QUALITY ASSURANCE AND SURVEILLANCE PLAN
40 CFR 146.90(k), 16 TAC 5.203(a)(4)

Sugarberry CCS Hub

Facility Information

Facility Name: Sugarberry CCS Hub

Facility Contact: Sugarberry CCS, LLC
14302 FNB Parkway
Omaha, NE 68154

RRC Organization Report Number: 102245

Well Locations: Projection WGS84

Well	County/State	Latitude	Longitude
SB-01	Hopkins, TX	33.202707	-95.338539
SB-02	Hopkins, TX	33.189225	-95.375952
SB-03	Hopkins, TX	33.196028	-95.405035
SB-04	Hopkins, TX	33.219565	-95.434859
SB-05	Hopkins, TX	33.207361	-95.385666

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List of Acronyms/Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
ANSI	American National Standards Institute
AoR	Area of Review
APHA	American Public Health Association
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CCS	Carbon Capture and Storage
CFR	Code of Federal Regulations
CIL	Casing Inspection Log
CO_2	Carbon Dioxide
DAS	Distributed Acoustic Sensing
DID	Discharge Ionization Detector
DFOS	Distributed Fiber Optic Sensing
DSS	Distributed Strain Sensing
DTS	Distributed Temperature Sensing
EPA	Environmental Protection Agency
ERRP	Emergency and Remedial Response Plan
FID	Flame Ionization Detector
Ft-BGS	Feet Below Ground Surface
Ft/hr	Feet per Hour
Ft-MSL	Feet Relative to Mean Sea Level
GC	Gas Chromatography
GC-P	Gas Chromatography-Pyrolysis
GS	Geologic Sequestration
HDPE	High-Density Polyethylene
H_2S	Hydrogen Sulfide
ICP	Inductively Coupled Plasma
ISBT	International Society of Beverage Technologists
lb/MMSCF	Pounds per million standard cubic feet of gas per day
mA	Milliamperes
MASP	Maximum Surface Pressure
MIT	Mechanical Integrity Testing
MoI%	Percentage of Total Moles
MS	Mass Spectrometry
NACE	National Association of Corrosion Engineers
OES	Optical Emission Spectrometry
PISC	Post-Injection Site Care
PNC	Pulsed Neutron Capture
ppmv	Parts per million – volume
ppmw	Parts per million – weight
psi	Pounds per square inch
QASP	Quality Assurance and Surveillance Plan

List of Acronyms/Abbreviations (cont.)

QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RRC	Railroad Commission of Texas
S&A	Sampling and Analysis
SCD	Sulfur Chemiluminescence Detector
TAC	Texas Administrative Code
TBD	To be Determined
TCD	Thermal Conductivity Detector
TD	Total Depth
TDS	Total Dissolved Solids
UIC	Underground Injection Control
USDW	Underground Source of Drinking Water
VSP	Vertical Seismic Profile

Title and Approval Sheet

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

Signature TBD Project Manager	Date
Signature TBD Operations Manager	Date

Distribution List

The following project participants will receive the completed Quality Assurance and Surveillance Plan (QASP) and all future updates for the duration of the project.

Name	Organization	Project Role	Contact (telephone, email)
TBD	Sugarberry CCS, LLC	Project Manager	TBD
TBD	Sugarberry CCS, LLC	Operations Manager	TBD

A. Project Management

A.1. Project/Task Organization

A.1.A/B. Key Individuals and Responsibilities

The project will be owned and operated by Sugarberry CCS, LLC, who will serve as the lead on all project tasks while supervising the performance of subcontractors when required for individual tasks. The Sugarberry CCS Hub Project Manager will be responsible for implementation of this plan during pre-operation testing, and the Sugarberry CCS Hub Operations Manager will be responsible for implementation of this plan during injection and post-injection. Tasks which are related to testing and monitoring at the Sugarberry CCS Hub that will require supervision for purposes of quality control and assurance are broadly divided into:

1. Groundwater Sampling and Analysis
2. Well Logging
3. Mechanical Integrity and Operational Testing
4. Injection Monitoring
5. CO_2 Stream Sampling and Analysis
6. Geophysical Monitoring

A.1.C. Independence from Project QA Manager and Data Gathering

Most of the physical samples collected and other data gathered as part of the testing and monitoring program will be analyzed, processed, or witnessed by third parties independent and outside of the project management structure. Sugarberry CCS, LLC will provide the UIC Program Director with the name and credentials of any vendors, subcontractors, or testing laboratories used for testing and monitoring protocols during each semi-annual reporting period.

A.1.D. QA Project Plan Responsibility

Sugarberry CCS, LLC will be responsible for maintaining and distributing the official, approved Quality Assurance Surveillance Plan (QASP), under the oversight of those individuals listed in the distribution list. Sugarberry CCS, LLC will periodically review this QASP and consult the UIC Program Director if/when changes to the plan are warranted based on changes made to the Testing and Monitoring Plan.

A.1.E. Organizational Chart for Key Project Personnel

Sugarberry CCS, LLC will add an organization chart for key project personnel once determined.

A.2. Problem Definition/Background

A.2.A. Reasoning

Sugarberry CCS Hub, LLC is proposing to design, permit and implement a Carbon Capture and Storage (CCS) project in Hopkins County, near Sulphur Springs, Texas. CCS projects must include a Testing and Monitoring Plan and associated QASP to ensure that the injection well maintains mechanical integrity, that fluid migration and the associated pressure front follow the predicted AoR, and that USDWs, human health, and the environment are not endangered as a result of injection activities. This QASP was developed to ensure the quality and standards of the testing and monitoring program and to specifically meet the requirements of 40 CFR 146.90(k).

The Testing and Monitoring Plan can be subdivided into operational monitoring, verification, and environmental monitoring components. Operational monitoring is conducted for the safety and protection of USDWs during injection, for monitoring the injection interval at the wellsite, and for monitoring the CO_2 plume and pressure front migration. Key monitoring parameters include downhole pressure, wellhead pressure, flow rate, annulus pressure and fluid volume, and above-zone fluid geochemistry. The verification component of the Testing and Monitoring Plan will provide data to evaluate if leakage of CO_2 through the caprock or wellbores is occurring or has the potential to occur. This includes corrosion monitoring, pressure and temperature monitoring, MITs, vertical seismic profile (VSP) surveys, and formation fluid monitoring in injection zone, above-confining zone unit, and USDWs. Pressure and geophysical data will be used to validate the geologic and reservoir models [40 CFR 146.90(b) and (f)-(g)].

A.2.B. Reasons for Initiating the Project

The objective of the project is to develop a safe and commercially viable CO_2 storage site available to CO_2 sources in the region while ensuring protection of groundwater resources and environmental and public health.

A.2.C. Regulatory Information, Applicable Criteria, Action Limits

Sugarberry CCS, LLC is required to perform several testing and monitoring activities during the lifetime of the CO_2 storage project to ensure that the injection well maintains its mechanical integrity, that fluid and pressure front migration are consistent with the model predictions and operating parameters are within the limits of the permit, and that USDWs, public health and safety, and the local environment will not be endangered by this project. Monitoring procedures include injection well and in-zone observation well MITs; continuous injection pressure, rate, and volume monitoring; CO_2 plume and pressure front tracking; and groundwater quality geochemical monitoring. Full details of monitoring methods and activities are provided in the **Testing and Monitoring Plan (Section 7)**. This QASP discusses data measurement methods as well as the steps Sugarberry CCS, LLC will take to ensure that the quality of all gathered samples and data provide confidence in making project decisions and protecting USDWs within the AoR.

A.3. Project/Task Description

A.3.A/B. Summary of Work to be Performed/Instrumentation

As summarized in **Table 7.1.1,** Sugarberry CCS, LLC plans to drill five (5) injection wells and nine (9) observation wells strategically placed in specific formations with a specified function. **Table 7.1.2** describes the general testing and monitoring activities, location, and purpose. Please refer to the **Testing and Monitoring Plan (Section 7)** and associated tables and figures for detailed descriptions of planned activities and methods, monitoring frequencies, and sample locations.

