Application No. *45079, 45080, 46169, 46170, and 46171*

TESTING AND MONITORING PLAN

Pelican Sequestration Project

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1.0 Facility Information

Facility name: Pelican Sequestration Project
Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5 wells

Facility contacts: Tyler Spoede, Project Manager
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Well location: Livingston Parish, Louisiana

Well Name	Longitude (NAD 27)	Latitude (NAD 27)	Longitude (NAD 83)	Latitude (NAD 83)
Pelican CCS 1	-90° 40' 55.76"	30° 35' 19.16"	-90° 40' 56.10"	30° 35' 19.83"
Pelican CCS 2	-90° 40' 58.83"	30° 34' 53.98"	-90° 40' 59.17"	30° 34' 54.66"
Pelican CCS 3	-90° 43' 50.13"	30° 36' 10.56"	-90° 43' 50.48"	30° 36' 11.24"
Pelican CCS 4	-90° 44' 29.72"	30° 36' 41.03"	-90° 44' 30.06"	30° 36' 41.70"
Pelican CCS 5	-90° 46' 30.21"	30° 37' 35.26"	-90° 46' 30.56"	30° 37' 35.93°

This Testing and Monitoring Plan describes how the Pelican Sequestration Hub, LLC, will monitor the Pelican Sequestration Project (the Project) site pursuant to LAC 43:XVII.3625. 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.

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.

Several components are integrated into the master monitoring plan for the Pelican Sequestration Hub, LLC, 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-1 shows a summary of the different methods proposed to monitor the proposed AoR, based on the qualitative risk assessment that was also used to inform the Emergency and Remedial Response Plan. The Testing and Monitoring plan is designed to monitor the CO_2 plume and pressure front from the five CO_2 injection wells proposed at the Pelican Sequestration Hub, LLC, Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5.

Table TM-1—Summary of Pelican Sequestration Project Testing and Monitoring Plan.

Description	Method	Location	Pre-Injection	Injection Period	Requirement
Operational testing and monitoring during injection.	Carbon Dioxide Stream Analysis.	Sampling point upstream CO_2 Injector wells		Quarterly	LAC 43:XVII.3625(A)(1)
	Measurement of injection pressure and temperature on surface - surface transducers	Flow line of CO_2 Injector wells		Continuously	LAC 43:XVII.3621(A)(6)(a) through (A)(6)(a)(iv) LAC 43:XVII.3625(A)(2) LAC 43:XVII.3627(A)(2) through (A)(2)(b)
	Measurement of casing-tubing annular pressure in surface- surface transducers	Wellhead of CO_2 Injector wells		Continuously	LAC 43:XVII.3621(A)(6)(a) through (A)(6)(a)(iv) LAC 43:XVII.3625(A)(2) LAC 43:XVII.3627(A)(2) through (A)(2)(b)
	Measurement of rate and injection volume in surface - Coriolis flow meter	Flow Line CO_2 Injector wells		Continuously	LAC 43:XVII.3621(A)(6)(a) through (A)(6)(a)(iv) LAC 43:XVII.3625(A)(2) LAC 43:XVII.3627(A)(2) through (A)(2)(b)
	Measurement of casing-tubing annular pressure above packer- donwhole gauges	Downhole CO_2 Injector wells		Continuously	LAC 43:XVII.3627(A)(2) through (A)(2)(b)
	Measurement of pressure and temperature at top of the perforations - downhole gauges	Downhole CO_2 Injector wells		Continuously	LAC 43:XVII.3621(A)(6)(a) through (A)(6)(a)(iv) LAC 43:XVII.3621(A)(1)
	Automatic surface shutoff devices.	Flow Line CO_2 Injector wells		Continuously	LAC 43:XVII.3621(A)(7)(a)(i)
	Corrosion coupons analysis.	Upstream CO_2 Injector wells		Quarterly	LAC 43:XVII.3625(A)(3)(a)
	Pressure Falloff test	CO_2 Injector Well	x	Every 5 years	LAC 43:XVII.3625(A)(6)
	Measurements of tubing pressure and temperature on surface- Surface transducers	Wellhead of MLR, ACZ, and USDW wells		Continuously	
	Measurement of downhole conditions - Downhole sensors and Gauges	Completion of MLR, ACZ, and USDW wells		Continuously	
	Visual inspections and handheld monitors (LEL, H_2S, CO_2)	General facilities	x	Weekly	
	Leak detection and repair (LDAR) program using Optical Gas Imaging cameras , handheld during inspections	General facilities		Quarterly	

Table TM-1—Summary of Pelican Sequestration Project Testing and Monitoring Plan (continued).

Mechanical Integrity testing.	Ultrasonic cement evaluation , CBL, VDL	CO_2 injector wells		x		LAC 43XVII.3617.(B)(1)(b)(ii) LAC 43XVII.3617.(B)(1)(c)(ii)
	Ultrasonic cement evaluation , CBL, VDL	MLR well		x		
	Ultrasonic casing inspection log	CO_2 injector wells		x	During workover or well maintenance	LAC 43XVII.3627(A)(3)
	Pulse neutron log	CO_2 injector wells		x	Annually	LAC 43XVII.3625(A)(5)
	DTS fiber alongside the casing to the top of the perforations	CO_2 injector wells		x	Continuously	LAC 43XVII.3627(A)(3) LAC 43XVII.3625(A)(5)
	DTS fiber alongside the casing to total depth.	MLR well		x	Continuously	
	Pulse neutron, temperature log,or electromagnetic log	MLR well		x	Every 5 years if there is not fiber on the wells or fiber fails .	
	Annular pressure test	CO_2 injector wells		x	After every WO; At least yearly	LAC 43:XVII.3627(A)(2) through (A)(2)(b)
	Annular pressure test	MLR well			Annually	
Ground water quality and geochemical monitoring	Water sampling and testing in Above confining zone well (ACZ) and USDW monitoring well	ACZ and USDW wells	Initial sample before injection.		Quarterly	LAC 43XVII.3625(A)(4)
	Water sampling and testing in legacy shallow fresh aquifer water wells.	Legacy water wells	Quarterly samples from selected wells for minimum 1 year before injection.		Quarterly first 3 years of injection. As needed based on other monitoring tools.	LAC 43XVII.3625(A)(4)
	Measurement of pressure and temperature downhole in ACZ well - Downhole Gauges	ACZ Monitoring well		x	Continuously	LAC 43XVII.3625(A)(7)(a)
	Isotopic fingerprinting of water in shallow aquifers, overburden, and injection targets	MLR, ACZ, USDW or CO2 injector wells	Initial samples before injection during well construction .			LAC 43XVII.3625(A)(4) LAC 43XVII.3625(A)(8)

Table TM-1—Summary of Pelican Sequestration Project Testing and Monitoring Plan (continued).

Carbon Dioxide Plume and Pressure Front Tracking	Timed lapsed Pulse Neutron Log for CO_2 plume tracking	CO_2 injector and MLR wells		x	Annually	LAC 43XVII.3625(A)(7)(a)
	Measurement of pressure and temperature in the reservoir - Downhole gauges	CO_2 injectors and MLR wells			Continuously	LAC 43XVII.3625(A)(7)(a)
	3D surface seismic survey - baseline	AoR		x	As required based on other monitoring techniques.	
	2D time lapsed surface seismic survey	AoR		x	Every 5 years	LAC 43XVII.3625(A)(7)(a)
	Gravity survey	AoR		x	As required based on other monitoring techniques.	
	3D time-lapsed VSP	CO2 injectors and MLR wells		x	Annually in CO2 injectors until plume extend beyond detection. Annually in MLR well starting year 5 until plume extends beyond detection or stabilizes.	
Near Surface & Surface	Airborne electromagnetic survey	AoR		x		
	Airborne Magnetic Survey	AoR		x		
	Process-based soil gas approach	AoR	Minimum(1) year characterization		Quarterly	LAC 43XVII.3625(A)(8)
	Isotopic fingerprinting of the soil gas	AoR	Minimum(1) year characterization		If required to compliment other methods	LAC 43XVII.3625(A)(4) LAC 43XVII.3625(A)(8)
	Atmospheric CO_2 sensors in wellhead.	CO_2 injector wells			Continuously	LAC 43XVII.3625(A)(8)
	Atmospheric CO_2 sensors in wellhead.	MLR well			Continuously	LAC 43XVII.3625(A)(8)
Induced Seismicity	Surface seismometers network	AoR	Minimum (1) year baseline		Continuously	

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 focus 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 that monitoring and storage performance objectives are achieved and new technologies are appropriately incorporated, per LAC 43:XVII.3625.

2.1 Quality Assurance Procedures

A quality assurance and surveillance plan (QASP) for testing and monitoring activities, required pursuant to LAC 43:XVII.3625(A)(11), is provided as a separate document in this permit.

2.2 Reporting Procedures

The Pelican Sequestration Hub, LLC, will report the results of all testing and monitoring activities to Louisiana Department of Conservation and Energy (C&E) in compliance with the requirements under LAC 43:XVII.3625.

3.0 Well Monitoring Network Design

The Pelican Sequestration Hub, LLC, plans to drill five CO_2 injection wells that will also act as in-zone monitoring wells as part of the field development plan for the Pelican Sequestration Project: Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5. The monitoring program proposed is designed based on the modeled CO_2 plume extension and propagation of the pressure front for the five wells injecting simultaneously, according to the AoR delineation process.

The proposed monitoring plan includes a layout of six in-zone (reservoir) monitoring wells, (Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, Pelican CCS 5, and Pelican MLR 004), one above-confining-zone well (Pelican ACZ 1), and two USDW wells (Pelican USDW 1 and Pelican USDW 2).

Figure TM-1 shows the location of the monitoring wells relative to the CO_2 injection wells and predicted CO_2 plume.

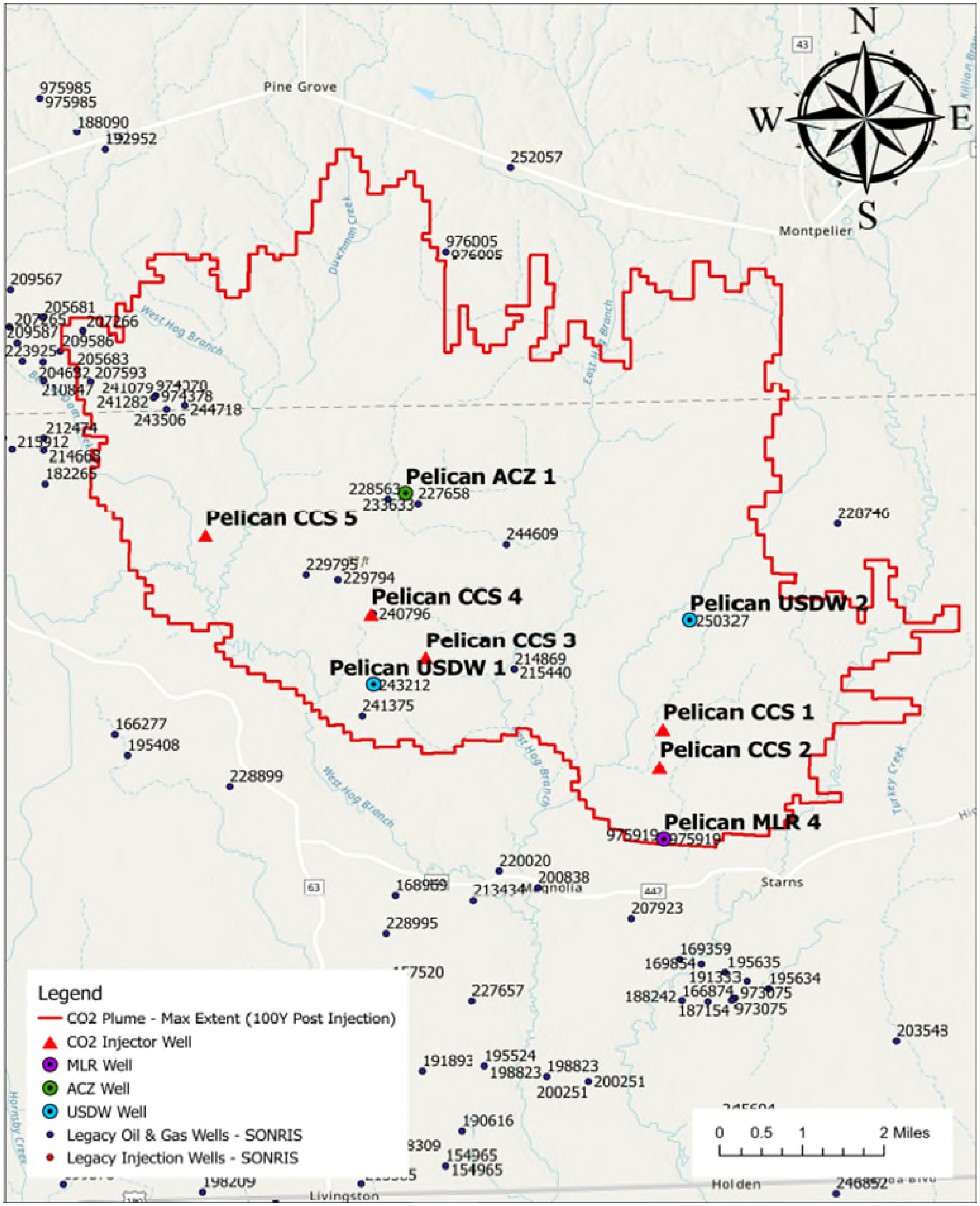

Figure TM-1—Location and layout of in-zone, above-zone and USDW monitoring wells relative to the CO_2 injector wells and the predicted CO_2 plume.

