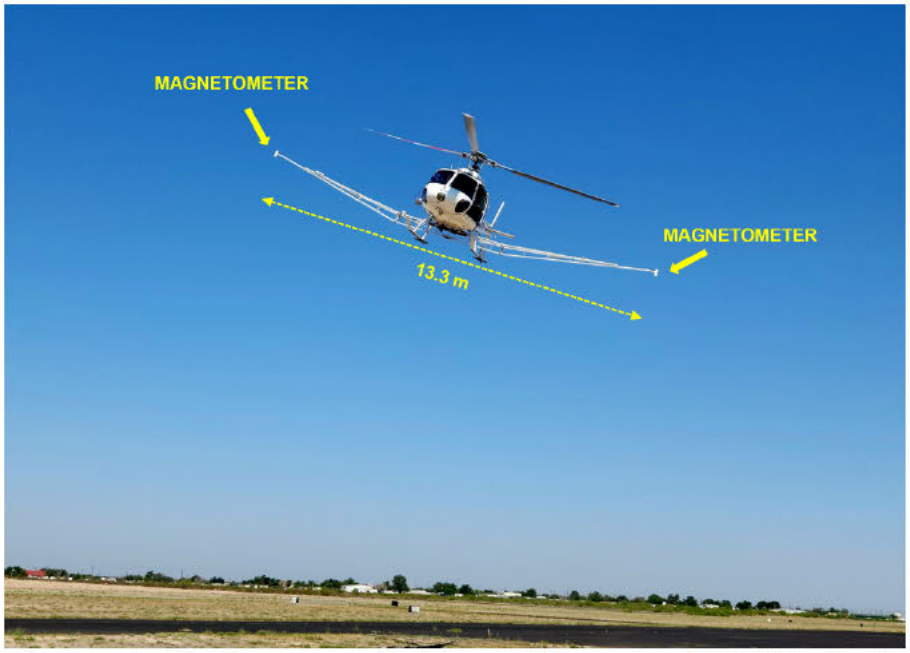

Figure TM-34: An example of heliborne magnetic data acquisition system (MIDAS by Xcalibur Inc.) used in a previous Oxy magnetic survey.

Claimed as PBI [redacted] The data will be acquired at an average elevation between 20-40 m above the ground with allowed departures in populated areas and if safety hazards are expected. Data lines will be spaced at a regular interval, depending on the data acquisition system, of 15-20 m apart and acquired in an approximately north-south orientation. Tie lines oriented perpendicular to the data lines will be spaced to 1:10 ratio to the data flight lines.

The data will be processed by a contractor using standard airborne magnetic data processing techniques that include removing spikes and dropouts, diurnal and lag corrections, removing International Geomagnetic Reference Field (IGRF), line leveling, and micro leveling. No processing of the video data will be required.

8.4.2 Methodology to Interpret Airborne Magnetic Survey.

The Bluebonnet Sequestration Hub, LLC, will perform advanced data processing in house that includes transformations of the anomalous magnetic field to reduce the effects of inclination, declination, and remanent magnetization. Examples of such transformations are reduction to pole, magnetic magnitude (or magnetic amplitude), and their derivatives such as total gradient of the magnetic anomaly and normalized source signal. All transformations are intended to focus the magnetic signal close to the location of a source, independent of magnetization orientation.

The processed magnetic data will be used to interpret locations of magnetic anomalies associated with surface and near-surface expression of steel-cased wells. These data will be combined with helicopter-acquired video and high-resolution imagery to interpret sources of magnetic anomalies. Data interpretation will take up to two months to complete.

In addition to the surface locations of steel-cased wellbores, the Bluebonnet Sequestration Hub, LLC, will be able to identify magnetic responses resulting from pipelines, electric power lines, and industrial activity. These features are located at the surface or near-surface and do not present a leakage hazard.

Table TM-28: Airborne magnetic survey.

Claimed as PBI

9.0 Induced Seismicity Monitoring

The Bluebonnet Sequestration Hub, LLC, will deploy a seismometer monitoring network to determine the locations, magnitudes, and focal mechanisms of the injection-induced seismic events when observed. This information will be used to address public concerns and identify features that may help to evaluate the plume and pressure front behavior.