Table 7.1.1. Sugarberry CCS Hub Well Summary

Well Type	Well Acronym	CCS System Zone	Zone Formation	Zone Depth (ft-BGS)[1]	Quantity
USDW Observation	**UOB** UOB-01, UOB-04	USDW	Taylor Group	Est. 713-782 (top depth)	2
Above-Zone Observation	**AOB** AOB-01, AOB-04, AOB-05	1st Permeable Zone above Confining Zone	Subclarksville Sandstone Member	Est. 3,064 to 3,202	3
In-Zone Observation	**IOB** IOB-01, IOB-02, IOB-3, IOB-04	Injection Zone	Woodbine and Paluxy	Est. 3,458 to 4,356 (Woodbine) and 4,958 to 5,656 (Paluxy)	4
Injection	**SB** SB-01, SB-02, SB-03, SB-04, SB-05	Injection Zone	Woodbine and Paluxy	Est. 3,482 to 4,279 (Woodbine) and 4,982 to 5,579 (Paluxy)	5
1. ft-BGS = feet below ground surface.					

Table 7.1.2. Summary of Testing & Monitoring

Activity	Location(s)	Method	Analytical Technique	Purpose
CO_2 Stream Analysis[1]	Downstream of all CO_2 source points within main trunkline prior to CCS Hub manifold	Gas Chromatograph and Injectate Sampling	Chemical Analysis	Analysis of injectate 40 CFR 146.90(a)
Injection Pressure	SB (01-05) wellheads	Tubing pressure gauge	Continuous measurement	Continuous monitoring of injection pressure 40 CFR 146.90(b)
Injection Rate and Volume	SB (01-05) wellheads	Mass Flow Meter	Continuous measurement	Continuous monitoring of injection rate and volume 40 CFR 146.90(b)

Activity	Location(s)	Method	Analytical Technique	Purpose
Annular Pressure	SB (01-05) wellheads	Annular pressure gauge	Continuous measurement	Continuous monitoring of annular pressure 40 CFR 146.90(b)
Annular Volume	SB (01-05) wellheads	Annular volume gauge and record	Continuous direct measurement	Continuous monitoring of annulus fluid volume 40 CFR 146.90(b)
Corrosion Monitoring	SB (01-05) wellheads	Corrosion Coupons Analysis	Chemical analysis	Corrosion monitoring 40 CFR 146.90(c)
Groundwater Quality and Geochemistry[1]	SB (01-05), IOB (01-04)[2], AOB (01, 04, 05), UOB (01, 04)	Fluid Sampling & Analysis and Bottom Hole Pressure Gauges	Chemical analysis and continuous direct measurement	Groundwater quality and geochemistry monitoring 40 CFR 146.90(d)
Mechanical Integrity	SB (01-05) External only: IOB (01-04)	Internal – Annular pressure gauge monitoring injection wells	Direct measurement	Demonstration of internal and external mechanical integrity of the wellbore 40 CFR 146.90(e)
		External – Distributed Temperature Sensing (DTS)	Distributed indirect measurement	
Pressure Falloff Testing	SB (01-05)	Pressure gauge or wireline tool	Direct measurement	Pressure falloff testing 40 CFR 146.90(f)
CO_2 Plume and Pressure Front Monitoring	SB (01-05) IOB (01-04)	Downhole pressure gauges, Pulsed Neutron Capture (PNC) logs, and 3D Distributed Acoustic Sensing (DAS) VSPs	Direct and indirect measurements	CO_2 plume imaging and pressure front tracking 40 CFR 146.90(g)
Injection Zone 1. Pressure 2. Temperature	SB (01-05) IOB (01-04)	1. Down Hole Pressure Gauges 2. DTS	Direct measurement	Continuous monitoring of injection zone pressure and temperature 40 CFR 146.90(g)(1)

1. *Sampling and analysis frequencies may be reduced based on project-specific benchmarks that will be defined from baseline monitoring data and/or injection phase monitoring data.*

Activity	Location(s)	Method	Analytical Technique	Purpose
2. IOB-1 through IOB-04 will monitor pressure changes only. In-zone geochemistry will be monitored at the injection wells (SB-01 through SB-05) only.				

Table 7.1.3 shows the instrumentation summary that will be used to conduct the Testing and Monitoring Plan. Please refer to the **Testing and Monitoring Plan (Section 7)** for a detailed description of the testing and monitoring frequencies.

Table 7.1.3. Instrumentation Summary

Monitoring Location	Instrument Type	Explanation	Monitoring Target (Formation or Other)	Data Collection Location(s)
CO_2 Facility	Gas Chromatograph and Injectate Sampling and Analysis	Used to analyze the chemical characteristic of the injectate stream to ensure compliance with the operators expected injectate stream composition.	N/A	Downstream of all CO_2 source points within main trunkline prior to CCS Hub manifold
SB (01-05)	Mass Flow Meter	Used to record total mass of CO_2 injected.	N/A	Wellhead
	Pressure Gauges	Used to monitor injection zone for direct pressure front evolution, and for containment loss detection.	Woodbine and Paluxy	Injection Zones
	DTS	Injection well external mechanical integrity, identify the vertical intervals taking injectate within the reservoir for use in computational model updates, and containment loss detection.		
	PNC Logging [1]	Pre-injection baseline, CO_2 containment loss detection/verification, and vertical CO_2 saturation profiling for use in computational model updates		
	3D DAS VSP	Indirect CO_2 plume imaging		
	Groundwater S&A	ID pre-injection groundwater quality and geochemistry; Early CO_2 and reservoir brine		

Monitoring Location	Instrument Type	Explanation	Monitoring Target (Formation or Other)	Data Collection Location(s)
		containment loss detection/verification		
IOB (01-04)	Pressure Gauges	Used to monitor injection zone direct pressure front evolution, and for containment loss detection.	Woodbine and Paluxy	Injection Zones
	DTS	Identify the vertical intervals taking injectate within the reservoir for use in computational model updates, and containment loss detection.		
	PNC Logging [1]	Pre-injection baseline, CO_2 containment loss detection/verification, & vertical CO_2 saturation profiling for use in computational model updates		
	3D DAS VSP	Indirect CO_2 plume imaging		
AOB (01, 04, 05)	Pressure Gauges	Used to monitor pressure front evolution, and for containment loss detection.	Sub-Clarksville Sandstone Member (upper sands)	Above-Confining Zone
	PNC Logging [1]	Pre-injection baseline, CO_2 containment loss detection/verification, & vertical CO_2 saturation profiling for use in computational model updates		
	Groundwater S&A	ID pre-injection groundwater quality and geochemistry; Early CO_2 and reservoir brine containment loss detection/verification		
UOB (01, 04)	Pressure Gauges	Used to monitor pressure front evolution, and for containment loss detection.	Taylor Group	USDW
	PNC Logging[1]	Pre-injection baseline, CO_2 containment loss detection/verification, & vertical CO_2 saturation profiling for use in computational model updates		
	Groundwater S&A	ID pre-injection groundwater quality and geochemistry; CO_2 and reservoir brine		

Monitoring Location	Instrument Type	Explanation	Monitoring Target (Formation or Other)	Data Collection Location(s)
		containment loss detection/verification		
[1]*PNC logging or equivalent will occur in all wells in the above table during the baseline phase and only in wells with CO_2 breakthrough or wells with detected containment loss during the injection and post injection phases of the project.*				

The objective of the storage site monitoring program is to select and implement a suite of monitoring technologies that are both technically robust, cost-effective and provide an effective means of 1) evaluating CO_2 mass balance (i.e., verify that the site is operating as permitted) and 2) detecting any unforeseen containment loss (i.e., verify that the site is not endangering any USDWs). Both direct and indirect measurements will be used collaboratively with numerical models of the injection process to verify that the storage site is operating as expected and that CO_2 is effectively sequestered within the targeted geologic formation. The approach is based in part on reservoir-monitoring wells, pressure fall-off testing, and indirect (e.g., geophysical) methods. Early-detection monitoring wells will target regions of increased leakage potential (e.g., proximal to wells that penetrate the caprock).

During baseline monitoring, a comprehensive suite of geochemical and isotopic analyses will be performed on fluid samples collected from the reservoir and overlying monitoring intervals. These analytical results will be used to characterize baseline geochemistry and provide a metric for comparison during operational phases. Selection of this initial analyte list (provided in the **Testing and Monitoring Plan, Section 7, Table 7-6**) was based on relevance for detecting the presence of reservoir formation fluids and CO_2. The results for this comprehensive set of analytes will be evaluated and a determination made regarding which analytes to carry forward through the operational phases of the project.