The well locations show the approximate position of the monitoring wells. The exact locations might vary slightly 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 Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5 are designed to maximize CO_2 injection rates and operate the site efficiently. These wells will also act as in-zone monitoring wells. 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 the surface to the top of the perforations for real-time tracking of 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 CO_2 plume in 3D and validate the CO_2 containment 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)

In-zone monitoring wells consist of the five CO_2 injection wells and the Pelican MLR 004. Figure TM-2 shows the location of the in-zone monitoring well relative to the CO_2 injection wells and development of the CO_2 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 risks. These areas included faults and a high density of legacy wells, amongst others.

The in-zone monitoring well locations and completions (Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, Pelican CCS 5, and Pelican MLR 004) allow for tracking the movement of the CO_2 plume through the application of 3D vertical seismic profile (VSP). 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.

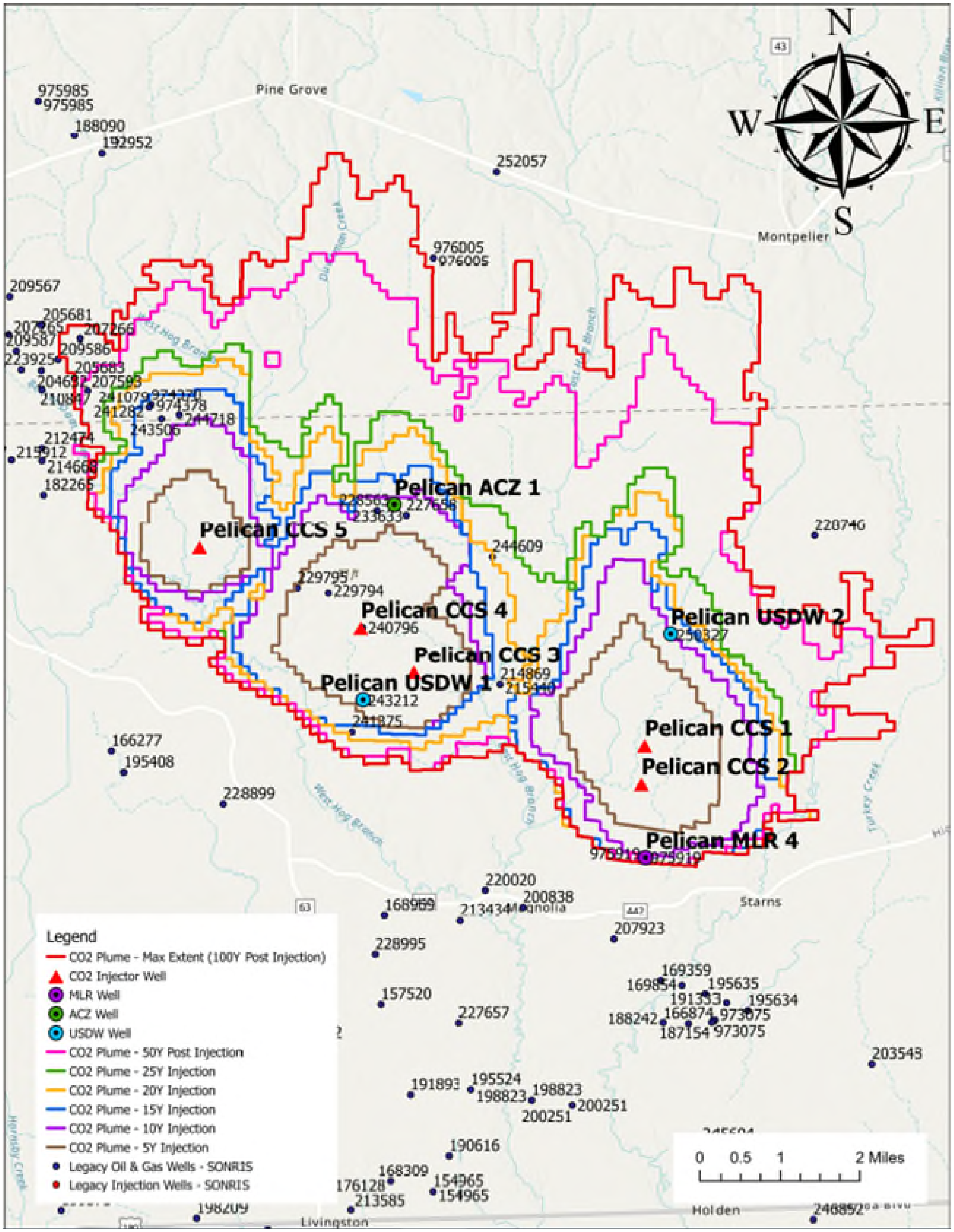

Figure TM-2—Location of the monitoring wells and CO_2 injector wells relative to the development of the CO_2 plume.

3.2.1 Pelican MLR 004

The Pelican MLR 004 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 south of the Pelican CCS 1 and Pelican 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 Frio and Anahuac Injection zones.

The proposed schematic for this well is presented in Figure TM-3.

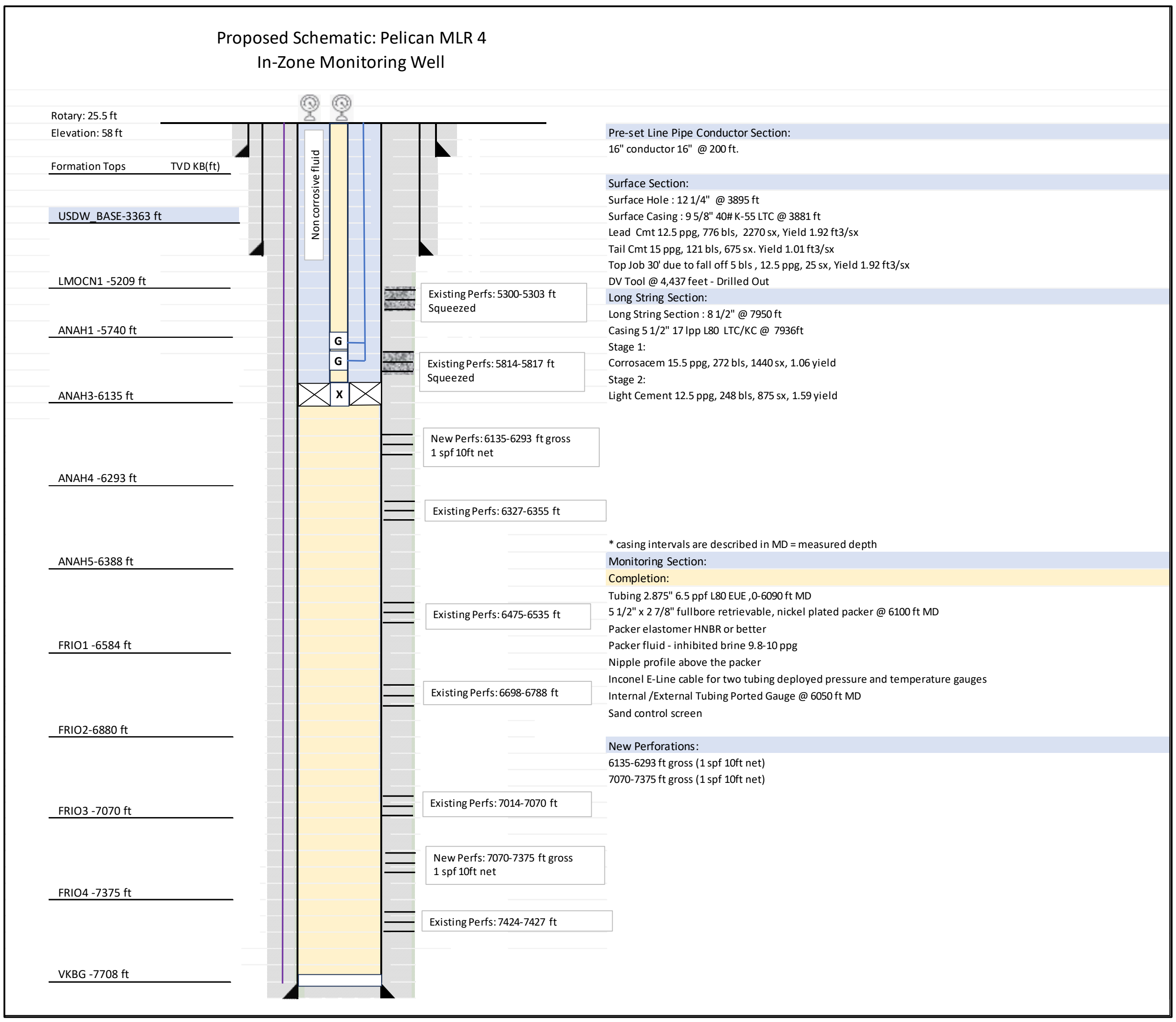

Figure TM-3—Well design and schematic for Pelican MLR 004.

3.3 Above-Confining-Zone and USDW Monitoring Wells

The project team plans to construct one above-confining-zone and two USDW monitoring wells across the AoR to closely monitor the above-confining zone and USDW by acquiring water samples. The above-confining-zone well will also monitor real time pressure and temperature. Pelican ACZ 1 will be drilled into the first permeable sand (LMOCN3) above the Anahuac (ANAH1), while Pelican USDW 1 and Pelican USDW 2 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-4 shows the proposed well schematic for Pelican ACZ 1. Figure TM-5 and Figure TM-6 show the proposed construction for the two USDW monitoring wells.