9.1 Monitoring Location and Frequency for Induced Seismicity Measurement

The seismometer monitoring network contains 14 sensors strategically placed throughout the Bluebonnet Project area. The network is designed to provide a magnitude threshold equivalent to 0.0 on the Richter scale around the injection wells as well as along faults outside the AoR that are more likely to respond to reservoir pressure increases. Geomechanical modeling indicates that injection pressures will remain significantly below the threshold needed to initiate seismic movement along area faults, but those faults are still included in the seismometer monitoring network. The modeled seismometer network and modeled magnitude threshold in relation to the AoR is shown in Figure TM-35, and the coordinates of the seismometers are available in Table TM-30. The location of the sensors may change slightly at the time of installation.

Claimed as PBI [redacted]

Figure TM-35: Seismometer monitoring network with 14 sensors placed in relation to the CO_2 injector wells and the AoR.

Table TM-29: Seismicity monitoring tools and frequency.

Claimed as PBI [redacted]

Table TM-30: Location of the seismometers.

Claimed as PBI

[redacted]

9.2 Traffic Light System Protocol

The Richter Magnitude (or Local Magnitude) defines the local magnitude (ML) of an earthquake observed at a station to be ML = log A - log Ao (Δ), where A is the maximum amplitude in millimeters recorded on the Wood Anderson seismograph for an earthquake at epicentral distance of Δ km and Ao (Δ) is the maximum amplitude at Δ km for a standard earthquake; seismometers are calibrated so that consistent magnitudes are recorded from different seismographs. The local magnitude is thus a number characteristic of the earthquake, and is independent of the location of the recording station.

While the historical seismicity of the project area indicates no measured earthquakes in the area, the project intends to maintain a surface array for the duration of the project to ensure the safe operation of both the storage facility and adjacent infrastructure in the area. This seismic monitoring will be conducted with a surface array deployed to ensure detection of events above ML 2.0 with epicentral locations within 5.6 miles of any injection well covering an area of 100 square miles.

This areal coverage was determined by referencing the Texas Railroad Commission's historic designation of Seismic Response Areas (SRA). SRAs are areas determined by RRC seismologists for which consistent identification and seismic response approach will be implemented after the occurrence of seismic events with a magnitude of 3.5 or greater (TRRC, January 2022). For example, after a magnitude 5.4 earthquake occurred on December 19, 2022, the RRC designated the SRA with a radial area of 100 square miles (TRRC December 2022). Out of an abundance of caution, the seismic monitoring area for this project is designed to preemptively cover an area equivalent to the RRC's post-event SRA coverage.

If an event is recorded by either the local private array or public national array to have occurred within 5.6 miles of the injection well, the operator will implement its response plan, subject to detected earthquake magnitude limits defined below to eliminate or reduce the magnitude and/or frequency of seismic events.

- For events above ML 2.0 within 5.6 miles of the injection well, the project team will closely monitor seismic activity and may pause operations or continue operations at a reduced rate, should analysis indicate a causal relationship between injection operations and detected seismicity.

- For events above ML 4.0 within 5.6 miles of the injection well, the project team will reduce the injection rate by at least 50%. A detailed analysis will be conducted to determine if a causal relationship exists. Should a causal relationship be determined, a revised injection plan will be developed to reduce or eliminate operationally related seismicity. Such plans will be dependent on the pressures and seismicity observed and may include, but not be limited to:

    1. Pausing operations until reservoir pressures fall below a critical limit,
    2. Continuing operations at a reduced rate and/or below a revised maximum operation pressure.

- For events above ML 4.5 within 5.6 miles of the injection well, the Bluebonnet Hub operations team will stop injection as soon as safely practical. The project team will inspect surface infrastructure for damage that may have resulted from the earthquake. The project team will then immediately inform the regulator of seismic activity and inform them that operations have stopped pending a technical analysis.

    A detailed analysis will be conducted to determine if a causal relationship exists between injection operations and observed seismic activity. Should a causal relationship be determined, a revised injection plan will be developed to reduce or eliminate operationally related seismicity before resuming injection operations and will be discussed with the UIC Director. Such plans will be dependent on the pressures and seismicity observed, and may include, but not be limited to:

    1. Pausing operations until reservoir pressures fall below a critical limit,
    2. Continuing operations at a reduced rate and/or below a revised maximum operation pressure.

Claimed as PBI

[redacted]