A.3.C. Geographic and Stratigraphic Locations

Surface locations within the AoR of all injection and observation wells, identified containment loss risks, and the CO_2 plume extents throughout the project are shown in **Testing and Monitoring Plan, Section 7, Figure 7-1**. Injection wells and in-zone observation wells will be completed in the Woodbine and Paluxy Formations. Above-zone observation wells will be completed in the first porous and permeable interval above the primary confining layer, the Sub-Clarksville Sandstone Member. USDW observation wells will be completed in potential USDWs within the AoR, likely within the Taylor Group.

A.3.D. Resource and Time Constraints

Sugarberry CCS, LLC will coordinate deployment and uses of the monitoring and testing equipment described in the **Testing and Monitoring Plan (Section 7)** and in this QASP appropriate for field operations, service company availability (where necessary), other field-level logistics and operations, CO_2 source and pipeline operations, and community input.

A.4. Quality Objectives and Criteria

A.4.A. Performance/Measurement Criteria

The overall objective for this QASP is to develop and implement procedures for subsurface monitoring, field sampling, laboratory analysis, and reporting which will provide results to meet the characterization and non-endangerment goals of the Sugarberry CCS Hub. **Tables 7.1.4 through Table 7.1.16** summarize the specifications and action limits of technologies used for testing and monitoring.

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Table 7.1.4. Summary of Analytical & Field Parameters for Fluid Sampling

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Cations: Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se, and Tl	ICP-MS EPA Method 6020B (U.S. EPA, 2014a) or EPA Method 200.8 (U.S. EPA, 1994a)	0.001 to 5 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily Calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Cations: Ca, Fe, K, Mg, Na, and Si	ICP-AES / ICP-OES EPA Method 6010D (U.S. EPA, 2014b) or EPA Method 200.7 (U.S., EPA, 1994b)	0.005 to 2 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily Calibration; blanks, duplicates, and matrix spikes at 10% or greater frequency
Anions: Br, Cl, NO3, and SO4	Ion Chromatography EPA Method 300.0 (U.S. EPA, 1993)	0.02 to 0.13 mg/L (Analyte, dilution, and matrix dependent)	±15%	Daily Calibration: blanks and duplicates at 10% or greater frequency
Dissolved CO_2	Coulometric Titration ASTM 513-16 (ASTM, 2016)	25 mg/L	±15%	Duplicate measurement; standards at 10% or greater frequency

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Total Dissolved Solids	Gravimetry APHA 2540C (APHA)	12 mg/L	±15%	Balance calibration, duplicate analysis
Alkalinity	APHA 2320B (APHA 1997)	4-10 mg/L	±3 mg/L	Duplicate Analysis
pH (field)	EPA 150.1 (U.S. EPA, 1982)	2 to 12.5 pH units	±0.2 pH unit	User Calibration per manufacturer recommendation
Specific Conductance (field)	APHA 2510 (APHA, 1992)	0 to 200 mS/cm	±1% of reading	User calibration per manufacturer recommendation
Temperature (field)	Thermocouple	-5 to 50 ºC	±0.2 ºC	Factory Calibration
Water Density	ASTM D4052	0.01 g/mL	±10%	Daily calibration, blanks, duplicates, and matrix spikes at 10% or greater frequency
Isotopes: $\delta^{13}C$ of DIC	Isotope Ratio Mass Spectrometry	12.2mg/L HCO_3^- for $\delta^{13}C$	±0.15% for $\delta^{13}C$	10% duplicates; 4 standards/batch

1. *An equivalent method may be employed with the prior approval of the UIC Program Director.*
2. *Abbreviations: ICP=inductively coupled plasma; MS= mass spectrometry; OES= Optical emission spectrometry; GC-P=Gas chromatography-Pyrolysis*

Table 7.1.5. Summary of Analytical Parameters for CO_2 Stream

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
CO_2 Purity	ISBT 2.0 Caustic absorption Zahm-Nagel or online gas quality equipment	90.00% to 99.9%	± 15% of reading	User calibration per manufacturer
Water Content	Online gas quality equipment	To be updated with manufacturer specifications	To be updated with manufacturer specifications	To be updated with manufacturer specifications
Total Hydrocarbons	ISBT 10.0 THA (FID) or online gas quality equipment	1 uL/L to 10,000 uL/L (ppm by volume)	5 - 10% of reading relative across the range	daily blank, daily standard within 10% of calibration, secondary standard after calibration
Nitrogen	ISBT 4.0 (GC/DID) GC/TCD or online gas quality equipment	1 uL/L to 5,000 uL/L (ppm by volume)	± 15% of reading	daily standard within 10% of calibration, secondary standard after calibration
Inert Gasses	ISBT 4.0 (GC/DID) GC/TCD	1 uL/L to 5,000 uL/L (ppm by volume)	± 10% of reading	daily standard within 10% of calibration, secondary standard after calibration

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
	or online gas quality equipment			
Alcohols, aldehydes, esters	ISBT 11.0 (GC/FID) or online gas quality equipment	0.1 uL/L to 100 uL/L (ppm by volume)-dilution dependent	5 - 15% of reading relative across the range	daily blank, daily standard within 10% of calibration, secondary standard after calibration
Hydrogen Sulfide	ISBT 14.0 (GC/SCD) or online gas quality equipment	0.1 uL/L to 100 uL/L (ppm by volume)-dilution dependent	5 - 15% of reading relative across the range	daily blank, daily standard within 10% of calibration, secondary standard after calibration
Total Sulfur	ISBT 14.0 (GC/SCD) or online gas quality equipment	0.01 uL/L to 50 uL/L (ppm by volume)-dilution dependent	5 - 10% of reading relative across the range	daily blank, daily standard within 10% of calibration, secondary standard after calibration
Oxygen, Hydrogen	ISBT 4.0 (GC/DID) GC/TCD or online gas quality equipment	1 uL/L to 5,000 uL/L (ppm by volume)	± 10% of reading	daily standard within 10% of calibration, secondary standard after calibration
Carbon Monoxide	ISBT 5.0 Colorimetric ISBT 4.0	5 uL/L to 100 uL/L	± 20% of reading	duplicate analysis

Parameters	Analytical Methods[1]	Detection Limit/Range	Typical Precisions	QC Requirements
	(GC/DID) or online gas quality equipment	(ppm by volume)		
Sulfur dioxide	ISBT 14.0 (GC/SCD)	0.01 uL/L to 50 uL/L (ppm by volume)-dilution dependent	5 - 15% of reading relative across the range	daily blank, daily standard within 10% of calibration, secondary standard after calibration
Oxides of nitrogen	ISBT 7.0 Colorimetric	5 uL/L to 100 uL/L (ppm by volume)	± 20% of reading	duplicate analysis
Methane, Ethane, Ethylene	ISBT 10.1 (FID)	10 ppmv	± 15% of reading	daily standard within 10% of calibration, secondary standard after calibration
Ethanol	ISBT 11.0 (GC/FID)	0.5 ppmv	20%	Daily calibration/CCV, blank, LCS, MS/MSD, ICV
Ammonia	ISBT 6.0 (DT)	0.1 ppmv	± 15% of reading	daily standard within 10% of calibration, secondary standard after calibration

1. *An equivalent method may be employed with the prior approval of the UIC Program Director.*
2. *Analytical parameters presented are for physical bottle sampling and laboratory analysis. A gas chromatograph will be installed to continuously detect CO_2 purity, total hydrocarbons, inert gases, hydrogen, alcohols, oxygen, carbon monoxide, and glycol. Quarterly bottle analysis will be performed to analyze the CO_2 stream for hydrogen sulfide and total sulfur. The detection range, accuracy, precision, and calibration requirements of the gas chromatograph will be shared with the UIC Program Director as requested.*

Parameters	Analytical Methods(1)	Detection Limit/Range	Typical Precisions	QC Requirements
3. *Abbreviations: GC=Gas Chromatography; FID=Flame Ionization Detector; DID=Discharge Ionization Detector; TCD=Thermal Conductivity Detector; SCD=Sulfur Chemiluminescence Detector*				

Table 7.1.6. Summary of Analytical Parameters for Corrosion Coupons

Parameters	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements
Mass	NACE RP0775-2018 (NACE, 2018)	0.005 mg	±2%	Annual Calibration of Scale (3rd Party)
Thickness	NACE RP0775-2018 (NACE, 2018)	0.001 mm	±0.005 mm	Factory calibration

Table 7.1.7. Specifications for MIT Testing and Geophysical Monitoring Technology