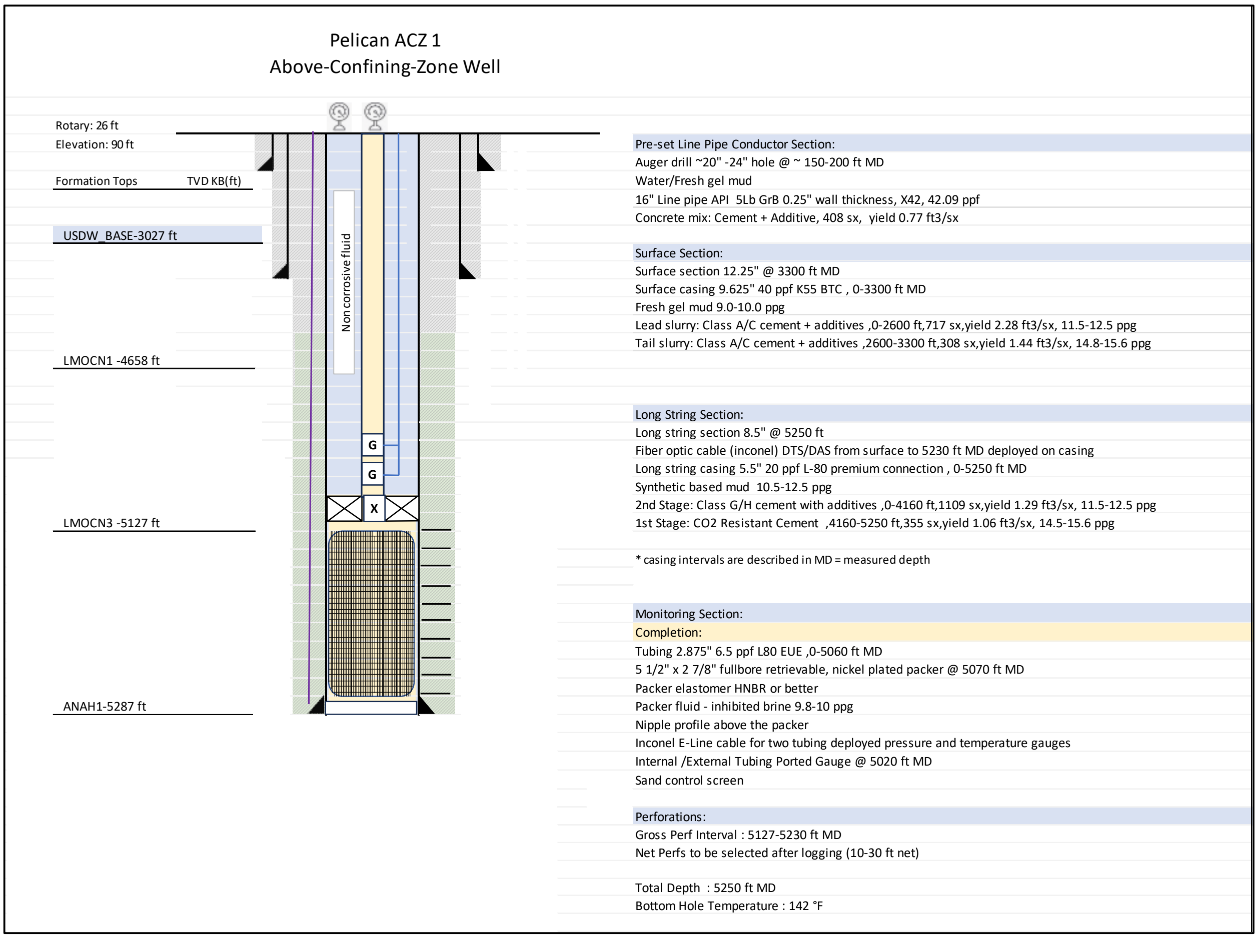

Figure TM-4—Well design and schematic for Pelican ACZ 1.

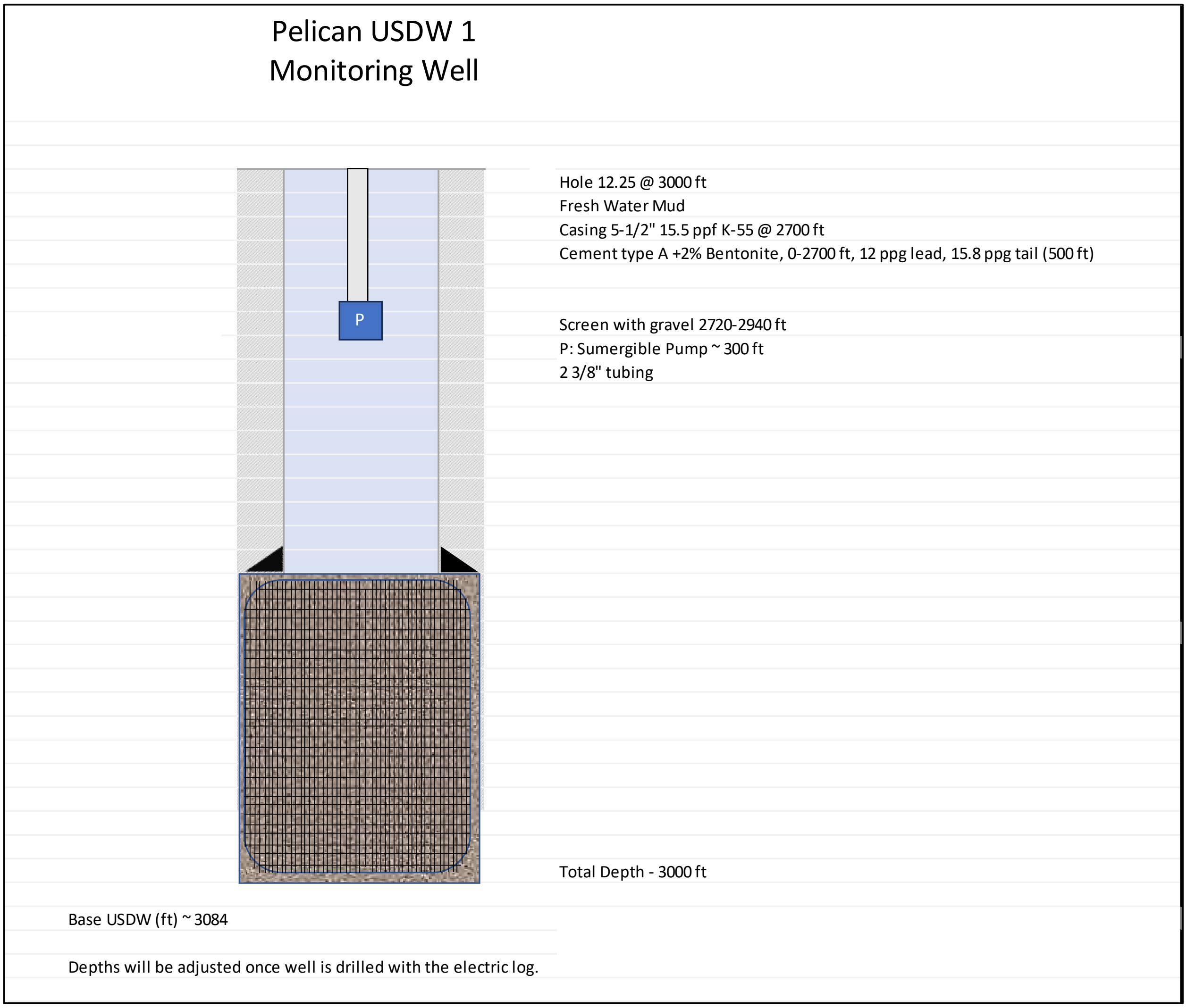

Figure TM-5—Well design and schematic for Pelican USDW 1.

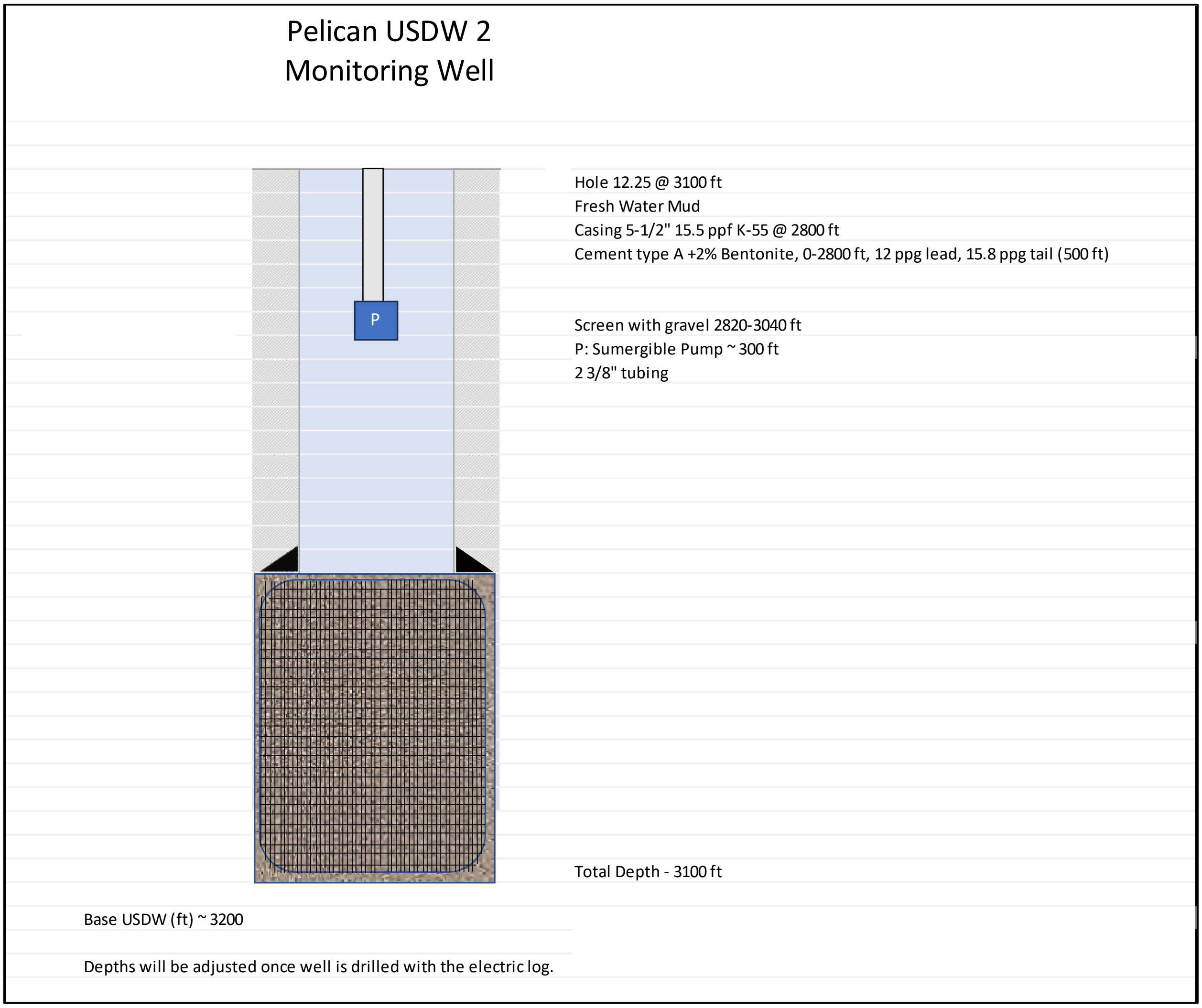

Figure TM-6—Well design and schematic for Pelican USDW 2.

4.0 Operational Testing and Monitoring During Injection

4.1 CO_2 Stream Analysis

Pursuant to LAC 43:XVII.3625(A)(1), during the operation period, Pelican 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-2, 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-2— CO_2 Stream specifications.

Component	Specification
CO_2 (% mol)	>97
Water (lbs/MMCF)	<4
Nitrogen (% mol)*	<3
Oxygen (ppm by wt)**	<30
Hydrogen (% mol)*	<1
SO_x (ppm by wt)	<1
NO_x (ppm by wt)	<1
Hydrogen Sulfide (ppmw)	<20
Hydrocarbons – Other than CH_4 (%mol)	<1
Carbon Monoxide (ppm by wt)	<4,250
Glycol (gal/MMSCF)	<0.3
Argon (%mol)*	<1
Sulfur (ppm by wt)	<35
Amines (ppmw)	<1
Alcohols (methanol + ethanol) (ppmv)	<250
CH_4 (% mol)*	<1.5
NH_3 (ppm by wt)	<50
Comp. Lube Oil (ppmw)	<50
Particulates (ppm by wt)	<1
Mercury (nanograms/liter)	<5

*Cumulative maximum of N_2, Ar, H_2 and CH_4 is 3 mol%
**O_2 specification will remain 30 ppm wt until such time as Sequestration Manager or Company demonstrates, using industry-standard equipment, the ability to accurately and consistently measure to a specification of <10ppm wt in accordance with standard industry practice and Customer's reasonable satisfaction. At such a time, the O_2 specification will become and remain 10 ppm wt.

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 Pelican Sequestration Hub, LLC will analyze the CO_2 for the constituents identified in Table TM-3 as a minimum (but not limited to) requirement.

Table TM-3—CO_2 stream analysis.

Component	Frequency	Analytical Method
CO_2 (% mol)	Quarterly	Gas chromatography
Water (lbs/MMCF)	Quarterly	Gas chromatography.
Nitrogen (% mol)	Quarterly	Gas chromatography
Oxygen (ppm)	Quarterly	Gas chromatography
Hydrogen (% mol)	Quarterly	Gas chromatography
SO_x (ppm)	Quarterly	Gas chromatography
NO_x (ppm)	Quarterly	Gas chromatography
Hydrogen Sulfide (ppm)	Quarterly	Gas chromatography
Hydrocarbons (%)	Quarterly	Gas chromatography
Carbon Monoxide (ppm)	Quarterly	Gas chromatography
Glycol (gal/MMSCF)	Quarterly	Gas chromatography
Ammonia (ppm by wt)	Quarterly	Gas chromatography
Argon (%mol)	Quarterly	Gas chromatography
Sulfur (ppm by wt)	Quarterly	Gas chromatography
Amines (ppmw)	Quarterly	Gas chromatography
Alcohols (ppmv)	Quarterly	Gas chromatography
Mercury (nanograms/liter)	Quarterly	Gas chromatography

Component	Frequency	Analytical Method
$\delta^{13}C$ of CO_2	During Characterization	Chromatographic separation with combustion and dual-inlet isotope ratio mass spectrometry (IRMS) or compound-specific analysis (GC-C-IRMS)
^{14}C of CO_2	During Characterization	Accelerator mass spectrometry (AMS)

The project team may deem it necessary to test additional elements to ensure the CO_2 delivered to the Pelican Sequestration Project 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 QASP.

4.2 Monitoring and Recording of Operating Parameters in CO_2 Injector Wells

The Pelican 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 injection wells (Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5) as required by LAC 43:XVII.3621(A)(6), 3627(A)(2) through (A)(2)(b), and 3625(A).

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 changes of pressure above the packer in the annulus in real time.

The Project team will add packer fluid to the casing-tubing annulus with a pump truck. 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 target 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.

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 [LAC 43:XVII.3621(A)(7)(a)]. The Pelican Sequestration Hub, LLC will perform the activities identified in Table TM-4 to monitor operational parameters. All monitoring will take place at the locations and frequencies shown in the table.

Table TM-4—Monitoring devices, locations, and frequencies for continuous monitoring during injection operations in the CO_2 injector wells.

Parameter	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Injection Pressure	Pressure Transducer	Flowline close to the wellhead	1 sec	15 sec
Injection Rate	Coriolis Meter	Flowline into the wellhead	1 min	1 hr
Injection Volume	Coriolis Meter	Flowline into the wellhead	15 sec	15 sec
Injection Temperature	Temperature Transducer	Flowline close to the wellhead	1 sec	15 sec
Surface Annular Pressure	Pressure Transducer	Wellhead Injector	1 sec	15 sec
Annulus Volume	Calibrates Surface Tank	Wellhead	Weekly	Daily
Downhole Annular Pressure and Temperature	Pressure Gauges, Temperature Sensor	Deployed in tubing ported to annular above packer	15 sec	30 sec
Distributed Temperature Profile	Fiber Optic + DTS Interrogator	Alongside long string	10 min	30 min
Downhole Injection Pressure and Temperature	Pressure Gauges, Temperature Sensor	Deployed in tubing ported to tubing above packer	15 sec	30 sec
Automatic Surface Shutoff Devices	Electric/Hydraulic Actuated Valve	Each exit of the flowline in the wellhead	n/a	n/a

4.2.2 Monitoring Devices Description and Technical Specifications

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

4.3 Corrosion Monitoring

To meet the requirements of LAC 43:XVII.3625(A)(3), the Pelican 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 Pelican 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 injection wells.

During well material selection, the Pelican Sequestration Hub, LLC, simulated the chemical reactions of the selected material, formation waters, and proposed CO_2 stream at downhole conditions. The project team will 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-5—Monitoring location and frequency of corrosion coupon testing.

Tool	Location	Pre-Injection	Injection
Corrosion coupons	Flowline CO_2 stream	n/a	Quarterly

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-6—Summary of methods to evaluate corrosion coupons.

Parameters	Analytical Method	Resolution Instruments	Precisions/Std Dev
Mass	NACE SP0775-2018-SC	0.05 mg	2%
Thickness	NACE SP0775-2018-SC	0.01 mm	± 0.05 mm

NACE SP0775-2018-SC—Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Oilfield Operations

Table TM-7—List of equipment with materials of construction.

Equipment Coupon	Material of Construction
Pipeline	Carbon Steel
Long String Casing – CO_2 Injector Well (above injection zone)	Carbon Steel L80
Long String Casing – CO_2 Injector Well (injection zone)	CRA 2507 min 80 ksi
Tubing (Internally Coated) – CO_2 Injector Well	Carbon Steel L80
Wellhead – CO_2 Injector Well (no CO_2 wetted areas)	Carbon Steel DD specification
Injection Tree and Tubing Hanger – CO_2 Injector Well	Sour Service - HH specifications
Packers – CO_2 Injector Well and In-Zone Monitoring Wells	Nickel-Plated
Long String Casing – In-Zone and Above-Confining-Zone Monitoring Wells	Carbon Steel L80
Tubing – In-Zone and Above-Confining-Zone Monitoring Wells	Carbon Steel L80
Wellhead and Tree – In-Zone and Above-Confining-Zone Monitoring Wells	Carbon Steel DD specification

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-8. 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-8—Monitoring locations and frequency of visual inspections and LDAR program.

Tool	Location	Pre-Injection	Injection
Leak detection and repair (LDAR) program using optical gas imaging cameras, handheld during inspections	Surface facilities and wellheads	n/a	Quarterly
Visual inspections and handheld monitors (LEL, H_2S, CO_2)	Surface facilities and wellheads	Before start of injection	Weekly

Notes:

1. Multiple inspections using OGI cameras will be performed during the startup of the well (first injection) after authorization to inject is received and will continue quarterly as minimum frequency during the injection period.

4.5 Pressure Falloff Testing in CO_2 Injector Wells

The Pelican 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 LAC 43:XVII.3625(A)(6).

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 Pelican 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-9 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.

Table TM-9—Monitoring locations and frequency of pressure and temperature measurement in in-zone monitoring wells.

Tool	Location	Pre-Injection	Injection	Min. Sampling Frequency	Min. Recording Frequency
Surface P/T transducers	Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, Pelican CCS 5, Pelican MLR 004	n/a	Continuously	1 sec	15 sec
Downhole P/T gauges	Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, Pelican CCS 5, Pelican MLR 004	n/a	Continuously	15 sec	30 min

In the event the downhole sensor fails before a planned well maintenance operation, the project team may install temporary pressure gauges in the well and limit the collection of data to one sample per day.

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

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

The project team also plans to install P/T gauges in the upper completion of the above-confining-zone and USDW monitoring wells to track changes in the downhole conditions.

4.7.1 Monitoring Location and Frequency

Table TM-10—Monitoring locations and frequency of pressure and temperature measurement for above-confining-zone and USDW monitoring wells.

Tool	Location	Pre-Injection	Injection	Min. Sampling Frequency	Min. Recording Frequency
Surface P/T transducers	Pelican ACZ 1 Pelican USDW 1 Pelican USDW 2	n/a	Continuously	1 sec	15 sec
Downhole P/T gauges	Pelican ACZ 1 Pelican USDW 1 Pelican USDW 2	n/a	Continuously	15 sec	30 min

5.0 Mechanical Integrity Testing

5.1 External Mechanical Integrity Testing

The Pelican 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 injection and in-zone monitoring wells [LAC 43:XVII.3617(B)(1)(b)(ii) and LAC 43:XVII.3617(B)(1)(c)(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 (LAC 43:XVII.3627(A)(3) and LAC 43:XVII.3625(A)(5)).

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 LAC 43:XVII.3627(A)(3) and LAC 43:XVII.3525(A)(5).

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.

In the future, the Pelican Sequestration Hub, LLC, may use a different test method for mechanical integrity testing by giving notice to the UIC Director.

The project team will run a PNL in the in-zone monitoring wells 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.

A fiber optic cable alongside the casing of the Pelican MLR 004 will allow tracking of mechanical integrity in real time as well as changes in reservoir conditions.

If the fiber optic cable fails in the Pelican MLR 004, 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

5.1.1 Testing Location and Frequency

Table TM-11 below provides a summary of the external mechanical integrity tools.

Table TM-11—Corrosion monitoring and surface leak detection tools.

Tool	Location	Pre-Injection	Injection
USIT, CBL, VDL	Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5 Pelican MLR 004	After long-string installation before completion	If required by future operations.
Pulse Neutron	Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5	After completion installation or before injection to set baseline.	Once a year.
Pulse Neutron	Pelican MLR 004	After completion installation or before injection to set baseline.	Annually to track CO_2 plume. Mechanical integrity will be monitored continuously with DTS fiber.
Electromagnetic casing inspection tool, Temperature Log or Pulse Neutron	Pelican MLR 004	After completion installation or before injection to set baseline.	Every 5 years or during planned well maintenance or workover activities
DTS survey	Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5	Before injection as baseline	Continuously
DTS survey	Pelican MLR 004	Before injection as baseline	Continuously

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 technologies readily available 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 that uses acoustic wave measurements. 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 wave attenuation 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-7 and Figure TM-8 show examples of CBL and VDL output.

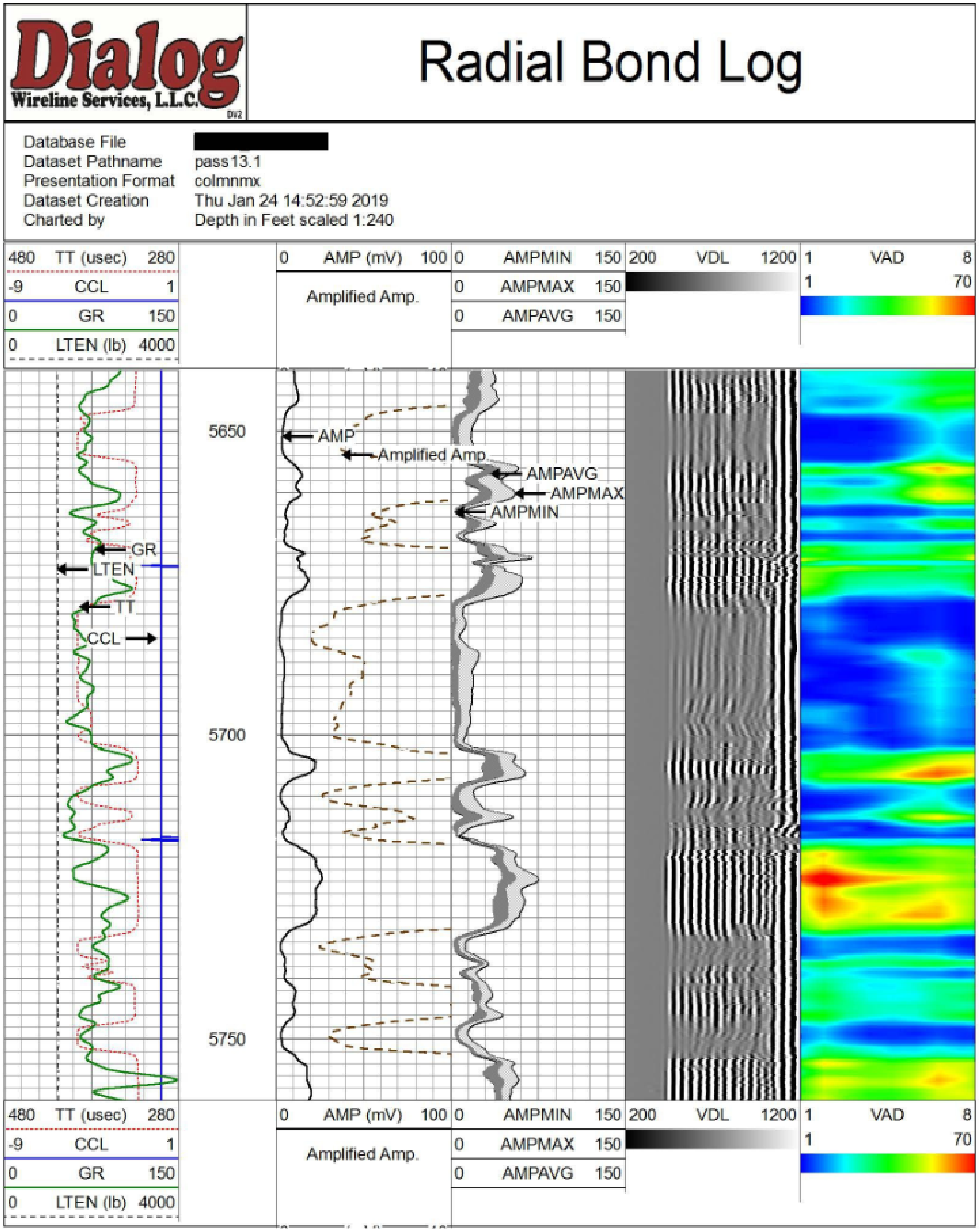

Figure TM-7—CBL and VDL example from dialog wireline services web page.