Logging Tool	Analytical Methods	Detection Limit/Range	Typical Precisions	QC Requirements	Calibration Frequency
Ultrasonic Cement Bong Log (SLB USI Tool)	Vendor best practice	0-10 MRayl (acoustic impedence)	±0.5 MRayl (acoustic impedence)	Vendor Calibration (3rd party)	Per Vendor Discretion
PNC Logging (SLB Pulsar and RST Tool)	Vendor best practice	Porosity: 0 to 60 porosity units	TBD	Vendor Calibration (3rd party)	Per Vendor Discretion
DTS	Vendor best practice	-40 ºF to 149 ºF	0.01 ºC	Vendor Calibration (3rd party)	Per Vendor Discretion

Table 7.1.8. Summary of Measurement Parameters for Field Gauges/CO_2 Injection Process Monitoring

Parameters	Methods	Detection Limit/Range	Vendor Specified Accuracy	QC Requirements	Calibration Frequency
Operational Annular Pressure Monitoring	ISO/IEC 17025 (2017)	0-3,000 psi	± 0.5% FS	Annual Calibration (3rd party)	As suggested by control system/gauge manufacturer
Wellhead Injection pressure (*e.g., PPS PPS31 Wellhead Pressure Logger or similar product*)	ISO/IEC 17025 (2017)	0-5,000 psi	±0.03% FS	Annual Calibration (3rd party)	As suggested by gauge manufacturer
Injection mass flow rate (*e.g.*, *Emerson Coriolis mass flow meter or similar product*)	AGA Report 3 API Chapter 14 Part 3 (API, 2016)	547.95-3,561.64 mt/day	±0.1% of rate for liquid ±0.35% of rate for gas	Annual Calibration (3rd party)	As suggested by gauge manufacturer
Downhole Pressure (*e.g.*, *Baker Hughes SureSENS QPT ELITE pressure/temperature gauge of similar product*)	NA	200 psi to 10,000 psi	± 0.015% FS	Initial Manufacturer Calibration	Not required on downhole gauges

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Table 7.1.9. Actionable Testing & Monitoring Outputs

Activity or Parameter	Project Action Limit	Detection Limit	Anticipated Reading
DTS	Action to be taken when a temperature anomaly is observed	Refer to **Table 7.1.6**	Difference between profiles observed during baseline & injection stream temperature
DAS	Action to be taken when an acoustic anomaly is observed	Refer to **Table 7.1.6**	Baseline and injection noise
Injection rate	Injection rate is reduced if max instantaneous rate of 2,958 mt/d is reached	Refer to **Table 7.1.7**	Average 2,465 mt/d
Surface/Down hole pressure	Injection stops if maximum surface injection pressure (MASP) is reached or 90% fracture pressure downhole is reached	Refer to **Table 7.1.7**	< 2,000 psi at surface < 6,400 psi downhole (see Injection Well Operations Plan)
Annular pressure	<3% pressure loss over 1 hour	Refer to **Table 7.1.7**	>3% pressure loss over 1 hour
Annular volume	10% loss of annular volume or continuous fluid make up exceeding 24 hours	Tank fluid level indicator	Annular fluid make up is expected when temperature of the fluid changes
Annular pressure/ volume	Action to be taken when annulus pressure is below 250 psi, above 500 psi, or less than injection pressure downhole in injection wells	Refer to **Table 7.1.7**	250-500 psi at surface Volume TBD during baseline
Above-zone water quality (fluid sampling)	Action to be taken when chemical profile anomaly is observed	Refer to **Table 7.1.4**	Profiles TBD during baseline
Above-confining-zone pressure	Action will be taken when a pressure/temperature anomaly occurs	Refer to **Table 7.1.11**	Profiles TBD during baseline

Activity or Parameter	Project Action Limit	Detection Limit	Anticipated Reading
PNC Logging	Action to be taken when a CO_2 saturation anomaly is observed	Refer to **Table 7.1.7**	Brine saturated ~ 60 capture units (typical readings for fully saturated conditions) CO_2 saturated ~ 8 capture units (typical readings for fully saturated conditions)
CO_2 plume monitoring	Action to be taken if CO_2 plume is observed outside of expected/modeled spatial limits/geologic intervals	Dependent on geologic conditions	Profiles TBD during baseline

A.4.B. Precision

For groundwater sampling, data accuracy will be assessed through field blanks and trip blanks. Field and trip blanks will be taken no less than one per sampling event to check for sample bottle contamination. Assessment of analytical precision will be the responsibility of the individual laboratories. Third party laboratories used will be EPA approved and certified laboratories. Industry standard sampling and analysis procedures will be followed to obtain sample results with the highest possible level of precision.

A.4.C. Bias

Assessment of analytical bias is to be the responsibility of the individual laboratories per their standard operating procedures and analytical methodologies.

A.4.D. Representativeness

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

A.4.E. Completeness

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

A.4.F. Comparability

Data comparability is the confidence with which one dataset can be compared to another. Datasets for the Sugarberry CCS Hub will be generated in accordance with a consistent methodology so that each dataset is directly comparable to another. This allows for appropriate data comparison and identification of anomalies if present. To ensure appropriate QA/QC standards, direct pressure, temperature, and logging measurements obtained through the proposed operations will be directly comparable to data previously obtained.

A.4.G. Method Sensitivity

Table 7.1.10 through Table 7.1.16 summarize additional details on gauge and logging tool specifications and sensitivities.

Table 7.1.10. Downhole Pressure Gauge Vendor Specifications

Parameter	Value
Calibrated working pressure range	200 psi to 10,000 psi
Initial pressure accuracy	+-0.015% (1.5 psi at full scale)
Pressure resolution	0.0001 psi
Pressure drift stability	2.0 psi per year at full scale
Note: Specifications from the Baker Hughes SureSENS QPT ELITE Pressure Gauge are provided as an example of typical specifications from a vendor. A similar product may be used.	

Table 7.1.11. Representative Logging Tool Specifications

Parameter	Ultrasonic Imager Log	PNC/ Reservoir Saturation Tool	DAS Fiber	DTS Fiber
Logging speed	1,800 ft/hr.	150-200 ft/hr.	NA	NA
Vertical resolution	6 inches	24 inches	25cm	25-50 cm
Investigation	Casing-to-cement interface	4-6 inches	0-24.8 miles	At fiber location
Temperature rating	350°F (175°C)	300°F (150°C)	500°F (250°C)	500°F (250°C)
Pressure rating	20,000 psi	15,000 psi	20,000 psi	20,000 psi

**Note: Specifications from Baker Hughes are provided as an example of typical specifications from a vendor. A similar product may be used.*

Table 7.1.12. Wellhead Pressure/Temperature Gauge

Parameter	Value
Calibrated working pressure range	0-5,000 psi
Initial pressure accuracy	±0.03% full scale
Pressure resolution	0.0003% full scale
Pressure drift stability	< 3.0 psi
Calibrated working temperature range	-4 ºF to 158 ºF
Initial temperature accuracy	±0.09 ºF
Temperature resolution	0.02 ºF
Max temperature	158 ºF
Note: Specifications from a PPS PPS31 Wellhead Pressure Logger are provided as an example of typical specifications from a vendor. A similar product may be used.	

Table 7.1.13. Pressure Field Gauge-Injection Tubing & Pipeline Pressure

Parameter	Value
Calibrated working pressure range	0 – 5,000 psi and 4-20 mA
Initial pressure accuracy	<0.05%
Pressure resolution	0.001 psi and 0.00001 mA
Pressure drift stability	To be determined after first year

Table 7.1.14. Pressure Field Gauge-Annulus Pressure

Parameter	Value
Calibrated working pressure range	0 to 5,000 psi
Initial pressure accuracy	< 0.05 %
Pressure resolution	0.001 psi
Pressure drift stability	To be determined after first year

Table 7.1.15. Temperature Field Gauge-Injection Tubing, Annulus, Pipeline Temperature

Parameter	Value
Calibrated working temperature range	0 to 500 degrees Fahrenheit and 4-20ma
Initial temperature accuracy	<0.0055%
Temperature resolution	0.001 degrees Fahrenheit and 0.0001 mA
Temperature drift stability	To be determined after first year

Table 7.1.16. Mass Flow Rate Field Gauge-CO_2 Mass Flow Rate

Parameter	Value
Calibrated working flow rate range	547.95-3,561.64 mt/d; Range spanning maximum anticipated injection rate per well with typical precision and accuracy of 0.5%
Initial mass flow rate accuracy	±0.10% of rate (liquid), ±0.35% of rate (gas)
Mass flow rate resolution	±0.10% of rate (liquid), ±0.20% of rate (gas)
Mass flow rate drift stability	To be determined
Note: Specifications from an Emerson Coriolis Mass Flow Meter are provided as an example of typical specifications from a vendor. A similar product may be used.	