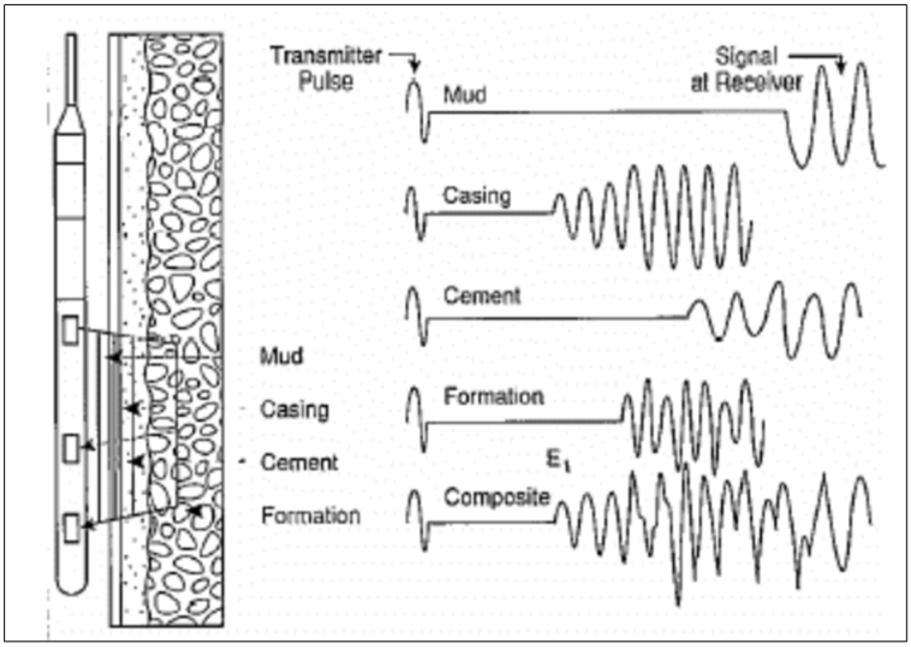

Figure TM-8—Signal received by CBL-VDL.

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 by measuring 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 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 rapid total thickness calculation that determines 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 the casing (see example in Figure TM-9). 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 spinner flowmeters. Temperature logs are run continuously, typically at cable speeds of 20 to 30 ft/min. (A. Daniel Hill 2021).

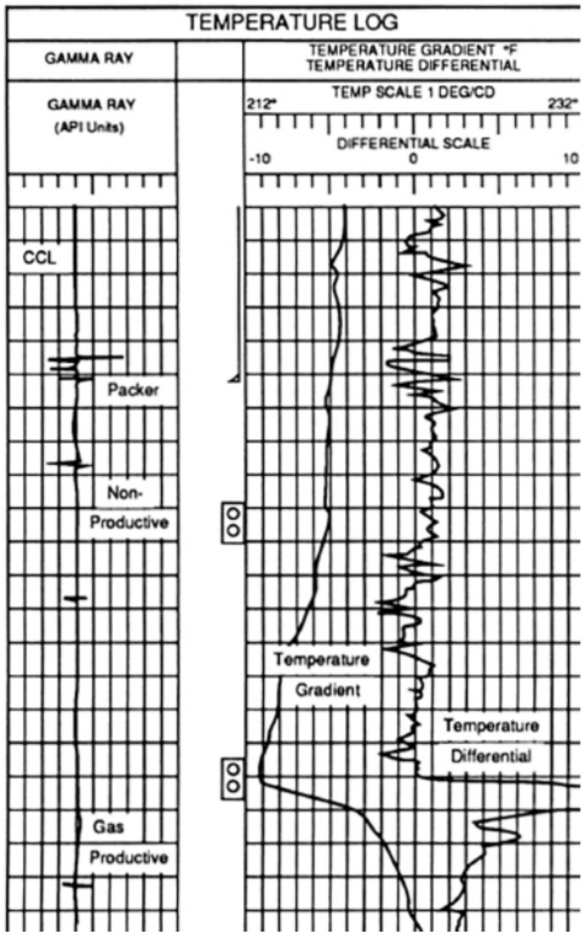

Figure TM-9—Example of temperature log output.

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 Pelican Sequestration Hub, LLC, will perform an annular pressure test in the CO_2 injection wells and in the in-zone monitoring wells to demonstrate internal mechanical integrity, according to LAC 43:XVII.3627(A)(2) through (A)(2)(b).

Annular pressure testing is used to validate mechanical integrity. Tests will be performed according to the frequency presented in Table TM-12.

Table TM-12—Annular pressure testing frequency.

Tool	Location	Pre-Injection	Injection
Annular Pressure Test	Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5	After long-string installation before completion	After every well maintenance operation or at least once every 12 months in accordance with LAC 43:XVII.3627 (A)(2)(a)(ii)
Annular Pressure Test	Pelican MLR 004	After long-string installation before completion	Annually

If the additional monitoring systems indicate a potential mechanical integrity issue, the Pelican 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 (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, prepare a plan to repair the well and discuss it with the UIC 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 Pelican Sequestration Hub, LLC, will monitor groundwater quality and geochemical changes above confining zones during the operation period to meet the requirements of LAC 43:XVII.3625(A)(3). Figure TM-10 shows the proposed well network for groundwater and above-confining-zone/USDW monitoring wells.

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 gravity or 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.

Examples of associated above confining zone and USDW monitoring include installation of DTS fiber optics along injector wells will be utilized to monitor for potential vertical fluid movement above confining zones and the USDW. Pelican Sequestration Hub also plans to recomplete stratigraphic test well MLR 004 as an In Zone monitoring well. The In Zone monitoring wells also serves as above confining zone and USDW monitoring wells when conducting pulse activated neutron logging and indirect methods such as 2D time lapsed surface seismic or gravity surveys.

Pelican Sequestration Hub, LLC, selected seventeen (17) legacy water supply wells distributed around the AoR to sample and characterize local groundwater resources. Candidate wells for water sampling are completed in the Chicot aquifer, and water use varies from domestic, industrial and public supply.

The Pelican Sequestration project will drill and complete one (1) Above Confining Zone monitoring wells and two (2) USDW monitoring wells. USDW monitoring wells will target the lower section of the USDW in the first permeable zones overlying confining shales. Fluid samples will be collected from all monitoring wells to characterize and monitor pre- and post-injection fluid geochemistry above the upper confining zone.

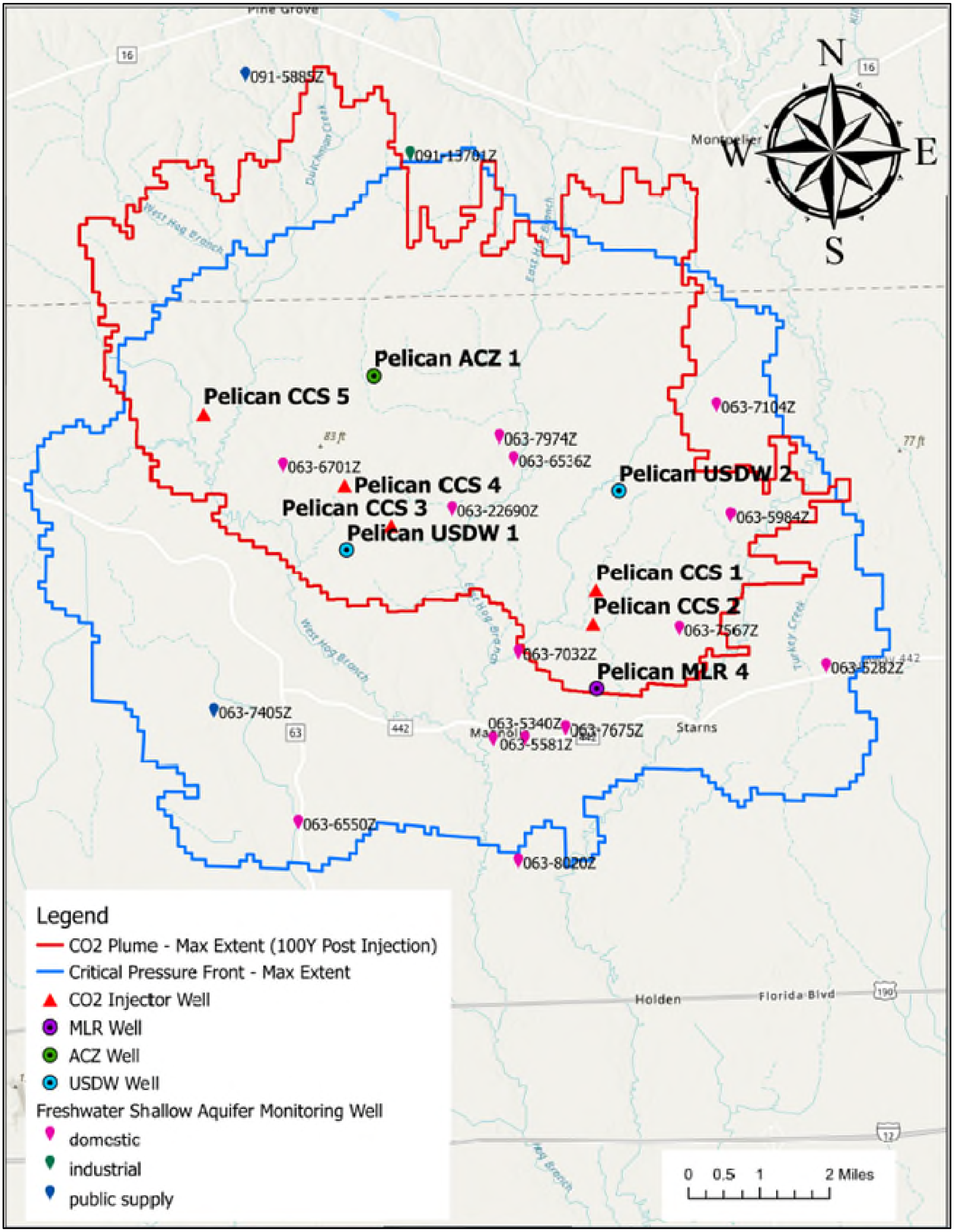

Figure TM-10—Proposed well network for groundwater, above-confining-zone, and USDW monitoring wells.

6.1 Freshwater Shallow Aquifer Water Sampling and Testing

Groundwater production for drinking and municipal use in Livingston and St. Helena Parishes is primarily sourced from shallow wells completed in the Chicot equivalent aquifer. Therefore, proposed locations for sampling and testing the shallow freshwater (< 1,000 mg/l TDS) aquifer utilize existing wells completed in the Chicot equivalent aquifer (Table TM-13).

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-14). Detailed analytical suite for water samples is shown in Table TM-17, 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-13 shows the proposed locations for sampling the freshwater shallow aquifer and Table TM-14 shows the frequencies proposed (LAC 43:XVII.3625(A)(4)(a) and (b)).

Table TM-13—Location of the freshwater shallow water wells selected for sampling in the AoR.

Well ID	Parish	Use	Latitude	Longitude	Depth (ft)	Aquifer
091-5885Z	St Helena	public supply	90°41'42.00"N	90°45'48.00"W	130	Chicot equivalent
091-13701Z	St Helena	industrial	30°40'40.98"N	90°43'27.98"W	200	Chicot equivalent
063-8020Z	Livingston	domestic	30°31'54.00"N	90°42'8.00"W	180	Chicot equivalent
063-5282Z	Livingston	domestic	30°34'14.00"N	90°37'40.00"W	200	Chicot equivalent
063-5984Z	Livingston	domestic	30°36'8.00"N	90°38'59.00"W	220	Chicot equivalent
063-7567Z	Livingston	domestic	30°34'44.00"N	90°39'45.00"W	160	Chicot equivalent
063-7675Z	Livingston	domestic	30°33'32.00"N	90°41'25.00"W	150	Chicot equivalent
063-6701Z	Livingston	domestic	30°36'52.00"N	90°45'23.00"W	230	Chicot equivalent
063-7405Z	Livingston	public supply	30°33'50.00"N	90°46'27.00"W	200	Chicot equivalent
063-6550Z	Livingston	domestic	30°32'26.00"N	90°45'16.00"W	130	Chicot equivalent
063-5581Z	Livingston	domestic	30°33'25.00"N	90°42'27.00"W	190	Chicot equivalent
063-5340Z	Livingston	domestic	30°33'25.00"N	90°41'60.00"W	170	Chicot equivalent
063-7032Z	Livingston	domestic	30°34'29.00"N	90°42'4.00"W	155	Chicot equivalent
063-7104Z	Livingston	domestic	30°37'29.00"N	90°39'9.00"W	80	Chicot equivalent
063-7974Z	Livingston	domestic	30°37'9.00"N	90°42'17.00"W	190	Chicot equivalent
063-6536Z	Livingston	domestic	30°36'53.00"N	90°42'5.00"W	205	Chicot equivalent
063-22690Z	Livingston	domestic	30°36'16.98"N	90°42'58.98"W	120	Chicot equivalent

Table TM-14—Sampling frequency for existing shallow freshwater wells (LAC 43:XVII.3625(A)(4)(a) and (b)).

Monitoring Location(s)	Monitoring Activity	Target Formation	Pre-Injection	Injection Period
17 shallow water wells distributed in the AoR.	Fresh water sampling and analysis.		Baseline minimum (1) year before injection, (1) sample every quarter.	First sample 3 months after start of injection and quarterly after that for year 1 to year 3.

6.2 USDW Monitoring Wells Water Sampling and Testing

Table TM-15 and Table TM-16 show the location, monitored formation, and sampling frequency for USDW monitoring wells Pelican USDW 1 and Pelican USDW 2 (LAC 43:XVII.3625(A)(4)(a) and (b)).

Two (2) USDW monitoring wells will be drilled to the base of the Jasper Aquifer (Table TM-15). Specific completion intervals at each USDW well will be determined using onsite drilling and logging data and interpreted base USDW from offset logs. Site-specific base USDW will be confirmed from field investigations conducted during drilling and completion of USDW wells, including fluid sampling and analysis for gravimetric TDS.

USDW monitoring wells will be sampled prior to injection to establish geochemical baselines, and during the injection period for water quality monitoring (Table TM-16). USDW sampling will follow USGS methods and utilize an ESP. Detailed analytical suite for water samples collected from USDW monitoring wells is shown in Table TM-17 and is identical to the analytical suite used for the existing shallow freshwater wells.

Table TM-15—Planned and drilled USDW wells for water sampling and testing.

Well Name	Latitude (NAD 27)	Longitude (NAD 27)	Elevation (ft)	Status	Approx. Measured Depth (ft)	Target Aquifer
Pelican USDW 1	30° 35' 52.64" N	090° 44' 29.05" W	73	To be Drilled	3,100	Jasper equivalent
Pelican USDW 2	30° 36' 32.55" N	090° 40' 34.10" W	74	To be Drilled	3,200	Jasper equivalent

Table TM-16—Location and frequency of the water sampling and testing in the USDW wells.

Monitoring Location(s)	Monitoring Activity	Pre-Injection	Injection Period
Pelican USDW 1 Pelican USDW 2	Water Sampling	Baseline sample acquired after the well is drilled and completed.	First samples 3 months after start of injection and quarterly after that

6.3 Above Confining Zone Well water sampling and testing

Table TM-17 and **Table TM-18** show the location, interval, formation, and sampling frequency for the above-confining-zone monitoring well Pelican ACZ 1 (LAC 43:XVII.3625(A)(4)(a) and (b)).

One ACZ monitoring well will be drilled and completed in the first permeable sand (LMOCN3) above the Anahuac (ANAH1) (Table TM-17). Specific completion intervals will be determined using onsite drilling and logging data and interpreted offset logs.

Pressure transducers will be deployed in Pelican ACZ 1 monitoring well for high frequency monitoring of fluid levels and temperature during injection required by LAC 43:XVII.3625(A). Depending upon timing of scheduled maintenance, permanent downhole gauge failures may result in setting temporary downhole gauges with wireline.

The ACZ monitoring well will be sampled prior to injection to establish geochemical baselines, and during the injection period for water quality monitoring (Table TM-18). The ACZ monitoring well will be equipped with a U-Tube sampling system to facilitate collection of fluid samples, described in further detail in the QASP. Alternatively, in the case that a U-Tube line is not functional, ACZ monitoring wells will be sampling with downhole PVT sampling canisters. The detailed analytical suite for water samples collected from ACZ monitoring wells is shown in Table TM-19 and is identical to the analytical suite used for the USDW monitoring wells.

Table TM-17—Location of Pelican ACZ 01.

Well Name	Latitude (NAD 27)	Longitude (NAD 27)	Elevation (ft)	Status	Measured Depth (ft)	Target Formation
Pelican ACZ 1	30° 38' 01.12" N	090° 44' 02.46" W	90	Planned	5,250	LMOCN3

Table TM-18—Location and Frequency of Water Sampling and Testing in Above Confining Zone wells.

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
Pelican ACZ 1	Pressure and temperature measurement with downhole gauges	LMOCN3	Baseline. Data acquired during installation of the completion	Continuously
Pelican ACZ 1	Water sampling and testing	LMOCN3	Baseline. Data acquired during installation of the completion	First samples 3 months after start of injection and quarterly after that

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

The Pelican 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, ACZ, 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-19 outlines the analytical suite for water quality samples collected from existing shallow freshwater wells, USDW, and 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-19—Measured parameters and analytical methods summary for existing shallow freshwater wells and USDW/ACZ monitoring wells.

Parameter	Analytical Method
Cations: Al, Ba, B, Cd, Ca, Cu, Cr, Fe, Pb, Li, Mg, Mn, Ni, P, K, Si, Na Sr, Zn	ICP-OES, EPA Method 6010d, ICP-MS Method 200.8 or equivalent
Other Metals: As, U, Co, Se, Pb, Mo, V	ICP-MS Method 200.8 or equivalent
Mercury	EPA 245.7 CVAA, or equivalent

Parameter	Analytical Method
Anions: Cl^-, Br^-, F^-, SO_4^{2-}, PO_4^{3-}, NO_3^-, NO_2^-	Ion Chromatography, EPA Method 300.1 or similar
Alkalinity (carbonate, bicarbonate and hydroxide)	Titration, ASTM D3875.
Gravimetric Total Dissolved Solids (TDS)	Gravimetric Method Standard Methods 2540C, ASTM D5907 or equivalent
Water Density (specific gravity)	ASTM D5057, ASTM D4052 or equivalent
Stable Carbon Isotopes $\delta^{13}C$ of DIC in Water	Gas Bench and CF-IRMS for $\delta^{13}C$
Radiocarbon ^{14}C of DIC in Water	AMS for ^{14}C
Hydrogen and Oxygen Isotopes δ^2H and $\delta^{18}O$ of Water	CRDS H_2O
Carbon and Hydrogen Isotopes (^{14}C, $\delta^{13}C$, δ^2H) of Dissolved Methane in Water	Offline Prep & Dual Inlet IRMS for $\delta^{13}C$; AMS for ^{14}C
Compositional Analysis of Dissolved Gas in Water (including N_2, CO_2, O_2, Ar, H_2, He, CH_4, C_2H_6, C_3H_8, iC_4H10, nC_4H_{10}, iC_5H_{12}, nC_5H_{12}, and C_{6+})	GC, ASTM 1945D, RSK 175 or equivalent
pH	ASTM D1293, EPA 150.23 or equivalent
Temperature	ASTM 2550
Conductivity	ASTMD1125
Conductivity (field)	EPA 120.1
ICP-OES = inductively coupled plasma optic emission spectrometry; ICP-MS = inductively coupled plasma mass spectrometry; GC/MS = gas chromatography–mass spectrometry; AMS = accelerator mass spectrometry; CRDS = cavity ring down spectrometry; IRMS = isotope ratio mass spectrometry; CVAA: Cold Vapor Atomic Absorption;	

6.5 Sampling Methods for Groundwater, Above-Confining-Zone, and USDW Water Samples

Fluid sampling will be performed by qualified field personnel with oversight from licensed geologists or engineers. Appropriate fluid sampling procedures (e.g., USGS, USEPA) or industry best practices will be applied to ensure sample integrity and chain of custody are maintained. Sampling procedures and technical specification of tools are provided in the QASP. Operators may audit procedures and results of selected laboratories with a third party to improve quality control.

6.6 Laboratory to be Used/Chain of Custody Procedures

Fluid samples will be analyzed by third-party certified laboratories using applicable laboratory analytical methods (e.g., USEPA, ASTM) and best industry practices for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Quality inspections will be periodically conducted based on adherence to appropriate applicable laboratory analytical methods outlined in the analytical suite. Sampling methods and chain of custody procedures are further 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-20 presents methods that Pelican 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 Pelican Sequestration Project to comply with LAC 43:XVII.3625(A)(7).

Table TM-20—Summary of methods for monitoring CO_2 plume extension and pressure front.

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
AoR	2D Time-lapsed surface seismic or gravity surveys	Reservoir, seal, and overburden	Baseline acquisition before injection	Every 5 years
AoR	3D Surface seismic survey	Reservoir, seal, and overburden	Baseline acquisition before injection	n/a
Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5 Pelican MLR 004	3D VSP time lapsed survey	Reservoir, seal, and overburden	Baseline acquisition before injection	Annually in CO_2 injectors until plume extends beyond detection. Annually in MLR well starting year 5 until plume extends beyond detection or stabilizes
Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5	Pulse Neutron Log	Reservoir, seal, and overburden	Baseline will be acquired once the wells are drilled	Annually
Pelican MLR 004	Pulse Neutron Log	Reservoir, seal, and overburden	Baseline will be acquired once the wells are drilled	Annually
Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5 Pelican MLR 004	Downhole gauges; pressure and temperature.	Reservoir	Baseline line will be acquired during completion of the wells	Continuously

7.2 Pressure and Temperature Measurement in the Reservoir

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

Table TM-21—Summary of the sampling frequency for downhole pressure measurements in CO_2 injectors and in-zone monitoring wells

Location	Device(s)	Location	Min. Sampling Frequency	Min. Recording Frequency
Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5	Pressure and temperature gauges	Downhole deployment on tubing	1 sec	15 sec
Pelican MLR 004	Pressure and temperature gauges	Downhole deployment on tubing	15 sec	30 min

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-22—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.

Tool	Location	Pre-Injection	Injection
Pulse Neutron	Pelican CCS 1 Pelican CCS 2 Pelican CCS 3 Pelican CCS 4 Pelican CCS 5	After completion installation or before injection to set baseline.	Once a year
Pulse Neutron	Pelican MLR 004	After completion installation or before injection to set baseline.	Annually to track CO_2 Plume

7.4 Geophysical Methods for CO_2 Plume Extension Monitoring Details

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

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

During the injection period, 3D VSP timelapse surveys will be acquired and analyzed annually as needed, to provide high quality imaging and temporal resolution of plume movement proximal to injection wells Pelican CCS 1, Pelican CCS 2, Pelican CCS 3, Pelican CCS 4, and Pelican CCS 5, and monitoring well Pelican MLR 004. 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 within year 5 of injection in the respective injection zone.

A timelapse 2D surface seismic or gravity survey will be acquired and analyzed every five years during injection to monitor plume movement and saturation. The 2D seismic or gravity 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 and gravity program is conceptual and will be refined as needed to suit monitoring needs.

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

7.3.1 3D Surface Seismic Baseline Survey

A 3D surface seismic baseline survey will be acquired covering the maximum plume extension prior to injection as seen in Figure TM-10. Notional acquisition parameters for the survey are specifically designed to provide full-fold coverage of the storage complex and strata above. The 3D baseline is planning to be acquired with Vibroseis or dynamite. The survey will use 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 3D outline and is designed to image from surface to basement on a broad frequency band. 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, 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 and gravity response given predicted CO_2 saturation values.

7.3.2 2D Surface Seismic and Gravity Base Line and Timelapse Surveys

2D surface seismic and microgravity (gravity) surveys will be acquired prior to injection to establish a baseline. The 2D surface seismic and gravity baseline survey is designed to cover the extent of the 100 year post injection plume and beyond.