A.5. Special Training/Certifications

A.5.A. Specialized Training and Certifications

All sampling equipment and wireline logging tools will be operated by trained, qualified, and, where required, certified personnel according to the service company which provides the equipment. Subsequent data will be processed and analyzed by technically skilled personnel according to industry standards. Groundwater sampling and laboratory chemical analysis will be evaluated by EPA certified laboratories. Sugarberry CCS, LLC will provide relevant certifications for all vendor/subcontractor staff upon request.

A.5.B/C. Training Provider and Responsibility

A Sugarberry CCS, LLC designated subcontractor will provide necessary training for personnel for the testing and monitoring activities.

A.6. Documentation and Records

The monitoring program is broken down into several focus areas:

- *Operational Monitoring:* CO_2 stream analysis, CO_2 injection rate and pressure, annular pressure/volume, corrosion monitoring, wellhead/valve leak detection.
- *Hydrogeologic Testing:* Pressure fall-off tests.
- *Mechanical Integrity Testing:* DTS and PNC logging.
- *Direct Plume/Pressure Monitoring:* Fluid sampling, downhole and pressure gauges
- *Indirect Plume Subsurface Monitoring:* PNC logging, DAS, VSPs, DTS.
- *Above-Zone Monitoring:* Downhole pressure gauges, fluid sampling.
- *USDW Monitoring:* Downhole pressure gauges, fluid sampling.

Each of the various monitoring areas will produce variable data types and will have unique data management needs. To organize and utilize data as required, databases will be developed for each of the data types based on their data management needs. Raw data will be screened, validated, and pre-processed as needed by qualified professionals to produce data ready for interpretation and reporting.

A.6.A. Report Format and Package Information

Sugarberry CCS, LLC will provide the UIC Program Director and RRC Director with semi-annual reports containing all relevant project data and testing and monitoring information for the reporting period in compliance with 40 CFR 146.91(a). Refer to **Section B.4 of the Testing and Monitoring Plan** for further detail on the timing and content of reporting for specific events and operations.

A.6.B. Other Project Documents, Records, and Electronic Files

Other documents, records, and electronic files such as well and testing logs, installation and plugging reports, or other data will be stored and maintained for 10 years following site closure and provided at the request of the UIC Program Director.

A.6.C/D. Data Storage and Duration

Pursuant to 40 CFR 146.91(f)(3), any monitoring data collected through implementation of the Testing and Monitoring Plan will be retained for at least 10 years after it is collected. All site characterization data will be retained throughout the life of the geologic sequestration project and for at least 10 years following site closure.

A.6.E. QASP Distribution Responsibility

The Sugarberry CCS Hub Project Manager during pre-operational testing or the Sugarberry CCS Hub Operations Manager during injection and post-injection will be designated as the responsible party for ensuring that all those on the distribution list will receive the most current copy of the approved QASP.

B. <u>Data Generation and Acquisition</u>

B.1. Sampling Process Design

This section describes the design of the proposed monitoring network, which was developed to ensure safe, long-term containment of CO_2 within the injection intervals and non-endangerment of USDWs, human health, and the local environment.

B.1.A. Design Strategy

CO_2 Stream Monitoring Strategy

The objective of routinely analyzing the CO_2 stream is to evaluate the potential interactions of CO_2 and/or other constituents of the injectate with formation solids and fluids. This analysis can also identify (or rule out) potential interactions with well materials. Establishing the chemical composition of the injectate also supports regulatory determinations under the Resource Conservation and Recovery Act (RCRA, 1976) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 1980). Additionally, monitoring the chemical and physical characteristics of the CO_2 may help distinguish the injectate from the native fluids and gases if unintended leakage from the storage reservoir (i.e., injection zone) occurs.

Sugarberry CCS, LLC expects multiple sources of CO_2 from the region, with the potential for additional sources to be added throughout the life of the project. Each source will have a different gas stream composition, and the composition of the final injected gas stream will change slightly depending on which sources are operational. To detect any significant changes in the physical or chemical properties of the CO_2 stream that may result in a deviation from the permitted specifications, Sugarberry CCS, LLC will analyze the CO_2 stream continuously with a gas chromatograph located downstream of all CO_2 source points within the main trunk line. Physical samples will also be taken through a sampling port near the gas chromatograph.

Corrosion Monitoring Strategy

Well materials selected for the Sugarberry CCS Hub will be appropriate for the downhole conditions within the injection zones based on recent EPA guidance (see **Injection Well**

Construction Plan, Section 4). Corrosion coupon analyses will be conducted quarterly to aid in ensuring the mechanical integrity of the equipment in contact with the CO_2. Analyses will be conducted in accordance with the NACE RP0775-2018 (NACE, 2018) standard to determine and document corrosion wear rates based on mass loss.

Shallow Groundwater Monitoring Strategy

Shallow groundwater observation wells will be installed and screened in USDWs to monitor the geochemistry of groundwater commonly accessed by water wells in the area. The proposed wells will be located on the same well pad or adjacent to the SB-01 and SB-04 well pads to give a representative spatial distribution around the planned CO_2 injection wells and modeled plume development. The analyte list in **Table 7-6** of the **Testing and Monitoring Plan (Section 7)** is intended for both baseline and operational monitoring. After baseline is collected and sufficiently characterized, Sugarberry CCS, LLC may request a reduced set of analytes in consultation with the UIC Program Director. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the original set of monitoring parameters.

Deep Groundwater Monitoring Strategy

Above-Zone

Sugarberry CCS, LLC will conduct groundwater geochemical monitoring above the confining zone to meet the requirements of 40 CFR 146.90(d). The proposed observation wells will be constructed to monitor the sands within the Sub-Clarksville Sandstone Member, which is the first reasonably permeable sand unit above the primary confining zone, at the SB-01, SB-04, and SB-05 well pads. The purpose of the above-zone wells is to detect early leakage above the confining zone. MIT and downhole pressure monitoring at the injection wells will also provide data to ensure maintained well mechanical integrity. Prior to injection, baseline conditions will be documented and natural variability in conditions will be characterized. During injection or post-injection, unintended brine or CO_2 leakage will be detected, and sufficient data will be collected to demonstrate long-term containment is limited to the storage reservoir.

Parameters will include selected constituents that: (1) have primary and secondary EPA drinking water maximum contaminant levels, (2) will geochemically interact with CO_2 or brine, (3) are needed for quality control, and (4) may be needed for geochemical modeling. The analyte list in **Table 7-6** of the **Testing and Monitoring Plan (Section 7)** includes the same analytes for monitoring during baseline sampling and during injection. After the baseline is established, Sugarberry CCS, LLC may request a reduced set of analytes that are (1) the most responsive to interaction with CO_2 or brine and (2) are needed for quality control to accurately test for and monitor the presence (or lack thereof) of CO_2 migration. Implementation of a reduced set of parameters would be done at the approval of the UIC Program Director. During any period where a reduced set of analytes is used, if statistically significant trends are observed that are the result of unintended CO_2 or brine migration, the analytical list would be expanded to the original set of monitoring parameters. All groundwater and formation fluid samples will be analyzed using a laboratory meeting the requirements under the EPA Environmental Laboratory Accreditation

Program. The full list of analytical parameters and methods is provided in **Table 7-6 of the Testing and Monitoring Plan** and **Table 7.1.5** of this QASP.

Direct CO_2 Plume and Pressure Front Monitoring Strategy

Distributed Fiber Optic Sensing (DFOS) technology (DTS/DAS) will be deployed at the injection well and in-zone monitoring wells to continuously monitor temperature and pressure within the injection zone. Downhole pressure gauges will also be installed to monitor for changes in the formation pressure.

Indirect CO_2 Plume and Pressure Front Monitoring Strategy

Several technologies will be deployed within the injection and in-zone observation wells to indirectly monitor the presence/absence of the CO_2 plume and elevated pressure front. A fiberoptic line with DTS/DAS capabilities will be cemented along the outside of the long-string casing through the confining zone and into the injection zone to continuously record temperature and acoustic variations. External mechanical integrity at all deep wells (injection and in-zone) will be monitored continuously using DTS. PNC logging techniques will be utilized to verify external MIT for each injection and deep monitoring well by detecting the presence or absence of CO_2 in critical formations. Noise and temperature logging will be utilized to verify external MIT for the injection well throughout the injection phase. PNC logging will also serve to track the CO_2 plume progression in the in-zone observation wells.

B.1.B. Type and Number of Samples/Test Runs

Please refer to **Table 7.1.2** for descriptions of sampling and test runs type. The number of samples and test runs are described in detail in the **Testing and Monitoring Plan (Section 7).**

B.1.C. Site/Sampling Locations

Please refer to **Tables 7.1.1** and **Table 7.1.2** and the **Testing and Monitoring Plan (Section 7)** for descriptions of sampling and test locations.

B.1.D. Sampling Site Contingency

All testing and monitoring techniques will take place on private property of the project stakeholders, and Sugarberry CCS, LLC will have leased all well pad locations and established agreements for access. If inclement weather makes site access difficult, sampling schedules will be revised, and alternative dates may be selected that would still meet permit-related conditions.

B.1.E. Activity Schedule

Please refer to the **Testing and Monitoring Plan (Section 7)** for sampling and test schedules.

B.1.F. Critical/Informational Data

During sampling and analysis activities, detailed field and laboratory documentation will be collected in standard forms or notebooks. Critical information will include the time, date, and location of the activity; personnel involved; analytical equipment used; and a record of the analytical parameters, calibrations, and standards. For laboratory analyses, many critical data are generated during the analysis process and provided to end users in digital and printed formats. Noncritical data may include appearance and odor of the sample, issues with well or sampling equipment, and weather conditions.

B.1.G. Sources of Variability

Potential sources of variability relating to testing and monitoring activities include:

- Natural variation in formation pressure/temperature, fluid quality, and seismic activity.
- Variation in formation pressure/temperature, fluid quality, and seismic activity associated with nominal project operations.
- Changes in recharge due to precipitation (seasonal variation).
- Changes in instrument calibration during sampling or analytical activity.
- Different personnel collecting or analyzing samples.
- Variation in environmental conditions during field sampling.
- Changes in analytical data quality during the life of the project.
- Data entry errors.

Variability related to testing and monitoring activities may be eliminated or mitigated through the following methods:

- Gathering sufficient baseline data to observe natural variation in monitoring parameters.
- Evaluating data within the appropriate holding times after collection to observe anomalies that can be addressed by resampling or reanalyzing.
- Conducting statistical analysis of data to determine whether variability is natural/expected variation or unexpected variation.
- Maintaining weather-related data from onsite sources or from nearby locations (such as a local airport).
- Verifying instrument calibration before, during, and after sampling and analysis.
- Ensuring that staff are fully trained and certified if appropriate.
- Performing laboratory quality assurance checks using third party reference materials, and/or blind/duplicate samples.
- Utilizing a systematic review process of data that may include sample-specific data quality checks.

B.2. Sampling Methods

B.2.A/B. Sampling Standard Operating Procedures

The primary groundwater sampling method will be a low-flow sampling method consistent with ASTM D6452-99 (ASTM, 2005) or Puls and Barcelona (Puls et al., 1996). Prior to sampling, wells will be purged to ensure samples are representative of formation fluids. Before any purging or sampling activities begin, static water levels will be measured using an electronic water level indicator. Each groundwater monitoring well will contain a dedicated pump (e.g., bladder pumps) to minimize potential cross contamination between wells. Given sufficient flow rates and volumes, field parameters such as groundwater pH, temperature, specific conductance, and dissolved oxygen will be monitored in the field using portable probes and a flow-through cell consistent with standard methods (APHA 2005). If a flow-through cell is not used, field parameters will be measured in grab samples. Field chemistry probes will be calibrated at the beginning of each sampling day according to equipment manufacturer procedures using standard reference solutions. When a flow-through cell is used, field parameters will be continuously monitored and will be considered stable when three successive measurements made three (3) minutes apart meet the criteria listed in **Table 7.1.17.**

Table 7.1.17. Stabilization Criteria of Water Quality Parameters During Shallow Well Purging

Field Parameter	Stabilization Criteria
pH, temperature, specific conductance, dissolved oxygen, turbidity	*Parameter measurement until ±10% value stabilization
**Exact parameter stabilization threshold will depend on which purge method is selected from ASTM DX.*	

Groundwater samples will be collected after field parameters have stabilized. Flow-through filter cartridges (0.45 micrometers [µm]) will be utilized as required and consistent with ASTM D6564-00 (ASTM, 2017) for samples requiring field-filtering prior to analysis. Prior to sample collection, filters will be purged with a minimum of 100 milliliters (mL) of well water (or as advised by the filter manufacturer). For alkalinity and total CO_2 samples, efforts will be made to minimize exposure to the atmosphere during filtration, collection in sample containers, and analysis.

B.2.C/D. In-Situ and Continuous Monitoring

In-situ monitoring of groundwater chemistry is not planned. Continuous monitoring is discussed below.

Injection Monitoring

Data related to the operational process (injection rate and volume, annular pressure and volume, and injection pressure) will be continuously monitored with pressure gauges, flow meters, and the annulus monitoring system, all of which will be linked to the surface control system controlled by Sugarberry CCS, LLC. This operational data will ensure that injection is operating safely, efficiently, and not posing a risk to any USDWs. Additionally, continuously monitored operational parameters will be utilized in the reservoir and computational models to validate that the CO_2 plume and pressure front are migrating as expected.

Distributed Temperature Sensing (DTS)

DTS technology will continuously collect temperature data along a fiberoptic line installed along the outside of the long-string casing. The DTS line will collect temperature data along the long-string casing at set intervals of time which will be used when running external mechanical integrity tests to verify mechanical integrity and monitor the presence or absence of the CO_2 plume.

Distributed Acoustic Sensing (DAS)

DAS technology will continuously collect acoustic data along the long-string casing. Additionally, DAS will be utilized during VSPs to measure the arrival times of seismic waves in the subsurface to monitor the footprint of the CO_2 plume through imaging and to passively monitor and report micro-seismic events.

Pressure Gauges

Downhole pressure gauges will be deployed within all deep wells to continuously measure pressure variations within the injection interval and the above-zone monitoring intervals. These gauges will directly monitor the presence or absence of the injection-related pressure front.

B.2.E. Sample Homogenization, Composition, Filtration

See **Section B.2.A/B** for further information.

B.2.F. Sample Containers and Volumes

All samples will be collected in new or sanitized containers using industry-accepted standards and practices. Container type and size for each sample type are listed in **Table 7.1.18** and **Table 7.1.19.**

B.2.G. Sample Preservation

Sample preservation methods are outlined in **Table 7.1.18** and **Table 7.1.19.**

Table 7.1.18. Summary of Sample Containers, Preservation Treatments, & Holding Times for CO_2 Gas Stream Analysis

Sample	Volume/Container Material	Preservation Technique	Sample Holding time (max)
CO_2 gas stream	(2) 2L MLB Polybags (1) 75 cc Mini Cylinder	Sample Storage Cabinets	72 Hours

Table 7.1.19. Summary of Anticipated Sample Containers, Preservation Treatments, & Holding Times for Groundwater Samples

Target Parameters	Volume/Container Material	Preservation Technique	Sample Holding Time
Cations: Ca, Fe, K, Mg, Na, Si, Al, Ba, Mn, As, Cd, Cr, Cu, Pb, Sb, Se, Tl	250 mL/HDPE	Trace metal-grade nitric acid, cool 4°C	60 days
Dissolved CO_2	2 × 60 mL/HDPE	Filtered, cool 4°C	14 days
Isotopes: δ13C	2 × 60 mL/HDPE	Cool 4°C	4 weeks
Alkalinity, anions (Br, Cl, F, NO3, SO4)	500 mL/HDPE	Cool 4°C	45 days
Field Confirmation: Temperature, dissolved oxygen, specific conductance, pH	200 mL/glass jar	None	< 1 hour
Field Confirmation: Density	60 mL/HDPE	None	< 1 hour
Total Dissolved Solids	150-1000 mL/HDPE	None	14 days

B.2.H. Cleaning/Decontamination of Sampling Equipment

Dedicated pumps (e.g., bladder pumps) will be installed in each groundwater monitoring well to mitigate potential cross contamination among wells. Each installed pump will remain in the well for the duration of the project except for maintenance or replacement. The pumps will be cleaned on the outside before installation with a non-phosphate detergent. The pump will then be rinsed appropriately with deionized water. At least 1.0 liter (L) of deionized water will be cycled through the pump and tubing. Individual prepared pumps and tubing will be placed in clean containers for transport to the field for installation. All sampling glassware (such as pipettes, beakers, filter holders, etc.) will be cleaned using tap water and then washed in a dilute nitric acid solution before being thoroughly rinsed with deionized water prior to use.