Surface time-lapse microgravity monitoring is a passive geophysical technique used to detect subsurface mass redistribution resulting from CO_2 injection. The method relies on precise measurements of gravity acceleration changes over time, which correlate with density variations in the reservoir due to CO_2 replacing brine

Gravity methods are directly sensitive to changes in bulk density. The 3D gravity simulations for Pelican show that density changes due to CO_2 injection become detectable within five years of injection, with modeled gravity responses exceeding instrument noise levels of 0.002–0.005 mGal. This makes gravity particularly effective for long-term monitoring of mass redistribution, especially as for the Pelican project in high porosity deep saline formations.

Pelican Sequestration Hub, LLC. developed an in-house advanced 3D time-lapse gravity feasibility workflow, utilizing density differences derived from reservoir simulations. The modeling results have confirmed that surface microgravity surveys are effective for monitoring CO_2 plume propagation at the Pelican site. These simulations, which track temporal changes in subsurface density distributions resulting from CO_2 injection, demonstrate that gravity anomalies will be detectable well above instrument noise thresholds (Figure TM-11).

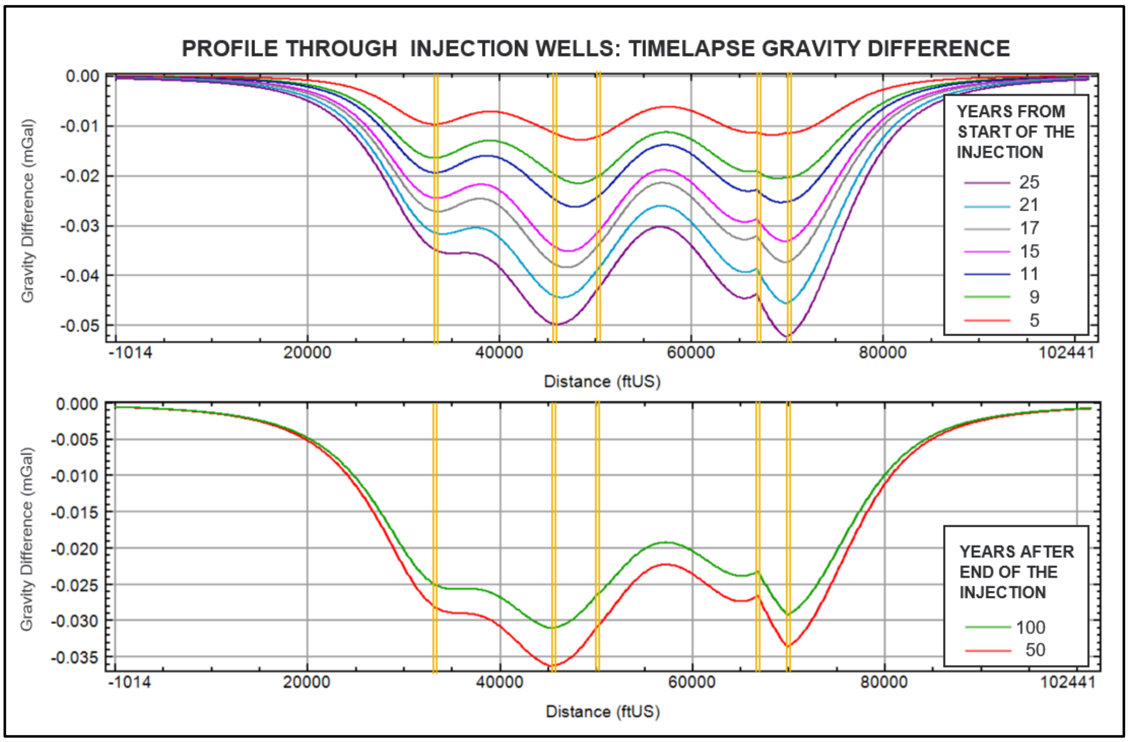

Figure TM-11—Profile of time-lapse gravity differences due to CO_2 plume propagation. Vertical yellow bars represent locations of injection wells.

To facilitate optimal monitoring of CO_2 plume migration at Pelican, a strategically distributed network of gravity stations will be established. High-resolution gravity data will be acquired through an integrated approach employing both relative and absolute gravity measurements, ensuring optimal spatial coverage and data fidelity. Potential noise sources, such as water table fluctuations and surface deformation, will be systematically monitored and rigorously accounted for during data processing following well established procedures (Kennedy et al., 2021; Gettings, 2009).

For the quantitative recovery of subsurface density and CO_2 saturation changes and caused by CO_2 injection, a constrained 3D gravity inversion workflow will be applied to characterize plume dynamics.

The 2D surface seismic baseline survey will be acquired primarily with Vibroseis as the energy source; however, dynamite may be used in some areas due to surface conditions. The survey will use a high density of sources and receivers designed to increase the definition of shallow horizons above the confining zone. The 2D surface seismic baseline survey data will be processed with 2D preprocessing and pre-stack migration workflows, 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 seismic or gravity timelapse surveys will be acquired (using the same acquisition parameters as the 3D and gravity baseline) every five years during injection. The 2D seismic or gravity 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 seismic 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.

Additional 2D surface seismic or gravity surveys may be acquired to delineate the plume as it expands and deviates from expected trends. These surveys will be acquired on an as-needed basis for the project.

New seismic acquisition methods are going to be tested with less surface impact. If the results from these methods show to be as reliable as conventional ones proposed above, it could be a replacement for 2D seismic or gravity in the future.

7.3.3 3D VSP baseline and timelapse surveys

The 3D baseline VSP surveys will be acquired at the injection wells and the MLR 004 well using permanent DAS fiber optic cables installed in the wellbores with conventional Vibroseis vehicles and/or SOV (surface orbital vibroseis) as the surface source. All VSP surveys 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 miles. 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 during early injection (using the same acquisition parameters as the VSP baseline surveys) until the plume is determined to have moved beyond the imaging radius for a particular location or the plume has stabilized. The timelapse surveys will be processed using state-of-the-art joint parallel VSP time-lapse 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-imaging-resolution and acquisition of repeat VSP surveys is 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 seals, the rate of CO_2 movement, and the fidelity of the subsurface geomodel and resulting simulation.

Additional timelapse VSP surveys may be acquired in the event that unexpected CO_2 movement is detected at the injection or monitoring wellbores. The ability to collect high-resolution VSP data at the wellbores will allow for rapid evaluation and characterization of the plume and response to unexpected CO_2 migration in such an event.

8.0 Surface and Near Surface Monitoring [LAC 43:XVII.3625(A)(8)]

8.1 Soil Gas Monitoring and Isotopic Fingerprinting

Pelican Sequestration Hub, LLC will install soil gas sample stations and collect soil gas samples using the Gulf Coast Carbon Center (GCCC) methodology (Figure TM-12 and Table TM-23). Samples will be analyzed by a certified laboratory to determine bulk gas and gas isotopic compositions. Analytical results will be used to develop a process-based soil gas monitoring approach for evaluation and attribution of potential geochemical and ecological changes over time at the site. Soil gas geochemical modeling in concert with subsurface geochemical data from monitoring wells will be used to define diagnostic parameters soil gas source attribution.

Soil gas well sampling will occur quarterly and commence a minimum of one year prior to injection to establish baseline geochemical characterization and site variability. Soil gas will be analyzed quarterly for CO_2, O_2, N_2, CH_4, C1-C5 hydrocarbons, $\delta^{13}C$ and ^{14}C of CO_2, and CH_4 and $\delta^{2}H$ of CH_4 (Table TM-23). Baseline geochemical characterization will be used to develop site-specific protocols for evaluating soil gas geochemical data such as soil gas source differentiation of potential vertical upward CO_2 migration. Following baseline characterization, sampling frequency for gas isotopic compositions may be reduced unless required for source attribution.

8.1.1 Soil Gas Well Installation and Sampling

Permanent soil gas wells will be installed by a licensed driller who is qualified to drill and install permanent soil gas wells using drilling equipment and methods that are appropriate for site conditions and will not introduce contaminants into the borehole or casing. Anticipated depths for soil gas wells range from 3 to 6 feet below ground surface. Four protective bollards and a cement pad will be installed at each soil gas well location. Soil gas wells will be completed at the surface with stickup, protective steel cover, locking cap, and scribed well ID or tags.

Soil gas probes will be installed using Geoprobe® dual tube sampling system to advance each boring to target depth, resulting in a minimum amount of soil disturbance around the borehole annulus. The dual-tube sampling system typically involves advancing a 2-1/2-in. diameter inner sampling probe followed by advancing a 3-1/2-in. diameter outer casing. Drill cuttings will be continuously screened for VOCs and logged using USCS methodology during drilling activities and recorded on a field boring log along with any applicable observations. Depending on soil permeability, soil gas wells will be constructed with solid casing and prefabricated screen intervals. Low-permeability soils may require open hole completions with thick screen intervals (sand). Soil gas wells will utilize 1/4-in. stainless steel tubing for the gas sampling probe. Soil gas well installation activities will involve setting casing and screen in the borehole followed by appropriate clean sand pack material, bentonite seal, and neat-cement grout. Soil gas probes will be fitted with airtight stainless steel compression fittings (e.g., Swagelok®) with valves to allow for an airtight connection to soil gas sampling equipment. Following soil gas well installation, vacuum and helium leak tests will be conducted on each soil gas probe to confirm isolation of screened interval. Soil gas well installation and sampling will be performed with the understanding that field conditions are variable and can result in changes to drilling, sampling, and installation strategies.

Sampling will be performed by qualified field personnel with oversight from a licensed professional geologist or engineer. Appropriate sampling procedures (e.g., USGS, USEPA) or industry best practices will be applied to ensure sample integrity and chain of custody are maintained. Sampling procedures and technical specification of tools are provided in the QASP.

Fluid samples will be analyzed by third-party certified laboratories using appropriate laboratory analytical methods (e.g., USEPA, ASTM) and best industry practices for gas chromatography, mass spectrometry, detector tubes, and photo ionization. Quality inspections will be periodically conducted based on adherence to appropriate applicable laboratory analytical methods outlined in the analytical suite. Sampling methods and chain of custody procedures are further described in the QASP.

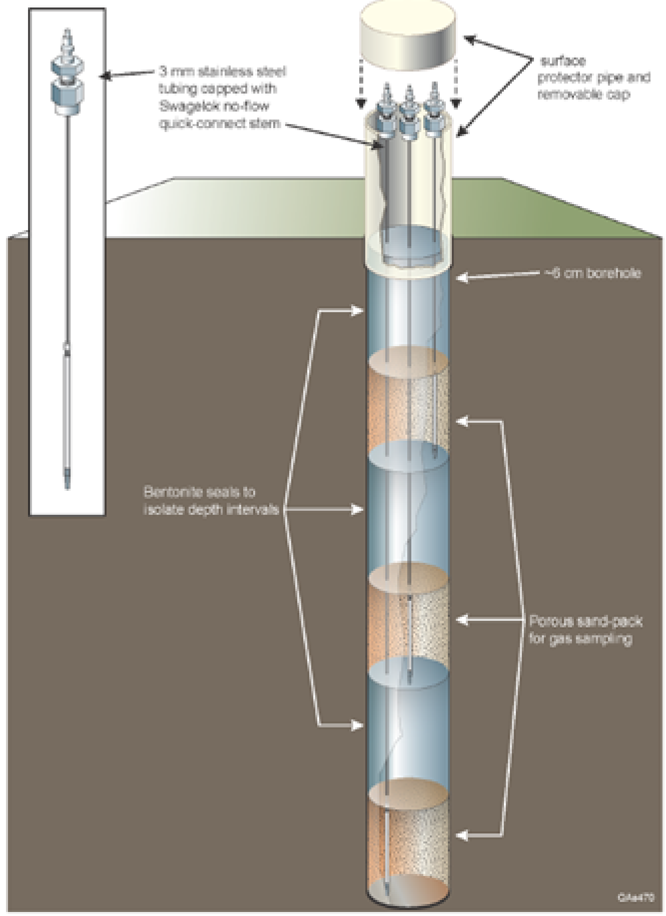

Figure 1. Schematic of gas sampling station construction showing individual gas wells set at different levels. Not to scale.

Figure TM-12—Schematic of soil gas sampling station.

Table TM-23—Soil gas sampling locations and frequencies.

Monitoring Locations	Monitoring Activity	Target Formation	Pre-injection	Injection Period
Soil gas stations	Soil gas sampling and compositional gas analysis	Vadose zone	Minimum 1 years of characterization, 1 sample per station per quarter	Quarterly starting 3 months after injection is approved, 1 sample per station
Soil gas stations	Isotopic compositions of CH_4 and CO_2	Vadose zone	Minimum 1 year of characterization, 1 sample per station per quarter	As required
AoR	Electromagnetic airborne survey	Surface	Minimum 1 year before injection	As required based on other monitoring techniques responses

Table TM-24—Soil gas analysis parameters.

Soil Gas Parameter	Analysis method
CO_2, N_2, O_2,	Gas Chromatography (GC)
CH_4, C_2-C_4	Gas Chromatography (GC)
C_5-C_6	Gas Chromatography (GC)
$\delta^{13}C$ of CO_2	Gas chromatography with combustion isotope ratio mass spectrometry (GC/C/IRMS)
$\delta^{13}C$ of CH_4	Gas chromatography with combustion isotope ratio mass spectrometry (GC/C/IRMS)
$\delta^{2}H$ of CH_4	Gas chromatography combustion isotope ratio mass spectrometry (GC/C/IRMS)
^{14}C of CO_2	Accelerated mass spectrometry (AMS).
^{14}C CH_4	Accelerated mass spectrometry (AMS).

8.2 CO_2 Sensors in Surface - Wellheads

The Pelican Sequestration Hub, LLC, will install infrared gas detectors close to the wellheads of the injection, 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-25—Atmospheric CO_2 sensor in wellhead.

Tool	Pre-Injection	Injection
Atmospheric CO_2 sensor in wellhead – CO_2 injector well	n/a	Continuously
Atmospheric CO_2 sensor in wellhead – In-zone monitoring wells	n/a	Continuously

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 60 m. The ATEM data acquisition systems vary depending on the provider but can be summarized as one of the options shown in Figure TM-13.

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 the subsurface and time.

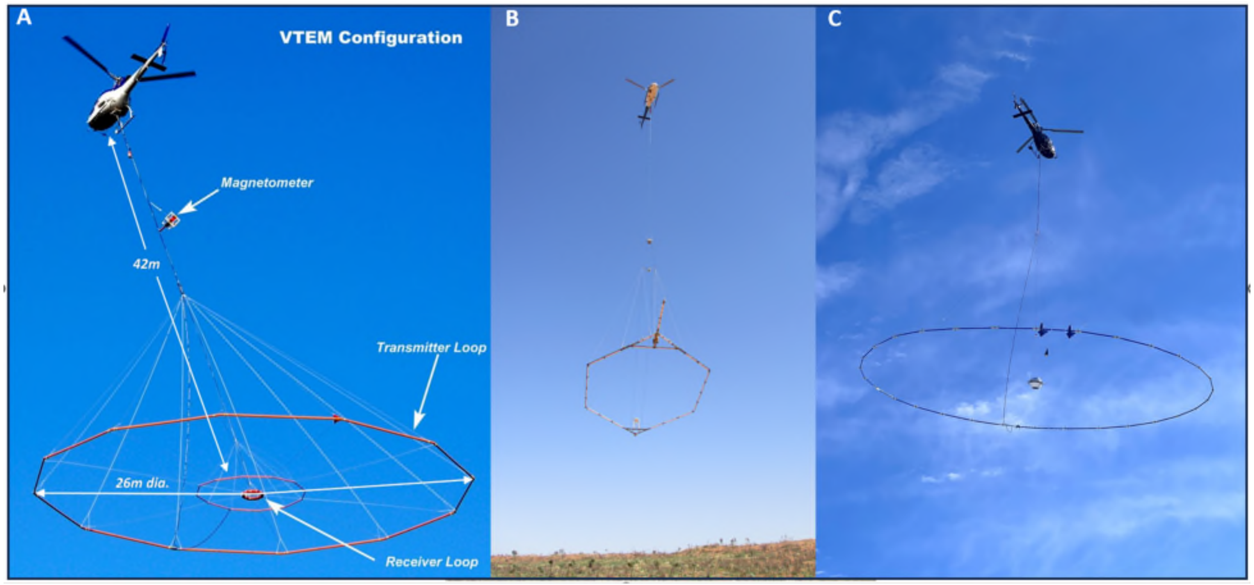

Figure TM-13—Different configurations of airborne time-domain electromagnetic systems: A. Geotech VTEM system, courtesy of Geotech (https://geotech.ca/papers/helicopter-electromagnetic-vtem-ztem-applications-gold-exploration); B. SkyTEM system, courtesy of SkyTEM; and C. HeliTEM system, courtesy of Xcalibur Multiphysics.

The Pelican ATEM survey is located in Livingston and St. Helena Parishes in Louisiana and comprises an area of 327 km^2 depicted in Figure TM-14. The data will be acquired at an average loop elevation of 30 m above the ground. Data lines will be spaced at regular intervals, depending on the data acquisition system, approximately 100 m apart.

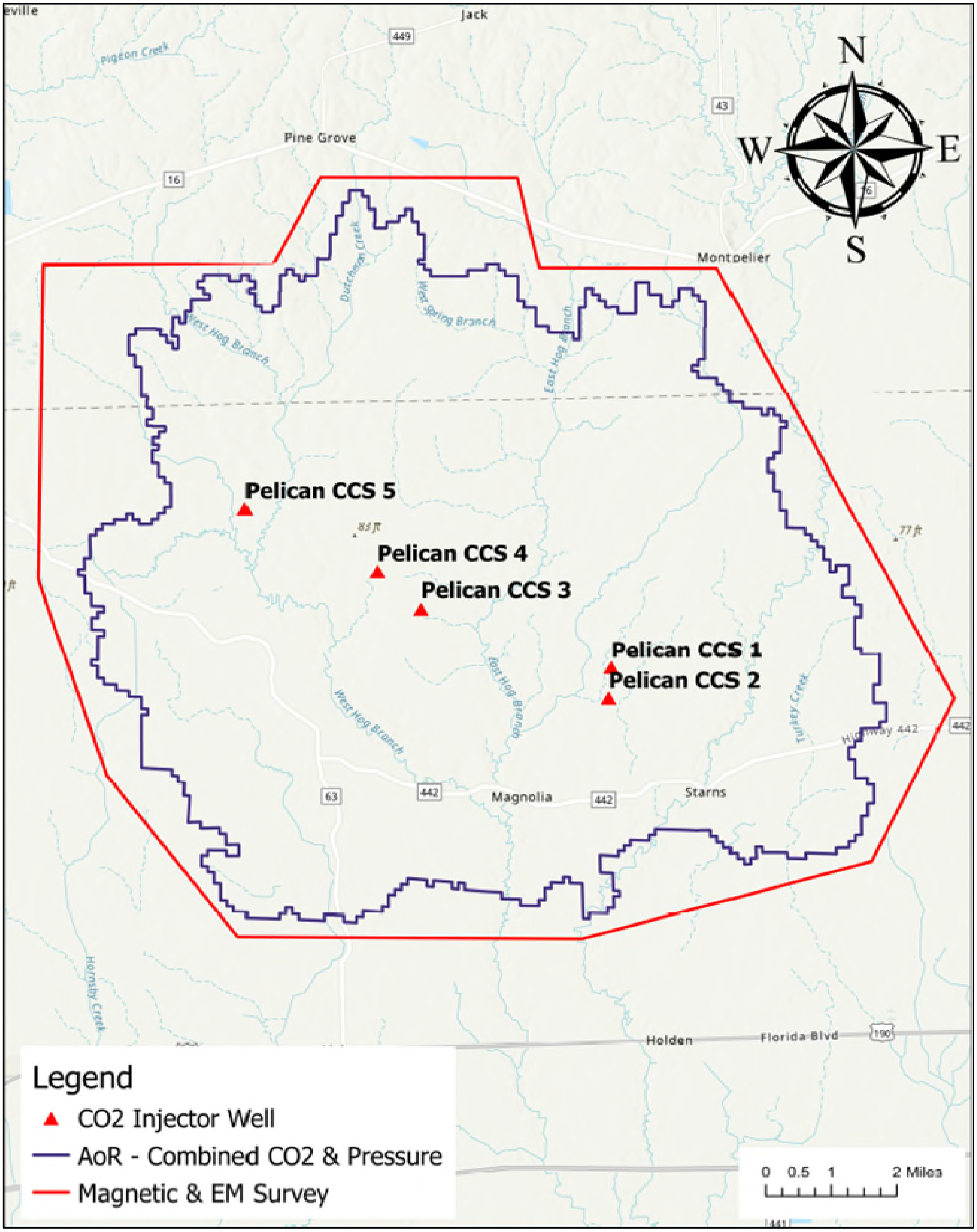

Figure TM-14—Location and the outline of the time-domain electromagnetic survey.

The Pelican 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 used. In addition, the Pelican Sequestration Hub, LLC, will provide data from nearby USDW wells to the third party to calibrate the inversion procedure.

Table TM-26—Airborne electromagnetic survey.

Tool	Pre-Injection	Injection
Airborne Electromagnetic Survey	Minimum 1 year prior the injection	As needed based on other monitoring techniques

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 Pelican 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 – 30 m above ground level and with line spacing not larger than 20 m. The Pelican 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-15).

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.

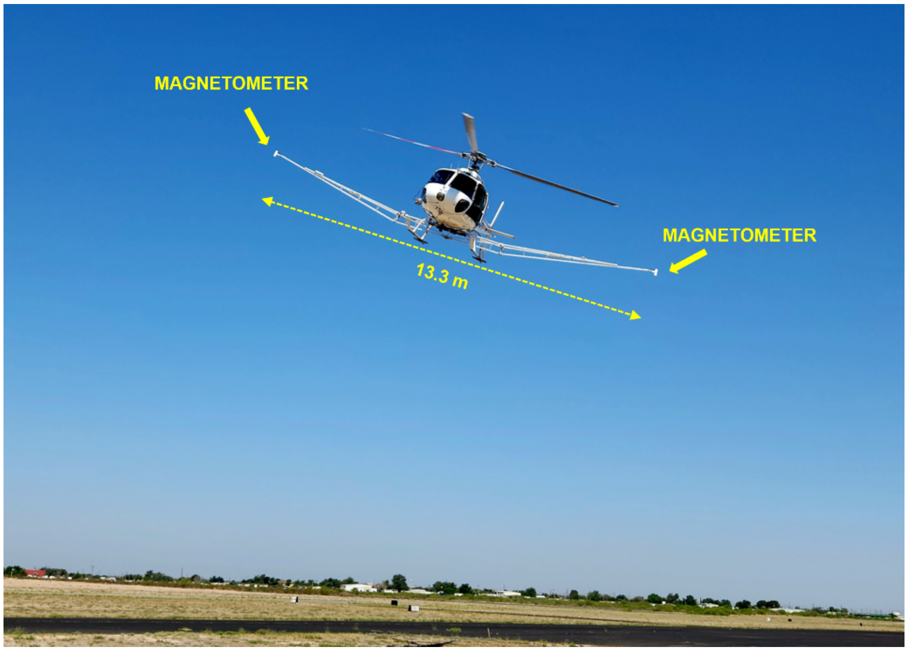

Figure TM-15—An example of heliborne magnetic data acquisition system (MIDAS by Xcalibur Inc.) used in a previous Oxy magnetic survey.

The Pelican Sequestration Hub, LLC, magnetic survey will be located in Livingston and St Helena Parish, Louisiana and comprises an area of 327 km^2 depicted in Figure TM-14. The data will be acquired at an average elevation between 20-30 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, between 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 Pelican 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 Pelican 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-27—Airborne magnetic survey.

Tool	Pre-Injection	Injection
Airborne Magnetic Survey	Prior to injection	n/a

9.0 Induced Seismicity Monitoring

While induced seismicity is not anticipated, Pelican Sequestration Hub LLC, will deploy a seismometer monitoring network to determine the locations, magnitudes, and focal mechanisms of any seismic events observed near the injection site. This information may be used to address public concerns and identify other features that may help to evaluate the plume and pressure front behavior.

9.1 Monitoring Location and Frequency for Induced Seismicity Measurement

Table TM-28—Seismicity monitoring tools.

Tool	Pre-Injection	Injection
Seismometer network on surface to measure potential induced seismicity events.	Minimum one-year baseline before injection	Continuously

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 of seismometers 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 Pelican Sequestration Project 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. 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.