B.2.I. Support Facilities

The following tools may be needed to sample groundwater: generator, vacuum pump, compressor, multi-electrode water quality sonde, and various meters to take analytical measurements such as pH and electrical conductance. Analytical field activities may take place in field vehicles and/or portable onsite trailers. Well gauges used for verification will be handled using industry standard best practices and procedures recommended from the vendor. Proper PPE, including nitrile gloves, safety goggles, hard hat, high-visibility clothing, and steel-toed boots will be worn by field and support personnel during field activities.

Coupons consisting of material that will directly contact the CO_2 stream will be placed within a flowline. Each sample will be attached to an individual holder and inserted in a flow through pipe arrangement, exposing the samples to the CO_2 stream, and allowing access for removal and testing. The flow through pipe arrangement will be located at the well location downstream of all process compression, dehydration, and pumping equipment. A parallel stream of high-pressure CO_2 will be routed from the flowline through the corrosion monitoring system. This loop will operate while injection is occurring, providing representative exposure of the samples to the CO_2 composition, temperature, and pressures that will be seen at the wellhead and injection tubing. Injection will be able to continue while samples are removed for testing.

B.2.J. Corrective Action, Personnel, and Documentation

Properly testing equipment and implementing corrective actions on broken or malfunctioning field equipment will be the responsibility of field personnel. If corrective action is not possible in the field, then equipment will be sent back to the manufacturer or qualified technician to be repaired, serviced, or replaced. Substantial corrective actions that may impact analytical results will be documented in field notes. If defective equipment causes disruptions to the sampling schedule, Sugarberry CCS, LLC will contact the UIC Program Director.

B.3. Sample Handling and Custody

Sample handling and hold times will comply with US EPA (US EPA, 1974), APHA (APHA, 2005), Wood (Wood, 1976), and ASTM Method D6517-00 (ASTM, 2005) standards. Samples will be kept at their preservation temperature and sent to the selected laboratory within 24 hours of collection, or sooner if warranted by hold times. Analysis of the samples will be completed within the holding time specified in **Table 7.1.19.** If alternative sampling methods become necessary, these methods will be discussed with the UIC Program Director prior to sampling and the Testing and Monitoring plan will be modified as necessary.

B.3.A. Maximum Hold Time/Time Before Retrieval

Please refer to **Table 7.1.18** and **Table 7.1.19** for details.

B.3.B. Sample Transportation

Samples will be transported in coolers with ice maintained to approximately 4 degrees Celsius and sent to the selected laboratory within 24 hours of sampling, or sooner if warranted by hold times.

B.3.C. Sampling Documentation

Sampling personnel will assess field documentation for completeness before departing the field and will compile field documentation for all samples collected. Field notes will be archived.

B.3.D. Sample Identification

Each groundwater sample container will have a label with the following information: project name/number, sample date and location, sample ID number, fresh or brine water, volume taken, analyte, filtration used (if applicable), and preservative used (if any). Refer to **Table 7.1.18** and **Table 7.1.19.**

B.3.E. Sample Chain-of-Custody

A standardized form will be used to document groundwater sample chain-of-custody. Copies of this form will be provided to laboratory personnel upon delivery of groundwater samples for analysis. These forms will be archived for future reference.

B.4. Analytical Methods

B.4.A. Analytical Standard Operating Procedures

Analytical standard operating procedures are referenced in **Tables 7.1.4** through **Table 7.1.16.** Other laboratory-specific standard operating procedures utilized by the contracted laboratory will be determined after the laboratory is selected. Upon request, Sugarberry CCS, LLC will provide the UIC Program Director with all laboratories' standard operating procedures developed for the specific parameter using the appropriate standard method.

B.4.B. Equipment/Instrumentation Needed

Details on the equipment and instrumentation needed are provided in **Tables 7.1.4** through **Table 7.1.16.**

B.4.C. Method Performance Criteria

Nonstandard method performance criteria are not anticipated for this project.

B.4.D. Analytical Failure

Each laboratory conducting the analyses in **Tables 7.1.4** through **Table 7.1.16** will be responsible for appropriately addressing analytical failure according to their individual standard operating procedures and the applicable analytical method.

B.4.E. Sample Disposal

Each laboratory conducting the analyses in **Tables 7.1.4** through **Table 7.1.16** will be responsible for appropriate sample disposal according to their individual standard operating procedures.

B.4.F. Laboratory Turnaround

Laboratory turnaround will vary by laboratory, but turnaround of verified analytical results within two months will be suitable for project needs.

B.4.G. Method Validation for Nonstandard Methods

Non-standard methods are not anticipated for this project. Sugarberry CCS, LLC would consult with the UIC Program Director should non-standard methods be needed during the project.

B.5. Quality Control

B.5.A. QC activities

Blanks

Field blanks will be utilized during groundwater sampling to identify potential contamination resulting from the sample collection and transportation processes. Field blanks will be collected and analyzed for the inorganic analytes listed in **Table 7-6 of the Testing and Monitoring Plan** at a frequency of one set of blanks per event. Field and trip blanks allow for QC of the groundwater samples because they are collected in the field and transported together; as such, they were subjected to the same field and transportation conditions.

Duplicates

During each round of groundwater sampling, a second groundwater sample will be collected from one well, selected based on a rotating schedule. These duplicate samples are collected from the same source and at the same time as the original sample in a separate, identical sample container. Duplicate samples are processed with the other groundwater samples and are used to assess sample heterogeneity and analytical precision.

B.5.B. Exceeding Control Limits

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

B.5.C. Calculating Applicable QC Statistics

Charge Balance

The groundwater sample analytical results are evaluated based on anion-cation charge balance calculation. All potable waters are electrically neutral; in theory, the chemical analyses should produce equally negative and positive ionic activity. The cation-anion charge balance will be calculated using the formula:

$$\% \text{ difference} = 100 * (\sum \text{cations} - \sum \text{anions} / \sum \text{cations} + \sum \text{anions}),$$

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

Mass Balance

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

$$1.0 < * \text{ (measured TDS / Calculated TDS)} < 1.2,$$

with anticipated values between 1.0 and 1.2.

Outliers

The identification of one or more statistical outliers is essential prior to the statistical evaluation of groundwater. This project will use the EPA's Unified Guidance (U.S. EPA, 2009) as a basis for selection of recommended statistical methods to identify outliers in groundwater chemistry data sets as appropriate. These techniques include Probability Plots and Box and Whisker Plots. The EPA-1989 (U.S. EPA, 2009) outlier test may also be used as another screening tool to identify potential outliers.

B.6. Instrument/Equipment Testing, Inspection, and Maintenance

All equipment and instrumentation will be inspected regularly and maintained, serviced, and calibrated per industry best practices and manufacturer standards. Spare parts that may be needed should be on-hand during field sampling events. Laboratory equipment testing, inspection, and maintenance will be the responsibility of the analytical laboratory per standard practice or method-specific protocol.

B.7. Instrument/Equipment Calibration and Frequency

B.7.A. Calibration and Frequency of Calibration

Pressure gauge calibration information is in **Table 7.1.10 and 7.1.13 through 14.** All field and downhole gauges will be calibrated prior to use by the equipment supplier. Gauges will be recalibrated as needed based on results of inspection, after any repairs or maintenance, or as required by the manufacturer. Logging tool calibration will be at the discretion of the service company providing the equipment, following manufacturer recommendations and/or standard industry practices. CO_2 flow meters will be calibrated using industry standards and at a frequency recommended by the manufacturer.

For groundwater sampling, portable field meters or multiprobe sondes used to determine field parameters (e.g., pH, temperature, specific conductance, dissolved oxygen) will be calibrated according to manufacturer recommendations and equipment manuals before sample collection begins. Recalibration is performed if any components yield atypical values or fail to stabilize during sampling. Handheld meters will be rinsed with deionized water between sampling locations to prevent potential cross contamination.

For CO_2 stream sampling, the gas chromatograph will be calibrated based on the manufacturer requirements.

B.7.B. Calibration Methodology

As discussed in **Section B.7.A**, logging tool and all field and downhole gauge calibration methodology will follow standard industry practices recommended by the respective manufacturers.

For groundwater sampling, standards used for calibration typically require a pH of 7 and 10, a standard at a particular microseimens per centimeter (µS/cm) value at 25°C for specific conductance, and a 100% dissolved oxygen solution. Calibration of pH meters will be performed per manufacturer's specifications using a 2-point calibration bounding the range of the sample. For coulometry, sodium carbonate standards (typically with a concentration of 4,000 mg CO_2/L) are routinely analyzed to evaluate instruments.

B.7.C. Calibration Resolution and Documentation

Calibration resolution and documentation will follow standard industry practices. Groundwater sampling equipment calibration occurs regularly, and values are recorded in sampling records, with any errors in calibration noted. When possible, an additional set of field equipment should be on-hand if calibration issues cannot be resolved.

B.8. Inspection/Acceptance for Supplies and Consumables

B.8.A/B. Supplies, Consumables, and Responsibilities

Individual vendors and subcontractors selected and approved by Sugarberry CCS, LLC will be responsible for obtaining supplies and consumables for field operations and ensuring they are acceptable for data collection activities. Analysis related supplies and consumables will be the responsibility of the laboratory conducting water analyses in accordance with the established standard methodologies and operating procedures.

B.9. Non-direct Measurements

B.9.A. Data Sources

Plume development will also be monitored via DTS, 3D DAS VSP, and PNC logging. PNC logs detect CO_2 concentration surrounding the wellbore and repeat logging runs will be compared to the baseline conducted prior to injection operations. DTS monitors variations in temperature along the wellbore at a high resolution, measured at regular intervals, in real-time. DAS measures strain caused by acoustic waves passing through/near the fiberoptic cable.

B.9.B. Relevance to Project

Time-lapse VSPs, in-zone geochemical monitoring, and scheduled PNC logging will be used to track CO_2 plume evolution and migration. After initial baseline testing is conducted prior to injection, processing and comparison of subsequent surveys will allow Sugarberry CCS, LLC to monitor the extent of the plume. Numerical modeling will be updated with new seismic, pressure, and saturation data throughout the project to best characterize the CO_2 plume growth and movement over time.

B.9.C. Acceptance Criteria

The collection of seismic data will follow standard industry practices to ensure accuracy in the resulting data. Similar ground conditions, seismic shot points located within acceptable limits, carefully inspected and operational geophones, and uniform seismic input signal will be used for each survey to ensure repeatability.

Gauges and other logging equipment used to collect non-direct measurements will be checked periodically and maintained according to manufacturer recommendations for equipment care and operation, to ensure the accuracy of readings as they are incorporated into the model.

B.9.D. Resources/Facilities Needed

Sugarberry CCS, LLC will subcontract all necessary resources and facilities for testing and monitoring activities.

B.9.E. Validity Limits and Operating Conditions

Seismic surveys and numerical modeling will be validated against industry standards by trained and experienced personnel designated by Sugarberry CCS, LLC.

B.10. Data Management

B.10.A. Data Management Scheme

Sugarberry CCS, LLC will conduct all project data, recordkeeping, and reporting per the requirements of 40 CFR 146.91(f). Sugarberry CCS, LLC or their designated contractor will maintain the required project data as described in **Section A.6** of this plan. Data will be backed up on secure servers.

B.10.B. Recordkeeping and Tracking Practices

All records of gathered data will be securely held and properly labeled for auditing purposes and for Sugarberry CCS, LLC internal records management procedures.

B.10.C. Data Handling Equipment/Procedures

All equipment used to store data will be properly maintained and operated according to proper industry standards. Sugarberry CCS, LLC will ensure that all necessary supervisory control and data acquisition (SCADA) systems and vendor data acquisition systems will interface with one another, and that all subsequent data will be held on a secure server.

B.10.D. Responsibility

The Sugarberry CCS Hub Project Manager will be responsible for ensuring proper data management is maintained during pre-operational testing and the Operations Manager for the injection and post-injection periods.

B.10.E. Data Archival and Retrieval

All data will be held and maintained by Sugarberry CCS, LLC as described in **Section A.6** of this plan. Data will be backed up on secure servers to be accessed by project personnel as required.

B.10.F. Hardware and Software Configurations

Sugarberry CCS, LLC will verify that vendor hardware and software configurations will interface appropriately and can integrate multiple data sources and maintain large quantities of data prior to implementation.

B.10.G. Checklists and Forms

Checklists and forms will be generated and completed, as necessary to ensure proper management, security, and quality of data collected.

C. Assessment and Oversight

C.1. Assessments and Response Actions

C.1.A. Activities to be Conducted

Refer to the **Testing and Monitoring Plan (Section 7)** for a summary of work to be performed and proposed work schedule. After completion of sample analysis, the results will be reviewed for quality control criteria as noted in **Section B.5** of this plan. If the data fails to meet the established quality criteria, samples will be reanalyzed if still within the holding time criteria. If outside of holding time criteria, additional samples may be collected, or sample results may be excluded from data evaluations and interpretations. Evaluation for data consistency will be performed according to procedures described in the EPA 2009 Unified Guidance.

C.1.B. Responsibility for Conducting Assessments

Each organization gathering data will be responsible for conducting their own internal assessments. All stop-work orders will be handled internally within each individual organization.

C.1.C. Assessment Reporting

All assessment information will be reported to Sugarberry CCS, LLC Project Manager during pre-operational testing or Operations Manager during injection and post-injection.

C.1.D. Corrective Action

All corrective actions which may affect a single organization's data collection responsibility shall be addressed, verified, and documented by the individual project managers, and communicated to others, as necessary. Corrective actions affecting multiple organizations should be addressed by all members of the project leadership and communicated to other members on the QASP distribution list. Integration of information from multiple monitoring sources (operational, in-zone monitoring, above-zone monitoring) may be required to determine whether data and/or measurement method corrections are required, as well as the most effective and cost-efficient action to implement. Sugarberry CCS, LLC will coordinate multiorganization assessments and correction efforts as needed.

C.2. Reports to Management

C.2.A/B. QA Status Reports

QA status reports are not required unless there are significant adjustments to the methods and procedures listed above. If adjustments are needed, this QASP will be reviewed and updated appropriately after consultation with the UIC Program Director. The revised QASP will be distributed by Sugarberry CCS, LLC to the full distribution list noted at the beginning of this document.

D. Data Validation and Usability

D.1. Data Review, Verification, and Validation

D.1.A. Criteria for Accepting, Rejecting, or Qualifying Data

Validation of data will include a review of concentration units, sample holding times, and the review of duplicate, blank, and other appropriate QA/QC results. Sugarberry CCS, LLC will maintain copies of all the laboratory's analytical test results and/or reports. Analytical results will be reported as required by the UIC Program Director. In the semi-annual reports, groundwater analysis data will be presented in graphical and tabular formats as appropriate to characterize general groundwater quality and identify interwell and intrawell variability with time. After sufficient data have been collected, additional methods, such as those described in the EPA 2009 Unified Guidance will be used to evaluate interwell and intrawell variations for groundwater constituents, to evaluate if significant changes have occurred that could be the result of CO_2 or brine seepage beyond the intended storage reservoir.

D.2. Verification and Validation Methods

D.2.A. Data Verification and Validation Processes

See **Sections D.1. and B.5** of this plan. Appropriate statistical software will be utilized to determine data consistency.

D.2.B. Data Verification and Validation Responsibility

Sugarberry CCS, LLC or its designated subcontractor will verify and validate all analytical data.

D.2.C. Issue Resolution Process and Responsibility

The Sugarberry CCS Hub Project Manager during pre-operations testing or Operations Manager during injection and post-injection will oversee the data handling, management, and assessment process. Staff involved in these processes will consult with the Project Manager or Operations Manager to determine actions required to resolve any issues.

D.2.D. Checklist, Forms, and Calculations

Checklists and forms will be developed specifically to meet permit requirements. These checklists will depend on the parameters that are being tested as well as standard operating procedures of the subcontractors and laboratories that will be gathering the data and conducting the analyses. Sugarberry CCS, LLC will provide these forms and checklists to the UIC Program Director upon request.

D.3. Reconciliation with User Requirements

D.3.A. Evaluation of Data Uncertainty

Statistical software will be used to evaluate data consistency using methods consistent with standard data analysis procedures (i.e., EPA 2009 Unified Guidance).

D.3.B. Data Limitations Reporting

Each vendor or subcontractor will be responsible for ensuring that data presented by their respective organizations is developed with the appropriate data-use limitations. Sugarberry CCS, LLC will ensure that the data-use limitations are known and presented properly.

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